PN – 211220

REPORT ON

# GEOTECHNICAL INVESTIGATIONS

FOR THE PROPOSED

# Degree College
# In
# Govt. Mahila High School Campus, Jamui

Your Letter No.- BSEIDC/Tech/1960/2018-8409 Dated – 04.12.2021

Submitted to
The Chief Engineer
BSEIDC, Patna

December, 2021


**BIHAR FOUNDATION CONSULTANTS**
[A unit of Baidyanath Foundation Consultants Pvt. Ltd.]
Having an
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# Degree College in Govt. Mahila High School Campus, Jamui

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[A Unit : Baidyanath Foundation Consultants Pvt. Ltd.]

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## CONTENTS



## Appendix

**[ Containing Figures and Tables ]**

## INTRODUCTION

The subsoil investigations reported herein were taken up (vide W.O. No. BSEIDC/Tech/1960/2018-8409 Dated – 04.12.2021 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.

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*It was learnt from Sri Bipin Ji, the J.E. [Mob. No. 9470254520] that the original site for this College was in the campus of Govt. Mahila High School, Jamui. But due to some reasons that site had been changed by the D.M. to the present one in Village Sekariya.

## 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

(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 subsoil in all BH's is silty sand [type SM-SP] up to the investigated depth of 10.5 m bgl.

*Ground water table was struck at about 4.40 m to 4.60 m depth below GL in December, 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 subsoil in all BH's is silty sand [type SM-SP] up to the investigated depth of 10.5 m bgl.

*Ground water table was struck at about 4.40 m to 4.60 m depth below GL in December, 2021 It is subject to seasonal variations.*

Hence,

1. The subsoil is loose to very loose up to about 4 m depth. Hence the proposed structure may be provided with shallow foundation at a depth of 4.0 m or more.
2. Alternatively plane piles of lengths 4.0 m to 10.0 m with shaft diameters 0.25 m, 0.30 m, 0.40 m and 0.50 m may be provided. A casing will have to be used during boring for the pile. If concreting for a pile has to be done under water, DMC and tremie method of concreting should be adopted.

By way of example, the values of safe capacities of

[1] Shallow foundations and [2] Plane piles of the above mentioned sizes and depths have been calculated (vide Samples of Calculations in Appendix F) and the safe capacities are given below in Tables 1 and 2 respectively.

**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 | |
| 4.0 | 2 | 6.9 | 6.9 | … | 50 |
| | 3 | 6.4 | 6.4 | … | 50 |
| | 10 | … | … | 5.8 | 75 |
| 4.5 | 2 | 6.9 | 6.9 | … | 50 |
| | 3 | 6.4 | 6.4 | … | 50 |
| | 10 | … | … | 6.1 | 75 |
| 5.0 | 2 | 8.1 | 8.1 | … | 50 |
| | 3 | 7.4 | 7.4 | … | 50 |
| | 10 | … | … | 9.4 | 75 |
| 6.0 | 2 | 9.3 | 9.3 | … | 50 |
| | 3 | 8.5 | 8.5 | … | 50 |
| | 10 | … | … | 10.0 | 75 |

**Table 2. 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** |
| 4.0 | 2.1 | 2.8 | 4.3 | 6.1 |
| 6.0 | 4.0 | 5.7 | 9.1 | 12.6 |
| 8.0 | 5.8 | 8.4 | 14.2 | 21.0 |
| 10.0 | 7.7 | 11.1 | 19.0 | 28.7 |

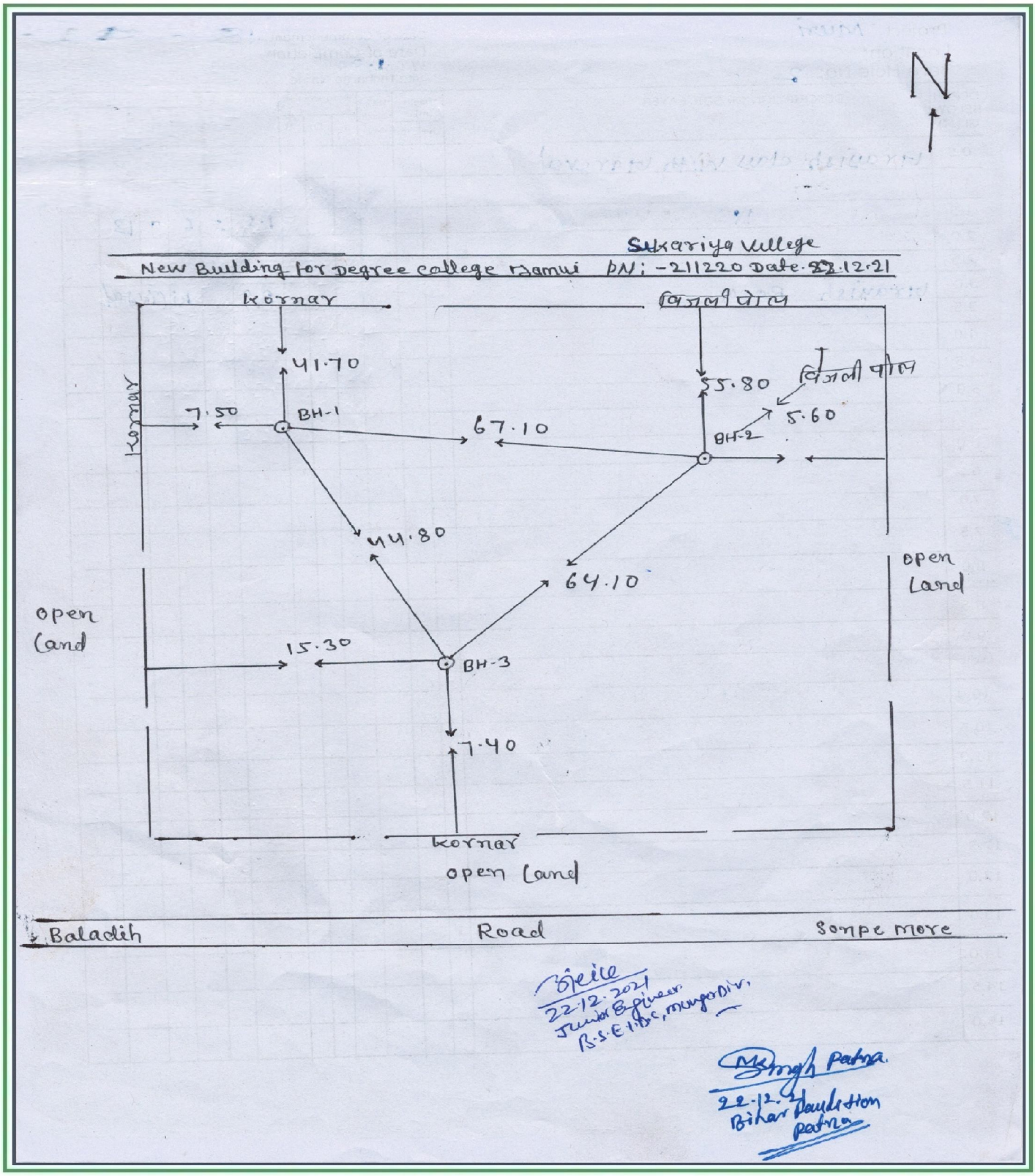
*For a preliminary checking of the slenderness ratio, the modulus of subgrade reaction (k) may be estimated from the following empirical relation given in IS: 2950-1981 (Second Revision) Table 1. k ($kN/m^3$) = 240 c, where c ($kN/m^2$) is the value of cohesion of the soil at the concerned depth.**Notes:**

