

March 30, 2020

Municipal Corporation Of Greater Mumbai

Dy.Ch.E. (HIC)

Municipal Engineering Hub Bldg.,

3rd, Floor, Dr. E. Moses Road,

Acharya Atre Chowk, Worli,

Mumbai - 400 018

Contact No.: 022-24916920

Sub: Soil investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.

Re: Geotechnical Report for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.

Ref: Ch.E/BM/6511/II HIC Dtd.06.07.2018

Dear Sir,

Enclosed is our Geotechnical Engineering Report for the soil investigation work with reference to your letter stated in the subject above. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you and look forward for providing additional Geotechnical Engineering and Structural Consultancy Services in the future.

Thanking you.

Sincerely,

Noble Geo-Structs



Dr. R. U. Kulkarni

Ph.D. (Geotechnical)

Copies Submitted: (3) Hard copies



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**GEOTECHNICAL DRAFT REPORT
FOR
PROPOSED ISOLATION WARD FOR CORONA VIRUS AT KASTURBA HOSPITAL IN E
WARD.**

NOBLE GEO-STRUCTS PROJECT NO. SI-20191

March 30, 2020

1. INTRODUCTION

Noble Geo-Structs (NGS) is pleased to submit our Geotechnical report for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward. This project was authorized by Dy.Ch.E. (HIC)

The purpose of this report is to describe the subsurface conditions observed at the three bore holes drilled for this study, analyze and evaluate the test data, and provide recommendations with respect to

- Engineering properties and
- Foundation considerations

2. SCOPE OF WORK

The scope of work includes drilling of three bore hole, collection of samples and transportation to NGS laboratory. The scope also includes testing of samples in NGS's NABL accredited laboratory for determining their engineering properties. Further the foundation design considerations are to be recommended.

2.1 LABORATORY TESTING

The representative soil and rock core samples meant for testing were transported to NGS's NABL accredited laboratory. Samples obtained during the field program were visually classified in the laboratory by a Geotechnical Engineer and/or a senior technician.

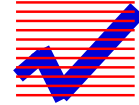
A testing programme was conducted on the samples, as directed by the Geotechnical Engineer in NGS's NABL accredited laboratory, as per relevant Indian Standards, in compliance with the technical specifications of the contract to aid in classification and evaluation of engineering properties required for analysis.

The laboratory tests include liquid limit, plastic limit, shrinkage limit, water content, sieve analysis, hydrometer, specific gravity on soil specimens. The laboratory tests also include unconfined compressive strength, water absorption, dry density, specific gravity, porosity on rock specimens. The scope also includes chemical tests (pH, sulphate and chloride).

Geotechnical Report for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.

Noble Geo-Structs Project No. SI-20191

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2.2 FIELD WORK

Subsurface conditions were evaluated by drilling three bore holes to depth within the proposed site location. The bore hole was drilled using calyx drilling equipment at the approximate location shown on the plan of bore hole in Appendix I.

The borehole is located with respect to the existing site features shown on the drawing provided to us without the use of surveying equipment. Boring depths were measured from the existing ground surface at the time of our field activities. The log of boring, presenting the subsurface soil descriptions, type of sampling used and additional field data are shown in the borelog Appendix II.

The soils were sampled by means of the Standard Penetration Test (SPT). This test consists of measuring the number of blows (N) required for a 63.5 kg hammer free falling 75 cm to drive a standard split-spoon sampler 12 inches into the subsurface material after being seated 30 cm. This blow count or SPT N-value is used to evaluate the stratum. Samples were removed from samplers in the field, visually classified and appropriately sealed in sample containers to preserve their in-situ moisture contents. Samples were transported to our laboratory in Mumbai, Maharashtra.

