PN – 230912

REPORT ON

GEOTECHNICAL INVESTIGATIONS

FOR THE PROPOSED

G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter

at

Sitamarhi,
DIET Dumra Sitamarhi

Your Letter No.- BSEIDC/Tech/1960/2018-7138 Patna, Dated – 02.09.2023

Submitted to
The Chief Engineer
BSEIDC, Patna

September, 2023

BIHAR FOUNDATION CONSULTANTS
[A unit of Baidyanath Foundation Consultants Pvt. Ltd.]
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G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi

Bihar Foundation Consultants,
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Appendix

[Containing Figures and Tables]

1. INTRODUCTION

The subsoil investigations reported herein were taken up (vide W.O. No. BSEIDC/Tech/1960/2018-7138 Patna, Dated – 02.09.2023 to find out the nature of subsoil at the site of the proposed construction and to recommend the capacity and type of its foundation. After certain tests on the soil, as detailed below, the desired recommendations have been made on **page 3-4** of this Report.

2. FIELD WORK

The fieldwork consisted of sinking bore holes, collecting soil samples and conducting the necessary field tests.

2.1. Boring

Taking guidance from IS: 1892, 150 mm diameter bore holes were sunk at locations shown in the bore hole location map.

2.2 Sampling

2.2.1 Undisturbed Soil Samples

Open drive samplers of 100-mm diameter and about 450-mm length were used for obtaining undisturbed samples of cohesive soils. The collection, sealing, labeling and transportation of the samples to the laboratory were done as per the IS guide-lines.

2.2.2 Disturbed Soil Samples

Disturbed soil samples were collected at suitable intervals of depth (not more than 2.5 m) and at all depths of change in the nature of the subsoil. These samples were sealed in polythene bags with proper identification labels.

2.3 Field Tests

2.3.1 Standard Penetration Tests (SPT)

These tests were conducted as per IS: 2131 – 1963. The depth interval between two consecutive tests was 1 to 1.5 m. The tests were located in between the levels at which undisturbed soil samples were collected.

3. LABORATORY TESTS

Some or all of the following laboratory tests, as necessary, were done on the collected soil samples. Representative soil samples were selected for this from the different soil strata encountered during boring. The tests were performed as per the relevant Indian Standard Codes of Practice.

(a) Natural moisture content

(b) Bulk density

(c) Grain size analysis (using sieves and / or hydrometer)

(d) Specific gravity of soil solids

(e) Atterberg's limit tests (liquid, plastic and shrinkage limits)

(f) Shear Tests :

- [I] Triaxial compression test (unconsolidated – undrained), generally for fine- grained soils
- [II] Unconfined compression tests, only on cohesive soils
- [III] Direct shear tests, generally for coarse-grained soils

(g) Other tests as and when required.

4. PRESENTATION OF TEST RESULTS

The field and laboratory test results are given in the **Appendix B.**

5. SOIL STRATIFICATION

The results of field tests in three bore holes sunk at the site [vide Location Sketch in App. A] and the results of laboratory tests conducted on the collected soil samples indicate that the soil stratification at the site is as describe below.

The subsoil in all 3 BH's is silty clay / sandy silty clay [type CL/CI] up to the investigated depth of 10.5 m bgl. But it is clayey silty sand [type SC-SM] from about 3.0 m to 4.5 m depth bgl in all BH's. The subsoil is also gritty at some locations and depths.

Ground water table was struck at about 1.30 m to 1.50 m depth below GL in September, 2023. It is subject to seasonal variations.

6. FOUNDATION ANALYSIS

The safe capacity of foundation of any type and size may be determined on the basis of the soil data given in this Report by using the standard methods of foundation design and following the relevant Indian Standard Codes.

7. RECOMMENDATIONS

The design of the foundation for the proposed structure depends on the nature of both [a] the subsoil and [b] the structure.

The subsoil in all 3 BH's is silty clay / sandy silty clay [type CL/CI] up to the investigated depth of 10.5 m bgl. But it is clayey silty sand [type SC-SM] from about 3.0 m to 4.5 m depth bgl in all BH's. The subsoil is also gritty at some locations and depths.

Ground water table was struck at about 1.30 m to 1.50 m depth below GL in September, 2023. It is subject to seasonal variations.

Hence,

1. The subsoil is soft up to about 2.0 m in BH 1. Hence the proposed structure may be provided with shallow foundation at a depth of 2.0 m or more.
2. The subsoil is clayey silty sand from about 3.0 m to 4.5 m in all BH's. Hence U/r piles of lengths 6.0 m to 10.0 m may be used. The diameter of the bulb should be two times the stem diameter. The stem diameters may be taken as 0.25 m, 0.30 m, 0.40 m, and 0.50 m.

By way of example, the values of safe capacities of each one of the above two types of foundations of the above mentioned sizes and depths have been calculated (vide Samples of Calculations in Appendix F) and are tabulated below.

Table 1: Allowable Net Bearing Pressures [q_{na}] and Settlements Expected [s]

Depth (m) below Ground Level	Width (m)	Net allowable bearing pressure (t/m^2)			Maximum expected settlement (mm)
		Strip footing	Square footing	Raft footing	
2.0	2	5.6	6.7	…	75
	3	5.1	6.4	…	75
	10	…	…	6.0	100
2.5	2	6.2	7.4	…	75
	3	5.8	6.9	…	75
	10	…	…	6.4	100
3.0	2	6.9	8.2	…	75
	3	6.4	7.6	…	75
	10	…	…	6.9	100
3.5	2	8.9	10.6	…	75
	3	7.1	9.7	…	75
	10	…	…	8.0	100
4.0	2	11.1	13.2	…	75
	3	7.8	12.0	…	75
	10	…	…	8.4	100

Table 2. Safe Capacities of U/R Piles [Factor of safety = 3.0]

[Bulb diameter = 2.0 times the shaft diameter]

Pile length below pile Cap (m)	Safe Pile Capacity [tonnes] *(SUBJECT TO CHECKING FOR SLENDERNESS RATIO**)*							
	Stem diameter (m)							
	0.25		0.30		0.40		0.50	
	One bulb	Two bulbs	One bulb	Two bulbs	One bulb	Two bulbs	One bulb	Two bulbs
6.0	3.0	4.3	6.1	5.9	6.8	10.0	10.2	15.1
8.0	4.8	6.4	6.4	8.6	10.3	14.2	15.0	21.1
10.0	5.6	7.2	7.3	9.7	11.5	15.7	16.5	23.0

**For a preliminary checking of the slenderness ratio, the modulus of subgrade reaction (k)
(a) <u>for cohesive soils</u> may be estimated from the following empirical relation given in IS: 2950-1981 (Second Revision) Table 1.: k (kN/m^3) = 240 c, where c (kN/m^2) is the value of cohesion of the soil at the concerned depth.
(b) <u>for cohesionless</u> soils the IS Code shall be consulted

