ENGINEERING CLASSIFICATION OF SOME SOIL SAMPLES OF MIRPUR AREA, DHAKA,BANGLADESH

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ABSTRACT

This paper deals with the geotechnical index parameters of subsurface soil of Mirpur area of Dhaka. Geotechnical parameters such as moisture content, specific gravity, grain size, liquid limit, plastic limit, plasticity index have been determined and evaluated for ground condition. The natural moisture content range from 21.15% to 24.94% which is very closer to the plastic limit values that represents the soil is normally consolidated. The analyzed soil is well graded. The specific gravity values of analyzed soil are very closer to each other and nearer to the typical value of kaolinite. Soils of the study area are characterized by yellowish brown very dense medium to fine sand, silty sand and stiff silty clay. The sand, silt and clay percentages range from 3% to 85%, 20% to 78% and about 20% respectively. The sand is increasing with depth and silt is decreasing with depth. The liquid limit ranges from 17% to 47% which suggest that the soil is intermediate plasticity clay soil. Plastic liquid limit ranges from 31% to 34% and plasticity index 13% to 16%. The liquid limit, plastic limit and plasticity index values are closer to the typical values for kaolinite. The analyzed soil is intermediate plasticity clay and is grouped medium plasticity (MI) from their position of plasticity chart.

Keyword : *Atterberg Limit; Engineering Soil Classification; Geotechnical parameters; Mirpur; Specific gravity.*

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1. INTRODUCTION

The aim of evaluation of geotechnical parameters is to determine the subsurface condition and soil strength that helps to develop structure or foundation in an area. Concern geotechnical analysis is required because it provides useful information about the subsurface soils of an area, which is needed for civil construction [1]-[5]. To knowledge about geotechnical properties of soil has a vital role in every project that involves earth structures that requires a soil or rock foundation or that is constructed below the ground surface [6].

The study area is located at police staff college, Mirpur -14 in Kafrul Thana, Dhaka district and located within latitude 23º49´ to 23°47′ and longitude 90º23´ to 90º24´ (Fig. 1) and bounded by Pallabi, Tejgao, Mirpur Model and Cantonment Thana. This paper deals with the behavior of the soil samples of the investigated area which include the geotechnical parameters such as moisture content, specific gravity, grain size, liquid limit, plastic limit, plasticity index parameters of the soil. The borehole locations are shown in Fig 1.

Geologically the study area is located on Madhupur clay. The area is covered by brown clay with grey silt. The area is potential for urbanization, commercial and residential point of view. In the recent time many multistoried buildings and many other constructed here. This is why, details geotechnical properties of the respective organizations and local government program.

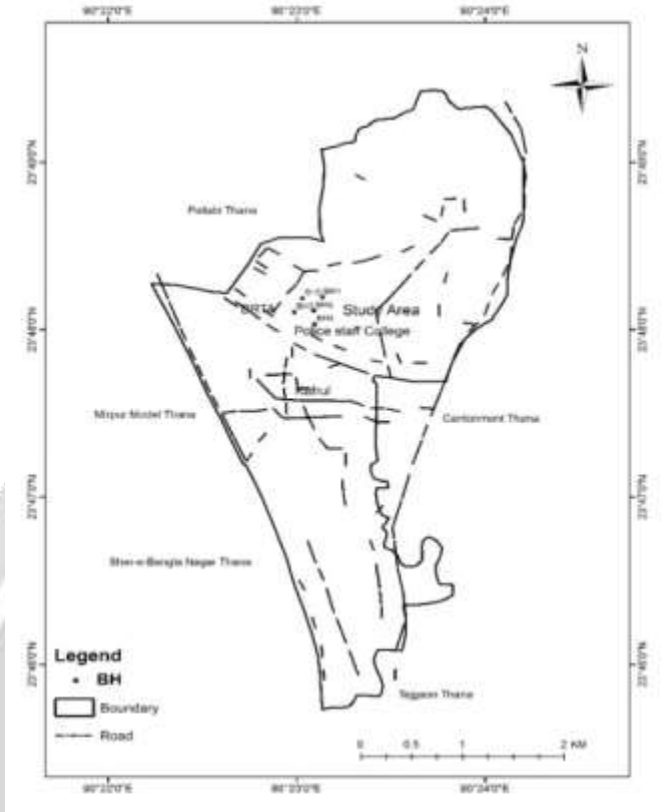

Fig -1: Location map of the study area.

