# GEOTECHNICAL INVESTIGATION REPORT for the Proposed Warehouse at Village Khurrampur, Tehsil - Farukhnagar, District Gurugram, Haryana

## *EXECUTIVE SUMMARY*

Vardhman Custom Clearing and Forwarding Agents are in the process of constructing a Warehouse Building at Khurrampur, Tehsil - Farukhnagar, District Gurugram, Haryana.

The proposed structure is a Warehouse Building.

The Geotechnical investigation programme has been undertaken at the site, as per the scope of investigations, stipulated by the client. The scope of work consisted of conducting boreholes down to 15m depth at four locations.

The borehole investigations indicate that the subsoil strata consists of sandy soils down to about 5m depth and also beyond 11m depth down to the depth investigated whereas subsoil consists of clayey sandy silt between 5m and 11m depths below the existing ground level.

The N-values (N-values 5 - 18) indicate that the subsoil is loose to medium dense down to about 3m depth below the existing ground level below which the subsoil is medium dense (N-values 13 - 67) down to the depth investigated.

Ground water table had not been encountered in of the any of the borehole down to the depth investigated, i.e. 15m below the existing ground level, during the period of field investigation i.e. December 2022.

Considering the type of structure involved and the subsoil characteristics as determined from the geotechnical investigations, Isolated/Strip Footings have been recommended at a depth of 2m below the existing ground level. Net allowable bearing pressures varying between 12 - 17 t/m$^2$ have been recommended for various widths of foundations for an allowable settlement of 50mm.

Precaution :

The foundation surface should be watered for atleast 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.

## *1.0 INTRODUCTION*

1.1 Vardhman Custom Clearing and Forwarding Agents are in the process of constructing a Warehouse Building at Village Khurrampur, Tehsil - Farukhnagar, District Gurugram, Haryana. Aashray Design Consultants Pvt. Ltd., K - 8, First Floor, South Extension Part - I, New Delhi - 110049 are the Structural Design Consultant for the proposed project.

1.2 To design the substructures for the proposed structure, adequate information regarding the subsoil conditions is required. For this purpose, a detailed soil investigation has been undertaken at the site of the proposed structure.

1.3 This report contains the details of the soil investigations conducted along with the results and analysis of the investigations and the recommendations thereof.

1.4 The geotechnical investigation has been carried out as per the authorisation of Mr. Rahul Kumar of Aashray Design Pvt Ltd.. This authorization has been given in response to our offer no. NCD/Q/ADCPL/141/2022 dated 17th December 2022.

## *2.0 PROJECT DETAILS*

### *2.1 Site Location*

2.1.1 The site for the proposed project is located near Village Khurrampur, on Farukhnagar - Haily Mandi Road, Farukhnagar, Gurugram, Haryana which is located at a distance of about 7 km from Farukhnagar bus stand towards Haily Mandi, behind World College of Technology, Farukhnagar, Gurugram, Haryana.

### *2.2 Site Layout and Topography*

2.2.1 A schematic site plan showing the dimensions and other details of the site is enclosed in this report (fig. 1).

2.2.2 The site had been observed to be almost levelled in its topography. However the general

level of the site had been observed to be about 0.5m below of the nearby road.

2.2.3 A school building of about G+5 storey had been observed to be existing near to the Norther - Eastern boundary of the plot, during the period of field investigations.

2.2.4 Vegetation in the form of grass, bushes and occasional bushes had been observed at the site, during the period of field investigations.

2.2.5 The colour of the surface earth had been observed to be Yellowish brown.

**2.3 Seismic Zone**

2.3.1 The present site is located in the Seismic Zone IV which is an area of high seismic activity and earthquake intensity, as per the seismic zoning map of India given in BIS code IS:1893 (Part1)-2016.

**2.4 The Structure**

2.4.1 The proposed structure is a Warehouse Building.

2.4.2 The structure is understood to be a framed one and that the construction is proposed to be of Reinforced Cement Concrete.

***3.0 OBJECT OF INVESTIGATIONS***

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

a) Type of foundation

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

c) Allowable bearing pressure at the foundation level

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

a) The subsoil profile indicating thickness of the various soil strata, to a depth within 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 strength of soil 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.

## *4.0 SCOPE OF INVESTIGATIONS*

4.1 The scope of investigations as stipulated by the client consists of :

a) Conducting boreholes in soil strata down to 15m depth at four locations.

b) Conducting chemical analysis on soil samples.

c) Conducting relevant laboratory tests on soil samples recovered.

d) Preparation and submission of a technical report in three copies containing the details of the tests carried out, their analysis and recommendations regarding the foundation system to be adopted.

4.2 The following operations were to be undertaken while progressing the boreholes:

a) Conducting standard penetration tests at 1.5/3intervals.

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

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

## *5.0 FIELD INVESTIGATIONS*

### 5.1 Preliminary Details

5.1.1 Field investigations had been carried out between 23rd December 2022 and 27th December 2022.

5.1.2 A schematic site plan showing the test locations is given in fig. 1.

**5.2 Boreholes**

5.2.1 All the boreholes were progressed by shell and auger method.

5.2.2 The diameter of the boreholes was 150/100mm. method.Casing pipe were used to stabilize the sides of the boreholes.

5.2.3 All the boreholes, BH1 to BH4, had been progressed down to the stipulated depth of 15m below the existing ground level.

5.2.4 Standard penetration tests were conducted at 1.5/3m intervals. Disturbed soil samples recovered from split spoon samplers were retained for identification purposes.

5.2.5 Undisturbed soil samples were recovered by thin walled tubes conforming to IS : 2132. These tubes had an area ratio of less then 10%.

5.2.6 The diameter of undisturbed soil samples was 50mm and the length was 45cm.

5.2.7 The ends of sample tubes were sealed by wax to prevent loss/ ingress of moisture. Disturbed soil samples were enclosed in polythene bags.

5.2.8 The samples thus recovered were transported to the laboratory for testing purposes.

5.2.9 Ground water table had not been encountered in any of the borehole down to the depth investigated i.e. 15m below the existing ground level, during the period of field investigation i.e. December 2022.

## *6.0 LABORATORY INVESTIGATIONS*

**6.1 Tests on soil samples from boreholes**

6.1.1 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 Bulk Density & Water Content

d) Strength parameters like cohesion, angle of shearing resistance

6.1.2 In order to determine the above properties, the following tests have been conducted :

a) Sieve analysis on coarse grained soil fraction

b) Hydrometer analysis on fine grained soil fraction

c) Atterberg Limits namely Liquid and Plastic Limits

d) Natural Density and Water Content

e) Triaxial compression tests

**6.2 Chemical Analysis**

6.2.1 As the ground water table had not been encountered in the any of the borehole down to the depth investigated, the soil samples collected from the boreholes have been tested to determine the pH-value and the presence of salts harmful to reinforced cement concrete construction namely Chloride and Sulphate contents.

***7.0 RESULTS & ANALYSIS***

**7.1 Presentation of Results**

7.1.1 The results of the boreholes investigations have been presented in the form of soil profile tables.

7.1.2 The soil profile tables indicate the following:

a) Standard penetration test values at various depths

b) Soil description identifying the type of soil

c) Grain size analysis indicating composition of subsoil

d) Atterberg limits

e) Natural density and water content

f) Triaxial test results

**7.2 Soil Profile**

7.2.1 A perusal of the data presented in the soil profile tables indicates that the subsoil mainly consists of the following three strata in the four boreholes:

a) Stratum - I : Silty sand with occasional clay and gravel

b) Stratum - II : Clayey sandy silt with occasional gravel

c) Stratum - III : Sand with traces of silt and occasional gravel/ sand with silt

7.2.2 The thickness of the three strata in the four boreholes are as follows :

| BH. No. | Strata (depth in m : from : to) | | |
|---|---|---|---|
| | **Stratum - I** | **Stratum - II** | **Stratum - III** |
| 1 | 0 - 4.8 | 4.8 - 11.2 | 11.2 - 15 |
| 2 | 0 - 2<br>3.4 - 5<br>11.4 - 12.8 | 5 - 11.4 | 2 - 3.4<br>12.8 - 15 |
| 3 | 10.5 - 12.4 | 5.2 - 10.5 | 0 - 5.2<br>12.4 - 15 |
| 4 | 0 - 2.2<br>3.8 - 5.4<br>11.4 - 12.5<br>14.4 - 15 | 5.4 - 11.4 | 2.2 - 3.8<br>12.5 - 14.4 |

N.E. : not encountered

7.2.3 The above results show that :

a) Stratum - I consisting predominantly of sandy soils with significant percentages of silt and occasional clay, has been encountered in occasional thin layers down to about 5.4m depth and also beyond 10.5m depth down to the depth investigated.

b) Stratum - II consisting predominantly of silty soils with varying percentages of clay and sand, has been encountered between 4.8m and 11.4m depths below the existing ground level.

c) Stratum - III consisting predominantly of sandy soils, has been encountered down to about 5.2m depth below existing ground level and also beyond 11.2m depth down to the depth investigated.

