GEOTECHNICAL INVESTIGATION REPORT for the Proposed Wagon Tippler, Additive Storage and Transfer Tower at WCL, Line - IV, Nimbahera, Rajasthan

EXECUTIVE SUMMARY

Wonder Cement Limited, Udaipur - 313 004, Rajasthan are in the process of constructing Wagon Tippler, Additive Storage and Transfer Tower at WCL, Line - IV Nimbahera, District Chittorgarh, Rajasthan.

The proposed structures are Wagon Tippler, Additive Storage and Transfer Tower.

To obtain adequate information regarding the subsoil/rock conditions, for the design of the substructures for the proposed structures of the Cement Plant, a detailed geotechnical investigation programme has been undertaken at the site.

The scope of work for these structures as specified by the clients consisted of conducting boreholes in soil/ rock strata down to 20m depth at one location and down to 10m depth at two locations.

The results of the investigations have indicated the presence of filled-up strata down to a maximum depth of about 0.6m below the existing ground level. Refusal/ rock strata in the form of Limestone at a depth varying between 0.5m and 2.4m below the existing ground level, down to the maximum depth investigated i.e. 20m below the existing ground level. The subsoil strata down to the depths of refusal/ rock strata generally consists of sandy silt/ silty sand.

The refusal/ rock strata encountered consists of Whitish grey / Greyish pink Limestone. The rock is in different states of weathering down to the maximum depth investigated.

Core recoveries ranging between 12% to 99% have been recorded whereas RQD values ranging from nil to 98% have been observed at different depths in different boreholes.

Ground water table had been encountered at a depth of about 13m below the existing ground level, only in boreholes SBH1, during the period of field investigations i.e. December 2022.

The N-values indicate that the subsoil is medium dense down to the depth of refusal/ rock strata.

Considering the type of structures involved and the subsoil/rock characteristics as determined from the geotechnical investigations, Isolated/ Strip Footings or Raft foundations have been recommended at a depth of minimum 0.3m in rock/ refusal strata consisting of Limestone.

The following recommendations have been provided for various structures for the foundations resting on rock strata.

Recommended Net Allowable Bearing Pressures for Foundations Resting at a Depth of Minimum 0.3m in Rock Strata

Structure	*BH No.*	*Depth of Refusal/ Rock Strata (m) below EGL*	*Depth of Foundation (m)*	*Net allowable bearing pressure (t/m^2)*
Wagon Tippler	SBH1	0.9m	between 10m and 16m	120 t/m^2
Additive Storage	SBH2	0.5m	0.3m in virgin rock strata	80 t/m^2
Transfer Tower	SBH3	2.4m	0.3m in virgin rock strata	40 t/m^2

EGL : existing ground level

Precaution :

For foundations resting on rock strata, loose pockets if encountered shall be removed and backfilled with concrete. A levelling course of concrete shall be laid and construction of foundations can be taken up subsequently.

1.0 INTRODUCTION

1.1 Wonder Cement Limited, 17 Old Fatehpura, Near Seva Mandir, Udaipur - 313 004, Rajasthan are in the process of constructing Wagon Tippler, Additive Storage and Transfer Tower at WLC, Line - IV, Nimbahera, Rajasthan within the existing premises of Cement Grinding Unit at Nimbahera, District Chittorgarh, Rajasthan.

1.2 To design the substructures for the proposed structures, adequate information regarding the subsoil conditions is required. For this purpose, detailed geotechnical investigations have been undertaken at the site of the proposed project.

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

1.4 Geotechnical investigations for this purpose have been carried out as per the authorization given by Wonder Cement Limited, vide their work order reference no. 107PO2300543 dated 30th November 2022. This authorization has been given in response to our offer no. NCD/Q/WCL/125A/2022 dated 21st November 2022.

2.0 PROJECT DETAILS

2.1 Site Location

2.1.1 The site for the proposed structures are with in the premises of existing Cement Plant of the Wonder Cement Ltd. The existing plant itself is located at a distance of about 8km in a North - West direction from Nimbahera, Rajasthan.

2.1.2 The site for the proposed structures are located in the North - West direction of the existing grinding unit.

2.2 Site Layout and Topography

2.2.1 Schematic site plans showing the dimensions and other details of the sites are enclosed in this report (fig.1a to fig.1c).

2.2.2 The site had been observed to be almost levelled in its topography and the general level of the site had been observed to be almost same as that of the adjacent plant road.

2.2.3 The site for the proposed Wagon Tippler has been observed to be used as Truck Parking yard, during the period of field investigations.

2.2.4 Concrete flooring had been observed at the location of Wagon Tippler (Truck Parking).

2.2.5 Excavations down to about 13m depth had been observed to be under progress at the location of Wagon Tippler, during the period of field investigations.

2.2.6 The colour of the surface earth had been observed to be Yellowish brown / brownish grey at the site.

2.3 Geology of the Site

2.3.1 The geology of the site has been assessed based on the published detailed geological studies carried out by the Geological Survey of India (GSI).

2.3.2 The present site is located in the South East part of the state of Rajasthan at Nimbahera, at a latitude of about 24° 40' and longitude of about 74° 37'. The state of Rajasthan is located on the North West of Indian Peninsula.

2.3.3 The rocks strata encountered at the present site generally belongs to Khorip group (lower Vindhyan group) of Vindhyan Super Group. As per Geological Time Scale (GTS), these formations belong to late Stenian to middle Ectasian period of Mesoproterozoic era which is the middle of Proterozoic Eon of Precambrian ages.

2.3.4 Vindhyan System of Indian Stratigraphy derives its name from the Vindhyan Mountains and consists of an extensively developed sequence of stratified formations which cover more than one lakh square km of area extending from Sasaram and Rohtas in Bihar to Chittorgarh in Aravalis.

