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CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
Thalamuthu Natarajan Building, No.1, Gandhi Irwin Road, Egmore,
Chennai - 600 008
Phone : 28414855 Fax: 91-044-28548416
E-mail: mscmda@tn.gov.in
Web site: www.cmdachennai.gov.in.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the Thiru / Tmt. / M/s. **Dr. B. Ram Prasad** has enrolled as **Registered Geo Tech Engineer** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **Equivalent degree** and experience in the relevant field for **35** years.

He/She has been given the Registration No. **GTE/2024/2/0055** on **29-Feb-2024** He/She 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 **27-Feb-2029.**

Signature valid
Name :A. Meganathan
Designation :Superintendent
Date :02/29/2024 3:07:28 PM

SELF ATTESTED

A Meganathan

Superintendent

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

GEOTECHNICAL SITE INVESTIGATION

BORING 1 THROUGH 5

PROPOSED RESIDENTIAL APARTMENTS BUILDING SITE

OLD S NO 1110 PART (OLD TS NO 3 AND 5/2, WARD D, BLOCK NO 115)

NEW TS NO 3/1 AND 5/6, WARD D, BLOCK NO 115, G N T ROAD MOOLAKADAI, CHENNAI 600 060.

MADHAVARAM VILLAGE AND TALUK, CHENNAI DISTRICT, TN.

Report to

M/s. DRA Aadithya South City Projects Pvt. Ltd.
N. No. 109, 111 & 113 Lloyds Road (Avvai Shanmugan Salai)
Royapettah, Chennai 600 114, TN.

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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

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Phone: 044 - 2363 7146; e-mail: paygec@yahoo.com
CIN: U74210TN1992PTC023645

Report No. 041/GI/23-24.
June 24, 2023.

M/s. DRA Aadithya South City Projects Pvt. Ltd.
N. No. 109, 111 & 113 Lloyds Road (Avvai Shanmugan Salai)
Royapettah, Chennai 600 114, TN.

Geotechnical Site Investigation
Boring 1 through 5
Proposed Residential Apartments Building Site
Old S No 1110 Part (Old TS No 3 and 5/2, Ward D, Block No 115)
New TS No 3/1 and 5/6, Ward D, Block No 115, G N T Road
Moolakadai, Chennai 600 060
Madhavaram Village and Taluk, Chennai 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 work was authorized by your confirmation e-mail received on May 31, 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

(041brpt)
Copies Submitted: (3)

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

Dr. B. Ramprasad
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Managing Director

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

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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

SUMMARY

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation for the Proposed Residential Apartments Building Site, Old S No 1110 Part (Old TS No 3 and 5/2, Ward D, Block No 115), New TS No 3/1 and 5/6, Ward D, Block No 115, G N T Road, Moolakadai, Chennai 600 060, Madhavaram Village and Taluk, Chennai District, TN. The primary purpose of our investigation was to obtain data to identify suitable foundation type and estimate load carrying capacity of the selected foundation for the proposed either Stilt + Upper Stilt + 12 floors building. For the proposed building typical maximum column load was expected to be about 350 tons. This load detail was used only for estimating the preliminary foundation size and type of foundation.

The field investigation was performed on June 3 through 8, 2023. Number and location of the borings was selected to cover the four corners and center of the proposed building area. Boring 1 through 5 were drilled to 17.5-, 20.5-, 17.5-, 17.5- and 17.5-M below the Existing Ground Level (EGL), respectively. Borings were drilled beyond 10-M depth as the soils from 3-M below EGL mostly sand soils that may be possible to provide raft foundation for the proposed building, check that there were no significant variations in the soils under the building with possible shallow foundation, and check the liquefaction potential of the soil profile. All corner borings were drilled at least 3-M into confirmed hard stratum with at least three successive SPT "N" $\geq$ 75. The center boring (Boring 2) was drilled to hard strata weathered rock formation beyond 17.5-M. Tests were conducted to determine the pertinent index and engineering properties of the soils, and weathered rock encountered. We then performed engineering analyses to develop the required design data.

Natural topography of the site reflects a flat terrain with ramp of filling material near the entrance area. Visual observation inferred EGL of major portion of the site was about 1.8-M below the Existing Road Level (ERL) of road in front of the site. EGL of the main entrance area and Boring 3 were at about ERL and gradually sloping towards EGL of inside area of the site. Site had compound walls along rear boundary, and along the BPCL petrol bunk boundaries. Metal sheet cladding was present along all other remaining boundaries of the site. No significant vegetation was present in the site during the investigation. Proposed construction will be the first major construction activity of this magnitude to cover this site. The soil stratigraphy at the borings is tabulated below:

Boring – 1:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Coarse Sand with Stone Pieces – Filled Up Soil
II	1.0	3.0	Brown Silty Fine to Medium Sand with Clay Binder
III	3.0	9.0	Brown Fine to Medium Sand with Silt
IV	9.0	14.5	Brown Gray Silty Fine Sand
V	14.5	17.5+	Brown Fine to Medium Sand with Silt

Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt and Roots

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II	1.0	4.0	Brown Silty Fine Sand
III	4.0	8.0	Brown Fine to Medium Sand
IV	8.0	11.5	Gray Green Fine to Medium Sand with Silt
V	11.5	19.0	Gray Brown Silty Fine to Medium Sand
VI	19.0	20.5+	Gray Brown Weathered Rock

Boring – 3:

Stratum	Penetration, M From	To	Description
I	0	1.75	Brown Gravely Fine to Coarse Sand with Silt - Filled Up Soil
II	1.75	4.0	Brown Silty Fine Sand
III	4.0	6.0	Gray Brown Very Stiff Clay
IV	6.0	7.75	Brown Fine to Medium Sand with Silt
V	7.75	10.0	Gray Fine to Medium Sand with Silt
VI	10.0	14.5	Gray Silty Fine Sand
VII	14.5	17.5	Brown Silty Fine to Medium Sand
VIII	17.5+		Gray Very Hard Clay - Shale

Boring – 4:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Brown Fine to Coarse Sand with Rubbish – Filled Up Soil
II	1.0	1.75	Brown Very Stiff Clay
III	1.75	2.5	Brown Silty Fine Sand
IV	2.5	3.25	Gray Fine Sand with Clay Seams
V	3.25	8.0	Brown Fine to Medium Sand with Silt
VI	8.0	14.5	Gray Silty Fine to Medium Sand
VII	14.5	17.5+	Brown Silty Fine to Medium Sand

Boring – 5:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt - Rubbish
II	1.0	1.75	Brown Silty Fine Sand
III	1.75	2.5	Brown Very Stiff Clay
IV	2.5	8.0	Brown Fine to Medium Sand
V	8.0	14.5	Gray Silty Fine to Medium Sand
VI	14.5	17.5+	Brown Silty Fine to Medium Sand

The EGL of site was at about 1.8-M below ERL. For the site's surface drainage it will be necessary to raise the site level at least 1-M above the ERL of road in front of the site. For the proposed building Stilt + Upper Stilt + 12 floors site will require nearly 2.8-M thick site filling. To avoid having foundation in fill soils and top loose soils shallow foundation has to be located at least 1-M below EGL. Thus from the Finished Ground Level (FGL) it will be nearly 3.8-M. With such depth it will be difficult for proper compaction of fill soils between columns and in narrow spaces. Improper compaction will lead to settlement of the stilt floor resting on the fill soil. Therefore, for the proposed building it was recommended to provide "**Tractor Mounted Direct Mud Circulation (DMC) Cast In-Situ Pile**" foundation. This type of pile installation work will have low construction vibrations otherwise it may

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affect the existing building foundations and also lead to objections from adjacent building owners. Pile capacities were estimated for **14.5- and 13.5-M below EGL (16.3- and 15.3-M below FGL) total and effective length piles** with top 1-M pile cutoff for pile caps and tie beams. Ultimate and allowable pile capacities of various pile diameters were summarized below:

Pile Dia. M	Compressive Capacity		Uplift Capacity		Lateral Capacity @ 5 mm Defl.
	Ultimate Tons	Allowable Tons	Ultimate Tons	Allowable Tons	Allowable Tons
0.45	196.68	79	112.88	38	2.15
0.50	244.20	98	125.82	42	2.67
0.55	282.56	113	138.84	46	3.25
0.60	322.98	129	151.94	51	3.66
0.75	458.97	184	191.72	64	5.69

It was recommended to provide at least a two-pile group using suitable pile diameter instead of single pile - single column for better resistance to bending forces from column loads and seismic forces. In case of columns for lift or staircase area or places with close column spacing, and low column loads single pile per column can be provided with a common pile cap. Also, piles should be **structurally designed for higher bending / flexural capacity** to resist moments due to lateral forces during seismic events. All the pile caps should be tied together through rigid tie-beams. In case of single pile and single column unit extreme care should be taken to match center line of pile and column to minimize eccentricity to avoid additional bending moments in the pile. All the piles should be terminated in the hard strata with at least 1.5-M embedment.

