GEOTECHNICAL INVESTIGATION WORK

All Major Bridges

CLIENTS NAME: Gujarat Rail Infrastructure Development Corporation Limited

BY

Bhajan
InfraTech Pvt. Ltd.

1003/B, Jolly Enclave, Opp. Panchvati wadi, Nr. Varachha (E) Zone office,
L. H. Road, Surat – 395006. (M): +91-9725001300.
Email: mail@bhajanec.com

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ABBREVIATION

C	Cohesion
DS	Disturbed Sample
UDS	Undisturbed Sample
SPT	Standard Penetration Test
GWT	Ground Water Table
EGL	Existing Ground Level
SBC	Safe Bearing Capacity
BH	Borehole
FOS	Factor of Safety
Γ	Density of Soil
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non-Plastic
DST	Direct Shear Test

IS CLASSIFICATION

GW:	Well Graded Gravels
GP:	Poorly Graded Gravels
GM:	Silty Gravels
GC:	Clayey Gravels
SW:	Well Graded Sands
SP:	Poorly Graded Sands
SC:	Clayey Sands
SM:	Silty Sands
ML:	Inorganic Silt with Non to low Plasticity
CL:	Inorganic Clay with low Plasticity
OL:	Organic Silts and Organic Silty Clay of Low Plasticity
MI:	Inorganic Silt with Non to Medium Plasticity
CI:	Inorganic Clay with Medium Plasticity
OI:	Organic Silts and Organic Silty Clay of Medium Plasticity
MH:	Inorganic Silt with Non to High Plasticity
CH:	Inorganic Clay with High Plasticity
OH:	Organic Silts and Organic Silty Clay of High Plasticity
Pt:	Peat and other Highly Organic Soil with Very High Compressibility

1. INTRODUCTION

Gujarat Rail Infrastructure Development Corporation Limited Proposed to Conduct "Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.". Accordingly, land soil investigations were envisaged to evolve various soil parameters in order to carry out engineering analysis and foundation design. In this connection, the soil investigation work was awarded to "**Bhajan InfraTech Private Limited, Surat**" to carry out land soil investigation at the proposed site.

Broad objectives of the investigation are as follows,

a) To evaluate the parameters of soil at the proposed site.
b) To assess the engineering parameters and to estimate the safe bearing capacity of soil.

2. FIELD WORK

2.1 Boring

The exploratory borehole of 100mm diameter was drilled by Rotary drilling method without casing. The depth of the test bore at the proposed location is as under:

Bore Hole No.	As per Summery Sheet
Location	As per Summery Sheet
Depth of Borehole below EGL(m)	As per Below Report

2.2 Sampling

2.2.1 Disturbed Samples

Disturbed samples were collected during the boring and also from the split spoon sampler. The samples recovered were logged, labelled and placed in polythene bags and sent to laboratory for testing.

2.2.2 Undisturbed Samples

Undisturbed soil samples were collected in thin-walled Shelby tubes and using piston type sampler as per IS-2132. The samples were sealed with wax, labelled and transported to our laboratory at Surat for testing.

2.2.3 Standard Penetration Test

The Standard Penetration Tests (SPT) (IS-2131, 1981) was carried out in the bore hole at predetermined depths. It gives indirect evaluation of strength–deformation characteristics of the sub soil. The test includes driving a split spoon sampler using a 63.5 kg hammer with a free fall of 750mm. The first 15cm is considered as seating drive. The No. of blows required to penetrate next 30 cm is reported as N-value. Empirical relations are established to correlate N-Value with the shear parameters or bearing capacity of soil. A disturbed soil sample is collected inside the split spoon sampler which can be used to find soil classification and In-situ water content. If the no. of blows exceeds 50 before desired penetration is achieved, it is reported as N-value >50 with the actual achieved.

3. LABORATORY WORK

Following laboratory tests are carried out to determine the physical and engineering properties of undisturbed and disturbed soil samples.

1. Dry Density and Natural Moisture Content (IS– 2720, Part -- Il)
2. Particle Size Analysis (IS - 2720, Part --IV, 1985)
3. Atterberg's Limit (IS -2720, Part -V, 1985)
4. Free Swell Index;(IS – 2720, Part -40, 1977)
5. Specific Gravity (IS -2720, Part III -1980)
6. Shear Test (IS:2720, Part-XI)

4. PHYSICAL PROPERTIES OF SOIL

4.1 Natural Moisture Content & Field Dry Density

The weight of undisturbed soil sample with sampler (Shelby tube) is determined after removing paraffin wax and loose soil. The total length of soil sample recovery is determined after deducting empty length from the total length of sampler. The volume of soil mass retained in sampler is thus determined from the known inside diameter of sampler and total length of soil mass. The soil mass is then removed and the average moisture content is determined by keeping the soil sample along with crucible in oven at 100-105 degree centigrade for 24 hours. The empty weight of the sampler is then found out. From the total weight of sampler with soil mass, the weight of empty sampler is deducted.

4.2 Particle Size Analysis

The sieve analysis is carried out in accordance with IS-2720, Part-IV, 1985. The results are presented in the form of Grain size distribution curve.

❖ **Soil fraction passing 4.75 IS Sieve**

The portion of the soil passing 4.75 mm ISS is oven dried at 105°C to 110°C. The portion is coned & quartered to obtain required representative quantity of the material. The material is weighed and. placed in tray/bucket filled with water for soaking and loosening the adhered cohesive materials. The soaked soil specimen is then washed on 75 microns IS Sieve until the water passing the sieve is almost clear. The material retained on 75 microns IS Sieve is then transferred in a tray, dried in oven.

Sieve analysis is then conducted on a nest of sieves (viz. 2 mm, 425- and 75-micron ISS) either by hand or by using mechanical sieve shaker. The fraction retained on each of the sieves is weighed separately and masses recorded. Cumulative mass of soil fraction retained on each sieve is then calculated. The weights are then converted into cumulative percentage retained and passing on the basis of the mass of the sample passing 4. 75 ISS taken. The combined gradation on the basis of the total sample taken for analysis is finally calculated.

4.3 Atterberg's Limit

Liquid, Plastic and Shrinkage Limits are determined by using procedure given in IS: 2720, Part-V, 1985.

4.3.1 Liquid Limit

The cylindrical cup of cone penetrometer ensuring that no air is trapped in this process. Finally, the wet soil is levelled up to the top of the cup and placed on the base of the cone penetrometer apparatus. The penetrometer shall be adjusted that the cone point just touches the surface of the soil paste in the cup clamped obtained 200 gm in of soil sample shall be worked well into a paste with addition of distil water. In the case of highly clayey soils, to ensure uniform moisture distribution, it is recommended that the soil in the mixed state is left for sufficient time (24 hours) in an air-tight container. The wet soil paste shall then be transferred in to in this position. The initial reading is either adjusted to zero or noted down as is shown on the graduated scale. The vertical clamp is then released allowing the cone to penetrate in to the soil paste under its own weight.

The penetration of the cone after 5 sec. shall be noted to the nearest millimetres. If the difference in penetration lies between 14 and 28 mm, the test is repeated with suitable adjustment to moisture either by addition of more water or exposure of the spread paste on a glass plate for reduction in moisture content. The test shall then be repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. The exact moisture content of each trial shall be determined.

A graph representing water content on the y-axis and cone penetration on the x-axis. The best fitting straight line is then drawn. The moisture content corresponding to cone penetration of 20 mm shall be taken as the liquid limit of the soil and shall be expressed to the nearest first decimal place.

4.3.2 Plastic Limit

For determination of plastic limit, a soil sample weighing at least 20 gm from the soil sample passing 425 microns IS sieve is thoroughly mixed with water such that it can be easily moulded with fingers. A ball is formed with about 8 to 10 gm of this soil & is rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter of 3mm throughout its length. The soil is then kneaded together to a uniform mass and rolled again. The process is continued until the thread crumbles. The pieces of crumbled soil thread are collected and moisture content is determined and reported as plastic limit.

4.3.3 Shrinkage Limit

The procedure for carrying out Shrinkage limit test on remoulded soil sample is given here. About 30 g of dry pulverized soil passing 425-micron sieve is weight out. The soil sample is placed in the evaporating dish & bubbles. The water content to from the paste may be readily worked into without entrapping air cleaned, dried and weighed. The inside of the cleaned Shrinkage dish is coated with a thin layer of Vaseline or heavy grease to prevent adhesion of soil to the dish. The soil pastes equal to roughly one third the volume of the Shrinkage dish is placed in the centre of the dish & the paste is allowed to flow to the edges by tapping the dish on a firm surface cushioned with a few layers of blotting paper or similar material. Then another equal quantity of paste is added & the dish tapped so that all the air bubbles entrapped come to the top & the paste gets compacted. The process is continued till the paste fills the dish completely and starts overflowing. The excess paste is struck off level with the top edge of the Shrinkage dish by a straight edge and the outside of the dish is wiped clean.

The dish with the soil sample is immediately weighed and then the soil sample in the dish is allowed to dry in air till the colour of the pat becomes lighter. The dish with the soil sample is then kept in an oven at 105°c to 110°c to constant weight, cooled in a desiccator and weighed to find the weight of dish and the dry pat of soil sample. The weight of the clean, empty dish is determined so that the weight of dry pat of soil sample can be calculated.

The volume of the Shrinkage dish is found by pouring mercury until it overflows, removing the excess by pressing the plain glass plate flush with surface of glass cup. The weight of mercury in the Shrinkage dish is

found to an accuracy of 0.1 g. The volume of the Shrinkage dish is calculated by dividing the weight of mercury by the unit weight of mercury (13.59 g\m1). The volume the Shrinkage dish may also be determined by pouring the mercury from the dish into the graduated jar, as an additional check.

4.4 Specific Gravity

The specific gravity of soil solids is determined by a 50ml density bottle. The weight (W1) of the empty dry bottle is taken first. A sample of oven-dried soil about 10-20 g cooled in a desiccator, is put in the bottle, and weight (W2) of the bottle and the soil is taken. The bottle is then filled with distilled water gradually removing the entrapped air either by applying vacuum or by shaking the bottle. The weight (W3) of the bottle, soil and water (full up to the top) is then taken. Finally, the bottle is emptied completely and thoroughly washed and clean water is filled to the top and the weight (W4) is taken.

$$\textbf{Specific Gravity (G)} = (W_2 - W_1) / [(W_2 - W_1) - (W_3 - W_4)]$$

4.5 Free Swell Index

Take two 10 g soil specimens of oven dry soil passing through 425 microns IS sieve. (Note: In the case of highly swelling soils, such as sodium bentonites, the sample size may be 5 g or alternatively a cylinder of 250 ml capacity may be used. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity.) One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100 ml. After removal of entrapped air (by gentle shaking or stirring with a glass rod), the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 h) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soils in each of the cylinders shall be read out.

Calculation: -

The level of the soil in the kerosene graduated cylinder shall be read as the original volume of the soil samples (V_k), kerosene being a non-polar liquid does not cause swelling of the soil. The level of the soil in the distilled water cylinder shall be read as the free swell level (V_d). The free swell index of the soil shall be calculated as follows:

Free swell index, percent = $\frac{V_d - V_k}{V_k}$ *100

Where,

V_d = the volume of soil specimen read from the graduated cylinder containing distilled water

V_k = the volume of soil specimen read from the graduated cylinder containing kerosene

5. SHEAR PROPERTIES OF SOIL

Shear tests were carried out by three methods.

- Unconfined compressive strength as per IS 2720 part-10 for the saturated plastic soil.
- Triaxial shear test is to be carried out on samples of size 38mm dia and 76 mm in height on motorized 30 speed load frame. The confining pressure 63 is applied to the cell by oilwater constant pressure system. The tests are carried out for the three conditions,

a. Unconsolidated Undrained (UU) test without pore water pressure measurement asper IS 2720-part 11.

b. Consolidated Undrained (CU) test without pore water pressure measurement as perIS 2720 part 12.

The condition decided on type of sample and water table condition or designer specifications.

- Direct/box shear test on non-cohesive medium to coarse sandy soil as per IS 2720 part 13.The graph for triaxial shear test is plotted by modified method.

6. COMPUTATION OF SOIL BEARING CAPACITY

6.1 Safe Bearing Capacity Based on Shear Criteria:

For Shear Criteria IS-6403 Ultimate Bearing Capacity Equation is used based on laboratory shear parameters.
A factor of safety = 3.0 against shear failure.
Settlement calculations are based on IS-8009 for an allowable settlement of 60mm as per IS 1904.
Bearing Capacity Equation: Shear Criteria (IS 6403 – 1981)
For Local Shear Failure Criteria:

$$qnu = \frac{1}{F}\left[\frac{2}{3}cN_c s_c d_c i_c + \gamma d(N_q - 1)s_q d_q i_q + 0.5\gamma BN_\gamma s_\gamma d_\gamma i_\gamma W'\right]$$

Where,
qna = net allowable bearing pressure N/m2, Shear Criteria
c, c4 = shear parameters
Nc, Nq, Nγ = Bearing Capacity factors based on c4 for General Shear Failure
N'c, N'q, N'γ = Bearing Capacity factors based on c4' for Local Shear Failure
where, c4' = tan –1 (0.67 tan c4)
B = Width of footing
D = Depth of footing
γ = unit weight of soil,
Rw = 0.5 {1 + (Dw –D) / B} & if Dw < Df, Rw = 0.5 & if Dw > (D + B), Rw =1.0 = 0.50 for GWT at and above Footing Level
Dw = depth of GWT from Ground Level
Sc, Sq, Sγ = Shape factors, For Square Footing Sc = 1.3, Sq = 1.2, Sγ = 0.8 = 1 for Strip Footing
ic, iq, iγ = inclination factors =1 for vertical loads.
dc = 1 +0.2 Df / B * (tan (45+c4/2) dq, dγ = 1 for c4< 10
dq, dγ = 1 +0.1 Df / B * sqrt (tan (45+c4/2) for c4>10

7. REFERENCE

IS 1498	Classification and identification of soils for general engineering purposes
IS 1892	Code of practice for subsurface investigation for foundations
IS 1904	Code of practice for design and construction of foundations in soils: General requirements
IS 2131	Method of standard penetration test for soils
IS 2132	Code of practice for thin-walled tube sampling of soils
IS 2720 (P-1)	Methods of test for soils: Part 1 Preparation of dry soil samples for various tests
IS 2720 (P-2)	Methods of test for soils: Part 2 Determination of water content
IS 2720 (P-3/Sec-1)	Methods of test for soils: Part 3 Determination of specific gravity, Section 1 Fine grained soils
IS 2720 (P-3/Sec-2)	Methods of test for soils: Part 3 Determination of specific gravity, Section 2 Fine, medium and coarse-grained soils
IS 2720 (P-4)	Methods of test for soils: Part 4 Grain size analysis
IS 2720 (P-5)	Methods of test for soils: Part 5 Determination of liquid and plastic limit
IS 2720 (P-6)	Methods of test for soils: Part 6 Determination of shrinkage factors
IS 2720 (P-10)	Methods of test for soils: Part 10 Determination of unconfined compressive strength
IS 2720 (P-11)	Methods of test for soils: Part 11 Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure
IS 2720 (P-13)	Methods of test for soils: Part 13 Direct shear test
IS 2720 (P-14)	Methods of test for soils: Part 14 Determination of density index (relative density) of cohesionless soils
IS 2720 (P-15)	Methods of test for soils: Part 15 Determination of consolidation properties
IS 2720 (P-39/Sec-1)	Methods of test for soils: Part 39 Direct shear test for soils containing gravel, Section 1 Laboratory test
IS 2720 (P-39/Sec-2)	Methods of test for soils: Part 39 Direct shear test for soils containing gravel, Section 2 In-situ shear test
IS 2720 (P-40)	Methods of test for soils: Part 40 Determination of free swell index of soils

IS 2720 (P-41)	Methods of test for soils: Part 41 Measurement of swelling pressure of soils
IS 6403	Code of practice for determination of bearing capacity of shallow foundations
IS 8009 (P-1)	Code of practice for calculation of settlements of foundations: Part 1 Shallow foundations subjected to symmetrical static vertical loads
Murthy V.N.S.	Soil Mechanics and Foundation Engineering
Lambe T.W.	Soil Testing Engineers
Peck, R.S. Hanson	Foundation Engineering
Nayak N.V.	Foundation Engineering Manual
Kaniraj S.R.	Design Aids in Soil Mechanics and Foundation Engineering
Alam Singh	Modern Geotechnical Engineering
Hunt	Foundation Engineering Analysis
Shamsher Prakash	Analysis and Design of Foundation and Retaining Structures
Winterkorn H.F. & Fang H. Y	Foundation engineering Handbook
Dr. B. P. Verma	Rock Mechanics for Engineers

GEOTECHNICAL INVESTIGATION WORK

FOR BRIDGE NO. 20 (CH-536.43)

BOREHOLE DETAIL

Table No. 1 Borehole Detail

Size of Bridge	Bore Hole No.	Location	Depth Below Ground Level (m)
6 x 3.05m	BH-1	Abutment 1 (CH-527.28)	10.00 m
	BH-2	Pier 4 (CH-536.43)	11.00 m
	BH-3	Abutment 2 (CH-545.58)	10.50 m

SUMMARY OF SOIL BEARING CAPACITY

Table No. 2 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Continuous strip footing (1m x 7.8m)	2.00	25.49	76.45	25.49
	3.00	31.35	76.45	31.35
	4.00	37.35	76.45	37.35
Square footing (1.5m x 1.5m)	2.00	16.21	98.04	16.21
	2.50	20.23	98.04	20.23
	3.00	24.46	98.04	24.46
Square footing (2m x 2m)	2.00	16.52	93.28	16.52
	2.50	20.31	93.28	20.31
	3.00	24.26	93.28	24.26
Square footing (2.5m x 2.5m)	2.00	17.00	89.29	17.00
	2.50	20.65	89.29	20.65
	3.00	24.43	89.29	24.43
Square footing (3m x 3m)	2.00	17.56	87.11	17.56
	2.50	21.12	87.11	21.12
	3.00	24.78	87.11	24.78

CONCLUSION & RECOMMENDATION

1. Up to 3.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 3.00 m to 6.00 m, Soil material contain majorly Highly Weathered Rock particles.
3. For 6.00 m to 10.00 m, Soil material contain majorly Sand Stone particles.
4. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 3 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Borehole No.(Chainage):	**Abutment-1 (CH-527.28)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**10**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	100	780	200	0.00	30.00	15.978	6.184	6.335	1	1	1	1.075	1.037	1.037	1	1	1	1.720	1.00	25.49
2	100	780	300	0.00	30.00	15.978	6.184	6.335	1	1	1	1.112	1.056	1.056	1	1	1	1.720	1.00	31.35
3	100	780	400	0.00	30.00	15.978	6.184	6.335	1	1	1	1.150	1.075	1.075	1	1	1	1.720	1.00	37.35
4	150	150	200	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.389	1.195	1.195	1	1	1	1.720	1.00	16.21
5	150	150	250	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.486	1.243	1.243	1	1	1	1.720	1.00	20.23
6	150	150	300	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.584	1.292	1.292	1	1	1	1.720	1.00	24.46
7	200	200	200	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.292	1.146	1.146	1	1	1	1.720	1.00	16.52
8	200	200	250	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.365	1.182	1.182	1	1	1	1.720	1.00	20.31
9	200	200	300	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.438	1.219	1.219	1	1	1	1.720	1.00	24.26
10	250	250	200	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.233	1.117	1.117	1	1	1	1.720	1.00	17.00
11	250	250	250	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.292	1.146	1.146	1	1	1	1.720	1.00	20.65
12	250	250	300	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.350	1.175	1.175	1	1	1	1.720	1.00	24.43

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Borehole No.(Chainage):	**Abutment-1 (CH-527.28)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**10**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
13	300	300	200	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.195	1.097	1.097	1	1	1	1.720	1.00	17.56
14	300	300	250	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.243	1.122	1.122	1	1	1	1.720	1.00	21.12
15	300	300	300	0.00	30.00	15.978	6.184	6.335	1.3	1.2	0.8	1.292	1.146	1.146	1	1	1	1.720	1.00	24.78

Table No. 4 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
7.80	2.00	42	-	50	1.00	6.54	76.45
7.80	3.00	42	-	50	1.00	6.54	76.45
7.80	4.00	42	-	50	1.00	6.54	76.45
1.50	2.00	42	-	50	1.00	5.10	98.04
1.50	2.50	42	-	50	1.00	5.10	98.04
1.50	3.00	42	-	50	1.00	5.10	98.04
2.00	2.00	42	-	50	1.00	5.36	93.28
2.00	2.50	42	-	50	1.00	5.36	93.28
2.00	3.00	42	-	50	1.00	5.36	93.28
2.50	2.00	42	-	50	1.00	5.60	89.29
2.50	2.50	42	-	50	1.00	5.60	89.29
2.50	3.00	42	-	50	1.00	5.60	89.29
3.00	2.00	42	-	50	1.00	5.74	87.11
3.00	2.50	42	-	50	1.00	5.74	87.11
3.00	3.00	42	-	50	1.00	5.74	87.11