2. MATERIALS AND METHODS

In the investigated area, five (5) borings each extending 20m depth have been selected for this research work. Both disturbed and undisturbed samples were collected in the field. The disturbed soil samples have been collected by using split spoon sampler with the standard penetration test (SPT). These soil samples have been extracted from every 1.5m depth up to the investigation in case of all the bore holes. The undisturbed soil samples were collected from the cohesive layers by hydraulic rotary drilling method with the help of thin open Shelby tubes (U75). Soil samples both in the disturbed and undisturbed state were collected continuously.

The geotechnical parameters were determined in the soil test laboratory in the Housing and Building Research Institute (HBRI), according to standard practice [7] for their specific purposes, and the analyzed data were collected to complete this research.

3. BOREHOLE LITHOLOGY

Stratigraphy of the study area is revealed from the rocks encountered in the borehole of the area. Five (5) borings, each extending to the depth of 20m have been selected. The stratigraphic succession of the area is given in the Table 1. From the borelog data, the top layer including fine sand and silty clay, extending to the depth of 7.5m, usually has the consistency that varies from loose and medium to stiff in nature. The consistency of the underlying layer extending to the depth of 10m to below gradually increases from medium dense to very dense in nature. The subsequent deep layers of the non-cohesive soil generally have been observed in a dense to hard. The SPT value suggests that the deep foundation preferably pile may be provided at the study area.

Table -1: The Stratigraphic Succession of the study area.

Unit	Soil/Rock type	Lithologic Description	Depth (m)	Thickness (m)	SPT (N) Value
D	Fine sand	Grey loose fine sand	0-4.0	4.0	0-5
C	Silty clay	Bluish grey to yellowish brown, stiff silty clay	4.0-7.5	3.5	2-15
B	Sandy silt	Brown to yellowish brown, medium dense sandy silt	7.5- 10.0	2.5	14-30
A	Silty Fine sand	Yellowish brown, very dense silty fine sand	10.0-20.0	10.0	28-91

4. EXPERIMENTAL RESULTS

The basic engineering properties (such as moisture content, grain size analysis, specific gravity, Atterberg consistency limits, etc.) are the most important factor to identification and determination the behavior of clay. The geotechnical properties of the collected and analyzed soil samples are presented in different tables.

4.1 Grain Size Analysis

The particle size distribution of all the samples of the study area is listed in Table 2. In all the boreholes the sand, silt and clay range from 3% to 85%, 20% to 78% and about 20% respectively. It is observed that there is a range of variation in the size of particles. The sand ranges from 3% to 67%, 4% to 80%, 38% to 78% and 43% to 85% at BH-1, BH-2, BH-3 and BH-4 respectively. The particle size distributions of some selected samples of study area are given in Fig 2. The grain size of soil sample involves determining the percentage by weight of grains within the different size ranges [8]. The grain size or the fineness of particles largely affects limit values and permeability values of a soil [9]. The particle size distribution influences the strength and compressibility of soils, both of which are important inconsideration of bearing and stability of engineering purposes [10].

Table -2: Grain size distribution results of the study soils.