3. SUB SURFACE CONDITIONS

The particular subsurface stratigraphy observations may be made from the bore hole data/geotechnical investigation report provided by the client. The subsurface generally consisted of filled up material, clayey sand and completely to highly weathered Breccia

Compelety to Highly Weathered Breccia of brownish to greyish colour is encountered at a depth from 7.5m to 20 m in BH-1, 7 m to 20 m in BH-2 and 8.5 m to 18 m in BH-3. Rock Quality Designation (RQD) varies from Nil to 44% in all Boreholes. Core recovery (CR) varies from 15 % to 90% in all Boreholes.

Water Table in BH-1 is 4.10m.

Water Table in BH-1 is 3.90m.

Water Table in BH-1 is 4.30m.



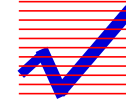
Foundation Recommendation

Geotechnical Investigation is conducted at Kasturba Hospital in E ward Chinchpokli, Mumbai, Maharashtra. The propose structure is G+2 Building for Isolation ward for Corona Virus.

Subsurface profile generally indicates presence of Breccia in all the boreholes. SPT value varies from 10 to R in all boreholes. Rock Quality Designation (RQD) varies from Nil to 44% and Core recovery (CR) varies from 15 % to 90% in all Boreholes. UCS value ranges from 8.06MPa to 34.01MPa.

Pile foundation capacity is recommended for the proposed structure based on the laboratory test results and field observations. Pile capacity is estimated as per IRC-78 (2014).

The following table presents the summary of pile capacity provided for 300mm, 400mm, 500mm, 600mm, 750mm pile diameter. Vertical capacity, Lateral capacity and uplift capacity are presented next. Based on construction viability and loading requirement, the diameter and termination criteria for pile may be adopted.