**7.3 Soil Composition**

7.3.1 The grain size distributions of the soil samples in the four boreholes have been presented in the form of grain size analysis curves in figs. 5a to 5e.

7.3.2 The variations in the grain size distributions in each of the three strata in the four boreholes are as follows:

a) Stratum - I : Silty sand with occasional clay and gravel

| BH. No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 - 2 | 50 - 76 | 24 - 36 | 0 - 14 |
| 2 | 0 - 11 | 60 - 71 | 29 - 33 | 0 |
| 3 | 2 | 70 | 28 | 0 |
| 4 | 0 - 8 | 62 - 67 | 30 - 35 | 0 |

b) Stratum - II : Clayey sandy silt with occasional gravel

| BH. No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 3 | 40 | 47 | 10 |
| 2 | 2 - 6 | 18 - 37 | 48 - 63 | 9 - 17 |
| 3 | 2 - 19 | 15 - 32 | 49 - 69 | 8 - 15 |
| 4 | 0 - 21 | 26 - 38 | 38 - 59 | 5 - 12 |

c) Stratum - III : Sand with traces of silt and occasional gravel/ sand with silt

| BH. No. | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| 1 | 0 - 2 | 78 - 98 | 3 - 20 | 0 |
| 2 | 0 - 2 | 93 - 96 | 4 - 5 | 0 |
| 3 | 0 - 2 | 80 - 96 | 4 - 20 | 0 |
| 4 | 2 - 3 | 81 - 92 | 5 - 17 | 0 |

7.3.3 The above results indicate that :

a) Stratum - I consists of about 50% to 76% sand and 24% to 36% of silt with occasional clay and gravel.

b) Stratum - II consists of about 38% to 69% of silt, 18% to 38% of sand with rest of the soil matrix consisting of clay and occasional gravel.

c) Stratum - III consists of about 78% to 98% of sand 3% to 20% of silt with occasional gravel.

**7.4 Natural Density and Water Content**

7.4.1 The natural bulk densities, water contents and dry densities in the four boreholes vary as follows :

| BH. No. | Bulk Density ($g/cm^3$) | Water Content (%) | Dry Density ($g/cm^3$) |
|---|---|---|---|
| 1 | 1.60 - 2.05 | 5.9 - 18.8 | 1.53 - 1.79 |
| 2 | 1.72 - 2.02 | 4.1 - 18.3 | 1.60 - 1.82 |
| 3 | 1.64 - 2.04 | 5.1 - 17.9 | 1.52 - 1.76 |
| 4 | 1.69 - 2.05 | 5.0 - 15.4 | 1.56 - 1.83 |

7.4.2 The dry densities of the soil have also been presented in the form of plots of dry density vs depth for the four boreholes conducted, in fig. 3.

7.4.3 The above results indicate that the subsoil is in a loose to medium dense state down to about 3m depth below which the subsoil is in a medium dense state down to the depth investigated i.e 15m below the existing ground level.

**7.5 Atterberg Limits**

7.5.1 The Atterberg limits indicate that the subsoil is generally non plastic down about 5.4m depth below the existing ground level and also beyond a depth of about 11.2m down the depth investigated. However, subsoil between 5.4m and 11.2m depths is low plastic. The variation in the Atterberg limits in the Stratum -II are as follows:

a) Liquid limit (LL) % : 24 - 32

b) Plastic limit (PL) % : 15 - 22

**7.6 Standard Penetration Test Values (N-values)**

7.6.1 The observed Standard Penetration Test values (N-values) vary between 5 and 67 as indicated in the soil profile tables and as also shown in the fig. 4 wherein the observed N-values have been plotted with respect to depths.

7.6.2 The above results indicate that the subsoil is in a loose to medium dense state down to about 3m depth below which the subsoil is in a medium dense state down to the depth investigated i.e 15m below the existing ground level.

**7.7 Triaxial Test Results**

7.7.1 The results of triaxial tests are indicated in the respective soil profile tables. These results have been considered in providing the recommendations. The results of the triaxial tests in the form of shear strength parameters i.e. angle of internal resistance ($\phi$) and cohesion (c) varies as follows :

a) Angle of internal resistance : 25° -31°

b) Cohesion ($kg/cm^2$) : 0.03 - 0.11

## 7.8 Compiled Soil Profile

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

7.8.2 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.

## 7.9 Chemical Analysis

7.9.1 The results of the chemical analysis conducted on soil samples collected from the boreholes, for determining the presence of any harmful salts which can have adverse effects on construction, are as follows :

| Borehole no. / Depth (m) | pH value | Chloride Content (ppm) | Sulphate Content (ppm) |
|---|---|---|---|
| BH1/ 5.4m | 6 | 28 | 43 |
| BH2/ 3m | 6.5 | 22 | 49 |
| BH3/ 3.9m | 6.5 | 31 | 56 |
| BH4/ 6m | 6.5 | 35 | 62 |

| *IS LIMITS* | |
|---|---|
| ***pH value*** | ***Not less than 6*** |
| ***Chloride content (ppm)*** | ***Maximum 500 ppm*** |
| ***Sulphate content (ppm)*** | ***Maximum 400 ppm*** |

7.9.2 The above results indicate that the soil encountered in the boreholes will not have any aggressive effect on normal concrete construction works.

## *8.0 DESIGN CRITERIA*

### 8.1 Design Parameters

8.1.1 The parameters required for the design of the foundation system for the proposed structure 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/rock at the foundation level

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

### 8.2 Type of Foundation

8.2.1 The type of foundation depends upon the following :

a) Subsoil conditions

b) Type of structure

c) Configuration of loading points

d) Loading intensity on each column at the foundation level

8.2.2 The proposed structure is a Warehouse Building. Considering this, medium heavy loads can be anticipated on the foundations.

8.2.3 The results of the investigations have indicated that the subsoil is in a loose to medium dense state down to about 3m depth below which the subsoil is in a medium dense state down to the depth investigated.

8.2.4 In view of the above, the foundations for the proposed structure can be supported over ***Isolated/ Strip Footings.***

## 8.3 Depth of Foundations

8.3.1 The minimum depth of foundation depends upon the following factors :

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

b) Adequate depth of soil above founding level, to ensure mobilization of full safe bearing capacity

c) Adequate depth of soil strata below founding level of requisite strength to mobilize the safe bearing capacity

8.3.2 The results of the investigations indicate that the subsoil below the likely founding level is a medium dense state down to the depth investigated.

8.3.3 Considering the above, the foundations for the proposed structures can be placed at a depth of ***2m below the existing ground level***.

8.3.4 The soil available at the founding level will be ***Yellowish brown sandy soils.***

8.3.5 Excavations down to the above mentioned depths, can be carried out by ordinary methods by providing necessary side slopes.

## 8.4 Allowable Bearing Pressure

8.4.1 Allowable bearing pressure depends upon the allowable settlement. 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 criterion using average soil data

b) Settlement criterion taking SPT values

8.4.3 On the basis of the above analysis, the following recommendations regarding the net allowable bearing pressure are being made :

**Net allowable bearing pressure for various widths of Isolated/Strip Footings for an allowable settlement of 50mm**

| *Width of foundation (m)* | *1.5* | *3* | *>4.5* |
|---|---|---|---|
| *Net Allowable Bearing Pressure ($t/m^2$)* | *12* | *14* | *17* |

## *9.0 RECOMMENDATION*

### 9.1 Type of Foundations

*Isolated/ Strip Footings*

### 9.2 Depth of Foundations

*2m below the existing ground level*

### 9.3 **Allowable Bearing pressure**, for an allowable settlement of 50mm

| *Width of foundation (m)* | *1.5* | *3* | *>4.5* |
|---|---|---|---|
| *Net Allowable Bearing Pressure ($t/m^2$)* | *12* | *14* | *17* |

### 9.4 SPECIAL NOTE

The foundation surface should be watered for atleast 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.

## 9.5 NOTE

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

## 9.6 Appendices

9.6.1 An appendix sheet showing the typical analysis of the allowable bearing pressure has been given in Appendix - A of this report

9.6.2 A list of IS Codes referred for providing the recommendations and that which might be required to implement the same is also enclosed in this report in Appendix - B

## *9.7 LIMITATIONS*

This soil investigations have been carried out at locations in the site chosen by the clients so as to represent the entire site. The recommendations provided in this report are hence valid only for these test locations. However, if there is any change in subsoil conditions and properties at places between or beyond chosen test locations, fresh investigations will have to be carried out at such location.

