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A GEOTECHNICAL PROFILE OF HAOR AREA OF BANGLADESH

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Abstract

Analyzing soil parameter is an utmost important job for design and foundation and it is likewise important wherever the structure is to be constructed and what type of structure is to be built on. With a view to making available information on foundation soils to the design engineer, a study is made to investigate the engineering soil parameters around the haor areas of the country. Accordingly, an effort is made to study on haor area soils of Bangladesh focusing soil profile along with its physical and index properties and to disseminate them to the geotechnical engineers. The data have been collected from the Soil Mechanics Division of River Research Institute (RRI) by testing of relevant engineering parameters of haor areas soil of Bangladesh. As River Research Institute has been testing disturbed and undisturbed soil samples collected mainly from the Bangladesh Water Development Board (BWDB) through accomplishment of soil borings by the geologist of the same throughout the country. In this study it is found that brown and grey in colour soils are existed in those area up to the maximum depth of about (0-102´). Their natural moisture content of cohesive soils is varying from (25%-752%). At the same time their plasticity indices are varying from (5%-153%), which has been seen in observation. Of course, their strength is different, which varies from 0 to 383.04kN/m^2.On the other hand, relative densities of those soils are varying from very loose to dense. The findings of the study are in general that cohesive and non-cohesive soil layers exists almost every region of the haor areas of Bangladesh. However, exceptions have also found in different locations and different layers. Soil profiles and geotechnical properties are expected to provide a comprehensive idea for the selection of appropriate measures to the respective zone and if necessary to take proper decision by the design engineers. The findings of this paper might also help the design engineer to get a preliminary concept about the soil of haor areas of the country.

Introduction

Bangladesh is a riverine country with low lying land. It has about 8, 58,000 hectare of haor areas wherever agriculture and fisheries are the main economy. It has about 2 crores of population. We know haor-baor is an abandoned meander isolated from the main stream channel by deposition and filled with water. Accordingly, baors/haors are situated in the North-Eastern part of Bangladesh and they are in the districts Sunamgonj, Habigobj, Sylhet, Moulovibazar, Netrokona, Kishoregonj and Brahmanbaria. The problems of the haor areas are enormous. Flash and normal monsoon flood and lack of communication are the major problems in that area. The first one hampers production of crops and another makes suffering to the public lives. For these reasons, about 28% people are in poverty line. Considering such situation,

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Bangladesh government has undertaken sustainable development project to mitigate these problems, at which construction of structure is one of the main component. In order to accomplish the structures, project authority is conducting different tests of soil samples to collect design parameters. This attempt has been made to facilitate the construction works of haor areas through exploring the engineering soil properties of such areas. To accomplish this study, a number of soil testing parameters are collected from the soil mechanics division of geotechnical research directorate of River Research Institute (RRI). These analyzing parameters will focus an indication to the engineering properties of soil such as, index and physical properties of the haor areas from which a design engineer may know the soil conditions. It will also help the design engineer to design structures in the same area.

Literature review

Geologically, Bangladesh is a part of the Bengal Basin, one of the largest geosynclines in the world (Sajjadur 2008). The Bangladesh landmass has gone through several historical ages to arrive to this present formation. The major divisions of these ages are the PreCambrian, the Paleocene, the Eocene, the Miocene, the Pliestocene and the Holocene ages. Table1 shows the ages, lithology and characters of those formations and their accessible locations.

Table 1. The lithology of Bangladesh

Ages	Formation	Lithology and Character	Location
Holocene	Alluvium	Aquifers of Sand Silt and Clay	Flood Plains
Pliestocene	Modhupur	Red Clay, Ferruginous Nodules	Barind
Pliocene	Dihing	Sandstone	Deep
	DhupiTila	Aquifer of Sandstone and Clay	Deep
Miocene	Tipam	Aquifer of Sandstone and Clay	Very Deep
Miocene	Bokabil	Gas Producing	Eastern
	Bhuban	Sandstone and Shale	Folds
Oligocene	Barail	Sandstone	Sunamgonj
Eocene	Kopili	Shale, Fossiliferous Sandstone	Sunamgonj
	Sylhet	Exposed Sandstone, Limestone	Sunamgonj
Paleocene	Tura	Exposed Sandstone	Sherpur
Jurassic	Rajmahal	Volcanic rock of Rajmahal Trap	Bogra
Permian	Gondwana	Sandstone, Shale and Coal beds	Dinajpur
PreCambrian	Basement	Igneous and Metamorphic rocks	Dinajpur

