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 Nawabganj Upazila

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Submitted By

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Letter of Transmittal

EXECUTIVE SUMMARY

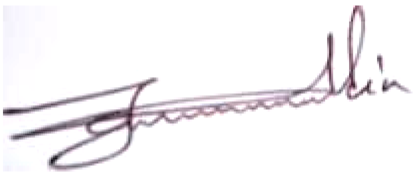
Development plan of Nawabganj Upazila, District Dhaka has been taken under package-1 and the project titled 'Preparation of Development Plan for Fourteen Upazilas' a initiative of Urban Development Directorate (UDD). In this development plan, subsurface geological and geotechnical information's has been 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, 21 boreholes with SPT program, five MASW and three Down-hole seismic survey programs have been conducted into the field at Nawabganj 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 146 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 Peak Ground Velocity (PGV) map, recommended building height maps for both high rise building and low rise building, liquefaction and 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

Nawabganj is an upazila under Dhaka District having an area of 244.80 sq km. It is situated in between 23°34´and 23°45´north latitudes and in between 90°01´ and 90°17´ east longitudes. Nawabganj Thana was formed in 1874 and was turned into an upazila in 1983.

Singair upazila is the northern boundary of Nawabganj Upazila, while Dohar upazila is on the south. Keraniganj and Sirajdikhan upazilas on the east and Harirampur upazila and Manikganj Sadar upazilas are on the west. The upazila is composed of 14 unions and 329 villages. There is no pourashava in the upazila.

Map 1: Nawabganj Upazila Map

Map Source: Banglapedia

There is debate about naming of the upazila. One legend says that during the Nababireign, when travelling from Murshidabad to Dhaka, the Nabab and his army used take rest here setting up tent. Besides, small staff used to stay here for collection of revenue. Gradually, settlements developed here and became a ganj or a market place, and thus the place came to be known as Nawabganj.

Nawabganj is very close to the Dhaka city, about 1 hour journey from the Dhaka zero point by bus. It is a place where people from different religions are living together with fraternity and harmony.

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.

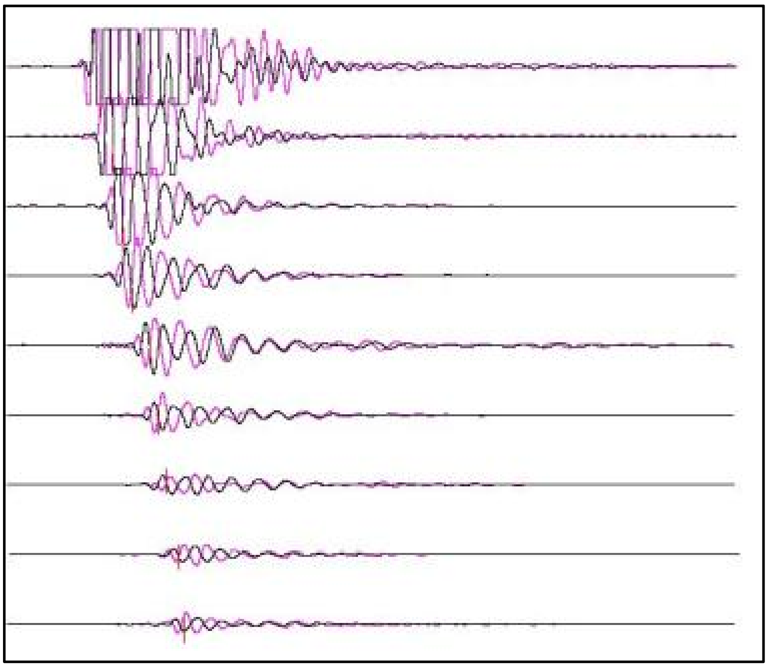
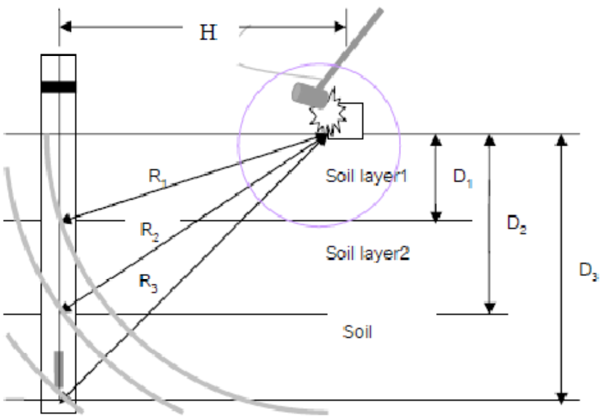


Figure 1: Determination of the Arrival Time of S-Wave

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.

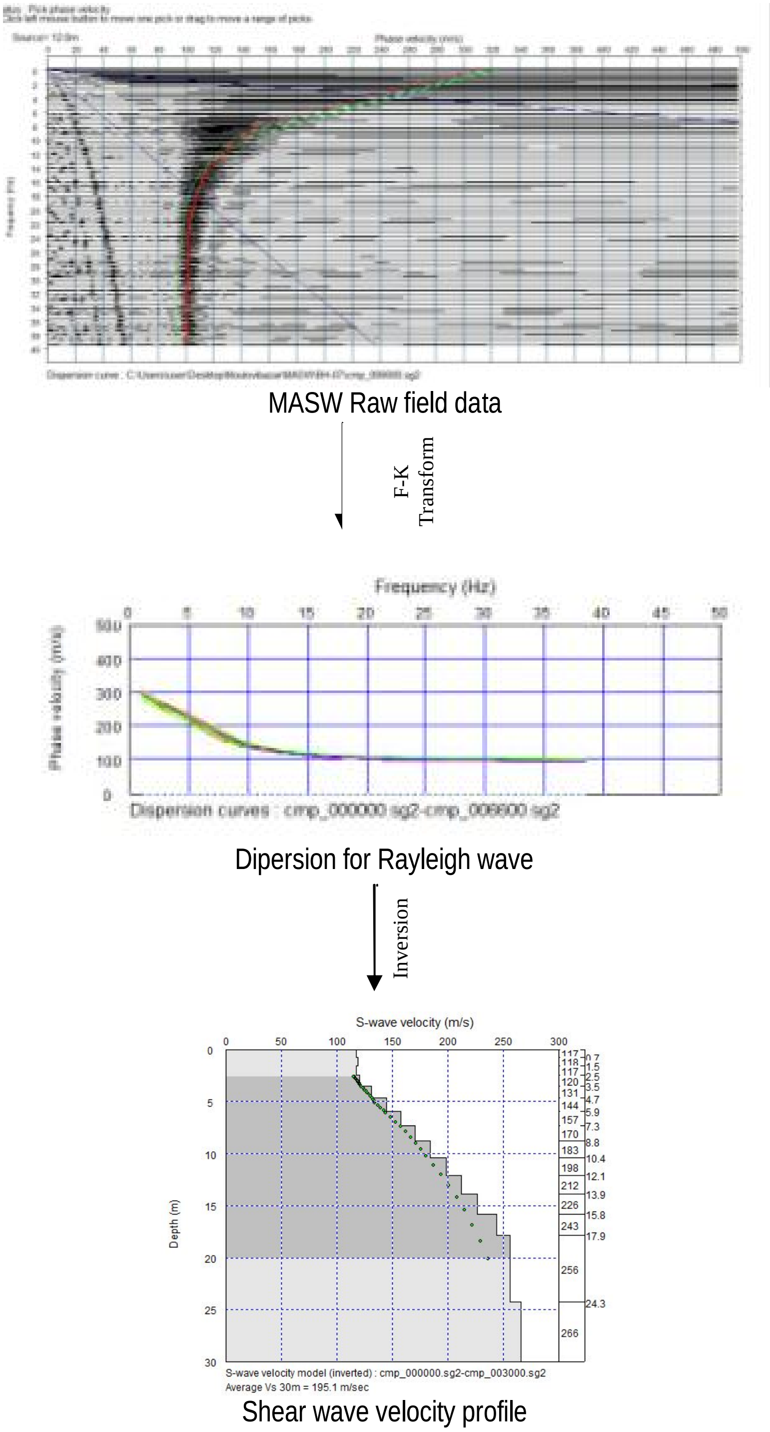


Figure 3: Main Step of the MASW Processing Technique

2.3. TEST DETAILS AND PROCEDURE OF STANDARD PENETRATION TEST

The geotechnical boreholes have been constructed using wash boring method. In this investigation, 21 numbers of boreholes have been prepared at Nawabganj 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.

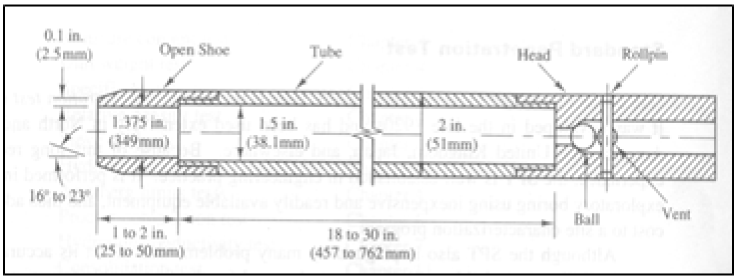


Figure 4: Split-spoon sampler.

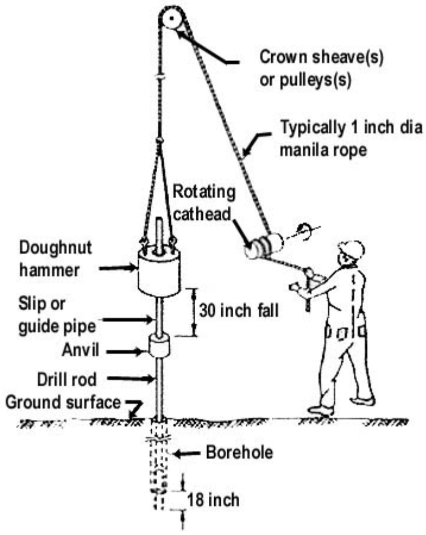


Figure 5: The SPT sampler in place in the boring with hammer

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.

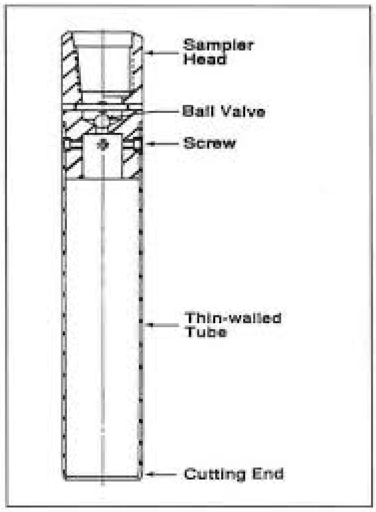
Soft clays are extremely sensitive to sampling disturbance, the effects being more pronounced in clays of low plasticity than in those of high plasticity. The central core of a soft clay sample will be relatively less disturbed than the outer zone adjacent to the sampling tube. Immediately after sampling,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



Standard thin-walled (Shelby) tube sampler

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).

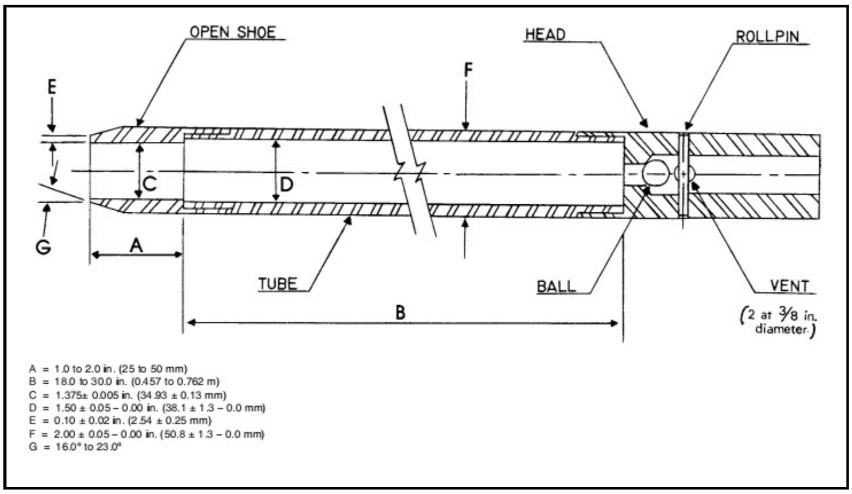


Figure 7: Undisturbed (Split-Spoon) Sampler

CHAPTER-03: SURVEY RESULT AT NAWABGANJ 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 Nawabganj 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).

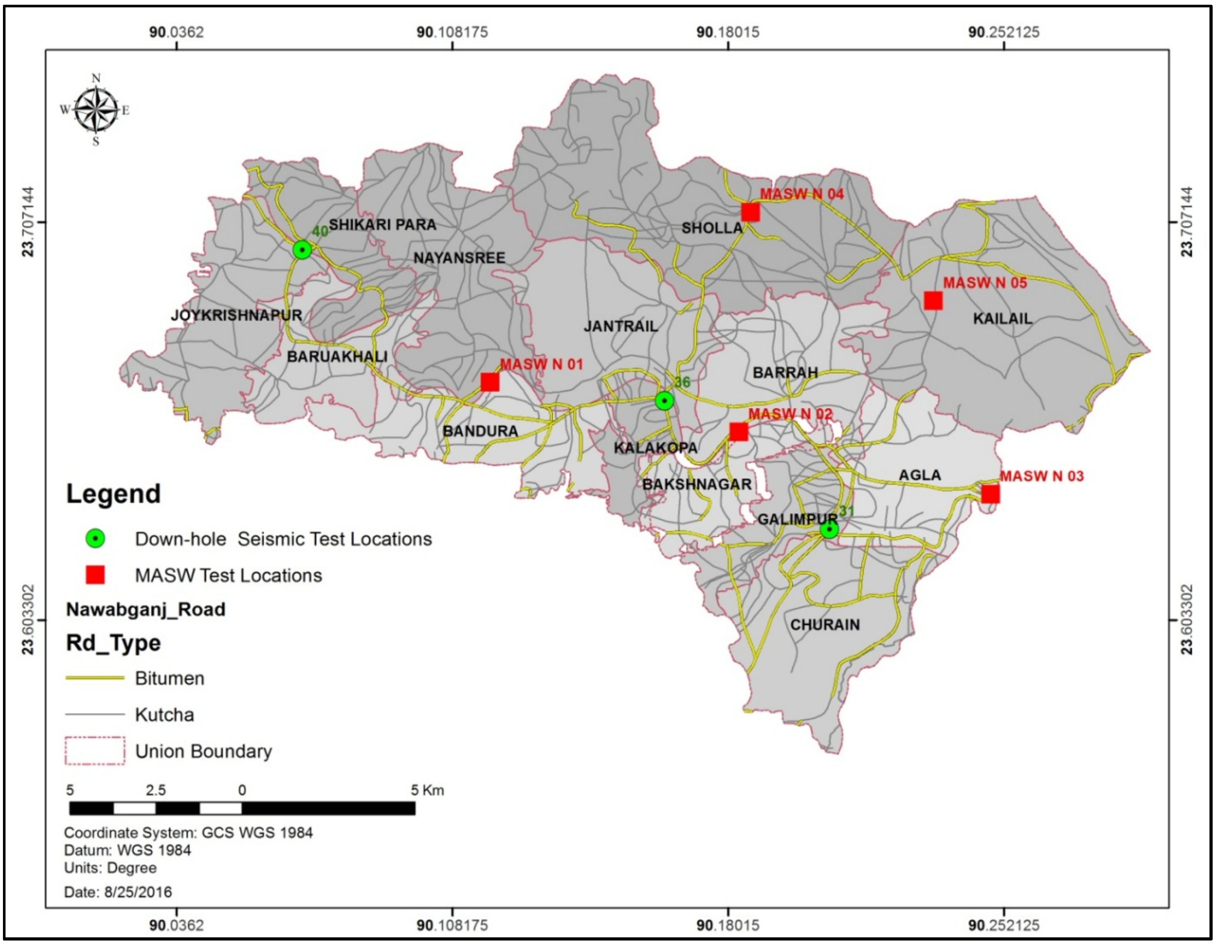
Seismic downhole test is a direct measurement method for obtaining the shear wave velocity profile of soil stratum. However, the test requires borehole which is not time and cost effective for the project. Multichannel analysis of surface waves (MASW) is a non-invasive technique which can be used to 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
Nawabganj	Downhole Seismic Test (PS Logging)	BH-31	Galimpur sanaban girls high school field, Galimpur	23.62696	90.20647
		BH-40	Shikaripara T. K. M. high school field, Shikari Para	23.69993	90.06897
		BH-36	Nawabganj press club, Nawabganj Sadar upazila	23.66061	90.16345
	Multichannel analysis of surface waves (MASW)	MASW N 01	Near Bandura Union Office, Nawabganj	23.66543	90.11801
		MASW N 02	Bardhanpara Govt. Primary School, Boynagar Union, Nawabganj	23.65251	90.18288
		MASW N 03	Banokhali, Last Boundary of Agla Union, Agla Union, Nawabganj	23.63617	90.24857
		MASW N 04	Sholla High School Field, Sholla Union, Nawabganj	23.70975	90.18594
		MASW N 05	Kailail Hanafi Dakhil Madrasah, Kailail Union, Nawabganj	23.68668	90.23368

Source: Field Survey, 2016

Map 2: Locations Map of the geophysical tests at Nawabganj 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 N 01- Near Bandura Union Office, Nawabganj

Plate 7: MASW Data Acquisitions at Nawabganj Upazila

Preparing PVC Casing for PS Logging Test

Test hole

Data Acquisition Unit

Geophone Installation into the Borehole

Shikaripara T. K. M. high school field, Shikari Para (BH-40)

Plate 8: PS logging Data Acquisitions at Nawabganj 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 Nawabganj 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

