Government of the People's Republic of Bangladesh
Ministry of Housing and Public Works
Urban Development Directorate (UDD)

Preparation of Development Plan for Fourteen Upazilas

Package 01

Draft Survey Report

Geological Survey of Shibchar Upazila

September 2016

Submitted By

Desh Upodesh Ltd. In Association with AAIMA International BD Ltd. and Tech-SUS Ltd.

Letter of Transmittal

EXECUTIVE SUMMARY

Development plan of Shibchar Upazila, District Dhaka has been taken under package-1 and the project titled 'Preparation of Development Plan for Fourteen Upazilas' a initiative of Urban Development Directorate (UDD). In this development plan, subsurface geological and geotechnical information's has been considered for a durable and sustainable urban environment. This is basically done to determine the state of the soil below the surface of the project area and natural, such as earthquakes, landslides and soil erosion as a result of the design of the infrastructure development such as geological and hydro-meteorological hazards are evaluated.

To know the subsurface environment of the study area, surveys has been carried out up to 30 meter below the earth surface in the field. Investigations and surveys are geo-morphological survey; drilling of boreholes and preparation of borehole logs; collection of undisturbed and disturbed soil sample as per standard guide line; conducting standard penetration tests (SPTs); drilling of boreholes and casing by PVC pipe for conducting Down-hole seismic test; conducting Down-hole seismic test and conducting Multi-Channel Analysis of Surface Wave (MASW). Laboratory testing of soil samples such as Grain Size analysis, Natural moisture Content, Atterberg Limits, Specific Gravity, Direct Shear Test, Unconfined Compression strength, etc has been performing in the laboratory which will give more qualitative and quantitative information about the subsurface materials. To meet the above geological, geotechnical and geophysical task, 24 boreholes with SPT program, five MASW and three Down-hole seismic survey programs have been conducted into the field at Shibchar Upazila.

From the borehole log, six numbers of soil layers are found at this upazila. The upper three layers are mostly silty sand; Clayey Silt and organic Clay have SPT value range below 10. But SPT value gradually higher by increasing depth. From the Down hole seismic Test (PS Logging) the average shear wave velocity (AVS 30) up to 30 m are 141 to 160 m/s. According to MASW test result, shear wave velocity of the project area is showing soft to moderate soil condition for foundation. MASW-01, MASW-02 and MASW -04 test results are showing more than 180 m/s but others two locations the average velocity is bellow 180m/s.

Field and laboratory investigation data will be analyzed and result will be integrated with all information's in a module which can generate geomorphologic map, sub-surface litho-logical 3D model of different layers, engineering geological mapping based on AVS30, Seismic Hazard Assessment Map (risk sensitive micro-zonation maps), soil type map, seismic intensity map, Peak Ground Acceleration (PGA) and recommended building height maps for both high rise building and low rise building, Ground Failure Map etc.

From above geotechnical and geological data base would give a clear idea about the geo-hazard status of particular landscape where newly urban developing activities or any other mega infrastructure project is going on and this mentioned investigation also gives idea about the vulnerability of existing build up infrastructure of a particular area. Based on these results, proper management techniques as well as other necessary adaptation process could be addressed before or after the development activities in the studied area. On the other hand, if the infrastructures are built according to this risk informed physical land-use plan, the long-term maintenance cost will be reduced and the developed structure will withstand against the potential natural hazards.

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Abbreviations

ASTM	:	American Society for Testing and Materials
AVS30	:	Average Shear Wave velocity of 30 meter depth
BH	:	Borehole
MASW	:	Multi-Channel Analysis of Surface Wave
N value	:	Soil resistance or compactness
PGA	:	Peak Ground Acceleration
PGV	:	Peak Ground Velocity
PS logging	:	Primary and Shear wave logging (Down-hole seismic test)
SA	:	Spectral Acceleration
SPAC	:	Spatial Autocorrelation
SPT	:	Standard Penetration Tests
UDD	:	Urban Development Directorate
EGL		Existing Ground Level
GWL		Ground Water Level

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CHAPTER-01: INTRODUCTION

1.1. BACKGROUND:

Horizontal expansion of urban area is rapidly increasing in Bangladesh with respect to their rapid population growth and increasing life expectance of the peoples. But present trend of planning practice is mostly oriented towards planning of major cities and towns, not in all other towns or growth centers because huge amount of financial allocation/grants involvement. Recent policy of government, the upazila has been recognized as the most significant tier of administration. So that these areas are need to be planned and developed to accommodate all social, economic, administrative, infrastructure services and service facilities. The government's intention is to reflect the national policy of bringing development administrative and service facilities to the door step of rural masses and to ensure better delivery of government services to the people. Realizing the fact and importance of formulating development plans for upazilas, Urban Development Directorate has come up with a great initiative to plan those areas. At the first phase of this initiative UDD has decided to prepare development plan for 14 Upazilas all over Bangladesh into five different packages. For each package separate consultancy team has been appointed to carry out that job more fruitfully. Desh Upodesh Ltd. in Association with AAIMA International BD Ltd. and Tech-SUS Ltd has been selected for package-1 (covering Dohar Upazila, Dist: Dhaka; Nawabganj Upazila, Dist: Dhaka; and Shibchar Upazila, Dist: Madaripur) by project evaluation committee of UDD.

Subsurface geological and geotechnical information's has been considered for a durable and sustainable urban environment. Primarily this work is to determine subsurface soil condition of the project area and evaluating of natural geological and hydro-meterological hazards such as earthquake, landslide and ground failure which integrate the consequence into the design of the infrastructure.

Regarding this study, following investigations and surveys has been carried out in the field which are geo-morphological survey; drilling of boreholes and preparation of borehole logs; collection of undisturbed and disturbed soil sample as per standard guide line; conducting standard penetration tests (SPTs); drilling of boreholes and casing by PVC pipe for conducting Down-hole seismic test; conducting Down-hole seismic test and conducting Multi-Channel Analysis of Surface Wave (MASW). Geologically and structurally the area is not much complex, that's why geotechnical and geophysical investigations are covered whole floodplain area except low or marshy land up to 30 meter depth from ground level and almost everywhere soil sediments are fluvial type of deposit which are much soft and thicker.

Following laboratory testing of soil samples such as Grain size analysis, Natural moisture content, Atterberg limits, Specific Gravity, Direct Shear Test, Unconfined Compression strength, etc has been performing in the laboratory which will give more qualitative and quantitative information about the subsurface materials. These field and laboratory test data will be analyzed and integrated into a module to produce risk sensitive micro-zonation maps.

1.2. SCOPE OF WORK:

The aim of this work is to determine subsurface soil condition of the project area and evaluating of natural geological and hydro-meterological hazards such as earthquake, liquefaction, ground failure and integrate the consequence into the design of the infrastructure. The main objective will be achieved through accomplishment of the following sub-objectives:

a) Preparation of Geological map of the study area.
b) Preparation of sub-surface lithological 3D model of different layers through geo- technical investigation

c) Preparation of engineering geological mapping based on AVS30
d) Determination of soil type in the project area
e) Foundation layer identification
f) Preparation of Seismic Hazard Map
g) Finally intensity map is prepared for high rise and low rise building

1.3. BRIEF DESCRIPTION OF THE AREA

Shibchar Upazila under Madaripur district has an area of 321.88sq km (Shibchar Upazila at a Glance)and located in between 23°15' and 23°30' north latitudes and in between 90°05' and 90°17' east longitudes (Banglapedia,2015). The upazila has the Sadarpur Upazila and the Padma river on the north, Madaripur Sadar and Rajoir Upazila on the south; Zinzira Upazila on the east. The upazila is comprised of 19 unions and 506 villages.Shibchar has 212 villages under 19 unions. There is also a paurashava in the upazila.

Map 1: Shibchar Upazila Map

Map Source: Banglapedia

The exact reason for naming of the upazila is not clear. But it was named according to the Hindu god Shib. This upazila is famous for great Islamic reformist and freedom fighter of Bengal HAJI SHARIATULLAH(1781-1840) who was born in this upazila at village Shamail. He was the initiator of Faraizi Movement in this region in the nineteenth century that subsequently spread all over East Bengal. His son Muhsinuddin Ahmad Alias Dudumiyan (1819-1862) re-established the '*Panchayet System*' in the Faraizi dominated region; he even formed a *lathial bahini* (affray fighters) for self-defense.

CHAPTER-02: METHODOLOGY

The methods and materials used to carry out of these activities have been described below-

2.1. TEST DETAILS AND PROCEDURE OF DOWN-HOLE SEISMIC TEST (PS LOGGING)

Main objectives of downhole seismic test to measure the travelling time of elastic wave from the ground surface to some arbitrary depths beneath the ground. The seismic wave was generated by striking a wooden plank by a sledge hammer. The plank was placed on the ground surface at around 1 m in horizontal direction from the top of borehole. The plank was hit separately on both ends to generate shear wave energy in opposite directions and is polarized in the direction parallel to the plank.

The shear wave emanated from the plank is detected by a tri-axial geophone. The geophone was lowered to 1 m below ground surface and attached to the borehole wall by inflating an air bladder. Then, the measurements were taken at every 1 m interval until the geophone was lowered to 30 m below ground surface. For each elevation, 3 records were taken and then used to calculate the shear wave velocity.

Plate 1: Downhole Seismic Test data logger

2.2.1. Procedure of Field Work and Analysis

a) A wooden plank with an approximate dimension of 2 ft x 1 ft x 2 ft is fixed to the ground. The wooden plank is placed about 1m from the borehole as shown in Plate 2.

Plate 2: Wooden Plank as the Vibration Source

b) Cables are wired from the geophone Plate 3 and the trigger to the data acquisition unit Plate 4. Signals in the vertical, radial and transverse directions are recorded by the data acquisition unit.

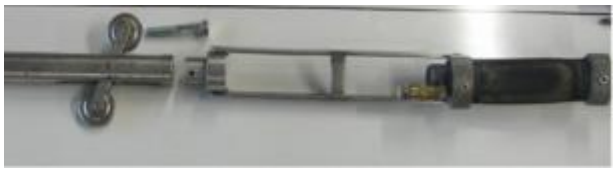


Plate 3: Geophone

Plate 4: Data Acquisition Unit

c) The geophone is lowered into the borehole as shown in Plate 5 Then, air is pumped into the air bag to fix the geophone to the casing (PVC pipe) at 1 m interval in depth basically.

Plate 5: Geophone Lowering In the Borehole

d) Excitations are generated by hitting the wooden plank in three directions by the hammer.

Plate 6: Direction of Excitations

e) Data is recorded in the data acquisition unit. Figure 1 illustrates a typical dataset in obtaining the arrival time of S-wave. Hitting the wooden plank in opposite directions generates signals as shown in the

figure. The time that two curves begin to separate is the arrival time of shear wave. By doing the same analysis for every depth, S-wave profiles are obtained throughout the depth of the borehole.

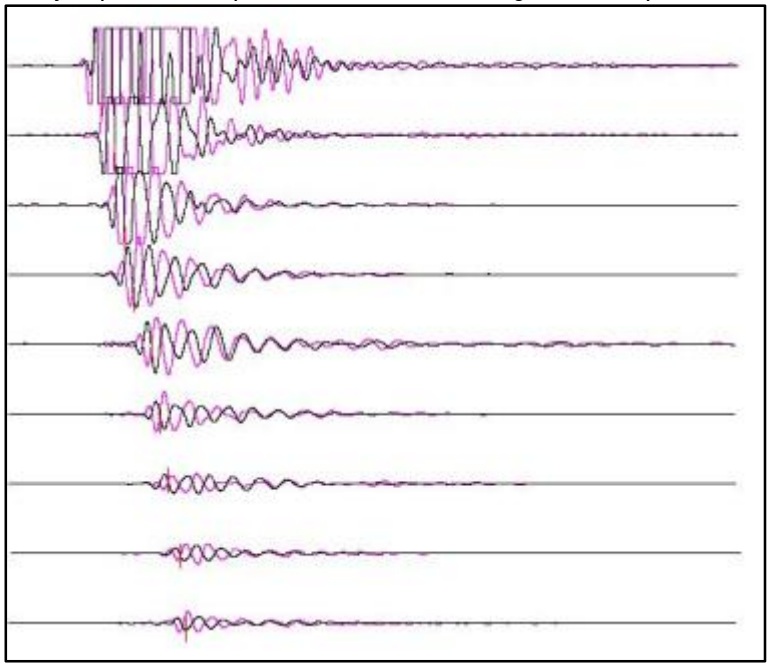
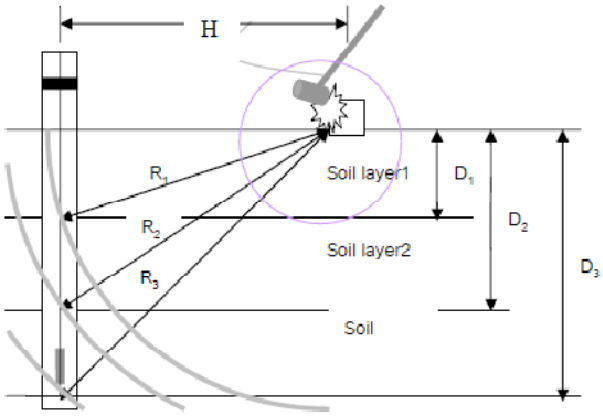


Figure 1: Determination of the Arrival Time of S-Wave

f) Using the raw data of the test depth (D), the shortest pass (R) and the recorded arrival time of S-wave (t) in the inclined path is calculated to the travel time, t_c, in the vertical path as shown in Figure 2.



$$t_c = D\frac{t}{R}$$

Where
t_c is the corrected travel time
D is the testing depth from ground surface,
t is the first arrival time from test
R is the distance between the source an receiver

[*Auld 1977*]

Figure 2: Calculation of the Travel Time

g) By plotting the corrected travel time versus depth, the velocity of every 1 m interval is calculated from (Auld 1977)

$$V_d = \frac{\Delta D}{\Delta t_c} \text{ [Auld 1977]}$$

Where, ΔD is depth interval showing similar slope and Δt_c is the corrected travel time difference of ΔD.

2.2. TEST DETAILS AND PROCEDURE OF MULTI-CHANNEL ANALYSIS OF SURFACE WAVE (MASW)

Multichannel Analysis of Surface Wave (MASW) is recent and very popular method for computation of shear wave velocity. This method is widely used for seismic microzonation. A MASW is a seismic surface method, widely used for subsurface characterization and is increasingly being applied for seismic microzonation and site response studies (Anbazhagan and Sitharam, 2008). It is also used for the geotechnical characterization of near surface materials (Park and Miller, 1999; Xia et al., 1999; Miller et al., 1999; Anbazhagan and Sitharam, 2008). MASW is used to identify the subsurface material boundaries, spatial and depth variations of weathered and engineering rocks (Anbazhagan and Sitharam, 2009). We have used the MASW system consisting of 12 channels Geode seismograph with 12 vertical geophones of 10 Hz capacity.

The measuring procedure in this project is shown as follows:

I. To decide the measuring line
II. To set receivers along the line at the ground surface. The intervals of each geophone are 3m.
III. To set an acrylic board at a half interval outside the line
IV. To shoot it vertically. Then generated elastic waves are recorded by receivers.
V. To shift the acrylic board between second receiver and the third receiver, and shoot it vertically. Then generated elastic waves are recorded at receivers.
VI. To iterate this procedure up to setting the acrylic boards at a half interval outside the other side of the line.

The data acquisition parameters are given in table 1.

Table 1: MASW Data Acquisition Parameters

Seismic refraction	
Number of channels	12
Geophone spacing	3m
Array length	33m
Sampling rate	1ms
Record length	2 sec
Natural frequency of Geophone	10 Hz
Source	8 kg hammer
Shot number	13 points, 11 between geophones and 2 outside of measuring line

Source: Park and Miller, 1999; Xia et al. 1999; Miller et al. 1999; Anbazhagan and Sitharam, 2008.

2.2.1. Analysis of MASW

Data processing consists of two main steps: (i) Obtaining the dispersion curves of Rayleigh wave phase velocity from the records; (ii) Determining the V s profiles from which the Vs30 values are calculated (see figure 3). In the phase velocity analysis, SPAC (Spatial Autocorrelation) method (Okada, 2003) is employed. Okada (2003) shows Spatial Autocorrelation function ρ (ώ, r) is expressed by Bessel function.

$$\rho(\omega, r) = J_0(\omega r / c(\omega))$$ [*Okada, 2003*]

Where, r is the distance between receivers, ώ is the angular frequency, c (ώ) is phase velocity of waves, J_0 is the first kind of Bessel function. The phase velocity was obtained at each frequency using equation (2). A one dimensional inversion using a non-linear least square method has been applied to the phase velocity curves. In the inversion, the following relationship between P-wave velocity (Vp) and Vs (Kitsunezaki et. al., 1990):

$$Vp = 1.29 + 1.11Vs$$ [*Kitsunezaki et. al., 1990*]

Where, Vs is S-wave velocity (km/s), Vp is P-wave velocity (km/s). In order to assume density ρ (g/cm3) from S-wave velocity, the relationship of Ludwig et al. (1970) is used.

$$\rho = 1.2475 + 0.399Vp - 0.026Vp^2$$ [*Ludwig et al. (1970)]*

These calculations are carried out along the measuring line, and the S-wave velocity distribution section was analyzed.

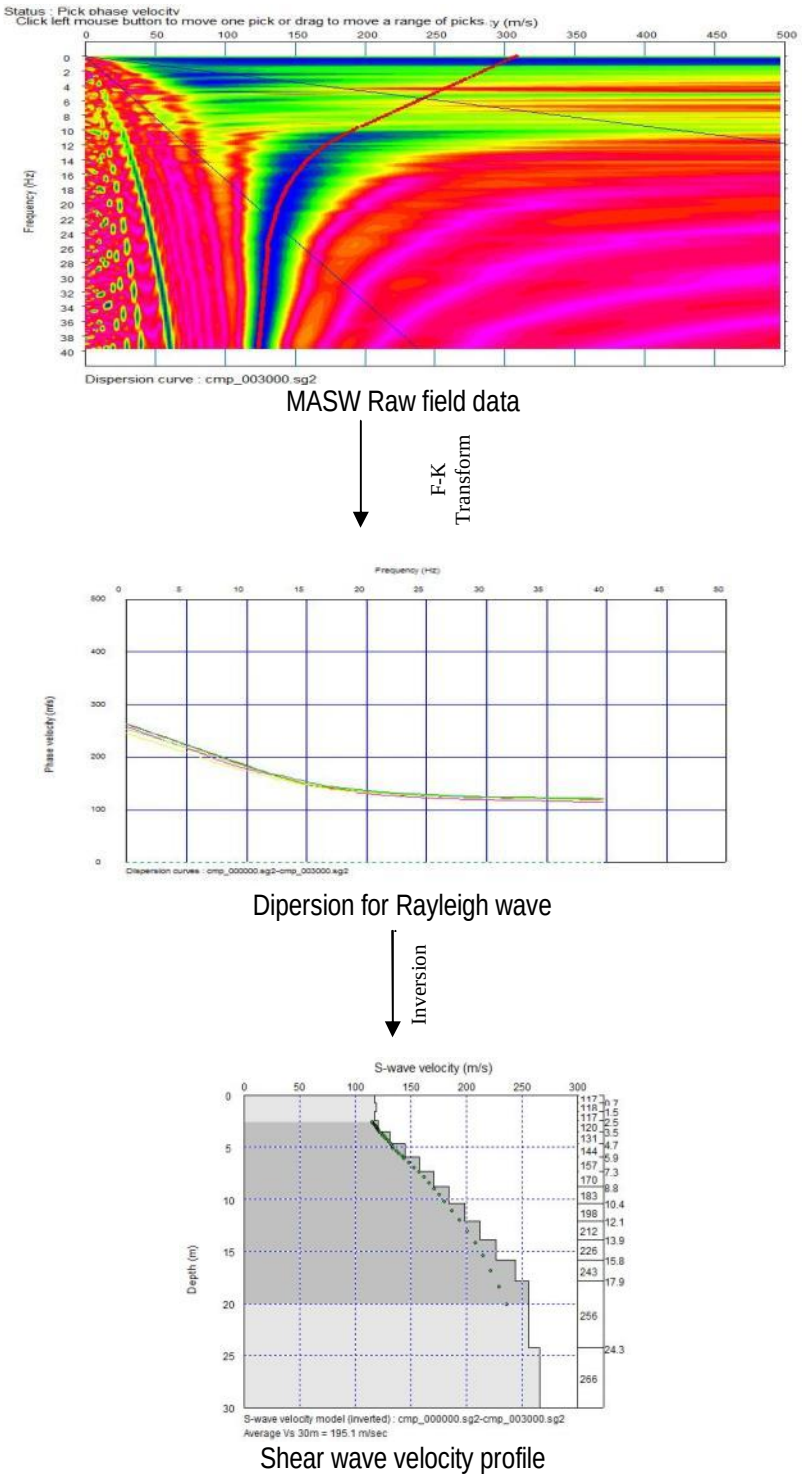


Figure 3: Main Step of the MASW Processing Technique

2.3. TEST DETAILS AND PROCEDURE OF STANDARD PENETRATION TEST

The geotechnical boreholes have been constructed using wash boring method. In this investigation, 24 numbers of boreholes have been prepared at Shibchar Upazila. The borehole logs are enclosed in the Appendix C. The boring method has been described in the following section.

2.3.1. Drilling

The bore holes are being drilled through mechanical percussion wash boring method at the locations previously decided. As 30 m boring is so complicated and time consuming moreover it has done continuously to the end to prevent the possibility of caving of the boring wall, is will been decided to send two sets of worker who will work in 8 hrs until desired depths will be achieved. In this manner the estimated time for boring execution will 13- shifts and 12- shifts are considered for mobilization, assemble and disassemble of the equipment, site cleanup and backfill the bore holes to their pre-existing condition.

2.3.2. Data Collection

The field data are being collected according to the respective standard methods. First of all the location, areal coverage, topography, geomorphology of the test site are note down. The soil sample collection procedure is mentioned in the section 2.3.4. While SPT soil samples are collected. At the same time, the ground water table is note down.

2.3.3. SPT Execution

As it mentioned earlier, the geotechnical boreholes will be constructed using mechanical boring method. The depth of those boreholes is to 30m. In this method N values (standard Penetration Test) is counted and soil sample also be taken in every 1.5m depth interval. The subsequent procedure which has been followed during the field work is furnished as follows:

I. Drill a 100-200 mm (2.5-8 in) diameter exploratory boring to the depth of the first test.
II. Insert the SPT sampler (also known as a Split-spoon Sampler) into the boring. The shape and dimensions of this sampler are shown in Figure 4. It is connected via steel rods to a 63.5 kg (140 lb) hammer, as shown in Figure 5.
III. An automatic tripping mechanism (in case of rotary drilling used this technique in this investigation), raise the hammer a distance of 760 mm (30 in) and allow it to fall. This energy drives the sampler into the bottom of the boring. Repeat this process until the sampler has penetrated a distance of 450 mm (18 in), recording the number of hammer blows required for each 150 mm (6 in) interval.
IV. Compute the N-value by summing the blow counts for the last 300 mm (12 in) of penetration. The blow count for the first 150 mm (6 in) is retained for reference purposes, but not used to compute N because the bottom of the boring is likely to be disturbed by the drilling process and may be covered with loose soil that fell from the sides of the boring.
V. Extract the SPT sampler, then remove and save the soil sample (disturbed sample).
VI. Drill the boring to the depth of the next test and repeat steps 2 through 6 as required.

