Soil Investigation Report

CLIENT

Executive Engineer

Shariatpur O&M Division,

BWDB, Shariatpur

PROJECT

Protection from Erosion & Beautification Work and Construction of Culvert after Re-excavation of Matarbari Khal from KM 0.00 To KM 0.64 in Upazila- Damudya of District-Shariatpur Under Shariatpur O&M Division, BWDB, Shariatpur.

(November 2020)

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CONTENT

APPENDICES

Abbreviation

BH	Bore Hole
BH. WL	Bore-hole water level
c	Average cohesion for the soil stratum
Cc	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
Po'	Effective Overburden Pressure
q_{pa}	Allowable Point Bearing Capacity
$qu_{"pocket"}$	Unconfined Compressive Strength obtained from pocket penitrometer test
f_{sa}	Allowable Skin Friction
q_u	Unconfined Compressive Strength
α	Adhesion Factor
δ	Effective Friction Angle Between Soil & Pile Material

Introduction

This report represents the soil investigation works of the project Named "**Protection from Erosion & Beautification Work and Construction of Culvert after Re-excavation of Matarbari Khal From KM 0.00 To KM 0.64 in Upazila- Damudya of District-Shariatpur Under Shariatpur O&M Division, BWDB, Shariatpur".** After being instructed by Executive Engineer, Soil investigation at the site Executed in November 2020.

Scope of Work

According to the Scope of works, prepared by covering execution of Standard Penetration Tests (S.P.T.), including collection of disturbed soil samples at 1.5 m intervals, collection of undisturbed soil samples from significant cohesive zones, encountered in the exploratory boreholes, recording of soil stratification, Ground Water Table (G.W.T) etc. 3 (Three) boreholes up to 18 m depth (below EGL) have been carried out at respective borehole locations. Field works was carried out under strict supervision of the representative of the Client and site engineer of Smart Building Technologies. The borehole locations were marked at site by the representative of Client.

The subsurface exploration program included -

- Executing 3 boreholes (maximum depth of each BH is 18.0 m from EGL)
- Performing Standard Penetration Test (SPT)
- Collecting disturbed & undisturbed samples
- Evaluating bearing capacity of soil at different layers

Site Description

The site is fairly level.
Borehole location plan is presented in Appendix A.

Field Works

a) Performing Standard Penetration Test (SPT):

Standard Penetration Test (SPT) has been executed in each bore at 1.50 intervals from the existing ground level to the depth of exploration.

The test was made by using a split spoon of 50.8 mm outer dia and 38 mm inner dia, Attached to the lower end of drill rod. A 63.52 kg Hammer was allowed to fall freely from a height of 760 mm on a socket attached to the drill rod. The blows of the hammer drove the spoon into the soil up to 450mm. The number of blows requires each 150mm of penetration of spoon was recorded. The blows required for last 300 mm of the layer is presented on Bore log.

a) Extraction of Disturbed Soil Samples:

Soil samples in the disturbed state have been extracted from each 1.5m depth interval up to the depth of investigation along each borehole. After extraction, these soil samples have been classified in site to help stratification of the soil layers and preserved to carry out laboratory tests.

b) Extraction of Undisturbed Soil Samples:

Both the index and engineering properties of soil are greatly affected by the disturbance of the soil samples, so soil samples of undisturbed state are preferred to perform certain laboratory tests. This eventually helps to evaluate the bearing capacity and other geo-technical properties of the soil. Undisturbed soil samples are collected only in possible and necessary cases.

c) Ground water Table:

Ground Water Table- after completion of each borehole G.W.T. has been recorded in the boreholes for 24-hrs, and such G.W.T, shown in the respective bore logs.

Laboratory Tests

All Laboratory Tests conducted on soil samples collected either in the disturbed or in the undisturbed state. All tests were done as per ASTM procedures are as follow:

a) Natural Moisture Content:

The water content of a 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 weight both in natural state and in over dry state and the moisture content is calculated by dividing the loose of weight of the sample by its dry weight.

b) Complete grain size 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 particles size, comprising a soil sample. The process consists of either sieve analysis or hydrometer analysis on both.

c) Specific Gravity Test:

The specific gravity of soil particles (Gs) is defined as the ratio of the mass of give volume of soil particles to the mass of an equal volume of water at 4°C. The specific gravity of a solid for most natural soils falls in general range of 2.60 to 2.80.

d) Direct shear Test:

Direct shear test can be performed for both cohesion less & cohesive soil to determine shear strength, angle of internal friction, cohesion c, and volume change etc. The test is done in a direct shear machine which consists of a normal loading device; shearing displacement of approximately 10mm per minute is often for sample used for a sample thickness of about 1.2cm.

e) Unconfined Compression Test:

Unconfined compression test is a simple method for determination of shearing strength of cohesive soil which is important to determine the bearing capacity of soil.

f) Moisture Content and Bulk Density Test

Moisture content and Bulk Density tests were tested in accordance with BS. 5930: 1999.Initial weight of original sample was measured and dried in the oven under 105 to 110 C until constant weight was achieved. The dry weight of sample was measured and the moisture content was calculated. (Weight of Wet Sample) – (Weight of Dry Sample) Moisture Content = Weight of Dry Sample Bulk density is the ratio of mass over volume. Specimen was cut by the cutting ring and the weight and volume was measured. Bulk density was calculated as follow: Bulk Density = Weight of Sample Volume.

Index Properties

a) NMCs, dry densities of cohesive soil are presented below-

Bore hole	Depth (M)	N.M.C(%)	Dry density(g/cc)
BH-1	2.45	29.8	1.50
BH-2	2.45	28.2	1.52
BH-3	2.45	29.5	1.51

b) Grain size distribution curves are given in Appendix C.

Engineering Properties

The engineering properties of the subsoil formation of the project area has been evaluated based on laboratory tests (Ref. -Unconfined Compressive Strength, Direct Shear)

a) **Unconfined Compressive strength:**

Unconfined comprehensive strengths of the top layer at different depth are as follows:

Bore hole	Depth (m/RL)	qu (kPa)
BH-1	2.45/30.0	66
BH-2	2.45/30.0	71.5
BH-3	2.45/30.0	39

b) **Friction Angle:**

Friction angles of soil at different depths are given below:

Bore hole	**Depth (m)**	**(φ)**	**c (psi)**
BH-1	4.50	29.6	0
	10.50	31.7	0
	15.0	33.8	0
BH-2	3.0	28.3	0
	6.0	31.6	0
	15.0	33.9	0
BH-3	1.50	28.5	0
	9.0	33.1	0
	15.0	34.5	0

Correction of Field SPT Values

N-value at the shallow depth, usually show lesser value than actually it appears value should be corrected by N adjust = N (50)/ (P+10) where P is the effective over burden pressure in PSI.

