Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2017, 4(8):308-317

ISSN: 2394-2630
CODEN(USA): JSERBR

Research Article

Mineralogy & Microfabric of Some Soils of the North-eastern Part of Dhakacity & Ichapur, Narayanganj and their Implications in Geological Engineering

Hossain A.T.M.S.[1], Islam M.R.[1], Shushupti O.[2], Miah M.Y.[3]

[1]Engineering Geology, Geotechnics & Geohazards (EGG) Research Group, Department of Geological Sciences, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh
[2]Department of Soil, Water & Environment, University of Dhaka, Dhaka-1000, Bangladesh
[3]BCSIR Laboratory, Joypurhat, Bangladesh

Abstract This research has evaluated the mineralogy and micro-fabric features of some soil samples collected from the North-Eastern part of Dhaka city and Ichapur area of Rupganj, Narayanganj. Microfabric & mineralogy of the selected soil samples have been carefully studied and their implications in geological engineering& infrastructures are discussed. It is established that soils of the investigated area are mainly consist of silts and clays with some sands. Micro and macro pores together with granular assemblages make the overall fabric. Connectors, intergranular pore spaces, clay particle matrices, coated grain-grain contact features constitutes the randomly oriented silt clay fabric of the soil. Both clay and non-clay minerals are identified in the XRD analysis. X-ray diffractograms of the analyzed samples suggest that these soils are mainly composed of illite, muscovite, quartz and calcite. Presence of Illite might produce cracks & fractures on the engineering infrastructures due to swelling and shrinkage nature.

High water holding capacity, low specific gravity, low dry density, low bearing capacity, low SPT and high plasticity index values indicate that these soils contain organic contents. The presence of organic contents in these soils must have an influence on the long term settlement and localized subsidence in the investigated area. The amount of subsidence of the organic layer ranges from 10.56% to 20.91%. This variation may be due to the variation of thickness and moisture content of the organic layer. It is also established that soil fabric & mineralogy of these soils might have an influence on the geological engineering and infrastructures of the investigated area. This should be taken into considerations in case of constructing any engineering structures in the investigated area.

Keywords Micro-fabric, pores, mineralogy, soil & infrastructures

Introduction

Dhaka is the capital of Bangladesh, which is expanding very rapidly. Due to shortage of land in the central part of the city area, Dhaka is expanding in the North-Eastern side (Figure 1) as well as in the Ichapur area of Rupganj, Narayanganj. Geotechnical information of the subsoil in an urban area is important for civil works. But unfortunately, except few commercial works no research has yet been carried out on the soils of the North-Eastern part of Dhaka city and surrounding areas for proper urbanization. Therefore, the present research was performed with a view to evaluate the fabric, mineralogy and basic engineering geological properties of the soils of the North-Eastern part of Dhaka city and Ichapur area of Rupganj, Narayanganj and finally to establish the relationship between mineralogy, fabric and engineering properties of soils.

Figure 1: Urbanization in the North-Eastern part of Dhaka (Concord Lake City area).

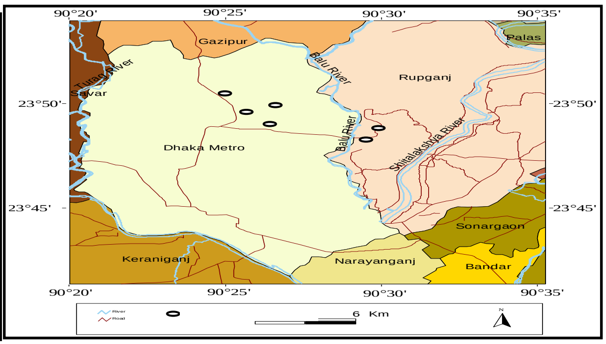

Figure 2: Location Map of the Study Area

This research is carried out from the realization of three different aspects. One is the evaluation of the micro-fabric features and mineralogy of the soils. Secondly, the evaluation of the basic engineering properties and finally, their relationship with mineralogy. The investigated area lies between latitudes 23°42'N to 23° 52'N and longitudes 90° 23'E to 90° 33'E. The location map of the study area is shown in Figure 2. Samples were collected from Concord Lake City site & Ichapur site.

Materials & Methods

Samples were collected from the site in accordance with [1] and ground conditions were evaluated using field SPT (Standard Penetration Test) data. Experimental tests for geotechnical parameters and Organic content percent (%) of some of the soils were measured in accordance with [2]. Fabric of the soils was evaluated using S.E.M. (Scanning Electron Microscope) analysis using Hitachi VP-SEM S-3400N machine. X-ray diffraction analyses of the samples were performed using a Philips PANalytical X'Pert Pro MPD (PW3040) automated powder diffractometer equipped with a Cu X-ray radiation source using 40kV-30mA. Samples were X-rayed using Cu X-ray tube for X-ray diffraction, assembly of cathode on ceramic insulator, Cu anode. The analytical work was carried out at the laboratories of the Institute of Mining, Mineralogy and Metallurgy (IMMM), Bangladesh Council of Scientific and Industrial Research (BCSIR), Joypurhat, Bangladesh.

