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# GEOTECHNICAL SITE INVESTIGATION

## BORING 1 THROUGH 3

## PROPOSED RESIDENTIAL APARTMENTS BUILDING SITE

## "LAVANYA"

## NO. 236, KILPAUK GARDEN ROAD

## KILPAUK, CHENNAI 600 010, TN.

Report to

M/s. RMS Infrastructure P. Ltd.
No. 45 / 2, College Road
Nungambakkam, Chennai 600 006, TN.

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Report No. 002/BRP/23-24.
May 15, 2023.

M/s. RMS Infrastructure P. Ltd.
No. 45 / 2, College Road
Nungambakkam, Chennai 600 006, TN.

**Geotechnical Site Investigation**
**Boring 1 through 3**
**Proposed Residential Apartments Building Site**
**"Lavanya"**
**No. 236, Kilpauk Garden Road**
**Kilpauk, Chennai 600 010, 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 work order No. 4 dated May, 5, 2023.

Estimated capacities of the foundations recommended 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,

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

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## 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



A Meganathan

Superintendent

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## SUMMARY

A geotechnical site investigation was performed at the Proposed Residential Apartments Building Site, "**Lavanya**", No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN. The primary purpose of our investigation was to obtain data for selecting foundation type and estimate bearing capacity of the soil for the proposed Stilt + 5 Floors building. Typical expected maximum column load for the proposed building will be about 150 tons. These load details were only used for estimating the preliminary foundation size and type of foundation.

The field investigation was performed on May 8 through 11, 2023. The proposed site was about 6 grounds in area. For this site three borings were drilled at two corners of a diagonal and near center of the site with due consideration to presence of existing buildings. Boring 1 through 3 were drilled to 11.5-, 17.5-, and 10-M penetration below the Existing Ground Level (EGL), respectively. Tests were conducted to determine the pertinent index and engineering properties of the soils encountered. We then performed engineering analyses to develop the required design data.

Natural topography of the site reflects a flat terrain. The Existing Ground Level (EGL) of the site was about the Existing Road Level (ERL) of road in front of the site. In the site G + 1 floor RCC buildings were present. Site had compound walls on all sides of the plot. Site had many well grown trees and plant spread over the site around the existing buildings. Proposed construction will be the first major construction activity at 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 Medium Sand with Silt |
| II | 1.0 | 2.0 | Brown Silty Fine to Medium Sand |
| III | 2.0 | 3.0 | Brown Very Stiff Clay |
| IV | 3.0 | 11.5+ | Gray Brown Fine to Medium Sand |

**Boring – 2:**

| Stratum | Penetration, M From | To | Description |
|---|---|---|---|
| I | 0 | 1.75 | Brown Fine to Medium Sand with Silt |
| II | 1.75 | 4.0 | Brown Very Stiff Clay |
| III | 4.0 | 10.0 | Gray Fine to Medium Sand |
| IV | 10.0 | 17.5+ | Brown Fine to Medium Sand with Silt |

**Boring – 3:**

| Stratum | Penetration, M From | To | Description |
|---|---|---|---|
| I | 0 | 1.75 | Brown Fine to Medium Sand with Silt |
| II | 1.75 | 3.0 | Brown Stiff Clay |
| III | 3.0 | 10.0+ | Brown Fine to Medium Sand |

Data from the borings infer presence of good sand soil from 3- / 4-M onwards. The soil between 2- and 3 / 4--M was stiff to very stiff clay with SPT "N" values varying from 11 to 27. With such variable consistency clay soils total settlements will be highly variable and will happen over a long



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period of time. Therefore, avoid such variable settlements and related uncertainties for the proposed building it was recommended to provide "**Isolated Column Footing**" foundation at 3-M below ERL. Minimum footing size of 1.5-M was considered in the analysis. Estimated ultimate and recommended allowable bearing capacities were 99 and 22.5 tons/$M^2$, respectively. Estimated total settlement for the considered foundation was about 27 mm, less than the IS: 1904 - 1978 code limiting settlement of 60 mm for isolated column footing foundations on granular soils for framed structures. **In case clay soil was encountered at 3-M as observed in Boring 2** then in such footings 0.1-M thick 1:4 (Lime : Sand) bed followed by 0.25-M thick PCC should be provided instead of typical 0.1- / 0.125-M thick PCC to reduce the bearing pressure on clay soil.

In the site a defunct bore well of unknown depth was present in the site at about 7.3-M from Boring 2. Groundwater was at about 4.1-M below EGL in the Boring 1. Since the bore well was not in a working condition at the site, groundwater sample was collected from a bore well of unknown depth located in the plot across the road at about 40-M from Boring 1 for construction suitability tests. Test results indicate that tested groundwater from the bore well was suitable for construction purposes as per IS: 456-2000. Chemical tests were performed on soil sample from 2-M depth of Boring 1 through 3. Soil sample was 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 adverse chemicals in the tested soil samples less than the limiting values of water quality for construction purposes as per IS: 456-2000.

We don't expect construction problems at this site due to site soil and groundwater conditions in non-rainy seasons. Site's EGL was about ERL of road in front of the site. In order to minimize future site and building flooding from road runoff it was recommended to raise FGL of the site by **at least 0.6-M above ERL** of road in front of the site. FFL of **stilt floor** should be at least 0.15-M above FGL of the site. All footings should be rigidly interconnected with surrounding footings. Old buildings present in the site should be cleared for the proposed construction.

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

All structures at this site have to be designed for higher seismic forces (**Zone III**) due to increased seismic activity in peninsular India in the last two decades. Seismic events of 5.1 magnitude on August 24, 2021, 5.1 magnitude on February 12, 2019, 7.9 magnitude on April 25, 2015, 6.0 magnitude on May 21, 2014, 8.4 magnitude on April 11, 2012, 7.2 magnitude on June 13, 2010, and 7.6 magnitude on August 11, 2009 with epicenters in Himalayas, Bay of Bengal, and near Andaman Islands were felt at Chennai. Plinth beams must be designed to be rigid to allow redistribution of loads in case of differential settlements. For Boring 1 and 2 soil profile and GWL at 1-M below EGL infers "No"



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seismic susceptibility. **At EGL** under a seismic event of **6.0 Richter scale**, and peak ground acceleration of **0.16g** the total estimated vertical settlement was 0.14 cms and total horizontal displacement was about 1.02 cms. 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

A geotechnical site investigation was performed at the Proposed Residential Apartments Building Site, "Lavanya", No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN. The primary purpose of our investigation was to obtain data for selecting foundation type and estimate bearing capacity of the soil for the proposed Stilt + 5 Floors building. Typical expected maximum column load for the proposed building will be about 150 tons. These load details were only used for estimating the preliminary foundation size and type of foundation. To accomplish these purposes, the following tasks were performed:

(1) Three detailed bores were drilled to 11.5-, 17.5-, and 10-M penetration respectively below EGL in the site to explore the subsurface stratigraphy to obtain soil samples for laboratory 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 the proposed building were explored by Boring 1 through 3. Bore location details were presented on Plate 1. The proposed site was about 6 grounds in area. For this site three borings were drilled at two corners of a diagonal and near center of the site with due consideration to presence of existing buildings. Boring 1 through 3 were drilled to 11.5-, 17.5-, and 10-M penetration below EGL, respectively. Tests were conducted to determine the pertinent index and engineering properties of the soils encountered. We then performed engineering analyses to develop the required design data. Groundwater was at about 4.1-M below EGL in Boring 1. Log of Boring is presented on Plate 2 through 4.