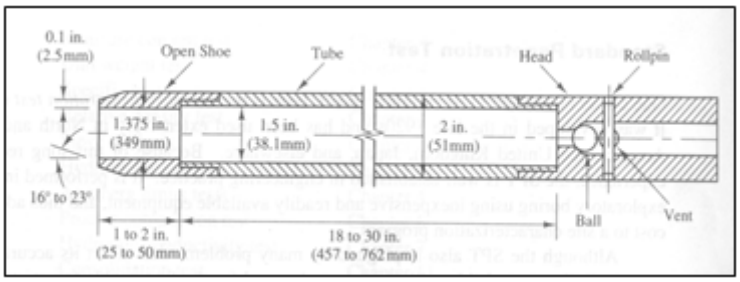


Figure 4: Split-spoon sampler.

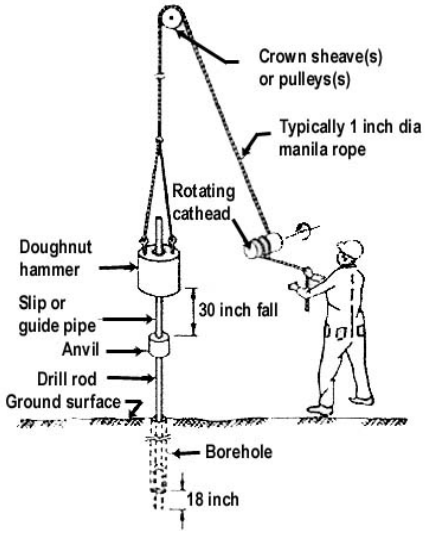


Figure 5: The SPT sampler in place in the boring with hammer

2.3.4. SOIL SAMPLING

Two main categories of soil samples are collected, undisturbed and disturbed. Undisturbed samples, which are required mainly for shear strength and consolidation tests, are obtained by techniques which aim at preserving the in-situ structure and water content of the soil. In boreholes, undisturbed samples can be obtained by withdrawing the boring tools (except when hollow-stem continuous-flight augers are used) and driving or pushing a sample tube into the soil at the bottom of the hole. The sampler is normally attached to a length of boring rod which can be lowered and raised by the cable of the percussion rig. When the tube is brought to the surface, some soil is removed from each end and molten wax is applied, in thin layers, to form a seal approximately 25mm thick: the ends of the tube are then covered by protective caps. Undisturbed block samples can be cut by hand from the bottom or sides of a trial pit. During cutting, the samples must be protected from water, wind and sun to avoid any change in water content: the samples should be covered with molten wax immediately they have been brought to the surface. It is impossible to obtain a sample that is completely undisturbed, no matter how elaborate or careful the ground investigation and sampling technique might be. In the case of clays, for example, swelling will take place adjacent to the bottom of a borehole due to the reduction in total stresses when soil is removed and structural disturbance may be caused by the action of the boring tools; subsequently, when a sample is removed from the ground the total stresses are reduced to zero.

Soft clays are extremely sensitive to sampling disturbance, the effects being more pronounced in clays of low plasticity than in those of high plasticity. The central core of a soft clay sample will be relatively less disturbed

than the outer zone adjacent to the sampling tube. Immediately after sampling, the pore water pressure in the relatively undisturbed core will be negative due to the release of the in-situ total stresses. Swelling of the relatively undisturbed core will gradually take place due to water being drawn from the more disturbed outer zone and resulting in the dissipation of the negative excess pore water pressure: the outer zone of soil will consolidate due to the redistribution of water within the sample. The dissipation of the negative excess pore water pressure is accompanied by a corresponding reduction in effective stresses. The soil structure of the sample will thus offer less resistance to shear and will be less rigid than the in-situ soil.

A disturbed sample is one having the same particle size distribution as the in-situ soil but in which the soil structure has been significantly damaged or completely destroyed; in addition, the water content may be different from that of the in-situ soil. Disturbed samples, which are used mainly for soil classification tests, visual classification and compaction tests, can be excavated from trial pits or obtained from the tools used to advance boreholes (e.g. from augers and the clay cutter). The soil recovered from the shell in percussion boring will be deficient in fines and will be unsuitable for use as a disturbed sample. Samples in which the natural water content has been preserved should be placed in airtight, non-corrosive containers: all containers should be completely filled so that there is negligible air space above the sample.

All samples should be clearly labeled to show the project name, date, location, borehole number, depth and method of sampling; in addition, each sample should be given a serial number. Special care is required in the handling, transportation and storage of samples (particularly undisturbed samples) prior to testing. The types of tube samplers used in this study are described below.

Thin-walled Sampler

Thin-walled samplers (Figure 6) have been used to collected undisturbed samples from boreholes. These samplers are used in soils which are sensitive to disturbance such as soft to firm clays and plastic silts. The sampler does not employ a separate cutting shoe, the lower end of the tube itself being machined to form a cutting edge. The internal diameter may range from 35 to 100 mm. The area ratio is approximately 10% and samples of first-class quality can be obtained provided the soil has not been disturbed in advancing the borehole. In trial pits and shallow boreholes the tube can often be driven manually

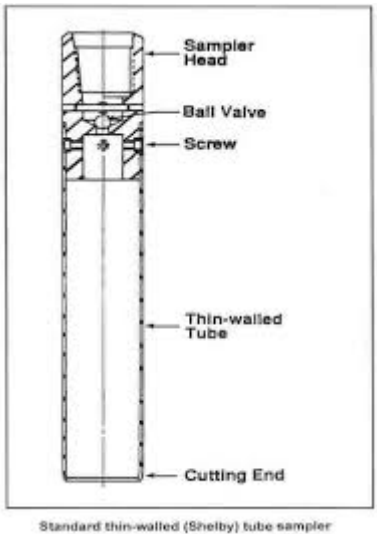


Figure 6: Thin-Walled (Shelby Tube) Sampler

Split-spoon sampler

Split-spoon samplers (Figure 7) have been to collect disturb samples. It consists of a tube which is split longitudinally into two halves: a shoe and a sampler head incorporating air-release holes are screwed onto the ends. The two halves of the tube can be separated when the shoe and head are detached to allow the sample to be removed. The internal and external diameters are 35 and 50 mm, respectively, the area ratio being approximately 100%, with the result that there is considerable disturbance of the sample. This sampler is used mainly in sands, being the tool specified in the standard penetration test (SPT).

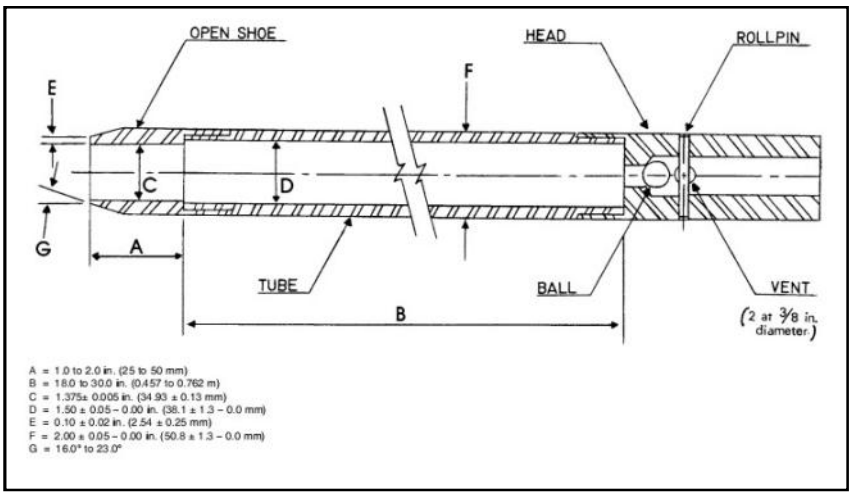


Figure 7: Undisturbed (Split-Spoon) Sampler

CHAPTER-03: SURVEY RESULT AT SHIBCHAR UPAZILA

3.1. GEOPHYSICAL INVESTIGATIONS

The main objectives of these investigation to estimate local site effects against earthquakes and the task has been segregated by three-fold: 1) To determine shear wave velocity profile at various sites, 2) To classify soil conditions according to seismic design specifications and 3) To analyze soil amplifications in the area. Field measurements of shear wave velocities were conducted in Shibchar Upazila and described in below.

Shear wave velocity profile (Vs profile) in the field were carried out by two geophysical exploration methods namely 1) seismic downhole test and 2) Multichannel Analysis of Surface Wave (MASW).

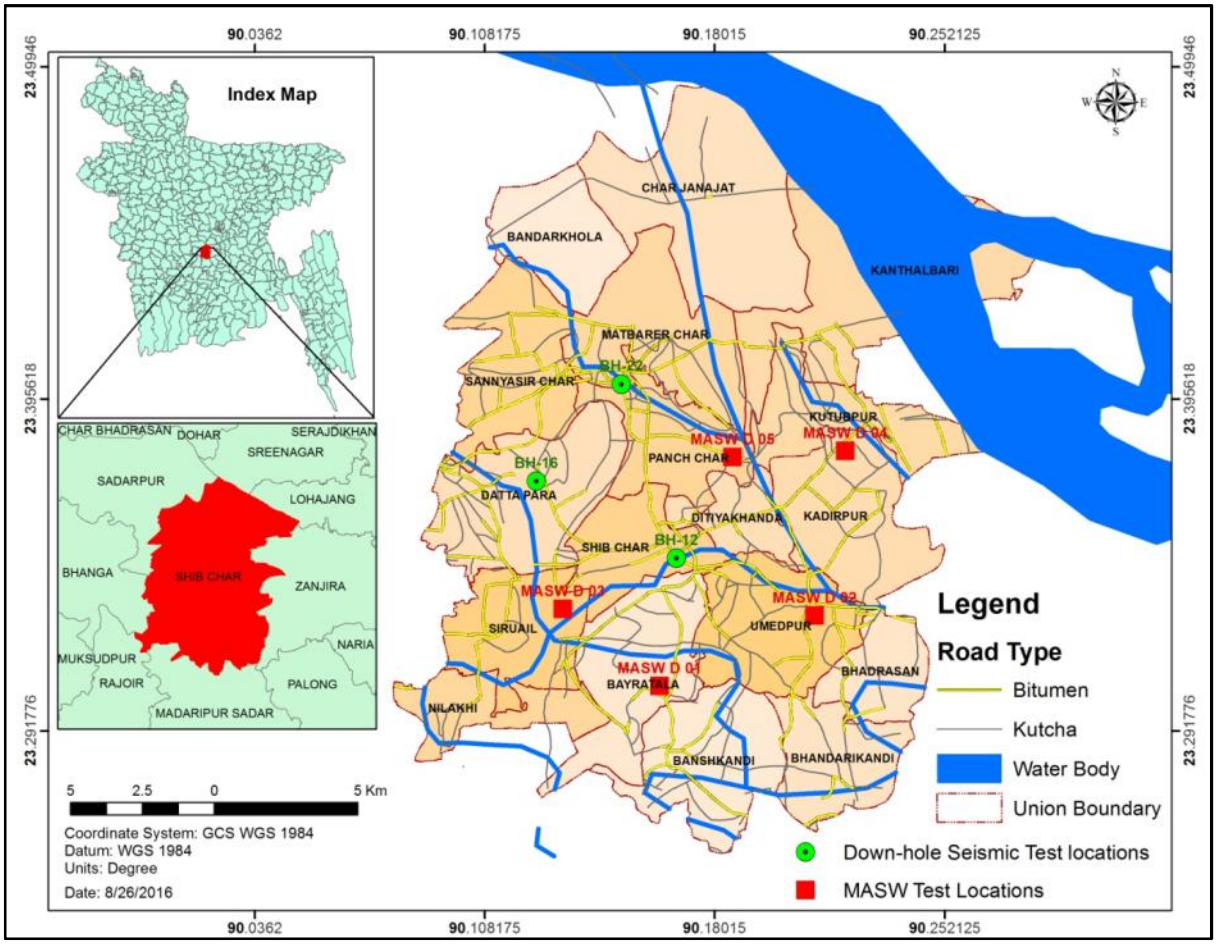
Seismic downhole test is a direct measurement method for obtaining the shear wave velocity profile of soil stratum. However, the test requires borehole which is not time and cost effective for the project. Multichannel analysis of surface waves (MASW) is a non-invasive technique which can be used to determine the Vs profile at sites. In this project, the seismic downhole and MASW tests were performed at 3 and 5 locations respectively. Locations of seismic downhole test and MASW tests are shown in Map 2. The GPS coordinate of the test locations are showing in Table 2.

Table 2: Down-hole Seismic Test (PS logging) and MASW test locations

Upazila Name	Test/ Survey Name	ID	Location Name	Coordinate	
				Latitude	Longitude
Shibchar	Downhole Seismic Test (PS Logging)	BH-12	Shibchar Model Govt. Primary school, Shibchar Sadar Pouroshava, Shibchar Upazila	23.34572	90.168121
		BH-16	Bachamora Bablatola Govt. Primary School, Bablatola Bazar, Datta Para Union	23.36984	90.124282
		BH-22	Paschar Girls High school, Matbarer Char union	23.40017	90.15089
	Multichannel analysis of surface waves (MASW)	MASW S 01	Chargojari Govt. Primary School, Uttar Bayratala Union, Shibchar	23.30574	90.16282
		MASW S 02	Nurul Amin University College, Umedpur Union, Shibchar	23.32779	90.21139
		MASW S 03	PurbaKakor High School, Charshamail, Siruail Union, Shibchar	23.32985	90.13261
		MASW S 04	Hazratali, Baparikandi, Kadirpur Union, Shibchar	23.37936	90.221
		MASW S 05	Hoglarmat S.K.P. High School, Hoglarmat, Panch Char Union, Shibchar	23.3774	90.18571

Source: Field Survey, 2016

Map 2: Locations Map of the geophysical tests at Shibchar Upazila



Set receivers along the line at the ground surface and the intervals of each geophone are 3m

Vertical Geophone of 10 Hz capacity

Data Acquisition unit

shoot it vertically by 8kg hammer to generated elastic waves

MASW S 03- Purba Kakor High School, Charshamail, Siruail Union, Shibchar

Plate 7: MASW Data Acquisitions at Shibchar Upazila

Preparing PVC Casing for PS Logging Test

Test hole

Data Acquisition Unit

Geophone Installation into the Borehole

Paschar Girls High school, Matbarer Char union (Borehole ID: BH-22)

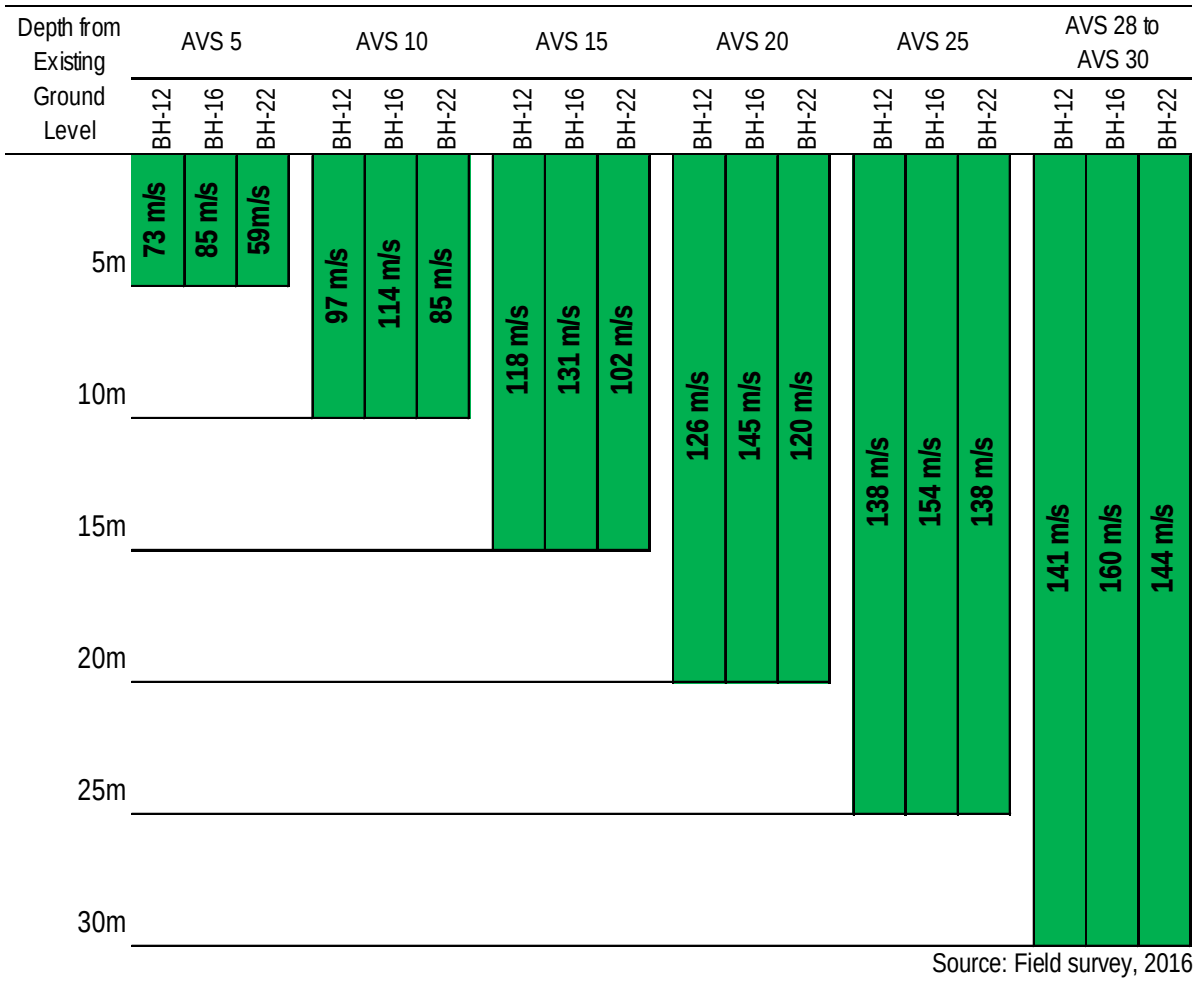
Plate 8: PS logging Data Acquisitions at Shibchar Upazila

3.1.1. Down-Hole Seismic (PS Logging) Test Results

As a fundamental parameter, shear wave velocity is required to define the dynamic properties of soils. If the soil velocity is less then 180m/s, it can be say as loose or soft soil. Estimation of shear wave velocity (Vs) / average shear wave velocity (AVS) and mapping is a way to characterize varying site conditions, and it can also be used to model earthquake-related ground shaking. Estimation of AVS aims to generate a map of estimated shear wave velocities for the upper 30m of the subsurface. Further this map can be used for seismic site response analysis i.e., to determine peak ground acceleration (PGA) and spectral acceleration (SA) values of both bedrock and ground surface. In this context, Downhole seismic test data acquisition has been completed at Shibchar Upazilla in three different locations on date 28th June 2016.

The average shear wave velocity (AVS) of each PS logging test are tabulated in Table 3. Work plan of the test depth was 30m, however, in some locations did not reach the geophone to the 30 m in depth due to adverse conditions of PVC.

Table 3: Summary of PS Logging Test Result



Source: Field survey, 2016

According to down hole seismic test results, the average shear wave velocities up to depth 30 are 141 m/s to 160 m/s. if considering 30 meter depth position, the average shear wave velocity of all borehole locations are showing soft or loose soil condition as foundation soil on the other hand if considering below 20 meter to 30 meter depth position, the average velocity of shear wave is showing moderate soil condition.. But actual soil condition (soil type, engineering properties and seismic behavior of soil) will be known when all the field data (SPT and soil laboratory test result, down hole seismic test result and MASW test result) has been integrated in a module to produces different type of maps including micro-zonation map of the project area.

The shear wave velocities at every 1m interval of each site are given in Appendix A at tabular and also graphical format.

3.1.2. MASW Survey Result

To predict subsurface shear-wave interval velocities, multi-spectral analyses of surface waves (MASW) are popularly used. Shear wave velocities can also extract additional velocity-related information such as mechanical properties of soils and rocks. In general, MASW data compare favorably to other geophysical methods for predicting interval velocities. Furthermore, comparisons to vertical seismic profiles correlate well with MASW predicted shear wave interval velocities. In this perspective, MASW test has been completed at five different locations at Shibchar Upazilla by 30th June and field raw data has been processed and also interpreted. The results of the MASW test are enclosed in Appendix B at tabular and also graphical format.

According to MASW test result, shear wave velocity of the project area is showing soft to moderate soil condition for foundation. MASW-01, MASW-02 and MASW -04 test results are showing more than 180 m/s but others two locations the average velocity is bellow 180m/s. The detail MASW survey results are shown in Table 4.