Results

Field SPT Data Analysis: The recorded SPT data are listed in Table 1.

Table 1: Field SPT values of different boreholes

Depth (m.)	BH-01	BH-02	BH-03	BH-04
1	9	1	2	1
2	10	1	1	1
3	12	1	2	2
4	8	3	4	7
5	8	5	9	18
6.3	16	10	26	17
8.5	16	25	51	35
10.5	20	34	-	35

From the field SPT (Standard Penetration Tests) records, it is observed that the ground is more or less unstable up to a depth of 5 m. but below this depth ground is stable. Low SPT values at shallower depths might be due to the presence of organic matter in the some soil samples. A thin layer (up to 0.8m.) of soft organic soils is also encountered at 2-4 m depths. These organic soils might have an influence on the infrastructures. According to Terzaghi & Peck [3], Low SPT values indicating poor ground condition up to a depth of 5 m. with UCS (Unconfined Compressive Strength) values range from 24.5 to 98.0 kPa. High SPT values at greater depths indicating a stiff ground condition with very high UCS (Unconfined Compressive Strength) values range from 100-196 kPa.

Mineralogy of the Soils

Two whole soil samples from two different depth zones were analyzed using X-ray diffraction method (XRD). The whole powdered samples were analyzed after air dried condition and X-ray diffractograms of the analyzed samples are shown in Figure 3. Identified minerals are listed in Table 2.

Table 2: X.R.D. results

Depth Zone	Sample No.	Identified minerals
Zone- A (0.8 m.-1.5m.)	S-1	Illite, Muscovite, Quartz &Calcite
Zone- B (3.0m-4 m.)	S-2	Illite, Muscovite, Quartz & Calcite

Both clay minerals and non-clay minerals are identified in the X-ray diffraction analysis. Illite is a major and most common clay mineral present in both the samples. From both the X-ray diffractograms (Figure 3), it is evident that there are no meaningful variations in illite peak intensities with respect to depth. Muscovite is another identified clay mineral present in both the samples. From both the X-ray diffractograms it is also evident that there are no meaningful variations in Muscovite peak intensities with respect to depth. The presence of illite minerals indicate that these soils might create some geo-engineering problems viz. cracks, fractures on the infrastructures due to swelling and shrinkage behavior of soils.

The non-clay minerals that are identified in the X-ray diffraction analysis are quartz and calcite. Quartz is one of the most dominant non-clay minerals found in both the samples (Figures 3A & 3B). The peak of quartz is more intense than the other mineral peaks. Such more intense peak of quartz might be due to the presence of Muscovite and Feldspar minerals. As the soil is mainly composed of silt size particles, so it may be the main reason of the abundance of quartz. Calcite is another non-clay mineral that identified in both the samples by the X-ray diffraction analysis. The identified peak of calcite might be due to the presence of organic shell particles in the samples.

