

REPORT ON
GEOTECHNICAL INVESTIGATIONS

FOR THE PROPOSED

**Education Building
at
K.P. High School, Bettiah
Dist. West Champaran**

Your Letter No.- BSEIDC/TECH/1960/2018-954 Dated - 11.02.2021

Submitted to
**The Chief Engineer
BSEIDC, Patna**

January, 2021



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BIHAR FOUNDATION CONSULTANTS

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Education Building at K.P. High School, Bettiah, Dist. West Champaran



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PN - 210206

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1. INTRODUCTION

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The subsoil investigations reported herein were taken up 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) Chemical tests on soil/ground water
- (h) 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 sub soil in all BH's is silty clay / sandy silty clay [type CL] up to the depth of about 4.5 m followed be silty sand [type SM-SP] up to the investigated depth of 10.5 m bgl.

Ground water table was struck at about 1.20 m to 1.50 m depth below GL in February, 2021 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 sub soil in all BH's is silty clay / sandy silty clay [type CL] up to the depth of about 4.5 m followed by silty sand [type SM-SP] up to the investigated depth of 10.5 m bgl.

Ground water table was struck at about 1.20 m to 1.50 m depth below GL in February, 2021 It is subject to seasonal variations.

As the soil formation up to 5 m is fine grained soil and below the top soil, the consistency up to 5 m is soft to very soft over sandy formation up to investigated depth of 10.5 m. Placement of shallow foundation is not likely to be desirable as the soft to very soft silty clay formation up to 5 m will not be economical to place shallow foundation.

Hence it is recommended that pile with stabilization of soft to very soft soil and underlying sandy formation may be placed with suitable supervision.

The pile of 6 m to 10 m lengths and shaft diameters 0.25 m, 0.30 m, 0.40 and 0.50 m may be provided.

By way of example, the values of safe capacities of pile of the above mentioned sizes and depths have been calculated (vide Samples of Calculations in Appendix F) and are tabulated below in Table 1.

**Table 1. Safe Capacities of Plane Piles
[Factor of safety = 2.5 in skin friction and 3 in bearing]**

Pile length [m]	Safe Capacities [tonnes] (subject to checking for slenderness ratio*) for Piles of diameters (m):			
	0.25 m	0.30 m	0.40 m	0.50 m
6.0	3.1	4.4	7.3	10.2
7.0	4.0	5.7	9.8	13.9
8.0	4.9	6.9	12.1	18.0
9.0	5.8	8.2	14.4	21.8
10.0	6.7	9.5	16.8	25.4

* For calculation of Slenderness Ratio, Modulus of subgrade reaction (k) may be taken as follows:

For preliminary estimates in [A] clay soils, the following empirical relation as given in IS: 2950-1981 (Second Revision) Table 1, may be used based on the value of cohesion c of the soil at the concerned depth: $k \text{ (kN/m}^3\text{)} = 240 c$, c being in kN/m^2 .

In [B] cohesionless soils, for $N = 10$ to 30 ,
 k (submerged, and for $30 \text{ cm} \times 30 \text{ cm}$ plate) = 0.9 to 2.9 kg/cm^3 .

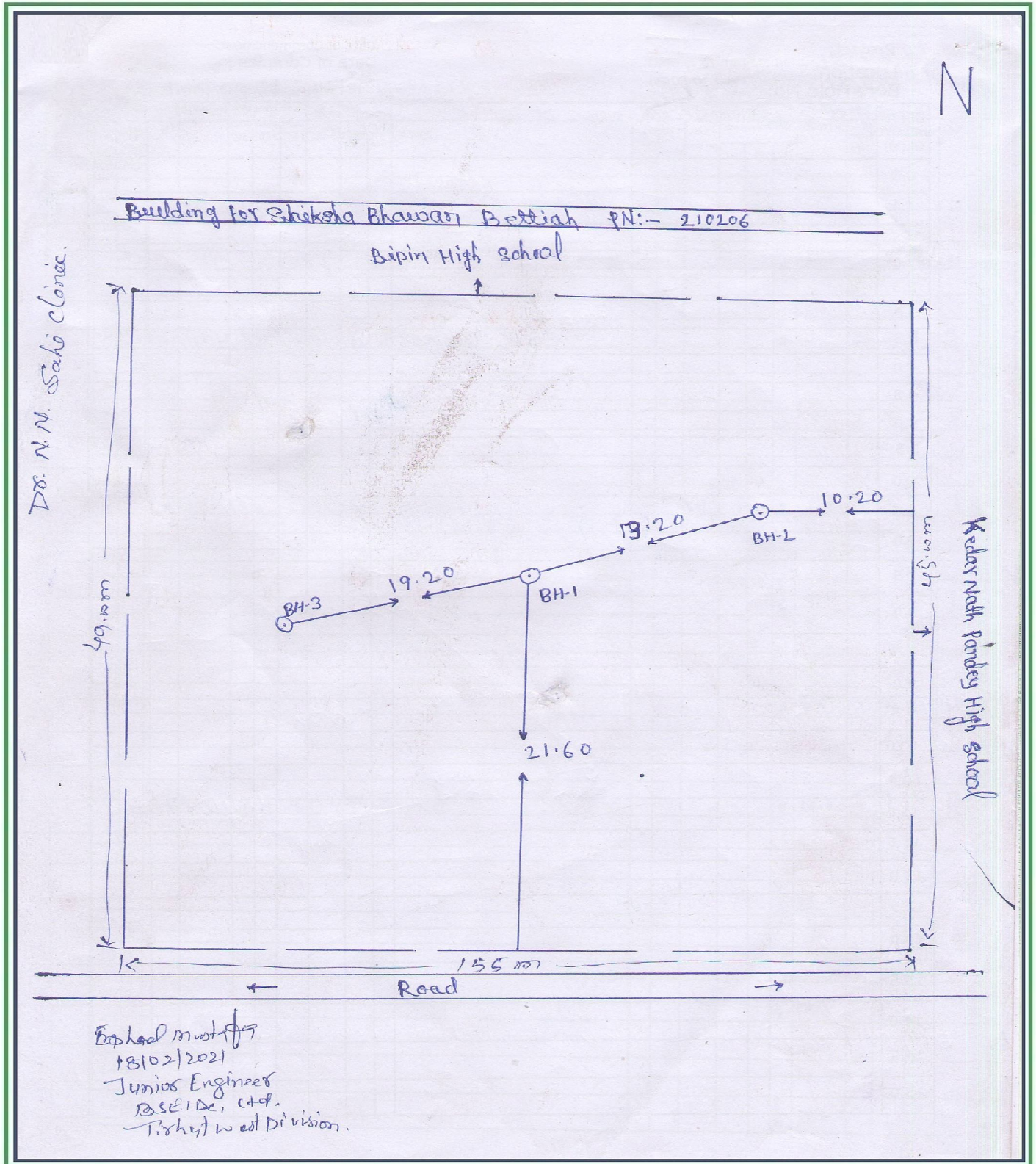
Notes:

