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**PROJECT**

## PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (TWO BASEMENT + STILT FLOOR + 17 UPPER FLOORS) AT ST. MARYS ROAD, ALWARPET, CHENNAI.

**CLIENT**

M/s A.R.FOUNDATIONS PVT. LTD.,
CHENNAI

**TITLE**

## GEOTECHNICAL INVESTIGATION REPORT

**PROJECT NO: GEC-JC-GT-5089-A/2023-2024**

**DATE: 02/02/2024**

GEO ENGINEERING CONSULTANTS Chennai 600 042

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# REPORT TEXT

CHAPTER-1

# INTRODUCTION

## 1.0 Project Information Matrix

| | |
|---|---|
| Nature of project | : Proposed Residential Building (2B+Stilt + 17 Upper Floors) |
| Project Client | : **M/s A.R.FOUNDATIONS PVT. LTD.** |
| Project Location | : St. Marys Road, Alwarpet, Chennai |
| Job Code | : JC-GT-5089-A |

## 1.1 Scope Of Work

### 1.1.1 Field Work

- Conducting two soil investigation bore holes of 150 mm & NX diameter up to 32.0m depth or up to the refusal strata with SPT>100
- Conducting Standard Penetration Test (SPT) within the borehole at every 1.0m depth interval up to 5.0m and thereafter at every 1.5m interval up to 20.0m after that 2.0m interval up to the termination depth
- Collection disturbed/undisturbed soil samples
- Collection of water samples if groundwater table met within the investigation depth

### 1.1.2 Laboratory Work

- Natural Moisture Content
- Atterberg's limits
- Grain Size Analysis
- Chemical Analysis test on soil and water samples to give pH, Chlorides and Sulphates

## 1.2 Structure of the Report

- Contents
- Introduction
- Investigation Methodology & Test Results
- Geology &Sub-Surface Stratification
- Foundation System
- Recommendation
- Annexure

CHAPTER-2

# INVESTIGATION METHODOLOGY & TEST RESULTS

## 2.0 Preamble:

Two soil investigation boreholes were put as per the planning of the engineer in-charge and these locations are shown in Fig.2.0.The equipment used and the methodology adopted to carry out the fieldwork is described below.

## 2.1 Methodology of Field Work:

### 2.1.1 Equipment Used and Method of Drilling:

All the boreholes were sunk by conventional rotary drilling rigs. For borehole Methodology followed for boring conformed to IS: 1892 -2000. Boring was progressed by the cutting action of rotating bit with water circulation and stabilizing the side of the boreholes by using casing pipes/bentonite slurry up to required depth to prevent collapse of sidewall. Boring was continued by normal boring process using MS soil cutter in soil. However Tungsten Carbide (TC) bit drilling was resorted to drill in highly weathered rock stratum where the normal boring process became slow. Diamond Core (DC) bit drilling was adopted in moderately weathered rock formations where penetration using TC bit was became slow.

### 2.1.2 Standard Penetration Tests:

This is a field test to determine "Penetration Resistance of Stratum at the Test Depth". This has been conducted in the boreholes generally up to refusal depth using procedures described in IS: 2131- 2002. In this test, split spoon sampler (50.8 mm OD and 35 mm ID) has replaced driving bit. Sampler is then driven by dropping 63.5 kg hammer on top of driving collar with free fall of 75 cm. The length of sampler is 60 cm.

The tests were conducted at the depth intervals indicated in Chapter-1 (Sec.1.1.1).

### 2.1.3 Collection of Soil Samples:

#### 2.1.3.1 Disturbed Samples:

The SPT-samples collected were used as disturbed soil samples. These samples were used for visual and physical identification and for conducting laboratory classification tests as per I.S.1498-1970.

### 2.1.4 Collection of Ground Water Samples:

One representative water sample from each borehole was collected after 24 hours of completing the borehole if water table met within the investigated depth.

**Note on Groundwater Table Record:**

- Groundwater table observation in geotechnical report is predominantly to arrive at foundation design criteria and shall not be construed as design guidelines for the design of dewatering systems
- The groundwater level indicated in the bore logs is specific to the duration of investigation and intensity of the monsoon rains during the time of investigation.

Hence, the level shall be taken as guidelines only to plan the investigation for the dewatering system

- ❖ No foundation excavation or basement excavations if anticipated within the groundwater table zone shall be carried out without implementing groundwater lowering schemes

## 2.2 Laboratory testing:

### 2.2.1 On Coarse Grained Soil

On the representative samples, sieve analysis tests were conducted to arrive at grain size distribution. These tests were conducted as per I.S.2720 (part 4)-1985 and the results are presented in Tables-2.1 to 2.2. The graphical representation of grain size distribution curve for the representative samples in each bore is presented in Fig. 2.3 to 2.4.

### 2.2.2 On Fine Grained Soil

On the SPT sample index property tests were conducted to estimate consistency. These test results are presented in Tables-2.1 to 2.2. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig.2.5 to 2.8.

### 2.2.3 Chemical Analysis Tests

On representative soil and water samples chemical analysis tests were conducted to estimate pH, Chloride and Sulphates and these results are presented in Table - 2.3.

## 2.3 Summary:

The locations of the field investigation boreholes are shown in site plan given in Fig.2.0. The average sub soil profiles encountered at each location along with their classification and engineering properties are presented in Figs.2.1to 2.2.

# SOIL PROFILE

# SITE INVESTIGATION RECORD

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BORE HOLE No. | BH-01 | | | | | | |
| SHEET | 1 | OF | 4 | | | | |
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | | | DIA OF BORE HOLE | 150mm ✓ / NX | | |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 | CHAINAGE (m) | - | BORE START DATE | 24/10/2023 |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary | CO-ORDINATES | N - | BORE END DATE | 24/10/2023 |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite | | E - | TOTAL DRILL DAYS | 1 |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | SPT Details: Blows/cm. 15-30 | SPT Details: Blows/cm. 30-45 | SPT 'N' Value | Sample Details: Depth | Sample Details: No. | Sample Details: Type | Sample Details: RL (m) | Layer Data: Legend | Layer Data: No | Layer Data: Depth | Layer Data: Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 09 | 25 | | | | | | | | | | | | | | | |
| | | To | | SC | - | - | | | | | | | | | | L1 | 0.5 | **Filled Up Soil** Brown, Sand with Concrete Material |
| | | 09 | 28 | | | | | | | | | | | | | | | |
| 1 | | | | | | | 1 | 1 | 1 | 2 | 1.00 | 1 | SS | -1.0 | | | | |
| | | 09 | 38 | | | | | | | | 1.45 | | | | | | | |
| | | To | | SC | - | - | | | | | | | | | | | | Greyish Brown, Moist, Very Soft to Soft, **Sandy Silty Clay (Cl)**, Silty Clay of Medium Plasticity |
| | | 09 | 43 | | | | | | | | | | | | | | | |
| 2 | | | | | | | 1 | 1 | 2 | 3 | 2.00 | 2 | SS | -2.0 | | | | |
| | | 09 | 53 | | | | | | | | | | | | | | | |
| | | To | | SC | - | - | | | | | 2.45 | | | | | | | |
| | | 09 | 54 | | | | | | | | | | | | | | | |
| 3 | | | | | | | 3 | 3 | 3 | 6 | 3.00 | 3 | SS | -3.0 | | L2 | 3.0 | |
| | | 10 | 05 | | | | | | | | | | | | | | | |
| | | To | | SC | - | - | | | | | 3.45 | | | | | | | Greyish Brown, Moist, Loose, Poorly Graded, **Clayey SAND (SC)** Sand-Clay Mixture |
| | | 10 | 06 | | | | | | | | | | | | | | | |
| 4 | | | | | | | 5 | 8 | 9 | 17 | 4.00 | 4 | SS | -4.0 | | L3 | 4.0 | |
| | | 10 | 16 | | | | | | | | | | | | | | | |
| | | To | | SC | - | - | | | | | 4.45 | | | | | | | Greyish Brown, Moist, Medium Dense, Poorly Graded, **Silty SAND (SP-SM)**, Sand -Silt Mixture |
| | | 10 | 17 | | | | | | | | | | | | | | | |
| 5 | 24/10/2023 | | | | | | 1 | 1 | 3 | 4 | 5.00 | 5 | SS | -5.0 | | L4 | 5.0 | |
| | | 10 | 27 | | | | | | | | | | | | | | | |
| | | To | | SC | - | - | | | | | 5.45 | | | | | | | Greyish Black, Moist, Soft, **Silty Clay (CH)**, Silty Clay of High Plasticity |
| | | 10 | 28 | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | L5 | 6.0 | |
| | | | | | | | 1 | 1 | 3 | 4 | 6.50 | 6 | SS | -6.5 | | | | |
| | | 10 | 38 | | | | | | | | 6.95 | | | | | | | |
| 7 | | To | | SC | - | - | | | | | | | | | | | | Greyish, Moist, Very Loose, Poorly Graded, **Clayey SAND (SC)** Sand-Clay Mixture |
| | | 10 | 39 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | L6 | 8.0 | |
| 8 | | | | | | | 6 | 4 | 5 | 9 | 8.00 | 7 | SS | -8.0 | | | | |
| | | 10 | 49 | | | | | | | | 8.45 | | | | | | | |
| | | To | | SC | - | - | | | | | | | | | | | | Greenish Grey, Moist, Loose, Poorly Graded, **Silty SAND (SM)**, Sand -Silt Mixture |
| | | 10 | 50 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | L7 | 9.5 | |
| | | | | | | | 1 | 1 | 2 | 3 | 9.50 | 8 | SS | -9.5 | | | | |
| | | | | | | | | | | | 9.95 | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | Greenish Grey, Moist, Very Loose, Poorly Graded, **Silty SAND (SM)**, Sand -Silt Mixture |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | | REMARKS | |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 24/10/2023 | GROUND LEVEL (m) | 0.00 | | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) | 1.30 | | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) | 0.00 | | |