Depth from Existing Ground Level	AVS 5			AVS 10			AVS 15			AVS 20			AVS 25			AVS 28 to AVS 30		
	BH-31	BH-36	BH-40	BH-31	BH-36	BH-40	BH-31	BH-36	BH-40	BH-31	BH-36	BH-40	BH-31	BH-36	BH-40	BH-31	BH-36	BH-40
5m	87 m/s	91 m/s	94m/s															
10m				112 m/s	116 m/s	117 m/s												
15m							124 m/s	130 m/s	135 m/s									
20m										136 m/s	142 m/s	146 m/s						
25m													142 m/s	154 m/s	155 m/s			
30m																146 m/s	160 m/s	159 m/s

Source: Field survey, 2016

According to down hole seismic test results, the average shear wave velocities up to depth 30 are 146 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 Nawabganj Upazilla by 27th 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 N 1		MASW N 2		MASW N 3		MASW N 4		MASW N 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	143	0.0	118	0.0	99	0.0	100	0.0	102
1.7	143	1.7	122	1.7	104	1.1	98	1.1	101
3.8	154	3.8	147	3.8	124	2.3	106	2.3	102
6.3	182	6.3	192	6.3	161	3.7	133	3.7	113
9.2	226	9.2	215	9.2	199	5.3	169	5.3	136
12.5	266	12.5	217	12.5	201	7.0	205	7.0	163
16.2	272	16.2	215	16.2	201	8.9	239	8.9	193
20.4	273	20.4	212	20.4	199	11.0	270	11.0	204
25.0	273	25.0	209	25.0	197	13.2	302	13.2	206
40.0	293	40.0	217	40.0	204	15.6	302	15.6	205
						18.1	301	18.1	203
						20.9	299	20.9	201
						23.7	298	23.7	199
						26.8	297	26.8	198
						36.4	302	36.4	206
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*	

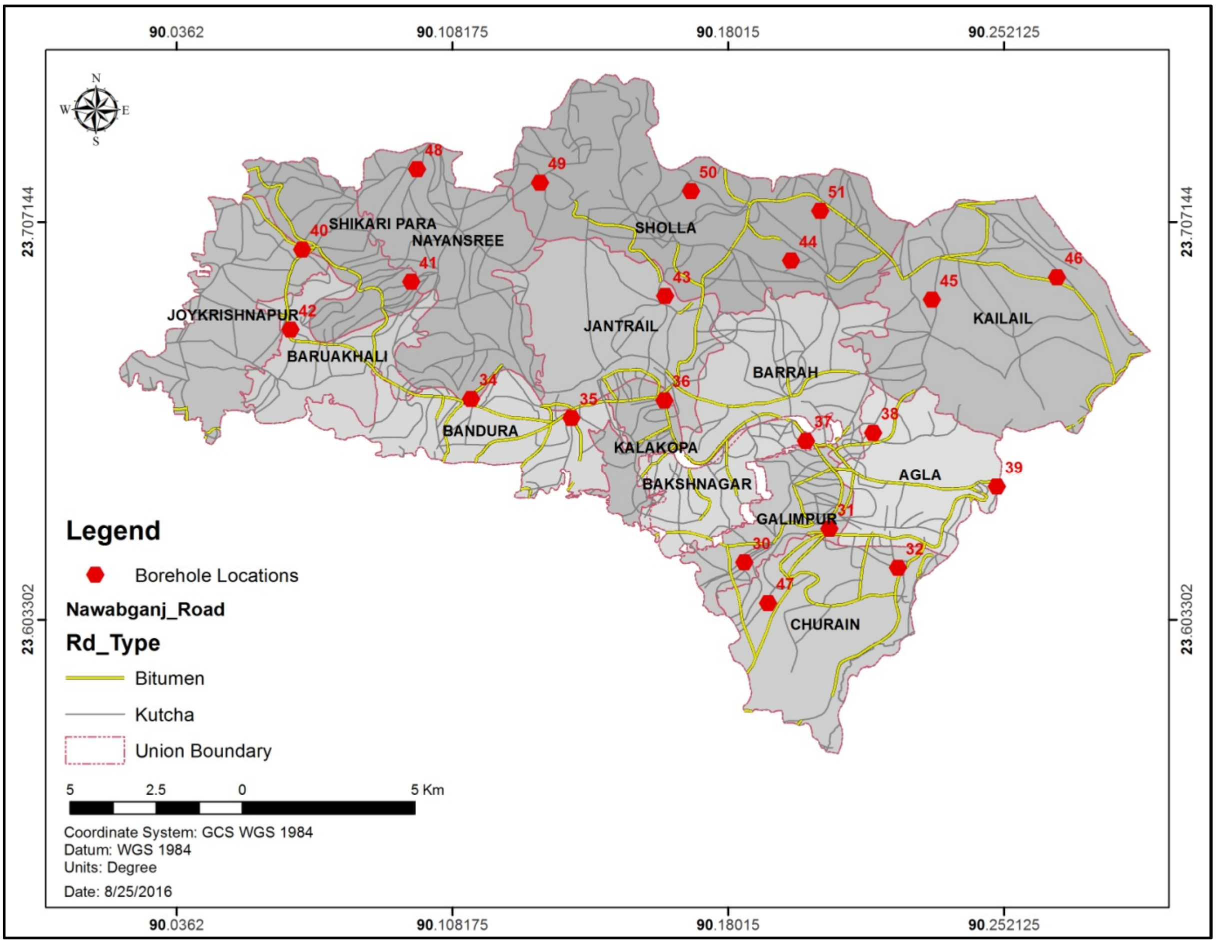
Velocity below 160m/s
Velocity 160m/s to 200m/s
Velocity 200m/s to 240m/s
Velocity 240m/s to 280m/s
Velocity 280m/s to 300m/s
Velocity above 300m/s

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 21 points at Nawabganj Upazila.

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

BH ID	Location	Coordinate		Union	Minimum SPT N Value	Maximum SPT N Value
		Lat	Long			
30	Payeksha Kaboresthan Mosque, Galimpur	23.61821	90.18433	Galimpur	3	47
31	Galimpur sanaban girls high school field, Galimpur	23.62696	90.20647	Galimpur	6	30
32	88 no. churain govt. primary school, churain	23.6168	90.22437	Churain	4	37
34	Bandura Al- amin Madrasha, Bandura Union	23.66103	90.11303	Bandura	2	38
35	Sadapur progoti govt. primary school,Bandura	23.65603	90.13924	Bandura	2	50
36	Nawabganj press club, Nawabganj Sadar upazila	23.66061	90.16345	Kalakopa	2	50
37	74 no. Chowkighata govt. primary school, Agla	23.65007	90.20043	Agla	2	43
38	80 no. Mazpara govt. primary school field, Agla	23.65214	90.21791	Agla	7	38
39	Kharsur high school, Agla	23.63808	90.25023	Agla	5	29
40	Shikaripara T. K. M. high school field, Shikari Para	23.69993	90.06897	Shikari para	3	48
41	Bokchar govt. primary school, Daudpur, Nayanshree	23.69151	90.09744	Nayanshree	5	43
42	Barruakhali govt. primary school, Po Hat Baruakhali	23.67906	90.06593	Baruakhali	3	44
43	Chondrokola Kali Mondir, Jantrail union	23.68779	90.16364	Jantrail	2	60
44	Hayat kanda Mosque, Sholla Union	23.69704	90.19654	Sholla	2	42
45	Kailail Mosque, Kailail gram	23.68686	90.23328	Kailail	5	50
46	Malikanda govt. hospital, Bottola, Kailail	23.69273	90.26591	Kailail	5	50
47	Khan Para (Mushim Hati), Churain	23.60762	90.19053	Churain	2	48
48	Uttar Barra, Nayanshree Union	23.72091	90.0989	Nayanshree	2	45
49	Sholla Union	23.71735	90.13104	Sholla	3	42
50	Chokuriya Chokbari govt. primary school, Sholla	23.7151451	90.1704712	Sholla	2	50
51	Sultanpur govt. primary school, Modhon Mohonpur, Sholla Union	23.70997	90.20408	Sholla	7	50

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

Nawabganj 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, 21 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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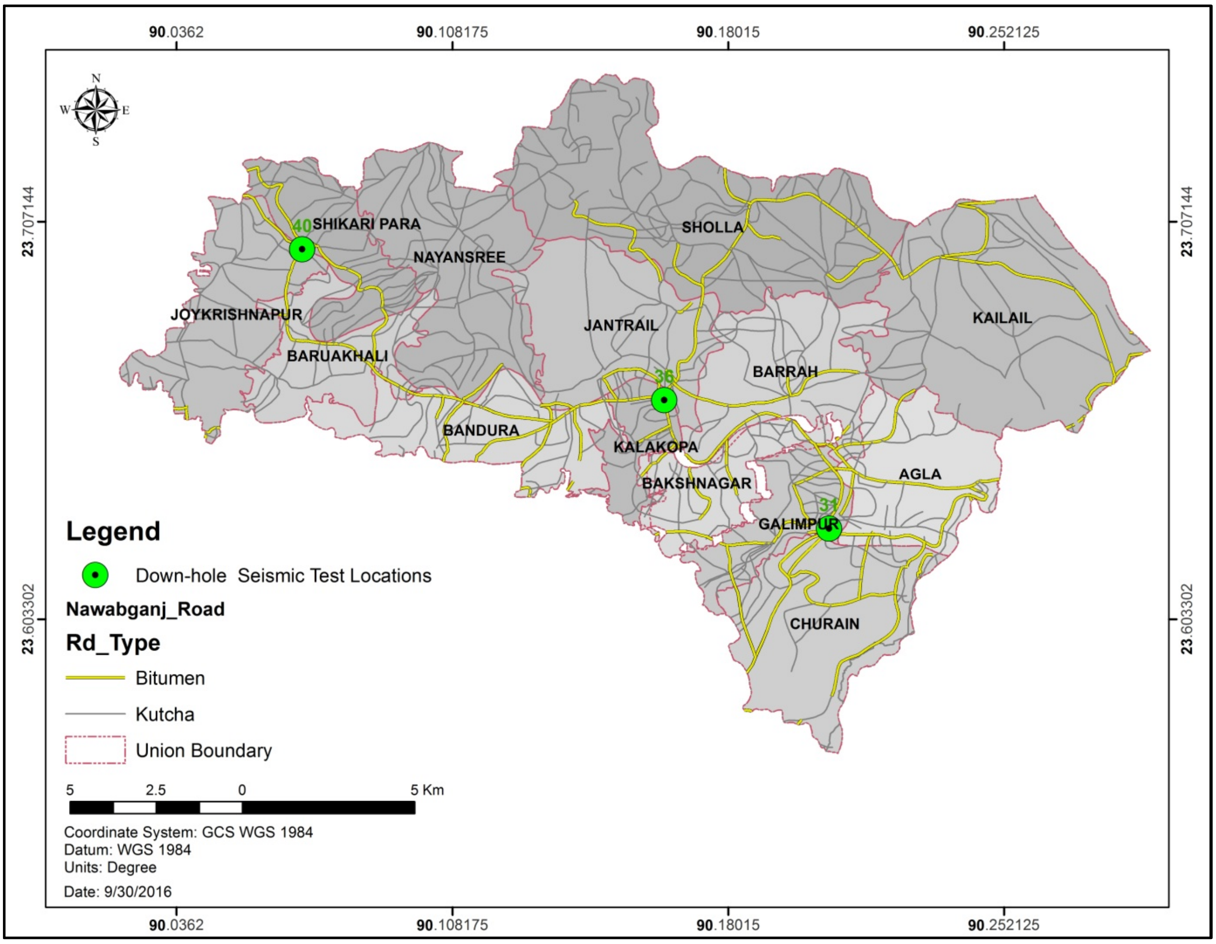
Appendix A

Downhole Seismic Test (PS Logging) Results and Graphs

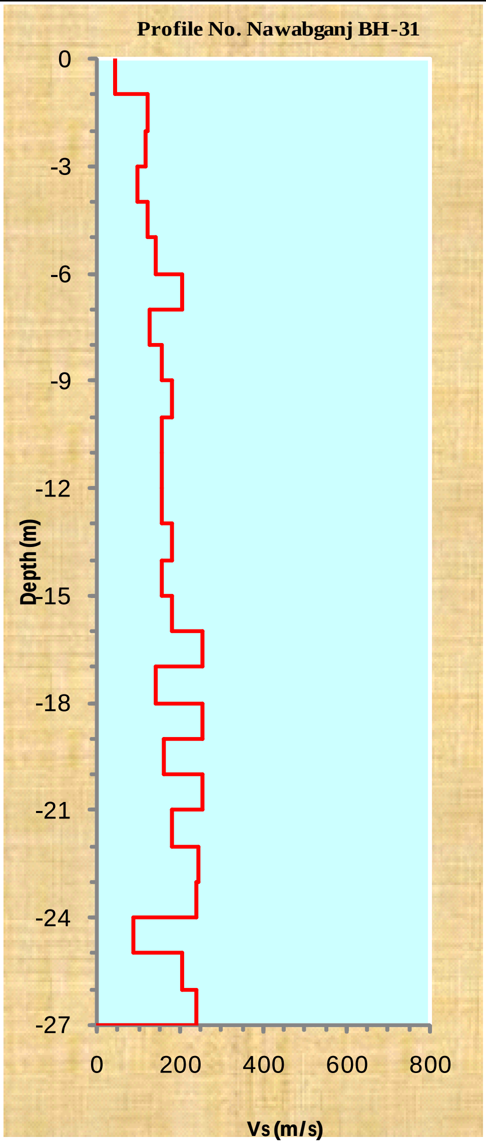


SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 28/06/2016	Source : 7kg Sledge Hammer
Location : Galimpur sanaban girls high school field, Galimpur, Nawabganj Upazila	Downhole Receiver : Tri-axial Geophone
PS Id : BH-31	Recording Equipment: Freedom Data PC
Coordinate : Lat-23.62696 Long-90.20647	Borehole Information : Grouted Cased
Operator : The Olson Instruments Downhole Seismic system	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						
0.031978	-1	1.41	0.0226	0.0226	44	AVS 5 87
0.034573	-2	2.24	0.0309	0.0083	120	
0.041494	-3	3.16	0.0394	0.0084	118	
0.051010	-4	4.12	0.0495	0.0101	99	
0.058796	-5	5.10	0.0577	0.0082	122	
0.065717	-6	6.08	0.0648	0.0072	139	AVS 10 112
0.070467	-7	7.07	0.0698	0.0049	203	
0.078328	-8	8.06	0.0777	0.0080	126	
0.084616	-9	9.06	0.0841	0.0064	157	
0.090119	-10	10.05	0.0897	0.0056	179	
0.096408	-11	11.05	0.0960	0.0063	158	AVS 15 124
0.102696	-12	12.04	0.1023	0.0063	158	
0.108985	-13	13.04	0.1087	0.0063	158	
0.114487	-14	14.04	0.1142	0.0055	181	
0.120776	-15	15.03	0.1205	0.0063	158	
0.126279	-16	16.03	0.1260	0.0055	181	AVS 20 136
0.130209	-17	17.03	0.1300	0.0040	253	
0.137284	-18	18.03	0.1371	0.0071	141	
0.141214	-19	19.03	0.1410	0.0039	253	
0.147503	-20	20.02	0.1473	0.0063	159	
0.151433	-21	21.02	0.1513	0.0039	254	AVS 25 142
0.156936	-22	22.02	0.1568	0.0055	181	
0.161056	-23	23.02	0.1609	0.0041	242	
0.165265	-24	24.02	0.1651	0.0042	237	
0.176489	-25	25.02	0.1763	0.0112	89	
0.181400	-26	26.02	0.1813	0.0049	203	AVS 27 146
0.185609	-27	27.02	0.1855	0.0042	237	