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 the depth of a shallow foundation is below the water table, dewatering of the foundation trench has to be done, and its side walls may have to be suitably supported at the time of the construction of the foundation.
3. In case a basement is being provided, its base and side walls have to be safeguarded against the likely ingress of ground-water.
4. If concreting for a pile has to be done under water, DMC and tremie method of concreting should be adopted.
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

(Dr. K.S.P. Singh, FIE, MIGS)
Senior Consultant.

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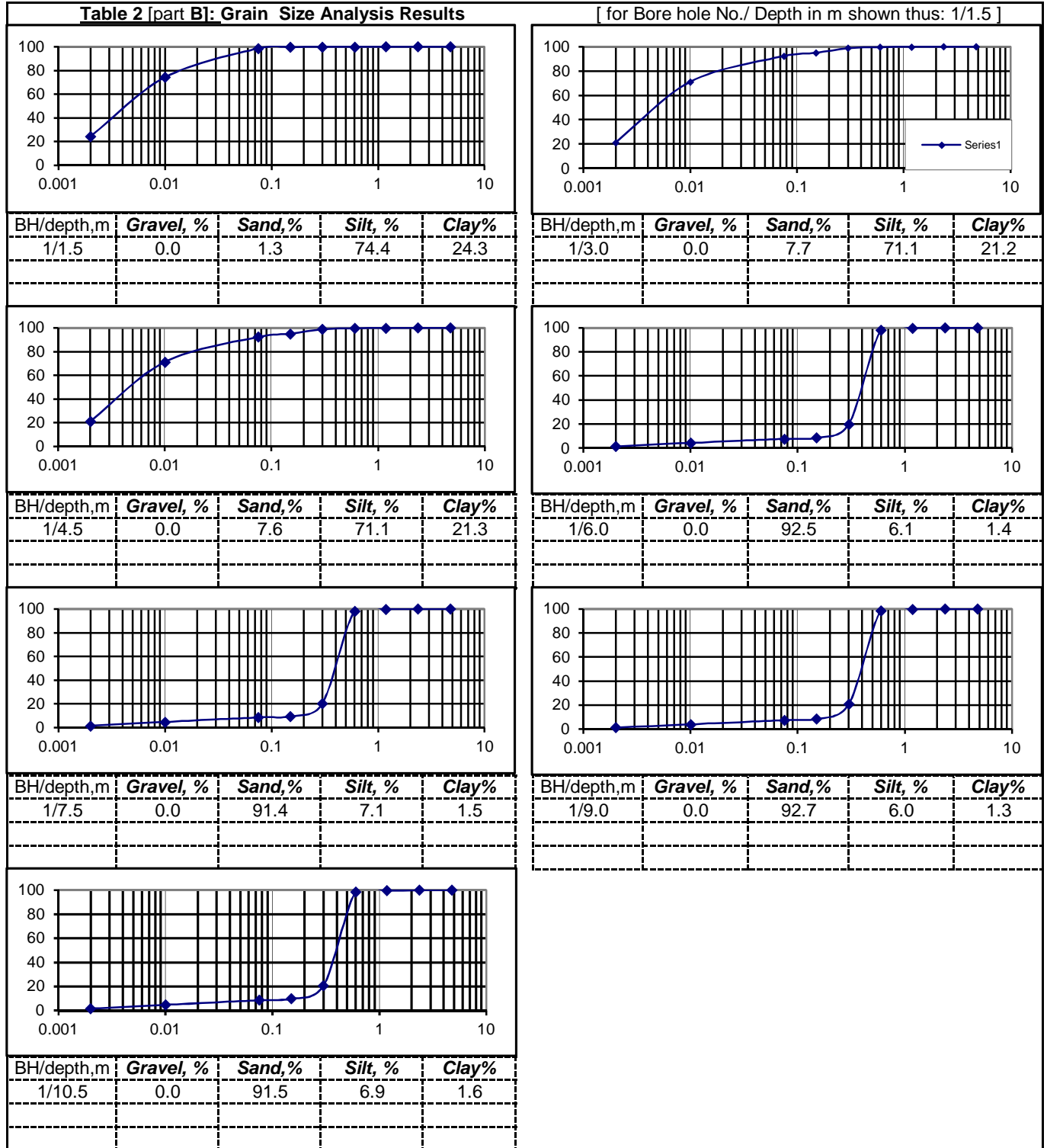
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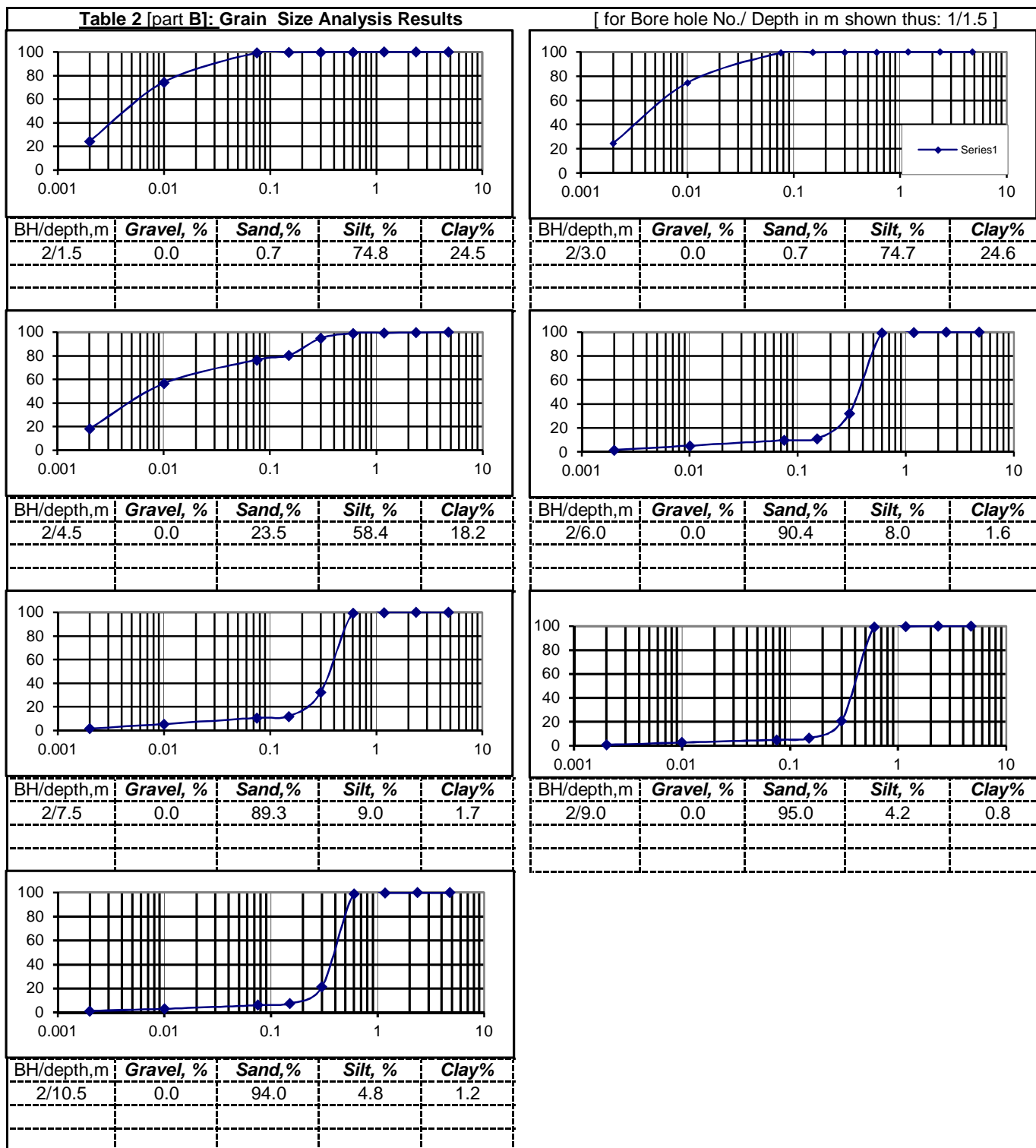
Appendix - A