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 of 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

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

# Degree College in Govt. Mahila High School Campus, Jamui

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**PN - 211220** **Appendix - A**

| NAME OF WORK : Sub soil Investigation for C/O | | | | | | | BORING FINISH DATE : 22.12.2021 | | | | | WATER TABLE : 4.50 m bgl | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Degree College in Govt. Mahila High School Campus, Jamui** | | | | | | | BORING METHOD : Rotary | | | | | | | | | |
| BORE HOLE NO. : 1 | | Site Incharge - Mukesh Singh | | | | | TERMINATION DEPTH : 10.5 m | | | | | RECORD ON : 22.12.2021 | | | | |

| 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 ($C_c$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Type of Test | Cohesion, c ( kg/cm2 ) | Friction Angle, $\phi$ ° | |
| | | Obsr. | | from | to | | | | | | | | | | | |
| 1.0 | | | Greyish silty sand, SM-SP | 0.0 | | 4.5 | | | | | | | | | | |
| 1.5 | S1 | 4 | | | | | | | | 1.91 | 30.0 | 2.63 | | 0.00 | 26.2 | |
| 2.5 | | | | | | | | | | | | | | | | |
| 3.0 | S2 | 4 | | | | | | | | 1.91 | 30.0 | 2.63 | | 0.00 | 26.2 | |
| 4.0 | | | | | | | | | | | | | | | | |
| 4.5 | S3 | 7 | | | 4.5 | | | | | 1.91 | 30.3 | 2.64 | | 0.00 | 28.0 | |
| 5.5 | | | Greyish yellowish silty sand, SM-SP | 4.5 | | 6.0 | | | | | | | | | | |
| 6.0 | S4 | 21 | | | | | | | | 1.87 | 32.7 | 2.62 | | 0.00 | 29.1 | |
| 7.0 | | | | | | | | | | | | | | | | |
| 7.5 | S5 | 23 | | | | | | | | 1.87 | 32.9 | 2.62 | | 0.00 | 29.3 | |
| 8.5 | | | | | | | | | | | | | | | | |
| 9.0 | S6 | 26 | | | | | | | | 1.86 | 33.7 | 2.62 | | 0.00 | 29.6 | |
| 10.0 | | | | | | | | | | | | | | | | |
| 10.5 | S7 | 30 | | | 10.5 | | | | | 1.85 | 34.6 | 2.62 | | 0.00 | 30.0 | |

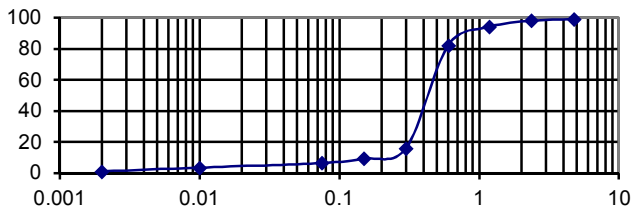
| NAME OF WORK : Sub soil Investigation for C/O | | | | | | | BORING FINISH DATE : 22.12.2021 | | | | | WATER TABLE : 4.60 m bgl | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Degree College in Govt. Mahila High School Campus, Jamui** | | | | | | | BORING METHOD : Rotary | | | | | | | | | |
| BORE HOLE NO. : 2 | | Site Incharge - Mukesh Singh | | | | | TERMINATION DEPTH : 10.5 m | | | | | RECORD ON : 22.12.2021 | | | | |

| 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 ($C_c$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Type of Test | Cohesion, c ( kg/cm2 ) | Friction Angle, $\phi$ ° | |
| | | Obsr. | | from | to | | | | | | | | | | | |
| 1.0 | | | Greyish silty sand, SM-SP | 0.0 | | 4.5 | | | | | | | | | | |
| 1.5 | S1 | 3 | | | | | | | | 1.92 | 30.0 | 2.63 | | 0.00 | 25.5 | |
| 2.5 | | | | | | | | | | | | | | | | |
| 3.0 | S2 | 4 | | | | | | | | 1.91 | 30.0 | 2.30 | | 0.00 | 26.2 | |
| 4.0 | | | | | | | | | | | | | | | | |
| 4.5 | S3 | 9 | | | 4.5 | | | | | 1.90 | 30.5 | 2.63 | | 0.00 | 28.0 | |
| 5.5 | | | Greyish yellowish silty sand, SM-SP | 4.5 | | 6.0 | | | | | | | | | | |
| 6.0 | S4 | 22 | | | | | | | | 1.87 | 32.8 | 2.62 | | 0.00 | 29.2 | |
| 7.0 | | | | | | | | | | | | | | | | |
| 7.5 | S5 | 25 | | | | | | | | 1.86 | 33.6 | 2.62 | | 0.00 | 29.5 | |
| 8.5 | | | | | | | | | | | | | | | | |
| 9.0 | S6 | 29 | | | | | | | | 1.85 | 34.5 | 2.62 | | 0.00 | 29.9 | |
| 10.0 | | | | | | | | | | | | | | | | |
| 10.5 | S7 | 31 | | | 10.5 | | | | | 1.85 | 34.7 | 2.62 | | 0.00 | 30.1 | |