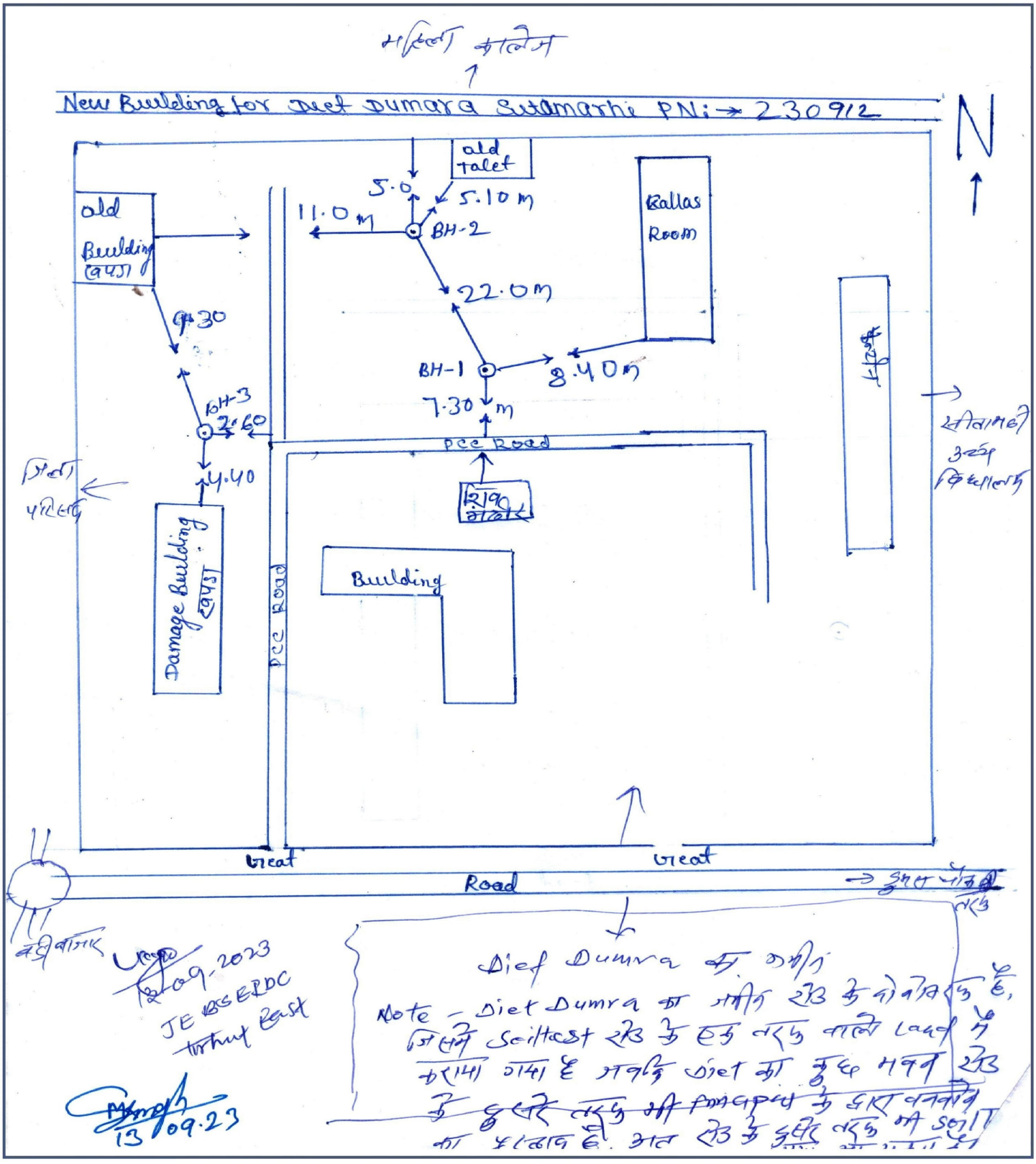
Notes:

1. If a subsoil condition much different from those reported herein is met with during foundation trenching or piling, suitable steps should be taken.
2. If concreting of piles is to be done below water table, DMC and tremie method should be adopted.
3. If u/r piles are provided, care should be taken to ensure proper formation of bulbs.
4. Shallow foundations or pile caps should be isolated from the surrounding expansive soil by layers of compacted local sand.
5. As per the provisions of the IS Code, **an appropriate number of piles must be subjected to routine load tests to check the veracity of the above recommended values of the safe capacities of piles.**

For Bihar Foundation Consultants

(Prof. C.N. Sinha, Dr.-Ing., FIE)
Chief Consultant.

G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi



Bihar Foundation Consultants,
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PN -230912 **Appendix - A**

NAME OF WORK : Sub soil Investigation for C/O							BORING FINISH DATE : 13.09.2023					WATER TABLE : 1.30 m bgl				
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi							BORING METHOD : Rotary									
BORE HOLE NO. : 1			Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m					RECORD ON : 13.09.2023				

Depth Below GL (m)	Sample No.	SPT 'N' Value observation	Visual Description of Soil with IS Classification	Depth(m)		Thickness (m)	Liquid Limit	Plastic Limit	Plasticity Indix,%	Bulk Density (gm/cm3)	Natural Moisture Content (%)	Specific Gravity	Shear Test			Compression Index (C_c)
		Obsr.		from	to								Type of Test	Cohesion, c (kg/cm2)	Friction Angle, ϕ °	
1.0			Greyish silty clay, CL	0.0		3.0										
1.5	S1	4					32.1	20.8	11.3	1.94	29.4	2.69		0.20	2.8	
2.5																
3.0	S2	5			3.0					1.95	29.2	2.69		0.25	3.1	0.160
4.0			Greish clayey silty sand, SC-SM	3.0		1.5										
4.5	S3	6			4.5					1.91	30.2	2.64		0.00	28.0	
5.5			Greyish sandy silty clay, CL	4.5		6.0										
6.0	S4	7								1.97	27.8	2.70		0.35	4.1	
7.0																
7.5	S5	8					28.0	20.3	7.7	1.98	27.3	2.70		0.40	4.6	
8.5																
9.0	S6	6								1.96	28.6	2.70		0.30	3.6	
10.0																
10.5	S7	10			10.5		31.6	20.8	10.8	2.00	26.2	2.70		0.48	5.0	

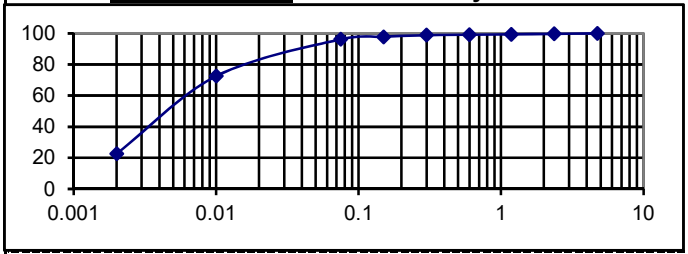
NAME OF WORK : Sub soil Investigation for C/O							BORING FINISH DATE : 13.09.2023					WATER TABLE : 1.50 m bgl				
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi							BORING METHOD : Rotary									
BORE HOLE NO. : 2			Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m					RECORD ON : 13.09.2023				

Depth Below GL (m)	Sample No.	SPT 'N' Value observation	Visual Description of Soil with IS Classification	Depth(m)		Thickness (m)	Liquid Limit	Plastic Limit	Plasticity Indix,%	Bulk Density (gm/cm3)	Natural Moisture Content (%)	Specific Gravity	Shear Test			Compression Index (C_c)
													Type of Test	Cohesion, c (kg/cm2)	Friction Angle, ϕ °	
		Obsr.		from	to											
1.0			Greyish silty clay, CI	0.0		3.0										
1.5	S1	5								1.95	29.2	2.69		0.25	3.1	
2.5																
3.0	S2	6			3.0		35.4	23.3	12.1	1.96	28.6	2.70		0.30	3.6	0.156
4.0			Greish clayey silty sand, SC-SM	3.0		1.5										
4.5	S3	8			4.5					1.91	30.4	2.64		0.00	28.0	
5.5			Greyish silty clay, CL	4.5		3.0										
6.0	S4	10					34.4	22.7	11.7	2.00	26.2	2.70		0.48	5.0	
7.0																
7.5	S5	11			7.5					2.01	25.5	2.70		0.52	5.1	
8.5			Greyish sandy silty clay, CL with grits	7.5		3.0										
9.0	S6	7					33.8	22.3	11.5	1.97	27.8	2.70		0.35	4.1	
10.0																
10.5	S7	11			10.5					2.01	25.5	2.70		0.52	5.1	

