REPORT ON:

Geo-Technical Investigation Report for Lower Bhadra River, Botiaghata, Khulna

Installing Casing Pipe

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Boring Work

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Counting SPT

Collecting Samples

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INDEX FOR ANNEXURE

ABBAREVIATION

BH	Bore Hole
BH.WL	Bore-hole water level
C	Average cohesion for the soil stratum of interest
C_c	Compression Index
C_{vane}	Cohesion obtained from laboratory vane shear apparatus
D_f	Depth of foundation.
EGL	Existing ground level
GWT	Ground water table
K	Coefficient of lateral earth pressure
NMC	Natural Moisture Content
N’	Corrected SPT for Overburden Pressure.
N”	Corrected SPT for Dilatancy Effect.
N_f	Field SPT.
P_o’	Effective Overburden Pressure.
q_{pa}	Allowable Point Bearing Capacity .
F_{sa}	Allowable Skin Friction
Q_u	Unconfined Compressive Strength
A	Adhesion Factor.
Δ	Effective Friction Angle Between soil & pile Material

CHAPTER-ONE
GENERAL

1.1 Introduction

After being appointed **"Baseline Infrastructure Development Consultants Ltd. (bidcon ltd.)"** carried out Geo-Technical Investigation at Lower Bhadra River, Polder-29 , Batiaghata, Khulna.

The sub-surface exploration program includes –

- Executing Three (3) bore holes (each bore hole is approx. 30.00 deep from EGL).
- Performing Standard Penetration Tests (SPT)
- Collecting disturbed samples.
- Collecting undisturbed samples.
- Performing different field and laboratory tests.
- Evaluating bearing capacity of soil at different layer's and
- Recommending for appropriate foundation type.

1.2 Objective

Sub-soil explorations were conducted to obtain the information useful for following purposes:

- To select the type & depth of foundation for given structure.
- To determine the bearing capacity of the soil.
- To determine the probable maximum and differential settlement.
- To establish the ground water level.
- To select suitable construction techniques
- The relevant information was obtained by drilling holes, taking the soil samples and determining the index engineering properties of soil.

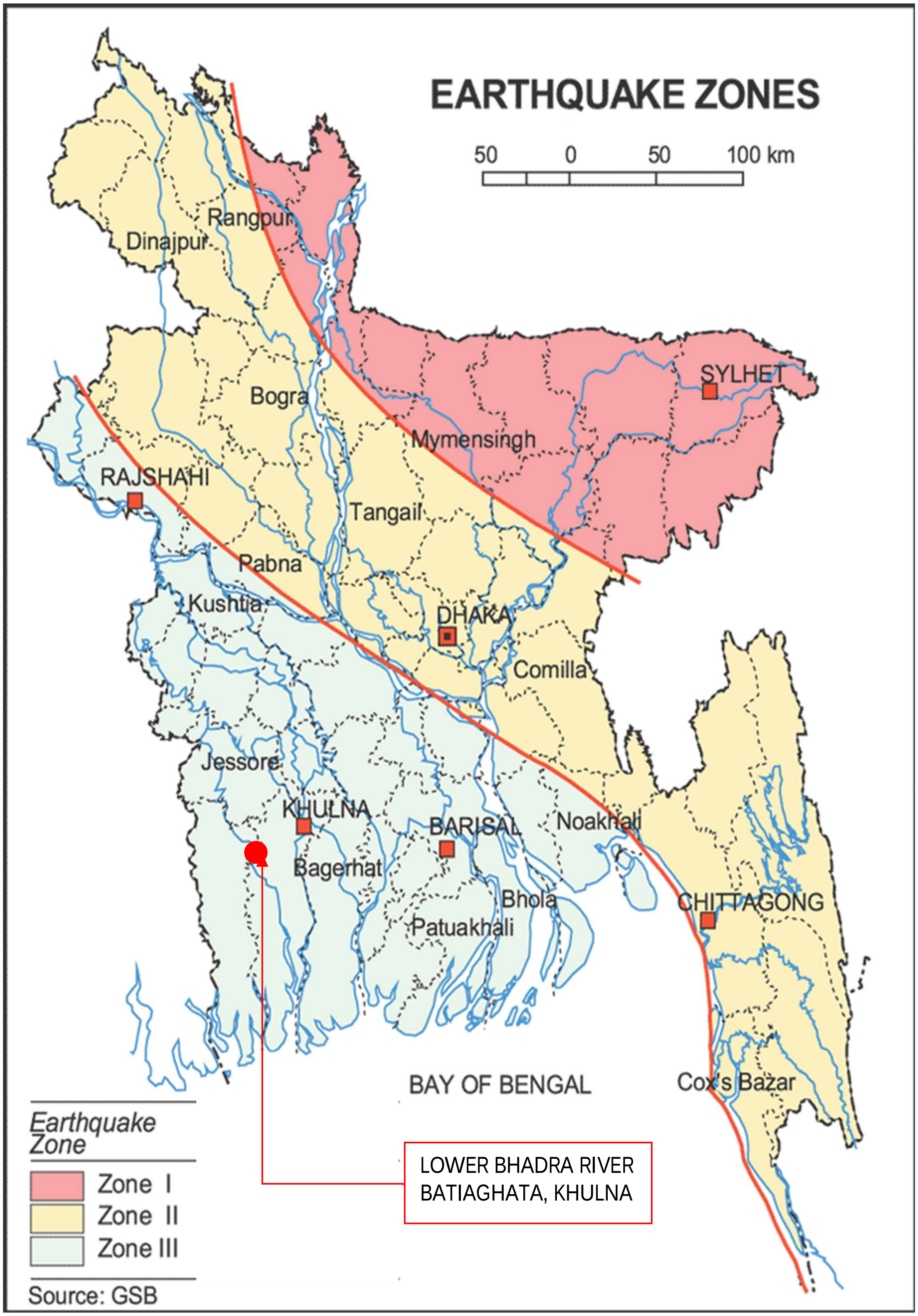
1.3 Site description

Geo-Technical Investigation at Lower Bhadra River, Polder-29, Batiaghata, Khulna. Borehole location map is presented in appendix A-1.

1.4 Seismic Information for the site

Based on the severity of earthquakes Bangladesh has been divided into three seismic zones namely Zone 1, Zone 2 and Zone 3, which have seismic zoning coefficient, Z of 0.075, 0.15 and 0.25 respectively (BNBC-1993).

According to this zoning the project site at Lower Bhadra River, Batiaghata, Khulna is situated in Zone 3. A copy of the Seismic Zoning Map from BNBC-1993



1.5 Scope of work

Scope of the work of Sub-Soil Investigation work are stated below-

a) Execution of exploratory of Bore hole.
b) Execution of Standard Penetration Test (SPT) in every 1.50 meter (5 feet) interval and count blows for penetration of each 15 cm (6”).
c) Collection of Disturbed and Undisturbed Sample as required.
d) Measure of Ground Water Table (GWT) of each bore hole after 24 hours from completion of boring.
e) Perform Laboratory Test.
f) Analysis of test results and recommendation for structural foundation.
g) Preparation of report.

1.6 Methodology of Field work

1.6.1 Method of Advancing Borehole

Boreholes were drilled by wash boring technique. Initially a hole was made by driving vertically a 10.16 cm diameter steel casing into the ground upto a suitable depth. Soil inside the casing was broken up by repeated drops of a chopping bit attached to the lower end of a drilling rod, upper end of which was fitted to swivel head through which water or clay slurry as required was forced at high pressure. Forced slurry or water emerged at high velocity through the pore of the chopping bit and returned to the surface through the annular space between drilling rod and the side of the casing or hole, carrying with it the broken up soils for inspection and recording of strata as the bore was advanced. In this way drilling was advanced upto a level of 15 cm (6") above the depth where SPT had to be executed and this 15 cm of soil had not been broken up by drops of chopping bit.

Relevant ASTM D1586 & ASTM D1587 specifications were followed for the subsurface exploration with measurement of standard penetration resistance (SPT N-value) and collection of disturbed (D) and undisturbed (UD) samples.

1.6.2 Performing Standard Penetration Test(SPT)

Standard penetration test was executed in all the bore holes at 1.5 m intervals. In this test, a split-barrel sampler as specified in ASTM D1586 was used to penetrate 45 cm (18") into the soil by drops of a hammer weighing 63.5 kg (140 lbs) falling freely from a height of 76 cm (30"). The number of blows required for penetration of total 60 cm (24") was recorded in the logs of borings shown in Fig. The number of blows required for the middle 30 cm (12") penetration was taken as the standard penetration resistance (SPT N-value). Soil sample in the spilt spoon of the sampler was collected and preserved in airtight container with proper identification and transported to Laboratory Dhaka for laboratory testing.

1.6.3 Collection of Disturbed Sample

Soil sample in the spilt spoon of the sampler was collected and preserved in airtight container with proper identification and transported to “bidcon ltd”s Geotechnical Laboratory Dhaka for laboratory testing. This soil sample was considered as disturbed (D) sample.

1.6.4 Collection of Undisturbed Sample

75 mm diameter seamless thin-walled steel tube (commonly known as Shelby tube) was used for collection of undisturbed (UD) cohesive soil sample in accordance with ASTM D1587 method. Before collection of sample, the hole was washed and cleaned. The Shelby tube was attached to the lower end of the drill rod with the help of an adapter and was lowered into the hole. The sampler was then pushed down into the ground until the tube, except 100 mm from the top, was filled with soil sample. After the Shelby tube was taken out of the hole, the ends were cleaned and sealed with molten wax as per standard method in order to prevent any change in moisture content of the collected soil sample during transportation and storage until laboratory test. The Shelby tube sample was properly identified with labels - one label pasted on the body of the tube and the other label tied with a port of the tube.

1.6.5 Observation of Ground Water Table

Generally, Ground Water Table is measure and record of each borehole after 24 hours from completion of boring.

1.6.6 Field Inspection and Records

During the advancing of the borehole shavings and cuttings of soils brought up by the boring tools were examined visually and by touch at the site. The depth, where the soil indicated change in soil characteristics, was recorded and a borehole log was made in the field with field identification and classification of soil samples.

1.7 Correlation of soil property with SPT

1.7.1 Cohesion less Soil Deposits

The sand deposits where encountered within the boreholes were grouped depending on their relative density assessed using the measured SPT results and the correlation between relative density and SPT N-value (Terzaghi and Peck, 1967).

Relationships exist between the SPT N-value and the angle of shearing resistance, ϕ for granular soils (Peck, Hanson and Thornburn, 1974). For silty uniformly graded fine sands, typical ϕ values range from about 27^0 for very loose sand, upto a maximum of about 34^0 for dense and very dense sands for Bangladesh soils.

Based on the results of the SPT tests and grading analysis, the following values for angle of shearing resistance, ϕ are suggested for the granular soils of the proposed site for use in the computation of the ultimate and allowable load bearing capacity formulas suggested by different authors for different foundation types.

Table-1: Correlation between SPT N-value, Consistency and Angle of Internal Friction (Φ)

Relative Density	**SPT N-value**	**Φ degree**
Very loose sand	< 4	$< 28^0$
Loose sand	4 - 10	28^0-30^0
Medium dense sand	10 - 30	30^0-32^0
Dense sand	30 - 50	32^0 - 34^0
Very dense sand	> 50	34^0

1.7.2 Cohesive Soil Deposits

Choice of Soil Parameters: Unconfined Compressive Strength and Un-drained Shear Strength.

Terzaghi & Peck (1967) have provided correlations between SPT N-value, consistency and unconfined compressive strength, q_u, for saturated cohesive soils as shown in the Table below. This correlation is quite useful but has to be used according to the soil conditions encountered at the site.

Table-2: Correlation between SPT N-value, Consistency and Unconfined Compressive Strength

Consistency	SPT N-value	Unconfined Compressive Strength, q_u (kPa)
Very soft	0 - 2	< 25
Soft	2 - 4	25 - 50
Medium stiff	4 - 8	50 - 100
Stiff	8 - 15	100 - 200
Very stiff	15 - 30	200 - 400
Hard	> 30	> 400

Undrained shear strength (C_u) of the cohesive soil deposits is half of the unconfined compressive strength, q_u (i.e. $C_u = ½q_u$). The undisturbed cohesive soil samples taken from the site were tested in the laboratory for q_u. The values of q_u are presented in the report as mentioned earlier.

1.7.3 Correction of the field SPT values.

a) Dilatancy Correction:

Silty fine sands and fine sands below the water table develop pore pressure which is not easily dissipated. The pore pressure increases the resistance of the soil and hence the penetration number (N).

Terzaghi and Peck (1967) recommended the following correction in the case of silty fine sands when the observed value of N exceeds 15.
The corrected SPT number is $N_c = 15 + 0.5\ (N-15)$
Where N is the recorded value, and N_c is the corrected value.
If $N<15$, $N_{C}=N$.

b) Overburden pressure correction:

In granular soils, the overburden pressure affects the penetration resistance. If the two soils having the same relative density but different confining pressures are tested, the one with a higher confining pressure gives a higher penetration number. As the confining pressure in cohesion less soils increases with the depth, the penetration number for soil at shallow depths is under estimated and that at greater depths is over estimated. For uniformity, the *N* – values obtain from field tests under different effective overburden pressures are corrected to a standard effect overburden pressure.