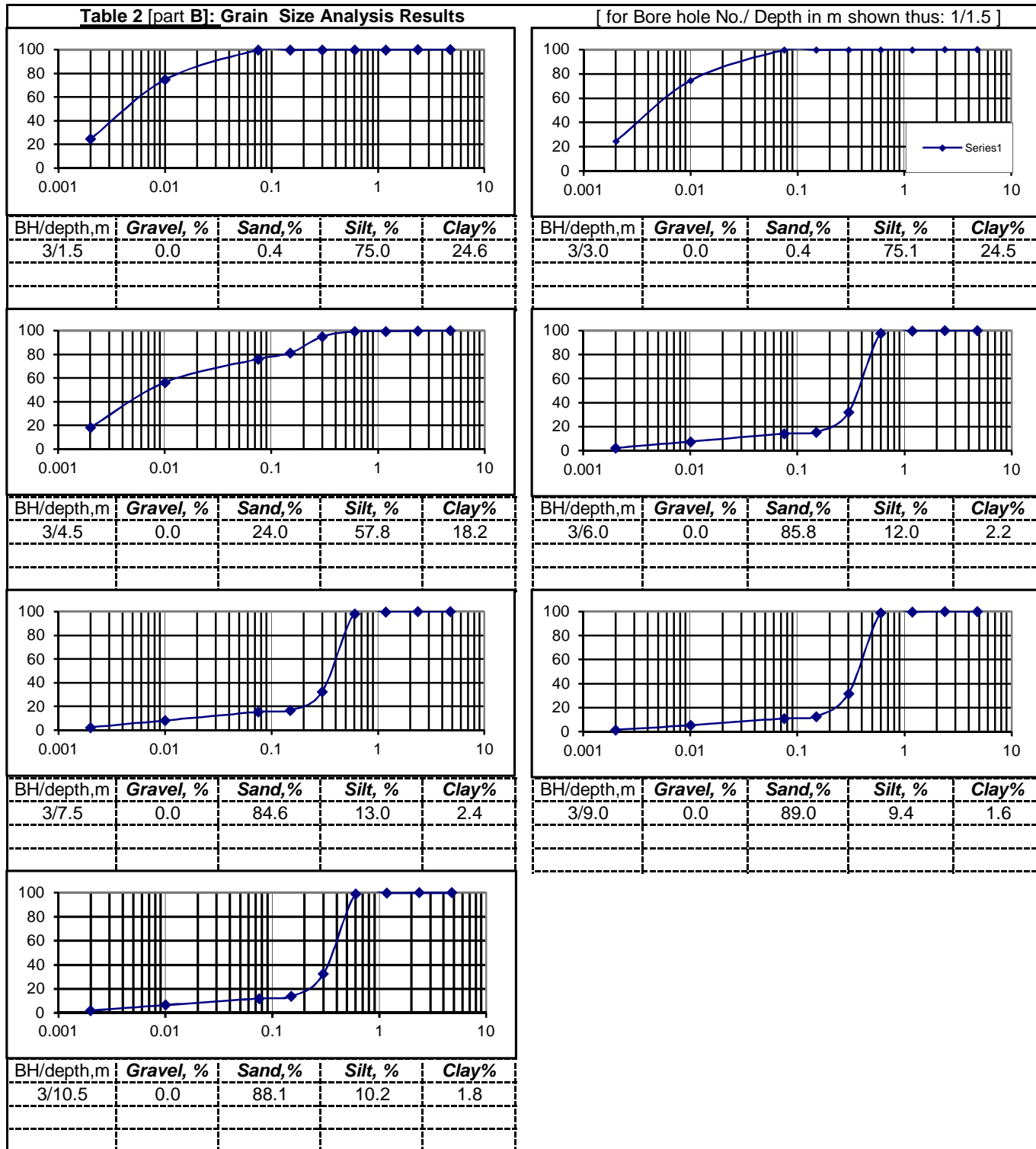
NAME OF WORK : Sub soil Investigation for C/O						BORING FINISH DATE : 18.02.2021				WATER TABLE : 1.50 m bgl								
Education Building at K.P. High School, Bettiah, Dist. West Champaran						BORING METHOD : Rotary												
BORE HOLE NO. : 1		Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m				RECORD ON : 18.02.2021								
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, f°			
1.0			Greyish silty clay, CL	0.0		4.5												
1.5	S1	11						29.9	21.2	8.7	2.00	26.0	2.70		0.40	4.5		
2.5																		
3.0	S2	3									1.94	29.9	2.70		0.15	2.0		
4.0																		
4.5	S3	5			4.5			31.4	22.7	8.7	1.95	29.3	2.70		0.25	3.0		
5.5			Greyish silty sand, SM-SP	4.5		6.0												
6.0	S4	7									1.91	30.3	2.64		0.00	28.0		
7.0																		
7.5	S5	9									1.90	30.5	2.63		0.00	28.0		
8.5																		
9.0	S6	11									1.90	30.7	2.63		0.00	28.1		
10.0																		
10.5	S7	14			10.5						1.89	31.2	2.62		0.00	28.4		

NAME OF WORK : Sub soil Investigation for C/O						BORING FINISH DATE : 18.02.2021				WATER TABLE : 1.50 m bgl								
Education Building at K.P. High School, Bettiah, Dist. West Champaran						BORING METHOD : Rotary												
BORE HOLE NO. : 2		Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m				RECORD ON : 18.02.2021								
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, f°			
1.0			Greyish silty clay, CL	0.0		3.0												
1.5	S1	10						29.2	15.9	13.3	2.00	26.0	2.70		0.40	4.5		
2.5																		
3.0	S2	6			3.0			28.8	21.3	7.5	1.96	28.6	2.70		0.30	3.5		
4.0			Greyish sandy silty clay, CL	3.0		1.5												
4.5	S3	4			4.5						1.94	29.7	2.70		0.20	2.5		
5.5			Greyish silty sand, SM-SP	4.5		6.0												
6.0	S4	7									1.91	30.3	2.64		0.00	28.0		
7.0																		
7.5	S5	10									1.90	30.6	2.63		0.00	28.0		
8.5																		
9.0	S6	11									1.90	30.7	2.63		0.00	28.10		
10.0																		
10.5	S7	13			10.5						1.89	31.1	2.62		0.00	28.2		

