URBAN DEVELOPMENT DIRECTORATE (UDD)

Government of the People's Republic of Bangladesh

Inception Report

ON

Engineering Geological and Geo-Physical Surveys

Under

Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism

Package No. 7 (Seven)

July, 2018

Submitted by

Environmental & Geospatial Solutions (EGS)

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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
PS logging : Primary and Shear wave logging (Down-hole seismic test)
SA : Spectral Acceleration
SPT : Standard Penetration Tests
UDD: Urban Development Directorate
EGL : Existing Ground Level
GWL : Ground Water Level

CONTENTS

LIST OF FIGURES

1. INTRODUCTION

1.1. Background

Bangladesh can earn money in local and also in foreign exchange by opening an environmental friendly tourist recourse at Barguna and Patuakhali dristrict. The spot, if properly developed, would become an excellent holiday resort and tourist center. The success of developing Barguna and Patuakhali district as a tourist center, seaport land area and industrial zone depends much on good communication facilities and availability of modern amenities. Moreover, the proposed sea port and industrial zone would generate lots of new financial activities including huge vehicular traffic such as air, rail, road and water. This phenomenon would have both positive and negative impacts on the socio-economic condition and existing land use pattern of the region. The proposed planning package would guide such probable changes in the socio-economic condition and landuse pattern of the region, and would also address the adverse impact of such changes.

Landuse planning is an impotent component for a modern urban development. A paradigm shift in landuse planning has beed taken place by mainstreaming disaster risk reduction in landuse planning in Bangladesh. This phenomenon involves integrating earthquake risk investigation in landuse planning in particular. Therefore an attempt has been taken to incorporate a rigorous geological and geotechnical site characterization, including a potential risk analysis in preparing Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism.

Urban development is being increasing very fast in Bangladesh. The government has planned to develop Barguna and Patuakhali district as a tourist center, seaport and industrial zone. However, risk sensitive urban planning is very important in such a disaster prone country like Bangladesh for a risk resilient urban development in these cities and surrounding area. Among those cities Amtali, Taltoli, Barguna Sadar and Pathargata upazila of Barguna dristrict and Galachipa, Rangabali and Kalapara upazila of Patuakhali dristrict is most disaster prone area because of the area is located near coastal area and relativlly less seismo-tectonically active zones. So this area covers the assessment and management of Geohazard like; earthquake and ground subsidence, and hydrometorological hazards in predominantly urban context. Considering the geohazard threat of the populated urban and rural areas of the project, UDD has taken many initiatives for a rigorous geological and geotechnical (engineering geology) site characterization of the 7 (Seven) upazilas, including Amtali, Taltoli, Barguna Sadar, Pathargata, Galachipa, Rangabali and Kalapara upazila under 'Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism'.

Therefore the geological and geotechnical site characterization of the areas including potential seismic hazard assessment and ground subsidence risk analysis are an important component for rick sensitive landuse planning of the populated urban and rural area. In here, Environmental & Geospatial Solutions (EGS) has been entrusted to conduct this project work.

1.2. Client: About Urban Development Directorate (UDD)

Urban Development Directorate (UDD) was established through a government order in 17th July 1965. This directorate is working under the Ministry of Housing and Public Works. Since its inception, UDD is contributing in developing Master Plan/Land Use Plan for small, medium and large town and cities of Bangladesh. Thus it is contributing in development of the localities and lifestyle of peoples of Bangladesh in direct and indirect ways.

vision of UDD is to augment the quality of life of the people by improving the environment through planned development activities for adequate infrastructure, services and utility provision, to make optimum utilization of resources especially land and to ensure a geographically balance urbanization. It also aims to reduce local and regional disparity by alleviating poverty and to create good governance in the country through people participation and empowering of woman.

1.3. Location and Accessibility

Barguna district (Barisal division) area 1831.31 sq km, located in between 21°48' and 22°29' North latitudes and in between 89°52' and 90°22' East longitudes. It is bounded by Jhalokati, Barisal, Pirojpur and Patuakhali districts on the North, Patuakhali district and Bay of Bengal on the South, Patuakhali district on the East, Pirojpur and Bagerhat districts on the West. Amtoli, Taltoli, Patharghata and Barguna Sadar upazila are selected as a project area from Barguna district.

On the other hand, Patuakhali district (Barisal division) area of 3220.15 sq km, located in between 21°48' and 22°36' North latitudes and in between 90°08' and 90°41' East longitudes. It is bounded by Barisal district on the North, Bay of Bengal on the South, Bhola district on the East, Barguna district on the West. The land of the district is composed of alluvial soil of the meghna basin and of a number of small char lands. Galachipa (Including New Created Rangabali Upazila) and Kalapara upazila are selected as a project area from Patuakhali District.

Kuakata a scenic sea beach on the South of Bangladesh. The most important attraction of the beach is that one can see both sunrise and sunset from some of its locations. Situated 320 km from Dhaka and 70 km from the Patuakhali district headquarters, Kuakata is part of Latachapli and Dhulasar unions of Kalapara upazila. On the other hand, Amtali upazila of Barguna District is on the way to Kuakata from Barisal. The only highway towards Kuakata from Barisal is running through Amtali upazila. Due to the reason, both Kalapara and Amtali upazila have been undertaken for "Preparation of Eco-Tourism Development Plan for Kuakata Coastal Region" to develop tourism in the area in an integrated and comprehensive manner on a regional planning concept. The best way to reach Kuakata from Dhaka is to first travel to Barisal by road, water, or air, and then to take the bus or boat/launch for the destination. The Bangladesh Road Transport Corporation introduced a direct bus service from Dhaka to Kuakata via Barisal. Besides, on the west of Kuakata, there is a reserve forest, Fatrar Char by name, which is part of Sundarbans and is a unique location for tourism development. Sonar char of Rangabali upazila is also a place of panoramic beauty. There is ample opportunity for tourism development in the area. Moreover, Paira Bandar, the third sea port has already been established at Ravnabad Channel near Kuakata, which would act as catalyst for radical change in the overall urbanization in the region.

Table: Area, Population and Density of the Project Area:

Name of District	**Name of the Upazila**	**Area**		**Population**	**Density of total Population per Sq.Km**
		Sq. Km	Acre		
Barguna	Barguna Sadar Upazila	454.38	112279.74	261343	575
Barguna	Pathargata Upazila	387.36	95718.74	163927	423
Barguna	Amtali Upazila (Including Taltoli Upazila)	720.75	178101.2	270802	376
Patuakhali	Galachipa (Including New Created Rangabali Upazila)	1268.37	313421.05	361518	285
Patuakhali	Kalapara Upazila	491.89	121548.67	237831	484
Total		**3322.77**	**821074**	**1295421**	**389.86**

