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NAGADI

REGISTERED OFFICE
*Bangalore :*

1014, Dr. Rajkumar Road, 4th Block,
Rajaji Nagar, Bangalore - 560 010.
Tel : +91-80-23156076; Fax : + 91-80-23303007
E-mail : bangalore@nagadi.co.in

REGIONAL OFFICE
*New Delhi :*

106/ID, Krishan Garh, Vasant Kunj,
New Delhi - 110 070.
Tel. : +91-11-26891980; Fax : +91-11-26897403
E-mail : delhi@nagadi.co.in

*Chennai :*

61C, East Coast Road, Thiruvanmiyur,
Chennai - 600 041.
Tel.: +91-40-24487870; Fax : +91-40-24488957
E-mail : chennai@nagadi.co.in

*Secunderabad:*

60, Manovikas Nagar, Opp. NIMH
Secunderabad - 500 009.
Tel : +91-40-27754446; Fax : +91-40-27751194
E-mail : secunderabad@nagadi.co.in

**Website : nagadi.co.in**

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# GEOTECHNICAL REPORT FOR

## RESIDENTIAL BUILDING AT T.NAGAR, CHENNAI - 600017

Client :

M/s. Rohini Property Developers
Chennai

Architect :

Consultant :

Structural Consultant :

Job No. : G(C)9929 Date : 25.04.2024

NAGADI CONSULTANTS PRIVATE LIMITED

Branch :

Chennai

**Project :**

**RESIDENTIAL BUILDING AT T.NAGAR, CHENNAI - 600017**

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# GEOTECHNICAL INVESTIGATION REPORT

## for Residential Building at T. Nagar, Chennai

### *EXECUTIVE SUMMARY*

M/s. Rohini Property Developers, Chennai are associated in construction of a Residential Building at Neelakanta Metha Street, T. Nagar, Chennai - 600017.

The site for the proposed Residential Building is situated at Plot No. Old No.34, New No.8 on the Western side of Neelakanta Metha Street off Boag road in T. Nagar, Chennai - 600017. The site measures approximately 18m x 48.7m in size. The site is having boundary wall on all the sides and is fairly level in topography.

The proposed residential building consists of a ground floor and five upper floors.

Geotechnical investigations have been undertaken at the site as per the scope of investigations, stipulated by the client, which consisted of conducting 2 boreholes down to refusal/rock strata (where N-value is >100) and further drilling in refusal/rock strata by 3m depth, as required by the client.

The results of borehole investigations indicate the presence of filled-up strata (soil with brickbats) down to depths of 0.9/1.6m depth below which virgin soil was encountered. The virgin soil encountered is Brown sandy silty clay/Dark grey/grey/brownish grey clayey silty sand with or without gravel/dark grey silty sand with or without gravel down to depths of 18m-18.5m at which refusal strata was encountered. The refusal strata encountered is in the form of sandy silty clay (Hard clay) which continued down to the termination depths of the boreholes of 21m-21.5m depth below the existing ground level.

The soil strata is in a medium stiff/ medium dense state down to the depths of refusal strata encountered between 18m and 18.5m depth below existing ground level.

Ground water table was encountered between 5.9m and 6.1m depth in the boreholes during the period of field investigations.

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
Chennai-600 041.
chennai@nagadi.co.in

In view of the observed subsoil conditions, the proposed Residential Building can be supported on *Isolated/Strip Footings at a depth of 3m below the existing ground level with a Net allowable bearing pressure of 10t/m$^2$ (1.0kg/cm$^2$) for widths of foundations ≥1.5m.*

Alternatively, the proposed residential building can be supported on *Bored Pile Foundations*. The safe capacity of various diameters of pile are given below:

| *Diameter of Pile (mm)* | *Depth of Pile Toe Below EGL (m)* | *Safe Pile Capacity (t)* | *Safe Uplift Capacity (t)* |
|---|---|---|---|
| *500* | *20* | *75* | *20* |
| | *21.5* | *120* | *40* |
| *600* | *20.5* | *110* | *30* |
| | *22* | *170* | *60* |
| *750* | *21* | *175* | *45* |
| | *23* | *270* | *95* |

*For Shallow Foundations -Isolated/Strip Footings*

The excavated soil cannot be used for backfilling purposes as the soil is medium swelling type. After the excavations for the foundations, the foundation surface should be watered for at least 24 hours. The top slush should then be removed and the surface compacted heavily. If any loose pockets are observed, the same shall be filled with brickbats/ gravel and compacted well. Foundations can subsequently be placed over such a prepared surface.

Stiff Tie-beams connecting the columns in both directions may be provided which will render additional rigidity to the structure.

*For Bored Pile Foundations*

The bottom of the pile bore should be properly cleaned as per the procedure given in the BIS IS:2911 (Part1/Sec2), prior to carrying out the tremie concreting. This is essential to ensure that the end bearing capacity of the pile is fully mobilised.

The bentonite slurry to be used for stabilising the pile bore during piling should conform to the requirements as given in BIS code IS:2911 (Part1/Sec2).

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
Chennai-600 041.

**REPORT ON GEOTECHNICAL INVESTIGATION FOR RESIDENTIAL BUILDING AT T. NAGAR, CHENNAI**

## *1.0 INTRODUCTION*

### 1.1 Overview

1.1.1 M/s. Rohini Property Developers, Chennai are associated in construction of a Residential Building at Neelakanta Metha Street, T. Nagar, Chennai - 600017.

1.1.2 The geotechnical investigations have been carried out to ascertain the soil conditions for the design of foundations of the proposed Residential Building.

### 1.2 Authority

A detailed geotechnical investigations programme has been conducted as per the authorisation by M/s. Rohini Property Developers, Chennai vide our oral Work Order No. NCC/OWO/RPD/029/C/2024.

## *2.0 PROJECT DETAILS*

### 2.1 Site Location

The site for the proposed Residential Building is situated at Plot No. Old No.34, New No.8 on the Western side of Neelakanta Metha Street off Boag road in T. Nagar, Chennai - 600017.

### 2.2 Site Layout and Topography

2.2.1 The site measures approximately 18m x 48.7m in size. The site is having boundary wall on all the sides and is fairly level in topography.

2.2.2 The colour of the exposed soil surface is Brown.

### 2.3 The Structure

As per information provided by the client, the proposed Residential Building consists of ground floor and five upper floors.

**2.4 Seismic Zone**

Site for the proposed Residential Building is situated in T. Nagar, Chennai District which falls under Seismic Zone III as per IS 1893 (Part 1) - 2016.

**2.5 Geographical Information**

2.5.1 Site for the proposed Residential Building is located at:

a) Latitude : 13°02'

b) Longitude : 80°14'

***3.0 OBJECT OF INVESTIGATIONS***

3.1 For designing the foundation system of the proposed Residential Building, the following data are required:

a) Type of foundation system.

b) Depth below the ground level at which the foundation system is to be laid.

c) Allowable bearing pressure at the foundations levels.

3.2 To determine above factors, the following information would be required:

a) The subsoil profile indicating thicknesses of the various soil strata, to a depth down to the influence zone below the foundations.

b) Engineering properties of the soil strata at various levels.

c) Physical characteristics of the soil strata.

d) Variation of the strength of the strata with depth.

3.3 For evaluating the above parameters, field investigations and laboratory investigations on the soil samples collected during the field investigations, have been carried out.

3.4 The results from these investigations have been analysed to provide the recommendations for the design of foundations.

Dr.N.SANTOSH RAO
CMDA, REGN.No. GTE / 19/04/019
Lab No.(C)9929

## *4.0 SCOPE OF INVESTIGATIONS*

4.1 Scope of investigations as given in the work order consisted of:

a) Conducting 2 boreholes down to refusal/rock strata (where N-value is >100) and further drilling in refusal/rock strata by minimum 3m, as required by the client.

b) Conducting standard penetration tests at 1.5m depth intervals.

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

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

e) Conducting relevant laboratory tests on soil samples recovered.

f) Preparation and submission of a technical report containing the details of the tests carried out, their analysis and recommendations regarding the foundation system to be adopted. Two copies of the report are to be submitted.

## *5.0 FIELD INVESTIGATIONS*

### 5.1 General Details

5.1.1 The locations of the boreholes were shown at site by the client's representative. A Schematic site plan showing the boreholes locations marked by the client is given in fig. 1.

5.1.2 Weather was clear during the period of field investigations which were carried out in the first week of April 2024.

### 5.2 Boreholes

5.2.1 The boreholes were progressed by mechanically operated rotary core drill method.

5.2.2 Refusal strata (i.e. N-value >100) was encountered at about 18/18.5m depth below the existing ground level in the form of sandy silty clay (Hard clay).

5.2.3 The boreholes were terminated after drilling a minimum of 3m in refusal/rock strata below existing ground level as per the stipulated scope of work.



DHANSANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
81-C, East Coast Road, Thiruvanmiyur, Chennai-600 041.

