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Development of Strength and Compressibility Correlations of Cohesive Soils of Some Regions in Khulna City

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Abstract: The strength and compressibility characteristics of cohesive soil are important aspects in foundation engineering such as the bearing capacity of shallow foundation and piles, the stability of slopes of dams and embankments and lateral earth pressure on retaining walls. In this project work the strength parameters (unconfined compressive strength and undrained shear strength) and compressibility parameters (compression index, recompression index and coefficient of consolidation) to index properties (liquid limit, plasticity index and initial void ratio) of cohesive soil of the study area have been described graphically and an attempt has been made to establish correlation among strength parameters, compressibility parameters and index properties of soil. Also the values of strength and compressibility parameters of cohesive soil have been furnished with lowest and highest range. These may help the design engineer for deigning the structures for construction in the study area. The value of unconfined compressive strength, undrained shear strength, N-value, compression index , recompression index and coefficient of consolidation of cohesive soil of the study area were found in ranges between 20 kPa to 128 kPa, 10 kPa to 64 kPa, 2 to13, 0.243 to 0.705, 0.00678 to 0.082 and 0.000714 cm^2/sec. to 0.0201 cm^2/sec. respectively.

Keywords: *Strength, Compressibility characteristics, Consolidation, Index Properties and Cohesive Soil*

1. Introduction:

1.1 Background of the Study:

Khulna City is situated on the southern region of Bangladesh. The soil in this region is formed by the alluvial deposits from different rivers such as the Rupsha and the Bhairab. As it is near the Sunderban Mangrove forest, so it is formed by deposition of different types of fallen trees. For this reason, most of the soil of this region is soft and organic having low bearing capacity. Also the silty clay materials are found in Khulna due to alluvial deposit. In the geotechnical engineering, the characteristics of soil in general are greatly influenced by the process of soil formation and these properties may therefore vary significantly from place to place (Rafizul et al, 2006). So for construction of any structures like building, irrigation canal, drainage channel, dams, bridge, tunnel, embankment, retaining wall etc. it is necessary to know the strength and compressibility characteristics of sub-soil of the respective zone. The strength and compressibility of soil govern the bearing capacity of soils, the stability of slopes in soils, the earth pressure against retaining structure, settlement of structures and many other problems.

Most recently Khulna City is moving forwards with large development projects including construction of high- rise building, oil storage tanks, long span bridges, port structures, flood protection embankment etc. So for the development of such structures in Khulna City, a design engineer must have sound knowledge on soil types and its strength and compressibility characteristics and other soil parameters. So this study includes computing the engineering properties and physical properties of sub-Soil of Khulna City and to establish correlation between different parameters graphically.

1.2 Justification of the Study:

Soils in Khulna region are most peculiar in nature. Its characteristics vary from place to place. Careful test of soil before any construction should be desirable. So a proper study on Khulna soil is needed to evaluate sub-soil parameters and to make their internal correlation which helps the designer in finding out one unknown parameters when other is known in the study area. Justification of this study lies on this aim.

2. Materials and Methods:

2.1 Testing procedure:

The soil samples were collected from six places of Khulna city named Rupsa, Nirala, New Market, Sonadanga, Khalispur, and Goalkhali. Then Laboratory tests were performed in three different phases.

In the first phase, the index properties (Liquid limit, Plastic limit, and initial void ratio) of the collected soil samples were determined in order to characterize the soil. The following tests were performed to determine the index properties of soil by using standard test procedures:

- Specific gravity test
- Atterberg limit test
- Grain size distribution

In the second phase, unconfined compressive strength was determined by unconfined compression test by following testing procedure of ASTM D2166-00.

In third phase, Compressibility parameters (compression index, recompression index and coefficient of consolidation) were determined by consolidation test by following standard testing procedure ASTM D2435.
Different soil reports were collected from CRTS (Consultancy Research and Testing Services), department of civil engineering, KUET, Khulna. From these reports necessary data were collected.

3. Illustrations:

3.1 Index properties:

Soil index properties are used extensively to determine strength and compressibility parameters of soil from different correlation among them which are established previously. In this study an attempt has been made to correlate among index properties, strength and compressibility parameters of soils. The correlations established for soils help the design engineer in finding out one unknown parameters when other is known in the study area and also to reduce time, labor and computation –intensive.

3.2 Strength Characteristics:

The unconfined compressive strength and shear strength of soils are important in aspect of foundation engineering such as the bearing capacity of shallow foundations and piles, the stability of slopes of dams and embankments and lateral earth pressure on retaining walls. In this study, the unconfined compressive strength and undrained shear strength characteristics of soils of the study area to index properties of soil (liquid limit, plasticity index and initial void ratio) have been described graphically. The unconfined compressive strength of study area soils are in the range of 20 kPa to 128 kPa. The undrained shear strength is in the range of 10 kPa to 64 kPa. So the soil of the study area is very soft to stiff.

