

REPORT

ON

**GEO-TECHNICAL INVESTIGATION FOR THE PROPOSED BLOCK-4
SUB-STATION SY NO-35, NEAR BALASAMUDRA VILLAGE**

**CLIENT: KARNATAKA SOLAR POWER
DEVELOPMENT CORPORATION
BANGALORE**

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SUB-STATION SY NO-35, NEAR BALASAMUDRA VILLAGE**

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GEO-TECHNICAL INVESTIGATION FOR THE PROPOSED BLOCK-4 SUB-STATION SY NO-35, NEAR BALASAMUDRA VILLAGE

1.0 INTRODUCTION

Mr. KARNATAKA SOLAR POWER DEVELOPMENT CORPORATION BANGALORE, to carry out the geotechnical investigation work for the proposed construction of Solar Power Plant at Block-4, sy No-35, near Balasamudra village.

This report consists of the details about the various field tests and laboratory tests performed to evaluate the Geotechnical characteristics of the site and the recommendations made based on the results of the tests.

The primary objectives of this investigation are

1. To ascertain the nature of the sub soil strata at the site through field and laboratory testing,
2. To locate the ground water table if encountered within the depth of exploration,
3. To obtain soil data required for assessing the allowable bearing pressure and for making the choice of type of foundation as well for the analysis and design of safe and economic foundations

2.0 SCOPE OF THE WORK

The scope of work involves conducting both field tests and laboratory tests, the data obtained by which is used for the characterization of the soil, estimation of safe bearing capacity which is required for carrying out analysis and design of foundations and also recommend or suggest treatment methods where required.

3.0 FIELD AND LABORATORY INVESTIGATIONS

This consists of the following

1. Visual and physical observation of soil and location survey
2. Drilling 4 bore holes using auger boring up to 6m depth or refusal strata whichever is earlier
3. Conducting Standard penetration test (SPT) in soil at every 1.5m depth or where ever strata changes up to 6m depth or refusal strata

4. Collecting undisturbed and Representative samples in each of the strata for the laboratory tests
5. Conducting suitable laboratory tests on Soil samples to determine Index and Engineering properties.

3.1 Boring and Sampling

150mm diameter boring was carried out in accordance with IS: 1892:- 1979 Code of Practice for sub-surface investigation of foundation (1992) using auger boring at four different locations. The bore holes locations are shown in figure1.

Representative / Undisturbed samples were collected at different depth as the bore holes were sunk. The undisturbed samples were collected at an interval of 1.5m or at every change in strata, whichever occurred earlier. The samples collected were used for different laboratory test.

3.2 Field Investigations

Standard Penetration Test

The standard penetration tests were conducted at relevant depths within the boreholes to determine the penetration resistance value (N) as per IS –2131- 1981. In this method, a standard split tube sampler (50.8 mm OD and 35 mm ID) is driven by dropping a 65 kg hammer on top of the driving collar with a free fall of 750mm. The length of the sampler is 600mm. The sampler is first driven through 150mm as a seating drive. It is further driven through 300mm. The number of blows required to drive the sampler for 300mm beyond the seating drive is recorded as the penetration resistance value N. Refusal is said to have been reached when the sampler penetration is less than 150mm for 50 blows or 300mm for 100 blows

3.3 Laboratory Investigations

Laboratory test were performed to evaluate both index and engineering properties of the soil samples collected during boring. All the tests are performed as per IS recommendations. Table 1 represents the Indian Standard Codes followed for the testing of Soil Samples.

Table: 1 Indian Standard Codes followed

Sl. No	Type of Test	IS Code
1	Grain size analysis	IS-2720 (Part4) -1985
2	Liquid limit and Plastic limit test	IS-2720 (Part4) -1985
3	Natural water content	IS-2720 (Part2) -1973
4	Field density	IS-2720 (Part10) -1993
5	Specific Gravity	IS-2720 (Part3) -1985 Sec1,2-1980
6	Tri-axial compression test (Quick test)	IS-2720 (Part11) -1993
7	Proctor density test	IS-2720 (Part17)-1980
8	California bearing ratio test	IS-2720(Part 16)-1987

The results of these laboratory tests are presented in Table 3 to Table 5

4.0 TEST RESULTS

Based on the visual observations and the laboratory tests carried out on soil samples procured from bore holes at four locations, the sub soil strata is classified as follows and laboratory test results are presented in table3 and table4

SUB SOIL PROFILE

The sub soil strata in general consist of yellowish brown silty Sand up to 1.5m depth followed by grayish yellow sandy Silt with clay binder up to 1.9/2.0m depth; extended to grayish to yellowish white moderately disintegrated weathered rock up to termination depth. All boreholes were terminated at varying depths of 1.5 to 2.2m depth from existing ground surface

5.CONCLUSIONS

The following conclusions are made based on field and laboratory investigations.