## Field and Laboratory Tests

Boring was drilled using Calyx drilling unit. In the boring in situ SPT was performed at 1-M interval upto 10-M, 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.



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The soil-testing program was designed to evaluate pertinent index and engineering properties of the foundation soils. During the field operations soil samples were collected at an interval of 1- and 1.5-M either disturbed or undisturbed as the case may be. All soil samples were shipped to our Madras 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 5. Grain size distribution curves of tested soil are presented on Plate 6. Summary of Water and Soil Chemical Tests are presented on Plate 7.

## GENERAL SOIL CONDITIONS

### Topography

Natural topography of the site reflects a flat terrain. EGL of the site was about ERL of road in front of the site. In the site G + 1 floor RCC buildings were present. Site had compound walls on all sides of the plot. Site had many well grown trees and plant spread over the site around the existing buildings. Proposed construction will be the first major construction activity at this site.

### Soil Stratigraphy

The soil stratigraphy disclosed by our investigation is presented on the log of boring on Plate 2 through 4. The soil stratigraphy is based on classification of soil samples recovered from the boring, and our observations during drilling operations. A generalized summary of the major soil strata is tabulated below:

**Boring – 1:**

| Stratum | Penetration, M From | To | Description |
|---|---|---|---|
| I | 0 | 1.0 | Brown Fine to Medium Sand with Silt |
| II | 1.0 | 2.0 | Brown Silty Fine to Medium Sand |
| III | 2.0 | 3.0 | Brown Very Stiff Clay |
| IV | 3.0 | 11.5+ | Gray Brown Fine to Medium Sand |

**Boring – 2:**

| Stratum | Penetration, M From | To | Description |
|---|---|---|---|
| I | 0 | 1.75 | Brown Fine to Medium Sand with Silt |
| II | 1.75 | 4.0 | Brown Very Stiff Clay |
| III | 4.0 | 10.0 | Gray Fine to Medium Sand |
| IV | 10.0 | 17.5+ | Brown Fine to Medium Sand with Silt |

**Boring – 3:**

| Stratum | Penetration, M From | To | Description |
|---|---|---|---|
| I | 0 | 1.75 | Brown Fine to Medium Sand with Silt |
| II | 1.75 | 3.0 | Brown Stiff Clay |
| III | 3.0 | 10.0+ | Brown 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 4.



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## Interpretation of Soil Properties

Shear strength parameters for cohesion less soils were selected based on the field SPT results, and grain size distribution analyses. Shear strength parameters for cohesive soils were selected based on the field SPT results. The unit weight (soil density) profiles of the soils in the borings were developed from estimated values based on correlations of unit weight with particle size gradation and field test results (Bowles, 1982.)

Foundation calculations presented in this report were based on the lower bound soil proprieties of the Boring 2 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 boring.

**Boring – 1:**

| Stratum | Penetration, M From | To | Properties |
|---|---|---|---|
| I | 0 | 1.0 | $\phi = 34^o$; $\gamma_{sat} = 1.8$ tons/M$^3$ |
| II | 1.0 | 2.0 | $\phi = 34^o$; $\gamma_{sat} = 1.8$ tons/M$^3$ |
| III | 2.0 | 3.0 | $C_u = 16$ tons/M$^2$; $\gamma_{sat} = 1.8$ tons/M$^3$ |
| IVa | 3.0 | 3.75 | $\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M$^3$ |
| IVb | 3.75 | 4.75 | $\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IVc | 4.75 | 7.0 | $\phi = 31^o$; $\gamma_{sat} = 1.65$ tons/M$^3$ |
| IVd | 7.0 | 9.0 | $\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IVe | 9.0 | 11.5 | $\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M$^3$ |
| IVd | 11.5+ | | $\phi = 34^o$; $\gamma_{sat} = 1.8$ tons/M$^3$ |

**Boring – 2:**

| Stratum | Penetration, M From | To | Properties |
|---|---|---|---|
| Ia | 0 | 1.0 | $\gamma_{sat} = 1.75$ tons/M$^3$ |
| Ib | 1.0 | 1.75 | $\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M$^3$ |
| IIa | 1.75 | 3.0 | $C_u = 10$ tons/M$^2$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IIb | 3.0 | 4.0 | $C_u = 13$ tons/M$^2$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IIIa | 4.0 | 4.75 | $\phi = 34^o$; $\gamma_{sat} = 1.8$ tons/M$^3$ |
| IIIb | 4.75 | 7.0 | $\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IIIc | 7.0 | 10.0 | $\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M$^3$ |
| IVa | 10.0 | 11.5 | $\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| IVb | 11.5 | 13.0 | $\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M$^3$ |
| IVc | 13.0 | 17.5 | $\phi = 35^o$; $\gamma_{sat} = 1.95$ tons/M$^3$ |
| IVd | 17.5+ | | $\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M$^3$ |

**Boring – 3:**

| Stratum | Penetration, M From | To | Properties |
|---|---|---|---|
| I | 0 | 1.75 | $\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M$^3$ |
| II | 1.75 | 3.0 | $C_u = 7$ tons/M$^2$; $\gamma_{sat} = 1.65$ tons/M$^3$. |
| IIIa | 3.0 | 4.0 | $\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M$^3$ |



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| | | | |
|---|---|---|---|
| IIIb | 4.0 | 4.75 | $\phi = 34^o$; $\gamma_{sat}$ = 1.8 tons/M$^3$ |
| IIIc | 4.75 | 8.0 | $\phi = 32^o$; $\gamma_{sat}$ = 1.7 tons/M$^3$ |
| IIId | 8.0 | 10.0+ | $\phi = 33^o$; $\gamma_{sat}$ = 1.75 tons/M$^3$ |

## DESIGN INFORMATION

Data from the borings infer presence of good sand soil from 3-M onwards. The soil between 2- and 3- / 4-M was stiff to very stiff clay with SPT "N" values varying from 11 to 27. With such variable consistency clay soils total settlements will be highly variable and will happen over a long period of time. Therefore, avoid such variable settlements and related uncertainties for the proposed building it was recommended to provide "**Isolated Column Footing**" foundation at 3-M below ERL. Minimum footing size of 1.5-M was considered in the analysis. For the considered foundation 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:

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

Where

| | |
|---|---|
| B = Width of Footing; | $\gamma'$ = Eff. Unit Weight of Soil; |
| $q_{ult}$ = Ultimate Bearing Capacity of the Soil; | $s_c, s_q, s_\gamma$ = Shape Factors; |
| C = Avg. Soil Undrained Shear Strength; | $d_c, d_q, d_\gamma$ = Depth Factors; |
| $N_c$, $N_q$ & $N_\gamma$ = Bearing Capacity Factors; | $i_c, i_q, i_\gamma$ = Inclination Factors; and |
| q = Eff. Vertical Pressure at Footing Level | |

For the considered foundation estimated ultimate and recommended allowable bearing capacities were 99 and 22.5 tons/M$^2$, respectively. Estimated total settlement for the considered foundation was about 27 mm, less than the IS: 1904 - 1978 code limiting settlement of 60 mm for isolated column footing foundations on granular soils for framed structures.. **In case clay soil was encountered at 3-M as observed in Boring 2** then in such footings 0.1-M thick 1:4 (Lime : Sand) bed followed by 0.25-M thick PCC should be provided instead of typical 0.1- / 0.125-M thick PCC to reduce the bearing pressure on clay soil. Sample calculations for each of the above are presented on Plate 8.