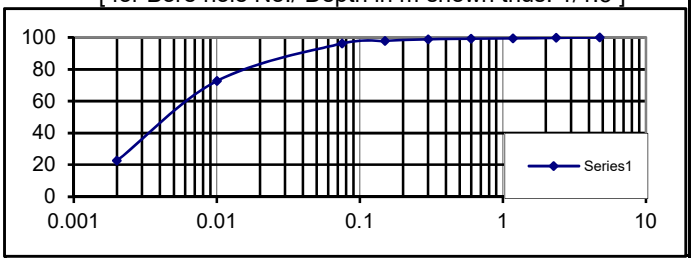
NAME OF WORK : Sub soil Investigation for C/O							BORING FINISH DATE : 14.09.2023					WATER TABLE : 1.40 m bgl				
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi							BORING METHOD : Rotary									
BORE HOLE NO. : 3			Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m					RECORD ON : 14.09.2023				

Depth Below GL (m)	Sample No.	SPT 'N' Value observation	Visual Description of Soil with IS Classification	Depth(m)		Thickness (m)	Liquid Limit	Plastic Limit	Plasticity Indix,%	Bulk Density (gm/cm3)	Natural Moisture Content (%)	Specific Gravity	Shear Test			Compression Index (C_c)
		Obsr.		from	to								Type of Test	Cohesion, c (kg/cm2)	Friction Angle, ϕ °	
1.0			Greyish silty clay, CI	0.0		3.0										
1.5	S1	5					35.7	23.8	11.9	1.95	29.2	2.62		0.25	3.1	
2.5																
3.0	S2	7			3.0					1.97	27.8	2.70		0.35	4.1	0.151
4.0			Greish clayey silty sand, SC-SM	3.0		1.5										
4.5	S3	8			4.5		27.4	24.8	2.6	1.91	30.4	2.64		0.00	28.0	
5.5			Greyish silty clay, CL with grits	4.5		3.0										
6.0	S4	9								1.99	26.7	2.71		0.44	5.0	
7.0																
7.5	S5	11			7.5		31.5	22.5	9.0	2.01	25.5	2.70		0.52	5.1	
8.5			Greyish sandy silty clay, CL	7.5		3.0										
9.0	S6	7								1.97	27.8	2.70		0.35	4.1	
10.0																
10.5	S7	12			10.5					2.01	25.3	2.70		0.56	5.1	

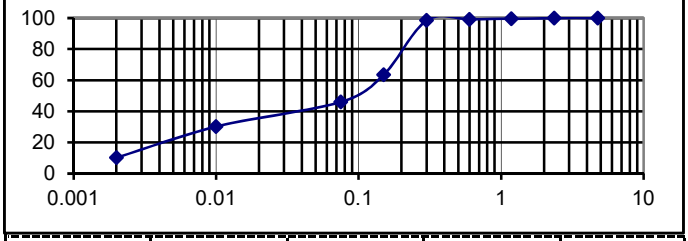
Table 2 [part **B]: Grain Size Analysis Results** [for Bore hole No./ Depth in m shown thus: 1/1.5]



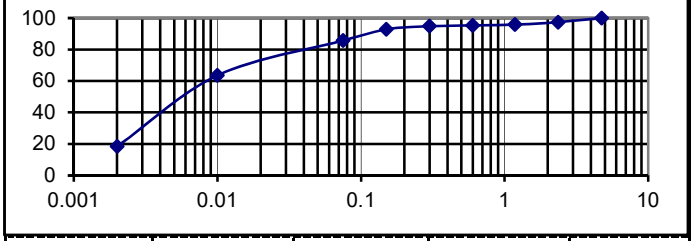
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/1.5	0.0	3.8	73.6	22.6



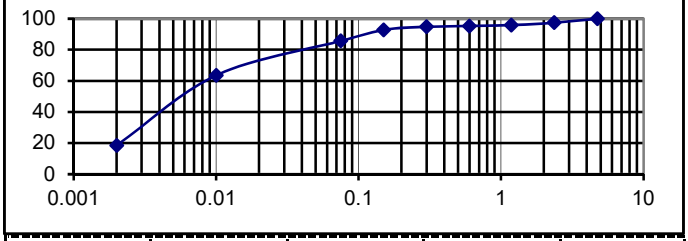
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/3.0	0.0	3.8	73.5	22.7



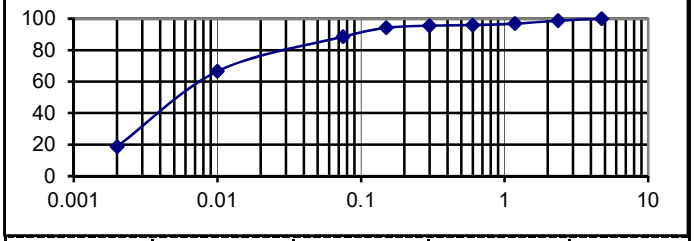
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/4.5	0.0	54.0	35.8	10.2



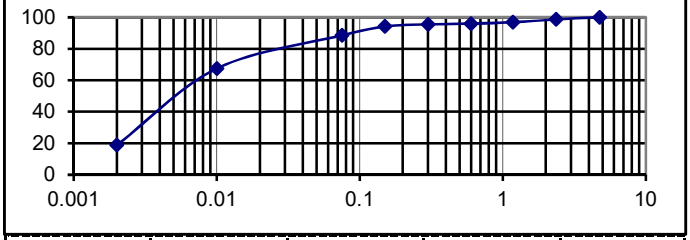
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/6.0	0.0	14.3	67.2	18.5



BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/7.5	0.0	14.3	67.1	18.6

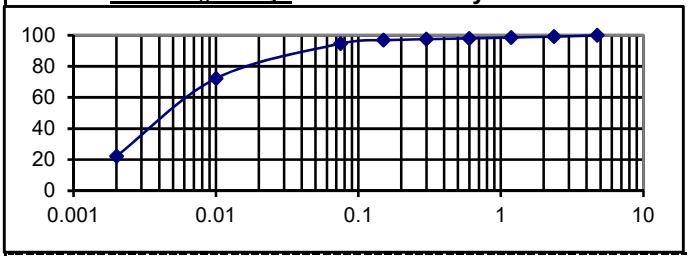


BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/9.0	0.0	11.4	69.8	18.8

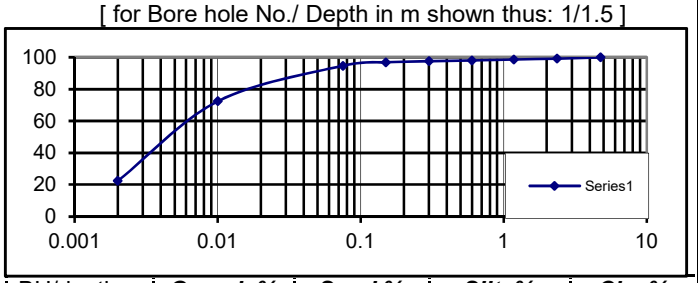


BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
1/10.5	0.0	11.4	69.7	18.9

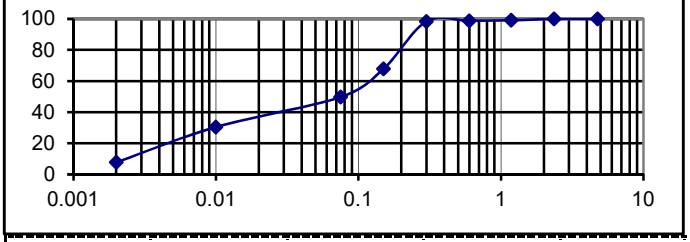
Table 2 [part **B]: Grain Size Analysis Results** [for Bore hole No./ Depth in m shown thus: 1/1.5]



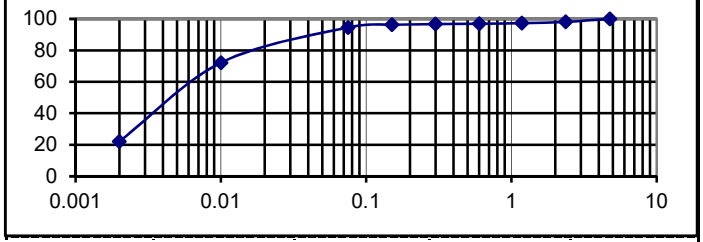
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/1.5	0.0	5.3	72.4	22.3



