Geo-Technical Investigation "from Chikabanavara via yeswanpur and Hebbal to Bayanapalli" & "From Helalige to Rajankunte" – Corridor 2 Bangalore Sub urban Railway Project

CLIENT

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GEO-TECHNICAL INVESTIGATION REPORT- 8 BOREHOLES

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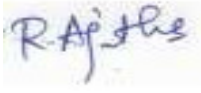
Draft copy-10			
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Acronyms and Abbreviations

The following acronyms and abbreviations are used throughout this document:

Abbreviation	Definition
BDL	Below Detection Limit
BH	Bore Hole
Cc	Compression Index
CR	Core Recovery
Cu	Consolidated Undrained
DL	Detection Limit
DS	Disturbed Sample
FSI	Free Swell Index
IR	Indian Railway
IS	Indian Standards
LC	Level Crossing
NP	Non Plastic
RA	Reaffirmed
RMR	Rock Mass Rating
RQD	Rock Quality Designation
SPT	Standard Penetration Test
UCC	Unconfined Compression
UCS	Unconfined Compressive Strength
UDS	Undisturbed Sample
UU	Unconsolidated Undrained
WS	Washing Sample
WT	Water Table

Contents

1.0 Introduction

M/S.MYRTLE PROJECT AND CONSULTANCY PVT LTD., had been awarded the work of Geo-Technical Investigation "from Chikabanavara via yeswanpur and Hebbal to Bayanapalli" & "From Helalige to Rajankunte" – Corridor 2 Bangalore Sub urban Railway Project. This report presents the details of Geo-Technical investigations carried out and data obtained from various field and laboratory tests, their presentation in graphical form and their compilation for Rail Infrastructure Development Company (Karnataka) Ltd, based on 8 Boreholes.

2.0 Scope of work

a. Drilling boreholes by Rotary drilling maximum upto 33.0 m as per IS: 1892 – 1979 of practice and at locations as directed by Engineer-in-Charge.
b. Conducting Standard Penetration tests in the bore holes at regular intervals of 1.50m or change in stratum as per IS: 2131-1981.
c. Collecting undisturbed soil samples in thin walled tube sampler as per IS: 2132 – 1986 at every 3m interval or as directed by the Engineer-in-Charge.
d. Collecting core samples from the bore holes as per IS: 4078 – 1980 and recording Rock Quality Designation (RQD) and Core recovery (CR).
e. Recording of water table level in the bore holes after drilling.
f. Conducting laboratory tests on relevant Soil /Rock samples as per IS Code specifications.
g. Conducting Chemical tests on Water Samples.
h. Preparation of report summarizing the details of soil classification, analysis of test data, type of foundation etc.
i. Survey of boreholes location and plotting the locations along with its elevation as per alignment plan. (as directed by Engineer-in-Charge)

3.0 Overview

3.1 Methodology of Field investigation

3.1.1. Boring

Boreholes were drilled by Rotary drilling maximum upto 33.0 m depth. In refusal strata, drilling was resorted by Nx size diamond bits as per IS :1892 - 1979 of practice and as directed by Engineer-in-charge. The details of Boreholes drilled, depth of the borehole, depth of water table and road level are as given in Table :4.1.

3.1.2. Standard Penetration test

Rotary Calyx Rig (Manual lifting and dropping type) was used to conduct SPT at field. In accordance with IS: 2131-1981,SPT was conducted at every change of stratum or at intervals of not more than 1.5 m depth whichever occurs earlier. It was done by connecting the split spoon sampler to SPT rod and driving it upto 45 cm using a 63.5 kg hammer falling freely from a height of 75 cm.The number of blows required to penetrate the initial 15 cm of the split spoon was ignored for seating the sampler due to possible presence of loose materials or cutting from the drilling operation. The cumulative number of blows required to penetrate the balance 30 cm out of 45 cm was termed as the SPT or N values.

3.1.3. Disturbed & Undisturbed samples

i) Conducting Standard Penetration Test at 1.5 m / 3.0 m intervals, disturbed soil samples were collected using a split spoon sampler.

ii) Undisturbed soil samples were collected in soil layers wherever possible by using thin walled sampling tube and mentioned in the respective bore logs.

3.1.4. Rock Coring

Tungsten Carbide (TC) / Diamond bits were used to drill through weathered rock / hard rock stratum. Recovered cores were measured and percentages of CR and RQD has been calculated as per below:

%CR = [(Length of core) / (Length of run)] * 100

%RQD = [(Length of core in pieces of 10cm & above) / (Length of run)] * 100

3.1.5. Ground Water table

Water table in each borehole was noted by allowing the water table level to stabilize for minimum 24 hrs. This can be noticed after the completion of drilling activity in each borehole. The depth of water level below EGL is noted in respective bore logs.

3.1.6. Backfilling of boreholes

All boreholes were backfilled in proper way after the termination of each boreholes. (as directed by Engineer incharge)

3.2 Laboratory Test

The following tests were performed in Laboratory on soil,rock & water samples collected from field.

3.2.1. For Soil

- Sieve Analysis- IS 2720 (Part 4) : 1985
- Hydrometer analysis - IS 2720 (Part 4) : 1985
- Bulk & Dry Density - IS 2720 (Part 29) : 1975
- Natural Moisture Content - IS 2720 (Part 2) : 1973
- Specific Gravity - IS 2720 (Part 3) : 1980
- Direct Shear - IS 2720 (Part 13) : 1986
- Liquid limit & Plastic limit – IS 2720 (Part 5): 1985
- Unconfined Compressive Test- IS 2720 (Part 10) : 1991
- Consolidation Test- IS 2720 (Part 15) : 1965

i) Sieve Analysis- IS 2720 (Part 4) : 1985

Sieving was done using sieve shaker by passing through the following IS sieves: 4.75 mm, 2.00 mm, 425.00 µ and 75.00 µ.

ii) Hydrometer analysis - IS 2720 (Part 4) : 1985

50g of soil passing 75 μ IS sieve was mixed with 3.3g sodium hexa-meta-phosphate and 0.7g sodium carbonate, transferred to 1000 ml measuring cylinder and made up to exactly 1000 ml with distilled water and then agitated thoroughly. Hydrometer was immersed to a depth slightly below its floating position and then allowed to float freely. Hydrometer readings are taken at 10, 20, 30 and 45 sec and then at 1, 2, 4, 8, 15 and 30 min and 1, 2, 4, 8 and 24 hours intervals. The diameter of the particle in suspension at any sampling time't' is calculated using "Stokes" formula and the percentage finer is calculated. Semi log graph was then plotted with grain size (mm) in 'x' axis and percentage finer in 'y' axis. The graph represents respective percentage of various particle sizes (clay, silt, sand, gravel (wherever encountered) etc.

iii) Bulk & Dry Density - IS 2720 (Part 29) : 1975

The weight of soil + container was noted as w_1. Weight of container alone was noted as w_2. Then the bulk density of the soil was calculated as below

Bulk Density = $(w_2-w_1) / V$ g/cc

Where , V= Volume of soil in cc

Dry Density = Bulk density / (1+W) g/cc

Where, W = Natural Moisture Content in %

iv) Natural Moisture Content - IS 2720 (Part 2) : 1973

A moisture container is weighed initially (w_1). The container is filled with soil sample and weighed with lid (w_2). It is then kept over oven with lid removed and maintained at temperature of oven at 105°C for 24 hours. The lid of the container is then replaced and the dry weight found out (w_3). The percentage of water content has been calculated using the formula.

$$w = [(w_2-w_3) / (w_3-w_1)] * 100$$

v) Specific Gravity - IS 2720 (Part 3) : 1980

Specific gravity of soil solids is defined as the weight of given volume of soil solids to the weight of equal volume of distilled water.

Specific gravity is found out using standard specific gravity bottle of 50 ml capacity by weighing empty bottle (w_1), bottle + dry soil (w_2), bottle + dry soil + water (w_3), bottle + water (w_4).

$$\text{Specific gravity of soil} = \frac{(W_2-W_1)}{(W_2-W_1) - (W_3-W_4)}$$

vi) Direct Shear - IS 2720 (Part 13) : 1986

In this test, soil specimen is confined in a square metal box split into two halves horizontally. Non-Perforated metal plates and porous stones are placed above and below the specimen to prevent any drainage. After applying vertical load, soil is gradually sheared off by applying horizontal force, which makes the two halves of the box move relative to each other. Shear is applied at a constant strain rate and measured in a proving ring. Vertical deformation is measured with dial gauge. Minimum of three specimens are tested and graph drawn with normal stress in 'X' axis and shear stress in 'Y' axis. From the straight-line plot, values of C and Phi are then measured.

vii) Liquid limit & Plastic limit – IS 2720 (Part 5): 1985

a. Liquid limit

Liquid limit is determined using Casagrande's method. 150 gms of air dried soil is taken in Porcelain Evaporating dish to form uniform paste. A portion of the paste is placed in the cup of liquid limit device and trim it to a depth of 1 cm at the point of maximum thickness. Lift and drop the cup by turning crank at the rate of two revolution per second until the two halves of soil cake come in contact each other for a length of about 12 mm. Number of blows shall be noted and the test was repeated with different moisture at least four more times for blows between 15 and 35. Ploting the relationship between water content (on y-axis) and number of blows (on x-axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 blows as read from the graph represents the liquid limit.

b. Plastic limit

About 15 g of oven-dried soil passing through 425 μ sieve was mixed with sufficient quantity of water to become plastic enough to be easily shaped into a ball. A portion of this ball was rolled on a glass plate with fingers with just sufficient pressure to roll the mass into a thread of uniform diameter of 3mm, and then the soil was re-moulded again into a ball. This process of rolling and remoulding was repeated until the thread starts just crumbling at a diameter of 3mm. The water content of such threads represents the plastic limit.

C. Plasticity Index

It is the difference between liquid limit & plastic limit (i.e.) I_P= LL - PL

viii) Unconfined Compressive Test- IS 2720 (Part 10) : 1991

Unconfined Compressive strength (qu) is the load per unit is at which an unconfined cylindrical specimen of soil will fail in the axial compression test. The specimen was placed at the mid of the base plate of the load frame (sandwiched between the end plates). Dial gauge was fixed to measure the vertical compression of the specimen. Then load was applied and the readings of proving ring & dial gauge were recorded for every 0.25 mm compression until the failure.

ix) Consolidation Test- IS 2720 (Part 15) : 1965

a. Sample Preparation

By means of a hydraulic jack, the sample was carefully ejected out from the tube, so that it intrudes into the ring. During the process, continuous trimming of the specimen has been done from outside of the consolidation ring to reduce friction. Finally the soil sample was trimmed and flushed with the ends of the consolidation ring so that the thickness of soil in the ring shall be greater than the height of consolidation ring. Extruded soil sample was loaded in the same direction relative to stratum as the applied force in the field.

b. Test Procedure

i) After the whole arrangement, the initial dial reading was read. And a 0.05 kg/cm^2 seating pressure was placed on the pan of weight hanger. Then the base plate of the consolidation cell was connected to water reservoir by means of rubber/plastic tube for saturating the soil specimen.The specimen was allowed to saturate for 24 hours. The test is continued with load increments such as 0.125, 0.25, 0.5, 1.0, 2.0, 4.0 kg/cm^2.

ii) The dial gauge readings were noted after application of each load with a time sequence of 0.25, 1.0, 2.25, 4, 6.25, 9, 12.25, 16, 20.25, 25, 36, 64, 81,100 minutes and thereafter 24 hours. With the help of the above time sequence, a plot with the specimen thickness against square root of time was plotted. The loads were reduced in stages and time-swelling readings were recorded accordingly.

