GEOTECHNICAL REPORT

PROJECT: PROPOSED CONSTRUCTION OF INSTITUTIONAL BUILDING OF COUNCIL OF ARCHITECTURE AT JNANABHARATHI NAGAR, BANGALORE.

SUBMITTED TO:

**M/S. COUNCIL OF ARCHITECTURE
NEW DELHI**

SUBMITTED BY:

**M/S UNIVERSAL CIVIL CONSULTANTS,
No: 41K 1ˢᵗ Floor, 19ᵗʰ 'B' Main Road,
14ᵗʰ Cross, 1ˢᵗ Block,
Rajajinagar, Bangalore-560010.
Mobile: 6364299888, 9482690555
Mail: universalcivilconsultant@gmail.com**

1.0 General

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.

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 Analysis and discussion based on field and laboratory investigations

This consists of

- Topography of the soil
- Drilling bore holes and conducting Standard penetration test (SPT)
- Conducting suitable laboratory tests on collected samples in each of the strata 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 05 Locations only.** The bore holes locations are shown in figure1. The undisturbed samples were collected at an interval of 1.5m or at every change in strata, whichever occurred earlier.

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 65kg 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.

Sub Soil Profile Data

BH No.	Depth (m)	Description
1	0.5-1.5m	Brownish Red silty sand
	3.0m	Greyish Reddish Brown clayey sand with gravel
	4.5m	Yellowish Greyish White silty sand
	5.5m **(T)**	Yellowish White silty sand (DWR)
2	0.5m	Brownish Red silty sand
	1.5m	Yellowish Brown clayey sand with gravel
	3.0m	Yellowish Greyish Red silty sand with gravel
	4.5m	Yellowish Greyish White silty sand with gravel
	5.0m **(T)**	Yellowish Brown silty sand (DWR)
3	0.50m	Yellowish Brown clayey sand with gravel
	1.5m	Yellowish Brownish Red silty sand with gravel
	3.0m	Greyish Pinkish Yellow silty sand with gravel
	4.3m **(T)**	Greyish Yellowish Green silty sand (DWR)
4	0.50m	Brownish Red silty sand
	1.5m	Yellowish Brown silty sand with gravel
	3.0m	Greyish Whitish Yellow silty sand with clay
	4.5m-5.0m **(T)**	Yellowish White silty sand (DWR)
5	0.5m	Brownish Red silty sand
	1.5m	Greyish Red clayey sand with gravel
	3.0m	Whitish Yellow silty sand
	4.8m **(T)**	Whitish Greyish Yellow silty sand (DWR)

NOTE: (T) – Termination Depth from Existing Ground Level, DWR= Disintegrated Weathered Rock

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 (Part5) -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

The results of these laboratory tests are presented in Table 3 & Table 4

Conclusions Based on the Study

1. The SPT values indicate that the soil strata up to refusal depth are very stiff in consistency and has considerable strength in considering of shear parameters

2. The clay/silt present in the soil is found to be low compressible in nature.

3. There is no water table was encountered in the bore hole points during the time of soil investigation.

4. On the detailed result obtained by the tests, considerable bearing capacity is seen so one can go for shallow foundation recommendation.

4.0. RECOMMENDATIONS

4.1 Depth and type of Foundation

Type of Foundations:

The type of foundations for any structure, depends upon the subsoil conditions, as well as, the loading intensity on each column. The subsoil encountered at an average founding levels is dense and is further underlain by dense strata. Hence, the load of the superstructure can be adequately supported on shallow foundations. The shallow foundations may be Isolated or Combined Footings/Raft Foundations depending upon the column loads, their spacing and configuration.

Depth of the Foundations:

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

- Foundation should be below top weak zone or filled-up soil, which is generally filled with root holes and other cavities.
- Depth of top weak zone /filled-up soil.
- Securing of adequate bearing capacity.
- Requirement of structure.