# SITE INVESTIGATION RECORD

| | | | |
|---|---|---|---|
| BORE HOLE No. | BH-01 | | |
| SHEET | 2 | OF | 4 |
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | DIA OF BORE HOLE | 150mm ✓ / NX |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 |
| CHAINAGE (m) | - | BORE START DATE | 24/10/2023 |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary |
| CO-ORDINATES | N - | BORE END DATE | 24/10/2023 |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite |
| CO-ORDINATES | E - | TOTAL DRILL DAYS | 1 |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | 15-30 | 30-45 | SPT 'N' Value | Sample Details: Depth | No. | Type | RL (m) | Layer Data: Legend | No | Depth | Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 24/10/2023 | 11 | 05 To 11 10 | SC | - | - | 1 | 2 | 3 | 5 | 11.00 / 11.45 | 9 | SS | -11.0 | | L8 | 11.5 | Greyish, Moist, Very Loose, Poorly Graded, **Silty SAND (SM),** Sand -Silt Mixture |
| 12 | | 11 | 20 To 11 25 | SC | - | - | 1 | 2 | 2 | 4 | 12.50 / 12.95 | 10 | SS | -12.5 | | L9 | 13.0 | Greenish Grey, Moist, Very Loose, Poorly Graded, **Clayey SAND (SC),** Sand -Clay Mixture |
| 13 | | 11 | 38 To 14 40 | SC | - | - | 1 | 1 | 1 | 2 | 14.00 / 14.45 | 11 | SS | -14.0 | | | | |
| 15 | | 11 | 52 To 11 53 | SC | - | - | 1 | 2 | 2 | 4 | 15.50 / 15.95 | 12 | SS | -15.5 | | | | Greyish Black, Moist,Very Soft to Soft **Silty Clay (CI/CH)**, Silty Clay of Medium/High Plasticity |
| 16 | | 12 | 10 To 12 12 | SC | - | - | 0 | 1 | 2 | 3 | 17.00 / 17.45 | 13 | SS | -17.0 | | | | |
| 18 | | 14 | 12 To 14 18 | SC | - | - | 2 | 3 | 4 | 7 | 18.50 / 18.95 | 14 | SS | -18.5 | | L10 | 18.5 | |
| 19 | | 14 | 43 To 14 48 | SC | - | - | 6 | 9 | 10 | 19 | 20.00 / 20.45 | 15 | SS | -20.0 | | L11 | 20.0 | Greyish Black, Moist, Medium Stiff, **Silty Clay (CH)**, Silty Clay of High Plasticity |
| 20 | | | | | | | | | | | | | | | | | | Greyish, Moist,Medium Dense, Poorly Graded, **Clayey SAND (SC)** |

| | | | | | |
|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | REMARKS |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 24/10/2023 | GROUND LEVEL (m) 0.00 | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) 1.30 | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) 0.00 | |

# SITE INVESTIGATION RECORD

| | | | |
|---|---|---|---|
| BORE HOLE No. | BH-01 | | |
| SHEET | 3 | OF | 4 |
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | DIA OF BORE HOLE | 150mm ✓ / NX |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 |
| CHAINAGE (m) | - | BORE START DATE | 24/10/2023 |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary |
| CO-ORDINATES | N - | BORE END DATE | 24/10/2023 |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite |
| CO-ORDINATES | E - | TOTAL DRILL DAYS | 1 |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | 15-30 | 30-45 | SPT 'N' Value | Sample Details: Depth | No. | Type | RL (m) | Layer Data: Legend | No | Depth | Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 24/10/2023 | 15 | 22 | SC | - | - | | | | | | | | | | L12 | 21.5 | Greyish, Moist, Medium Dense, Poorly Graded, **Clayey SAND (SC)** Sand-Clay Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 15 | 24 | | | | | | | | | | | | | | | |
| 22 | | | | | | | 3 | 7 | 11 | 18 | 22.00 | 16 | SS | -22.0 | | | | |
| | | | | | | | | | | | 22.45 | | | | | | | |
| 23 | | 16 | 08 | SC | - | - | | | | | | | | | | | | Greyish, Moist, Medium Dense, Poorly Graded, **Silty SAND (SM/SP-SM)**, Sand - Silt Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 16 | 15 | | | | | | | | | | | | | | | |
| 24 | | | | | | | 7 | 10 | 20 | 30 | 24.00 | 17 | SS | -24.0 | | | | |
| | | | | | | | | | | | 24.45 | | | | | | | |
| 25 | | 17 | 00 | SC | - | - | | | | | | | | | | | | |
| | | To | | | | | | | | | | | | | | | | |
| | | 17 | 04 | | | | | | | | | | | | | | | |
| 26 | | | | | | | 16 | 25 | 40 | 65 | 26.00 | 18 | SS | -26.0 | | L13 | 26.0 | |
| | | | | | | | | | | | 26.45 | | | | | | | |
| 27 | | 17 | 46 | SC | - | - | | | | | | | | | | | | Greyish, Moist, Very Dense, Poorly Graded, **Silty SAND (SP-SM)**, Sand -Silt Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 17 | 51 | | | | | | | | | | | | | | | |
| 28 | | | | | | | 17 | 32 | 48 | 80 | 28.00 | 19 | SS | -28.0 | | L14 | 28.0 | |
| | | | | | | | | | | | 28.45 | | | | | | | |
| 29 | | 18 | 32 | SC | - | - | | | | | | | | | | | | Greyish, Moist, Very Dense **Completely Weathered Rock** Descented from Charnockite |
| | | To | | | | | | | | | | | | | | | | |
| | | 18 | 37 | | | | | | | | | | | | | | | |
| 30 | | | | | | | 19 | 45 | 5cm Penet.for 50 Blows | >100 | 30.00 | 20 | SS | -30.0 | | | | |
| | | | | | | | | | | | 30.35 | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | REMARKS |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 00-01-1900 | GROUND LEVEL (m) 0.00 | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) 1.30 | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) 0.00 | |

**Borehole terminated at 26 m depth below E.G.L**

**FIG.2.1 Sub Soil Profile at BH-01 Location**

# SITE INVESTIGATION RECORD

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BORE HOLE No. | BH-01 | | | | | | |
| SHEET | 4 | OF | 4 | | | | |
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | | | DIA OF BORE HOLE | 150mm | ✓ | |
| | | | | | NX | | |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 | CHAINAGE (m) | - | BORE START DATE | 24/10/2023 |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary | CO-ORDINATES | N - | BORE END DATE | 24/10/2023 |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite | | E - | TOTAL DRILL DAYS | 1 |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | SPT Details: Blows/cm. 15-30 | SPT Details: Blows/cm. 30-45 | SPT 'N' Value | Sample Details: Depth | Sample Details: No. | Sample Details: Type | Sample Details: RL (m) | Layer Data: Legend | Layer Data: No | Layer Data: Depth | Layer Data: Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 24/10/2023 | 19 | 16 | SC | - | - | | | | | | | | | | | | Greyish Brown, Moist, Very Dense **Completely Weathered Rock** Descented from Charnockite |
| | | To | | | | | | | | | | | | | | | | |
| 32 | | 19 | 20 | | | | SPT Hammer Rebounded | | | >100 | 32.00 | 21 | WS | -32.0 | | L15 | 32.0 | |
| 33 | | | | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | | | | |
| 37 | | | | | - | - | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | | REMARKS |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 24/10/2023 | GROUND LEVEL (m) | 0.00 | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) | 1.30 | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) | 0.00 | |

**Borehole terminated at 32 m depth below E.G.L**

**FIG.2.1 Sub Soil Profile at BH-01 Location**

# SITE INVESTIGATION RECORD

| | | | |
|---|---|---|---|
| BORE HOLE No. | BH-02 | | |
| SHEET | 1 | OF | 3 |
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | DIA OF BORE HOLE | 150mm ✓ / NX |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 |
| CHAINAGE (m) | - | BORE START DATE | 25/10/2023 |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary |
| CO-ORDINATES | N - | BORE END DATE | 25/10/2023 |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite |
| CO-ORDINATES | E - | TOTAL DRILL DAYS | 1 |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | 15-30 | 30-45 | SPT 'N' Value | Sample Details: Depth | No. | Type | RL (m) | Layer Data: Legend | No | Depth | Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 25/10/2023 | 10 | 19 | | | | | | | | | | | | | L1 | 0.5 | **Filled Up Soil** Brown, Sand with Concrete Material |
| | | To | | SC | - | - | | | | | | | | | | | | |
| | | 10 | 20 | | | | | | | | | | | | | | | |
| 1 | | 10 | 30 | | | | 1 | 1 | 2 | 3 | 1.00 / 1.45 | 1 | SS | -1.0 | | | | Greyish Brown, Moist, Soft, **Sandy Silty Clay (CI)**, Silty Clay of Medium Plasticity |
| | | To | | SC | - | - | | | | | | | | | | | | |
| | | 10 | 33 | | | | | | | | | | | | | L2 | 2.0 | |
| 2 | | 10 | 41 | | | | 2 | 2 | 4 | 6 | 2.00 / 2.45 | 2 | SS | -2.0 | | | | |
| | | To | | SC | - | - | | | | | | | | | | | | |
| | | 10 | 42 | | | | | | | | | | | | | | | |
| 3 | | 10 | 52 | | | | 2 | 2 | 3 | 5 | 3.00 / 3.45 | 3 | SS | -3.0 | | | | Greyish Brown, Moist, Medium Stiff, **Sandy Silty Clay (CI)**, Silty Clay of Medium Plasticity |
| | | To | | SC | - | - | | | | | | | | | | | | |
| | | 10 | 53 | | | | | | | | | | | | | L3 | 4.0 | |
| 4 | | 11 | 03 | | | | 3 | 5 | 6 | 11 | 4.00 / 4.45 | 4 | SS | -4.0 | | | | |
| | | To | | SC | - | - | | | | | | | | | | | | Greyish Brown, Moist, Medium Dense, Poorly Graded, **Silty SAND (SP-SM)**, Sand -Silt Mixture |
| | | 11 | 04 | | | | | | | | | | | | | L4 | 5.0 | |
| 5 | | 11 | 14 | | | | 1 | 1 | 2 | 3 | 5.00 / 5.45 | 5 | SS | -5.0 | | | | |
| | | To | | SC | - | - | | | | | | | | | | | | |
| | | 11 | 16 | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | |
| | | 11 | 26 | | | | 1 | 2 | 2 | 4 | 6.50 / 6.95 | 6 | SS | -6.5 | | | | Greyish Black, Moist, Soft, **Silty Clay (CH/CI)**, Silty Clay of High/Medium Plasticity |
| 7 | | To | | SC | - | - | | | | | | | | | | | | |
| | | 11 | 28 | | | | | | | | | | | | | | | |
| 8 | | 11 | 38 | | | | 8 | 11 | 12 | 23 | 8.00 / 8.45 | 7 | SS | -8.0 | | L5 | 8.0 | |
| | | To | | SC | - | - | | | | | | | | | | | | Greenish Grey, Moist, Medium Dense, Poorly Graded, **Silty SAND (SM)**, Sand - Silt Mixture |
| | | 11 | 39 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | L6 | 9.5 | |
| | | | | | | | 1 | 2 | 2 | 4 | 9.50 / 9.95 | 8 | SS | -9.5 | | | | |
| 10 | | | | | | | | | | | | | | | | | | Greenish Grey, Moist, Very Loose, Poorly Graded, **Silty SAND (SM)**, Sand -Silt Mixture |

| | | | | | |
|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | REMARKS |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 25/10/2023 | GROUND LEVEL (m) 0.00 | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) 1.30 | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) 0.00 | |