3.2.2. For Rock

i) Unconfined compressive strength - IS 9143 : 1979

Unconfined Compressive strength (qu) (uniaxial compressive strength) of a rock sample is when crushed in one direction (uniaxial) without lateral restraint.

Specimen with L/D ratio 2 to 3 was taken and placed between two bearing discs. Load was continuously applied at a constant stress rate such that failure will take place in about 5 to 15 minutes of loading. Stress rate should lie within the limits of 0.5 MPa/s to 1.0 MPa/s. Maximum load was recored on the specimen at failure.

A summary of physical and Engineering properties of Soil & rock core samples were given in Annexure III.

3.2.3. Chemical analysis of water samples

Chemical content of water samples collected from the boreholes were determined by utilizing the following tests conforming to IS 2720 (relevant parts):

i) pH
ii) Total Dissolved Solids
iii) Chlorides
iv) Sulphates

A summary of chemical analysis results for water samples were given in Annexure I.

3.3 Geology of the Area

The existing soil types in Bangalore district can be broadly grouped into loamy soil and lateritic soil. Loamy soil type generally occurs on hilly to undulating land slope on granite and gneissic terrain. Laterite soil type occurs on undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in western parts of Bangalore North and south taluks. Peninsular gneiss covers a major portion of the Bangalore area and is highly migmatitic in nature. Their composition varies from tonalite and trondhjemite to granodiorite and has fine to medium-grained texture and generally grey in colour. In some places they are regularly banded with alternate bands of felsic and mafic minerals and at places the banding is irregular. These are noticed in and around Bangalore. The proposed area is observed as Clayey sand, Clay, Silty sand, sand, Sandy clay at top and soft disintegrated rock / Weathered rock. The underlying hard rock was Gneiss & Granitic Gneiss.

3.4 Seismicity

The area under study and its surroundings were seismically active and falls in Seismic **Zone –II** (as per IS 1893 -Part:1).

Recent Earthquake history: Bangalore felt mild tremors on Aug 16th, 2019.

4.0 Sub soil profile and strength characteristics of soil

For Corridor 2 –Rail Infrastructure Development Company (Karnataka) Limited, 8 Boreholes were drilled as directed by Engineer incharge.

S.No.	Bore Hole No.	IR Chainage No.	Station Name	Co-ordinate		Elevated stretch / At Grade stretch / Gate Stretch	Depth of Bore Hole (m)	Water table Detected (m)	Corridor No.
				X (Latitude)	Y (Longitude)				
1	13/500	13/500	Chikka Banavara station	13.074773	77.505243	Elevated	22.5	NIL	Corridor-2
2	12/200	12/200	Mydharhalli station	13.06783	77.514898	Elevated	15.0	9.0	Corridor-2
3	9/300	9/300	Shettyhalli station	13.05145	77.534511	Elevated	27.0	10.0	Corridor-2
4	214/100	214/100	Kanaka Nagar Station	13.035395	77.611146	Elevated	33.0	15.0	Corridor-2
5	211/100	211/100	kaverinagar Station	13.013371	77.37188	Elevated	12.0	10.5	Corridor-2
6	209/800	209/800	Banaswadi Station	13.006136	77.628426	Elevated	22.5	13.5	Corridor-2
7	206/800	206/800	Kasturinagar Station	13.004616	77.654765	Elevated	27.0	12.0	Corridor-2
8	205/100	205/100	Benniganahalli station	12.994843	77.662819	Elevated	10.5	NIL	Corridor-2

4.1 Borehole Details

Backfilling was obtained from 0.0 to 1.5m at top of some boreholes. The over burden strata were classified as Clay, Silt & Sand and composition of Silt, Sand, Clay and Gravel. Following the overburden strata, Hard rock was received. In Refusal strata, Boreholes were advanced by using Rotary drilling machine upto maximum depths of 33.0 m From the samples of the core recovery,drill log,representative samples, wash samples from bore holes, the Rock drilling was given upto drilled depth. The details of strata classification, Core Recovery and RQD obtained in each borehole are as given below.

4.1.1 Borehole No. 13/500

1	Borehole was drilled upto	=	22.5	m
2	Soft Disintegrated Rock obtained between	=	0 & 4.5	m
3	Rock Drilling between	=	4.5 & 22.5	m
4	CR varies between	=	3 & 53	%
5	RQD varies between	=	0 & 53	%

4.1.2 Borehole No. 12/200

1	Borehole was drilled upto	=	15	m
2	Backfilling obtained between	=	0 & 1.5	m
3	Silty Sand obtained between	=	1.5 & 4.5	m
4	Soft Disintegrated Rock obtained between	=	4.5 & 7.5	m
5	Rock Drilling between	=	7.5 & 15	m
6	CR varies between	=	7 & 76	%
7	RQD varies between	=	0 & 71	%

4.1.3 Borehole No. 9/300

1	Borehole was drilled upto	=	27	m
2	Silty Sand obtained between	=	0 & 7.5	m
3	Soft Disintegrated Rock obtained between	=	7.5 & 12	m
4	Rock Drilling between	=	12 & 27	m
5	CR varies between	=	10 & 61	%
6	RQD varies between	=	0 & 51	%

4.1.4 Borehole No. 214/100

1	Borehole was drilled upto	=	33	m
2	Silty Sand obtained between	=	0 & 9	m
3	Soft Disintegrated Rock obtained between	=	9 & 21	m
4	Rock Drilling between	=	21 & 33	m
5	CR varies between	=	6 & 60	%
6	RQD varies between	=	0 & 60	%

4.1.5 Borehole No. 211/100

1	Borehole was drilled upto	=	12.0	m
2	Backfilling obtained between	=	0 & 3	m
3	Soft Disintegrated Rock obtained between	=	3 & 4.5	m
4	Rock Drilling between	=	4.5 & 12	m
5	CR varies between	=	7 & 69	%
6	RQD varies between	=	0 & 48	%

4.1.6 Borehole No. 209/800

1	Borehole was drilled upto	=	22.5	m
2	Sandy Silt obtained between	=	0 & 12	m
3	Soft Disintegrated Rock obtained between	=	12 & 15	m
4	Rock Drilling between	=	15 & 22.5	m
5	CR varies between	=	13 & 50	%
6	RQD varies between	=	0 & 50	%

4.1.7 Borehole No. 206/800

1	Borehole was drilled upto	=	27.0	m
2	Silty Sand obtained between	=	0 & 9	m
3	Soft Disintegrated Rock obtained between	=	9 & 18	m
4	Rock Drilling between	=	18 & 27	m
5	CR varies between	=	11 & 53	%
6	RQD varies between	=	0 & 53	%

4.1.8 Borehole No. 205/100

1	Borehole was drilled upto	=	10.5	m
2	Backfilling obtained between	=	0 & 3	m
3	Sandy Silt obtained between	=	3 & 6	m
4	Rock Drilling between	=	6 & 10.5	m
5	CR varies between	=	61 & 71	%
6	RQD varies between	=	46 & 67	%

5 Design & Recommendation

5.1 Design Methodology

I) Pile Capacity:

a) Piles in Clay Soil:(As per IS:2911-part 1 /section 2 -2010 Annx-B.1)

The ultimate load capacity (Qu) of piles, in kN,

Q ult = Qe + Qf

Where,

Qe – end bearing resistance

Qf– skin friction resistance

End bearing resistance:

Qe= Ap x Nc x Cp …….(1)

Where,

Ap=cross-sectional area of pile tip, in m^2

Nc = bearing capacity factor, may be taken as 9

cp = average cohesion at pile tip, in kN/m^2

Skin friction resistance:

Qf $= \alpha$ x c x As …….(1)

Where,

α *= adhesion factor*

c = average cohesion, inkN/m^2

As = surface area of pile shaft, in m^2

b) Piles in Granular Soil:(As per IS:2911-part 1 /section 2 -2010 Annx-B.1)

The ultimate load capacity (Qu) of piles, in kN,

Q ult = Qe + Qf

Where,

Qe – end bearing resistance

Qf– skin friction resistance

End bearing resistance:

Qe= Ap x (0.5 x D x γx Nγ + P_d x Nq) …….(2)

Where,

Ap- cross-sectional area of pile tip, in m^2

D - diameter of pile shaft, in m

γ *- effective unit weight of the soil at piletip, in* kN/m^3

Nγ *- bearing capacity factors*

Nq- angle of internal friction

P_d *- effective overburden pressure at pile tip,in*kN/m^2

Skin friction resistance:

$Qf = K \times P_{di} \times \tan(\delta)$ .....(2)

Where,

K - coefficient of earth pressure

P_{di} - effective overburden pressure for the ith layer, in kN/m^2

δ- angle of wall friction between pile and soil

c) Piles in Rock:(As per IRC : 78-2014 - APEENDIX-5 : CL: 9.1)

The ultimate load capacity (Qu) of piles, in kN,

$Q\ ult = R_e + R_{af}$

$Q\ allow = (R_e/3) + (R_{af}/6)$

Where,

Qu– Ultimate capacity of pile socketed into rock, N

Q allow – Allowable capacity of pile

R_e – Ultimate end bearing

R_{af} – Ultimate side socket shear

Ultimate end bearing:

$R_e = K_{sp} \times q_c \times d_f \times A_b$

Where,

K_{sp} -An empirical co-efficient

q_c - Average UCC of rock core below base of pile, in MPa

d_f - Depth factor

A_b - Cross sectional area of base of pile

Ultimate side socket shear:

$R_{af} = A_s \times C_{us}$

Where,

A_s -Surface area of socket

C_{us} - Ultimate shear strength of rock along socket length

d) Pile Head Deflection/Lateral Capacity of Pile: (As per IS:2911-part 1/sec 2-Appendix C)

a) $Q_{(fixed\ head)} = Y*12*E_c*I/(L_f*100)^3/1000$

b) $Q_{(free\ head)} = Y*3*E_c*I/(L_f*100)^3/1000$

Where,

Y - Deflection

E_c - Modulus of elasticity

I - Moment of Inertia

Lf -Fixity length

II) Bearing Capacity:

a) For Soil:

As per Geotechnical Engineering Calculations and Rules of Thumb (Second Edition), Bearing capacity can be evaluated as Q=9.6*N

Where, N= SPT N value

b) For Rock:

Method 1: As per IS 13365:Part-1, Safe Bearing capacity for rock can be calculated based on Rock Mass Rating (RMR).

i. Uniaxial Compressive Strength of Intact Rock Material

The strength of intact rock material can be considered based on uniaxial compressive strength and point load strength test conducted for rock cores. The UCS/Point Load Strength rating is recommended as per IS:13365 (Part 1) are given below.

UCS value (MPa)	Point Load Strength value (MPa)	Rating
>250	>8	15
100 to 250	4 to 8	12
50 to 100	2 to 4	7
25 to 50	1 to 2	4
10 to 25	Use of uniaxial compressive strength is preferred	2
2 to 10		1
<2		0

Table: 5.2.1 – Strength of Intact Rock Material & Rating

ii. Rock Quality Designation (RQD)

RQD is a modified core recovery percentage in which all the pieces of sound core over 10 cm long are counted as recovery and are expressed as a "%" of the length drilled. The RQD rating recommended as per IS:13365 (Part 1) are given below.