*Dr. N. Santosh Rao*

*Technical Director*

*For **Nagadi Consultants Pvt. Ltd***

**Appendix A**

*(refer para no. 9.6.1)*

## ANALYSIS FOR ALLOWABLE BEARING PRESSURE

**Data**

(i) Soil Properties :

c (kg/cm$^2$) = 0.07 $\phi$ = 26° $\gamma$ (g/cm$^3$) =1.75

(ii) Depth of Foundation, D (m) = 2

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

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

$N_c'$ =17.68 $N_q'$ = 8.55 $N_\gamma'$ = 8.30 $R_w'$ =0.75 $R_w$ =0.75

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

| B (m) | 1.5 | 3 | >4.5 |
|---|---|---|---|
| $q_s$ (t/m$^2$) | 11.7 | 14.4 | 17.2 |

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

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

| B (m) | 1.5 | 3 | >4.5 |
|---|---|---|---|
| H (m) | 3 | 6 | 10 |
| $N_{av}$ | 11 | 15 | 18 |
| $q_a$ (kg/cm$^2$) | 15.0 | 18.9 | 22.2 |

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

| B (m) | 1.5 | 3 | >4.5 |
|---|---|---|---|
| H (m) | 3 | 6 | 10 |
| $m_v$ (t/m$^2$)$^{-1}$ | - | - | - |
| $q_a$ (t/m$^2$) | - | - | - |

| ADOPT | B (cm) | 1.5 | 3 | >4.5 |
|---|---|---|---|---|
| | q (t/m$^2$) | 12 | 14 | 17 |

***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.*

**Appendix - B**

*(refer para no. 9.6.2)*

## LIST OF IS CODES

### Field Investigation

1. IS : 1892 - 2021 : Code of practice for sub surface investigations for foundations
2. IS : 2131 - 1981 : Method of Standard Penetration Tests for soils (First revision)
3. 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 (Part 8) -1983: Determination of water content - dry density relation using heavy compaction. (First revision)

| | | |
|---|---|---|
| 7. | IS : 2720 - 1985 (Part 5) : | Method of test for soils : Determination of liquid and plastic limit (Second revision) |
| 8. | IS 2720-1981 Part 12: | Method of tests for soils : Determination of shear strength parameters using triaxial apparatus. |

**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) |

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | 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 ($g/cm^3$) | Water Cont (%) | Type | c ($kg/cm^2$) | Φ (°) |
| | 0.0 | | | | | | | | | | | | |
| 5 | 0.9 | Yellowish brown clayey silty sand | 0 | 50 | 36 | 14 | Low | Plastic | | | | | |
| | 1.5 | | | | | | | | 1.78 | 14.4 | | | |
| 8 | 2.4 | Yellowish brown silty sand with gravel | 2 | 72 | 26 | 0 | Non | Plastic | | | | | |
| | 3.0 | | | | | | | | 1.62 | 4.7 | CD | 0.08 | 26 |
| 19 | 3.9 | Yellowish brown silty sand | 0 | 76 | 24 | 0 | Non | Plastic | | | | | |
| | 4.5 | | | | | | | | 1.60 | 4.6 | | | |
| | 4.8 | Change of the strata | | | | | | | | | | | |
| 17 | 5.4 | Yellowish brown clayey sandy silt with gravel | 3 | 27 | 58 | 12 | 30 | 21 | | | | | |
| | 6.0 | | | | | | | | 1.84 | 9.6 | | | |
| 38 | 6.9 | Yellowish brown clayey sandy silt | 0 | 21 | 69 | 10 | 30 | 20 | | | | | |
| | 7.5 | | | | | | | | 1.94 | 12.4 | CD | 0.11 | 27 |
| 15 | 8.4 | Yellowish brown clayey sandy silt with gravel | 2 | 29 | 54 | 15 | 29 | 20 | | | | | |
| | 9.0 | | | | | | | | 1.94 | 12.1 | | | |


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# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 1

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| 26 | 9.9 | Yellowish brown clayey sandy silt with gravel | 3 | 40 | 47 | 10 | 27 | 18 | | | | | |
| | 10.5 | | | | | | | | 2.01 | 13.5 | | | |
| | 11.2 | Change of the strata | | | | | | | | | | | |
| 36 | 11.4 | Yellowish brown sand with silt and gravel | 2 | 78 | 20 | 0 | Non | Plastic | | | | | |
| | 12.0 | | | | | | | | 1.97 | 10.1 | | | |
| 60 | 12.9 | Yellowish brown sand with traces of silt | 0 | 97 | 3 | 0 | Non | Plastic | | | | | |
| | 13.5 | | | | | | | | 1.81 | 5.9 | | | |
| 41 | 14.4 | Yellowish brown sand with traces of silt | 0 | 97 | 3 | 0 | Non | Plastic | | | | | |
| | 15.0 | | | | | | | | 2.05 | 18.8 | | | |
| | | Observed 'N' values | | | | | | | | | | | |


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Job No. : G(D)4517

Sheet No. : 2

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 2

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| | 0.0 | | | | | | | | | | | | |
| | 0.9 | | | | | | | | 1.72 | 7.5 | | | |
| 12 | 1.5 | Yellowish brown silty sand | 0 | 71 | 29 | 0 | Non | Plastic | | | | | |
| | 2.0 | Change of the strata | | | | | | | | | | | |
| | 2.4 | | | | | | | | 1.73 | 4.1 | CD | 0.03 | 27 |
| 18 | 3.0 | Yellowish brown sand with traces of silt | 0 | 96 | 4 | 0 | Non | Plastic | | | | | |
| | 3.4 | Change of the strata | | | | | | | | | | | |
| | 3.9 | | | | | | | | 1.81 | 8.9 | | | |
| 13 | 4.5 | Yellowish brown silty sand | 0 | 67 | 33 | 0 | Non | Plastic | | | | | |
| | 5.0 | Change of the strata | | | | | | | | | | | |
| | 5.4 | | | | | | | | 1.85 | 10.7 | | | |
| 28 | 6.0 | Yellowish brown clayey sandy silt with gravel | 4 | 24 | 62 | 10 | 28 | 18 | | | | | |
| | 6.9 | | | | | | | | 2.02 | 11.2 | CD | 0.10 | 29 |
| 43 | 7.5 | Yellowish brown clayey sandy silt with gravel | 2 | 18 | 63 | 17 | 32 | 22 | | | | | |
| | 8.4 | | | | | | | | 1.99 | 18.3 | | | |
| 14 | 9.0 | Yellowish brown clayey sandy silt with gravel | 2 | 23 | 58 | 17 | 31 | 20 | | | | | |


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Job No. : G(D)4517

Sheet No. : 3

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 2

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| | 9.9 | | | | | | | | 2.01 | 11.2 | | | |
| 25 | 10.5 | Yellowish brown clayey sandy silt with gravel | 6 | 37 | 48 | 9 | 26 | 17 | | | | | |
| | 11.4 | Change of the strata | | | | | | | 1.95 | 17.3 | CD | 0.09 | 28 |
| 32 | 12.0 | Yellowish brown silty sand with gravel | 11 | 60 | 29 | 0 | Non | Plastic | | | | | |
| | 12.8 | Change of the strata | | | | | | | | | | | |
| | 12.9 | | | | | | | | 1.96 | 14.0 | | | |
| 65 | 13.5 | Yellowish br. sand with traces of silt & gravel | 2 | 94 | 4 | 0 | Non | Plastic | | | | | |
| | 14.4 | | | | | | | | Tube | bent | | | |
| 67 | 15.0 | Yellowish br. sand with traces of silt & gravel | 2 | 93 | 5 | 0 | Non | Plastic | | | | | |
| | | Observed ‘N’ values | | | | | | | | | | | |


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Job No. G(D)4517

Sheet No. : 4

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 3

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | ϕ (°) |
| | 0.0 | | | | | | | | | | | | |
| 7 | 0.9 | Yellowish brown sand with silt | 0 | 80 | 20 | 0 | Non | Plastic | | | | | |
| | 1.5 | | | | | | | | 1.73 | 13.8 | | | |
| 12 | 2.4 | Yellowish br. sand with traces of silt & gravel | 2 | 94 | 4 | 0 | Non | Plastic | | | | | |
| | 3.0 | | | | | | | | 1.64 | 6.0 | CD | 0.04 | 26 |
| 14 | 3.9 | Yellowish brown sand with silt | 0 | 86 | 14 | 0 | Non | Plastic | | | | | |
| | 4.5 | | | | | | | | 1.71 | 5.1 | | | |
| | 5.2 | Change of the strata | | | | | | | | | | | |
| 17 | 5.4 | Yellowish br. clayey sandy silt with gravel | 19 | 24 | 49 | 8 | 26 | 17 | | | | | |
| | 6.0 | | | | | | | | 1.83 | 9.3 | | | |
| 43 | 6.9 | Yellowish brown clayey sandy silt with gravel | 4 | 15 | 69 | 12 | 31 | 21 | | | | | |
| | 7.5 | | | | | | | | 2.04 | 18.7 | CD | 0.11 | 28 |
| 23 | 8.4 | Yellowish brown clayey sandy silt with gravel | 2 | 24 | 59 | 15 | 31 | 22 | | | | | |
| | 9.0 | | | | | | | | 2.01 | 14.1 | | | |