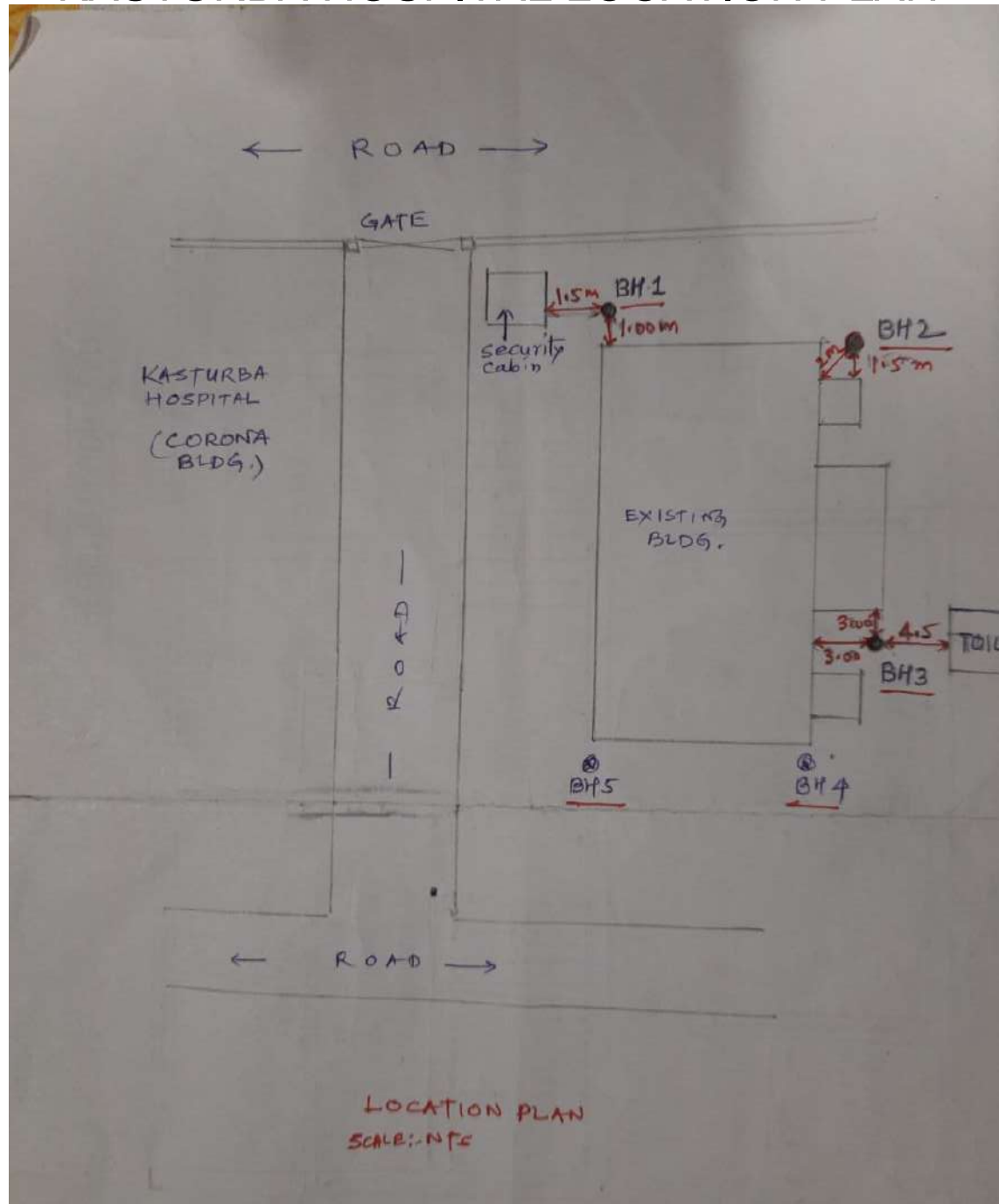
Pile Capacity Table											
Sr. No.	BH No.	Pile Diameter	Pile Length	Depth of IGM	Tensile Pile Capacity	Compression Pile Capacity	Depth of fixity	Lateral Pile Capacity as per IS 2911 part 4	Lateral Pile Capacity for 10% of Pile Diameter	Structural capacity	Recommended Compression Pile Capacity
		m	m	m	MN	MN	m	MN	MN	MN	MN
1	1	0.30	13.50	3.00	0.20	0.99	2.83	0.03	0.19	0.66	0.66
2	1	0.40	12.10	3.00	0.36	1.09	3.77	0.04	0.33	1.24	1.09
3	1	0.50	11.00	3.00	0.57	1.16	4.71	0.05	0.52	1.99	1.16
4	1	0.60	10.80	3.00	0.81	1.48	5.65	0.06	0.75	2.92	1.48
5	1	0.75	10.88	3.00	1.13	2.20	7.07	0.08	1.17	4.64	2.20
6	2	0.30	17.40	9.50	0.20	1.01	2.96	0.03	0.16	0.66	0.66
7	2	0.40	15.30	8.00	0.36	1.19	3.95	0.04	0.29	1.24	1.19
8	2	0.50	15.30	8.00	0.36	1.07	4.93	0.05	0.45	1.99	1.07
9	2	0.60	13.50	6.50	0.81	1.16	5.92	0.05	0.65	2.92	1.16
10	2	0.75	11.00	4.00	1.27	1.16	7.40	0.07	1.02	4.64	1.16
11	3	0.30	23.50	15.00	0.20	1.05	4.31	0.03	0.22	0.66	0.66
12	3	0.40	18.50	10.00	0.36	1.03	4.31	0.03	0.22	1.24	1.03
13	3	0.50	16.00	7.50	0.57	1.08	5.39	0.03	0.35	1.99	1.08
14	3	0.60	14.00	5.50	0.81	1.12	6.47	0.04	0.50	2.92	1.12
15	3	0.75	12.00	3.50	1.24	1.21	8.09	0.05	0.78	4.64	1.21

4 REFERENCES

- Indian Standard, IS: 2720 Part 4 (1995, Reaffirmed 2015). “Grain size analysis of soil” BIS, New Delhi
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APPENDIX I
Location Plan