Graphical Representation of Vs

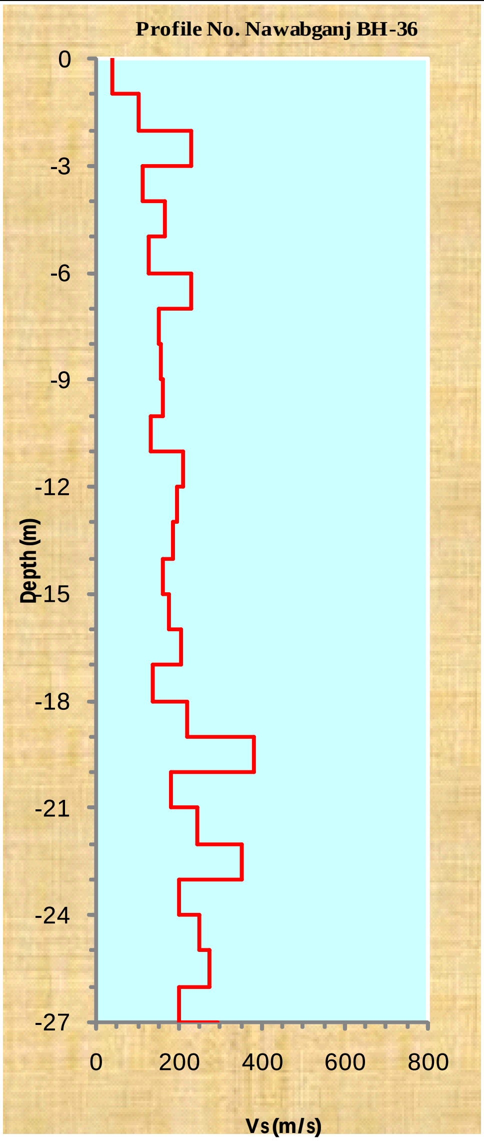


SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 28/06/2016	Source : 7kg Sledge Hammer
Location :Nawabganj press club,Nawabganj Sadar upazila, Nawabganj Upazila	Downhole Receiver : Tri-axial Geophone
PS Id : BH-36	Recording Equipment: Freedom Data PC
Coordinate : Lat-23.345724 Long-90.168121	Borehole Information : Grouted Cased
Operator : The Olson Instruments Downhole Seismic system	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						
0.036723	-1	1.41	0.0260	0.0260	39	AVS 5 91
0.040029	-2	2.24	0.0358	0.0098	102	
0.042332	-3	3.16	0.0402	0.0044	230	
0.050412	-4	4.12	0.0489	0.0087	114	
0.056055	-5	5.10	0.0550	0.0061	165	
0.063802	-6	6.08	0.0629	0.0080	126	AVS 10 116
0.068007	-7	7.07	0.0673	0.0044	228	
0.074484	-8	8.06	0.0739	0.0066	152	
0.080794	-9	9.06	0.0803	0.0064	156	
0.086933	-10	10.05	0.0865	0.0062	161	
0.094516	-11	11.05	0.0941	0.0076	131	AVS 15 130
0.099187	-12	12.04	0.0988	0.0047	212	
0.104333	-13	13.04	0.1040	0.0052	193	
0.109738	-14	14.04	0.1095	0.0054	184	
0.116014	-15	15.03	0.1158	0.0063	159	
0.121626	-16	16.03	0.1214	0.0056	178	AVS 20 142
0.126464	-17	17.03	0.1262	0.0049	206	
0.133846	-18	18.03	0.1336	0.0074	135	
0.138419	-19	19.03	0.1382	0.0046	218	
0.141021	-20	20.02	0.1408	0.0026	382	
0.146530	-21	21.02	0.1464	0.0055	181	AVS 25 154
0.150606	-22	22.02	0.1505	0.0041	245	
0.153439	-23	23.02	0.1533	0.0028	352	
0.158482	-24	24.02	0.1583	0.0051	198	
0.162489	-25	25.02	0.1624	0.0040	249	
0.166126	-26	26.02	0.1660	0.0036	274	AVS 28 160
0.171169	-27	27.02	0.1711	0.0050	198	
0.174608	-28	28.02	0.1745	0.0034	290	

Graphical Representation of Vs

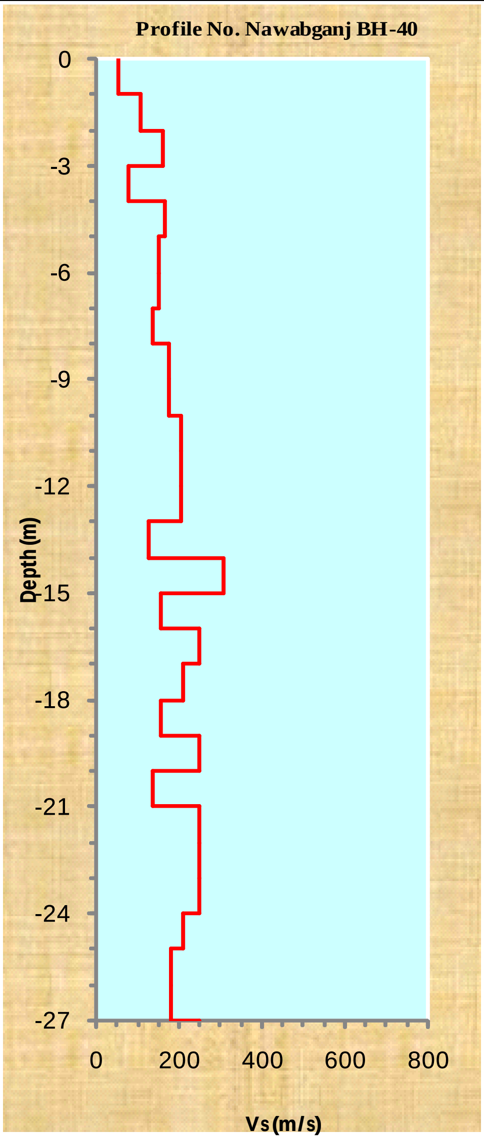


SHEAR WAVE VELOCITY MEASURMENTS DOWNHOLE SEISMIC TEST (PS LOGGING)

Tested Date(dd/mm/yyyy) : 28/06/2016	Source : 7kg Sledge Hammer
Location : Shikaripara T. K. M. high school field, Shikari Para, Nawabganj Upazila	Downhole Receiver : Tri-axial Geophone
PS Id : BH-40	Recording Equipment: Freedom Data PC
Coordinate : Lat-23.69993 Long-90.06897	Borehole Information : Grouted Cased
Operator : The Olson Instruments Downhole Seismic system	Casing Diameter : 75mm PVC Casing

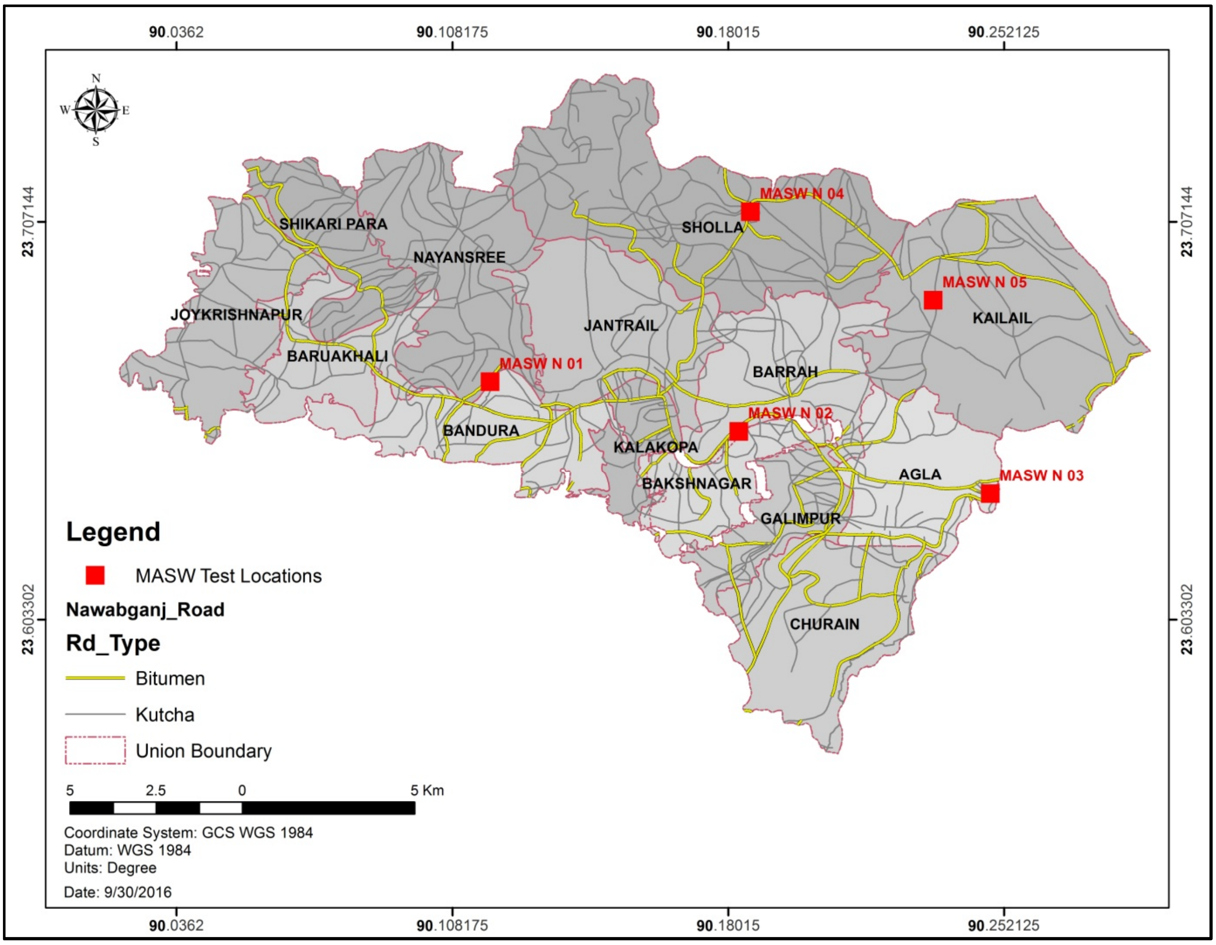
Time arrival (s)	Recorded Geophone Depth from Existing Ground Level (m)	Source Saint Distance (m), R	Corrected Travel Time for Comprettional Wave, tc=D*t/R (s)	Interval Time, ΔTs	Shear Wave Velocity Vs, Vs=D/tc (m/s)	Average Shear Wave Velocity (m/s)
Existing Ground Level						
0.027243	-1	1.41	0.0193	0.0193	52	AVS 5 94
0.032051	-2	2.24	0.0287	0.0094	106	
0.036858	-3	3.16	0.0350	0.0063	159	
0.048878	-4	4.12	0.0474	0.0125	80	
0.054487	-5	5.10	0.0534	0.0060	166	
0.060897	-6	6.08	0.0601	0.0066	151	AVS 10 117
0.067307	-7	7.07	0.0666	0.0066	152	
0.074519	-8	8.06	0.0739	0.0073	137	
0.080128	-9	9.06	0.0796	0.0057	176	
0.085737	-10	10.05	0.0853	0.0057	176	
0.090544	-11	11.05	0.0902	0.0049	206	AVS 15 135
0.095352	-12	12.04	0.0950	0.0049	206	
0.100160	-13	13.04	0.0999	0.0048	207	
0.108173	-14	14.04	0.1079	0.0080	124	
0.111378	-15	15.03	0.1111	0.0032	309	
0.117788	-16	16.03	0.1176	0.0064	156	AVS 20 146
0.121794	-17	17.03	0.1216	0.0040	248	
0.126602	-18	18.03	0.1264	0.0048	207	
0.133012	-19	19.03	0.1328	0.0064	156	
0.137019	-20	20.02	0.1368	0.0040	249	
0.144230	-21	21.02	0.1441	0.0072	139	AVS 25 155
0.148237	-22	22.02	0.1481	0.0040	249	
0.152243	-23	23.02	0.1521	0.0040	249	
0.156250	-24	24.02	0.1561	0.0040	249	
0.161057	-25	25.02	0.1609	0.0048	208	
0.166666	-26	26.02	0.1665	0.0056	178	AVS 28 159
0.172275	-27	27.02	0.1722	0.0056	178	
0.176282	-28	28.02	0.1762	0.0040	249	

Graphical Representation of Vs



Appendix B

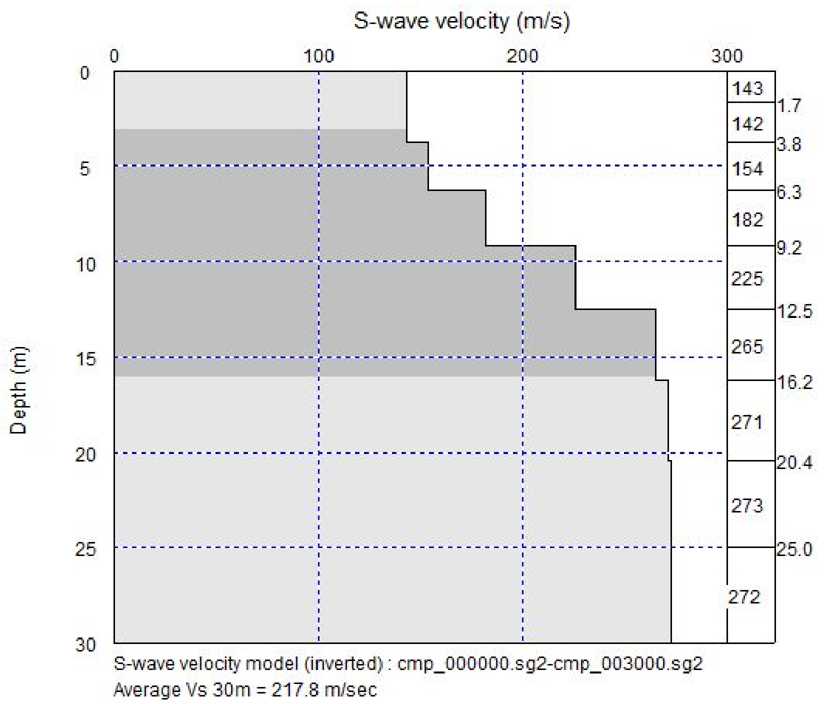
Multi-channel Analysis of Surface Wave (MASW) Results and Graphs



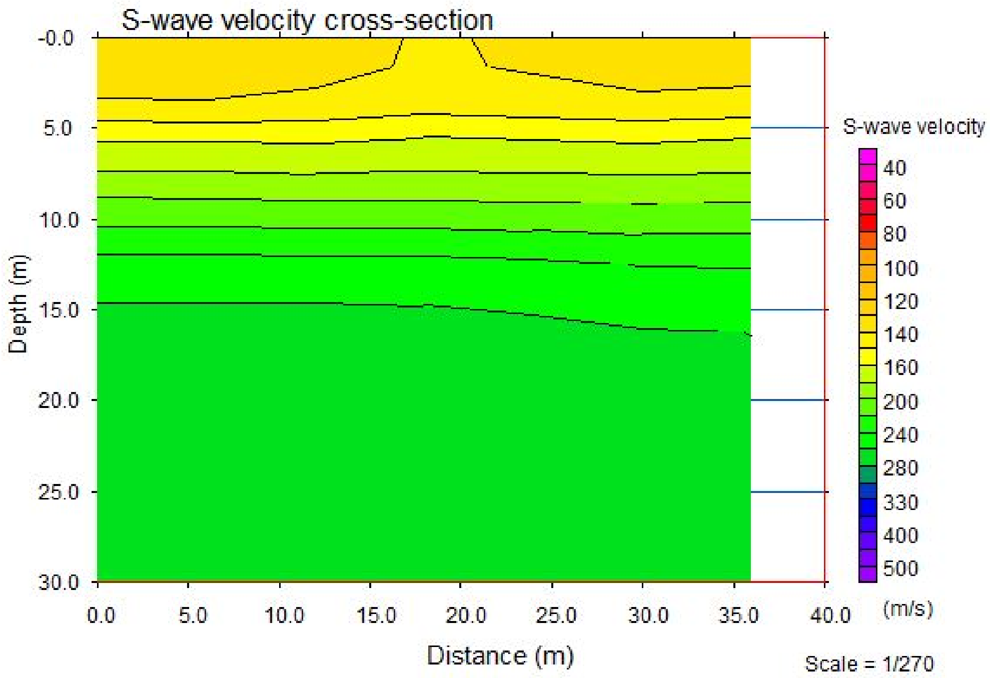
MASW ID: N1 Date: 27.06.2016
Coordinate (1st Geophone): 23.66543/90.11801,Coordinate (Last Geophone):23.66514/90.11800
Location: Near Bandura Union Office, Nawabganj

Depth	S-Wave Velocity
0.0	143
1.7	143
3.8	154
6.3	182
9.2	226
12.5	266
16.2	272
20.4	273
25.0	273
40.0	293

1D Model



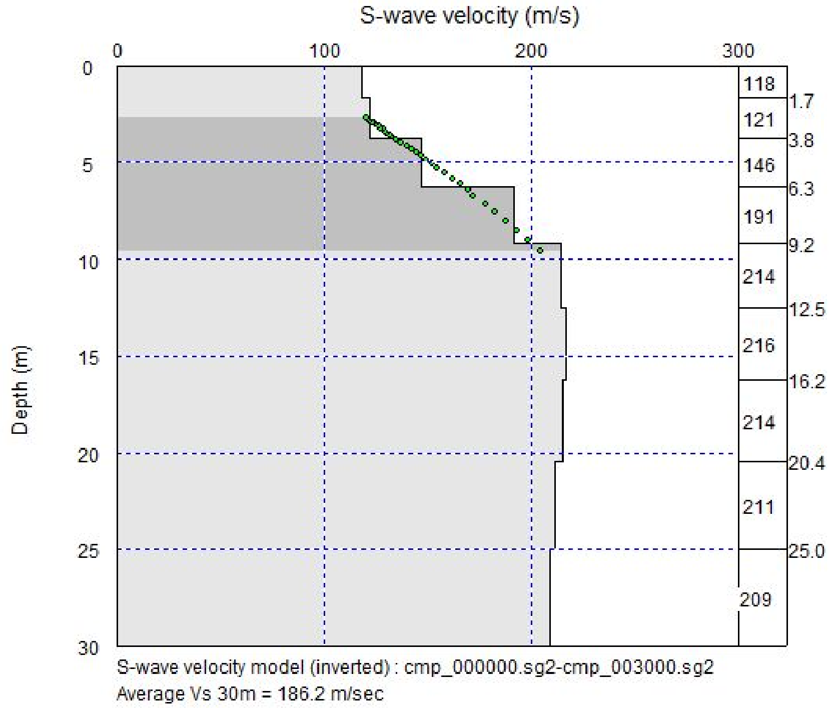
2D Model



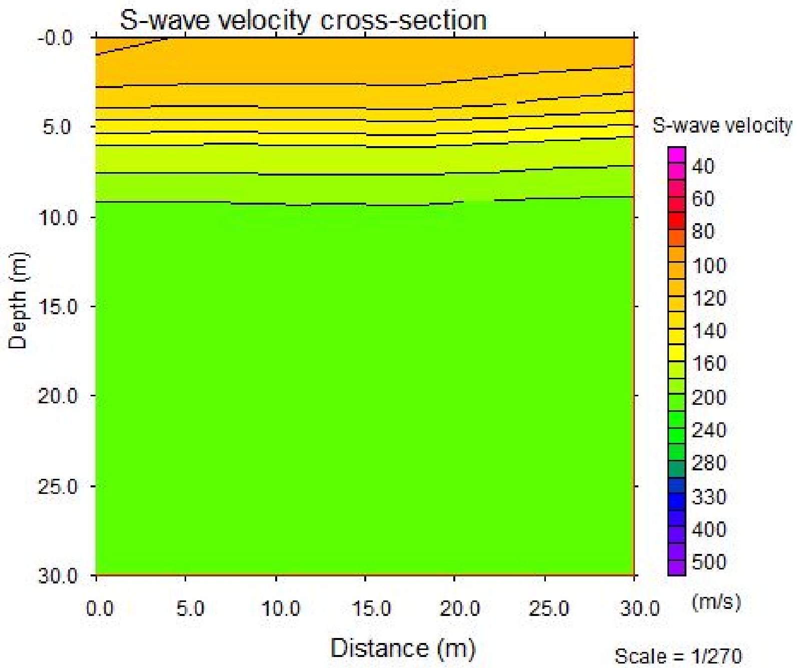
MASW ID: N2 Date: 27.06.2016
Coordinate (1st Geophone): 23.65251/90.18288 ,Coordinate (Last Geophone): 23.65269/90.18264
Location: Bardhanpara Govt. Primary School, Boynagar Union, Nawabganj