## GROUNDWATER AND SOIL CHEMICAL ANALYSIS

In the site a defunct bore well of unknown depth was present in the site at about 7.3-M from Boring 2. Groundwater was at about 4.1-M below EGL in the Boring 1. Since the bore well was not in a working condition at the site, groundwater sample was collected from a bore well of unknown depth located in the plot across the road at about 40-M from Boring 1 for construction suitability tests. Test results indicate that tested groundwater from the bore well was suitable for construction purposes as per IS: 456-2000. Chemical tests were performed on soil sample from 2-M depth of Boring 1 through 3. Soil sample was 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 adverse chemicals in the tested soil samples less than the limiting values of water quality for construction purposes as per IS: 456-2000. Summary of groundwater and soil chemical test results are presented on Plate 7.



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## CONSTRUCTION CONSIDERATIONS

We don't expect construction problems at this site due to site soil and groundwater conditions in non-rainy seasons. Site's EGL was about ERL of road in front of the site. In order to minimize future site and building flooding from road runoff it was recommended to raise FGL of the site by **at least 0.6-M above ERL** of road in front of the site. FFL of **stilt floor** should be at least 0.15-M above FGL of the site. All footings should be rigidly interconnected with surrounding footings. Old buildings present in the site should be cleared for the proposed construction.

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

All structures at this site have to be designed for higher seismic forces (**Zone III**) due to increased seismic activity in peninsular India in the last two decades. Seismic events of 5.1 magnitude on August 24, 2021, 5.1 magnitude on February 12, 2019, 7.9 magnitude on April 25, 2015, 6.0 magnitude on May 21, 2014, 8.4 magnitude on April 11, 2012, 7.2 magnitude on June 13, 2010, and 7.6 magnitude on August 11, 2009 with epicenters in Himalayas, Bay of Bengal, and near Andaman Islands were felt at Chennai. Plinth beams must be designed to be rigid to allow redistribution of loads in case of differential settlements. For Boring 1 and 2 soil profile and GWL at 1-M below EGL infers "No" seismic susceptibility. **At EGL** under a seismic event of **6.0 Richter scale**, and peak ground acceleration of **0.16g** the total estimated vertical settlement was 0.14 cms and total horizontal displacement was about 1.02 cms. 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 9.



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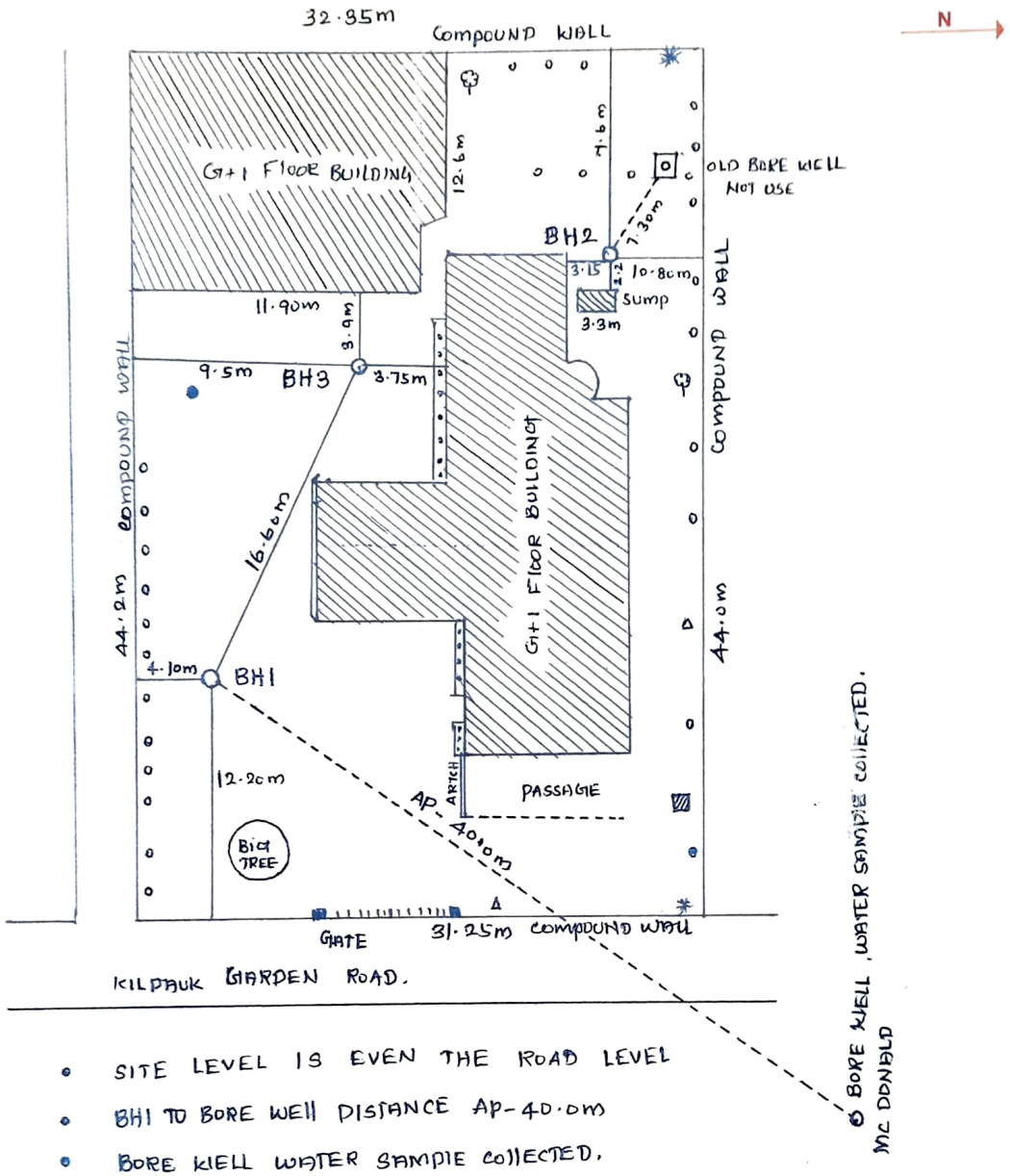
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- SITE LEVEL IS EVEN THE ROAD LEVEL
- BH1 TO BORE WELL DISTANCE Ap-40.0m
- BORE WELL WATER SAMPLE COLLECTED.

✱ NEEM TREES.

MANGO TREES.

△ COCONUT TREES.

O UNKNOWN TREES.

BH2 TO BORE WELL NOT USE [OLD BORE WELL] 7.30m DISTANCE.

(Not to Scale)

Site EGL = ERL of Road In Front of the Site.

BORE HOLE LOCATION DETAILS.

PLATE 1

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# LOG OF BORING

**Project:** Proposed Residential Apartments Building Site, "Lavanya" No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN.