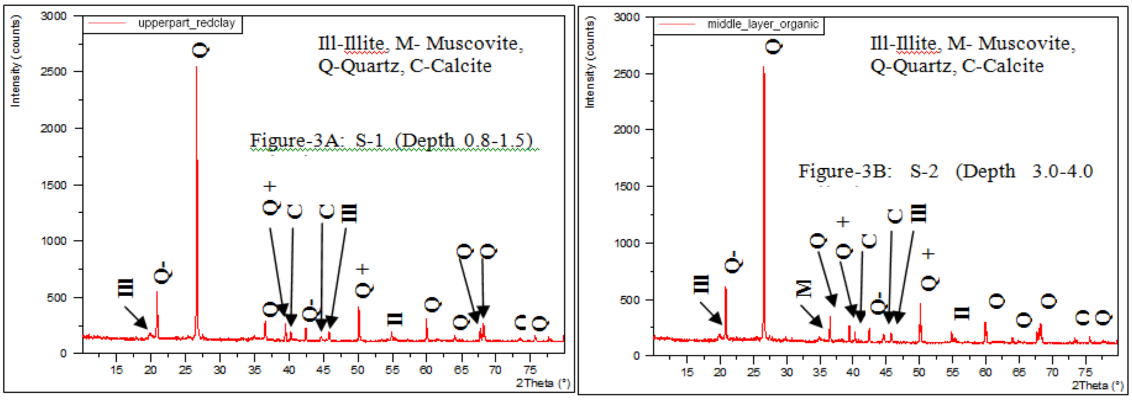

Figure 3: X-ray diffractograms of the analyzed soil samples

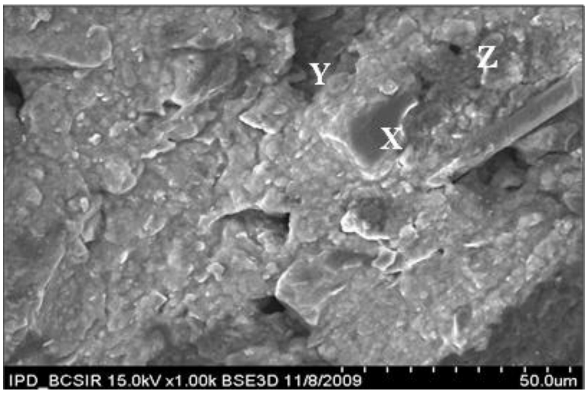

Figure 4: Scanning electron micrograph of sample SEM1at a depth of 1.5-2.5 m. Scale 50um. X= A large silt grain, Y= Macro-pore, Z= Micro-pore

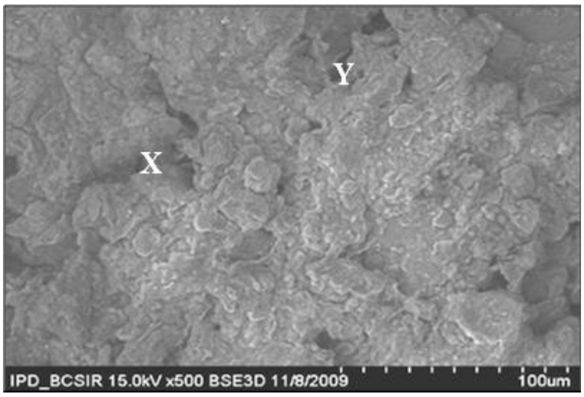

Figure 5: Scanning electron micrograph of sample SEM1at a depth of 3-4 m. Scale 100um. X= Connector, Y= Intergranular space, Z= Micro-pore

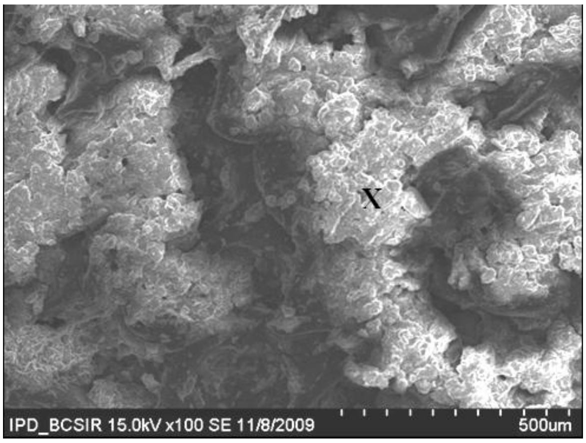

Figure 6: Scanning electron micrograph of sample SEM_1at a depth of 1.5-2.5m. Scale 500um. X= Granular particle matrix

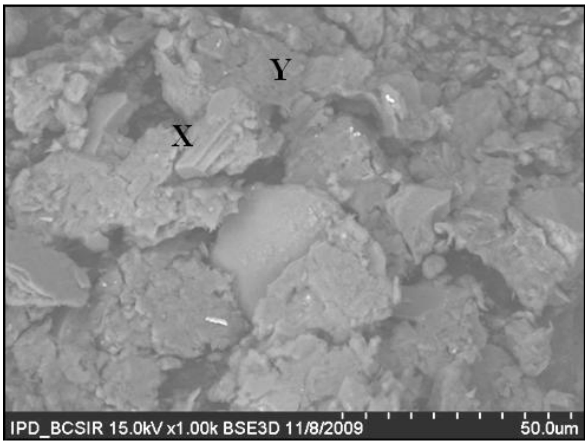

Figure 7: Scanning electron micrograph of sample SEM_2at a depth of 3-4 m.Scale 50um. X= Intergranular space, Y= Connector