RQD	Rating
90 to 100	20
75 to 90	17
50 to 75	13
25 to 50	8
<25	3

Table: 5.2.2 – RQD & Rating

iii.Spacing of Discontinuities

The term discontinuity covers joints, beddings or foliations, shear zones, minor faults/other surfaces of weakness. The linear distance between two adjacent discontinuities should be measured for all sets of discontinuities. The details of ratings as per IS:13365 (Part 1) are given below.

Spacing in m		Rating
Very wide	>2	20
Wide	0.6 to 2	15
Moderate	0.2 to 0.6	10
Close	0.06 to 0.2	8
Very close	<0.06	5

Table: 5.2.3 – Spacing of Discontinuities & Rating

iv.Condition of Discontinuities

This parameter includes roughness of discontinuity surfaces, their separation, length or continuity, weathering of the wall rock or the planes of weakness and infilling (gauge) material. The details of rating as per IS:13365(Part 1) are given below.

Condition	Very rough and un-weathered wall rock, tight and discontinuous, no separation	Rough and slightly weathered wall rock surface, separation <1mm	Slightly rough and moderately to highly weathered wall rock surface, separation <1mm	Slickensided wall rock surface or 1-5 mm thick gauge or 1-5 mm wide opening, continuous discontinuity	5 mm thick soft gauge 5mm wide continuous discontinuity
Rating	30	25	20	10	0

Table: 5.2.4 – Condition of Discontinuities & Rating

v.Ground Water Condition

The rate of inflow of ground water, a general condition can be described as completely dry, damp, wet, dripping and flowing. The ratings of above parameters as per IS:13365 (Part 1) are given below

General description	Completely dry	Damp	Wet	Dripping
Rating	15	10	7	4

Table: 5.2.5 – Ground Water Condition & Rating

The rating for ground water condition is considered as 7 which correspond to "Wet" in all cases.

vi.Orientation of Discontinuities

Orientation of discontinuities means the strike and dip of discontinuities. The strike should be recorded with reference to magnetic north. The dip angle is the angle between the horizontal and the discontinuity plane taken in a direction in which the plane dips.

vii.Adjustment for joint orientation

The influence of the strike and the dip of the discontinuities are considered with respect to the orientation of tunnel axis or slope face or foundation alignment. The values of adjustment for joint orientation are considered as per IS:13365 (Part 1).

Strike and dip orientation of joints for	Very favourable	Favourable	Fair	Un-Favourable
Tunnels	0	-2	-5	-10
Raft foundation	0	-2	-7	-15

Table: 5.2.6 – Adjustment for Joint orientation & Rating

Estimation of Rock Mass Rating & Net Safe bearing pressure

The rock mass rating can be determined as an algebraic sum of ratings for all the parameters mentioned above from (i) to (vii). The sum of items (i) to (vii) is referred as Rock Mass Rating.

On the basis of rock mass rating values, the rock mass can be classified as below.

Rock Mass Rating	Class	Classification of Rock Mass	q_n (t/m^2)
100 to 81	I	Very Good	600 to 448
80 to 61	II	Good	440 to 228
60 to 41	III	Fair	280 to 151
40 to 21	IV	Poor	145 to 58
<20	V	Very Poor	55 to 40

Table: 5.2.7 – RMR Rating & Net Safe bearing pressure

Method 2: IS 12070- Pg:7 & 9, Safe Bearing capacity for rock can be computed as

$Q=q_o*N_j$

Where, q_o= Average Compressive strength of rock

N_j= Empirical coefficient depending on the spacing of discontinuities

Comparing above two methods, Minimum of two values is to be considered as SBC.

5.2 Computation

I) Safe capacity of pile:(1000 mm dia pile for BH-13/500 at the depth of 22.5m)

For combination of Sand, Clay & Rock layers :

i) The Vertical capacity of pile calculates to be:

$Q_{e(v)}$ = (($Qe_{(1)}$ + $Qe_{(2)}$)/2.5) + (Re/3)

= ((0+0)/2.5) +392.6991 = 392.70 T

$Q_{f(v)}$ = (($Qf_{(1)}$ + $Qf_{(2)}$)/2.5) + (Raf/6)

= ((0+236.24)/2.5) +323.9515 = 418.45 T

$Q_{safe\ (v)}$ = Q_e +Q_f

= 392.6991 + 418.4475 = 811.15 T = 811 T

ii) The Uplift capacity of pile calculates to be:

$Q_{f\ (u)}$ = $Q_{f(v)}$ * 0.5 = 209.22 T = 209 T

$Q_{safe\ (u)}$ = (209.22375/3)+(0/3) = 69.74 T = 70 T

iii) Pile Head Deflection/Lateral Capacity of Pile calculates to be:

a) Q (fixed head) = $(Y*12*E*I)/((L_1+L_f)*100)^3/1000$

= (0.5*12*295804*4909000)/((0+6.614337)*100)^3)/100

= 30.1 T

b) Q (free head) = $(Y*3*E*I)/((L_1+L_f)*100)^3/1000$

= (0.5*3*295804*4909000)/((0+5.66092)*100)^3)/1000

= 12.0 T

II) Safe Bearing capacity for Soil (BH-13/500 at the depth of 1.5m)

Bearing capacity (Q) = 9.6*N

= 9.6*50 = 480 kPa = 48.96 T

III) Safe Bearing capacity for Rock (BH-13/500 at the depth of 22.5m)

Method 1: Based on Rock Mass Rating (RMR) - IS 13365:Part-1:

Parameter	Value	Rating
UCS of Rock (MPa)	114	12
Rock quality Designation %	53	13
Spacing of discontinuities	Moderate	10
Conditions of discontinuities	as per code	20
Ground water condition	Wet	7
Adjustment for joint orientation	Fair	-5
Total		57

* Classification of rock = III

* Classification of rock Mass = Fair

* Net safe bearing pressure will vary between = 280 to 151

* Net safe bearing pressure (By Linear interpolation) = 259.63 t/m^2

= 250.00 t/m^2

Method 2: **Based on UCS Value (IS: 12070):**

Bearing capacity for rock (Q) = $q_o * N_j$

= 114*10

= 1140 t/m^2

From above two results, SBC is recommended as = 250.00 t/m^2

5.3 Recommendations

Recommendations are based on the assumption that the soil profile found in the boreholes tested is indicative of the surrounding plot area.

I) Considering grade of Concrete to be used = M35
II) Considering concreting is to be done in underwater, take only 75% capacities
III) Recommended Pile capacities are based on the borehole strata and its strength obtained
IV) Recommended Pile capacities are given without considering the socketing depth.

Pile vertical capacity, Uplift capacity and lateral capacity for each Borehole with different depths are tabulated as follows.

BH.No.	Depth (m)	Pile dia (m)	Vertical capacity (T)	Uplift capacity (T)	Lateral Capacity (T)	
					Fixed Head	Free Head
BH-13/500	15.0	1.00	265.4	12.3	30.1	12.0
		1.20	429.2	16.4	40.3	16.1
	18.0	1.00	286.0	15.7	30.1	12.0
		1.20	458.8	21.3	40.3	16.1
	22.5	1.00	811.1	69.7	30.1	12.0
		1.20	1082.2	86.1	40.3	16.1
BH-12/200	15.0	1.00	664.6	45.3	26.1	10.4
		1.20	891.8	54.4	34.9	13.9
BH-9/300	18.0	1.00	257.2	12.0	24.1	9.6
		1.20	409.1	14.8	32.2	12.8
	21.0	1.00	277.8	15.4	24.1	9.6
		1.20	438.7	19.7	32.2	12.8
	24.0	1.00	548.4	26.0	24.1	9.6
		1.20	759.7	32.4	32.2	12.8
BH-214/100	25.0	1.00	304.6	19.9	17.3	6.9
		1.20	477.4	26.1	23.1	9.2
	28.0	1.00	325.1	23.3	17.3	6.9
		1.20	506.9	31.1	23.1	9.2
	33.0	1.00	706.3	52.3	17.3	6.9
		1.20	961.5	66.0	23.1	9.2
BH-211/100	12.0	1.00	552.3	26.6	30.1	12.0
		1.20	757.0	31.9	40.3	16.0

BH.No.	Depth (m)	Pile dia (m)	Vertical capacity (T)	Uplift capacity (T)	Lateral Capacity (T)	
					Fixed Head	Free Head
BH-209/800	15.0	1.00	236.1	8.4	17.8	7.1
		1.20	330.0	10.1	23.8	9.5
	19.0	1.00	512.2	19.9	17.8	7.1
		1.20	709.5	24.0	23.8	9.5
	22.5	1.00	822.8	71.7	17.8	7.1
		1.20	1082.2	86.1	23.8	9.5
BH-206/800	18.0	1.00	257.0	11.9	22.0	8.8
		1.20	408.8	14.7	29.4	11.7
	22.5	1.00	287.8	17.1	22.0	8.8
		1.20	453.1	22.1	29.4	11.7
	27.0	1.00	741.5	58.1	22.0	8.8
		1.20	993.9	71.4	29.4	11.7
BH-205/100	10.5	1.00	692.8	50.0	30.1	12.0
		1.20	925.7	60.0	40.3	16.1

Table :5.3.1 – Summary of Pile and Lateral capacities

FOR MYRTLE PROJECT AND CONSULTANCY PVT. LTD.

S.PRASATH

Annexure I
(Chemical Analysis for water sample)

Chemical analysis for water

S.No.	Bore Hole No.	pH	Total Dissolved Solids		Chloride as Cl-		Sulphate as SO_4-	
		-	mg/l	%	mg/l	%	mg/l	%
1	12/200	7.44	155	0.0155	67	0.0067	B.D.L (DL:1)	B.D.L (DL:1)
2	9/300	7.36	158	0.0158	70	0.0070	1.20	0.0001
3	214/100	7.51	165	0.0165	85	0.0085	1.10	0.0001
4	211/100	7.55	164	0.0164	94	0.0094	1.10	0.0001
5	209/800	7.46	120	0.0120	63	0.0063	B.D.L (DL:1)	B.D.L (DL:1)
6	206/800	7.40	109	0.0109	54	0.0054	B.D.L (DL:1)	B.D.L (DL:1)

Table : A.1.1- Chemical Analysis of water

* *BDL - Below Detection Limit*
* *DL - Detection Limit*

Annexure II
(Borelog & Figures)

BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-13/500

ROAD LEVEL : -

DEPTH OF WATER TABLE : NIL

BORE HOLE TERMINATION: 22.50 m

CORRIDOR NO. : CORRIDOR 2

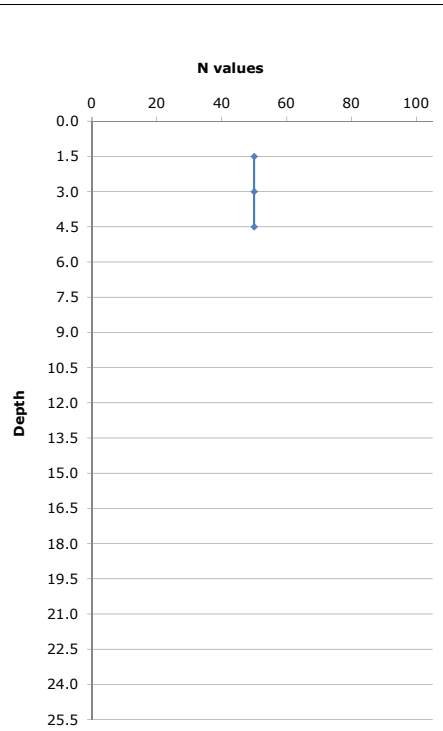
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 15-09-2021 & 18-09-2021