Table No. 5 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Borehole No.(Chainage):	**Abutment-1 (CH-527.28)**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**10**

Calculation of Immediate Settlement As Per IS 8009-Part-1

$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r * D_f * S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.00	7.80	2.00	42	76.45	0.8	0.5	4357.80	0.737	2.07	212.45	125.26
2	1.00	7.80	3.00	42	76.45	0.8	0.5	4357.80	0.737	2.07	212.45	125.26
3	1.00	7.80	4.00	42	76.45	0.8	0.5	4357.80	0.737	2.07	212.45	125.26
4	1.50	1.50	2.00	42	98.04	0.8	0.5	4357.80	0.737	1.00	25.31	14.92
5	1.50	1.50	2.50	42	98.04	0.8	0.5	4357.80	0.737	1.00	25.31	14.92
6	1.50	1.50	3.00	42	98.04	0.8	0.5	4357.80	0.737	1.00	25.31	14.92
7	2.00	2.00	2.00	42	93.28	0.8	0.5	4357.80	0.737	1.00	32.11	18.93
8	2.00	2.00	2.50	42	93.28	0.8	0.5	4357.80	0.737	1.00	32.11	18.93
9	2.00	2.00	3.00	42	93.28	0.8	0.5	4357.80	0.737	1.00	32.11	18.93
10	2.50	2.50	2.00	42	89.29	0.8	0.5	4357.80	0.737	1.00	38.42	22.65
11	2.50	2.50	2.50	42	89.29	0.8	0.5	4357.80	0.737	1.00	38.42	22.65
12	2.50	2.50	3.00	42	89.29	0.8	0.5	4357.80	0.737	1.00	38.42	22.65
13	3.00	3.00	2.00	42	87.11	0.8	0.5	4357.80	0.737	1.00	44.98	26.52
14	3.00	3.00	2.50	42	87.11	0.8	0.5	4357.80	0.737	1.00	44.98	26.52
15	3.00	3.00	3.00	42	87.11	0.8	0.5	4357.80	0.737	1.00	44.98	26.52

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1002	**Type of Boring :** Machine Drilling
Borehole No : 1 [Abutment 1] (CH-527.28)	**Water Table** : NA	**Termination Depth** : 10.00m	**Br. No** : 20

Depth (m)	**Description of Sample**	**Symbol/ Hatching**	**Thickness of Strata(m)**	**Sampling Type**	**Sample Depth (m)**	**SPT Value Number**
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	**SC**	**1.50**	SPT	1.50	>50
2.00						
3.00	Reddish Brown colour Granular material (High Weathered Rock)	HWR	**3.00**	UDS	3.00	-
4.00				DS	4.50	-
5.00	Highly Weathered Yellowish Coloured Sand Stone	**Rock (Sand Stone)**	**5.50**	DS	6.00	-
6.00						
7.00				DS	7.50	-
8.00						
9.00				DS	9.00	-
10.00				DS	10.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

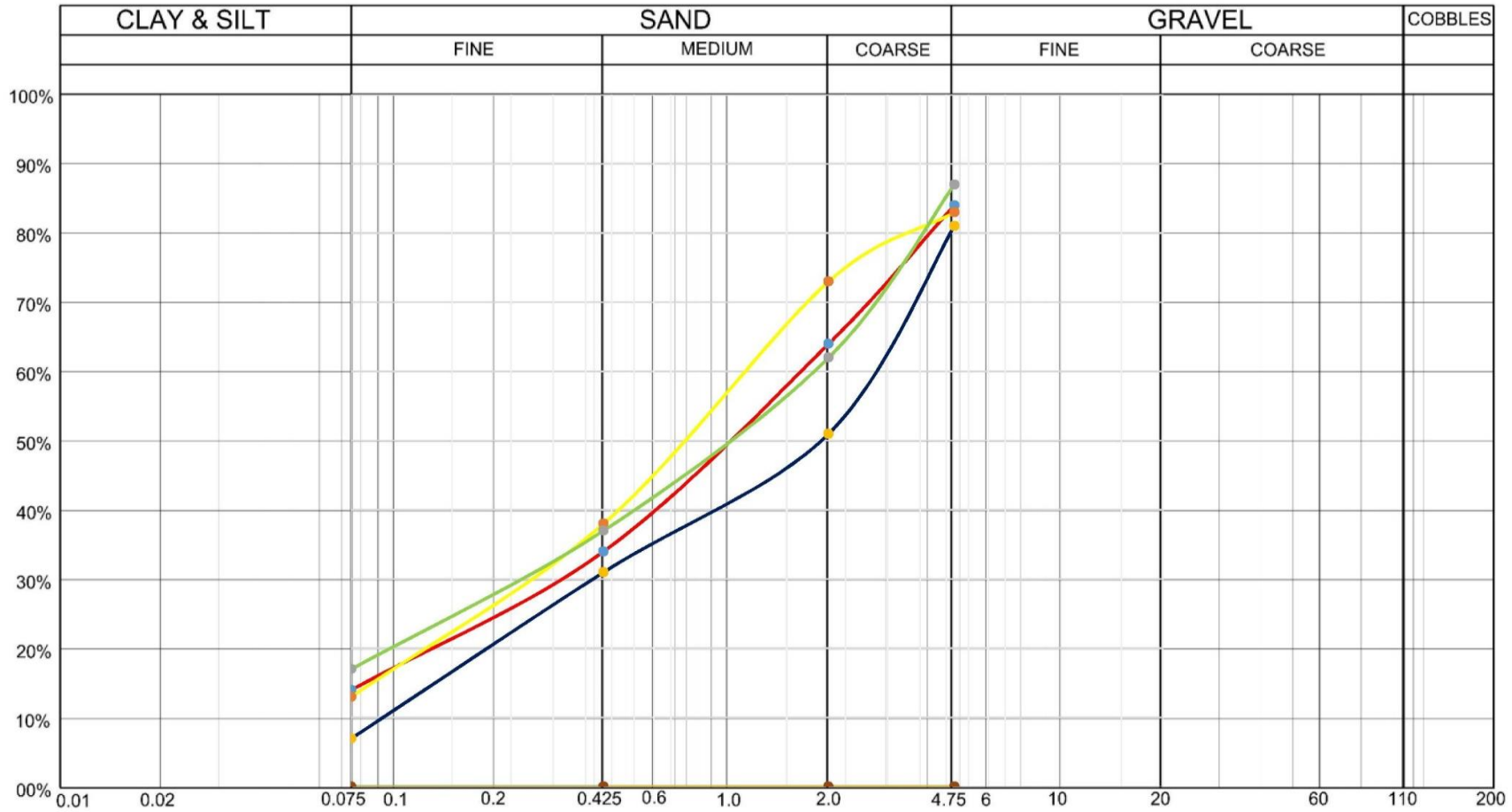
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Borehole No: 1 [Abutment 1] (CH-527.28) | Termination Depth: 10.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	16	70	14	-	-	-	-	-	-	-	-	-
1.50	SPT	>50	-	-	-	-	17	70	13	29	17	12	SC	-	-	-	-	-
3.00	UDS	-	2.63	1.72	1.65	4.10	13	70	17	16	NP	NP	HWR	DST	0	30	-	-
4.50	DS	-	-	-	-	-	19	74	7	-	-	-	HWR	-	-	-	-	-
6.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
7.50	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.67	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client:- Gujarat Rail Infrastructure Development Corporation Limited.	Abutment 1 (CH-527.28) Br No.: 20 (CH-536.43)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1002	**Type of Boring :** Machine Drilling
Borehole No : 2 [Pier 3] (CH-536.43)	**Water Table** : NA	**Termination Depth** : 11.00m	**Br. No** : 20

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	**SC**	**1.50**	SPT	1.50	>50
2.00	Reddish Brown colour Granular material (High Weathered Rock)	HWR	**3.00**	SPT	3.00	>50
3.00						
4.00				UDS	4.50	-
5.00	Highly Weathered Yellowish Coloured Sand Stone	**Rock (Sand Stone)**	**6.50**	DS	6.00	-
6.00						
7.00				DS	7.50	-
8.00						
9.00				DS	9.00	-
10.00				DS	10.50	-
11.00				DS	11.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

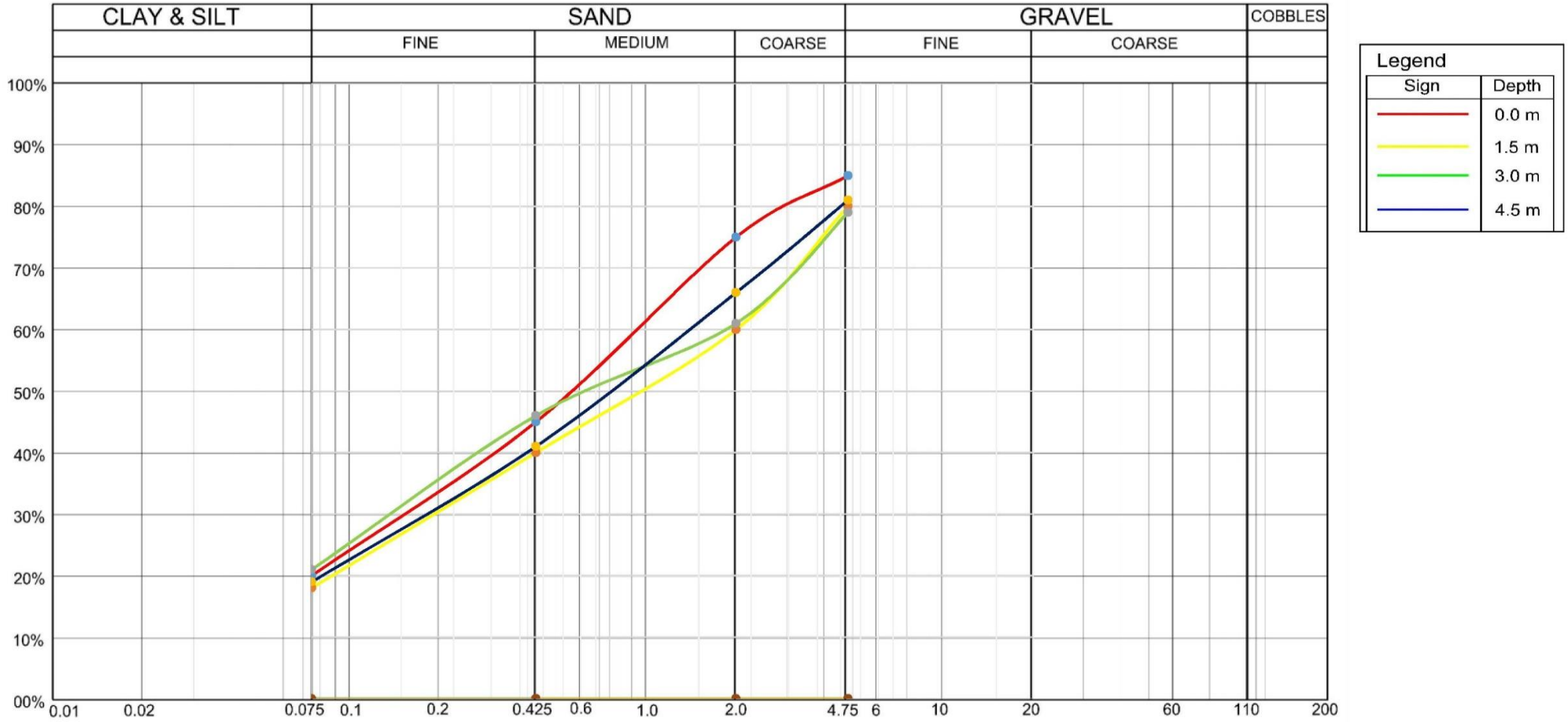
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Borehole No: 2 [Pier 3] (CH-536.43) | Termination Depth: 11.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	15	65	20	-	-	-	-	-	-	-	-	-
1.50	SPT	>50	-	-	-	-	20	62	18	30	17	13	SC	-	-	-	-	-
3.00	SPT	>50	-	-	-	-	21	58	21	20	NP	NP	HWR	-	-	-	-	-
4.50	UDS	-	2.64	1.75	1.61	8.62	19	62	19	18	NP	NP	HWR	DST	0	28	-	-
6.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
7.50	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.67	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.67	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
11.00	DS	-	2.67	-	-	-	-	-	-	-	-	-	Rock	-	-	-	.	-

GRAIN SIZE DISRIBUTION



Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client:- Gujarat Rail Infrastructure Development Corporation Limited.	Pier 3 (CH-536.43) Br No.: 20 (CH-536.43)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1002	**Type of Boring :** Machine Drilling
Borehole No : 3 [Abutment 1] (CH-545.58)	**Water Table** : NA	**Termination Depth** : 10.50m / **Br. No** : 20

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	**SC**	**1.50**	SPT	1.50	>50
2.00						
3.00	Reddish Brown colour Granular material (High Weathered Rock)	HWR	**3.00**	SPT	3.00	>50
4.00				UDS	4.50	-
5.00						
6.00	Highly Weathered Yellowish Coloured Sand Stone	**Rock (Sand Stone)**	**6.00**	DS	6.00	-
7.00				DS	7.50	-
8.00						
9.00				DS	9.00	-
10.50				DS	10.50	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

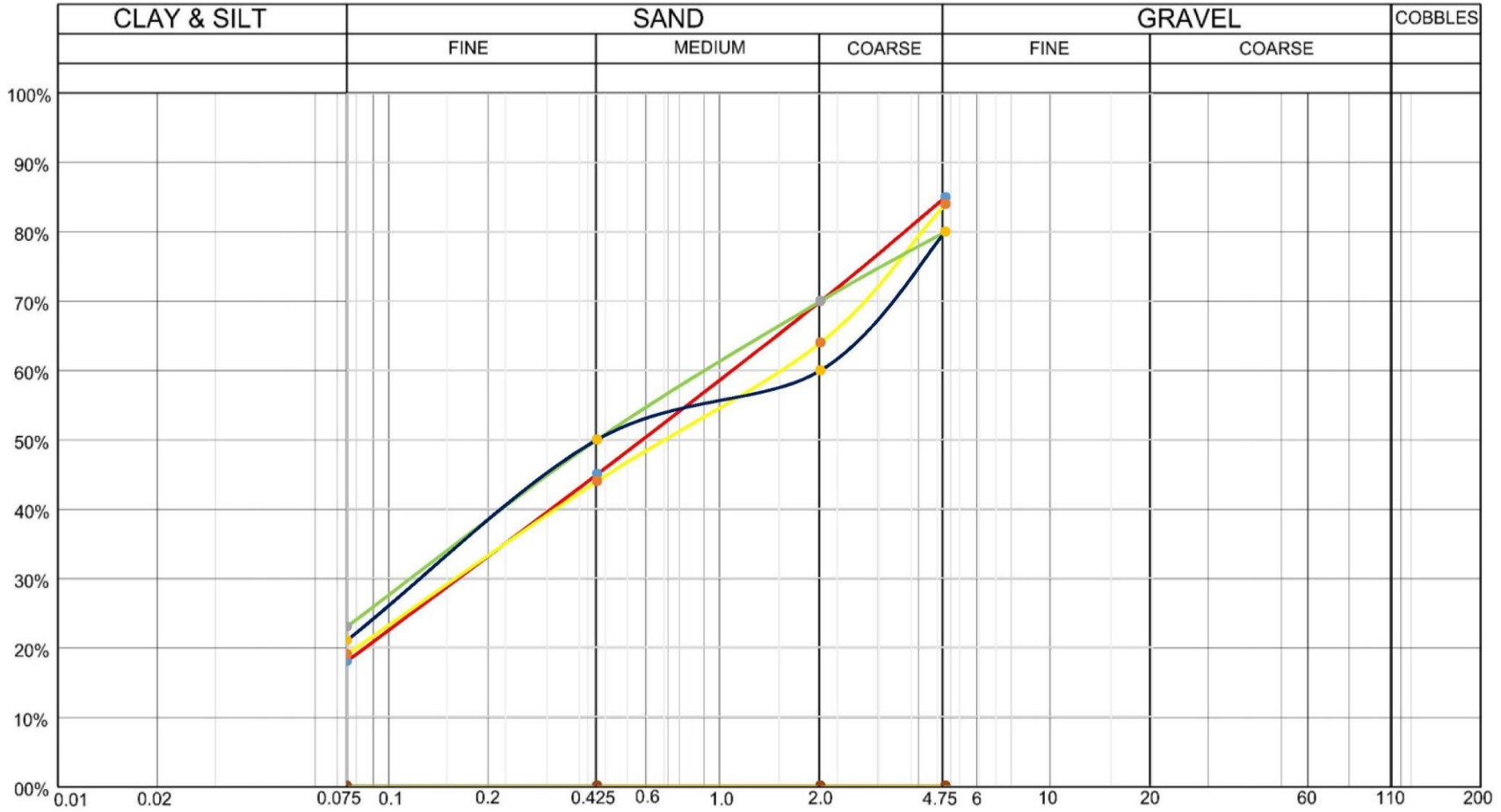
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited — W.T Below G.L: NA

Borehole No: 3 [Abutment 2] (CH-545.58) — Termination Depth: 10.50m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	15	67	18	-	-	-	-	-	-	-	-	-
1.50	SPT	>50	-	-	-	-	16	65	19	28	12	16	SC	-	-	-	-	-
3.00	SPT	>50	-	-	-	-	20	57	23	15	NP	NP	HWR	-	-	-	-	-
4.50	UDS	-	2.65	1.74	1.62	7.62	20	59	21	20	NP	NP	HWR	DST	0.08	29	-	-
6.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
7.50	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client:- Gujarat Rail Infrastructure Development Corporation Limited.	Abutment 2 (CH-545.58) Br No.: 20 (CH-536.43)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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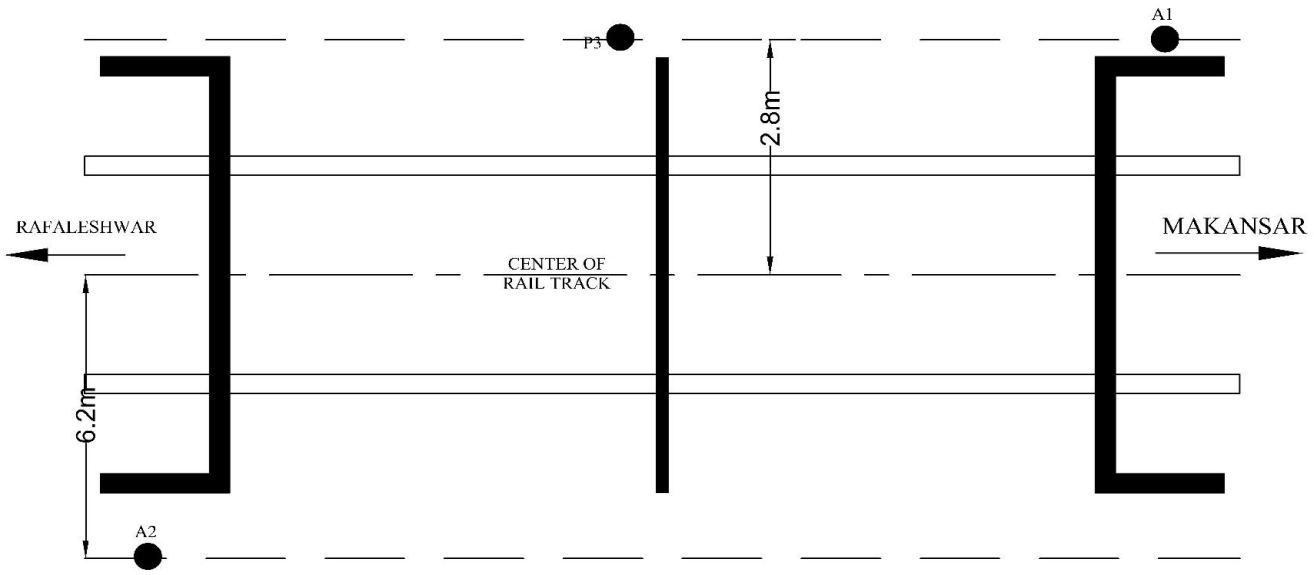
BORE HOLE LOCATION PLAN



Br No. :- 20 (CH-536.43)			
Size: 6 x 3.05 m		PSC SLAB	
Sr. No.	Location	Chainage	Symbol
1	Abutment 1	527.28	A1
2	Pier 3	536.43	P3
3	Abutment 2	545.58	A2

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client :- Gujarat Rail Infrastructure Development Corporation Limited.