5.2.4 The depth at which ground water table was encountered in the boreholes during the period of field investigations and termination depths of the boreholes are given below:

| Borehole No. | Depth of Ground Water Table Below EGL (m) | Termination Depth Below EGL (m) |
|---|---|---|
| 1 | 6.1 | 21 |
| 2 | 5.9 | 21.5 |

5.2.5 Ground water table was encountered between 5.9m and 6.1m in the boreholes during the period of field investigations.

5.2.6 Standard Penetration Tests were conducted in soil strata at 1.5m depth intervals.

5.2.7 Disturbed soil samples recovered from split spoon sampler were packed in polythene bags, labelled and retained for identification purposes.

5.2.8 Undisturbed soil samples were recovered by thin walled tubes conforming to IS 2132. These tubes had an area ratio of less than 10%. The diameter of soil samples were 50mm and length 45cm.

## *6.0 LABORATORY INVESTIGATIONS*

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

a) Type of soil and its gradation

b) Consistency limits

c) Natural density

d) Natural water content

e) Shear strength properties

6.2 In order to determine the above properties listed in 6.1, the following tests were conducted.

Dr. N.SANTOSH RAO
CMDA: REGN. No. GTE / 19/04/019
61-C, East Coast Road, Kiruvanmiyur, Chennai 600 041.

a) Sieve analysis on the coarse grained soil fraction

b) Hydrometer analysis on the fine grained soil fraction

c) Liquid and plastic limits

d) Natural Density and Water Content tests

e) Triaxial tests

f) Free Swell Index tests

## *7.0 RESULTS AND ANALYSIS*

### 7.1 Presentation of Results

7.1.1 The results of borehole investigations and of the laboratory investigations conducted on the soil samples collected from the boreholes have been presented in the form of soil profile tables in Table Nos.1 to 4.

7.1.2 The soil profile tables indicate the following:

a) Standard Penetration Test Values (i.e. N- values observed) at various depths

b) Soil description identifying the type of soil

c) Grain size analysis indicating composition of subsoil

d) Consistency limits

e) In-situ bulk density and Water content

f) Triaxial test results

### 7.2 Analysis of Soil Profile

7.2.1 A perusal of the data presented in the soil/rock profile tables indicate the presence of the following substrata.

a) Stratum - I : Filled up Strata (soil with brickbats)

b) Stratum - II : Brown sandy silty clay

c) Stratum - III : Brown/dark grey/grey silty sand with or without gravel

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

d) Stratum - IV : Dark grey/grey/brownish grey clayey silty sand with or without gravel

e) Stratum - V : Refusal strata - Brown sandy silty clay (Hard clay)

7.2.2 The thicknesses in each borehole of each strata described in 7.2.1 is given in the table below:

| BH No. | Depth (m) : from - to | | | | |
|---|---|---|---|---|---|
| | Stratum - I | Stratum - II | Stratum - III | Stratum - IV | Stratum - V |
| 1 | 0.0 - 0.9 | 0.9 - 5.8 | 5.8 - 7.4 | 7.4 - 18 | 18 - 21 |
| 2 | 0.0 - 1.6 | 1.6 - 6.3 | 6.3 - 16.8 | 16.8 - 18.5 | 18.5 - 21.5 |

7.2.3 The above results show that :

a) Stratum - I consisting of Filled-up strata (soil with brickbats) has been encountered from ground level down to 0.9/1.6m depths below existing ground level.

b) Stratum - II consisting of Brown sandy silty clay having significant percentages of clay and varying percentages of silt and sand, has been encountered from 0.9/1.6 to 5.8/6.3m depths below existing ground level.

c) Stratum - III consisting of Brown/dark grey/grey silty sand with or without gravel having significant percentages of sand and varying percentages of silt and gravel, has been encountered from 5.8/6.3m to 7.4/16.8m depths below existing ground level.

d) Stratum - IV consisting of Dark grey/grey/brownish grey clayey silty sand with or without gravel having significant percentages of sand and varying percentages of clay, silt and gravel, has been encountered from 7.4/16.8m to 18/18.5m depths below existing ground.

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
84 C, East Coast Road Thiruvanmiyur, Chennai-600 041.

e) Stratum - V consisting of Refusal strata - Brown sandy silty clay (Hard clay) having significant percentages of clay and varying percentages of silt and sand, has been encountered from 18/18.5 down to the termination depths of the boreholes of 21/21.5m below existing ground level.

**7.3 Soil Composition**

7.3.1 The grain size distribution of the soil samples at various depths, as determined in the laboratory have been presented in the form of grain size analysis curves in figs. 3a to 3d.

7.3.2 The variations in the grain size distribution - strata wise across the boreholes are as follows:

a) Stratum - II : Brown sandy silty clay

| BH No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 | 16 - 26 | 34 - 38 | 40 - 46 |
| 2 | 0 | 15 - 29 | 33 - 41 | 38 - 44 |

b) Stratum - III : Brown/dark grey/grey silty sand with or without gravel

| BH No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 - 4 | 82 | 14 | 0 |
| 2 | 0 - 3 | 87 - 91 | 8 - 11 | 0 |

c) Stratum - IV : Dark grey/grey/brownish grey clayey silty sand with or without gravel

| BH No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 - 18 | 41 - 76 | 14 - 34 | 6 - 23 |
| 2 | 0 - 22 | 45 | 23 | 10 |

d) Stratum - V : Refusal Strata - Brown sandy silty clay (Hard clay)

Dr.N.SANTOSH RAO
CMDA REGN No. GTE / 19/04/019
61-C,East Coast Road Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

| BH No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 | 11 - 15 | 38 - 40 | 47 - 49 |
| 2 | 0 | 11 - 15 | 38 - 40 | 47 - 49 |

7.3.3 The above results indicate that :

a) Stratum - II consists of about 15-29% of sand, 33-41% of silt and 38-46% of clay.

b) Stratum - III consists of about 8-14% of silt, 82-91% of sand and 0-4% of gravel.

c) Stratum - IV consists of about 6-23% of clay,14-34% of silt, 41-76% of sand and 0-22% of gravel.

d) Stratum - V consists of about 11-15% of sand, 38-40% of silt and 47-49% of clay.

**7.4 In-situ Density, Water Content and Dry density**

7.4.1 The bulk/in-situ bulk densities, water contents and dry densities obtained from undisturbed soil samples are tabulated below.

| BH No. | Depth (m) | In-situ Bulk Density (g/cm$^3$) | Water Content (%) | Dry Density (g/cm$^3$) |
|---|---|---|---|---|
| | 2 | 1.82 | 16.2 | 1.57 |
| | 4 | 1.91 | 19.4 | 1.6 |
| 1 | 5.5 | 1.95 | 19.6 | 1.63 |
| | 8.5 | 1.92 | 15.7 | 1.66 |
| | 10 | 1.86 | 15.1 | 1.62 |
| | 3 | 1.79 | 15.3 | 1.55 |
| 2 | 4.5 | 1.88 | 17.7 | 1.6 |
| | 6 | 1.94 | 20.8 | 1.61 |

Dr. N. SANTOSH RAO
CMDA. REG. No. GTE / 19/04/019
61-C, East Coast Road, Kanathur, Thiruvanmiyur, Chennai-600 041.

7.4.2 The above test results indicate that the soil strata is in a medium dense / medium stiff state. Undisturbed soil samples could not be collected satisfactorily at some depths beyond 6m, as the samples were cohesionless and sampling was done below ground water table level.

**7.5 Consistency Limits**

7.5.1 The Consistency Limits determined for the soil in Stratum - II (Brown sandy silty clay) indicate that the liquid limit varies between 49% to 57%, plastic limit varies between 22% to 25% and plasticity index varies between 27% to 32 %.

7.5.2 The Consistency Limits determined for the soil in Stratum - III (Brown/dark grey/grey silty sand with or without gravel) indicate that the soil in this strata is non plastic in nature.

7.5.3 The Consistency Limits determined for the soil in Stratum - IV (Dark grey/ grey/ brownish grey clayey silty sand with or without gravel) indicate that the liquid limit varies between 27% to 30%, plastic limit varies between 14% to 18% and plasticity index varies between 12% to 13 %.

7.5.4 The Consistency Limits determined for the soil in Stratum - V (Brown sandy silty clay - Hard clay) indicate that the liquid limit varies between 57% to 63%, plastic limit varies between 25% to 27% and plasticity index varies between 32% to 36 %.

7.5.5 The Consistency Limits for the soil in

a) Stratum - II (Brown sandy silty clay) indicate that the soil is high plastic in nature.

b) Stratum - III (Brown/dark grey/grey silty sand with or without gravel) indicate that the soil is non plastic in nature.

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C, East Coast Road, Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

c) Stratum - IV (Dark grey/grey/brownish grey clayey silty sand with or without gravel) indicate that the soil is low plastic in nature.

d) Stratum - V (Brown sandy silty clay - Hard clay) indicate that the soil is high plastic in nature.