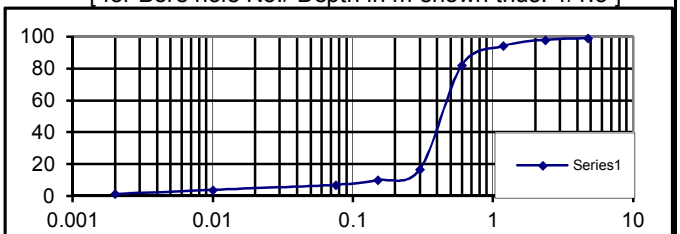
| NAME OF WORK : Sub soil Investigation for C/O | | | | | | | BORING FINISH DATE : 23.12.2021 | | | | | | WATER TABLE : 4.40 m bgl | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Degree College in Govt. Mahila High School Campus, Jamui** | | | | | | | BORING METHOD : Rotary | | | | | | | | | | |
| BORE HOLE NO. : 3 | | Site Incharge - Mukesh Singh | | | | | TERMINATION DEPTH : 10.5 m | | | | | | RECORD ON : 23.12.2021 | | | | |

| 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 ($C_c$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Type of Test | Cohesion, c ( kg/cm2 ) | Friction Angle, $\phi$ ° | |
| | | Obsr. | | from | to | | | | | | | | | | | |
| 1.0 | | | Greyish silty sand, SM-SP | 0.0 | | 10.5 | | | | | | | | | | |
| 1.5 | S1 | 4 | | | | | | | | 1.91 | 30.0 | 2.63 | | 0.00 | 26.2 | |
| 2.5 | | | | | | | | | | | | | | | | |
| 3.0 | S2 | 5 | | | | | | | | 1.91 | 30.1 | 2.63 | | 0.00 | 28.0 | |
| 4.0 | | | | | | | | | | | | | | | | |
| 4.5 | S3 | 8 | | | | | | | | 1.91 | 30.4 | 2.63 | | 0.00 | 28.0 | |
| 5.5 | | | | | | | | | | | | | | | | |
| 6.0 | S4 | 20 | | | | | | | | 1.88 | 32.2 | 2.62 | | 0.00 | 29.0 | |
| 7.0 | | | | | | | | | | | | | | | | |
| 7.5 | S5 | 24 | | | | | | | | 1.87 | 33.0 | 2.62 | | 0.00 | 29.4 | |
| 8.5 | | | | | | | | | | | | | | | | |
| 9.0 | S6 | 27 | | | | | | | | 1.86 | 33.8 | 2.62 | | 0.00 | 29.7 | |
| 10.0 | | | | | | | | | | | | | | | | |
| 10.5 | S7 | 31 | | | 10.5 | | | | | 1.85 | 34.7 | 2.62 | | 0.00 | 30.1 | |

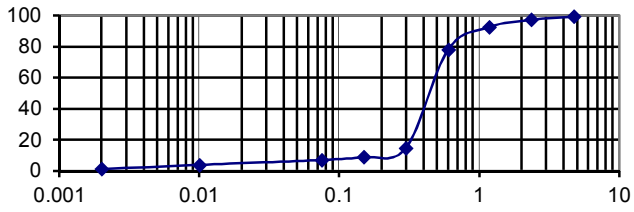
**Table 2** [part **B]: Grain Size Analysis Results** [ for Bore hole No./ Depth in m shown thus: 1/1.5 ]



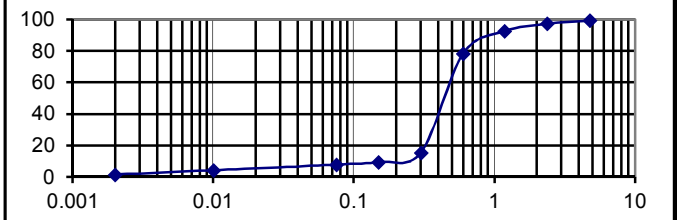

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/1.5 | 1.0 | 92.6 | 5.3 | 1.2 |



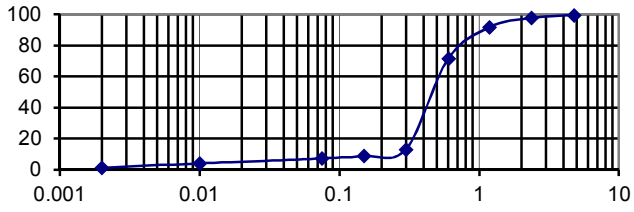

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/3.0 | 0.9 | 92.0 | 5.8 | 1.3 |



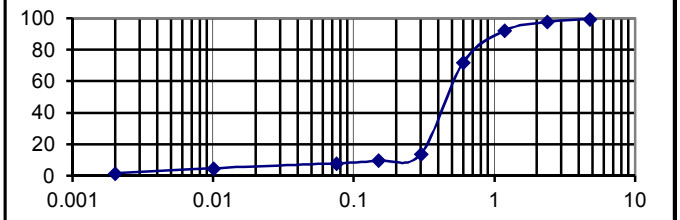

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/4.5 | 0.7 | 92.2 | 5.8 | 1.3 |



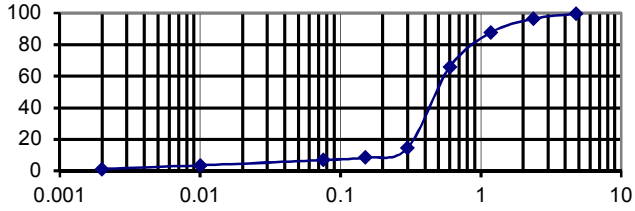

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/6.0 | 0.7 | 91.5 | 6.3 | 1.5 |




| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/7.5 | 0.5 | 92.2 | 5.9 | 1.4 |