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Sheet No. : 5

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# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 3

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| 25 | 9.9 | Yellowish brown clayey sandy silt with gravel | 9 | 32 | 51 | 8 | 25 | 16 | | | | | |
| | 10.5 | Change of the strata | | | | | | | 1.98 | 15.9 | | | |
| 32 | 11.4 | Yellowish brown silty sand with gravel | 2 | 70 | 28 | 0 | Non | Plastic | | | | | |
| | 12.0 | | | | | | | | 1.97 | 17.9 | CD | 0.07 | 30 |
| | 12.4 | Change of the strata | | | | | | | | | | | |
| 67 | 12.9 | Yellowish brown sand with traces of silt | 0 | 90 | 10 | 0 | Non | Plastic | | | | | |
| | 13.5 | | | | | | | | 1.93 | 17.9 | | | |
| 69 | 14.4 | Yellowish brown sand with traces of silt | 0 | 91 | 9 | 0 | Non | Plastic | | | | | |
| | 15.0 | | | | | | | | 1.85 | 10.7 | | | |
| | | Observed ‘N’ values | | | | | | | | | | | |

Job No. : G(D)4517

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 4

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| | 0.0 | | | | | | | | | | | | |
| | 0.9 | | | | | | | | 1.71 | 9.4 | | | |
| 8 | 1.5 | Yellowish brown silty sand with gravel | 8 | 62 | 30 | 0 | Non | Plastic | | | | | |
| | 2.2 | Change of the strata | | | | | | | | | | | |
| | 2.4 | | | | | | | | 1.69 | 5.0 | CD | 0.04 | 25 |
| 16 | 3.0 | Yellowish br. sand with traces of silt & gravel | 3 | 92 | 5 | 0 | Non | Plastic | | | | | |
| | 3.8 | Change of the strata | | | | | | | | | | | |
| | 3.9 | | | | | | | | 1.76 | 6.0 | | | |
| 23 | 4.5 | Yellowish brown silty sand | 0 | 65 | 35 | 0 | Non | Plastic | | | | | |
| | 5.4 | Change of the strata | | | | | | | 1.86 | 8.5 | CD | 0.08 | 27 |
| 33 | 6.0 | Yellowish br. clayey sandy silt with gravel | 12 | 26 | 53 | 9 | 28 | 19 | | | | | |
| | 6.9 | | | | | | | | 1.93 | 13.2 | | | |
| 44 | 7.5 | Yellowish br. clayey sandy silt with gravel | 21 | 36 | 38 | 5 | 24 | 15 | | | | | |
| | 8.4 | | | | | | | | 2.03 | 15.4 | CD | 0.10 | 29 |
| 16 | 9.0 | Yellowish brown clayey sandy silt | 0 | 29 | 59 | 12 | 29 | 19 | | | | | |


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Job No. : G(D)4517

Sheet No. : 7

# SOIL PROFILE

Project : Proposed Warehouse at Village Khurrampur, Farukhnagar

B.H. Location : | Water Table : N.E. | Term. Depth : 15m | B.H. No.: 4

| N - Value | Depth (m) | Soil Description | Grain Size Analysis | | | | Atterberg | | In-situ | | Triaxial Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Liquid (%) | Plastic (%) | Density (g/cm$^3$) | Water Cont (%) | Type | c (kg/cm$^2$) | Φ (°) |
| | 9.9 | | | | | | | | 2.05 | 12.0 | | | |
| 31 | 10.5 | Yellowish brown clayey sandy silt with gravel | 8 | 38 | 45 | 9 | 25 | 16 | | | | | |
| | 11.4 | Change of the strata | | | | | | | 1.90 | 7.5 | | | |
| 38 | 12.0 | Yellowish brown silty sand with gravel | 4 | 64 | 32 | 0 | Non | Plastic | | | | | |
| | 12.5 | Change of the strata | | | | | | | | | | | |
| | 12.9 | | | | | | | | 1.77 | 7.7 | CD | 0.06 | 31 |
| 59 | 13.5 | Yellowish brown sand with silt and gravel | 2 | 81 | 17 | 0 | Non | Plastic | | | | | |
| | 14.4 | Change of the strata | | | | | | | 1.82 | 6.4 | | | |
| 50 | 15.0 | Yellowish brown silty sand | 0 | 67 | 33 | 0 | Non | Plastic | | | | | |

Observed ‘N’ Values


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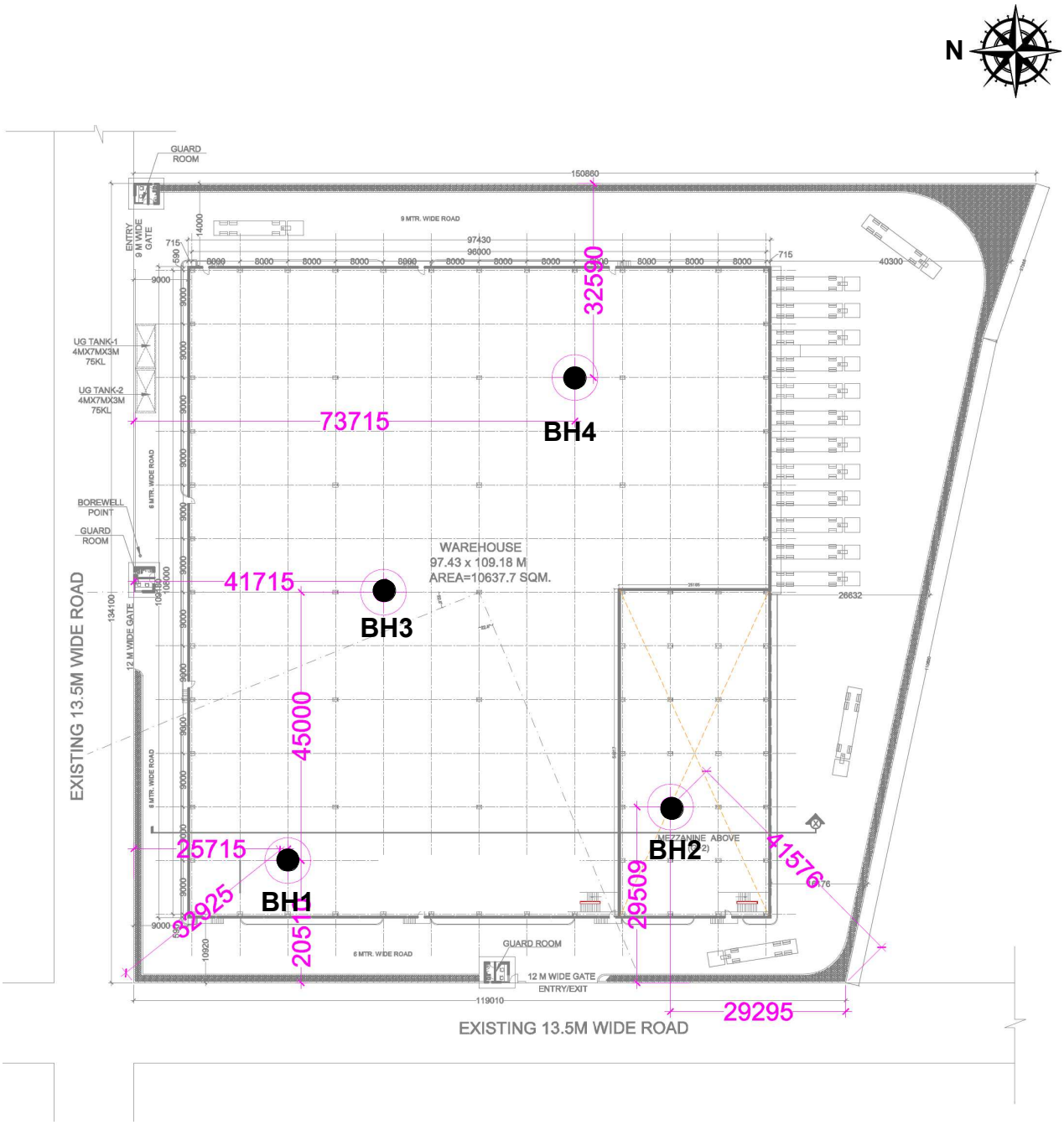
Job No. G(D)4517

Sheet No. : 8




**Legend**

● Borehole (BH)