# SITE INVESTIGATION RECORD

| | | | |
|---|---|---|---|
| BORE HOLE No. | BH-02 | | |
| SHEET | 2 | OF | 3 |
| DIA OF BORE HOLE | 150mm ✓ / NX | | |
| BORE START DATE | 25/10/2023 | | |
| BORE END DATE | 25/10/2023 | | |
| TOTAL DRILL DAYS | 1 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | | | | | | |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 | CHAINAGE (m) | - | | |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary | CO-ORDINATES | N | - | |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite | | E | - | |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | 15-30 | 30-45 | SPT 'N' Value | Sample Details: Depth | No. | Type | RL (m) | Layer Data: Legend | No | Depth | Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 25/10/2023 | 11 | 49 To 52 | SC | - | - | 2 | 3 | 3 | 6 | 11.00 / 11.45 | 9 | SS | -11.0 | | L7 | 11.5 | Greyish, Moist, Loose, Poorly Graded, **Silty SAND (SM),** Sand -Silt Mixture |
| 12 | | 12 | 02 To 04 | SC | - | - | 8 | 4 | 5 | 9 | 12.50 / 12.95 | 10 | SS | -12.5 | | L8 | 13.0 | Greenish Grey, Moist, Loose, Poorly Graded, **Clayey SAND (SC),** Sand -Clay Mixture |
| 13 | | | | | | | | | | | | | | | | | | |
| 14 | | 12 | 20 To 23 | SC | - | - | 1 | 1 | 2 | 3 | 14.00 / 14.45 | 11 | SS | -14.0 | | | | |
| 15 | | 12 | 40 To 42 | SC | - | - | 1 | 2 | 1 | 3 | 15.50 / 15.95 | 12 | SS | -15.5 | | | | Greyish Black, Moist, Soft **Silty Clay (CI/CH)**, Silty Clay of Medium/High Plasticity |
| 16 | | | | | | | | | | | | | | | | | | |
| 17 | | 12 | 58 To 59 | SC | - | - | 1 | 1 | 2 | 3 | 17.00 / 17.45 | 13 | SS | -17.0 | | | | |
| 18 | | 13 | 42 To 43 | SC | - | - | 1 | 3 | 3 | 6 | 18.50 / 18.95 | 14 | SS | -18.5 | | L9 | 18.5 | |
| 19 | | | | | | | | | | | | | | | | | | Greyish Black, Moist, Medium Stiff, **Silty Clay (CH)**, Silty Clay of High Plasticity |
| 20 | | 14 | 05 To 08 | SC | - | - | 7 | 11 | 11 | 22 | 20.00 / 20.45 | 15 | SS | -20.0 | | L10 | 20.0 | Greyish, Moist,Medium Dense, Poorly Graded, **Clayey SAND (SC)** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | | REMARKS | |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 25/10/2023 | GROUND LEVEL (m) | 0.00 | | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) | 1.30 | | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) | 0.00 | | |

# SITE INVESTIGATION RECORD

| | | | |
|---|---|---|---|
| BORE HOLE No. | BH-02 | | |
| SHEET | 3 | OF | 3 |
| DIA OF BORE HOLE | 150mm ✓ / NX | | |
| BORE START DATE | 25/10/2023 | | |
| BORE END DATE | 25/10/2023 | | |
| TOTAL DRILL DAYS | 1 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT NAME | PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT ALWARPET | | | | | | |
| LOCATION | St. Marys Road, Alwarpet, Chennai | MACHINE No. | CR-01 | CHAINAGE (m) | - | | |
| STRUCTURE | 2B+Still +17 Floors | DRILLING METHOD | Rotary | CO-ORDINATES | N | - | |
| JOB CODE | GEC-JC-GT-5089-A | FLUSHING MEDIUM | Bentonite | | E | - | |

| Depth below E.G.L. (m) | Drilling progress per metre: Date | Time: Hr. | Time: Min. | Type of Drill Bit (SC / TCB / DB) | Core Details: Total Core Recovery % | Core Details: R.Q.D % | SPT Details: Blows/cm. 0-15 | 15-30 | 30-45 | SPT 'N' Value | Sample Details: Depth | No. | Type | RL (m) | Layer Data: Legend | No | Depth | Geotechnical Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 25/10/2023 | 14 | 27 | SC | - | - | | | | | | | | | | L11 | 21.5 | Greyish, Moist, Medium Dense, Poorly Graded, **Clayey SAND (SC)** Sand-Clay Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 14 | 29 | | | | | | | | | | | | | | | |
| 22 | | | | | | | 5 | 9 | 11 | **20** | 22.00 | 16 | SS | -22.0 | | | | |
| | | | | | | | | | | | 22.45 | | | | | | | |
| 23 | | 15 | 05 | SC | - | - | | | | | | | | | | | | Greyish, Moist, Medium Dense, Poorly Graded, **Silty SAND (SM),** Sand -Silt Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 15 | 08 | | | | | | | | | | | | | | | |
| 24 | | | | | | | 11 | 20 | 32 | **52** | 24.00 | 17 | SS | -24.0 | | L12 | 24.0 | |
| | | | | | | | | | | | 24.45 | | | | | | | |
| 25 | | 15 | 36 | SC | - | - | | | | | | | | | | | | Greyish, Moist, Very Dense, Poorly Graded, **Silty SAND (SM/SP-SM)**, Sand - Silt Mixture |
| | | To | | | | | | | | | | | | | | | | |
| | | 15 | 39 | | | | | | | | | | | | | | | |
| 26 | | | | | | | 15 | 28 | 37 | **65** | 26.00 | 18 | SS | -26.0 | | | | |
| | | | | | | | | | | | 26.45 | | | | | | | |
| 27 | | 16 | 13 | SC | - | - | | | | | | | | | | L13 | 27.0 | |
| | | To | | | | | | | | | | | | | | | | |
| | | 16 | 15 | | | | | | | | | | | | | | | |
| 28 | | | | | | | 18 | 32 | 44 | **76** | 28.00 | 19 | SS | -28.0 | | | | Greyish, Moist, Very Dense **Completely Weathered Rock** Descented from Charnockite |
| | | | | | | | | | | | 28.45 | | | | | | | |
| 29 | | 17 | 05 | SC | - | - | | | | | | | | | | | | |
| | | To | | | | | | | | | | | | | | | | |
| | | 17 | 11 | | | | | | | | | | | | | | | |
| 30 | | | | | | | SPT Hammer Rebounded | | | **>100** | 30.00 | 20 | WS | -30.0 | | L14 | 30.0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| CS - Core Sample | DS - Disturbed Sample | LOGGED | M.PANDIRAJAN | PROJECT SITE DETAILS | | REMARKS |
| SS - Split Spoon Sample | SC - Soil Cutter | DATE | 00-01-1900 | GROUND LEVEL (m) | 0.00 | |
| UDS- Undisturbed Sample | TCB - Tungsten Carbide Bit | CHECKED | JALEEL YASIN | WATER TABLE (m) | 1.30 | |
| WS - Wash Sample | DB - Diamond Bit | DATE | 02/02/2024 | CASING DEPTH (m) | 0.00 | |