If sand is very fine or contains large amount of silt and in addition If in submerged condition may indicate a relative density of considerable greater than actual density of the formation. Under these conditions N-values greater than 15 should be corrected according to the following formula:-P+10.

Actual density
N = 15-0.50(N-15)
Where N- actual number of blows obtained from the test. Number of blows to be assumed for design purpose.

Bearing Capacity Analysis

The bearing capacity for the Shallow Foundation:

Utilizing the **Terzaghi's bearing capacity theory:**

For strip footing $\quad qu = c'Nc + \gamma Df\, Nq + 0.5\ \gamma B\, Ny$

For square footing $\quad qu = 1.2\ c'Nc + \gamma Df\, Nq + 0.4\ \gamma B\, Ny$

For circular footing $\quad qu = 1.2\ c'Nc + \gamma Df\, Nq + 0.3\ \gamma B\, Ny$

Where,

Nc, Nq, Ny	=	Terzaghi's bearing capacity factors
D_f	=	Depth of foundation
C'	=	Cohesion
B	=	Width of footing

Utilizing the**Hansen's bearing capacity theory:**

$$q_u = c'N_cSc\ dc\ ic + \gamma D_fN_qSqdqiq + 0.5\ \gamma B\ N_ySydyiy$$

Where,

Nc, Nq, Ny	=	Hansen's bearing capacity factors
Sc, Sq, Sy	=	Shape factors
dc, dq, dy	=	Depth factors
ic, iq, iy	=	Inclination factors
D_f	=	Depth of foundation

Conclusion and Recommendation

Soil stratification shows that **3.0m is brown silty clay** boreholes and after that **medium to dense to very dense sandy soil** governs up to the depth of investigation (18.0 m from EGL).

Bearing capacity may be the governing criterion for shallow foundation design. From the various field and laboratory test result **the allowable bearing capacity can be taken as 0.75 Tsf (1.50 ksf) at the depth of excavation of 5`-0`` from the existing ground level.**

R. C. C. PRE- CAST DRIVING PILE:

For R.C.C. pre-cast pre-stressed driven pile Skin Friction & End Bearing of Single Pile are stated in (Table – 2) Appendix-E.

R.C.C CAST-IN-SITU PILE:

The average bearing capacities(**Tons**) (F.S =2.5) of different diameter pile with the different embedment length from EGL of each boring may be considered as follows:

Pile Length (ft)	BORE HOLE NO : 1	
	20 inch (500 mm)	24 inch (600 mm)
50	78	107
55	83	113

Pile Length (ft)	BORE HOLE NO : 2	
	20 inch (500 mm)	24 inch (600 mm)
50	77	105
55	81	111

Pile Length (ft)	BORE HOLE NO : 3	
	20 inch (500 mm)	24 inch (600 mm)
50	75	103
55	79	109

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Notes:

1) Foundation type does not depend on soil parameters rather some other factors like architectural lay out, loading condition, importance factor, financial constraints, availability of building material in particular region & construction technique etc. also play important role.
2) The geo technical /structural engineer may select any foundation type according to this soil test report.
3) There are existing buildings near the property line so sufficient precaution should be taken during construction and thereafter.

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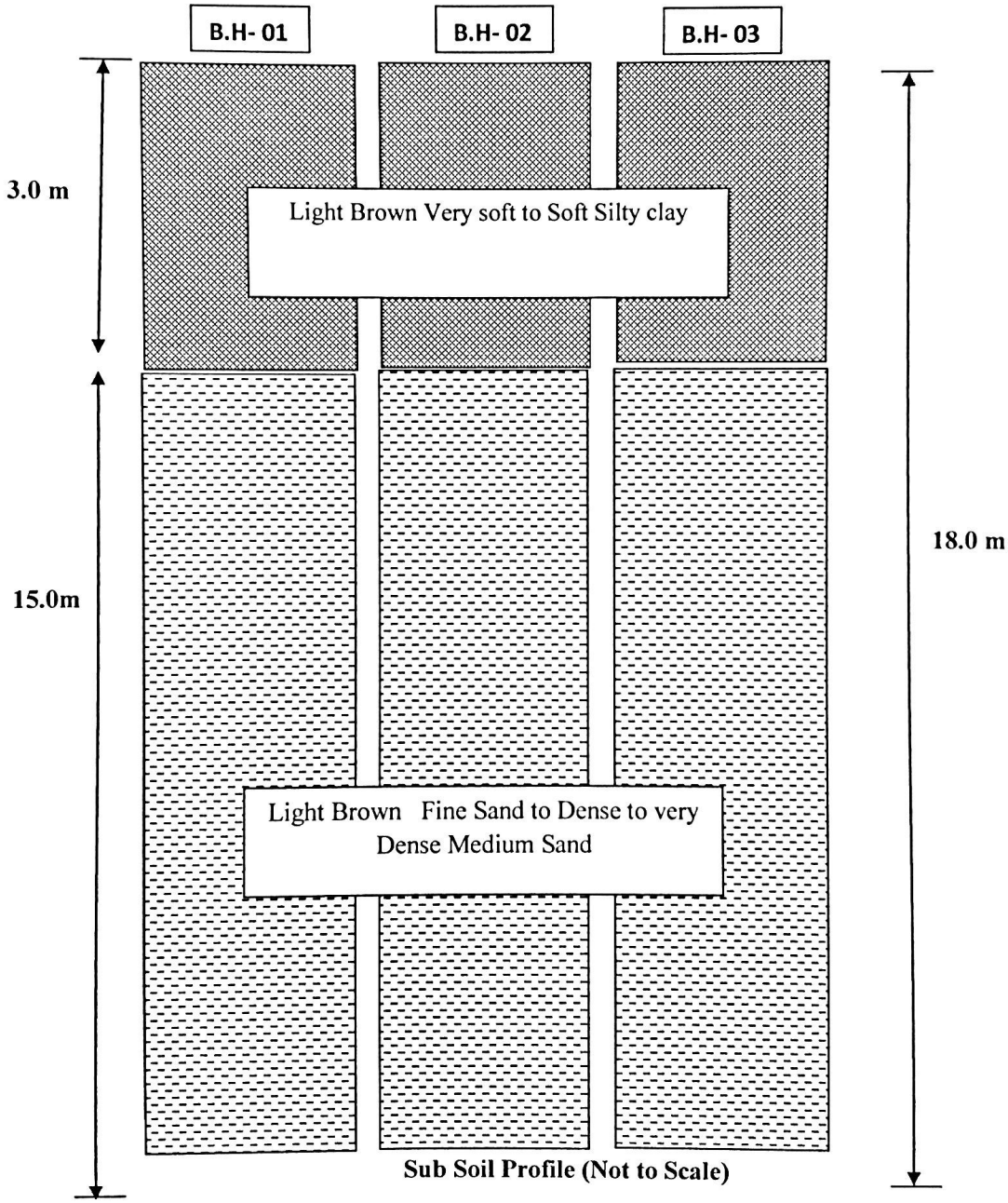
Appendix – B: Soil Profile