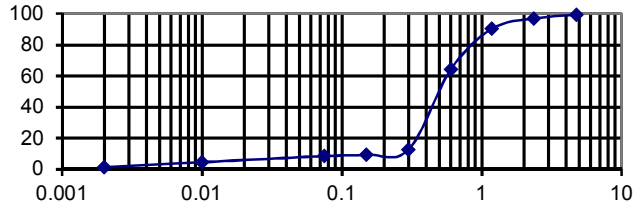



| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/9.0 | 0.5 | 91.5 | 6.4 | 1.5 |

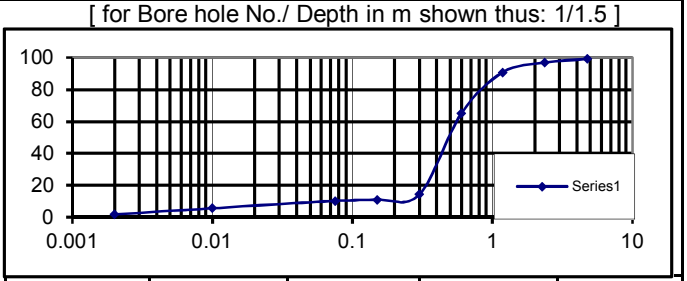



| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 1/10.5 | 0.2 | 92.9 | 5.6 | 1.2 |

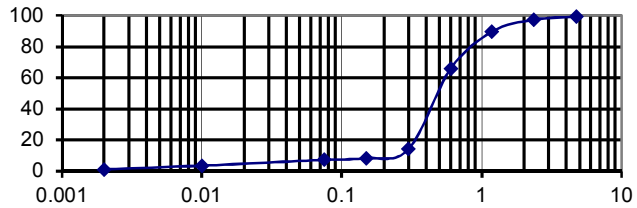
**Table 2** [part **B]: Grain Size Analysis Results** [ for Bore hole No./ Depth in m shown thus: 1/1.5 ]



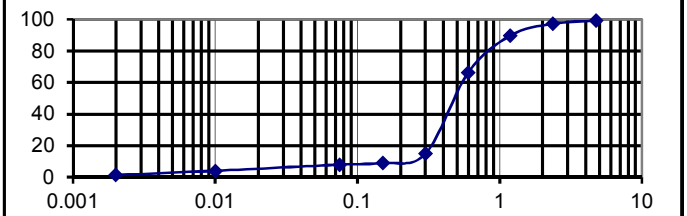

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/1.5 | 0.8 | 90.7 | 7.1 | 1.5 |



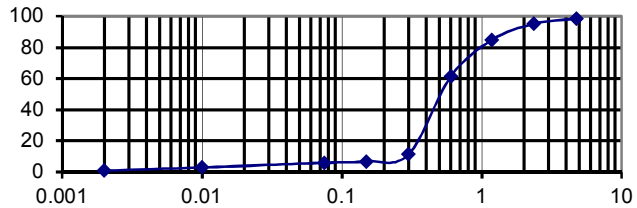

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/3.0 | 0.7 | 89.0 | 8.6 | 1.7 |



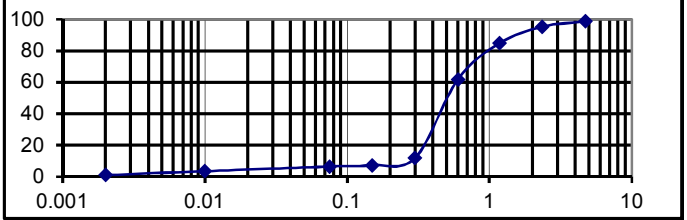

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/4.5 | 0.7 | 92.1 | 6.1 | 1.2 |



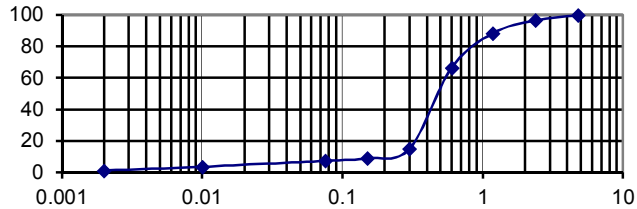

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/6.0 | 0.7 | 91.4 | 6.7 | 1.3 |




| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/7.5 | 1.4 | 92.7 | 5.0 | 0.9 |

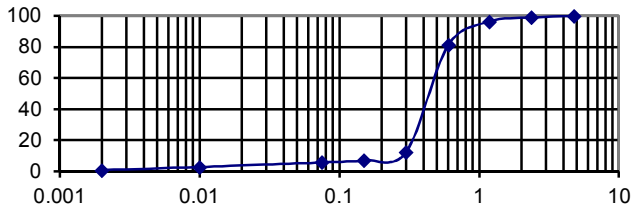



| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/9.0 | 1.3 | 92.1 | 5.4 | 1.1 |

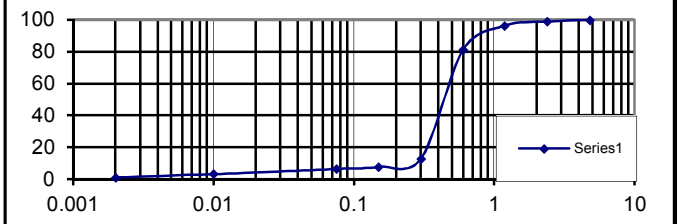



| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 2/10.5 | 0.3 | 92.4 | 6.2 | 1.2 |

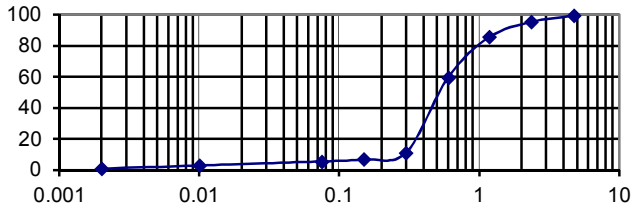
**Table 2** [part **B]: Grain Size Analysis Results** [ for Bore hole No./ Depth in m shown thus: 1/1.5 ]