**Borehole terminated at 30 m depth below E.G.L**

**FIG.2.2 Sub Soil Profile at BH-02 Location**

# Grain Size Distribution Curves

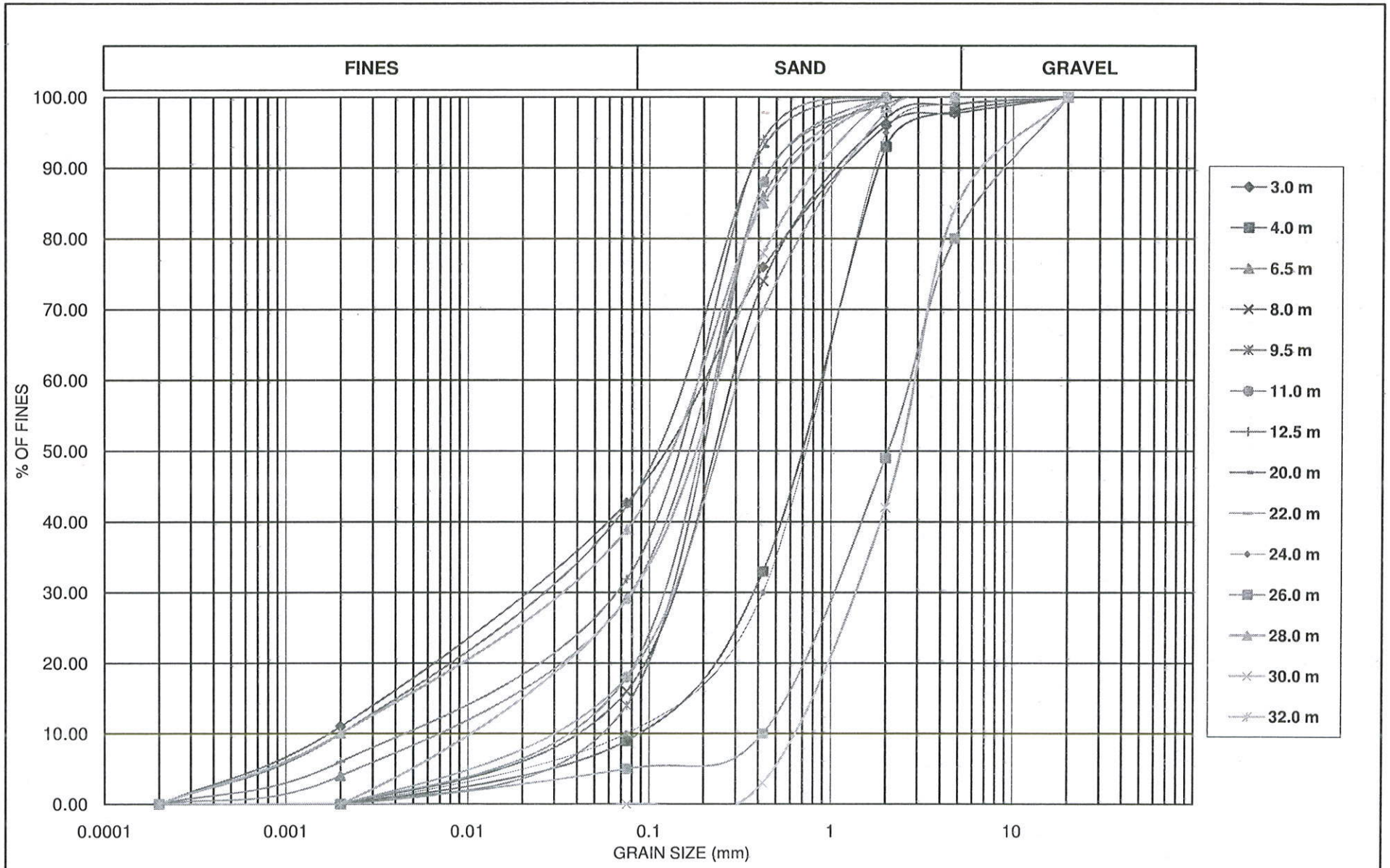



**Fig. 2.3 GRAIN SIZE DISTRIBUTION CURVE - BH-01**

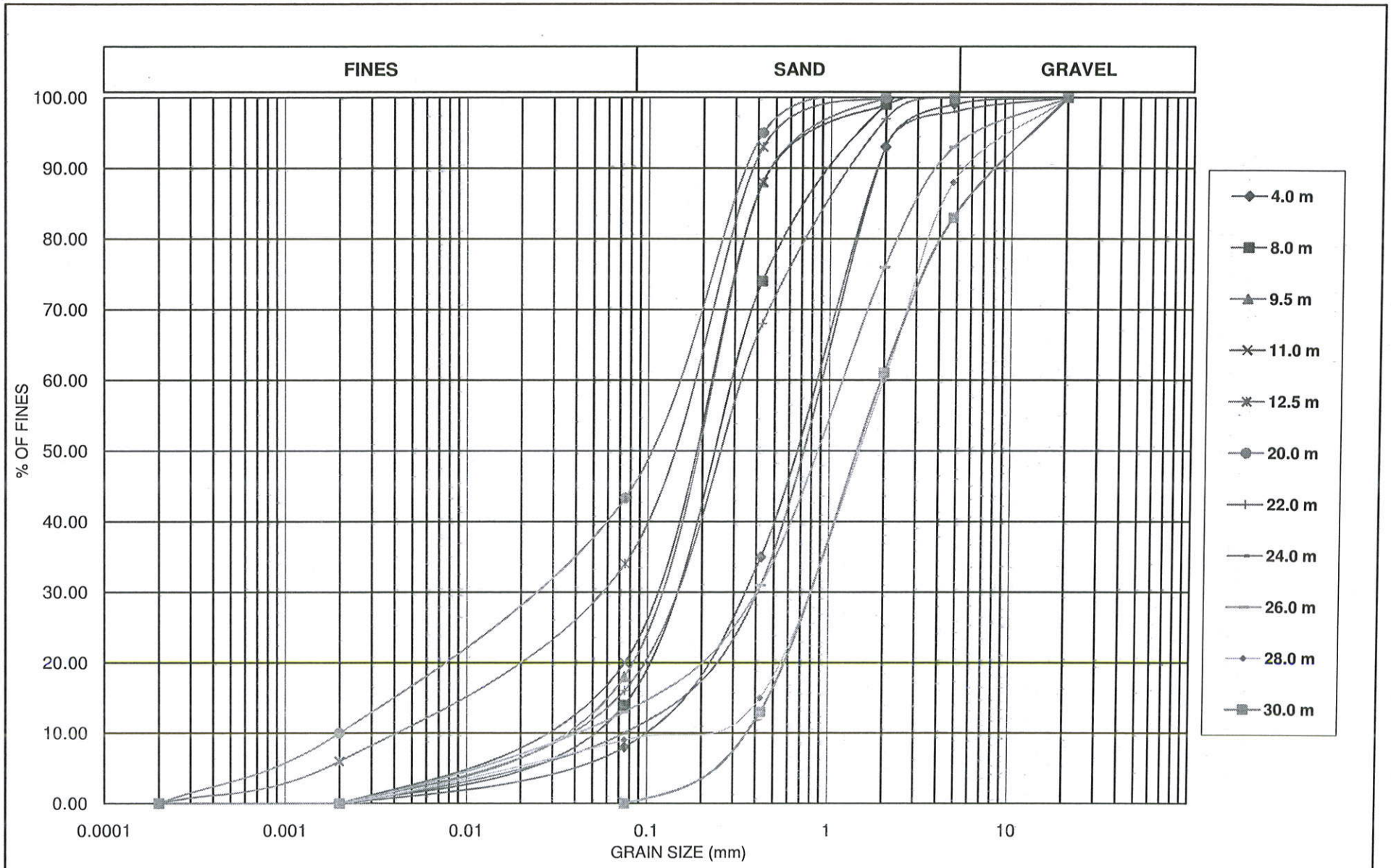



**Fig. 2.4 GRAIN SIZE DISTRIBUTION CURVE - BH-02**

# HYDROMETER ANALYSIS CURVE

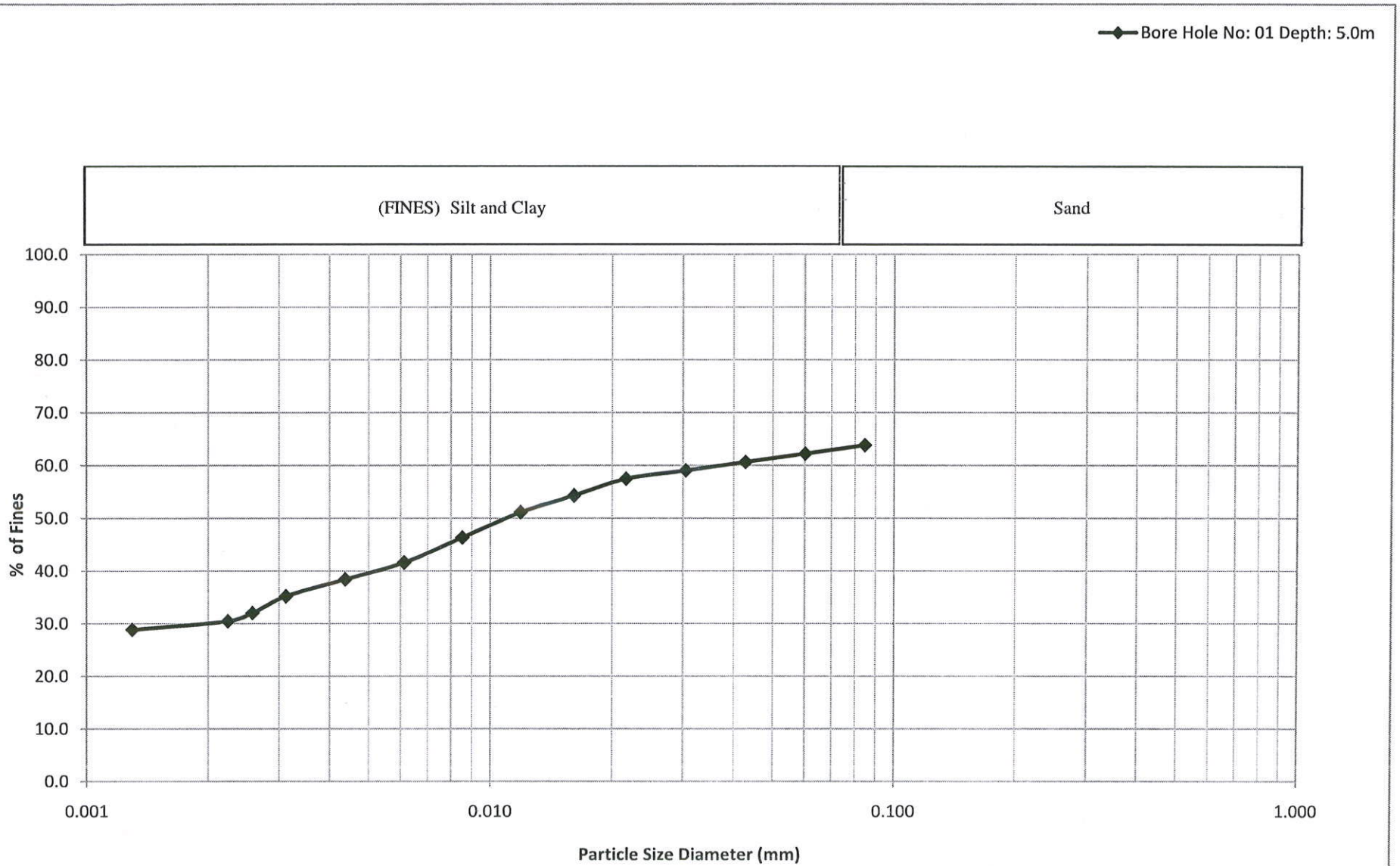



**Fig 2.5 Hydrometer Analysis Master Curve**

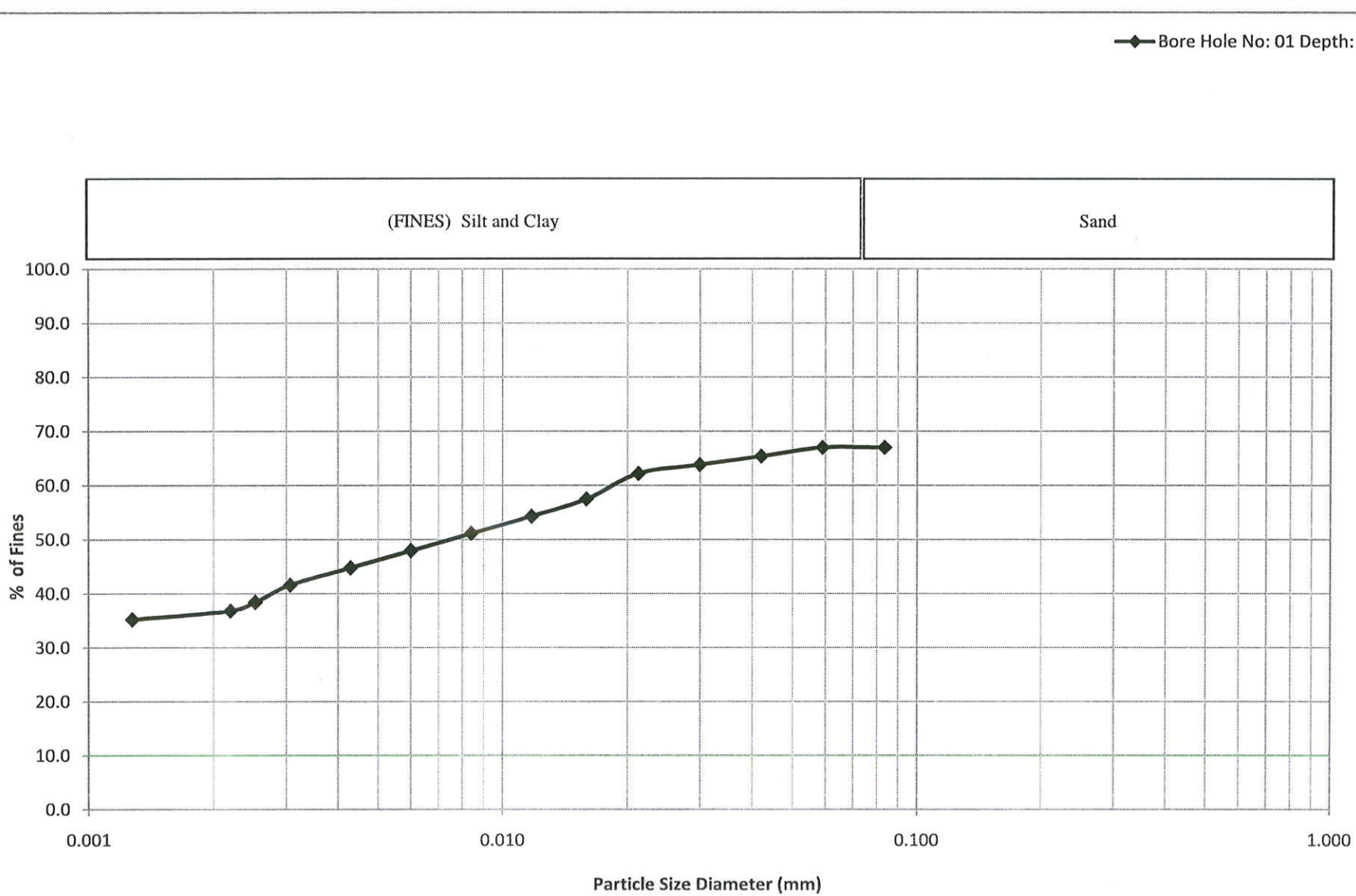



**Fig 2.6 Hydrometer Analysis Master Curve**

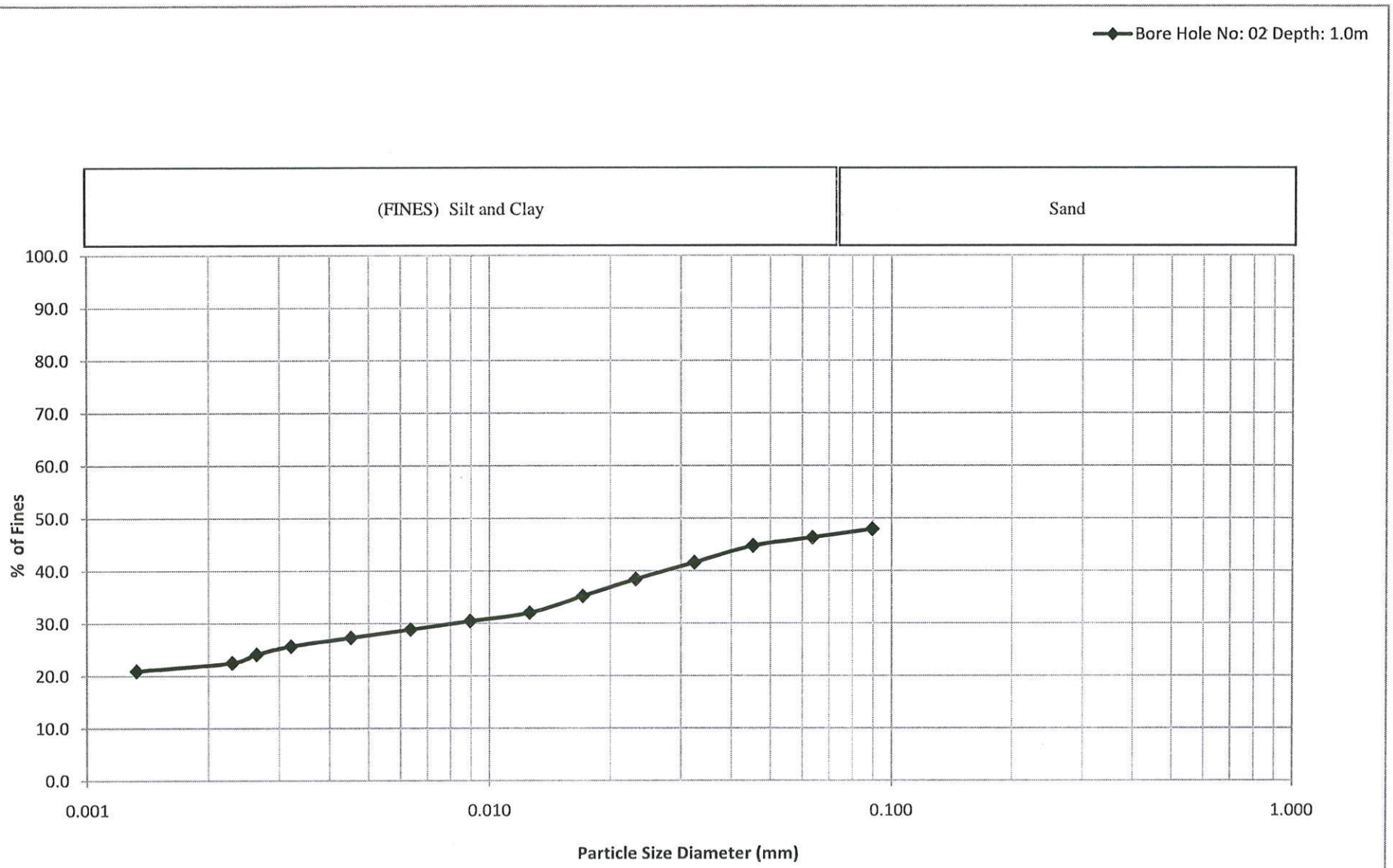



**Fig 2.7 Hydrometer Analysis Master Curve**

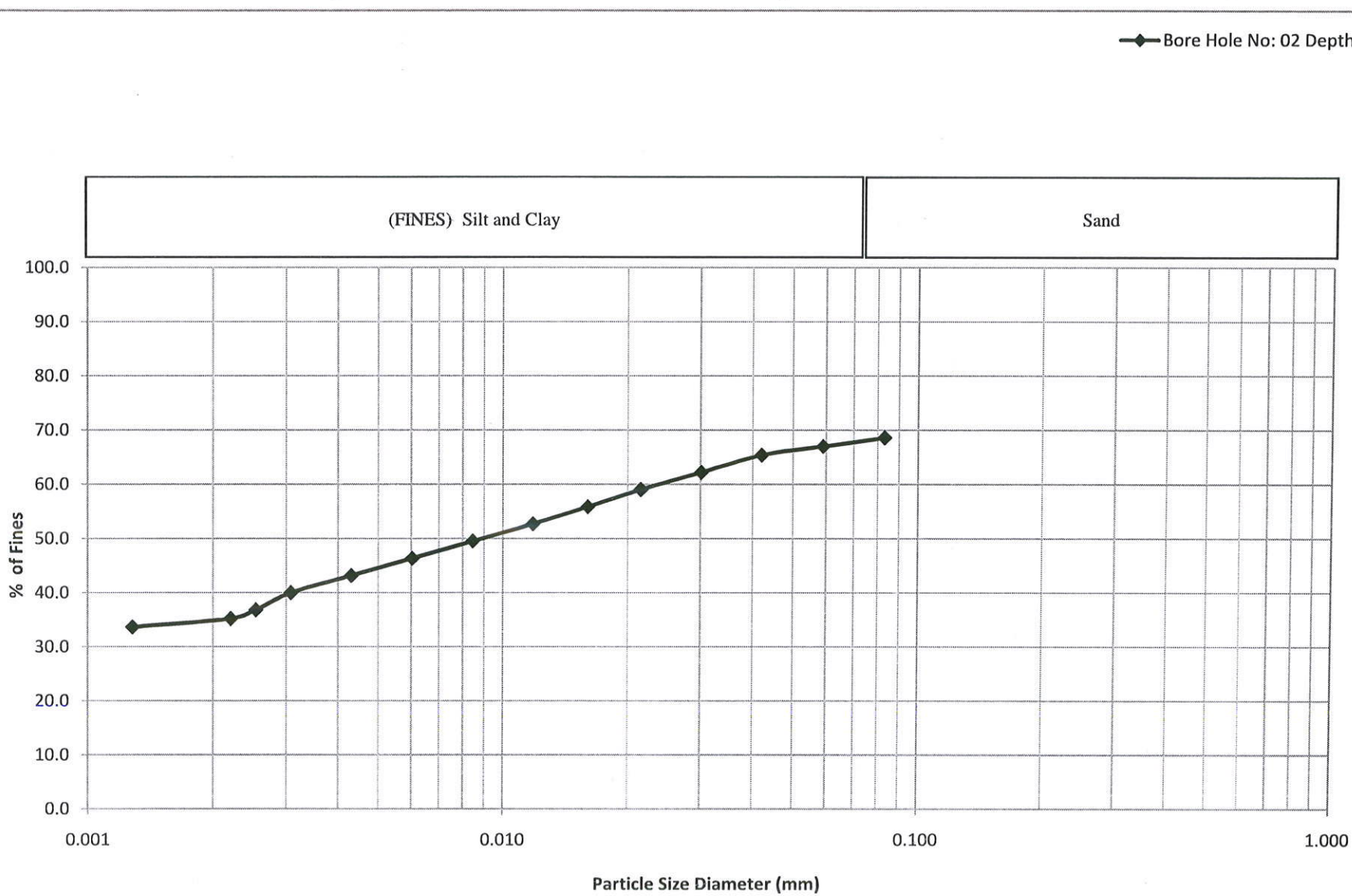



**Fig 2.8 Hydrometer Analysis Master Curve**

# LABORATORY TEST RESULTS

## Table-2.1 Laboratory Classification of Soil Samples from BH-01

| Depth of Sample below E.G.L. (m) | SPT-Value | Type of Sample | Sub Soil Classification | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fine Grained (FG) | | | | | | | | | | Coarse Grained (CG) | | | | | | | | | | | | | IS-Notation | |
| | | | NMC(%) | LL (%) | PL (%) | $I_P$ | Ic | SL (%) | FS (%) | Consistancy | Position With Respect to A-Aline | IS:Notation | Gravel (%) | Coarse (%) | Medium (%) | Fine (%) | Silt (%) | Clay (%) | $D_{10}$ (mm) | $D_{30}$(mm) | $D_{60}$ (mm) | $C_U=D_{60}/D_{10}$ | $C_c=D_{30}^2/(D_{10}xD_{60})$ | Relative Density | Gravel | Sand |
| 1.0 | 2 | SS | 37 | 39 | 20 | 19 | 0.11 | 15 | 44 | Very Soft | Above | CI | 0 | 0 | 24 | 21 | 37 | 18 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 2.0 | 3 | SS | 29 | 36 | 19 | 17 | 0.41 | 15 | 32 | Soft | Above | CI | 0 | 0 | 20 | 20 | 43 | 17 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 3.0 | 6 | SS | 23 | 32 | 18 | 14 | 0.64 | 18 | 28 | CG>50% | Above | - | 2 | 2 | 20 | 27 | 38 | 11 | - | - | - | - | - | Loose | <50% | SC |
| 4.0 | 17 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 2 | 5 | 60 | 24 | 9 | 0 | - | - | - | - | - | M.Dense | <50% | SP-SM |
| 5.0 | 4 | SS | 49 | 58 | 28 | 30 | 0.30 | 12 | 64 | Soft | Above | CH | - | - | - | - | 72 | 28 | - | | - | - | - | FG>50% | FG>50% | FG>50% |
| 6.5 | 4 | SS | 25 | 28 | 19 | 9 | 0.33 | 19 | 22 | CG>50% | Above | - | 0 | 0 | 14 | 54 | 28 | 4 | - | - | - | - | - | V.Loose | <50% | SC |
| 8.0 | 9 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 1 | 2 | 23 | 58 | 16 | 0 | - | - | - | - | - | Loose | <50% | SM |
| 9.5 | 3 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 1 | 11 | 74 | 14 | 0 | - | - | - | - | - | V.Loose | <50% | SM |
| 11.0 | 5 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 0 | 12 | 70 | 18 | 0 | - | - | - | - | - | Loose | <50% | SM |
| 12.5 | 4 | SS | 34 | 44 | 23 | 21 | 0.48 | 14 | 60 | CG>50% | Above | - | 0 | 0 | 6 | 58 | 30 | 6 | - | - | - | - | - | V.Loose | <50% | SC |
| 14.0 | 2 | SS | 50 | 48 | 24 | 24 | -0.08 | 13 | 64 | Very Soft | Above | CI | 0 | 0 | 0 | 20 | 55 | 25 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 15.5 | 4 | SS | 35 | 41 | 22 | 19 | 0.32 | 15 | 67 | Soft | Above | CI | 0 | 0 | 0 | 38 | 42 | 20 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 17.0 | 3 | SS | 62 | 84 | 29 | 55 | 0.40 | 13 | 248 | Soft | Above | CH | - | - | - | - | 68 | 32 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 18.5 | 7 | SS | 56 | 91 | 35 | 56 | 0.63 | 12 | 268 | M.Stiff | Above | CH | - | - | - | - | 65 | 35 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 20.0 | 19 | SS | 17 | 28 | 19 | 9 | 1.22 | 21 | 22 | CG>50% | Above | - | 0 | 0 | 7 | 45 | 38 | 10 | - | - | - | - | - | M.Dense | <50% | SC |