In the site there was no known groundwater source. In the borings groundwater was seen at depth beyond 6-M below EGL. However, groundwater was not clear due to non-settlement of bentonite solution used in the borings. A bore well of unknown depth was present in the adjacent BPCL petrol bunk at a distance of about 20-M from Boring 5. Groundwater sample was collected from the BPCL's bore well for construction suitability tests. Test results indicate that tested groundwater was suitable for construction purposes as per IS: 456-2000. After installation of a bore well or open well in the site, groundwater from the site should be checked for construction suitability purposes at regular intervals from beginning and during construction period. **If necessary, suitable water treatment should be provided to make groundwater suitable for construction purposes.** Chemical tests were performed on ten soil samples collected at the rate of two samples per boring (one sample at upper level and one sample at deeper level). 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 concentration of tested chemicals within the acceptable limits as per IS: 456 - 2000 code guideline values for construction water.

We do not expect construction problems at this site due to site soil, and groundwater conditions in non-rainy seasons. Site's EGL was at 1.8-M below ERL of road in front of the site. The site's Finished Ground Level (FGL) should be at least 1-M above ERL for suitably surface drainage slopes and minimize site flooding from road runoff. The Finished Floor Level (FFL) of stilt floor should be 0.2-M above FGL of the site. Foundation excavation, site, and building basement fillings should be done with granular soils with proper compaction to achieve a minimum unit weight of 2.0 tons/M^3.

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Proper care should be taken in pile installation to avoid pile necking / bulging / improper concreting during pile installation due to presence of thick layers of sandy soils. **At pile termination depth bore should be properly washed and cleaned of all loosened material to prevent low end bearing capacity of the pile**. At pile termination depth strata will be very dense silty sand. **Therefore, after reaching recommended final depth SPT may be performed in the initial piles to gain understating of the soil behavior for drilling. Based on site specific experience further piles can be terminated accordingly.** For this site soil conditions **hydraulic rotary rig was not recommended.** Pile load tests should be conducted as per relevant IS code to confirm the load carrying capacities recommended above and also to check the quality of pile installation.

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. For lower bound soil profile of Boring 5 with groundwater at 1-M below EGL infers **"No"** seismic susceptibility. Under a seismic event of **6.0 Richter scale**, and IS code recommended peak ground acceleration of **0.16g at EGL** the total estimated vertical settlement was 0.01 cms and total horizontal displacement was 0.19 cms. Iwasaki liquefaction potential was 0.00 inferring **"No Liquefaction."**

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INTRODUCTION

Purpose and Scope

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation for the Proposed Residential Apartments Building Site, Old S No 1110 Part (Old TS No 3 and 5/2, Ward D, Block No 115), New TS No 3/1 and 5/6, Ward D, Block No 115, G N T Road, Moolakadai, Chennai 600 060, Madhavaram Village and Taluk, Chennai District, TN. The primary purpose of our investigation was to obtain data to identify suitable foundation type and estimate load carrying capacity of the selected foundation for the proposed either Stilt + Upper Stilt + 12 floors building. For the proposed building typical maximum column load was expected to be about 350 tons. This load detail was used only for estimating the preliminary foundation size and type of foundation. To accomplish these purposes, the following tasks were performed:

(1) Five detailed bore were drilled to 17.5-, 20.5-, 17.5-, 17.5- and 17.5-M depth below EGL to explore the subsurface stratigraphy and obtain soil and weathered rock samples for lab testing;

(2) 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 foundation.

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 calculations followed by a brief on construction considerations for this project.

FIELD AND LABORATORY INVESTIGATIONS

Exploratory Borings

Soil conditions at the site for proposed buildings were explored by Boring 1 through 5. Boring location details are presented on Plate 1. Number and location of the borings was selected to cover the four corners and center of the proposed building area. Boring 1 through 5 were drilled to 17.5-, 20.5-, 17.5-, 17.5- and 17.5-M below EGL, respectively. Borings were drilled beyond 10-M depth as the soils from 3-M below EGL mostly sand soils that may be possible to provide raft foundation for the proposed building, check that there were no significant variations in the soils under the building with possible shallow foundation, and check the liquefaction potential of the soil profile. All corner borings were drilled at least 3-M into confirmed hard stratum with at least three successive SPT "N" $\geq$ 75. The center boring (Boring 2) was drilled to hard strata weathered rock formation beyond 17.5-M. Tests were conducted to determine the pertinent index and engineering properties of the soils, and weathered rock encountered. We then performed engineering analyses to develop the required design data. Groundwater was seen at depths beyond 6-M below EGL. Log of Boring are presented on Plate 2 through 6.

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Field and Laboratory Tests

Borings were drilled using Calyx drilling unit. In the borings SPT was performed at 1-M interval to 10-M, and at 1.5-M interval beyond 10-M. SPT consists of driving a standard split spoon sampler, 51-mm outside diameter and 38-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 rock samples were collected at 1-, and 1.5-M intervals either disturbed or undisturbed as the case may be. All soil, rock, and water 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 are tabulated on the Summary of Test Results on Plate 7. Grain size distribution curve of tested soil are presented on Plate 8. Summary of Water Test and Soil Chemical Test Results are presented on Plate 9.

GENERAL SOIL CONDITIONS

Topography

Natural topography of the site reflects a flat terrain with ramp of filling material near the entrance area. Visual observation inferred EGL of major portion of the site was about 1.8-M below ERL of road in front of the site. EGL of the main entrance area and Boring 3 were at about ERL and gradually sloping towards EGL of inside area of the site. Site had compound walls along rear boundary, and along the BPCL petrol bunk boundaries. Metal sheet cladding was present along all other remaining boundaries of the site. No significant vegetation was present in the site during the investigation. Proposed construction will be the first major construction activity of this magnitude to cover this site.

Soil Stratigraphy

Soil stratigraphy disclosed by our investigation is presented on the log of boring on Plate 2 through 6. 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	Brown Fine to Coarse Sand with Stone Pieces – Filled Up Soil
II	1.0	3.0	Brown Silty Fine to Medium Sand with Clay Binder
III	3.0	9.0	Brown Fine to Medium Sand with Silt
IV	9.0	14.5	Brown Gray Silty Fine Sand
V	14.5	17.5+	Brown Fine to Medium Sand with Silt

For PRASAD ARMSTRONG YEN
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Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt and Roots
II	1.0	4.0	Brown Silty Fine Sand
III	4.0	8.0	Brown Fine to Medium Sand
IV	8.0	11.5	Gray Green Fine to Medium Sand with Silt
V	11.5	19.0	Gray Brown Silty Fine to Medium Sand
VI	19.0	20.5+	Gray Brown Weathered Rock

Boring – 3:

Stratum	Penetration, M From	To	Description
I	0	1.75	Brown Gravely Fine to Coarse Sand with Silt - Filled Up Soil
II	1.75	4.0	Brown Silty Fine Sand
III	4.0	6.0	Gray Brown Very Stiff Clay
IV	6.0	7.75	Brown Fine to Medium Sand with Silt
V	7.75	10.0	Gray Fine to Medium Sand with Silt
VI	10.0	14.5	Gray Silty Fine Sand
VII	14.5	17.5	Brown Silty Fine to Medium Sand
VIII	17.5+		Gray Very Hard Clay - Shale

Boring – 4:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Brown Fine to Coarse Sand with Rubbish – Filled Up Soil
II	1.0	1.75	Brown Very Stiff Clay
III	1.75	2.5	Brown Silty Fine Sand
IV	2.5	3.25	Gray Fine Sand with Clay Seams
V	3.25	8.0	Brown Fine to Medium Sand with Silt
VI	8.0	14.5	Gray Silty Fine to Medium Sand
VII	14.5	17.5+	Brown Silty Fine to Medium Sand

Boring – 5:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt - Rubbish
II	1.0	1.75	Brown Silty Fine Sand
III	1.75	2.5	Brown Very Stiff Clay
IV	2.5	8.0	Brown Fine to Medium Sand
V	8.0	14.5	Gray Silty Fine to Medium Sand
VI	14.5	17.5+	Brown Silty Fine to Medium Sand

Detailed soil descriptions that include textural variations and inclusions are noted on the log of boring presented on Plate 2 through 6.

For PRASAD ARMSTRONG YEN
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Interpretation of Soil Properties

Shear strength parameters for cohesion less soils were selected based on the field SPT results, grain size distribution analyses, and associated correlation. Shear strength parameters for cohesive soils were selected based on the field SPT results, and associated correlation. 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.)

Foundation calculations presented in this report were based on the lower bound soil proprieties of the Boring 1 and 3. A reevaluation of the recommendations in this report may be necessary if variations in the soil profile are encountered during the foundation excavation work. In addition, there may be a need to drill additional borings to investigate soil variability at that location. Based on the field and laboratory test results the following are the properties for soils encountered in the borings.