Table 4: Summary of MASW Test Results

MASW S 1		MASW S 2		MASW S 3		MASW S 4		MASW S 5	
Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)
0.0	111	0.0	117	0.0	104	0.0	117	0.0	142
1.1	107	1.1	113	1.1	102	1.1	114	1.1	133
2.3	112	2.3	111	2.3	104	2.3	114	2.3	132
3.7	125	3.7	125	3.7	115	3.7	119	3.7	136
5.3	141	5.3	145	5.3	139	5.3	135	5.3	145
7.0	160	7.0	164	7.0	169	7.0	158	7.0	157
8.9	181	8.9	168	8.9	200	8.9	180	8.9	172
11.0	197	11.0	169	11.0	218	11.0	201	11.0	186
13.2	200	13.2	168	13.2	219	13.2	206	13.2	196
15.6	201	15.6	167	15.6	219	15.6	208	15.6	198
18.1	201	18.1	165	18.1	217	18.1	208	18.1	200
20.9	200	20.9	163	20.9	215	20.9	208	20.9	200
23.7	199	23.7	162	23.7	213	23.7	207	23.7	201
26.8	198	26.8	161	26.8	212	26.8	207	26.8	201
36.4	209	36.4	169	36.4	219	36.4	208	36.4	201
AVS 30- 217.8 m/s		*AVS 30- 186.2 m/s*		*AVS 30- 167 m/s*		*AVS 30- 213 m/s*		*AVS 30- 167 m/s*	

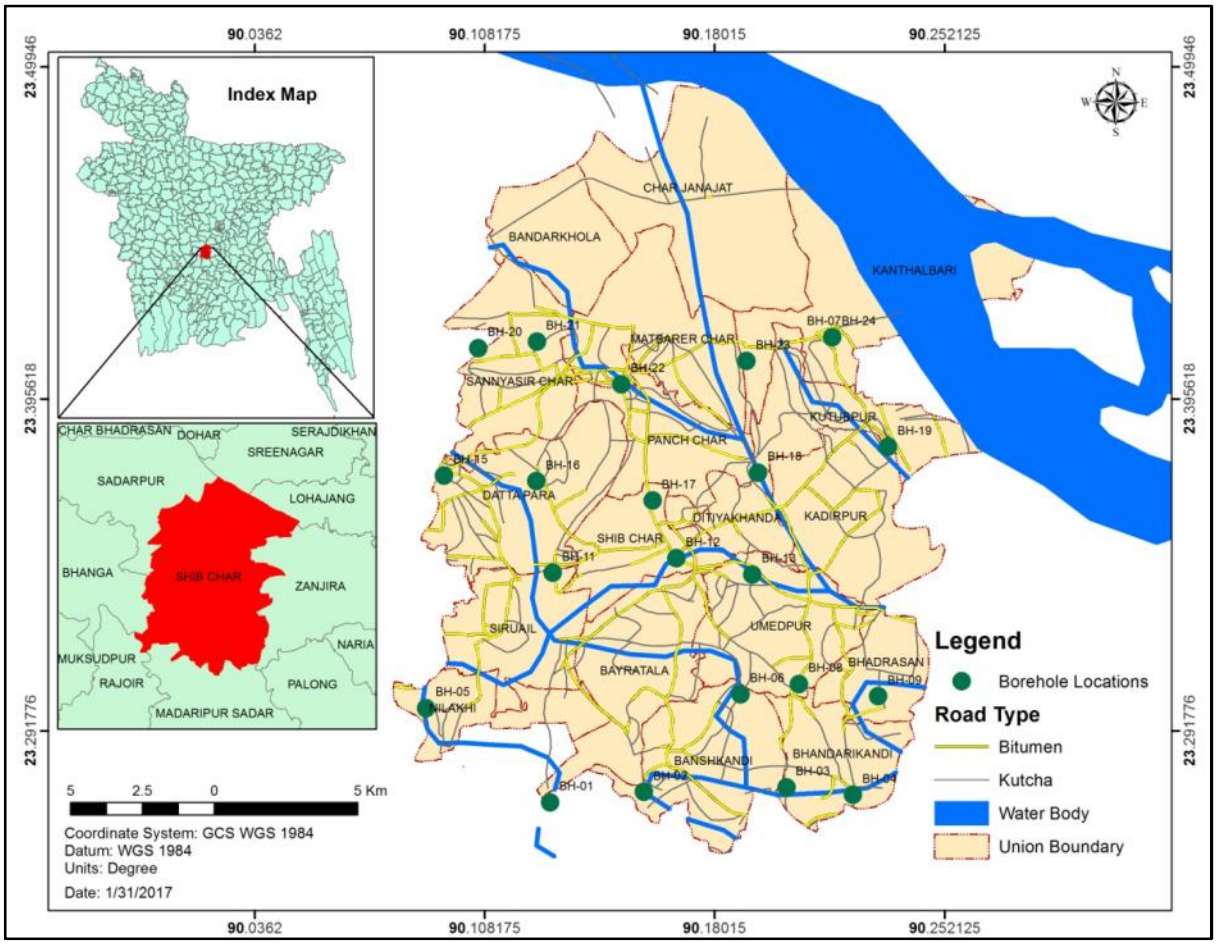
Velocity below 160m/s
Velocity 160m/s to 200m/s
Velocity 200m/s to 240m/s
Velocity 240m/s to 280m/s
Velocity 280m/s to 300m/s
Velocity above 300m/s

Source: Field survey, 2016

3.2. GEOTECHNICAL INVESTIGATIONS

To ensure safety of human beings and materials, geotechnical investigations have become an essential component of every construction, it includes a detailed investigation of soil strength, composition, water content, and other important soil characteristics. Investigation borings with standard penetration test were conducted in order to know vertical geological conditions. The borings with SPT were carried out at 24 points at Shibchar Upazila.

Map 3: Locations Map of the Standard Penetration tests (SPT) at Shibchar Upazila



3.2.1. Standard Penetration Test (SPT) Log Analysis and Interpretation

SPT is a common in-situ testing method used to determine the geotechnical engineering properties of subsurface soils. It was developed in the late 1920s and has been used extremely in North and South America, the United Kingdom, Japan, and elsewhere. Because of this long record of experience, the SPT is well-established in engineering practice. It is performed inside exploratory boring using inexpensive and readily available equipment, and thus adds little cost to a site characterization program. Although the SPT also is plagued by many problems that affect its accuracy and reproducibility, it probably will continue to be used for the foreseeable future, primarily because of its low cost. However, it is partially being replaced by other test methods, especially on larger and more critical projects.

All the borings has to be conducted and preparation of field bore log by visual classification has to be done in the presence of the experienced technical personnel. The borehole records have to be taken that include soil type, nature of sample, soil moisture content and consistency, SPT blow counts (N Value), ground water observation

and apparent origin (fill, alluvium, recent sediments, etc.) and daily field logs have been prepared. The bore locations are given in following table 5 and the geotechnical borehole log are enclosed in the below section.

Table 5: Bore Hole Information Summary at Shibchar Upazila

BH ID	Location	Coordinate		Union	Minimum SPT N Value	Maximum SPT N Value
		Lat	Long			
BH-01	Bayratala, Bayratala Union, Shibchar Upazil	23.26939	90.12854	Bayratala Union	2	48
BH-02	Char Shomvuk Bazar Jamai Mosque, Banshkandi Union	23.27265	90.15796	Banshkandi	2	49
BH-03	Tengramari Govt. Primary School, Bhandarikandi Union	23.27408	90.20258	Bhandarikandi	2	48
BH-04	BhandariKandi Union Complex Mat, BhandariKandi Union	23.27172	90.22341	BhandariKandi	4	54
BH-05	Nilakhi Union Porishod Bhovon, Nilakhi Union	23.29888	90.08979	Nilakh	2	38
BH-06	Bayratala Govt. Primary school, Dakhin Bayratala Union	23.3032	90.18824	Dakhin Bayratala	2	45
BH-07	53 no Chor Gojaria Govt. Primary School, Uttar Bayratala Union	23.41491	90.21689	Uttar Bayratala	2	46
BH-08	Aleshpur Mia bari Govt. Primary School, Umedpur Union	23.30641	90.20652	Umedpur	2	50
BH-09	Bhadrasan Mongol Howladar Bari, village-Kukchar, Bhadrasan Union,	23.30257	90.23129	Bhadrasan	7	49
BH-10	Aulia Jamai Mosgid, Patrail Dighirpar, Near Dattapara Union	23.84158	90.08948	Dattapara	5	42
BH-11	Utrail Munsi kandi govt. primary school, Siruail Union	23.3412	90.12942	Siruail	2	38
BH-12	Sibchor Model Govt. Primary School, Sibchar Pourashava	23.345724	90.168121	Sibchar Sadar	2	36
BH-13	Chor kasi kata Adarsha Govt. Primary School, Umedpur Union	23.34068	90.19188	Umedpur	3	53
BH-14	Bhadrasan Zinnatun Govt. Primary School, Bhadrasan Union	23.82462	90.23215	Bhadrasan	7	54
BH-15	Gubtar kandi A M (Abdul Mannan) Govt. Primary School, Datta Para Union	23.37161	90.09534	Datta Para	4	47
BH-16	Bachamara Bablatola Govt. Primary School, Datta Para Union	23.369838	90.124282	Datta Para	4	42
BH-17	Khan Kandi, Nilghora, Shibchar Pourashava,	23.36378	90.16066	Sibchar Sadar	1	49
BH-18	Chor Kesobpur Howlader Bari Mosjid, Village- Gajaria Kandi, Ditiyakhanda Union	23.37255	90.1937	Ditiyakhanda	2	40
BH-19	Kutubpur High School, Kutubpur Union, Shibchar	23.38058	90.23438	Kutubpur	3	70
BH-20	Al Jamiatul Koumi Madrasha, Village-Rajarchar, Sannyasirchar Union,	23.4115	90.10606	Sannyasirchar	7	44
BH-21	Sannyasirchar Union Complex, Sannyasirchar Union	23.41354	90.12445	Sannyasirchar	4	43
BH-22	Pacchor girls High School, Matbarer Char Union	23.40017	90.15089	Matbarer Char	1	49
BH-23	Omar Bapary Kandi Govt. Primary School, Kanthalbari Union	23.40743	90.19003	Kanthalbari	3	40
BH-24	Kanthalbari Union Complex, Kanthalbari Union,	23.41491	90.21689	Kanthalbari	6	65

Source: Field data, 2016

While boring and SPT testing, soil samples are being visually classified in the following way:

Sieve	**Soils**	**Designations**
+No 4 (4.76mm)	Gravel	
No.4 to No 10(2.00mm)	Coarse	Sand
No. 10 to No 40 (0.42mm)	Medium	Sand
No. 40 to No 200 (0.07mm)	Fine	Sand
No.200	Silt or Clay	

Some soil has one dominant lithology with minuscule amount of other soil type. In such cases, minor soil sample are written in the following manner with along with dominant soil type.

1. Trace 1 to 10%
2. Little 10 to 25%
3. With 25 to 35%

SPT- N value is also note down while SPT Testing. Then the collected soil samples are being cross checked with SPT-N values to ensure quality data collection.

Based on N-values, other very useful soil parameters may be obtained from the co-relation charts given by different research workers. Two such useful co-relations for cohesive and non-cohesive soils after K. Terzaghi are given below:

Table 6: Values of Relative Density (Dr.), Friction Angle and Unit Weight of Non- cohesive soil based on N-values

N-values	**Condition**	**Relative Density**	**Angle of Internal friction (Degree)**	**Moist Unit Weight (Pcf)**
0-4	Very Loose	0-15%	28^0	70-100
4-10	Loose	15-35%	28^0-30^0	95-125
10-30	Medium dense	35-65%	30^0-36^0	110-130
30-50	Dense	65-85%	36^0-41^0	110-140
Over 50	Very dense	85-100%	Over 41^0	> 130

Table 7**:** Values of Unconfined Compressive Strength based on N-values for Cohesive Soil (Approximate):

N-values	**Condition**	**Unconfined Compressive Strength (Tsf)**
Below 2	Very soft	Below 0.25
2-4	Soft	0.25-0.50
4-8	Medium stiff	0.50-1.00
8-16	Stiff	1.00-2.00
16-32	very stiff	2.00-4.00
Over 32	Hard	over 4.00

In the above table the shear strength of cohesive soil is equal to ½ of unconfined compressive strength and the angle of shearing resistance is equal to zero. It should be remembered that the co-relation for cohesive soil is not always much reliable.

The litholog are already written down in a standard format and has been attached in the appendix C.

CHAPTER-04: CONCLUSION

Shibchar Upazila and its adjoining areas is mostly comprises by monotonous flood plain area except few depression. Soil quality of the project area is varying as morphological difference, that's why geological, geotechnical and geophysical investigations has been carried out such a pattern to cover all morphological unit. In this consequences, 24 boreholes with SPT, 3 downhole seismic tests and 5 MASW program has been completed in the field as a part of this survey investigation. During this survey, soil samples (disturbed and undisturbed) are also collected for further laboratory test which will give idea about the soil engineering properties. This investigation data will be analyzed and integrated in a module from which it can possible to generate geomorphologic map, sub-surface litho-logical 3D model of different layers, engineering geological mapping based on AVS30, Seismic Hazard Assessment Map (risk sensitive micro-zonation maps), soil type map, seismic intensity map, Peak Ground Acceleration (PGA) and recommended building height maps for both high rise building and low rise building etc

Above investigation and outcomes would give a clear idea about the geo-hazard status of particular landscape where newly urban developing activities or any other mega infrastructure project is going on and this mentioned investigation also gives idea about the vulnerability of existing build up infrastructure of a particular area. Based on these results, proper management techniques as well as other necessary adaptation process could be addressed before or after the development activities in the studied area. It is to be mentioned that the long-term maintenance cost will be reduced and the developed structure will withstand against the potential natural hazards if the infrastructures are built following the risk informed physical land-use plan.

CHAPTER 5: REFERENCES

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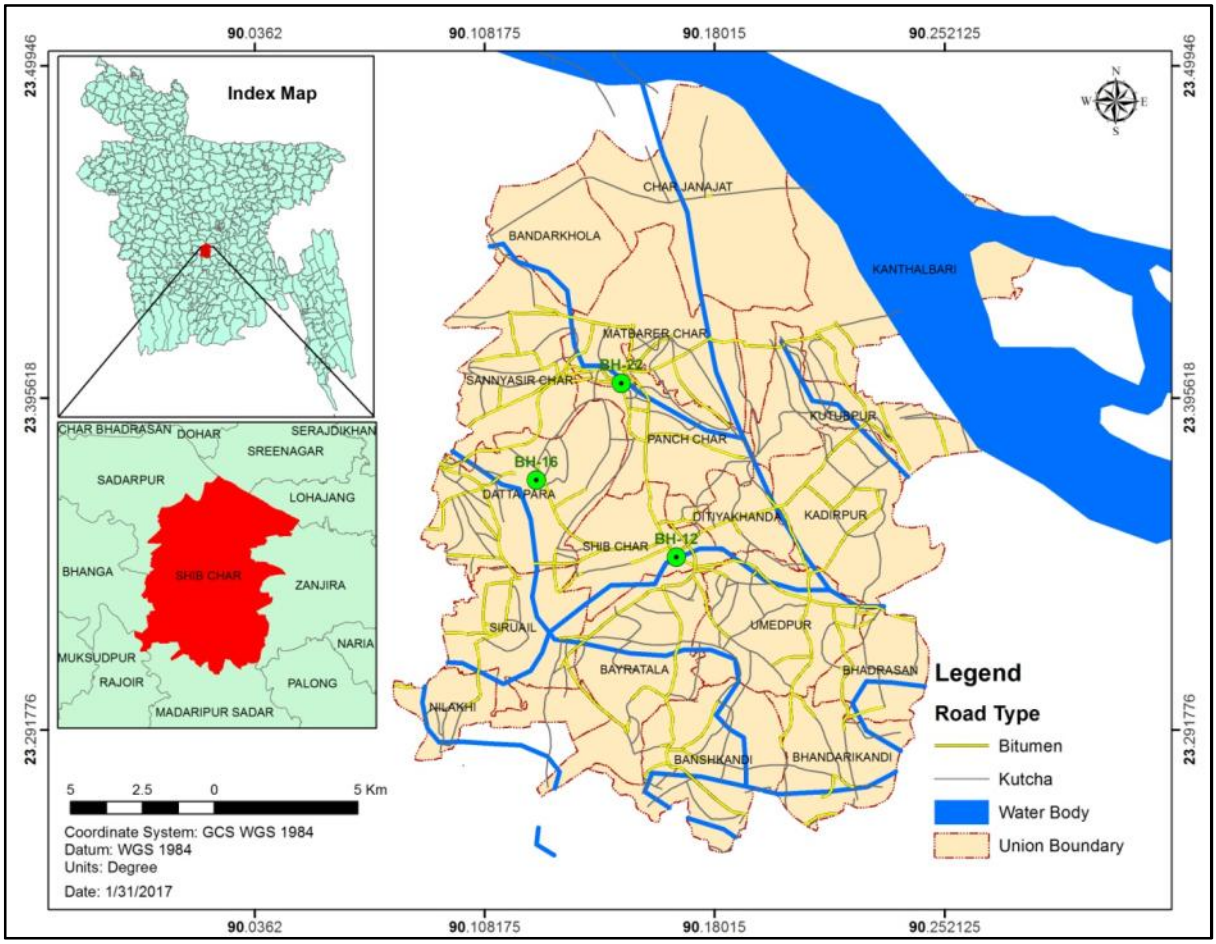
Appendix A

Downhole Seismic Test (PS Logging) Results and Graphs



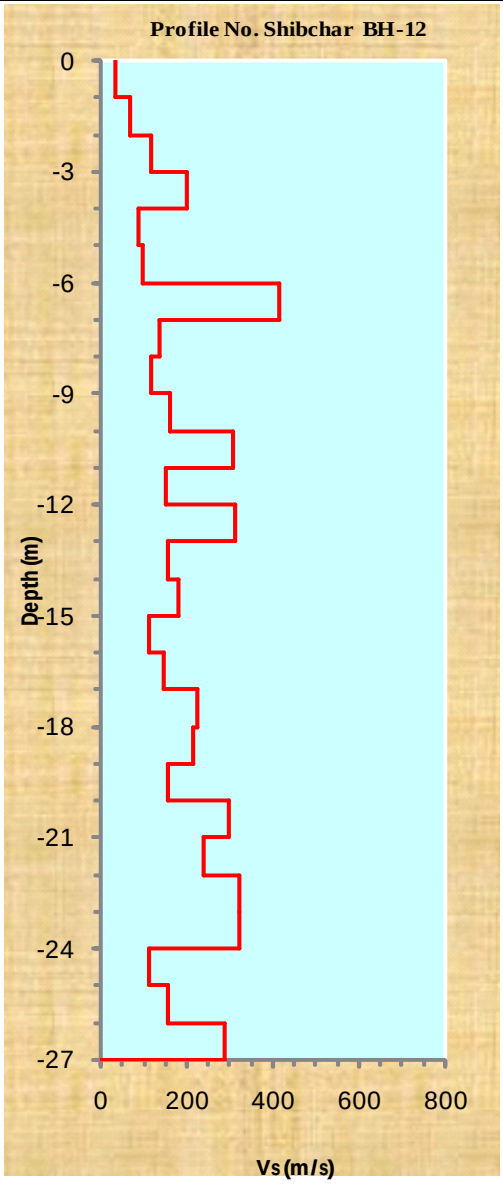
SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 30/06/2016
Location : Shibchar Model Govt. Primary school, Shibchar Sadar Pouroshava, Shibchar Upazila
PS Id : BH-12
Coordinate : Lat-23.345724 Long-90.168121
Operator : The Olson Instruments Downhole Seismic system

Source : 7kg Sledge Hammer
Downhole Receiver : Tri-axial Geophone
Recording Equipment: Freedom Data PC
Borehole Information : Grouted Cased
Casing Diameter : 75mm PVC Casing

Time arrival (s)	Recorded Geophone Depth from Existing Ground Level (m)	Source Saint Distance (m), R	Corrected Travel Time for Compretional Wave, tc=D*t/R (s)	Interval Time,ΔTs	Shear Wave Velocity Vs, Vs=D/tc (m/s)	Average Shear Wave Velocity (m/s)
Existing Ground Level						
0.039219	-1	1.41	0.0277	0.0277	36	AVS 5 73
0.047635	-2	2.24	0.0426	0.0149	67	
0.053762	-3	3.16	0.0510	0.0084	119	
0.057699	-4	4.12	0.0560	0.0050	201	
0.068822	-5	5.10	0.0675	0.0115	87	
0.078649	-6	6.08	0.0776	0.0101	99	AVS 10 97
0.080818	-7	7.07	0.0800	0.0024	412	
0.088052	-8	8.06	0.0874	0.0074	136	
0.096489	-9	9.06	0.0959	0.0085	117	
0.102640	-10	10.05	0.1021	0.0062	160	
0.105846	-11	11.05	0.1054	0.0033	305	AVS 15 118
0.112326	-12	12.04	0.1119	0.0065	153	
0.115461	-13	13.04	0.1151	0.0032	314	
0.121777	-14	14.04	0.1215	0.0063	158	
0.127315	-15	15.03	0.1270	0.0056	180	
0.136058	-16	16.03	0.1358	0.0088	114	AVS 20 126
0.142986	-17	17.03	0.1427	0.0069	144	
0.147418	-18	18.03	0.1472	0.0045	225	
0.152108	-19	19.03	0.1519	0.0047	212	
0.158518	-20	20.02	0.1583	0.0064	156	
0.161865	-21	21.02	0.1617	0.0034	297	AVS 25 138
0.166060	-22	22.02	0.1659	0.0042	238	
0.169147	-23	23.02	0.1690	0.0031	323	
0.172258	-24	24.02	0.1721	0.0031	320	
0.181274	-25	25.02	0.1811	0.0090	111	
0.187693	-26	26.02	0.1876	0.0064	156	AVS 27 141
0.191184	-27	27.02	0.1911	0.0035	286	

Graphical Representation of Vs



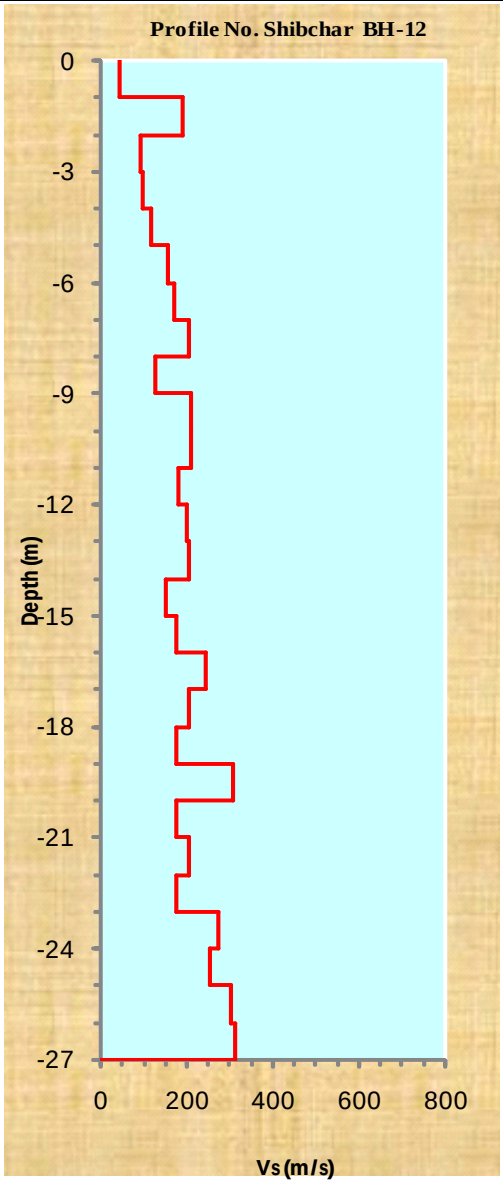
SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 30/06/2016
Location : Bachamora Bablatola Govt. Primary School, Bablatola Bazar, Datta Para Union
PS Id : BH-16
Coordinate : Lat-23.345724 Long-90.168121
Operator : The Olson Instruments Downhole Seismic system

Source : 7kg Sledge Hammer
Downhole Receiver : Tri-axial Geophone
Recording Equipment: Freedom Data PC
Borehole Information : Grouted Cased
Casing Diameter : 75mm PVC Casing

Time arrival (s)	Recorded Geophone Depth from Existing Ground Level (m)	Source Saint Distance (m), R	Corrected Travel Time for Compretional Wave, tc=D*t/R (s)	Interval Time,ΔTs	Shear Wave Velocity Vs, Vs=D/tc (m/s)	Average Shear Wave Velocity (m/s)
Existing Ground Level						
0.032051	-1	1.41	0.0227	0.0227	44	
0.031250	-2	2.24	0.0280	0.0053	189	
0.040865	-3	3.16	0.0388	0.0108	92	
0.050480	-4	4.12	0.0490	0.0102	98	
0.058732	-5	5.10	0.0576	0.0086	116	AVS 5 85
0.064903	-6	6.08	0.0640	0.0064	156	
0.070512	-7	7.07	0.0698	0.0058	173	
0.075223	-8	8.06	0.0746	0.0048	207	
0.083076	-9	9.06	0.0826	0.0079	126	AVS 10 114
0.087788	-10	10.05	0.0874	0.0048	209	
0.092500	-11	11.05	0.0921	0.0048	210	
0.097997	-12	12.04	0.0977	0.0055	181	
0.103002	-13	13.04	0.1027	0.0050	198	
0.107896	-14	14.04	0.1076	0.0049	203	AVS 15 131
0.114422	-15	15.03	0.1142	0.0065	153	
0.120133	-16	16.03	0.1199	0.0057	175	
0.124211	-17	17.03	0.1240	0.0041	244	
0.129106	-18	18.03	0.1289	0.0049	204	
0.134816	-19	19.03	0.1346	0.0057	175	AVS 20 145
0.138079	-20	20.02	0.1379	0.0033	305	
0.143790	-21	21.02	0.1436	0.0057	175	
0.148684	-22	22.02	0.1485	0.0049	204	
0.154394	-23	23.02	0.1542	0.0057	175	AVS 25 154
0.158025	-24	24.02	0.1579	0.0036	275	
0.161952	-25	25.02	0.1618	0.0039	254	
0.165242	-26	26.02	0.1651	0.0033	303	
0.168448	-27	27.02	0.1683	0.0032	311	AVS 27 160