2.3.5 The Vindhyan System rocks rest unconformably over the old cuddapah rocks wherever the latter are developed. Further, within the Vindhyan System itself, two sub divisions are easily recognized on the basis of an unconformity; the Lower Vindhyan and the Upper Vindhyan.

2.3.6 The sedimentary rocks of lower Vindhyan System is composed mainly of rocks of marine origin such as limestone and shales.

2.3.7 At the present site, Limestone rocks have been met which belongs to the Nimbahera rock formation of Khorip group of the Lower Vindhyan super group.

2.4 Seismic Zone

2.4.1 The present site is located in the Seismic Zone - II which is the zone of low seismic intensity, as per the seismic zoning map of India given in BIS code IS:1893 (Part1)-2016

2.5 The Structure/s

2.5.1 The proposed structures are Wagon Tippler, Additive Storage and Transfer Tower.

2.5.2 The structures are understood to be framed ones and the construction to be of Reinforced Cement Concrete.

3.0 OBJECT OF INVESTIGATIONS

3.1 For designing the foundation system of the proposed structures, 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/rock profile indicating thicknesses of the various soil/rock strata, to a depth within the influence zone below the foundations

b) Engineering properties of the soil/rock strata at various levels

c) Physical characteristics of the soil/rock strata

d) Variation of strength of soil/rock strata with depth

3.3 For evaluating the above parameters, field investigations and laboratory investigations on the soil/rock 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/ rock strata down to 20m depth at one location and down to 10m depth at two locations.

b) Conducting chemical analysis on soil / water samples.

c) Conducting relevant laboratory tests on soil / rock samples recovered.

d) Preparation and submission of a technical report in ten 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 regular intervals in soil strata.

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

c) Recovering rock core samples in rock strata.

d) 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 17th December 2022 and 25th December 2022.

5.1.2 A Schematic site plans showing the test locations at the sites has been given in fig. 1a of the report.

5.1.3 Photographs showing the view of the sites and work under progress have been given in fig. 1b and 1c.

5.2 Boreholes

5.2.1 The locations, termination depths and depths at which the refusal/ rock strata had been encountered in three boreholes are as follows :

Structures	BH No.	Depth of Refusal/ Rock Strata (m) below EGL	Termination depth (m) below EGL
Wagon Tippler	SBH1	0.9	20
Additive Storage	SBH2	0.5	10
Transfer Tower	SBH3	2.4	10

EGL: exiting ground level

5.2.2 All the boreholes had been conducted down to the stipulated depths. Borehole SBH1 had been conducted down to the stipulated depth of 20m below the existing ground level whereas boreholes SBH2 and SBH3 had been conducted down to stipulated depth of 10m below the existing ground level.

5.2.3 All the boreholes had been progressed by Shell and Auger method down to the refusal depths that is depths at which the boreholes could not be progressed by this method.

5.2.4 Drilling in refusal/ rock strata had been carried out in all the three boreholes, so as to ensure that adequate information regarding the rock strata below the likely foundation level is obtained.

5.2.5 Drilling in refusal / rock strata had been carried out beyond the depths of refusal / rock strata down to a maximum depth of 20m below the existing ground level, by rotary drilling machine using diamond bits of Nx size.

5.2.6 In the soil strata, Standard Penetration Tests (SPT) had been conducted at 1.5m intervals. Disturbed soil samples recovered from split spoon samplers had been retained for identification purposes. However, Standard Penetration Test had also been conducted at occasional depths in weathered rock strata for the confirmation of refusal/ rock strata.

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

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

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

5.2.10 In the rock strata, the rock core samples, where recovered from the boreholes had been preserved in the core boxes with proper marking on each sample and the borelogs had been maintained appropriately.

5.2.11 Soil / rock samples had been transported to the laboratory for testing purposes.

5.2.12 Ground water table had been encountered at a depth of 13.1m below the existing ground level, only in boreholes SBH1, during the period of field investigations i.e December 2022.

6.0 LABORATORY INVESTIGATIONS

6.1 Tests on soil and rock samples from boreholes

6.1.1 The soil samples brought to the laboratory had been subjected to various tests to determine the following properties :

a) Type and gradation of soil

b) Consistency limits

c) Density and water content

d) Shear strength parameters

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) Triaxial compression tests

d) Maximum and minimum dry densities

e) Density and water content determination tests

f) Liquid and plastic limits

6.1.3 The rock samples brought to the laboratory had been subjected to various tests to determine the following properties :

a) Unit weight

b) Porosity

c) Water absorption

d) Unconfined compressive strength

e) Point load strength index

6.2 Chemical Analysis

6.2.1 The water and soil sample collected from the borehole had 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 borehole investigations and of the laboratory investigations conducted on the soil/ rock samples collected from the boreholes, have been presented in the form of soil profile tables and rock 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

7.1.3 The rock profile tables indicate the following :

a) Strata description identifying the type of rock strata

b) Number of core pieces of different sizes and thereupon the core recovery

c) Rock quality designation (RQD)

d) Rock properties like unit weight and water absorption

e) Unconfined compressive strength of the rock

f) Point load strength of the rock

7.2 Soil/Rock Profile

7.2.1 A perusal of the data presented in the soil and rock profile tables indicates the presence of the following three soil/rock strata at the site :

a) Stratum - I : Filled-up soil with stone pieces

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

c) Stratum - III : Whitish grey / Greyish pink Limestone

7.2.2 The depths at which these three strata have been encountered in the three boreholes are as follows :

BH. No.	Strata (depth in m : from : to)		
	Stratum - I	Stratum - II	Stratum - III
SBH1	0 - 0.7	0.7 - 0.9	0.9 - 20
SBH2	N.E.	0 - 0.5	0.5 - 10
SBH3	0 - 0.6	0.6 - 2.4	2.4 - 10

N.E. : not encountered

7.2.3 The above results show that :

a) Stratum - I consisting of Filled-up soil has been encountered down to a maximum depth of about 0.7m below the existing ground level, only in boreholes SBH1 and SBH3. Additionally, concrete flooring at existing ground level had also been observed at the location of SBH1.

b) Stratum - II consisting predominantly of silty soil with varying percentages of clay and sand, has been encountered down to the depths of refusal/ rock strata.

c) Stratum - III consisting of Whitish grey and Greyish pink Limestone has been encountered at a depth varying between 0.5m and 2.4m below the existing ground level, down to the maximum depth investigated i.e. 20m below the existing ground level.