Boring – 1:

Stratum	Penetration, M From	To	Properties
I	0	1.0	γ_{sat} = 1.7 tons/M^3
II	1.0	3.0	$\phi = 32^o$; γ_{sat} = 1.7 tons/M^3
IIIa	3.0	4.0	$\phi = 33^o$; γ_{sat} = 1.75 tons/M^3
IIIb	4.0	5.0	$\phi = 35^o$; γ_{sat} = 1.95 tons/M^3
IIIc	5.0	9.0	$\phi = 36^o$; γ_{sat} = 2.0 tons/M^3
IVa	9.0	10.0	$\phi = 36^o$; γ_{sat} = 2.0 tons/M^3
IVb	10.0	14.5	$\phi = 37^o$; γ_{sat} = 2.1 tons/M^3
Va	14.5	16.0	$\phi = 37^o$; γ_{sat} = 2.1 tons/M^3
Vb	16.0	17.5+	$\phi = 38^o$; γ_{sat} = 2.2 tons/M^3

Boring – 2:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 32^o$; γ_{sat} = 1.7 tons/M^3
IIa	1.0	1.75	$\phi = 34^o$; γ_{sat} = 1.8 tons/M^3
IIb	1.75	2.5	$\phi = 32^o$; γ_{sat} = 1.7 tons/M^3
IIc	2.5	3.25	$\phi = 31^o$; γ_{sat} = 1.65 tons/M^3
IId	3.25	4.0	$\phi = 32^o$; γ_{sat} = 1.7 tons/M^3
IIIa	4.0	5.0	$\phi = 33^o$; γ_{sat} = 1.75 tons/M^3
IIIb	5.0	6.0	$\phi = 34^o$; γ_{sat} = 1.8 tons/M^3
IIIc	6.0	8.0	$\phi = 36^o$; γ_{sat} = 2.05 tons/M^3
IVa	8.0	9.75	$\phi = 36^o$; γ_{sat} = 2.0 tons/M^3
IVb	9.75	11.5	$\phi = 34^o$; γ_{sat} = 1.85 tons/M^3
Va	11.5	13.0	$\phi = 37^o$; γ_{sat} = 2.1 tons/M^3
Vb	13.0	15.75	$\phi = 38^o$; γ_{sat} = 2.2 tons/M^3
Vc	15.75	19.0	$\phi = 37^o$; γ_{sat} = 2.1 tons/M^3
VI	19.0	20.5+	$\phi = 38^o$; γ_{sat} = 2.2 tons/M^3

Boring – 3:

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

For PRASAD ARMSTRONG YEN
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IIa	1.75	2.5	$\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M^3
IIb	2.5	3.75	$\phi = 35^o$; $\gamma_{sat} = 1.9$ tons/M^3
IIIa	3.75	5.0	$C_u = 10$ tons/M^2; $\gamma_{sat} = 1.7$ tons/M^3
IIIb	5.0	6.0	$C_u = 15$ tons/M^2; $\gamma_{sat} = 1.75$ tons/M^3
IVa	6.0	7.0	$\phi = 36^o$; $\gamma_{sat} = 2.0$ tons/M^3
IVb	7.0	7.75	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
V	7.75	10.0	$\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M^3
VIa	10.0	11.0	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIb	11.0	14.5	$\phi = 36^o$; $\gamma_{sat} = 2.05$ tons/M^3
VII	14.5	17.5	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIII	17.5+		$C_u = 40$ tons/M^2; $\gamma_{sat} = 2.2$ tons/M^3

Boring – 4:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\gamma_{sat} = 1.65$ tons/M^3
II	1.0	1.75	$C_u = 11$ tons/M^2; $\gamma_{sat} = 1.7$ tons/M^3
III	1.75	2.5	$\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M^3
IV	2.5	3.25	$\phi = 31^o$; $\gamma_{sat} = 1.7$ tons/M^3
V	3.25	8.0	$\phi = 36^o$; $\gamma_{sat} = 2.0$ tons/M^3
VIa	8.0	9.75	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIb	9.75	11.5	$\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M^3
VIc	11.5	14.5	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIIa	14.5	16.0	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIIb	16.0	17.5+	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3

Boring – 5:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\gamma_{sat} = 1.7$ tons/M^3
II	1.0	1.75	$\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M^3
III	1.75	2.5	$C_u = 15$ tons/M^2; $\gamma_{sat} = 1.8$ tons/M^3
IVa	2.5	3.25	$\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M^3
IVb	3.25	4.0	$\phi = 30^o$; $\gamma_{sat} = 1.65$ tons/M^3
IVc	4.0	5.0	$\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M^3
IVd	5.0	8.0	$\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M^3
Va	8.0	11.5	$\phi = 35^o$; $\gamma_{sat} = 2.0$ tons/M^3
Vb	11.5	13.0	$\phi = 36^o$; $\gamma_{sat} = 2.05$ tons/M^3
Vc	13.0	14.5	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIa	14.5	17.5	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
VIb	17.5+		$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3

DESIGN INFORMATION

The EGL of site was at about 1.8-M below ERL. For the site's surface drainage it will be necessary to raise the site level at least 1-M above the ERL of road in front of the site. For the proposed building Stilt + Upper Stilt + 12 floors site will require nearly 2.8-M thick site filling. To avoid having foundation in fill soils and top loose soils shallow foundation has to be located at least 1-M below EGL. Thus from

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FGL it will be nearly 3.8-M. With such depth it will be difficult for proper compaction of fill soils between columns and in narrow spaces. Improper compaction will lead to settlement of the stilt floor resting on the fill soil. Therefore, for the proposed building it was recommended to provide "**Tractor Mounted Direct Mud Circulation (DMC) Cast In-Situ Pile**" foundation. This type of pile installation work will have low construction vibrations otherwise it may affect the existing building foundations and also lead to objections from adjacent building owners. Pile capacities were estimated for **14.5- and 13.5-M below EGL (16.3- and 15.3-M below FGL) total and effective length piles** with top 1-M pile cutoff for pile caps and tie beams. Pile capacity was estimated as per the IS: 2911 - 2010 (Part 1 / Sec. 2) Code guidelines. Ultimate and allowable pile compressive and uplift capacities of various pile diameters are summarized below:

Pile Dia. M	Compressive Capacity		Uplift Capacity		Lateral Capacity @ 5 mm Defl.
	Ultimate Tons	Allowable Tons	Ultimate Tons	Allowable Tons	Allowable Tons
0.45	196.68	79	112.88	38	2.15
0.50	244.20	98	125.82	42	2.67
0.55	282.56	113	138.84	46	3.25
0.60	322.98	129	151.94	51	3.66
0.75	458.97	184	191.72	64	5.69

It was recommended to provide at least a two-pile group using suitable pile diameter instead of single pile - single column for better resistance to bending forces from column loads and seismic forces. In case of columns for lift or staircase area or places with close column spacing, and low column loads single pile per column can be provided with a common pile cap. Also, piles should be **structurally designed for higher bending / flexural capacity** to resist moments due to lateral forces during seismic events. All the pile caps should be tied together through rigid tie-beams. In case of single pile and single column unit extreme care should be taken to match center line of pile and column to minimize eccentricity to avoid additional bending moments in the pile. All the piles should be terminated in the hard strata with at least 1.5-M embedment. Sample calculations are presented on Plate 10.

GROUNDWATER AND SOIL CHECMIAL ANALYSIS

In the site there was no known groundwater source. In the borings groundwater was seen at depth beyond 6-M below EGL. However, groundwater was not clear due to non-settlement of bentonite solution used in the borings. A bore well of unknown depth was present in the adjacent BPCL petrol bunk at a distance of about 20-M from Boring 5. Groundwater sample was collected from the BPCL's bore well for construction suitability tests. Test results indicate that tested groundwater was suitable for construction purposes as per IS: 456-2000. After installation of a bore well or open well in the site, groundwater from the site should be checked for construction suitability purposes at regular intervals from beginning and during construction period. **If necessary, suitable water treatment should be provided to make groundwater suitable for construction purposes.** Chemical tests were performed on ten soil samples collected at the rate of two samples per boring (one sample at upper level and one sample at deeper level). 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 concentration of tested chemicals within the acceptable limits as per IS: 456 - 2000 code guideline values for construction water. Summary of ground water test results are presented on Plate 9.

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CONSTRUCTION CONSIDERATIONS

We do not expect construction problems at this site due to site soil, and groundwater conditions in non-rainy seasons. Site's EGL was at 1.8-M below ERL of road in front of the site. The site's FGL should be at least 1-M above ERL for suitably surface drainage slopes and minimize site flooding from road runoff. FFL of stilt floor should be 0.2-M above FGL of the site. Foundation excavation, site, and building basement fillings should be done with granular soils with proper compaction to achieve a minimum unit weight of 2.0 tons/M^3.

Proper care should be taken in pile installation to avoid pile necking / bulging / improper concreting during pile installation due to presence of thick layers of sandy soils. **At pile termination depth bore should be properly washed and cleaned of all loosened material to prevent low end bearing capacity of the pile**. At pile termination depth strata will be very dense silty sand. **Therefore, after reaching recommended final depth SPT may be performed in the initial piles to gain understating of the soil behavior for drilling. Based on site specific experience further piles can be terminated accordingly.** For this site soil conditions **hydraulic rotary rig was not recommended.** Pile load tests should be conducted as per relevant IS code to confirm the load carrying capacities recommended above and also to check the quality of pile installation.

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. For lower bound soil profile of Boring 5 with groundwater at 1-M below EGL infers "No" seismic susceptibility. Under a seismic event of **6.0 Richter scale**, and IS code recommended peak ground acceleration of **0.16g at EGL** the total estimated vertical settlement was 0.01 cms and total horizontal displacement was 0.19 cms. Iwasaki liquefaction potential was 0.00 inferring "No Liquefaction." Liquefaction analysis results are presented on Plate 11.