Graphical Representation of Vs



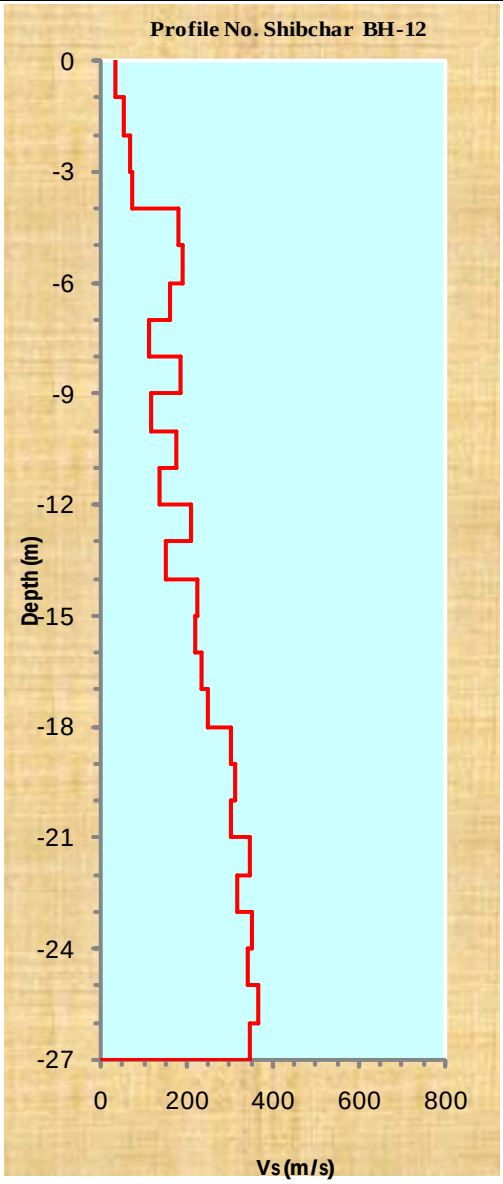
SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 30/06/2016
Location : Paschar Girls High school, Matbarer Char union, Shibchar Upazila
PS Id : BH-22
Coordinate : Lat-23.345724 Long-90.168121
Operator : The Olson Instruments Downhole Seismic system

Source : 7kg Sledge Hammer
Downhole Receiver : Tri-axial Geophone
Recording Equipment: Freedom Data PC
Borehole Information : Grouted Cased
Casing Diameter : 75mm PVC Casing

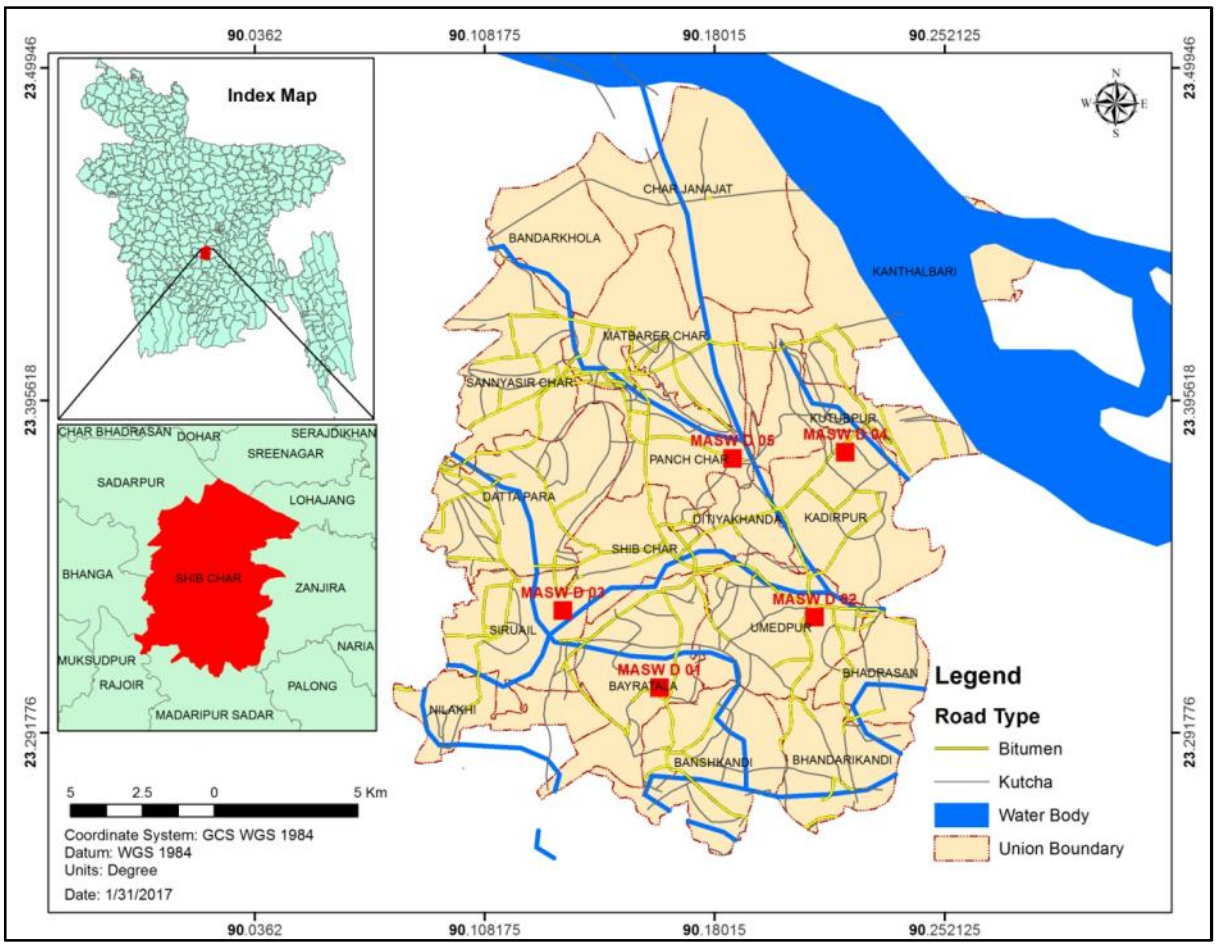
Time arrival (s)	Recorded Geophone Depth from Existing Ground Level (m)	Source Saint Distance (m), R	Corrected Travel Time for Compretional Wave, tc=D*t/R (s)	Interval Time,ΔTs	Shear Wave Velocity Vs, Vs=D/tc (m/s)	Average Shear Wave Velocity (m/s)
Existing Ground Level						
0.043139	-1	1.41	0.0305	0.0305	33	AVS 5 59
0.055051	-2	2.24	0.0492	0.0187	53	
0.067287	-3	3.16	0.0638	0.0146	69	
0.079911	-4	4.12	0.0775	0.0137	73	
0.084752	-5	5.10	0.0831	0.0056	179	
0.089597	-6	6.08	0.0884	0.0053	190	AVS 10 85
0.095496	-7	7.07	0.0945	0.0062	162	
0.104239	-8	8.06	0.1034	0.0089	112	
0.109564	-9	9.06	0.1089	0.0055	183	
0.118180	-10	10.05	0.1176	0.0087	115	
0.123853	-11	11.05	0.1233	0.0058	174	AVS 15 102
0.131230	-12	12.04	0.1308	0.0074	135	
0.135963	-13	13.04	0.1356	0.0048	209	
0.142642	-14	14.04	0.1423	0.0067	149	
0.147082	-15	15.03	0.1468	0.0045	223	
0.151625	-16	16.03	0.1513	0.0046	219	AVS 20 120
0.155871	-17	17.03	0.1556	0.0043	234	
0.159874	-18	18.03	0.1596	0.0040	248	
0.163147	-19	19.03	0.1629	0.0033	304	
0.166315	-20	20.02	0.1661	0.0032	314	
0.169583	-21	21.02	0.1694	0.0033	305	AVS 25 138
0.172476	-22	22.02	0.1723	0.0029	344	
0.175628	-23	23.02	0.1755	0.0032	316	
0.178485	-24	24.02	0.1783	0.0029	349	
0.181425	-25	25.02	0.1813	0.0029	339	
0.184159	-26	26.02	0.1840	0.0027	365	AVS 27 144
0.187047	-27	27.02	0.1869	0.0029	345	

Graphical Representation of Vs



Appendix B

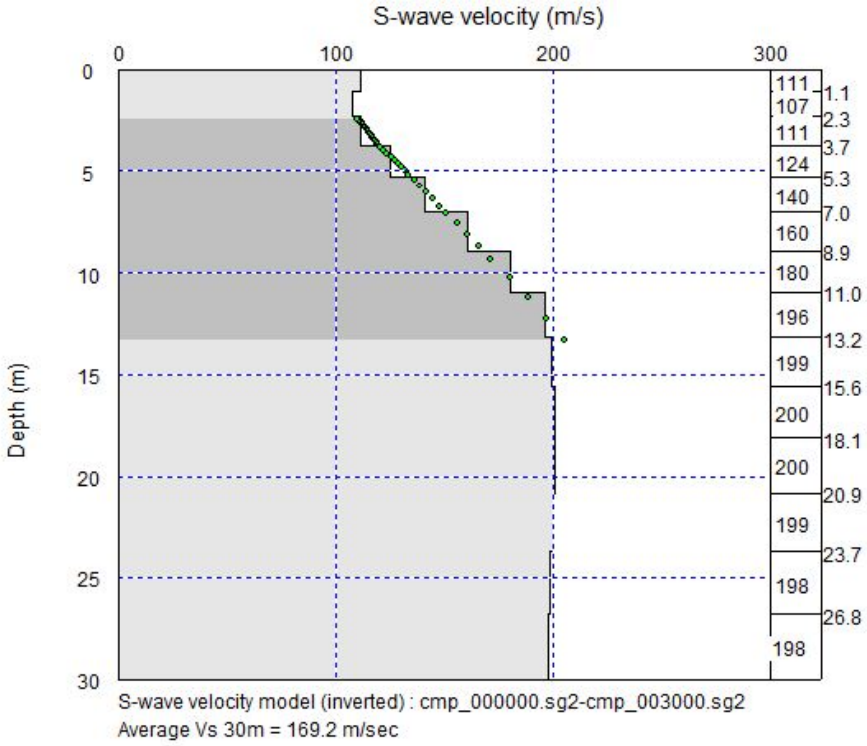
Multi-channel Analysis of Surface Wave (MASW) Results and Graphs



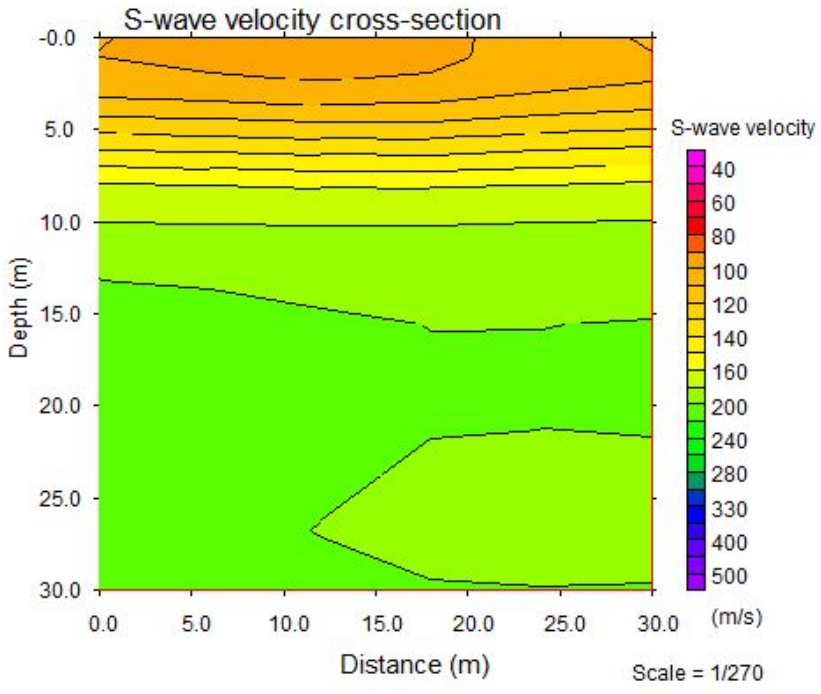
MASW ID:S 1 Date: 30.06.2016
Coordinate (1St Geophone): 23.30574/90.16282,Coordinate (Last Geophone):23.30576/90.16247
Location: Chargojari Govt. Primary School, Uttar Bayratala Union, Shibchar

Depth	S-Wave Velocity
0	111.46
1.071429	107.41
2.307692	111.56
3.708791	124.65
5.274725	140.84
7.005495	160.48
8.901099	180.70
10.961538	196.62
13.186812	199.67
15.576922	200.78
18.131867	200.67
20.851647	199.84
23.736263	198.84
26.785713	198.15
36.428571	209.16

1D Model



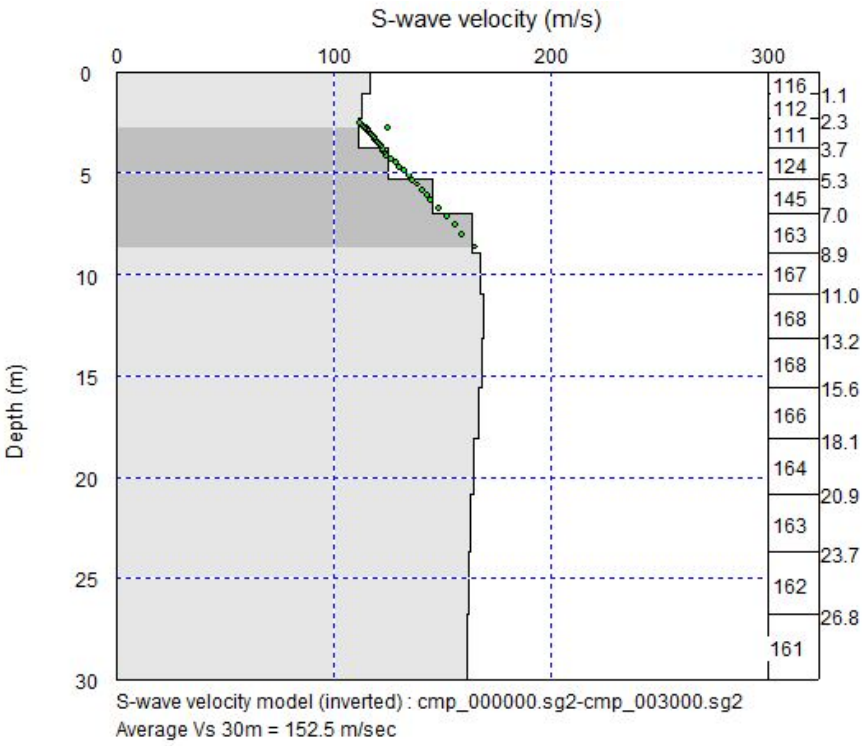
2D Model



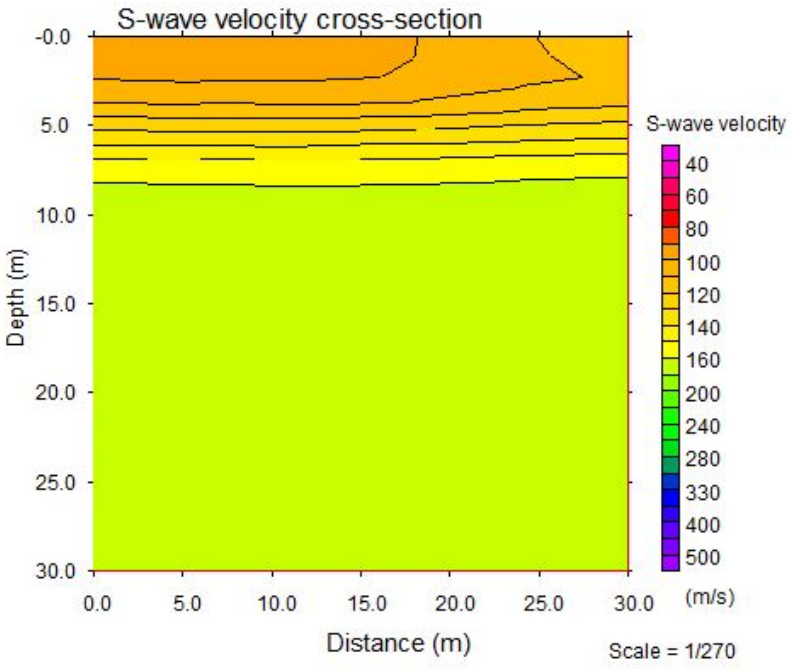
MASW ID: S2 Date: 30.06.2016
Coordinate (1St Geophone): 23.32779/90.21139 ,Coordinate (Last Geophone): 23.32752/90.21123
Location: Nurul Amin University College, Umedpur Union, Shibchar

Depth	S-Wave Velocity
0	116.92
1.071429	112.97
2.307692	111.27
3.708791	124.75
5.274725	145.43
7.005495	163.70
8.901099	167.59
10.961538	168.90
13.186812	168.11
15.576922	166.52
18.131867	164.70
20.851647	163.14
23.736263	162.02
26.785713	161.34
36.428571	168.90

1D Model



2D Model



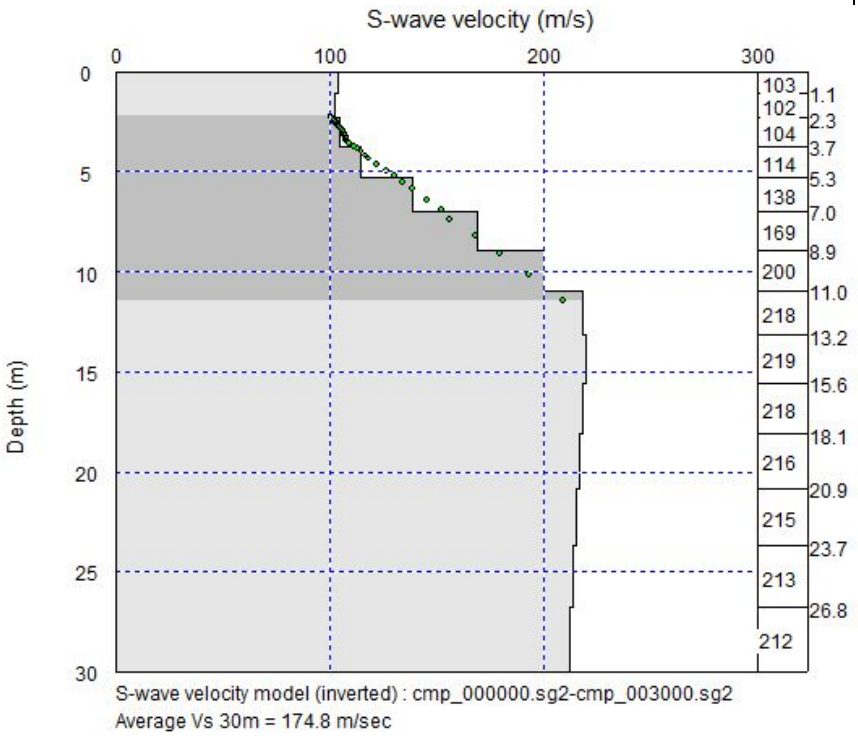
MASW ID: S 3 Date: 30.06.2016

Coordinate (1St Geophone): 23.32985/90.13261 ,Coordinate (Last Geophone): 23.32963/90.13240

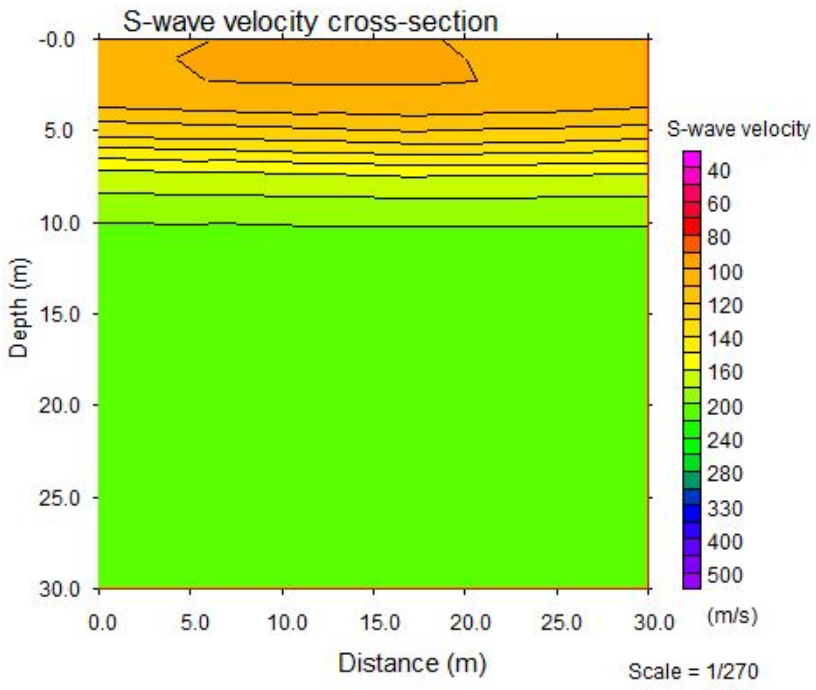
Location: PurbaKakor High School, Charshamail, Siruail Union, Shibchar

Depth	S-Wave Velocity
0	103.73
1.071429	102.34
2.307692	104.48
3.708791	114.74
5.274725	138.68
7.005495	169.18
8.901099	200.23
10.961538	218.13
13.186812	219.36
15.576922	218.65
18.131867	216.93
20.851647	215.02
23.736263	213.42
26.785713	212.35
36.428571	219.36