Br No. :- 20 (CH-536.43)

SCALE: NOT TO SCLAE

LEGEND:-

●	**BORE HOLE**

DRAWING PREPARED BY:

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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GEOTECHNICAL INVESTIGATION WORK

FOR BRIDGE NO. 25 (CH-2594.72)

BOREHOLE DETAIL

Table No. 1 Borehole Detail

Size of Bridge	Bore Hole No.	Location	Depth Below Ground Level (m)
8 x 3.05m	BH-1	Abutment 1 (CH-2582.52)	14.00 m
	BH-2	Pier 4 (CH-2594.72)	13.00 m
	BH-3	Abutment 2 (CH-2606.92)	14.50 m

SUMMARY OF SOIL BEARING CAPACITY

Table No. 2 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Continuous strip footing (1m x 7.8m)	2.00	20.91	33.56	20.91
	3.00	25.95	39.37	25.95
	4.00	31.09	46.73	31.09
Square footing (1.5m x 1.5m)	2.00	13.65	44.64	13.65
	2.50	17.05	51.02	17.05
	3.00	20.60	55.56	20.60
Square footing (2m x 2m)	2.00	13.90	40.00	13.90
	2.50	17.10	46.30	17.10
	3.00	20.44	50.00	20.44
Square footing (2.5m x 2.5m)	2.00	14.27	37.88	14.27
	2.50	17.37	42.37	17.37
	3.00	20.57	45.45	20.57
Square footing (3m x 3m)	2.00	14.71	36.66	14.71
	2.50	17.74	40.65	17.74
	3.00	20.84	43.48	20.84

CONCLUSION & RECOMMENDATION

1. For 0.00 m to 6.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 6.00 m to 14.00 m, Soil material contain majorly Sand Stone particles.
2. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 3 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Borehole No.(Chainage):	**Abutment-1 (CH-2582.52)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**14**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	$q_{s,}$, (t/m^2)
1	100	780	200	0.05	28.00	14.482	5.162	5.106	1	1	1	1.073	1.036	1.036	1	1	1	1.680	1.00	20.91
2	100	780	300	0.05	28.00	14.482	5.162	5.106	1	1	1	1.109	1.055	1.055	1	1	1	1.680	1.00	25.95
3	100	780	400	0.05	28.00	14.482	5.162	5.106	1	1	1	1.145	1.073	1.073	1	1	1	1.680	1.00	31.09
4	150	150	200	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.378	1.189	1.189	1	1	1	1.680	1.00	13.65
5	150	150	250	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.473	1.236	1.236	1	1	1	1.680	1.00	17.05
6	150	150	300	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.567	1.284	1.284	1	1	1	1.680	1.00	20.60
7	200	200	200	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.284	1.142	1.142	1	1	1	1.680	1.00	13.90
8	200	200	250	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.355	1.177	1.177	1	1	1	1.680	1.00	17.10
9	200	200	300	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.425	1.213	1.213	1	1	1	1.680	1.00	20.44
10	250	250	200	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.227	1.113	1.113	1	1	1	1.680	1.00	14.27
11	250	250	250	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.284	1.142	1.142	1	1	1	1.680	1.00	17.37
12	250	250	300	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.340	1.170	1.170	1	1	1	1.680	1.00	20.57

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Borehole No.(Chainage):	**Abutment-1 (CH-2582.52)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**14**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	$q_{s,}$, (t/m^2)
13	300	300	200	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.189	1.095	1.095	1	1	1	1.680	1.00	14.71
14	300	300	250	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.236	1.118	1.118	1	1	1	1.680	1.00	17.74
15	300	300	300	0.05	28.00	14.482	5.162	5.106	1.3	1.2	0.8	1.284	1.142	1.142	1	1	1	1.680	1.00	20.84

Table No. 4 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
7.80	2.00	21	-	50	1.00	14.90	33.56
7.80	3.00	25	-	50	1.00	12.70	39.37
7.80	4.00	28	-	50	1.00	10.70	46.73
1.50	2.00	21	-	50	1.00	11.20	44.64
1.50	2.50	23	-	50	1.00	9.80	51.02
1.50	3.00	25	-	50	1.00	9.00	55.56
2.00	2.00	21	-	50	1.00	12.50	40.00
2.00	2.50	23	-	50	1.00	10.80	46.30
2.00	3.00	25	-	50	1.00	10.00	50.00
2.50	2.00	21	-	50	1.00	13.20	37.88
2.50	2.50	23	-	50	1.00	11.80	42.37
2.50	3.00	25	-	50	1.00	11.00	45.45
3.00	2.00	21	-	50	1.00	13.64	36.66
3.00	2.50	23	-	50	1.00	12.30	40.65
3.00	3.00	25	-	50	1.00	11.50	43.48

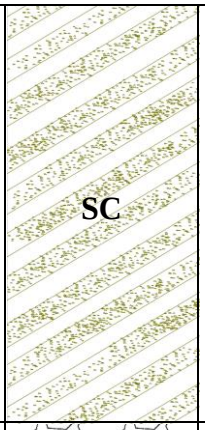
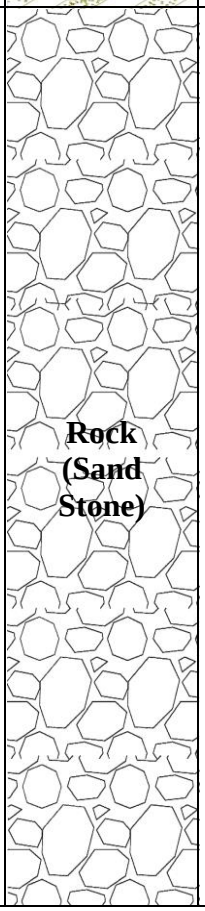
Table No. 5 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Borehole No.(Chainage):		**Abutment-1 (CH-2582.52)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**14**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r*D_f*S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.00	7.80	2.00	21	33.56	0.8	0.5	2752.29	0.735	2.07	147.64	86.81
2	1.00	7.80	3.00	25	39.37	0.8	0.5	3058.10	0.736	2.07	155.90	91.79
3	1.00	7.80	4.00	28	46.73	0.8	0.5	3287.46	0.736	2.07	172.13	101.35
4	1.50	1.50	2.00	21	44.64	0.8	0.5	2752.29	0.735	1.00	18.25	10.73
5	1.50	1.50	2.50	23	51.02	0.8	0.5	2905.20	0.736	1.00	19.76	11.63
6	1.50	1.50	3.00	25	55.56	0.8	0.5	3058.10	0.736	1.00	20.44	12.03
7	2.00	2.00	2.00	21	40.00	0.8	0.5	2752.29	0.735	1.00	21.80	12.82
8	2.00	2.00	2.50	23	46.30	0.8	0.5	2905.20	0.736	1.00	23.90	14.07
9	2.00	2.00	3.00	25	50.00	0.8	0.5	3058.10	0.736	1.00	24.53	14.44
10	2.50	2.50	2.00	21	37.88	0.8	0.5	2752.29	0.735	1.00	25.80	15.17
11	2.50	2.50	2.50	23	42.37	0.8	0.5	2905.20	0.736	1.00	27.35	16.10
12	2.50	2.50	3.00	25	45.45	0.8	0.5	3058.10	0.736	1.00	27.87	16.41
13	3.00	3.00	2.00	21	36.66	0.8	0.5	2752.29	0.735	1.00	29.97	17.62
14	3.00	3.00	2.50	23	40.65	0.8	0.5	2905.20	0.736	1.00	31.48	18.54
15	3.00	3.00	3.00	25	43.48	0.8	0.5	3058.10	0.736	1.00	31.99	18.84

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1008	**Type of Boring :** Machine Drilling
Borehole No : 1 [Abutment 1] (CH-2582.52)	**Water Table** : NA	**Termination Depth** : 14.00m	**Br. No** : 25

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	 **SC**	**4.50**	SPT	1.50	23
2.00						
3.00				UDS	3.00	-
4.00				SPT	4.50	44
5.00	Highly Weathered Yellowish Coloured Sand Stone	 **Rock (Sand Stone)**	**9.50**			
6.00				DS	6.00	-
7.00				DS	7.50	-
8.00						
9.00				DS	9.00	-
10.00				DS	10.50	-
11.00						
12.00				DS	12.00	-
13.00				DS	14.00	-
14.00						

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

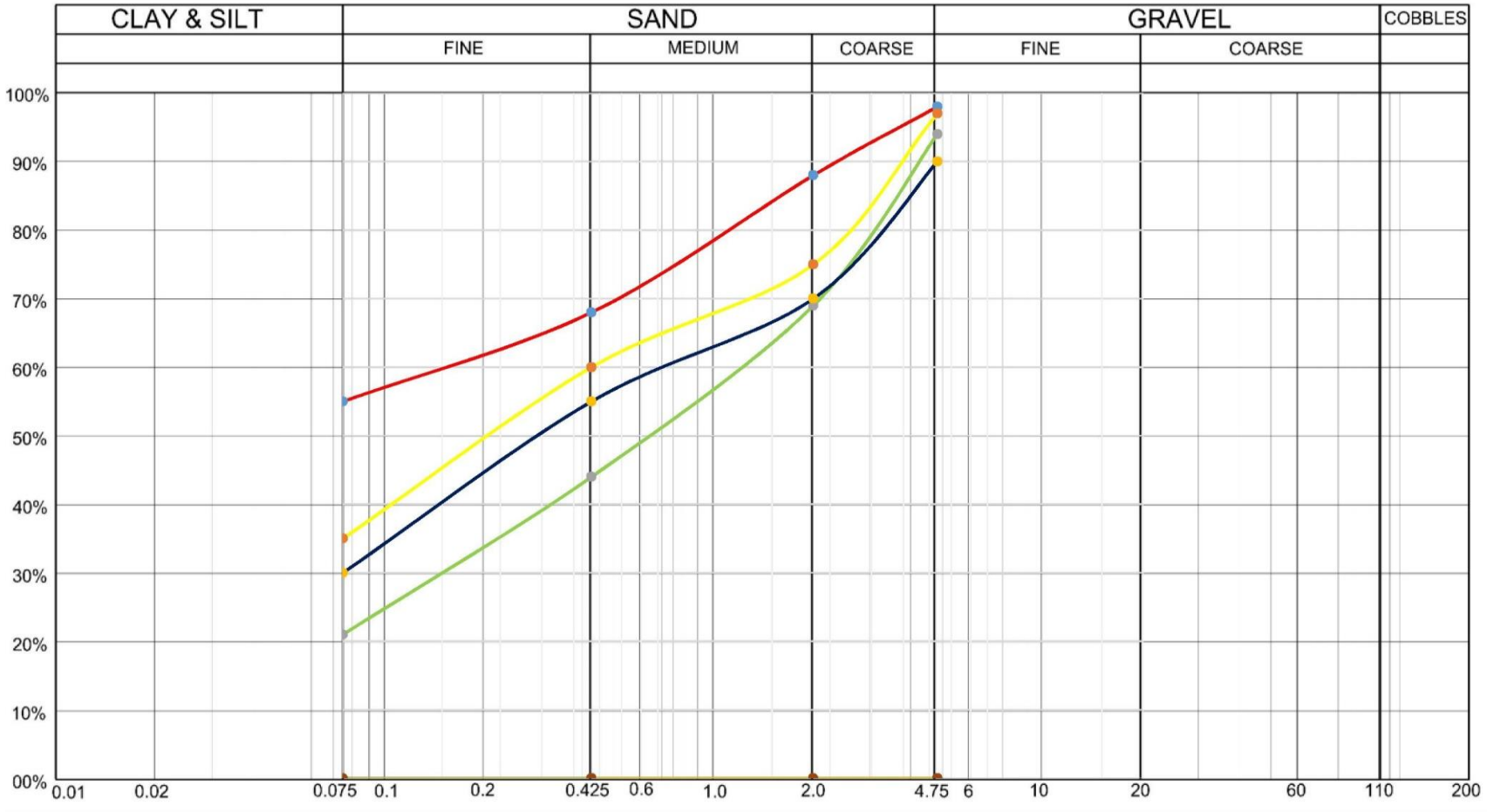
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited — W.T Below G.L: NA

Borehole No: 1 [Abutment 1] (CH-2582.52) — Termination Depth: 14.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	2	43	55	-	-	-	-	-	-	-	-	-
1.50	SPT	23	-	-	-	-	3	62	35	30	16	14	SC	-	-	-	-	-
3.00	UDS	-	2.61	1.68	1.62	3.70	6	73	21	29	16	13	SC	DST	0.05	28	-	-
4.50	SPT	44	-	-	-	-	10	60	30	30	17	13	SC	-	-	-	-	-
6.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
7.50	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.67	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.68	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
12.00	DS	-	2.68	-	-	-	-	-	-	-	-	-	Rock	-	-	-	.	-
14.00	DS	-	2.69	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Abutment 1 (CH-2582.57)

Br No.: 25 (CH-2594.72)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1008	**Type of Boring :** Machine Drilling
Borehole No : 2 [Pier 4] (CH-2594.72)	**Water Table** : NA	**Termination Depth** : 13.00m	**Br. No** : 25

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	**SC**	**6.00**	SPT	1.50	26
2.00						
3.00				SPT	3.00	39
4.00				UDS	4.50	-
5.00						
6.00				SPT	6.00	49
7.00	Highly Weathered Yellowish Coloured Sand Stone	**Rock (Sand Stone)**	**7.00**	DS	7.50	-
8.00						
9.00				DS	9.00	-
10.00				DS	10.50	-
11.00						
12.00				DS	12.00	-
13.00				DS	13.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

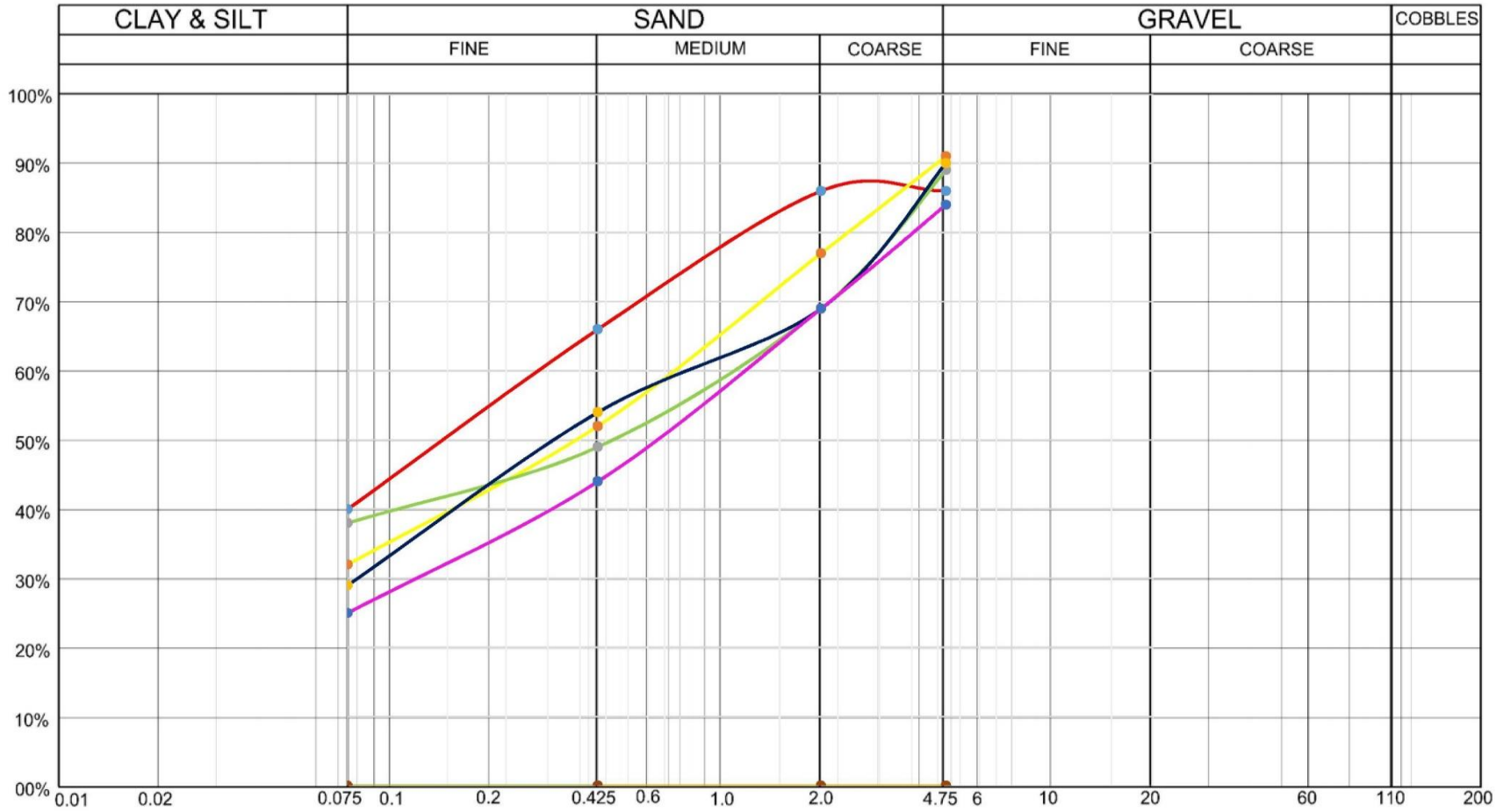
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited — W.T Below G.L: NA

Borehole No: 2 [Pier 4] (CH-2594.22) — Termination Depth: 13.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	14	46	40	-	-	-	-	-	-	-	-	-
1.50	SPT	26	-	-	-	-	9	59	32	28	11	17	SC	-	-	-	-	-
3.00	SPT	39	-	-	-	-	11	51	38	30	15	15	SC	-	-	-	-	-
4.50	UDS	-	2.64	1.73	1.62	6.58	10	61	29	32	16	16	SC	DST	0.12	26	-	-
6.00	SPT	49	-	-	-	-	16	59	25	33	13	20	SC	-	-	-	-	-
7.50	DS	-	2.63	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.62	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.62	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
12.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	.	-
13.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m
	6.0 m

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Pier 4 (CH-2594.72)

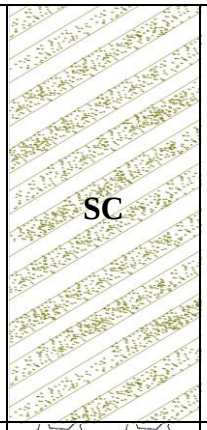
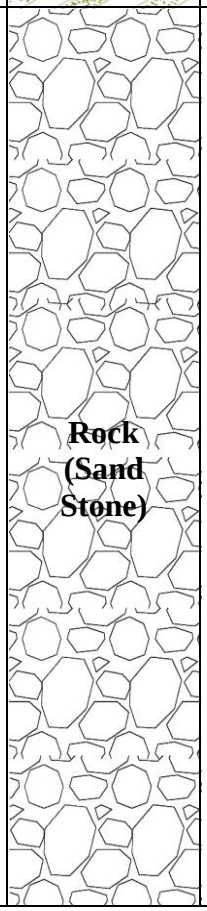
Br No.: 25 (CH-2594.72)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1008	**Type of Boring :** Machine Drilling
Borehole No : 3 [Abutment 1] (CH-2606.92)	**Water Table** : NA	**Termination Depth** : 14.50m	**Br. No** : 25

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	 **SC**	**4.50**	SPT	1.50	29
2.00						
3.00				SPT	3.00	40
4.00				UDS	4.50	-
5.00	Highly Weathered Yellowish Coloured Sand Stone	 **Rock (Sand Stone)**	**10.00**			
6.00				DS	6.00	-
7.00				DS	7.50	-
8.00						
9.00				DS	9.00	-
10.00				DS	10.50	-
11.00						
12.00				DS	12.00	-
13.00				DS	14.50	-
14.50						