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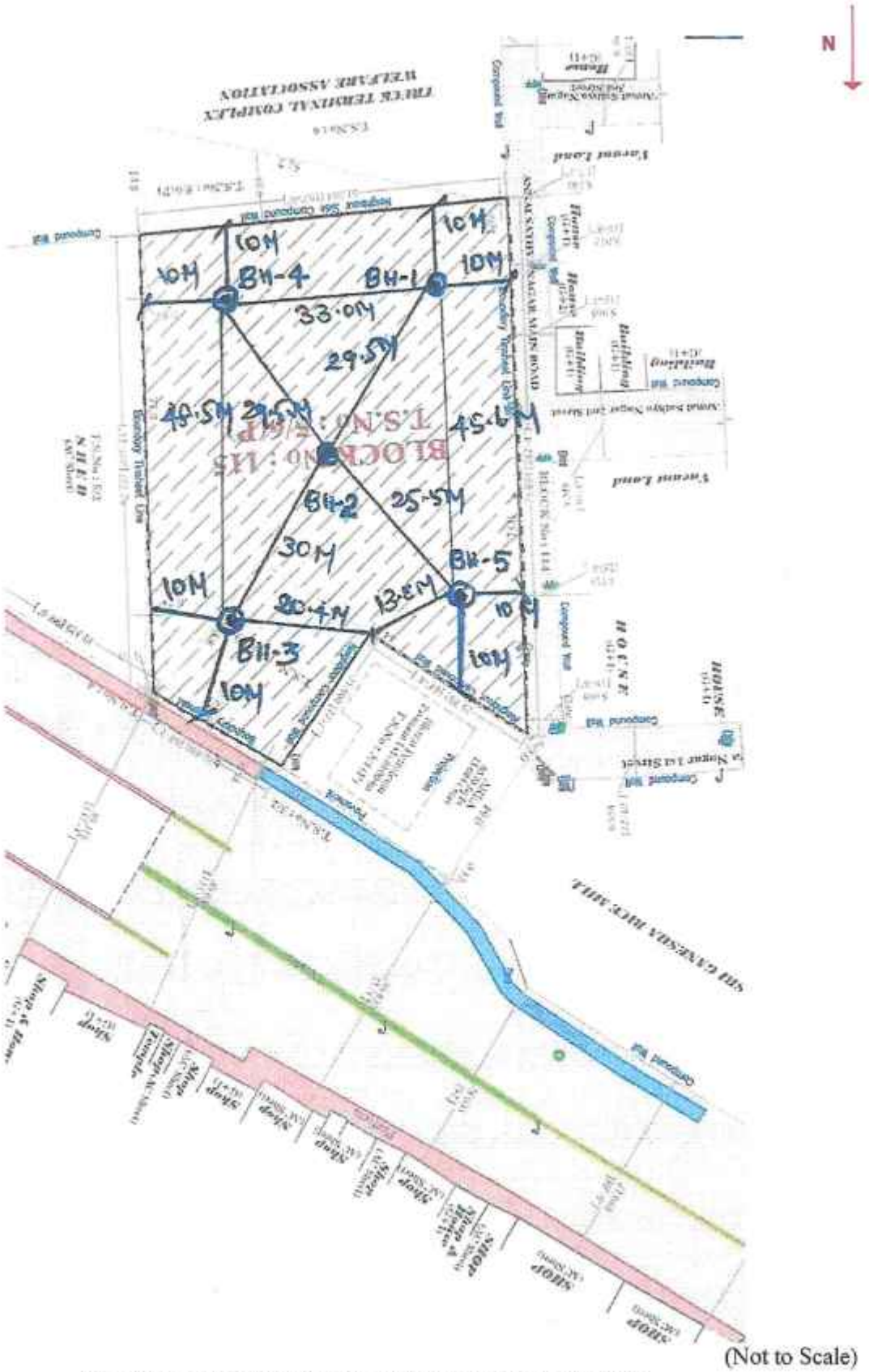

(Not to Scale)

Site EGL = 1.5-M Below ERL of Road In-Front of the Site.

BORE HOLE LOCATION DETAILS.

PLATE 1

For PRASAD ARMSTRONG YEN
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LOG OF BORING

Project: Proposed Residential Apartments Building Site, Old S No 1110 Part (Old TS No 3 and 5/2, Ward D, Block No 115), New TS No 3/1 and 5/6, Ward D, Block No 115, G N T Road, Moolakadal, Chennai 600 060, TN.

Bore Hole No.: 3 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 7-06-'23 **Ended on:** 8-06-'23 **Field Work In Charge:** Y Saravanan
Final Depth: 17.5-M **Depth to G W S:** 6.0-M & Deeper **Remarks:** Continued from Plate 4a.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	GRAY SILTY FINE SAND (To 14.5-M)	SPT @ 11.5 M 15/23/25 = 48 Blows		■ ♦
12.0				
13.0	11.0- to 14.5-m - ϕ = 36°; γ_t = 2.05 tons/M^3 (N_{req} = 60)	SPT @ 13 M 14/24/ 8 cms for 20 Blows		♦ ■
14.0	-fine to mediums sand with silt at 14.5-m	SPT @ 14.5M 18/28/ 4 cms for 10 Blows		■♦
15.0	BROWN SILTY FINE TO MEDIUM SAND (To 17.5-M)	3 cms for 10 Blows		
16.0	14.5- to 17.5-m - ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{req} > 75)	SPT @ 16 M 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)		■♦
17.0	-gray very hard clay - shale at 17.5-m	SPT @ 17.5 M 3 cms for 10 Blows		♦
18.0	17.5-m+ - C_u = 40 tons/M^2; γ_t = 2.2 tons/M^3 (N_{req} > 100)	2 cms for 10 Blows (Hammer Rebound)		
19.0				
20.0				
21.0				
22.0				

BORE HOLE TERMINATED AT 17.5-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 4b

For PRASAD ARMSTRONG YEN
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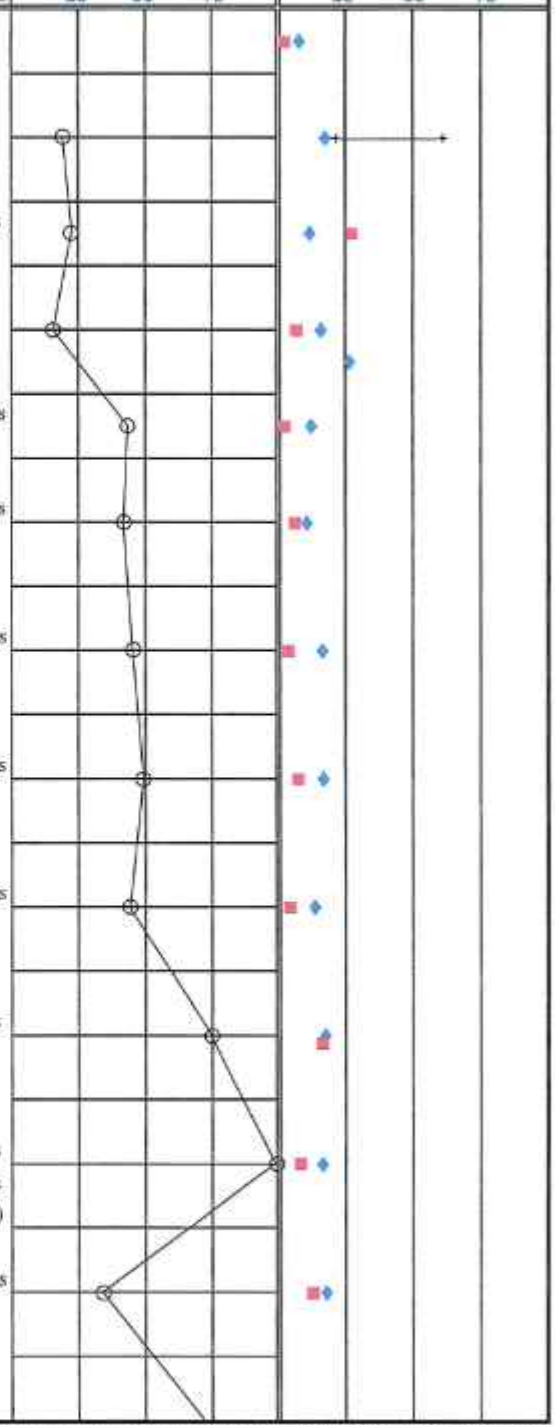
Bore Hole No.: 4 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 5-06-'23 **Ended on:** 6-06-'23 **Field Work In Charge:** Y Saravanan
Final Depth: 17.5-M **Depth to G W S:** 6.0-M & Deeper **Remarks:** None.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE
	RED BROWN FINE TO MEDIUM SAND with rubbish - Filled Up Soil (To 1.0-M)	DS @ 0.25 M
	0.0- to 1.0-m – γ_t = 1.65 tons/M^3 (N_{req} = 12)	SPT @ 1 M
1.0		6/8/10 = 18 Blows
	BROWN VERY STIFF CLAY (To 1.75-M)	
	1.0- to 1.75-m – C_u = 11 tons/M^2; γ_t = 1.7 tons/M^3 (N_{req} = 18)	SPT @ 1.75 M
2.0		6/10/12 = 22 Blows
	BROWN SILTY FINE SAND (To 2.5-M)	
	1.75- to 2.5-m – ϕ = 33°; γ_t = 1.75 tons/M^3 (N_{req} = 22)	SPT @ 2.5 M
		8/9/6 = 15 Blows
3.0	GRAY FINE SAND with clay seams (To 3.25-M)	
	2.5- to 3.25-m – ϕ = 31°; γ_t = 1.7 tons/M^3 (N_{req} = 15)	SPT @ 3.25 M
		14/20/22 = 42 Blows
	BROWN FINE TO MEDIUM SAND with silt (To 8.0-M)	
4.0		SPT @ 4 M
		14/20/20 = 40 Blows
5.0		SPT @ 5 M
		16/22/26 = 48 Blows
	3.25- to 8.0-m – ϕ = 36°; γ_t = 2.0 tons/M^3 (N_{req} = 45)	
6.0		SPT @ 6 M
		14/24/26 = 50 Blows
7.0	-gray brown color at 7-m	SPT @ 7 M
		17/21/25 = 46 Blows
8.0		SPT @ 8 M 28/ 8 cms for 10 Blows
	GRAY SILTY FINE TO MEDIUM SAND (To 14.5-M)	
9.0	8.0- to 9.75-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{req} > 75)	SPT @ 9 M 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)
10.0		SPT @ 10 M 10/13/18 = 31 Blows
	9.75- to 11.5-m – ϕ = 34°; γ_t = 1.85 tons/M^3 (N_{req} = 31)	
11.0		