| 22.0 | 18 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 2 | 28 | 52 | 18 | 0 | - | - | - | - | - | M.Dense | <50% | SM |
| 24.0 | 30 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 1 | 4 | 65 | 20 | 10 | 0 | - | - | - | - | - | M.Dense | <50% | SP-SM |
| 26.0 | 65 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 8 | 11 | 50 | 19 | 12 | 0 | - | - | - | - | - | V.Dense | <50% | SP-SM |
| 28.0 | 80 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 20 | 31 | 39 | 5 | 5 | 0 | - | - | - | - | - | V.Dense | <50% | SP-SM |
| 30.0 | >100 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 14 | 12 | 43 | 16 | 15 | 0 | - | - | - | - | - | V.Dense | <50% | SM |
| 32.0 | >100 | WS | - | - | - | - | - | - | - | CG>50% | - | - | 16 | 42 | 39 | 3 | 0 | 0 | - | - | - | - | - | V.Dense | <50% | SP |

FG = Fine Grained
CG = Coarse Grained
NMC= Nature Moisture Content
LL = Liquid Limit
PL = Plastic Limit
Ip = Plasticity Index
Ic = (LL-NMC)/Ip
SL = Shrinkage Limit
FS = Differential Frees Well Index
$C_U$ = Uniformity Coefficient
$C_C$ = Coefficient of Curvature
IP=LL-PL

| | |
|---|---|
| LAB IN-CHARGE | M.PRAVEEN |
| REVIEWED BY | JALEEL YASIN |

## Table-2.2 Laboratory Classification of Soil Samples from BH-02

| Depth of Sample below E.G.L. (m) | SPT-Value | Type of Sample | Sub Soil Classification | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fine Grained (FG) | | | | | | | | | | Coarse Grained (CG) | | | | | | | | | | | | IS-Notation | |
| | | | NMC(%) | LL (%) | PL (%) | $I_P$ | Ic | SL (%) | FS (%) | Consistancy | Position With Respect to A-Aline | IS:Notation | Gravel (%) | Coarse (%) | Medium (%) | Fine (%) | Silt (%) | Clay (%) | $D_{10}$ (mm) | $D_{30}$(mm) | $D_{60}$ (mm) | $C_U=D_{60}/D_{10}$ | $C_c=D_{30}^2/(D_{10}xD_{60})$ | Relative Density | Gravel | Sand |
| 1.0 | 3 | SS | 35 | 41 | 21 | 20 | 0.30 | 14 | 46 | Soft | Above | CI | 0 | 0 | 15 | 25 | 39 | 21 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 2.0 | 6 | SS | 26 | 38 | 20 | 18 | 0.67 | 15 | 39 | M.Stiff | Above | CI | 0 | 0 | 17 | 22 | 44 | 17 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 3.0 | 5 | SS | 27 | 37 | 19 | 18 | 0.56 | 17 | 35 | M.Stiff | Above | CI | 0 | 1 | 19 | 25 | 39 | 16 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 4.0 | 11 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 1 | 6 | 58 | 27 | 8 | 0 | - | - | - | - | - | M.Dense | <50% | SP-SM |
| 5.0 | 3 | SS | 50 | 60 | 29 | 31 | 0.32 | 12 | 63 | Soft | Above | CH | - | - | - | - | 70 | 30 | - | | - | - | - | FG>50% | FG>50% | FG>50% |
| 6.5 | 4 | SS | 33 | 38 | 19 | 19 | 0.26 | 16 | 42 | Soft | Above | CI | - | - | - | - | 82 | 18 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 8.0 | 23 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 1 | 25 | 60 | 14 | 0 | - | - | - | - | - | M.Dense | <50% | SM |
| 9.5 | 4 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 0 | 12 | 70 | 18 | 0 | - | - | - | - | - | V.Loose | <50% | SM |
| 11.0 | 6 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 1 | 11 | 68 | 20 | 0 | - | - | - | - | - | Loose | <50% | SM |
| 12.5 | 9 | SS | 23 | 38 | 20 | 18 | 0.83 | 14 | 65 | CG>50% | Above | - | 0 | 0 | 7 | 55 | 32 | 6 | - | - | - | - | - | Loose | <50% | SC |