BH No.	Sample No.	Depth (m)	Grain Percent			Grading Properties	
			Sand (%)	Silt (%)	Clay (%)	C_u	Cg
BH-1	D-3	4.5	03	77	20	5.71	0.7
	D-8	12.0	67	33	--	-	-
BH-2	D-4	6.0	04	78	18	7.50	0.83
	D-10	15.0	80	20	--	-	-
BH-3	D-5	7.5	38	62	--	2.9	0.65
	D-9	13.5	78	22	--	-	-
BH-4	D-6	9.0	43	57	--	4.44	0.7
	D-11	16.5	85	15	--	-	-

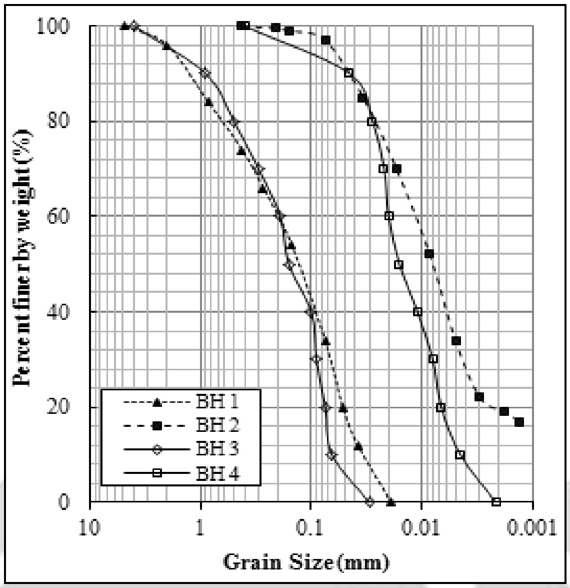

Fig -2: Grain size distribution chart of the study soils.

The co-efficient of uniformity (C_u) and co-efficient of gradation (C_g) have been determined and the values are presented in the Table 2. The co-efficient of uniformity values range from 2.9 to 7.50 and the co-efficient of gradation range from 0.65to 0.83. The clay percentages are not found for each sample in the study area, so co-efficient of uniformity (C_u) and co-efficient of gradation (C_g) cannot measure accurately. Reference [11] mentioned that if C_u< 4.0, then the soil is uniformly graded and C_u> 4.0 represents well graded. But according to reference [12], C_u < 3.0 represents uniform graded soil and C_u> 5.0 represents well graded soil. He also mentioned that most well graded soils will have the value of 'C_g' from 0.5 to 2.0. From the grain size distribution curve, it is observed that the value of Cu and Cg is well graded soil according to [11] & [12]. Thus, the grading properties suggest that the soil may be suitable for civil constructions.

In all the boreholes, the sand percentage is increasing with increasing depth up to about 16.5 m. The amount of silt decreases with increasing depth of the area. It is also evident that the clay (%) is variable in different depth as well as in different boreholes (Table 2). In general it is lower in the higher depth and higher in the lower depth.

4.2 Moisture Content

The natural moisture content values of all samples are shown in Table 3. The natural moister content value ranges from 21.15% to 24.94% and the average 23.09%.The moisture content values vary in different boreholes and at different depths and generally decreases with increasing depth with a few exceptions (Table 3). Small variation of moisture content is observed in different boreholes in same depth. This variation may be due to the sample collection and preparation, the seasonal variation of groundwater level and climatic effects. The moisture content values of the analyzed samples are closed to the recommended values that of [1], [3], [13]-[17].

Table-3: Moisture Content and specific gravity values of the study soils.

Borehole No.	Sample No	Depth (m)	Moisture content (%)	Specific Gravity
BH-1	UD-1	4.0	24.89	2.65
	D-3	4.5	---	2.65
	D-8	12.2	---	2.60
BH-2	UD-1	4.0	22.76	----
	D-4	6.0	---	2.65
	UD-10	15.25	---	2.60
BH-3	UD-1	4.0	24.94	2.66
BH-4	UD-1	4.0	21.15	
	D-6	9.0	---	2.62
	D-11	16.5	---	2.60
BH-5	UD-1	4.0	21.75	2.66

4.3 Specific Gravity

The specific gravity values of all the samples are shown in Table 3. The observed specific gravity value range from 2.60 to 2.65 and the average is 2.63. In all the boreholes, the analyzed samples show close or little variation of specific gravity with respect to depth. The small variations of specific gravity in different samples may be due to the variation of grain size, range, the technique of pretest preparation and testing procedure and the types of clay minerals and due to the degree of desiccation or drying [18].The specific gravity values almost decreases with increasing depth in most cases. The observed value of the analyzed soil is very close to that of [1], [3], [5], [15], [19].