## SCHEMATIC SITE PLAN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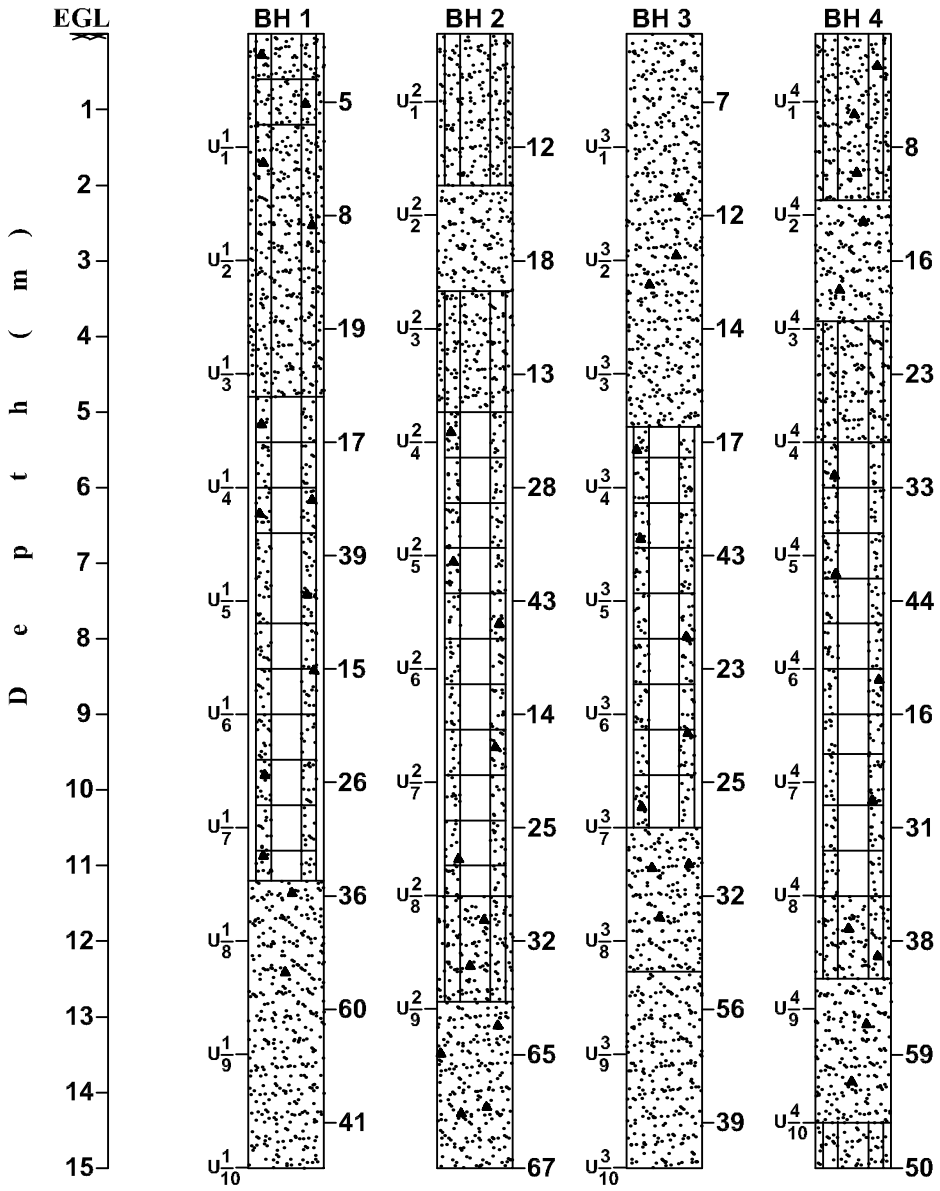
Job No. : G(D)4517

Sheet No. : 1




**LEGEND**

Yellowish brown silty sand with occasional clay and gravel
(24-36)% (50-76)% (0-14)% (0-11)%

Yellowish brown clayey sandy silt with occasional gravel
(5-17)% (15-40)% (38-69)% (0-21)%

Yellowish brown sand with traces of silt and occasional gravel/ sand with silt
(78-98)% (3-20)% (0-3)%

39 Observed ' N ' Values $U_2^1$ 2nd undisturbed soil sample of BH 1

Ground Water table had not been encountered.

# COMPILED SOIL PROFILE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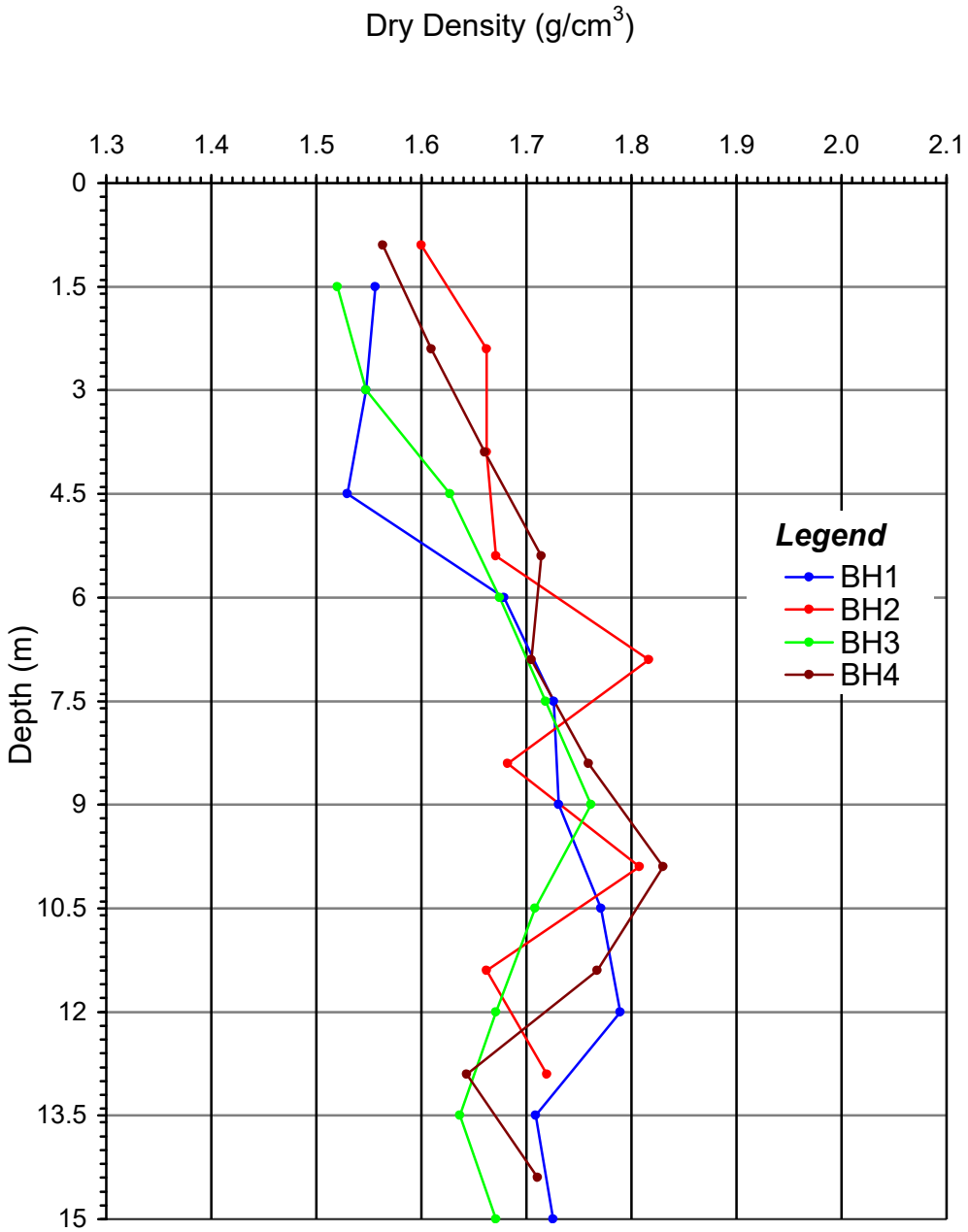
Job No. :

Sheet No. :