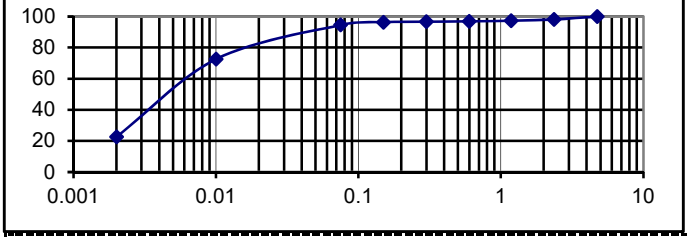
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/3.0	0.0	5.3	72.3	22.4



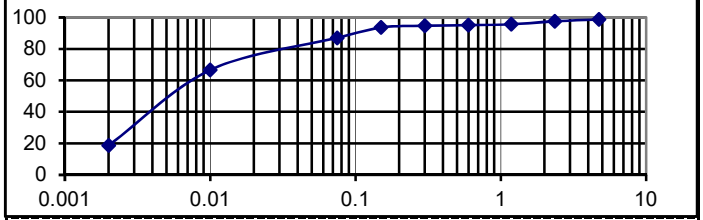
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/4.5	0.0	50.3	41.9	7.8



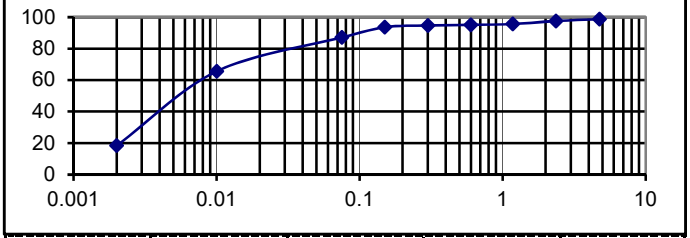
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/6.0	0.0	5.4	72.4	22.2



BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/7.5	0.0	5.4	72.0	22.6

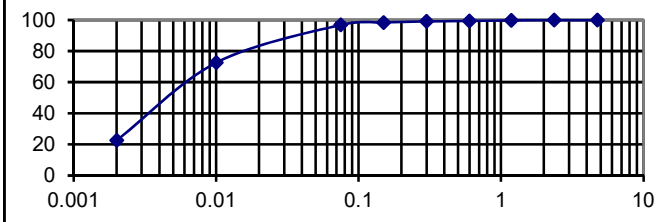


BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/9.0	1.3	11.6	68.4	18.7

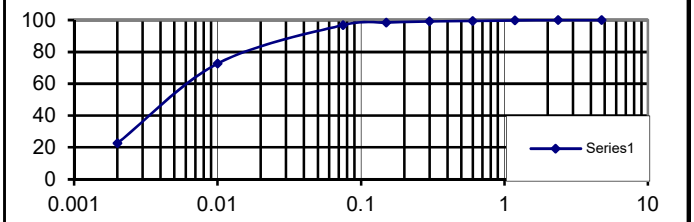


BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
2/10.5	1.3	11.6	68.7	18.4

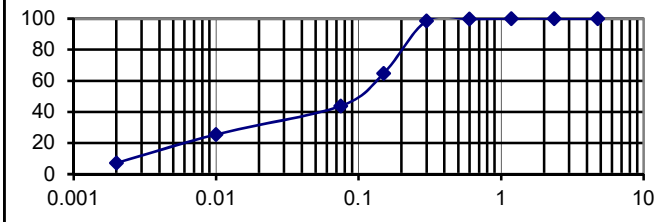
Table 2 [part **B]: Grain Size Analysis Results** [for Bore hole No./ Depth in m shown thus: 1/1.5]



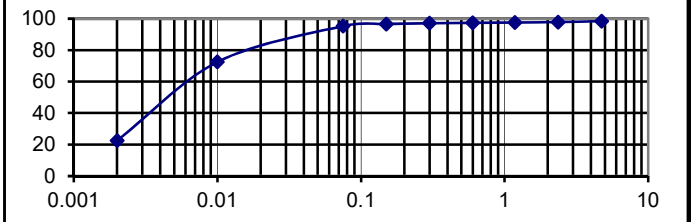
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/1.5	0.0	3.2	74.2	22.6



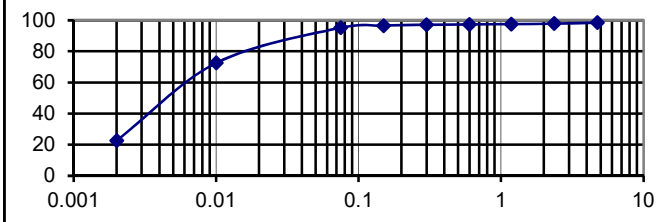
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/3.0	0.0	3.1	74.2	22.7



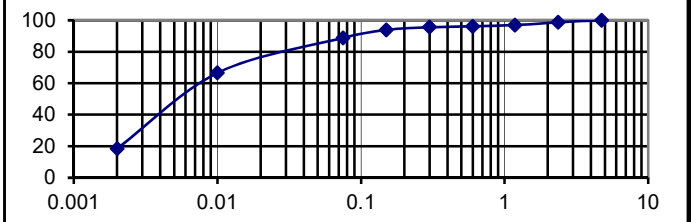
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/4.5	0.0	56.2	36.6	7.2



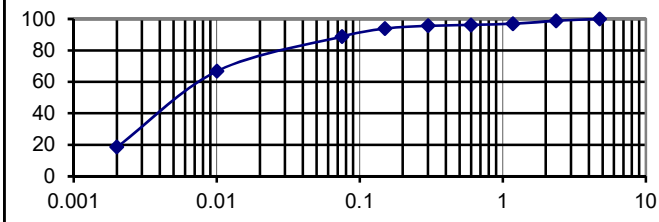
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/6.0	1.5	3.2	72.7	22.5



BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/7.5	1.5	3.2	72.7	22.6



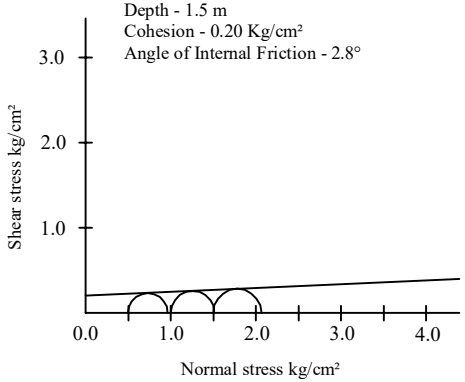
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/9.0	0.0	11.1	70.4	18.5



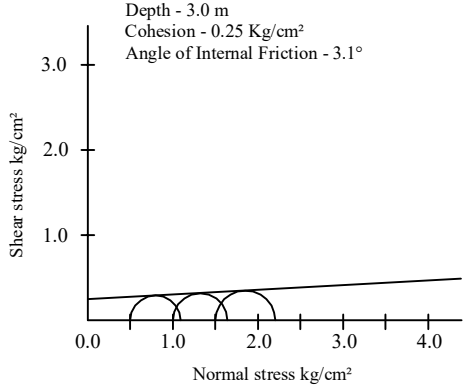
BH/depth,m	*Gravel, %*	*Sand,%*	*Silt, %*	*Clay%*
3/10.5	0.0	11.1	70.3	18.6

TRIAXIAL / DIRECT SHEAR TEST PLOTS

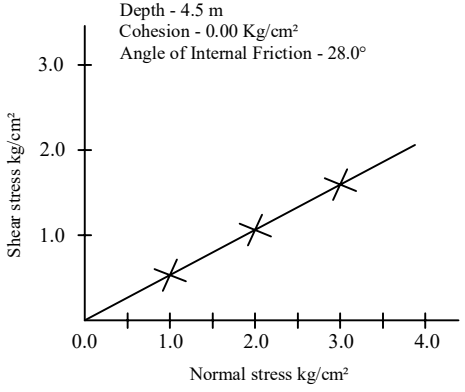
BH: - 1
Depth - 1.5 m
Cohesion - 0.20 Kg/cm²
Angle of Internal Friction - 2.8°