CONTINUED ON PLATE 5b.

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 5a

For PRASAD ARMSTRONG YEN
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Bore Hole No.: 4 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 5-06-'23 **Ended on:** 6-06-'23 **Field Work In Charge:** Y Saravanan
Final Depth: 17.5-M **Depth to G W S:** 6.0-M & Deeper **Remarks:** Continued from Plate 5a.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	GRAY SILTY FINE TO MEDIUM SAND (To 14.5-M)	SPT @ 11.5 M 24/ 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)		
12.0				
13.0	11.5- to 14.5-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{req} > 75)	SPT @ 13 M 28/ 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)		
14.0				
15.0	BROWN SILTY FINE TO MEDIUM SAND (Below 14.5-M) 14.5- to 16.0-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{req} = 100)	SPT @ 14.5 M 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)		
16.0	-white brown color at 16-m	SPT @ 16 M 3 cms for 10 Blows		
	-fine to medium sand with limestone nodules at 16-m	2 cms for 10 Blows (Hammer Rebound)		
17.0	16.0- to 17.5-m – ϕ = 38°; γ_t = 2.2 tons/M^3 (N_{req} > 100)			
	-brown gray color at 17.5-m	SPT @ 17.5 M 30/ 3 cms for 10 Blows 2 cms for 10 Blows (Hammer Rebound)		
18.0				
19.0				
20.0				
21.0				
22.0				

BORE HOLE TERMINATED AT 17.5-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 5b

For PRASAD ARMSTRONG YEN
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Bore Hole No.: 5 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 6-06-'23 **Ended on:** 7-06-'23 **Field Work In Charge:** Y Saravanan
Final Depth: 17.5-M **Depth to G W S:** 6.0-M & Deeper **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 rubbish - Filled Up Soil (To 1.0-M)	DS @ 0.25 M		
	0.0- to 1.0-m – γ_t = 1.7 tons/M^3 (N_{avg} = 16)	SPT @ 1 M 8/10/12 = 22 Blows		
1.0				
	BROWN SILTY FINE SAND (To 1.75-M)			
	1.0- to 1.75-m – ϕ = 33°; γ_t = 1.75 tons/M^3 (N_{avg} = 22)	SPT @ 1.75 M 11/13/15 = 28 Blows		
2.0				
	BROWN VERY STIFF CLAY (To 2.5-M)			
	1.75- to 2.5-m – C_u = 15 tons/M^2; γ_t = 1.8 tons/M^3 (N_{avg} = 28)	SPT @ 2.5 M 13/10/12 = 22 Blows		
	BROWN FINE TO MEDIUM SAND (To 8.0-M)			
3.0	2.5- to 3.25-m – ϕ = 33°; γ_t = 1.75 tons/M^3 (N_{avg} = 22)	SPT @ 3.25 M 3/3/9 = 12 Blows		
	3.25- to 4.0-m – ϕ = 30°; γ_t = 1.65 tons/M^3 (N_{avg} = 12)	SPT @ 4 M 7/10/14 = 24 Blows		
4.0				
	4.0- to 5.0-m – ϕ = 33°; γ_t = 1.75 tons/M^3 (N_{avg} = 24)	SPT @ 5 M 11/15/19 = 34 Blows		
5.0				
		SPT @ 6 M 12/14/17 = 31 Blows		
6.0				
	5.0- to 8.0-m – ϕ = 34°; γ_t = 1.85 tons/M^3 (N_{avg} = 34)	SPT @ 7 M 12/16/20 = 36 Blows		
7.0				
		SPT @ 8 M 14/18/22 = 40 Blows		
8.0				
	GRAY SILTY FINE TO MEDIUM SAND (To 14.5-M)			
9.0		SPT @ 9 M 15/17/21 = 38 Blows		
	8.0- to 11.5-m – ϕ = 35°; γ_t = 2.0 tons/M^3 (N_{avg} = 41)			
10.0		SPT @ 10 M 16/20/24 = 44 Blows		
11.0				

CONTINUED ON PLATE 6b.

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 6a

For PRASAD ARMSTRONG YEN
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Bore Hole No.: 5 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 6-06-'23 **Ended on:** 7-06-'23 **Field Work In Charge:** Y Saravanan
Final Depth: 17.5-M **Depth to G W S:** 6.0-M & Deeper **Remarks:** Continued from Plate 6a.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	GRAY SILTY FINE TO MEDIUM SAND (To 14.5-M)	SPT @ 11.5M 18/20/ 4 cms for 10 Blows		
12.0	11.5- to 13.0-m – ϕ = 36°; γ_t = 2.05 tons/M^3 (N_{avg} = 58)			
13.0		SPT @ 13 M 26/ 8 cms for 20 Blows		
14.0	13.0- to 14.5-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{avg} = 75)			
		SPT @ 14.5 M 4 cms for 10 Blows		
15.0	BROWN SILTY FINE TO MEDIUM SAND (Below 14.5-M)	3 cms for 10 Blows (Hammer Rebound)		
16.0	14.5- to 17.5-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{avg} = 100)	SPT @ 16 M 4 cms for 10 Blows 3 cms for 10 Blows (Hammer Rebound)		
17.0		SPT @ 17.5 M 3 cms for 10 Blows		
	gray brown color at 17.5-m	2 cms for 10 Blows (Hammer Rebound)		
18.0	17.5-m+ – ϕ = 38°, γ_t = 2.2 tons/M^3 (N_{avg} > 100)			
19.0				
20.0				
21.0				
22.0				

BORE HOLE TERMINATED AT 17.5-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 6b

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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

SUMMARY OF TEST RESULTS

Boring No.	Depth, M	w %	PL	LL	-75μ%	SAND			GRAVEL	IS CLASS.
						Fine%	Medium%	Coarse%	%	
1	0.25	18			3					
	1.0	15			6					
	2.0	20			22	74	4	0	0	SM
	3.0	17			10					
	4.0	12			5	74	21	0	0	SP
	5.0	17			4					
	6.0	18			7	63	29	1	0	SP
	7.0	13			2					
	8.0	14			4	40	48	7	1	SP
	9.0	19			10					
	10.0	17			19	73	8	0	0	SM
	11.5	20			15					
	13.0	20			24	67	9	0	0	SM
	14.5	16			11					
	16.0	19			7	66	27	0	0	SP
	17.5	18			7	42	26	5	20	SP
2	0.25	14			8					
	1.0	14			19	76	5	0	0	SM
	1.75	17			10					
	2.5	24			27	68	5	0	0	SM
	3.25	21			10					
	4.0	10			6	70	24	0	0	SP
	5.0	18			3					
	6.0	17			4	51	44	1	0	SP
	7.0	16			1					
	8.0	19			9	79	12	0	0	SP-SM
	9.0	19			10					
	10.0	19			13	83	4	0	0	SM
	11.5	18			18					
	13.0	16			21	60	18	1	0	SM
	14.5	13			10					
	16.0	27			16	53	29	2	0	SM
	17.5	18			13					
	19.0	17			1	76	17	4	2	SP
	20.5	15			10	78	12	0	0	SP-SM
3	0.25	1			1					
	1.0	6			6	29	28	26	11	SW
	1.75	7			5					
	2.5	15			15	85	0	0	0	SM
	3.25	14			15	84	1	0	0	SM
	4.0	32	22	64						CH
	5.0	22	30	60						CH
	6.0	18			7	80	13	0	0	SP
	7.0	16			4					
	8.0	13			7	49	43	1	0	SP
	9.0	14			4					
	10.0	17			18	77	5	0	0	SM
	11.5	16			8					
	13.0	18			20	74	6	0	0	SM
	14.5	13			9					
	16.0	12			16	60	23	1	0	SM
	17.5	26	hard	shale						