**Dry Density vs Depth Curves**

*(Refer paragraph no. 7.4.2)*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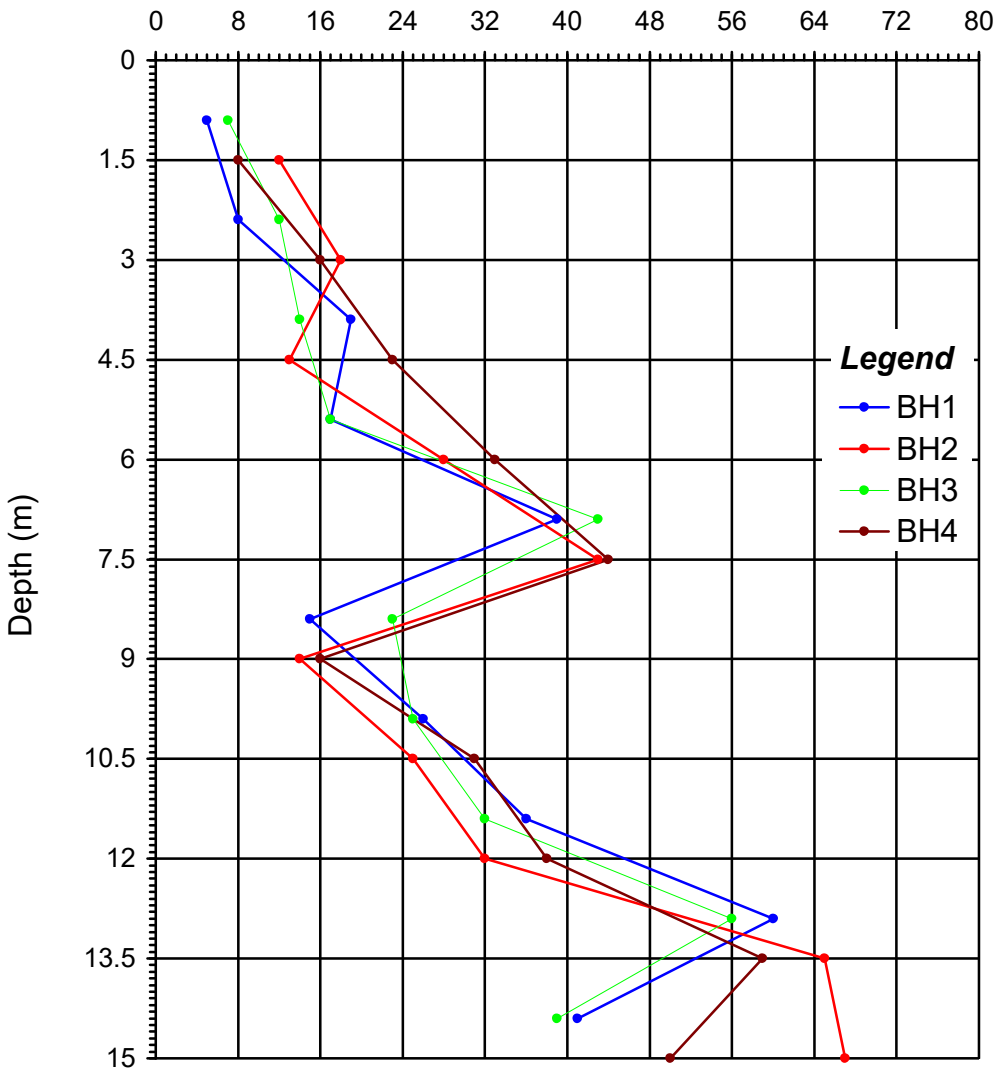
Job No. G(D)4517

N - Values (Observed)




**N - Values vs Depth Curves**

*(Refer paragraph no. 7.6.1)*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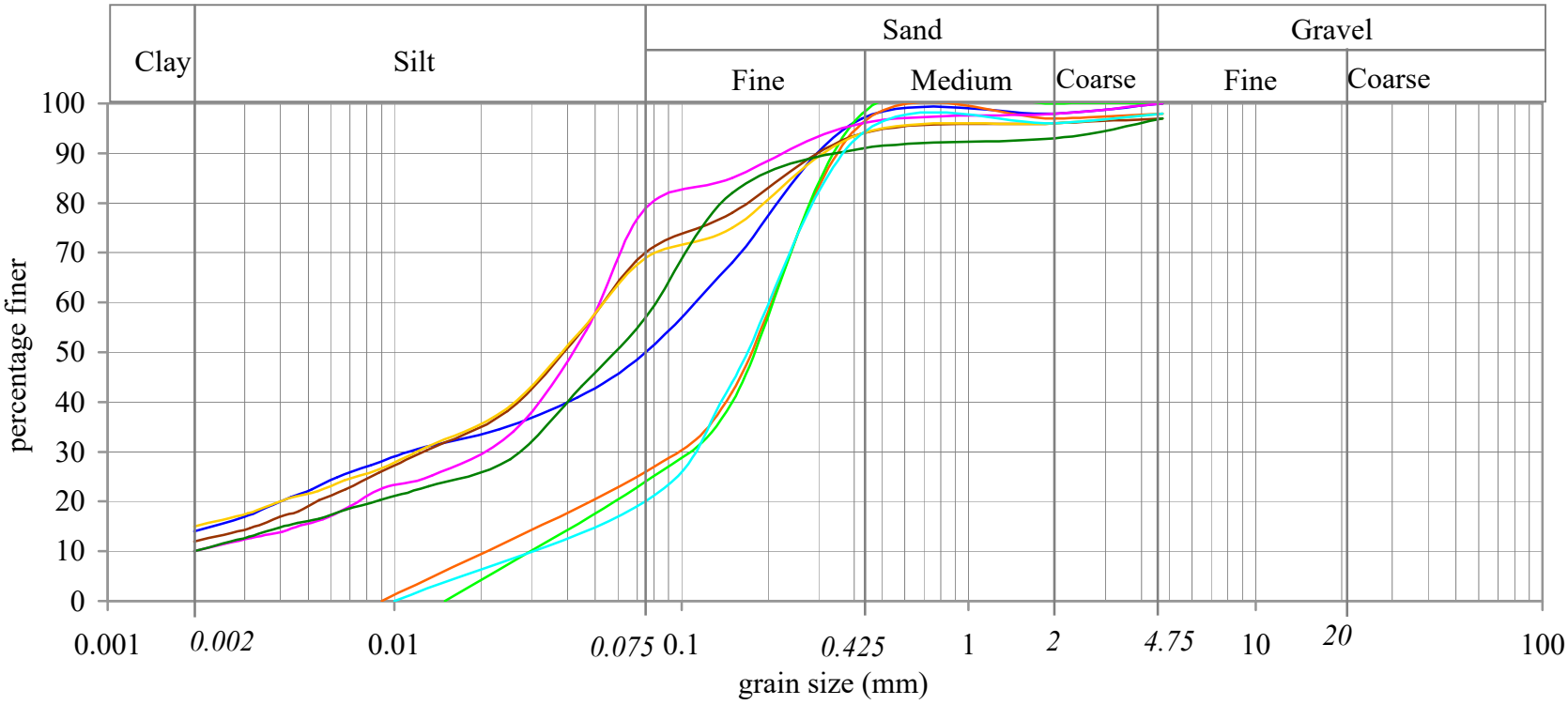
Job No. : G(D)4517

Sheet No. : 5a

## Grain Size Analysis Curves *(refer paragraph no. 7.3.1)*




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 0.9 | Clayey silty sand | 0 | 50 | 36 | 14 | 0.11 | - | - |
| | 1 | 2.4 | Silty sand with gravel | 2 | 72 | 26 | 0 | 0.051 | 0.021 | 2.4 |
| | 1 | 3.9 | Silty sand | 0 | 76 | 24 | 0 | 0.21 | 0.031 | 6.8 |
| | 1 | 5.4 | Clayey sandy silt with gravel | 3 | 27 | 58 | 12 | 0.051 | - | - |
| | 1 | 6.9 | Clayey sandy silt | 0 | 21 | 69 | 10 | 0.051 | 0.002 | 25.5 |
| | 1 | 8.4 | Clayey sandy silt with gravel | 2 | 29 | 54 | 15 | 0.052 | - | - |
| | 1 | 9.9 | Clayey sandy silt with gravel | 3 | 40 | 47 | 10 | 0.081 | 0.002 | 40.5 |
| | 1 | 11.4 | Sand with silt and gravel | 2 | 78 | 20 | 0 | 0.21 | 0.029 | 7.2 |