Project: Protection from Erosion & Beautification Work and Construction of Culvert after Re-excavation of Matarbari Khal From KM 0.00 To KM 0.64 in Upazila-Damudya of District-Shariatpur Under Shariatpur O&M Division, BWDB, Shariatpur.

Soil Profile along Bore Hole BH 01, BH 02 & BH 03

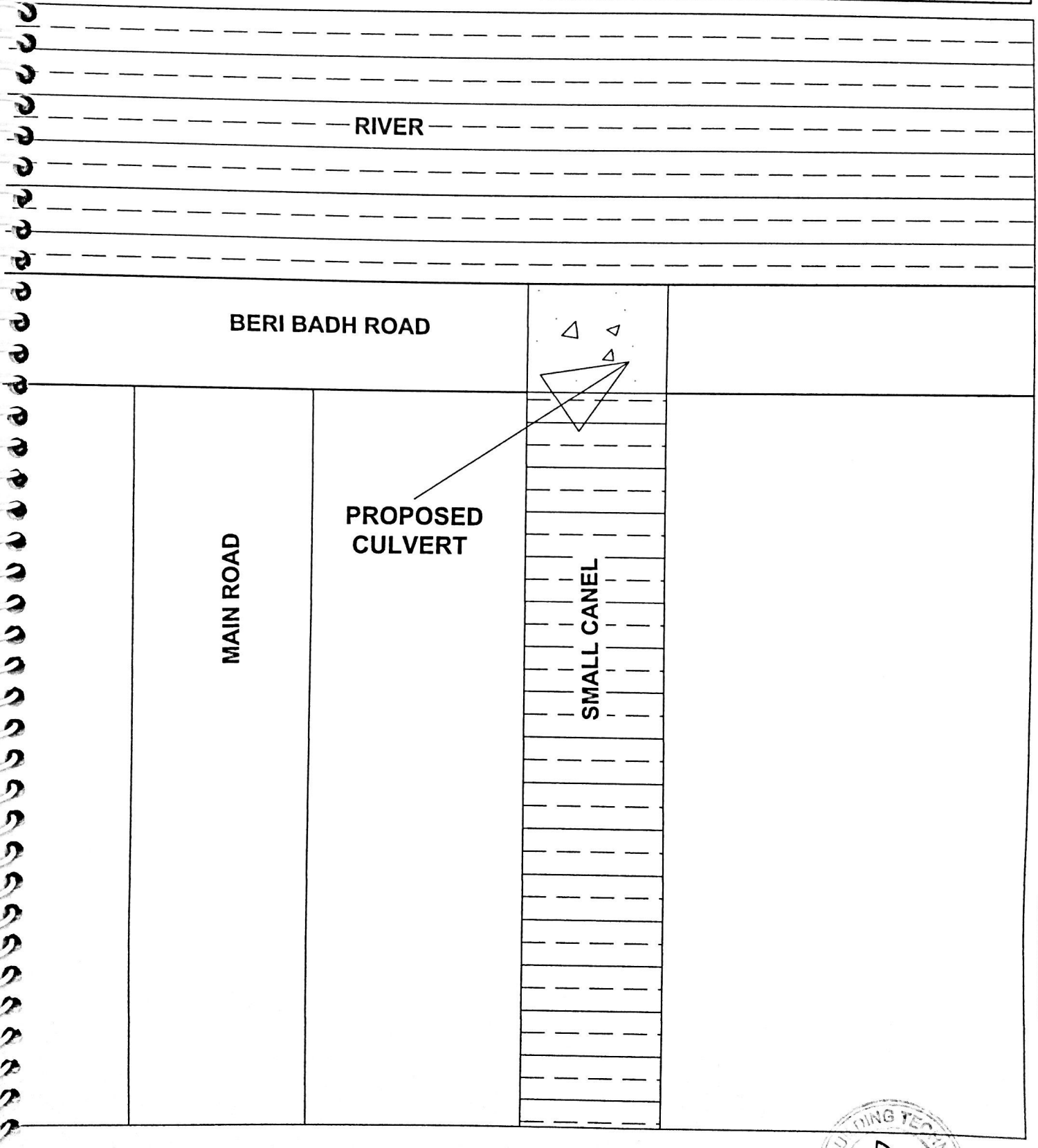


Sub Soil Profile (Not to Scale)