The overburden correction is applied first and then the dilatancy correction is to be applied.

The correction given by Bazaraa (1967), and also by Peck and Bazaraa (1969), is one of the commonly used corrections. According to them,

N_C = 4N / (1+0.0418 P_o) if P_o < 71.8 kN/m^2 and

N_C = 4N / (3.25+0.0104 P_o) if P_o>71.8 kN/m^2 and

N_C = N if P_o = 71.8 kN/m^2

Where N is the recorded SPT value, N_c is the corrected SPT value and P_o is overburden pressure.

CHAPTER-TWO
LABORATORY TEST AND ANALYSIS

2.1 INTRODUCTION

All the samples were carefully inspected visually and by touch in the laboratory and respective samples were selected for necessary tests in the laboratory. The following physical and geotechnical properties as considered necessary for and applicable to the type of the selected soil samples were determined by different laboratory tests as per relevant ASTM specifications:

2.2 LABORATORY TEST OF SOIL

The list of laboratory test are stated below-

Sl. No.	Name of the Tests	Number of Test	Remarks
01	Natural Moisture Content	18 Nos.	
02	Grain Size distribution test	18 Nos.	

2.2.1 Natural Moisture Content:

The water content of the soil sample is the ratio of the weight of the water in the sample to its dry weight. It is usually expressed as a percentage. The soil sample is weighted both in natural state and in oven dry state and moisture content is calculated by driving the loss of weight of the sample by its dry weight.

2.2.2 Grain Size Distribution Analysis:

The object of grain size analysis is to determine the size of the soil grains, and the percentage by weight of soil particles of different particle size, comprising a soil sample. The process consists of either sieve analysis or hydrometer analysis or both. The Hydrometer analysis is adopted for sample passing sieve No 200.

For hydrometer analysis, a 50 g of oven dry sample is thoroughly mixed with required quantities of water in a calibrated glass cylinder. In order to avoid flocculation, a little dispersing agent (5 g) is adding. The density of the suspension is measured at specified time intervals, by means of a hydrometer or special design. At any particular time, the size of largest particle remounting in suspension at the level of the hydrometer can be computed by means of

Stocks law, whereas the weight of the particles finer than size, can be computed from the density of the suspension at the same level.

For sieve analysis soil sample is washed through U.S Standard sieve No. 200 and the fraction retained is dried. The fraction retained of each sieve is weighted for calculation of the percentage of different fraction. The results are represented by cumulative curves plotted on semi logarithmic graph paper.

2.2.3 Atterberg Limits:

Physical properties of clay are greatly influenced by water content. A given soil behaves as a fluid or a soil or, as plastic materials, depending on how much water it contains. The water contents that correspond to the boundaries between the states of consistency are called as the Atterberg limit.

Liquid Limit is the minimum water content at which a clay soil just starts behaving like a fluid. It is determined with the help of a standard limit device which consists of brass cup and an arrangement to impart blows to cup at a uniform as the limit.

The plastic limits is the minimum water content at which a soil is just plastic and is determine by rolling out a soil sample at a slowly decreasing water content until, the desired water content is reached, at which a thread of 1/8 inch diameter. Just beginning to crumble, the thread is rolled on glass plate with hand.

2.2.4 Specific Gravity Tests:

The specific gravity of a solid defined as the ratio of the unit weight of the solid in air to the unit weight of water. To determine the specific gravity of soil sample, 20 grams of oven dried soil sample is thoroughly pulverized and is placed in a calibrated pycnometer. Water is poured inside the pycnometer until its top is slightly below the calibrated mark. The mixture is then boiled thoroughly in order to eliminate the air baubles. More water is then added to mixture, the temperature is then recorded and the bottle is weighted. The Specific Gravity G_S is given by:

$G_S = (Gt \times W_S) \div (W_S - W_{PSW} + W_{PW})$

Where, G_S = Specific Gravity of water at TOC.

W_S = The weight of over dry soil (20 gms)

W_{PSW} = Weight of Pycnometer + soil + water

W_{PW} = Weight of Pycnometer + water

2.3 Physical Properties

The physical properties of the sub soil formation of the proposed site have been evaluated on the basis of 3 (three) nos. borehole depth 30 meter as have been selected and pointed out by the client.

These may be summarized as follows:

a) Ground water table:

The position of ground water table (GWT) elevation and existing ground elevation at boring point are stated at boring layout plan.

b) Stratification of soil

The overall soil formations of the investigated site are almost regular in between the borehole locations. The top layer of the investigated site has been encountered with comprising medium dense sandy silt. The underlying soil is of medium dense to very dense condition gray fine sand, little to some silt. (Ref. Bore logs).

c) Natural moisture content:

Natural moisture of the soil varies from 17% to 28%.

CHAPTER-THREE
BEARING CAPACITY ANALYSIS

3.1 INTODUCTION

The Bearing capacities of the foundation including both of the shallow and the Deep have been evaluated for the existing sub-soil condition. In doing so, the overall field SPT values have been corrected due to the effect of the overburden pressure at the different layers of investigation in the case of each borehole. There are discussed in detail in the following articles.

3.2 STANDARD PENETRATION TEST

The Standard penetration test is the most commonly used in situ test, especially for cohesion less soils which cannot be easily sampled. The test is extremely useful for determining the relative density and the angle of shearing resistance of cohesion less soils. It can also be used to determine the unconfined compressive strength of cohesive soil.
If the number of blows for 150 mm drive exceeds 50, it is taken as refusal and the test is discontinued. The standard penetration number is corrected for dilatancy correction and overburden correction as explained.

3.3 SHALLOW FOUNDATION

The Bearing Capacity of the shallow foundation including the Continuous wall/RCC strip as well as the isolated type footing foundations particularly for the cohesive soil may roughly be evaluated on the basis of SPT value as suggested by Tergaghi according to the following table.

Table-3.3.1: The Bearing Capacities of the shallow foundation values in tsf (F.S.-3.0)

SPT range	Consistency	Allowable Bearing Capacity, q_a in tsf)	
		Continuous Footing	Isolated Column Footing
0 ~ 2	Very soft	0.000 – 0.225	0.000 – 0.300
2 ~ 4	Soft	0.225 – 0.450	0.300 – 0.600
4 ~ 8	Medium	0.450 – 0.900	0.600 – 1.200
8 ~ 16	Stiff	0.900 – 1.800	1.200 – 2.400
16 ~ 32	Very Stiff	1.800 – 3.600	2.400 – 4.800
> 32	Hard	➢ 3.600	➢ 4.800

Note:

a. The above values are the net allowable Bearing Capacities

3.3.1 Cohesive Soil

The Bearing Capacity of the shallow foundation including the continuous wall/RCC strip as well as the isolated type footing foundations have been evaluated according to the general bearing capacity equation as suggested by Terzaghi. The equation is as follows.

q_{ult} = C $N_c S_c$ +q' N_q +0.5 y B N_y S_y

Where, q_a= Allowable bearing capacity of the shallow foundation (F. S. = 3.0)

C = Cohesion = $q_u/2$

q_u= Unconfined compression strength (obtain from the laboratory test or estimated from the corrected SPT values).

S_c= Shape factor=1.0 for continuous footing and 1.3 for square footing.

N_c= Bearing capacity factor for the shallow foundation.

3.3.2 Non cohesive soil

The bearing capacities of the shallow foundation particularly for the frictional cohesive soil may be evaluated according to the equations of the bearing capacity of the soil as suggested by Meyerhof (which is subsequently adjusted by J.E. Bowles after increasing 50%). The equations are as follows-

q_a= N/F_1 x K_d x C_w for B< F_4

q_a= N/F_2 x ((B +F_3)/B)2 x K_d x C_w for B> F_4

Where,

q_a= Allowable bearing pressure in KPa or Ksf (for maximum settlement 1").

N= Statical average of the corrected SPT values (N) within the pressure influence zone of about 0.5 B above the footing base to at least 2B below the same.

K_d=1.0 +0.33 x D_f/B <1.33.

C_w=0.5 + 0.5 x ((D_w/(D_f+B)) = Water table correction factor.

D_f = Depth of foundation.

B = Width of foundation, B=1.5 m and 2.5 m have been considered respectively for the continuous and the isolated footing foundation.

According to the SI system, the factors are as follows.

F_1=0.05, F_2=0.08, F_3=0.30, F_4=1.20

Based on the above formula, the bearing capacities of the shallow foundation including both of the continuous and the isolated type of footing foundation have been evaluated on the basis of the soil parameters obtain from the laboratory tests or from the corrected SPT values.

Table: 3.3.1: Allowable Bearing Capacity for Shallow Foundation (F.S.-3.00)

Borehole No.	Depth (ft.)	Allowable Bearing Capacity, q_a, kN/m^2	
		Square Footing	Strip Footing
BH-01	1.00	664.36	537.35
	2.00	573.92	464.20
	3.00	543.77	439.82
	4.00	543.77	439.82
BH-02	1.00	694.51	561.73
	2.00	419.79	339.53
	3.00	419.79	339.53
	4.00	387.60	313.50
BH-03	1.00	724.65	586.12
	2.00	724.65	586.12
	3.00	754.80	610.50
	4.00	694.51	561.73

Notes:

a) Depth has been measured from EGL of boreholes

b) Factor of Safety, F.S.-3.00

c) Allowable Bearing Capacity (q_a) in kN/m^2

3.4 DEEP FOUNDATION

a) Cohesive soil

The skin friction and the end bearing capacities of the Pile may be evaluated by the following formula. (Ref. Foundation Analysis and Design by J.E. Bowels, 2nd Editions, P-599 & P-600).

The static ultimate bearing capacity of pile in clay soil is-

$Q_u = Q_b + Q_f = C_b N_c A_b + a c_u A_s$

The value of the bearing capacity factor N_c that is generally accepted is 9 which is the value proposed by Skempton (1951) for circular foundations for a L/B ratio greater than. The base capacity of a pile in clay soil may now be expressed as-

$Q_b = 9 c_b A_b$

The value of c_b may be obtained either from laboratory tests on undisturbed sample or from the relationships established between c_u and field penetration tests.

Meyerhof has suggested a semi-empirical relationship for estimating skin friction in clays.
By utilizing a value of 20^0 for **Ø'** for the stiff to very stiff clays, the expressions reduce to-f_s = 0.36 c_u
In practice the maximum value of unit friction for bored piles is restricted to100 kPa.

b) Cohesion less soil

Whenever necessary Deep Foundation preferably pile may be used .To evaluate skin friction and end bearing capacity following formula may be used-

According to Mayerhof for granular soil

$Q_u = Q_b + Q_f = q_b A_b + f_{su} A_s$

$f_{su} = 0.67 N_{corrected}\ (average)$ for bored Piles

$= 2N_{corrected}\ (average)$ for displacement Piles

$q_b = 133 N_{corrected}$ for bored Piles

$= 40 N_{corrected}\ (L/d)$ for displacement Piles,

where $40 N_{corrected}\ (L/d) < 400\ N_{corrected}$

where,

Q_u	=	ultimate total load kN
$N_{corrected}$	=	average corrected SPT value below pile tip
$N_{corrected}(avg)$	=	average corrected SPT value along the pile shaft
A_b	=	Base area of pile, m^2
A_s	=	Shaft surface area in, m^2

Bearing Capacity of 500 mm (20 inch) dia Bored Pile has been computed at different depth from existing ground level (EGL). The computed values have been stated in **Table-3.4.1 to Table-3.4.03.**

Table-3.4.1: Allowable Load Bearing Capacity of 500mm dia Board cast-in-situ pile.

BH-01

Depth (m)	Skin Friction (f_{su}), kN/sqm	Base Resistance (q_{pu}),kN/sqm	Bearing Capacity		Allowable Bearing Capacity, kN $Q = \frac{Q_s + Q_b}{3.0}$
			Q_s , kN	Q_b , kN	
1.00	14.740	2926.000	23.149	574.410	199.187
2.00	13.735	2527.000	44.720	496.082	180.267
3.00	13.177	2394.000	65.414	469.972	178.462
4.00	12.898	2394.000	85.669	469.972	185.214
5.00	12.596	2261.000	105.451	443.863	183.105
6.00	12.730	2660.000	125.444	522.191	215.878
7.50	12.730	2527.000	155.433	496.082	217.171
9.00	12.646	2394.000	185.224	469.972	218.399
10.50	13.028	3192.000	215.914	626.630	280.848
12.00	13.534	3591.000	247.797	704.958	317.585
13.50	13.765	3192.000	280.225	626.630	302.285
15.00	14.126	3591.000	313.502	704.958	339.487
16.50	14.534	3857.000	347.740	757.177	368.306
18.00	14.740	3458.000	382.464	678.849	353.771
19.50	14.874	3325.000	417.503	652.739	356.747
21.00	15.201	3990.000	453.312	783.287	412.200
22.50	15.528	4123.000	489.893	809.396	433.096
24.00	15.708	3724.000	526.896	731.068	419.321
25.50	15.833	3591.000	564.195	704.958	423.051
27.00	16.114	4256.000	602.155	835.506	479.220
28.50	16.399	4389.000	640.787	861.616	500.801
30.00	16.659	4389.000	603.439	861.616	488.351

Notes:

a) *Q = Total Load Bearing Capacity of pile, kN*

b) *Q_b = Total Base Resistance of pile, kN*

c) *Q_s = Total Shaft Resistance of pile, kN*

d) *Factor of Safety = 3.00*

Table-3.4.2: Allowable Load Bearing Capacity of 500mm dia Board cast-in-situ pile.