Depth | **S-Wave Velocity** | **1D Model**

Depth	S-Wave Velocity
0.0	118
1.7	122
3.8	147
6.3	192
9.2	215
12.5	217
16.2	215
20.4	212
25.0	209
40.0	217



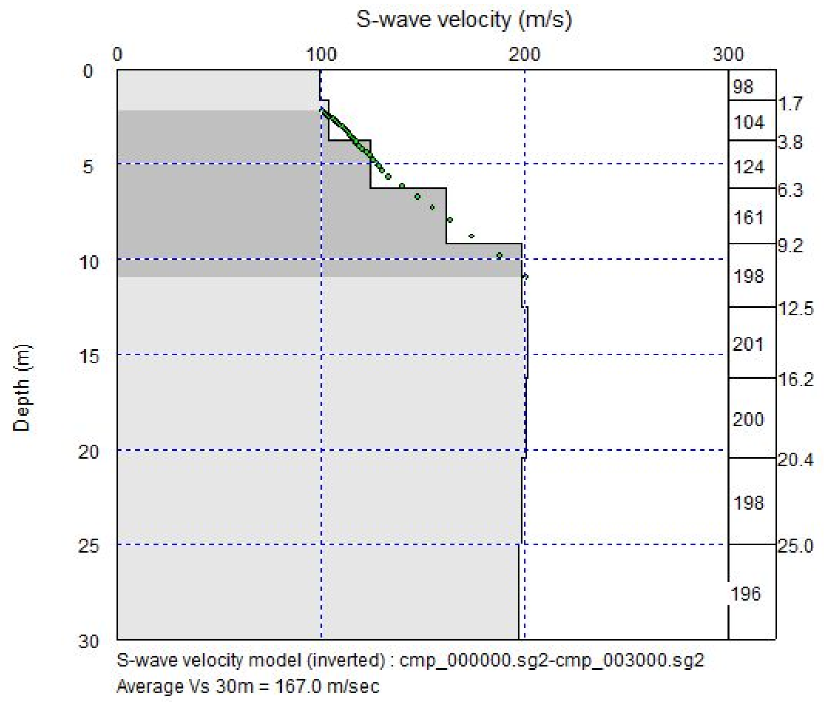
2D Model



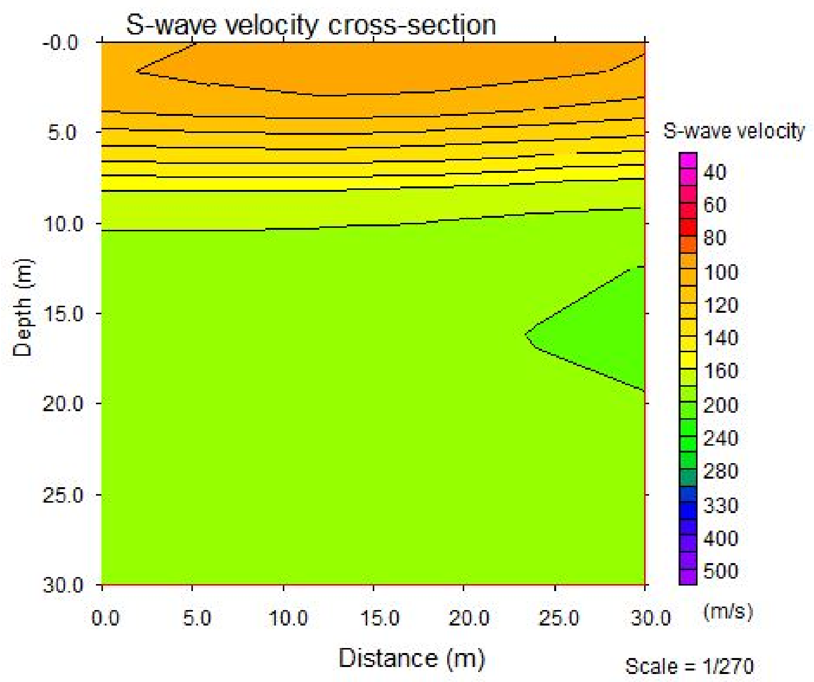
MASW ID: N3 Date: 27.06.2016
Coordinate (1st Geophone): 23.63617/90.24857 ,Coordinate (Last Geophone): 23.63643/90.24866
Location: Banokhali, Last Boundary of Agla Union, Agla Union, Nawabganj

Depth	S-Wave Velocity
0.0	99
1.7	104
3.8	124
6.3	161
9.2	199
12.5	201
16.2	201
20.4	199
25.0	197
40.0	204

1D Model



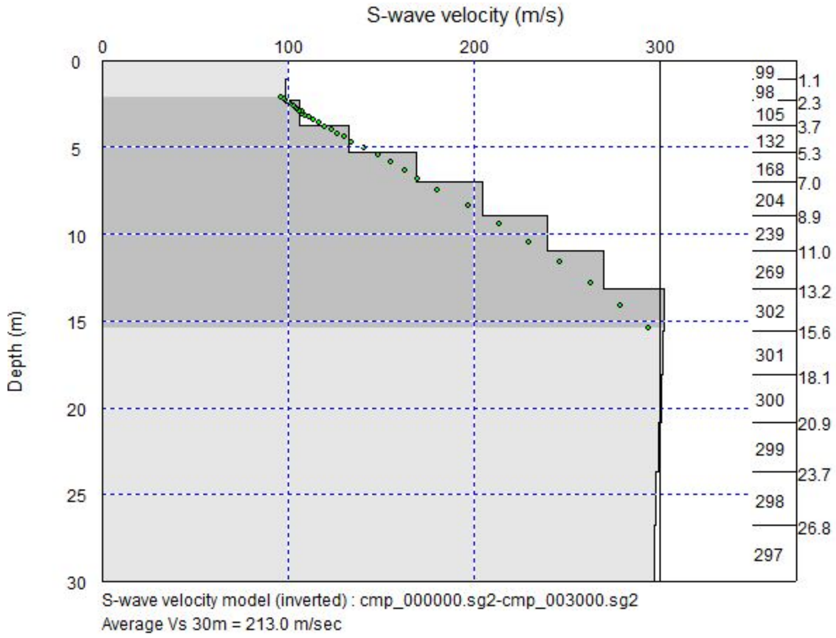
2D Model



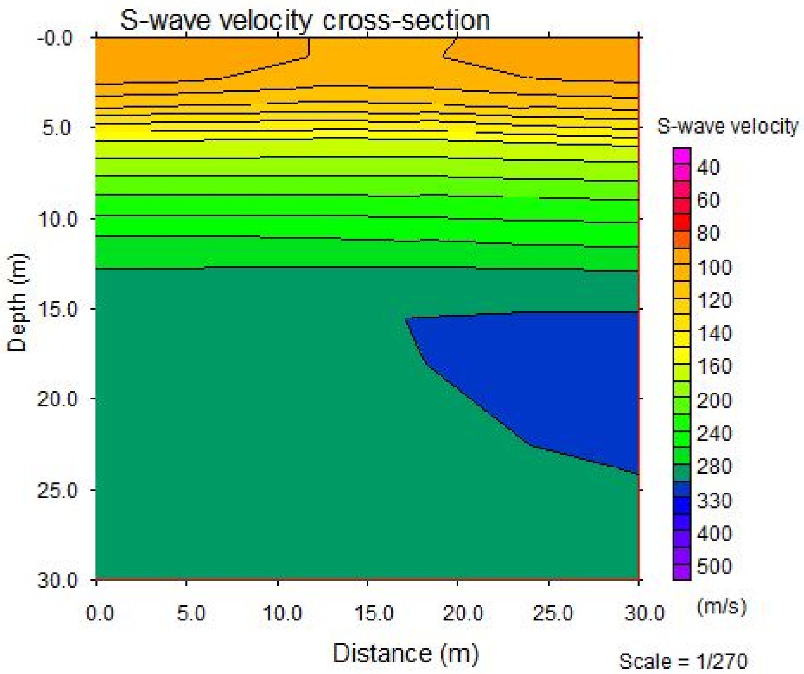
MASW ID: N4 Date: 27.06.2016
Coordinate (1St Geophone): 23.70975/90.18594 ,Coordinate (Last Geophone): 23.70950/90.18589
Location: Sholla High School Field, Sholla Union, Nawabganj

Depth	S-Wave Velocity
0.0	100
1.1	98
2.3	106
3.7	133
5.3	169
7.0	205
8.9	239
11.0	270
13.2	302
15.6	302
18.1	301
20.9	299
23.7	298
26.8	297
36.4	302

1D Model



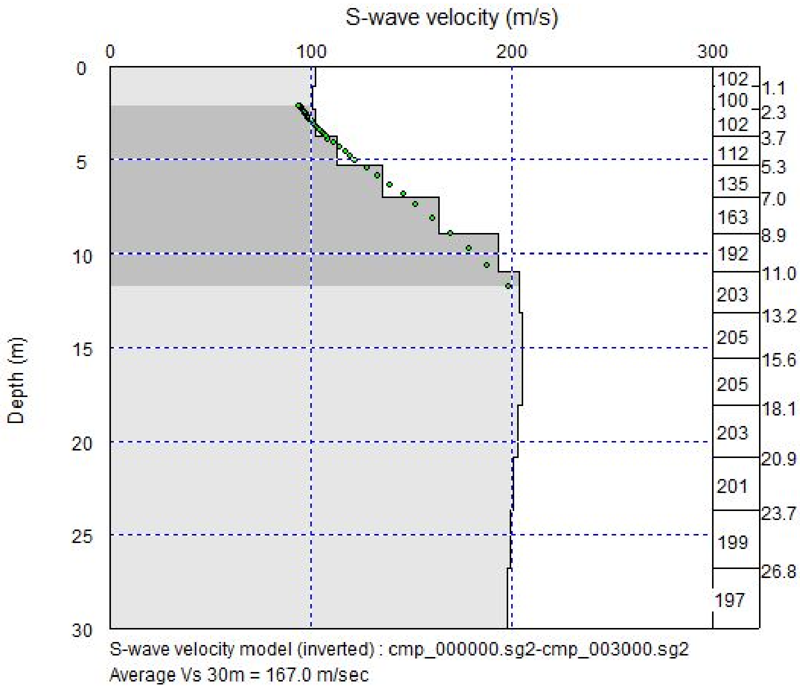
2D Model



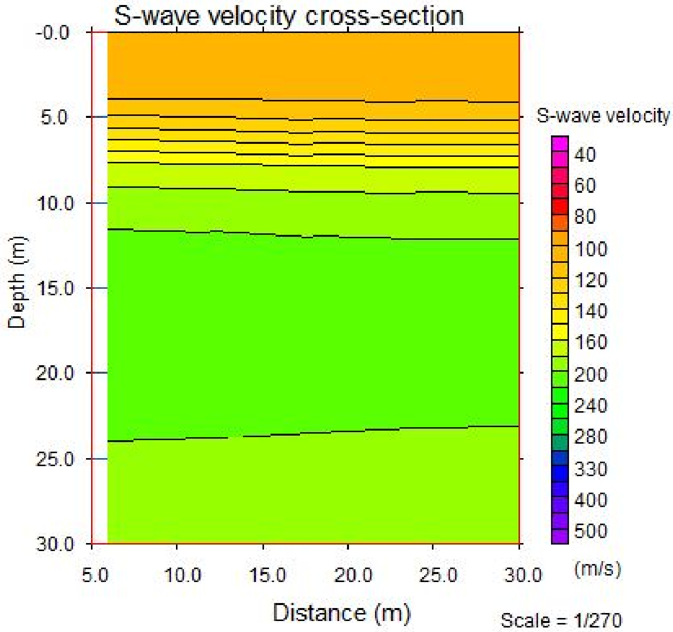
MASW ID: N5 Date: 27.06.2016
Coordinate (1st Geophone): 23.68668/90.23368 ,Coordinate (Last Geophone): 23.68658/90.23401
Location: Kailail Hanafi Dakhil Madrasah, Kailail Union, Nawabganj

Depth	S-Wave Velocity
0.0	102
1.1	101
2.3	102
3.7	113
5.3	136
7.0	163
8.9	193
11.0	204
13.2	206
15.6	205
18.1	203
20.9	201
23.7	199
26.8	198
36.4	206

1D Model

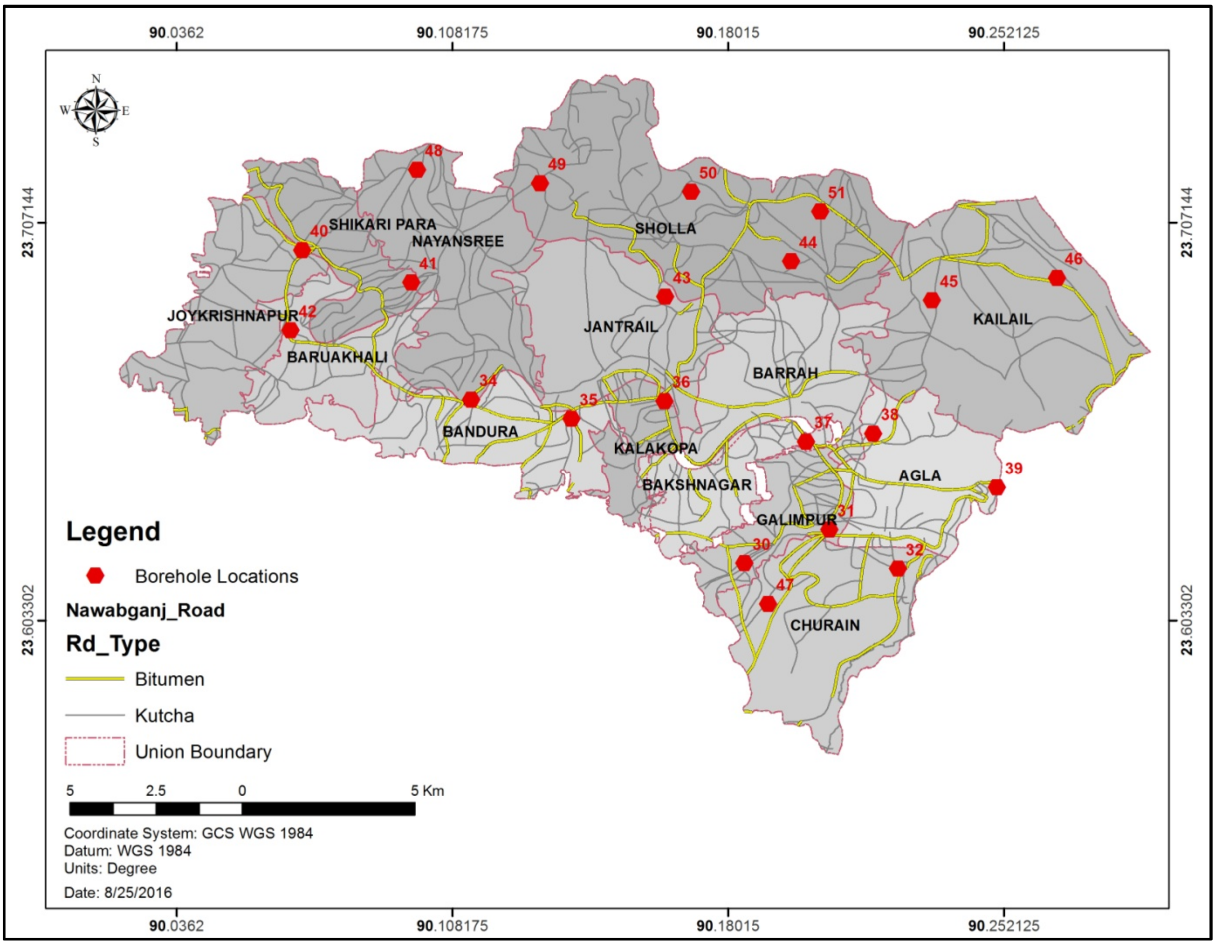


2D Model



Appendix C

Geotechnical Logs and Laboratory Test Results and Graphs



GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-30
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