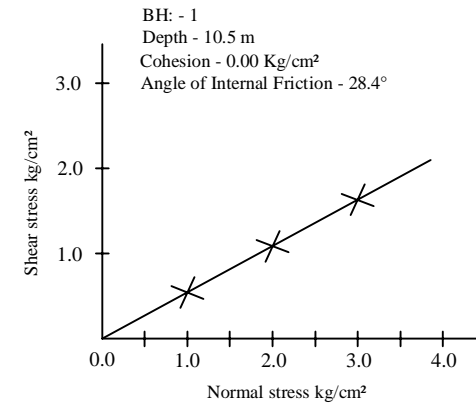
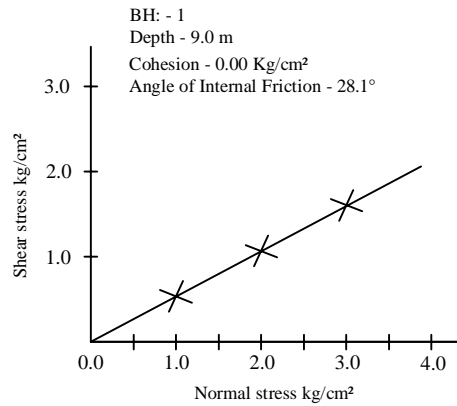
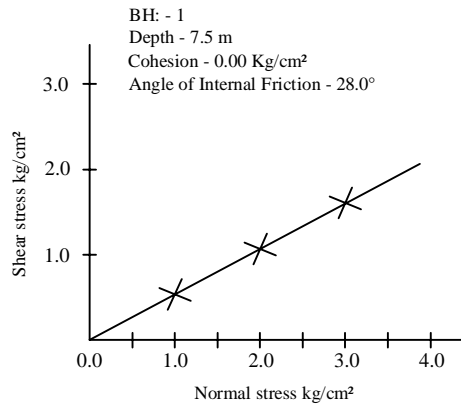
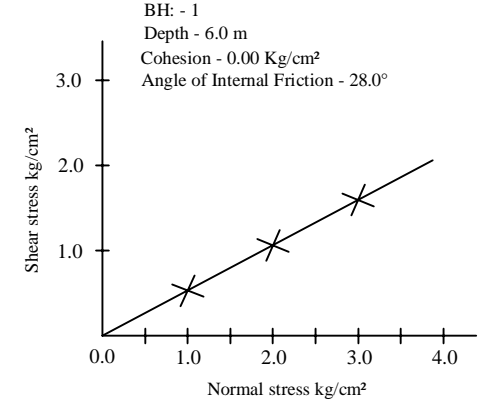
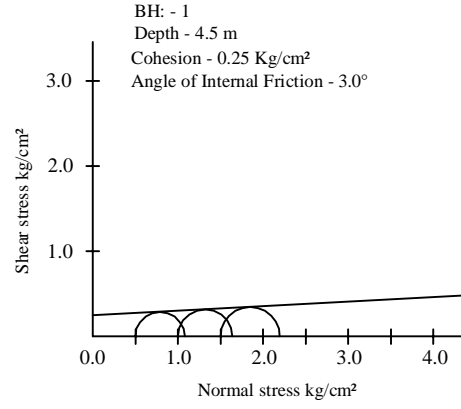
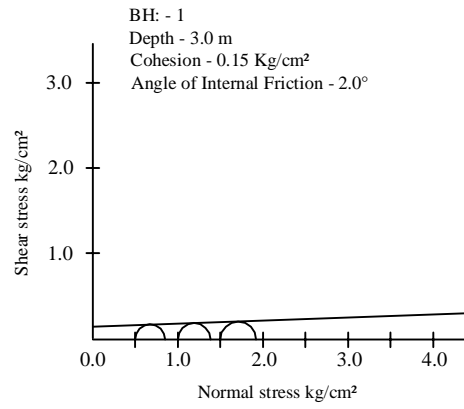
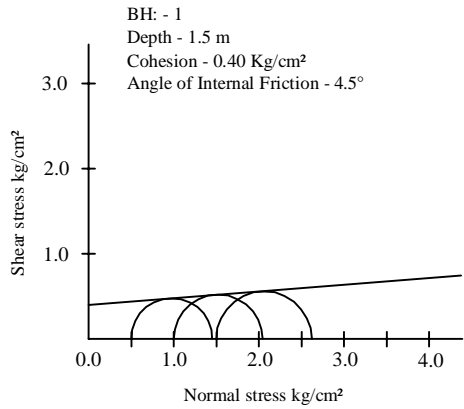
NAME OF WORK : Sub soil Investigation for C/O						BORING FINISH DATE : 19.02.2021				WATER TABLE : 1.20 m bgl								
Education Building at K.P. High School, Bettiah, Dist. West Champaran						BORING METHOD : Rotary												
BORE HOLE NO. : 3		Site Incharge - Mukesh Singh				TERMINATION DEPTH : 10.5 m				RECORD ON : 19.02.2021								
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, f°			
1.0			Greyish silty clay, CL	0.0		3.0												
1.5	S1	8						28.9	21.3	7.6	1.98	27.3	2.70		0.38	4.4		
2.5																		
3.0	S2	4			3.0						1.94	29.7	2.70		0.20	2.5		
4.0			Greyish sandy silty clay, CL	3.0		1.5												
4.5	S3	5			4.5			32.1	22.6	9.5	1.95	29.3	2.70		0.25	3.0		
5.5			Greyish silty sand, SM-SP	4.5		6.0												
6.0	S4	8									1.91	30.4	2.64		0.00	28.0		
7.0																		
7.5	S5	10									1.90	30.6	2.63		0.00	28.0		
8.5																		
9.0	S6	13									1.89	31.1	2.62		0.00	28.3		
10.0																		
10.5	S7	15			10.5						1.89	31.3	2.62		0.00	28.5		