4.2 Safe Bearing Capacity

In geotechnical engineering, bearing capacity is the capacity of soil to support the loads applied to the round the bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should produce shear failure in the soil. Based on the shear criterion the SBC and based on the settlement criterion the allowable bearing pressure has been worked out as per IS 6403-1982 & IS 8009 (Part –I) -1976. 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		
Bore Hole No	Depth of Foundation from Ground Level in meter	Allowable Bearing Pressure in (t/m²)
BH-1 & BH-2	1.5	23
	2.0	26
	3.0	32
	4.5	37
	5.0	39

o **Based on the Field and Laboratory test results and analysis of the same, we recommend foundation type as Isolated Footings.**

o **Minimum Depth of the Foundation should be at least 2.15m (7.0 feet) from below the Existing Ground Level.**

o **The Bottom of the Foundation Trenches should be well compacted before concreting**

o **It is recommended that the Back filling in the foundation should be carried out with proper compaction.**

o **Backfilling should be done with Cohesive Non Swelling (CNS) soil.**

o **All observations and calculations were made based on the field investigation and laboratory testing, if there is any drastic change it shall be brought to our notice.**

o **It is also recommended to provide Reinforced cement concrete plinth beam of suitable size as per design at ground level connecting the structure.**

5. PRECAUTIONS

1. 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. 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 leveling course of lean concrete should then be laid over the aggregate course and construction of foundation can be taken up subsequently.

3. 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	Natural Moisture content, w %	Atterberg Limits, %		Grain Size Distribution, %		
			Liquid Limit (W$_L$)	Plastic Limit (W$_P$)	Clay & Silt	Sand	Gravel
BH-1	**1.5**	10	23	NP	37	40	23
	2.0	13	30	13	45	50	5
	3.0	11	28	12	44	49	7
	4.5	10	NP		30	61	9
	5.5	7	NP		Yellowish White silty sand (DWR)		
BH-2	**1.5**	6	26	09	31	50	19
	2.0	7	27	NP	46	48	6
	3.0	8	28	NP	47	52	1
	4.5	10	26	NP	43	55	2
	5.0	16	NP		Yellowish Brown silty sand (DWR)		
BH-3	**1.5**	25	NP		53	37	10
	2.0	22	NP		55	40	5
	3.0	21	NP		53	37	10
	4.3	13	NP		Greyish Yellowish Green silty sand (DWR)		
BH-4	**1.5**	15	NP		35	47	18
	2.0	13	30	14	50	48	2
	3.0	17	32	17	60	37	3
	4.5	9	NP		Yellowish White silty sand (DWR)		
	5.0	10					
BH-5	**1.5**	9	29	NP	44	44	12
	2.0	10	26	NP	40	55	5
	3.0	7	23	NP	38	62	0
	4.8	5	NP		Whitish Greyish Yellow silty sand (DWR)		

NP: No-Plastic, DWR = Disintegrated Weathered Rock

TABLE: 4 SHEAR STRENGTH PARAMETERS

Bore Hole No	Depth, m	Density, Υ t/m^3	Water content, %	Shear Parameters	
				Cohesion, c t/m^2	Angle of internal friction, ϕ in degrees
BH-1	1.5	1.78	10	0.25	26
	2.0	1.75	13	0.75	24
	3.0	1.73	11	0.55	25
BH-2	1.5	1.76	6	0.45	24
	2.0	1.73	7	0.15	25
	3.0	1.76	8	0.30	25
	5.0	1.81	10	0.0	27
BH-3	1.5	1.76	15	0.15	26
	2.0	1.75	22	0.20	25
	3.0	1.76	21	0.25	25
BH-4	1.5	1.77	15	0.0	26
	2.0	1.73	13	0.45	24
	3.0	1.75	17	0.65	23
BH-5	1.5	1.77	9	0.25	24
	2.0	1.75	10	0.30	25
	3.0	1.78	7	0.20	26

LOCATION OF BOREHOLE POINTS
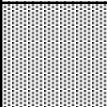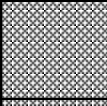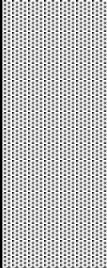
Fig 1: Location of Borehole Points (Drawing not to scale)

BORE LOGS

BORE HOLE NUMBER BH: 1
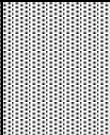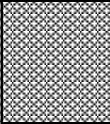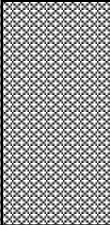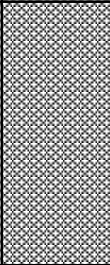
Ground Water Table: Nil   Type of Boring: Auger   Sampler used: Split Spoon