1D Model



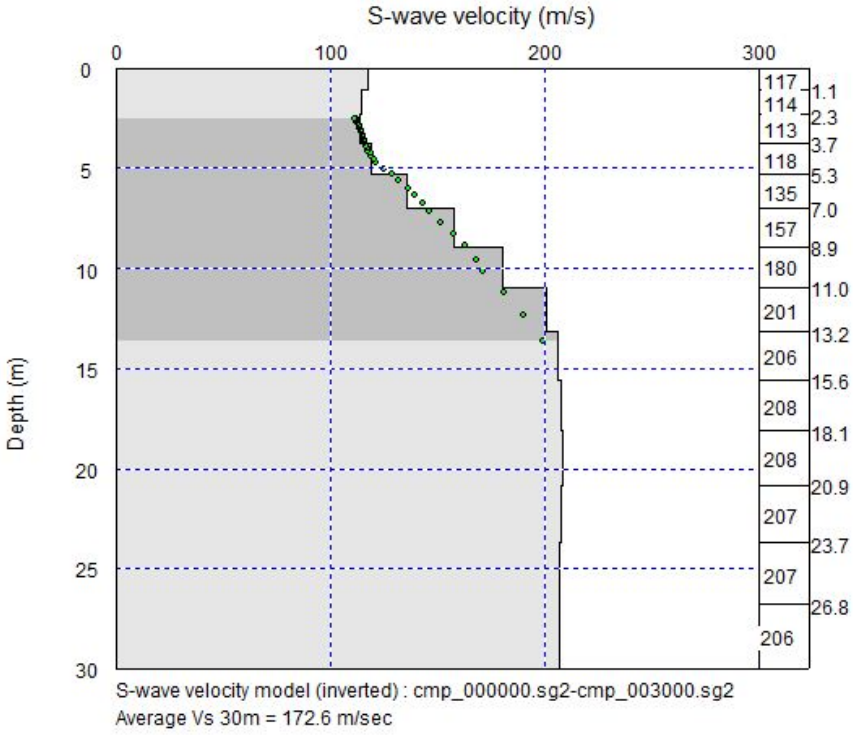
2D Model



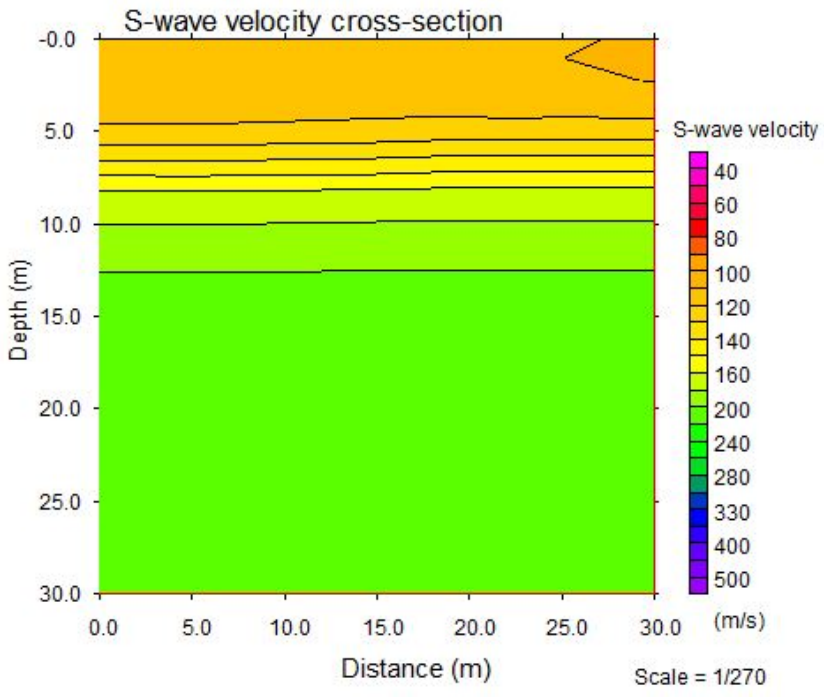
MASW ID: S 4 Date: 30.06.2016
Coordinate (1St Geophone): 23.37936/90.22100 ,Coordinate (Last Geophone): 23.37910/90.22076
Location: Hazratali, Baparikandi, Kadirpur Union, Shibchar

Depth	S-Wave Velocity
0	117.04
1.071429	114.37
2.307692	113.95
3.708791	118.59
5.274725	135.39
7.005495	157.94
8.901099	180.46
10.961538	201.23
13.186812	206.08
15.576922	208.04
18.131867	208.48
20.851647	207.94
23.736263	207.10
26.785713	206.60
36.428571	208.48

1D Model



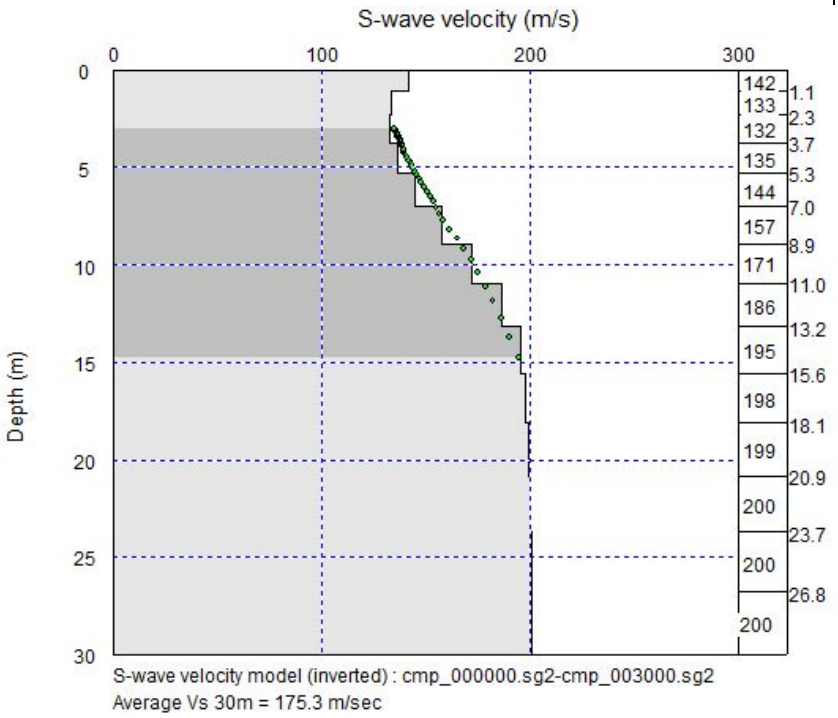
2D Model



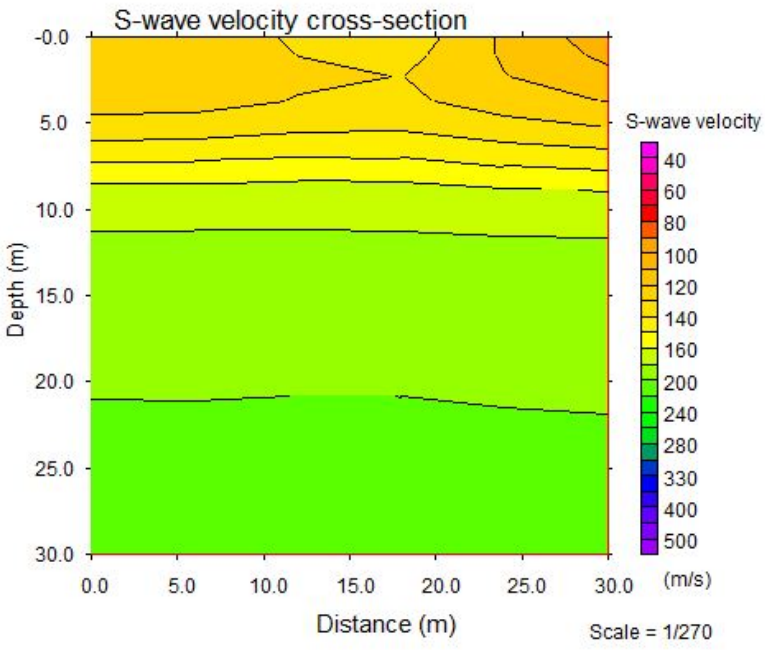
MASW ID: S 5 Date: 30.06.2016
Coordinate (1St Geophone): 23.37740/90.18571 ,Coordinate (Last Geophone): 23.37713/90.18567
Location: Hoglarmat S.K.P. High School, Hoglarmat, Panch Char Union, Shibchar

Depth	S-Wave Velocity
0	142.14
1.071429	133.15
2.307692	132.42
3.708791	135.94
5.274725	144.90
7.005495	157.21
8.901099	171.87
10.961538	186.07
13.186812	195.86
15.576922	198.27
18.131867	199.73
20.851647	200.36
23.736263	200.57
26.785713	200.90
36.428571	200.90

1D Model

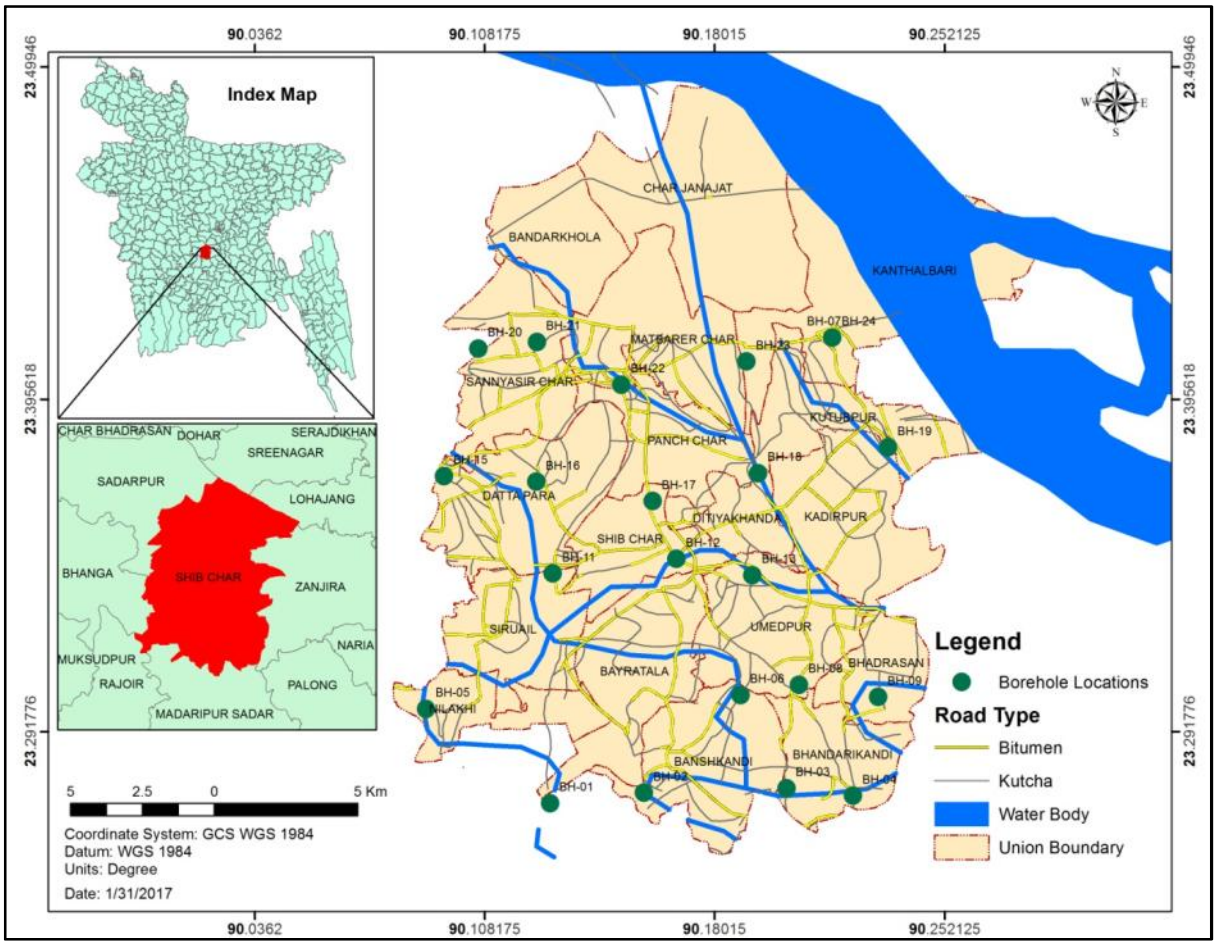


2D Model



Appendix C

Geotechnical Logs and Laboratory Test Results and Graphs



GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-01
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5m below EGL
Started on: 17.06.2016
Completed on: 17.06.2016

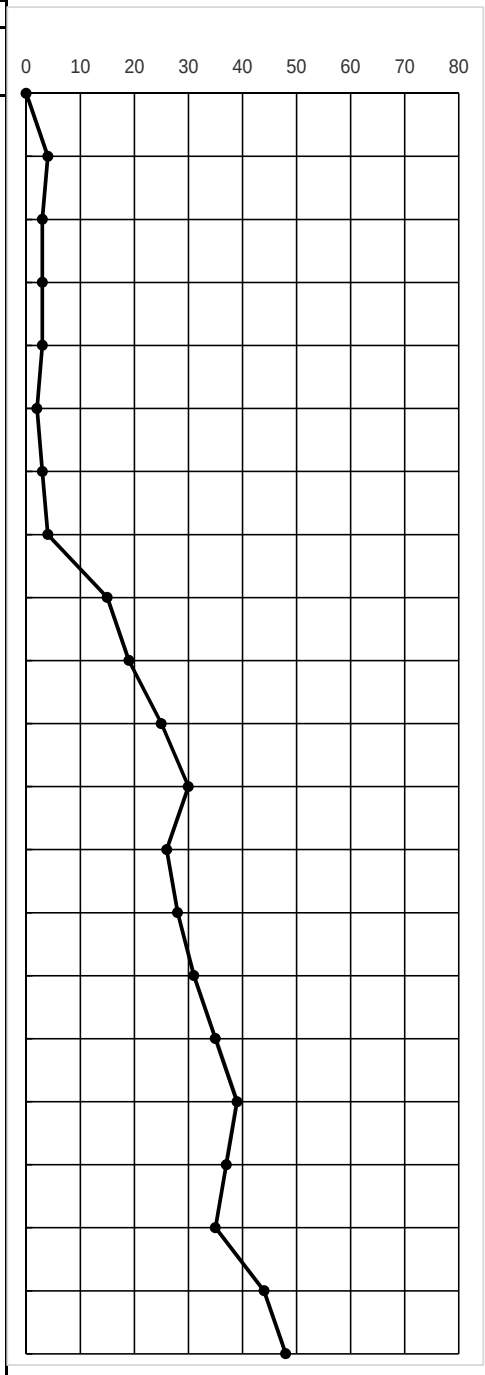
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Bayratala, Bayratala Union, Shibchar Upazila

Legend: Clay, Silt, Sand

Coordinates: Lat-23.26939 Long-90.12854

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose fine SAND with silt			1	8.0	1	2	2	4
3.0						1	1	2	3
4.5						1	1	2	3
6.0						1	1	2	3
7.5						1	1	1	2
9.0	Brownish grey soft Clayey SILT			2	3.0	1	1	2	3
10.5						1	2	2	4
12.0	Light grey medium dense to dense fine SAND with silt			5	19.0	5	5	10	15
13.5						6	7	12	19
15.0						7	11	14	25
16.5						7	15	15	30
18.0						7	11	15	26
19.5						6	11	17	28
21.0						9	13	18	31
22.5						10	15	20	35
24.0						12	17	22	39
25.5						10	15	22	37
27.0						12	16	19	35
28.5						13	19	25	44
30.0	End of Boring					14	20	28	48

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-02
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5m below EGL
Started on: 17.06.2016
Completed on: 17.06.2016

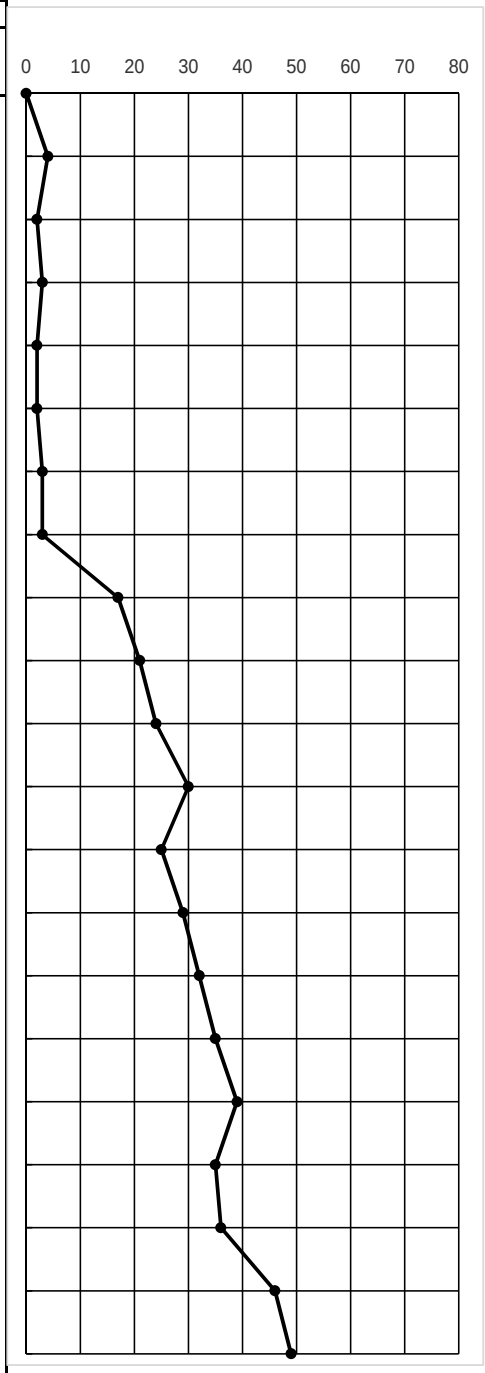
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Char Shomvuk Bazar Jamai Mosque, Banshkandi Union, Shibchar Upazila

Legend: Clay, Silt, Sand

Coordinates: Lat-23.27265 Long-90.15796

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose fine SAND with silt			1	8.0	1	2	2	4
3.0						1	1	1	2
4.5						1	1	2	3
6.0						1	1	1	2
7.5						1	1	1	2
9.0	Brownish grey soft Clayey SILT			2	3.0	1	1	2	3
10.5						1	1	2	3
12.0	Light grey medium dense to dense fine SAND with silt			5	19.0	5	7	10	17
13.5						6	9	12	21
15.0						7	10	14	24
16.5						8	15	15	30
18.0						7	10	15	25
19.5						8	12	17	29
21.0						9	14	18	32
22.5						10	15	20	35
24.0						12	17	22	39
25.5						10	15	20	35
27.0						12	16	20	36
28.5						13	20	26	46
30.0	End of Boring					14	22	27	49

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-03
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 2.5 m below EGL
Started on: 22.06.2016
Completed on: 22.06.2016

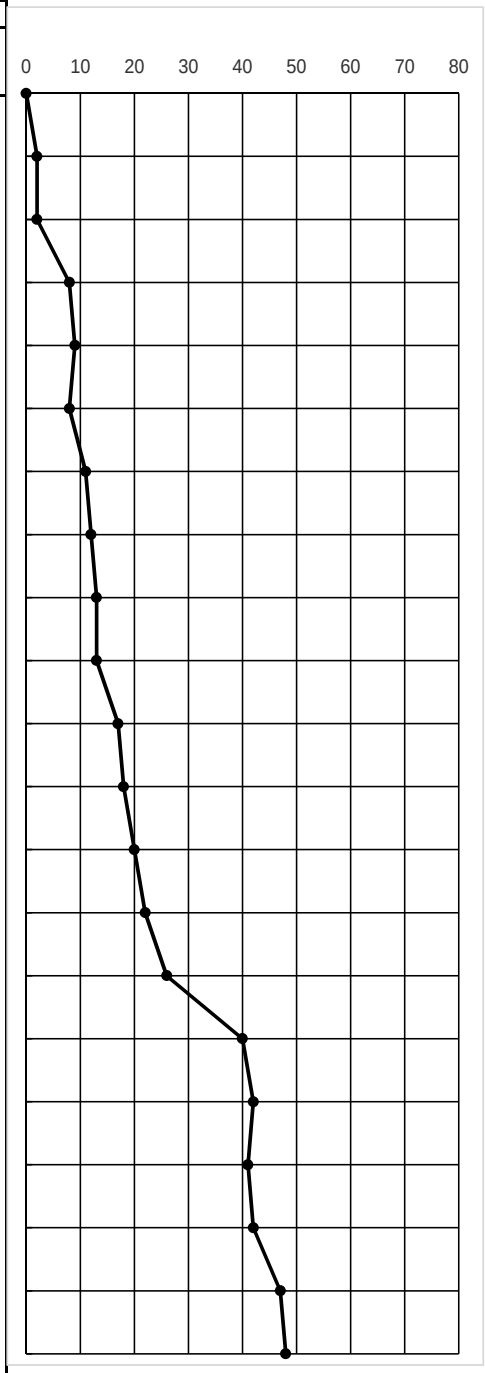
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Tengramari Govt. Primary School, Bhandarikandi Union, Sibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.27408 Long-90.20258

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose very fine to fine SAND with silt			2	4.0	1	1	1	2
3.0						1	1	1	2
4.5	Light grey loose to medium dense very fine to fine SAND little silt			4	9.0	3	3	5	8
6.0						3	4	5	9
7.5						3	4	4	8
9.0						3	5	6	11
10.5						4	6	6	12
12.0						3	6	7	13
13.5	Light grey medium dense fine SAND little silt			5	9.0	4	6	7	13
15.0						6	8	9	17
16.5						6	8	10	18
18.0						7	9	11	20
19.5						8	10	12	22
21.0						9	12	14	26
22.5	Light grey dense fine to medium SAND little silt			6	8.0	11	18	22	40
24.0						12	18	24	42
25.5						13	19	22	41
27.0						14	20	22	42
28.5						15	22	25	47
30.0	End of Boring					16	23	25	48

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-4
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5 00m below EGL
Started on: 21.06.2016
Completed on: 21.06.2016

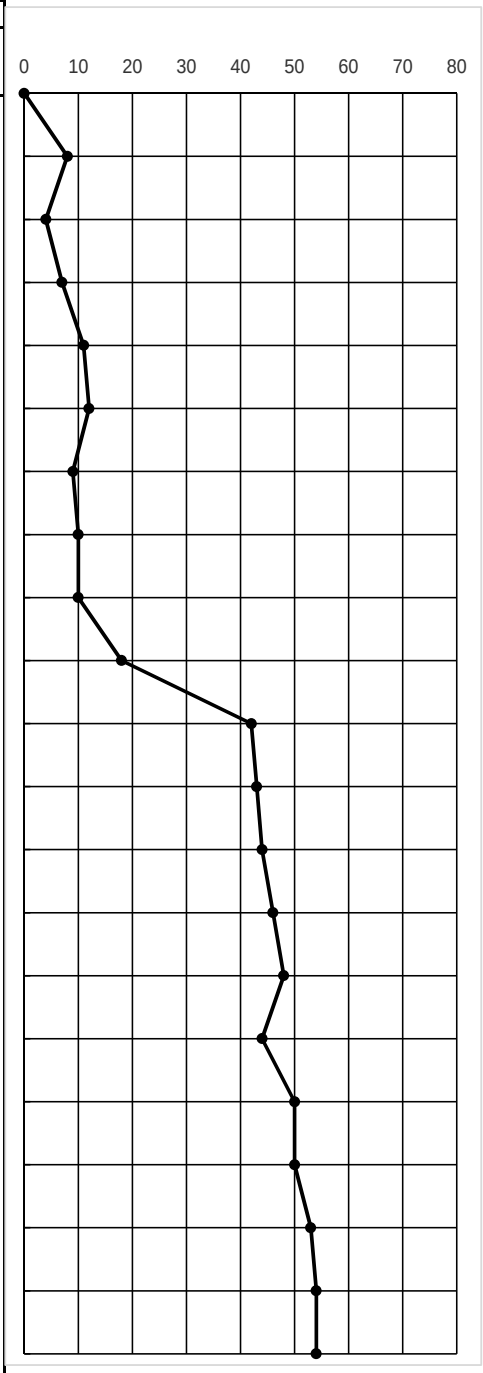
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : BhandariKandi Union Complex Mat, BhandariKandi Union, Shibchar Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.27172 Long-90.22341