Reference [18] mentioned that the specific gravity of illite ranges from 2.64 to 3.00, chlorite from 2.60 to 3.00, kaolinite from 2.60 to 2.68 and montmoritlonite from 2.22 to 2.75. The obtained values of specific gravity suggest that the analyzed soil is kaolinite according to [18].

4.4 Liquid Limit (L_L)

The liquid limit values are given in Table 4. The liquid limit values ranges from 17% to 47% with an average percentage of 55% and the values are varies with depth (Table 4). The variation of liquid limit values with respect to depth for different boreholes may be due to the change in mineralogy, particularly type of clay minerals, due to variations of grain size, degree of mixing of clay prior to testing, variation of exchangeable cation and due to presence of organic matter [18]. The observed value of the studied soil is very close to the values of quoted by [4], [15], [20]-[21].

Reference [22] mentioned that in low plasticity clays the liquid limit is <30%, in intermediate plasticity clays, the liquid limit ranges from 30% to 50% and the high plasticity clays, the liquid limit is 50%. The obtained results suggest that the studied soil is intermediate plasticity clay, according to [22].

Reference [9] pointed out that the montmorillonites and illites have higher liquid limit values whereas kaolinites have generally lower values. For montmorillonites the liquid limit values vary from about 119% to 700%, for illites from 29% to 100% and for kaolinites from 35% to 75% for illite-montmorillonite mixture from 48% to 62%. The obtained values are closer to the values for kaolinite according to [9]. According to [23] classification of potential soil expansion, the studied soils have low potential soil expansion based on liquid limit.

Table -4: Atterberg Consistency limits values of the soils.

BH No.	Sample No.	Depth (m)	Atterberg Limit Values (%)		
			Liquid limit (%)	Plastic limit (%)	Plasticity Index (%)
BH-1	UD-1	4.0	46	32	14
	D-3	4.5	45	32	13
BH-2	UD-1	4.0	17	33	16
	D-3	4.5	45	32	13
BH-3	UD-1	4.0	46	32	14
	D-3	4.5	44	31	13
BH-4	UD-1	4.0	47	33	14
	D-3	4.5	45	32	13
BH-5	UD-1	4.0	47	34	13
	D-3	4.5	45	32	13

4.5 Plastic Limit (P_L)

The plastic limit values are given in Table 4. The plastic limit values are ranges from 31% to 33%. The results are variable in different samples. The observed value of the studied soil is very close to several authors of [4], [15], [20]-[21]. The plastic limit values are very closer to the natural moisture content values which suggest that the analytical soil of the study area is normally consolidated in nature.

The montmorillonites and illites have higher plastic limits, whereas kaolinite has generally lower values according to [9]. He also mentioned that the plastic limit values vary from 48% to 97% for montmorilonites, 30% to 37% for kaolinite and from 25% to 36% for mixture of illite and montmorillonite. But reference [24] noted a lower limit of the plastic limit values for montmorillonite and kaolinite and the values range between 31% to 41% for montmorillonite and 41% to 44% for kaolinite. The plastic limit values of montmorillonite, illite and kaolinite range from 51% to 97%, 34% to 43% and 26% to 38% respectively [25]. The plastic limit values vary from about 60% to 100% for montmorilonite, about 35% to 50% for illite and from 25% to 35% for kaolinite [26]. The obtained values are closer to the values recommended by different authors of [14]-[16].

4.6 Plasticity Index (PI)

The plasticity index values are given in Table 4. The obtained plasticity index values lie between 13 % and 16 % which are very close to one another. The observed value of the studied soil is very close to different authors of [1], [4]-[5], [15]-[16], [21].