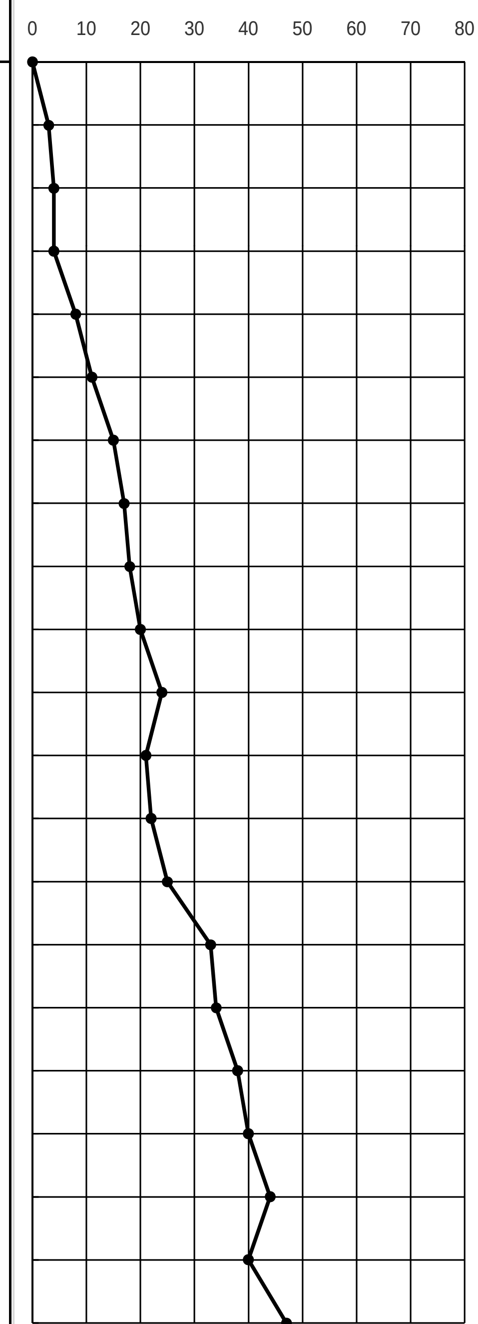
Exixting ground level:
Ground water level: 1.0m below EGL
Started on: 10.06.2016
Completed on: 10.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Payeksha Kaboresthan Mosque, Galimpur, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.61821 Long-90.18433

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft to medium stiff SILT with clay	Silt	Disturbed	2	5.0	1	1	2	3
3.0			Disturbed			1	2	2	4
4.5			Disturbed			2	2	2	4
6.0	Brown loose very fine silty SAND little clay	Sand	Disturbed	4	1.0	2	3	5	8
7.5	Light grey medium dense to dense fine SAND little silt	Sand	Disturbed	5	17.0	3	4	7	11
9.0			Disturbed			4	6	9	15
10.5			Disturbed			5	7	10	17
12.0			Disturbed			5	8	10	18
13.5			Disturbed			6	8	12	20
15.0			Disturbed			6	10	14	24
16.5			Disturbed			7	9	12	21
18.0			Disturbed			8	10	12	22
19.5			Disturbed			10	12	13	25
21.0			Disturbed			10	15	18	33
22.5			Disturbed			12	14	20	34
24.0	Grey dense fine to medium SNAD trace silt	Sand	Disturbed	6	7.0	12	16	22	38
25.5			Disturbed			10	15	25	40
27.0			Disturbed			12	17	27	44
28.5			Disturbed			13	18	22	40
30.0	End of Boring		Disturbed			15	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-31
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

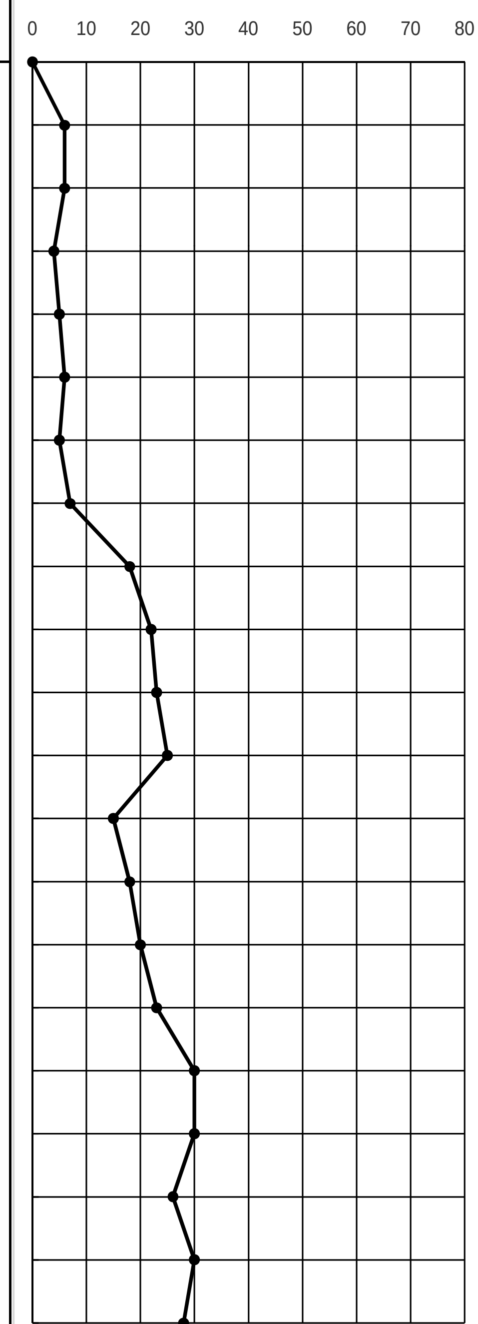
Exixting ground level:
Ground water level: 4.20m below EGL
Started on: 02.06.2016
Completed on: 02.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Galimpur sanaban girls high school field, Galimpur, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.62696 Long-90.20647

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values (30cm)
1.5	Brown to grey medium stiff SILT with very fine sand	2	11.0	1	2	4	6
3.0				1	3	3	6
4.5				1	2	2	4
6.0				1	2	3	5
7.5				1	3	3	6
9.0				1	3	2	5
10.5				1	3	4	7
12.0	Grey medium dense to dense fine SAND little silt	5	19.0	5	8	10	18
13.5				6	10	12	22
15.0				6	10	13	23
16.5				6	10	15	25
18.0				3	5	10	15
19.5				5	7	11	18
21.0				6	7	13	20
22.5				6	8	15	23
24.0				5	13	17	30
25.5				6	12	18	30
27.0				6	11	15	26
28.5				6	13	17	30
30.0	End of Boring			7	12	16	28

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-32
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

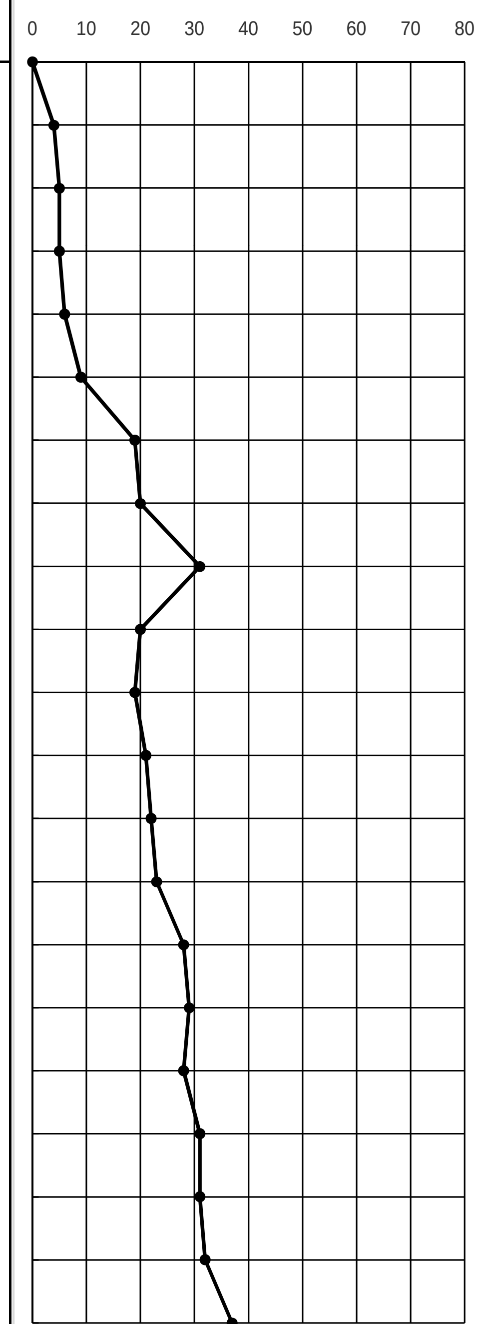
Exixting ground level:
Ground water level: 2.50m below EGL
Started on: 01.06.2016
Completed on: 01.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : 88 no. churain govt. primary school, churain, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.61680 Long-90.22437

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft to medium stiff clayey SILT trace sand	2	7.0	1	2	2	4
3.0				1	2	3	5
4.5				1	2	3	5
6.0				2	3	3	6
7.5	Brownish grey loose fine to very fine SAND with silt and mica	4	1.5	3	3	6	9
9.0	Grey medium dense fine SAND little silt	5	11.0	4	8	11	19
10.5				6	7	13	20
12.0				8	11	20	31
13.5				6	8	12	20
15.0				5	7	12	19
16.5				6	8	13	21
18.0				7	10	12	22
19.5				8	11	12	23
21.0	Grey medium dense to dense fine to medium SAND trace silt & mica	6	9.5	8	13	15	28
22.5				7	12	17	29
24.0				7	13	15	28
25.5				8	15	16	31
27.0				8	14	17	31
28.5				9	16	16	32
30.0	End of Boring			8	17	20	37

SPT blows per 0.3 m penetration



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

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-34
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

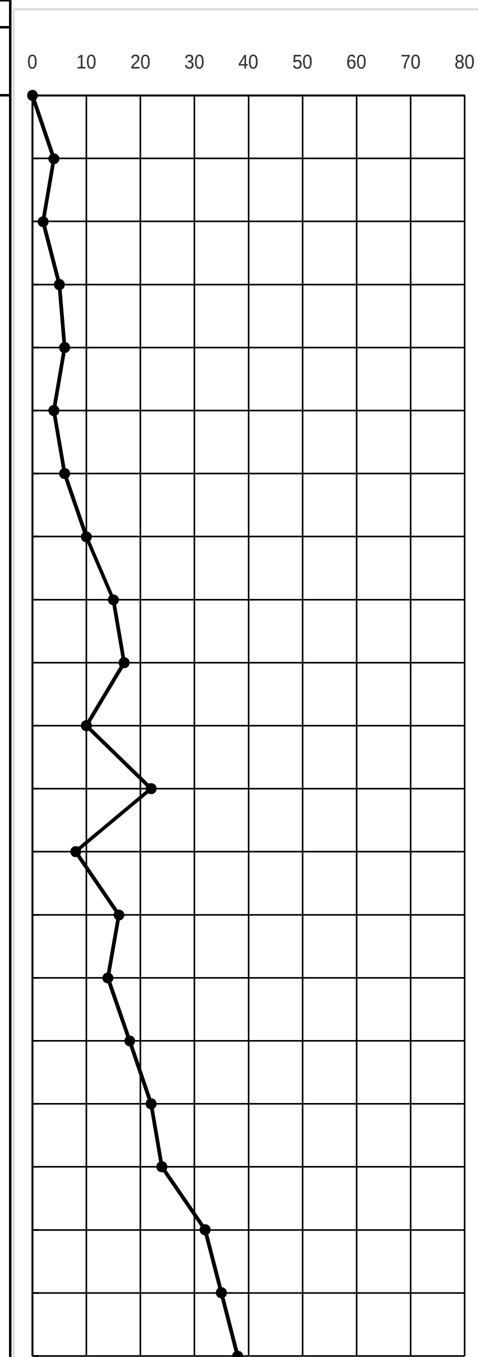
Exixting ground level:
Ground water level: 4.26m below EGL
Started on: 06.06.2016
Completed on: 06.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Bandura Al- amin Madrasha, Bandura Union, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.66103 Long-90.11303

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	15cm	15cm	15cm	30cm (N-Values)
1.5	Brownish grey soft to medium stiff Clayey SILT	Silt		2	8.0	1	2	2	4
3.0						1	1	1	2
4.5						1	2	3	5
6.0						2	3	3	6
7.5						2	2	2	4
9.0	Grey loose silty fine to very fine SAND	Sand		4	3.0	3	4	6	6
10.5						5	7	8	10
12.0	Grey dense fine SAND little silt	Sand		5	8.0	8	7	10	15
13.5						4	5	5	17
15.0						8	10	12	10
16.5						3	3	5	22
18.0						6	7	9	8
19.5	Grey dense fine to medium SAND trace silt	Sand		6	11.0	5	6	8	16
21.0						7	8	10	14
22.5						6	9	13	18
24.0						10	11	13	22
25.5						12	15	17	24
27.0						13	17	18	32
28.5						12	18	20	35
30.0	End of Boring					0	0	0	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-35
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.30m below EGL
Started on: 06.06.2016
Completed on: 06.06.2016

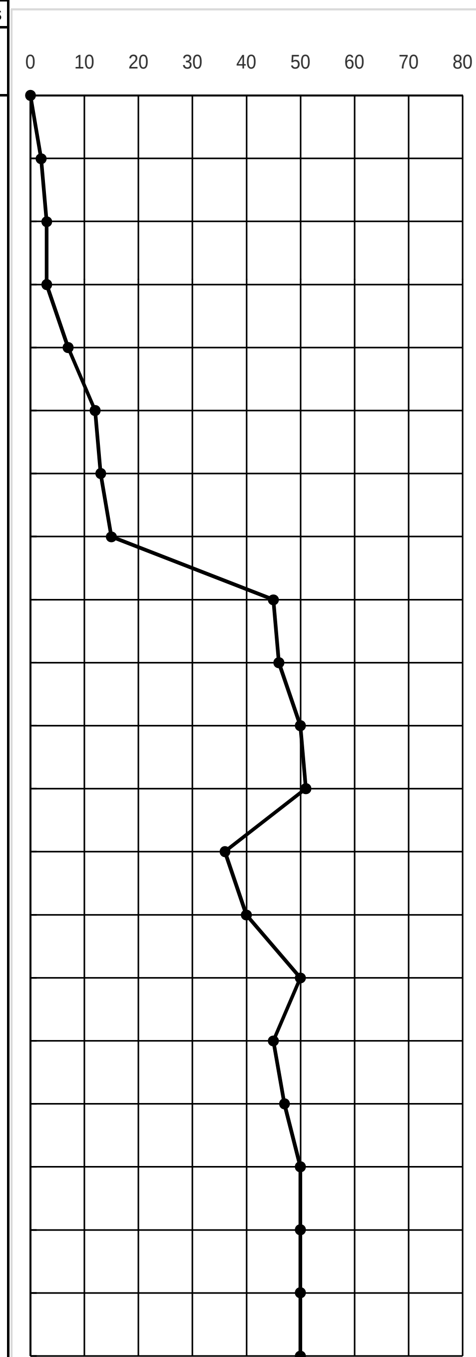
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Sadapur progoti govt. primary school,Bandura , Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.65603 Long-90.13924

Depth (m)	Visual Description	Symbols	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values 30cm
1.5	Brownish grey loose very fine to fine SAND little silt	Sand	1	2.0	1	1	1	2
3.0	Brown soft to medium stiff Clayey SILT little sand	Silt	2	5.0	1	1	2	3
4.5					1	1	2	3
6.0					1	3	4	7
7.5	Dark grey organic CLAY	Clay	3	1.0	4	5	7	12
9.0	Grey medium dense fine to very fine SAND woith silt	Sand	4	3.0	5	6	7	13
10.5					5	7	8	15
12.0	Grey dense fine SAND little silt	Sand	5	10.0	10	20	25	45
13.5					12	20	26	46
15.0					13	22	28	50
16.5					14	22	29	51
18.0					11	16	20	36
19.5					10	18	22	40
21.0					15	22	28	50
22.5	Grey dense to very dense fine to medium SAND trace silt	Sand	6	8.0	16	20	25	45
24.0					18	22	25	47
25.5					18	23	27	50
27.0					19	24	26	50
28.5					20	25	25	50
30.0	End of Boring				21	26	24	50

Standard Penetration Test — Blows on Spoon / N-Values

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-36
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

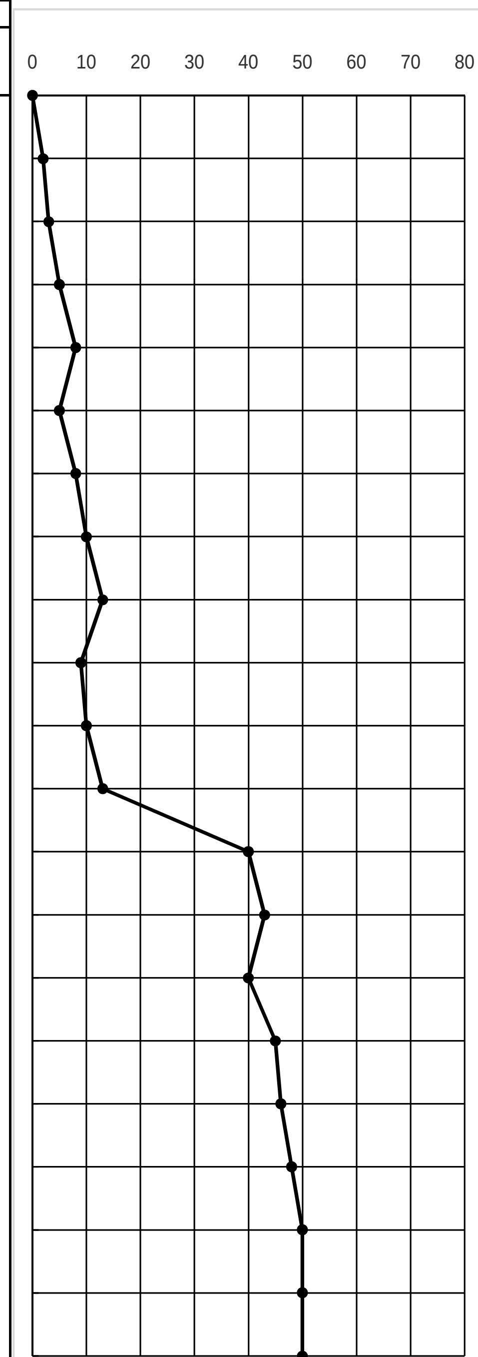
Exixting ground level:
Ground water level: 5.20m below EGL
Started on: 05.06.2016
Completed on: 05.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Nawabganj press club,Nawabganj Sadar upazila, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.66061 Long-90.16345