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

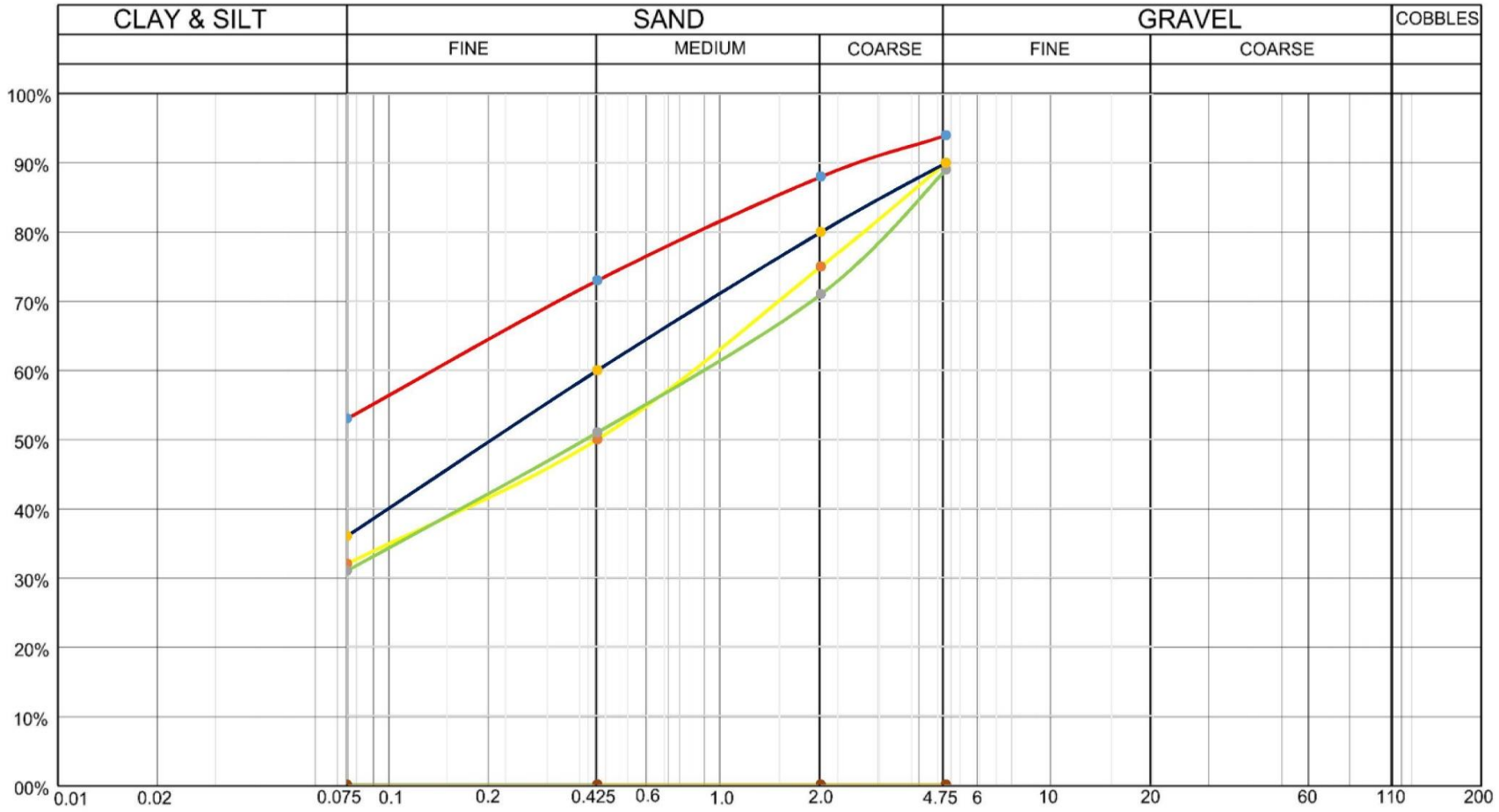
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited — W.T Below G.L: NA

Borehole No: 3 [Abutment 2] (CH-2606.92) — Termination Depth: 14.50m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	6	41	53	-	-	-	-	-	-	-	-	-
1.50	SPT	29	-	-	-	-	10	58	32	24	10	14	SC	-	-	-	-	-
3.00	SPT	40	-	-	-	-	11	58	31	23	7	16	SC	-	-	-	-	-
4.50	UDS	-	2.65	1.74	1.61	8.20	10	54	36	24	7	17	SC	DST	0.12	26	-	-
6.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
7.50	DS	-	2.64	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
9.00	DS	-	2.64	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
10.50	DS	-	2.63	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-
12.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	.	-
14.50	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client:- Gujarat Rail Infrastructure Development Corporation Limited.	Abutment 2 (CH-2606.92) Br No.: 25 (CH-2594.72)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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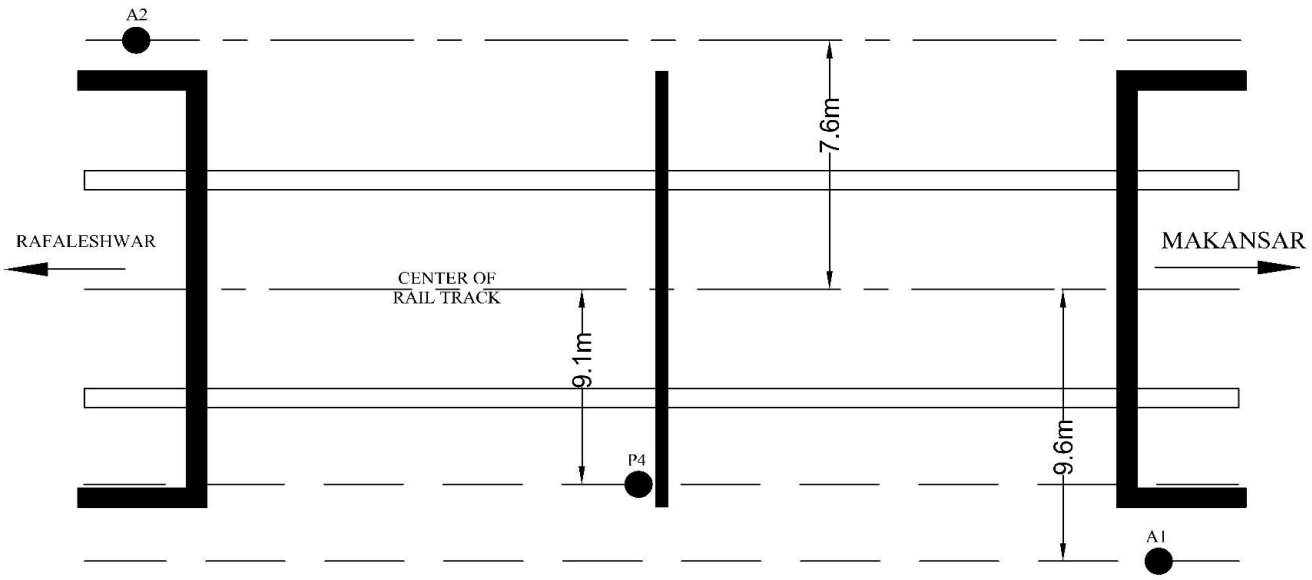
BORE HOLE LOCATION PLAN



Br No. :- 25 (CH-2594.72)			
Size: 8 x 3.05 m		**PSC SLAB**	
Sr. No.	Location	Chainage	Symbol
1	Abutment 1	2582.52	A1
2	Pier 4	2594.72	P4
3	Abutment 2	2606.92	A2

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client :- Gujarat Rail Infrastructure Development Corporation Limited.

Br No. :- 25 (CH-2594.72)

SCALE: NOT TO SCLAE

LEGEND:-

●	**BORE HOLE**

DRAWING PREPARED BY:

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
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GEOTECHNICAL INVESTIGATION WORK

All Minor Bridges

CLIENTS NAME: Gujarat Rail Infrastructure Development Corporation Limited

BY

Bhajan
InfraTech Pvt. Ltd.

1003/B, Jolly Enclave, Opp. Panchvati wadi, Nr. Varachha (E) Zone office,
L. H. Road, Surat – 395006. (M): +91-9725001300.
Email: mail@bhajanec.com

INDEX

Summary Sheet		
Sr. No.	**Bridge No. (Chainage)**	**Page No.**
1	Br.18A (CH-386.33)	10
2	Br.21 (CH-979.93)	18
3	Br.22 (CH-1063.37)	26
4	Br.23 (CH-1473.09)	34
5	Br.24 (CH-1650.47)	42
6	Br.24A (CH-2151.59)	50

ABBREVIATION

C	Cohesion
DS	Disturbed Sample
UDS	Undisturbed Sample
SPT	Standard Penetration Test
GWT	Ground Water Table
EGL	Existing Ground Level
SBC	Safe Bearing Capacity
BH	Borehole
FOS	Factor of Safety
Γ	Density of Soil
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non-Plastic
DST	Direct Shear Test

IS CLASSIFICATION

GW:	Well Graded Gravels
GP:	Poorly Graded Gravels
GM:	Silty Gravels
GC:	Clayey Gravels
SW:	Well Graded Sands
SP:	Poorly Graded Sands
SC:	Clayey Sands
SM:	Silty Sands
ML:	Inorganic Silt with Non to low Plasticity
CL:	Inorganic Clay with low Plasticity
OL:	Organic Silts and Organic Silty Clay of Low Plasticity
MI:	Inorganic Silt with Non to Medium Plasticity
CI:	Inorganic Clay with Medium Plasticity
OI:	Organic Silts and Organic Silty Clay of Medium Plasticity
MH:	Inorganic Silt with Non to High Plasticity
CH:	Inorganic Clay with High Plasticity
OH:	Organic Silts and Organic Silty Clay of High Plasticity
Pt:	Peat and other Highly Organic Soil with Very High Compressibility

1. INTRODUCTION

Gujarat Rail Infrastructure Development Corporation Limited Proposed to Conduct "Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.". Accordingly, land soil investigations were envisaged to evolve various soil parameters in order to carry out engineering analysis and foundation design. In this connection, the soil investigation work was awarded to "**Bhajan InfraTech Private Limited, Surat**" to carry out land soil investigation at the proposed site.

Broad objectives of the investigation are as follows,

a) To evaluate the parameters of soil at the proposed site.
b) To assess the engineering parameters and to estimate the safe bearing capacity of soil.

2. FIELD WORK

2.1 Boring

The exploratory borehole of 100mm diameter was drilled by Rotary drilling method without casing. The depth of the test bore at the proposed location is as under:

Bore Hole No.	As per Summery Sheet
Location	As per Summery Sheet
Depth of Borehole below EGL(m)	6.00

2.2 Sampling

2.2.1 Disturbed Samples

Disturbed samples were collected during the boring and also from the split spoon sampler. The samples recovered were logged, labelled and placed in polythene bags and sent to laboratory for testing.

2.2.2 Undisturbed Samples

Undisturbed soil samples were collected in thin-walled Shelby tubes and using piston type sampler as per IS-2132. The samples were sealed with wax, labelled and transported to our laboratory at Surat for testing.

2.2.3 Standard Penetration Test

The Standard Penetration Tests (SPT) (IS-2131, 1981) was carried out in the bore hole at predetermined depths. It gives indirect evaluation of strength–deformation characteristics of the sub soil. The test includes driving a split spoon sampler using a 63.5 kg hammer with a free fall of 750mm. The first 15cm is considered as seating drive. The No. of blows required to penetrate next 30 cm is reported as N-value. Empirical relations are established to correlate N-Value with the shear parameters or bearing capacity of soil. A disturbed soil sample is collected inside the split spoon sampler which can be used to find soil classification and In-situ water content. If the no. of blows exceeds 50 before desired penetration is achieved, it is reported as N-value >50 with the actual achieved.

3. LABORATORY WORK

Following laboratory tests are carried out to determine the physical and engineering properties of undisturbed and disturbed soil samples.

1. Dry Density and Natural Moisture Content (IS– 2720, Part -- Il)
2. Particle Size Analysis (IS - 2720, Part --IV, 1985)
3. Atterberg's Limit (IS -2720, Part -V, 1985)
4. Free Swell Index;(IS – 2720, Part -40, 1977)
5. Specific Gravity (IS -2720, Part III -1980)
6. Shear Test (IS:2720, Part-XI)

4. PHYSICAL PROPERTIES OF SOIL

4.1 Natural Moisture Content & Field Dry Density

The weight of undisturbed soil sample with sampler (Shelby tube) is determined after removing paraffin wax and loose soil. The total length of soil sample recovery is determined after deducting empty length from the total length of sampler. The volume of soil mass retained in sampler is thus determined from the known inside diameter of sampler and total length of soil mass. The soil mass is then removed and the average moisture content is determined by keeping the soil sample along with crucible in oven at 100-105 degree centigrade for 24 hours. The empty weight of the sampler is then found out. From the total weight of sampler with soil mass, the weight of empty sampler is deducted.

4.2 Particle Size Analysis

The sieve analysis is carried out in accordance with IS-2720, Part-IV, 1985. The results are presented in the form of Grain size distribution curve.

❖ **Soil fraction passing 4.75 IS Sieve**

The portion of the soil passing 4.75 mm ISS is oven dried at 105°C to 110°C. The portion is coned & quartered to obtain required representative quantity of the material. The material is weighed and. placed in tray/bucket filled with water for soaking and loosening the adhered cohesive materials. The soaked soil specimen is then washed on 75 microns IS Sieve until the water passing the sieve is almost clear. The material retained on 75 microns IS Sieve is then transferred in a tray, dried in oven.

Sieve analysis is then conducted on a nest of sieves (viz. 2 mm, 425- and 75-micron ISS) either by hand or by using mechanical sieve shaker. The fraction retained on each of the sieves is weighed separately and masses recorded. Cumulative mass of soil fraction retained on each sieve is then calculated. The weights are then converted into cumulative percentage retained and passing on the basis of the mass of the sample passing 4. 75 ISS taken. The combined gradation on the basis of the total sample taken for analysis is finally calculated.

4.3 Atterberg's Limit

Liquid, Plastic and Shrinkage Limits are determined by using procedure given in IS: 2720, Part-V, 1985.

4.3.1 Liquid Limit

The cylindrical cup of cone penetrometer ensuring that no air is trapped in this process. Finally, the wet soil is levelled up to the top of the cup and placed on the base of the cone penetrometer apparatus. The penetrometer shall be adjusted that the cone point just touches the surface of the soil paste in the cup clamped obtained 200 gm in of soil sample shall be worked well into a paste with addition of distil water. In the case of highly clayey soils, to ensure uniform moisture distribution, it is recommended that the soil in the mixed state is left for sufficient time (24 hours) in an air-tight container. The wet soil paste shall then be transferred in to in this position. The initial reading is either adjusted to zero or noted down as is shown on the graduated scale. The vertical clamp is then released allowing the cone to penetrate in to the soil paste under its own weight.

The penetration of the cone after 5 sec. shall be noted to the nearest millimetres. If the difference in penetration lies between 14 and 28 mm, the test is repeated with suitable adjustment to moisture either by addition of more water or exposure of the spread paste on a glass plate for reduction in moisture content. The test shall then be repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. The exact moisture content of each trial shall be determined.

A graph representing water content on the y-axis and cone penetration on the x-axis. The best fitting straight line is then drawn. The moisture content corresponding to cone penetration of 20 mm shall be taken as the liquid limit of the soil and shall be expressed to the nearest first decimal place.

4.3.2 Plastic Limit

For determination of plastic limit, a soil sample weighing at least 20 gm from the soil sample passing 425 microns IS sieve is thoroughly mixed with water such that it can be easily moulded with fingers. A ball is formed with about 8 to 10 gm of this soil & is rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter of 3mm throughout its length. The soil is then kneaded together to a uniform mass and rolled again. The process is continued until the thread crumbles. The pieces of crumbled soil thread are collected and moisture content is determined and reported as plastic limit.

4.3.3 Shrinkage Limit

The procedure for carrying out Shrinkage limit test on remoulded soil sample is given here. About 30 g of dry pulverized soil passing 425-micron sieve is weight out. The soil sample is placed in the evaporating dish & bubbles. The water content to from the paste may be readily worked into without entrapping air cleaned, dried and weighed. The inside of the cleaned Shrinkage dish is coated with a thin layer of Vaseline or heavy grease to prevent adhesion of soil to the dish. The soil pastes equal to roughly one third the volume of the Shrinkage dish is placed in the centre of the dish & the paste is allowed to flow to the edges by tapping the dish on a firm surface cushioned with a few layers of blotting paper or similar material. Then another equal quantity of paste is added & the dish tapped so that all the air bubbles entrapped come to the top & the paste gets compacted. The process is continued till the paste fills the dish completely and starts overflowing. The excess paste is struck off level with the top edge of the Shrinkage dish by a straight edge and the outside of the dish is wiped clean.

The dish with the soil sample is immediately weighed and then the soil sample in the dish is allowed to dry in air till the colour of the pat becomes lighter. The dish with the soil sample is then kept in an oven at 105°c to 110°c to constant weight, cooled in a desiccator and weighed to find the weight of dish and the dry pat of soil sample. The weight of the clean, empty dish is determined so that the weight of dry pat of soil sample can be calculated.

The volume of the Shrinkage dish is found by pouring mercury until it overflows, removing the excess by pressing the plain glass plate flush with surface of glass cup. The weight of mercury in the Shrinkage dish is

found to an accuracy of 0.1 g. The volume of the Shrinkage dish is calculated by dividing the weight of mercury by the unit weight of mercury (13.59 g\m1). The volume the Shrinkage dish may also be determined by pouring the mercury from the dish into the graduated jar, as an additional check.

4.4 Specific Gravity

The specific gravity of soil solids is determined by a 50ml density bottle. The weight (W1) of the empty dry bottle is taken first. A sample of oven-dried soil about 10-20 g cooled in a desiccator, is put in the bottle, and weight (W2) of the bottle and the soil is taken. The bottle is then filled with distilled water gradually removing the entrapped air either by applying vacuum or by shaking the bottle. The weight (W3) of the bottle, soil and water (full up to the top) is then taken. Finally, the bottle is emptied completely and thoroughly washed and clean water is filled to the top and the weight (W4) is taken.

$$\textbf{Specific Gravity (G)} = (W_2 - W_1) / [(W_2 - W_1) - (W_3 - W_4)]$$

4.5 Free Swell Index

Take two 10 g soil specimens of oven dry soil passing through 425 microns IS sieve. (Note: In the case of highly swelling soils, such as sodium bentonites, the sample size may be 5 g or alternatively a cylinder of 250 ml capacity may be used. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity.) One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100 ml. After removal of entrapped air (by gentle shaking or stirring with a glass rod), the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 h) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soils in each of the cylinders shall be read out.

Calculation: -

The level of the soil in the kerosene graduated cylinder shall be read as the original volume of the soil samples (V_k), kerosene being a non-polar liquid does not cause swelling of the soil. The level of the soil in the distilled water cylinder shall be read as the free swell level (V_d). The free swell index of the soil shall be calculated as follows:

Free swell index, percent = $\frac{V_d - V_k}{V_k}$ *100

Where,

V_d = the volume of soil specimen read from the graduated cylinder containing distilled water

V_k = the volume of soil specimen read from the graduated cylinder containing kerosene

5. SHEAR PROPERTIES OF SOIL

Shear tests were carried out by three methods.

- Unconfined compressive strength as per IS 2720 part-10 for the saturated plastic soil.
- Triaxial shear test is to be carried out on samples of size 38mm dia and 76 mm in height on motorized 30 speed load frame. The confining pressure 63 is applied to the cell by oilwater constant pressure system. The tests are carried out for the three conditions,

a. Unconsolidated Undrained (UU) test without pore water pressure measurement asper IS 2720-part 11.

b. Consolidated Undrained (CU) test without pore water pressure measurement as perIS 2720 part 12.

The condition decided on type of sample and water table condition or designer specifications.

- Direct/box shear test on non-cohesive medium to coarse sandy soil as per IS 2720 part 13.The graph for triaxial shear test is plotted by modified method.