**7.6 Standard Penetration Tests**

7.6.1 Standard Penetration Test values (N-values observed) are presented in the soil profile table nos.1 and 2.

7.6.2 The N-values indicate that virgin soil strata is in a medium dense /medium stiff state down to the depths of refusal strata encountered between 18/18.5m depth below existing ground level with N-values ranging between 7 and 46.

**7.7 Triaxial Test Results**

7.7.1 The cohesion 'c' obtained from consolidated drained triaxial compression test varies between 0.17kg/cm² and 0.34kg/cm² and the angle of shearing resistance 'ϕ' of the soil varies between 13° and 23°.

7.7.2 The undrained cohesion '$c_u$' obtained from unconfined compression test (UCC) is 0.92kg/cm² at 6m depth at the location of borehole BH2.

**7.8 Free Swell Index**

7.8.1 The free swell index of the soil samples collected at various depths are given below:

| BH No. | Free Swell Index (%) at Depth (m) | | | |
|---|---|---|---|---|
| | 1.5 | 2 | 3 | 3.5 |
| 1 | 60 | - | 50 | - |
| 2 | - | 55 | - | 55 |

7.8.2 The above results indicate that the soil strata is medium swelling in nature. Hence, the excavated soil cannot be used for backfilling purposes.

Dr.N.SANTOSH RAO
CMDA REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

## 7.9 Compiled Soil Profile

7.9.1 An overview of the results and their analysis has been presented in the form of a compiled soil (fig. 2).

7.9.2 The above figure shows the various strata encountered and their thicknesses in each of the boreholes and also gives the soil composition and the observed N-values at various depths along with the depth at which undisturbed soil samples were collected.

## *8.0 DESIGN CRITERIA*

## 8.1 Design Parameters

8.1.1 The parameters required for the design of foundation system for the proposed Residential Building are:

a) Type of foundation to be adopted

b) Depth at which the foundations have to be laid

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

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

## 8.2 Type of Foundations

8.2.1 The type of foundation depends on the following:

a) Subsoil conditions

b) Type of structure

c) Configuration at loading points

d) Loading intensity on each sub-structure/structural element.

8.2.2 As per information provided by the client, the proposed Residential Building consists of a ground floor and five upper floors.

Dr.N.SANTOSH RAO
CMDA REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

8.2.3 The results of the investigations have shown that soil strata is in a medium dense /medium stiff state down to the depths of refusal strata encountered at 18/18.5m depths below existing ground level.

8.2.4 In view of the above, *Shallow Foundations - Isolated/Strip Footings* can be adopted for the proposed Residential Building. Alternatively, *Bored Pile Foundations* can be adopted.

**8.3 Depth of Foundations**

8.3.1 The depth at which foundations should be laid will be governed by the following criteria.

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

b) There should be sufficient thickness of soil above the footing/foundations so that the bearing capacity of the soil can be fully mobilised.

c) Soil below the level of footings/foundations should have the requisite strength to support the anticipated bearing pressures on the foundations without allowing the settlement of footings/foundations to exceed the acceptable limits.

d) Requirements of the type of structure (Residential Building consisting of a ground floor and five upper floors).

8.3.2 The results of the investigations have shown that the subsoil down to 6m depth is high plastic and medium swelling in nature.

8.3.3 In view of the above factors, foundations of the proposed Residential Building can be laid at a minimum depth of *3m below the existing ground level*. The soil available at the founding level will be Brown sandy silty clay.

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-G East Coast Road, Thiruvanmiyur, Chennai-600 041.
chennai@nagadi.co.in

## 8.4 Allowable Bearing Pressure

8.4.1 An allowable settlement of 50mm has been considered to evaluate the allowable bearing pressure for Isolated/Strip footings.

8.4.2 Allowable bearing pressure has been evaluated by:

a) Shear failure criteria based on the average soil data

b) Settlement criteria based on the SPT values (N-values)

c) Settlement criteria based on deformation modulus

8.4.3 A water table correction factor of 0.5 has been considered.

8.4.4 On the basis of the above analysis, *net allowable bearing pressure of 10t/m² can be adopted for widths of foundations ≥1.5m.*

## 8.5 Depth of Pile Foundations

8.5.1 To ensure similarity of settlement of all the pile foundations for the proposed residential building, the pile foundations should be founded in the refusal strata (where N-value is >100).

8.5.2 To ensure the mobilization of the adequate capacity, the Bored Piles should be embedded or socketed in refusal strata to a minimum depth equivalent to six times the diameter of the pile.

8.5.3 Alternatively, the Bored Piles with lower pile capacities can also be adopted when the piles are embedded or socketed in refusal strata to a minimum of 3 times the diameter of pile.

8.5.4 Accordingly, the depth at which the toe of the piles of various diameters will rest, are as given below:

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur
Chennai-600 041.
chennai@nagadi.com

| Diameter of Piles (mm) | Socketing in Refusal strata by Times the Diameter of Pile | Depth of Pile Toe Below EGL (m) |
|---|---|---|
| 500 | | 20 |
| 600 | 3D | 20.5 |
| 750 | | 21 |
| 500 | | 21.5 |
| 600 | 6D | 22 |
| 750 | | 23 |

D - Diameter of Pile

## 8.6 Pile Capacities

The safe pile capacities for different diameters of piles are given below:

| *Diameter of Pile (mm)* | *Depth of Pile Toe Below EGL (m)* | *Safe Pile Capacity (t)* | *Safe Uplift Capacity (t)* |
|---|---|---|---|
| *500* | *20* | *75* | *20* |
| | *21.5* | *120* | *40* |
| *600* | *20.5* | *110* | *30* |
| | *22* | *170* | *60* |
| *750* | *21* | *175* | *45* |
| | *23* | *270* | *95* |

## *9.0 RECOMMENDATIONS*

## 9.1 Type of Foundations

a) *Shallow Foundations - Isolated/Strip Footings* Or

b) *Bored Pile Foundations*

## 9.2 Depth of Foundations

*Minimum 3m depth below the existing ground level*

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai 600 041.
chennai@nagadi.co.in

## 9.3 Allowable Bearing Pressure

*Net Allowable Bearing Pressure of 10t/m² for widths of footings ≥1.5m for an allowable settlement of 50mm.*

## 9.4 Safe Pile Capacity

Safe Pile Capacity for various diameters of pile are given below:

| *Diameter of Pile (mm)* | *Depth of Pile Toe Below EGL (m)* | *Safe Pile Capacity (t)* | *Safe Uplift Capacity (t)* |
|---|---|---|---|
| *500* | *20* | *75* | *20* |
| | *21.5* | *120* | *40* |
| *600* | *20.5* | *110* | *30* |
| | *22* | *170* | *60* |
| *750* | *21* | *175* | *45* |
| | *23* | *270* | *95* |

## 9.5 Construction Advisories

9.5.1 The soil of each strata has been described with name, colour etc. During excavation, any variations observed in the nature and condition of the soil from those given in this Report should be noted and appropriate action should be taken.

9.5.2 *For Shallow Foundations -Isolated/Strip Footings*

9.5.2.1 The excavated soil cannot be used for backfilling purposes as the soil is medium swelling type.

9.5.2.2 After the excavations for the foundations, the foundation surface should be watered for at least 24 hours. The top slush should then be removed and the surface compacted heavily. If any loose pockets are observed, the same shall be filled with brickbats/ gravel and compacted well. Foundations can subsequently be placed over such a prepared surface.

Dr.N.SANTOSH RAO
CMDA. REGN No. GTE / 19/04/019
Chennai-600 041 No. G(C)9929

9.5.2.3 Stiff Tie-beams connecting the columns in both directions may be provided which will render additional rigidity to the structure.

9.5.3 *For Bored Pile Foundations*

9.5.3.1 The bottom of the pile bore should be properly cleaned as per the procedure given in the BIS IS:2911 (Part1/Sec2), prior to carrying out the tremie concreting. This is essential to ensure that the end bearing capacity of the pile is fully mobilised.

9.5.3.2 The bentonite slurry to be used for stabilising the pile bore during piling should conform to the requirements as given in BIS code IS:2911 (Part1/Sec2).

**9.6 Appendices**

9.6.1 The calculations for the allowable bearing pressure have been provided in Appendix-A of this report.

9.6.2 The typical analysis of the capacity of piles has been given in Appendix-B of this report.

9.6.3 The List of IS codes referred for providing the recommendations and that which might be required to implement the same have been given in Appendix-C of this report.

**9.7 Notes**

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

9.7.2 The entire report should be studied before adopting the recommendations given in the report.

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

## *10.0 LIMITATIONS*

This Geotechnical investigation has been carried out at locations in the site chosen by the client as representing the entire site. The recommendations provided in this Report are hence valid only for those test locations. However, if there is any change in the subsoil conditions and properties at places between or beyond the chosen test locations, Nagadi may be contacted for further actions. Fresh investigations will have to be carried out at such locations.