According to [27], if the plasticity index value is <1%, then the soil termed as non -plastic. Similarly if it is 1% to 7%, 7% to 17%, 17% to35% and greater than 35% than this termed as slightly plastic, moderately plastic, highly plastic and extremely plastic. The obtained values suggest that the analytical soil might be moderately plastic, in nature according to [27]. The montmorillonite has a plasticity index value of 75% to 60%, illite 23% to 50%, kaolinite has 1% to 40%, with usual value about 25% according to [9]. He also pointed that the smectite mixture shows higher plasticity index value. The obtained values are closer to the values recommended by [9] for kaolinite. The plasticity index values along with clay content suggest that the analytical soil is low to medium swell potential according to [28].

4.7 Engineering Classification of Soil

According to the plasticity chart [29], soil classification is shown in fig 3. It is observed that most of the plotted samples lie under “A-line” except sample like UD-1 (BH-2). According to British Soil Classification System, the soil of the study area can be characterized as intermediate to low plasticity silt clay. The empirical boundary (A-line) suggest that the analytical soil is mainly silt dominated and clay is inorganic in nature. The studied soils are classified as MI from their position on the plasticity chart (Fig 3).

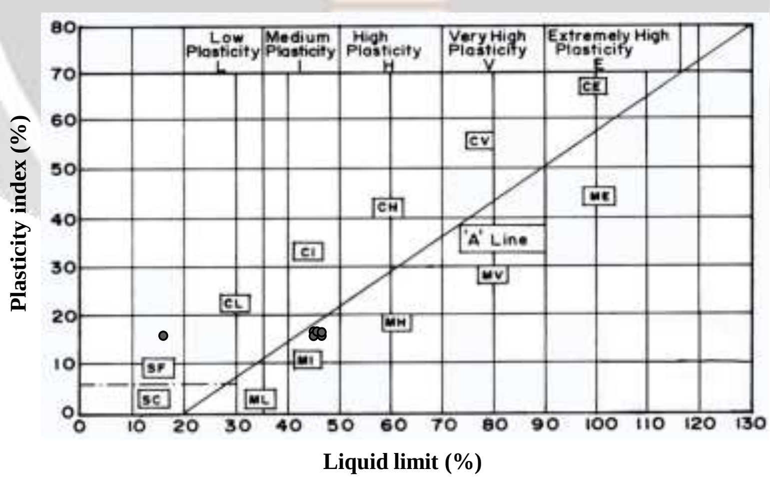

Fig -3: Engineering classification of the study soils modified after [29].

5. CONCLUSIONS

From the above result and discussion it is recognized from the grain size analysis that these soil samples are mainly composed of silt and sand size particles with small amount of clay. The sand ranges from 3% to 85% (average 49.75%) and the values are increased with increasing depth. The silt ranges from 20% to 78% (average 45.5%) and the values are decreased with increasing depth. The clay fraction is not found in all the samples in the study area. The obtained values of Cu and Cg suggest the analyzed soil is well graded. The moisture content values of the study area soils range from 21.15% to 24.94%. The moisture content is closer to the plastic limit value of the soil which suggests that the soil is normally consolidated in nature. The obtained specific gravity values of all samples range from 2.60 to 2.65. The results recommend that the clay soils are nearer to the typical values for kaolinite clay minerals. The liquid limit values range from 17% to 47%. The plastic limit values range from 31% to 33%. The obtained results suggest that the analyzed samples show medium to low plasticity observed from the plasticity chart. The plasticity index values lie in between 13 % and 16 %. The liquid limit, plastic limit and plasticity index values are closer to the typical values for kaolinite and illite and the soil may be semi plastic in nature. The liquid limit shows that the soil has low potential expansion and plasticity index suggests that the soil has medium swell potential. According to British soil classification system, the soils of the study area can be characterized as intermediate plasticity silty soil and classified as MI from their position on the plasticity chart.

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