6. COMPUTATION OF SOIL BEARING CAPACITY

6.1 Safe Bearing Capacity Based on Shear Criteria:

For Shear Criteria IS-6403 Ultimate Bearing Capacity Equation is used based on laboratory shear parameters.
A factor of safety = 3.0 against shear failure.
Settlement calculations are based on IS-8009 for an allowable settlement of 60mm as per IS 1904.
Bearing Capacity Equation: Shear Criteria (IS 6403 – 1981)
For Local Shear Failure Criteria:

$$qnu = \frac{1}{F}\left[\frac{2}{3}cN_c s_c d_c i_c + \gamma d(N_q - 1)s_q d_q i_q + 0.5\gamma BN_\gamma s_\gamma d_\gamma i_\gamma W'\right]$$

Where,
qna = net allowable bearing pressure N/m2, Shear Criteria
c, c4 = shear parameters
Nc, Nq, Nγ = Bearing Capacity factors based on c4 for General Shear Failure
N'c, N'q, N'γ = Bearing Capacity factors based on c4' for Local Shear Failure
where, c4' = tan –1 (0.67 tan c4)
B = Width of footing
D = Depth of footing
γ = unit weight of soil,
Rw = 0.5 {1 + (Dw –D) / B} & if Dw < Df, Rw = 0.5 & if Dw > (D + B), Rw =1.0 = 0.50 for GWT at and above Footing Level
Dw = depth of GWT from Ground Level
Sc, Sq, Sγ = Shape factors, For Square Footing Sc = 1.3, Sq = 1.2, Sγ = 0.8 = 1 for Strip Footing
ic, iq, iγ = inclination factors =1 for vertical loads.
dc = 1 +0.2 Df / B * (tan (45+c4/2) dq, dγ = 1 for c4< 10
dq, dγ = 1 +0.1 Df / B * sqrt (tan (45+c4/2) for c4>10

7. REFERENCE

IS 1498	Classification and identification of soils for general engineering purposes
IS 1892	Code of practice for subsurface investigation for foundations
IS 1904	Code of practice for design and construction of foundations in soils: General requirements
IS 2131	Method of standard penetration test for soils
IS 2132	Code of practice for thin-walled tube sampling of soils
IS 2720 (P-1)	Methods of test for soils: Part 1 Preparation of dry soil samples for various tests
IS 2720 (P-2)	Methods of test for soils: Part 2 Determination of water content
IS 2720 (P-3/Sec-1)	Methods of test for soils: Part 3 Determination of specific gravity, Section 1 Fine grained soils
IS 2720 (P-3/Sec-2)	Methods of test for soils: Part 3 Determination of specific gravity, Section 2 Fine, medium and coarse-grained soils
IS 2720 (P-4)	Methods of test for soils: Part 4 Grain size analysis
IS 2720 (P-5)	Methods of test for soils: Part 5 Determination of liquid and plastic limit
IS 2720 (P-6)	Methods of test for soils: Part 6 Determination of shrinkage factors
IS 2720 (P-10)	Methods of test for soils: Part 10 Determination of unconfined compressive strength
IS 2720 (P-11)	Methods of test for soils: Part 11 Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure
IS 2720 (P-13)	Methods of test for soils: Part 13 Direct shear test
IS 2720 (P-14)	Methods of test for soils: Part 14 Determination of density index (relative density) of cohesionless soils
IS 2720 (P-15)	Methods of test for soils: Part 15 Determination of consolidation properties
IS 2720 (P-39/Sec-1)	Methods of test for soils: Part 39 Direct shear test for soils containing gravel, Section 1 Laboratory test
IS 2720 (P-39/Sec-2)	Methods of test for soils: Part 39 Direct shear test for soils containing gravel, Section 2 In-situ shear test
IS 2720 (P-40)	Methods of test for soils: Part 40 Determination of free swell index of soils

IS 2720 (P-41)	Methods of test for soils: Part 41 Measurement of swelling pressure of soils
IS 6403	Code of practice for determination of bearing capacity of shallow foundations
IS 8009 (P-1)	Code of practice for calculation of settlements of foundations: Part 1 Shallow foundations subjected to symmetrical static vertical loads
Murthy V.N.S.	Soil Mechanics and Foundation Engineering
Lambe T.W.	Soil Testing Engineers
Peck, R.S. Hanson	Foundation Engineering
Nayak N.V.	Foundation Engineering Manual
Kaniraj S.R.	Design Aids in Soil Mechanics and Foundation Engineering
Alam Singh	Modern Geotechnical Engineering
Hunt	Foundation Engineering Analysis
Shamsher Prakash	Analysis and Design of Foundation and Retaining Structures
Winterkorn H.F. & Fang H. Y	Foundation engineering Handbook
Dr. B. P. Verma	Rock Mechanics for Engineers

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 18A (CH-386.33)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	13.17	84.46	13.17
	2.50	16.44	86.51	16.44
	3.00	19.87	86.51	19.87
Square footing (2m x 2m)	2.00	13.39	78.86	13.39
	2.50	16.50	81.17	16.50
	3.00	19.71	81.17	19.71
Square footing (2.5m x 2.5m)	2.00	13.74	75.76	13.74
	2.50	16.74	78.13	16.74
	3.00	19.83	78.13	19.83
Square footing (3m x 3m)	2.00	14.15	73.31	14.15
	2.50	17.08	75.99	17.08
	3.00	20.09	75.99	20.09

CONCLUSION & RECOMMENDATION

1. Up to 3.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 3.00 m to 6.00 m, Soil material contain majorly Highly Weathered Rock particles.
3. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br-18A (CH-386.33)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.373	1.186	1.186	1	1	1	1.740	1.00	13.17
2	150	150	250	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.466	1.233	1.233	1	1	1	1.740	1.00	16.44
3	150	150	300	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.559	1.280	1.280	1	1	1	1.740	1.00	19.87
4	200	200	200	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.280	1.140	1.140	1	1	1	1.740	1.00	13.39
5	200	200	250	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.350	1.175	1.175	1	1	1	1.740	1.00	16.50
6	200	200	300	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.419	1.210	1.210	1	1	1	1.740	1.00	19.71
7	250	250	200	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.224	1.112	1.112	1	1	1	1.740	1.00	13.74
8	250	250	250	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.280	1.140	1.140	1	1	1	1.740	1.00	16.74
9	250	250	300	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.336	1.168	1.168	1	1	1	1.740	1.00	19.83
10	300	300	200	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.186	1.093	1.093	1	1	1	1.740	1.00	14.15
11	300	300	250	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.233	1.117	1.117	1	1	1	1.740	1.00	17.08
12	300	300	300	0.00	27.00	13.812	4.718	4.589	1.3	1.2	0.8	1.280	1.140	1.140	1	1	1	1.740	1.00	20.09

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	37	-	50	1.00	5.92	84.46
1.50	2.50	38	-	50	1.00	5.78	86.51
1.50	3.00	38	-	50	1.00	5.78	86.51
2.00	2.00	37	-	50	1.00	6.34	78.86
2.00	2.50	38	-	50	1.00	6.16	81.17
2.00	3.00	38	-	50	1.00	6.16	81.17
2.50	2.00	37	-	50	1.00	6.60	75.76
2.50	2.50	38	-	50	1.00	6.40	78.13
2.50	3.00	38	-	50	1.00	6.40	78.13
3.00	2.00	37	-	50	1.00	6.82	73.31
3.00	2.50	38	-	50	1.00	6.58	75.99
3.00	3.00	38	-	50	1.00	6.58	75.99

Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br-18A (CH-386.33)**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

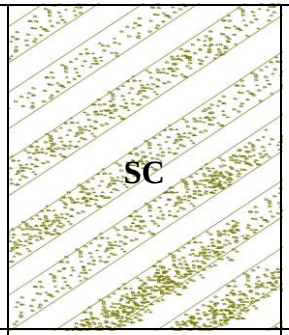
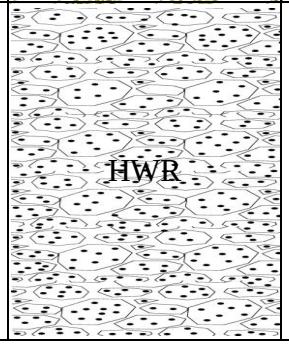
Calculation of Immediate Settlement As Per IS 8009-Part-1

$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r * D_f * S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	37	84.46	0.8	0.5	3975.54	0.736	1.00	23.90	14.07
2	1.50	1.50	2.50	38	86.51	0.8	0.5	4051.99	0.737	1.00	24.02	14.16
3	1.50	1.50	3.00	38	86.51	0.8	0.5	4051.99	0.737	1.00	24.02	14.16
4	2.00	2.00	2.00	37	78.86	0.8	0.5	3975.54	0.736	1.00	29.76	17.52
5	2.00	2.00	2.50	38	81.17	0.8	0.5	4051.99	0.737	1.00	30.05	17.72
6	2.00	2.00	3.00	38	81.17	0.8	0.5	4051.99	0.737	1.00	30.05	17.72
7	2.50	2.50	2.00	37	75.76	0.8	0.5	3975.54	0.736	1.00	35.73	21.04
8	2.50	2.50	2.50	38	78.13	0.8	0.5	4051.99	0.737	1.00	36.15	21.31
9	2.50	2.50	3.00	38	78.13	0.8	0.5	4051.99	0.737	1.00	36.15	21.31
10	3.00	3.00	2.00	37	73.31	0.8	0.5	3975.54	0.736	1.00	41.49	24.43
11	3.00	3.00	2.50	38	75.99	0.8	0.5	4051.99	0.737	1.00	42.19	24.88
12	3.00	3.00	3.00	38	75.99	0.8	0.5	4051.99	0.737	1.00	42.19	24.88

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1001	**Type of Boring :** Machine Drilling
Br No : 18A (CH-386.33)	**Water Table** : NA	**Termination Depth** : 6.00m

epth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil		**3.00**	SPT	1.50	>50
2.00						
3.00				UDS	3.00	-
4.00	Reddish Brown colour Granular material (High Weathered Rock)		**3.00**	DS	4.50	-
5.00						
6.00				DS	6.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

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ANNEXURE 2: LABORATORY TEST RESULTS

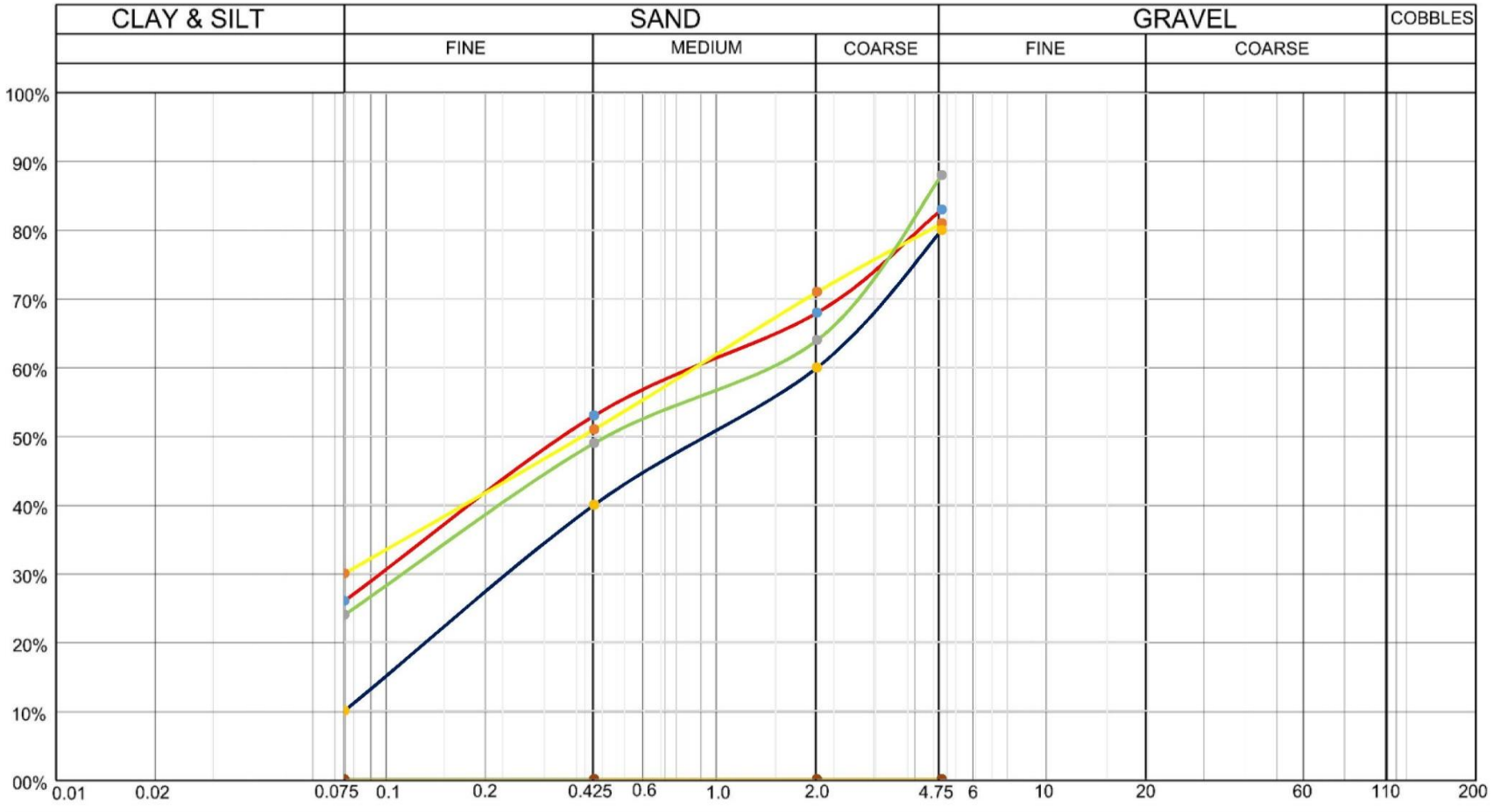
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Br No : 18A (CH-386.33) | Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	17	57	26	-	-	-	-	-	-	-	-	-
1.50	SPT	>50	-	-	-	-	19	51	30	30	16	14	SC	-	-	-	-	-
3.00	UDS	-	2.66	1.74	1.62	7.63	12	64	24	19	NP	NP	SC	DST	0	27	-	-
4.50	DS	-	-	-	-	-	20	70	10	28	13	15	HWR	-	-	-	-	-
6.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	HWR	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

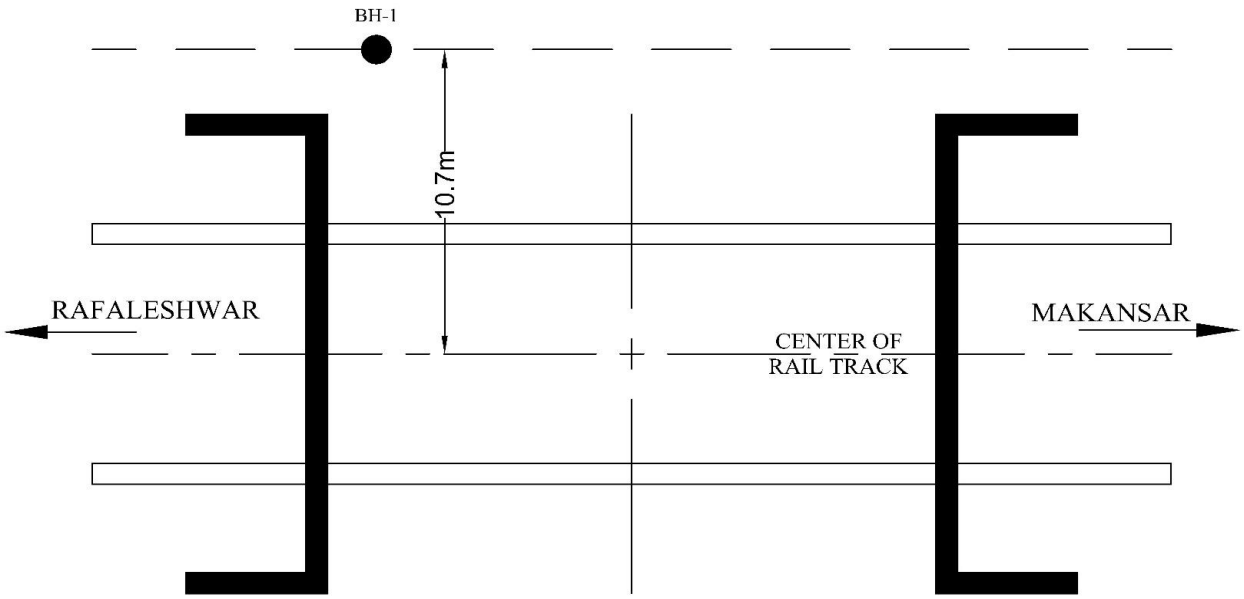
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 18A
(CH-386.33)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



Br. No.: 18A
(CH-386.33)

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client :- Gujarat Rail Infrastructure Development Corporation Limited.	
Br. No.: 18A (CH-386.33)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
LEGEND:- ● **BORE HOLE**	

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 21 (CH-979.93)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	11.82	69.44	11.82
	2.50	14.76	75.76	14.76
	3.00	17.83	84.46	17.83
Square footing (2m x 2m)	2.00	12.00	62.50	12.00
	2.50	14.80	69.25	14.80
	3.00	17.70	78.86	17.70
Square footing (2.5m x 2.5m)	2.00	12.29	58.82	12.29
	2.50	15.01	65.79	15.01
	3.00	17.79	75.76	17.79
Square footing (3m x 3m)	2.00	12.63	57.47	12.63
	2.50	15.29	63.61	15.29
	3.00	18.01	73.31	18.01

CONCLUSION & RECOMMENDATION

1. Up to 3.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 3.00 m to 6.00 m, Soil material contain majorly Highly Weathered Rock particles.
3. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br-21 (CH-979.93)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.363	1.181	1.181	1	1	1	1.790	1.00	11.82
2	150	150	250	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.453	1.227	1.227	1	1	1	1.790	1.00	14.76
3	150	150	300	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.544	1.272	1.272	1	1	1	1.790	1.00	17.83
4	200	200	200	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.272	1.136	1.136	1	1	1	1.790	1.00	12.00
5	200	200	250	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.340	1.170	1.170	1	1	1	1.790	1.00	14.80
6	200	200	300	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.408	1.204	1.204	1	1	1	1.790	1.00	17.70
7	250	250	200	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.218	1.109	1.109	1	1	1	1.790	1.00	12.29
8	250	250	250	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.272	1.136	1.136	1	1	1	1.790	1.00	15.01
9	250	250	300	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.326	1.163	1.163	1	1	1	1.790	1.00	17.79
10	300	300	200	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.181	1.091	1.091	1	1	1	1.790	1.00	12.63
11	300	300	250	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.227	1.113	1.113	1	1	1	1.790	1.00	15.29
12	300	300	300	0.00	25.00	12.606	3.941	3.714	1.3	1.2	0.8	1.272	1.136	1.136	1	1	1	1.790	1.00	18.01

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	30	-	50	1.00	7.20	69.44
1.50	2.50	33	-	50	1.00	6.60	75.76
1.50	3.00	37	-	50	1.00	5.92	84.46
2.00	2.00	30	-	50	1.00	8.00	62.50
2.00	2.50	33	-	50	1.00	7.22	69.25
2.00	3.00	37	-	50	1.00	6.34	78.86
2.50	2.00	30	-	50	1.00	8.50	58.82
2.50	2.50	33	-	50	1.00	7.60	65.79
2.50	3.00	37	-	50	1.00	6.60	75.76
3.00	2.00	30	-	50	1.00	8.70	57.47
3.00	2.50	33	-	50	1.00	7.86	63.61
3.00	3.00	37	-	50	1.00	6.82	73.31

Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Br No.(Chainage):		**Br-21 (CH-979.93)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**6.00**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r*D_f*S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	30	69.44	0.8	0.5	3440.37	0.736	1.00	22.71	13.37
2	1.50	1.50	2.50	33	75.76	0.8	0.5	3669.72	0.736	1.00	23.22	13.67
3	1.50	1.50	3.00	37	84.46	0.8	0.5	3975.54	0.736	1.00	23.90	14.07
4	2.00	2.00	2.00	30	62.50	0.8	0.5	3440.37	0.736	1.00	27.25	16.04
5	2.00	2.00	2.50	33	69.25	0.8	0.5	3669.72	0.736	1.00	28.31	16.67
6	2.00	2.00	3.00	37	78.86	0.8	0.5	3975.54	0.736	1.00	29.76	17.52
7	2.50	2.50	2.00	30	58.82	0.8	0.5	3440.37	0.736	1.00	32.06	18.88
8	2.50	2.50	2.50	33	65.79	0.8	0.5	3669.72	0.736	1.00	33.61	19.79
9	2.50	2.50	3.00	37	75.76	0.8	0.5	3975.54	0.736	1.00	35.73	21.04
10	3.00	3.00	2.00	30	57.47	0.8	0.5	3440.37	0.736	1.00	37.59	22.13
11	3.00	3.00	2.50	33	63.61	0.8	0.5	3669.72	0.736	1.00	39.00	22.96
12	3.00	3.00	3.00	37	73.31	0.8	0.5	3975.54	0.736	1.00	41.49	24.43

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1003	**Type of Boring :** Machine Drilling
Br No : 21 (CH-979.93)	**Water Table** : NA	**Termination Depth** : 6.00m

epth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil	**SC**	**1.50**	UDS	1.50	-
2.00						
3.00	Reddish Brown colour Granular material (High Weathered Rock)	**HWR**	**4.50**	SPT	3.00	58
4.00				SPT	4.50	72
5.00				DS	6.00	-
6.00						