Dr. N. Santosh Rao
*Technical Director*
***For NAGADI CONSULTANTS PVT. LTD.***

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

## ANALYSIS FOR ALLOWABLE BEARING PRESSURE

**Data**

(i) Soil Properties :

c (kg/cm$^2$) = 0.32 $\phi$ = 13° $\gamma$ (g/cm$^3$) = 1.8

(ii) Depth of Foundation, D (m) = 3

(iii) Allowable Settlement, s (mm) = 50

**Shear Failure Criterion (Ref. IS : 6403)**

$N_c$ = 8.81 $N_q$ = 2.73 $N_\gamma$ = 1.47 $R_w$ = 0.50 $R_w'$ = 0.50

$$q_s = \frac{1}{3}\left(c \cdot N_c + \gamma D \cdot N_q \cdot R_w + 0.5 \cdot \gamma \cdot B \cdot N_\gamma \cdot R'_w\right) - \gamma D.R_w$$

| | | |
|---|---|---|
| B (m) | 1.5 | ≥3 |
| $q_s$ (t/m$^2$) | 9.5 | 9.8 |

**Settlement Criterion (Ref. IS : 8009)**

***(i) From N Values***

| | | |
|---|---|---|
| B (m) | 1.5 | ≥3 |
| H (m) | 3 | 6 |
| $N_{av}$ | 12 | 13 |
| $q_a$ (t/m$^2$) | 11.2 | 10.5 |

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

| | | |
|---|---|---|
| B (m) | 1.5 | ≥3 |
| H (m) | 3 | 6 |
| E (kg/cm$^2$) | 80 | 95 |
| $q_a$ (t/m$^2$) | 19.0 | 11.3 |

| | | | |
|---|---|---|---|
| **ADOPT** | **B (m)** | **1.5** | **≥3** |
| | **q (t/m$^2$)** | **10** | **10** |

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

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041
chennai@nagadi.co.in

## TYPICAL CALCULATIONS OF PILE CAPACITIES

Typical calculations for the pile capacity has been given hereunder for a pile of diameter 500mm. For piles of other diameters, a similar procedure has been used to arrive at the recommended pile capacities.

### A.1 Pile Capacity

A.1.1 As per IS 2911 (Part 1/sec 2):2010, the safe pile capacity or the allowable load on the pile is calculated using the formula given below :

$Q_a = C_{u1}N_c.\pi B^2/4F_s + \alpha c_{u2}.\pi BL/F_s$

Where, $c_{u1}$ = shear strength of rock below the base of the pile, in kN/m²

= 600kN/m² (as per fig 3 of IS 2911 (Part I/Sec 2)-2010)

$N_c$ = bearing capacity factor taken as 9;

$F_s$ = factor of safety usually taken as 3;

$\alpha$ = 0.9 (recommended value);

$c_{u2}$ = average shear strength of rock in the socketed length of pile, in kN/m²

= 600kN/m² (as per fig 3 of IS 2911 (Part I/Sec 2)-2010)

$B$ = minimum width of pile shaft (diameter in case of circular piles), in m

= 0.5m

$L$ = socket length of pile, in m = 6 x 0.5 = 3m.

A.1.2 Substituting the values in the above equation we get,

$Q_a$ = 35.34t + 84.82t

= 120.2t

A.1.3 Therefore, adopt ***Safe Pile Capacity = 120t***

### A.2 Uplift Capacity

A.2.1 The safe uplift capacity is calculated based on the safe skin friction capacity of the pile in uplift using the formula given below :

$Q_{au} = \alpha c_u.\pi BL/F_s$

where $\alpha$ = 0.9 (recommended value);

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

$c_u$ = average shear strength of rock in the socketed length of pile, in kN/m²

= 600kN/m² (as per fig 3 of IS 2911 (Part I/Sec 2)-2010)

$B$ = minimum width of pile shaft (diameter in case of circular piles)=0.5m

$L$ = socket length of pile, in m = 6 x 0.5 = 3m.

$F_s$ = factor of safety usually taken as 6

A.2.2 Substituting the values in the above equation we get $Q_a$ = 42.4t.

A.2.3 Therefore adopt ***Safe Uplift Capacity = 40t***

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

*Appendix-C*

## LIST OF IS CODES

**Field Investigation**

| | | |
|---|---|---|
| 1. | IS : 1498 - 1970 : | Classification and identification of soils for general engineering purposes (First Revision) (Amendment 2) |
| 2. | IS : 1892 - 1979 : | Code of practice for sub surface investigations for foundations (First revision) |
| 3. | IS : 2131 - 1981 : | Method of Standard Penetration Tests for soils (First revision) |
| 4. | IS : 2132 - 1986 : | Code of practice for thin walled tube sampling of soils (Second revision) |

**Laboratory Tests**

| | | |
|---|---|---|
| 1. | IS : 2720 - 1983 (Part 1) : | Methods of test for soils: Preparation of dry soil samples for various tests (Second revision) |
| 2. | IS : 2720 - 1980 (Part 2) : | Method of test for soils: Determination of water content (Second revision) Amendment 1 |
| 3. | IS : 2720 - 1980 (Part 3/Sec 1) : | Method of test for soils : Determination of Specific Gravity : Fine grained soils. (First revision) |
| 4. | IS : 2720 - 1980 (Part 3/Sec 2) : | Method of test for soils : Determination of Specific Gravity : Fine, Medium & Coarse grained soils. (First revision). |
| 5. | IS : 2720 - 1985 (Part 4) : | Method of test for soils : Grain size analysis (Second revision) |
| 6. | IS : 2720 - 1985 (Part 5) : | Method of test for soils : Determination of liquid and plastic limit (Second revision) |
| 7. | IS : 2720 - 1977 (Part 40) : | Methods of tests for soils: Determination of free swell index of soils. |

**Foundation Construction**

| | | |
|---|---|---|
| 1. | IS : 1080 - 1986 : | Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell) (Second revision) |
| 2. | IS : 1904 - 1986 : | Code of practice for design and construction of foundation in soils: General requirements (Third revision) |
| 3. | IS 6403 - 1981 : | Code of practice for determination of bearing capacity of shallow foundations : First revision (Amendment 1) |
| 4. | IS 8009 - 1976 (Part 1) : | Code of practice for calculation of settlements of foundations : Shallow foundations subject to symmetrical static vertical loads (Amendment 2) |
| 5. | IS 2911 (Part I to IV) : | Design and construction of Pile Foundations |

Dr.N.SANTOSH RAO
CMDA, REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600041.
chennai@nagadi.co.in

# TABLES



# SOIL PROFILE

Project: Proposed Residential Building at Neelakanta Mehta Street, T.Nagar, Chennai - 600017

B. H. Location: | Water Table: 6.10m | Term. Depth : 21m | B.H. No. : 1

| N - Value# | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg Limits | | In-situ properties | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density* (g/cm³) | Water Cont (%) | Type | c (kg/cm²) | Φ (°) |
| | 0.0 | Ground level | | | | | | | | | | | |
| | | Filled up soil | | | | | | | | | | | |
| | 0.9 | Change of strata | | | | | | | | | | | |
| 8 | 1.5 | Brown sandy silty clay | 0 | 16 | 38 | 46 | 57 | 25 | | | | | |
| | 2.0 | Brown sandy silty clay | | | | | | | 1.82 | 16.2 | CD | 0.34 | 13 |
| 12 | 3.0 | Brown sandy silty clay | 0 | 26 | 34 | 40 | 51 | 22 | | | | | |
| | 4.0 | Brown sandy silty clay | | | | | | | 1.91 | 19.4 | CD | 0.32 | 14 |
| 14 | 4.5 | Brown sandy silty clay | 0 | 19 | 38 | 43 | 55 | 23 | | | | | |
| | 5.5 | Brown sandy silty clay | | | | | | | 1.95 | 19.6 | CD | 0.33 | 16 |
| | 5.8 | Change of strata | | | | | | | | | | | |
| 20 | 6.0 | Brown silty sand with gravel | 4 | 82 | 14 | 0 | - | NP | | | | | |
| | 7.0 | Brown silty sand with gravel | | | | | | | Sample slipped | | | | |
| | 7.4 | Change of strata | | | | | | | | | | | |
| 12 | 7.5 | Dark grey clayey silty sand with gravel | 2 | 41 | 34 | 23 | 30 | 18 | | | | | |
| | 8.5 | Dark grey clayey silty sand with gravel | | | | | | | 1.92 | 15.7 | CD | 0.18 | 22 |


NAGADI

NAGADI CONSULTANTS PRIVATE LIMITED

Geotechnical Consultants

Delhi: 011 (T) 26891980 (F) 26897403

Bangalore: 080 (T) 23156076 (F) 2330307

Chennai: 044 (T) 24487870 (F) 24488957

Secunderabad: 040 (T) 27754446 (F) 27751194

Dr. N. SANTOSH RAO
CMDA Regn. No. GT/E/C/0929

61, East Coast Road, Thiruvanmiyur, Chennai-600 041

Sheet No. : 1

# SOIL PROFILE

Project: Proposed Residential Building at Neelakanta Mehta Street, T.Nagar, Chennai - 600017