Source: BBS, 2011

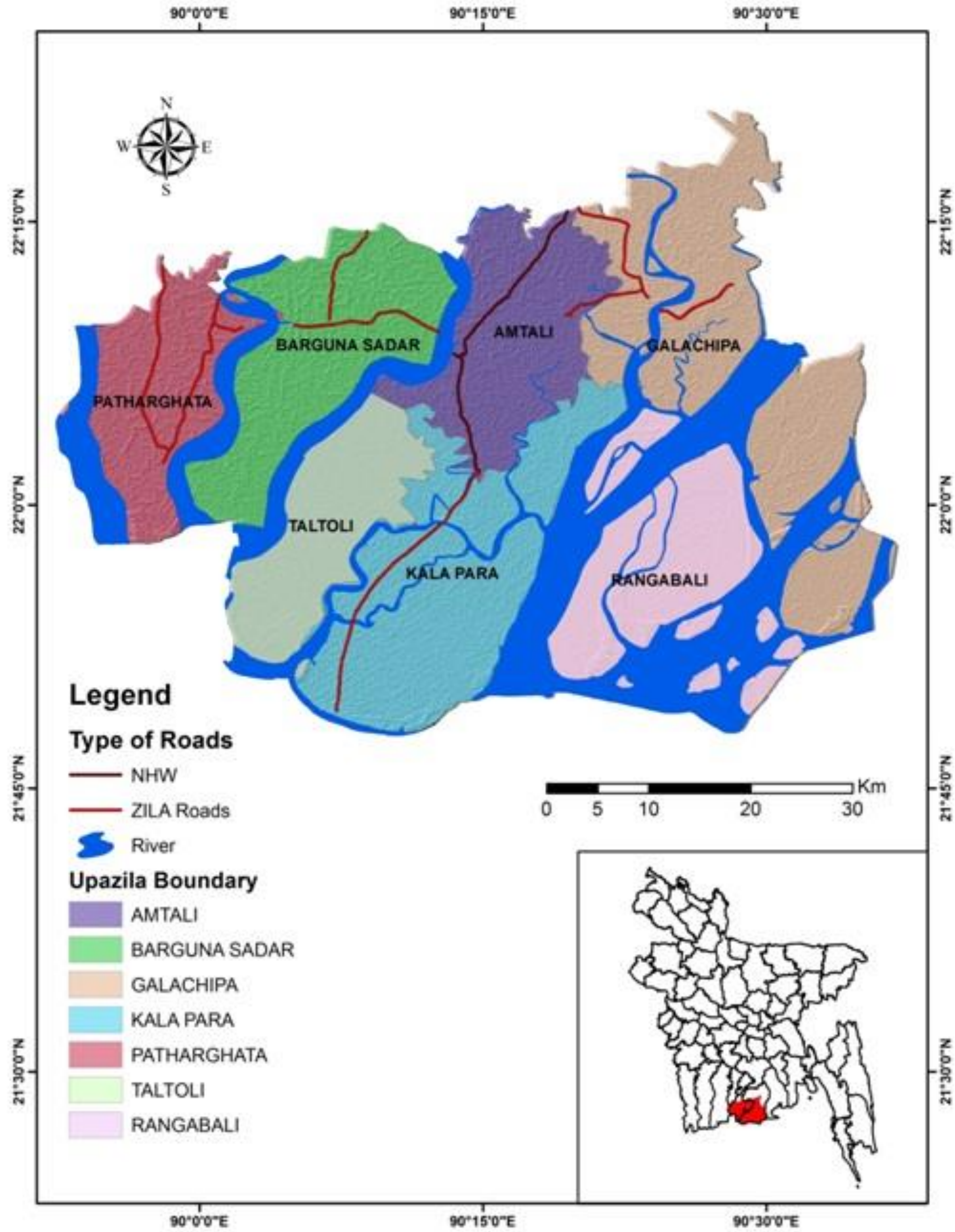


Figure 1.1 Location map of the project area

2. AIMS AND OBJECTIVES

The main objective of this project is to carry out a Engineering Geological and Geo-Physical Surveys of the 7 (Seven) upazila including Amtoli, Taltoli, Barguna Sadar and Patharghata of Barguna district and Galachipa, Rangabali and Kalapara upazila of Patuakhali district under Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism. The main objective will be achieved through accomplishment of the following sub-objectives:

i. Preparation of geological and geomorphologic map of the study area.
ii. Development of sub-surface lithological 3D model of the study area.
iii. Preparation of soil classification map by using geophysical and geotechnical investigations of the study area.
iv. Development of engineering geological map based on AVS30 values of the study area.
v. Foundation layers delineation and determination of engineering properties of the sub-soil.
vi. PGA, Sa (T) Maps of 5% damping at 0.2 and 1.0 second periods values of 10% exceedance probability during next 50 years for local site condition determination of the study area.
vii. Risk Sensitive Building Height determination of the study area.
viii. To Help UDD for formulating of Policies and plans for mitigation of different types of hazards, minimizing the adverse impacts of climate change and recommend possible adaptation strategies for the region.

3. METHODOLOGY

3.1. Strategic Methodology

The methodology consists of both field and laboratory investigations. To conduct this project work, geomorphological, geotechnical and geophysical data of soil will be collected, analysed and interpreted. Geomorphological data will be collected from satellite image (provided by UDD) of the study area to prepare a geomorphological map. Geotechnical data will be collected from field investigations *i.e.*, boring, standard penetration test (SPT), and laboratory investigations *i.e.*, soil physical properties test, consolidation test, direct shear test and triaxial test of soil sample. Geophysical data will be collected from down-hole seismic test (PS logging); Multi-channel analysis of surface wave (MASW) and Singles Microtremor survey. The total works will be conducted through the following methodology-

3.1.1. Geophysical Investigation

Field geophysical investigation is conducted to achieve the purpose of seismic risk assessment. The main objective of seismic site characterization is analyzing seismic wave propagation velocity, which acquired from shallow depth. P-S logging (Downhole seismic), Multi Channel Analysis of Surface Wave (MASW) and Microtremor tools are involved in geophysical investigation.

General purposes of the geophysical survey:

- To estimate shear wave velocity and measure soil/rock properties (i.e. shear modulus, bulk modulus, compressibility, and Poisson’s ratio)
- To develop Engineering geological map based on AVS30
- To Seismic site response study
- To prepare Risk Sensitive Building Height map
- Utilize these information for seismic hazard analysis

3.1.2. Geotechnical Investigation

Geotechnical investigations have become an essential component of every construction to ensure safety of human beings and materials. It includes a detailed investigation of the soil to determine the soil strength, composition, water content, and other important soil characteristics.

Geotechnical investigations are executed to acquire information regarding the physical characteristics of soil and rocks. The purpose of geotechnical investigations is to design earthworks and foundations for structures, and to execute earthwork repairs necessitated due to changes in the subsurface environment. A geotechnical examination includes surface and subsurface exploration, soil sampling, and laboratory analysis. Geotechnical investigations are also known as foundation analysis, soil analysis, soil testing, soil mechanics, and subsurface investigation. The samples are examined prior to the development of the location. Geotechnical investigations have acquired substantial importance in preventing human and material damage due to the earthquakes, foundation cracks, and other catastrophes. Geotechnical investigations can be as simple as conducting only a visual assessment of the site or as detailed as a computer-aided study of the soil using laboratory tests.

General purposes of the geotechnical survey:

- To develop sub-surface lithological 3D model
- To delineate foundation layers and define engineering properties of the sub-soil
- To prepare liquefaction susceptibility or liquefaction potential index (LPI) map

However, following investigations will be conducted for collecting both geotechnical and geophysical data in the Project area:

Name of Upazila	Name of investigations			
	Borelog with SPT *(upto 30m)*	PS logging *(30m depth)*	MASW *(30m depth)*	Single Microtremor
Amtoli, Taltoli, Barguna Sadar, Patharghata, Galachipa, Rangabali and Kalapara	90	15	25	40

3.2. Brief Procedures Of Surveys/Tests

The method of tests/surveys and application of Geophysical and Geotechnical investigation are given below-

3.2.1. Test Procedure of Downhole Seismic Test (Ps Logging)

Seismic down hole test is a direct measurement method for obtaining the shear wave velocity profile of soil stratum. The seismic down hole test aims 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 7kg sledge hammer. The plank was placed on the ground surface at around 3 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, 9 records were taken and then used to calculate the shear wave velocity. The first arrival time of an elastic wave from the source to the receivers at each testing depth can be obtained from the downhole seismic test.

Figure 3.1 Field Data Acquisition by PS logger

Instrument List

The PS logging test equipments are listed below-

1. One Freedom NDT PC
2. Two High Sensitive Tri-axial Geophones.
3. Two set Cable/Air lineSpool
4. Wooden Plank.
5. 7kg weight Hammer.

Figure 3.2 Freedom Data PC with P-SV Downhole Source and 1 Tri-axial Geophone Receiver used in Crosshole Seismic Investigations

Application of PS Logging Test

Downhole Seismic (PS Logging) system is useable for providing information on dynamic soil and rock properties for earthquake design analyses for structures, liquefaction potential studies, site development, and dynamic machine foundation design. The investigation determines shear and compressional wave depth versus velocity profiles. Other parameters, such as Poisson's ratios and moduli, can be easily determined from the measured shear and compressional wave velocities. The PS Logging is a downhole method for the determination of material properties of soil and rock.

3.2.2. Test Procedure of Multi-Channel Analysis Of Surface Wave (MASW)

MASW utilizes the frequency dependent property of surface wave velocity, or the dispersion property, for Vs profiling. It analyses frequency content in the data recorded from a geophone array deployed over a moderate distance.