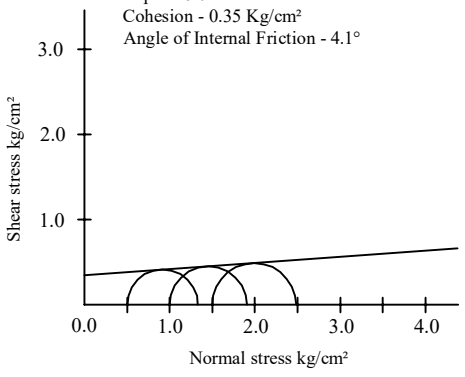
BH: - 1
Depth - 3.0 m
Cohesion - 0.25 Kg/cm²
Angle of Internal Friction - 3.1°



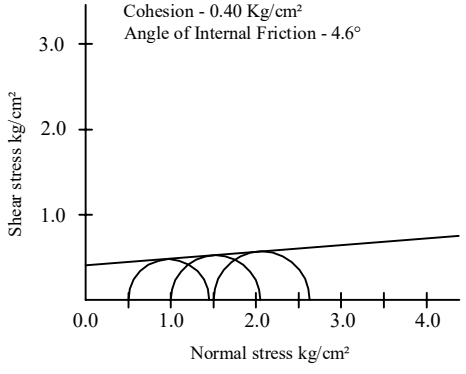
BH: - 1
Depth - 4.5 m
Cohesion - 0.00 Kg/cm²
Angle of Internal Friction - 28.0°



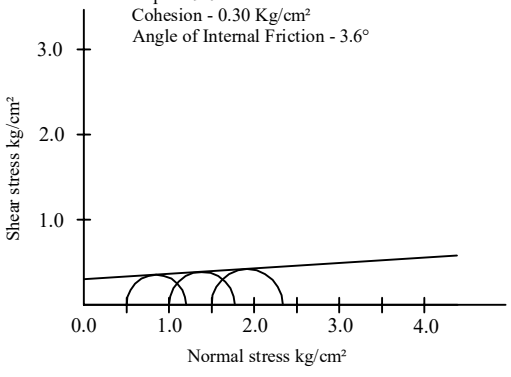
BH: - 1
Depth - 6.0 m
Cohesion - 0.35 Kg/cm²
Angle of Internal Friction - 4.1°



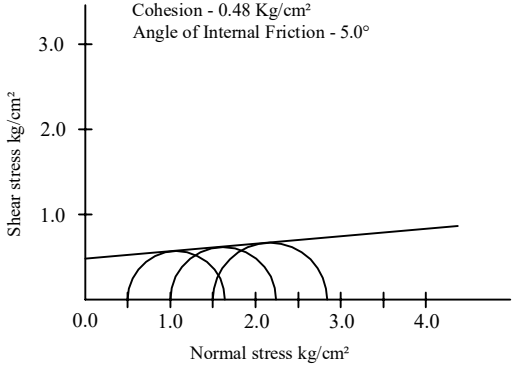
BH: - 1
Depth - 7.5 m
Cohesion - 0.40 Kg/cm²
Angle of Internal Friction - 4.6°



BH: - 1
Depth - 9.0 m
Cohesion - 0.30 Kg/cm²
Angle of Internal Friction - 3.6°



BH: - 1
Depth - 10.5 m
Cohesion - 0.48 Kg/cm²
Angle of Internal Friction - 5.0°



Appendix - D1

Bihar Foundation Consultants,
[A unit of Baidyanath Foundation Consultants Pvt. Ltd.]

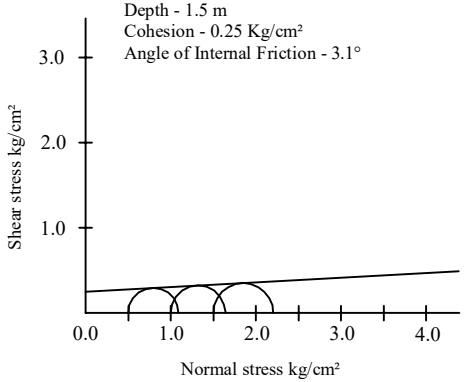
Project No. 220912

For the Proposed

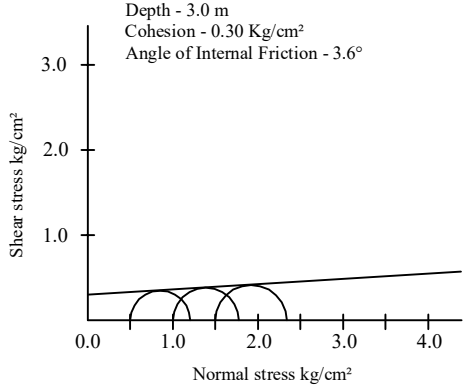
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi

TRIAXIAL / DIRECT SHEAR TEST PLOTS

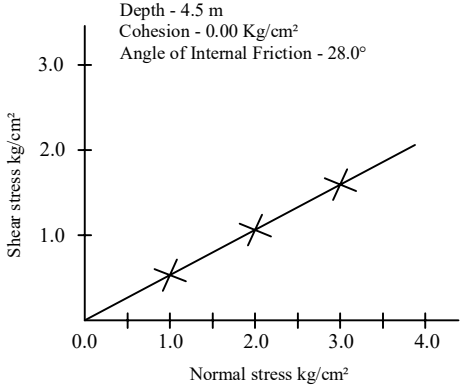
BH: - 2
Depth - 1.5 m
Cohesion - 0.25 Kg/cm²
Angle of Internal Friction - 3.1°



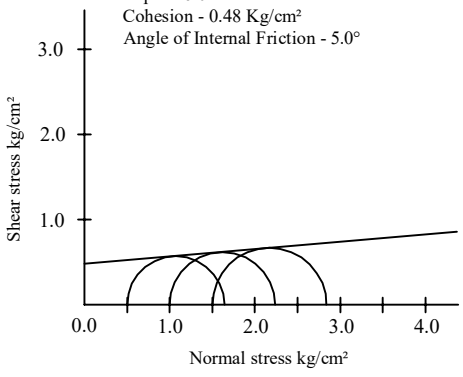
BH: - 2
Depth - 3.0 m
Cohesion - 0.30 Kg/cm²
Angle of Internal Friction - 3.6°



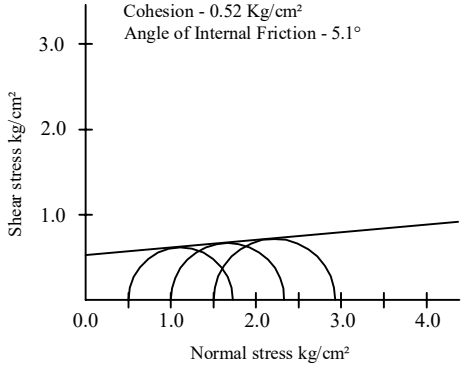
BH: - 2
Depth - 4.5 m
Cohesion - 0.00 Kg/cm²
Angle of Internal Friction - 28.0°



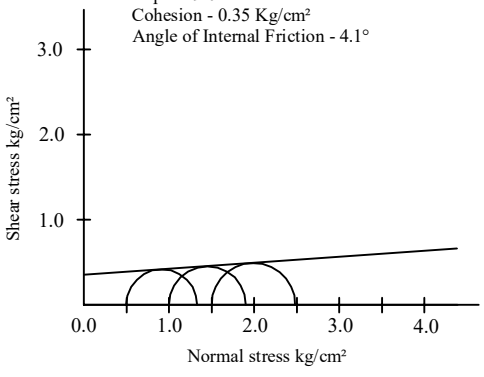
BH: - 2
Depth - 6.0 m
Cohesion - 0.48 Kg/cm²
Angle of Internal Friction - 5.0°