B. H. Location: | Water Table: 6.10m | Term. Depth : 21m | B.H. No. : 1A

| N - Value# | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg Limits | | In-situ properties | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density* ($g/cm^3$) | Water Cont (%) | Type | c ($kg/cm^2$) | Φ (°) |
| 10 | 9.0 | Dark grey clayey silty sand | 0 | 50 | 29 | 21 | 30 | 15 | | | | | |
| | 10.0 | Dark grey clayey silty sand | | | | | | | 1.86 | 15.1 | CD | 0.17 | 23 |
| 17 | 10.5 | Grey clayey silty sand | 0 | 54 | 28 | 18 | 27 | 14 | | | | | |
| | 11.5 | Grey clayey silty sand | | | | | | | Sample slipped | | | | |
| 19 | 12.0 | Grey clayey silty sand with gravel | 2 | 69 | 19 | 10 | - | NP | | | | | |
| | 13.0 | Grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |
| 21 | 13.5 | Grey clayey silty sand with gravel | 4 | 76 | 14 | 6 | - | NP | | | | | |
| | 14.5 | Grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |
| 32 | 15.0 | Grey clayey silty sand with gravel | 18 | 50 | 22 | 10 | - | NP | | | | | |
| | 16.5 | Grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |
| | 18.0 | Change of strata | | | | | | | | | | | |
| >100 (151/40cm) | | Brown sandy silty clay (Hard clay) | 0 | 15 | 38 | 47 | 58 | 25 | | | | | |
| >100 (103/27cm) | 19.5 | Brown sandy silty clay (Hard clay) | 0 | 13 | 39 | 48 | 60 | 26 | | | | | |
| >100 (60/7cm) | 21.0 | Brown sandy silty clay (Hard clay) | 0 | 11 | 40 | 49 | 63 | 27 | | | | | |

*-Natural Bulk Density # -N Values (Observed)


NAGADI

NAGADI CONSULTANTS PRIVATE LIMITED

Geotechnical & Structural Consultants

Dr. N. SANTOSH RAO

Delhi: 011 (T) 26891980 (F) 26891981 CIDA, REGN. No. 1/3/2/2/2000-01

Bangalore: 080 (T) 23156076 (F) 23301907, East coast road, Kottivakkam, Thiruvanmiyur,

Chennai: 044 (T) 24487870 (F) 24488967 Chennai-600 041 chennai@nagadi.co.in

Secunderabad: 040 (T) 27754446 (F) 27754447 hanmanthrao@nagadi.co.in


Job No. : G(C)9929

Sheet No. : 2

NAGADI

NAGADI CONSULTANTS PRIVATE LIMITED
Geotechnical Consultants

Delhi: 011 (T) 26891980 (F) 26897405 CMDA. REGD. NO. GIR/CON/1004/(GC)9929
Bangalore: 080 (T) 23156076 (F) 23303061-C, Eashwar Nagar, Thiruvanmiyur,
Chennai: 044 (T) 24487870 (F) 24488950 Chennai-600 041. nagadi@nagadi.co.in
Secunderabad: 040 (T) 27754446 (F) 27751194 chennai@nagadi.co.in

# SOIL PROFILE

Project: Proposed Residential Building at Neelakanta Mehta Street, T.Nagar, Chennai - 600017

B. H. Location: | Water Table: 5.90m | Term. Depth : 21.5M | B.H. No. : 2

| N - Value# | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg Limits | | In-situ properties | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density* (g/cm³) | Water Cont (%) | Type | c (kg/cm²) | Φ (°) |
| | 0.0 | Ground level | | | | | | | | | | | |
| | | Filled up soil | | | | | | | | | | | |
| | 1.6 | Change of strata | | | | | | | | | | | |
| 7 | 2.0 | Brown sandy silty clay | 0 | 15 | 41 | 44 | 55 | 23 | | | | | |
| | 3.0 | Brown sandy silty clay | | | | | | | 1.79 | 15.3 | CD | 0.32 | 13 |
| 11 | 3.5 | Brown sandy silty clay | 0 | 16 | 40 | 44 | 55 | 24 | | | | | |
| | 4.5 | Brown sandy silty clay | | | | | | | 1.88 | 1.88 | CD | 0.33 | 15 |
| 12 | 5.0 | Brown sandy silty clay | 0 | 29 | 33 | 38 | 49 | 22 | | | | | |
| | 6.0 | Brown sandy silty clay | | | | | | | 1.94 | 20.8 | UCC | 0.92 | 0 |
| | 6.3 | Change of strata | | | | | | | | | | | |
| 16 | 6.5 | Brown silty sand with gravel | 4 | 89 | 8 | 0 | - | NP | | | | | |
| | 7.5 | Brown silty sand with gravel | | | | | | | Sample slipped | | | | |
| 18 | 8.0 | Dark grey clayey silty sand with gravel | 2 | 87 | 11 | 0 | - | NP | | | | | |
| | 9.0 | Dark grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |
| 16 | 9.5 | Dark grey clayey silty sand with gravel | 3 | 87 | 10 | 0 | - | NP | | | | | |
| | 10.5 | Dark grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |

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Sheet No. : 3

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# SOIL PROFILE

Project: Proposed Residential Building at Neelakanta Mehta Street, T.Nagar, Chennai - 600017

B. H. Location: | Water Table: 5.90m | Term. Depth : 21.5m | B.H. No. : 2A

| N - Value# | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg Limits | | In-situ properties | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density* (g/cm³) | Water Cont (%) | Type | c (kg/cm²) | Φ (°) |
| 19 | 11.0 | Dark grey silty sand with gravel | 2 | 87 | 11 | 0 | - | NP | | | | | |
| | 12.0 | Dark grey silty sand with gravepl | | | | | | | Sample slipped | | | | |
| 25 | 12.5 | Grey silty sand | 0 | 91 | 9 | 0 | - | NP | | | | | |
| | 13.5 | Grey silty sand | | | | | | | Sample slipped | | | | |
| 33 | 14.0 | Grey silty sand with gravel | 2 | 89 | 9 | 0 | - | NP | | | | | |
| | 15.0 | Grey silty sand with gravel | | | | | | | Sample slipped | | | | |
| 36 | 15.5 | Grey silty sand with gravel | 2 | 87 | 11 | 0 | - | NP | | | | | |
| | 16.5 | Grey silty sand with gravel | | | | | | | Sample slipped | | | | |
| | 16.8 | Change of strata | | | | | | | | | | | |
| 46 | 17.0 | Brownish grey clayey silty sand with gravel | 22 | 45 | 23 | 10 | - | NP | | | | | |
| | 18.0 | Brownish grey clayey silty sand with gravel | | | | | | | Sample slipped | | | | |
| | 18.5 | Change of strata | | | | | | | | | | | |
| >100 (145/40cm) | | Brown sandy silty clay (Hard clay) | 0 | 15 | 38 | 47 | 57 | 25 | | | | | |
| >100 (113/20cm) | 20.0 | Brown sandy silty clay (Hard clay) | 0 | 12 | 39 | 49 | 61 | 26 | | | | | |
| >100 (60/8cm) | 21.5 | Brown sandy silty clay (Hard clay) | 0 | 11 | 40 | 49 | 63 | 27 | | | | | |

*-Natural Bulk Density # -N Valueps (Observed)


NAGADI

NAGADI CONSULTANTS PRIVATE LIMITED

Geotechnical Consultants

Delhi: 011 (T) 26891980 (F) 26891403, N.S.A. NIGAM Block, Delhi-110 009

Bangalore: 080 (T) 23156076 (F) 23305076 A. RAGHAVENDRA RAO No.6, 1st Floor, 1st Cross, Gandhi Nagar, Bangalore-560 009

Chennai: 044 (T) 24487870 (F) 24488956, East Coast Road, Thiruvanmiyur, Chennai-600 041