KASTURBA HOSPITAL LOCATION PLAN



APPENDIX II
BORELOG

APPENDIX A

Log of Borings No. BH-1

CLIENT:		Municipal Corporation Of Greater Mumbai			PROJECT:		Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.													
LOCATION:		Chinchpokli			Start Date:		March 5, 2020				End Date:		March 9, 2020							
Depth, m	R.L. m	Graphic Log	Description		Sampler Type	IS Classification	LL, %	SL, %	PI, %	G	c, kg/cm ²	φ, degree	Penetration, cm				CR N	RQD %	Water Content / Absorption %	UCS, MPa
			Approximate Surface Elevation: Existing Surface Elevation										15	30	45	60				
0.5			Filled up Material brownish silty clay with gravels & boulders etc		DS-1															
1																				
1.5																				
2																				
2.5					UDS-1															
3																				
3.5																				
4	▼				SPT-1							8	12	15	15	27				
4.5																				
5					SPT-2							8	10	13	18	23				
5.5																				
6																				
6.5					SPT-3							19	20	24	24	44				
7																				
7.5					SPT-4							19	50	R	R	R				
8				CORE											30	NIL			8.88	
8.5																				
9				CORE											58	NIL				
9.5																				
10				CORE											30	NIL			8.06	
10.5																				
THE BOREHOLE IS TERMINATED AT DEPTH 20.00 m BELOW GROUND LEVEL																				
The insitu boundary layers shown are approximate. The actual limits may be more gradual. REMARKS: Rotary Drilling; NX Size Double Tube Core Barrel																				
▼ Ground Water Table:		4.10 m			Casing:		7.0 m													
Abbreviations: LL - Liquid Limit PI - Plasticity Index SL - Shrinkage Limit G- Specific Gravity																				
NP - Non-Plastic CR - Core recovery RQD -Rock Quality Designation UDS - Undisturbed sample																				
UCS - Unconfined Compressive Strength N - Standard penetration test (SPT)																				
										Project No. SI-20191										

APPENDIX A

Log of Borings No. BH-02

CLIENT:		Municipal Corporation Of Greater Mumbai			PROJECT:		Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.													
LOCATION:		Chinchpokli			Start Date:		February 8, 2020			End Date:		March 12, 2020								
Depth, m	R.L. m	Graphic Log	Description		Sampler Type	IS Classification	LL, %	SL, %	PI, %	G	c, kg/cm ²	φ, degree	Penetration, cm				CR N	RQD %	Water Content / Absorption %	UCS, MPa
			Approximate Surface Elevation: Existing Surface Elevation										15	30	45	60				
0.5			Filled up Material brownish black silty clay with gravels		DS-1															
1																				
1.5																				
2																				
2.5			Brownish yellow Silty clay		UDS-1															
3																				
3.5					SPT-1							7	9	12	17	21				
4	▼		Brownish gravels		CORE															
4.5																				
5																				
5.5																				
6			Yellowish Silty clay with gravels		SPT-2															
6.5																				
7					SPT-3							14	17	20	27	37				
7.5			Completely Weathered Breccia brownish yellow fractured & jointed		CORE											15	Nil			
8																				
8.5																				
9					CORE												40	Nil	27.38	
9.5																				
10		CORE												17	Nil					
10.5																				

THE BOREHOLE IS TERMINATED AT DEPTH 20.00 m BELOW GROUND LEVEL

The insitu boundary layers shown are approximate. The actual limits may be more gradual. **REMARKS:** Rotary Drilling; NX Size Double Tube Core Barrel

▼ **Ground Water Table: 3.90 m**

Casing: 7.0 m

Abbreviations: LL - Liquid Limit PI - Plasticity Index SL - Shrinkage Limit G- Specific Gravity
 NP - Non-Plastic CR- Core recovery RQD -Rock Quality Designation UDS - Undisturbed sample
 UCS - Unconfined Compressive Strength N - Standard penetration test (SPT)