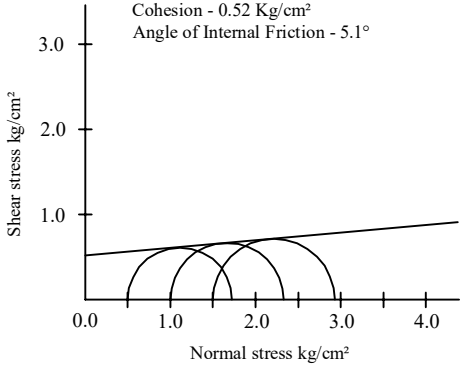
BH: - 2
Depth - 7.5 m
Cohesion - 0.52 Kg/cm²
Angle of Internal Friction - 5.1°



BH: - 2
Depth - 9.0 m
Cohesion - 0.35 Kg/cm²
Angle of Internal Friction - 4.1°



BH: - 2
Depth - 10.5 m
Cohesion - 0.52 Kg/cm²
Angle of Internal Friction - 5.1°



Appendix - D2

Bihar Foundation Consultants,
[A unit of Baidyanath Foundation Consultants Pvt. Ltd.]

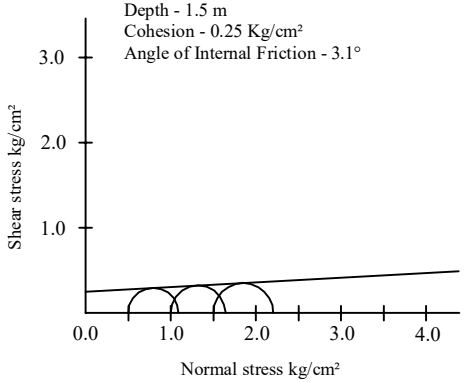
Project No. 220912

For the Proposed

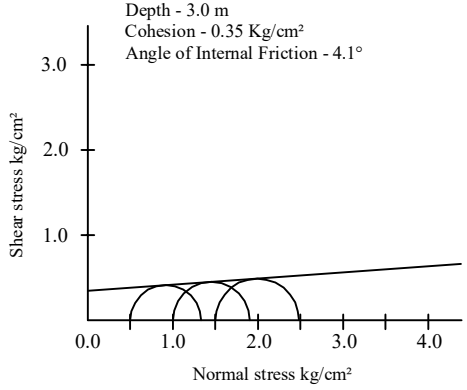
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi

TRIAXIAL / DIRECT SHEAR TEST PLOTS

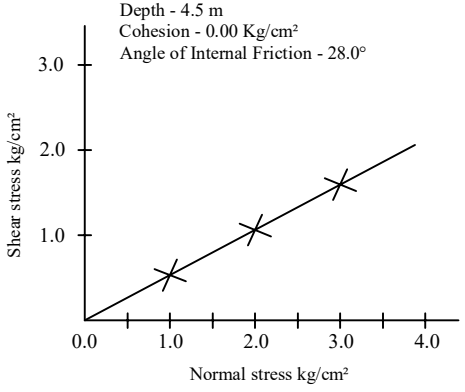
BH: - 3
Depth - 1.5 m
Cohesion - 0.25 Kg/cm²
Angle of Internal Friction - 3.1°



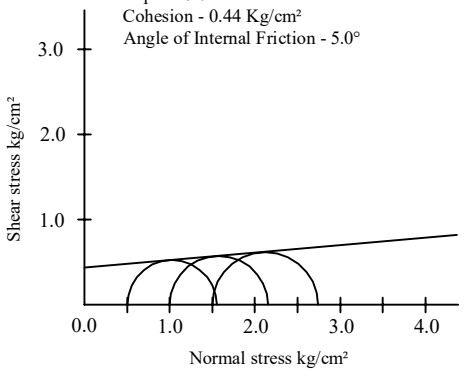
BH: - 3
Depth - 3.0 m
Cohesion - 0.35 Kg/cm²
Angle of Internal Friction - 4.1°



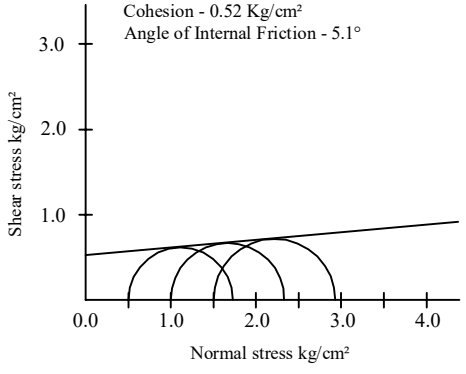
BH: - 3
Depth - 4.5 m
Cohesion - 0.00 Kg/cm²
Angle of Internal Friction - 28.0°



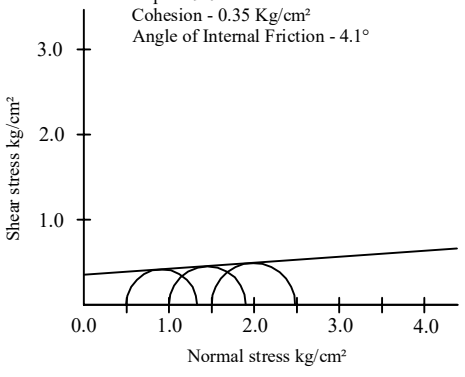
BH: - 3
Depth - 6.0 m
Cohesion - 0.44 Kg/cm²
Angle of Internal Friction - 5.0°



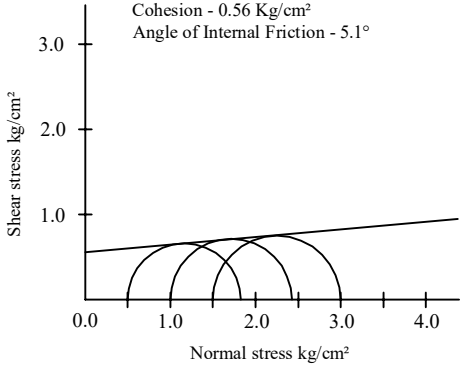
BH: - 3
Depth - 7.5 m
Cohesion - 0.52 Kg/cm²
Angle of Internal Friction - 5.1°



BH: - 3
Depth - 9.0 m
Cohesion - 0.35 Kg/cm²
Angle of Internal Friction - 4.1°



BH: - 3
Depth - 10.5 m
Cohesion - 0.56 Kg/cm²
Angle of Internal Friction - 5.1°



Appendix - D3

Bihar Foundation Consultants,
[A unit of Baidyanath Foundation Consultants Pvt. Ltd.]