**Bore Hole No.:** 1 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
**Started on:** 8.05.'23 **Ended on:** 9.05.'23 **Field Work In Charge:** R.Murugesan
**Final Depth:** 11.5 M **Depth to G W S:** 4.1 M **Remarks:** None

| DEPTH M | SOIL DESCRIPTION | SPT / VANE & SAMPLE TYPE | SPT 'N' PROFILE 10 20 30 | INDEX TEST DATA 25 50 75 |
|---|---|---|---|---|
| | BROWN FINE TO MEDIUM SAND with silt (Up to 1.0 M) | SPT @ 0.25 M 4/11/15 = 26 Blows | | |
| | 0.0 to 1.0 m $\phi$ = 31° $\gamma_t$ = 1.8 tons/M$^3$ ($N_{avg}$ = 26) | SPT @ 1 M 8/12/15 = 27 Blows | | |
| 1.0 | | | | |
| | BROWN SILTY FINE TO MEDIUM SAND (Up to 2.0 M) | | | |
| | 1.0 to 2.0 m $\phi$ = 34° $\gamma_t$ = 1.8 tons/M$^3$ ($N_{avg}$ = 27) | SPT @ 2 M 12/13/14 = 27 Blows | | |
| 2.0 | | | | |
| | BROWN VERY STIFF SANDY CLAY (Up to 3.0 M) | | | |
| | 2.0 to 3.0 m $C_u$ = 16 tons/M$^2$ $\gamma_t$ = 1.8 tons/M$^3$ ($N_{avg}$ = 27) | SPT @ 3 M 16/17/17 = 34 Blows | | |
| 3.0 | | | | |
| | GRAY BROWN FINE TO MEDIUM SAND (Below 3.0 M) ($N_{avg}$ = 31) | | | |
| | 3.0 to 3.75 m $\phi$ = 34° $\gamma_t$ = 1.85 tons/M$^3$ | SPT @ 4 M 7/8/12 = 20 Blows | | |
| 4.0 | gray brown color at 4 m | | | |
| | with silt at 4 m | | | |
| GWL | 3.75 to 4.75 m $\phi$ = 32° $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 20) | | | |
| | | SPT @ 5 M 4/5/7 = 12 Blows | | |
| 5.0 | gray color 5 to 9 m | | | |
| | | | | |
| | | SPT @ 6 M 4/6/7 = 13 Blows | | |
| 6.0 | 4.75 to 7.0 m $\phi$ = 31° $\gamma_t$ = 1.65 tons/M$^3$ ($N_{avg}$ = 12) | | | |
| | | SPT @ 7 M 6/7/9 = 16 Blows | | |
| 7.0 | | | | |
| | | | | |
| | | SPT @ 8 M 6/8/10 = 18 Blows | | |
| 8.0 | 7.0 to 9.0 m $\phi$ = 32° $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 17) | | | |
| | | | | |
| | brown color 9 to 11.5 m | SPT @ 9 M 6/8/12 = 20 Blows | | |
| 9.0 | with silt 9 to 11.5 m | | | |
| | | | | |
| | | SPT @ 10 M 7/11/12 = 23 Blows | | |
| 10.0 | 9.0 to 11.5 m $\phi$ = 33° $\gamma_t$ = 1.75 tons/M$^3$ ($N_{avg}$ = 22) | | | |
| | | | | |
| 11.5 | 11.5 m $\phi$ = 34° $\gamma_t$ = 1.8 tons/M$^3$ ($N_{avg}$ = 28) | SPT @ 11.5 M 8/12/16 = 28 Blows | | |

BORE HOLE TERMINATED AT 11.5 M.

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

PLATE 2

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# LOG OF BORING

**Project:** Proposed Residential Apartments Building Site, "Lavanya" No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN.

**Bore Hole No.:** 2 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
**Started on:** 10-05-'23 **Ended on:** 10-05-'23 **Field Work In Charge:** R Murugesan
**Final Depth:** 17.5-M **Depth to G W S:** 4.1-M **Remarks:** GWL from Boring 1.

| DEPTH, M | SOIL DESCRIPTION | SPT / VANE & SAMPLE TYPE | SPT "N" PROFILE (10 20 30) | INDEX TEST DATA (25 50 75) |
|---|---|---|---|---|
| | **BROWN FINE TO MEDIUM SAND with silt (To 1.75-M)** | DS @ 0.25 M | | |
| | 0.0- to 1.0-m – $\gamma_t$ = 1.75 tons/M$^3$ ($N_{avg}$ = 22) | SPT @ 1 M 11/11/12 = 23 Blows | | |
| 1.0 | 1.0- to 1.75-m – $\phi$ = 33°; $\gamma_t$ = 1.75 tons/M$^3$ ($N_{avg}$ = 23) | | | |
| 2.0 | **BROWN VERY STIFF CLAY (To 4.0-M)** | SPT @ 2 M 6/7/8 = 15 Blows | | |
| | 1.75- to 3.0-m – $C_u$ = 10 tons/M$^2$; $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 15) | | | |
| 3.0 | | SPT @ 3 M 14/11/8 = 19 Blows | | |
| | 3.0- to 4.0-m – $C_u$ = 13 tons/M$^2$; $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 19) | SPT @ 4 M 12/18/11 = 29 Blows | | |
| 4.0 | -brown color at 4-m | | | |
| GWL | **GRAY FINE TO MEDIUM SAND (To 10.0-M)** 4.0- to 4.75-m – $\phi$ = 34°; $\gamma_t$ = 1.8 tons/M$^3$ ($N_{avg}$ = 29) | SPT @ 5 M 5/6/10 = 16 Blows | | |
| 5.0 | | | | |
| 6.0 | 4.75- to 7.0-m – $\phi$ = 32°; $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 17) | SPT @ 6 M 8/9/9 = 18 Blows | | |
| | | SPT @ 7 M 8/10/11 = 21 Blows | | |
| 7.0 | | | | |
| 8.0 | | SPT @ 8 M 7/11/13 = 24 Blows | | |
| | 7.0- to 10.0-m – $\phi$ = 33°; $\gamma_t$ = 1.75 tons/M$^3$ ($N_{avg}$ = 23) | SPT @ 9 M 10/11/12 = 23 Blows | | |
| 9.0 | | | | |
| 10.0 | | SPT @ 10 M 8/9/10 = 19 Blows | | |
| | **BROWN FINE TO MEDIUM SAND with silt (Below 10.0-M)** 10.0- to 11.5-m – $\phi$ = 32°; $\gamma_t$ = 1.7 tons/M$^3$ ($N_{avg}$ = 19) | | | |
| 11.0 | | | | |

CONTINUED ON PLATE 3b

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 3a**

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Report No. 002/BRP/23-24

Dr. B. Ram Prasad, [illegible], Chennai-[illegible]

# LOG OF BORING

**Project:** Proposed Residential Apartments Building Site, Lavanya No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN.

**Bore Hole No.:** 2 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm

**Started on:** 10.05.'23 **Ended on:** 10.05.'23 **Field Work In Charge:** P. Murugesan

**Final Depth:** 17.5 M **Depth to G W S:** 4.1 M **Remarks:** Continued from Plate 3a

| DEPTH M | SOIL DESCRIPTION | SPT / VANE & SAMPLE TYPE | SPT 'N' PROFILE 10 20 30 | INDEX TEST DATA 25 50 75 |
|---|---|---|---|---|
| | BROWN FINE TO MEDIUM SAND with silt (Below 10.0 M) | SPT @ 11.5 M 11/14/19 – 33 Blows | | |
| 12.0 | 11.5 to 13.0 m $\phi$ = 33°, $\gamma_b$ = 1.85 tons/M$^3$ ($N_{avg}$ = 33) | | | |
| 13.0 | | SPT @ 13 M 12/18/21 – 39 Blows | | |
| 14.0 | | | | |
| | | SPT @ 14.5 M 9/15/22 – 37 Blows | | |
| 15.0 | 13.0 to 17.5 m $\phi$ = 35°, $\gamma_b$ = 1.95 tons/M$^3$ ($N_{avg}$ = 39) | | | |
| 16.0 | | SPT @ 16 M 14/20/20 – 40 Blows | | |
| 17.0 | | SPT @ 17.5 M 28/ 6 cms for 20 Blows | | |
| 18.0 | 17.5 m+ $\phi$ = 37°, $\gamma_b$ = 2.1 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 3b

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# LOG OF BORING

**Project:** Proposed Residential Apartments Building Site, "Lavanya" No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN.