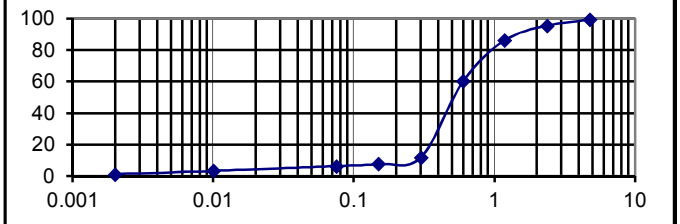

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/1.5 | 0.1 | 94.1 | 4.9 | 0.8 |



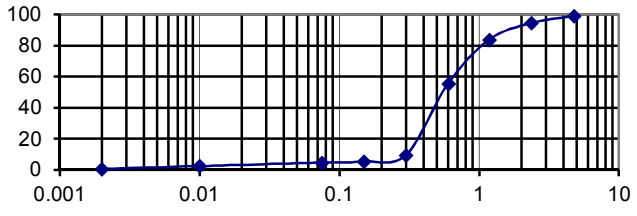

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/3.0 | 0.2 | 93.5 | 5.2 | 1.1 |



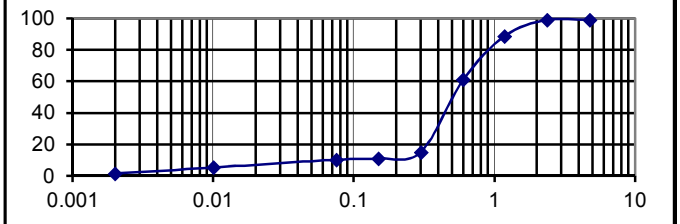

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/4.5 | 0.6 | 93.8 | 4.6 | 1.0 |



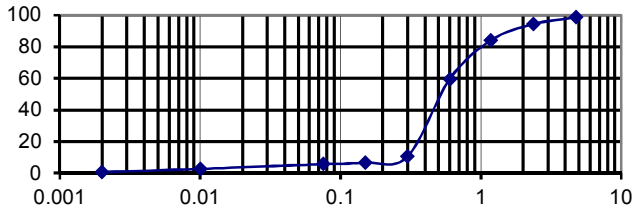

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/6.0 | 0.6 | 93.0 | 5.2 | 1.2 |




| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/7.5 | 1.0 | 94.3 | 4.1 | 0.7 |

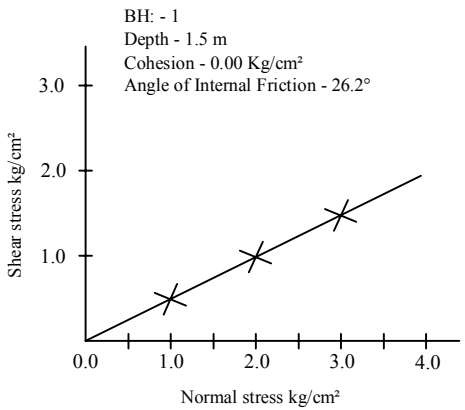


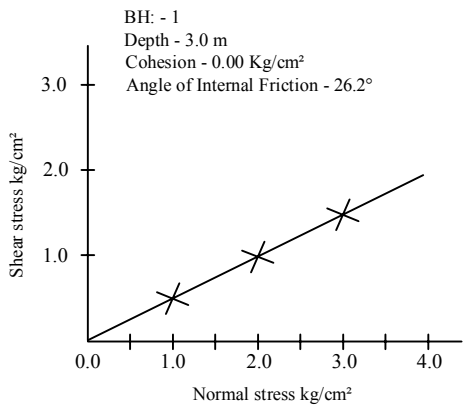

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/9.0 | 1.0 | 88.8 | 8.8 | 1.5 |

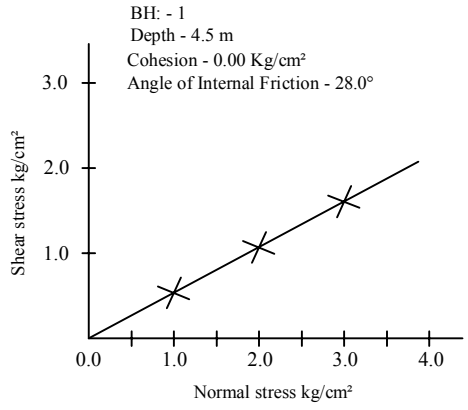


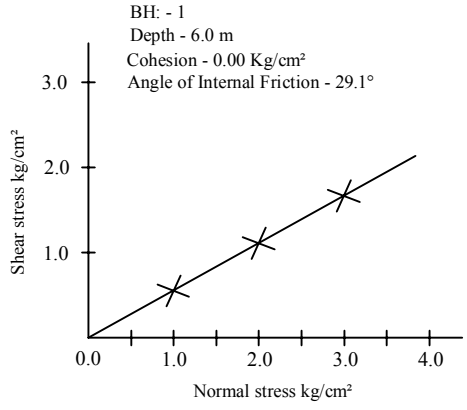

| BH/depth,m | *Gravel, %* | *Sand,%* | *Silt, %* | *Clay%* |
|---|---|---|---|---|
| 3/10.5 | 1.2 | 93.2 | 5.0 | 0.6 |