The micrographs of both samples at different magnifications are shown in Figures 4 to 7. The scanning electron micrograph images of two samples were taken with magnification of 1000x, 500x and100 x with an accelerating voltage of 15KV. Scale of micrograph images are 50μm, 100μm, 500μm. SEM images of S-1 and S-2 are named as SEM_1 and SEM_2 respectively. From the micrograph (SEM_1) of S-1 (Figure 4) a large silt grain is identified and marked by 'X'. Macro-pore and micro-pore are also identified and marked by 'Y' and 'Z' respectively. In Figure 5, connector, intergranular space and micro-pores are marked by 'X', 'Y' and 'Z' respectively. It can be seen from Figure 6 that the micrograph showed an irregular assemblage of granular particle matrix. Particle matrices are found throughout the micrograph and may act as a binding agent within the overall microfabric. Micropores are also marked by black areas, which are coated with clay. It is interesting to note that both the grains and pores are coated with clay. From the micrograph (SEM_2) of S-2 (Figure 7) intergranular space and connectors are identified and marked by 'X' and 'Y' respectively. Collins & McGown [4] stated that, the soil microfabric contribution to soil sensitivity appears to be associated with clay particle matrices, presence of relatively open microfabrics. Paul et al. [5] studied the SEM results of Carse clay of Bothkennar and observed the occasional local bonding between silt particles, involving aluminosilicates, iron compounds or silica. Many silt particles float in the clay matrix with occasional aggregates of silt grain which is reflected in this study. From the micro-fabric observations, it is established that the soils of the investigated area mainly consists of silts and clays with some sands. Micro and macro pores together with granular assembles make the overall fabric. Connectors, intergranular spaces, clay particle matrices, coated grain-grain contact features constitutes the randomly oriented silt clay fabric of the soil.

Engineering Geological Properties

Grain size analysis was carried on 4 (four) different borehole samples to determine the original percentage of Sand, silt and Clay. The results are listed in Table 3.

Table 3: Grain size distributions of the soils of the study area

BH No.	Depth (m)	Grain percent %		
		Sand %	Silt %	Clay %
BH-01	0.91	7	71	22
	9.14	91	9	-
BH-02	4.57	7	69	24
	9.14	87	13	-
BH-03	6.10	86	14	-
	7.62	89	11	-
BH-04	3.66	8	70	22
	9.14	91	9	-

From the obtained results it is observed that the percentage of sand size particles are high at greater depths in each borehole. On the other hand silt and clay percentage is high at shallow depths in each borehole. It is also established that the soil comprises high silt percentages at lower depths and high sand percentages at greater depths. The clay percentage ranges from 22% to 24 %. Based on the overall analyses, it is established that the soils of the study area at shallow depth may be defined as silty clay and at higher depths may be defined as silty sand. The observed variations in the particle size percentages at different depths and boreholes might be due to the natural variability of the samples and also might be due to the differences in sample dispersion [6].

Natural moisture content values obtained from Concord Lake City area and Ichapur site are listed in Table 4. The natural moisture content values of the soils of the Ichapur site lie between 12.12% to 24.41%. The natural moisture content values of the soils of Concord LakeCity site lie between 6.1% to 24.9%.

Table 4: Natural moisture content (NMC %) of the soils

Depth (m.)	Ichapur Site		Concord Lake City site	
	Sample No.	NMC (%)	Sample No.	NMC (%)
BH 1 (1.5- 3 m)	S-1	24.41	S-1	23.2
BH 2 (3.0-4 m.)	S-2	22.16	S-2	18.1
BH 3 (4.0-5 m.)	S-3	12.12	S-3	16.5

The natural moisture content value varies with depth. Several samples obtained from same depth also showed variation in moisture content values, which might be due to the seasonal variation of ground water table, climatic effects and inhomogenity of soil samples. Lower natural moisture content values with increasing depths are also observed in both sites. Mitchel [7] pointed out that soils containing organic matter have higher value of moisture content. Shome [8], reported that natural moisture content values of Kapasia clay soil of Dhaka lie between 20.79% to 72.26%, which are illitic. The higher values of moisture content may indicate the presence of high amount of organic matter and presence of Illitic minerals in these soils. The presence of small amount of Illite and organic contents might show some influences on the engineering infrastructures of the investigated area.

The determined specific gravity, dry density, bulk density and unit weight of different samples collected from two different sites are listed in Table 5. The observed specific gravity values lie between 2.46 to 2.70.The specific gravity values varied at different depths and locations. The lower values might be due to the presence of organic matter in these soils.

Table 5: Specific gravity, dry density & unit weight of soils

Location-Concord Lake City					
Depth Zone/ Depth (m.)	Sample No.	Specific Gravity	Bulk density (Mg/m^3)	Dry density (Mg/m^3)	Unit weight (KN/m^3)
BH 1 (1.5-3 m)	S-1	2.46	1.7	1.4	17.00
BH 2	S-2	2.66	1.9	1.5	18.72

(3.0-4 m.)					
BH 3 (4.0-5 m)	S-3	2.70	2.0	1.8	19.81
Location: Ichapur Site					
1.5- 3.0 m	S-1	2.57	1.9	1.7	19.55
3.0-4.0 m.	S-2	2.70	1.7	1.4	16.34
4.0-5.0 m.	S-3	2.69	1.8	1.5	17.85

Grim [9] mentioned that the specific value of all clay minerals vary within the range of 2.3 to 2.8. The higher values might be found in the iron-rich clay minerals. According to Singh (1992), the clay minerals generally have higher values in the range of 2.70 to 2.85 and organic soil has a low and quite variable specific gravity such as in the range of 2.20 to 2.64. The results are in consistent with [9-10] for organic clay soils.