CO-ORDINATES : 13.074773 (Latitude) , 77.505243 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5		SPT			24	50/7cm	Rebound	>50	-	-	-	48.96
	1.5	3.0	4.5	SPT	Soft Disintegrated Rock		50/10cm	Rebound		>50	-	-	-	48.96
	3.0	4.5		SPT			50/2cm	Rebound		>50	-	-	-	48.96
	4.5	6.0		CORE			-	-	-	-	3	NIL	2(SP)+3=5cm	55.00
	6.0	7.5		CORE			-	-	-	-	5	NIL	5+3=8cm	55.00
	7.5	9.0		CORE			-	-	-	-	3	NIL	2+3=5cm	55.00
	9.0	10.5		CORE			-	-	-	-	5	NIL	2+5=7cm	55.00
	10.5	12.0	13.5	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	8	NIL	6+6=12cm	55.00
	12.0	13.5		CORE			-	-	-	-	7	NIL	6+5=11cm	55.00
	13.5	15.0		CORE			-	-	-	-	14	NIL	3+15(SP) +3=21cm	55.00
	15.0	16.5		CORE			-	-	-	-	10	NIL	8+7(SP)=15cm	55.00
	16.5	18.0		CORE			-	-	-	-	7	NIL	4+3+4(SP) =11cm	55.00
	18.0	19.5	1.5	CORE	Gneiss with High weathering (Grade IV)		-	-	-	-	15	15	12+10=22cm	100.00
	19.5	21.0	3.0	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	48	45	26+5+20+21 =72cm	150.00
	21.0	22.5		CORE			-	-	-	-	53	53	16+17+26+21 =80cm	250.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-12/200

ROAD LEVEL : -

DEPTH OF WATER TABLE : 9.00 m

BORE HOLE TERMINATION: 15.00 m

CORRIDOR NO. : CORRIDOR 2

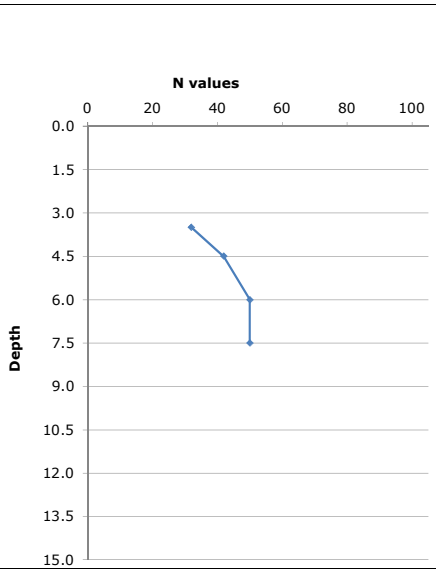
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 20-09-2021 & 22-09-2021

CO-ORDINATES : 13.06783(Latitude), 77.514898 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	1.5	DS	Backfilling		-	-	-	-	-	-	-	-
	1.5	3.0	3.0	UDS	Red and Yellow colored Silty SAND (SM)		-	-	-	-	-	-	-	-
	3.0	3.5		SPT			9	14	18	32	-	-	-	31.33
	3.5	4.5		SPT			12	18	24	42	-	-	-	41.13
	4.5	6.0	3.0	SPT	Soft Disintegrated Rock		18	27	50/7cm	>50	-	-	-	48.96
	6.0	7.5		SPT			50/4cm	Rebound		>50	-	-	-	48.96
	7.5	9.0	3.0	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	7	NIL	2(SP)+4+4=10 cm	55.00
	9.0	10.5		CORE			-	-	-	-	11	NIL	4+8(SP)+3+1 =16cm	55.00
	10.5	12.0	1.5	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	57	39	9+3+5+9+24 +19+16=85cm	190.00
	12.0	13.5	3.0	CORE	Gneiss with Slight weathering (Grade II)		-	-	-	-	69	65	21+6+20+15+ 14+28=104cm	250.00
	13.5	15.0		CORE			-	-	-	-	76	71	22+8+20+31 +33=114cm	250.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-9/300

ROAD LEVEL : -

DEPTH OF WATER TABLE : 10.00m

BORE HOLE TERMINATION: 27.00 m

CORRIDOR NO. : CORRIDOR 2

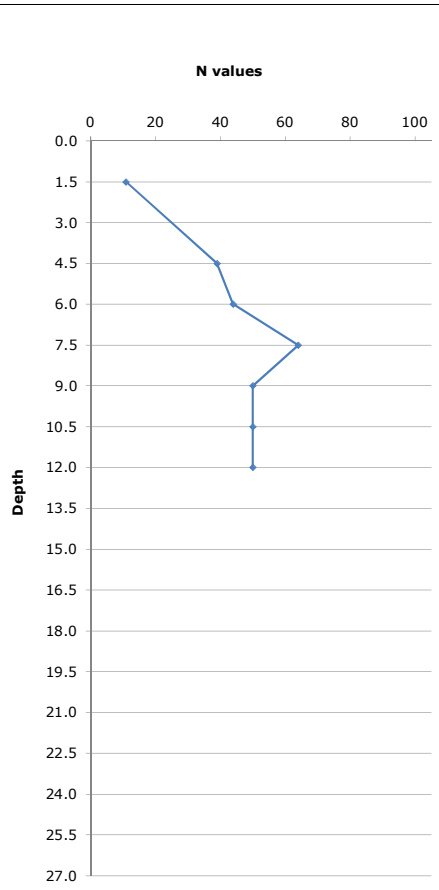
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 24-09-2021 & 28-09-2021

CO-ORDINATES : 13.05145 (Latitude), 77.534511 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5		SPT	Red and Brown colored Silty SAND (SM)		6	5	6	11	-	-	-	10.77
	1.5	3.0		UDS			-	-	-	-	-	-	-	-
	3.0	4.5	7.5	SPT			12	18	21	39	-	-	-	38.19
	4.5	6.0		SPT			15	20	24	44	-	-	-	43.08
	6.0	7.5		SPT			20	28	36	64	-	-	-	48.96
	7.5	9.0		SPT	Soft Disintegrated Rock		24	31	50/10cm	>50	-	-	-	48.96
	9.0	10.5	4.5	SPT			25	34	50/7cm	>50	-	-	-	48.96
	10.5	12.0		SPT			50/4cm	Rebound		>50	-	-	-	48.96
	12.0	13.5		CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	11	NIL	7(SP)+5+4 =16cm	55.00
	13.5	15.0		CORE			-	-	-	-	10	NIL	4+5+6=15cm	55.00
	15.0	16.5		CORE			-	-	-	-	17	NIL	5+6+5+9 =25cm	55.00
	16.5	18.0	9.0	CORE			-	-	-	-	12	NIL	14(SP)+4 =18cm	55.00
	18.0	19.5		CORE			-	-	-	-	25	NIL	5+6+4+22(SP) =37cm	55.00
	19.5	21.0		CORE			-	-	-	-	50	NIL	7+8+8+4+4 +4+4+3+3 +30(SP)=75cm	55.00
	21.0	22.5		CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	48	35	5+6+10+18+9 +14+10=72cm	200.00
	22.5	24.0	4.5	CORE			-	-	-	-	61	49	13+14+11+7 +11+7+5+25 =92cm	230.00
	24.0	25.5		CORE			-	-	-	-	57	51	5+4(SP)+35 +14+12+15 =85cm	230.00
	25.5	27.0	1.5	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	55	8	12+4+5+6+7+ 5+5+6+20(SP) +4+3+6=83cm	60.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-214/100

ROAD LEVEL : -

DEPTH OF WATER TABLE : 15.00m

BORE HOLE TERMINATION: 33.00 m

CORRIDOR NO. : CORRIDOR 2

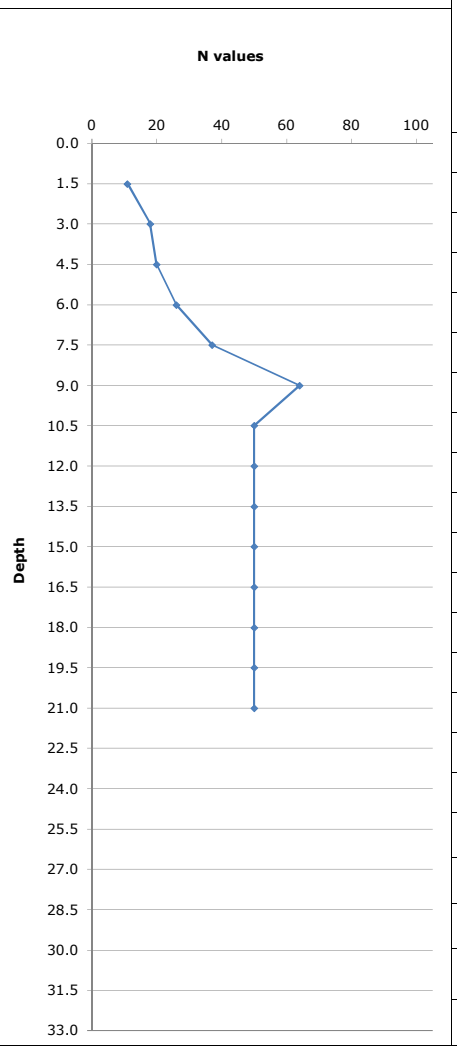
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 16-09-2021 & 20-09-2021

CO-ORDINATES : 13.035395 (Latitude), 77.611146 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	9.0	SPT	Yellow and Brown colored Silty SAND (SM)		4	5	6	11	-	-	-	10.77
	1.5	3.0		SPT			6	8	10	18	-	-	-	17.63
	3.0	4.5		SPT			7	9	11	20	-	-	-	19.58
	4.5	6.0		SPT			11	12	14	26	-	-	-	25.46
	6.0	7.5		SPT			14	17	20	37	-	-	-	36.23
	7.5	9.0		SPT			26	30	34	64	-	-	-	48.96
	9.0	10.5	12.0	SPT	Soft Disintegrated Rock		40	50/10cm	Rebound	>50	-	-	-	48.96
	10.5	12.0		SPT			Rebound			>50	-	-	-	48.96
	12.0	13.5		SPT			Rebound			>50	-	-	-	48.96
	13.5	15.0		SPT			Rebound			>50	-	-	-	48.96
	15.0	16.5		SPT			Rebound			>50	-	-	-	48.96
	16.5	18.0		SPT			Rebound			>50	-	-	-	48.96
	18.0	19.5		SPT			Rebound			>50	-	-	-	48.96
	19.5	21.0		SPT			Rebound			>50	-	-	-	48.96
	21.0	22.5	7.5	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	6	NIL	4+2+3 = 9cm	55.00
	22.5	24.0		CORE			-	-	-	-	6	NIL	5+4 = 9cm	55.00
	24.0	25.5		CORE			-	-	-	-	7	NIL	4+3+4=11cm	55.00
	25.5	27.0		CORE			-	-	-	-	7	NIL	4+3+4=11cm	55.00
	27.0	28.5		CORE			-	-	-	-	12	NIL	5+7+6=18cm	55.00
	28.5	30.0	4.5	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	55	55	18+13+11+10 +10+21=83cm	140.00
	30.0	31.5		CORE			-	-	-	-	60	60	10+10+10+11 +15+12+12+10 =90cm	140.00
	31.5	33.0		CORE			-	-	-	-	52	52	14+19+14+10+ 10+11=78cm	140.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-211/100