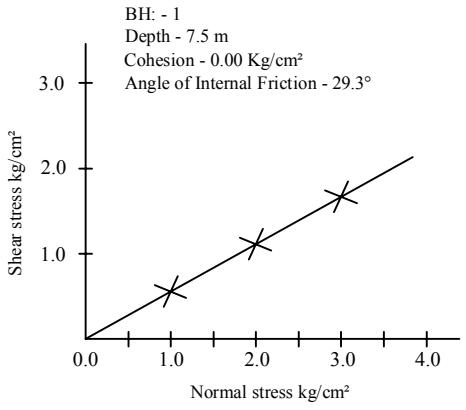
# TRIAXIAL / DIRECT SHEAR TEST PLOTS

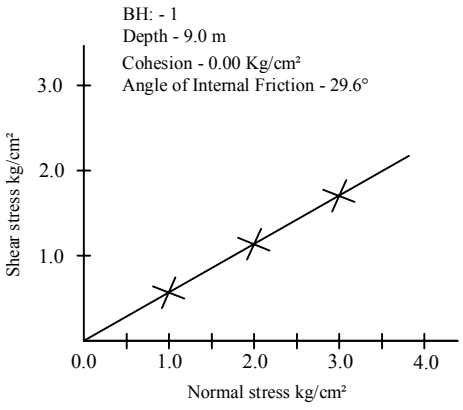


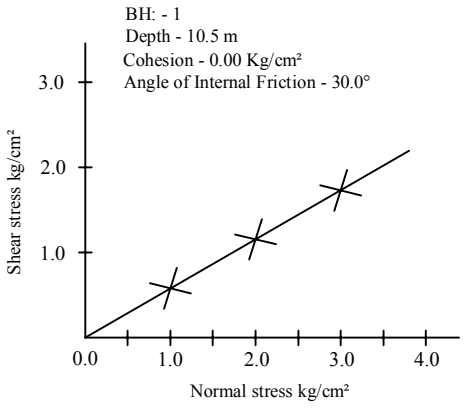




Appendix - D1

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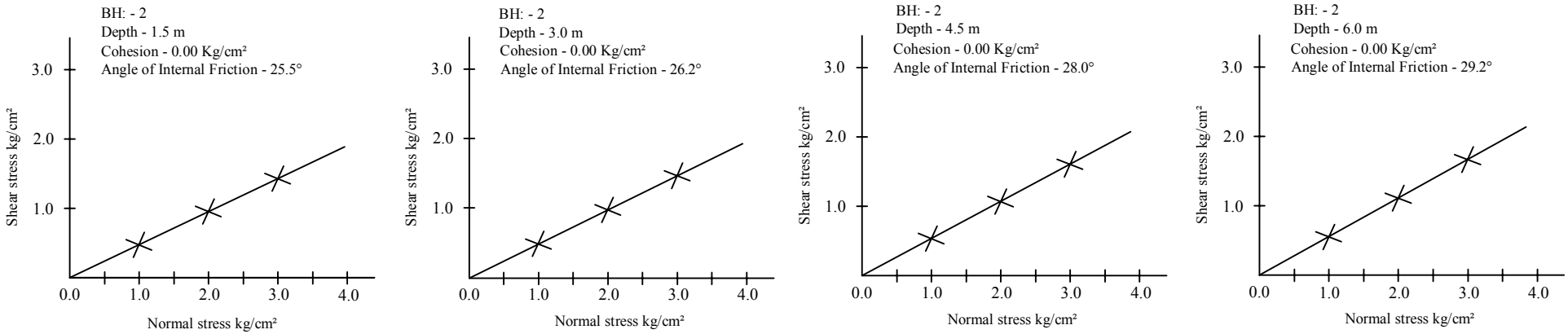
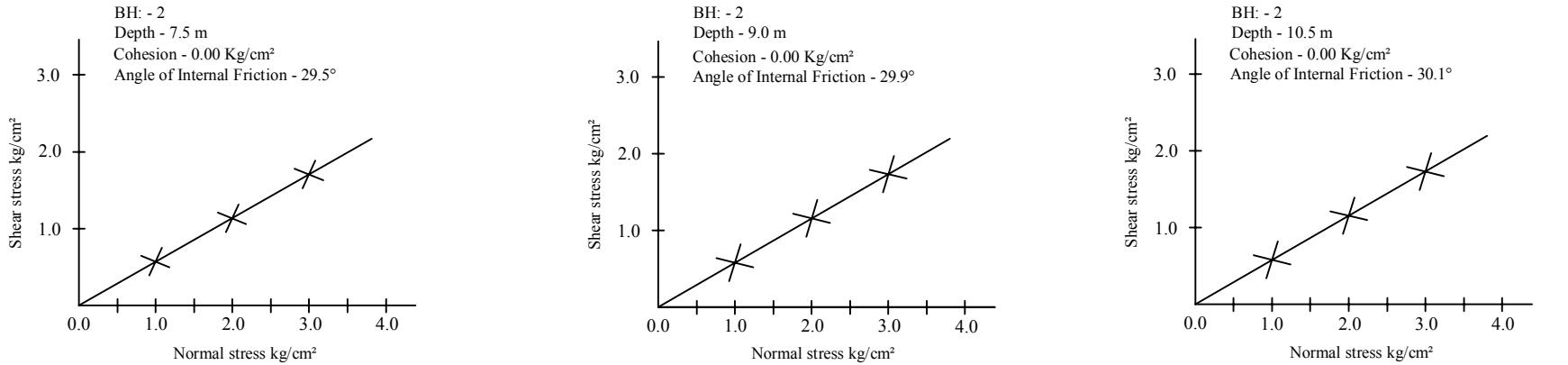
**Project No. 211220**

For the Proposed

Degree College in Govt. Mahila High School Campus, Jamui

# TRIAXIAL / DIRECT SHEAR TEST PLOTS




Appendix - D2

Bihar Foundation Consultants,
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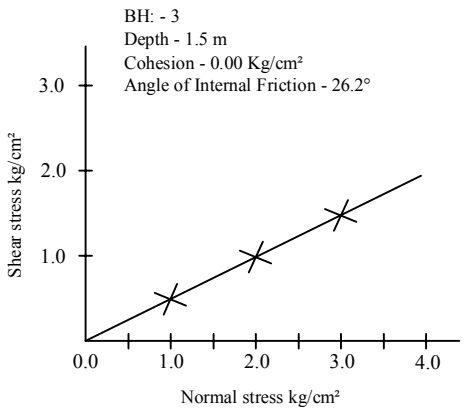
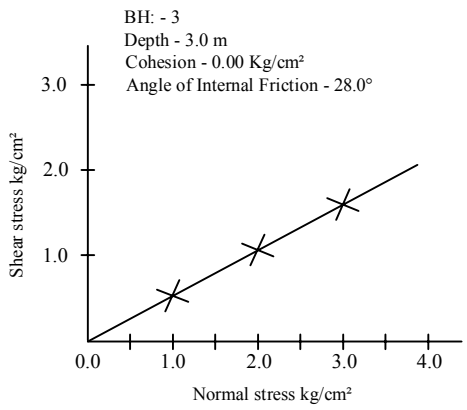
**Project No. 211220**