BH-02

Depth (m)	Skin Friction (f_{su}), kN/sqm	Base Resistance (q_{pu}),kN/sqm	Bearing Capacity		Allowable Bearing Capacity, kN $Q = \frac{Q_s + Q_b}{3.0}$
			Q_s , kN	Q_b , kN	
1.00	15.410	3059.000	24.201	600.520	208.240
2.00	12.395	1862.000	43.668	365.534	136.401
3.00	11.390	1862.000	61.556	365.534	142.363
4.00	10.720	1729.000	78.392	339.424	139.272
5.00	10.184	1596.000	94.385	313.315	135.900
6.00	9.827	1596.000	109.818	313.315	141.044
7.50	9.380	1330.000	131.915	261.096	131.004
9.00	8.961	1197.000	153.026	234.986	129.337
10.50	9.678	3059.000	175.824	600.520	258.781
12.00	10.452	3458.000	200.446	678.849	293.098
13.50	10.842	2926.000	225.987	574.410	266.799
15.00	11.223	3059.000	252.424	600.520	284.315
16.50	11.596	3192.000	279.742	626.630	302.124
18.00	12.012	3458.000	308.040	678.849	328.963
19.50	12.641	4256.000	337.818	835.506	391.108
21.00	12.981	3591.000	368.398	704.958	357.786
22.50	13.203	3325.000	399.501	652.739	350.747
24.00	13.586	3990.000	431.507	783.287	404.931
25.50	13.964	4123.000	464.403	809.396	424.600
27.00	14.271	3990.000	498.022	783.287	427.103
28.50	14.644	4389.000	532.520	861.616	464.712
30.00	14.984	4389.000	499.701	861.616	453.772

Notes:

a) *Q = Total Load Bearing Capacity of pile, kN*

b) Q_b *= Total Base Resistance of pile, kN*

c) Q_s *= Total Shaft Resistance of pile, kN*

d) *Factor of Safety = 3.00*

Table-3.4.3: Allowable Load Bearing Capacity of 500mm dia Board cast-in-situ pile.

BH-03

Depth (m)	Skin Friction (f_{su}), kN/sqm	Base Resistance (q_{pu}),kN/sqm	Bearing Capacity		Allowable Bearing Capacity, kN $Q = \frac{Q_s + Q_b}{3.0}$
			Q_s , kN	Q_b , kN	
1.00	16.080	3192.000	25.254	626.630	217.294
2.00	16.080	3192.000	50.507	626.630	225.712
3.00	16.303	3325.000	76.112	652.739	242.950
4.00	16.080	3059.000	101.365	600.520	233.962
5.00	15.812	2926.000	126.198	574.410	233.536
6.00	15.857	3192.000	151.101	626.630	259.243
7.50	15.984	3325.000	188.756	652.739	280.498
9.00	15.745	2793.000	225.847	548.301	258.049
10.50	15.484	2660.000	262.325	522.191	261.505
12.00	15.276	2660.000	298.311	522.191	273.501
13.50	15.227	2926.000	334.183	574.410	302.864
15.00	15.243	3059.000	370.090	600.520	323.537
16.50	15.307	3192.000	406.150	626.630	344.260
18.00	15.601	3857.000	442.903	757.177	400.027
19.50	15.767	3591.000	480.047	704.958	395.002
21.00	16.038	3990.000	517.828	783.287	433.705
22.50	16.198	3724.000	555.987	731.068	429.018
24.00	16.266	3458.000	594.306	678.849	424.385
25.50	16.538	4256.000	633.267	835.506	489.591
27.00	16.817	4389.000	672.883	861.616	511.500
28.50	17.069	4389.000	713.094	861.616	524.903
30.00	17.298	4389.000	674.017	861.616	511.877

Notes:

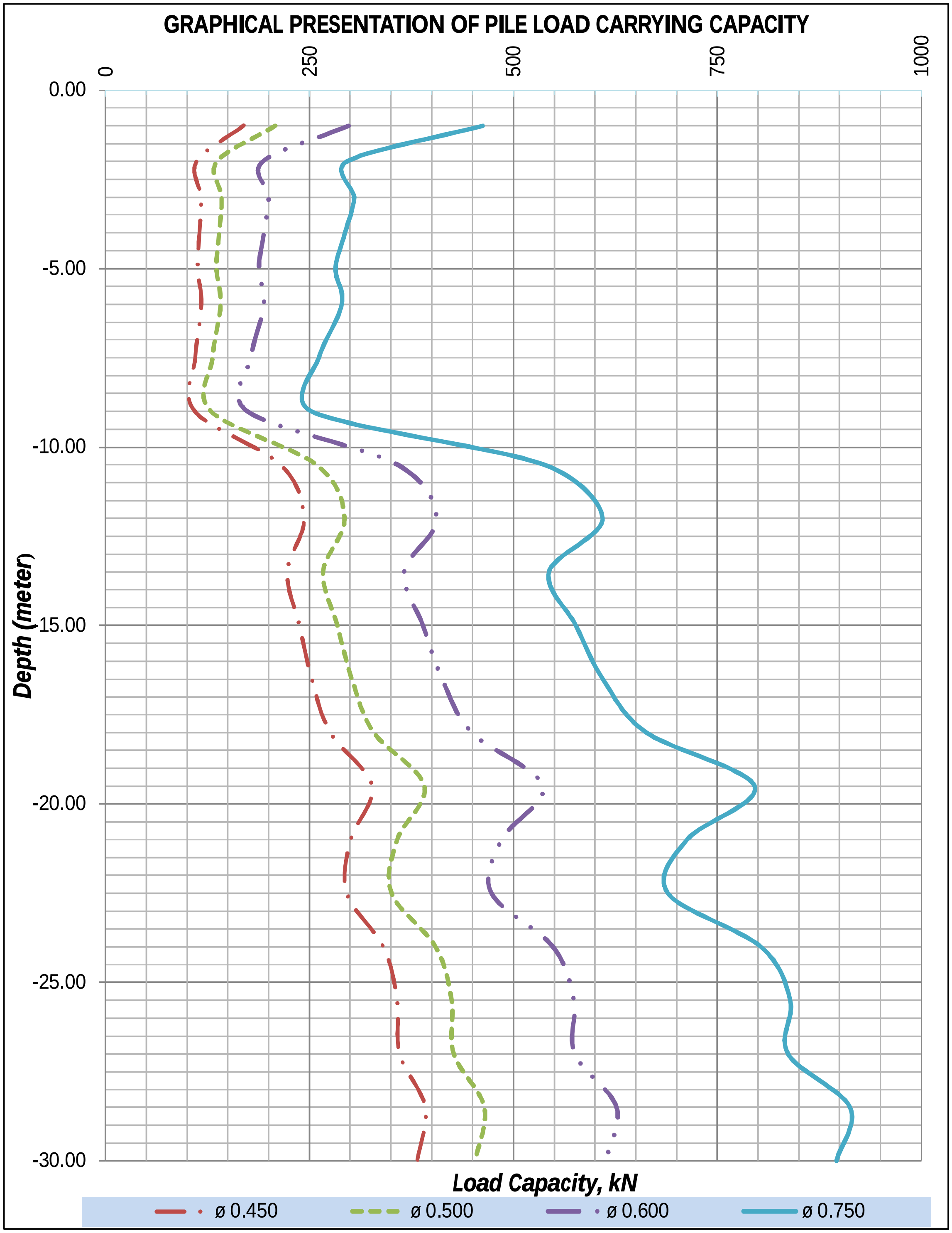
a) *Q* = *Total Load Bearing Capacity of pile, kN*

b) Q_b = *Total Base Resistance of pile, kN*

c) Q_s = *Total Shaft Resistance of pile, kN*

d) *Factor of Safety = 3.00*

Graphical Representation of Pile Load Bearing Capacity of Different dia pile Considering Bore hole no. BH- 02 in Fig. 3.4.1



Notes:

a) *Q = Total Load Bearing Capacity of pile, kN*
b) *Q_b = Total Base Resistance of pile, kN*
c) *Q_s = Total Shaft Resistance of pile, kN*
d) *Factor of Safety = 3.00*

CHAPTER-FOUR
CONCLUSION AND RECOMMENDATION

4.1 CONCLUSIONS:

On the basis of above analysis and discussion, the following conclusions may be drawn regarding the sub-soil condition of the project area.

a) The overall soil formations of the investigated site are almost regular in between the borehole locations.
b) The top layer of the investigated site has been encountered with comprising medium dense sandy silt (Ref. Bore logs).
c) The underlying soil is of medium dense to very dense condition gray fine sand, little to some silt. (Ref. Bore logs).
d) Shallow and Pile foundation may be provided for the project site.

4.2 RECOMMENDATION:

On the basis of aforesaid conclusion, the following recommendations are suggested for the project.

a) DEEP FOUNDATION:

Allowable bearing capacity (F.S.=3.0) of 500mm diameter pile may be obtained from the table stated in **Table-3.4.1 to 3.4.03.**

The bearing capacities (F.S.=3.0) of different dia pile with the embedment length up to 30 meter from EGL is considering BH-02 (**please see Fig. 3.4.1)**-

= 383 kN for 450 mm dia pile.
= 454 kN for 500 mm dia pile.
= 613 kN for 600 mm dia pile.
= 896 kN for 750 mm dia pile.

The designer would finally select the appropriate type, size and depth of foundation.

- Foundation base should be kept dry during construction Period.
- Pile load test should be performed. If pile load test is not performed then the value of capacity should be modified.

ANNEXURE

ANNEX-A

(Borehole Location Map)

BOREHOLE LOCATION MAP
Lower Bhadra River
Batiaghata, Khulna
E 749612
N 2509478
BH-01
264.0m
E 749472
N 2509254
BH-02
230.0m
E 749383
N 2509042
BH-03
Polder-29
415.0m
E 749212
N 2508662
TBM, RL-3.976 m PWD
Lower Bhadra River
Image © 2017 CNES / Airbus
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ANNEX-B

(Soil Strata & Boring Log)

GEO-TECHNICAL LABORATORY
bidcon limited
978, East Shewrapara, Mirpur
Dhaka- 1216, Bangladesh

Client : DIRECTOR, SURVEY AND DATA DIVISION
INSTITUTE OF WATER MODELLING (IWM)

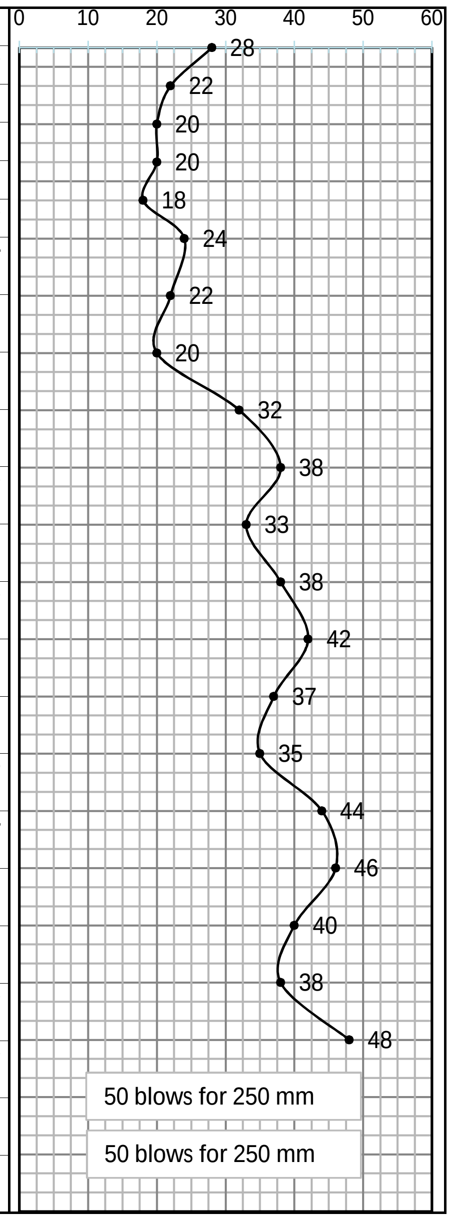
Project: GEO-TECHNICAL INVESTIGATION AT LOWER BHADRA RIVER
POLDER-29, BOTIAGHATA, KHULNA