ROAD LEVEL : -

DEPTH OF WATER TABLE : 10.5 m

BORE HOLE TERMINATION: 12.00 m

CORRIDOR NO. : CORRIDOR 2

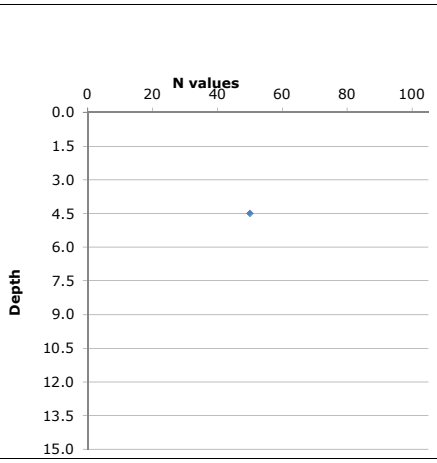
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 08-09-2021 & 09-09-2021

CO-ORDINATES : 13.013371(Latitude), 77.37188 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	3.0	DS	Backfilling		-	-	-	-	-	-	-	-
	1.5	3.0		DS			-	-	-	-	-	-	-	-
	3.0	4.5	1.5	SPT	Soft Disintegrated Rock		Rebound			>50	-	-	-	48.96
	4.5	6.0	3.0	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	7	NIL	4+3+4=11cm	55.00
	6.0	7.5		CORE			-	-	-	-	11	NIL	3+4+5+4 =16cm	55.00
	7.5	9.0	4.5	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	63	45	19+16+9+33+ 9 +8=94cm	100.00
	9.0	10.5		CORE			-	-	-	-	54	44	24+7+15+8+ 10 +17=81cm	100.00
	10.5	12.0		CORE			-	-	-	-	69	48	9+8+12+8+7 +20+21+19 =104cm	110.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-209/800

ROAD LEVEL : -

DEPTH OF WATER TABLE : 13.50 m

BORE HOLE TERMINATION: 22.50 m

CORRIDOR NO. : CORRIDOR 2

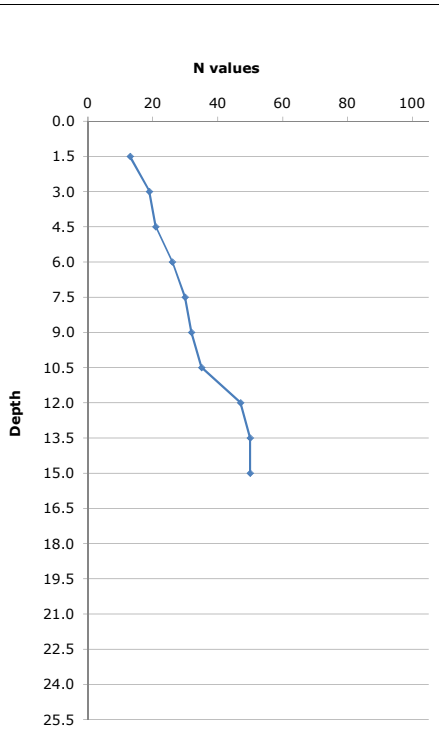
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 22-09-2021 & 25-09-2021

CO-ORDINATES : 13.006136 (Latitude), 77.628426 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	12.0	SPT	Yellow and Brown colored Sandy SILT (ML)		5	6	7	13	-	-	-	12.73
	1.5	3.0		SPT			7	9	10	19	-	-	-	18.60
	3.0	4.5		SPT			9	10	11	21	-	-	-	20.56
	4.5	6.0		SPT			11	12	14	26	-	-	-	25.46
	6.0	7.5		SPT			13	14	16	30	-	-	-	29.38
	7.5	9.0		SPT			14	15	17	32	-	-	-	31.33
	9.0	10.5		SPT			10	17	18	35	-	-	-	34.27
	10.5	12.0		SPT			15	20	27	47	-	-	-	46.02
	12.0	13.5	3.0	SPT	Soft Disintegrated Rock		50/10cm	Rebound		>50	-	-	-	48.96
	13.5	15.0		SPT			50/12cm	Rebound		>50	-	-	-	48.96
	15.0	16.5	1.5	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	13	NIL	2+2+3+2+3+3 +4=19cm	55.00
	16.5	18.0	1.5	CORE	Gneiss with High weathering (Grade IV)		-	-	-	-	45	23	13+10+8+7+11 +8+6+5=68cm	80.00
	18.0	19.5	1.5	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	43	33	23+8+16+11 +7=65cm	120.00
	19.5	21.0	3.0	CORE	Gneiss with High weathering (Grade IV)		-	-	-	-	34	22	5+7+6+11+12 +10=51cm	100.00
	21.0	22.5		CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	50	50	75cm	120.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-206/800

ROAD LEVEL : -

DEPTH OF WATER TABLE : 12.00m

BORE HOLE TERMINATION: 27.00 m

CORRIDOR NO. : CORRIDOR 2

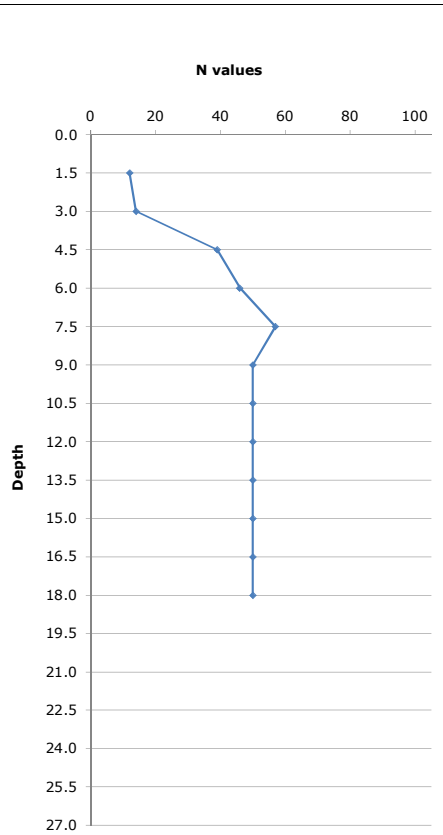
ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 11-09-2021 & 14-09-2021

CO-ORDINATES : 13.004616 (Latitude), 77.654765 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	9.0	SPT	Yellow and Brown colored Silty SAND (SM)		4	5	7	12	-	-	-	11.75
	1.5	3.0		SPT			5	6	8	14	-	-	-	13.71
	3.0	4.5		SPT			14	18	21	39	-	-	-	38.19
	4.5	6.0		SPT			17	21	25	46	-	-	-	45.04
	6.0	7.5		SPT			20	27	30	57	-	-	-	48.96
	7.5	9.0		SPT			Rebound			>50	-	-	-	48.96
	9.0	10.5	9.0	SPT	Soft Disintegrated Rock		Rebound			>50	-	-	-	48.96
	10.5	12.0		SPT			Rebound			>50	-	-	-	48.96
	12.0	13.5		SPT			Rebound			>50	-	-	-	48.96
	13.5	15.0		SPT			Rebound			>50	-	-	-	48.96
	15.0	16.5		SPT			Rebound			>50	-	-	-	48.96
	16.5	18.0		SPT			Rebound			>50	-	-	-	48.96
	18.0	19.5	4.5	CORE	Gneiss with Complete weathering (Grade V)		-	-	-	-	12	NIL	5+9+4=18cm	55.00
	19.5	21.0		CORE			-	-	-	-	11	NIL	4+3+4 +6=17cm	55.00
	21.0	22.5		CORE			-	-	-	-	22	NIL	4+6+5+8+6 +4=33cm	55.00
	22.5	24.0	4.5	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-	53	53	18+16+11+10 +10+15=80cm	150.00
	24.0	25.5		CORE			-	-	-	-	51	45	22+10+11+13 +9+12=77cm	150.00
	25.5	27.0		CORE			-	-	-	-	47	47	21+10+14+10 +15=70cm	150.00

Depth Vs N Value



BORE LOG (SOIL & ROCK)

MPAC PVT. LTD.

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-205/100

ROAD LEVEL : -

DEPTH OF WATER TABLE : NIL

BORE HOLE TERMINATION: 10.50 m

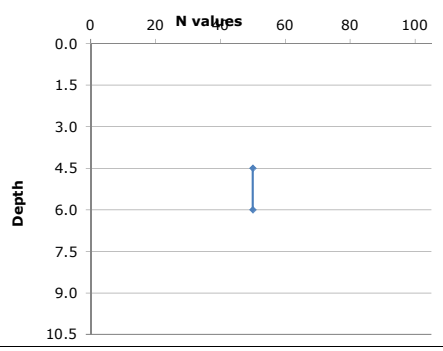
CORRIDOR NO. : CORRIDOR 2

ELEVATED/AT GRADE/GATE : ELEVATED

DATE OF START & FINISH : 10-09-2021 & 13-09-2021

CO-ORDINATES : 12.994843 (Latitude), 77.662819 (Longitude)

Reduced Level	Depth (m) From	Depth (m) To	Thickness of Layer (m)	Type	Description	Profile	SPT Test 0.0 -0.15 m	SPT Test 0.15 - 0.30 m	SPT Test 0.30 -0.45 m	SPT Test N Value	Depth Vs N Value	Core Recovery (%)	RQD (%)	Remarks	Bearing capacity Values (t/m^2)
	0.0	1.5	3.0	DS	Backfilling		-	-	-	-		-	-	-	
	1.5	3.0					-	-	-	-		-	-	-	
	3.0	4.5	3.0	SPT	Yellow and Brown colored Sandy SILT (ML)		21	50/8cm	Rebound	>50		-	-	-	48.96
	4.5	6.0		SPT			50/4cm	Rebound		>50		-	-	-	48.96
	6.0	7.5	3.0	CORE	Gneiss with Moderate weathering (Grade III)		-	-	-	-		61	46	7+4+3+8+17 +17+23+12 =91cm	150.00
	7.5	9.0		CORE			-	-	-	-		61	56	8+12+17 +55=92cm	190.00
	9.0	10.5	1.5	CORE	Gneiss with Slight weathering (Grade II)		-	-	-	-		71	67	25+63+12 +7=107cm	220.00



Annexure III
(Soil & Rock Results)

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-13/500

Date of testing : 01/10/2021 to 03/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample			Specific Gravity of soil	Atterberg Limits (%)			Shear Parameters of soil				Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)		Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)			
0.0	1.5	SPT	-	-	-	-	-	-	-	1.87	1.70	10	-	-	-	-	-	-	-	-	-	-	-
1.5	3.0	SPT	-	-	-	-	-	-	-	1.91	1.79	7	-	-	-	-	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	-	-	-	-	1.95	1.86	5	-	-	-	-	-	-	-	-	-	-	-
4.5	6.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.0	7.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.5	9.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.0	10.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.5	12.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.0	13.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.5	15.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.0	16.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.5	18.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.0	19.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	95.9	-
19.5	21.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	110.2	-
21.0	22.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	113.6	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-12/200