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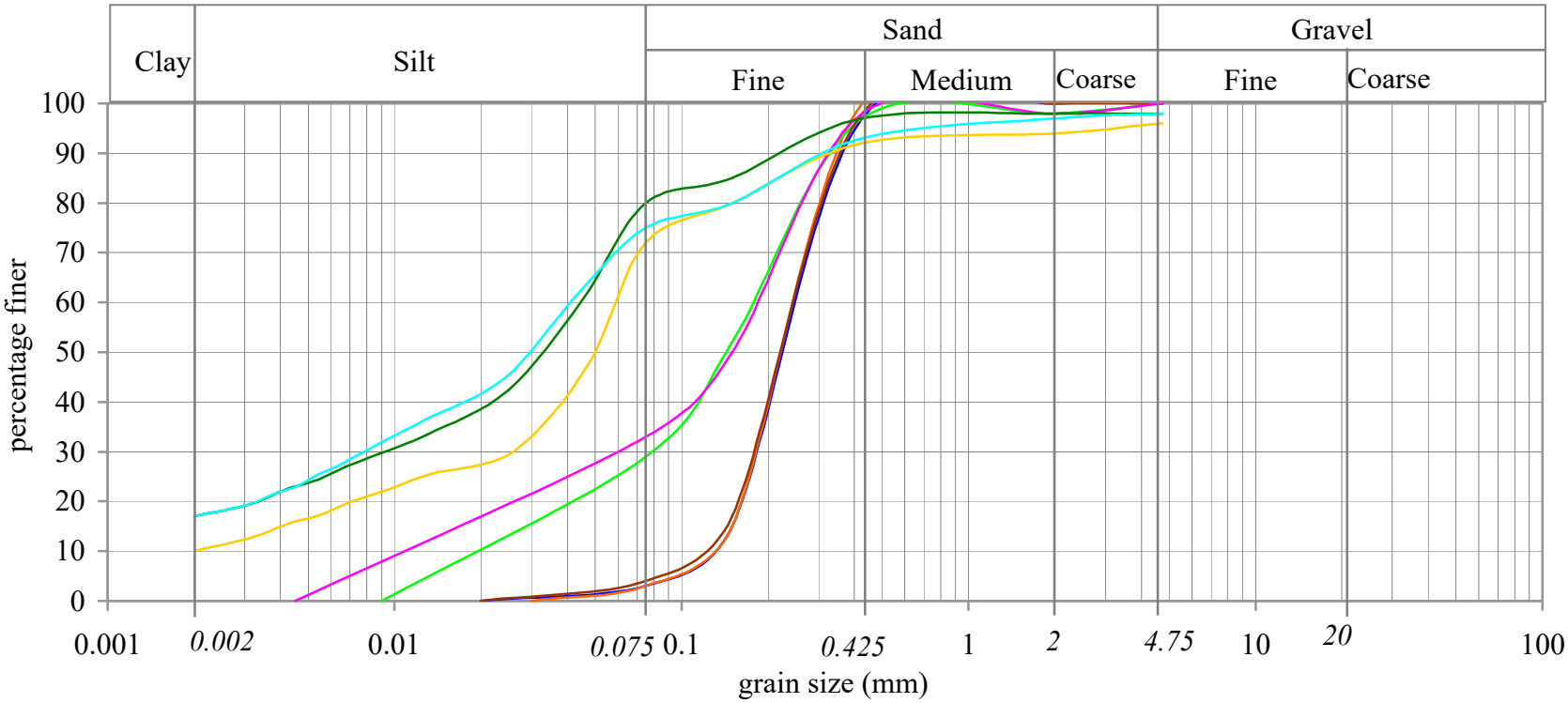
Job No. : G(D)4517

Sheet No. : 5b

## Grain Size Analysis Curves *(refer paragraph no. 7.3.1)*




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 12.9 | Sand with traces of silt | 0 | 97 | 3 | 0 | 0.25 | 0.13 | 1.9 |
| | 1 | 14.4 | Sand with traces of silt | 0 | 97 | 3 | 0 | 0.25 | 0.14 | 1.8 |
| | 2 | 1.5 | Silty sand | 0 | 71 | 29 | 0 | 0.17 | 0.019 | 8.9 |
| | 2 | 3 | Sand with traces of silt | 0 | 96 | 4 | 0 | 0.25 | 0.14 | 1.8 |
| | 2 | 4.5 | Silty sand | 0 | 67 | 33 | 0 | 0.17 | 0.011 | 15.5 |
| | 2 | 6 | Clayey sandy silt with gravel | 4 | 24 | 62 | 10 | 0.17 | 0.002 | 85.0 |
| | 2 | 7.5 | Clayey sandy silt with gravel | 2 | 18 | 63 | 17 | 0.045 | - | - |
| | 2 | 9 | Clayey sandy silt with gravel | 2 | 23 | 58 | 17 | 0.041 | - | - |

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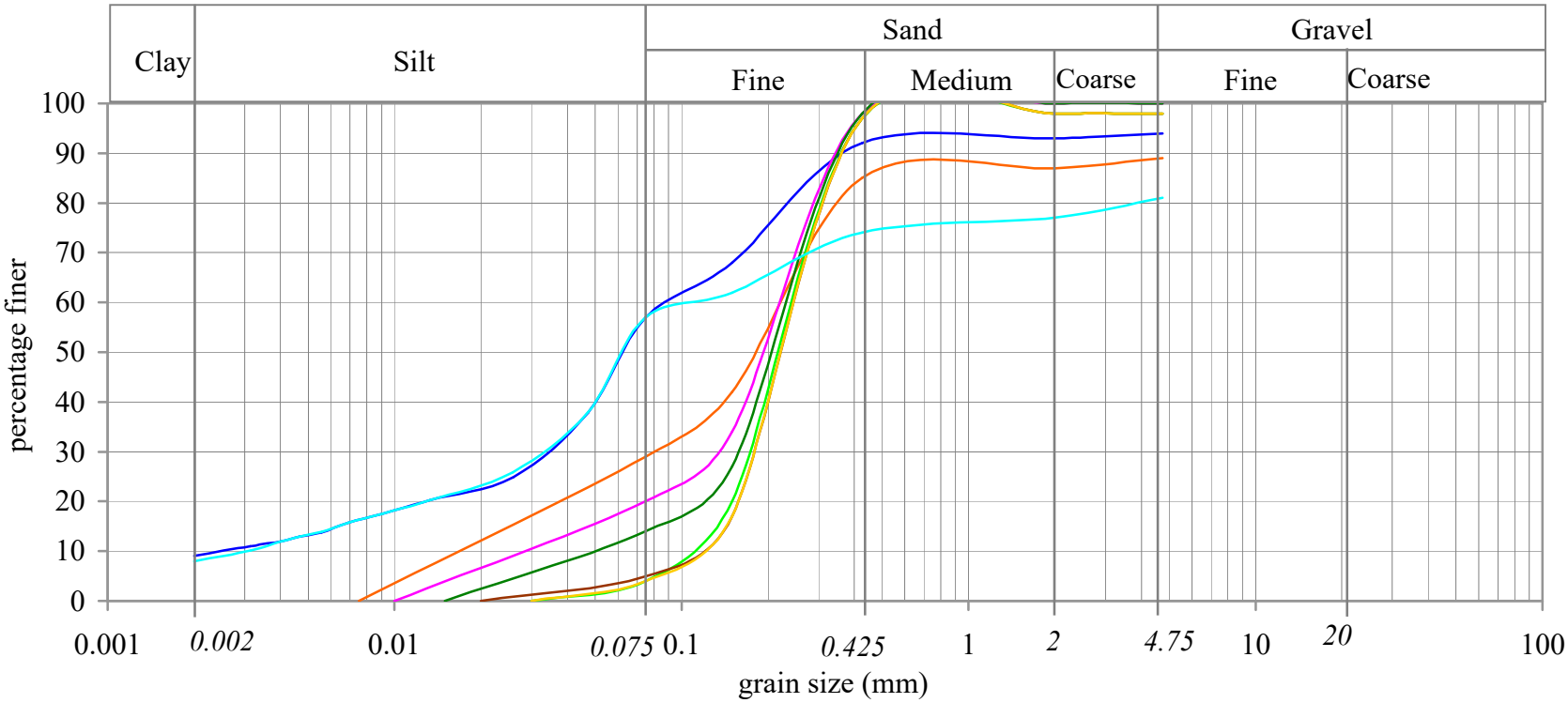
Job No. : G(D)4517

Sheet No. : 5c

## Grain Size Analysis Curves *(refer paragraph no. 7.3.1)*




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 10.5 | Clayey sandy silt with gravel | 6 | 37 | 48 | 9 | 0.085 | 0.0025 | 34.0 |
| | 2 | 12 | Silty sand with gravel | 11 | 60 | 29 | 0 | 0.22 | 0.018 | 12.2 |
| | 2 | 13.5 | Sand with traces of silt and gravel | 2 | 94 | 4 | 0 | 0.24 | 0.11 | 2.2 |
| | 2 | 14.4 | Sand with traces of silt and gravel | 2 | 93 | 5 | 0 | 0.24 | 0.13 | 1.8 |
| | 3 | 0.9 | Sand with silt | 0 | 80 | 20 | 0 | 0.21 | 0.029 | 7.2 |
| | 3 | 2.4 | Sand with traces of silt and gravel | 2 | 94 | 4 | 0 | 0.24 | 0.13 | 1.8 |
| | 3 | 3.9 | Sand with silt | 0 | 86 | 14 | 0 | 0.24 | 0.049 | 4.9 |
| | 3 | 5.4 | Clayey sandy silt with gravel | 19 | 24 | 49 | 8 | 0.11 | 0.0028 | 39.3 |