Secunderabad: 040 (T) 27754446 (F) 27754446 secunderabad@nagadi.co.in

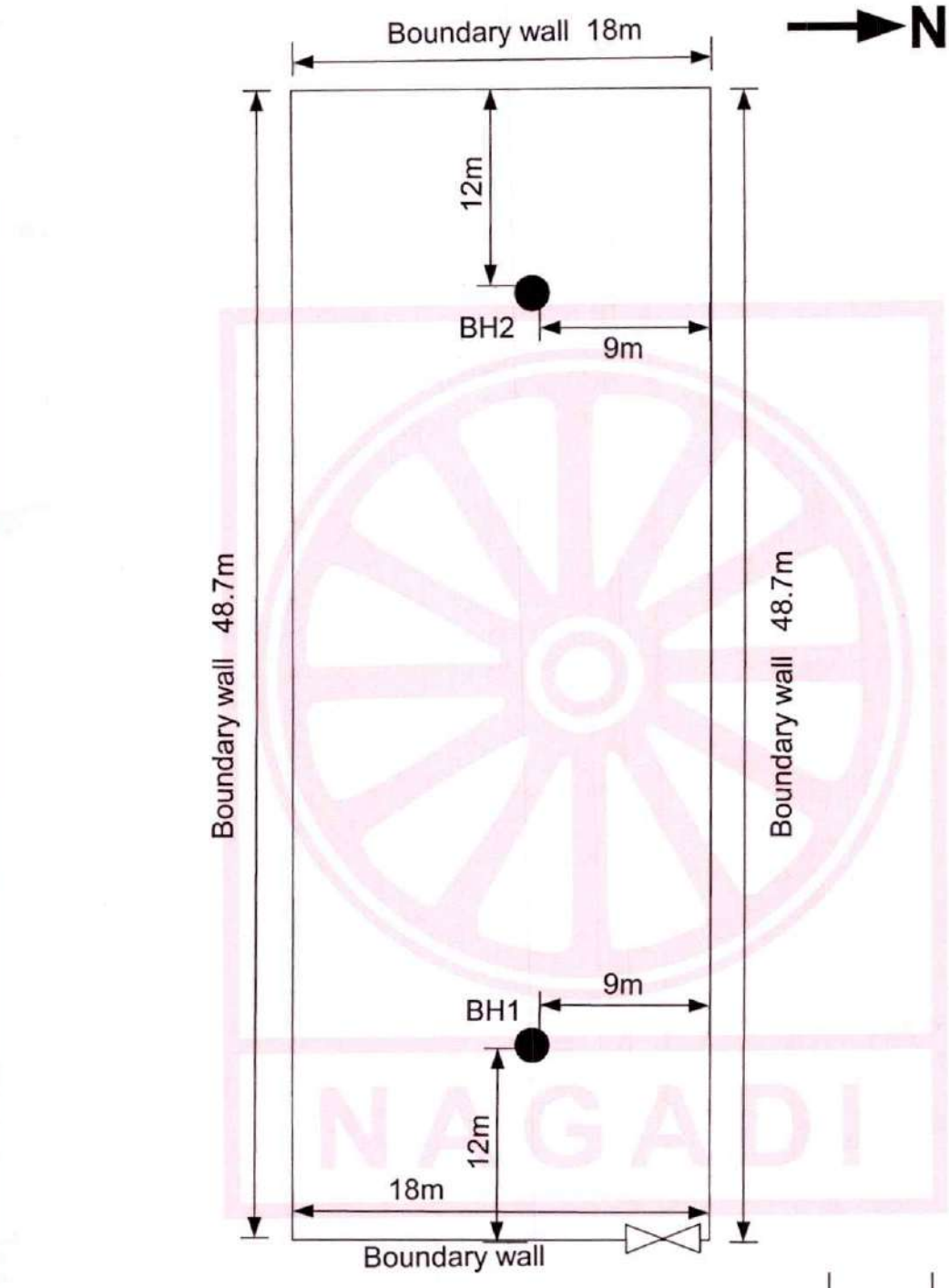
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Sheet No. : 4

# FIGURES






**LEGEND**

● BH : Borehole

**SCHEMATIC SITE PLAN**
(NOT TO SCALE)

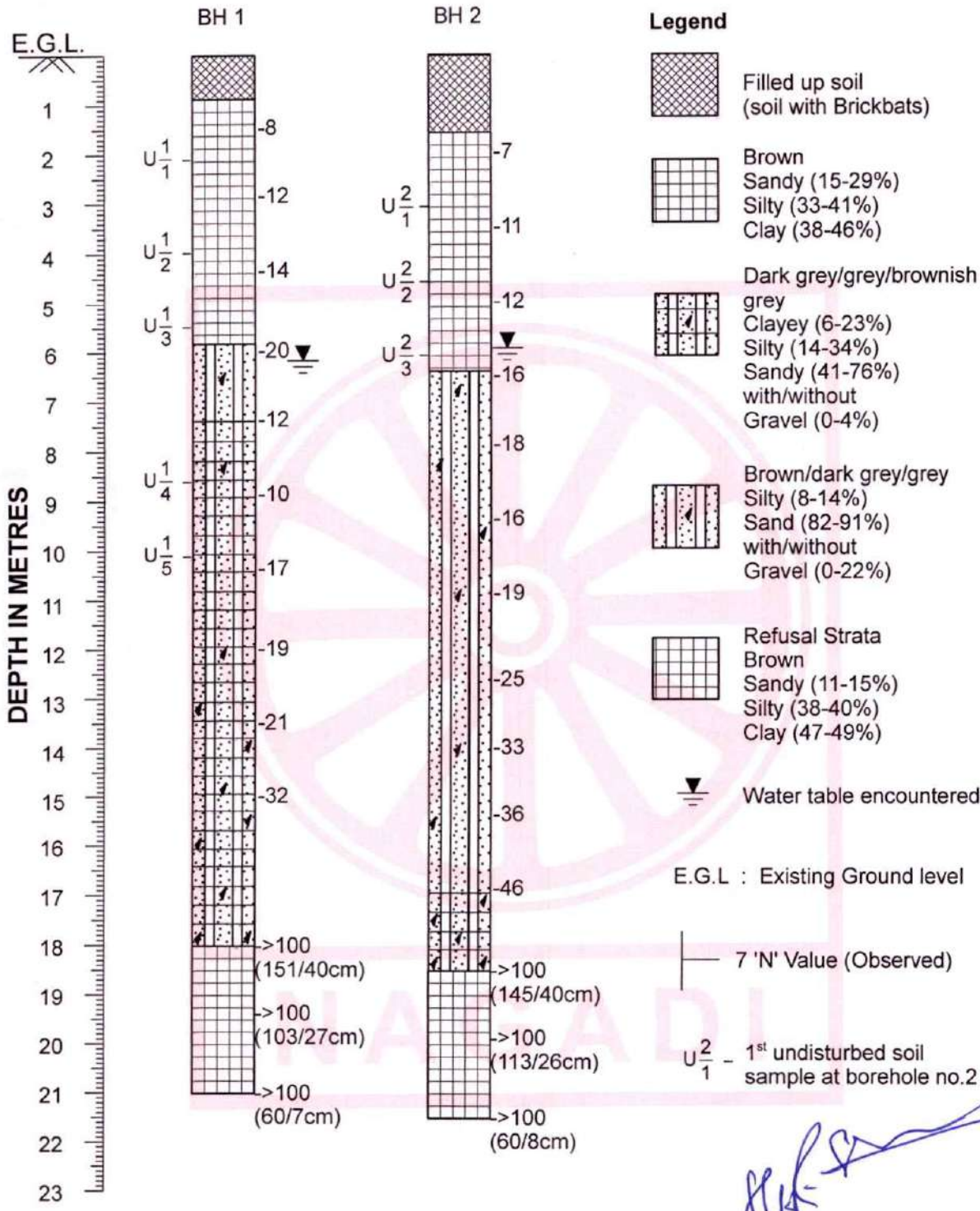
Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in


**NAGADI CONSULTANTS PRIVATE LIMITED**
Geotechnical Consultants

| | | |
|---|---|---|
| Delhi: | 011 (T) 26891980 (F) 26897403 | delhi@nagadi.co.in |
| Bangalore: | 080 (T) 23156076 (F) 23303007 | bangalore@nagadi.co.in |
| Chennai: | 044 (T) 24487870 (F) 24488957 | chennai@nagadi.co.in |
| Secunderabad: | 040 (T) 27754446 (F) 27751194 | secunderabad@nagadi.co.in |


Job No G(C)9929

Sheet No. : 1




**COMPILED SOIL PROFILE**

Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
chennai@nagadi.co.in

**PROJECT : RESIDENTIAL BUILDING AT T. NAGAR, CHENNAI**


NAGADI

**NAGADI CONSULTANTS PRIVATE LIMITED**
Geotechnical Consultants

| | | | |
|---|---|---|---|
| Delhi: | 011 (T) 26891980 | (F) 26897403 | delhi@nagadi.co.in |
| Bangalore: | 080 (T) 23156076 | (F) 23303007 | bangalore@nagadi.co.in |
| Chennai: | 044 (T) 24487870 | (F) 24488957 | chennai@nagadi.co.in |
| Secunderabad: | 040 (T) 27754446 | (F) 27751194 | secunderabad@nagadi.co.in |