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

Dr. B. Ramprasad
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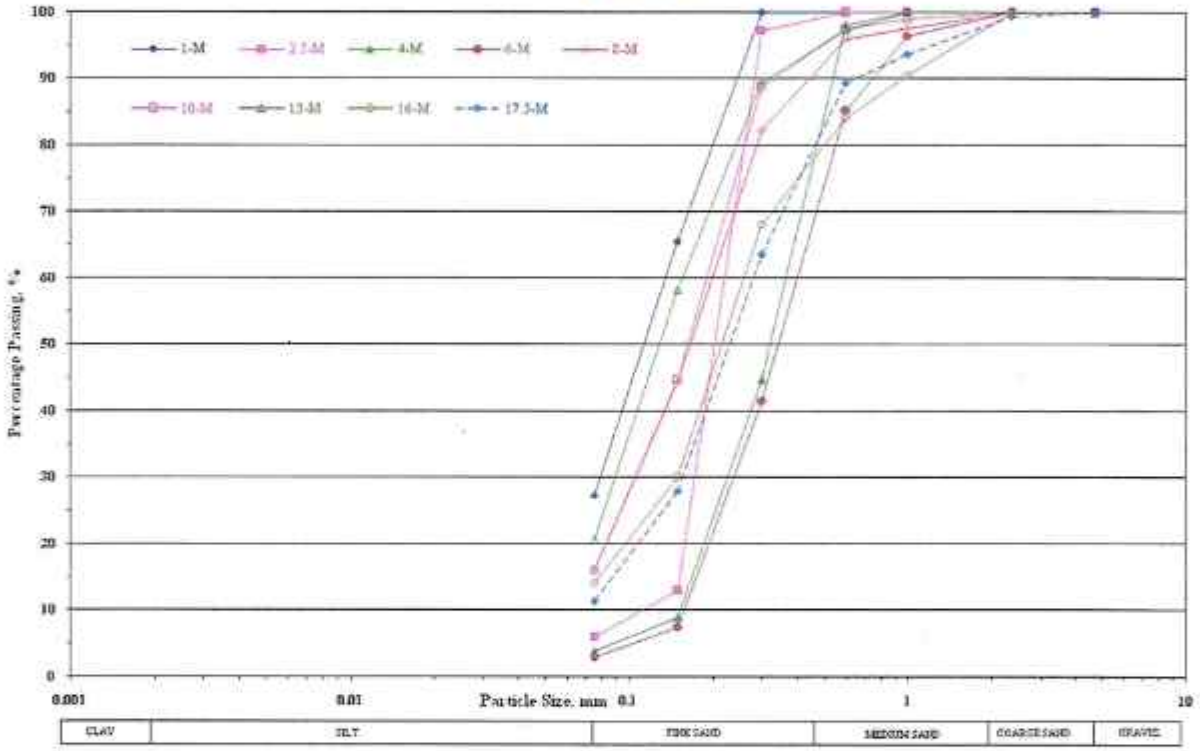
Managing Director

PLATE 7a

Grain Size Distribution Curves
Boring 5



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

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Managing Director

PLATE 8c

SUMMARY OF WATER TEST RESULTS

ADJACENT PLOT'S BROE WELL (BPCL PETROL BUNK); DEPTH = UNNOWN

DISTANCE FROM BORING 5 = 20-M; WATER LEVEL > 6-M IN BORINGS.

S. No.		Description	Results Obtained	As per IS:456 – 2000
1		To neutralize 100 cc of water using phenolphthalein as indicator	0.40 ml	Not more than 5 ml of 0.02N NaOH
2		To neutralize 100 cc of water using methyl orange as indicator	23.8 ml	Not more than 25 ml of 0.02N H_2SO_4
3	a	Organic Solids, mg/liter	40	200 Max.
	b	Inorganic Solids, mg/liter	990	3,000 Max.
	c	Sulphates as SO_3, mg/liter	98	400 Max.
	d	Chlorides as Cl, mg/liter	213	2,000 Max. - Plain Concrete 500 Max. RCC
	e	Suspended Solids, mg/liter	0	2,000 Max.
	f	pH	7.26	6 Min.

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

SUMMARY OF SOIL CHEMICAL TEST RESULTS

S. No.	Boring	Depth, M	pH	Chlorides	Sulphates, ppm	
				ppm	SO_4	SO_3
1	BH-1	3.0	7.85	80	48	40
2		16.0	8.38	108	59	49
3	BH-2	3.25	7.89	60	40	33
4		16.0	8.49	50	38	33
5	BH-3	4.0	7.96	0	0	0
6		14.5	6.80	690	380	317
7	BH-4	2.5	7.64	740	428	357
8		14.5	8.23	115	72	60
9	BH-5	3.25	8.48	42	28	23
10		13.0	8.07	38	22	19

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.

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

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Managing Director

SAMPLE CALCULATIONS FOR ROTARY RIG BORED CAST IN SITU PILES.

PILE CAPACITY CALCULATIONS - By IS : 2911 (Part 1 / Sec. 2) - 2010 Method.

PROPOSED RESIDENTIAL APARTMENTS BUILDING SITE

IId S No 1110 Part (Old TS No 3 & 5/2, Ward D, Block No 115), New TS No 3/1 & 5/6, Ward D, Block No 115, GNT Road, Moolakadai, Chennai 600 060, TN.

Bored Cast In-Situ Pile Details:

Total Pile Length = **16.30 M** below FGL
Top Pile Cutoff Length = 1.00 M Pile Cutoff for Pilecaps
Pile Effective Concreting Length = 15.30 M
Pile Diameters Considered: 0.45 0.50 0.55 0.60 0.75 -M.

Design Soil Profile Used in the Pile Capacity Calculations (Boring 3 Data)

S.No.	Soil Description	From	To	N_{avg}	C_u, T/M^2	ϕ^0	γ_T, T/M^3
1	Filled Up Soil - Yet To Be Done	0.00	1.80	10		28	1.60
2	Brown Gravely F to C Sand - Filled Up S	1.80	3.55	> 75		32	1.85
3a	Brown Silty Fine Sand	3.55	4.30	20		32	1.70
3b	Brown Silty Fine Sand	4.30	5.55	36		35	1.90
4a	Gray Brown Very Stiff Clay	5.55	6.80	16	10.00		1.70
4b	Gray Brown Very Stiff Clay	6.80	7.80	24	15.00		1.75
5a	Brown Fine to Medium Sand with Silt	7.80	8.80	46		36	2.00
5b	Brown Fine to Medium Sand with Silt	8.80	9.55	75		37	2.10
6	Gray Fine to Medium Sand with Silt	9.55	11.80	33		34	1.85
7a	Gray Silty Fine Sand	11.80	12.80	> 75		37	2.10
7b	Gray Silty Fine Sand	12.80	16.30	60		36	2.05
8	Brown Silty Fine to Medium Sand	16.30	19.30	> 75		37	2.10

For Cohesive Soils :-

C_u	α
10.00	0.42
15.00	0.30

Pile Capacity Calculations by IS : 2911 (Part I / Sec. 2) Method.

Unit Skin Friction in Clay Soils, f_s = αC_u
Unit Skin Friction in Sand Soils, f_s = $\sigma' K_o \tan\delta$ K_o = 1.00
Skin Friction of the Each Strata, Q_{si} = $f_s * \pi D L_i$
Total Ult. Skin Frition, $Q_{s\,ult}$ = ΣQ_{si}
Unit End Bearing in Clay Soils, q_{ult} = $9C_u$
Unit End bearing in Sand Soils, q_{ult} = $\sigma' N_q + 0.5 D \gamma N_\gamma$
Ultimate End Bearing, $Q_{p\,ult}$ = $q_{ult} * \pi D^2/4$

Total Ultmate Pile Capacity, Q_{ult} = $Q_{s\,ult} + Q_{p\,ult}$
Allowable Pile Capacity, Q_{all} = Q_{ult}/FS FS = Factor of Safety = **2.50**

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

Dr. B. Ramprasad
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Managing Director