Multi-channel Analysis of Surface Wave Survey (MASW) is one of the geophysical surveys to detect the distributions of S-wave velocity Vs profile. The generation, recording, and analysis of seismic surface waves (Raleigh waves) to determine subsurface shear wave velocities. Shear wave velocity is a direct indication of the stiffness of subsurface materials

Data Acquisition

In a field, all seismic sensors (receivers) are installing along a line on the ground surface, and acrylic board is installing between each receiver. When shooting an acrylic board by a big hammer, generated elastic wave including different frequencies is received by seismic sensors (receivers). In general the higher frequency elastic wave is influenced by the shallower zone of shear wave velocity (Vs) distribution on the contrary the lower frequency elastic wave is influenced by the deeper zone of shear wave velocity (Vs) distribution. In this principle, the Vs distribution section is analyzed.

The measuring procedure is shown as follows:

(1) To decide the measuring line

(2) To set receivers along the line at the ground surface. The intervals of each geophone are 3m.

(3) To set an acrylic board at a half interval outside the line

(4) To shoot it vertically. Then generated elastic waves are recorded by receivers.

(5) To shift the acrylic board between second receiver and the third receiver, and shoot it vertically. Then generated elastic waves are recorded at receivers.

(6) To iterate this procedure up to setting the acrylic boards at a half interval outside the other side of the line.

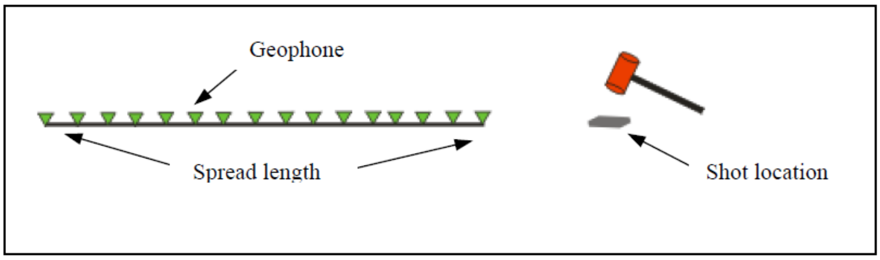


Figure 3.3 Schematic of linear active source spread configuration

During our field work we will be used 12 channels with 3m interval, 1.5 m source (sledge hammer) offset, 0.125 ms sample interval, 2 seconds record length and auto trigger option.

Figure 3.4 MASW Field Data Acquisition

Application of MASW Test

MASW data to provide shear wave maps of the subsurface for earth quake design site classification (like site class E, D, or C) as per the 2003 International Building Code. MASW surveys are also use to map voids, top of bedrock, and soft or weaker bedrock zones. This information is important in both geotechnical and environmental applications. The main application of this surveys are listed below-

- Void Mapping
- Earthquake Design Data
- Top of Bedrock
- Shear Wave Data
- Bedrock Fracture Zones
- Abandoned Mine Location

3.2.3. Test Detail And Procedure Of Microtremor Measurement (Single Microtremor)

Microtremor method is a practical and economical seismic survey since it has potential to explore deep soils without a borehole. Microtremors are the phenomenon of very small vibrations of the ground surface even during ordinary quiet time as a result of a complex stacking process of various waves propagating from remote man-made vibration sources caused by traffic systems or machineries in industrial plants and from natural vibrations caused by tidal and volcanic activities. Observation of microtremors can give useful information of dynamic properties of the site such as predominant period, amplitude, peak ground acceleration and shear wave velocity.

Field Data Acquisition System

Microtremor observations are performed using portable equipment, which is equipped with a super-sensitive sensor, a wire comprising a jack in one site and USB port in another site, and a laptop computer is also used. The microtremor equipment need to be set on the free surface on the ground without any minor tilting of the equipment. The N-S and E-W directions are properly maintained following the directions arrowed on the body of the equipment. The sampling frequency for all equipments is set at 200Hz. The low-pass filter of 40Hz is set in the data acquisition unit. Like the seismometer or accelerometer, the velocity sensor used can measure three components of vibrations: two horizontal and one vertical. The natural period of the sensor is 2 sec. A global positioning system (GPS) is used for recording the coordinates of the observation the available frequency response range for the sensor is 0.5-20Hz. sites. The length of record for each observation was 10 min.

Figure 3.5 Field data acquisition of Single microtremor

3.2.4. Standard Penetration Test (SPT) Method

The Standard Penetration test (SPT) is a common in situ testing method used to determine the geotechnical engineering properties of subsurface soils. The test procedure is described in the British Standard BS EN ISO 22476-3, ASTMD1586. A short procedure of SPT N-value test is described in the following paragraph.

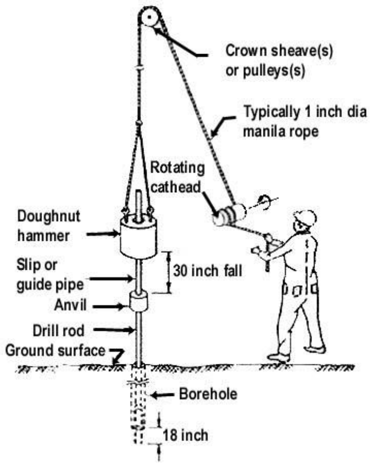


Figure 3.6 The SPT sampler in place in the boring with hammer, rope and cathead (Adapted from Kovacs, et al., 1981)

The test in our field uses a thick-walled sample tube, with an outside diameter of 50 mm and an inside diameter of 35 mm, and a length of around 650 mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5 kg (140 lb) falling through a distance of 760 mm (30 in). The sample tube is driven 150 mm into the ground and then the number of blows needed for the tube to penetrate each 150 mm (6 in) up to a depth of 450 mm (18 in) is recorded. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance" or the "N-value". In cases where 50 blows are insufficient to advance it through a 150 mm (6 in) interval the penetration after 50 blows is recorded. The blow count provides an indication of the density of the ground, and it is used in many empirical geotechnical engineering formulae.

The main objective of SPT is as follows:

a) Boring and recording of soil stratification.
b) Sampling (both disturbed and undisturbed).
c) Recording of SPT N-value
d) Recording of ground water table.

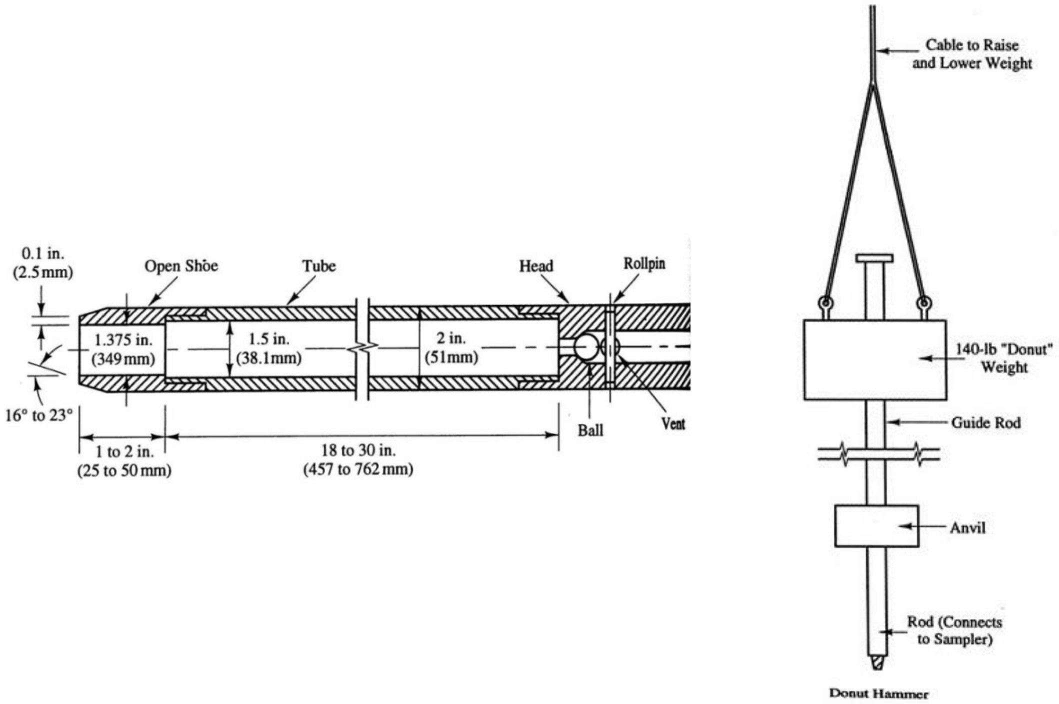


Figure 3.7 SPT Sampler and Donut Hammer

3.2.5. Grain Size Analysis (Sieve And Hydrometer Analysis)

Purpose:

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles.