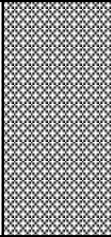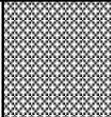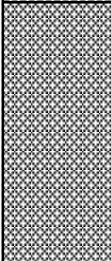Diameter of Boring: 150mm   Inclination: Vertical   Date of Boring: **09-02-2022**

Description of soil stratum	Legend	Depth in m	N-Value	Sample		Remark
				Type	No	
Brownish Red silty sand		0.5		DS	1	
		1.5	30	SPT	1	
Greyish Reddish Brown clayey sand with gravel		2.0		UDS	1	**Water Table was not encountered soil investigstion**
		3.0	49	SPT	1	
Yellowish Greyish White silty sand		4.5	60	SPT	1	
Yellowish White silty sand (DWR)		5.5	>60	SPT	1	**Refusal = N > 50**

Universal Civil Consultants, Bangalore

BORE HOLE NUMBER BH: 2

Ground Water Table: Nil   Type of Boring: Auger   Sampler used: Split Spoon
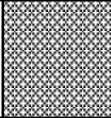
Diameter of Boring: 150mm   Inclination: Vertical   Date of Boring: **09-02-2022**

Description of soil stratum	Legend	Depth in m	N-Value	Sample Type	Sample No	Remark
Brownish Red silty sand		0.5		DS	1	
Yellowish Brown clayey sand with gravel		1.5	24	SPT	1	
		2.0		UDS	1	
Yellowish Greyish Red silty sand with gravel		3.0	42	SPT	1	**Water Table was not encountered soil investigstion**
Yellowish GreyishWhite silty sand with gravel		4.5	66	SPT	1	
Yellowish Brown silty sand (DWR)		5.0	>60	SPT	1	**Refusal = N > 50**

Universal Civil Consultants, Bangalore

BORE HOLE NUMBER BH: 3

Ground Water Table: Nil   Type of Boring: Auger   Sampler used: Split Spoon
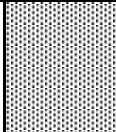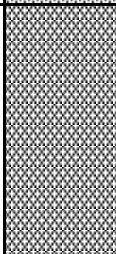
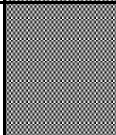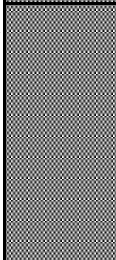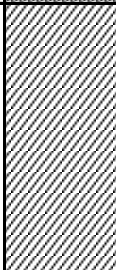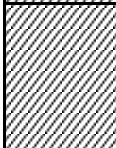Diameter of Boring: 150mm   Inclination: Vertical   Date of Boring: **09-02-2022**

Description of soil stratum	Legend	Depth in m	N-Value	Sample Type	Sample No	Remark
Yellowish Brown clayey sand with gravel		0.5		DS	1	
Yellowish Brownish Red silty sand with gravel		1.5	38	SPT	1	
		2.0		UDS	1	**Water Table was not encountered soil investigstion**
Greyish Pinkish Yellow silty sand with gravel		3.0	64	SPT	1	
Greyish Yellowish Green silty sand (DWR)		4.3	>60	SPT	1	**Refusal = N > 50**

Universal Civil Consultants, Bangalore

BORE HOLE NUMBER BH: 4

Ground Water Table: Nil   Type of Boring: Auger   Sampler used: Split Spoon
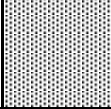
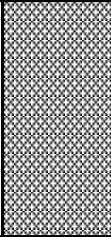Diameter of Boring: 150mm   Inclination: Vertical   Date of Boring: **09-02-2022**

Description of soil stratum	Legend	Depth in m	N-Value	Sample		Remark
				Type	No	
Brownish Red silty sand		0.5		DS	1	
Yellowish Brown silty sand with gravel		1.5	30	SPT	1	
Greyish WhitishYellow silty sand with clay		2.0		UDS	1	**Water Table was not encountered soil investigstion**
		3.0	43	SPT	1	
Yellowish White silty sand (DWR)		4.5	49	SPT	1	
		5.0	>50	SPT	1	**Refusal = N > 50**

BORE HOLE NUMBER BH: 5

Ground Water Table: Nil   Type of Boring: Auger   Sampler used: Split Spoon
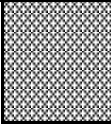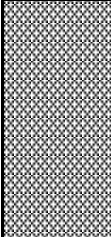
Diameter of Boring: 150mm   Inclination: Vertical   Date of Boring: **09-02-2022**