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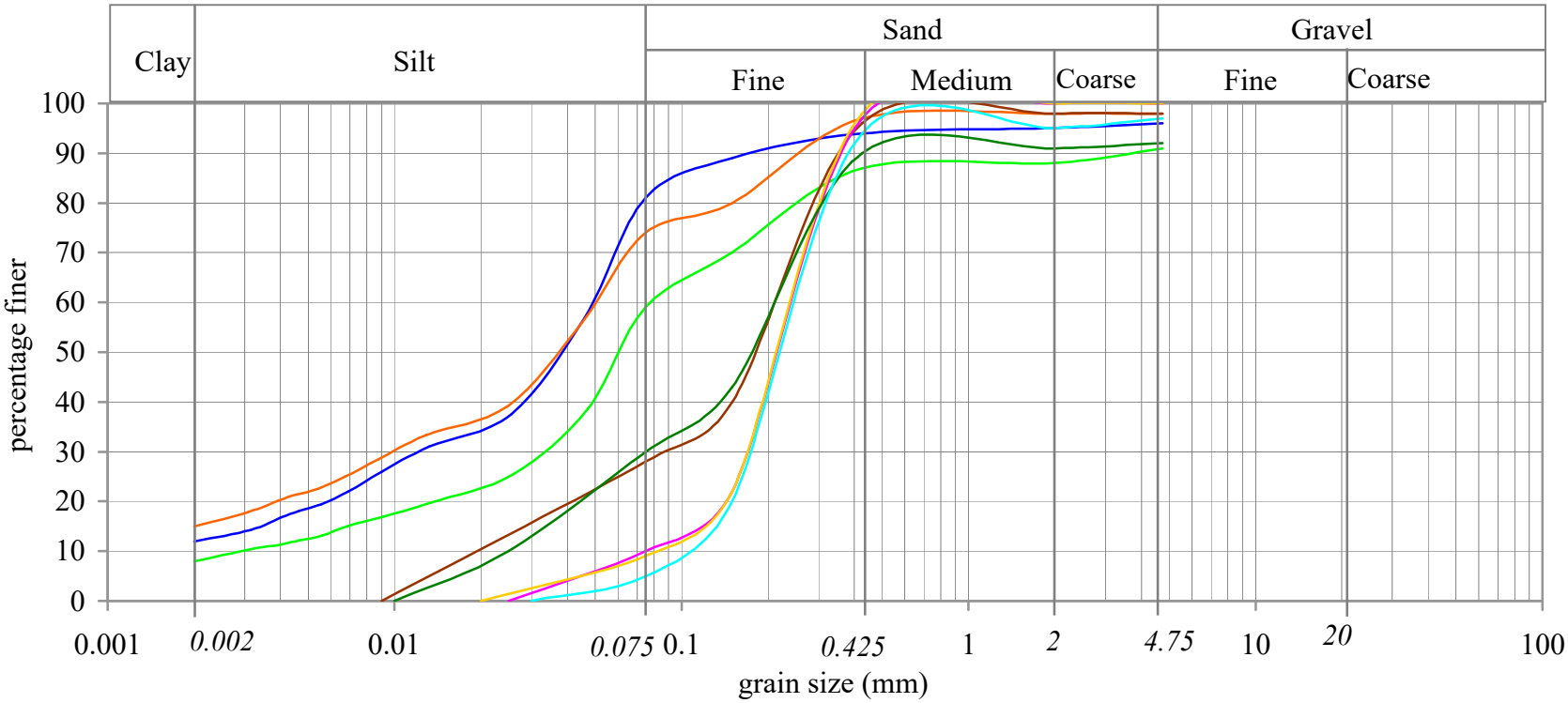
Job No. : G(D)4517

Sheet No. : 5d

## Grain Size Analysis Curves *(refer paragraph no. 7.3.1)*




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 6.9 | Clayey sandy silt with gravel | 4 | 15 | 69 | 12 | 0.049 | - | - |
| | 3 | 8.4 | Clayey sandy silt with gravel | 2 | 24 | 59 | 15 | 0.051 | - | - |
| | 3 | 9.9 | Clayey sandy silt with gravel | 9 | 32 | 51 | 8 | 0.081 | 0.0029 | 27.9 |
| | 3 | 11.4 | Silty sand with gravel | 2 | 70 | 28 | 0 | 0.21 | 0.019 | 11.1 |
| | 3 | 12.9 | Sand with traces of silt | 0 | 90 | 10 | 0 | 0.25 | 0.081 | 3.1 |
| | 3 | 14.4 | Sand with traces of silt | 0 | 91 | 9 | 0 | 0.24 | 0.081 | 3.0 |
| | 4 | 1.5 | Silty sand with gravel | 8 | 62 | 30 | 0 | 0.22 | 0.024 | 9.2 |
| | 4 | 3 | Sand with traces of silt and gravel | 3 | 92 | 5 | 0 | 0.24 | 0.11 | 2.2 |

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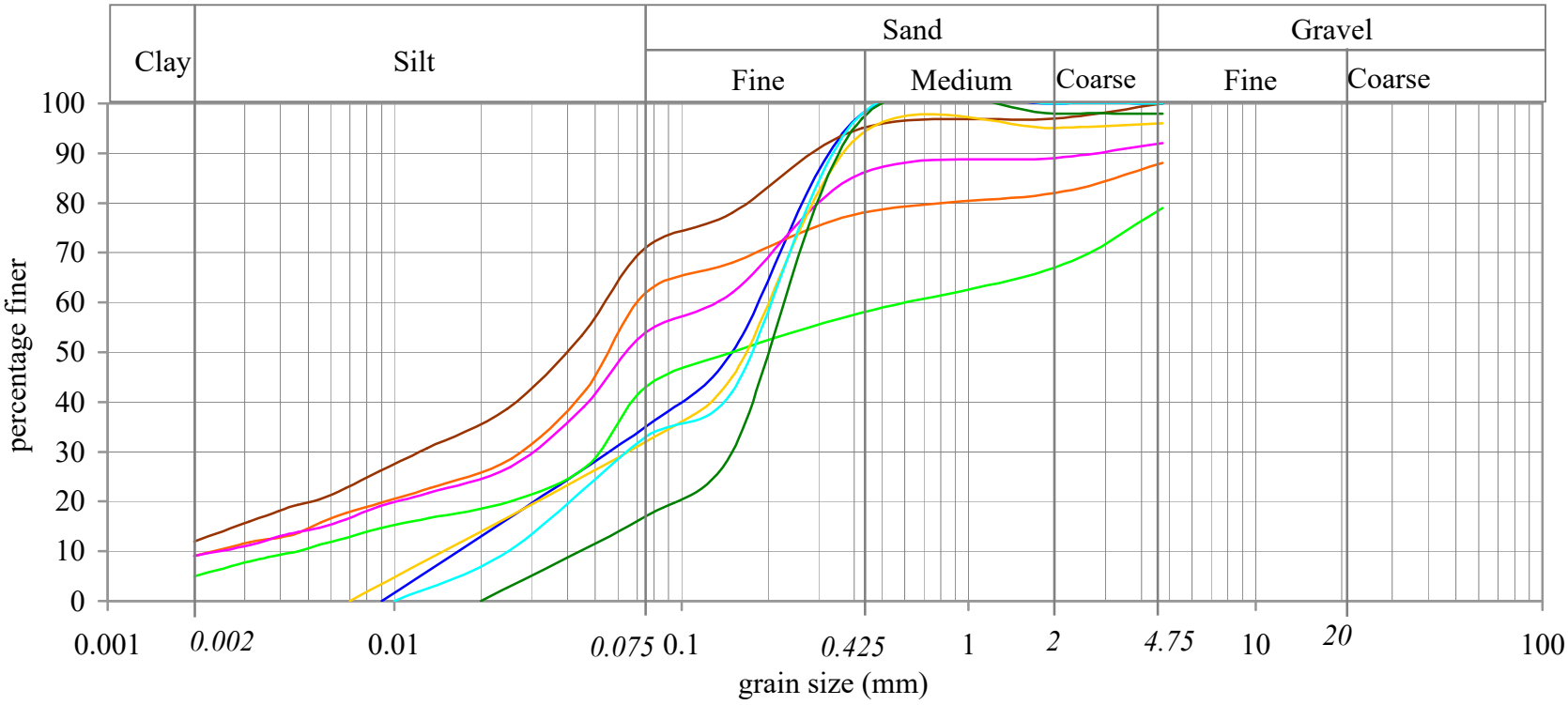
Job No. : G(D)4517

Sheet No. : 5e

## Grain Size Analysis Curves *(refer paragraph no. 7.3.1)*




| Line Style | Bore hole | Depth (m) | Description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | $d_{60}$ | $d_{10}$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 4.5 | Silty sand | 0 | 65 | 35 | 0 | 0.18 | 0.018 | 10.0 |
| | 4 | 6 | Clayey sandy silt with gravel | 12 | 26 | 53 | 9 | 0.071 | 0.0023 | 30.9 |
| | 4 | 7.5 | Clayey sandy silt with gravel | 21 | 36 | 38 | 5 | 0.35 | 0.0045 | 77.8 |
| | 4 | 9 | Clayey sandy silt | 0 | 29 | 59 | 12 | 0.055 | - | - |
| | 4 | 10.5 | Clayey sandy silt with gravel | 8 | 38 | 45 | 9 | 0.12 | 0.0023 | 52.2 |
| | 4 | 12 | Silty sand with gravel | 4 | 64 | 32 | 0 | 0.21 | 0.015 | 14.0 |
| | 4 | 13.5 | Sand with silt and gravel | 2 | 81 | 17 | 0 | 0.23 | 0.045 | 5.1 |
| | 4 | 15 | Silty sand | 0 | 67 | 33 | 0 | 0.21 | 0.024 | 8.8 |