Appendix - A : SITE LOCATION MAP

NAME OF THE PROJECT

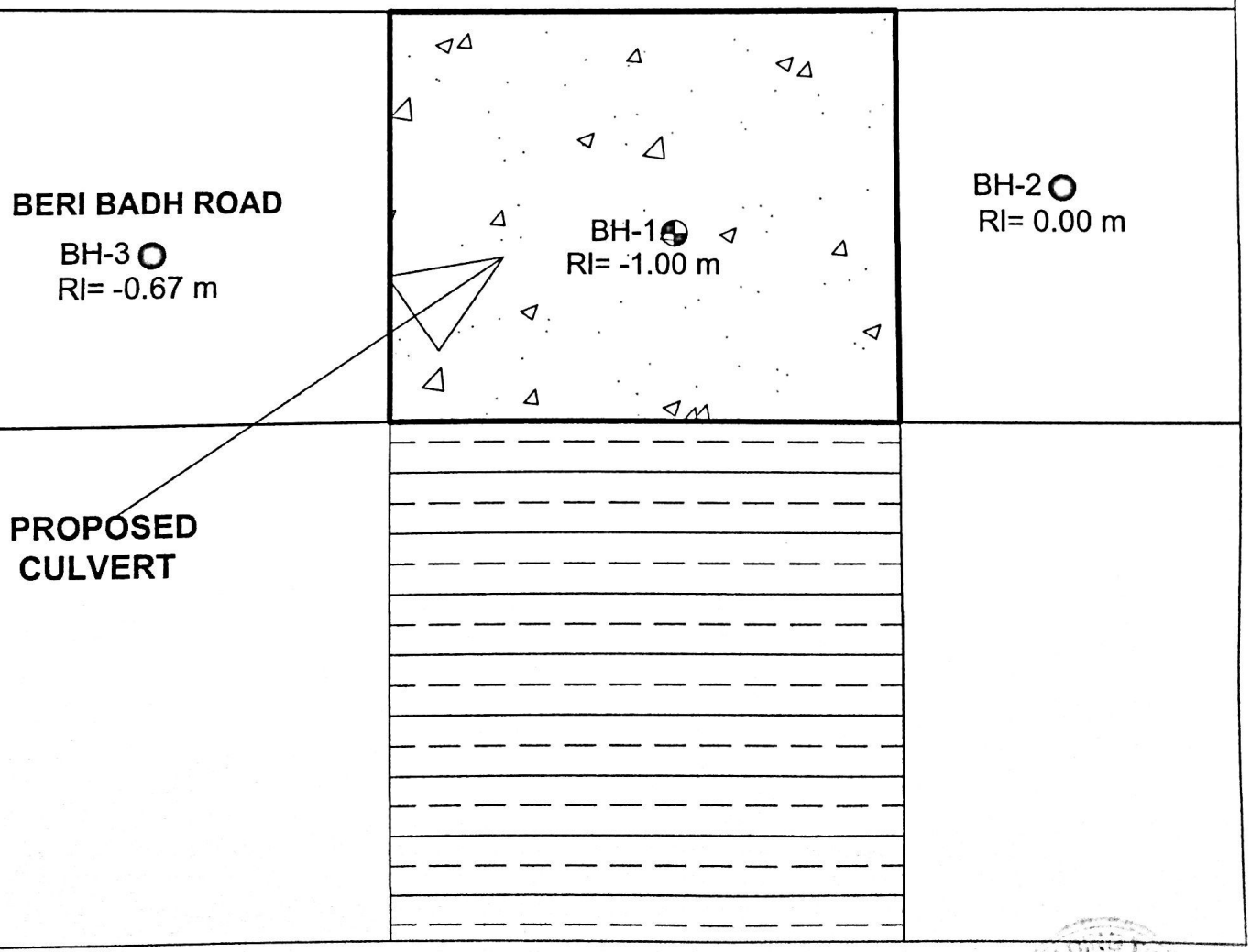
Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur Under Shariatpur O&M Division, BWDB, Shariatpur



Appendix - A : BOREHOLE LOCATION MAP

NAME OF THE PROJECT

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur Under Shariatpur O&M Division, BWDB, Shariatpur



.. RL of the road level is taken as 0.00 m

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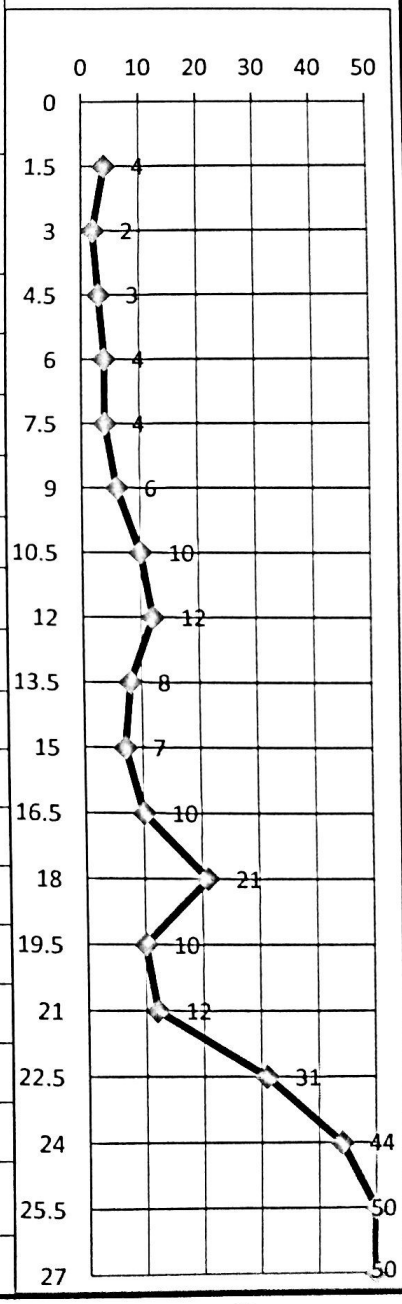
Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	:	**BH 01**	BORE LOG	
Method of Boring	:	Percussion Method		
Boring Dia	:	0.1 m		
Depth of Boring	:	27.0m	EGL(RL in Meter)	0.00 m
Soil Classification	:	ASTM D-2487 & D-2488	Date of Exploration	**27/11/2020**
Location	:	**Janjira Upazila of district Shariatpur.**	Water level	-3.00 m

Depth Below EGL(Meter)	Sample ID	Sample Type	Thickness	Description of Soil Strata	Symbol	SPT	First 150 mm	Middle 150 mm	Last 150 mm	N-Value
1.5	D-1			**Blackish to Grey Very Soft to Soft to Medium Stiff Silty clay.**		5	1	2	2	4
2.45	UD-2									
3.0	D-3					10	1	1	1	2
4.5	D-4					15	1	1	2	3
6.0	D-5					20	1	2	2	4
7.5	D-6					25	1	2	2	4
9.0	D-7					30	1	3	3	6
10.5	D-8			**Light medium Dense to very Dense Fine Sand.**		35	3	4	6	10
12.0	D-9					40	4	5	7	12
13.5	D-10					45	2	4	4	8
15.0	D-11					50	2	2	5	7
16.5	D-12					55	3	4	6	10
18.0	D-13					60	6	10	11	21
19.5	D-14					65	3	4	6	10
21.0	D-15					70	3	5	7	12
22.5	D-16					75	9	13	18	31
24.0	D-17					80	12	17	27	44
25.5	D-18					85	11	20	30	50
27.0	D-19					90	13	25	25	50