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values 30cm
1.5	Brown very soft to soft SILT with very fine SAND	2	4.0	1	1	1	2
3.0				1	1	2	3
4.5	Grey very loose to medium dense very fine to fine SAND little silt	4	13.0	1	2	3	5
6.0				2	3	5	8
7.5				2	2	3	5
9.0				2	3	5	8
10.5				3	4	6	10
12.0				3	6	7	13
13.5				2	3	6	9
15.0				4	4	6	10
16.5				4	6	7	13
18.0	Light grey dense fine SAND trace silt	5	13.0	12	17	23	40
19.5				13	18	25	43
21.0				12	16	24	40
22.5				10	20	25	45
24.0				12	20	26	46
25.5				13	22	26	48
27.0				14	20	30	50
28.5				16	21	29	50
30.0	End of Boring			18	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-37
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

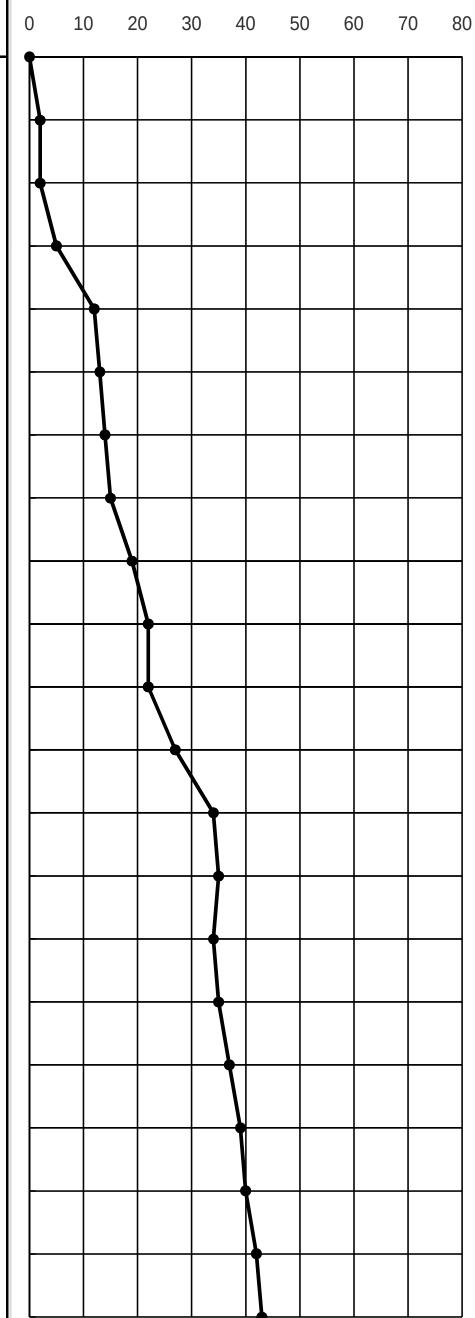
Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 04.06.2016
Completed on: 04.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : 74 no. Chowkighata govt. primary school, Agla, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.65007 Long-90.20043

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values 30cm
1.5	Brown soft to medium stiff SILT with very fine SAND	2	5.0	1	1	1	2
3.0				1	1	1	2
4.5				1	2	3	5
6.0	Grey medium dense silty very fine SAND	4	3.0	3	5	7	12
7.5				3	6	7	13
9.0	Grey medium dense fine SAND little silt	5	9.0	5	8	6	14
10.5				5	7	8	15
12.0				8	9	10	19
13.5				7	10	12	22
15.0				6	10	12	22
16.5				7	12	15	27
18.0	Grey dense fine to medium SAND trace silt	6	13.0	7	12	22	34
19.5				7	12	23	35
21.0				7	12	22	34
22.5				8	12	23	35
24.0				9	13	24	37
25.5				10	14	25	39
27.0				11	15	25	40
28.5				12	16	26	42
30.0	End of Boring			13	16	27	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-38
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

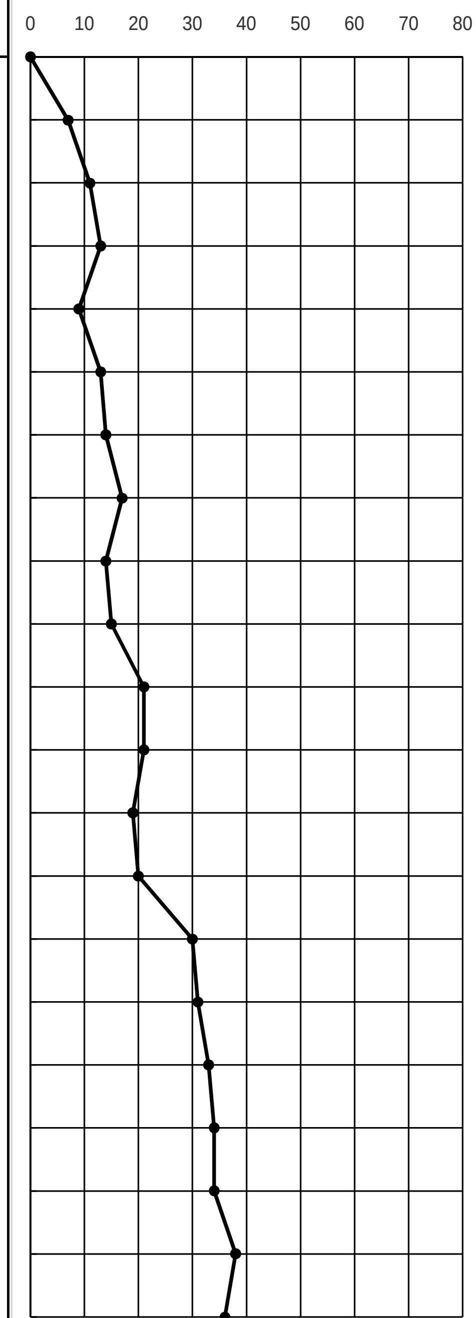
Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 03.06.2016
Completed on: 03.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : 80 no. Mazpara govt. primary school field, Agla, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.65214 Long-90.21791

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values (30cm)
1.5	Brown loose to medium dense fine SAND with silt	1	4.0	2	3	4	7
3.0				2	4	7	11
4.5	Grey medium dense fine SAND little silt	5	16.5	3	5	8	13
6.0				3	4	5	9
7.5				3	6	7	13
9.0				3	7	7	14
10.5				3	8	9	17
12.0				3	7	7	14
13.5				4	7	8	15
15.0				7	10	11	21
16.5				6	8	13	21
18.0				6	7	12	19
19.5				6	8	12	20
21.0	Grey medium dense fine SAND little silt	6	9.5	8	14	16	30
22.5				9	15	16	31
24.0				9	16	17	33
25.5				8	15	19	34
27.0				10	14	20	34
28.5				12	20	18	38
30.0	End of Boring			15	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-39
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

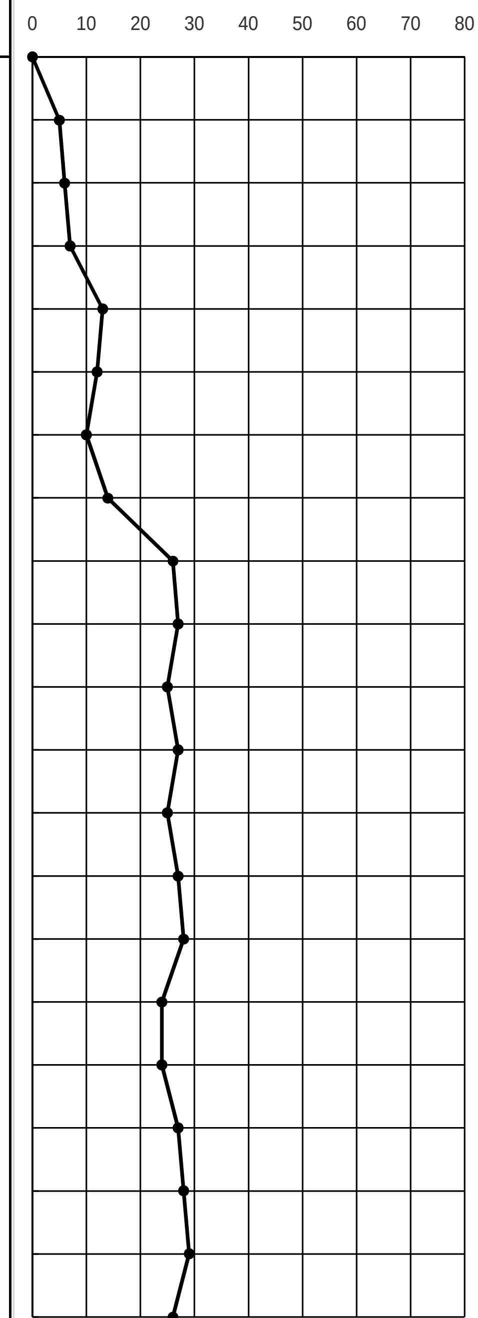
Exixting ground level:
Ground water level: 4.20m below EGL
Started on: 31.05.2016
Completed on: 31.05.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Kharsur high school, Agla, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.63808 Long-90.25023

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose to loose fine SAND little silt	Sand	Disturbed	1	5.0	2	2	3	5
3.0			Disturbed			2	3	3	6
4.5			Disturbed			2	3	4	7
6.0	Grey medium dense fine SAND little silt	Sand	Disturbed	5	25.0	4	6	7	13
7.5			Disturbed			4	5	7	12
9.0			Disturbed			3	4	6	10
10.5			Disturbed			5	6	8	14
12.0			Disturbed			7	13	13	26
13.5			Disturbed			8	12	15	27
15.0			Disturbed			7	12	13	25
16.5			Disturbed			7	13	14	27
18.0			Disturbed			8	10	15	25
19.5			Disturbed			8	11	16	27
21.0			Disturbed			7	12	16	28
22.5			Disturbed			7	10	14	24
24.0			Disturbed			8	11	13	24
25.5			Disturbed			7	12	15	27
27.0			Disturbed			8	13	15	28
28.5			Disturbed			8	12	17	29
30.0	End of Boring		Disturbed			7	12	14	26

SPT blows per 0.3 m penetration



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

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-40
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 6.000m below EGL
Started on: 08.06.2016
Completed on: 08.06.2016

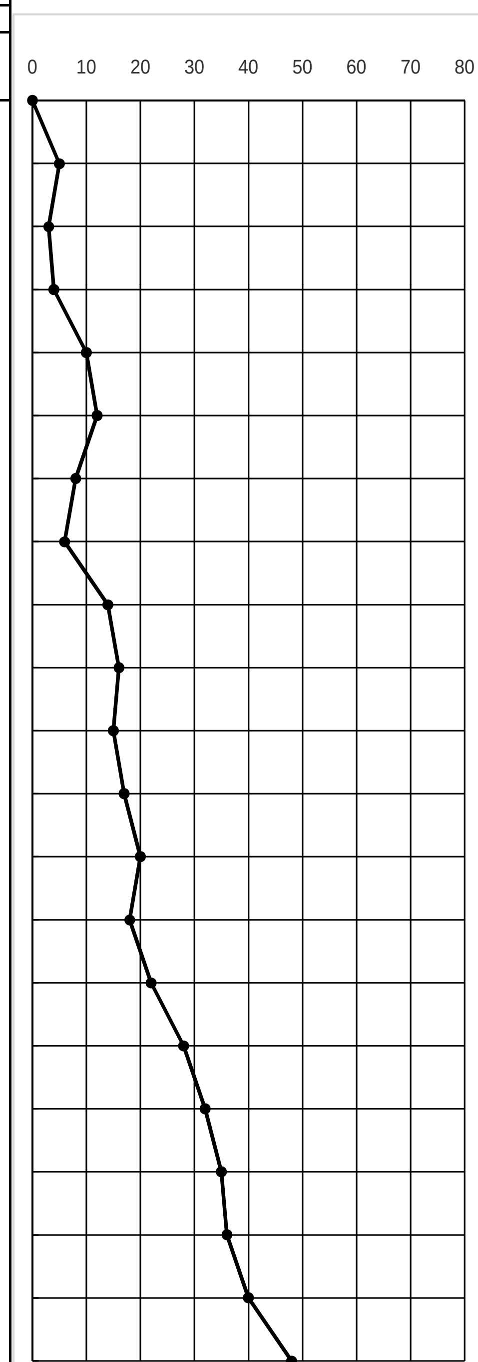
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Shikaripara T. K. M. high school field, Shikari Para, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.69993 Long-90.06897

Depth (m)	Visual Description	Symbols	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values (30cm)
1.5	Brownish grey soft to medium stiff SILT with fine sand	Silt	2	5.0	1	2	3	5
3.0					1	1	2	3
4.5					1	2	2	4
6.0	Brown medium dense fine SAND little silt	Sand	5	18.0	4	4	6	10
7.5					4	5	7	12
9.0					2	3	5	8
10.5					2	2	4	6
12.0					4	6	8	14
13.5					5	7	9	16
15.0					5	6	9	15
16.5					6	7	10	17
18.0					6	8	12	20
19.5					7	9	9	18
21.0					7	10	12	22
22.5					8	12	16	28
24.0	Grey dense fine to medium SAND trace silt	Sand	6	7.0	8	14	18	32
25.5					9	15	20	35
27.0					10	16	20	36
28.5					12	18	22	40
30.0	End of Boring				12	22	26	48

Standard Penetration Test — Blows on Spoon / N-Values

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-41
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 07.06.2016
Completed on: 07.06.2016

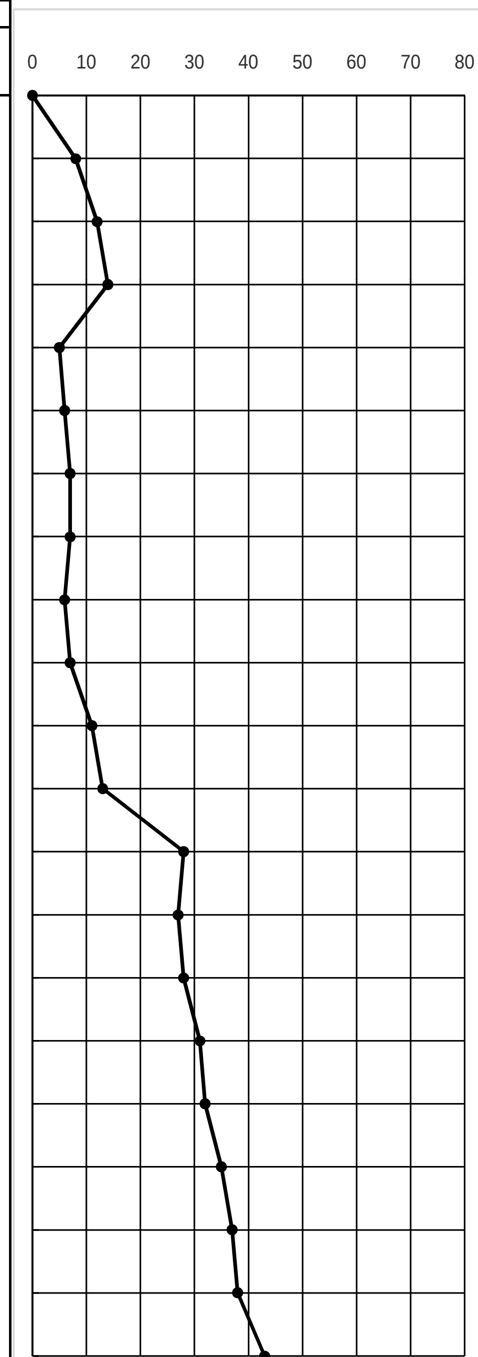
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Bokchar govt. primary school, Daudpur, Nayanshree, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.69151 Long-90.09744

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown stiff SILT with very fine sand	2	5.0	2	3	5	8
3.0				3	5	7	12
4.5				4	6	8	14
6.0	grey loose very fine SAND with silt	4	12.0	2	2	3	5
7.5				2	3	3	6
9.0				2	3	4	7
10.5				3	3	4	7
12.0				2	2	4	6
13.5				2	3	4	7
15.0				3	5	6	11
16.5				3	5	8	13
18.0	Grey medium dense fine SAND little silt	5	8.0	8	13	15	28
19.5				9	12	15	27
21.0				8	12	16	28
22.5				9	13	18	31
24.0				9	14	18	32
25.5	Grey dense fine to medium SAND trace silt	6	5.0	10	15	20	35
27.0				10	17	20	37
28.5				12	16	22	38
30.0				12	18	25	43

End of Boring

Standard Penetration Test
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-42
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 06.06.2016
Completed on: 06.06.2016