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

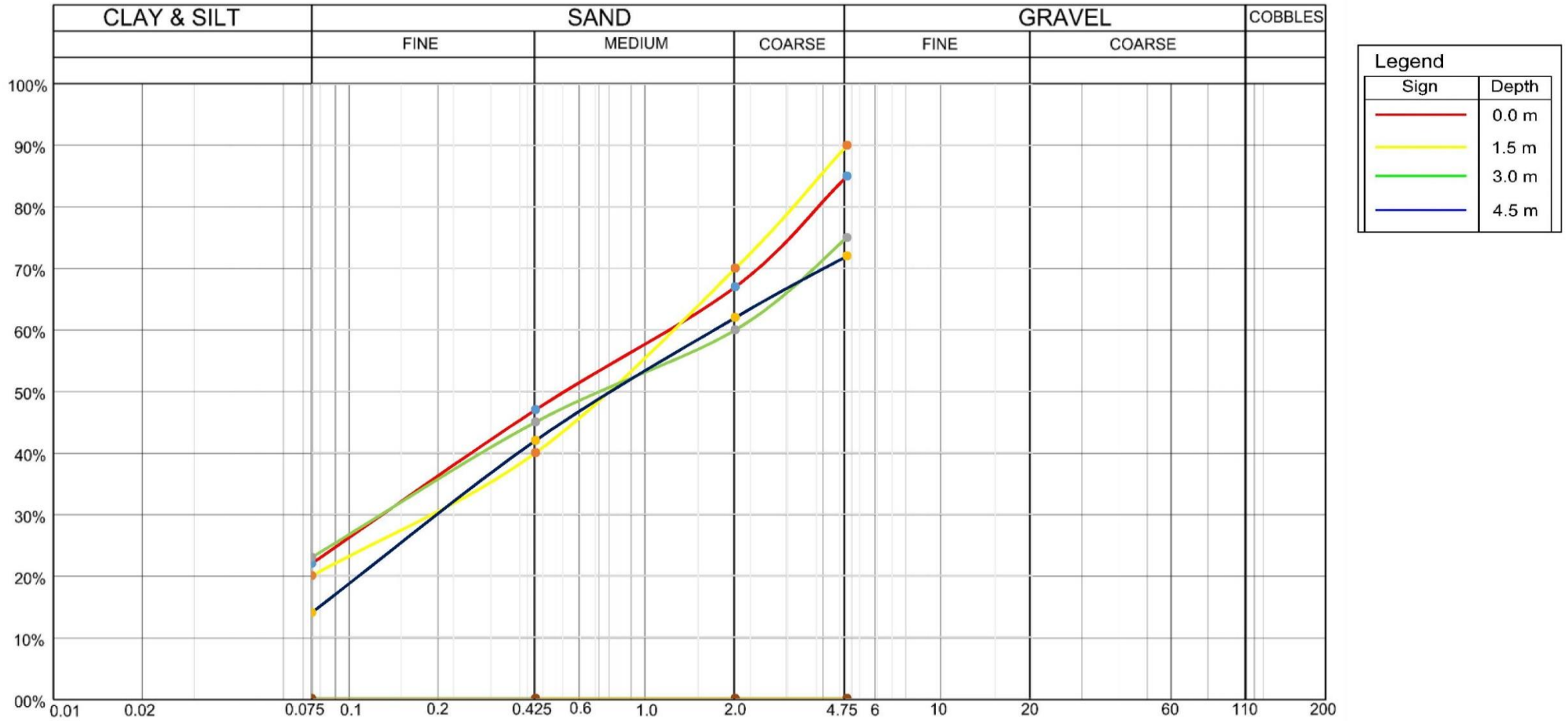
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Br No : 21 (CH-979.93) | Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	15	63	22	-	-	-	-	-	-	-	-	-
1.50	UDS	-	2.67	1.79	1.65	8.52	10	70	20	25	NP	NP	SC	DST	0	25	-	-
3.00	SPT	58	-	-	-	-	25	52	23	15	NP	NP	HWR	-	-	-	-	-
4.50	SPT	72	-	-	-	-	28	58	14	18	NP	NP	HWR	-	-	-	-	-
6.00	DS	-	2.64	-	-	-	-	-	-	-	-	-	HWR	-	-	-	-	-

GRAIN SIZE DISRIBUTION



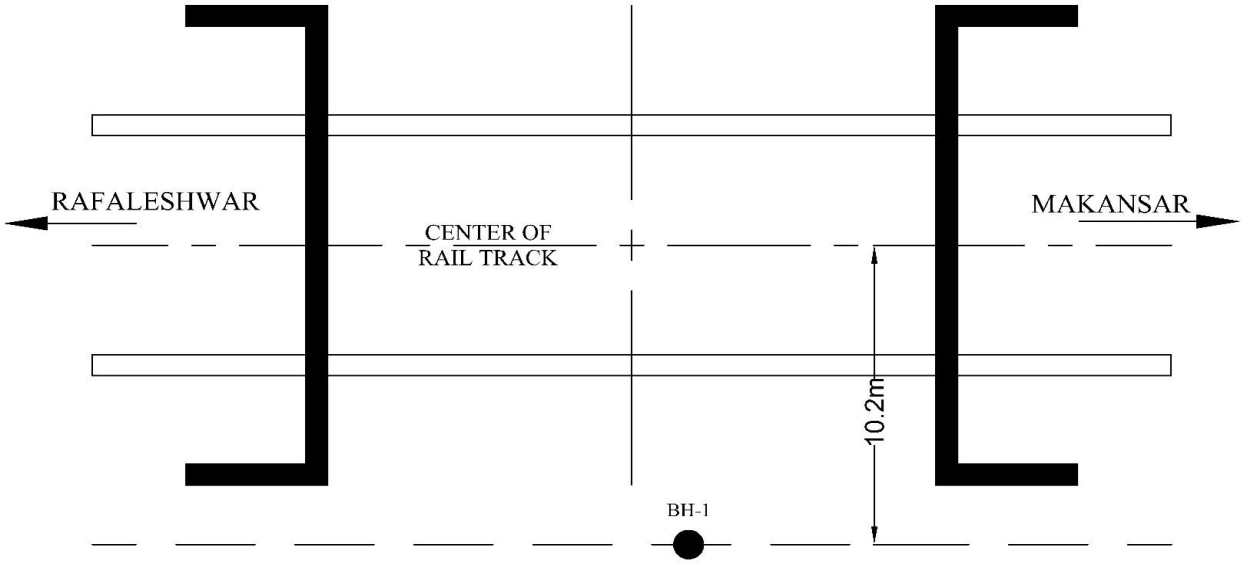
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 21
(CH-979.93)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



Br. No.: 21
(CH-979.93)

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client :- Gujarat Rail Infrastructure Development Corporation Limited.	
Br. No.: 21 (CH-979.93)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
LEGEND:- ● **BORE HOLE**	

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 22 (CH-1063.37)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	12.79	80.65	12.79
	2.50	15.97	80.65	15.97
	3.00	19.29	80.65	19.29
Square footing (2m x 2m)	2.00	13.00	74.63	13.00
	2.50	16.02	74.63	16.02
	3.00	19.14	74.63	19.14
Square footing (2.5m x 2.5m)	2.00	13.32	71.43	13.32
	2.50	16.25	71.43	16.25
	3.00	19.25	71.43	19.25
Square footing (3m x 3m)	2.00	13.71	68.49	13.71
	2.50	16.56	68.49	16.56
	3.00	19.49	68.49	19.49

CONCLUSION & RECOMMENDATION

1. Up to 3.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 4.50 m to 6.00 m, Soil material contain majorly Highly Weathered Rock particles.
3. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br-22 (CH-1063.37)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.368	1.184	1.184	1	1	1	1.810	1.00	12.79
2	150	150	250	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.460	1.230	1.230	1	1	1	1.810	1.00	15.97
3	150	150	300	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.552	1.276	1.276	1	1	1	1.810	1.00	19.29
4	200	200	200	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.276	1.138	1.138	1	1	1	1.810	1.00	13.00
5	200	200	250	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.345	1.172	1.172	1	1	1	1.810	1.00	16.02
6	200	200	300	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.414	1.207	1.207	1	1	1	1.810	1.00	19.14
7	250	250	200	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.221	1.110	1.110	1	1	1	1.810	1.00	13.32
8	250	250	250	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.276	1.138	1.138	1	1	1	1.810	1.00	16.25
9	250	250	300	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.331	1.165	1.165	1	1	1	1.810	1.00	19.25
10	300	300	200	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.184	1.092	1.092	1	1	1	1.810	1.00	13.71
11	300	300	250	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.230	1.115	1.115	1	1	1	1.810	1.00	16.56
12	300	300	300	0.11	26.00	13.188	4.312	4.127	1.3	1.2	0.8	1.276	1.138	1.138	1	1	1	1.810	1.00	19.49

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	35	-	50	1.00	6.20	80.65
1.50	2.50	35	-	50	1.00	6.20	80.65
1.50	3.00	35	-	50	1.00	6.20	80.65
2.00	2.00	35	-	50	1.00	6.70	74.63
2.00	2.50	35	-	50	1.00	6.70	74.63
2.00	3.00	35	-	50	1.00	6.70	74.63
2.50	2.00	35	-	50	1.00	7.00	71.43
2.50	2.50	35	-	50	1.00	7.00	71.43
2.50	3.00	35	-	50	1.00	7.00	71.43
3.00	2.00	35	-	50	1.00	7.30	68.49
3.00	2.50	35	-	50	1.00	7.30	68.49
3.00	3.00	35	-	50	1.00	7.30	68.49

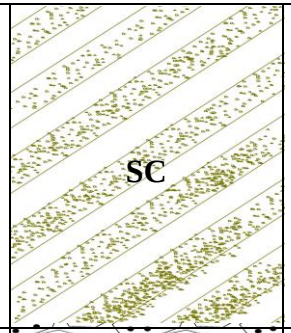
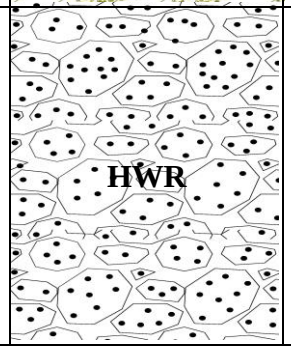
Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Br No.(Chainage):		**Br-22 (CH-1063.37)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**6.00**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r * D_f * S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	35	80.65	0.8	0.5	3822.63	0.736	1.00	23.73	13.97
2	1.50	1.50	2.50	35	80.65	0.8	0.5	3822.63	0.736	1.00	23.73	13.97
3	1.50	1.50	3.00	35	80.65	0.8	0.5	3822.63	0.736	1.00	23.73	13.97
4	2.00	2.00	2.00	35	74.63	0.8	0.5	3822.63	0.736	1.00	29.28	17.24
5	2.00	2.00	2.50	35	74.63	0.8	0.5	3822.63	0.736	1.00	29.28	17.24
6	2.00	2.00	3.00	35	74.63	0.8	0.5	3822.63	0.736	1.00	29.28	17.24
7	2.50	2.50	2.00	35	71.43	0.8	0.5	3822.63	0.736	1.00	35.04	20.63
8	2.50	2.50	2.50	35	71.43	0.8	0.5	3822.63	0.736	1.00	35.04	20.63
9	2.50	2.50	3.00	35	71.43	0.8	0.5	3822.63	0.736	1.00	35.04	20.63
10	3.00	3.00	2.00	35	68.49	0.8	0.5	3822.63	0.736	1.00	40.32	23.74
11	3.00	3.00	2.50	35	68.49	0.8	0.5	3822.63	0.736	1.00	40.32	23.74
12	3.00	3.00	3.00	35	68.49	0.8	0.5	3822.63	0.736	1.00	40.32	23.74

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1004	**Type of Boring :** Machine Drilling
Br No : 22 (CH-1063.37)	**Water Table** : NA	**Termination Depth** : 6.00m

epth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Sandy Soil		**3.00**	SPT	1.50	55
2.00				UDS	3.00	-
3.00						
4.00	Reddish Brown colour Granular material (High Weathered Rock)		**3.00**	DS	4.50	-
5.00				DS	6.00	-
6.00						

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

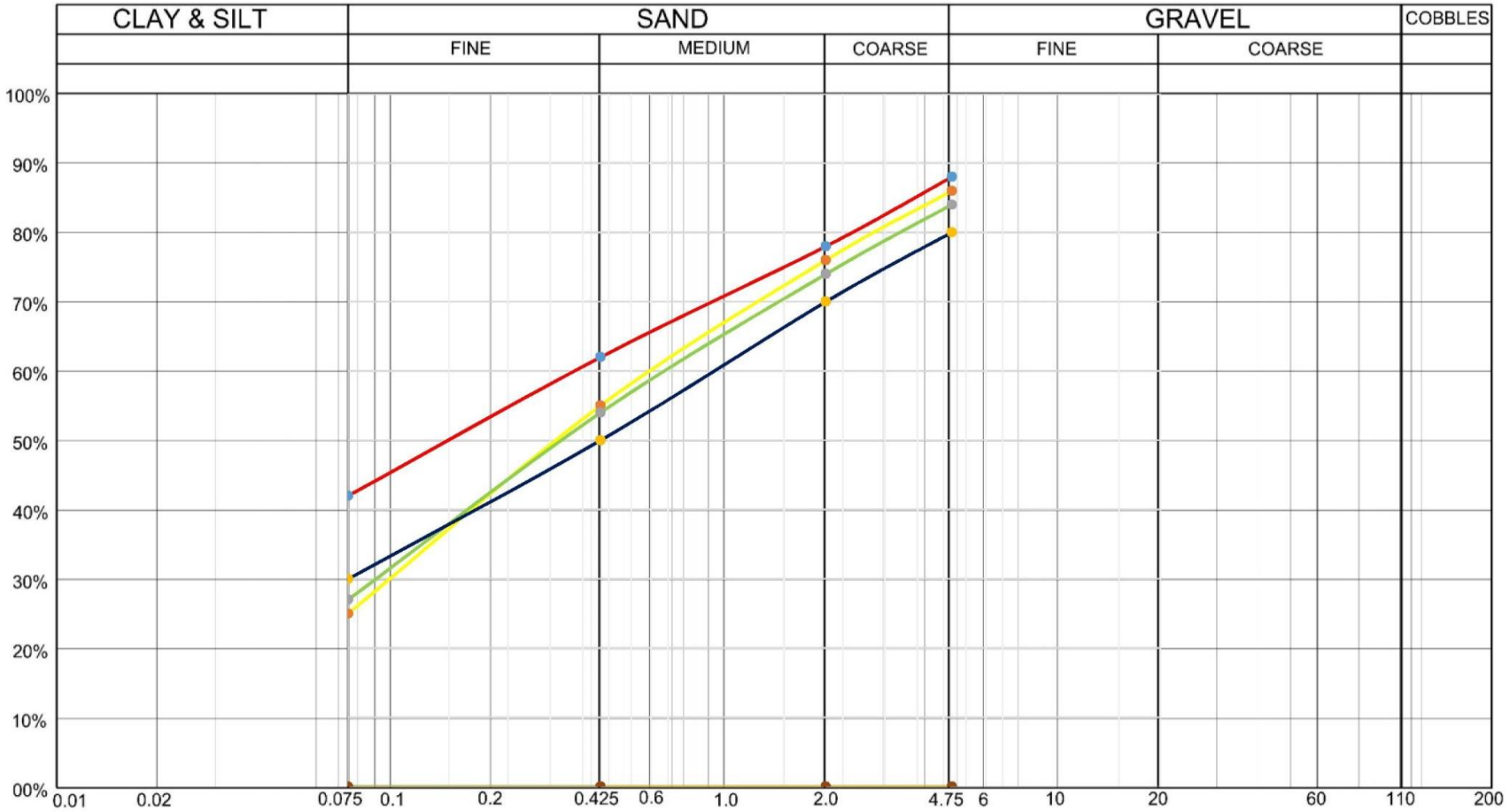
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Br No : 22 (CH-1063.37) | Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	12	46	42	-	-	-	-	-	-	-	-	-
1.50	SPT	55	-	-	-	-	14	61	25	15	NP	NP	SC	-	-	-	-	-
3.00	UDS	-	2.66	1.81	1.65	9.65	16	57	27	25	NP	NP	SC	DST	0.11	26	-	-
4.50	DS	-	2.65	-	-	-	20	50	30	18	NP	NP	HWR	-	-	-	-	-
6.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	HWR	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

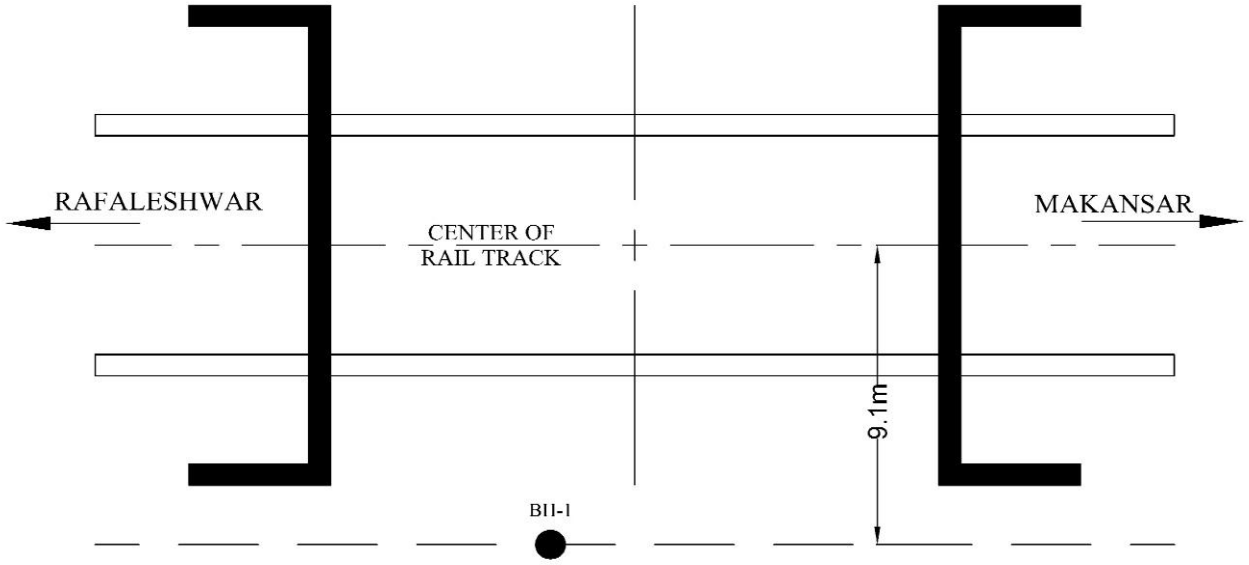
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 22
(CH-1063.37)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



Br. No.: 22
(CH-1063.37)

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client :- Gujarat Rail Infrastructure Development Corporation Limited.	
Br. No.: 22 (CH-1063.37)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
LEGEND:- ● **BORE HOLE**	

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 23 (CH-1473.09)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	10.64	55.56	10.64
	2.50	13.28	60.98	13.28
	3.00	16.04	66.49	16.04
Square footing (2m x 2m)	2.00	10.80	50.00	10.80
	2.50	13.32	54.35	13.32
	3.00	15.93	59.52	15.93
Square footing (2.5m x 2.5m)	2.00	11.05	45.45	11.05
	2.50	13.50	51.02	13.50
	3.00	16.01	56.18	16.01
Square footing (3m x 3m)	2.00	11.34	43.48	11.34
	2.50	13.74	49.70	13.74
	3.00	16.20	54.95	16.20

CONCLUSION & RECOMMENDATION

1. For 0.00 m to 4.50 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 4.50 m to 6.00 m, Soil material contain majorly Sand Stone particles.
2. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br 23 (CH-1473.09)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.358	1.179	1.179	1	1	1	1.720	1.00	10.64
2	150	150	250	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.447	1.224	1.224	1	1	1	1.720	1.00	13.28
3	150	150	300	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.537	1.268	1.268	1	1	1	1.720	1.00	16.04
4	200	200	200	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.720	1.00	10.80
5	200	200	250	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.336	1.168	1.168	1	1	1	1.720	1.00	13.32
6	200	200	300	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.403	1.201	1.201	1	1	1	1.720	1.00	15.93
7	250	250	200	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.215	1.107	1.107	1	1	1	1.720	1.00	11.05
8	250	250	250	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.720	1.00	13.50
9	250	250	300	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.322	1.161	1.161	1	1	1	1.720	1.00	16.01
10	300	300	200	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.179	1.089	1.089	1	1	1	1.720	1.00	11.34
11	300	300	250	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.224	1.112	1.112	1	1	1	1.720	1.00	13.74
12	300	300	300	0.00	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.720	1.00	16.20