**Bore Hole No.:** 3 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
**Started on:** 11-05-'23 **Ended on:** 11-05-'23 **Field Work In Charge:** R Murugesan
**Final Depth:** 10.0-M **Depth to G W S:** 4.1-M **Remarks:** GWL from Boring 1.

| DEPTH M | SOIL DESCRIPTION | SPT / VANE & SAMPLE TYPE |
|---|---|---|
| | BROWN FINE TO MEDIUM SAND with silt (To 1.75-M) | SPT @ 0.25 M 9/9/9 = 18 Blows |
| 1.0 | 0.0- to 1.75-m - $\phi$ = 32°, $\gamma_t$ = 1.7 tons M$^3$ ($N_{avg}$ = 16) | SPT @ 1 M 6/7/8 = 15 Blows |
| 2.0 | BROWN STIFF CLAY (To 3.0-M) | SPT @ 2 M 5/5/6 = 11 Blows |
| | 1.75- to 3.0-m - $C_u$ = 7 tons M$^2$, $\gamma_t$ = 1.65 tons M$^3$ ($N_{avg}$ = 11) | |
| 3.0 | -silty at 3-m | SPT @ 3 M 6/10/11 = 21 Blows |
| | GRAY BROWN FINE TO MEDIUM SAND (Below 3.0-M) | |
| 4.0 | 3.0- to 4.0-m - $\phi$ = 33°, $\gamma_t$ = 1.75 tons M$^3$ ($N_{avg}$ = 21) | SPT @ 4 M 6/12/17 = 29 Blows |
| GWL | 4.0- to 4.75-m - $\phi$ = 34°, $\gamma_t$ = 1.8 tons M$^3$ ($N_{avg}$ = 29) | |
| 5.0 | -gray color, 5- to 9-m | SPT @ 5 M 5/7/8 = 15 Blows |
| 6.0 | | SPT @ 6 M 5/7/9 = 16 Blows |
| | 4.75- to 8.0-m - $\phi$ = 32°, $\gamma_t$ = 1.7 tons M$^3$ ($N_{avg}$ = 17) | |
| 7.0 | | SPT @ 7 M 6/8/11 = 19 Blows |
| 8.0 | -brown color, 9- to 10-m | SPT @ 8 M 8/9/12 = 21 Blows |
| 9.0 | 8.0- to 10.0-m - $\phi$ = 33°, $\gamma_t$ = 1.75 tons M$^3$ ($N_{avg}$ = 24) | SPT @ 9 M 10/12/13 = 25 Blows |
| 10.0 | | SPT @ 10 M 8/13/14 = 27 Blows |
| 11.0 | | |

SPT "N" PROFILE: 10 20 30

INDEX TEST DATA: 25 50 75

BORE HOLE TERMINATED AT 10.0-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

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# SUMMARY OF TEST RESULTS

| Boring No. | Depth M | W % | PL | LL | -75µ% | SAND | | | GRAVEL % | IS CLASS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Fine% | Medium% | Coarse% | | |
| 1 | 0.25 | 7 | | | 8 | | | | | |
| | 0.5 | 12 | | | 16 | | | | | |
| | 1.0 | 22 | 24 | 55 | | | | | | |
| | 2.0 | 7 | | | 4 | 45 | 45 | 6 | 0 | SP |
| | 3.0 | 23 | | | 7 | 69 | 24 | 0 | 0 | SP |
| | 4.0 | 17 | | | 4 | | | | | |
| | 5.0 | 17 | | | 2 | 52 | 44 | 2 | 0 | SP |
| | 6.0 | 15 | | | 2 | | | | | |
| | 7.0 | 16 | | | 2 | 45 | 49 | 4 | 0 | SP |
| | 8.0 | 18 | | | 5 | | | | | |
| | 9.0 | 15 | | | 7 | 52 | 36 | 5 | 0 | SP |
| | 10.0 | 16 | | | 7 | 59 | 30 | 4 | 0 | SP |
| | 11.5 | | | | | | | | | |
| 2 | 0.25 | 6 | | | 5 | | | | | |
| | 0.5 | 12 | | | 6 | | | | | |
| | 1.0 | 21 | 22 | 57 | | | | | | CH |
| | 2.0 | 22 | 28 | 54 | | | | | | CH |
| | 3.0 | 22 | | | 4 | 65 | 31 | 0 | 0 | SP |
| | 4.0 | 15 | | | 2 | | | | | |
| | 5.0 | 15 | | | 2 | 45 | 48 | 5 | 0 | SP |
| | 6.0 | 15 | | | 2 | | | | | |
| | 7.0 | 14 | | | 3 | 28 | 56 | 13 | 0 | SP |
| | 8.0 | 15 | | | 3 | | | | | |
| | 9.0 | 15 | | | 8 | 66 | 63 | 3 | 0 | SP |
| | 10.0 | 14 | | | 7 | | | | | |
| | 11.5 | 17 | | | 7 | 69 | 24 | 0 | 0 | SP |
| | 13.0 | 19 | | | 7 | | | | | |
| | 14.5 | 16 | | | 7 | 61 | 30 | 2 | 0 | SP |
| | 16.0 | 17 | | | 5 | 51 | 36 | 4 | 4 | SP |
| | 17.5 | | | | | | | | | |
| 3 | 0.25 | 9 | | | 11 | | | | | |
| | 1.0 | 15 | | | 7 | | | | | |
| | 2.0 | 25 | 26 | 54 | | | | | | CH |
| | 3.0 | 16 | | | 20 | 68 | 12 | 0 | 0 | SM |
| | 4.0 | 21 | | | 4 | 68 | 28 | 0 | 0 | SP |
| | 5.0 | 17 | | | 2 | | | | | |
| | 6.0 | 16 | | | 2 | 49 | 45 | 4 | 0 | SP |
| | 7.0 | 17 | | | 2 | | | | | |
| | 8.0 | 15 | | | 3 | 48 | 46 | 3 | 0 | SP |
| | 9.0 | 13 | | | 3 | | | | | |
| | 10.0 | 16 | | | 4 | 44 | 48 | 4 | 0 | SP |