Graphical Representation of SPT N- Values



Split Spoon Sample :
Shelby Tube Sample :
Non cohesive Soil :
Cohesive Soil :

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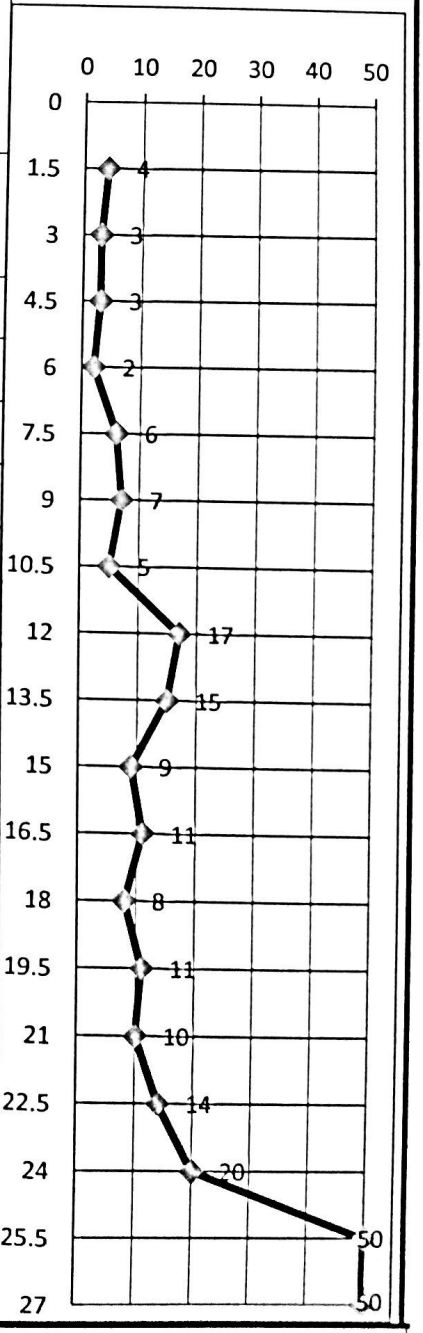
Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	:	**BH 02**	BORE LOG	
Method of Boring	:	Percussion Method		
Boring Dia	:	0.1 m		
Depth of Boring	:	27.0m	EGL(RL in Meter)	0.00 m
Soil Classification	:	ASTM D-2487 & D-2488	Date of Exploration	27&28-11-2020
Location	:	**Janjira Upazila of district Shariatpur.**	Water level	-3.00 m

Depth Below EGL(Meter)	Sample ID	Sample Type	Thickness	Description of Soil Strata	Symbol	SPT	First 150 mm	Middle 150 mm	Last 150 mm	N-Value
1.5	D-1			Blackish to Grey Very Soft to Soft to Medium Stiff Silty clay.		5	1	2	2	4
2.45	UD-2									
3.0	D-3					10	1	1	2	3
4.5	D-4					15	1	1	2	3
6.0	D-5					20	1	1	1	2
7.5	D-6					25	2	3	3	6
9.0	D-7					30	2	3	4	7
10.5	D-8			Light medium Dense to very Dense Fine Sand.		35	2	2	3	5
12.0	D-9					40	5	8	9	17
13.5	D-10					45	5	7	8	15
15.0	D-11					50	4	4	5	9
16.5	D-12					55	3	5	6	11
18.0	D-13					60	2	4	4	8
19.5	D-14					65	3	4	7	11
21.0	D-15					70	3	5	5	10
22.5	D-16					75	4	6	8	14
24.0	D-17					80	7	10	10	20
25.5	D-18					85	15	25	25	50
27.0	D-19					90	15	27	23	50

Graphical Representation of SPT N- Values



Split Spoon Sample :
Shelby Tube Sample :
Non cohesive Soil :
Cohesive Soil :

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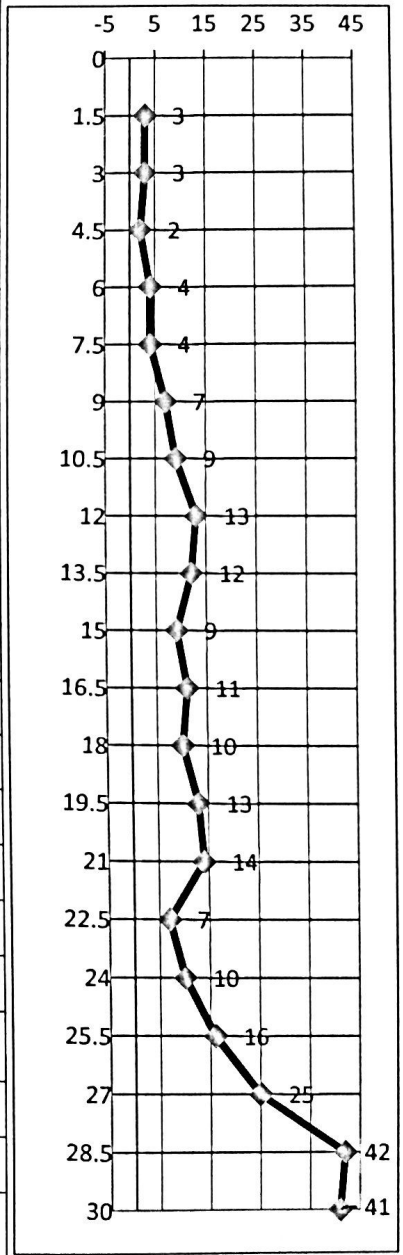
Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	:	BH 03	BORE LOG	
Method of Boring	:	Percussion Method		
Boring Dia	:	0.1 m		
Depth of Boring	:	27.0m	EGL(RL in Meter)	0.00 m
Soil Classification	:	ASTM D-2487 & D-2488	Date of Exploration	28-11-2020
Location	:	Janjira Upazila of district Shariatpur.	-1.00 m	-3.00 m