(Source: Haque 2008)

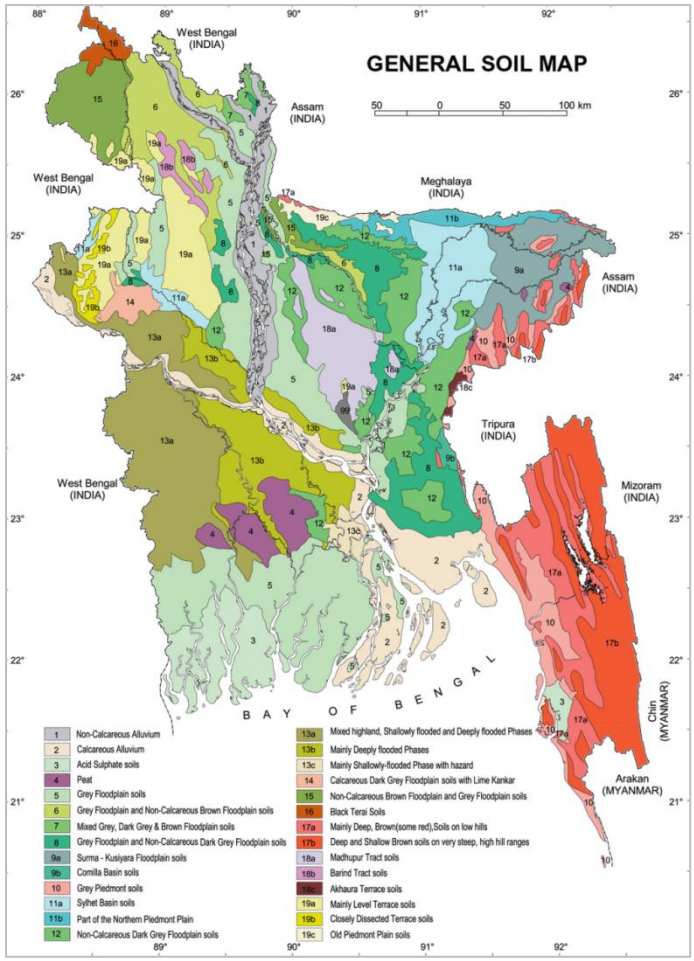

Figure 1. Ggeneral soil map of Bangladesh (Source: Google images, 2014)

The Eastern part of the floodplain is generally smooth, comprising broad ridges and extensive basins. The soils are mainly clay loams on the ridges and clays on the basins or depressions. The Sylhet Basin is a vast depressed area mainly comprising high river levees surrounding extensive basins (haors), the centers of which remain wet in the dry season. Even though the basin is located some 300 km from the coast, the lowest parts of the basin are less than five meters from mean sea level. The relief is locally irregular due to erratic nature of sedimentation during flash floods. Clay soil predominates in this area. Most of the land experiences deep to very deep flooding in the wet season, when the area often resembles an inland sea with substantial waves generated by monsoon winds. The haors remain wet for most or all of the dry season (Sajjadur 2008).

One of the large parts of the country in Sunamgonj, Netrokona, Kishoregonj and Habigonj districts have peat soils near the ground or just few meters below the ground. Peat soils are also found at the fringes of some other lowlands, under a layer of silt or sandy topsoil. All these happened because of morphological changes in the adjacent rivers, when they started carrying sand and silt during floods, and deposited them over the subsiding fossil soil (Haque 2008).