Date of testing : 01/10/2021 to 03/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample				Atterberg Limits (%)			Shear Parameters of soil							
										Density (g/cc)							Direct shear test		Unconfined compression test					
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)	Specific Gravity of soil	Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)	Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
0.0	1.5	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	3.0	UDS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.0	3.5	SPT	-	-	-	10	52	28	10	1.68	1.50	12	2.62	23	NP	NP	-	-	-	-	-	-	-
3.5	4.5	SPT	-	-	-	11	53	25	11	1.73	1.59	9	2.64	22	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	-	-	-	-	1.91	1.82	5	-	-	-	-	-	-	-	-	-	-	-
6.0	7.5	SPT	-	-	-	-	-	-	-	1.92	1.83	5	-	-	-	-	-	-	-	-	-	-	-
7.5	9.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.0	10.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.5	12.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58.9	-
12.0	13.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	61.2	-
13.5	15.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68.9	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-9/300

Date of testing : 01/10/2021 to 03/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample			Specific Gravity of soil	Atterberg Limits (%)			Shear Parameters of soil				Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)		Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)			
0.0	1.5	SPT	11	58	31	-	-	-	-	1.53	1.35	13	2.62	25	NP	NP	-	-	-	-	-	-	-
1.5	3.0	UDS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	11	53	28	8	1.69	1.54	10	2.64	26	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	10	54	30	6	1.73	1.57	10	2.65	24	NP	NP	-	-	-	-	-	-	-
6.0	7.5	SPT	-	-	-	10	54	31	5	1.74	1.60	9	2.67	24	NP	NP	-	-	-	-	-	-	-
7.5	9.0	SPT	-	-	-	-	-	-	-	1.82	1.72	6	-	-	-	-	-	-	-	-	-	-	-
9.0	10.5	SPT	-	-	-	-	-	-	-	1.86	1.77	5	-	-	-	-	-	-	-	-	-	-	-
10.5	12.0	SPT	-	-	-	-	-	-	-	1.91	1.82	5	-	-	-	-	-	-	-	-	-	-	-
12.0	13.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.5	15.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.0	16.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.5	18.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.0	19.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.5	21.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.0	22.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.1	-
22.5	24.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.5	-
24.0	25.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.5	-
25.5	27.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-214/100

Date of testing : 03/10/2021 to 04/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample				Atterberg Limits (%)			Shear Parameters of soil						
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)	Specific Gravity of soil	Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)	Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
0.0	1.5	SPT	14	58	28	-	-	-	-	1.58	1.37	15	2.59	24	NP	NP	-	-	-	-	-	-	-
1.5	3.0	SPT	13	62	25	-	-	-	-	1.61	1.42	13	2.61	26	NP	NP	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	4	55	31	10	1.63	1.46	12	2.62	25	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	9	53	30	8	1.65	1.47	12	2.62	25	NP	NP	-	-	-	-	-	-	-
6.0	7.5	SPT	-	-	-	7	57	28	8	1.65	1.50	10	2.64	23	NP	NP	-	-	-	-	-	-	-
7.5	9.0	SPT	-	-	-	5	59	29	7	1.68	1.54	9	2.66	23	NP	NP	-	-	-	-	-	-	-
9.0	10.5	SPT	-	-	-	-	-	-	-	1.75	1.61	9	-	-	-	-	-	-	-	-	-	-	-
10.5	12.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.0	13.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.5	15.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.0	16.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.5	18.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.0	19.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.5	21.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.0	22.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.5	24.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.0	25.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25.5	27.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.0	28.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28.5	30.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.8	-
30.0	31.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29.5	-
31.5	33.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.9	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-211/100

Date of testing : 03/10/2021 to 04/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample				Atterberg Limits (%)			Shear Parameters of soil						
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)	Specific Gravity of soil	Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)	Consolidation test [Compression Index (C_c)]	Unconfined Compression test of Rock (Mpa)	Remarks
0.0	1.5	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	3.0	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.5	6.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.0	7.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.5	9.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.5	-
9.0	10.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.6	-
10.5	12.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.4	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-209/800

Date of testing : 05/10/2021 to 06/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample				Atterberg Limits (%)			Shear Parameters of soil						
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)	Specific Gravity of soil	Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)	Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
0.0	1.5	SPT	11	29	60	-	-	-	-	1.55	1.35	15	2.57	28	NP	NP	-	-	-	-	-	-	-
1.5	3.0	SPT	11	31	58	-	-	-	-	1.59	1.41	13	2.59	26	NP	NP	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	9	24	56	11	1.62	1.42	14	2.61	27	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	9	26	52	13	1.63	1.46	12	2.63	25	NP	NP	-	-	-	-	-	-	-
6.0	7.5	SPT	-	-	-	11	25	54	10	1.65	1.49	11	2.62	26	NP	NP	-	-	-	-	-	-	-
7.5	9.0	SPT	-	-	-	11	24	56	9	1.67	1.49	12	2.62	25	NP	NP	-	-	-	-	-	-	-
9.0	10.5	SPT	-	-	-	10	20	61	9	1.71	1.55	10	2.65	23	NP	NP	-	-	-	-	-	-	-
10.5	12.0	SPT	-	-	-	9	23	58	10	1.79	1.63	10	2.67	22	NP	NP	-	-	-	-	-	-	-
12.0	13.5	SPT	-	-	-	-	-	-	-	1.85	1.73	7	-	-	-	-	-	-	-	-	-	-	-
13.5	15.0	SPT	-	-	-	-	-	-	-	1.92	1.79	7	-	-	-	-	-	-	-	-	-	-	-
15.0	16.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.5	18.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.4	-
18.0	19.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55.6	-
19.5	21.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60.1	-
21.0	22.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68.8	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-206/800

Date of testing : 05/10/2021 to 06/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample			Specific Gravity of soil	Atterberg Limits (%)			Shear Parameters of soil				Consolidation test [Compression Index (C_c)]	Unconfined Compression test of Rock (Mpa)	Remarks
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)		Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)			
0.0	1.5	SPT	9	59	32	-	-	-	-	1.55	1.36	14	2.62	24	NP	NP	-	-	-	-	-	-	-
1.5	3.0	SPT	-	-	-	10	50	29	11	1.62	1.45	12	2.64	23	NP	NP	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	9	49	30	12	1.64	1.49	10	2.65	22	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	8	49	31	12	1.66	1.54	8	2.66	23	NP	NP	-	-	-	-	-	-	-
6.0	7.5	SPT	-	-	-	9	51	30	10	1.69	1.56	8	2.66	23	NP	NP	-	-	-	-	-	-	-
7.5	9.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.0	10.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.5	12.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.0	13.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.5	15.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.0	16.5	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.5	18.0	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.0	19.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.5	21.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.0	22.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.5	24.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56.5	-
24.0	25.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62.9	-
25.5	27.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72.7	-

SOIL & ROCK RESULTS

Geo-Technical Investigation works and Associated works for Corridor–2 Bangalore Sub urban Railway Project

BH.NO: BH-205/100

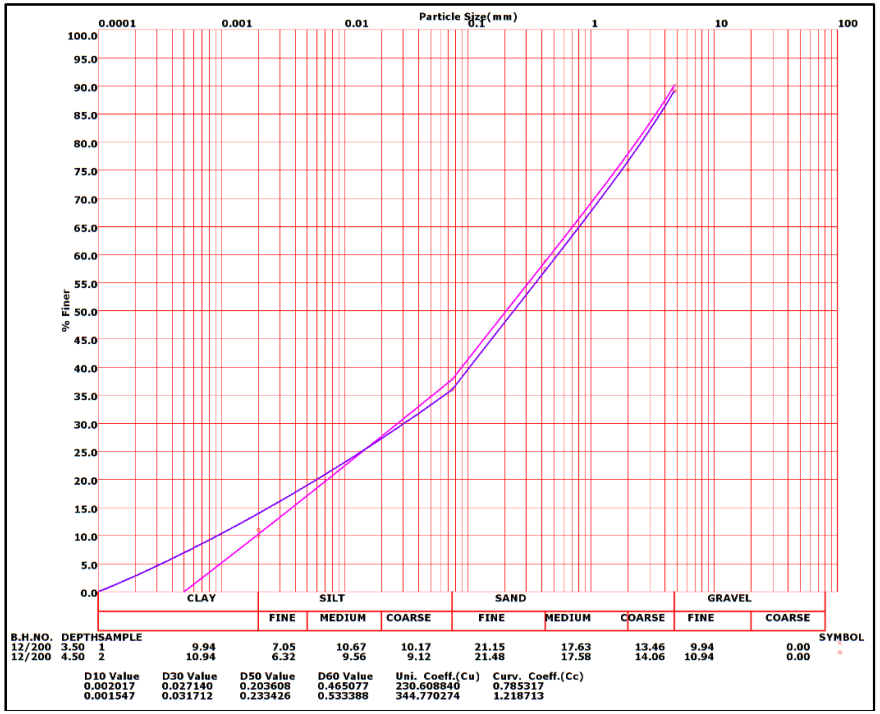
Date of testing : 05/10/2021 to 06/10/2021

Depth (m)			Grain size distribution by sieving (%)			Grain size distribution by Hydrometer analysis (%)				UD / DS sample				Atterberg Limits (%)			Shear Parameters of soil						
										Density (g/cc)							Direct shear test		Unconfined compression test				
From	To	Type	Gravel	Sand	Silt & Clay	Gravel	Sand	Silt	Clay	Bulk Density	Dry Density	Natural Moisture Content (%)	Specific Gravity of soil	Liquid Limit	Plastic imit	Plasticity Index	C (kPa)	phi (degrees)	C (kPa)	phi (degrees)	Consolidation test [Compression Index (C c)]	Unconfined Compression test of Rock (Mpa)	Remarks
0.0	1.5	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	3.0		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.0	4.5	SPT	-	-	-	8	30	50	12	1.62	1.50	8	2.63	21	NP	NP	-	-	-	-	-	-	-
4.5	6.0	SPT	-	-	-	8	29	53	10	1.65	1.53	8	2.65	21	NP	NP	-	-	-	-	-	-	-
6.0	7.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80.2	-
7.5	9.0	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80.7	-
9.0	10.5	CORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85.2	-

Annexure IV
(Graphs)