Depth Below EGL(Meter)	Sample ID	Sample Type	Thickness	Description of Soil Strata	Symbol	SPT Intervals(ft.)	First 150 mm	Middle 150 mm	Last 150 mm	N-Value
1.5	D-1			Blackish to Grey Very Soft to Soft to Medium Stiff Silty clay.		5	1	2	1	3
2.45	UD-2									
3.0	D-3					10	1	1	2	3
4.5	D-4					15	1	1	1	2
6.0	D-5					20	1	2	2	4
7.5	D-6					25	1	2	2	4
9.0	D-7					30	2	3	4	7
10.5	D-8			Light medium Dense to very Dense Fine Sand.		35	2	4	5	9
12.0	D-9					40	4	6	7	13
13.5	D-10					45	3	6	6	12
15.0	D-11					50	3	4	5	9
16.5	D-12					55	4	5	6	11
18.0	D-13					60	2	4	6	10
19.5	D-14					65	3	5	8	13
21.0	D-15					70	3	4	10	14
22.5	D-16					75	3	3	4	7
24.0	D-17					80	2	4	6	10
25.5	D-18					85	3	6	10	16
27.0	D-19					90	7	12	13	25
28.5	D-20					95	10	19	23	42
30.0	D-21					100	8	20	21	41

Graphical Representation of SPT N- Values



Split Spoon Sample:
Shelby Tube Sample :
Non cohesive Soil :
Cohesive Soil :

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Appendix – C: Laboratory Test Report

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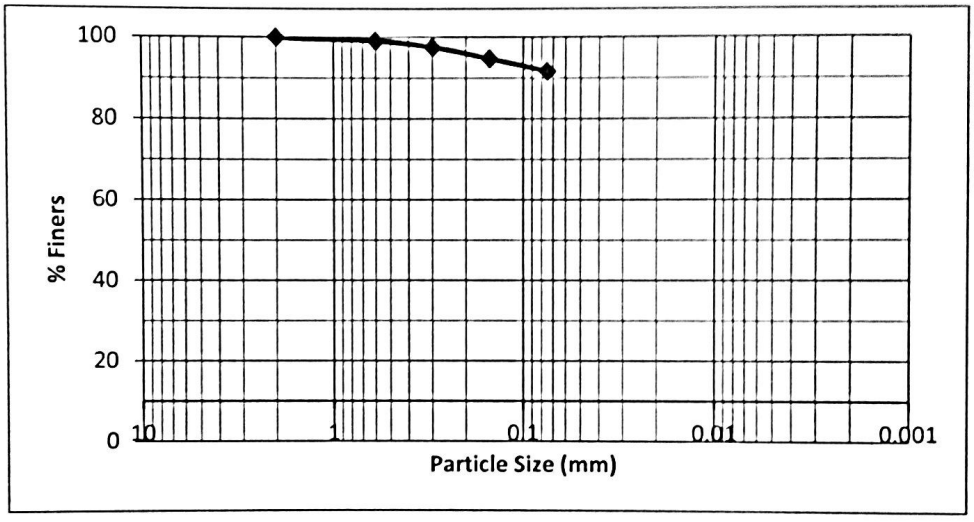
Particle size analysis of soil ASTM D 422

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No : BH-01
Sample No : D-1
Depth : 1.5 Meter.

Test Data

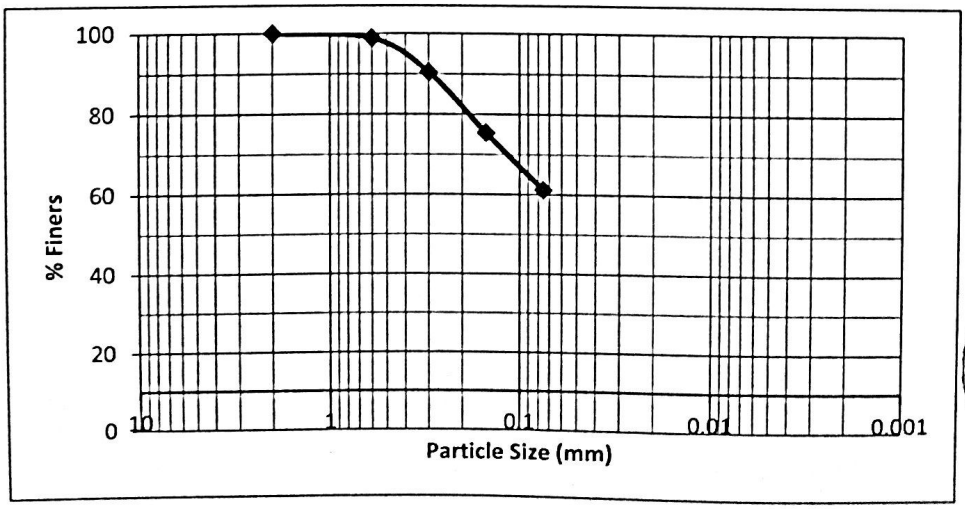
Sieve Size(mm)	Passing %
2	100
0.6	99.16
0.3	97.66
0.15	94.84
0.075	91.80

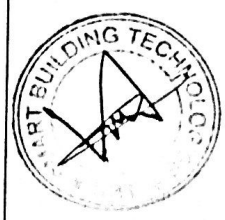


Borehole No : BH-01
Sample No : D-5
Depth : 12.0 Meter.

Test Data

Sieve Size(mm)	Passing %
2	100
0.6	98.90
0.3	90.42
0.15	75.40
0.075	61.20





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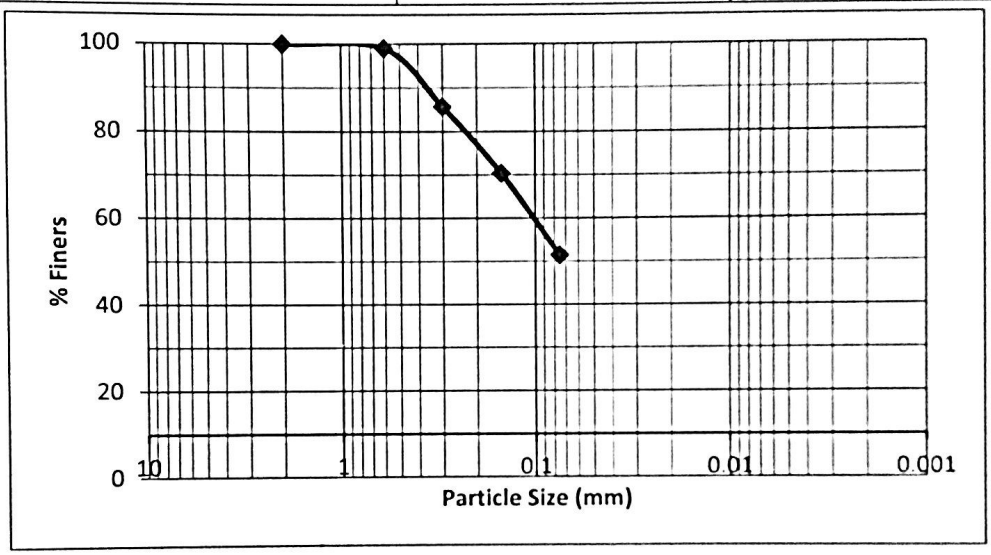
Particle size analysis of soil ASTM D 422

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No : BH-01
Sample No : D-10
Depth : 15.0Meter.