Methodology

Data of the geotechnical profile and its physical and index properties of the study area are collected from different soil testing reports of RRI. The whole vertical profile of the bored soil is considered in this study for the haor areas of Bangladesh such as, Sunamgonj, Sylhet, Moulovibazar, Habigonj, Brahmanbaria, Kishoregonj and Netrokona. Field survey data as well as laboratory testing data are collected and analyzed in this connection. Field data are collected from boring logs of Bangladesh Water Development Board (BWDB) as they sent the soil samples to RRI with survey information. Geologists of BWDB collected the disturbed soil samples in the polythene bag and undisturbed soil samples in the Shelby tube with SPT value and ground water level for each specific location.

Skilled scientists and technicians of RRI tested the samples with great care. Calculations are done through the conventional equations and plotting the calculative results in the graph from where required parameters are found out.

In this paper, a limited number of parameters are considered for introducing soil profile such as, natural moisture content, liquid limit, plasticity index, SPT value, particle size etc. Preliminary idea about soil strength is developed through SPT value and settlement characteristics are determined through the compression index C_c. The compression index of cohesive soil is related to its liquid limit. Terzagi and Peck gave the following empirical relationship,

a) For undisturbed soils, $C_c = 0.009\ (w_L\text{-}10)$
b) For remoulded soils, $C_c = 0.007\ (w_L\text{-}10)$

Where, w_L = liquid limit (%) (Arora, 2010)

Table 2. Relation of consistency of clay, number of blows N on sampling spoon and unconfined compressive strength q_u in tons/ft^2 and kN/m^2

Consistency	Very soft	Soft	Medium	stiff	Very stiff	Hard
N	0-2	2-4	4-8	8-15	15-30	>30
q_u	<0.25/23.94	(0.25-0.50)/47.88	(0.50-1.00)/95.76	(1.00-2.00)/191.52	(2.00-4.00)/383.04	>4.00

Table 3. Relative density of sands according to results of standard penetration test

Relative density	Very loose	loose	Medium dense	dense	Very dense
SPT (N)	0-4	4-10	10-30	30-50	Over 50

(Source: Peck 1967)

Results and discussion

To explore the soil properties around haor areas of Bangladesh in brief, seven haor districts are considered such as, Sunamgonj, Sylhet, Moulovibazar, Habigonj, Brahmanbaria, Kishoregonj and Netrokona districts, which have been shown in Table 4.

Table 4. Locations of different districts

Locations	Thana	District
Basuri	Jagannathpur	Sunamgonj
Shologhar	Sunamgonj	
Dohar	Dharmapasha	
Birakhali Khal	Jokigonj	Sylhet
Bosonter Khal, Debottor Khal and Tirashar Khal	Kanaighat	
Halkata Khal	Moulovibazar	Moulovibazar
Ranimura	Kulaura	
Shawnchara and Hazipur	Sreemongol	
Chautraghat and Mritinga	Kamalgonj	
Khowai Bridge (Chowdhury Bazar)	Hobigonj	Habigonj
Sherpur, Makal Kandi and Jatour Haor	Nabigonj	
Sharma	Bijoynagar	Brahmanbaria
Singer Beel (Primary School)	Brahmanbaria	
Jiul Khal and Shizli Khal	Itna	Kishoregonj
Batilonga (Gobinda)	Astagram	
Baganir Khal, KallerBeel and Ranichapur	Khaliajuri	Netrokona
Bhabanipur&Meharjani Khal	Durgapur	
Balia	Purbodhola	
Dubail Khal	Madan	

Relevant parameters such as depth, soil type, colour, natural moisture content, plasticity, SPT value, particle size, stiffness and relative density of soils are presented in Table 5. Some comparison graphs of depth, SPT, plasticity index, natural moisture content and particle sizes with depth are presented district wise in Figure 2 and Figure 3 respectively.