FIELD BORING LOG

METHOD OF BORING	=	WASH	STARTING	=	13/06/2017, 8:00 AM	BORE HOLE ID
BORE HOLE DIAMETER (m)	=	0.100	FINISHG	=	14/06/2017, 1:30 AM	**BH-01**
DEPTH OF BORING (m)	=	30.000	BORE HOLE POSITION (GPS CO-ORDINATE)			**WATER LEVEL**
BORING POINT EGL (RL), m PWD	=	(-) 6.237	EASTING	:	749612 (UTM)	HWL= 2.906m,PWD
GROUND WATER LEVEL (RL),m PWD	=	-	NORTHING	:	2509478 (UTM)	LWL= (-)1.664m,PW

SCALE	SAMPLE TYPE	BORING DEPTH (In Meter)	SAMPLE ID	LITHOLOGICAL DESCRIPTION	PHYSICAL: DENSITY	COLOR	MOISTURE	DILATANCY	BLOWS ON SPOON, DEPTH (mm): 0-150	150-300	300-450	450-600	SPT
		0.00	-										
		1.00	D-01	SAND SOME SILT	MEDIUM DENSE	GRAY	MOIST	NON - PLASTIC	8	12	16	20	**28**
		2.00	D-02						7	10	12	15	**22**
		3.00	D-03						6	8	12	16	**20**
		4.00	D-04						6	8	12	15	**20**
		5.00	D-05	SILTY SAND					6	8	10	14	**18**
		6.00	D-06						8	10	14	18	**24**
		7.50	D-07						8	10	12	15	**22**
		8.50	UD-1										
		9.00	D-08						6	8	12	14	**20**
		10.50	D-09	SILTY SAND	DENSE				8	14	18	22	**32**
		12.00	D-10						12	18	20	26	**38**
		13.50	D-11						10	15	18	23	**33**
		15.00	D-12						13	18	20	25	**38**
		16.50	D-13						13	18	24	30	**42**
		18.00	D-14						12	17	20	27	**37**
		19.50	D-15						10	15	20	25	**35**
		21.00	D-16	SAND SOME SILT					12	20	24	30	**44**
		22.50	D-17						12	20	26	32	**46**
		24.00	D-18						12	18	22	27	**40**
		25.50	D-19						12	16	22	30	**38**
		27.00	D-20						15	20	28	35	**48**
		28.50	D-21	SAND SOME SILT	V. DENSE				17	28	22	-	**50**
		30.00	D-22						17	30	20	-	**50**

GRAPHICAL PRESENTATION
(Nos. of Blows per 300mm penetration)



NOTES: Disturbed Sample
Undisturbed Sample

L.BR. = LIGHT BROWN
M.ST. = MEDIUM STIFF
M.D. = MEDIUM DENSE
S.PL. = SEMI PLASTIC
N.PL. = NON PLASTIC

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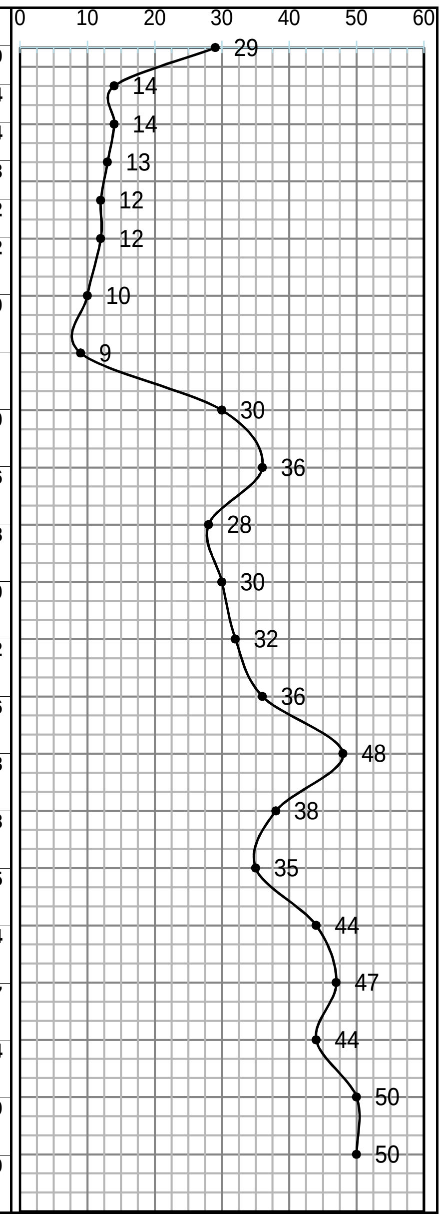
FIELD BORING LOG

METHOD OF BORING	=	WASH	STARTING	=	11/06/2017, 8:00 AM	BORE HOLE ID
BORE HOLE DIAMETER (m)	=	0.100	FINISHG	=	12/06/2017, 2:00 AM	**BH-02**
DEPTH OF BORING (m)	=	30.000	BORE HOLE POSITION (GPS CO-ORDINATE)			**WATER LEVEL**
BORING POINT EGL (RL), m PWD	=	(-)5.933	EASTING	:	749472 (UTM)	HWL= 2.906m,PWD
GROUND WATER LEVEL (RL),m PWD	=	-	NORTHING	:	2509254 (UTM)	LWL= (-)1.664m,PW

SCALE	SAMPLE TYPE	BORING DEPTH (In Meter)	SAMPLE ID	LITHOLOGICAL DESCRIPTION	PHYSICAL: DENSITY	COLOR	MOISTURE	DILATANCY	BLOWS ON SPOON, DEPTH (mm): 0-150	150-300	300-450	450-600	SPT
		0.00	-										
		1.00	D-01	SILTY SAND	MEDIUM DENSE	GRAY	MOIST	NON - PLASTIC	10	13	16	18	**29**
		2.00	D-02						4	6	8	11	**14**
		3.00	D-03						4	6	8	10	**14**
		4.00	D-04						3	5	8	10	**13**
		5.00	D-05						3	5	7	10	**12**
		6.00	D-06	SILTY SAND					3	5	7	10	**12**
		7.50	D-07						3	4	6	8	**10**
		8.50	UD-1										
		9.00	D-08						3	4	5	8	**9**
		10.50	D-09	SANDY SILT	DENSE				10	14	16	20	**30**
		12.00	D-10						12	16	20	23	**36**
		13.50	D-11						10	13	15	18	**28**
		15.00	D-12						10	14	16	18	**30**
		16.50	D-13						12	15	17	20	**32**
		18.00	D-14						13	16	20	24	**36**
		19.50	D-15						15	22	26	32	**48**
		21.00	D-16	SILTY SAND					12	16	22	30	**38**
		22.50	D-17						12	15	20	25	**35**
		24.00	D-18						14	20	24	28	**44**
		25.50	D-19						15	22	25	30	**47**
		27.00	D-20						13	20	24	30	**44**
		28.50	D-21	SAND SOME SILT	V. DENSE				16	22	28	35	**50**
		30.00	D-22						16	22	28	35	**50**

GRAPHICAL PRESENTATION
(Nos. of Blows per 300mm penetration)



NOTES: Disturbed Sample
Undisturbed Sample

L.BR. = LIGHT BROWN
M.ST. = MEDIUM STIFF
M.D. = MEDIUM DENSE
S.PL. = SEMI PLASTIC
N.PL. = NON PLASTIC

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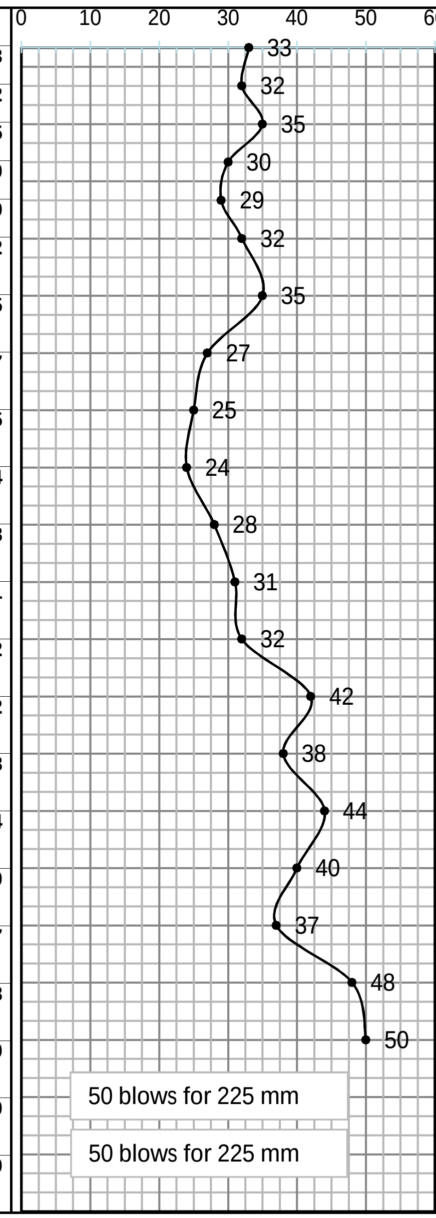
POLDER-29, BOTIAGHATA, KHULNA

FIELD BORING LOG

METHOD OF BORING	= WASH	STARTING	= 14/06/2017, 11:00 AM	BORE HOLE ID	
BORE HOLE DIAMETER (m)	= 0.100	FINISHG	= 15/06/2017, 6:00 PM	**BH-03**	
DEPTH OF BORING (m)	= 30.000	BORE HOLE POSITION (GPS CO-ORDINATE)		**WATER LEVEL**	
BORING POINT EGL (RL), m PWD	= (-) 6.230	EASTING	: 749383 (UTM)	HWL= 2.906m,PWD	
GROUND WATER LEVEL (RL),m PWD	= -	NORTHING	: 2509042 (UTM)	LWL= (-)1.664m,PW	

SCALE	SAMPLE TYPE	BORING DEPTH (In Meter)	SAMPLE ID	LITHOLOGICAL DESCRIPTION	PHYSICAL: DENSITY	COLOR	MOISTURE	DILATANCY	BLOWS ON SPOON, DEPTH (mm): 0-150	150-300	300-450	450-600	SPT
		0.00	-										
	■	1.00	D-01	SILTY SAND	DENSE	GRAY	MOIST	NON - PLASTIC	10	15	18	22	**33**
	■	2.00	D-02						10	14	18	22	**32**
	■	3.00	D-03						10	15	20	24	**35**
	■	4.00	D-04						8	14	16	20	**30**
	■	5.00	D-05						8	14	15	20	**29**
	■	6.00	D-06	SAND SOME SILT					10	14	18	23	**32**
	■	7.50	D-07		MEDIUM DENSE				10	15	20	25	**35**
	■	9.00	D-08						8	12	15	18	**27**
	■	10.50	D-09						8	10	15	20	**25**
	■	12.00	D-10						7	10	14	16	**24**
	■	13.50	D-11						8	12	16	20	**28**
	■	15.00	D-12		DENSE				10	13	18	24	**31**
	■	16.50	D-13	SILTY SAND					10	14	18	24	**32**
	■	18.00	D-14						12	18	24	30	**42**
	■	19.50	D-15						12	16	22	27	**38**
	■	21.00	D-16						14	20	24	30	**44**
	■	22.50	D-17	SAND SOME SILT					13	18	22	27	**40**
	■	24.00	D-18						12	17	20	25	**37**
	■	25.50	D-19						16	22	26	31	**48**
	■	27.00	D-20						16	22	28	34	**50**
	■	28.50	D-21	SAND LITTLE SILT	V. DENSE				18	30	20	-	**50**
	■	30.00	D-22						18	30	20	-	**50**

GRAPHICAL PRESENTATION
(Nos. of Blows per 300mm penetration)



NOTES: ■ Disturbed Sample
Undisturbed Sample

L.BR. = LIGHT BROWN
M.ST. = MEDIUM STIFF
M.D. = MEDIUM DENSE
S.PL. = SEMI PLASTIC
N.PL. = NON PLASTIC

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ANNEX-C

(Laboratory Test Results)

ANNEX-C-1

(Grain Size Distribution Test)