| 14.0 | 3 | SS | 40 | 48 | 23 | 25 | 0.32 | 13 | 68 | Soft | Above | CI | 0 | 0 | 0 | 18 | 58 | 24 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 15.5 | 3 | SS | 36 | 45 | 24 | 21 | 0.43 | 14 | 64 | Soft | Above | CI | 0 | 0 | 0 | 40 | 38 | 22 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 17.0 | 3 | SS | 58 | 81 | 28 | 53 | 0.43 | 12 | 228 | Soft | Above | CH | - | - | - | - | 67 | 33 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 18.5 | 6 | SS | 52 | 96 | 34 | 62 | 0.71 | 12 | 245 | M.Stiff | Above | CH | - | - | - | - | 66 | 34 | - | - | - | - | - | FG>50% | FG>50% | FG>50% |
| 20.0 | 22 | SS | 16 | 30 | 18 | 12 | 1.17 | 18 | 20 | CG>50% | Above | - | 0 | 0 | 5 | 46 | 39 | 10 | - | - | - | - | - | M.Dense | <50% | SC |
| 22.0 | 20 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 0 | 3 | 29 | 52 | 16 | 0 | - | - | - | - | - | M.Dense | <50% | SM |
| 24.0 | 52 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 2 | 5 | 62 | 21 | 10 | 0 | - | - | - | - | - | V.Dense | <50% | SP-SM |
| 26.0 | 65 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 7 | 17 | 45 | 18 | 13 | 0 | - | - | - | - | - | V.Dense | <50% | SM |
| 28.0 | 76 | SS | - | - | - | - | - | - | - | CG>50% | - | - | 12 | 28 | 45 | 6 | 9 | 0 | - | - | - | - | - | V.Dense | <50% | SP-SM |
| 30.0 | >100 | WS | - | - | - | - | - | - | - | CG>50% | - | - | 17 | 22 | 48 | 13 | 0 | 0 | - | - | - | - | - | V.Dense | <50% | SP |

FG = Fine Grained
CG = Coarse Grained
NMC= Nature Moisture Content
LL = Liquid Limit
PL = Plastic Limit
Ip = Plasticity Index
Ic = (LL-NMC)/Ip
SL = Shrinkage Limit
FS = Differential Frees Well Index
$C_U$ = Uniformity Coefficient
$C_C$ = Coefficient of Curvature
IP=LL-PL

| | |
|---|---|
| **LAB IN-CHARGE** | M.PRAVEEN |
| **REVIEWED BY** | JALEEL YASIN |

| Table-2.3 Results of Chemical Analysis | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SL No. | Bore HoleNo. | Water | | | | Soil (2:1) | | | |
| | | Depth of Sample (m) | pH | Chlorides (ppm) | Sulphates (ppm) | Depth of Sample (m) | pH | Chlorides (ppm) | Sulphates (ppm) |
| 1 | BH-01 | 1.30 | 7.37 | 1256 | 630 | 3.0 | 7.36 | 956 | 685 |
| 2 | BH-02 | 1.30 | 7.37 | 1101 | 629 | 2.0 | 7.36 | 985 | 674 |

## CHAPTER-3

# GEOLOGY & SUB-SURFACE STRATIFICATION

### 3.0 Preamble:

Geotechnical investigation carried out at a specific site provides location specific sub surface characteristics based on which the design of sub structures/foundations is generally carried out. However, the macro-level understanding of the sub surface is also needed for a comprehensive understanding of the sub structure/foundation response to naturally super imposed loads like earthquake forces etc., The macro level understanding of the sub surface is better provided through the knowledge of the Geology of the region. Since, it is beyond the scope of the present study to carry out geological investigation to establish the geology of the study region; published data are presented below along with the sub surface stratification observed through the direct borehole investigation carried out at the specified locations.

### 3.1 Geology of Study Area (based on the published data)

Geologically, the present site is located in a coastal region with sub surface consisting of sedimentary deposits. The top sedimentary deposit is under laid by upper Gondwana system, particularly lower stage of Sriperumpudur (Shale Formation)/basement Archean Rock Formation.The formation mechanism of the sediments is chiefly due to transportation of surface water and marine deposition.