Table 5. Soil testing parameters of haor areas of Bangladesh

Location	Depth in ft(')	SPT value	Colour	N.M.C in%	L.L in%	P.I in %	Particle Size in mm	Strength in kN/m^2/Relative Density	Remarks
Sunamgonj	0-67'	0-13	Brown and grey	25-100	29-72	5-37	0.0014-0.074	0-191.52 (very soft to stiff)/Loose to medium dense	Particle sizes of Dharmapasha soils are about 4.76 mm
	67'-72'	6-30	Grey	Non cohesive soils			0.074-4.76		
Sylhet	0-102'	0-30	Brown and grey	17-752	28-113	8-66	0.0014-0.074	0-383.04 (very soft to very stiff)/Very loose to dense	Some soils are reddish brown
	Occasional layer	4-46	Brown and grey	Non cohesive soils			0.074-0.84		
Moulovibazar	0-72'	3-38	Brown and grey	10-267	28-177	6-92	0.0013-0.84	0-383.04 (very soft to very stiff)/Loose to medium dense	Some soils are black
	Occasional layer	5-16	Brown and grey	Non cohesive soils			0.074-2.0		
Habigonj	0-72'	2-19	Brown and grey	12-153	27-129	6-153	0.0014-0.074	0-383.04 (very soft to very stiff)/very Loose to dense	Fine Sand layers are found in its depth column.
	Occasional layer '	3-45	Brown and grey	Non cohesive soils			0.074-4.76		Cohesive soil layers are found in its depth column
Brahmanbaria	0-37'	4-17	Grey	25-36	35-55	8-27	0.0013-0.074	47.88-383.04 (soft to very stiff)/Loose to dense	Fine Sand layers are found in its depth column
	37'-72'	8-36	Brown and grey	Non cohesive soils					
Kishoregonj	0-28'	0-16	Brown and grey	20-64	35-62	9-43	0.0013-0.074	0-191.52 (very soft to stiff)/Very loose to dense	Exception found in Astagram Thana in where clay layer is upto 50'
	28'-72'	4-90	Grey	Non cohesive soils					
Netrokona	0-28'	1-10	Grey	18-210	18-66	10-58	0.0014-0.074	0-191.52 (very soft to stiff)/ Very loose to dense	
		2-40	Grey	Non cohesive soils			0.074-0.82		

N.B.: SPT- Standard Penetration resistance for Test; N.M.C.- Natural Moisture Content; L.L.- Liquid Limit; P.I.- Plasticity Index