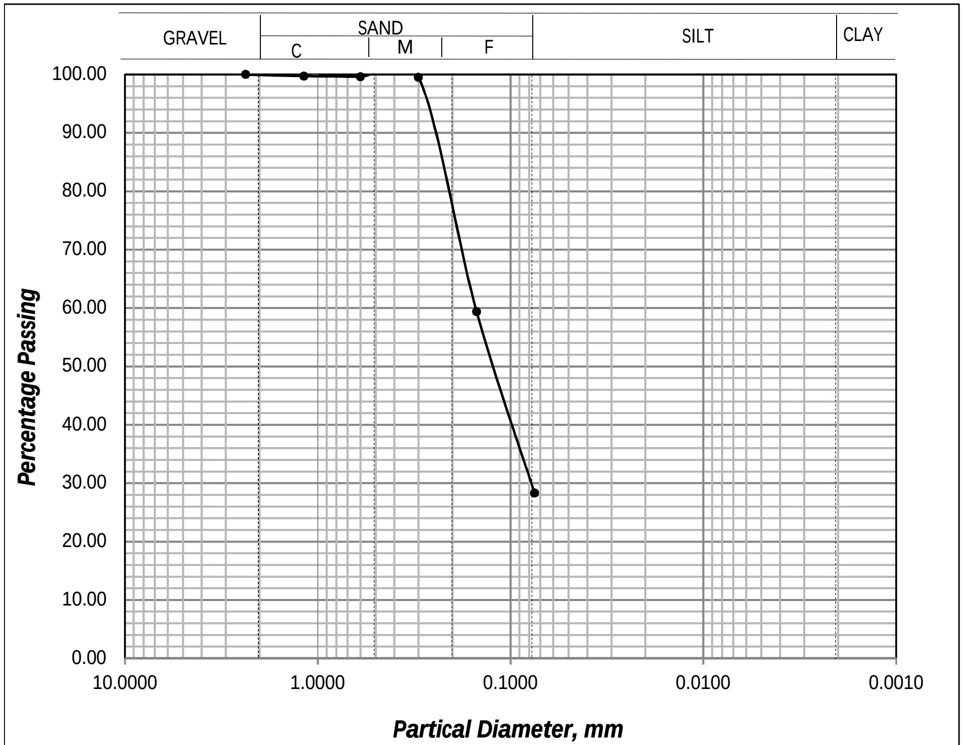
GEO-TECHNICAL LABORATORY **bidcon ltd.** 978, East Shewrapara, Level-2, Mirpur, Dhaka-1216	Client : DIRECTOR, SURV EY AND DATA DIVISION INSTITUTE OF WATER MODELLING (IWM) Project : GEO-TECHNICAL INVESTIGATION AT LOWER BHADRA RIVER POLDER-29, BATIAGHATA, KHULNA

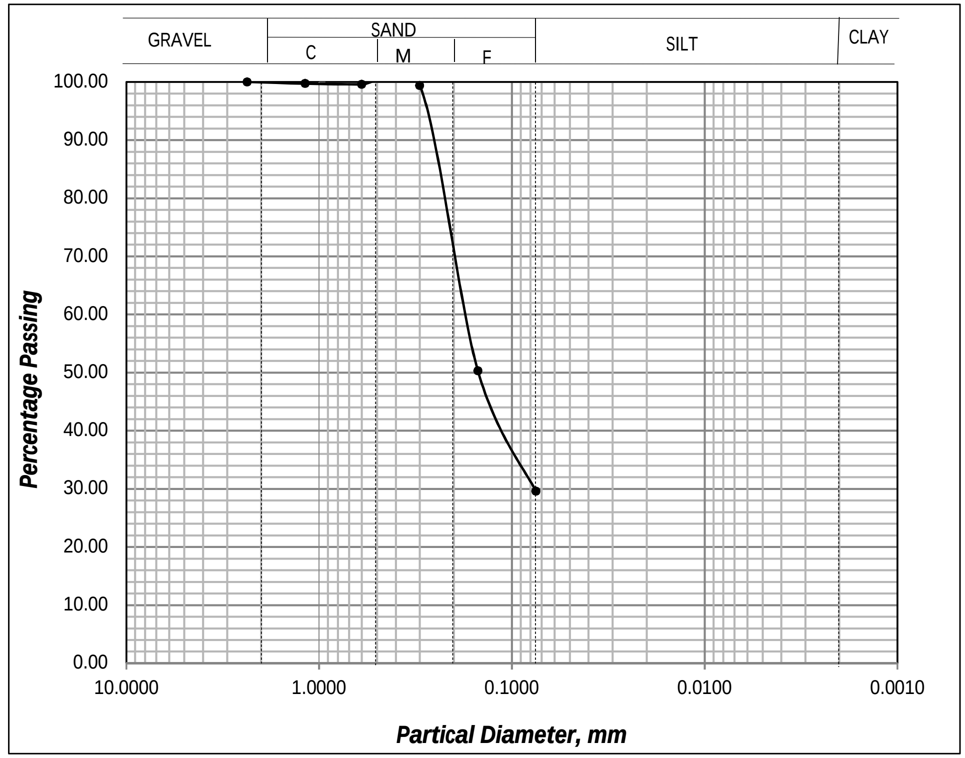
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-01	Sampling Date	:	13/06/2017~14/06/2017
Sample ID	:	D-02	Testing Date	:	19/06/2017
Sample Depth (m)	:	2.00	Soil Description	:	**Gray SAND, some silt**

Borehole #	:	BH-01	Sampling Date	:	13/06/2017~14/06/2017
Sample ID	:	D-05	Testing Date	:	19/06/2017
Sample Depth (m)	:	5.00	Soil Description	:	**Gray Silty SAND**





SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY (%)	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
●—●	**0%**	**23%**	**49%**	**28%**	**0%**	**0.160**	**0.088**	**-**	**-**	**-**	**25.94%**

SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
●—●	**0%**	**30%**	**40%**	**30%**	**0%**	**0.180**	**0.078**	**-**	**-**	**-**	**28.50%**

N.B. C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content

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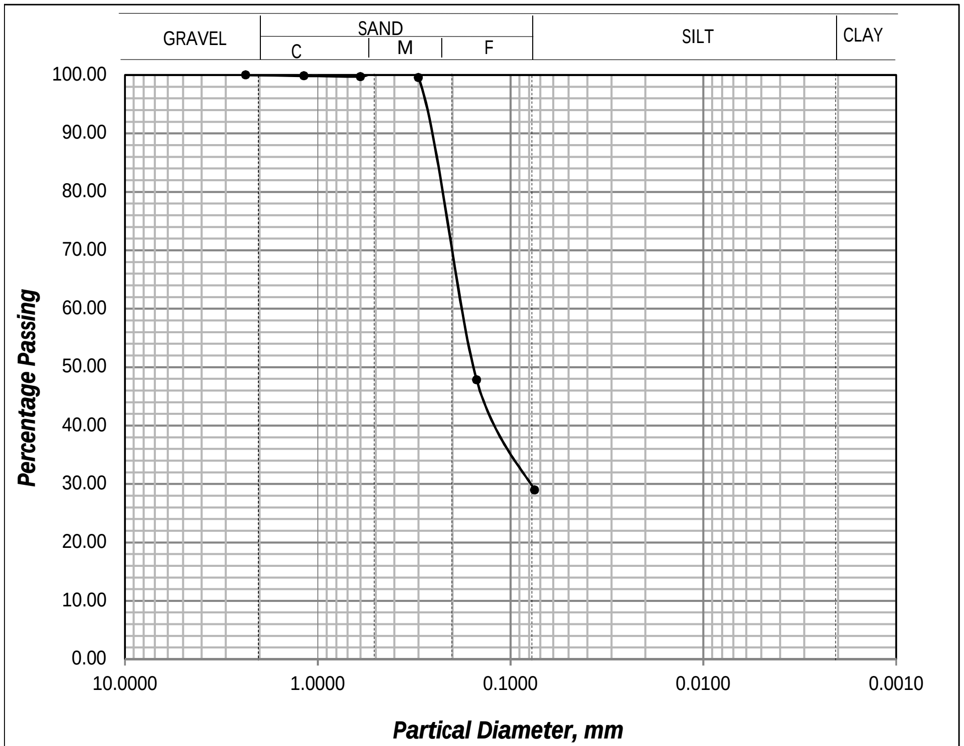
Project : *GEO-TECHNICAL INVESTIGATION AT LOWER BHADRA RIVER POLDER-29, BATIAGHATA, KHULNA*

Partical Size Distribution Test of Soil

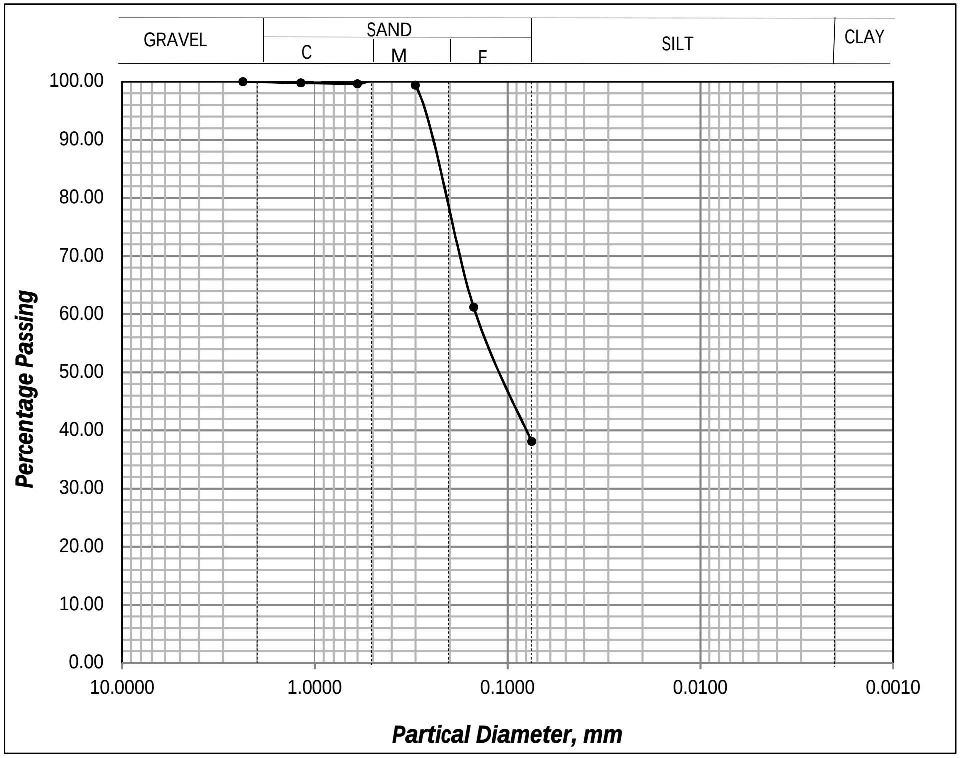
Test Method : ASTM D 422

Borehole #	: BH-01	*Sampling Date*	: 13/06/2017~14/06/2017		
Sample ID	: D-08	*Testing Date*	: 19/06/2017		
Sample Depth (m)	: 9.00	*Soil Description*	: ***Gray Silty SAND***		



SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY (%)	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	0%	***32%***	***39%***	***29%***	***0%***	**0.180**	**0.070**	**-**	**-**	**-**	***28.49%***

Borehole #	: BH-01	*Sampling Date*	: 13/06/2017~14/06/2017		
Sample ID	: D-12	*Testing Date*	: 19/06/2017		
Sample Depth (m)	: 15.00	*Soil Description*	: ***Gray Silty SAND***		



SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	0%	***23%***	***39%***	***38%***	***0%***	**0.160**	**-**	**-**	**-**	**-**	***27.60%***

N.B. *C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content*

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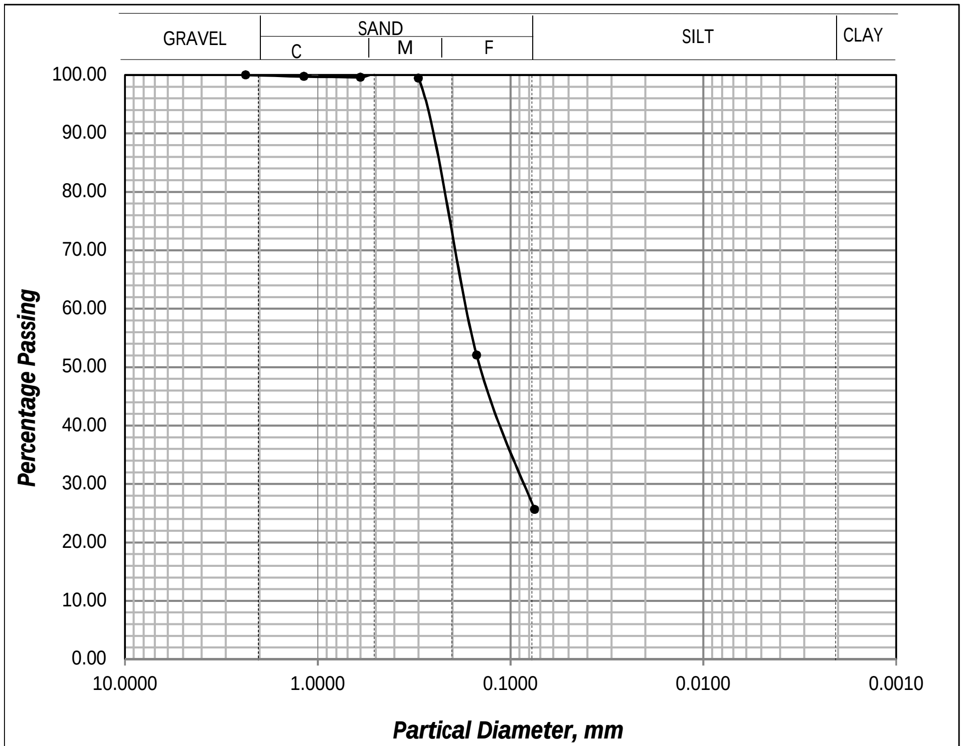
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-01	*Sampling Date*	:	13/06/2017~14/06/2017
Sample ID	:	D-16	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	21.00	*Soil Description*	:	***Gray SAND, some silt***