A more common use of density is as a measure of the state of packing of soil particles and for this dry density is a more appropriate measure [11]. The observed bulk density values of all the samples of both locations lie between 1.7 to 2.0 Mg/m^3 with an average 1.8 Mg/m^3. The observed dry density values of all the samples of both the locations lie between 1.4 Mg/m^3 to 1.8 Mg/m^3 with an average 1.5 Mg/m^3. The observed unit weight values of all the samples of both locations lie between 16.34 KN/m^3 to 19.81 KN/m^3 with an average 18.18 KN/m^3. The obtained values suggest that the soils of the investigated area are normally consolidated to over consolidated as discussed by [11].

The obtained liquid limit values using cone penetrometer method at different depths of both sites are listed in Table 6 with plastic limit, plasticity index and liquidity index values. The liquid limit values of the soils of the study area range from 40% to 52%. The variations of liquid limit values with respect to depth for different locations may be due to the change in mineralogy, particularly the type of clay minerals, due to the variation of grain size, degree of mixing of clay prior to testing, variation of exchangeable cations and due to the presence of organic matter [12]. The obtained liquid limit values are very close to the values quoted by [9] for illite and kaolinite minerals and also close to the values quoted by Hossain and Toll [13].

The plastic limit values range from 21% to 29%, with an average of 25% .A small variations of the plastic limit values are also observed. The higher plastic limit valus at some depths may be due to the presence of high organic matter. Gillot [14] pointed out that the plastic limit values vary from 60% to 100% for montmorillonite, about 35% to 50% for illite and from 25% to 35% for kaolinite. The obtained plastic limit values of the soils of the study area are closely related to the values reported by Grim [9] & Gillot [14] and the results are consistent with the mineralogy of the soil.

Table 6: Atterberg Consistency Limit values of the soils

Atterberg consistency limits of the soils						
Location-Ichapur site						
Depth Zone/ Depth (m.)	**Sample No.**	**Liquid limit %**	**Plastic limit %**	**Plasticity index %**	**Liquidity index %**	**Activity= Plasticity Index/ Clay (%)**
1.5- 3.0 m	S-1	40	21	19	0.181	0.87
3.0-4.0 m.	S-2	45	29	16	0.418	0.71
4.0-5.0 m.	S-3	47	26	21	0.654	0.97
Location-Concord Lake City site						
BH-1	S-1	49	24	25	0.032	1.14
BH-2	S-2	46	23	23	0.083	0.96
BH-3	S-3	52	25	27	0.315	1.42

The obtained plasticity index values of the study area lie between 16% to 27% with a small variations at different depths and sites. Bell [15] pointed out that organic clays have high plasticity values generally range from 17% to 35%. The analyzed values are close to the recommended values of Bell [15] for illitic clay. The liquidity index value of the soil of the study area ranges from 0.032 to 0.654 with an average of 0.129. No consistency is observed between the LI values at two locations. Grim [9] stated that if the water content is equal to the liquid limit, the liquidity index is 1.0. If the water content is greater or lower than the liquid limit, the liquidity index values are less than 1, which is reflected in this study.

The activity values have been calculated from the plasticity index values and the percentage of clay fractions. The obtained activity values of the soils of the study area ranges from 0.71 to 1.42 (Table 6). The variation of activity values might be due to the presence of clay minerals, clay percentage and presence of organic contents [12]. The obtained activity values suggest that these soils are inactive to active in nature as discussed by Skempton [16] and are close to the typical values of Illitic minerals.

The liquidity index values of all the samples have been calculated from the Atterberg limit values and moisture content values. The obtained results are listed in Table 6 with other Atterberg limit values. The liquidity index value of the soil of the study area ranges from 0.032 to 0.654. No consistency is observed between the LI values at two sites with respect to depth. Grim [9] stated that if the water content is equal to the liquid limit, the liquidity index is 1.0. If the water content is greater or lower than the liquid limit, the liquidity index values are less than 1. The obtained LI values are less than 1.0. The lower LI values might be due to the presence of huge amount of non-clay minerals like Calcite and Quartz with Illite and Muscovite.