## FREE SWELL INDEX TEST RESULTS

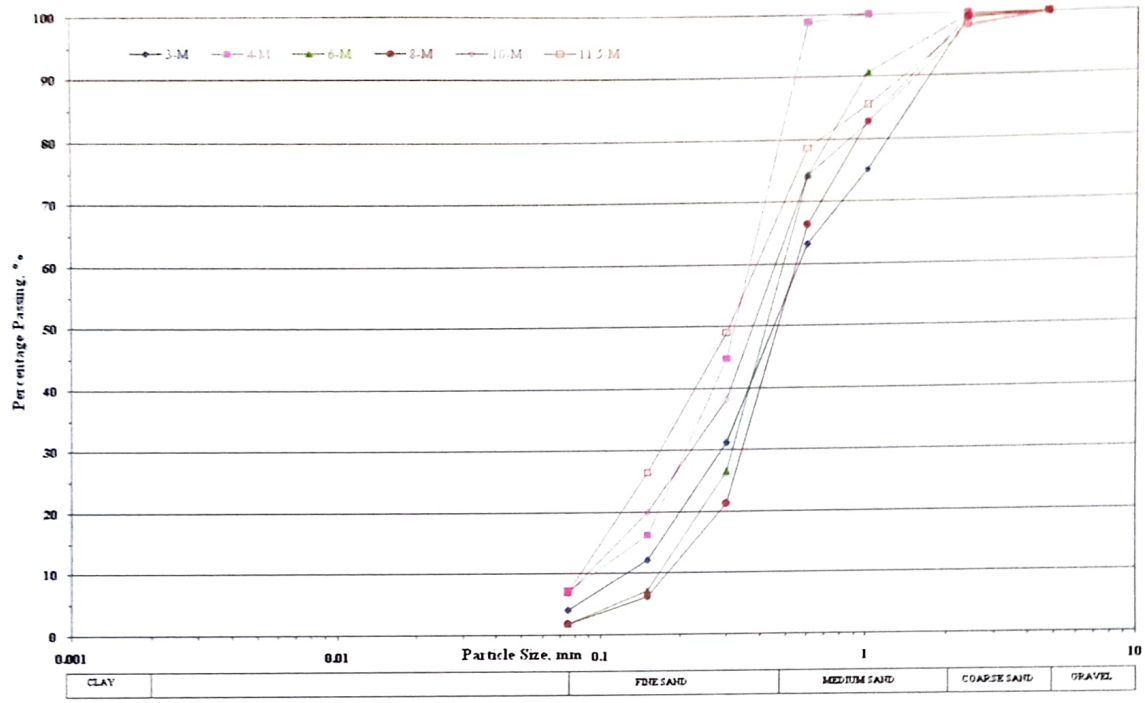
| BORE NO. | DEPTH, M | FREE SWELL INDEX, % |
|---|---|---|
| 1 | 1.0 | 71 |
| 2 | 2.0 | 133 |
| | 3.0 | 73 |
| 3 | 2.0 | 75 |

PLATE 5

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## Grain Size Distribution Curves
### Boring 1




## Grain Size Distribution Curves
### Boring 2

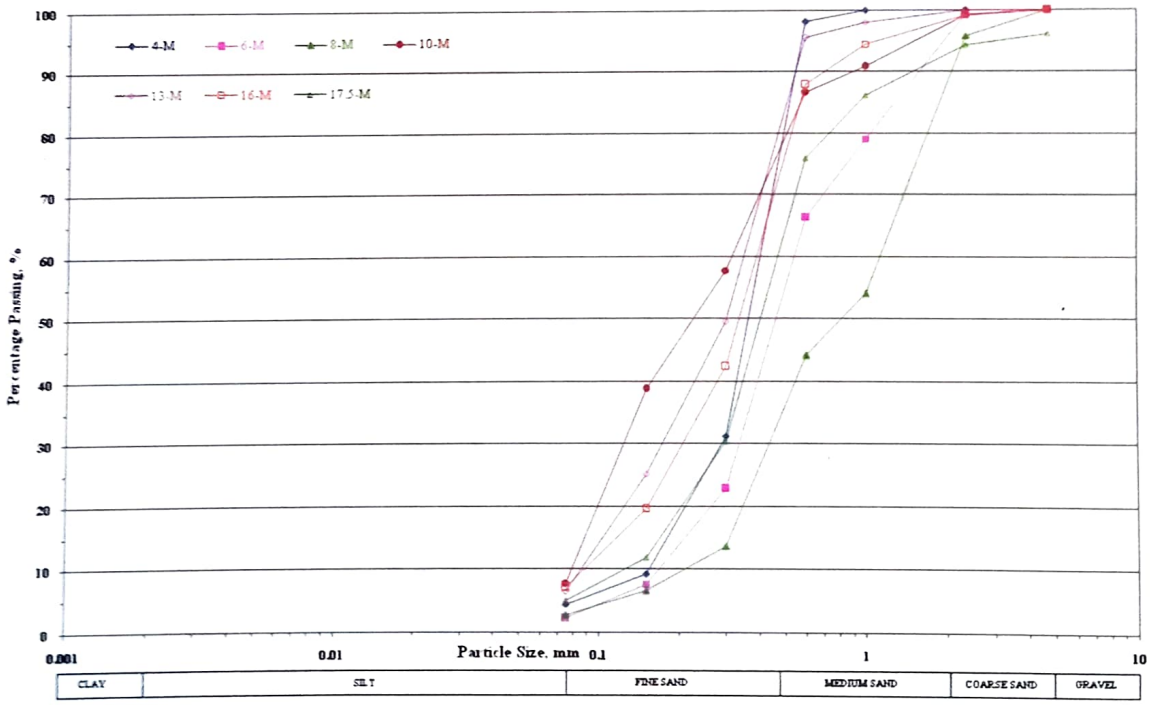



**PLATE 6a**

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## Grain Size Distribution Curves
### Boring 3

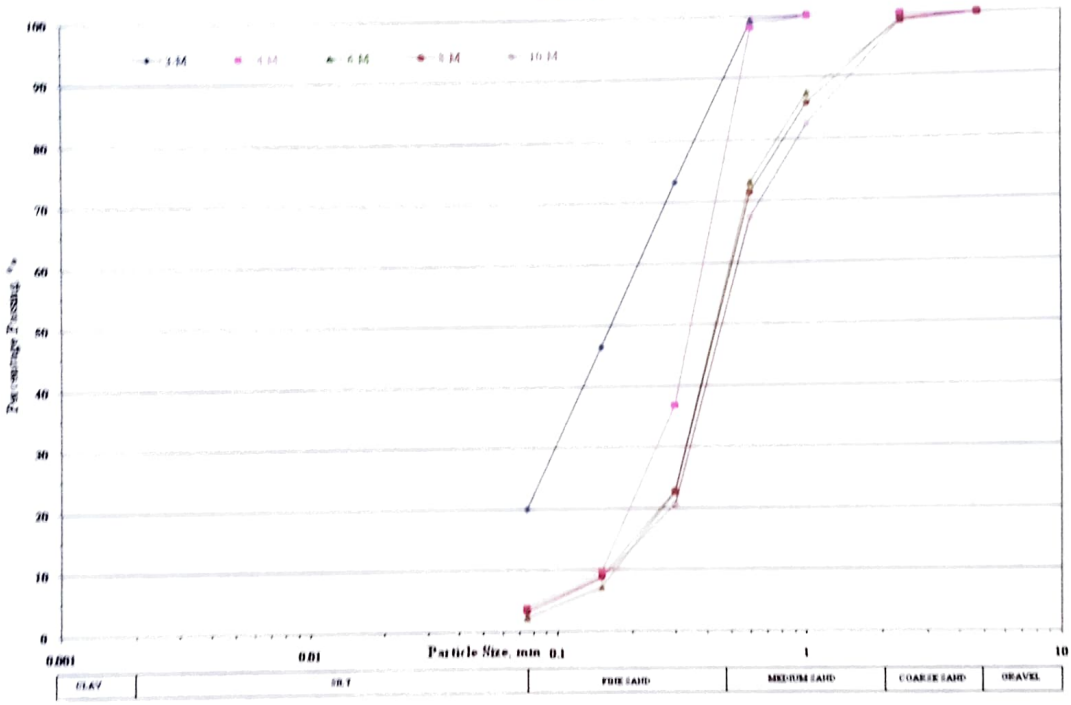



PLATE 6b

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## SUMMARY OF WATER TEST RESULTS