COMPRESSIVE PILE CAPACITY CALCULATIONS

Skin Friction Calculations

S.No.	Soil Description	From	To	ϕ^0 / C_u	$\delta = \phi$	γ', T/M^3	σ'_{Mid}, T/M^2	f_s, T/M^2	Pile Dia 0.45 Q_s, T	0.50 Q_s, T	0.55 Q_s, T	0.60 Q_s, T	0.75 Q_s, T	-M.
1	Filled Up Soil - Yet To Be Done	0.00	1.80	28	28	0.60	0.54	0.00	0.00	0.00	0.00	0.00	0.00	Cutoff
2	Brown Gravely F to C Sand - Filled Up S	1.80	3.55	32	32	0.85	1.82	1.14	2.82	3.13	3.45	3.76	4.70	
3a	Brown Silty Fine Sand	3.55	4.30	32	32	0.70	2.83	1.77	1.88	2.08	2.29	2.50	3.13	
3b	Brown Silty Fine Sand	4.30	5.55	35	35	0.90	3.66	2.56	4.52	5.03	5.53	6.03	7.54	
4a	Gray Brown Very Stiff Clay	5.55	6.80	10.00		0.70	4.66	4.20	7.43	8.25	9.08	9.90	12.38	
4b	Gray Brown Very Stiff Clay	6.80	7.80	15.00		0.75	5.47	4.50	6.36	7.07	7.78	8.49	10.61	
5a	Brown Fine to Medium Sand with Silt	7.80	8.80	36	36	1.00	6.34	4.61	6.52	7.24	7.97	8.69	10.86	
5b	Brown Fine to Medium Sand with Silt	8.80	9.55	37	37	1.10	7.26	5.47	5.80	6.44	7.09	7.73	9.66	
6	Gray Fine to Medium Sand with Silt	9.55	11.80	34	34	0.85	8.62	5.82	18.51	20.57	22.62	24.68	30.85	
7a	Gray Silty Fine Sand	11.80	12.80	37	37	1.10	10.13	7.63	10.80	12.00	13.19	14.39	17.99	
7b	Gray Silty Fine Sand	12.80	16.30	36	36	1.05	12.52	9.09	45.02	50.02	55.02	60.02	75.03	
8	Brown Silty Fine to Medium Sand	16.30	16.30	37	37	1.10	14.36	10.82	0.00	0.00	0.00	0.00	0.00	
							Net Total Ultimate Skin Friction, $Q_{s\,ult}$=		109.65	121.83	134.01	146.19	182.74	

@ 16.3-M below Finished G. L. Soil	N = > 75
Formation - Very Dense Silty Sand	N_q = 75
L/D of Pile = 16.3/0.45 > 20	N_γ = 70
L/D of Pile = 16.3/0.50 > 20	
L/D of Pile = 16.3/0.55 > 20	
L/D of Pile = 16.3/0.60 > 20	
L/D of Pile = 16.3/0.75 > 20	
Use Lim. Value or Actual σ'_{base}	

		0.45	0.50	0.55	0.60	0.75	-M
	Base A=	0.1591	0.1964	0.2377	0.2829	0.4420	-M^2
	σ'_{base} =	7.06	8.05	8.90	9.80	12.99	T/M^2
	$q_{b\,ult}$ =	547.01	623.00	688.68	758.10	1003.13	T/M^2
Limited to as per IRC 78 - 2014: (Page 80, Note-2)	$q_{b\,all}$ =	625.00	625.00	625.00	625.00	625.00	T/M^2
	$Q_{b\,ult}$ =	87.03	122.38	148.55	176.79	276.23	Tons
	$Q_{s\,ult}$ =	109.65	121.83	134.01	146.19	182.74	Tons
	$Q_{tot\,ult}$ =	196.68	244.20	282.56	322.98	458.97	Tons
	F.S. =	2.5	2.5	2.5	2.5	2.5	
Allowable Compressive Capacity =	Q_{All} =	78.67	97.68	113.02	129.19	183.59	Tons
Use	Q_{All} =	79	98	113	129	184	Tons

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

Dr. S. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

Note:-

1 Pile Load Test must be conducted as per relavant IS Code to confirm the above estimated pile capacities before completion of installtion of all piles.
2 Pile installation must be done with extreme care to prevent "Necking" and "Buldging" problems due to presence of thick sand layers;
3 Ground water level was assumed to rise to ground level in worst case conditions.
4 Limiting All. End Bearing Pressure in "Hard Rock" as per IRC code was 500 tons/M^2. Therefore, q_b (all) is limited to 250 tons/M^2 in Very Dense Silty Sand.

UPLIFT PILE CAPACITY CALCULATIONS

Skin Friction Calculations

S.No.	Soil Description	From	To	ϕ^0 / C_u	$\delta = \phi$	γ', T/M^3	σ'_{Mid}, T/M^2	f_s, T/M^2	Pile Dia 0.45 Q_s, T	0.50 Q_s, T	0.55 Q_s, T	0.60 Q_s, T	0.75 Q_s, T	-M.
1	Filled Up Soil - Yet To Be Done	0.00	1.80	28	28	0.60	0.54	0.00	0.00	0.00	0.00	0.00	0.00	Cutoff
2	Brown Gravely F to C Sand - Filled Up S	1.80	3.55	32	32	0.85	1.82	1.14	2.82	3.13	3.45	3.76	4.70	
3a	Brown Silty Fine Sand	3.55	4.30	32	32	0.70	2.83	1.77	1.88	2.08	2.29	2.50	3.13	
3b	Brown Silty Fine Sand	4.30	5.55	35	35	0.90	3.66	2.56	4.52	5.03	5.53	6.03	7.54	
4a	Gray Brown Very Stiff Clay	5.55	6.80	10.00		0.70	4.66	4.20	7.43	8.25	9.08	9.90	12.38	
4b	Gray Brown Very Stiff Clay	6.80	7.80	15.00		0.75	5.47	4.50	6.36	7.07	7.78	8.49	10.61	
5a	Brown Fine to Medium Sand with Silt	7.80	8.80	36	36	1.00	6.34	4.61	6.52	7.24	7.97	8.69	10.86	
5b	Brown Fine to Medium Sand with Silt	8.80	9.55	37	37	1.10	7.26	5.47	5.80	6.44	7.09	7.73	9.66	
6	Gray Fine to Medium Sand with Silt	9.55	11.80	34	34	0.85	8.62	5.82	18.51	20.57	22.62	24.68	30.85	
7a	Gray Silty Fine Sand	11.80	12.80	37	37	1.10	10.13	7.63	10.80	12.00	13.19	14.39	17.99	
7b	Gray Silty Fine Sand	12.80	16.30	36	36	1.05	12.52	9.09	45.02	50.02	55.02	60.02	75.03	
8	Brown Silty Fine to Medium Sand	16.30	16.30	37	37	1.10	14.36	10.82	0.00	0.00	0.00	0.00	0.00	
					Net Total Ultimate Skin Friction, $Q_{s\,ult}$=				109.65	121.83	134.01	146.19	182.74	

Unit Weight of Pile RCC = γ_{conc} 2.40 T/M^3

	0.45	0.50	0.55	0.60	0.75	-M
Base A=	0.1591	0.1964	0.2377	0.2829	0.4420	-M^2
Pile Length, L =	14.50	14.50	14.50	14.50	14.50	-M
Pile Volume, V =	2.31	2.85	3.45	4.10	6.41	-M^3
Submerged Pile Weight W =	3.23	3.99	4.82	5.74	8.97	Tons
$Q_{s\,ult}$ =	109.65	121.83	134.01	146.19	182.74	Tons
$Q_{tot\,ult}$=	**112.88**	**125.82**	**138.84**	**151.94**	**191.72**	Tons
F.S. =	3.0	3.0	3.0	3.0	3.0	
Allowable Uplift Capacity = Q_{All} =	37.63	41.94	46.28	50.65	63.91	Tons
Use Q_{All} =	**38**	**42**	**46**	**51**	**64**	**Tons**

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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

Note:-

1 Pile Load Test must be conducted as per relavant IS Code to confirm the above estimated pile capacities before completion of installtion of all piles.

2 Pile installation must be done with extreme care to prevent "Necking" and "Buldging" problems due to presence of thick sand layers;

3 Ground water level was assumed to rise to ground level in worst case conditions.

SAMPLE CALCULATIONS FOR ROTARY RIG BORED CAST IN SITU PILES.

PILE CAPACITY CALCULATIONS - By IS : 2911 (Part 1 / Sec. 2) - 2010 Method.

PROPOSED RESIDENTIAL APARTMENTS BUILDING SITE

Old S No 1110 Part (Old TS No 3 & 5/2, Ward D, Block No 115), New TS No 3/1 & 5/6, Ward D, Block No 115, GNT Road, Moolakadai, Chennai 600 060, TN.

Treat Soil Profile from 1- to 5-M = Fine to Medium Sand
Average "N" Value = ~ 16

As per IS : 2911 (Part 1 / Sec 2) : 2010, Annex C, Table 3, Page 14
For Submerged Sand Soil with Estimated N_{avg}, Subgrade Modulus = η_h = 2250 kN/M²/M
(Medium Dense Sand from 12.5- to 14.5-M)
As per IS : 2911 (Part 1 / Sec 2) : 2010, Annex C, Page 14, Section C. 2.3.1

Deflec., y = $\frac{H(e+Z_f)^3*1000}{12EI}$ mm

Stiffness Factor T, in M = $\sqrt[5]{\frac{EI}{\eta_h}}$

Lateral Load H = $\frac{y*12EI}{(e+Z_f)^3*1000}$ kN

Concrete Grade = M30
Min. % of Reinforcement Content = 0.40%
Modulus of Pile, E_c = 200000 Kg/cm² = 2.00E+07 kN/M²

Max. Comp. Stress in Bending f_c = 700 Tons/M² = 70 Kg/cm²

Pile Length Above Ground = L_1
Stiffness Factor = T (Sand & NC Clays)
Stiffness Factor = R (OC Clays)
Pile Fixity Length = L_e Pile L_e/ T From Figure 4, Page 15, IS: 2911 (Part 2 / Sec/ 1) - 2010.