1. The SPT values indicate that the soil strata up to termination depth are medium stiff to dense in nature up to termination depth.
2. The clay/silt present in the soil is found to be low to medium compressible in nature.

6. RECOMMENDATIONS

The following recommendations are made based on the detailed investigation conducted and the conclusions drawn. The recommendations are restricted to the location around the investigation points only.

6.1. TYPE OF FOUNDATION

The structure shall be founded on shallow foundations. This may be either isolated footings or combined footing. For load bearing walls continuous footing shall be employed

6.2. DEPTH OF FOUNDATION

The foundation for the proposed structure shall be taken to a minimum depth of 1.5m below the natural ground level.

6.3 SAFE BEARING CAPACITY

Based on the settlement criterion the allowable bearing pressure and based on the shear criterion the SBC has been worked out as per IS 6403-1982. Individual footing/combined footing may be designed using the recommended safe bearing capacity, with factor of safety of 3.0, against shear failure and for an allowable settlement of 25mm (specimen calculations for the same has been presented in the appendix)

TABLE: 2 Recommended Safe Bearing Capacity

Depth of foundation from ground level m	Safe Bearing Capacity kN/m ²	Safe Bearing Capacity T/m ²
1.5	200	20
2.0	250	25

6.4. PRECAUTIONS

1. All depth of foundations are given with respect to top of existing ground level. If any site leveling and grading takes place, it is important that foundation trenches in areas of "fill"(if any) be taken to the specified depth below the top of existing ground level.
2. The bottom of foundation shall be properly levelled and well compacted before the construction of foundation work is taken up
3. If any loose pockets of soil wherever encountered should be completely removed and back filled with well compacted earth. Thereafter a layer of 40-50 mm size stone aggregate should be rammed into the back filled earth. A levelling course of lean concrete should then be laid over the aggregate course and construction of foundation can be taken up subsequently.
4. The columns should be tied with R.C.C beam at plinth level.

LABORATORY TEST RESULTS

TABLE: 3 ATTERBERG'S LIMITS AND GRAIN SIZE DISTRIBUTION

Bore Hole No	Depth, m	Atterberg's limits, %		Grain Size Distribution, %		
		Liquid Limit	Plastic Limit	Clay & Silt	Sand	Gravel
BH-1	1.5	30	15	65	35	--
	1.9	14	08	15	55	30
BH-2	1.0	25	11	20	65	05
	1.5	13	NP	12	59	29
BH-3	1.5	35	16	62	37	--
	2.0	12	NP	15	50	35
BH-4	1.5	37	17	67	33	--
	2.0	14	NP	14	51	35

TABLE: 4 SHEAR STRENGTH PARAMETERS

Bore Hole No	Depth, m	Density, kN/m ²	Water content, %	Shear Parameters	
				Cohesion, kN/m ²	Angle of internal friction, Ø in degrees
BH-1	1.5	18.0	15	07	20
BH-2	1.0	18.5	12	02	24
BH-3	1.5	18.5	15	06	19
BH-4	1.5	18.8	15	07	20

TABLE: 5 UNCONFINED COMPRESSION TEST, SPECIFIC GRAVITY, SHRINKAGE LIMIT TEST

B.H. NO.	DEPTH (m)	SPECIFIC GRAVITY (G)*	MAXIMUM DRY DENSITY (kN/m ³)	OPTIMUM MOISTURE CONTENT (%)*	C.B.R (%)
1	0.5	2.79	19.0	16	10
2	0.5	2.80	18.9	17	09
3	0.5	2.75	18.9	17	08
4	0.5	2.76	19.0	16	09

BORE LOGS

BORE HOLE NUMBER BH: 1

Termination Depth: 2.1m
 Diameter of Boring: 150mm

Type of Boring: Auger
 Inclination : Vertical

Sampler used: Shell tube
 Date of Boring: 27-01-2016

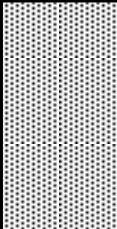


DESCRIPTION	Thickness of Strata	Legend	Depth m	Corrected N-Value	Sample		Remarks
					Type	No.	
			0	--	--	--	
Yellowish brown silty sand with gravel traces	1.5		0.5	--	DS	01	Ground water table was not encountered during investigation
Grayish yellow sandy silt with clay binder	0.4		1.5	36	SPT	01	
Grayish to whitish yellow moderately disintegrated weathered rock	0.2		1.9	RS	SPT	01	
			2.1	--	--	--	