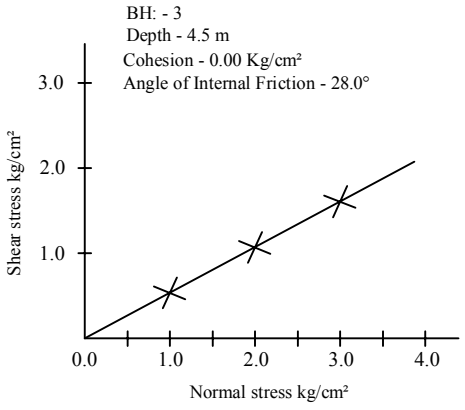
For the Proposed

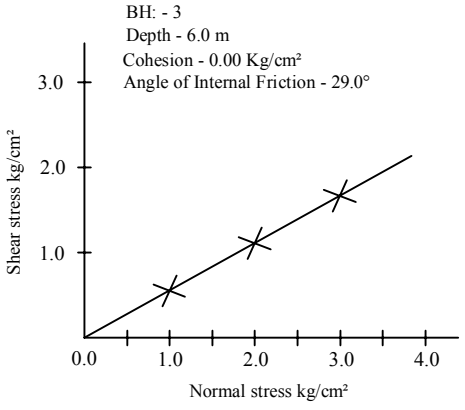
Degree College in Govt. Mahila High School Campus, Jamui

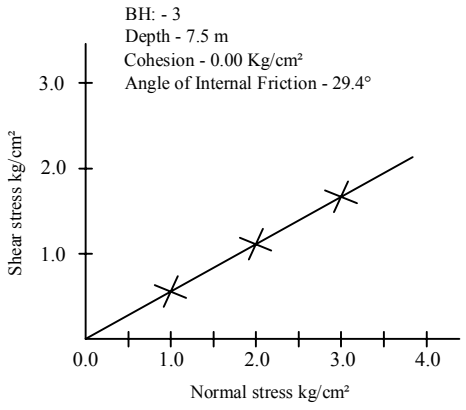
# TRIAXIAL / DIRECT SHEAR TEST PLOTS

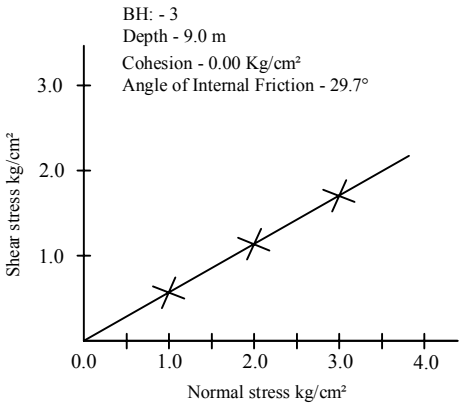


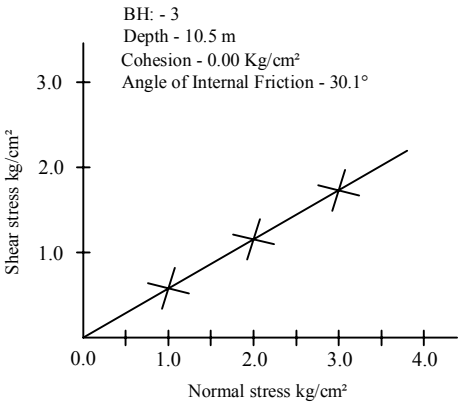




Appendix - D3

Bihar Foundation Consultants,
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**Project No. 211220**

For the Proposed

Degree College in Govt. Mahila High School Campus, Jamui

# Report on Sub Soil Investigation for the proposed Construction of
Degree College in Govt. Mahila High School Campus, Jamui

## SAMPLE CALCULATION OF BEARING CAPACITY OF SHALLOW FOUNDATION

The determination of the **net safe bearing capacity**, $q_{ns}$, is done first 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 ($t/m^2$)
$q$ = effective surcharge ($t/m^2$)
$\gamma$ = unit weight of subsoil ($t/m^3$)
$N_c, N_\gamma, N_q$ = bearing capacity factors, which are functions of $\phi$, the angle of internal friction of the soil
$s_c, s_q, s_\gamma$ = shape factors
$d_c, d_q, d_\gamma$ = depth factors
$I_c, I_q, I_\gamma$ = 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 $\phi$, the angle of internal friction of the soil. Their values 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 ( $\phi$') 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 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 |
| $s_\gamma$ = | 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 | $I_c, I_q, I_\gamma$ = 1 for vertical load | | | | these values | is linear. |

In the present case, the representative values of cohesion © and angle of internal friction ($\phi$)of the soil may be obtained from the soil data given earlier.

One example of calculation for a certain depth and width of a strip or square footing is given in the **Table A** on the next page. 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**. The net safe bearing capacity for a footing of the selected size and depth of footing is to be seen in its last column. Calculations of safe bearing capacities for other depths and widths of footings are done similarly.

**2 Calculation of allowable bearing capacity based on settlement criterion**

The **net soil pressure,** $q_s$ ( $t/m^2$ ) for a permissible settlement of 25 mm is give by Teng's formula:

$$q_s = 3.5\,[N'' - 3]\left[\frac{(B + 0.3)}{2B}\right]^2 w'\,F_d \quad t/m^2$$

where $N''$ = corrected value of N from SPT

$F_d$ = $[1 + D/B] <$ or = 2

D, B and w' are as defined before.

For a permissible settlement of **S** mm, the allowable bearing capacity

$$q'_s = S\, q_s /25$$

The corrected SPT N" values used in the calculations based on the above formula for different depths below G.L. may be found from the recorded data.

The N" value used in any case is to be for the influence zone below the footing, which depends on its width. A sample of calculation of the allowable soil pressure for the chosen size and depth of footing and for the permissible settlement is given in **Table B** in the next section.

The net allowable bearing pressure will be the lower of the values of bearing pressures found in the two Tables A and B.