Dia., D M	(I) Mom. of Inertia, M⁴	EI	T M	L_1 M	L_1/T	L_e/T	L_e M	y mm	L_1+L_e (Z_f) M	H Tons
0.45	0.00201	40257	1.78	1.00	0.562	2.15	3.83	5.00	4.83	**2.15**
0.50	0.00307	61357	1.94	1.00	0.516	2.15	4.16	5.00	5.16	**2.67**
0.55	0.00449	89833	2.09	1.00	0.478	2.15	4.49	5.00	5.49	**3.25**
0.60	0.00636	127231	2.24	1.00	0.446	2.20	4.93	5.00	5.93	**3.66**
0.75	0.01553	310622	2.68	1.00	0.373	2.20	5.89	5.00	6.89	**5.69**

For PRASAD ARMSTRONG YEN
GEOTECH ENGINEERING CONSULTANTS (P) LTD.
Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

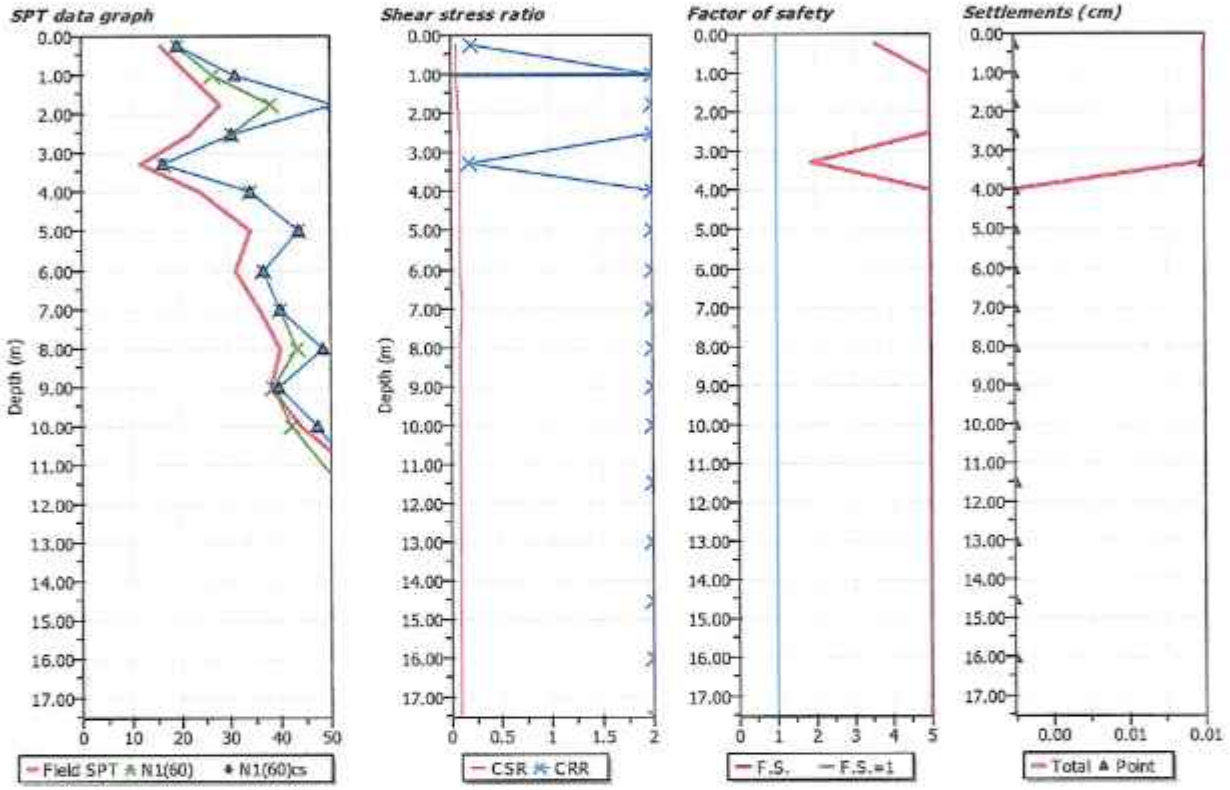
LIQUEFACTION ANALYSIS REPORT

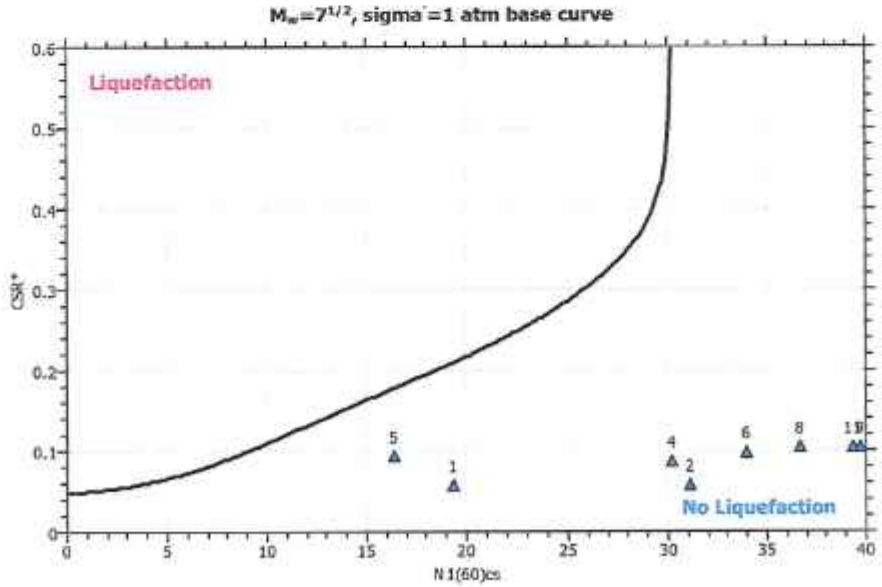
Project title : TS. No. 3 / 1 (P), 5 / 6 (P), Erukkanchery Main Road, Madhavaram, Chennai 600 110, TN.

Project subtitle : Boring 5 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

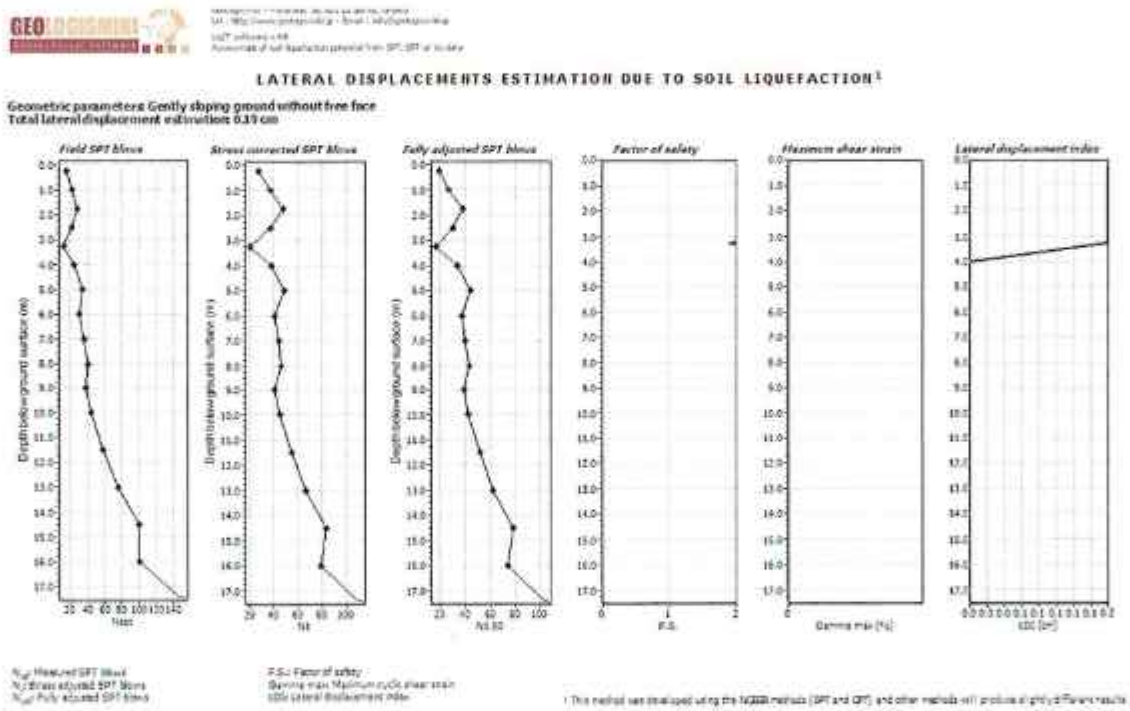




For PRASAD ARMSTRONG YEN
GEOTECH ENGINEERING CONSULTANTS (P) LTD.

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/2/0055
Managing Director

Horizontal Acceleration, $A_h = 0.16g$



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

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No. GTE/2024/20055
Managing Director

PLATE 11c

our services doesn't just end there

Buying & Selling Services

Property Buying Assistance, Property Selling Support, Market Price Analysis, Owner Outreach and Negotiation.

Legal & Documentation Services

Certified EC, Patta, legal opinions, property verification, due diligence, litigation solutions, and legal heir certificates.

Property Development & Approvals

Building plan approvals, construction, layout and sub-division approvals, zone conversion, and occupancy certification.

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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