Fig.2.Bore log at BH: 1

RS=Refusal strata

BORE HOLE NUMBER BH: 2

Termination Depth: 2.0m
 Diameter of Boring: 150mm

Type of Boring: Auger
 Inclination : Vertical

Sampler used: Shell tube
 Date of Boring: 27-01-2016

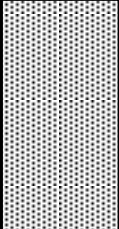

DESCRIPTION	Thickness of Strata	Legend	Depth m	Corrected N-Value	Sample		Remarks
					Type	No.	
			0	--	--	--	
Yellowish brown silty sand with gravel traces	1.5		0.5	--	DS	01	Ground water table was not encountered during investigation
			1.0	--	UDS	01	
			1.5	37	SPT	01	
Grayish to whitish yellow moderately disintegrated weathered rock	0.5		2.0	RS	SPT	01	

Fig.3.Bore log at BH: 2

RS=Refusal strata

BORE HOLE NUMBER BH: 3

Termination Depth: 2.2m
Diameter of Boring: 150mm

Type of Boring: Auger
Inclination : Vertical

Sampler used: Shell tube
Date of Boring: 27-01-2016

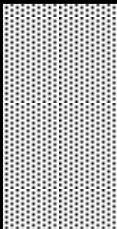


DESCRIPTION	Thickness of Strata	Legend	Depth m	Corrected N-Value	Sample		Remarks
					Type	No.	
			0	--	--	--	Ground water table was not encountered during investigation
Yellowish brown silty sand with gravel traces	1.5		0.5	--	DS	01	
Grayish yellow sandy silt with clay binder	0.5		1.5	38	SPT	01	
Grayish to whitish yellow moderately disintegrated weathered rock	0.2		2.0	RS	SPT	01	
			2.2	--	--	--	

Fig.4.Bore log at BH: 3

RS=Refusal strata

BORE HOLE NUMBER BH: 4

Termination Depth: 2.1m
 Diameter of Boring: 150mm

Type of Boring: Auger
 Inclination : Vertical

Sampler used: Shell tube
 Date of Boring: 27-01-2016

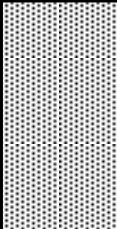


DESCRIPTION	Thickness of Strata	Legend	Depth m	Corrected N-Value	Sample		Remarks
					Type	No.	
			0	--	--	--	
Yellowish brown silty sand with gravel traces	1.5		0.5	--	DS	01	Ground water table was not encountered during investigation
			1.0	--	UDS	01	
Grayish yellow sandy silt with clay binder	0.5		1.5	40	SPT	01	
			2.0	RS	SPT	01	
Grayish to whitish yellow moderately disintegrated weathered rock	0.2		2.2	--	--	--	

Fig.5.Bore log at BH: 4

RS=Refusal strata

APPENDIX

SAFE BEARING PRESSURE BASED ON SETTLEMENT CRITERIA (25 mm SETTLEMENT)

Refer bore hole No 1: Proposing B = 2.0m and $D_f=1.5m$ from natural ground level and $N=43$ (average)

$$q_{ns} = 0.049 N R_{d1} Sa \quad \text{If } B < 1.20m$$

$$q_{ns} = 0.032 N R_{d2} (B+0.30)/B)^2 Sa \quad \text{If } B > 1.20m$$

$$q_{ns} = \text{Safe bearing pressure in } t/m^2$$

$$Sa = \text{Permissible settlement} = 25mm$$

$$R_{d1} = \text{Depth factor} = (1+0.2D/B) < 1.20$$

$$R_{d2} = \text{Depth factor} = (1+0.33D/B) < 1.33$$

$$\text{For a width } B = 2.0m \quad \text{Depth of footing } D_f = 2.0m \quad N_{ave} = 43$$

$$R_{d2} = 1.25$$

$$q_{ns} = 0.032 \times 29 \times 1.25 \times (2+0.30)/2)^2 \times 25$$

$$q_{ns} = 56.86T/m^2 \text{ or } 568.675 \text{ kN/m}^2$$

SBC OF SOIL BASED ON SHEAR CRITERIA, I.S: 6403-1981

Bore hole No 4: Proposing B = 1.0m and $D_f=1.5m$ from natural ground level

$$\text{Taking } C=07kN/m^2, \phi = 20^\circ, \gamma = 18.8kN/m^3$$

$$B = 1.0m, D_f = 1.5m,$$

$$\text{For } \phi = 20^\circ \quad N_c = 10.98, N_q = 3.94, N_r = 2.65, s_c=1.3, s_q=1.2, s_r=0.8, d_c=1.39, d_q=d_r=1.19$$

$$q_{safe} = \frac{c N_c s_c d_c + r D_f (N_q - 1) s_q d_q + 0.5 r B N_r s_r d_r}{F_s} + r D_f$$

$$q_{safe} = 200.488kN/m^2$$

Adopt $200.0kN/m^2$ or $20.0T/m^2$