Grain Size Analysis Graphs

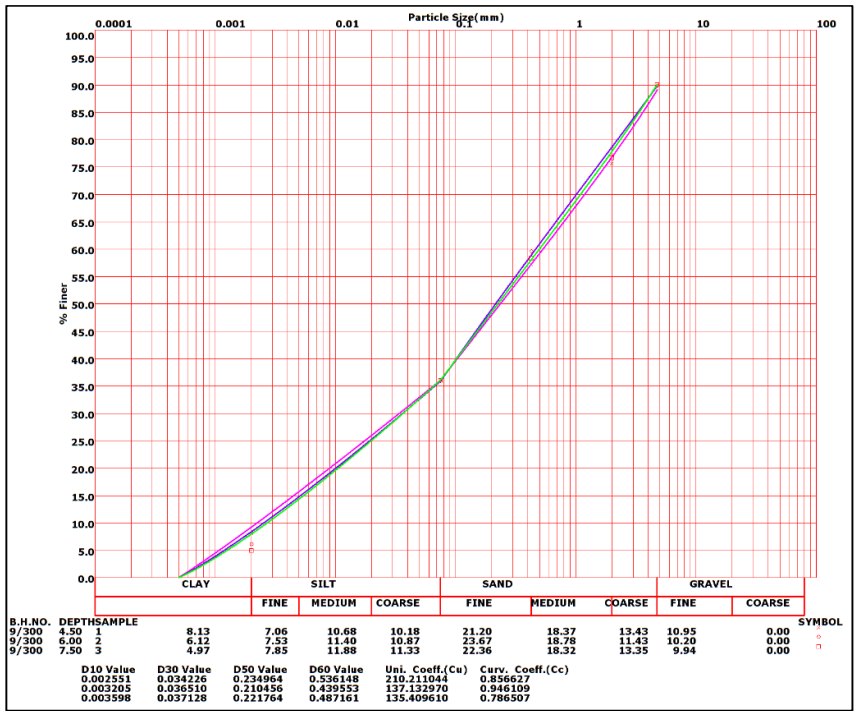
BH-12/200



B.H.NO.	DEPTH	SAMPLE									SYMBOL
12/200	3.50	1	9.94	7.05	10.67	10.17	21.15	17.63	13.46	9.94	0.00
12/200	4.50	2	10.94	6.32	9.56	9.12	21.48	17.58	14.06	10.94	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.002017	0.027140	0.203608	0.465077	230.608840	0.785317
0.001547	0.031712	0.233426	0.533388	344.770274	1.218713

BH-9/300

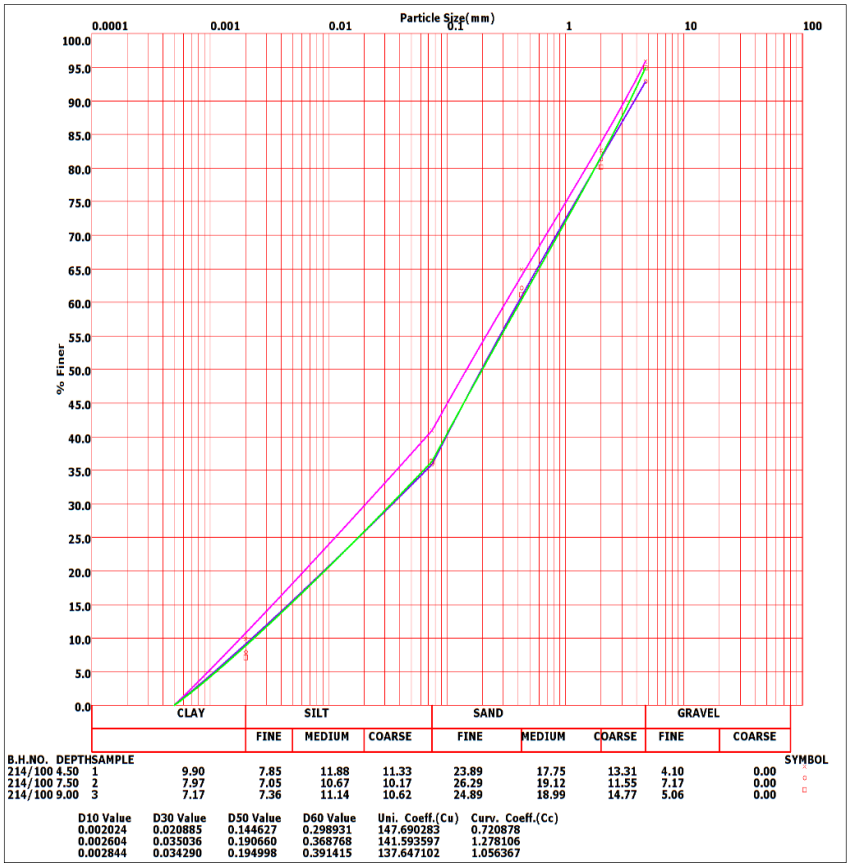


B.H.NO.	DEPTH	SAMPLE									SYMBOL
9/300	4.50	1	8.13	7.06	10.68	10.18	21.20	18.37	13.43	10.95	0.00
9/300	6.00	2	6.12	7.53	11.40	10.87	23.67	18.78	11.43	10.20	0.00
9/300	7.50	3	4.97	7.85	11.88	11.33	22.36	18.32	13.35	9.94	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.002551	0.034226	0.234964	0.536148	210.211044	0.856627
0.003205	0.036510	0.210456	0.439553	137.132970	0.946109
0.003598	0.037128	0.221764	0.487161	135.409610	0.786507

Grain Size Analysis Graphs

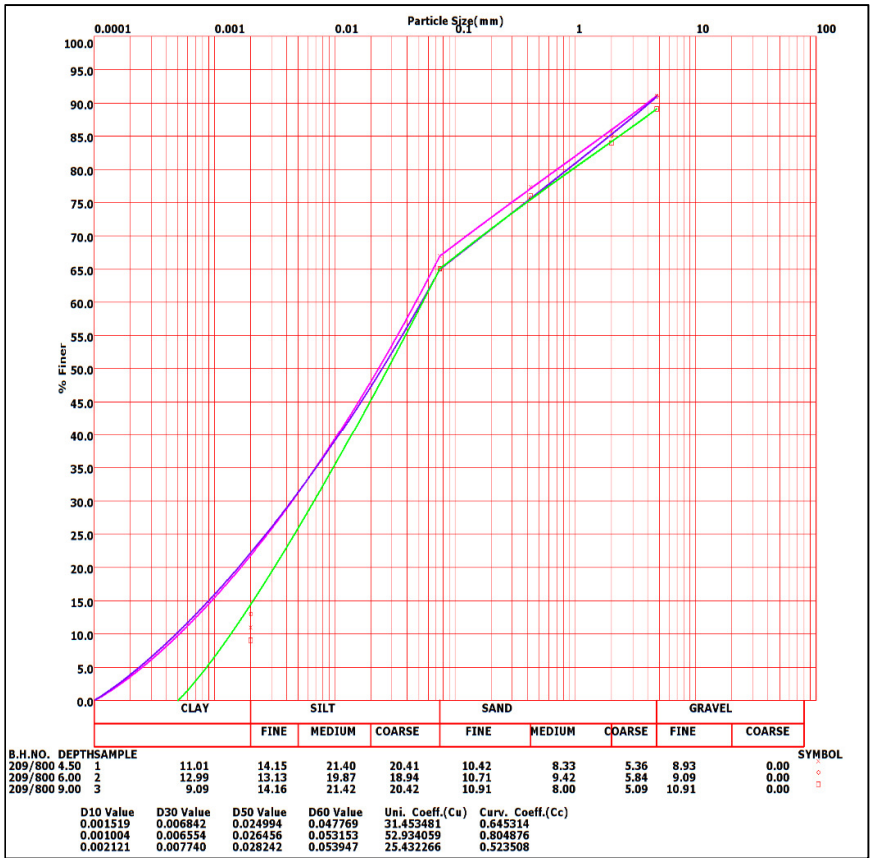
BH-214/100



B.H.NO.	DEPTH	SAMPLE									SYMBOL
214/100	4.50	1	9.90	7.85	11.88	11.33	23.89	17.75	13.31	4.10	0.00
214/100	7.50	2	7.97	7.05	10.67	10.17	26.29	19.12	11.55	7.17	0.00
214/100	9.00	3	7.17	7.36	11.14	10.62	24.89	18.99	14.77	5.06	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.002024	0.020885	0.144627	0.298931	147.690283	0.720878
0.002604	0.035036	0.190660	0.368768	141.593597	1.278106
0.002844	0.034290	0.194998	0.391415	137.647102	1.056367

BH-209/800

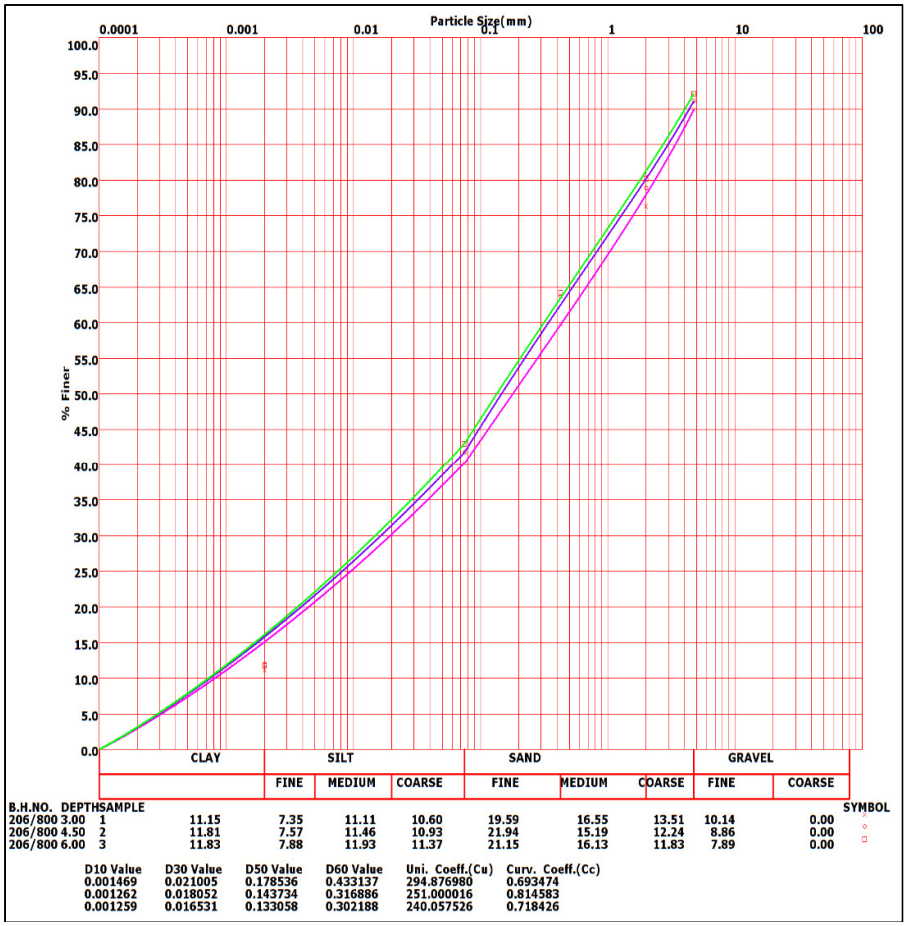


B.H.NO.	DEPTH	SAMPLE									SYMBOL
209/800	4.50	1	11.01	14.15	21.40	20.41	10.42	8.33	5.36	8.93	0.00
209/800	6.00	2	12.99	13.13	19.87	18.94	10.71	9.42	5.84	9.09	0.00
209/800	9.00	3	9.09	14.16	21.42	20.42	10.91	8.00	5.09	10.91	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.001519	0.006842	0.024994	0.047769	31.453481	0.645314
0.001004	0.006554	0.026456	0.053153	52.934059	0.804876
0.002121	0.007740	0.028242	0.053947	25.432266	0.523508