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	25	-	50	1.00	9.00	55.56
1.50	2.50	27	-	50	1.00	8.20	60.98
1.50	3.00	29	-	50	1.00	7.52	66.49
2.00	2.00	25	-	50	1.00	10.00	50.00
2.00	2.50	27	-	50	1.00	9.20	54.35
2.00	3.00	29	-	50	1.00	8.40	59.52
2.50	2.00	25	-	50	1.00	11.00	45.45
2.50	2.50	27	-	50	1.00	9.80	51.02
2.50	3.00	29	-	50	1.00	8.90	56.18
3.00	2.00	25	-	50	1.00	11.50	43.48
3.00	2.50	27	-	50	1.00	10.06	49.70
3.00	3.00	29	-	50	1.00	9.10	54.95

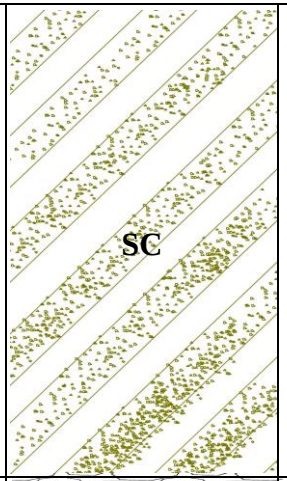
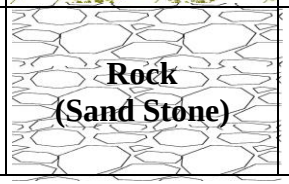
Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Br No.(Chainage):		**Br 23 (CH-1473.09)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**6.00**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r*D_f*S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	25	55.56	0.8	0.5	3058.10	0.736	1.00	20.44	12.03
2	1.50	1.50	2.50	27	60.98	0.8	0.5	3211.01	0.736	1.00	21.36	12.58
3	1.50	1.50	3.00	29	66.49	0.8	0.5	3363.91	0.736	1.00	22.24	13.09
4	2.00	2.00	2.00	25	50.00	0.8	0.5	3058.10	0.736	1.00	24.53	14.44
5	2.00	2.00	2.50	27	54.35	0.8	0.5	3211.01	0.736	1.00	25.39	14.95
6	2.00	2.00	3.00	29	59.52	0.8	0.5	3363.91	0.736	1.00	26.54	15.63
7	2.50	2.50	2.00	25	45.45	0.8	0.5	3058.10	0.736	1.00	27.87	16.41
8	2.50	2.50	2.50	27	51.02	0.8	0.5	3211.01	0.736	1.00	29.79	17.54
9	2.50	2.50	3.00	29	56.18	0.8	0.5	3363.91	0.736	1.00	31.31	18.44
10	3.00	3.00	2.00	25	43.48	0.8	0.5	3058.10	0.736	1.00	31.99	18.84
11	3.00	3.00	2.50	27	49.70	0.8	0.5	3211.01	0.736	1.00	34.83	20.51
12	3.00	3.00	3.00	29	54.95	0.8	0.5	3363.91	0.736	1.00	36.75	21.64

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1005	**Type of Boring :** Machine Drilling
Br No : 23 (CH-1473.09)	**Water Table** : NA	**Termination Depth** : 6.00 m

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Clayey-Sand Soil	 **SC**	**4.50**	SPT	1.50	29
2.00						
3.00				UDS	3.00	-
4.00				SPT	4.50	56
5.00						
6.00	Highly Weathered Yellowish Cooured Sand Stone	 **Rock (Sand Stone)**	**1.50**	DS	6.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

Bhajan InfraTech PVT. LTD.

ANNEXURE 2: LABORATORY TEST RESULTS

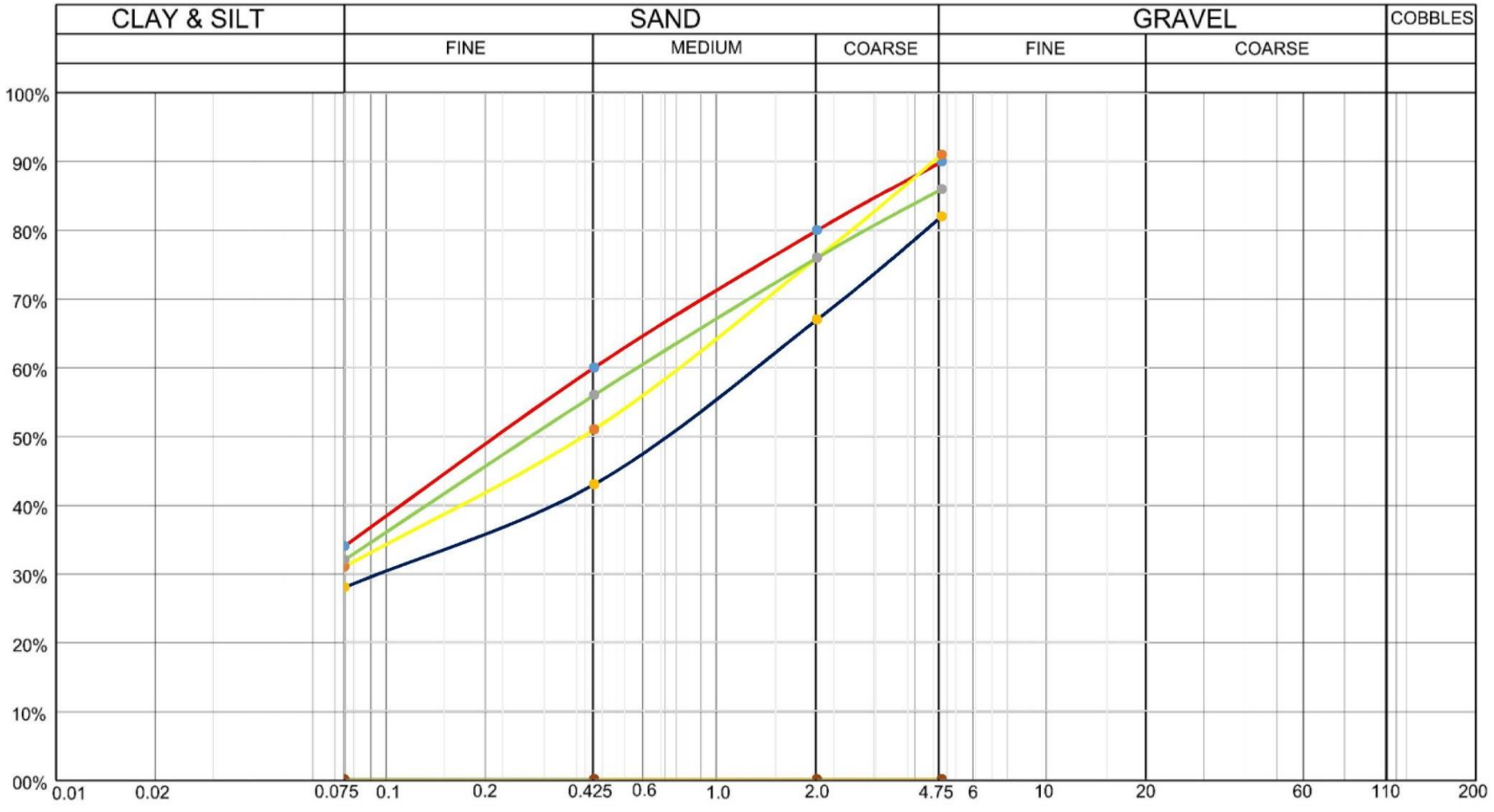
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Br No : 23 (CH-1473.09) | Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	10	56	34	-	-	-	-	-	-	-	-	-
1.50	SPT	29	-	-	-	-	9	60	31	27	13	14	SC	-	-	-	-	-
3.00	UDS	-	2.65	1.72	1.56	10.30	14	54	32	26	11	15	SC	DST	0	24	-	-
4.50	SPT	56	-	-	-	-	18	54	28	30	13	17	SC	-	-	-	-	-
6.00	DS	-	2.66	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

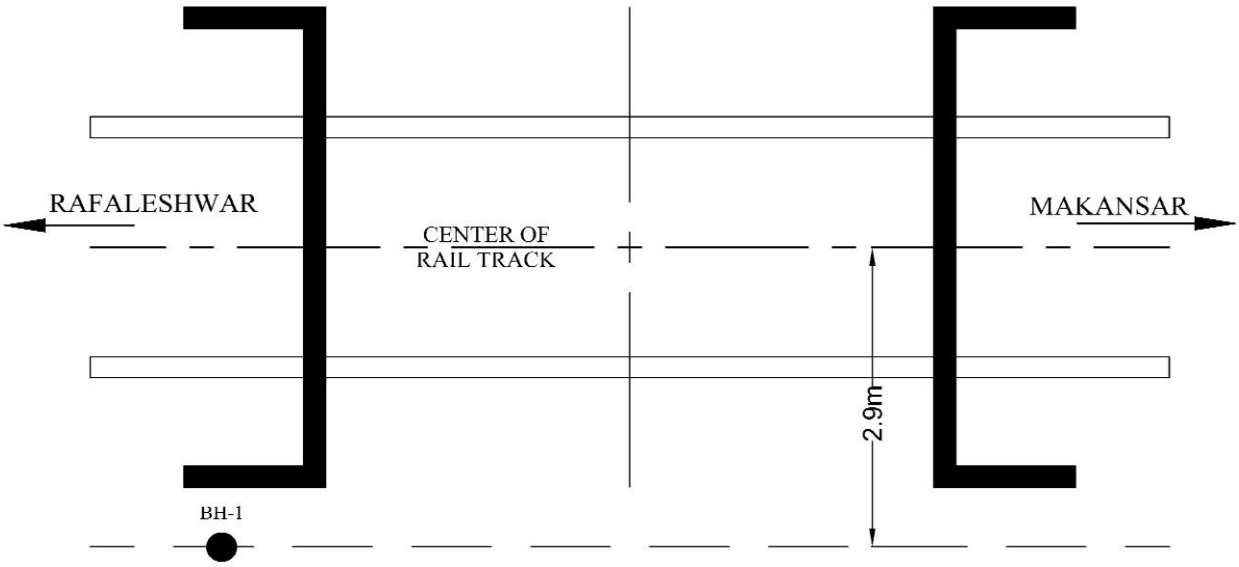
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 23
(CH-1473.09)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



Br. No.: 23
(CH-1473.09)

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client :- Gujarat Rail Infrastructure Development Corporation Limited.	
Br. No.: 23 (CH-1473.09)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
LEGEND:- ● **BORE HOLE**	

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 24 (CH-1650.47)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	10.51	51.02	10.51
	2.50	13.13	53.19	13.13
	3.00	15.86	55.56	15.86
Square footing (2m x 2m)	2.00	10.67	46.30	10.67
	2.50	13.17	48.08	13.17
	3.00	15.75	50.00	15.75
Square footing (2.5m x 2.5m)	2.00	10.92	42.37	10.92
	2.50	13.34	43.86	13.34
	3.00	15.83	45.45	15.83
Square footing (3m x 3m)	2.00	11.21	40.65	11.21
	2.50	13.58	42.02	13.58
	3.00	16.01	43.48	16.01

CONCLUSION & RECOMMENDATION

1. For 0.00 m to 4.50 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. For 4.50 m to 6.00 m, Soil material contain majorly Sand Stone particles.
2. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br 24 (CH-1650.47)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.358	1.179	1.179	1	1	1	1.700	1.00	10.51
2	150	150	250	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.447	1.224	1.224	1	1	1	1.700	1.00	13.13
3	150	150	300	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.537	1.268	1.268	1	1	1	1.700	1.00	15.86
4	200	200	200	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.700	1.00	10.67
5	200	200	250	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.336	1.168	1.168	1	1	1	1.700	1.00	13.17
6	200	200	300	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.403	1.201	1.201	1	1	1	1.700	1.00	15.75
7	250	250	200	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.215	1.107	1.107	1	1	1	1.700	1.00	10.92
8	250	250	250	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.700	1.00	13.34
9	250	250	300	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.322	1.161	1.161	1	1	1	1.700	1.00	15.83
10	300	300	200	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.179	1.089	1.089	1	1	1	1.700	1.00	11.21
11	300	300	250	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.224	1.112	1.112	1	1	1	1.700	1.00	13.58
12	300	300	300	0.05	24.00	12.062	3.600	3.343	1.3	1.2	0.8	1.268	1.134	1.134	1	1	1	1.700	1.00	16.01

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	23	-	50	1.00	9.80	51.02
1.50	2.50	24	-	50	1.00	9.40	53.19
1.50	3.00	25	-	50	1.00	9.00	55.56
2.00	2.00	23	-	50	1.00	10.80	46.30
2.00	2.50	24	-	50	1.00	10.40	48.08
2.00	3.00	25	-	50	1.00	10.00	50.00
2.50	2.00	23	-	50	1.00	11.80	42.37
2.50	2.50	24	-	50	1.00	11.40	43.86
2.50	3.00	25	-	50	1.00	11.00	45.45
3.00	2.00	23	-	50	1.00	12.30	40.65
3.00	2.50	24	-	50	1.00	11.90	42.02
3.00	3.00	25	-	50	1.00	11.50	43.48

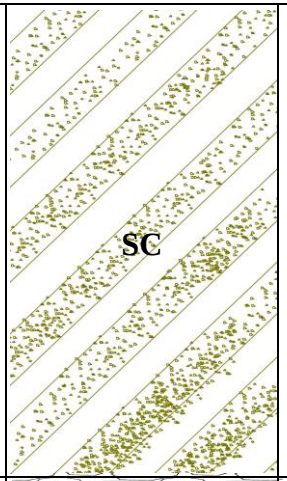
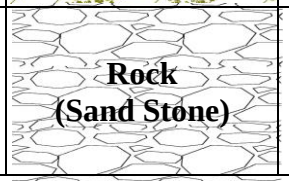
Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Br No.(Chainage):		**Br 24 (CH-1650.47)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**6.00**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r*D_f*S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	23	51.02	0.8	0.5	2905.20	0.736	1.00	19.76	11.63
2	1.50	1.50	2.50	24	53.19	0.8	0.5	2981.65	0.736	1.00	20.07	11.82
3	1.50	1.50	3.00	25	55.56	0.8	0.5	3058.10	0.736	1.00	20.44	12.03
4	2.00	2.00	2.00	23	46.30	0.8	0.5	2905.20	0.736	1.00	23.90	14.07
5	2.00	2.00	2.50	24	48.08	0.8	0.5	2981.65	0.736	1.00	24.19	14.24
6	2.00	2.00	3.00	25	50.00	0.8	0.5	3058.10	0.736	1.00	24.53	14.44
7	2.50	2.50	2.00	23	42.37	0.8	0.5	2905.20	0.736	1.00	27.35	16.10
8	2.50	2.50	2.50	24	43.86	0.8	0.5	2981.65	0.736	1.00	27.58	16.24
9	2.50	2.50	3.00	25	45.45	0.8	0.5	3058.10	0.736	1.00	27.87	16.41
10	3.00	3.00	2.00	23	40.65	0.8	0.5	2905.20	0.736	1.00	31.48	18.54
11	3.00	3.00	2.50	24	42.02	0.8	0.5	2981.65	0.736	1.00	31.71	18.67
12	3.00	3.00	3.00	25	43.48	0.8	0.5	3058.10	0.736	1.00	31.99	18.84

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1006	**Type of Boring :** Machine Drilling
Br No : 24 (CH-1650.47)	**Water Table** : NA	**Termination Depth** : 6.00 m

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Clayey-Sand Soil	 **SC**	**4.50**	SPT	1.50	28
2.00						
3.00				UDS	3.00	-
4.00				SPT	4.50	41
5.00						
6.00	Highly Weathered Yellowish Cooured Sand Stone	 **Rock (Sand Stone)**	**1.50**	DS	6.00	-

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

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ANNEXURE 2: LABORATORY TEST RESULTS

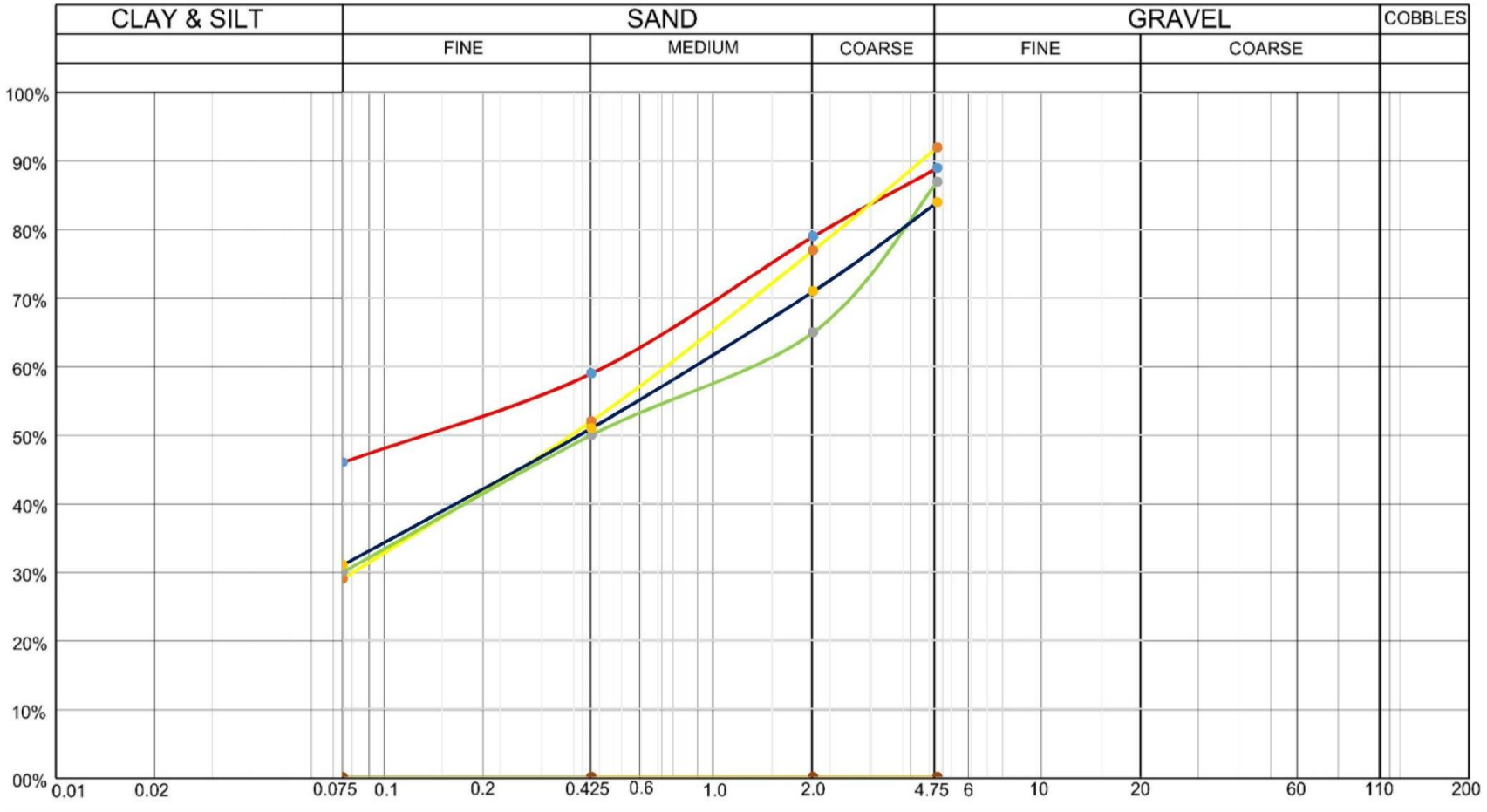
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited | W.T Below G.L: NA

Br No : 24 (CH-1650.47) | Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	11	43	46	-	-	-	-	-	-	-	-	-
1.50	SPT	28	-	-	-	-	8	63	29	29	16	13	SC	-	-	-	-	-
3.00	UDS	-	2.66	1.70	1.53	11.24	13	57	30	24	12	12	SC	DST	0.05	24	-	-
4.50	SPT	41	-	-	-	-	16	53	31	28	14	14	SC	-	-	-	-	-
6.00	DS	-	2.65	-	-	-	-	-	-	-	-	-	Rock	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m