Project No. 220912

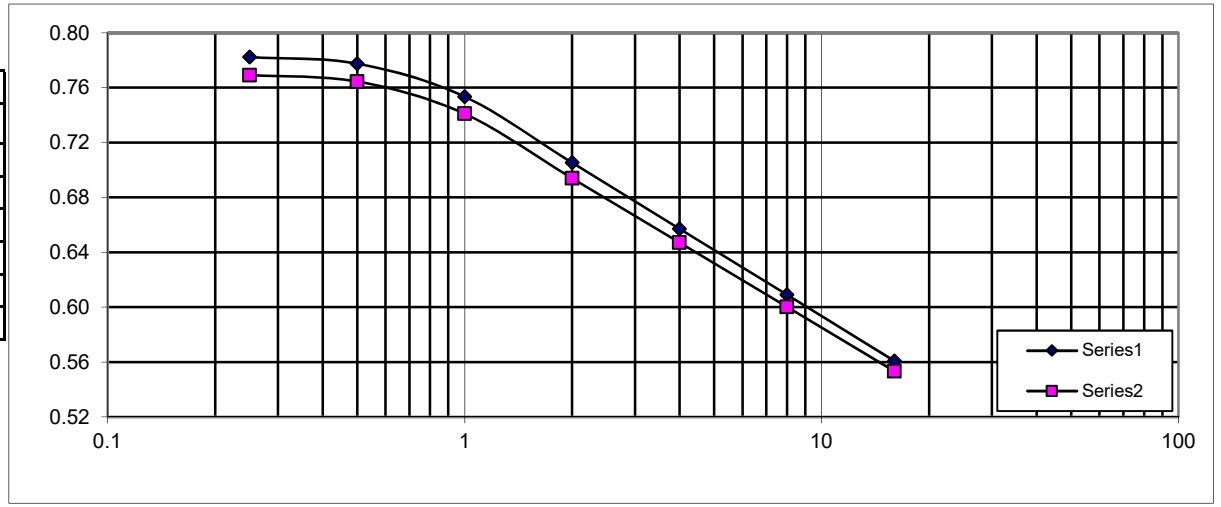
For the Proposed

G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi

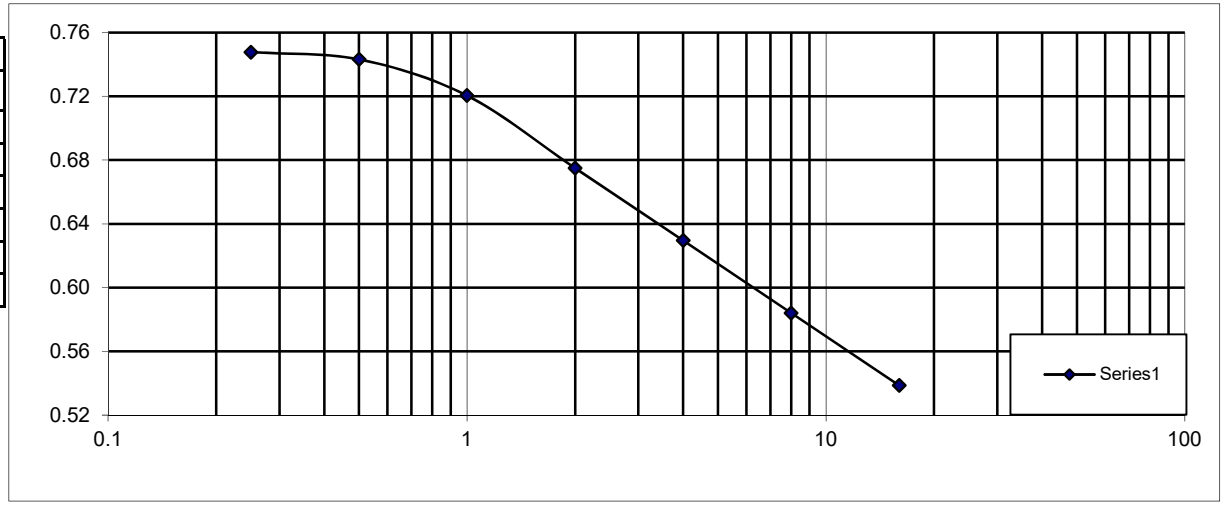
Fig. e - log p Plots from Consolidation Tests

X-axis : Pressure, p (kg/cm^2) on log scale. **Y-axis :** Void ratio, e

BH No./		Initial V.R.	
Depth (m)	**Cc**	e_0	CURVE
1/3.0	0.160	0.7855	Series1
2/3.0	0.156	0.7722	Series2



BH No./		Initial V.R.	
Depth (m)	**C_c**	e_0	CURVE
3/3.0	0.151	0.7506	Series1



SAMPLE CALCULATION OF BEARING CAPACITY OF SHALLOW FOUNDATION

The determination of the **net safe bearing capacity**, q_{ns}, is done on the basis of the shear failure criterion after dividing the value of the **net ultimate bearing capacity** q_{nf}, calculated as described below, by a suitable factor of safety. The **net soil pressure,** q_s, for a given permissible settlement is then calculated as explained in the next section. The lower of the two values, q_{ns} and q_s, thus determined is taken as the **allowable bearing capacity** of the soil.

1. Shear Failure Criterion :

The **net ultimate bearing capacity** q_{nf} (t/m^2) of a shallow foundation of breadth B (m) and depth D (m) is given as per IS:6403-1981 (Sec.5.1.2) by the following equation :

$$q_{nf} = c\,N_c\,s_c\,d_c\,I_c + q\,(N_q - 1)\,s_q\,d_q\,I_q + 0.5\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,I_\gamma\,w$$

where c = cohesion (t/m^2)
γ = unit weight of subsoil (t/m^3) [submerged unit weight, γ', is taken where so applicable]
q = effective surcharge (t/m^2) = γD
N_c, N_γ, N_q = bearing capacity factors, which are functions of ϕ, the angle of internal friction of the soil.
s_c, s_q, s_γ = shape factors
d_c, d_q, d_γ = depth factors
I_c, I_q, I_γ = inclination factors
} related to cohesion, surcharge and density of subsoil respectively
w = water table factor (= 0.5 to 1.0) depending on the depth, D_w of water table [vide Table below].

The bearing capacity factors (N's) are functions of ϕ, the angle of internal friction of the soil. The values of these factors are found for general shear failure by referring to standard tables. If subsoil conditions are such as to lead to local shear failure, the values of these factors are found for a reduced value of angle of internal friction (ϕ') given by the equation : $\tan \phi' = 0.67 \tan \phi$. The value of cohesion is also reduced to $c' = 0.67\,c$.

The values of the other factors in the above equation for usual conditions are as tabulated below :

s_c =	1.3	1+0.2B/L	1	$d_c = 1 + 0.2\,(N_\varphi)^{0.5}\,D/B$		D_w at	G.L.	Fou'dn.Level
s_q =	1.2	1+0.2B/L	1	$d_q = d_\gamma =$ 1	for $\varphi < 10^o$	w =	0.5	1
s_γ =	0.8//0.6	1-0.4B/L	1	$d_q = d_\gamma = 1 + 0.1(N_\varphi)^{0.5}\,D/B$	$\varphi > 10^o$		Interpolation	between
FOR	sq.// O	Rect.	STRIP	I_c, I_q, I_γ = 1 for vertical load			these values	is linear.

In the present case, the representative values of cohesion © and angle of internal friction (ϕ) may be obtained from the soil data given earlier. Full submergence of the soil has been assumed. The **safe bearing capacity**, q_{ns} has been obtained by dividing q_{nf} by a **safety factor, 3**.

One example of calculation of safe bearing capacity for a certain shape, depth and width of a footing is given in **Table A** on the next page. The net safe bearing capacity for the footing is entered in the last column of Table A. Calculations for other depths and widths of footings are done similarly.

The value of net safe bearing capacity (q_{ns}) calculated for each set of values of B and D is used for calculating the consolidation settlement s as explained in Sec. 2 below.

2. Settlement Criterion for Foundation on cohesive soil.

As per IS:8009(Part I)-1976, Sec. 9.2.2.2, the settlement s (in mm) is given by the equation :

$$s = [1000\,H\,C_c\,\log\,(1 + \Delta p/p_o)] / (1 + e_o)\,\lambda$$

where H = thickness (in m) of the compressible layer
C_c = compression index of the soil
e_o = initial void ratio at mid-height of compressible soil layer = its m/c (m) x sp. Gravity
p_o = initial effective pressure at mid-height of the layer (t/m^2)
Δp = pressure increment at the mid-height of the layer due to the foundation (t/m^2).

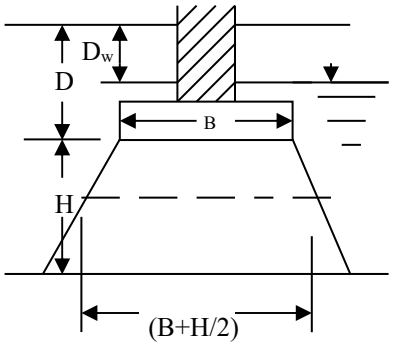
λ = correction factor

If there are different layers with different compression indices and void ratios, s is calculated for each one of these and then added together to get the settlement.