Standard Reference:

ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils

Significance:

The distribution of different grain sizes affects the engineering properties ofsoil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Equipment:

Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker,Timing device.

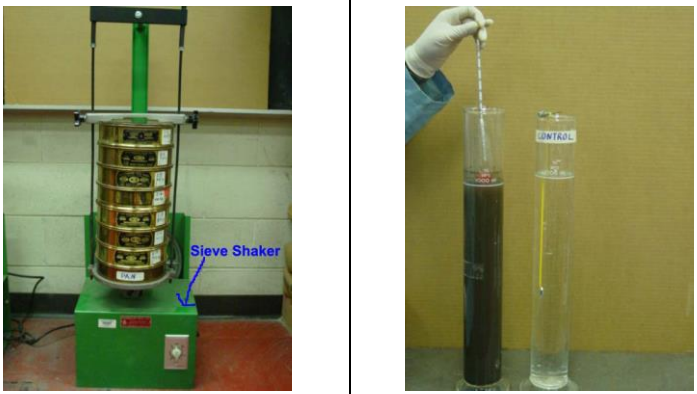


Figure 3.8 Grain size analysis test equipment

3.2.6. Specific Gravity Determination

Purpose:

This lab is performed to determine the specific gravity of soil byusing a pycnometer. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

Standard Reference:

ASTM D 854-00 – Standard Test for Specific Gravity of Soil Solids by Water Pycnometer.

Significance:

The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

Equipment:

Pycnometer, Balance, Vacuum pump, Funnel, Spoon.

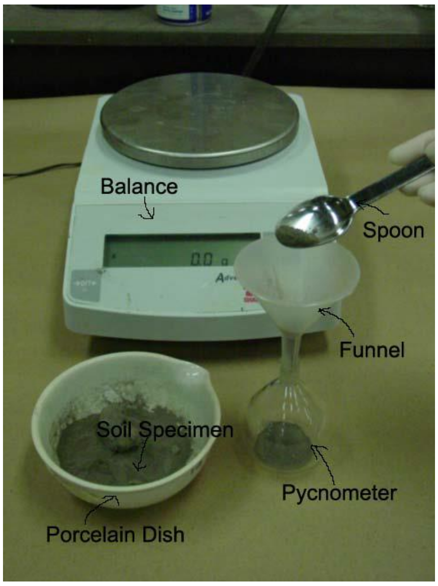


Figure 3.9 Specific gravity test equipment

3.2.7. Atterberg Limits Determination

Purpose:

This lab is performed to determine the plastic and liquid limits of a fine grained soil. The liquid limit (LL) is arbitrarily defined as the water content, inpercent, at which a pat of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit(PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

Standard Reference:

ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and

Plasticity Index of Soils

Significance:

The Swedish soil scientist Albert Atterberg originally defined seven “limits ofconsistency” to classify fine-grained soils, but in current engineering practice onlytwo of the limits, the liquid and plastic limits, are commonly used. (A third limit,called the shrinkage limit, is used occasionally.) The Atterberg limits are based onthe moisture content of the soil. The plastic limit is the moisture content that defines where the soil changes from a semi-solid to a plastic (flexible) state. Theliquid limit is the moisture content that defines where the soil changes from a plastic to a viscous fluid state. The shrinkage limit is the moisture content that defines where the soil volume will not reduce further if the moisture content is reduced. A wide variety of soil engineering properties have been correlated to the liquid andplastic limits, and these Atterberg limits are also used to classify a fine-grained soil according to the Unified Soil Classification system.

Equipment:

Liquid limit device, Porcelain (evaporating) dish, Flat grooving tool with gage, Eight moisture cans, Balance, Glass plate, Spatula, Wash bottle filled with distilled water, Drying oven set at 105°C.

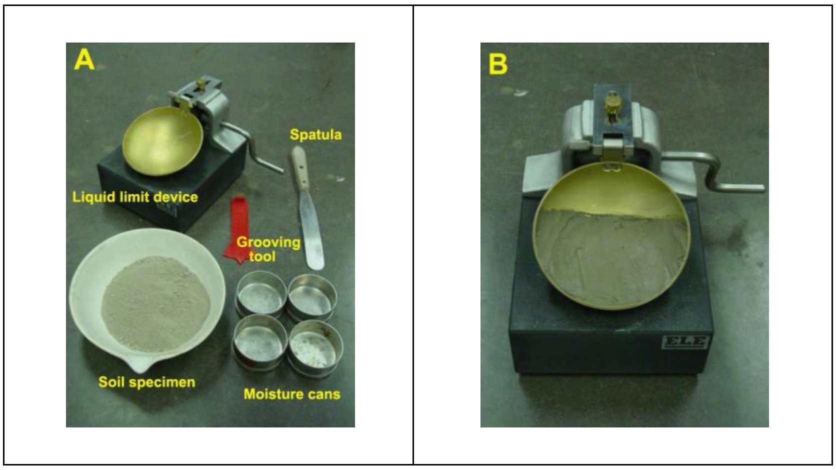


Figure 3.10 Atterberg limits test equipment

3.2.8. Direct Shear Determination

Purpose:

To determine the shearing strength of the soil using the direct shear apparatus.

Standard Reference:

ASTM D 3080- to measure the shear strength properties of soil.

Significance:

In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. The laboratory report cover the laboratory procedures for determining these values for cohesion less soils.

Equipment:

Direct shear box apparatus, Loading frame (motor attached), Dial gauge, Proving ring, Tamper, Straight edge, Balance to weigh upto 200 mg, Aluminum container and Spatula.

Figure 3.11 Direct Shear test equipment

3.2.9. Unconfined Compression Test

Purpose:

To determine shear parameters of cohesive soil.

Standard Reference:

ASTM D2166- To determine shear parameters of cohesive soil.

Significance:

It is not always possible to conduct the bearing capacity test in the field. Some times it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remoulded soil sample. Now we will investigate experimentally the strength of a given soil sample.

Equipment:

Loading frame, with constant rate of movement.Proving ring of 0.01 kg sensitivity for soft soils; 0.05 kg for stiff soils.Soil trimmer, Frictionless end plates of 75 mm diameter (Perspex plate with silicon grease coating), Evaporating dish (Aluminum container).

Soil sample of 75 mm length, Dial gauge (0.01 mm accuracy), Balance of capacity 200 g and sensitivity to weigh 0.01 g, Oven, Sample extractor and split sampler, Dial gauge (sensitivity 0.01mm), Vernier calipers.

Figure 3.12 Unconfined Compression test equipment

3.2.10. Triaxial Test (Unconsolidated-Undrained)

Purpose:

To find the shear of the soil by Undrained Triaxial Test.

Standard Reference:

ASTM D2850-70-To find the shear of the soil by Undrained Triaxial Test.

Significance:

The standard consolidated undrained test is compression test, in which the soil specimen is first consolidated under all round pressure in the triaxial cell before failure is brought about by increasing the major principal stress. It may be perform with or without measurement of pore pressure although for most applications the measurement of pore pressure is desirable.

Equipment:

3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes, Rubber ring, An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side, Stop clock, Moisture content test apparatus, A balance of 250 gm capacity and accurate to 0.01 gm.

Figure 3.13 Triaxial test equipment

3.2.11. Consolidation Test

Purpose:

This test is performed to determine the magnitude and rate of volume decrease that a laterally confined soil specimen undergoes when subjected to different vertical pressures. From the measured data, the consolidation curve (pressure-void ratio relationship) can be plotted. This data is useful in determining the compression index, the recompression index and the preconsolidation pressure (or maximum past pressure) of the soi. In addition, the data obtained can also be used to determine the coefficient of consolidation and the coefficient of secondary compression of the soil.

Standard Reference:

ASTM D 2435 - Standard Test Method for One-DimensionalConsolidation Properties of Soils.

Significance:

The consolidation properties determined from the consolidation test are used to estimate the magnitude and the rate of both primary and secondary consolidation settlement of a structure or an earthfill. Estimates of this type are of key importance in the design of engineered structures and the evaluation of their performance.

Equipment:

Consolidation device (including ring, porous stones, water reservoir, and load plate), Dial gauge (0.0001 inch = 1.0 on dial), Sample trimming device, glass plate, Metal straight edge, Clock, Moisture can, Filter paper.