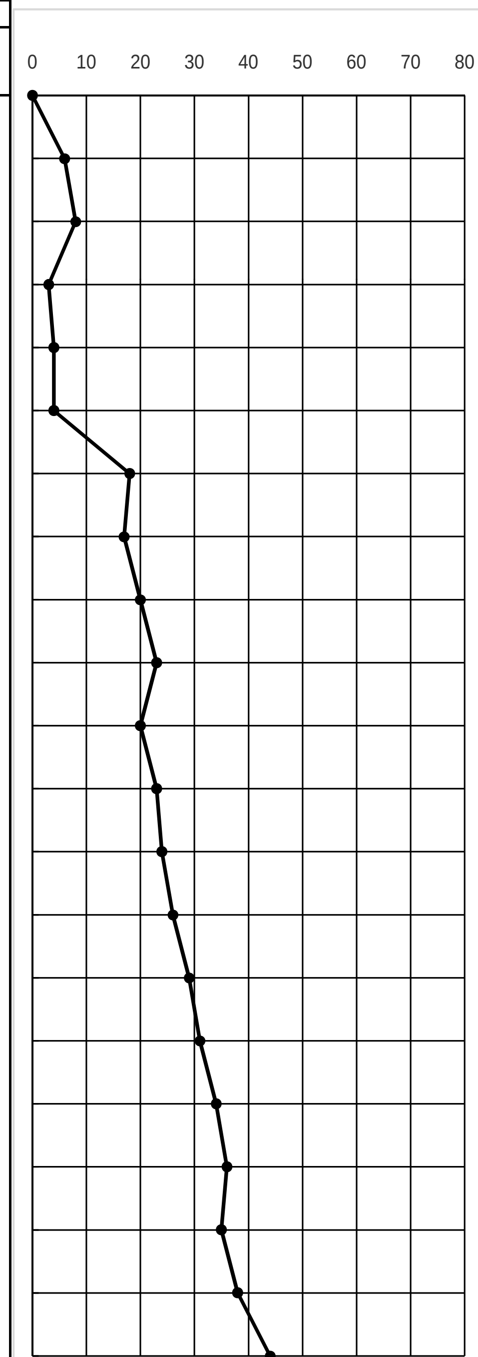
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Barruakhali govt. primary school, Po Hat Baruakhali, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.67906 Long-90.06593

Depth (m)	Visual Description	Symbols	Sample	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown medium stiff clayey SILT trace sand	Silt		2	4.0	2	2	4	6
3.0						2	3	5	8
4.5	Dark grey ORGANIC CLAY	Clay		3	4.0	1	1	2	3
6.0						1	2	2	4
7.5						2	2	2	4
9.0	Grey medium dense to dense fine SAND little silt	Sand		5	20.0	4	6	12	18
10.5						5	7	10	17
12.0						5	8	12	20
13.5						6	9	14	23
15.0						5	8	12	20
16.5						5	9	14	23
18.0						6	10	14	24
19.5						7	10	16	26
21.0						8	12	17	29
22.5						9	13	18	31
24.0						10	14	20	34
25.5						10	12	24	36
27.0						12	15	20	35
28.5	Grey dense fine to medium SAND trace silt	Sand		6	2.0	12	16	22	38
30.0	End of Boring					12	18	26	44

Standard Penetration Test

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-43
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

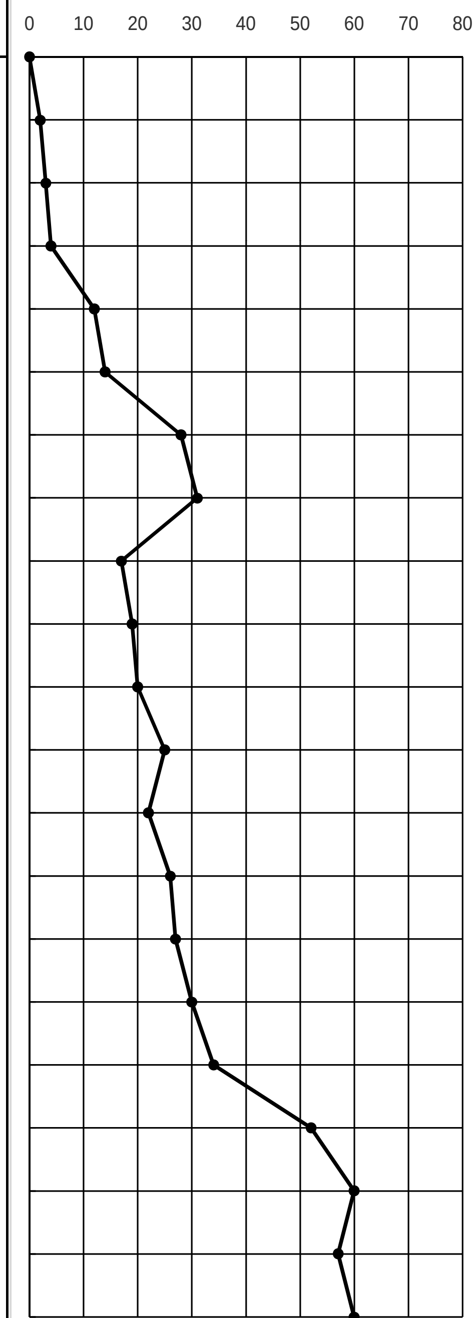
Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 04.06.2016
Completed on: 04.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Chondrokola Kali Mondir, Jantrail union, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.68779 Long-90.16364

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values 30cm
1.5	Brownish grey soft SILT with very fine sand little clay	2	5.0	1	1	1	2
3.0				1	1	2	3
4.5				1	2	2	4
6.0	Grey medium dense fine SAND little silt	5	20.0	3	5	7	12
7.5				4	6	8	14
9.0				7	12	16	28
10.5				9	13	18	31
12.0				6	7	10	17
13.5				7	7	12	19
15.0				7	10	10	20
16.5				8	12	13	25
18.0				6	10	12	22
19.5				7	12	14	26
21.0				8	10	17	27
22.5				8	12	18	30
24.0				10	14	20	34
25.5	Grey dense fine to medium SAND trace silt	6	5.0	12	24	28	52
27.0				14	27	33	60
28.5				14	22	35	57
30.0	End of Boring			15	24	36	60

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-44
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

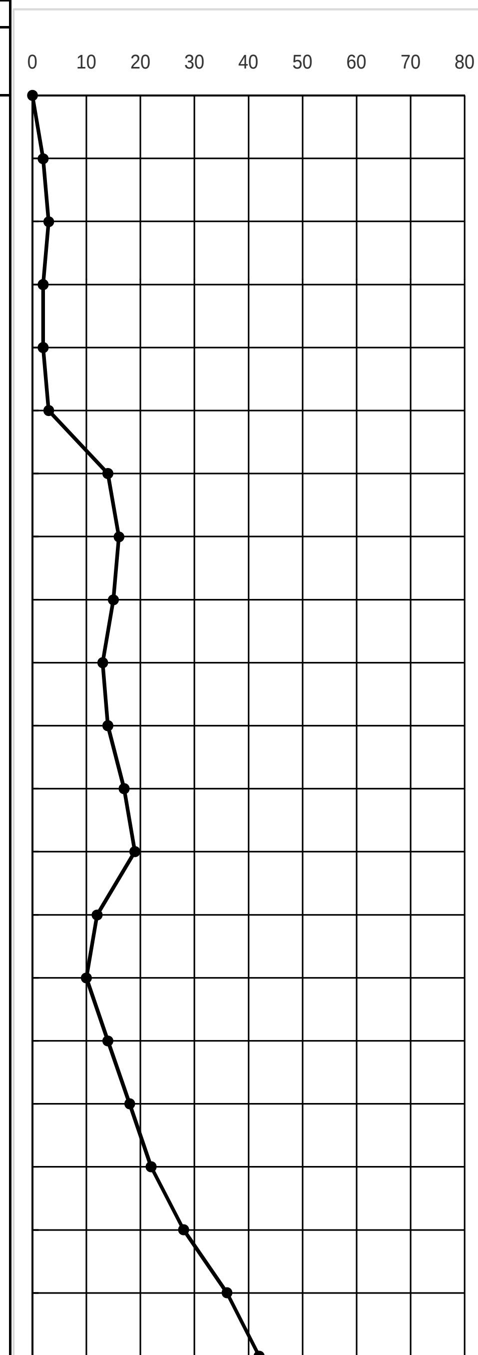
Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 03.06.2016
Completed on: 03.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Hayat kanda Mosque, Sholla Union, Nawabganj Upazila

Legend: Clay Silt Sand
Coordinates: Lat-23.69704 Long-90.19654

Depth (m)	Visual Description	Layer Number	Thickness(m)	15cm	15cm	15cm	N-Values 30cm
1.5	Grey soft clayey silt with sand	2	8.0	1	1	1	2
3.0				1	1	2	3
4.5				1	1	1	2
6.0				1	1	1	2
7.5				1	1	2	3
9.0	Grey medium dense fine SAND little silt	5	20.0	3	6	8	14
10.5				4	7	9	16
12.0				3	6	9	15
13.5				4	6	7	13
15.0				4	6	8	14
16.5				5	7	10	17
18.0				6	7	12	19
19.5				3	5	7	12
21.0				3	5	5	10
22.5				4	6	8	14
24.0				5	8	10	18
25.5				7	10	12	22
27.0				9	12	16	28
28.5	Grey denxse fine to medium SAND trace silt	6	2.0	10	16	20	36
30.0	End of Boring			12	18	24	42

SPT blows per 0.3 m penetration



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

GEOTECHNICAL BOREHOLE LOG

Bore hole No: BH-45
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 01.06.2016
Completed on: 01.06.2016

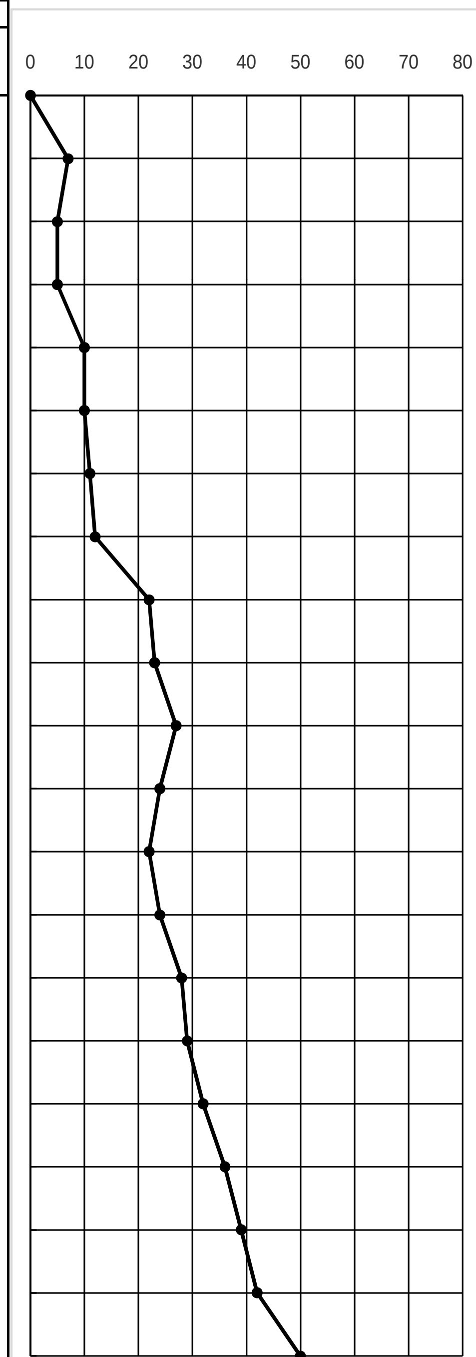
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Kailail Mosque, Kailail gram, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.68686 Long-90.23328

Depth (m)	Visual Description	Symbols	Layer Number	Thickness(m)	Blows on Spoon 15cm	Blows on Spoon 15cm	Blows on Spoon 15cm	N-Values 30cm
1.5	Brown medium stiff clayey SILT trace sand	Silt	2	4.0	2	3	4	7
3.0					2	2	3	5
4.5					1	2	3	5
6.0	Brownish grey loose very fine to fine SAND little silt	Sand	4	7.0	3	4	6	10
7.5					3	5	5	10
9.0					4	5	6	11
10.5					4	6	6	12
12.0	Grey medium dense fine SAND little silt	Sand	5	9.0	7	10	12	22
13.5					8	10	13	23
15.0					8	12	15	27
16.5					7	11	13	24
18.0					7	10	12	22
19.5					7	10	14	24
21.0	Grey medium dense to dense fine to medium SAND trace silt	Sand	6	10.0	8	12	16	28
22.5					9	11	18	29
24.0					10	15	17	32
25.5					10	16	20	36
27.0					12	17	22	39
28.5					14	20	22	42
30.0	End of Boring				15	24	26	50

Standard Penetration Test

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-46
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

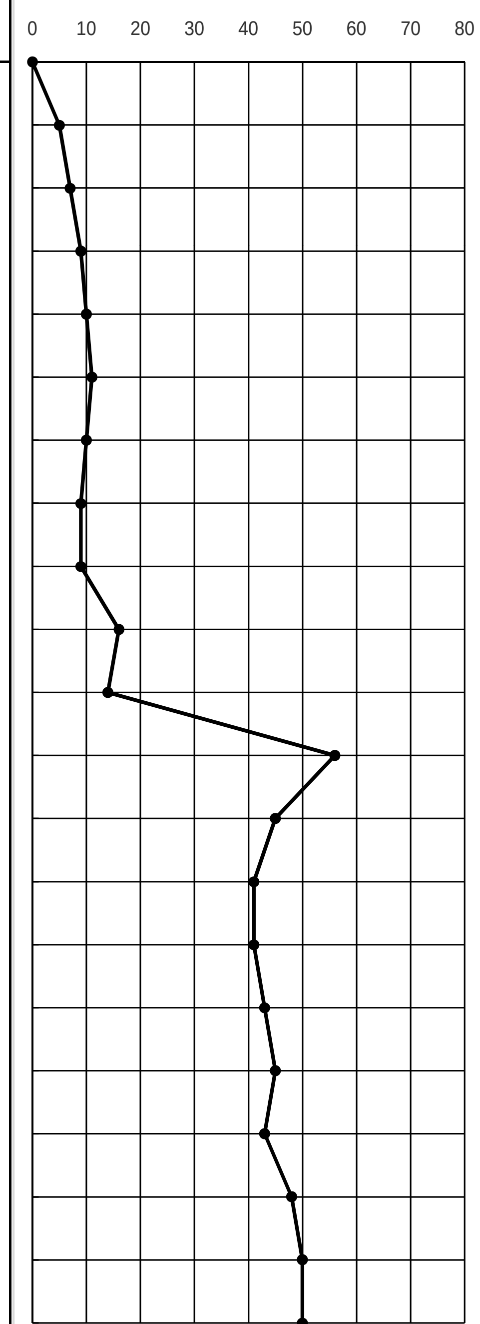
Exixting ground level:
Ground water level: 3.50m below EGL
Started on: 31.05.2016
Completed on: 31.05.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Malikanda govt. hospital, Bottola, Kailail, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.69273 Long-90.26591

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very loose silty fine SAND little silt	1	4.0	1	2	3	5
3.0				2	3	4	7
4.5	Brown stiff clayey SILT little sand	2	1.0	3	4	5	9
6.0	Brown to grey loose very fine to fine SAND	4	8.0	2	4	6	10
7.5				3	5	6	11
9.0				3	5	5	10
10.5				2	4	5	9
12.0				2	4	5	9
13.5	Grey medium dense fine SAND little silt with mica	5	3.0	4	6	10	16
15.0				4	5	9	14
16.5	Light grey very dense fine to medium SAND trace silt	6	14.0	16	26	30	56
18.0				15	20	25	45
19.5				14	18	23	41
21.0				16	19	22	41
22.5				15	18	25	43
24.0				16	21	24	45
25.5				15	20	23	43
27.0				16	22	26	48
28.5				17	20	30	50
30.0	End of Boring			16	22	28	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-47
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

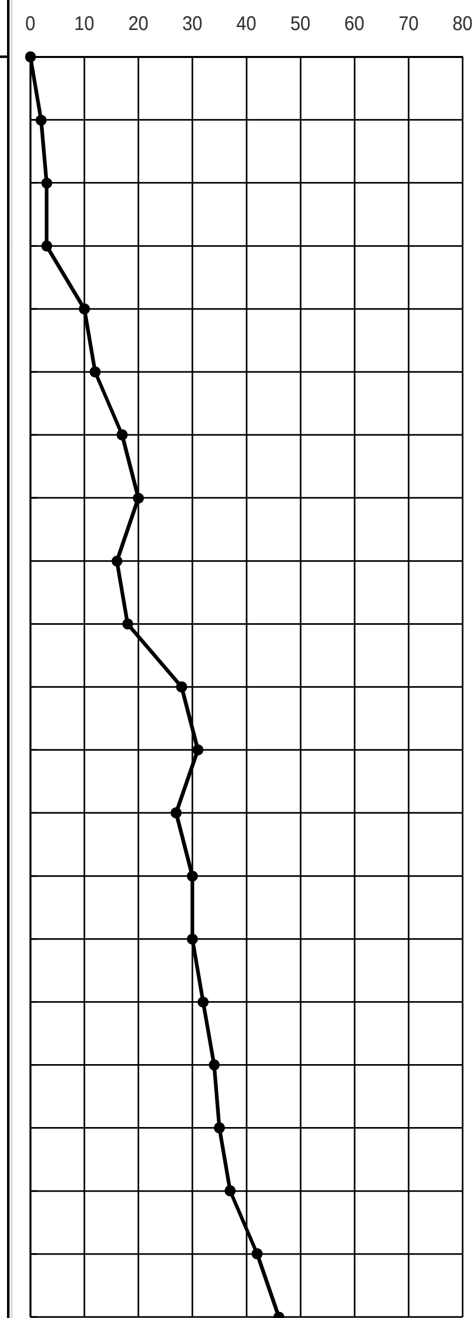
Exixting ground level:
Ground water level: 6.0m below EGL
Started on: 11.06.2016
Completed on: 11.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Khan Para (Mushim Hati), Churain, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.60762 Long-90.19053