## Table A

**Calculation of Net Safe Bearing Pressure** [ based on **shear failure** criterion]

| Shape of Foundation: STRIP | | | F.S.= 3 | γ, t/m³= 1.91 | | c = | ϕ = | Nc = | Nq = | Nγ = |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 28.0 | 25.80 | 14.72 | 16.72 |
| D [m] | B [m] | dc | dq = dg | c | q | I Term | II Term | III Term | qnf | qnf /F |
| 4 | 2 | 1.66 | 1.332 | 0 | 3.82 | 0.00 | 69.86 | 21.26 | 91.12 | 30.37 |

## Table B

**Calculation of Net Allowable Bearing Pressure** [ based on **settlement** criterion]

| D | B | Fd = | N" | w' | $q_{s=25}$ | S | $q_{s=S}$ |
|---|---|---|---|---|---|---|---|
| m | m | | | | t/m² | mm | t/m² |
| 4 | 2.0 | 2 | 6 | 0.5 | 3.4716 | 50 | 6.9431 |

The adjoining Table and the comments below it are for a footing of depth, **D = 4** m, and width, **B [m] = 2.0**

The value of allowable bearing pressure from the above Table for s = 50 mm is = 6.9 t/m²

The value of safe bearing capacity from shear criterion as found from Table A = 30.4 t/m²

**Hence the allowable bearing pressure for settlement, s= or < 50 mm will be = 6.9 t/m²**

The calculations for other depths and widths of footing are similar.

## Calculations of Capacity of Plane Pile for the proposed Degree College in Govt. Mahila High School Campus, Jamui

Based on IS:2911 (Part I, Sec. 2) 2010, Annex B, (Clauses 6.3.1.1 and 6.3.2)

using both cohesion (c), in $t/m^2$ and angle of internal friction ( $\phi^o$ ).

**WHEN** **Pile diameter, D ( m)=** **0.25** Area of pile base, **Ap** ($m^2$) = 0.049 & circ'mf'r'nce ( in m) of pile base, **j =** 3.14 x D = 0.785

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

In **CLAY:** **Skin friction** in clay, **Qs** $= c A$,

where Reduction factor, **$\alpha$ depends on c, as given in Fig. 2** of Annex. B of the above IS Code:2911

**End bearing, $Q_b = A_p c_p N_c$,** where $N_c$=9

In **SAND:** **Skin friction**, **Qs** = $KP_{mid} A \tan \delta$, where K = 1.5 and $\delta$ = .

**End bearing, Qb** = $Ap(0.5 D\gamma N_\gamma + P_{tip} N_q)$,

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

**and** the values of Nq and **N$\gamma$** are to be taken from the IS Code.

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

= 3.75 to 5 X $\gamma_{sub}$ $t/m^2$.

3.4125 to 4.55 t/m .

**Total Ultimate capacity of pile, Qu** = Qs + Qb.

**Safe capacity of pile, Qsf** = $(Qs/f_s + Qb/f_b)$

Let factor of safety in **friction, $f_s$ = 2.5** **bearing, $f_b$ = 3.0**

| Depth of soil layer (m) | Soil type | $\gamma_{sub}$ $t/m^3$ | c $t/m^2$ | $\alpha$ | $\varphi$ | t [m] | p = $\gamma$ x t $t/m^2$ | $P_{tip}$ =$\Sigma$p $t/m^2$ | Permissible $P_{tip}$ $t/m^2$ | Permissible $P_{mid}$ $t/m^2$ | A = j x t $m^2$ | Qs' (for 1 layer) t | Qs = $\Sigma$Qs' t | Qb t | Qu t | **Qsf** [runded off] **tonnes** | **Pile Length m** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0-0.5 | silty sand | | | | | 0.5 | 0.00 | 0.00 | 0.0 | 0.0 | Not considered due to cut-off and very soft layers. | | | | | | **0.5** |
| 0.5-2.0 | silty sand | 0.92 | 0.0 | | 25.50 | 1.5 | 1.38 | 1.38 | 1.4 | 0.7 | 1.18 | 0.58 | 0.58 | 0.85 | 1.43 | | **2.0** |
| 2.0-4.0 | silty sand | 0.91 | 0.0 | | 25.80 | 2.0 | 1.82 | 3.20 | 3.2 | 2.3 | 1.57 | 2.61 | 3.19 | 2.57 | 5.76 | **2.1** | **4.0** |
| 4.0-6.0 | silty sand | 0.91 | 0.0 | | 28.60 | 2.0 | 1.82 | 5.02 | 3.4 | 3.4 | 1.57 | 4.38 | 7.57 | 2.92 | 10.49 | **4.0** | **6.0** |
| 6.0-8.0 | silty sand | 0.87 | 0.0 | | 29.20 | 2.0 | 1.74 | 6.76 | 3.4 | 3.4 | 1.57 | 4.49 | 12.05 | 3.06 | 15.11 | **5.8** | **8.0** |
| 8.0-10.0 | silty sand | 0.86 | 0.0 | | 29.60 | 2.0 | 1.72 | 8.48 | 3.4 | 3.4 | 1.57 | 4.56 | 16.62 | 3.16 | 19.78 | **7.7** | **10.0** |

| | | | | **Qb** | for $\phi$ | | **Qb** for | c | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth,d | $\gamma_{sub}$ | $\phi^o$ | * $N_\gamma$ | * $N_q$ | | # Qb | c | # Qb | | | | | | | | | |
| 4.0 | 0.91 | 28.60 | 18.24 | 15.73 | | 2.57 | 0.0 | 0.00 | | | | | | | | | |
| 6.0 | 0.87 | 29.20 | 19.91 | 16.82 | | 2.92 | 0.0 | 0.00 | | | | | | | | | |
| 8.0 | 0.86 | 29.60 | 21.12 | 17.59 | | 3.06 | 0.0 | 0.00 | | | | | | | | | |
| 10.0 | 0.86 | 29.90 | 22.07 | 18.19 | | 3.16 | 0.0 | 0.00 | | | | | | | | | |



Bihar Foundation Consultants
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[A Unit : Baidyanath Foundation Consultants Pvt. Ltd.,]

बिहार राज्य शैक्षणिक आधारभूत संरचना विकास निगम लिमिटेड
BIHAR STATE EDUCATIONAL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
BSEIDC
(A Govt. of Bihar Undertaking)
ISO 9001:14001; OHSAS 18001
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पत्रांकः— BSEIDC/TECH/1960/2018 -8409 दिनांक 04/12/2021

प्रेषक,

मुख्य अभियंता
BSEIDC Ltd, Patna

सेवा 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

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विश्वासभाजन

मुख्य अभियंता