Figure 3.14 Consolidation Test equipment

4. EXPECTED OUTCOME

- Development of Subsurface lithological 3D model
- Surface Geological map preparation of the study area
- Foundation layer map which showing the depth of the foundation from existing ground level
- Development of engineering geological map based on average shear wave velocity up to depth 30m (Vs 30)
- Preparation of peak ground acceleration (PGA) map
- Preparation of spectrum acceleration for T= 0.2s period (SA 0.2s) and T= 1s period (SA 1s) map
- Preparation of earthquake intensity map
- Preparation of recommended building height maps for both high rise building and low rise building
- Development of liquefaction potential index (LPI) map

In addition, land or ground subsidence zone map will be prepared as per request of PEC committee.

5. WORK PLAN

An intensive geological and geomorphological, geotechnical, and geophysical survey will be carried out for site characterization and sustainable development plan at Amtali, Taltoli, Barguna Sadar and Patharghata upazila of Barguna district and Galachipa, Rangabali and Kalapara upazila of Patuakhali disrtict of Bangladesh. So geotechnical and geophysical investigations are essential tools for seismic risk assessment in this project area. To accomplish this project, our team has been started all field activities on 09/07/2018 and it will take 30 to 40 days to acquire all data. The geophysical investigations include PS-logging, Single Microtremor and Multi-channel Analysis of Surface Wave (MASW). The geotechnical investigations will contain geotechnical boreholes with Standard Penetration Test (SPT) and sample collection (disturbed and undisturbed samples). The geotechnical laboratory tests, such as Atterberg limits, grain size analysis, specific gravity determination, direct shear test, Unconfined compression strength, triaxial tests and consolation test will be conducted to prepare subsurface geological and geotechnical model for bearing capacity and other estimation. The average shear wave velocity up to the depth 30 m (AVS 30) will be determined interpreting the geophysical and geotechnical SPT data and geological and geotechnical subsurface model. An engineering geological map using AVS 30 will be prepared for site specific seismic hazard assessment.

90 Nos. of 30 m soils exploratory boring of 100 mm diameter is conducted by mechanical percussion wash boring method at the locations according to the work plan. To maintain our schedule we send four sets of SPT setup. In this manner the estimated time for boring execution 3- shifts will consider for mobilization, assemble and disassemble of the equipment, site cleanup and backfill the bore holes to their pre-existing condition. During boring work, geophysical survey will also be carried out during the same field work period. So a separate team will be involved to conduct this geophysical survey respectively, fifteen (15) PS Logging, twenty (20) MASW, and thirty (30) Microtremor (single array). Considering all these works and conditions a field work plan is submitted to the client as shown in the table below:

SL No	Types of Survey	No. of Test	Starting Date	Finishing Date	Remarks
1	Site Selection		09/07/2018	16/07/2018	
2	Standard Penetration Test	90	15/07/2018	12/07/2018	Four SPT will be completed per day
3	PS Logging	15	20/07/2018	12/08/2018	
5	MASW	25	20/07/2018	12/08/2018	
6	Microtremor (Single)	40	20/07/2018	12/08/2018	

5.1. Site Selection Activities

Our team has completed to visit to entire Payra-Kuakata project area from 09th July 2018 to 16th July, 2018 for suitable site selection. To accomplish this project Ninety (90) no. borehole sites have been selected for SPT test. Beside this, geophysical investigations sites are also selected such as fifteen (15) Downhole seismic, twenty-five (25) MASW, forty (40) single Microtemor respectively. All investigated points (i.e. Borehole, Downhole seismic, MASW and Microtemor) have been selected by considering Surface geologic unit, upazila boundaries, accessibility and well distribution. However, MASW and Microtemor tests point will be shifted, due to field condition.

Geotechnical and Geophysical investigations sites selection

Location: Lat- 22.157138 Long- 90.047608

Location: Lat- 22.067503 Long- 89.927283

Location: Lat- 22.150878 Long- 89.947985

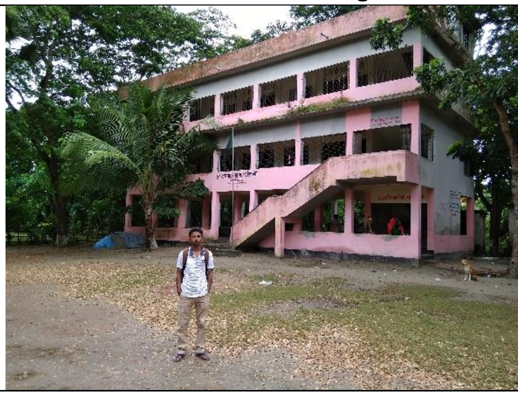
Location: Lat- 22.153119 Long- 90.199123

Location: Lat- 22.225376 Long- 90.129198

Location: Lat- 22.155764 Long- 90.122003

Location: Lat- 21.883064 Long- 90.159544

Location: Lat- 21.953924 Long- 90.071331

	
Location: Lat- 21.943614 Long- 90.099477	Location: Lat- 22.168507 Long- 90.461456
	
Location: Lat- 22.14077 Long- 90.08432	Location: Lat- 21.84741 Long- 90.21971
	
Location: Lat- 21.91169 Long- 90.14444	Location: Lat- 21.908114 Long- 90.405833
	
Location: Lat- 21.96068 Long- 90.45132	Location: Lat- 21.96952 Long- 90.250604

	
Location: Lat- 22.01222 Long- 90.46023	Location: Lat- 22.292854 Long- 90.430606
	
Location: Lat- 22.2295 Long- 90.307035	Location: Lat- 22.167904 Long- 90.424019
	
Location: Lat- 22.126798 Long- 90.397147	Location: Lat- 22.022 Long- 90.365601
	
Location: Lat- 22.168115 Long- 90.408955	Location: Lat- 22.083448 Long- 90.259355

The union based geotechnical and geophysical investigations of the proposed project are listed in below table-

S/N	Upazila name	Name of investigations			
		Bore-log with SPT	PS logging *(30m depth)*	MASW *(30m depth)*	Single Micro Tremor Measurement
1	Galachipa	15	2	4	7
2	Rangabali	11	2	3	4
3	Kalapara	14	3	4	7
4	Amtali	13	2	4	8
5	Taltoli	13	2	3	3
6	Barguna Sadar	14	2	4	7
7	Pathargata	10	2	3	4
	Total	**90**	**15**	**25**	**40**

Standard Penetration Test (SPT) Locations

BH_ID	Latitude	Longitude	BH_ID	Latitude	Longitude
BH-01	21.81944	90.12091	BH-46	22.067503	89.927283
BH-02	21.84741	90.21971	BH-47	22.067929	89.984847
BH-03	21.896795	90.040669	BH-48	22.106045	89.996869
BH-04	21.85402	90.12362	BH-49	22.097637	90.06131
BH-05	21.878603	90.13385	BH-50	22.083612	90.071353
BH-06	21.84739	90.18428	BH-51	22.088656	90.146443
BH-07	21.90024	90.23511	BH-52	22.059275	90.186166
BH-08	21.911389	90.064722	BH-53	22.133484	90.230084
BH-09	21.943614	90.099477	BH-54	22.108494	90.293883
BH-10	21.91169	90.14444	BH-55	22.132797	90.319892
BH-11	21.89282	90.18957	BH-56	22.022	90.365601
BH-12	21.92845	90.24364	BH-57	22.039678	90.526369
BH-13	21.897865	90.32456	BH-58	22.078819	90.518992
BH-14	21.908114	90.405833	BH-59	22.119288	89.929288
BH-15	21.836913	90.495846	BH-60	22.150878	89.947985
BH-16	21.932089	90.06625	BH-61	22.177767	90.015177
BH-17	21.98446	90.083894	BH-62	22.13251	90.076761
BH-18	21.93322	90.16382	BH-63	22.122942	90.096608
BH-19	21.95308	90.18301	BH-64	22.157271	90.087346
BH-20	21.98503	90.22015	BH-65	22.153119	90.199123
BH-21	21.96068	90.45132	BH-66	22.141493	90.233098
BH-22	21.944397	90.412697	BH-67	22.15555	90.294022
BH-23	21.974417	90.435536	BH-68	22.126798	90.397147
BH-24	21.901461	90.523381	BH-69	22.082895	90.428391
BH-25	21.993467	89.964499	BH-70	22.167904	90.424019
BH-26	22.019223	89.998116	BH-71	22.195257	89.968453