### BORE WELL LOCATED IN THE PLOT ACROSS THE ROAD

### DISTANCE FROM BORING 1 ~ 40-M; WATER LEVEL = 4.1-M in BORING 1.

| 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 0.02% NaOH |
| 2 | | To neutralize 100 cc of water using methyl orange as indicator | 24.2 ml | Not more than 25 ml of 0.02% $H_2SO_4$ |
| 3 | a | Organic Solids, mg/liter | 32 | 200 Max. |
| | b | Inorganic Solids, mg/liter | 892 | 3,000 Max. |
| | c | Sulphates as $SO_3$, mg/liter | 78 | 400 Max. |
| | d | Chlorides as Cl, mg/liter | 149 | 2,000 Max. - Plain Concrete<br>500 Max. RCC |
| | e | Suspended Solids, mg/liter | 0 | 2,000 Max. |
| | f | pH | 7.12 | 6 Min. |

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

## SUMMARY OF SOIL CHEMICAL TEST RESULTS

| Boring No. | Depth, M | pH | Chlorides | Sulphates, ppm | |
|---|---|---|---|---|---|
| | | | ppm | $SO_4$ | $SO_3$ |
| 1 | 2.0 | 8.80 | 138 | 86 | 72 |
| 2 | 2.0 | 7.43 | 64 | 40 | 33 |
| 3 | 2.0 | 7.30 | 88 | 53 | 44 |

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.

PLATE 7

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## SAMPLE CALCULATIONS FOR RECOMMENDED FOUNDATION

Bearing capacity was estimated using soil properties from Boring 2 and 3. Following is a list of design assumptions:

| | | |
|---|---|---|
| Type of Foundation | = | Isolated Column Footing Foundation; |
| Foundation Depth below EGL | = | 3-M below EGL; |
| Minimum Site Filling Above EGL | = | 0.6-M; |
| Foundation Depth below FGL | = | 3.6-M (3.0 + 0.60); |
| Worst Case Ground Water Level | = | At EGL; |
| Minimum Footing Size | = | 1.5- by 1.5-M; and |
| Maximum Column Load | = | 150 tons. |

Bearing Capacity Calculations:

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

| | | |
|---|---|---|
| $\phi$ (avg) | = | $0^o$ |
| $C_u$ (Undrained Shear Strength) | = | 13 tons/$M^2$ |
| $N_c$ (Bearing Capacity Factor) | = | 5.14 |
| $N_q$ (Bearing Capacity Factor) | = | N/A |
| $N_\gamma$ (Bearing Capacity Factor) | = | N/A |
| $S_c$ (Shape Factor) | = | $1 + 0.2*(B/L) = 1.0 + 0.2*(1.5/1.5) = 1.20$; |
| $D_c$ (Depth Factor) | = | $1 + 0.2*D_f/B*\tan(45 + \phi/2) = 1.24$ |
| $S_q$ (Shape Factor) | = | $1 + 0.2*(B/L) = 1.0 + 0.2*(1.5/1.5) = 1.20$ |
| $d_q$ (Depth Factor) | = | $1 + 0.1*(D_f/B) * Sqrt(\tan^2(\pi/4 + \phi/2)) = 1.12$ |
| $S_\gamma$ (Shape Factor) | = | $1 - 0.4*(B/L) = 1- 0.4*(1.5/1.5) = 0.60$; |
| $d_\gamma$ (Depth Factor) | = | $1 + 0.1*(D_f/B) * Sqrt(\tan^2(\pi/4 + \phi/2)) = 1.12$ |
| q'(O B @ Footing) | = | N/A |

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

$q_{ult} = 13.0*5.14*1.20*1.24 + 0 + 0 = 99.43 \sim 99$ tons/$M^2$

$q_{all} = q_{ult} / 2.5 = 99 / 2.5 =$ 39.60 tons/$M^2$ **Use $q_{all}$ = 22.5 tons/$M^2$**

Footing Size for 150 tons = 150/*22.5 = 6.67-$M^2$ of L = B = 2.58 Say 2.6-M.

**Settlement Calculations**:

In case of isolated column footing foundation the "Zone of Influence" will extend to "2B" depth below footing or upto hard stratum level, whichever is earlier, i.e., 2.75 + 2*2.6 = 7.95-M below **EGL**. There will be both elastic (immediate) and consolidation (long term) settlements as the soil profile had both granular and cohesive soils in the influence zone.

Elastic or Immediate Settlement:-

1. 2.75- to 3.0-M = $H_1$ = 0.25-M; SPT "N" = ??; (PCC); $E_s$ = 7,000 tons/$M^2$
2. 3.0- to 4.0-M = $H_2$ = 1.0-M; SPT "N" = 19; (Clay); $C_u$ = 13 tons/$M^2$; $E_s$ = 350*13 = 4,550 tons/$M^2$
3. 4.0- to 4.75-M = $H_3$ = 0.75-M; SPT "N" = 29 (Sand); $E_s$ = 4,250 tons/$M^2$
4. 4.75- to 7.0-M = $H_4$ = 2.25-M; SPT "N" = 12 (Sand); $E_s$ = 1,750 tons/$M^2$
5. 7.0- to 8.0-M = $H_5$ = 1.2-M; SPT "N" = 17 (Sand); $E_s$ = 2,250 tons/$M^2$

$E_{savg} = (0.25*7000+1.0*4550+0.75*4250+2.25*1750+1.0*2250) / 5.25 = 2,985.71$ Say 3,000 tons/$M^2$

$q_0$ = 22.5 tons/$M^2$; H/B' = 5.2/1.3 = 4.0; L/B = 2.6/2.6 = 1; $\mu$ = 0.2; $E_s$ = 3,000 tons/$M^2$

PLATE 8a

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$I_f = 0.85$; $I_1 = 0.408$; $I_2 = 0.037$; $I_s = 0.436$;
$\Delta H_E = 2*22.5*1.3*(1-0.2^2)/3000*0.85*0.436*1000 =$ **6.94 mm**
Total Elastic Settlement $\Delta H_E = 6.94$ mm.

Consolidation Settlement:

1. 3.0- to 4.0-M = $H_1 = 1.0$-M; $C_u = 13$ tons/M$^2$; NMC = 22%; LL = 54%; $G_s = 2.68$ (Clay);
   $q_0 = 22.5$ tons/M$^2$; $\alpha$ (Over consolidation factor) = 0.25; $e_0 = 2.68*0.22 = 0.59$ Use 0.70
   $C_{c1} = 0.009*(LL - 10) = 0.009*(54-10) = 0.396$;
   $C_{c2} = 0.30*(e_o - 0.27) = 0.129$; Use $C_c = 0.30$
   $\sigma' = 1.75*1.75 + 1.0*1.7 + 0.5*1.7 = 5.61$ tons/M$^2$;
   $\Delta\sigma = (22.5*2.6^2)/(2.60+2*0.625)^2 = 10.26$ tons/M$^2$;
   $\Delta H_{c1} = 0.25*1.0/(1+0.70)*0.30*\log((5.61+10.26)/(5.61))*1000 =$ **19.92 mm**

Total Consolidation Settlement $\Delta H_C = 19.92$ mm.

Total Combined Settlement $\mathbf{\Delta H} = \Delta H_E + \Delta H_C = 6.94 + 19.92 =$ **26.86 ~ 27 mm**.