7.3 Soil Composition

7.3.1 As the refusal strata encountered at shallow depths varying between 0.5 and 2.4m depths below the existing ground level and also the filled-up soils have been encountered down to about 0.7m depth, only one disturbed soil sample (i.e. from SPT) could be recovered from virgin soil strata at 0.9m depth in borehole SBH3 for grain size analysis.

7.3.2 From grain size distribution, recovered soil sample of Stratum - II consists of about 21% of silt, 21% of sand and with 58% gravel. The grain size distribution of the soil sample have been presented in the form of grain size analysis curve in fig. 3.

7.4 Natural Density and Water Content

7.4.1 As refusal / rock strata had been encountered at shallow depths varying 0.5m and 2.4m depths, undisturbed soil samples could not be obtained in soil strata.

7.5 Atterberg Limits

7.5.1 The Atterberg limits indicate that the soil, where encountered, is generally low plastic to non - plastic near the depths of refusal/ rock strata.

7.6 Standard Penetration Tests Values (N-values)

7.6.1 The observed Standard Penetration Test values (N-values) are indicated in the soil profile tables.

7.6.2 The above results indicate that the soil where encountered is in a medium dense state down to the depths of the refusal/ rock strata.

7.7 Rock Conditions

7.7.1 An analysis of the data provided in the rock profile tables indicates the following :

a) The rock strata generally consists of Limestone down to the maximum depth investigated i.e.20m below the existing ground level.

b) The colour of the Limestone generally varies from Pinkish grey to Whitish grey, down to the maximum depth investigated.

c) Core recoveries ranging from 12% to 99% have been observed at different depths in different boreholes.

d) RQD values varying between nil to 98% have been observed at different depths in different boreholes.

e) The Limestone has been observed to have a wide range of weathered states from highly weathered (generally recognised by nil core recovery) to more or less sound rock (generally recognised by high core recovery and high RQD) at different depths in different boreholes.

f) Unit weight of the rock varies between 2.64 g/cm^3 and 3.03 g/cm^3.

g) Porosity of the rock varies between 0.18 % and 1.45 %.

h) Water absorption of the rock varies between 0.12% and 1.23%.

i) Uniaxial compressive strength of the rock varies between 219 kg/cm^2 and 564 kg/cm^2.

7.8 Compiled Soil And Rock Profile

7.8.1 An overview of the results and their analysis has been presented in the form of a compiled soil and rock 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 / rock composition and the observed N-values at various depths.

7.9 Chemical Analysis

7.9.1 The results of the chemical analysis conducted on water sample and soil sample collected from borehole SBH3, for determining the presence of any harmful salts which can have adverse effects on construction, are as follows :

a) Water sample

BH No.	pH value	Chloride Content (ppm)	Sulphate Content (ppm)
SBH3	6.5	62	85

b) Soil sample

BH no./ Depth (m)	pH value	Chloride Content (ppm)	Sulphate Content (ppm)
SBH3 / 0.9m	6.5	36	48

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 water and soil encountered at the site 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 structures 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/rock 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 structures are Wagon Tippler, Additive Storage and Transfer Tower Considering this, medium heavy to heavy loads can be anticipated on the foundations.

8.2.3 The results of the investigations have indicated that the refusal/ rock strata in the form of Limestone has been encountered at a depth varying between about 0.5m and 2.4m below the existing ground level.

8.2.4 The subsoil strata below the filled-up strata is in a medium dense state down to the depths of refusal/ rock strata.

8.2.5 In view of the above, the foundations for the proposed structures can be supported over ***Isolated/ Strip Footings*** or ***Raft Foundations*** depending upon the requirement.

8.3 Depth of Foundation

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

a) There should be sufficient thickness of soil above the footings/foundations so that they are neither exposed or undermined by natural/manmade forces in the future.

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

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

d) Requirements of the type of structure.

8.3.2 Giving due consideration to above and also as per the requirements, the foundations of the proposed heavy structures can be placed at a depth of ***minimum 0.3m in virgin rock strata***.

8.3.3 The depths at which the refusal/ rock strata have been encountered in the boreholes at various locations has been given hereunder.

Structures	BH No.	Depth of Refusal/ Rock Strata (m) below EGL
Wagon Tippler	SBH1	0.9
Additive Storage	SBH2	0.5
Transfer Tower	SBH3	2.4

EGL : existing ground level

8.3.4 The excavations down to the above mentioned depths can be carried out by ordinary methods by providing necessary side slopes.

8.4 Allowable Bearing Pressures

8.4.1 As the foundations are to typically rest on rock strata, the allowable bearing pressures on ***Isolated/ Strip footings*** or ***Raft foundations*** have been evaluated using the method based on the rock core strength as per the guidelines of Clause - 6 of IS: 12070 - 1987.

8.4.2 On the basis of the above evaluation, the recommended ***net allowable bearing pressures for Foundations Resting at a Depth of Minimum 0.3m in Rock Strata*** are given below.

Structure	*BH No.*	*Depth of Refusal/ Rock Strata (m) below EGL*	*Depth of Foundation (m)*	*Net allowable bearing pressure (t/m^2)*
Wagon Tippler	SBH1	0.9m	between 10m and 16m	120 t/m^2
Additive Storage	SBH2	0.5m	0.3m in virgin rock strata	80 t/m^2
Transfer Tower	SBH3	2.4m	0.3m in virgin rock strata	40 t/m^2

EGL : existing ground level

Note: It should be ensured that the foundations are resting at minimum 0.3m in virgin rock strata below the depth of refusal / rock strata.