Project No. SI-20191



Noble Geo-Structs

APPENDIX A

Log of Borings No. BH-02

CLIENT:	Municipal Corporation Of Greater Mumbai	PROJECT:	Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.
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LOCATION:	Chinchpokli	Start Date:	March 8, 2020	End Date:	March 12, 2020
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Depth, m	R.L. m	Graphic Log	Description Approximate Surface Elevation: Existing Surface Elevation	Sampler Type	IS Classification	LL, %	SL, %	PI, %	G	c, kg/cm ²	φ, degree	Penetration , cm				CR N	RQD %	Water Content / Absorption %	UCS, MPa				
												15	30	45	60								
												11			Completely Weathered Breccia brownish yellow					CORE			
11.5		21	Nil																				
12		32	Nil																				
12.5																							
13																							
13.5																							
14		35	Nil																				
14.5																							
15																							
15.5		49	10																				
16																							
16.5																							
17		53	9																				
17.5																							
18																							
18.5		73	39																				
19																							
19.5																							
20		84	22		11.62																		

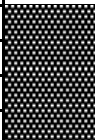
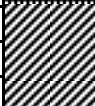

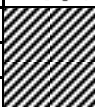


THE BOREHOLE IS TERMINATED AT DEPTH 20.00 m BELOW GROUND LEVEL

The insitu boundary layers shown are approximate. The actual limits may be more gradual. REMARKS: Rotary Drilling; NX Size Double Tube Core Barrel

<p>▼ Ground Water Table: 3.90 m</p> <p>Abbreviations: LL - Liquid Limit PI - Plasticity Index SL - Shrinkage Limit G- Specific Gravity</p> <p>NP - Non-Plastic CR- Core recovery RQD -Rock Quality Designation UDS - Undisturbed sample</p> <p>UCS - Unconfined Compressive Strength N - Standard penetration test (SPT)</p>	<p>Casing: 7.0 m</p> <p>Project No. SI-20191</p>	<p>Noble Geo-Structs</p>
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APPENDIX A

Log of Borings No. BH-03

CLIENT:		Municipal Corporation Of Greater Mumbai			PROJECT:		Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.													
LOCATION:		Chinchpokli			Start Date:		March 12, 2020			End Date:		March 15, 2020								
Depth, m	R.L. m	Graphic Log	Description		Sampler Type	IS Classification	LL, %	SL, %	PI, %	G	c, kg/cm ²	φ, degree	Penetration, cm				CR N	RQD %	Water Content / Absorption %	UCS, MPa
			Approximate Surface Elevation: Existing Surface Elevation										15	30	45	60				
0.5			Filled up Material brownish black silty clay with boulders		DS-1															
1																				
1.5																				
2																				
2.5			Greyish Brown Silty Clay		UDS-1															
3																				
3.5					SPT-1							4	5	5	5	10				
4	▼		Boulders brownish grey		CORE															
4.5																				
5																				
5.5																				
6			Brownish yellow Silty clay		SPT-2															
6.5																				
7													4	6	8	8	14			
7.5			Hard Murrum brownish yellow		SPT-3							50<	R	R	R	R				
8					SPT-4							50<	R	R	R	R				
8.5																				
9			Completely Weathered Breccia brownish yellow fractured		CORE										55	Nil		8.80		
9.5																				
10					CORE										29	Nil		8.54		
10.5																				

THE BOREHOLE IS TERMINATED AT DEPTH 18.00 m BELOW GROUND LEVEL

The insitu boundary layers shown are approximate. The actual limits may be more gradual. REMARKS: Rotary Drilling; NX Size Double Tube Core Barrel

▼ **Ground Water Table: 4.30 m**

Casing: 8.5 m

Abbreviations: LL - Liquid Limit PI - Plasticity Index SL - Shrinkage Limit G- Specific Gravity
 NP - Non-Plastic CR- Core recovery RQD -Rock Quality Designation UDS - Undisturbed sample
 UCS - Unconfined Compressive Strength N - Standard penetration test (SPT)