TRIAxIAL / DIRECT SHEAR TEST PLOTS



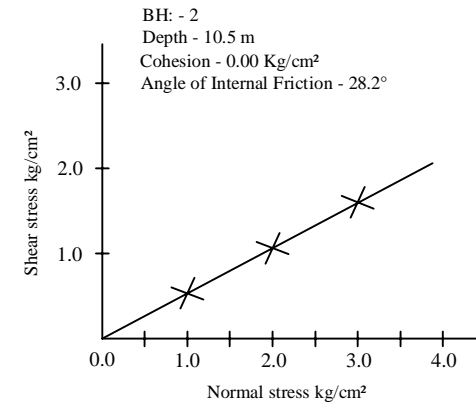
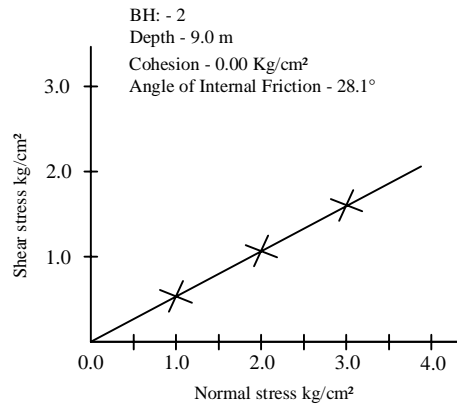
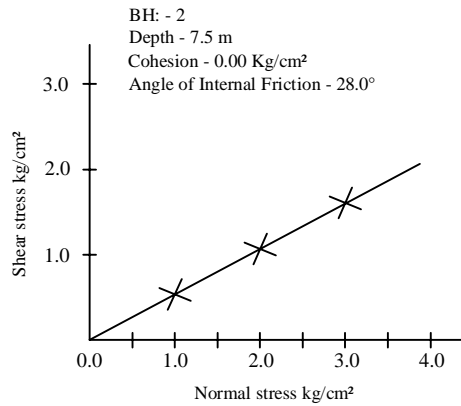
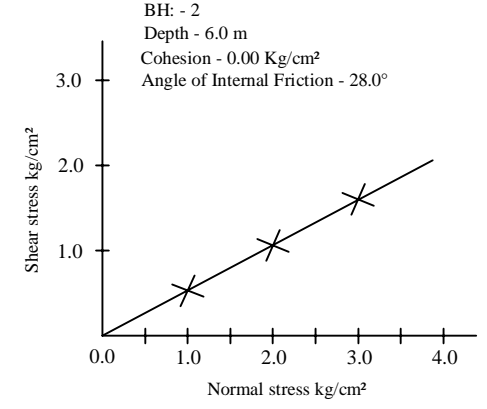
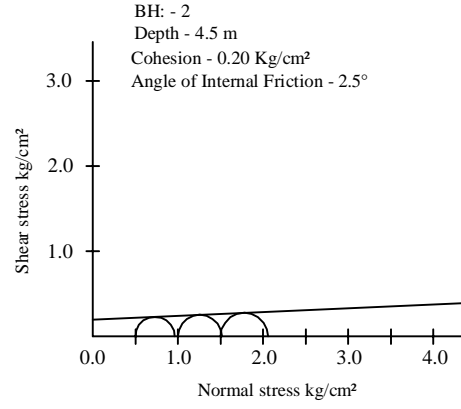
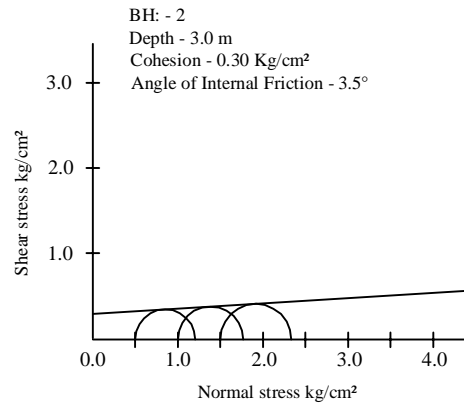
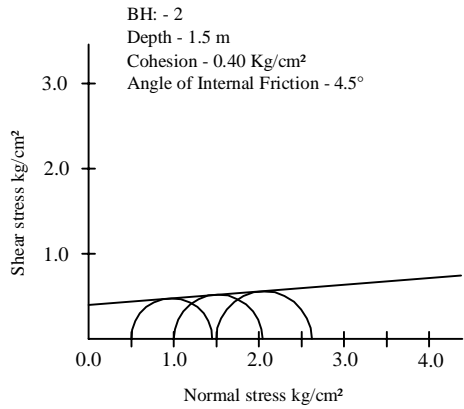
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TRIAXIAL / DIRECT SHEAR TEST PLOTS