9.0 RECOMMENDATIONS

9.1 Type of Foundation

Isolated / Strip Footings or *Raft Foundations*, depending upon the requirements

9.2 Depth of foundations

Minimum 0.3m in virgin rock strata

9.3 Allowable Bearing Pressures

Structure	*BH No.*	*Depth of Refusal/ Rock Strata (m) below EGL*	*Depth of Foundation (m)*	*Net allowable bearing pressure (t/m^2)*
Wagon Tippler	*SBH1*	*0.9m*	*between 10m and 16m*	*120 t/m^2*
Additive Storage	*SBH2*	*0.5m*	*0.3m in virgin rock strata*	*80 t/m^2*
Transfer Tower	*SBH3*	*2.4m*	*0.3m in virgin rock strata*	*40 t/m^2*

EGL : existing ground level

Note: It should be ensured that the foundations are resting at minimum 0.3m in virgin rock strata below the depth of refusal / rock strata.

9.4 Appendices

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

9.4.2 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.

9.5 SPECIAL NOTE

For foundations resting on rock strata, loose pockets if encountered shall be removed and backfilled with concrete. A levelling course of concrete shall be laid and construction of foundations can be taken up subsequently.

9.6 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.

9.7 LIMITATIONS

This Geotechnical investigation has 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/ rock conditions and properties at places between or beyond chosen test locations, fresh investigations will have to be carried out at such locations.

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Technical Director

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

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Appendix - A

(refer para 9.5.1)

TYPICAL ANALYSIS FOR ALLOWABLE BEARING PRESSURE FOR FOUNDATIONS RESTING ON ROCK

(Wagon Tippler, Depth of Foundation between 10m and16m below EGL)

A. The allowable bearing pressure has been evaluated from the core strength as per the guidelines of clause 6 of IS 12070 - 1987 as:

$$q_s = q_c \cdot N_j$$

Where q_c = average uniaxial compressive strength of rock cores

N_j = empirical coefficient depending in the spacing of discontinuities

B. The empirical coefficient 'N_j' is determined using the following formula :

$$N_j = \frac{3 + \frac{S}{B}}{10 \cdot \sqrt{1 + 300 \cdot \frac{\delta}{S}}}$$

where δ = Thickness of discontinuities/joints in cm

S = Spacing of discontinuities/joints in cm

B = Footing width in cm

C. The results of the investigations have shown that below the likely foundation levels, the core recovery in the rock strata is typically in the range of 90% to 95%. Accordingly, considering an average core recovery of 92.5%, the thickness of all discontinuities/joints will be 20% of the drill run. As on average the number of core pieces recovered in a drill run is about 15, the number of joints in the drill run can be considered as 15. Considering the number of discontinuities/joints as 15 in a drill run of 1.5m or 150cm, the thickness of

discontinuities/joints works out to about $\delta = 0.75$ cm.

D. Similarly, considering the average number of core pieces recovered in a drill run as 10 and an average core recovery of 92.5%, the average core size or spacing of discontinuities/joints works out to S = 9.25cm.

E. Considering the typical width of foundation 'B' as 2m or 200cm, the empirical coeffieicnt 'N_j' is determined to be = 0.0605.

F. Average unconfined/uniaxial compressive strength 'q_c' of the rock strata has been observed to be about 200 kg/cm^2.

G. Accordingly, the allowable bearing pressure on foundations resting on the rock strata is determined to be :

$$q_s = 200 \times 0.0605 = 12.1 \text{ kg/cm}^2$$

$$= 121 \text{ t/m}^2$$

$$\text{say} = 120 \text{ t/m}^2$$

Appendix - B

(refer para no. 9.5.2)

LIST OF IS CODES

Field Investigation

1. IS : 1892 - 1979 : 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)
4. IS : 11315 - 1985 (Part 11) : Method for the quantitative descriptions of discontinuities in rock masses
5. IS : 11315 - 1995 (Part 12) : Quantitative description of discontinuities in rock mass methods.

Laboratory Tests

1. IS : 2720 - 1983 (Part 1) : Methods of test for soils: Preparation of dry soil samples for various tests (Second revision)
2. IS : 2720 - 1980 (Part 2) : Method of test for soils: Determination of water content (Second revision) Amendment 1
3. IS : 2720 - 1980 (Part 3/sec 1) : Method of Test for Soils : Determination of Specific Gravity : Fine Grained Soils. (First Revision)
4. IS : 2720 - 1980 (Part 3/Sec 2) : Method of test for soils : Determination of Specific Gravity : Fine, Medium & Coarse grained soils. (First

revision).

5. IS : 2720 - 1985 (Part 4) : Method of test for soils : Grain size analysis (Second revision)

6. IS : 2720 - 1985 (Part 5) : Method of test for soils : Determination of liquid and plastic limit (Second revision)

7. IS : 2720 (Part 10) - 1973: Method of test for soils : Determination of shear strength parameters using Triaxial apparatus

8. IS: 4078 - 1980 : Code of practice for indexing and storage of drill cores (First Revision)

9. IS : 9143 : 1976 : Method for the determination of unconfined compressive strength of rock materials.

10. IS : 2720 -1987 (Part 26): Methods of tests for soils: Determination of pH value (Second revision).

11. IS :2720 - 1977 (Part 27): Methods of tests for soils: Determination of total soluble sulphate (First revision).

12. IS : 13030 : 1991 : Method of test for laboratory determination of water content, porosity, density and related properties of rock material.