BH-27	22.003005	90.050841
BH-28	22.035618	90.099704
BH-29	22.025846	90.164284
BH-30	21.984438	90.139164
BH-31	21.96952	90.250604
BH-32	22.05873	90.31988
BH-33	21.96746	90.362603
BH-34	22.025535	90.418347
BH-35	21.969547	90.576594
BH-36	22.042219	89.97143
BH-37	22.035766	90.025007
BH-38	22.044112	90.051524
BH-39	22.058749	90.114047
BH-40	22.046608	90.144795
BH-41	21.953924	90.071331
BH-42	22.04589	90.25025
BH-43	22.083448	90.259355
BH-44	22.01222	90.46023
BH-45	22.00028	90.43006

BH-72	22.157138	90.047608
BH-73	22.196093	90.119071
BH-74	22.155764	90.122003
BH-75	22.191372	90.179425
BH-76	22.174278	90.256693
BH-77	22.199496	90.282488
BH-78	22.179485	90.324827
BH-79	22.181953	90.391907
BH-80	22.168115	90.408955
BH-81	22.192693	90.481211
BH-82	22.225376	90.129198
BH-83	22.216233	90.275309
BH-84	22.2295	90.307035
BH-85	22.247763	90.322332
BH-86	22.250839	90.38435
BH-87	22.22561	90.45629
BH-88	22.197535	90.438764
BH-89	22.255466	90.445988
BH-90	22.292854	90.430606

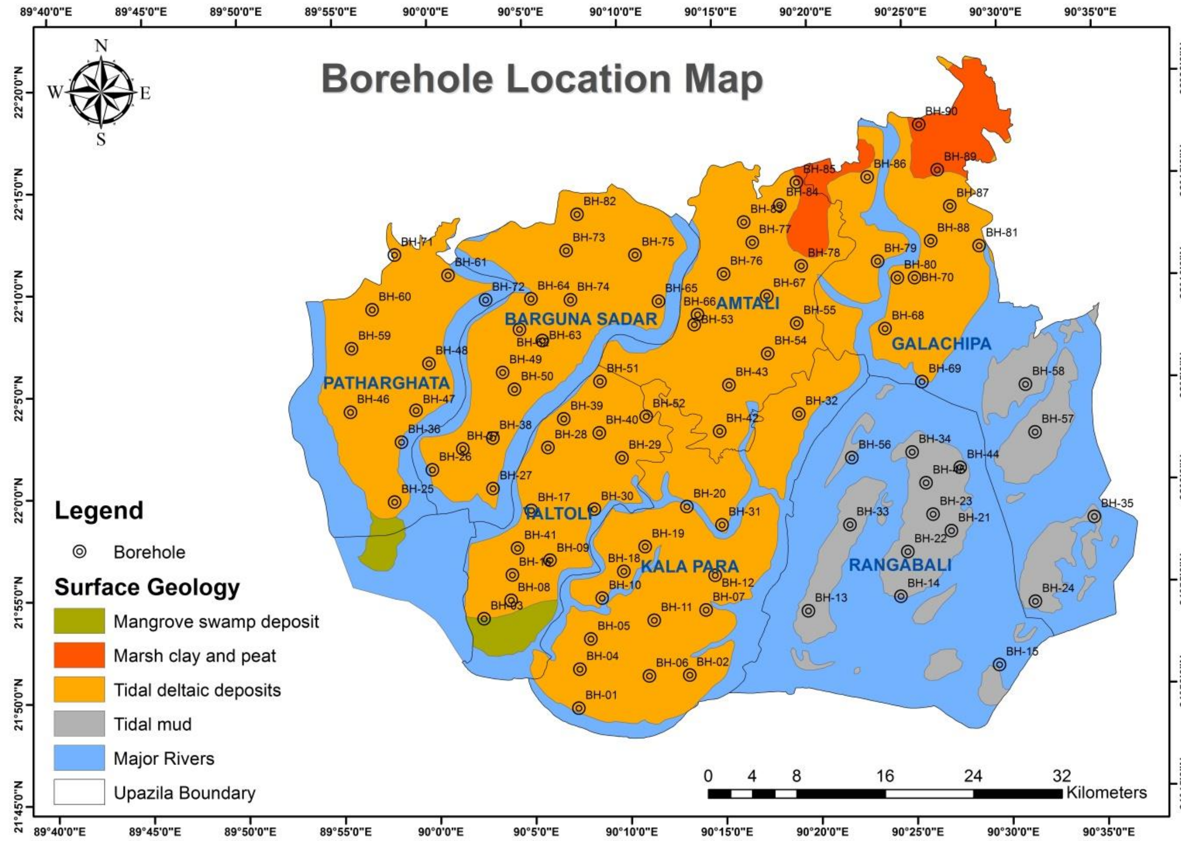


Figure 5.1 Location map for Borehole (SPT test)

MASW Survey Locations

ID_MASW	Latitude	Longitude		ID_MASW	Latitude	Longitude
MASW-01	21.896922	90.09624		MASW-14	22.168417	90.149975
MASW-02	21.856878	90.133068		MASW-15	21.972921	90.088349
MASW-03	22.064133	90.233002		MASW-16	22.072886	90.30279
MASW-04	21.947628	90.177573		MASW-17	22.102038	90.218399
MASW-05	21.930813	90.421332		MASW-18	21.978473	90.233746
MASW-06	21.829242	90.515129		MASW-19	22.163421	90.493973
MASW-07	22.088547	89.921828		MASW-20	22.210745	90.111824
MASW-08	22.133985	90.012633		MASW-21	22.218119	90.301839
MASW-09	22.185166	89.987518		MASW-22	22.0913	90.415183
MASW-10	22.142274	90.078016		MASW-23	21.858442	90.236906
MASW-11	22.036876	90.172085		MASW-24	22.267794	90.476066
MASW-12	22.012223	90.447358		MASW-25	22.160346	90.413511
MASW-13	22.052923	90.066759				