Project No. SI-20191



Noble Geo-Structs

APPENDIX A

Log of Borings No. BH-03

CLIENT:		Municipal Corporation Of Greater Mumbai		PROJECT:		Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward.														
LOCATION:		Chinchpokli		Start Date:		March 12, 2020				End Date:		March 15, 2020								
Depth, m	R.L. m	Graphic Log	Description		Sampler Type	IS Classification	LL, %	SL, %	PI, %	G	c, kg/cm ²	φ, degree	Penetration, cm				CR N	RQD %	Water Content / Absorption %	UCS, MPa
			Approximate Surface Elevation:	Existing Surface Elevation									15	30	45	60				
11		V V V V			CORE											25	Nil			
11.5		V V V V																		
12		V V V V																		
12.5		V V V V																		
13		V V V V			CORE											33	Nil		8.30	
13.5		V V V V																		
14		V V V V																		
14.5		V V V V			CORE											25	Nil			
15		V V V V																		
15.5		V V V V																		
16		V V V V			CORE											29	Nil		10.31	
16.5		V V V V																		
17		V V V V																		
17.5		V V V V			CORE											33	Nil			
18		V V V V																		

THE BOREHOLE IS TERMINATED AT DEPTH 18.00 m BELOW GROUND LEVEL

The insitu boundary layers shown are approximate. The actual limits may be more gradual. REMARKS: Rotary Drilling; NX Size Double Tube Core Barrel

Ground Water Table: 4.3 m

Casing: 8.5 m

Abbreviations: LL - Liquid Limit PI - Plasticity Index SL - Shrinkage Limit G- Specific Gravity
 NP - Non-Plastic CR- Core recovery RQD -Rock Quality Designation UDS - Undisturbed sample
 UCS - Unconfined Compressive Strength N - Standard penetration test (SPT)

Project No. SI-20191



Noble Geo-Structs

APPENDIX III
LABORATORY TEST RESULTS

ROCK TEST RESULTS

Client : Project: Source of Sample Number of Sample Tested Sample Details Period of Test: The method followed Sample Description Sample Quantity Sample Date of Receipt Sample Condition	Municipal Corporation Of Greater Mumbai Geotechnical investigation for Proposed Isolation Ward for Corona Virus at Kasturba Hospital in E ward. Noble Geo-Structs 12 Rock Core March 17, 2020 For Rock - IS 9143,1124 and 13030 Rock Core Sufficient March 05, 2020 Acceptable
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Sr. No.	Bore hole No.	Sample ID	Piece No.	Depth, m		Unconfined Compressive Strength, Mpa
				From	To	
1	1	TC5428191000004498F	1	7.30	8.50	8.88
2	1	TC5428191000004499F	17	9.00	10.50	8.06
3	1	TC5428191000004500F	21	12.00	13.50	27.46
4	1	TC5428191000004501F	73	18.00	19.50	16.59
5	2	TC5428191000004490F	4	8.50	9.00	27.38
6	2	TC5428191000004491F	19	12.00	13.50	8.30
7	2	TC5428191000004492F	40	15.00	16.50	34.02
8	2	TC5428191000004493F	75	19.50	20.00	11.62
9	3	TC5428191000004506F	1	8.55	9.00	8.80
10	3	TC5428191000004507F	4	9.00	10.50	8.54
11	3	TC5428191000004508F	22	12.00	13.50	8.30
12	3	TC5428191000004509F	30	15.00	16.50	10.31



TC 5428

NOBLE GEO-STRUCTS



M : 9820285696, 9820285809 | lab@noblegeostructs.com |
www.noblegeostructs.com

Project No.:SI-20191

NOTE:

- 1) This test report refers only to the sample submitted for testing
- 2) This test report is valid at the time of and under the condition specified herein
- 3) This report may not be reproduced in part, without the specimen the permission of this laboratory
- 4) Any correction invalidates this test report
- 5) * Sample Not Sufficient

For Noble Geo-Structs

Mr.Mithilesh Kumar

Sr.Technical Manager

APPENDIX IV
Pile Capacity Calculation

**Axial Pile Capacity in Compression
as per IRC 78 (2014)**

Bore Hole Number	1	
Pile Length	12.10	m
Pile Diameter	0.4	m
Depth of IGM	3.00	m
Length of socket	1.60	m
Depth of Soil	7.5	m