Foundation Construction

1. IS : 12070 - 1987: Code of practice for design and construction of foundations on rocks (Reaffirmed 2015)

2. IS : 1904 - 1986 : Code of practice for design and construction of foundation in soils: General requirements (Third revision)

3. IS : 6403 - 1981 : Code of practice for determination of bearing capacity of shallow foundations : First revision (Amendment 1)

4.	IS : 8009 - 1976 (Part 1) :	Code of practice for calculation of settlements of foundations : Shallow foundations subject to symmetrical static vertical loads (Amendment 2)
5.	IS : 13063 : 1991 :	Code of practice for structural safety of buildings on shallow foundations.

SOIL PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

B.H. Location : Wagon Tippler | Water Table : 13.1m | Term. Depth : 20m | SBH. No.: 1

N - Value	Depth (m)	Soil Description	Grain Size Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: Liquid (%)	Plastic (%)	In-situ properties: Density (g/cm³)	Water Cont (%)	Triaxial Test: Type	c (kg/cm²)	ϕ (°)
	0.0	Concrete Flooring											
	0.3	Filled-up soil with stone pieces											
	0.7	Yellowish brown clayey sandy silt with gravel											
52 / 5cm	0.9	Refusal / rock strata (Greyish pink Limestone)											
		From 0.9m to 20m depth - Continued in Rock Profile Table											

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Job No. : G(D)4515

Sheet No. : 1

ROCK PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

Location : Wagon Tippler

B.H. Size : Nx | Water Table (m): 13.1m | Term. Depth (m): 20m | SBH. No. : 1

Depth (m)	Strata Description	No. of Core Pieces of Size (cm) <10	10-25	25-75	>75	Core Recovery (%)	RQD (%)	Run Time (min)	Unit Weight (g/cm³)	Porosity (%)	Water Absorption (%)	Unconfined Compressive Strength (kg/cm²)	Point Load Strength (kg/cm²)	Remarks
0.9	-													
	Greyish pink Limestone	15	0	0	0	36	0	65						Highly weathered to moderately weathered rock
2.5	-													
	Greyish pink Limestone	20	3	0	0	87	22	80	2.64	0.39	0.93	379		
4.0	-													
	Greyish pink Limestone	20	3	0	0	80	25	78						
5.5	-													
	Greyish pink Limestone	12	0	0	0	36	0	60						
7.0	-													
	Greyish pink Limestone	3	0	0	0	19	8	55	3.03	1.65	1.12	345		
8.5	-													
	Greyish pink Limestone	9	6	0	0	71	49	68						Moderately weathered rock
10.0	-													
	Greyish pink Limestone	13	3	1	0	97	48	90	2.73	1.83	1.23	227		
11.5	-													

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Job No. G(D)4515

Sheet No. : 2

ROCK PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

Location : Wagon Tippler

B.H. Size : Nx | Water Table (m): 13.1m | Term. Depth (m): 20m | SBH. No. : 1

Depth (m)	Strata Description	No. of Core Pieces of Size (cm) <10	10-25	25-75	>75	Core Recovery (%) 20	40	60	80	100		RQD (%)	Run Time (min)	Unit Weight (g/cm³)	Porosity (%)	Water Absorption (%)	Unconfined Compressive Strength (kg/cm²)	Point Load Strength (kg/cm²)	Remarks
11.5	-																		
	Greyish pink Limestone	1	3	2	0						93	87	95						Moderately weathered to more or less sound rock
13.0	-																		
	Greyish pink Limestone	17	5	0	0						94	45	96						
14.5	-																		
	Greyish pink Limestone	8	3	2	0						99	67	102	3.02	0.88	0.57	295		
16.0	-																		
	Whitish grey Limestone	0	4	2	0						98	98	106						Moderately weathered to sound rock
17.5	-																		
	Whitish grey Limestone	4	0	3	0						96	84	105						
19.0	-																		
	Whitish grey Limestone	4	2	1	0						89	70	72	2.80	1.45	0.99	311		
20.0	-																		

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Job No. G(D)4515

Sheet No. : 3

SOIL PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

B.H. Location : Additive Storage | Water Table : N.E. | Term. Depth : 10m | SBH. No.: 2

N - Value	Depth (m)	Soil Description	Grain Size Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg: Liquid (%)	Plastic (%)	In-situ: Density (g/cm^3)	Water Cont (%)	Triaxial Test: Type	c (kg/cm^2)	φ (°)
	0.0	Brownish grey clayey sandy silt with gravel											
50 / 5cm	0.5	Refusal / rock strata (Whitish grey Limestone)											
		From 0.5m to 10m depth - Continued in Rock Profile Table											

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Job No. : G(D)4515

ROCK PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

Location : Additive Storage

B.H. Size : Nx

Water Table (m): N.E.

Term. Depth (m): 10m

SBH. No. : 2

Depth (m)	Strata Description	No. of Core Pieces of Size (cm) <10	10-25	25-75	>75	Core Recovery (%)	RQD (%)	Run Time (min)	Unit Weight (g/cm^3)	Porosity (%)	Water Absorption (%)	Unconfined Compressive Strength (kg/cm^2)	Point Load Strength (kg/cm^2)	Remarks
0.5	-													
	Whitish grey Limestone	4	0	0	0	54	0	34						Highly weathered rock
1.0	-													
	Whitish grey Limestone	10	3	0	0	75	44	98	2.78	0.18	0.12	564		Moderately weathered to sound rock
2.5	-													
	Whitish grey Limestone	3	8	0	0	83	75	104						
4.0	-													
	Whitish grey Limestone	8	7	0	0	81	62	108	3.02	0.59	0.40	404		
5.5	-													
	Whitish grey Limestone	13	1	2	0	79	55	110						
7.0	-													
	Whitish grey Limestone	0	0	0	1	97	96	112						sound rock
8.5	-													
	Whitish grey Limestone	1	2	1	1	99	98	110	2.68	0.32	0.21	455		
10.0	-													