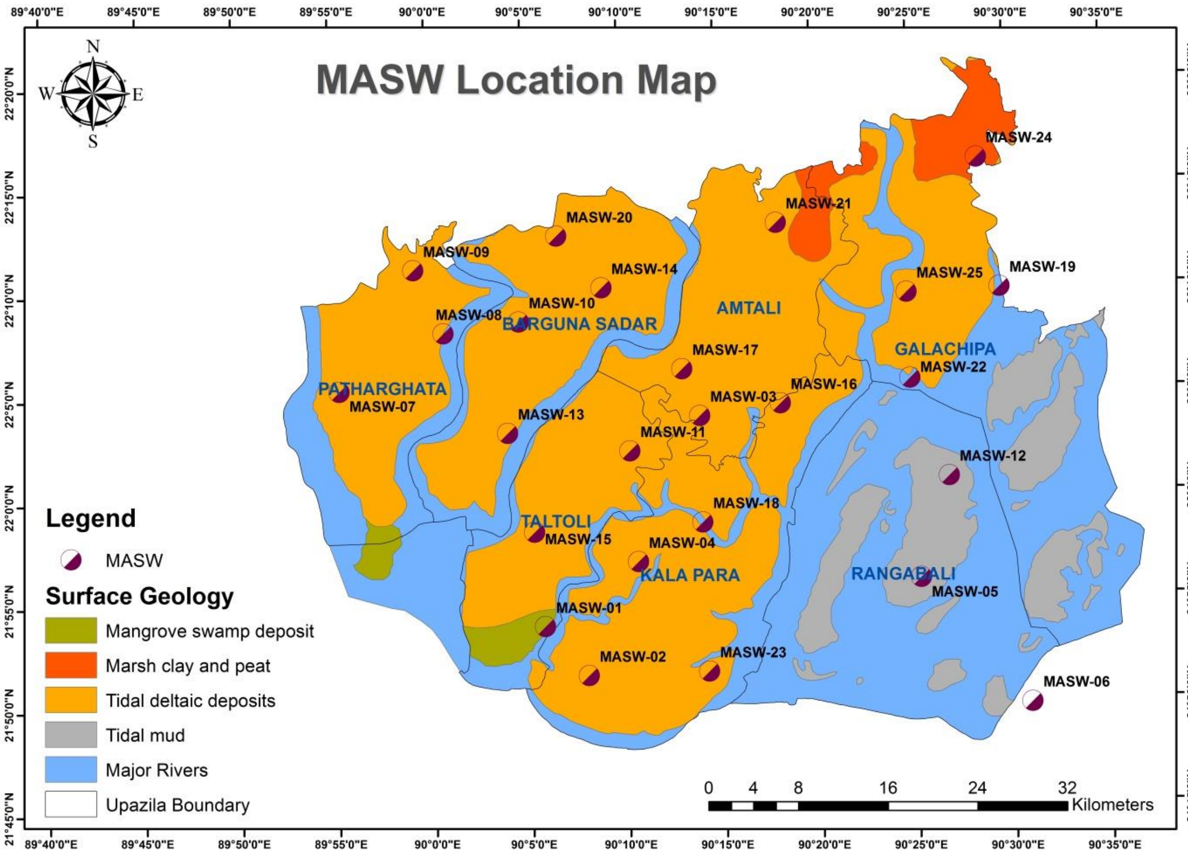


Figure 5.2 Location map for MASW survey

PS Logging Test Locations

ID_PS	Latitude	Longitude
PS01	21.822277	90.12091
PS02	21.908114	90.405833
PS03	21.98446	90.083894
PS04	21.98503	90.22015
PS05	22.025535	90.418347
PS06	22.067503	89.927283
PS07	22.044112	90.051524
PS08	22.059275	90.186166
PS09	22.168115	90.408955
PS10	22.141493	90.233098
PS11	22.058702	90.319881
PS12	22.177767	90.015177
PS13	22.155764	90.122003
PS14	22.247763	90.322332
PS15	22.22561	90.45629

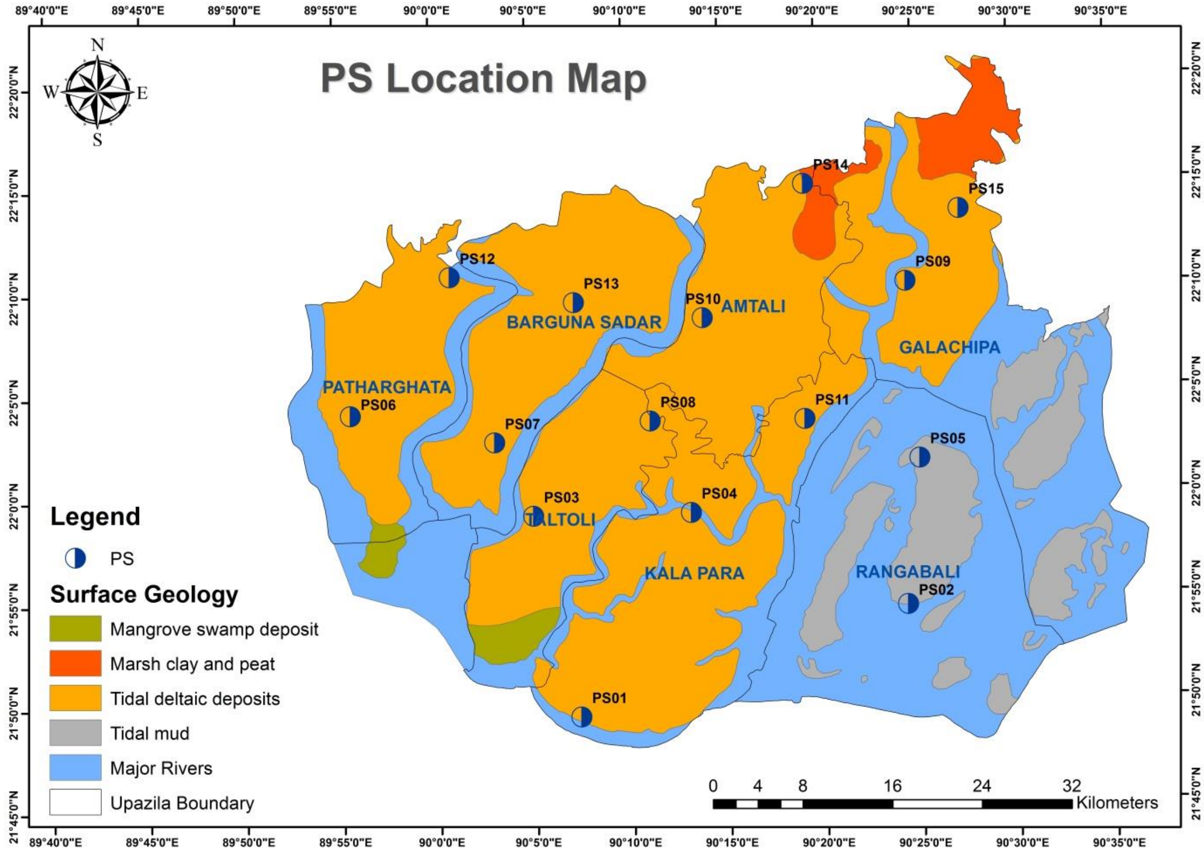


Figure 5.3 Location map for PS Logging test

Single microtremor survey Locations

ID_Microtremor	Latitude	Longitude
MT01	21.926969	90.061991
MT02	22.101941	90.173615
MT03	21.850113	90.148081
MT04	22.130917	90.268645
MT05	21.883699	90.161006
MT06	21.928616	90.444481
MT07	21.991456	90.383411
MT08	21.871507	90.328176
MT09	22.027685	89.950603
MT10	22.102134	89.969434
MT11	22.116172	89.919398
MT12	22.012887	90.029099
MT13	22.121194	90.048851
MT14	22.026134	90.119002
MT15	22.146639	90.194844
MT16	21.815251	90.148242
MT17	21.943229	90.276467
MT18	22.097126	90.331037
MT19	21.928744	90.519492
MT20	21.984512	90.430446

ID_Microtremor	Latitude	Longitude
MT21	22.185115	89.989181
MT22	22.089861	90.083426
MT23	22.20742	90.088136
MT24	21.969815	90.133746
MT25	22.145387	90.120303
MT26	22.149723	90.313822
MT27	22.178527	90.282775
MT28	22.007255	90.245958
MT29	22.168879	90.335111
MT30	22.08711	90.533732
MT31	22.042561	90.524967
MT32	22.220705	90.165621
MT33	22.192126	90.268195
MT34	22.029333	90.316556
MT35	22.242821	90.328227
MT36	21.894841	90.210935
MT37	22.21721	90.447836
MT38	22.264663	90.380562
MT39	22.289743	90.455259
MT40	22.179666	90.463625