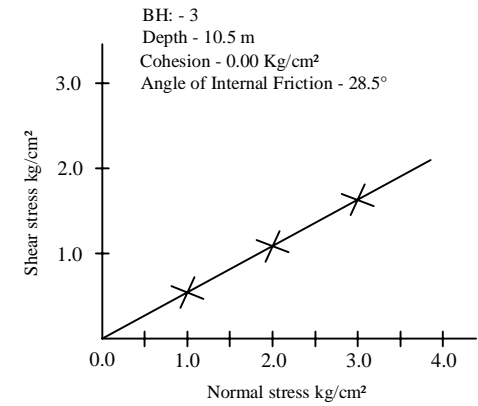
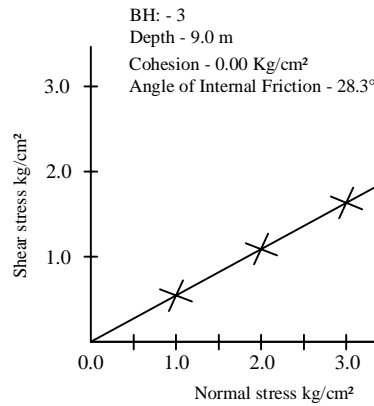
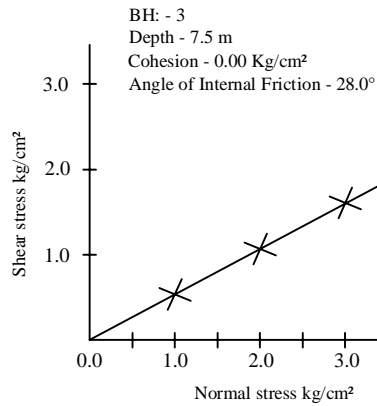
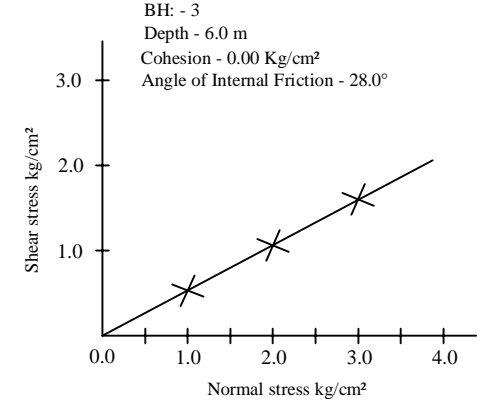
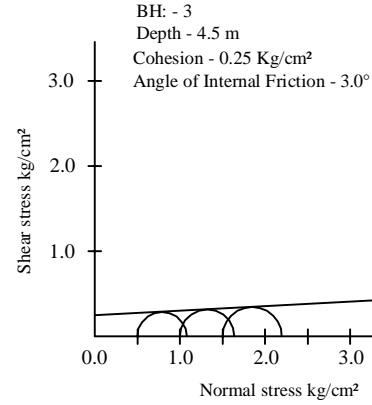
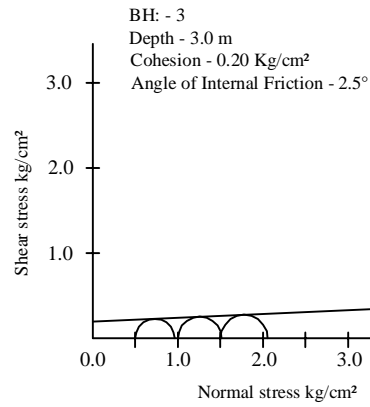
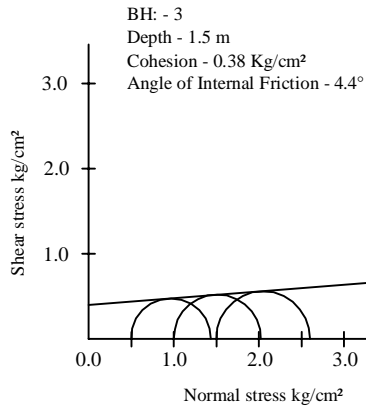
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TRIAXIAL / DIRECT SHEAR TEST PLOTS



Calculations of Capacity of U/R Pile for the proposed
Education Building at K.P. High School, Bettiah, Dist. West Champaran

CALCULATION OF CAPACITY OF PLANE PILE for C/O Education Building at K.P. High School, Bettiah, Dist. West Champaran

Based on IS:2911 (Part I, Sec. 2) 1979, Appendix B, Clause 5.3.1.1,

using both cohesion (c), in t/m^2 and angle of internal friction (ϕ).

WHEN Pile diameter, D (m) = **0.25** Area of pile base, A_p (m^2) = 0.049 & circmf'rance (in m) of pile base, j = $3.14 \times D = 0.785$

Surface area of pile's contact with soil, A (m^2) = $j \times t$ where t = thickness of soil layer in contact with pile.

In **CLAY**: Skin friction in clay, Q_s = C A , End bearing, Q_b = $A_p C_p N_c$,
where Reduction factor, a depends on N :-- where $N_c = 9$

N =	< 4	4 to 8	8 to 15	>15
a =	0.7	0.5	0.4	0.3

In **SAND**: Skin friction, Q_s = $K P_{mid} A \tan \phi$, where $K = 1.5$

and d = . End bearing, Q_b = $A_p(0.5 D_g N_q + P_{tip} N_q)$,

where P = overburden press.at mid-layer or pile tip , as the case be,

and the values of N_q and N_g are to be taken from the IS Code.

*Max'm permissible P [t/m^2] = 15 to 20 X pile diameter (D) X C_{sub}

$$= 3.75 \text{ to } 5 \times C_{sub} \text{ } t/m^2 .$$

$$3.525 \text{ to } 4.7 \text{ } t/m^2 .$$

Let factor of safety in

Total Ultimate capacity of pile, $Q_u = Q_s + Q_b$.