Shrinkage Behaviour of Soils the investigated area are also evaluated in terms of linear shrinkage percentages, volumetric shrinkage percentages, shrinkage limits and shrinkage ratios and the results are listed in Table 7. The linear shrinkage values lie between 12.14% to 13.57% with an average of 12.86% (Table 7). The volumetric shrinkage value ranges from 12.61% to 17.69 %.

According to Altmeyer [17] clays with shrinkage limit >12% are “non-critical” in terms of volume change, 10% to 12% are “marginal” and those with shrinkage limit <10% are “critical”. The obtained values of the shrinkage limit suggest that the studied clay soils are “non critical”. The obtained value of shrinkage ratio ranges from 1.39 to 1.86 with an average of 1.73.

Table 7: Shrinkage parameters of the soils

Location-Ichapur Site					
Depth (m.)	**Sample No.**	**Linear shrinkage (%)**	**Volumetric shrinkage (%)**	**Shrinkage Limit (%)**	**Shrinkage Ratio**
1.0-3.0m	S-1	13.57	17.69	15.23	1.735
3.0.3.5 m.	S-2	12.14	12.70	17.03	1.86
3.5-4.5 m.	S-3	12.86	14.46	13.34	1.395
Location –Concord Lake city Site					
1.0-3.0m	S-1	13.21	17.14	15.19	1.725
3.0.3.5 m.	S-2	12.50	12.61	16.94	1.86
3.5-4.5 m.	S-3	12.86	15.49	16.62	1.81

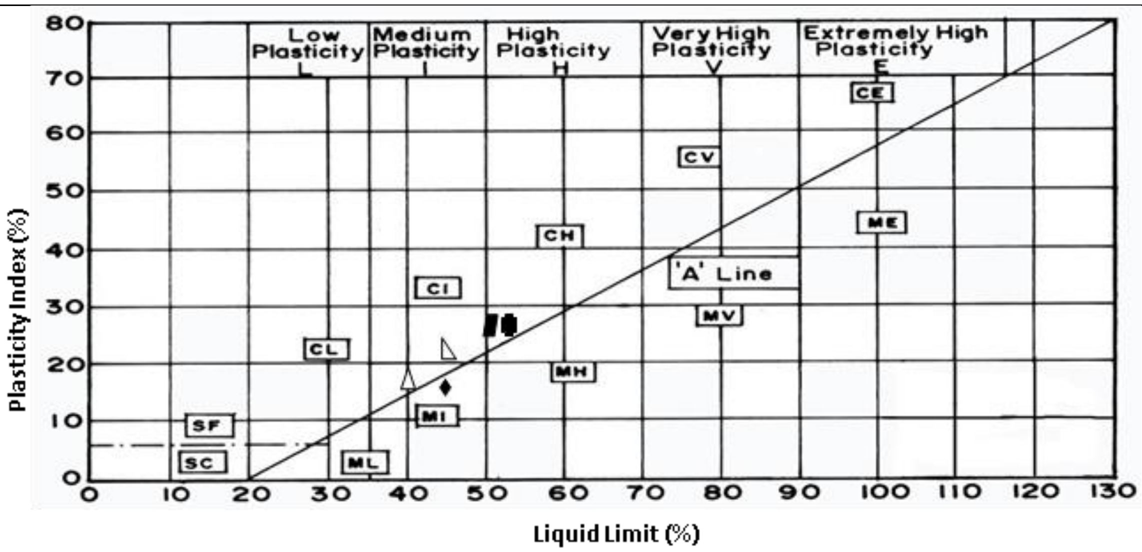

Figure 8: Engineering soil classification chart of the soils of the Study area

The obtained results of liquid limit and plasticity index are plotted in the standard plasticity chart (Figure 8). All samples except few lie above “A-line”. Some samples fall below“ A-line” and have high liquid limit values. The higher value at greater depths may be due to the presence of high organic matter. Craig [18] mentioned that fine clay soils containing significant amount of organic matter usually have high to extremely high liquid limits and samples fall below the "A-line" as organic silt. All samples show medium to high plasticity.