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown medium stiff SILT with clay			2	4.0	2	3	5	8
3.0						2	2	2	4
4.5	Light grey loose fine SAND with clay				4.5	3	3	4	7
6.0						4	5	6	11
7.5						5	6	6	12
9.0	Grey loose silty very fine SAND			4	6.0	3	4	5	9
10.5						3	4	6	10
12.0						5	5	5	10
13.5						6	8	10	18
15.0	Light grey dense fine to medium SAND trace silt			5	15.5	8	20	22	42
16.5						8	20	23	43
18.0						9	21	23	44
19.5						10	22	24	46
21.0						10	23	25	48
22.5						11	24	20	44
24.0						12	24	26	50
25.5						13	25	25	50
27.0						14	26	27	53
28.5						14	27	27	54
30.0	End of Boring					15	27	27	54

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-05
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5m below EGL
Started on: 25.06.2016
Completed on: 25.06.2016

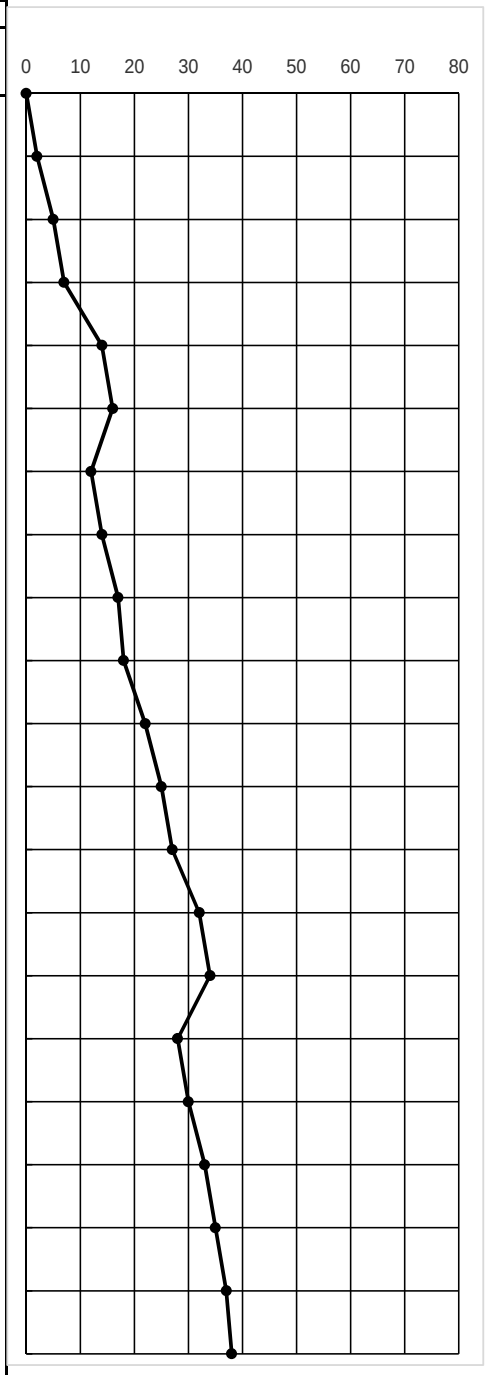
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Nilkhi Union Porishod Bhovon, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.29888 Long-90.08979

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brownish grey very soft to medium stiff clayey SILT					1	1	1	2
3.0				2	5.5	2	2	3	5
4.5						2	3	4	7
6.0	Light grey medium dense fine SAND with silt					4	6	8	14
7.5						5	7	9	16
9.0						4	6	6	12
10.5				3	9.0	4	6	8	14
12.0						5	7	10	17
13.5						6	8	10	18
15.0	Light grey medium dense to dense fine to medium SAND trace silt					7	10	12	22
16.5						8	12	13	25
18.0						8	12	15	27
19.5						9	15	17	32
21.0						10	16	18	34
22.5				5	15.5	7	12	16	28
24.0						8	12	18	30
25.5						9	15	18	33
27.0						10	15	20	35
28.5						11	17	20	37
30.0	End of Boring					12	16	22	38

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-06
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5m below EGL
Started on: 18.06.2016
Completed on: 18.06.2016

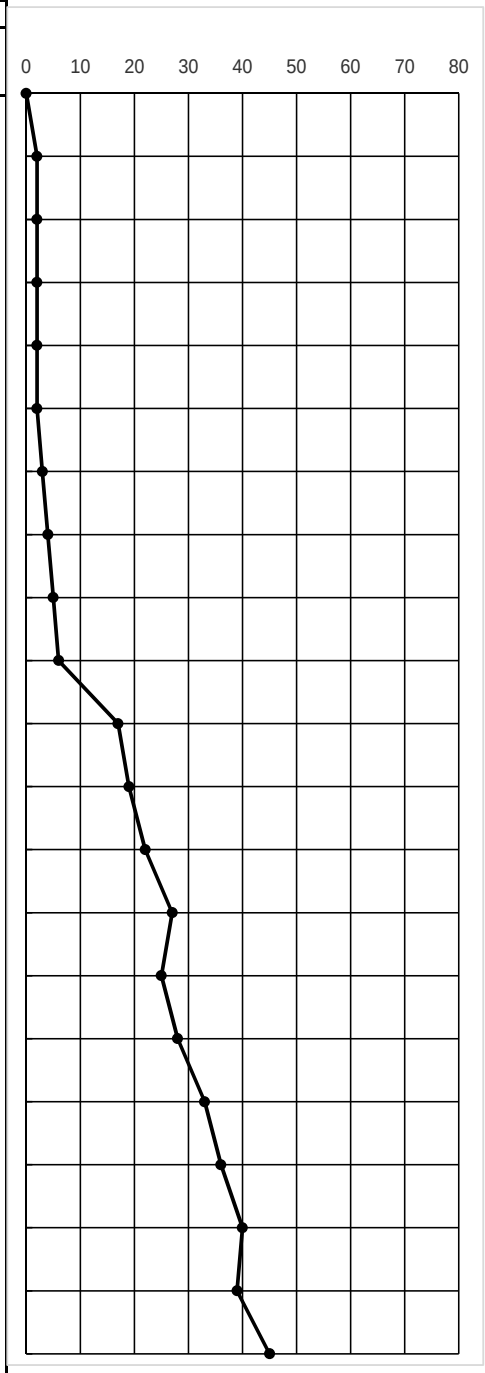
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Bohere tola sorkari pratomic school, Shibchor Upazila

Legend: Clay, Silt, Sand

Coordinates: Lat-23.30320 Long-90.18824

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Grey very soft SILT with clay little very fine sand			2	14.5	1	1	1	2
3.0						1	1	1	2
4.5						1	1	1	2
6.0						1	1	1	2
7.5						1	1	1	2
9.0						1	1	2	3
10.5						1	2	2	4
12.0						2	2	3	5
13.5						2	2	4	6
15.0	Light grey medium dense to dense fine SAND little silt			3	15.5	5	7	10	17
16.5						6	9	10	19
18.0						7	10	12	22
19.5						8	12	15	27
21.0						8	10	15	25
22.5						7	12	16	28
24.0						8	15	18	33
25.5						10	16	20	36
27.0						12	18	22	40
28.5						13	15	24	39
30.0	End of Boring					12	18	27	45

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-07
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

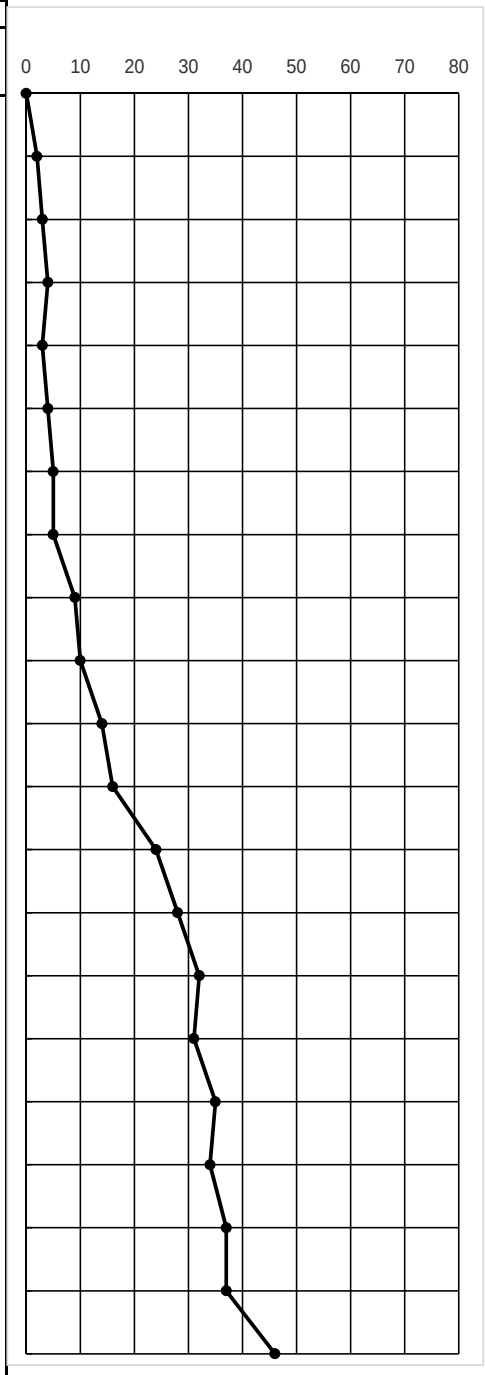
Exixting ground level:
Ground water level: 3.00 m below EGL
Started on: 16.06.2016
Completed on: 16.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : 53 no Chor Gojaria Sorkari Pratomic Bidhaloy, Sibchor, Madaripur

Legend: Clay, Silt, Sand
Coordinates: Lat-23.41491 Long-90.21689

Depth (m)	Visual Description	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft SILT with clay	2	5.5	1	1	1	2
3.0				1	1	2	3
4.5				1	2	2	4
6.0	Grey soft SILT with very fine sand		6.0	1	1	2	3
7.5				2	2	2	4
9.0				2	2	3	5
10.5				2	2	3	5
12.0	Grey loose to medium dense fine sand with silt	3	9.0	2	3	6	9
13.5				3	4	6	10
15.0				4	6	8	14
16.5				5	7	9	16
18.0				7	10	14	24
19.5				8	12	16	28
21.0	Grey dense to very dense fine to very fine SAND with silt	5	9.5	8	12	20	32
22.5				7	10	21	31
24.0				9	13	22	35
25.5				8	14	20	34
27.0				9	15	22	37
28.5				10	17	20	37
30.0	End of Boring			12	20	26	46

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-8
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 2.500m below EGL
Started on: 20.06.2016
Completed on: 20.06.2016

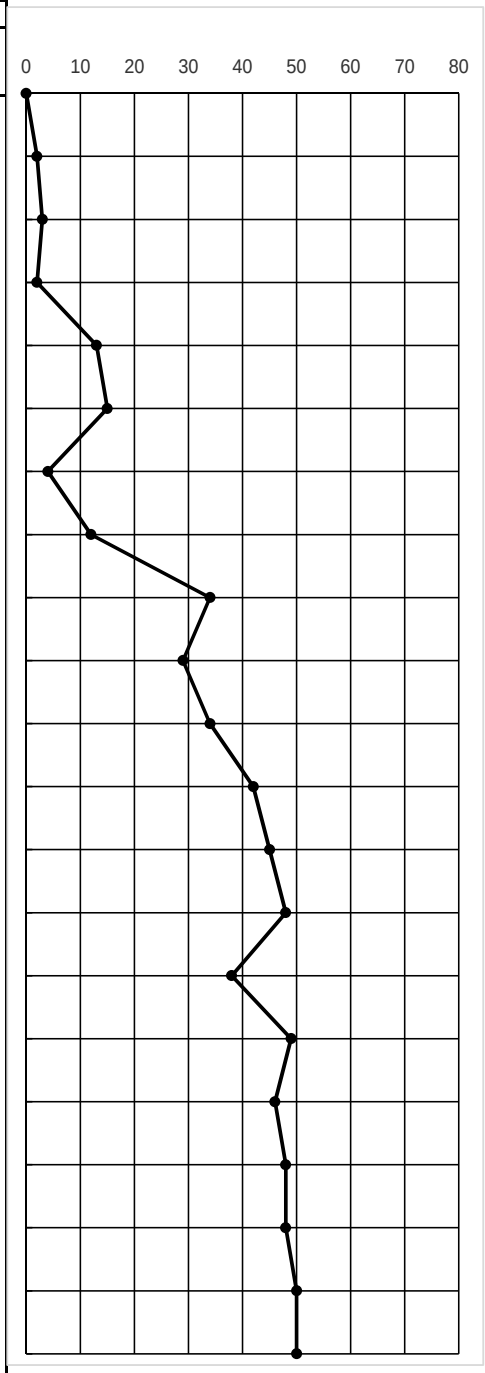
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Aleshpur Mia bari Govt. Primary School, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.30641 Long-90.20652

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very soft clayey silt trace sand					1	1	1	2
3.0					5.5	1	1	2	3
4.5						1	1	1	2
6.0	Light grey medium dense fine to very fine SAND little silt			2		5	6	7	13
7.5					3.0	5	7	8	15
9.0	grey medium stiff clayey silt				1.5	2	2	2	4
10.5	Grey medium dense silty fine SAND trace clay				1.5	4	5	7	12
12.0	Light grey dense fine SAND little silt					10	16	18	34
13.5					4.5	10	13	16	29
15.0						13	16	18	34
16.5	Light dense fine to medium SAND trace			5		15	20	22	42
18.0						15	22	23	45
19.5						18	25	23	48
21.0						16	18	20	38
22.5					14.0	19	23	26	49
24.0						20	22	24	46
25.5						21	23	25	48
27.0						20	24	24	48
28.5						21	26	24	50
30.0	End of Boring					22	25	25	50

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-09
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.2 m below EGL
Started on: 23.06.2016
Completed on: 23.06.2016

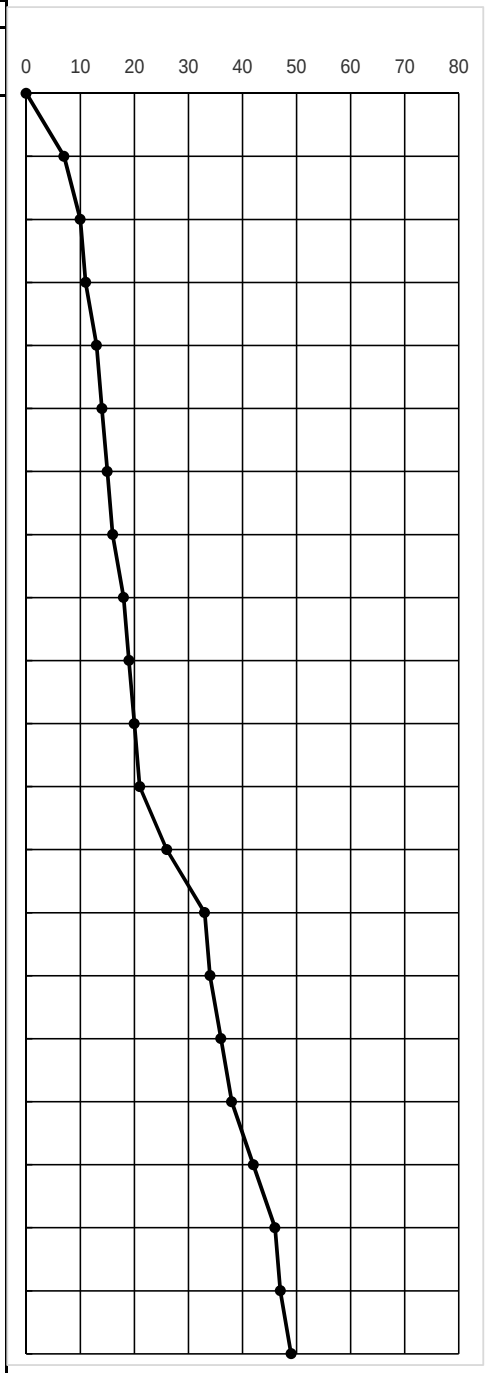
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Vodrashon Mongol Howladar Bari, Sibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.30257 Long-90.23129

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown loose fine sand			1	2.5	2	3	4	7
3.0						3	4	6	10
4.5						4	5	6	11
6.0						5	6	7	13
7.5						6	6	8	14
9.0						6	7	8	15
10.5	Light grey medium dense fine SAND			3	16.5	6	7	9	16
12.0						7	8	10	18
13.5						7	8	11	19
15.0						8	9	11	20
16.5						9	10	11	21
18.0						10	12	14	26
19.5						13	16	17	33
21.0						14	17	17	34
22.5						15	17	19	36
24.0	Light grey dense fine to medium SAND			5	11.0	15	18	20	38
25.5						16	20	22	42
27.0						17	22	24	46
28.5						18	22	25	47
30.0	End of Boring					19	24	25	49

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-10
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5 m below EGL
Started on: 24.06.2016
Completed on: 24.06.2016

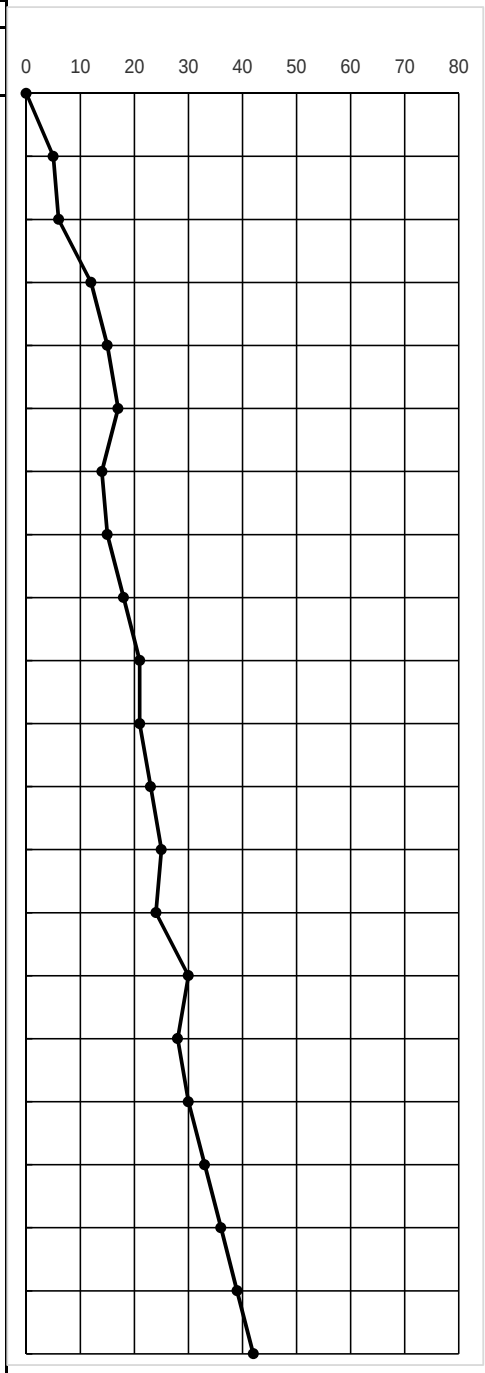
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Aulia Jama Mosgid, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.84158 Long-90.08948

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose fine SAND with still			1	4.0	2	2	3	5
3.0						2	3	3	6
4.5	Grey medium dense very fine to fine SAND with silt			4	4.5	3	5	7	12
6.0						5	7	8	15
7.5						5	7	10	17
9.0	Grey medium dense fine SAND little silt			5	12.0	4	5	9	14
10.5						5	6	9	15
12.0						6	8	10	18
13.5						6	9	12	21
15.0						5	8	13	21
16.5						6	9	14	23
18.0						6	10	15	25
19.5						7	10	14	24
21.0	Light grey dense fine to medium SAND trace silt			6	9.5	8	12	18	30
22.5						8	12	16	28
24.0						9	13	17	30
25.5						10	15	18	33
27.0						10	16	20	36
28.5						12	17	22	39
30.0	End of Boring					12	18	24	42

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-11
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.5 m below EGL
Started on: 19.06.2016
Completed on: 19.06.2016

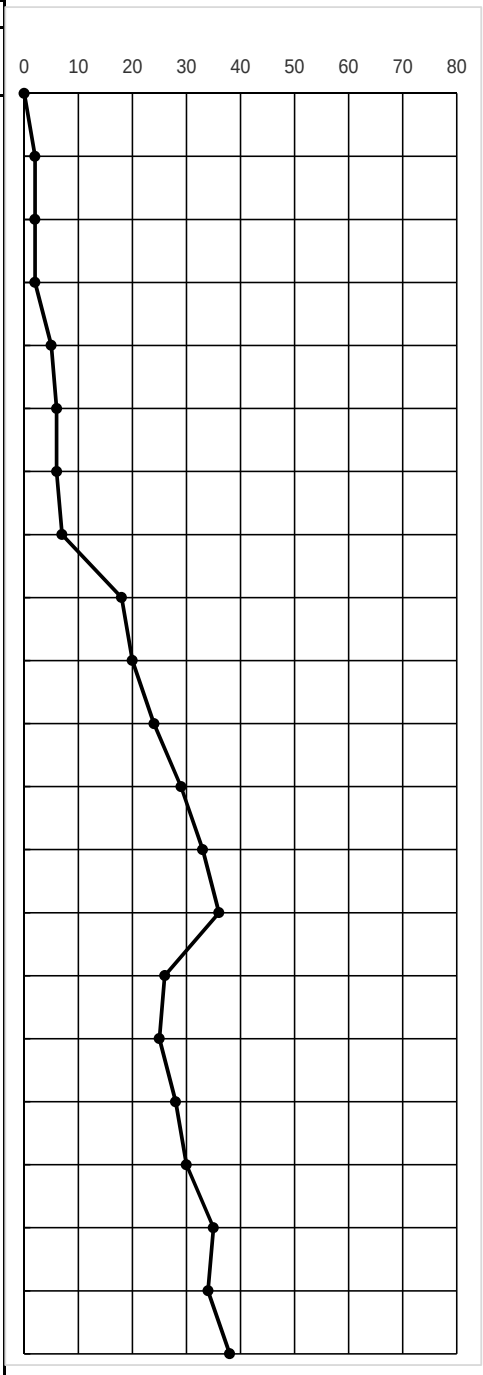
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Utrail Munsi kandi Sorkari Prathomic Bidloy, Shibchor

Legend: Clay, Silt, Sand

Coordinates: Lat-23.34120 Long-90.12942

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very soft SILT with clay and sand					1	1	1	2
3.0					5.5	1	1	1	2
4.5						1	1	1	2
6.0	Light grey loose fine SAND little silt			2		2	2	3	5
7.5						2	3	3	6
9.0					6.0	2	2	4	6
10.5						2	3	4	7
12.0	Light grey medium dense fine SAND little silt					6	8	10	18
13.5						7	9	11	20
15.0						7	10	14	24
16.5						8	12	17	29
18.0					12.0	8	15	18	33
19.5						10	16	20	36
21.0				5		6	10	16	26
22.5						7	10	15	25
24.0	Light grey dense fine to medium SAND trace silt					8	12	16	28
25.5						7	12	18	30
27.0					6.5	9	15	20	35
28.5						10	16	18	34
30.0	End of Boring					12	18	20	38