The above geological characteristics are also observed in the direct bore hole investigation, which confirms that the present site does not depict any surprising geological features that are different from that of the region

### 3.2 DESIGN SUB SOIL PROFILE:(WRT Foundation Engineering Application)

The sub soil characteristics obtained at the test location are further processed to arrive at the design soil parameters required for the design of sub structure using the following shear strength correlations with respect to the Standard Penetration Test Values of different layers.

- **For Coarse Grained Material, Ref. IS: 6403 to estimate Angle of Shearing Resistance (Reproduced and shown in Fig.A1)**
- **For Fine Grained Material, Ref. Terzaghi& Peck, 1948, to estimate Unconfined Compressive Strength (Reproduced and shown in Fig.A2)**

Based on the above, the average design soil characteristics are given below:

| REFERENCE BORE HOLE-BH: | | | | | 01 | Ref R.L. of G.L. (m): | | | 0.00 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Layer No. | Layer Thk. (m) | | | Type of Strata | Colour | Ave. Design SPT | Relative Density | Consistency | $(\gamma)$ kN/m$^3$ | Shear Parameters | |
| | Top. R.L. | Bot. R.L. | Thickness | | | | | | | $(C_u)$ kPa | $(\phi)$ Deg. |
| 1 | 0.00 | 0.50 | 0.50 | Filled Up Soil | Brown | - | - | - | - | - | - |
| 2 | 0.50 | 3.00 | 2.50 | Sandy Silty Clay | Greyish Brown | 3 | - | Soft | 14 | 20 | - |
| 3 | 3.00 | 4.00 | 1.00 | Cayey Sand | Greyish Brown | 6 | Loose | - | 14.5 | - | 29.2 |
| 4 | 4.00 | 5.00 | 1.00 | Silty Sand | Greyish Brown | 17 | Medium Dense | - | 18 | - | 32.1 |
| 5 | 5.00 | 6.00 | 1.00 | Silty Clay | Greyish Black | 4 | - | Soft | 14.5 | 27 | - |
| 6 | 6.00 | 8.00 | 2.00 | Cayey Sand | Greyish | 4 | Very Loose | - | 13.5 | - | 20.2 |
| 7 | 8.00 | 9.50 | 1.50 | Silty Sand | Greenish Grey | 9 | Loose | - | 14.5 | - | 29.8 |
| 8 | 9.50 | 11.50 | 2.00 | Silty Sand | Greyish | 4 | Very Loose | - | 13.5 | - | 20.2 |
| 9 | 11.50 | 13.00 | 1.50 | Cayey Sand | Greyish Black | 4 | Very Loose | - | 13.5 | - | 20.2 |
| 10 | 13.00 | 18.50 | 5.50 | Silty Clay | Greyish Black | 3 | - | Soft | 14 | 20 | - |
| 11 | 18.50 | 20.00 | 1.50 | Silty Clay | Greyish Black | 7 | - | Medium Stiff | 16 | 47 | - |
| 12 | 20.00 | 21.50 | 1.50 | Cayey Sand | Greyish Black | 19 | Medium Dense | - | 18 | - | 32.7 |
| 13 | 21.50 | 26.00 | 4.50 | Silty Sand | Greyish | 24 | Medium Dense | - | 18.5 | - | 34.2 |
| 14 | 26.00 | 28.00 | 2.00 | Silty Sand | Greyish | 65 | Very Dense | - | 21 | - | 42.5 |
| 15 | 28.00 | 32.00 | 4.00 | Completely Weathered Rock | Greyish | >100 | Very Dense | - | 21 | - | 42.5 |

| REFERENCE BORE HOLE-BH: | | | | | 02 | Ref R.L. of G.L. (m): | | | 0.00 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Layer No. | Layer Thk. (m) | | | Type of Strata | Colour | Ave. Design SPT | Relative Density | Consistency | $(\gamma)$ kN/m$^3$ | Shear Parameters | |
| | Top. R.L. | Bot. R.L. | Thickness | | | | | | | $(C_u)$ kPa | $(\phi)$ Deg. |
| 1 | 0.00 | 0.50 | 0.50 | Filled Up Soil | Brown | - | - | - | - | - | - |
| 2 | 0.50 | 2.00 | 1.50 | Sandy Silty Clay | Greyish Brown | 3 | - | Soft | 14 | 20 | - |
| 3 | 2.00 | 4.00 | 2.00 | Sandy Silty Clay | Greyish Brown | 6 | - | Medium Stiff | 15.5 | 40 | - |
| 4 | 4.00 | 5.00 | 1.00 | Silty Sand | Greyish Brown | 11 | Medium Dense | - | 15.5 | - | 30.3 |
| 5 | 5.00 | 8.00 | 3.00 | Silty Clay | Greyish Black | 4 | - | Soft | 14.5 | 27 | - |
| 6 | 8.00 | 9.50 | 1.50 | Silty Sand | Greyish | 23 | Medium Dense | - | 18.5 | - | 33.9 |
| 7 | 9.50 | 11.50 | 2.00 | Silty Sand | Greenish Grey | 5 | Loose | - | 14 | - | 20.4 |
| 8 | 11.50 | 13.00 | 1.50 | Cayey Sand | Greyish Black | 9 | Loose | - | 14.5 | - | 29.8 |
| 9 | 13.00 | 18.50 | 5.50 | Silty Clay | Greyish Black | 3 | - | Soft | 14 | 20 | - |
| 10 | 18.50 | 20.00 | 1.50 | Silty Clay | Greyish Black | 6 | - | Medium Stiff | 15.5 | 40 | - |
| 11 | 20.00 | 21.50 | 1.50 | Cayey Sand | Greyish Black | 20 | Medium Dense | - | 18 | - | 33 |
| 12 | 21.50 | 24.00 | 2.50 | Silty Sand | Greyish | 20 | Medium Dense | - | 18 | - | 33 |
| 13 | 24.00 | 27.00 | 3.00 | Silty Sand | Greyish | 59 | Very Dense | - | 20.5 | - | 42.4 |
| 14 | 27.00 | 30.00 | 3.00 | Completely Weathered Rock | Greyish | >100 | Very Dense | - | 21 | - | 42.5 |

# FOUNDATION SYSTEM

CHAPTER-4

# FOUNDATION SYSTEM

## 4.0 Preamble:

In the design of foundation system, the stress-strain compatibility of the super structure, sub structure and the bearing strata should be satisfied both individually and as a combined system. In view of this, the following data are needed for the design of foundation system, defined in terms of the type of sub structure and the bearing strata characteristics.

- The super structure characteristics along with the loading pattern on the sub structure
- The sub soil characteristics that define the required substructure configuration for a safe transfer of super-structural loads to the bearing strata

Considering the above aspects of the foundation design, the suitable type of foundation system is presented below.

## 4.1 Proposed Structures

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system.

In the present case, the proposed structure is configured with two basements plus stilt plus seventeen upper floors, and is meant for residential use. For this kind of structure, the column loads could vary between 4000kN to 5500kN. The above mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

## 4.2 Foundation System

For the kind of proposed structure and the sub soil conditions, it is not possible to adopt any kind of open foundation system from both shear and settlement considerations. Hence, it is advisable to adopt deep pile foundation system.

The piles can be installed by drilling with direct mud circulation technique **(Bored Cast In-situ Piles)** and the recommended safe load carrying capacity of bored cast in-situ piles in compression, tension and lateral for different depth and diameters is worked out as per IS 2911-Part-I-Section-2 and are presented in Table 4.1.

Typical computations are presented in Annexure

| Table:- 4.1 Recommended Safe Load Carrying Capacities of Bored Cast-in Situ Piles | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sl.No | Reference Bore hole No. | Length of Pile below E.G.L | Assumed Length of Cut-Off Below E.G.L/3Basement | Length of Pile below Cut-off | Dia.of Pile in (mm) | SAFE LOAD CARRYING CAPACITY (kN) | | |
| | | | | | | Vertical Load Carrying Capacity | Pull Out Capacity | Lateral Load Carrying Capacity |
| 1 | BH-01 | 30.0 | 6.0 | 24.00 | 500 | 1200 | 600 | 25 |
| 2 | | | | | 550 | 1400 | 700 | 28 |
| 3 | | | | | 600 | 1650 | 800 | 30 |
| 4 | | | | | 650 | 1900 | 850 | 34 |
| 5 | | | | | 750 | 1400 | 900 | 38 |
| 6 | | | | | 800 | 2750 | 950 | 41 |
| 7 | | | | | 950 | 3300 | 1100 | 47 |

# RECOMMENDATIONS

## CHAPTER-5

# RECOMMENDATIONS

### 5.1 Recommendation for Deep pile foundation system:

- If deep pile foundation system adopt, Bored Cast in situ piles are recommended as the suitable foundation system.
- The allowable safe load carrying capacities as per IS 2911-Part-I-Section-2 (2010) for different diameters of piles are given in Table-4.1 can be adopted as provisional design loads.
- As the load carrying capacity of piles not only depends upon the sub soil properties, but also depends on the care and experience of installation piles.
- The theoretical load carrying estimates of piles shall be confirmed by conducting pile loads tests as per the guide lines laid down in IS: 2911-Part-IV.
- The boring shall be carried out using direct mud circulation prepared out of sodium bentonite.
- After reaching the borehole termination depth, the borehole shall be cleaned using mud circulation for a minimum period of 30min or till the return mud is relatively clear of soil particles.
- After ensuring the borehole is clean, the tremie pipe shall be lowered and concrete can be done.

### 5.2 Construction method statement of pile foundation:

- For the bored cast in situ piles, a guide casing of 2.0m length can be adopted
- The mud used shall be made out of sodium bentonite with minimum frees swell index of more than 300% and liquid limit more than 100%. The silt content in bentonite shall not more than 5%.
- The mud was prepared using sodium bentonite with a density of 1.10 to 1.15 g/cc.

### 5.3 General Recommendation:

- Since, chlorides and sulphates are well within the permissible limits, no special steel or cement is required for the construction of footings

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## 5.4 Special Recommendations

- Since, the sub soil strata are very Loose to Loose silty sand layer between 9.0m and 13.0m depth and very soft to soft silty clay layer between 13.0m to 18.5m depth below ground level. The soft layer will affect when the pile boring of sub soil is necking and bulging factor upon the installation of pile, due to Lateral soil expansion. Hence, in order to assure quality of the pile, it is ideal to carryout **pile integrity test** on all piles.