BS 1377 [2] and Head [19] mentioned that in low plasticity clays the liquid limit is <30%, in intermediate plasticity clays, the liquid limit ranges from 30% to 50% and in high plasticity clays the liquid limit is >50%. According to the B.S. 5930[1] plasticity chart, the clay soils of study area can be classified as mainly intermediate to high plasticity clay (CI to CH). Some soils fall below " A" line can be classified as organic Silty Clay. Hossain and Toll [13] reported the liquid limit of some tropical clay soils of Dhaka ranges from 46% to 51%. The obtained liquid limit values are very close to the values quoted by Grim[9]for illite and kaolinite minerals and also close to the values quoted by Hossain and Toll [13] for Illitic soils. This is consistent with the XRD analysis results.
From the overall observations, it is established that these soils are mainly consist of silts and clays with some sands. Micro and macro pores together with granular assembles make the overall fabric. Connectors, intergranular spaces, clay particle matrices, coated grain-grain contact features constitutes the randomly oriented silt clay fabric of the soil. The presence of huge percentage of organic matter and illitic minerals might have an influence on the engineering infrastructures. Due to presence of organic matter, an attempt has been taken to determine the amount of subsidence of the organic layer using empirical formula proposed by Dradjad et al. [19] as mentioned below:

$$\frac{\Delta Z_s}{Z_i} = 1 - \frac{1/D_{su} + SP_u/100}{1/D_{si} + SP_i/100}$$

Where,

Z_i = Initial thickness of each organic layer (cm)
ΔZ_s = Subsidence (cm)
D_{su} = Ultimate bulk density (gm/cm^3)
D_{si} = Initial bulk density (gm/cm^3)
SP_i = Initial moisture content (%)
SP_u = Ultimate moisture content (%)

Table 8: Subsidence values of the organic layer

BH No.	**Z_i (cm)**	**Organic content (%)**	**D_{su} (gm/cm^3)**	**D_{si} (gm/cm^3)**	**SP_i (%)**	**Sp_u (%)**	**ΔZ_s (%)**
1.	-	-	-	-	-	-	-
2.	182.88	26.90	1.91	1.56	18.80	20.94	20.91
3.	274.32	25.30	2.02	1.80	13.26	15.05	16.79
4.	182.88	24.80	2.00	1.70	17.33	18.90	17.43
5.	91.44	21.60	1.67	1.38	28.99	29.71	10.56

The amount of subsidence of the organic layer ranges from 10.56% to 20.91%. This variation may be due to the variation of thickness and moisture content of the organic layer. This should be taken into considerations in case constructing any engineering structures in the investigated area.

Conclusion & Discussions

The soils of the investigated area are mainly composed of illite, muscovite, quartz and calcite revealed by the XRD analysis. The microfabric study of the investigated area revealed that the soils are characterized by a matrix of randomly oriented clay flakes and silts. Clay flakes might consists of K, Al, Fe and silicates. Presence of Illite might produce cracks & fractures on the engineering infrastuctures due to swelling and shrinkage nature. Grain to grain linkage with the presence of several micro and macro pores constitute the overall randomly oriented silt and clay fabric.

From the field SPT (Standard Penetration Tests) records, it is observed that the ground is more or less unstable up to a depth of 5 m. but below this depth ground is stable. Low SPT values at shallower depths might be due to the presence of organic matter in the some soil samples, indicating poor ground condition with UCS (Unconfined Compressive Strength) values range from 24.5 to 98.0 kPa. High SPT values at greater depths indicating a stiff ground condition with very high UCS (Unconfined Compressive Strength) values range from 100-196 kPa.

The result of grain size analysis of the investigated area shows that the soil comprises high silt percentages at shallow depths and high sand percentages at greater depths. The natural moisture content values of the soils of the investigated area range from 6% to 25%. The specific gravity value mainly varies from 2.47 to 2.72. The lower values may be due to the presence of organic matter. The analyzed specific gravity values suggest that the soil may be composed of illite [12]. The bulk density and dry density value varies from 1.7 to 2.0 Mg/m^3 and1.4 Mg/m^3 to 1.8 Mg/m^3 respectively, which suggest that the soils of the investigated area are normally consolidated to over consolidated as discussed by Carter and Bentley [11]. The liquid limit values of the soil of the study area range from 40% to 52%. The obtained liquid limit values suggest that the soils of the study area are mainly intermediate to high plasticity inorganic to organic silty clay and classified as CI to CH according to their position on the soil plasticity chart. The obtained liquid limit values are very close to the values quoted by Grim [9] for illite and kaolinite minerals and also close to the values quoted by Haque and Hossain [20] & Hossain and Toll [13] for other illitic soils. The plastic limit values range from 21% to 29%. The higher values may indicate the presence of organic matter. The obtained plastic limit values of the soils of the study area are closely related to the values reported by Grim [9] & Gillot [14] and the results are consistent with the mineralogy of the soil. The obtained plasticity index values lie between 16% to 27%. The analyzed values are close to the recommended values of Newill [6] and Bell [15].The activity values range from 0.71 to 1.42, suggesting that the soils of the study area are inactive to active. The obtained values show consistency with the values quoted by [11, 21] for illitic minerals. The linear shrinkage values range from 12.14% to 13.57% suggesting that these can be considered as “critical” according to Altmeyer [17]. The volumetric shrinkage value ranges from 12.61% to 17.69 % and shrinkage limit values of the soils range from 13.34% to 17.03%. The obtained shrinkage limit values are close to the values recommended by Dumbleton & Newill [22] and Lambe & Whitman [23] for illites. It is consistent with the XRD results. The moisture content values of the organic soil layer up to a depth of 15 m. are relatively high. High water holding capacity, low specific gravity, low dry density, low bearing capacity, low SPT and high plasticity index values indicate that these soils may contain organic contents. This can be justified by the determined percentages of organic contents. The presence of organic contents in these soils must have an influence on the long term settlement and localized subsidence in the investigated area. The amount of subsidence of the organic layer ranges from 10.56% to 20.91%.This variation may be due to the variation of thickness and moisture content of the organic layer. In addition, presence of Illitic minerals and activity values clearly indicate that soils of the investigated area might create foundation problems during and after construction. This should be taken into considerations during design and construction of any engineering infrastructures in the investigated area.