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-12
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00 m below EGL
Started on: 15.06.2016
Completed on: 15.06.2016

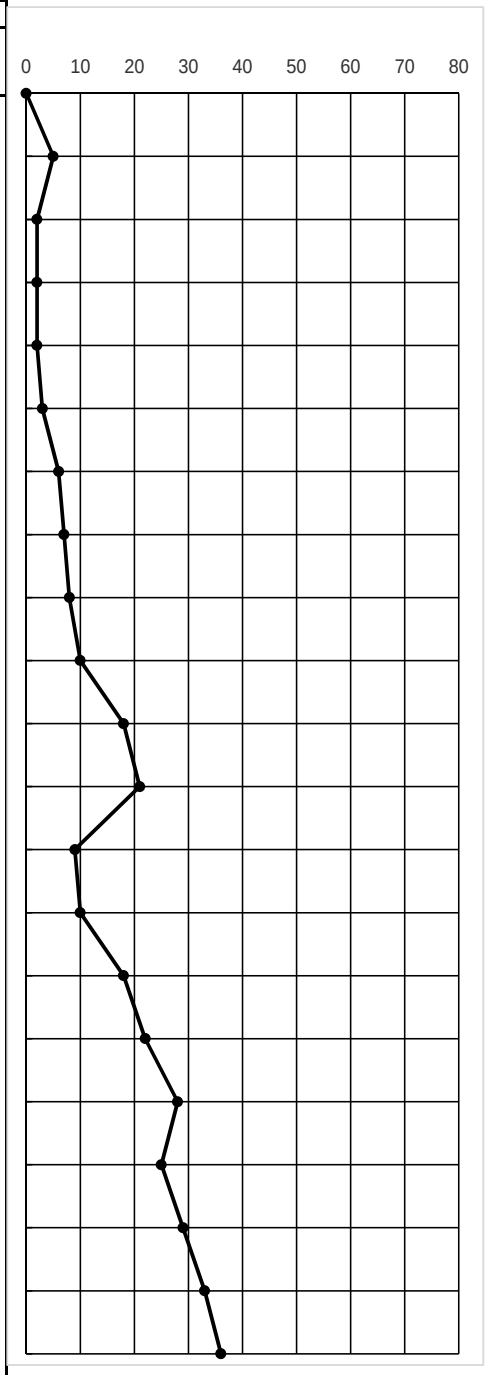
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Sibchor Model Sorkari Pratomic Bidhaloy, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.345724 Long-90.168121

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown loose fine SAND little silt			1	2.5	2	2	3	5
3.0	Brown very soft clayey SILT			2	3.0	1	1	1	2
4.5						1	1	1	2
6.0						1	1	1	2
7.5	Grey very soft clayey SILT with very fine sand				7.5	1	1	2	3
9.0						2	3	3	6
10.5						2	3	4	7
12.0						3	3	5	8
13.5	Light grey medium dense fine SAND little silt			3	4.5	3	4	6	10
15.0						6	8	10	18
16.5						7	9	12	21
18.0	Grey loose to medium fine to very fine sand with silt			4	4.5	4	4	5	9
19.5						4	5	5	10
21.0						6	8	10	18
22.5	Light grey medium dense to dense fine to medium SAND trace silt			6	8.0	7	10	12	22
24.0						7	12	16	28
25.5						8	10	15	25
27.0						9	12	17	29
28.5						10	15	18	33
30.0	End of Boring					12	16	20	36

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-13
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 19.06.2016
Completed on: 19.06.2016

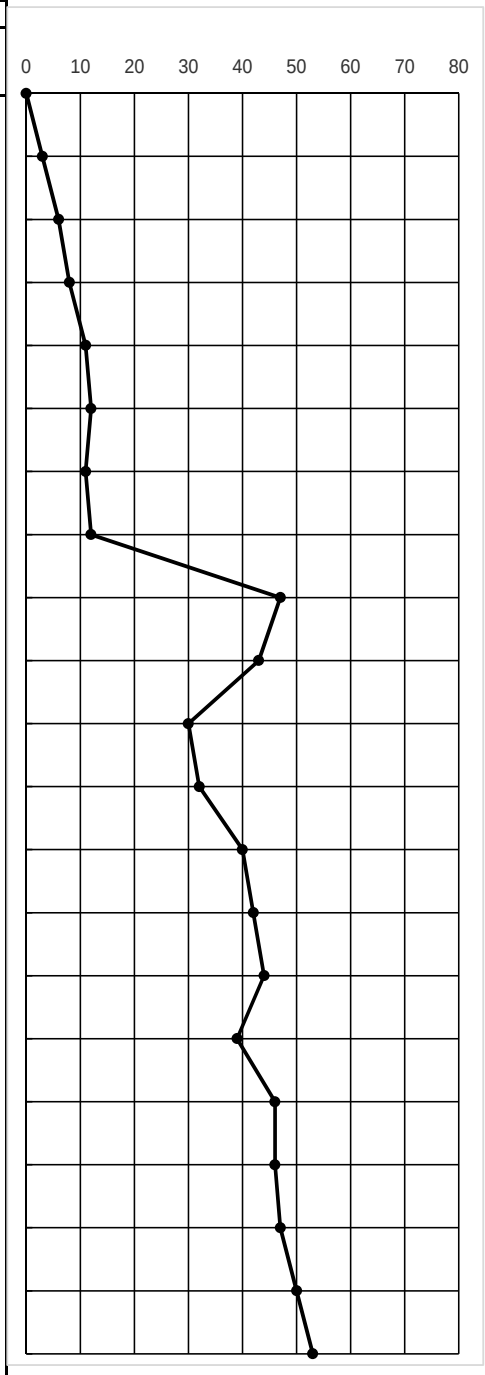
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Chor kasi kata Adarsha Sorkari Prothomic Bidhaloy, Sibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.34068 Long-90.19188

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft clayey SLIT				4.0	1	1	2	3
3.0						2	2	4	6
4.5				2		2	3	5	8
6.0						4	5	6	11
7.5	Light grey loose fine SAND little silt				7.5	4	5	7	12
9.0						3	5	6	11
10.5						3	5	7	12
12.0	Light grey dense fine SAND trace silt				3.0	1	22	25	47
13.5						9	20	23	43
15.0	Light grey dense fine to medium SAND trace silt			5	15.5	8	14	16	30
16.5						10	15	17	32
18.0						15	19	21	40
19.5						16	20	22	42
21.0						17	21	23	44
22.5						14	19	20	39
24.0						18	22	24	46
25.5						18	21	25	46
27.0						15	23	24	47
28.5						17	24	26	50
30.0	End of Boring					20	23	30	53

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-14
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

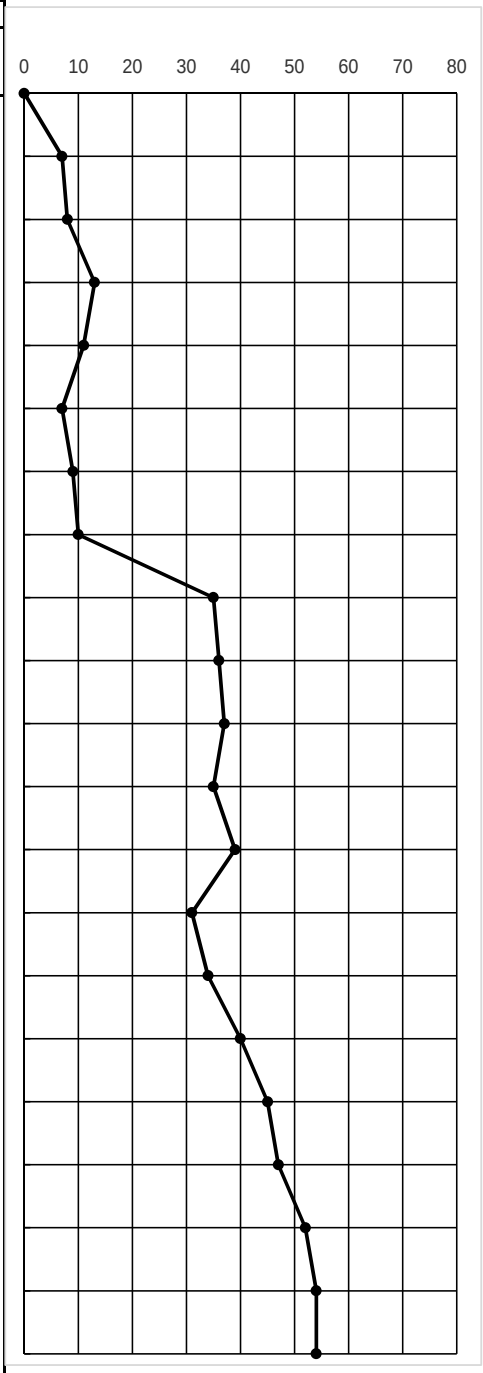
Exixting ground level:
Ground water level: 2.5m below EGL
Started on: 24.06.2016
Completed on: 24.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location :Vodrashon Zinnatun Sorkari Prathomic Bidhaloy, Shibchor, Madaripur

Legend: Clay, Silt, Sand
Coordinates: Lat-23.82462 Long-90.23215

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown loose fine SAND				4.0	2	3	4	7
3.0						3	4	4	8
4.5						5	6	7	13
6.0				1		4	5	6	11
7.5	Light grey loose to medium dense fine SAND				7.5	3	3	4	7
9.0						3	4	5	9
10.5						3	5	5	10
12.0						10	15	20	35
13.5						10	16	20	36
15.0						11	16	21	37
16.5						11	15	20	35
18.0						12	18	21	39
19.5						10	15	16	31
21.0	Light grey dense to very dense fine SAND			5	18.5	12	17	17	34
22.5						14	20	20	40
24.0						15	22	23	45
25.5						16	23	24	47
27.0						20	26	26	52
28.5						22	26	28	54
30.0	End of Boring					23	27	27	54

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-15
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 23.06.2016
Completed on: 23.06.2016

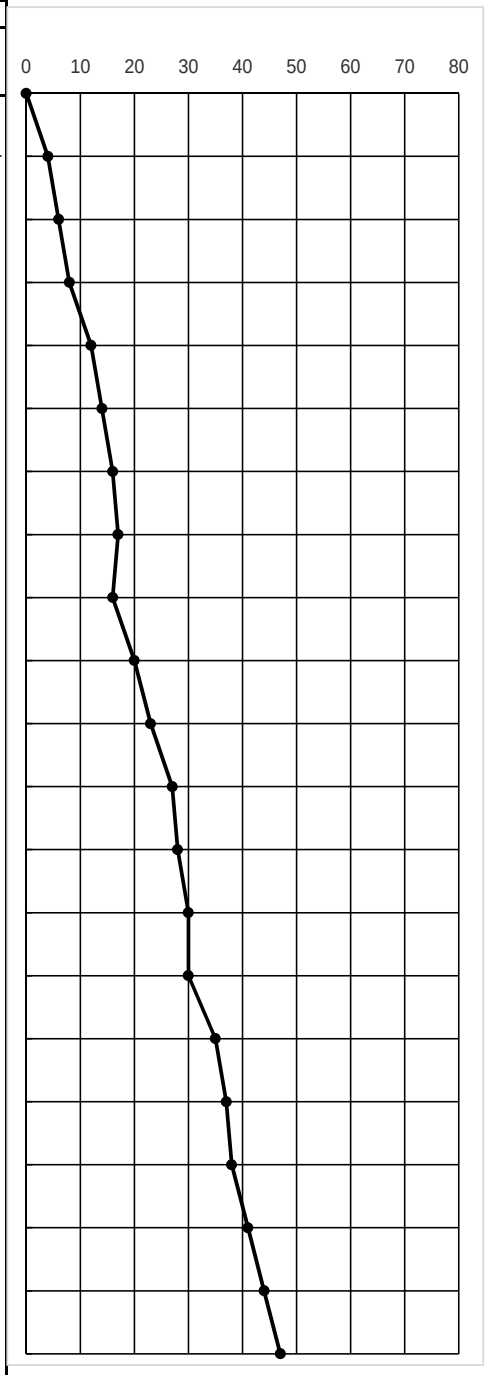
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Sorkari Prathomic Bidhaloy, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.37161 Long-90.09534

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose silty very fine to fine SAND			1	5.5	1	2	2	4
3.0						2	2	4	6
4.5						2	3	5	8
6.0	Light grey medium dense to dense fine SAND little silt			3	18.0	3	5	7	12
7.5						4	6	8	14
9.0						4	7	9	16
10.5						5	7	10	17
12.0						6	8	8	16
13.5						7	10	10	20
15.0						7	10	13	23
16.5						8	12	15	27
18.0						8	12	16	28
19.5						9	13	17	30
21.0						9	12	18	30
22.5						10	15	20	35
24.0	Light grey dense fine to medium SAND trace silt			6	6.5	10	17	20	37
25.5						12	16	22	38
27.0						11	17	24	41
28.5						12	18	26	44
30.0	End of Boring					12	20	27	47

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-16
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.20 m below EGL
Started on: 20.06.2016
Completed on: 20.06.2016

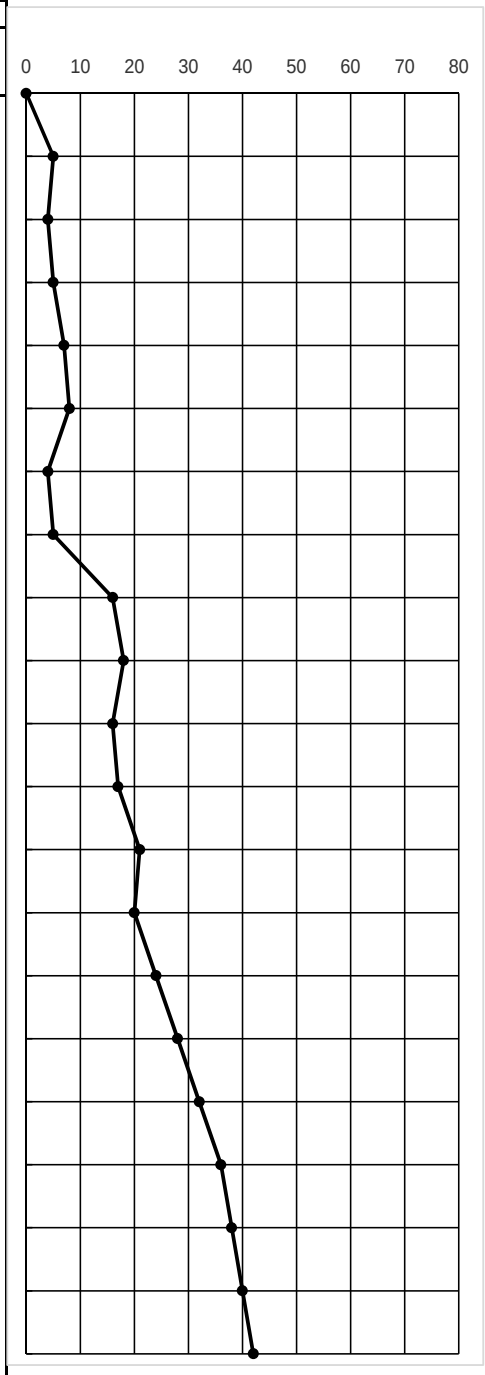
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Bachamara Bablatola Sorkari Prathomic Bidhaloy,Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.369838 Long-90.124282

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown medium stiff silt with clay little sand				4.0	1	2	3	5
3.0						1	2	2	4
4.5	Grey medium stiff moderate plastic silty clay			2	7.5	2	2	3	5
6.0						2	3	4	7
7.5						2	3	5	8
9.0						1	2	2	4
10.5						2	2	3	5
12.0	Light grey medium dense fine SAND little silt			3	12.0	4	7	9	16
13.5						5	8	10	18
15.0						3	7	9	16
16.5						4	7	10	17
18.0						5	9	12	21
19.5						6	8	12	20
21.0						7	10	14	24
22.5						8	12	16	28
24.0	Light grey dense fine to medium SAND trace silt			6	6.5	9	14	18	32
25.5						10	16	20	36
27.0						10	18	20	38
28.5						10	17	23	40
30.0	End of Boring					12	18	24	42

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-17
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 5.00 m below EGL
Started on: 15.06.2016
Completed on: 15.06.2016

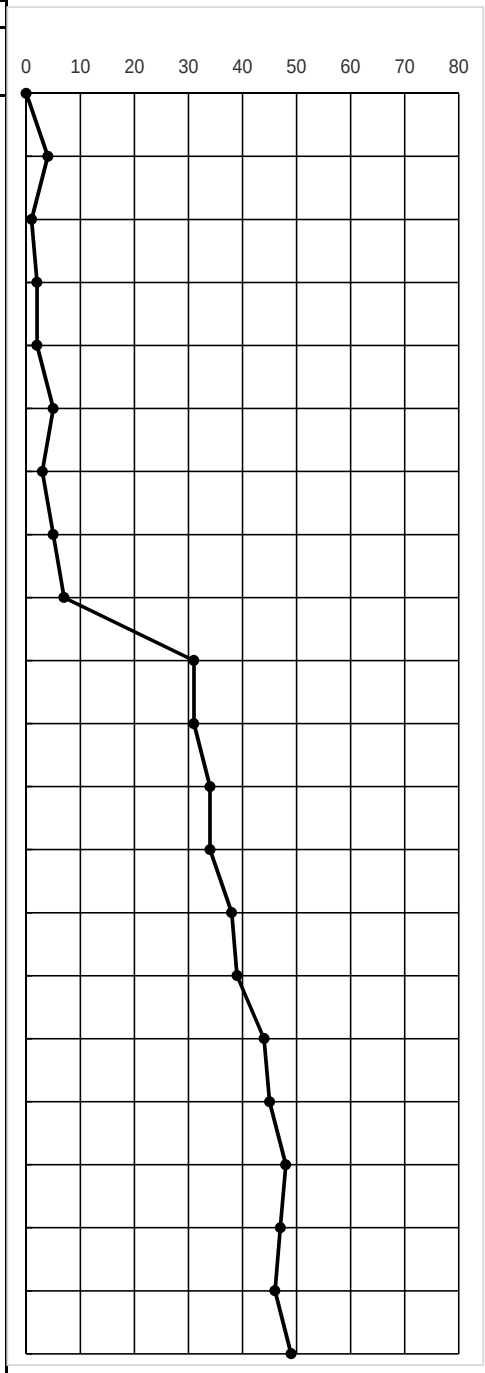
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Khan Kandi, Nilghora, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.36378 Long-90.16066

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose silty very fine SAND			1	2.5	1	2	2	4
3.0						1	0	1	1
4.5						1	1	1	2
6.0						1	1	1	2
7.5	Grey very soft high plastic silty clay			2	10.5	1	2	3	5
9.0						1	1	2	3
10.5						1	2	3	5
12.0						2	3	4	7
13.5						11	13	18	31
15.0						10	12	19	31
16.5						10	14	20	34
18.0						12	16	18	34
19.5						10	16	22	38
21.0	Light grey dense fine SAND LITTLE SILT			5	17.0	12	18	21	39
22.5						10	20	24	44
24.0						12	22	23	45
25.5						14	20	28	48
27.0						16	21	26	47
28.5						18	22	24	46
30.0	End of Boring					20	25	24	49

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-18
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

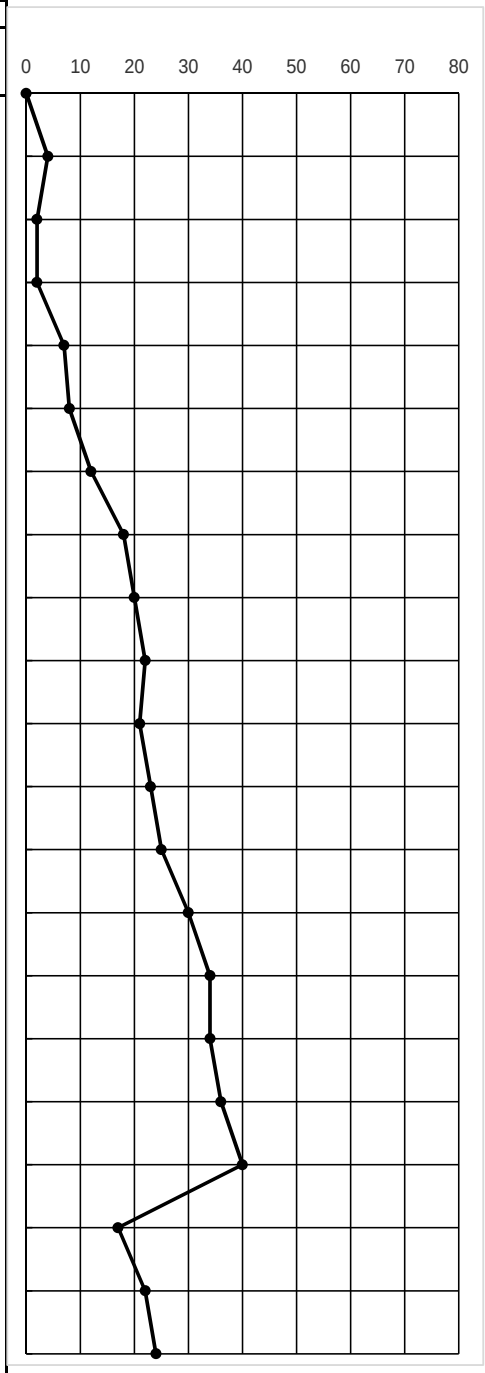
Exixting ground level:
Ground water level: 8.00m below EGL
Started on: 18.06.2016
Completed on: 18.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Chor Kesobpur Howlader Bari Mosjid, Shibchor, Madaripur

Legend: Clay, Silt, Sand
Coordinates: Lat-23.37255 Long-90.19370

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft SILT with very fine sand			2	5.5	1	2	2	4
3.0						1	1	1	2
4.5						1	1	1	2
6.0	Brown loose very fine SAND with silt			4	3.0	2	3	4	7
7.5						2	3	5	8
9.0	Light grey medium dense fine SAND little silt			5	21.5	4	5	7	12
10.5						6	8	10	18
12.0						6	9	11	20
13.5						6	10	12	22
15.0						5	8	13	21
16.5						6	9	14	23
18.0						7	11	14	25
19.5						7	13	17	30
21.0						8	15	19	34
22.5						8	14	20	34
24.0						10	16	20	36
25.5						10	18	22	40
27.0						6	7	10	17
28.5						7	10	12	22
30.0	End of Boring					7	10	14	24

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-19
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 2.5 m below EGL
Started on: 25.06.2016
Completed on: 25.06.2016