Job No G(C)9929

NAGADI

NAGADI CONSULTANTS PRIVATE LIMITED

Geotechnical Consultants

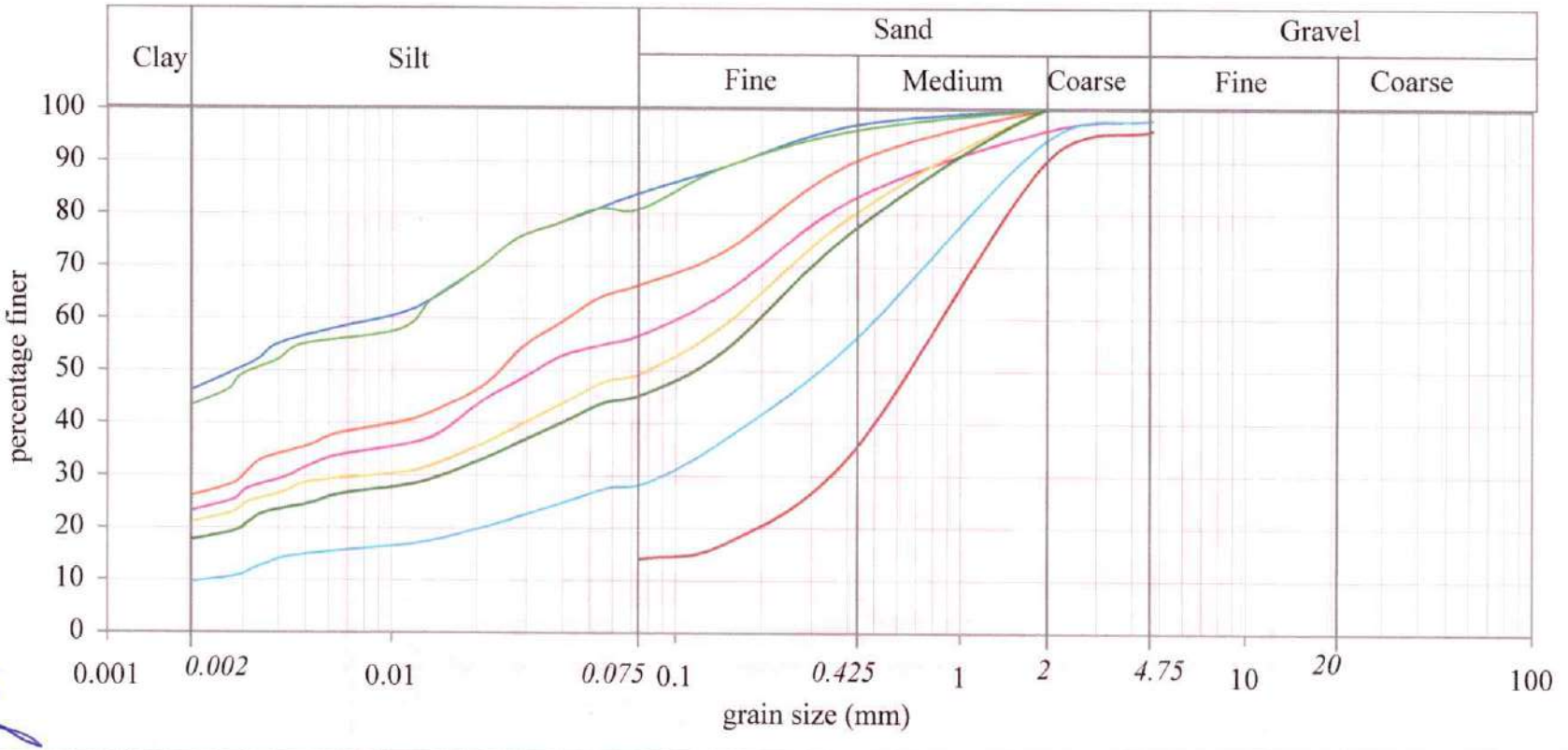
Delhi: 011 (T) 26891980 (F) 26897403 CMDA. REGN.No.GTC-10/04/049
Bangalore: 080 (T) 23156076 (F) 23303007 61-C, East Forest Road, Thiruvanmiyur,
Chennai: 044 (T) 24487870 (F) 24488957 Chennai-600 041
Secunderabad: 040 (T) 27754446 (F) 27751194 secunderabad@nagadi.co.in

Dr. N. SANTOSH RAO

chennai@nagadi.co.in

Job No. : G(C)9929

Sheet No. : 3a




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | U |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1.5 | Sandy silty clay | 0 | 16 | 38 | 46 | 0.009 | - | - |
| | 1 | 3.0 | Sandy silty clay | 0 | 26 | 34 | 40 | 0.040 | - | - |
| | 1 | 4.5 | Sandy silty clay | 0 | 19 | 38 | 43 | 0.013 | - | - |
| | 1 | 6.0 | Silty sand | 4 | 82 | 14 | 0 | 0.900 | - | - |
| | 1 | 7.5 | Clayey silty sand with gravel | 2 | 41 | 34 | 23 | 0.100 | - | - |
| | 1 | 9.0 | Clayey silty sand | 0 | 50 | 29 | 21 | 0.170 | - | - |
| | 1 | 10.5 | Clayey silty sand | 0 | 54 | 28 | 18 | 0.200 | - | - |
| | 1 | 12.0 | Clayey silty sand with gravel | 2 | 69 | 19 | 10 | 0.500 | - | - |

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Chennai: 044 (T) 24487870 (F) 24488957

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DR. N. SANTOSH RAO

CMDA. REGN. No. [illegible]

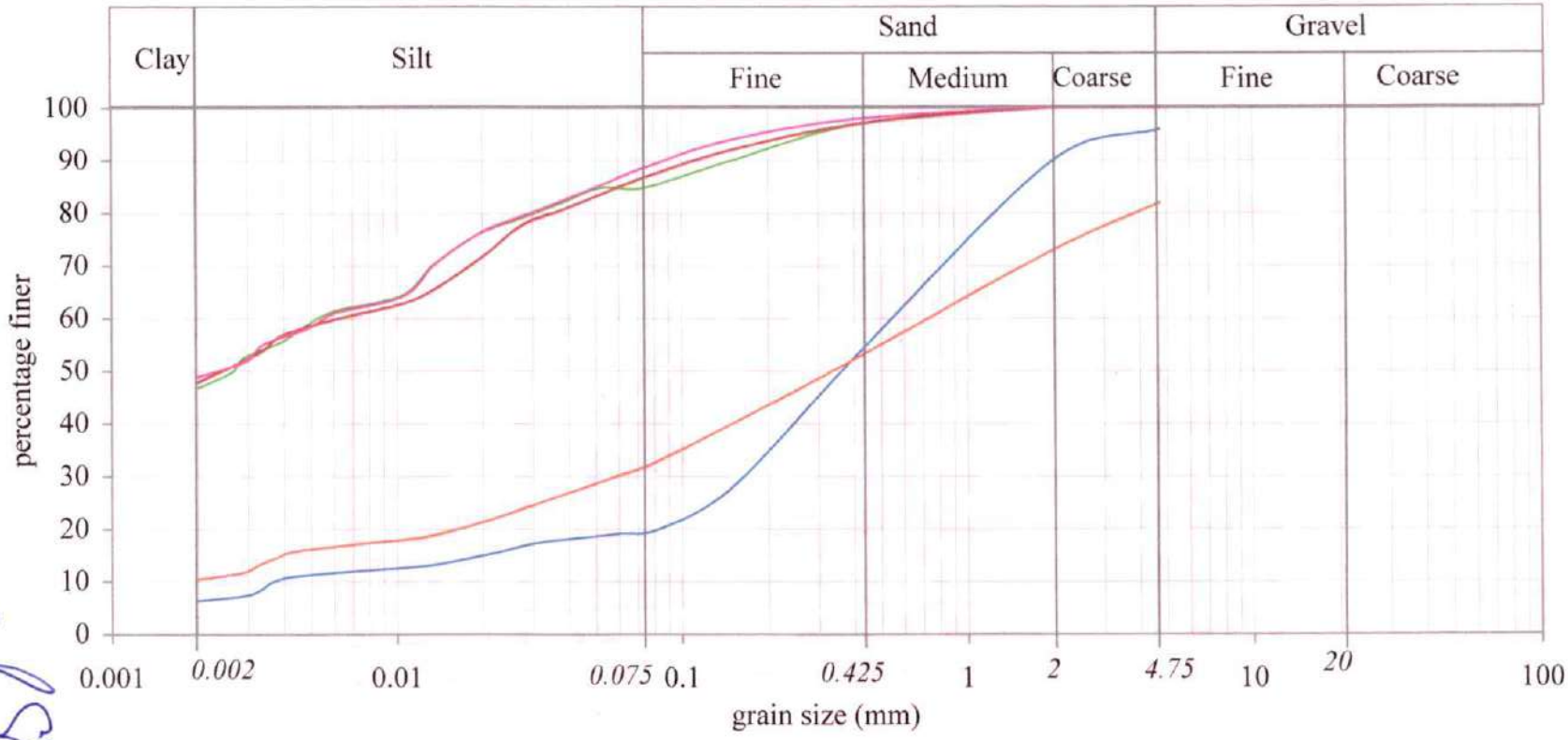
[illegible] East Coast Road, Thiruvanmiyur, Chennai-600 [illegible]