The pressure increment at any plane due to the footing load may be calculated by assuming the dispersion of load at a slope of 1 horizontal to 2 vertical. Hence the load applied over a width B of a foundation (vide the Fig. below) is spread at a depth H/2 below it over a width (B + H/2).

A correction factor λ = 0.80 is used as per IS Code to find the corrected settlement. If this value of corrected s is within the permissible limit specified in the Code, the corresponding value of q_{ns} is also the net allowable bearing capacity q_{na}. If not, trials give the desirued value of q_{na} . One example of this settlement analysis is given below the **Table B** in Sec. 3.

If D_w > (D+ 1.5 B/2), $p_o = \gamma$ (D+1.5 B/2) t/m^2, otherwise, $p_o = \gamma D_w + (\gamma - 1)(D - D_w + H/2)$ t/m^2



D_w = depth of water table below ground level .
D = depth of foundation
B = breadth of foundation
H = 1.5 x B = thickness of compressible soil layer in the zone of influence of the loaded foundation.
Breadth of the influence zone at the mid-plane of the compressible layer, of thickness H = (B + H/2).
In case of a rectangular or square footing a similar dispersion of load takes place along the other side of footing.

3. SAMPLE CALCULATION

Table A **Calculation of Net Safe Bearing Capacity**

Shape of Foundation: STRIP			F.S.= 3	γ, t/m^3= 1.95		c = 2.25	ϕ = 3.0	N_c = 5.90	N_q = 1.31	N_γ = 0.24
D [m]	B [m]	dc	dq = dg	c	q	I Term	II Term	III Term	qnf	qnf /F
2	2	1.21	1	2.25	1.95	16.08	0.60	0.24	16.92	5.64

The net safe bearing capacity for the footing is to be seen in the last column of the above Table A. This value is checked for settlement as shown below.

Table B **Calculation of Settlement**

m = 0.292		Gs = 2.69		eo = 0.7855		Cc = 0.156		Dw = 0	
Depth D [m]	Width B [m]	qnf /F t/m^2	po t/m^2	H m	Δp t/m^2	log (1+ Δp/po)	s [mm] mm	λs mm mm	Remarks
2.0	2.0	5.6	3.3	3.0	3.2	0.3	77.1	61.6	OK

Hence the **net allowable bearing pressure** for a strip footing of width 2.0 m and depth 2.0 m below ground level will be 5.6 t/m^2.

The calculations for footings of other sizes and depths are done similarly.

Calculations of Capacity of U\R Pile for the proposed
G+4, Boys' and Girls' Hostel, Educational Building and Principal-cum-Staff Quarter at Sitamarhi, DIET Dumra Sitamarhi

U/R **Pile Capacity Calculation**

Qu = Ap Nc cp+ AaNc c'a+ [0.5]As ca+ A's.ca'

where Ap = area of base of pile = pi $D^2/4$

Aa = area of annular ring = pi $Du^2/4$ - Ap

As = area of stem = pi D(L- 1.5 (n-1) Du-0.55-0.5)

As' = area of cyl. bet.bulbs= pi Du 1.5(n-1) Du

aver.coh.

at base, cp over depth (L-0.55) to (L+ 0.45)

at bulbs, c'a over depth (L-0.55- 1.5 Du) to (L-0.55)

on stem, ca over depth 0 -(L- 1.5 Du) & (L-0.55) to L

cyl. Bet. Bulbs, ca' Bulb dia = **2** x shaft dia

Factor of safety = ***3.00***

L	D,stem	Du	No.of bulbs,n=	Qs
6.0	0.25	0.50	1	3.0
6.0	0.25	0.50	2	4.3
8.0	0.25	0.50	1	4.8
8.0	0.25	0.50	2	6.4
10.0	0.25	0.50	1	5.6
10.0	0.25	0.50	2	7.2

L	D	Du	No.of bulbs, n=	Ap	Aa	As	As'	cp	c'a	ca	ca'
m	m	m		m^2	m^2	m^2	m^2	t/m^2	t/m^2	t/m^2	t/m^2
6.0	0.25	0.50	1	0.05	0.15	3.89	0.00	3.50	3.50	1.50	
6.0	0.25	0.50	2	0.05	0.15	3.30	1.18	3.50	3.50	1.50	3.50
8.0	0.25	0.50	1	0.05	0.15	5.46	0.00	4.50	4.50	2.40	
8.0	0.25	0.50	2	0.05	0.15	4.87	1.18	4.50	4.50	2.40	4.50
10.0	0.25	0.50	1	0.05	0.15	7.03	0.00	4.50	4.50	2.50	
10.0	0.25	0.50	2	0.05	0.15	6.44	1.18	4.50	4.50	2.50	4.80

L	D	Du	No.of bulbs, n=	ApNc cp	AaNc ca'	[0.5]As ca	As' ca'	Qu	Qs
m	m	m		t	t	t	t	t	t
6.0	0.25	0.50	1	1.55	4.64	2.92	0.00	9.10	3.0
6.0	0.25	0.50	2	1.55	4.64	2.47	4.12	12.78	4.3
8.0	0.25	0.50	1	1.99	5.96	6.55	0.00	14.50	4.8
8.0	0.25	0.50	2	1.99	5.96	5.84	5.30	19.10	6.4
10.0	0.25	0.50	1	1.99	5.96	8.79	0.00	16.74	5.6
10.0	0.25	0.50	2	1.99	5.96	8.05	5.65	21.66	7.2

बिहार राज्य शैक्षणिक आधारभूत संरचना विकास निगम लिमिटेड
BIHAR STATE EDUCATIONAL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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पत्रांक– BSEIDC/TECH/1960/2018– 7138 पटना, दिनांक–02/09/23

प्रेषक,

मुख्य अभियंता
BSEIDC, पटना।

सेवा में,

बिहार फाउंडेशन कंसल्टेन्ट
गंगा दर्शन अपार्टमेंट, फ्लैट नं०–403
सदाकत आश्रम के पश्चिम,
पटना–800010

विषयः– निर्माण स्थल पर मिट्टी जाँच के संबंध में।

प्रसंगः भवन निर्माण विभाग, बिहार, पटना के पत्र सं०–120, दिनांक–31.01.2023

महाशय,

उपर्युक्त बिहार राज्य शैक्षणिक आधारभूत संरचना विकास निगम के अधीन (i) Bhagalpur, DIET Bhagalpur (ii) Gaya, DIET Gaya (iii) Sitamarhi, DIET Dumra Sitamarhi (iv) Vaishali, DIET Dighi Hajipur, Vaishali में बालिका छात्रावास, बालक छात्रावास, शैक्षणिक भवन, प्रींसीपल–सह–स्टॉफ क्वॉटर के G+4 भवन निर्माण प्रस्तावित है। इस भवन निर्माण स्थल पर मिट्टी जाँच कराना है।

अतः अनुरोध है कि उपरोक्त स्थल का तीन बिन्दुओं पर आवश्यक गहराई तक प्रत्येक आवश्यकतानुसार मीटर गहराई में मिट्टी का नमूना संग्रह कर प्रतिवेदन समर्पित करें साथ ही विहित प्रपत्र में मिट्टी के भार वहन की क्षमता की गणना (Isolated एवं Pile Foundation के लिए अलग–अलग) भी Hard copy एवं Soft copy (C.D.) में समर्पित करें।

इस जाँच को इस तरह सम्पादित करें कि Transportation and Mobilization खर्च कम से कम हो। कार्य स्थल पर संपर्क व्यक्ति, कार्य से संबंधित प्राचार्य/संबंधित कार्यपालक अभियंता रहेंगे।

विश्वासभाजन

मुख्य अभियंता
BSEIDC, पटना।