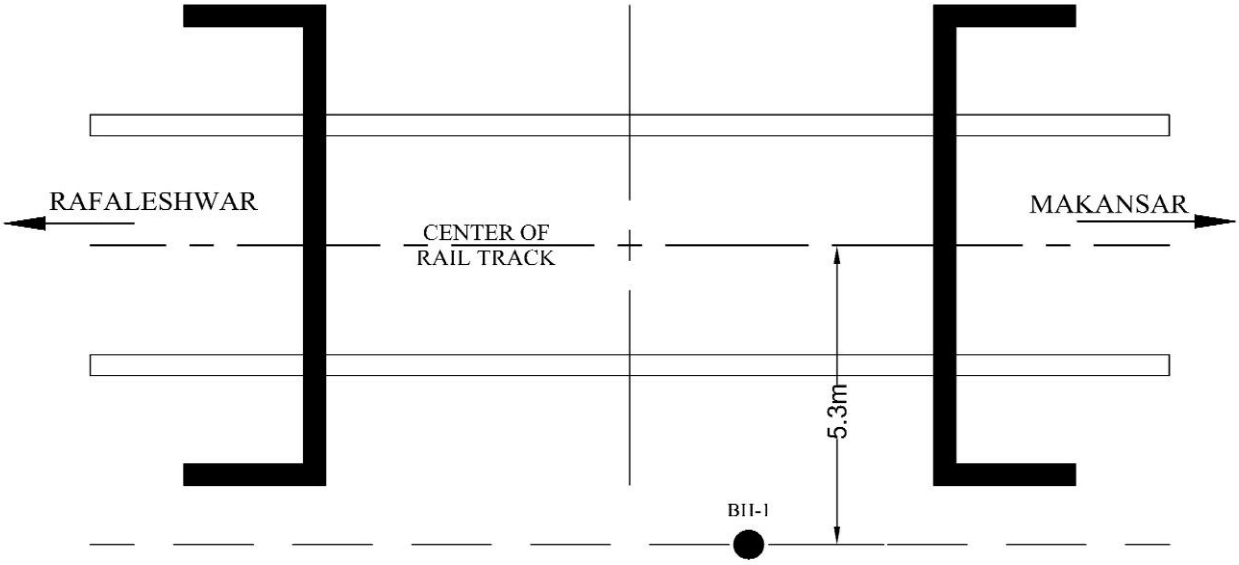
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 24
(CH-1650.47)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



Br. No.: 24
(CH-1650.47)

Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.	
Client :- Gujarat Rail Infrastructure Development Corporation Limited.	
Br. No.: 24 (CH-1650.47)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
LEGEND:- ● **BORE HOLE**	

GEOTECHNICAL INVESTIGATION WORK
FOR BRIDGE NO. 24A (CH-2151.59)

SUMMARY OF SOIL BEARING CAPACITY

Table No. 1 Summary of Soil Bearing Capacity

Size of Footing	Depth Below Ground Level (m)	Safe Bearing Capacity (t/m^2)	Safe Bearing Pressure Settlement (t/m2)	Recommended Bearing Capacity (t/m2)
Square footing (1.5m x 1.5m)	2.00	10.85	35.71	10.85
	2.50	13.57	38.46	13.57
	3.00	16.46	41.67	16.46
Square footing (2m x 2m)	2.00	11.74	32.77	11.74
	2.50	14.65	34.77	14.65
	3.00	17.71	37.04	17.71
Square footing (2.5m x 2.5m)	2.00	12.03	32.05	12.03
	2.50	14.85	33.78	14.85
	3.00	17.81	35.71	17.81
Square footing (3m x 3m)	2.00	12.36	30.79	12.36
	2.50	15.13	32.64	15.13
	3.00	18.03	34.72	18.03

CONCLUSION & RECOMMENDATION

1. For 0.00 m to 6.00 m, Soil is having mostly High Liquid limit characteristics and Soil material contain majorly Sand particles.
2. The safe bearing capacity is recommended as given vide Para of report.

For, Bhajan InfraTech PVT. LTD.

Authorized Signatory

Table No. 2 Calculation of Net Safe Bearing Capacity Based on Shear Parameters

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Br No.(Chainage):	**Br 24A (CH-2151.59)**	**Factor of Safety**	**3**	**GWT, cm**	**NA**	**Depth of Bore Hole, m**	**6.00**

Calculation of Net Safe Bearing Capacity Based on Shear Parameters (C and ϕ) as per IS: 6403-1981

$$qnu=1/F\ [(2/3)\ C.Nc.Sc.dc.ic + \gamma d(Nq-1).Sq.dq.iq + 0.5.\gamma.B.N\gamma.S\gamma.d\gamma.i\gamma.W']$$

Sr. No.	Size of Footing			Shear Parameters		Bearing Capacity Parameters			Shape Factors			Depth Factors			Inclination Factors			Unit Weight	Water Table Correction	Safe Bearing Capacity
	Length (cm)	Width (cm)	Depth (cm)	C, (kg/cm^2)	ϕ°	N_c	N_q - 1	N_γ	S_c	S_q	S_γ	d_c	d_q	d_γ	i_c	i_q	i_γ	γ, (gm/cm3)	W_γ	q_s, , (t/m^2)
1	150	150	200	0.26	25.17	12.700	4.000	3.780	1	1	1	1.364	1.182	1.182	1	1	1	1.73	1.00	10.85
2	150	150	250	0.43	25.33	12.796	4.061	3.847	1	1	1	1.456	1.228	1.228	1	1	1	1.73	1.00	13.57
3	150	150	300	0.61	25.50	12.892	4.122	3.915	1	1	1	1.548	1.274	1.274	1	1	1	1.73	1.00	16.46
4	200	200	200	0.26	25.17	12.700	4.000	3.780	1.3	1.2	0.8	1.273	1.136	1.136	1	1	1	1.73	1.00	11.74
5	200	200	250	0.43	25.33	12.796	4.061	3.847	1.3	1.2	0.8	1.342	1.171	1.171	1	1	1	1.73	1.00	14.65
6	200	200	300	0.61	25.50	12.892	4.122	3.915	1.3	1.2	0.8	1.411	1.205	1.205	1	1	1	1.73	1.00	17.71
7	250	250	200	0.26	25.17	12.700	4.000	3.780	1.3	1.2	0.8	1.218	1.109	1.109	1	1	1	1.73	1.00	12.03
8	250	250	250	0.43	25.33	12.796	4.061	3.847	1.3	1.2	0.8	1.273	1.137	1.137	1	1	1	1.73	1.00	14.85
9	250	250	300	0.61	25.50	12.892	4.122	3.915	1.3	1.2	0.8	1.329	1.164	1.164	1	1	1	1.73	1.00	17.81
10	300	300	200	0.26	25.17	12.700	4.000	3.780	1.3	1.2	0.8	1.182	1.091	1.091	1	1	1	1.73	1.00	12.36
11	300	300	250	0.43	25.33	12.796	4.061	3.847	1.3	1.2	0.8	1.228	1.114	1.114	1	1	1	1.73	1.00	15.13
12	300	300	300	0.61	25.50	12.892	4.122	3.915	1.3	1.2	0.8	1.274	1.137	1.137	1	1	1	1.73	1.00	18.03

Table No. 3 Calculation of Net Safe Bearing Pressure Based on SPT-N-Value-Settlement Criteria

Safe bearing Pressure based on settlement criteria as per IS 8009 Part-1, (Fig. 9, Page No. 17)							
As per Table-1 of IS-1904-1986(Page No.19) Total Permissible Settlement For Shallow Foundation							
Maximum Permissible Settlement For Isolated Footing On Sand= 50mm							
Maximum Permissible Settlement For Isolated Footing On Clay = 75mm							
Width of Footing, B (m)	Depth, D_f (m)	Average N-Value	GWT Level (m)	Permissible Settlement (mm)	GWT Correction, W'	Settlement (mm) For 10t/m^2	Permissible Load in t/m^2
1.50	2.00	18	-	50	1.00	14.00	35.71
1.50	2.50	19	-	50	1.00	13.00	38.46
1.50	3.00	20	-	50	1.00	12.00	41.67
2.00	2.00	18	-	50	1.00	15.26	32.77
2.00	2.50	19	-	50	1.00	14.38	34.77
2.00	3.00	20	-	50	1.00	13.50	37.04
2.50	2.00	18	-	50	1.00	15.60	32.05
2.50	2.50	19	-	50	1.00	14.80	33.78
2.50	3.00	20	-	50	1.00	14.00	35.71
3.00	2.00	18	-	50	1.00	16.24	30.79
3.00	2.50	19	-	50	1.00	15.32	32.64
3.00	3.00	20	-	50	1.00	14.40	34.72

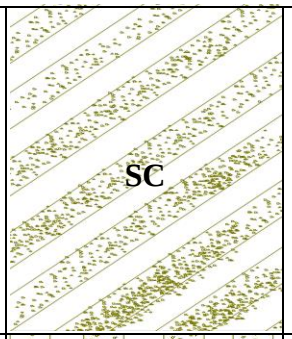
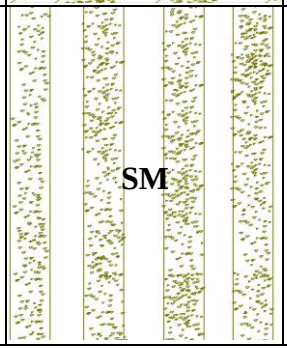
Table No. 4 Calculation of Immediate Settlement Analysis

Safe Bearing Capacity And Settlement Analysis												
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.												
Br No.(Chainage):		**Br 24A (CH-2151.59)**		**GWT, cm**		**NA**		**Depth of Bore Hole, m**			**6.00**	
Calculation of Immediate Settlement As Per IS 8009-Part-1												
$Si = qB/E(1-\mu^2)(I_f)$						$S_{ef} = C_r*D_f*S_i$						
Sr. No.	Length, (m)	Width, (m)	Depth, (m)	Corrected SPT N Value	Net Allowable Bearing Pressure,	Rigidity Factor	Poisson Ratio	Young's Modulus, Es=750(Ncor.+15)	Correction For Depth	Influence Factor	Immediate Settlement	Final Elastic Settlement
				N'	(Qns, t/m^2)	Cr	μ	t/m^2	C_d	I_f	S_i (mm)	S_{ef} (mm)
1	1.50	1.50	2.00	18	35.71	0.8	0.5	2522.94	0.734	1.00	15.93	9.35
2	1.50	1.50	2.50	19	38.46	0.8	0.5	2599.39	0.735	1.00	16.65	9.79
3	1.50	1.50	3.00	20	41.67	0.8	0.5	2675.84	0.735	1.00	17.52	10.30
4	2.00	2.00	2.00	18	32.77	0.8	0.5	2522.94	0.734	1.00	19.48	11.44
5	2.00	2.00	2.50	19	34.77	0.8	0.5	2599.39	0.735	1.00	20.06	11.80
6	2.00	2.00	3.00	20	37.04	0.8	0.5	2675.84	0.735	1.00	20.76	12.21
7	2.50	2.50	2.00	18	32.05	0.8	0.5	2522.94	0.734	1.00	23.82	13.99
8	2.50	2.50	2.50	19	33.78	0.8	0.5	2599.39	0.735	1.00	24.37	14.33
9	2.50	2.50	3.00	20	35.71	0.8	0.5	2675.84	0.735	1.00	25.03	14.72
10	3.00	3.00	2.00	18	30.79	0.8	0.5	2522.94	0.734	1.00	27.46	16.12
11	3.00	3.00	2.50	19	32.64	0.8	0.5	2599.39	0.735	1.00	28.25	16.61
12	3.00	3.00	3.00	20	34.72	0.8	0.5	2675.84	0.735	1.00	29.20	17.17

ANNEXURE 1: BORELOG DATA SHEET

Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client Name: Gujarat Rail Infrastructure Development Corporation Limited	**Report No**: BIPL/202209/1007	**Type of Boring :** Machine Drilling
Br No : 24A (CH-2151.59)	**Water Table** : NA	**Termination Depth** : 6.00m

Depth (m)	Description of Sample	Symbol/ Hatching	Thickness of Strata(m)	Sampling Type	Sample Depth (m)	SPT Value Number
0.00	**Filled up Soil**			DS	0.00	-
1.00	Yellowish Brown colour Clayey-Sand Soil		**3.00**	UDS	1.50	-
2.00						
3.00				SPT	3.00	25
4.00	Yellowish Brown colour Silty-Sand Soil		**3.00**	UDS	4.50	-
5.00						
6.00				SPT	6.00	39

Abbreviation: DS-Disturbed Sample, UDS-Undisturbed Sample, SPT-Standard Penetration Test, NA-Not Applicable

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ANNEXURE 2: LABORATORY TEST RESULTS

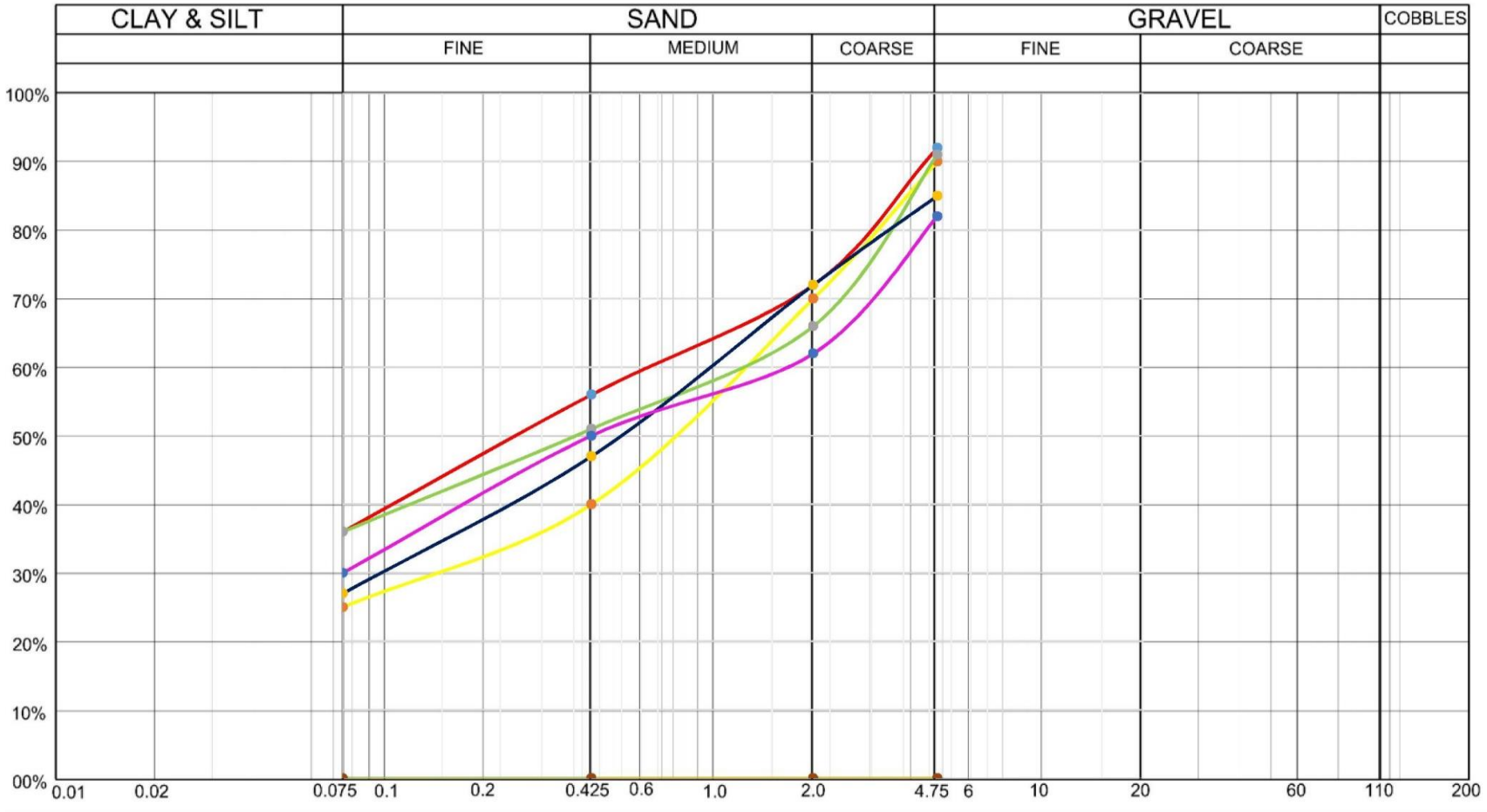
Name of Work: Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client: Gujarat Rail Infrastructure Development Corporation Limited — W.T Below G.L: NA

Br No : 24A (CH-2151.59) — Termination Depth: 6.00m

Depth	Sample Type	SPT Value Number	Specific Gravity	Field Bulk Density (Gm/cm3)	Field Dry Density (Gm/cm3)	Natural Water Content (%)	Sieve Analysis			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	I.S. Classification	Type Of Shear Test	Cohesion C(Kg/Cm^2)	Angle Of Int. Friction, Φ (°)	Shrinkage Limit (%)	Free Swell (%)
							Gravel (%)	Sand (%)	Silt & Clay (%)									
0.00	DS	-	-	-	-	-	8	56	36	-	-	-	-	-	-	-	-	-
1.50	UDS	-	2.63	1.72	1.57	9.32	10	65	25	25	12	13	SC	DST	0.09	25	-	-
3.00	SPT	25	-	-	-	-	9	55	36	27	12	15	SC	-	-	-	-	-
4.50	UDS	-	2.65	1.70	1.54	10.58	15	58	27	29	17	12	SM	DST	1.12	26	-	-
6.00	SPT	39	-	-	-	-	18	52	30	31	15	16	SM	-	-	-	-	-

GRAIN SIZE DISRIBUTION



Legend

Sign	Depth
	0.0 m
	1.5 m
	3.0 m
	4.5 m
	6.0 m

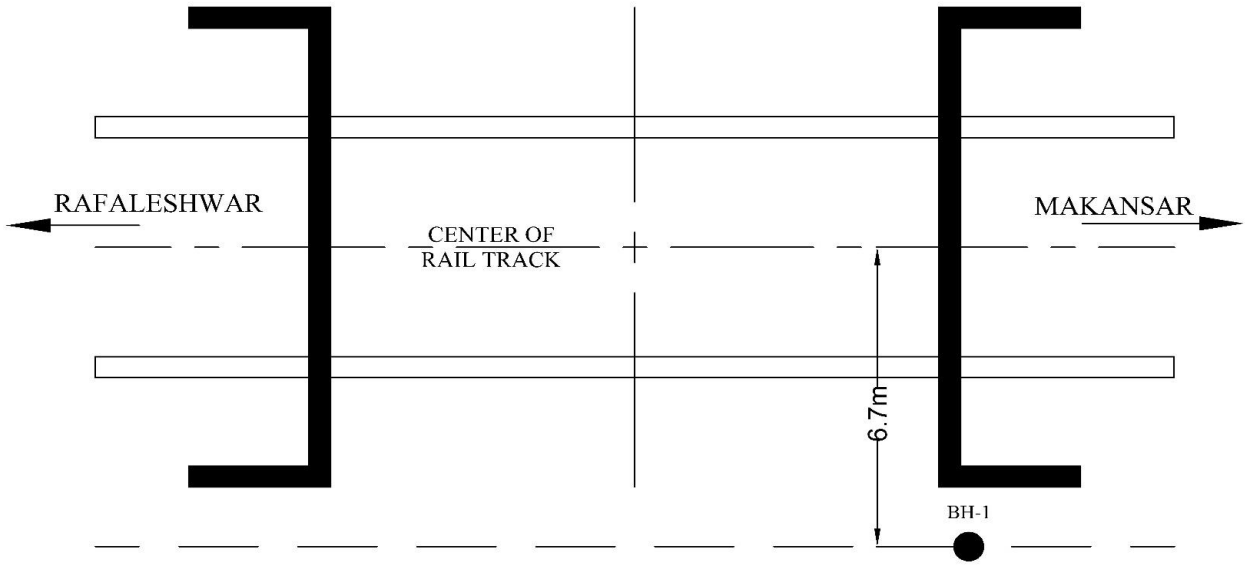
Name of Work:- Survey of existing infrastructure and Rail and road connectivity at Nargol, Navlakhi, Okha Port of Gujarat Maritime Board and Rafleshwar yard in the state of Gujarat.

Client:- Gujarat Rail Infrastructure Development Corporation Limited.

Br No.: 24A
(CH-2151.59)

InfraTech Pvt. Ltd.
B/1003, Jolly Enclave, Opp. Panchwati Wadi,
Nr. Varachha(E) Zone office, L.H.Road
Surat, 395006, GUJARAT, INDIA.
CONTACT:-+91-9725001300
VISIT US: http://www.BhajanEC.com
eMail: mail@bhajanec.com
Bhajan

BORE HOLE LOCATION PLAN



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Br No. :- 24A (CH-2151.59)	DRAWING PREPARED BY:
SCALE: NOT TO SCLAE	InfraTech Pvt. Ltd. B/1003, Jolly Enclave, Opp. Panchwati Wadi, Nr. Varachha(E) Zone office, L.H.Road Surat, 395006, GUJARAT, INDIA. CONTACT:-+91-9725001300 VISIT US: http://www.BhajanEC.com eMail: mail@bhajanec.com Bhajan
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