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Job No. : G(D)4515

Sheet No. : 5

SOIL PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

B.H. Location : Transfer T. | Water Table : N.E. | Term. Depth : 10m | SBH. No.: 3

N - Value	Depth (m)	Soil Description	Grain Size Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg: Liquid (%)	Plastic (%)	In-situ: Density (g/cm^3)	Water Cont (%)	Triaxial Test: Type	c (kg/cm^2)	ϕ (°)
	0.0	Filled-up soil with stone pieces											
	0.6	Change of the strata											
63	0.9	Yellowish brown gravelly sandy silt	58	21	21	0	Low	Plastic					
	1.5								Tube	bent			
48	2.4	Refusal / rock strata (Greyish pink Limestone)											
5cm													
		From 2.4m to 10m depth - Continued in Rock Profile Table											

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Job No. G(D)4515

Sheet No. : 6

ROCK PROFILE

Project : Proposed Wagon Tippler & Additive System at WLC, Line - IV, Nimbahera, Rajasthan

Location : Transfer Tower

B.H. Size : Nx

Water Table (m): N.E.

Term. Depth (m): 10m

SBH. No. : 3

Depth (m)	Strata Description	No. of Core Pieces of Size (cm) <10	10-25	25-75	>75	Core Recovery (%)	RQD (%)	Run Time (min)	Unit Weight (g/cm³)	Porosity (%)	Water Absorption (%)	Unconfined Compressive Strength (kg/cm²)	Point Load Strength (kg/cm²)	Remarks
2.4	-													
	Greyish pink Limestone	9	0	0	0	12	0	35						Highly weather rock
4.0	-													
	Greyish pink Limestone	7	0	0	0	13	0	68						N=36/3cm at 4m depth
5.5	-													
	Greyish pink Limestone	6	1	0	0	27	7	70						N=40/4cm at 5.5m depth
7.0	-													
	Greyish pink Limestone	14	4	0	0	89	33	88						Moderately weathered rock
8.5	-													
	Greyish pink Limestone	10	5	0	0	79	49	97	2.54	1.68	1.12	219		
10.0	-													

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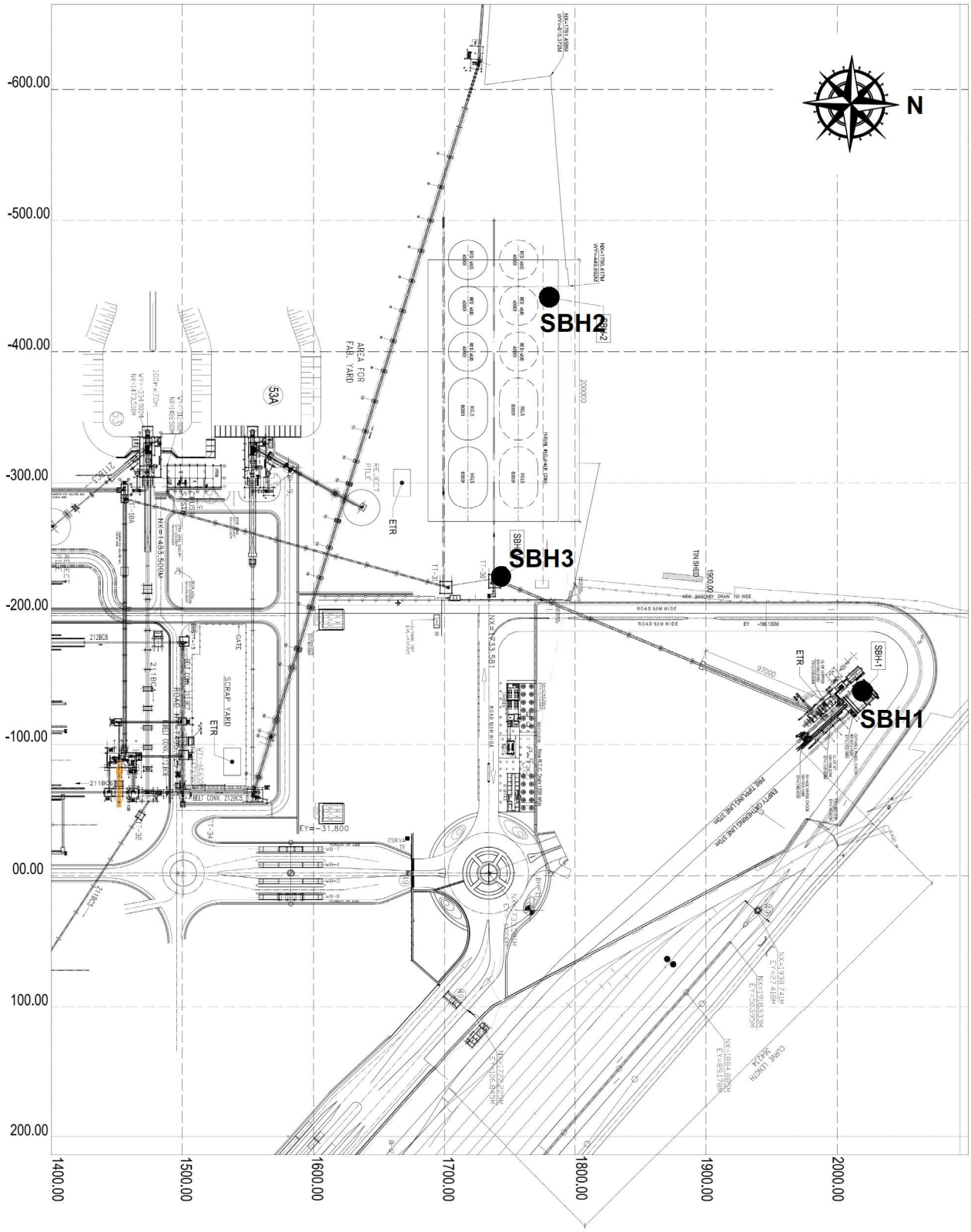