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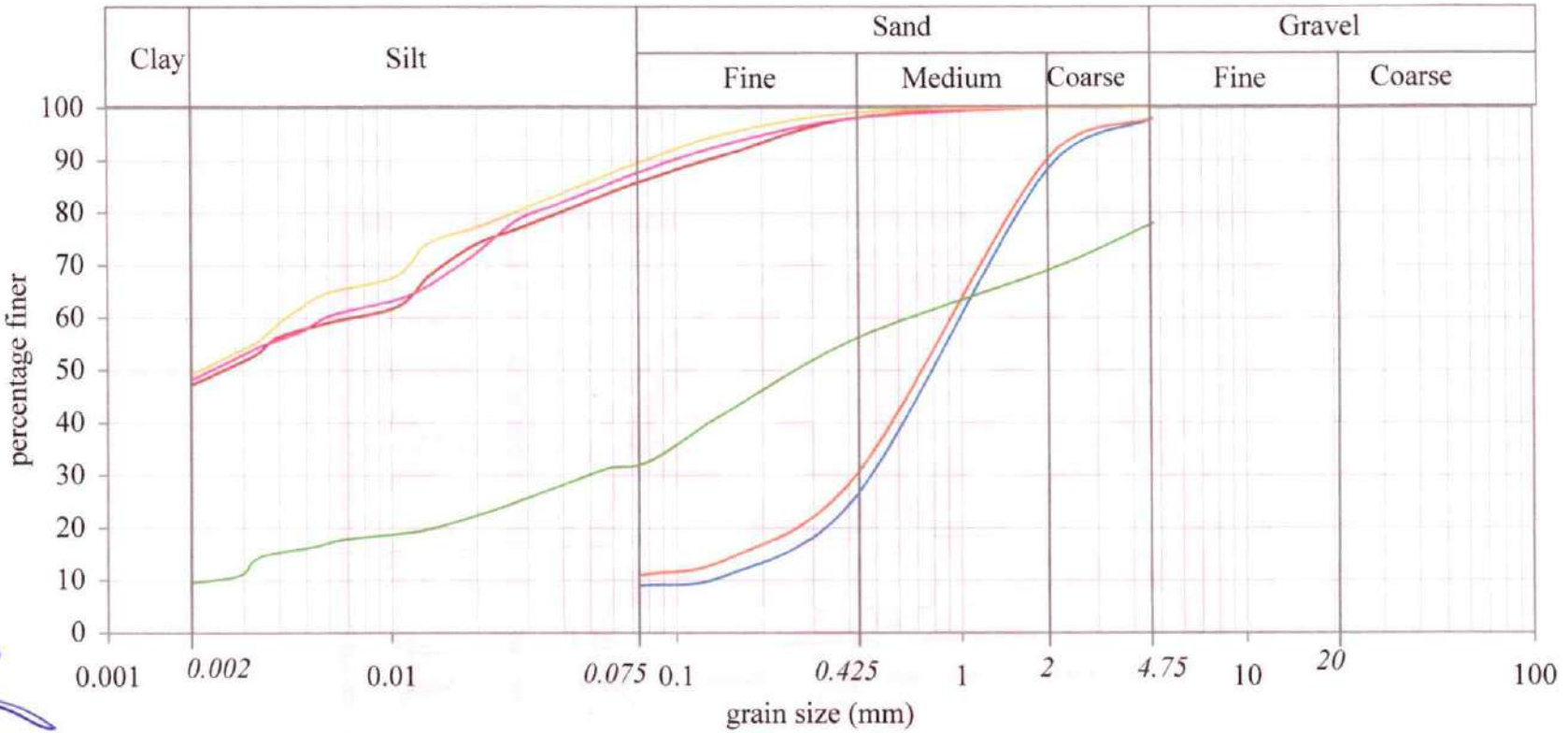

| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | U |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 13.5 | Clayey silty sand with gravel | 4 | 76 | 14 | 6 | 0.500 | 0.003 | 166.7 |
| | 1 | 15.0 | Clayey silty sand with gravel | 18 | 50 | 22 | 10 | 0.700 | - | - |
| | 1 | 18.0 | Sandy silty clay | 0 | 15 | 38 | 47 | 0.005 | - | - |
| | 1 | 19.5 | Sandy silty clay | 0 | 13 | 39 | 48 | 0.006 | - | - |
| | 1 | 21.0 | Sandy silty clay | 0 | 11 | 40 | 49 | 0.005 | - | - |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

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Geotechnical Consultants

Delhi: 011 (T) 26891980 (F) 26827403 delhi@nagadi.co.in
Bangalore: 080 (T) 23156076 (F) 23307007 blr@nagadi.co.in
Chennai: 044 (T) 24487870 (F) 24488957 chennai@nagadi.co.in
Secunderabad: 040 (T) 27754446 (F) 27751194 secunderabad@nagadi.co.in

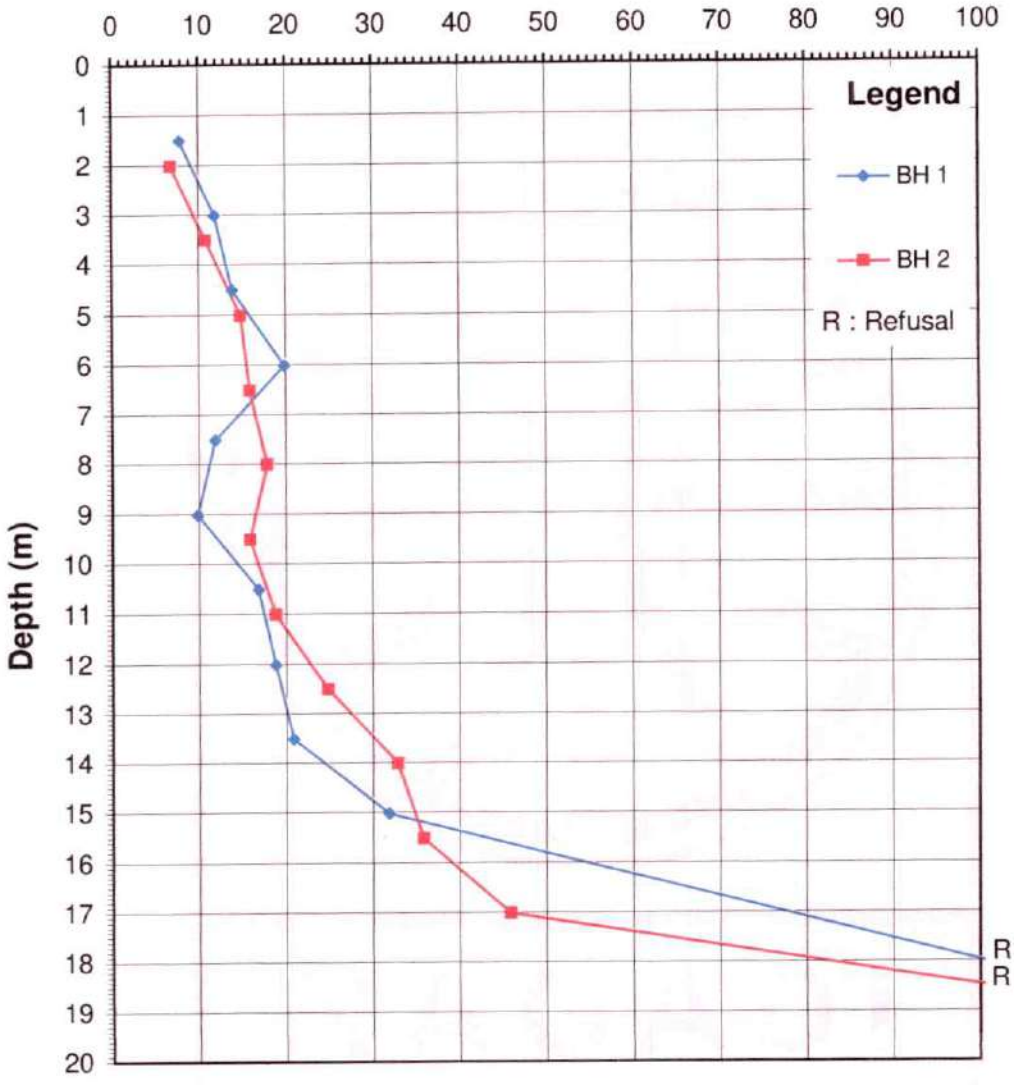



| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | U |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 14.0 | Silty sand with gravel | 2 | 89 | 9 | 0 | 1.000 | 0.14 | 7.1 |
| | 2 | 15.5 | Silty sand with gravel | 2 | 87 | 11 | 0 | 0.900 | - | - |
| | 2 | 17.0 | Clayey silty sand with gravel | 22 | 45 | 23 | 10 | 0.600 | - | - |
| | 2 | 18.5 | Sandy silty clay | 0 | 14 | 38 | 47 | 0.007 | - | - |
| | 2 | 20.0 | Sandy silty clay | 0 | 12 | 39 | 48 | 0.006 | - | - |
| | 2 | 21.0 | Sandy silty clay | 0 | 10 | 40 | 49 | 0.004 | - | - |
| | | | | | | | | | | |
| | | | | | | | | | | |

Job No. : G(C)9929

Sheet No. : 3d

## SPT Values (Observed)




**SPT Values (Observed) Vs Depth Curves**

for Dr.N.SANTOSH RAO
CMDA. REGN.No. GTE / 19/04/019
61-C,East Coast Road,Thiruvanmiyur,
Chennai-600 041.
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