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Brown very soft to soft clayey SILT trace sand	2	4.0	1	1	1	2
3.0				1	1	2	3
4.5	Dark grey soft ORGANIC CLAY	3	1.0	1	1	2	3
6.0	Brown to grey medium dense very fine to fine sand with silt	4	3.0	3	3	7	10
7.5				3	5	7	12
9.0	Grey medium dense to dense fine SAND dvlittle silt & mica	5	18.0	5	8	9	17
10.5				6	8	12	20
12.0				5	7	9	16
13.5				6	8	10	18
15.0				7	12	16	28
16.5				9	13	18	31
18.0				8	12	15	27
19.5				10	12	18	30
21.0				9	13	17	30
22.5				10	16	16	32
24.0				12	16	18	34
25.5				10	15	20	35
27.0	Grey dense fine to medium SAND trace silt	6	4.0	12	17	20	37
28.5				12	18	24	42
30.0	End of Boring			13	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-48
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

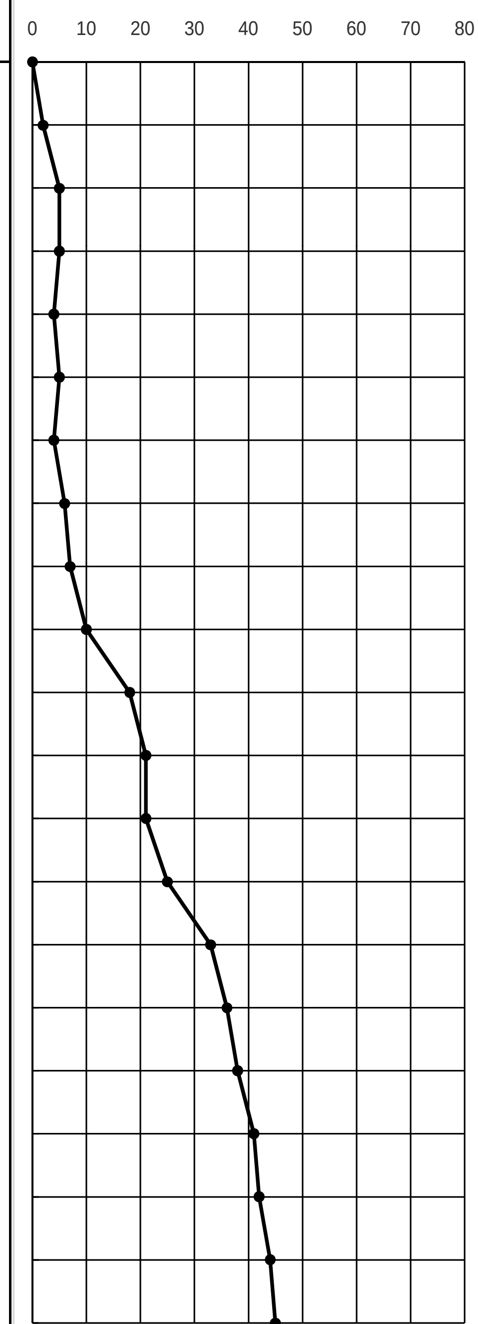
Exixting ground level:
Ground water level: 2.50m below EGL
Started on: 14.06.2016
Completed on: 14.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Uttar Barra, Nayanshree Union, Nawabganj Upazila

Legend: Clay, Silt, Sand
Coordinates: Lat-23.72091 Long-90.09890

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	15cm	15cm	N-Values 30cm
1.5	Filling SAND	1	2.0	1	1	1	2
3.0	Brown medium stiff clayey SILT	2	3.0	1	2	3	5
4.5				1	2	3	5
6.0	Grey very loose to loose silty very fine SAND	4	8.0	2	2	2	4
7.5				2	2	3	5
9.0				2	2	2	4
10.5				2	3	3	6
12.0				2	3	4	7
13.5				3	4	6	10
15.0	Grey medium dense to dense fine SAND little silt	5	11.0	6	8	10	18
16.5				6	9	12	21
18.0				7	9	12	21
19.5				9	11	14	25
21.0				10	13	20	33
22.5				12	14	22	36
24.0				12	15	23	38
25.5	Grey dense fine to medium SAND trace silt	6	5.0	13	16	25	41
27.0				15	20	22	42
28.5				15	21	23	44
30.0	End of Boring			17	22	23	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-49
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

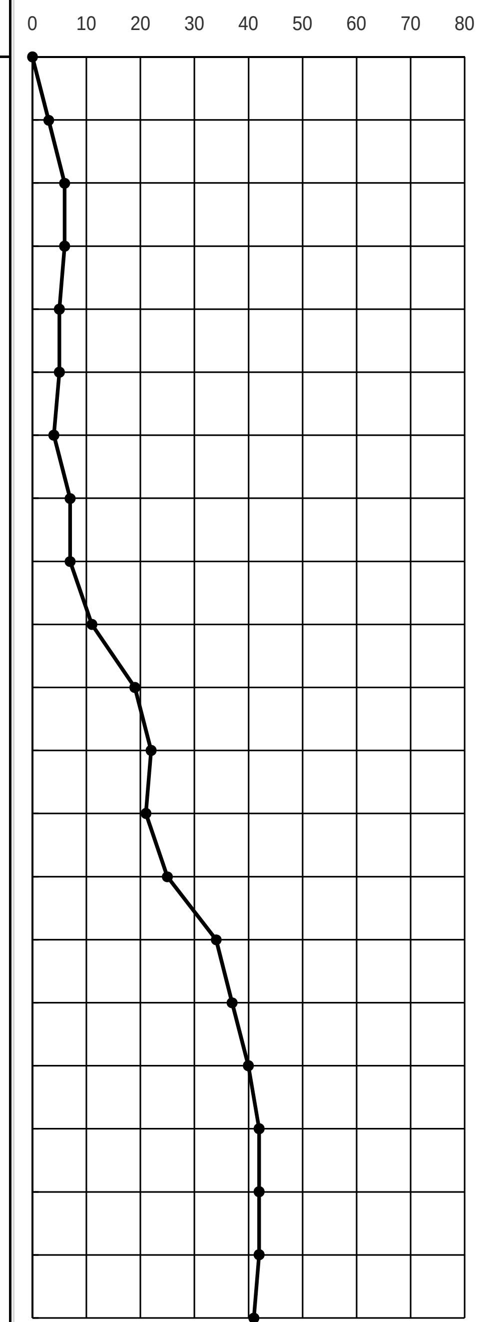
Exixting ground level:
Ground water level: 3.00m below EGL
Started on: 15.06.2016
Completed on: 15.06.2016

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

Legend: Clay, Silt, Sand
Coordinates: Lat-23.71735 Long-90.13104

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	Blows on Spoon 15cm	Blows on Spoon 15cm	N-Values 30cm
1.5	Filling SAND	1	2.0	1	1	2	3
3.0	Brown medium stiff clayey SILT	2	3.0	1	3	3	6
4.5				1	2	4	6
6.0	Grey very loose to loose silty very fine SAND	4	8.0	2	2	3	5
7.5				2	2	3	5
9.0				2	2	2	4
10.5				2	3	4	7
12.0				2	3	4	7
13.5				4	5	6	11
15.0	Grey medium dense to dense fine SAND little silt	5	11.0	5	8	11	19
16.5				7	9	13	22
18.0				7	9	12	21
19.5				9	11	14	25
21.0				11	14	20	34
22.5				10	15	22	37
24.0				13	17	23	40
25.5	Grey dense fine to medium SAND trace silt	6	5.0	14	17	25	42
27.0				13	19	23	42
28.5				14	20	22	42
30.0	End of Boring			15	20	21	41

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-50
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

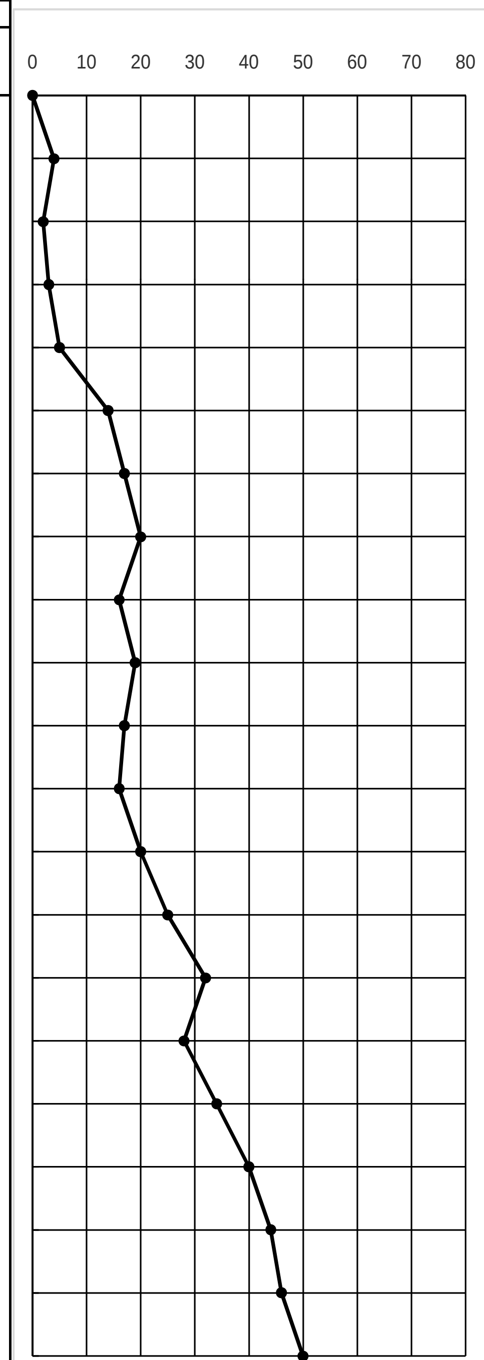
Exixting ground level:
Ground water level: 4.50m below EGL
Started on: 05.06.2016
Completed on: 05.06.2016

Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Chokuriya Chokbari govt. primary school, Sholla, Nawabganj

Legend: Clay Silt Sand
Coordinates: Lat-23.715145 Long-90.170471

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	Blows on Spoon 15cm	Blows on Spoon 15cm	N-Values 30cm
1.5	Brown very loose silty very fine SAND little clay	1	4.0	1	2	2	4
3.0				2	1	1	2
4.5	Dark grey soft ORGANIC CLAY	3	3.0	1	1	2	3
6.0				1	2	3	5
7.5	Grey medium dense fine SAND little silt trace mica	5	13.0	3	5	9	14
9.0				4	7	10	17
10.5				5	8	12	20
12.0				4	6	10	16
13.5				5	8	11	19
15.0				5	7	10	17
16.5				6	8	8	16
18.0				7	10	10	20
19.5				8	12	13	25
21.0	Grey dense fine to medium SAND trace silt	6	10.0	8	15	17	32
22.5				9	12	16	28
24.0				10	14	20	34
25.5				10	16	24	40
27.0				12	18	26	44
28.5				12	20	26	46
30.0	End of Boring			14	22	28	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-51
Method of Boring: Percussion
Boring Dia.:100(mm)
Boring Depth: 30.0m

Exixting ground level:
Ground water level: 4.0m below EGL
Started on: 02.06.2016
Completed on: 02.06.2016

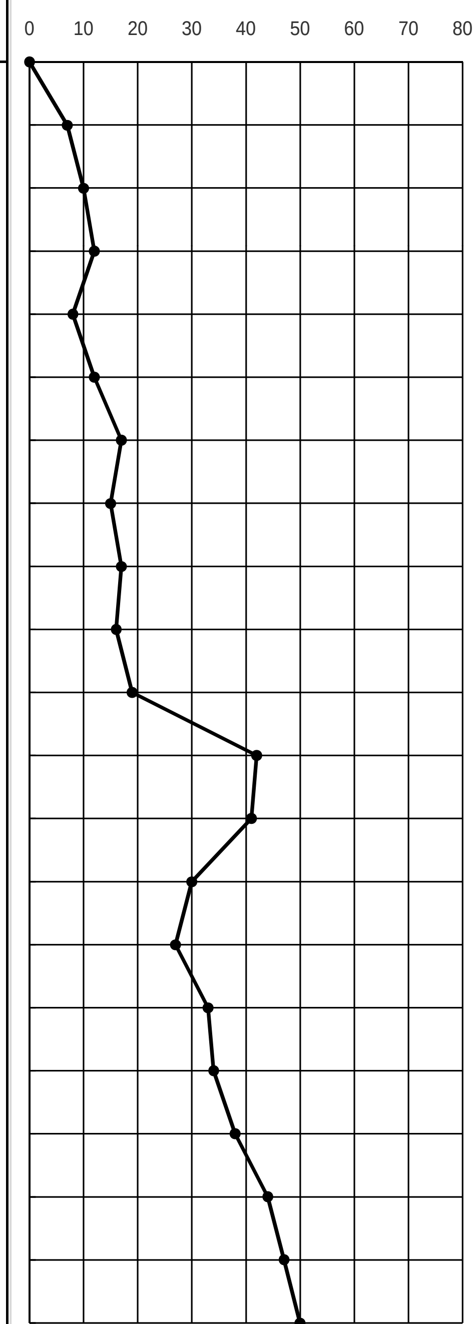
Client :Urban Development Directorate (UDD)
Project : Preparation of Development Plan for Fourteen Upazilas(Package-1)
Location : Sultanpur govt. primary school, Modhon Mohonpur, Sholla Union, Nawabganj Upazila

Legend: Clay, Silt, Sand

Coordinates: Lat-23.70997 Long-90.20408

Depth (m)	Visual Description	Layer Number	Thickness(m)	Blows on Spoon 15cm	Blows on Spoon 15cm	Blows on Spoon 15cm	N-Values 30cm
1.5	Brownish grey loose very fine to fine SAND little silt	1	2.0	2	3	4	7
3.0	Brownish grey loose SILT with clay	2	3.0	3	4	6	10
4.5				4	5	7	12
6.0	Grey loose to medium dense very fine to fine SAND little silt & mica	4	3.0	2	3	5	8
7.5				3	5	7	12
9.0	Grey medium dense fine SAND little silt	5	9.0	4	7	10	17
10.5				4	7	8	15
12.0				5	7	10	17
13.5				6	8	8	16
15.0				7	7	12	19
16.5	Grey dense fine SAND little silt		3.0	9	18	24	42
18.0				12	16	25	41
19.5	Grey dense fine to medium SAND trace silt	6	10.0	8	12	18	30
21.0				9	12	15	27
22.5				8	15	18	33
24.0				9	14	20	34
25.5				10	16	22	38
27.0				12	18	26	44
28.5				14	20	27	47
30.0	End of Boring			15	24	26	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

Appendix D
Photographical Representation of Survey Works

Kailail Mosque, Kailail gram (BH-45)

Malikanda govt. hospital, Bottola, Kailail (BH-46)

88 no. churain govt. primary school, churain(BH-32)

Sultanpur govt. primary school, Modhon Mohonpur, Sholla Union (BH-51)

Galimpur sanaban girls high school field, Galimpur (BH-31)

80 no. Mazpara govt. primary school field, Agla (BH-38)

Standard Penetration Test Drilling Activities at Nawabganj Upazila


Nawabganj press club, Nawabganj Sadar upazila (BH-36)


Nawabganj press club, Nawabganj Sadar upazila (BH-36)


Barruakhali govt. primary school, Po Hat Baruakhali (BH-42)

Barruakhali govt. primary school, Po Hat Baruakhali (BH-42)


Bokchar govt. primary school, Daudpur, Nayanshree (BH-41)


Shikaripara T. K. M. high school field, Shikari Para (BH-40)


Payeksha Kaboresthan Mosque, Galimpur (BH-30)


Sadapur progoti govt. primary school,Bandura (BH-35)

Standard Penetration Test Drilling Activities at Nawabganj Upazila

Nawabganj press club, Nawabganj Sadar upazila (BH-36)

Nawabganj press club, Nawabganj Sadar upazila (BH-36)

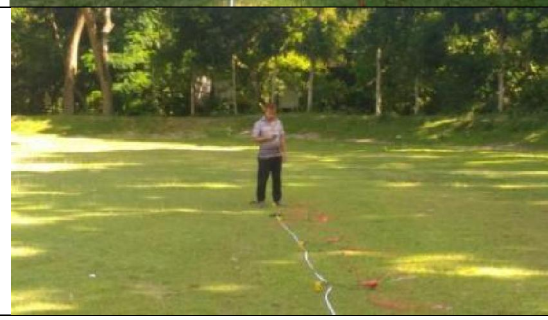
Shikaripara T. K. M. high school field, Shikari Para (BH-40)

Galimpur sanaban girls high school field, Galimpur (BH-31)

Galimpur sanaban girls high school field, Galimpur (BH-31)

Down-hole seismic test (PS logging) test activities at Nawabganj Upazila



MASW ID: N1
Data Acquisition Date: 27.06.2016
Coordinate (1st Geophone): 23.66543/90.11801,Coordinate (Last Geophone):23.66514/90.11800
Location: Near Bandura Union Office, Nawabganj




MASW ID: N2
Data Acquisition Date: 27.06.2016
Coordinate (1st Geophone): 23.65251/90.18288 ,Coordinate (Last Geophone): 23.65269/90.18264
Location: Bardhanpara Govt. Primary School, Boynagar Union, Nawabganj





MASW ID: N3
Data Acquisition Date: 27.06.2016
Coordinate (1st Geophone): 23.63617/90.24857 ,Coordinate (Last Geophone): 23.63643/90.24866
Location: Banokhali, Last Boundary of Agla Union, Agla Union, Nawabganj



MASW ID: N 4
Data Acquisition Date: 27.06.2016
Coordinate (1st Geophone): 23.70975/90.18594 ,Coordinate (Last Geophone): 23.70950/90.18589
Location: Sholla High School Field, Sholla Union, Nawabganj

MASW ID: N5
Data Acquisition Date: 27.06.2016
Coordinate (1st Geophone): 23.68668/90.23368 ,Coordinate (Last Geophone): 23.68658/90.23401
Location: Kailail Hanafi Dakhil Madrasah, Kailail Union, Nawabganj