Test Data

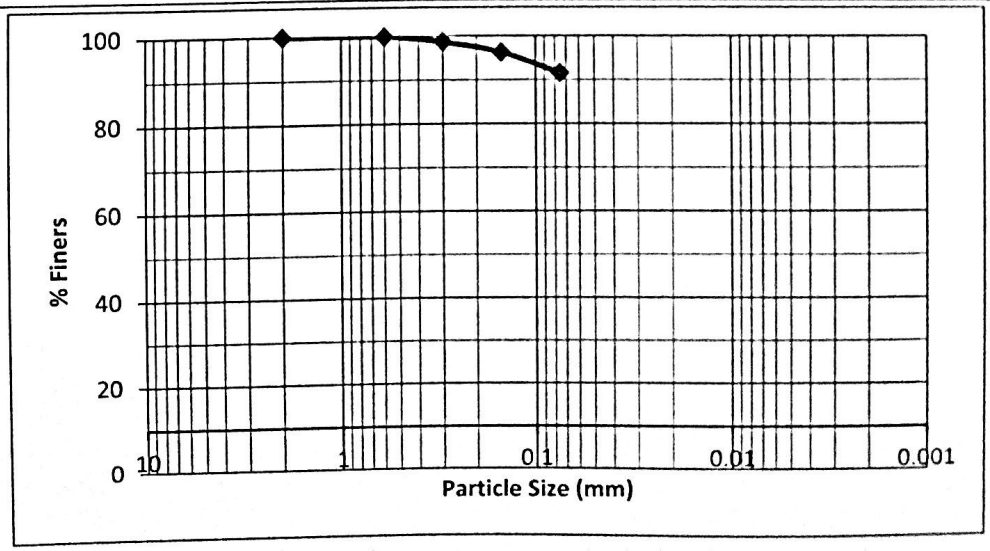
Sieve Size(mm)	Passing %
2	100
0.6	98.98
0.3	85.68
0.15	70.45
0.075	51.50



Borehole No : BH-02
Sample No : D-1
Depth : 1.5 Meter.

Test Data

Sieve Size(mm)	Passing %
2	100
0.6	99.97
0.3	98.70
0.15	96.30
0.075	91.62



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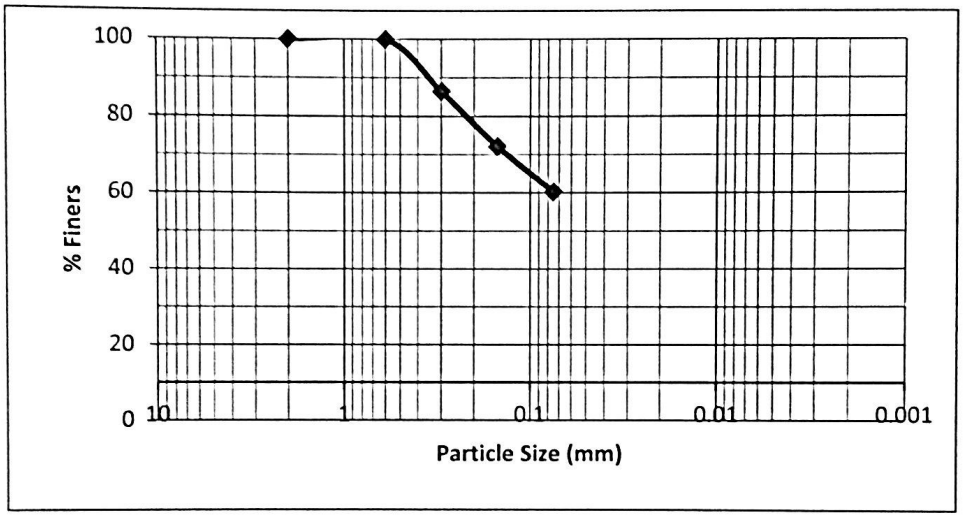
Particle size analysis of soil ASTM D 422

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	: BH-02
Sample No	: D-5
Depth	: 12.0Meter.

Test Data

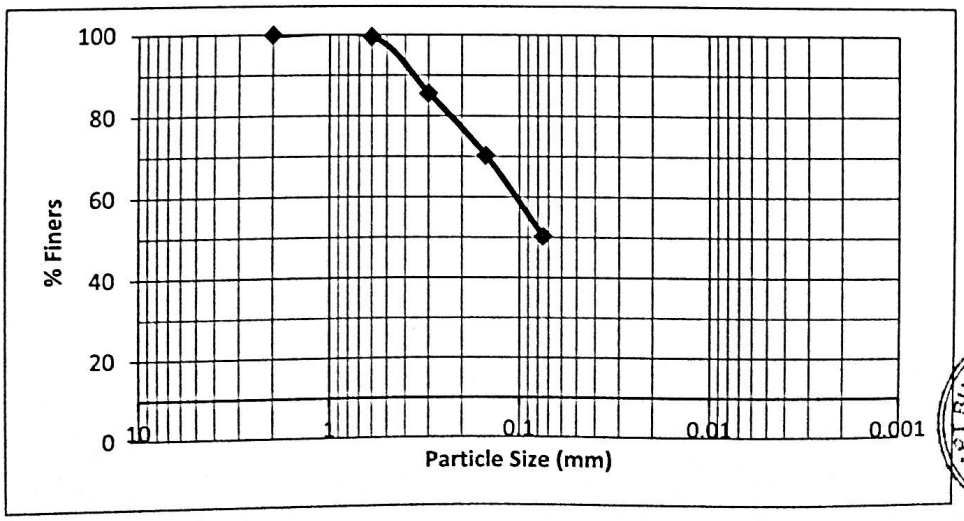
Sieve Size(mm)	Passing %
2	100
0.6	99.91
0.3	86.50
0.15	72.20
0.075	60.30



Borehole No	: BH-02
Sample No	: D-10
Depth	: 15.0 Meter.