*				
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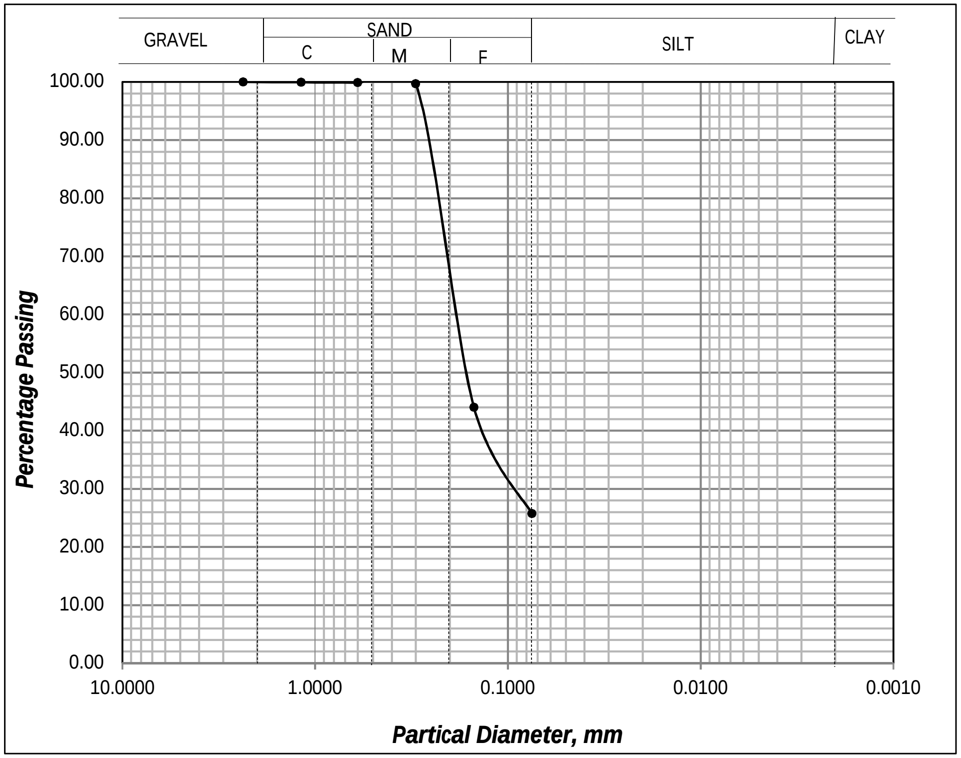
Borehole #	:	BH-01	*Sampling Date*	:	13/06/2017~14/06/2017
Sample ID	:	D-21	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	28.50	*Soil Description*	:	***Gray SAND, some silt***



SYMBOL	*SAND (%)*			*SILT*	*CLAY*	*D_{60}*	*D_{30}*	*D_{10}*	*C_c*	*C_u*	*NMC*
	C	*M*	*F*	*(%)*	*(%)*	*(mm)*	*(mm)*	*(mm)*			*(%)*
	0%	***29%***	***45%***	***26%***	***0%***	***0.180***	***0.085***	***-***	***-***	***-***	***28.15%***

SYMBOL	*SAND (%)*			*SILT*	CLAY	*D_{60}*	*D_{30}*	*D_{10}*	*C_c*	*C_u*	*NMC*
	C	*M*	*F*	*(%)*		*(mm)*	*(mm)*	*(mm)*			*(%)*
	0%	***32%***	***42%***	***26%***	***0%***	***0.190***	***0.095***	***-***	***-***	***-***	***26.39%***

N.B. *C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content*

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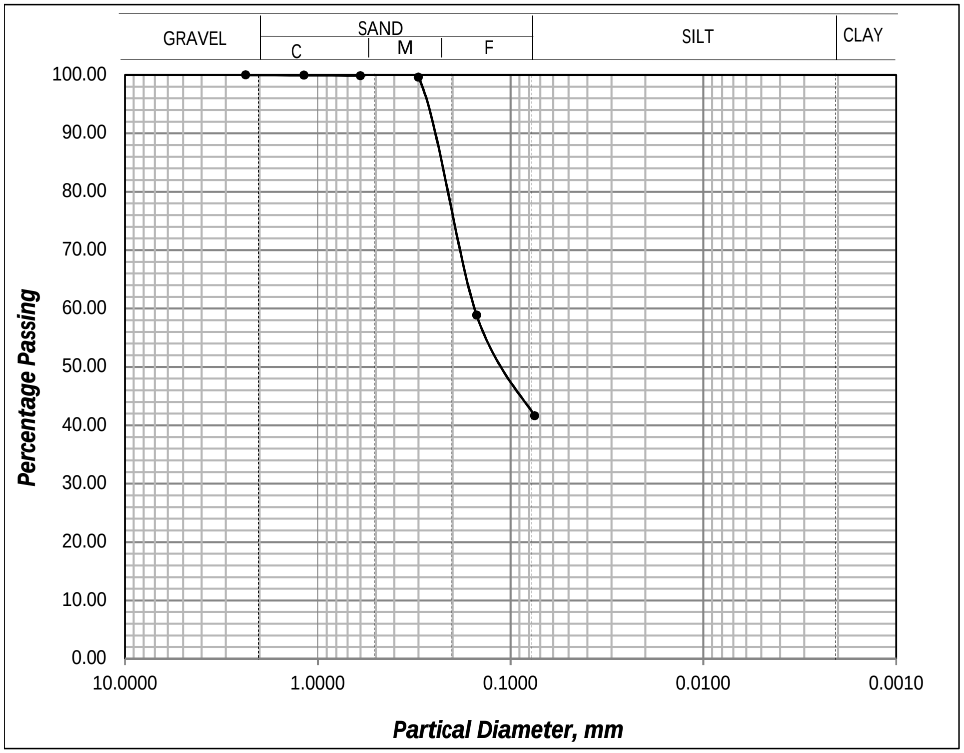
Partical Size Distribution Test of Soil

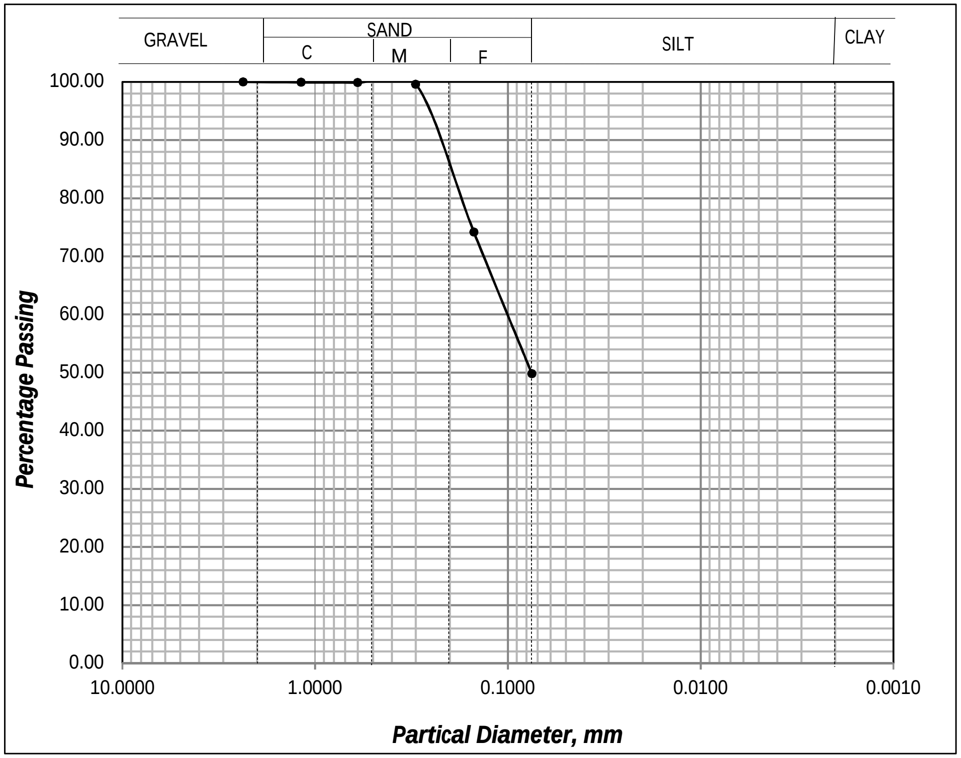
Test Method : ASTM D 422

Borehole #	:	BH-02	*Sampling Date*	:	11/06/2017~12/06/2017
Sample ID	:	D-03	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	3.00	*Soil Description*	:	***Gray silty SAND***



SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)	(%)	(mm)	(mm)	(mm)			(%)
	0%	**24%**	**34%**	**42%**	**0%**	**0.170**	**-**	**-**	**-**	**-**	**24.61%**

Borehole #	:	BH-02	*Sampling Date*	:	11/06/2017~12/06/2017
Sample ID	:	D-06	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	6.00	*Soil Description*	:	***Gray silty SAND***



SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)		(mm)	(mm)	(mm)			(%)
	0%	**14%**	**36%**	**50%**	**0%**	**0.100**	**-**	**-**	**-**	**-**	**27.13%**

N.B. *C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content*

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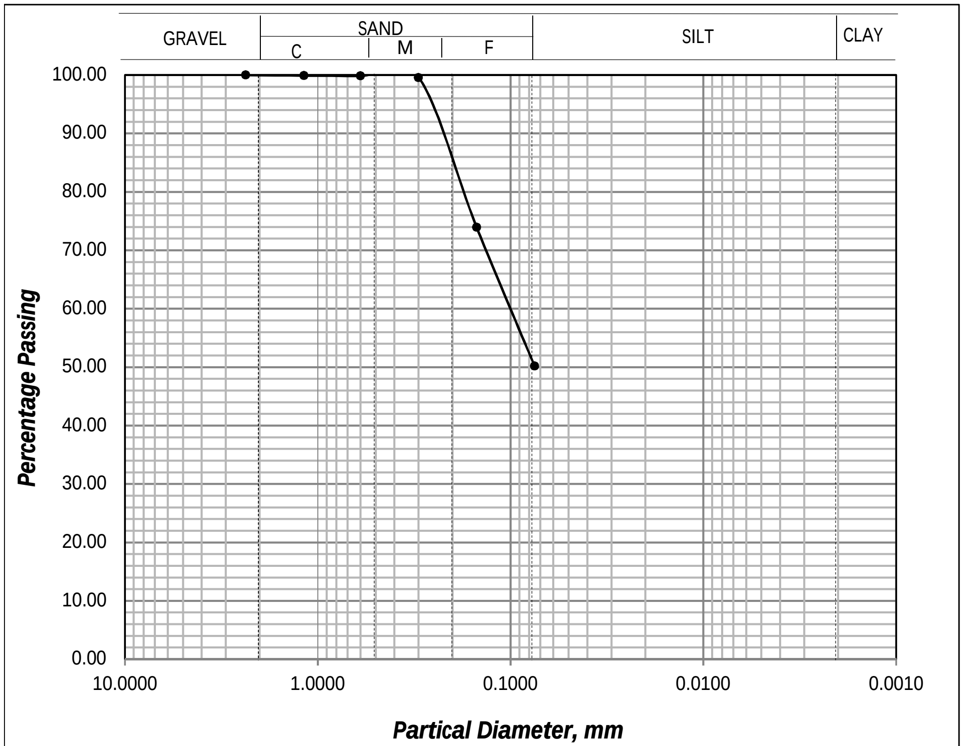
INSTITUTE OF WATER MODELLING (IWM)
Project : GEO-TECHNICAL INVESTIGATION AT LOWER BHADRA RIVER
POLDER-29, BATIAGHATA, KHULNA