Description of soil stratum	Legend	Depth in m	N-Value	Sample Type	Sample No	Remark
Brownish Red silty sand		0.5		DS	1	
Greyish Red clayey sand with gravel		1.5	32	SPT	1	
		2.0		UDS	1	**Water Table was not encountered soil investigstion**
Whitish Yellow silty sand		3.0	50	SPT	1	
Whitish Greyish Yellow silty sand (DWR)		4.8	>50	SPT	1	**Refusal = N > 50**

SPT = Standard Penetration Test   UDS = Undisturbed Sample
N = Standard Penetration value   DS = Disturbed Sample
Refusal strata when N > 50   DWR = Disintegrated Weathered Rock

Universal Civil Consultants, Bangalore

APPENDIX-I

TYPICAL SPECIMEN CALCULATIONS OF SAFE BEARING PRESSURE Q$_{NS}$ BY MEYEROFF'S CORRELATION AND SAFE BEARING CAPACITY OF SOIL BASED ON SHEAR CRITERIA AS PER IS 6403-1981

SBC OF SOIL BASED ON SETTLEMENT CRITERIA AS PER IS 8009 PART I 1976
BH No.1, Depth = 1.50m, GWT = Nil, Rw = 1

As per Fig. 9 of IS: 8009 (Part 1), for an allowable settlement of 25mm and for a width of 2.0m, the

allowable bearing pressure is calculated as follows:

Qa = Allowable settlement (m) x Conversion factor from kg/cm2 to t/m2 x Water table correction

Settlement (m) read from graph per unit pressure

'**N' Average** value considered at 1.5m below Existing Ground Level = 30.8

Qa = $\underline{0.025 \times 10 \times 1}$ = 34.24 t/m²

0.0073

Say **34 t/m²**

However, adopt Safe Bearing Pressure of 340 kN/m^2 or 34 t/m^2 at m depth from the existing ground surface for the conservative design purpose as per settlement criteria --------- (i)

BASED ON SHEAR CRITERIA AS PER IS 6403 – 1981
BH-1, Depth = 1.5m, GWT= Nil, Rw = 1

Soil Parameters: At a Depth of 1.50m, C= 0.25 t/m^2, ϕ = 26^0 and γ = 1.78 t/m^3, B = 2.0m, Rw = 1
Bearing capacity factors:
Nc = 22.6, N$_q$ = 12.2, N$_\gamma$ = 13.18
Depth factors:
d$_c$ = 1.24, d$_q$ =1.12, d$_\gamma$ = 1.12,
Shape factors: S$_c$ = 1.2, S$_q$ = 1.3 and S$_\gamma$ = 0.8
Substituting the above factors in,
Q$_f$ = C N$_c$ S$_c$ d$_c$ + ϒ D (N$_q$- 1) S$_q$ d$_q$ + Rw 0.5 ϒ B Nγ S$_\gamma$ d$_\gamma$
Q$_f$ = **70.32 t/m²**
Using a factor of safety of 3, Allowable Bearing Capacity, Q$_a$ = 23.43 t/m²…. (ii).
Safe Bearing Capacity q $_{Safe}$ = 230 kN/m² based on shear criteria ---- (ii). **However, adopt Safe Bearing Capacity is at least depth of 1.80m from the existing ground surface for the conservative design purpose**

REFERENCES

1. IS 1498 – 1970 : Classification and identification of soils for general engineering purposes

2. IS 1892 – 1979: Code of practice for site investigation for foundations

3. IS 2131 – 1981: Method of standard penetration test for soils

4. IS 2720 – 1972 : Methods of tests for soils

5. IS 2911(Part-I) – 1979: Code of practice for design and construction of pile foundations.

6. IS 4968 – 1976 : Method of subsurface sounding for soils

7. IS 6403 – 1981: Code of practice for determination of bearing capacity of shallow foundations

8. IS 8009(Part-I) – 1976 :   Code of practice for calculations of settlements of foundations

9. Taylor D.W :   Fundamentals of Soil Mechanics, John Wiley and Sons, Inc., New York

10. Nayak N.V : Foundation Design Manual , Dhanpat Rai and sons, New Delhi

11. Peck R.B, Hanson, W.E, Thorn burn T.H : Foundation Engineering, John Wiley and Sons, Inc., New York

Universal Civil Consultants, Bangalore