Test Data

Sieve Size(mm)	Passing %
2	100
0.6	99.50
0.3	85.65
0.15	70.30
0.075	50.35



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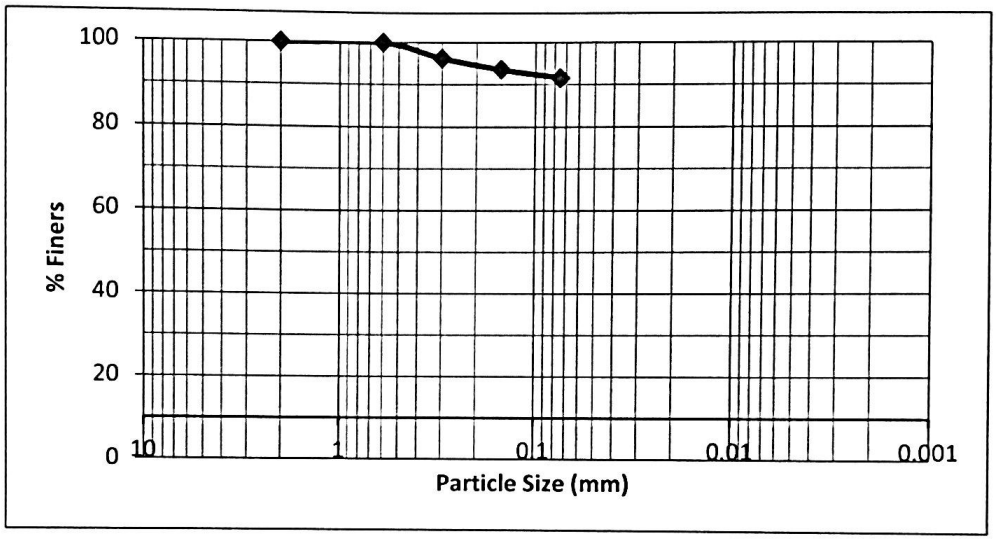
Particle size analysis of soil ASTM D 422

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	: BH-03
Sample No	: D-1
Depth	: 1.5 Meter.

Test Data

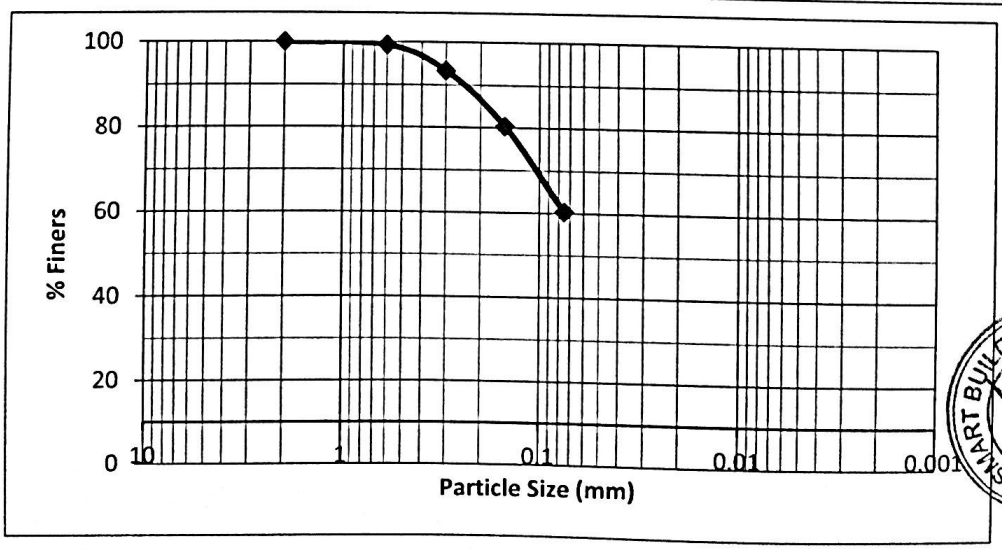
Sieve Size(mm)	Passing %
2	100
0.6	99.91
0.3	96.26
0.15	93.60
0.075	91.62



Borehole No	: BH-03
Sample No	: D-5
Depth	: 12.0 Meter.

Test Data

Sieve Size(mm)	Passing %
2	100
0.6	99.36
0.3	93.36
0.15	80.38
0.075	60.35



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Smart Building Technologies

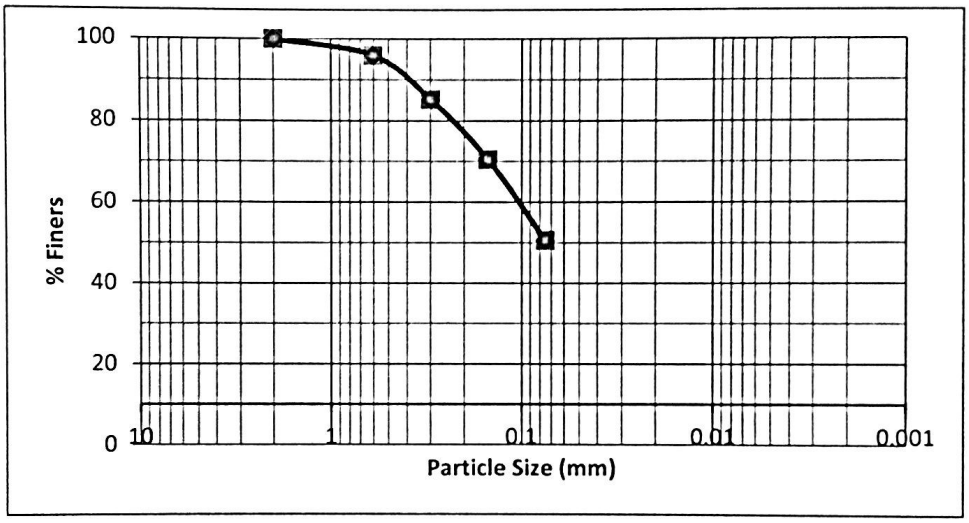
Particle size analysis of soil ASTM D 422

Soil Investigation of Protection of Right Bank of Padma River Naria &Janjira Upazila of district Shariatpur.

Borehole No	**: BH-03**
Sample No	**: D-10**
Depth	**: 15.0 Meter.**

Test Data

Sieve Size(mm)	Passing %
2	100
0.6	95.98
0.3	85.30
0.15	70.55
0.075	50.56



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