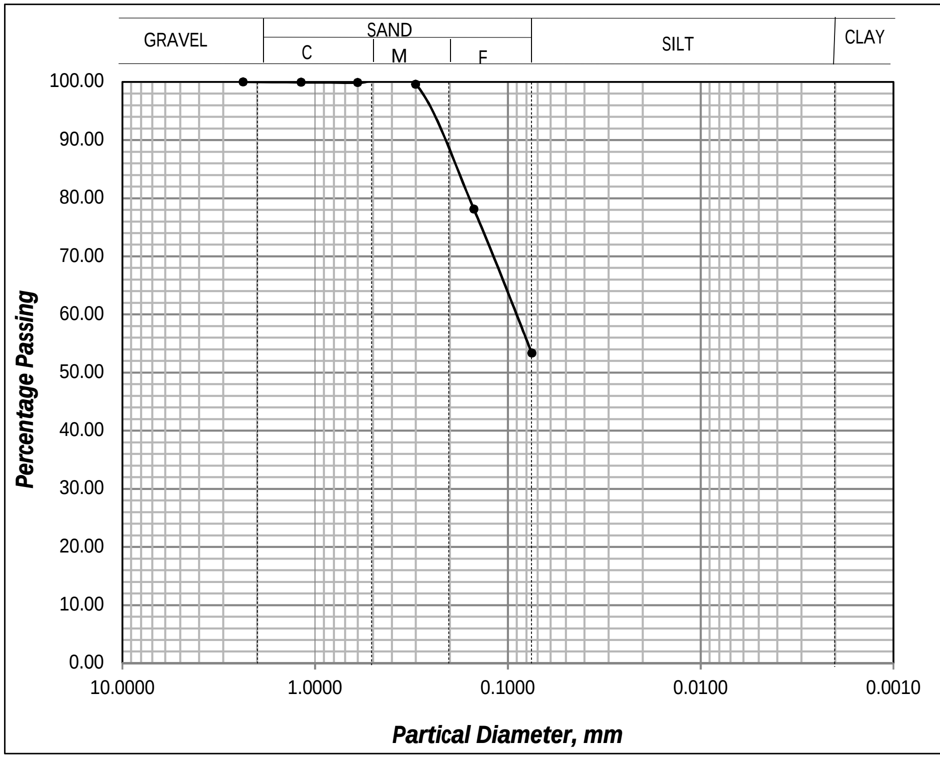
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-02	Sampling Date	:	11/06/2017~12/06/2017
Sample ID	:	D-08	Testing Date	:	19/06/2017
Sample Depth (m)	:	9.00	Soil Description	:	**Gray silty SAND**

Borehole #	:	BH-02	Sampling Date	:	11/06/2017~12/06/2017
Sample ID	:	D-12	Testing Date	:	19/06/2017
Sample Depth (m)	:	15.00	Soil Description	:	**Gray sandy SILT**





SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)	(%)	(mm)	(mm)	(mm)			(%)
	0%	**15%**	**35%**	**50%**	**0%**	**0.100**	**-**	**-**	**-**	**-**	**24.20%**

SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)		(mm)	(mm)	(mm)			(%)
	0%	**12%**	**34%**	**54%**	**0%**	**0.090**	**-**	**-**	**-**	**-**	**24.32%**

N.B. C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content

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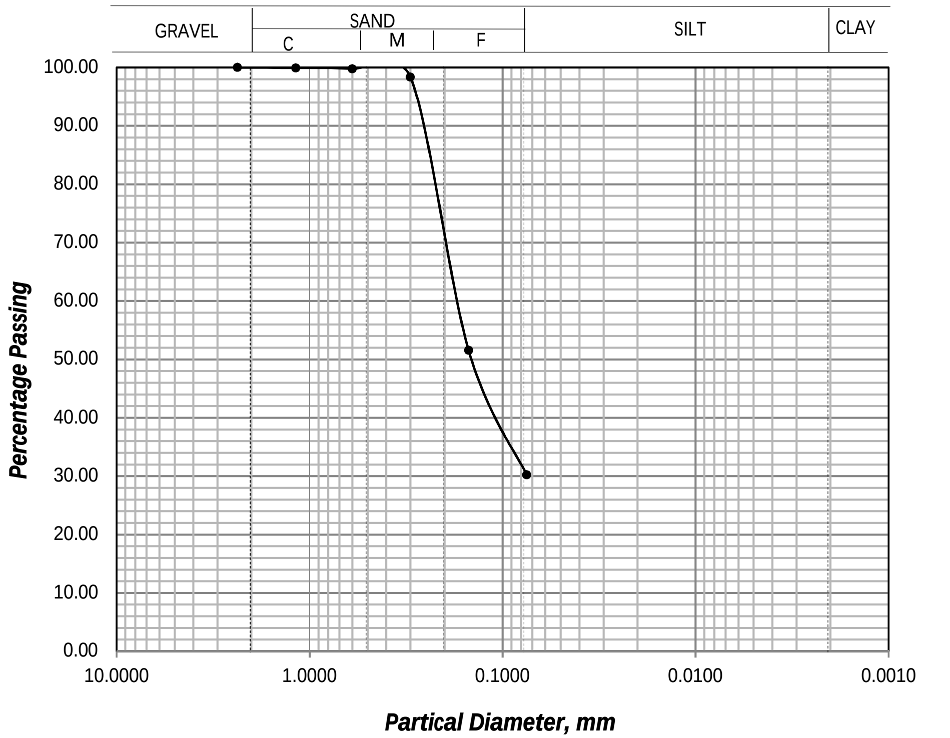
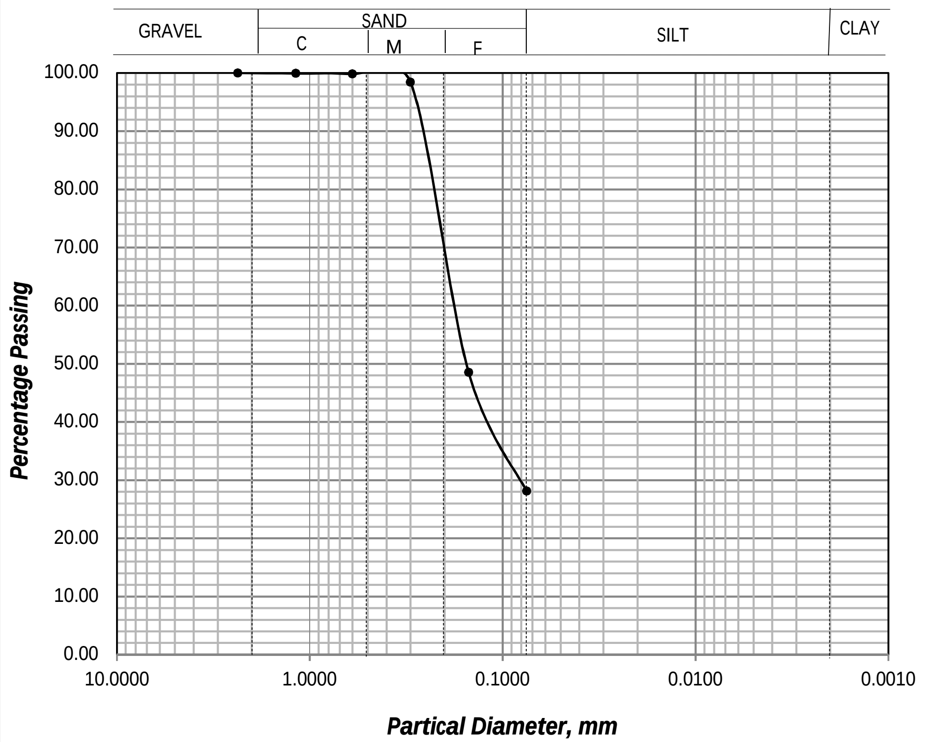
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-02	*Sampling Date*	:	11/06/2017~12/06/2017
Sample ID	:	D-16	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	21.00	*Soil Description*	:	***Gray silty SAND***

Borehole #	:	BH-02	*Sampling Date*	:	11/06/2017~12/06/2017
Sample ID	:	D-21	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	28.50	*Soil Description*	:	***Gray SAND, some silt***





SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY (%)	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	0%	***30%***	***40%***	***30%***	***0%***	***0.180***	***0.065***	***-***	***-***	***-***	***21.12%***

SYMBOL	SAND (%) C	SAND (%) M	SAND (%) F	SILT (%)	CLAY	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	0%	***31%***	***41%***	***28%***	***0%***	***0.180***	***0.082***	***-***	***-***	***-***	***20.51%***

N.B. *C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content*

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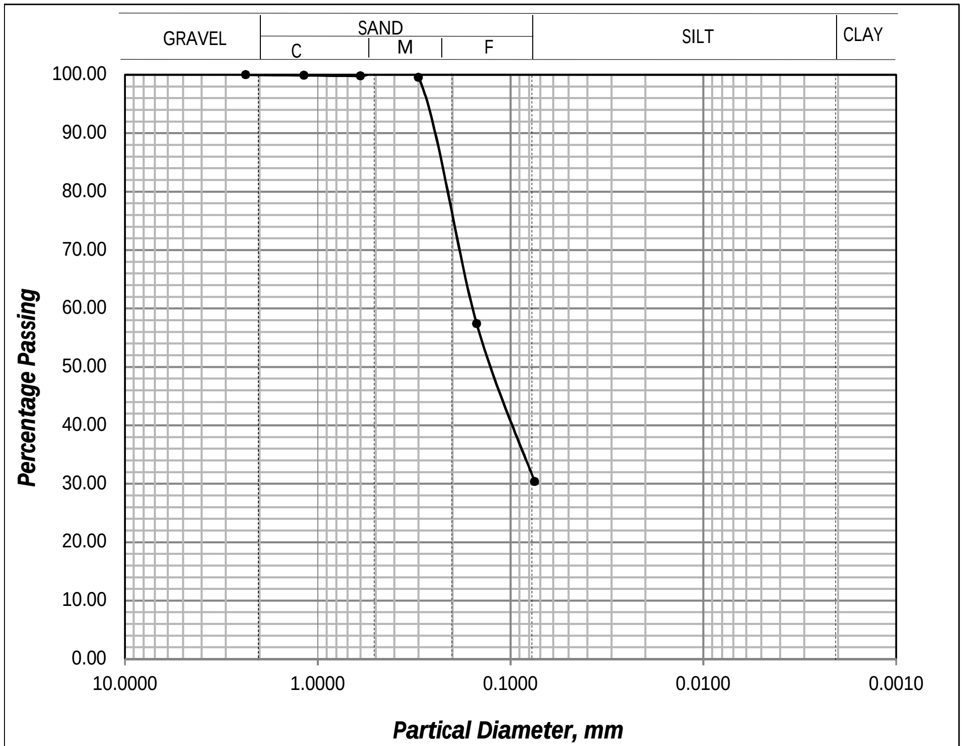
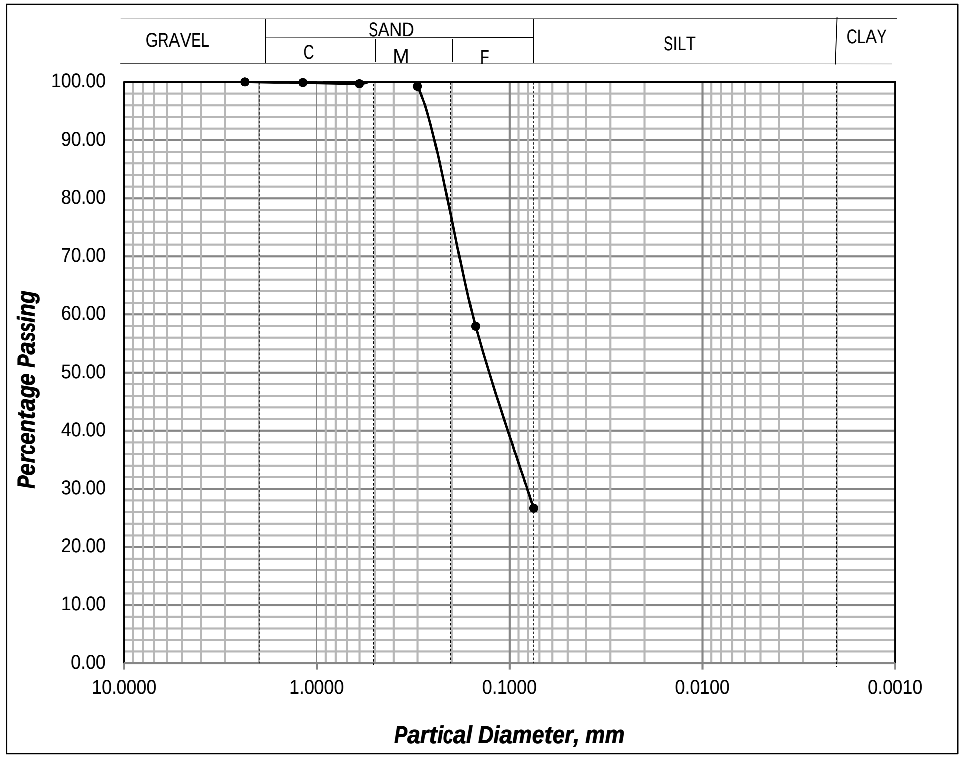
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-03	Sampling Date	:	14/06/2017
Sample ID	:	D-02	Testing Date	:	19/06/2017
Sample Depth (m)	:	2.00	Soil Description	:	**Gray silty SAND**

Borehole #	:	BH-03	Sampling Date	:	14/06/2017
Sample ID	:	D-06	Testing Date	:	19/06/2017
Sample Depth (m)	:	6.00	Soil Description	:	**Gray SAND, some silt**





SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)	(%)	(mm)	(mm)	(mm)			(%)
	0%	**24%**	**45%**	**31%**	**0%**	**0.160**	**-**	**-**	**-**	**-**	**25.60%**

SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)		(mm)	(mm)	(mm)			(%)
	0%	**24%**	**49%**	**27%**	**0%**	**-**	**-**	**-**	**-**	**-**	**17.33%**