Grain Size Analysis Graphs

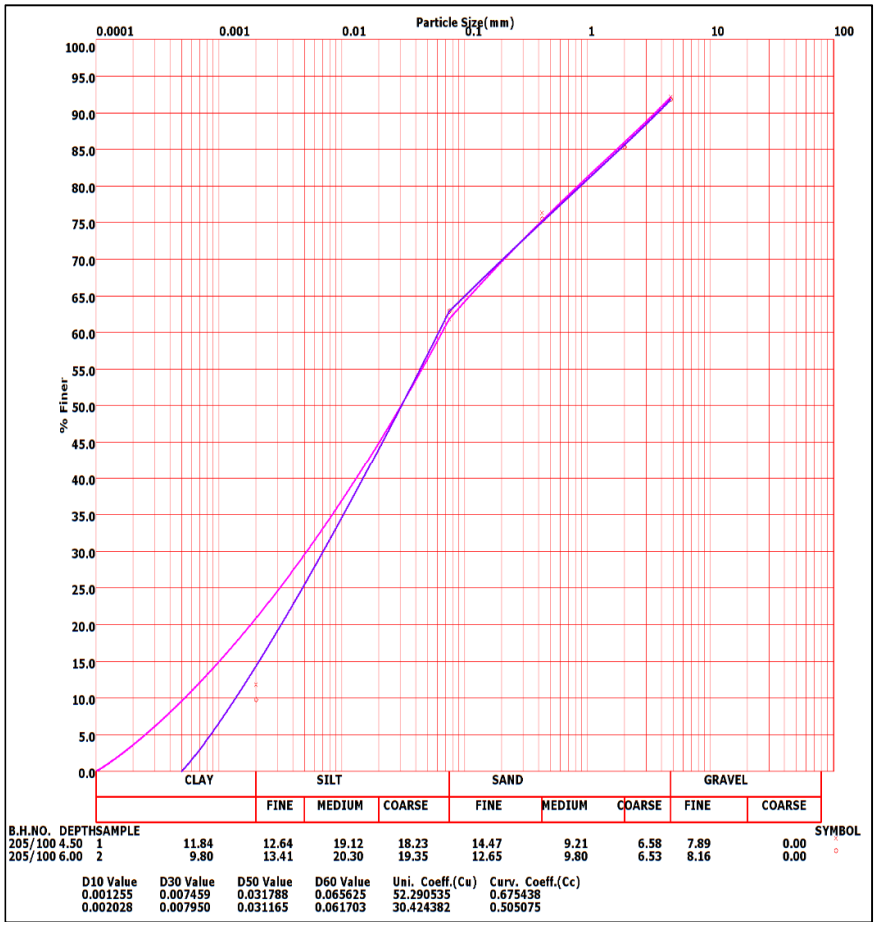
BH-206/800



B.H.NO.	DEPTH	SAMPLE									SYMBOL
206/800	3.00	1	11.15	7.35	11.11	10.60	19.59	16.55	13.51	10.14	0.00
206/800	4.50	2	11.81	7.57	11.46	10.93	21.94	15.19	12.24	8.86	0.00
206/800	6.00	3	11.83	7.88	11.93	11.37	21.15	16.13	11.83	7.89	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.001469	0.021005	0.178536	0.433137	294.876980	0.693474
0.001262	0.018052	0.143734	0.316886	251.000016	0.814583
0.001259	0.016531	0.133058	0.302188	240.057526	0.718426

BH-205/100



B.H.NO.	DEPTH	SAMPLE									SYMBOL
205/100	4.50	1	11.84	12.64	19.12	18.23	14.47	9.21	6.58	7.89	0.00
205/100	6.00	2	9.80	13.41	20.30	19.35	12.65	9.80	6.53	8.16	0.00

D10 Value	D30 Value	D50 Value	D60 Value	Uni. Coeff.(Cu)	Curv. Coeff.(Cc)
0.001255	0.007459	0.031788	0.065625	52.290535	0.675438
0.002028	0.007950	0.031165	0.061703	30.424382	0.505075

Annexure V
(Laboratory Test Photos)

LAB TEST PHOTOS

Grain Size Analysis (Soil)	Hydrometer Analysis (Soil)	Moisture Content Test (Soil)
		
Specific Gravity (Soil)	**Density (Soil)**	**Liquid Limit (Soil)**
		
Plastic Limit (Soil)	**UCS (Rock)**	
		

END OF SECTION

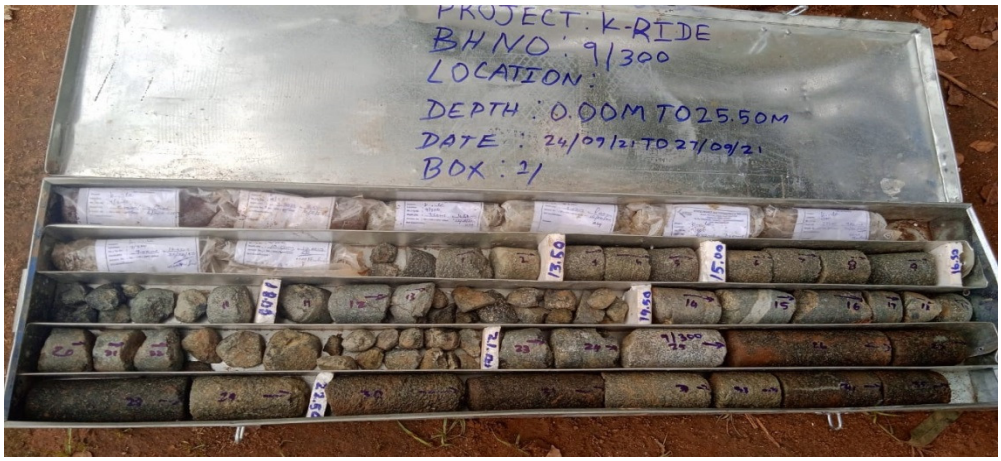
Annexure VI
(Site Photos)

Core Boxes

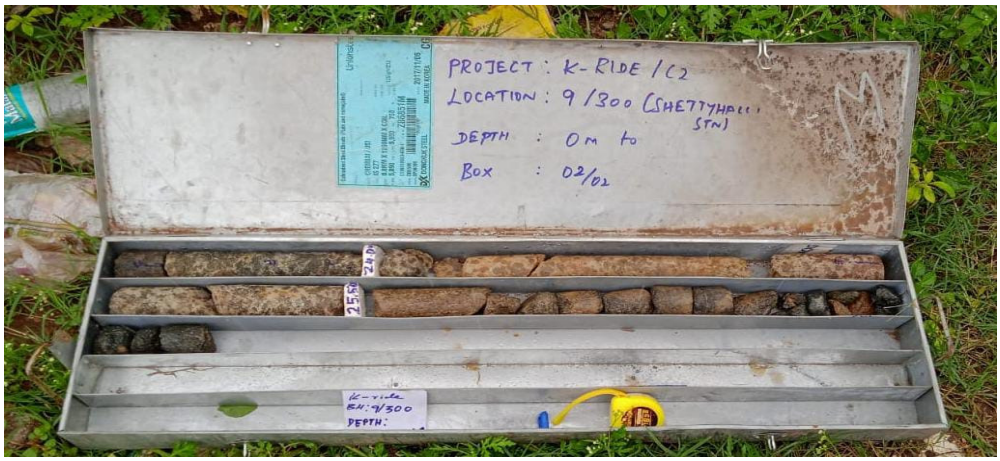
BH-13/500

BH-12/200

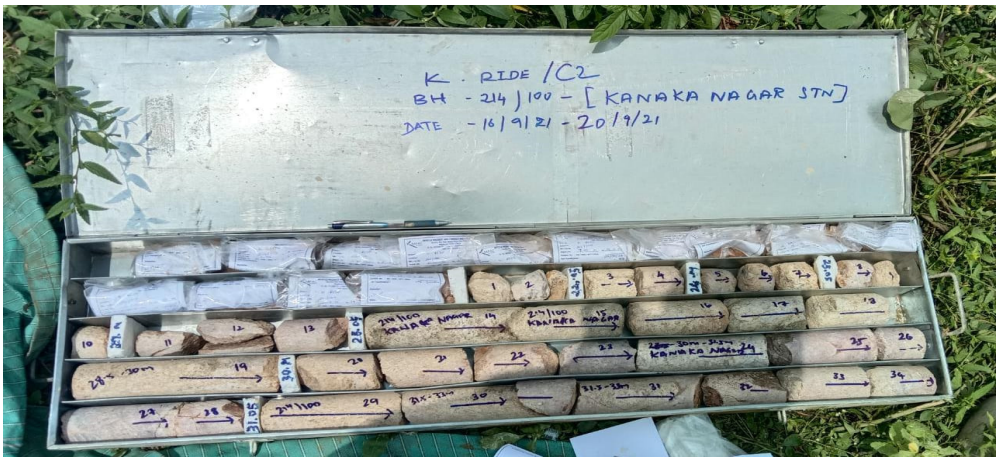
BH-9/300 (1st Box)



BH-9/300 (2nd Box)



BH-214/100

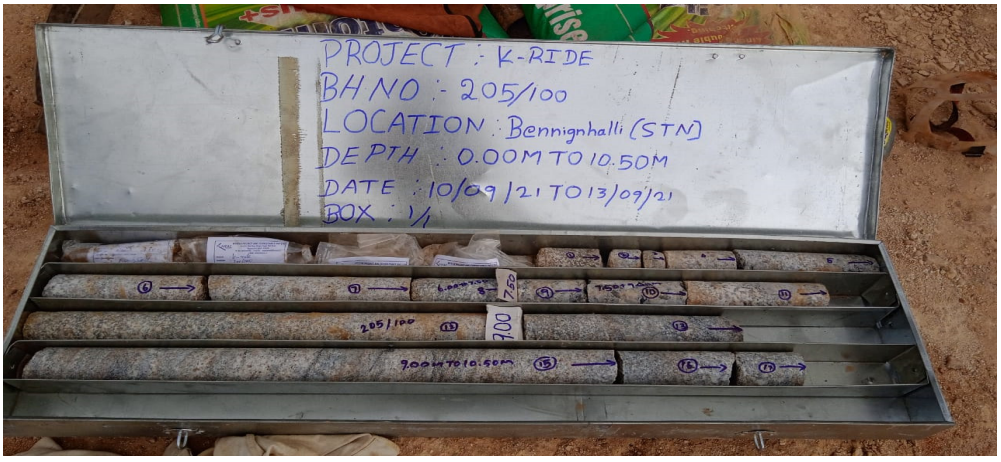


BH-211/100

BH-209/800

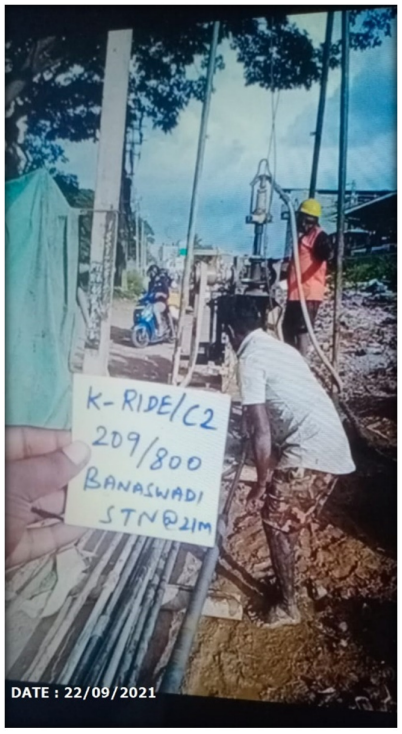
BH-206/800

BH-205/100



END OF SECTION

Field Photos



END OF SECTION