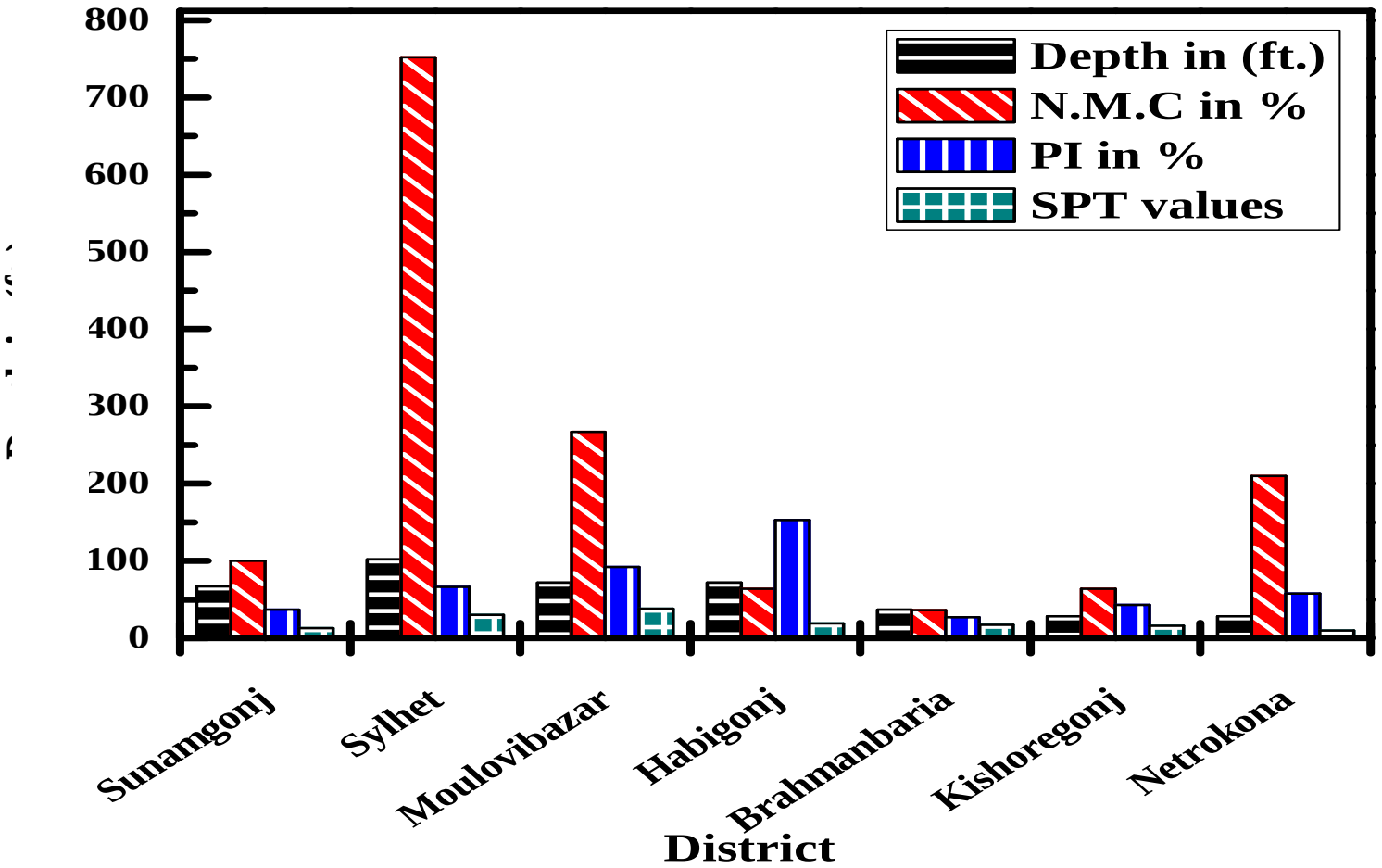

Figure 2. Comparison graph of Depth, NMC, PI and SPT values (district-wise)

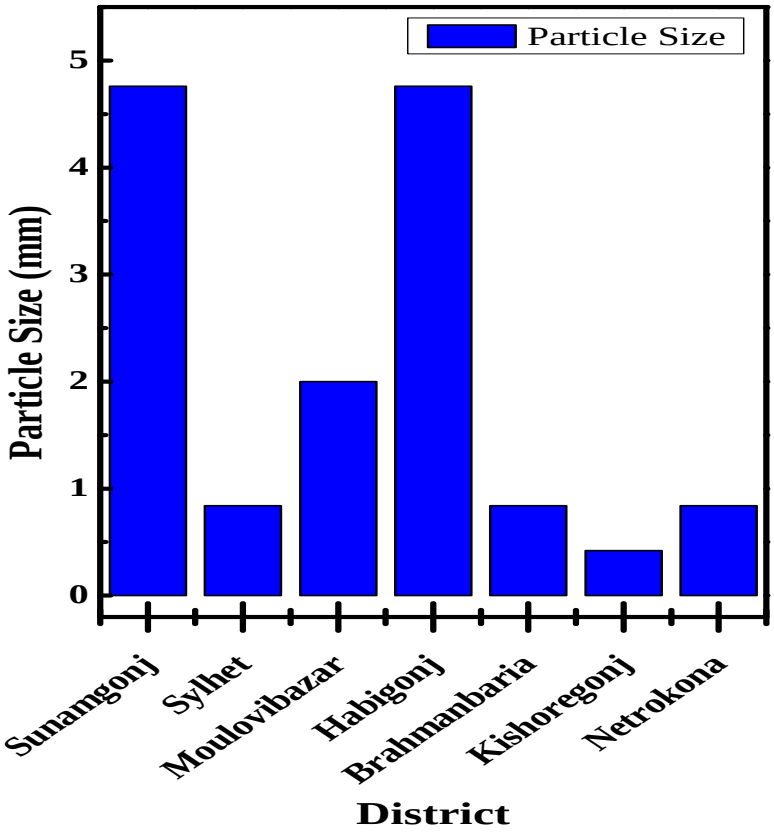

Figure 3. Comparison of Particle Sizes (district-wise)

Soil profile has been described briefly in both tabular presentation and graphical presentation.