N.B. C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content

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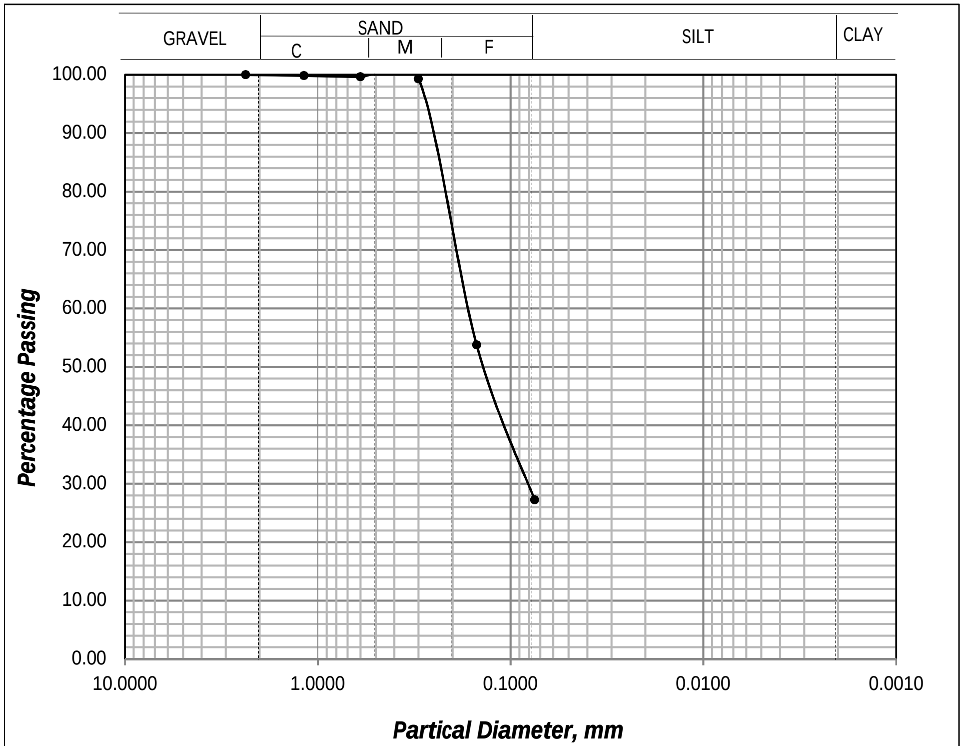
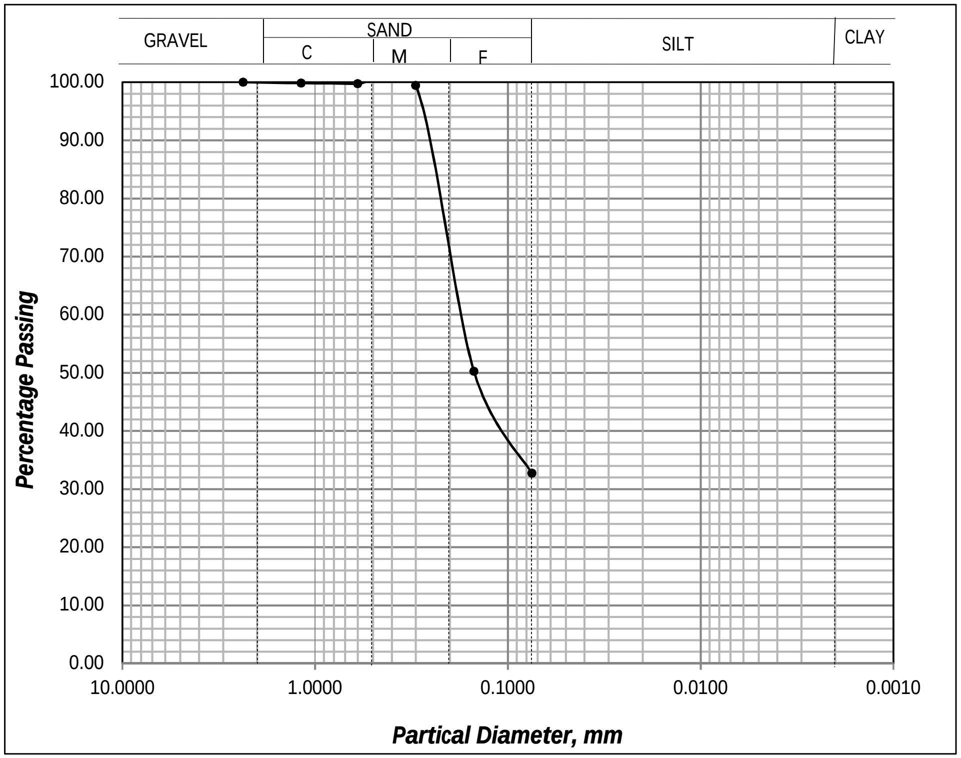
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-03	*Sampling Date*	:	14/06/2017
Sample ID	:	D-09	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	10.50	*Soil Description*	:	***Gray SAND, some silt***

Borehole #	:	BH-03	*Sampling Date*	:	14/06/2017
Sample ID	:	D-13	*Testing Date*	:	19/06/2017
Sample Depth (m)	:	16.50	*Soil Description*	:	***Gray silty SAND***





SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)	(%)	(mm)	(mm)	(mm)			(%)
●—●	**0%**	**27%**	**46%**	**27%**	**0%**	**0.180**	**0.083**	**-**	**-**	**-**	**21.08%**

SYMBOL	SAND (%)			SILT	CLAY	D_{60}	D_{30}	D_{10}	C_c	C_u	NMC
	C	M	F	(%)		(mm)	(mm)	(mm)			(%)
●—●	**0%**	**30%**	**37%**	**33%**	**0%**	**0.180**	**-**	**-**	**-**	**-**	**21.29%**

N.B. *C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content*

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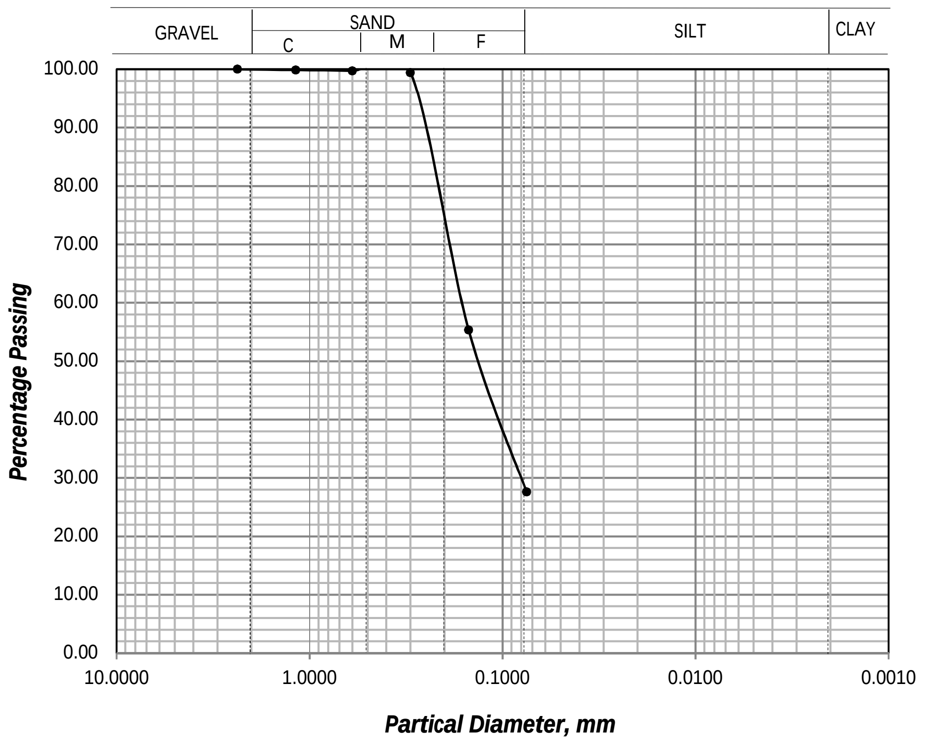
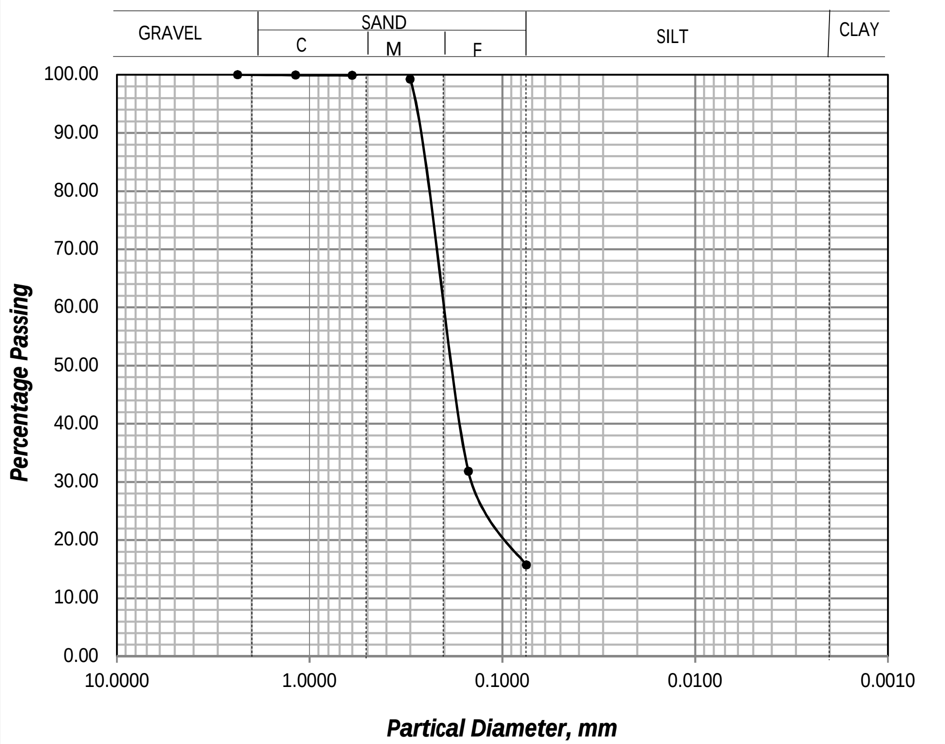
Partical Size Distribution Test of Soil

Test Method : ASTM D 422

Borehole #	:	BH-03	Sampling Date	:	14/06/2017
Sample ID	:	D-17	Testing Date	:	19/06/2017
Sample Depth (m)	:	22.50	Soil Description	:	**Gray SAND, some silt**

Borehole #	:	BH-03	Sampling Date	:	14/06/2017
Sample ID	:	D-21	Testing Date	:	19/06/2017
Sample Depth (m)	:	28.50	Soil Description	:	**Gray SAND, little silt**





SYMBOL	SAND (%)			SILT (%)	CLAY (%)	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	C	M	F								
●—●	**0%**	**25%**	**47%**	**28%**	**0%**	**0.170**	**0.082**	**-**	**-**	**-**	**23.41%**

SYMBOL	SAND (%)			SILT (%)	CLAY	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_c	C_u	NMC (%)
	C	M	F								
●—●	**0%**	**41%**	**43%**	**16%**	**0%**	**0.200**	**0.150**	**-**	**-**	**-**	**22.56%**

N.B. C_c = Co-efficient of curvatur, C_u = Co-efficient of uniformity, D_{10}, D_{30} & D_{60} = Partical diameter at % passing, NMC = Natural Moisture Content

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ANNEX-D

(Summary sheets)

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SUMMARY OF TEST RESULTS

BH. No.	Sample No.	Depth fr. EGL (m)	Moisture Content (%)	Density (gm/cc)		Specific Gravity	Atterbarg Limit			Grain Size Analysis			Unconfined Comp. Test		Direct Shear Test		Consolidation		
				Wet	Dry		LL (%)	PL (%)	PI (%)	Sand (%)	Silt (%)	Clay (%)	q_u(kPa)	Strain (%)	C (kPa)	Angle (ϕ)	C_0	C_C	C_r
BH-01	D-02	2.00	25.94%							72	28	0							
	D-05	5.00	28.50%							70	30	0							
	D-08	9.00	28.49%							71	29	0							
	D-12	15.00	27.60%							62	38	0							
	D-16	21.00	28.15%							74	26	0							
	D-21	28.50	26.39%							74	26	0							
BH-02	D-03	3.00	24.61%							58	42	0							
	D-06	6.00	27.13%							50	50	0							
	D-08	9.00	24.20%							50	50	0							
	D-12	15.00	24.32%							46	54	0							
	D-16	21.00	21.12%							70	30	0							
	D-21	28.50	20.51%							72	28	0							
BH-03	D-02	3.00	25.60%							69	31	0							
	D-06	6.00	17.33%							73	27	0							
	D-09	10.50	21.08%							73	27	0							
	D-13	16.50	21.29%							67	33	0							
	D-17	22.50	23.41%							72	28	0							
	D-21	28.50	22.56%							84	16	0							

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