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**AUTHORIZED SIGNATURE**

# ANNEXURE

## ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-INSITU PILES

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type of Pile** | | | Bored | **Diameter of Pile** | | | **Length of Pile below E.G.L.(m)** | | 30 | | **As Per IS:2911-(P-I,S-2)-2010** | | | | | | |
| **Reference Bore Hole** | | | BH-01 | | | | 500 | mm | **Surcharge Pressure** | | | 0 | | **kPa** | | | |

| Layer No. | Layer Thk. (m) | | | Type of Strata | Ave. SPT | (γ) kN/m³ | | Shear Parameters | | Effective Overburden Pressure (kPa) | | | Adhesion Factor (α) | Earth Pressure Coefficient (k) | Skin Friction ($Q_f$) kN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top. R.L. | Bot. R.L. | Thickness | | | of Layer | Ave. upto Layer | ($C_u$) kPa | (φ) Deg. | At top of Layer | At Bot. of Layer | At Mid. of Layer | | | | | |
| 1 | 0 | 6 | 6 | Cut-Off Level | | | | | | | | | | | | | |
| 2 | 6 | 8 | 2.0 | Sand | 4 | 13.5 | 13.5 | - | 20.2 | 0.0 | 7.0 | 3.5 | - | 1.0 | qf | 2 | 4.1 |
| 3 | 8 | 9.5 | 1.5 | Sand | 9 | 14.5 | 14.0 | - | 29.8 | 7.0 | 13.8 | 10.4 | - | 1.0 | qf | 3 | 14.0 |
| 4 | 9.5 | 11.5 | 2.0 | Sand | 4 | 13.5 | 14.0 | - | 20.2 | 13.8 | 20.8 | 17.3 | - | 1.0 | qf | 4 | 20.0 |
| 5 | 11.5 | 13 | 1.5 | Sand | 4 | 13.5 | 13.5 | - | 20.2 | 20.8 | 26.0 | 23.4 | - | 1.0 | qf | 5 | 20.3 |
| 6 | 13 | 18.5 | 5.5 | Clay | 3 | 14.0 | 13.8 | 20 | - | 26.0 | 48.0 | 37.0 | 1.0 | - | qf | 6 | 172.8 |
| 7 | 18.5 | 20 | 1.5 | Clay | 7 | 16.0 | 15.0 | 47 | - | 48.0 | 57.0 | 52.5 | 0.9 | - | qf | 7 | 99.7 |
| 8 | 20 | 21.5 | 1.5 | Sand | 19 | 18.0 | 17.0 | - | 32.7 | 57.0 | 69.0 | 63.0 | - | 1.1 | qf | 8 | 108.3 |
| 9 | 21.5 | 26 | 4.5 | Sand | 24 | 18.5 | 18.3 | - | 34.2 | 69.0 | 107.3 | 88.1 | - | 1.2 | qf | 9 | 513.4 |
| 10 | 26 | 28 | 2.0 | Sand | 50 | 20.5 | 19.5 | - | 41.0 | 107.3 | 128.3 | 117.8 | - | 1.5 | qf | 10 | 482.4 |
| 11 | 28 | 30 | 2.0 | Weathered Rock | 60 | 20.5 | 20.5 | - | 42.5 | 128.3 | 149.3 | 138.8 | - | 1.5 | qf | 11 | 599.8 |

Summation of Positive Skin Resitance (kN) $Q_f$= 2034.60

Summation of Negative Skin Resistance (kN) -Qf= 0.00

### Computation of End Bearing Resistance

| | | SPT | φ | $C_u$ | $N_q$ | $N_c$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Bearing Stratum** | Weathered Rock | 60 | 39.88 | - | 120.94 | - | Eff.Ht.of Overburden | 8 | m |
| | | | | | | | Effective Overburden Pressure | 44.25 | kN/m² |

End Bearing Resistance (kN) $Q_p$= 1050.76

| | | |
|---|---|---|
| Ultimate Load Carrying Capacity ($Q_{ult}$) | **$Q_u=Q_f-Q_f+Q_p$ (kN)** | 3085.36 |
| Safe Load Carrying Capacity ($Q_{safe}$) | **$Q_u/2.5$ (kN)** | 1234.14 |
| Allowable Safe Load Carrying Capacity | **$Q_{A\text{-}safe}$ (kN)** | 1200.00 |
| Allowable Safe Pull out Capacity | **$Q_{A\text{-}pull}$: Qf/3 (kN)** | 678.20 |

Skin Resistance in Clay Layer is $\pi*d*T_l*C_u*\alpha$

Skin Resistance in Sand Layer is $\pi*d*T_l*q_l*K*Tan(\phi)$

End Bearing Resistance in Clay Layer is $\pi*d^2/4*C_u*N_c$

End Bearing Resistance in Sand Layer is $\pi*d^2/4*Q*N_q$

Where

Cu=Undrained Shear Strength of Clay

ϕ=Angle of Shearing Resistance

$N_c$=Bearing Capacity Factor = 9

K=Coef. Earth Pressure at Rest

$q_l$=Effecitve Overburden Pressure at middle of Layer

$N_q$=Bearing Capacity Factor, Ref. Fig.1 of IS: Code Refered above

d=Dia. Of Pile

α=Adhession Factor

$T_l$=Thickness of Layer

Q (i.e) Effecitve Overburden Pressure at pile tip=Effective height of overburden X (γ-10)

Note: The End being is completely Weathered Rock modeld as Very Dense Sand with restricted to SPT-value of 60 corresponding phi angle 39.88

## LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

**Reference Bore Hole : BH-02**

### 1.0 Geometrical Data

| | | | |
|---|---|---|---|
| Type of Pile Head Considered | | Fixed | |
| Diameter of Pile (d) | : | 0.60 | m |
| Free standing Length of Pile (e) | : | 0 | m |
| Length of Pile below E.G.L (Le) | : | 30.0 | m |
| Cut-Off Level From E.G.L | : | 6.0 | |
| Length of Pile below Cut-Off Level (Le) | : | 24.0 | m |
| Grade of Concrete (M) | : | 25 | $MN/m^2$ |
| Young's Modulus of Concrete (E) | : | 25000000 | $kN/m^2$ |
| Momemnt of Inertia (I) | : | 0.006362 | $m^4$ |

### 2.0 Determination of Depth of Fixity

| | | | |
|---|---|---|---|
| Type of Soil Strata | : | clay | |
| Ground Water Condition | : | Submerged | |
| Average Design SPT "N" Value | : | 4 | |
| K=((k1/1.5)*(0.3/B)) | | | |
| (n can be read as η in the above and below equation in case of Sand) | | | |
| K1= | : | 9000 | $kN/m^3$ |
| K= | : | 3000 | $kN/m^2$ |
| R= | : | 3.07 | |
| L1/R | : | 0.00 | |
| Lf/R | : | 2.20 | |
| Depth of Fixity below Cut off ($z_f$) | : | 6.75 | m |

### 3.0 Determincation of Lateral Load and Moment Carrying Capacity for 0.005 m Lateral Deflection:

| | | | |
|---|---|---|---|
| Allowable Lateral Deflection (Y) | : | 0.005 | m |
| Lateral Load Carrying Capacity (H)= Y*12EI/(e+zf)^3 | : | 31.10 | kN |
| Recommended Design Lateral Load carrying Capacity | : | **30** | **kN** |
| Fixed End Moment,$M_F$=H(e+$z_f$)/2 | | 105 | |
| Reduction Factor ($L_1$/T) | : | 0.67 | m |
| Actual Moment (Fixed End Moment/Reduction Factor),$M_F$ | | **70** | kN-m |

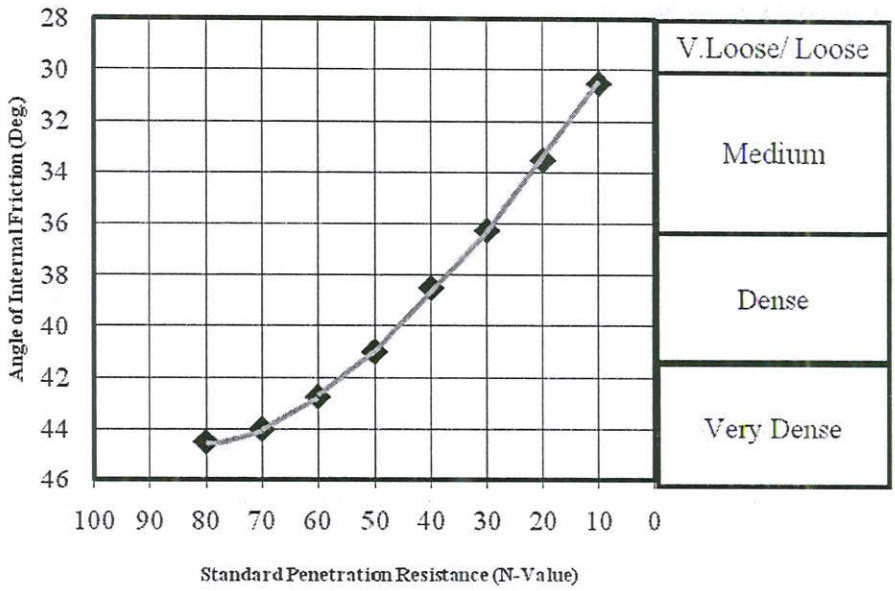



**FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)**

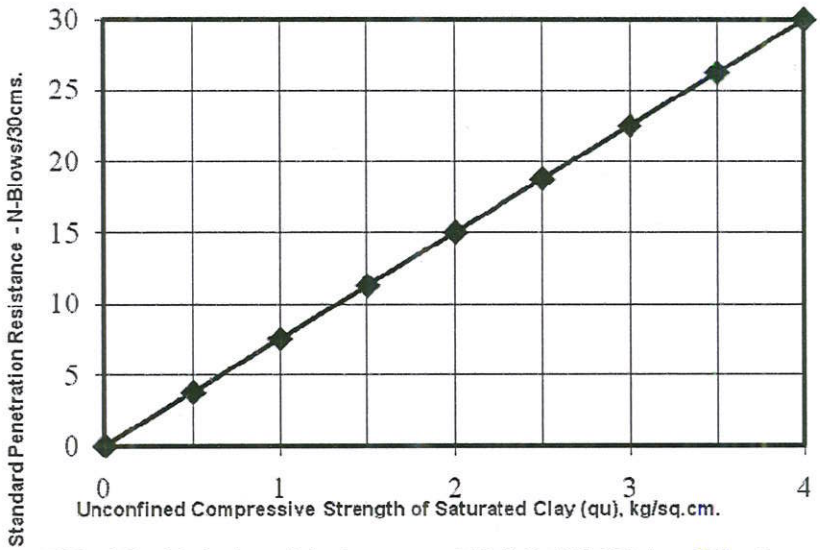



**FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)**

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