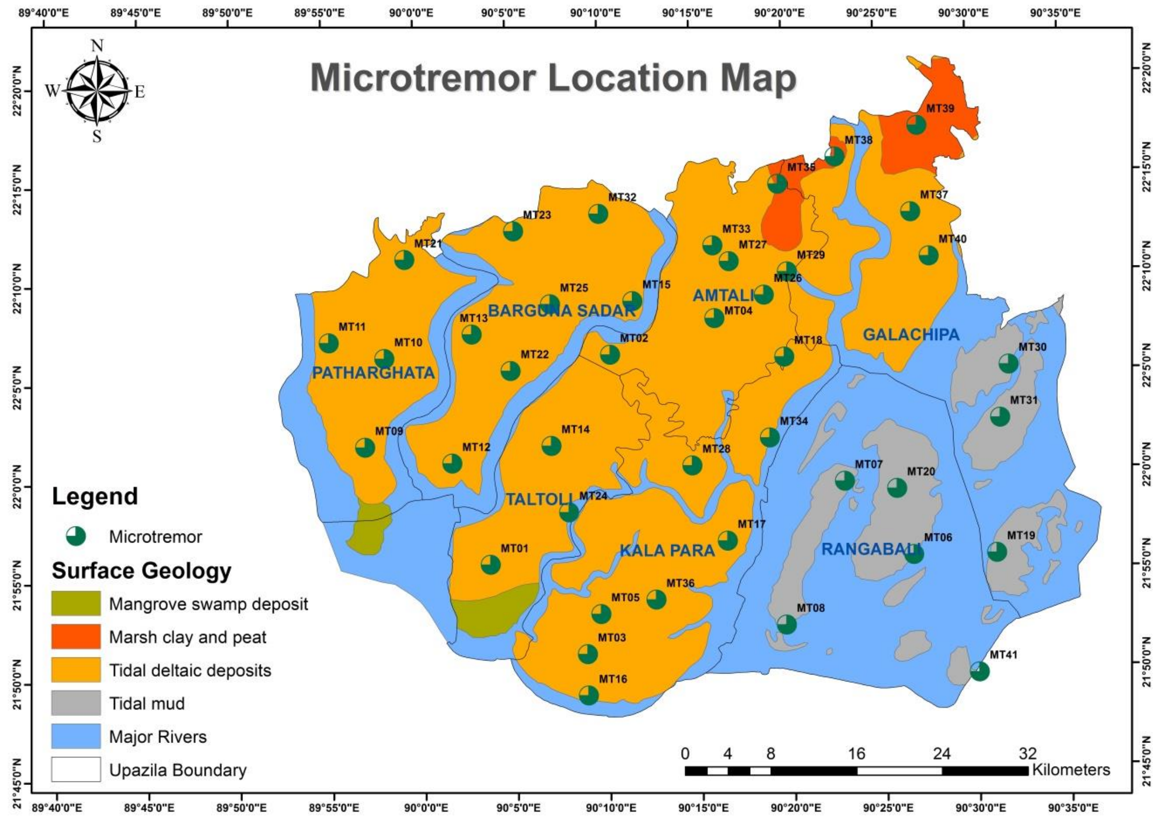
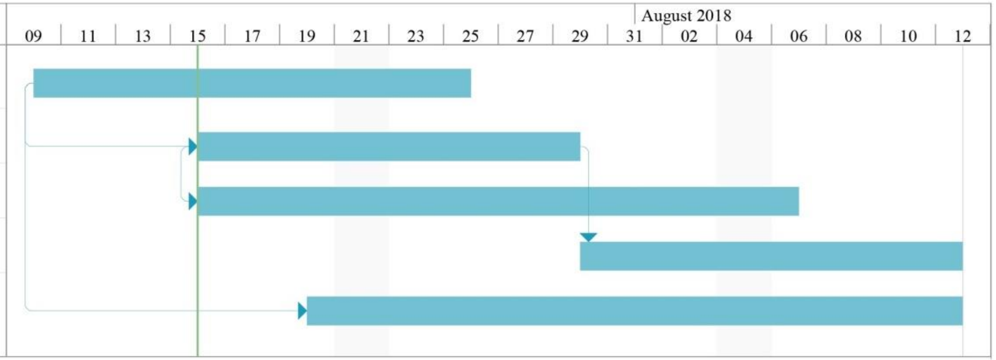


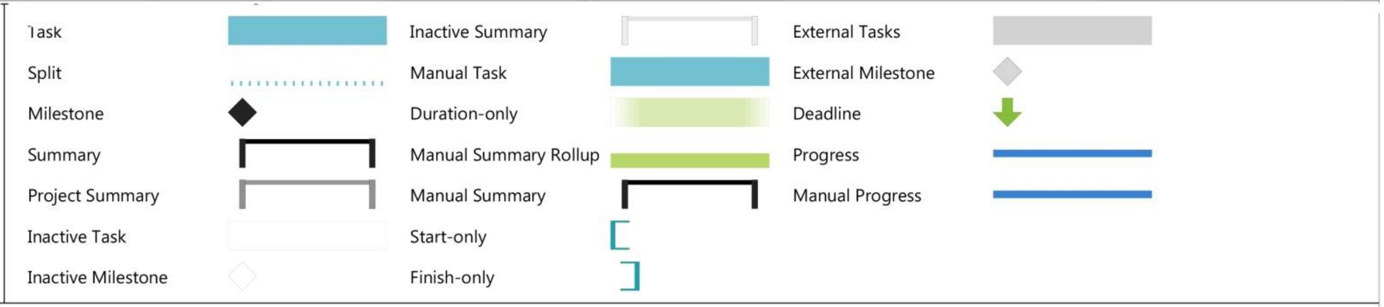
Figure 5. 4 Location map for single microtremor survey

5.2. Time Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		1 Site Selection for Geotechnical & Geophysical Works	12 days	Tue 10-07-18	Wed 25-07-18
2		2 Galachipa and Rangabali (Geotechnical Test)	11 days	Mon 16-07-18	Sun 29-07-18
3		3 Kalapara, Amtoli and Taltoli (Geotechnical Test)	17 days	Mon 16-07-18	Mon 06-08-18
4		4 Barguna Sadar and Patharghata (Geotechnical Test)	11 days	Mon 30-07-18	Sun 12-08-18
5		5 Geophysical Test: Downhole seismic (PS logging), MASW & Microtremor	18 days	Fri 20-07-18	Sun 12-08-18



Project: Payra_Kuakata Field
Date: Mon 16-07-18



5.3. Deliveries

The following reports will be submitted to the UDD on or before the following dates:

Serial no.	Deliveries	Submission date
1	Mobilization Report	05/07/2018
2	Inception Report	20/07/2018
3	Report on review of (i) Morphotectonic and Neotectonic studies of Bangladesh and its surrounding areas, (ii) Geodynamic model of Bangladesh, (iii) Updating fault model.	20/08/2018
4	Report on geophysical and geotechnical investigations, lab test and engineering geological mapping	20/11/2018
5	Draft report on Data relating to Geo-technical and Geo-physical Survey including Laboratory test results including seismic hazard assessment and its interpretation	20/12/2018
6	Final Report on seismic hazard assessment and its interpretation	20/01/2019

6. RESOURCE ALLOCATION

Geophysical Test		
SL No.	**Name of Test/Survey**	**Test Category**
1	PS Logging	Down-hole Seismic Test (DS)
		Cross-hole Seismic Test (CS)
2	Multi-channel Analysis of Surface Wave	Active
3	Small Scale Microtremor Measurement (SSMM)	Passive
4	Microtremor Survey	Single Array
		MT Array
5	Electrical Resistivity Survey	Vertical Electrical Sounding (VES)
		2D Resistivity (Electrical Tomography)
		Spontaneous Potential (SP)

Geotechnical Test	
SL No.	**Name of Test/Survey**
In-Situ (Field)	
1	Standard Penetration Test (SPT)
2	Field Permeability Test
3	Field Van Shear Test
4	Pressure Meter Test
5	Field Density Test
Laboratory Test	
1	Water Content Determination
2	Organic Matter Determination
3	Density (Unit Weight) Determination
4	Specific Gravity of Soil Particles Determination
5	Relative Density Determination
6.	Grain Size Analysis
7	Atterberg Limits
8	Moisture-Density Relation(Compaction) Test
9	Permeability (Hydraulic Conductivity) Test
10	Consolidation Test
11	Unconfined Compression Strength(UCS) Test
12	Direct Shear Test
13	Tri-axial Compression Test (UU)

INSTRUMENT LISTS

Geophysical Equipment's

1.		Down-hole/Cross-hole Seismic Logger OLSON INSTRUMENTS, U.S.A.
2.		Multi-channel Analysis of Surface Wave (MASW) Survey Instrument. EXPLORATION SEISMOGRAPH PASI MOD. ANTEO
3.		4 pole Resistivity Meter OYO JAPAN
4.		MicrotremorSurvey Instrument Japan

Geotechnical Equipments

1		Two sets of Standard Penetration Test Boring Rig
2		ELE International Triaxial Instrument
3		One Dimensional Consolidation Test Instrument ELE International
4		Direct Shear Test Instrument ELE International

5		Oven
6		Sieve shaker
7		Hydrometer

7. CONCLUSION

Seismically, Bangladesh is divided into three zones i.e. highly risk zone (zone 1), moderate risk zone (zone2) and low risk zone (zone3). Though Payra-Kuakata project area at Patuakhali and Barguna district of Bangladesh is situated in zone 3, this area is located near Arakan Megathrust and Deformation front. To propitiate the risk of earthquake some initiatives have been taken by the concerned authorities. One of the projects works named "Engineering Geological and Geo-Physical Surveys Under Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism" which has been initiated by Urban Development Directorate.

In this project work, both the geophysical and geotechnical investigations will be conducted. The duration of the project is seven months (21^{st} June, 2018 to 20^{th} January, 2019). In geotechnical survey 90 numbers of SPT boring (up to 30m) will be surveyed in the field and the soil samples collected from the field will be tested in the laboratory. And in geophysical Survey, fifteen (15) PS Logging, twenty five (25) MASW, and forty (40) Microtremor (single array) will be investigated by using some sophisticated instruments. Finally, by using these geotechnical and geophysical data, geological study and seismic hazard assessment will be prepared.