SCHEMATIC SITE PLAN

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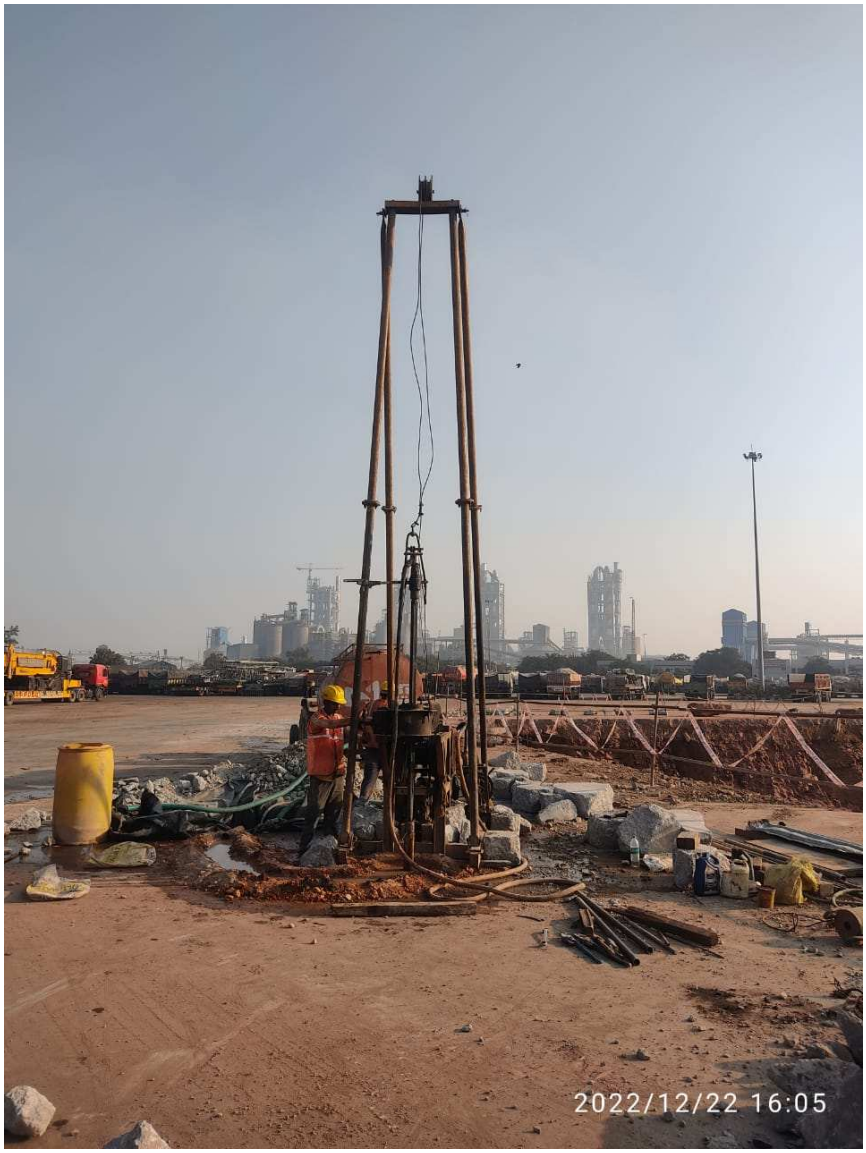

PHOTOGRAPHS SHOWING
VIEW OF THE SITE & BOREHOLES UNDER PROGRESS

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PHOTOGRAPHS SHOWING THE EXCAVATION UNDER PROGRESS NEAR TO BOREHOLE SBH1

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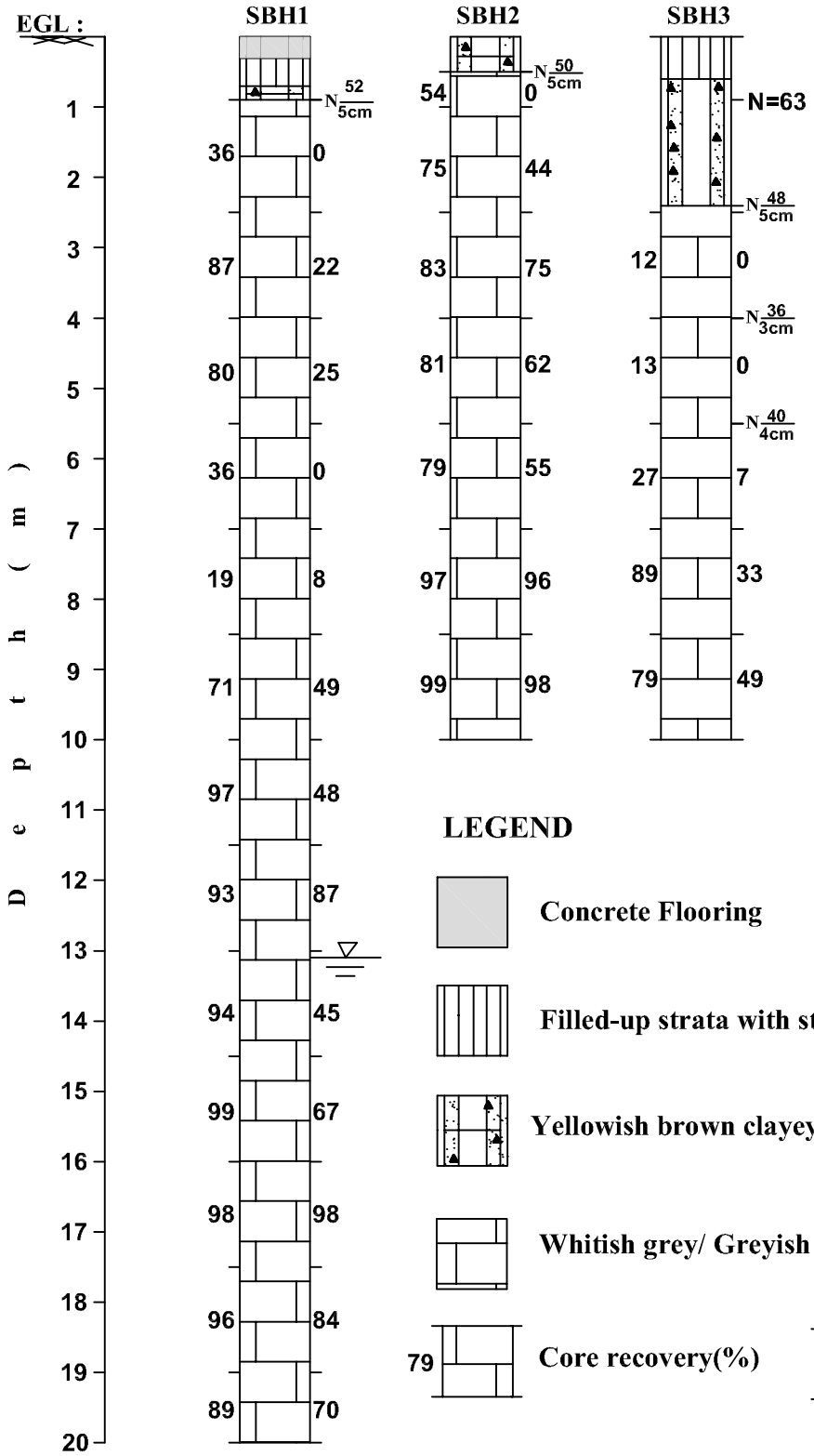