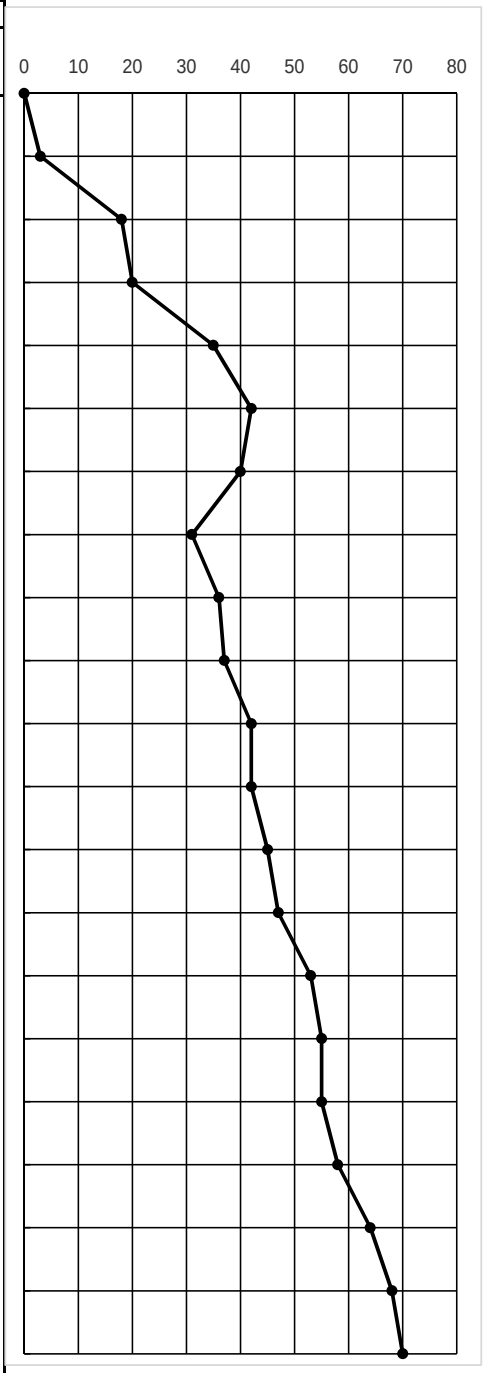
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Kutubpur Uccho Bidhaloy, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.38058 Long-90.23438

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft clayey SILT			2	2.5	1	2	1	3
3.0						5	8	10	18
4.5						5	9	11	20
6.0						10	15	20	35
7.5						12	16	26	42
9.0						12	17	23	40
10.5						12	15	16	31
12.0	Light grey medium dense to dense fine SAND			3		13	16	20	36
13.5						14	16	21	37
15.0						15	20	22	42
16.5					27.5	16	21	21	42
18.0						17	22	23	45
19.5						16	23	24	47
21.0						17	25	28	53
22.5						2	26	29	55
24.0						22	30	25	55
25.5	Light grey medium very dense fine SAND			6		20	28	30	58
27.0						24	30	34	64
28.5						25	32	36	68
30.0	End of Boring					25	33	37	70

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-20
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00 m below EGL
Started on: 22.06.2016
Completed on: 22.06.2016

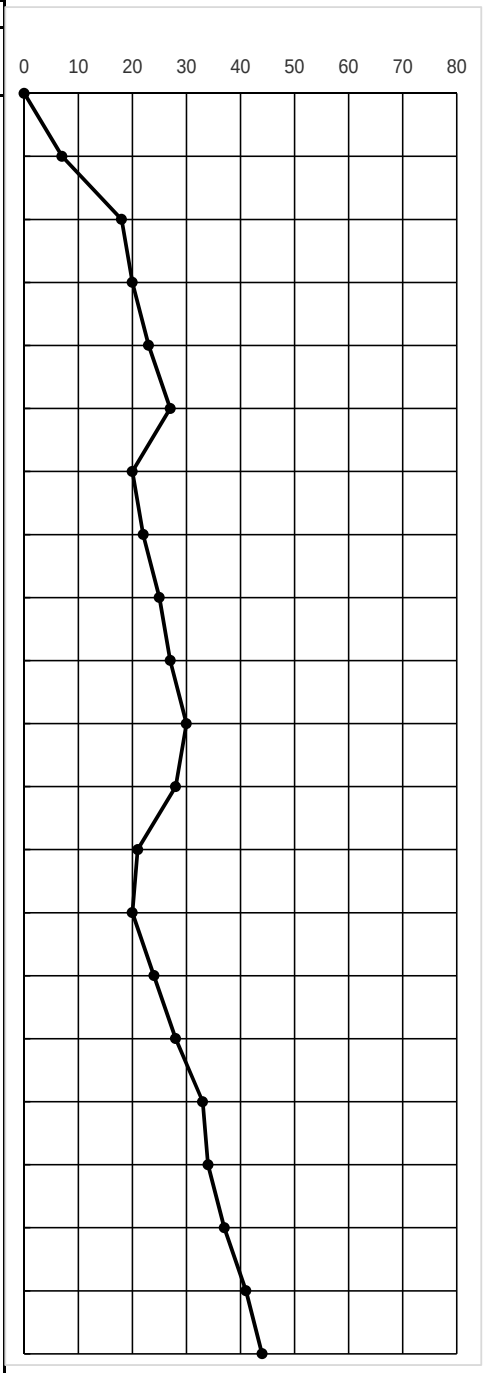
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Al Jamiatul Koumi Madrasha, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.41150 Long-90.10606

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown medium stiff silt little clay			2	2.5	2	3	4	7
3.0						5	8	10	18
4.5	Brownish grey medium dense very fine SAND with silt trace mica				4.5	6	8	12	20
6.0						7	10	13	23
7.5				3		8	12	15	27
9.0	Brownish grey medium dense fine SAND				3.5	5	9	11	20
10.5						6	10	12	22
12.0						7	12	13	25
13.5						8	12	15	27
15.0						8	13	17	30
16.5						9	12	16	28
18.0	Grey medium dense fine to medium SAND little silt			5	12.0	5	9	12	21
19.5						6	8	12	20
21.0						7	10	14	24
22.5						8	12	16	28
24.0						9	15	18	33
25.5						10	16	18	34
27.0	Grey dense fine SAND little silt			6	6.5	12	17	20	37
28.5						12	18	23	41
30.0	End of Boring					11	17	27	44

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-21
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 21.06.2016
Completed on: 21.06.2016

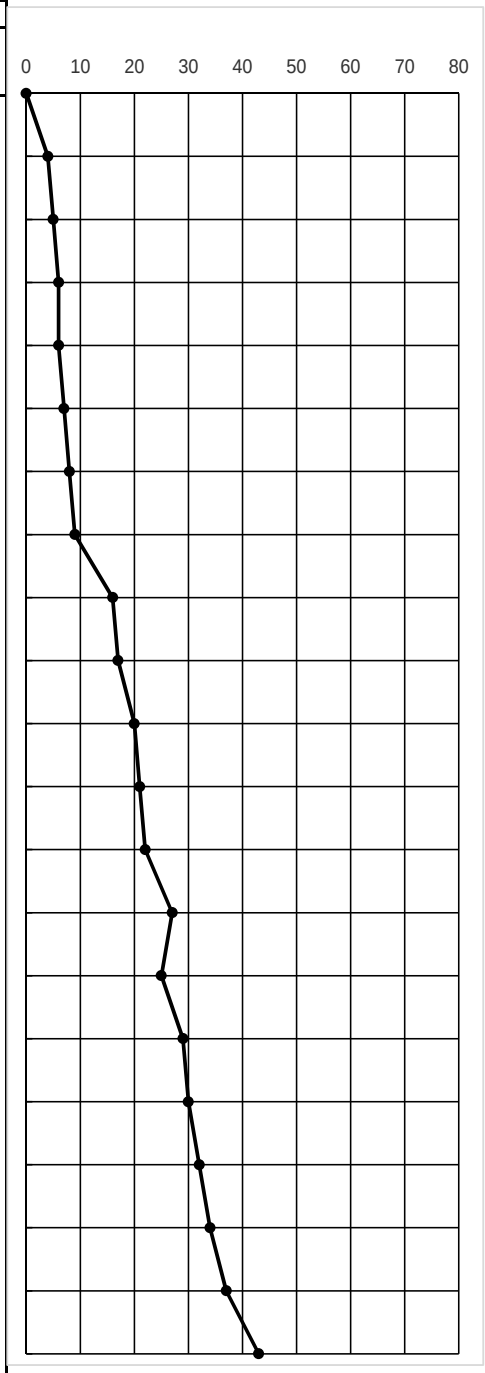
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Sonnashir Chor Union Porisod Bhovon, Sibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.41354Long-90.12445

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose silty very fine to fine SAND					1	2	2	4
3.0					5.5	2	2	3	5
4.5						2	2	4	6
6.0				1		2	3	3	6
7.5	Grey loose silty very fine SAND with clay					2	3	4	7
9.0					6.0	2	4	4	8
10.5						2	4	5	9
12.0	Light grey medium dense fine SAND little silt trace mica					4	7	9	16
13.5						5	7	10	17
15.0						5	8	12	20
16.5						6	9	12	21
18.0				3	12	7	10	12	22
19.5						8	12	15	27
21.0						9	10	15	25
22.5						9	12	17	29
24.0	Light grey dense fine to medium SAND ltrace silt					10	12	18	30
25.5						9	15	17	32
27.0				6	6.5	10	16	18	34
28.5						10	17	20	37
30.0	End of Boring					12	18	25	43

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-22
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 7.00m below EGL
Started on: 16.06.2016
Completed on: 16.06.2016

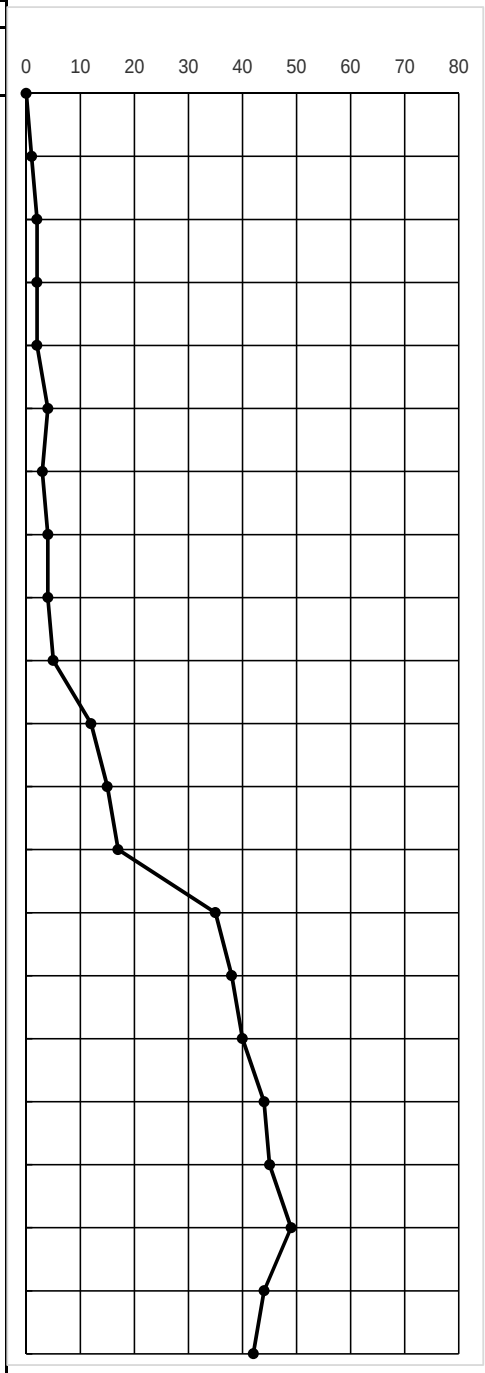
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Pacchor Balika uccho Bidhaloy, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.40017 Long-90.15089

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brownish grey very soft SILT with clay			2	14.5	1	0	1	1
3.0						1	1	1	2
4.5						1	1	1	2
6.0						1	1	1	2
7.5						1	2	2	4
9.0						1	1	2	3
10.5						1	2	2	4
12.0						1	2	2	4
13.5						1	2	3	5
15.0	Grey medium dense silty very fine SAND little clay			3	4.5	4	5	7	12
16.5						5	6	9	15
18.0						5	7	10	17
19.5	Light grey dense fine SAND with silt			5	11.0	14	17	18	35
21.0						14	18	20	38
22.5						10	20	20	40
24.0						12	21	23	44
25.5						14	20	25	45
27.0						14	22	27	49
28.5						16	24	20	44
30.0	End of Boring					12	19	23	42

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-23
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 9.00m below EGL
Started on: 17.06.2016
Completed on: 17.06.2016

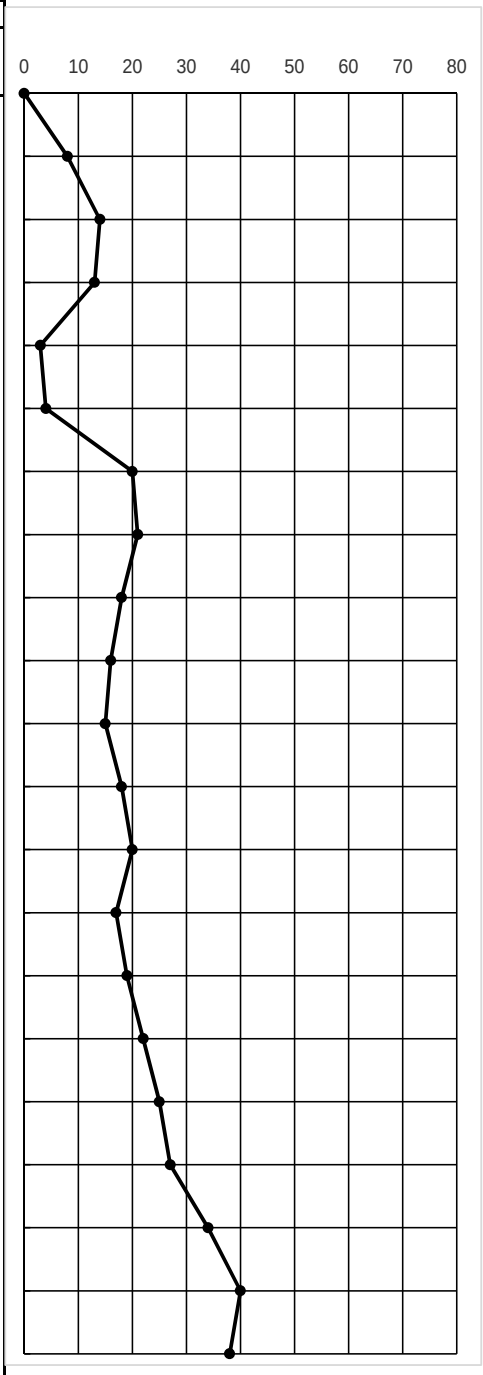
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Omar Bapary Kandi Sorkari Prathomic Bidhaloy, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.40743 Long-90.19003

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown loose fine to very fine SAND with silt			1	5.5	2	3	5	8
3.0						4	6	8	14
4.5						4	5	8	13
6.0	Grey soft SILT with very fine sand			2	3.0	2	1	2	3
7.5						1	2	2	4
9.0	Grey medium dense fine SAND little silt			3	15.0	6	8	12	20
10.5						6	8	13	21
12.0						7	8	10	18
13.5						5	7	9	16
15.0						5	8	7	15
16.5						6	8	10	18
18.0						6	9	11	20
19.5						9	7	10	17
21.0						6	8	11	19
22.5						8	10	12	22
24.0	Light grey medium dense to dense fine to medium SAND trace silt			6	6.5	8	11	14	25
25.5						10	13	14	27
27.0						10	15	19	34
28.5						12	17	23	40
30.0	End of Boring					10	16	22	38

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-24
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 2.00m below EGL
Started on: 26.06.2016
Completed on: 26.06.2016

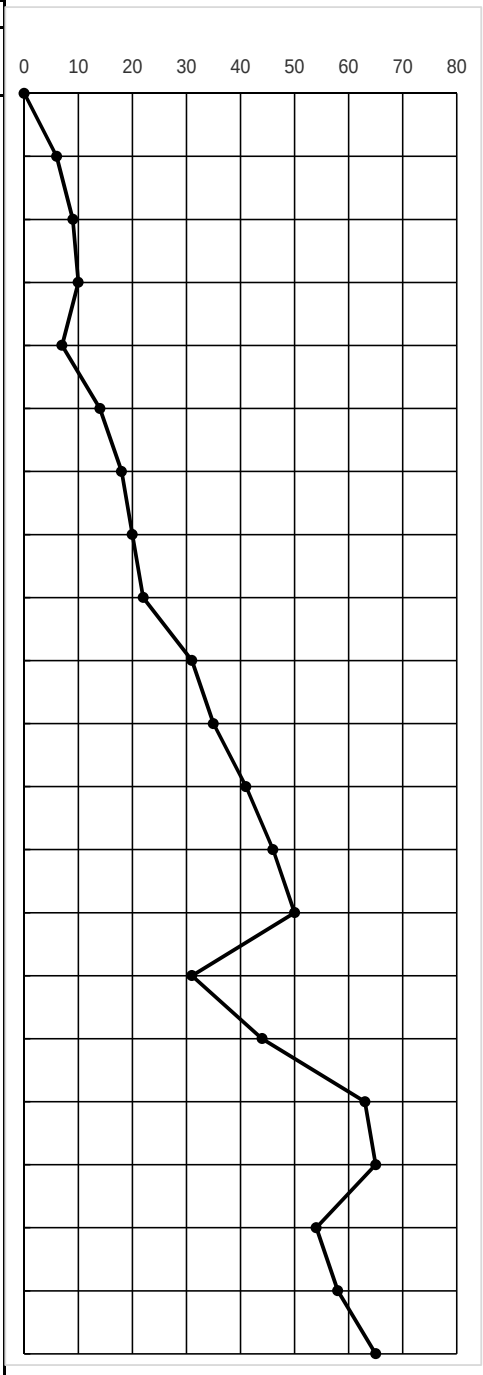
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Katal Bari Union Bhovon Mat, Shibchor, Madaripur

Legend: Clay, Silt, Sand

Coordinates: Lat-23.41491 Long-90.21689

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Standard Penetration Test: Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown loose fine SAND			1	5.5	2	2	4	6
3.0						3	4	5	9
4.5						3	5	5	10
6.0	Light medium dense fine to very fine SAND with silt			3	7.5	2	3	4	7
7.5						4	6	8	14
9.0						4	8	10	18
10.5						5	8	12	20
12.0						6	9	13	22
13.5	Light grey dense fine SAND			5	10.5	10	13	18	31
15.0						12	15	20	35
16.5						13	18	23	41
18.0						15	20	26	46
19.5						17	22	28	50
21.0						9	15	16	31
22.5						10	19	25	44
24.0	Light grey very dense fine SAND			6	6.5	19	30	33	63
25.5						20	31	34	65
27.0						19	26	28	54
28.5						18	28	30	58
30.0	End of Boring					20	30	35	65

SPT blows per 0.3 m penetration



Disturbed Sample(Split Spoon)
Undisturbed Sample(Shelby Tube)
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

BH-07

BH-07

BH-02

BH-02

BH-06

BH-06

BH-11

BH-11

BH-16

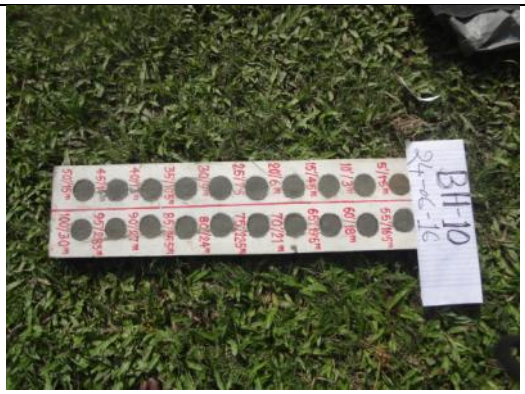
BH-16

BH-21

BH-21

BH-15

BH-10



BH-10

BH-05

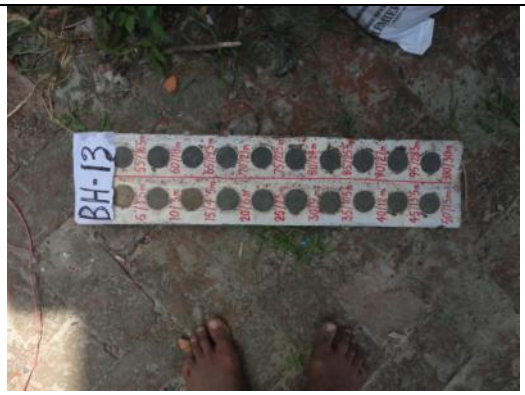
BH-05

BH-14

BH-23

BH-18

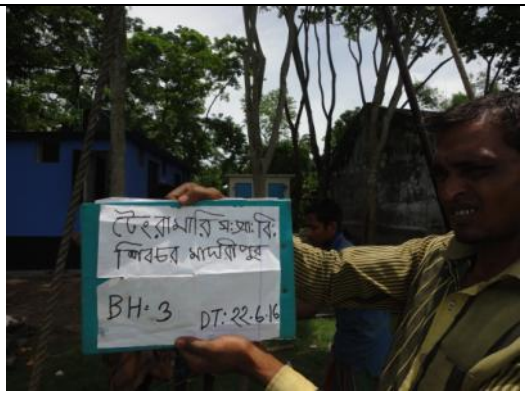
BH-13



BH-13

BH-04

BH-04



BH-03

BH-09

BH-14

BH-19

BH-24

BH-24

PS Logging Test at Shibchar Model Govt. Primary school, Shibchar Sadar Pouroshava, Shibchar Upazila (BH-12)

PS Logging Test at Bachamora Bablatola Govt. Primary School, Bablatola Bazar, Datta Para Union (BH-16)

PS Logging Test at Paschar Girls High school, Matbarer Char union (BH-22)

MASW ID:S1
Data Acquisition Date: 30.06.2016
Coordinate (1St Geophone): 23.30574/90.16282,Coordinate (Last Geophone):23.30576/90.16247
Location: Chargojari Govt. Primary School, Uttar Bayratala Union, Shibchar

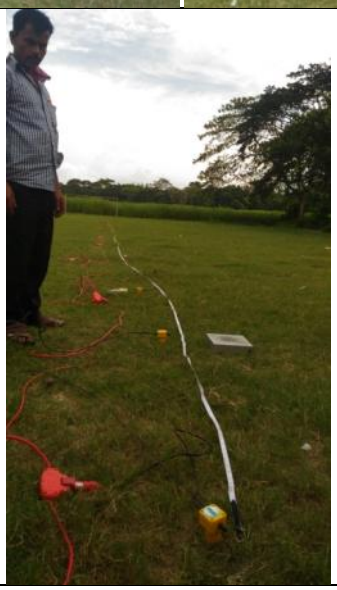
MASW ID: S2
Data Acquisition Date: 30.06.2016
Coordinate (1St Geophone): 23.32779/90.21139 ,Coordinate (Last Geophone): 23.32752/90.21123
Location: Nurul Amin University College, Umedpur Union, Shibchar


MASW ID: S3
Data Acquisition Date: 30.06.2016
Coordinate (1St Geophone): 23.32985/90.13261 ,Coordinate (Last Geophone): 23.32963/90.13240
Location: Purba Kakor High School, Charshamail, Siruail Union, Shibchar



MASW ID: S4
Data Acquisition Date: 30.06.2016
Coordinate (1St Geophone): 23.37936/90.22100 ,Coordinate (Last Geophone): 23.37910/90.22076
Location: Hazratali, Baparikandi, Kadirpur Union, Shibchar





MASW ID: S5
Data Acquisition Date: 30.06.2016
Coordinate (1St Geophone): 23.37740/90.18571 ,Coordinate (Last Geophone): 23.37713/90.18567
Location: Hoglarmat S.K.P. High School, Hoglarmat, Panch Char Union, Shibchar