In Sunamgonj district, brown and grey in colour cohesive and grey non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-67′), whose sizes vary about (0.0014-0.074) mm and stiffness varies from very soft to stiff and then there are non-cohesive soils up to depth 72′ whose sizes vary from (0.074-4.76) mm and the relative density varies between loose and medium dense. But exception has been found in Dharmapasha Thana's soil layers, whose particle sizes vary up to 4.76 mm (RRI 2014-15).

In Sylhet district, brown and grey in colour cohesive and non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-102′), whose sizes vary about (0.0014-0.074) mm and stiffness varies

from very soft to very stiff and the occasional non-cohesive soil layers are observed around the hole, whose sizes vary about (0.074-0.84) mm and the relative density varies from very loose to dense. But exception has been found in colour because some soils are reddish brown (RRI 2009; RRI 2010; RRI 2013-14; RRI 2014-15).

In Moulovibazar district, brown and grey in colour cohesive and non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-72′), whose sizes vary about (0.0013-0.074) mm and stiffness varies from very soft to very stiff and the occasional non-cohesive soil layers are observed around the hole, whose sizes vary about (0.074-2.0) mm and the relative density varies between loose and medium dense (RRI 2013-14).

In Habigonj district, brown and grey in colour cohesive and non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-72′), whose sizes vary about (0.0014-0.074) mm and the stiffness varies from very soft to very stiff. However, the occasional layers are found non-cohesive soils up to the depth of about 72′, whose sizes vary about (0.074-4.76) mm and the relative density varies from very loose to dense (RRI 1995; RRI 1996; RRI 2012-13).

In Brahmanbaria district, grey in colour cohesive and brown and grey non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-37′), whose sizes vary about (0.0013-0.074) mm and the stiffness varies from soft to very stiff and then they are non-cohesive soils upto the maximum depth of about 72′, whose sizes vary about (0.074-0.84) mm and the relative density varies from loose to dense (RRI 2010).

In Kishoregonj district, brown and grey in colour cohesive and grey non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-28′), whose sizes vary about (0.0013-0.074) mm and the stiffness varies from very soft to stiff and then they are non-cohesive soils upto the maximum depth of about 72′, whose sizes vary about (0.074-0.42) mm and the relative density varies from loose to very dense. But exception has been found in Astagram Thana, in where cohesive soil layer is up to (0-50´) (RRI 1992; RRI 2011).

In Netrokona district, grey in colour cohesive and non-cohesive soil layers are observed. Cohesive soil layers are found upto the maximum depth of about (0-28′), whose sizes vary about (0.0014-.074) mm and the stiffness varies from very soft to stiff and then the non-cohesive soils upto the depth of about 72′, whose sizes vary about (0.074-0.84) mm and the relative density varies from very loose to dense (RRI 2015-16).

Conclusions

In this study, a large number of soil testing data are analyzed at different haor areas of Bangladesh. Finally, a range of results are presented in this paper district wise. From the results it is observed that brown and grey in colour soils are existed in those area up to the maximum depth of about (0-102´). Their natural moisture content of cohesive soils is varying from (25%- 752%). At the same time their plasticity indices are varying from (5%-153%), which has been seen in observation. Of course, their strengths are different, which varies from 0 to 383.04 kN/m^2.On the other hand, relative densities of those soils are varying from very loose to dense.

The presented soil properties and layers would assist the design engineers to develop and visualize about the geotechnical information around the haor area. It is found in most cases that cohesive as well as non-cohesive soils are found in every region with exceptions. The particle sizes of (0.0013-.074) mm cohesive soils are observed in most of the haor districts up to the 102´, and there are some exceptions found in Brahmanbaria, Kishoregonj and Netrokona at which cohesive soil layers are observed up to the maximum depth of about (0-28´). Apart from that, exception is found in Astagram upazilla of Kishoregonj district, wherever cohesive soil layer is observed up to (0-50´). The findings and information of soil characteristics of haor areas are expected to help the design engineer for initial assessment of the proposed structure.

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