References

[1]. British Standards Institution, (1981), “Code of Practice for Site Investigations”, B.S.5930, London: 3-100.

[2]. British Standards Institution, (1975), “Methods of Test for Soils for Civil Engineering Purposes”, B.S.1377, London: 10-42.

[3]. Terzaghi, P and Peck , R.B., (1967), Soil Mechanics in Engineering Practice, John Wiley and Sons, New York.

[4]. Collins, K. and McGown, A., 1974, “The form and function of microfabric features in a variety of natural soils” Geotechnique, 24 (2): 223-225.

[5]. Paul, M. A., Peacock, J.D. & Wood, B. F., (1992), “The engineering geology of the Carse clay at the National Soft Clay Research Site, Bothkennar”, Geotechnique,42 (2): 183-198.

[6]. Newill, D., (1961), "A Laboratory Investigation of Two Red CLAYS from Kenya", Geotechnique, 11: 303-318.
[7]. Mitchell, J.K., (1976), "Fundamentals of Soil Behavior", John Wiley and Sons, New York: 1-422.
[8]. Shome, S.M., (2009), " Site Characterization and Compressibility Characteristics of Some Clay Soils of Kapasia Upazila, Gazaipur-An Engineering Geological Approach, M.S. Thesis, Dept. of Geological Sciences, J.U., 1-100.
[9]. Grim, R.E., (1962), "Applied Clay Mineralogy", McGraw Hill, New York: 5-99.
[10]. Singh, A., (1992), "Modern Geotechnical Engineering", CBS Publishers & Distributors Pvt. Ltd.": 1-846.
[11]. Carter, M. and Bentley, S.P., (1991), "Correlations of Soil Properties", Pentech Press Publishers, London: 1-40.
[12]. Gidigasu, M.D., (1976), "Laterite Soil Engineering", Elsevier Scientific Publishing Company, Amsterdam, Netherlands:1-554.
[13]. Hossain, A. T. M. S. & Toll, D. G., (2006), "Geomechanical aspects of some tropical clay soils from Dhaka, Bangladesh", IAEG 2006, Paper number 143.
[14]. Gillot, J.E., (1987), "Clay in Engineering Geology", Elsevier Science Publishers, Netherlands: 1-80.
[15]. Bell, F.G., (2000), "Engineering Properties of Soils and Rocks", 4th Edition, Black well Science Ltd., London: 1-86.
[16]. Skempton, A.W., (1953), "The Colloidal Activity of Clay", Proceedings of the 3rd International Conference on Soil Mechanics and Foundation Engineering, 1: 57-61.
[17]. Altmeyer, W.T., (1955), "Discussion on Engineering Properties of Expansive Clays", Proceeding ASCE, 81.
[18]. Craig, R.F., (1990), "Soil Mechanics", Chapman & Hall, London: 1-400.
[19]. Head, K.H., (1992), "Manual of Soil Laboratory Testing" Pentech Press, London, 1, 1-388.
[20]. Haque, M. E. & Hossain, A. T. M. S., (2002), "Clay minerals and Shrinkage Behavior of some Madhupur Clay Samples of Dhaka, Bangladesh: A Case Study", Jahangirnagar University Journal of Science, 25: 153-167.
[21]. Rowe, R.K. (2001), "Geotechnical and Geo-Environmental Engineering Handbook", Kluwer Academic Publishers, London.
[22]. Dumbleton, M.J., West, G., and Newill, D., (1962), "A Study of Properties of 19 tropical clay soil and the Relation of these Properties with the Mineralogical constitution of the soils", Laboratory note, LN 44: 1-45.
[23]. Lambe, T.W. and Whitman, R.V., (2000), "Soil Mechanics", John Wiley and Sons, New York: 32-34.