LEGEND

Concrete Flooring

Filled-up strata with stone pieces

Yellowish brown clayey sandy silt / gravelly sandy silt

Whitish grey/ Greyish pink Limestone

79 Core recovery(%)

49 RQD(%)

Ground water table as on December 2022.

63 Observed 'N' values

N 52/5cm 52 blows for 5cm. penetration

COMPILED SOIL/ ROCK PROFILE

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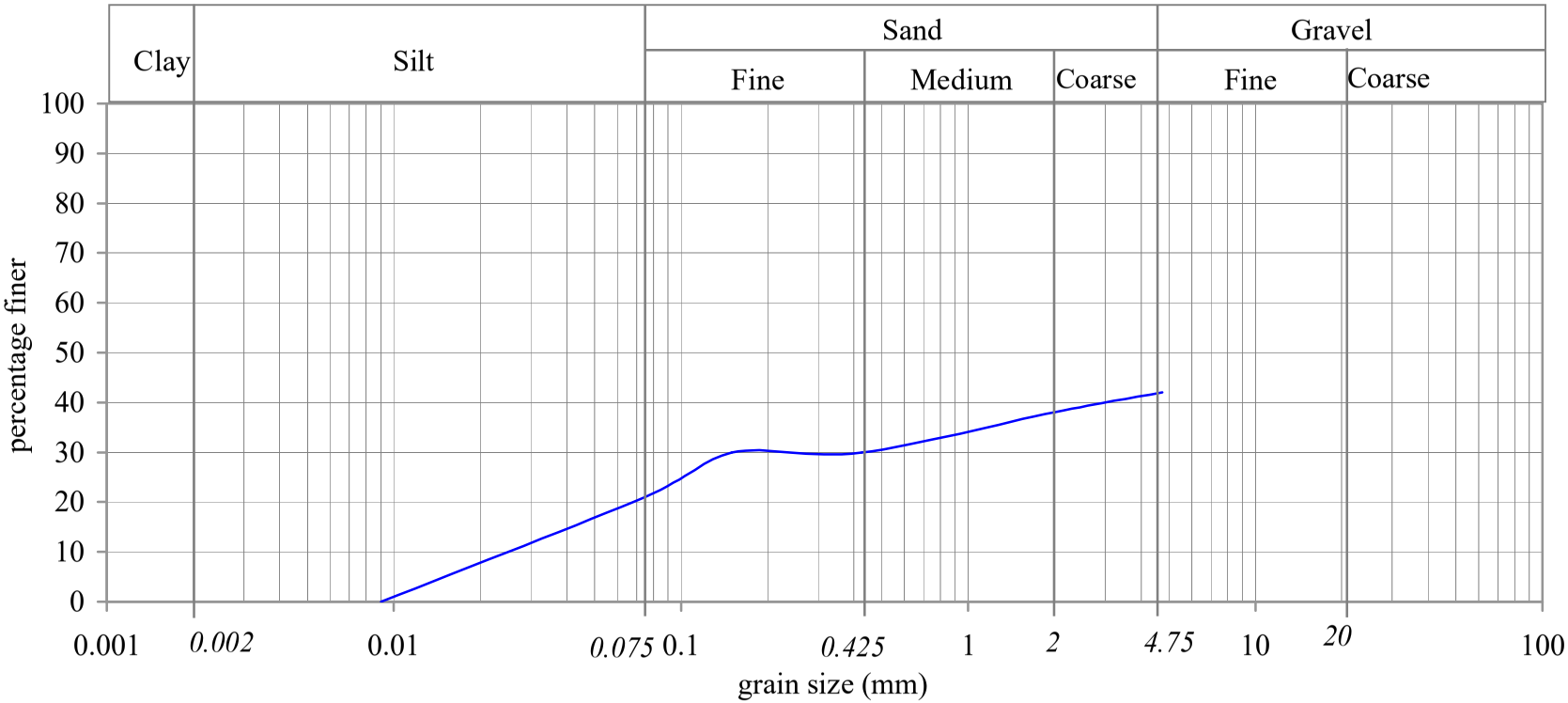
Sheet No. :

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
			Gravelly sandy silt	58	21	21	0	-	0.025	-

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