Safe capacity of pile, $Q_{sf} = (Q_s / f_s + Q_b / f_b)$

friction, $f_s = 2.5$

bearing, $f_b = 3.0$

Depth of soil layer (m)	Soil type	q_{sub} t/m^3	c t/m^2	a	ϕ	t [m]	p = $C \times t$ t/m^2	Permissible		A = $j \times t$ m^2	Qs' (for 1 layer) t	Qs = Q_s t	Qb t	Qu t	Qsf [runded off] tonnes	Pile Length m	
								$P_{tip} = S_p$ t/m^2	P_{mid} t/m^2								
0.0-0.5	silty clay					0.5	0.00	0.00	0.0							0.5	
0.5-3.0	sandy clayey silt	0.94	1.3	0.5	3.0	2.5	2.35	2.35	2.4	1.2	1.96	1.41	1.41	1.03	2.44		3.0
3.0-5.0	sandy clayey silt	0.94	2.0	0.5	2.5	2.0	1.88	4.23	3.5	3.3	1.57	1.91	3.32	2.64	5.95		5.0
5.0-6.0	sandy clayey silt	0.91	0.0			28.0	0.91	5.14	3.5	3.5	0.79	2.21	5.52	2.64	8.16	3.1	6.0
6.0-7.0	sandy clayey silt	0.90	0.0			28.0	0.90	6.04	3.5	3.5	0.79	2.21	7.73	2.64	10.37	4.0	7.0
7.0-8.0	sandy clayey silt	0.90	0.0			28.0	0.90	6.94	3.5	3.5	0.79	2.21	9.93	2.65	12.59	4.9	8.0
8.0-9.0	sandy clayey silt	0.90	0.0			28.1	0.90	7.84	3.5	3.5	0.79	2.21	12.14	2.70	14.84	5.8	9.0
9.0-10.0	silty sand	0.89	0.0			28.2	0.89	8.73	3.5	3.5	0.79	2.22	14.37	2.73	17.09	6.7	10.0
Depth, d	q_{sub}	f^p	$* N_g$	$* N_q$	$\# Q_b$	Q_b for f	Q_b for c	$\# Q_b$									
6.0	0.90	28.0	16.72	14.72	2.64	0.0	0.00										
7.0	0.90	28.0	16.72	14.72	2.64	0.0	0.00										
8.0	0.90	28.1	16.84	14.80	2.65	0.0	0.00										
9.0	0.89	28.2	17.21	15.05	2.70	0.0	0.00										
10.0	0.89	28.3	17.46	15.21	2.73	0.0	0.00										

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BIHAR STATE EDUCATIONAL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

(A Govt. of Bihar Undertaking)
ISO 9001:14001; OHSAS 18001

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पत्राकः— BSEIDC/TECH/1960/2018 - 954

दिनांक 11.02.2021

प्रेषक,

मुख्य अभियंता
BSEIDC Ltd, Patna

सम्पत्त में,

बिहार फाउंडेशन कंसल्टेन्ट
गंगा दर्शन अपार्टमेंट, फ्लैट न०-403,
सदाकत आश्रम के पश्चिम,
पटना- 800010

विषयः— निर्माण स्थल के मिट्टी जाँच हेतु।

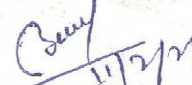
प्रसंगः— भवन निर्माण विभाग का पत्र संख्या-2030, दिनांक-21.04.2006 एवं आपका पत्रांक-37
दिनांक-13.12.2019

महाशय,

बिहार राज्य शैक्षणिक आधारभूत संरचना विकास निगम लि० के अधीन प्रस्तावित "शिक्षा भवन, बेतिया, पश्चिम चम्पारण" के निर्माण स्थल की मिट्टी जाँच रिपोर्ट में आपके द्वारा Silty clay / Sandy silty clay एवं Clayey silty sand/ Silty sand बताया गया है एवं Shallow foundation recommend किया गया है। किंतु वास्तविक कार्य संपादित करने पर कार्य स्थल दलदली पाया गया। इस संबंध में अपना प्रतिवेदन अधोहस्ताक्षरी के कार्यालय में समर्पित करना सुनिश्चित करें।

पुनः अनुरोध है कि उपरोक्त प्रस्तावित निर्माण कार्य हेतु चयनित नये स्थल (K.P. High School) का तीन बिन्दुओं पर 10.5 मीटर गहराई तक प्रत्येक 1.5 मीटर गहराई में मिट्टी का नमूना संग्रह कर जाँच प्रतिवेदन समर्पित करें। साथ ही संलग्न विहित प्रपत्र में मिट्टी के भार वहन क्षमता की गणना (Isolated एवं Pile Foundation के लिए अलग-अलग) भी Hard Copy एवं Soft Copy में समर्पित करें। कार्य स्थलों पर सम्पर्क व्यक्ति, कार्य से संबंधित पदाधिकारी / संबंधित कार्यपालक अभियंता (Manoj Kumar Pandey, Mob- 9661818750/9835806534) रहेंगे।

विश्वासभाजन


मुख्य अभियंता

Bihar Foundation Consultants
403, Ganga Darshan Apartment, Patna-10
[A Unit : Baidyanath Foundation Consultants Pvt. Ltd.]

PN - 210206

Appendix - G