Ultimate pile capacity = $Q_u = R_e + R_{af}$		
Empirical Coefficient, K_{sp}	0.33	MPa
Unconfined compressive strength of rock, q_c	27.0	MPa
Depth factor, $d_f = 1 + 0.4 \times (L_s/D)$	1.20	
Cross-sectional area of pile base, A_b	0.13	m^2
Unit End Bearing Resistance	10.55	MPa
End Bearing Resistance, $R_e = K_{sp} \cdot q_c \cdot d_f \cdot A_b$	1.33	MN

Skin Friction contribution from Socket		
Ultimate shear strength along pile length, C_{us}	1.17	MPa
Surface area of Socket, A_s	2.0	m^2
Ultimate side socket shear, $R_{af1} = C_{us} \cdot A_s$	2.35	MN
Skin Friction contribution from IGM		
Ultimate shear strength along pile length, C_{us}	0.40	MPa
Surface area of IGM, A_s	3.8	m^2
Ultimate side socket shear, $R_{af2} = C_{us} \cdot A_s$	1.51	MN
Ultimate side socket shear, R_{af}	3.86	MN

Ultimate pile capacity, Q_u	5.18	MN
Structural Capacity (M35 grade concrete)	0.90	MN
Allowable pile capacity, Q_{allow}	1.09	MN

Depth of Fixity
As per IS 2911 Part 1 Section 2 (2015)

Bore Hole Number	1	
k_1	12	MN/m ³
$K = \frac{k_1 \times 0.3}{1.5 \times B}$	6	
Pile Diameter	0.4	m
Stiffness Factor, $R = \sqrt[4]{\frac{EI}{KB}}$	1.98	m
Modulus of Elasticity of Pile for M35 grade concrete, E	29580.40	MN/m ²
Moment of Inertia of Pile = $\pi d^4/64$	0.00126	m ⁴
L_1	0.0	m
z_f/D	1.9	
Depth of Fixity below pile cap, z_f	3.77	m

Lateral Pile Capacity
As per IS 2911 Part 1 Section 2 (2015) Clause 6.5.2

Deflection, y as per IS 2911 Part 4 (2015)	0.005	m
Allowable Lateral Load, H $\frac{12 yEI}{(e + z f)^3}$	0.04	MN
Allowable Lateral Load, H $\frac{12 yEI}{(e + z f)^3}$	4.25	t

Deflection, y for 10% of pile diameter	0.040	m
Allowable Lateral Load, H $\frac{12 yEI}{(e + z f)^3}$	0.33	MN
Allowable Lateral Load, H $\frac{12 yEI}{(e + z f)^3}$	33.98	t

**Axial Pile Capacity in Tension
as per IRC 78 (2014)**

Bore Hole Number	BH-1	
Pile Length	12.10	m
Pile Diameter	0.4	m
Depth of IGM	3	m
Length of socket	1.6	m
Depth of Soil	7.5	m

Uplift pile capacity = $Q_u = W + R_{af}$		
Unconfined compressive strength of rock, q_c	27.0	MPa
Weight of pile	0.02	MN

Skin Friction contribution from Socket		
Ultimate shear strength along pile length, C_{us}	1.17	MPa
Surface area of Socket, A_s	1.6	m^2
Ultimate side socket shear, $R_{af1} = C_{us} \cdot A_s$	1.91	MN

Skin Friction contribution from IGM		
Ultimate shear strength along IGM length, C_{us}	0.40	MPa
Surface area of Socket, A_s	3.4	m^2
Ultimate side socket shear, $R_{af1} = C_{us} \cdot A_s$	1.36	MN

Uplift pile capacity, Q_u	3.29	MN
Structural Capacity (M35 grade concrete)	0.90	MN
Allowable pile capacity, Q_{allow}	0.36	MN