The estimated total settlement for a 2.6- by 2.6-M isolated column footing at **3-M below EGL** was about 27 mm – less than 60 mm – the limiting total settlements as per IS code for isolated column footing foundations for framed structures on granular soils. Therefore, isolated column footing can be used for the proposed building.

**PLATE 8b**

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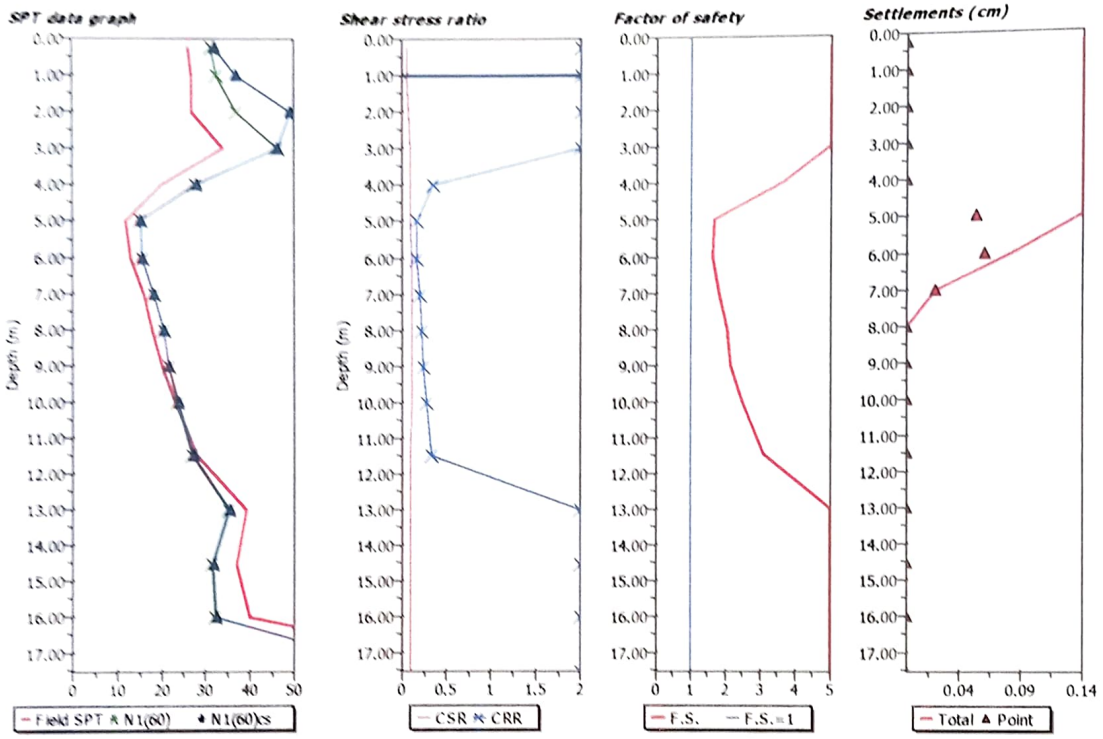
# LIQUEFACTION ANALYSIS REPORT

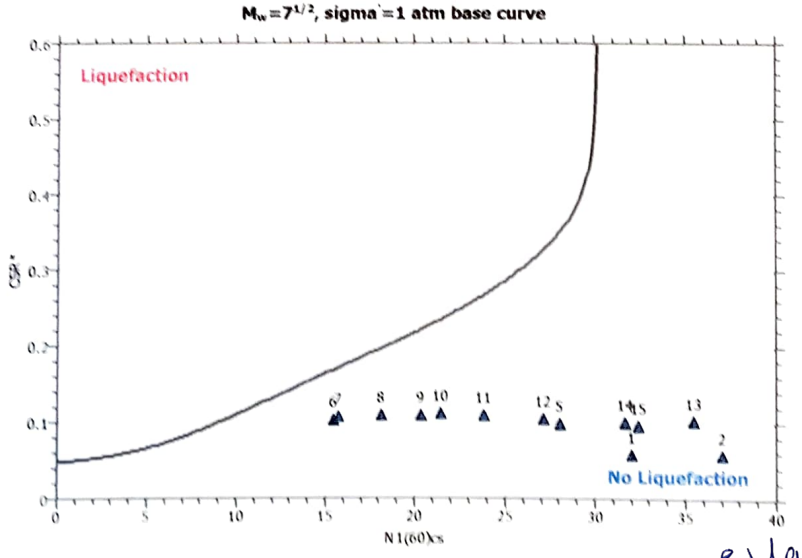
**Project title : No. 236, Kilpauk Garden Road, Kilpauk, Chennai 600 010, TN.**

**Project subtitle : Boring 1 Soil Profil upto 11.5-M and 2 Soil Profile beyond 11.5-M**

**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 |






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Dr. B. Ram Prasad ME PhD (Texas A&M), Chennai-96.

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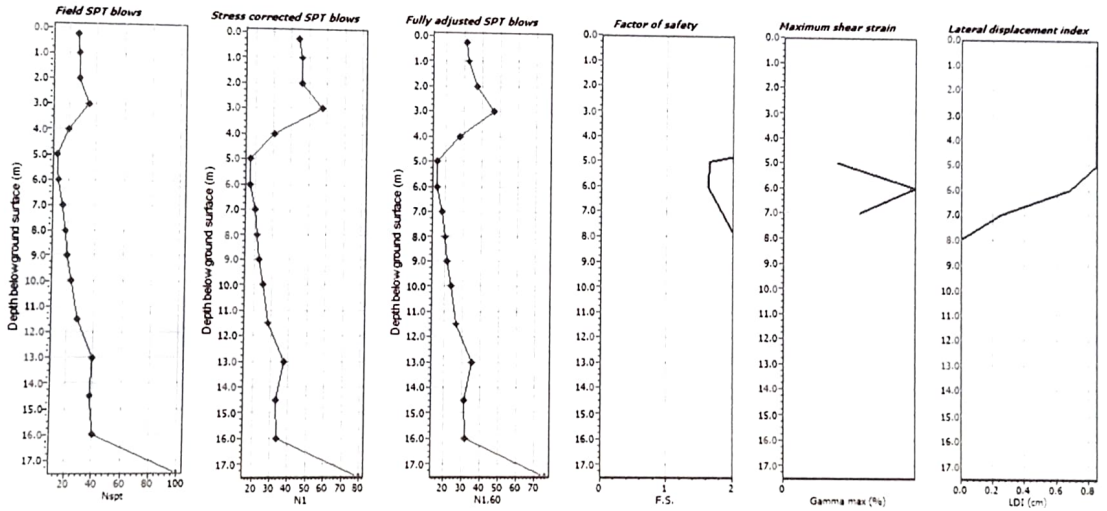
## Horizontal Acceleration, $a_h = 0.16g$

GEOLOGISMIKI Geotechnical Software

Geologismiki - Melanthios 56, 621 25 Stratos, Greece
Url: http://www.geologismiki.gr - Email: info@geologismiki.gr
LiqIT software v.4.6
Assessment of soil liquefaction potential from SPT, CPT or Vs data

### LATERAL DISPLACEMENTS ESTIMATION DUE TO SOIL LIQUEFACTION[1]

**Geometric parameters: Gently sloping ground without free face**
**Total lateral displacement estimation: 1.02 cm**




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

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

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

**PLATE 9b**



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