3.3 Compressibility Characteristics:

In this study one dimensional consolidation test was performed to determine compressibility parameters (compression index, recompression index and coefficient of consolidation).In this study, the compressibility characteristics of soils of the study area to index properties of soil (liquid limit, plasticity index and initial void ratio) have been described graphically. Hence, the outcome of the result helps the geotechnical engineers to do quick identification or estimation of the compressibility parameters of soil. Compressibility of soil is an important engineering consideration. Compressibility parameters are used to predict how much settlement will take place due to different structural loads.

3.4 Correlations:

3.4.1 Correlation between Undrained Shear Strength and Liquid Limit

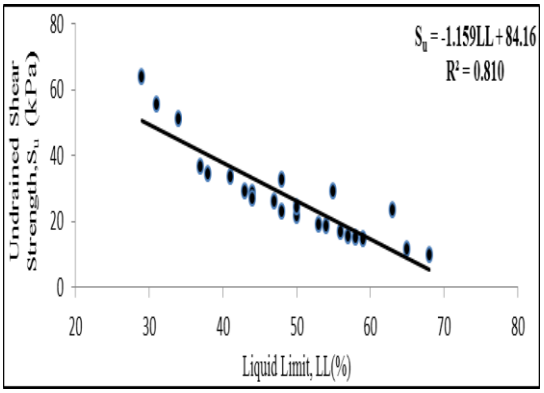

Figure 1: *Correlation between undrained shear strength and liquid limit*

3.4.2 Correlation between Un-drained Shear Strength and Initial Void Ratio

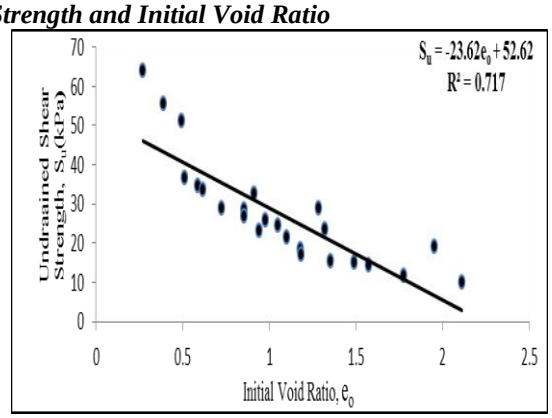

Figure 2*: Correlation between undrained shear strength and initial void ratio*

3.4.3 Correlation between Unconfined Compressive Strength and N-value

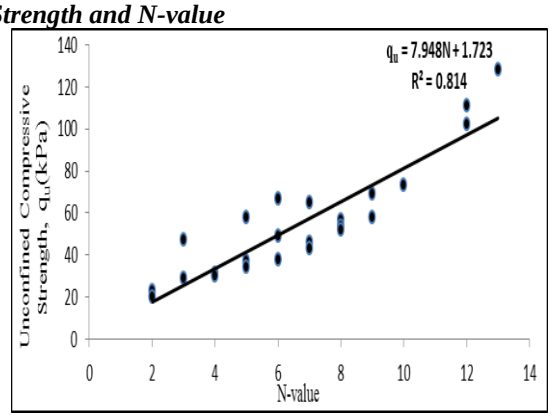

Figure 3*: Correlation between unconfined compressive strength and N-value*

3.4.4 Correlation between Compression Index and Liquid Limit

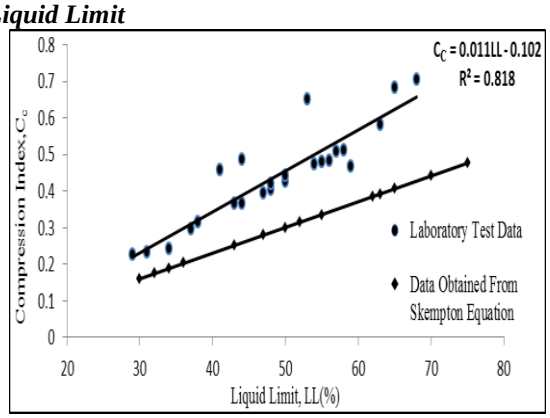

Figure 4: *Correlation between compression index and liquid limit*

3.4.5 Correlation between Compression Index and Plasticity Index

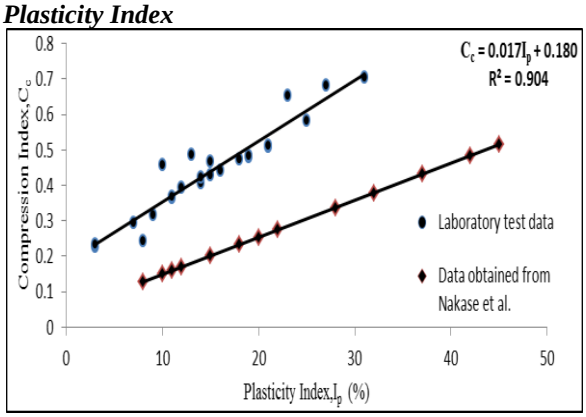

Figure 5*: Correlation between compression index and plasticity index*

3.4.6 Correlation between Compression Index and Initial Void Ratio

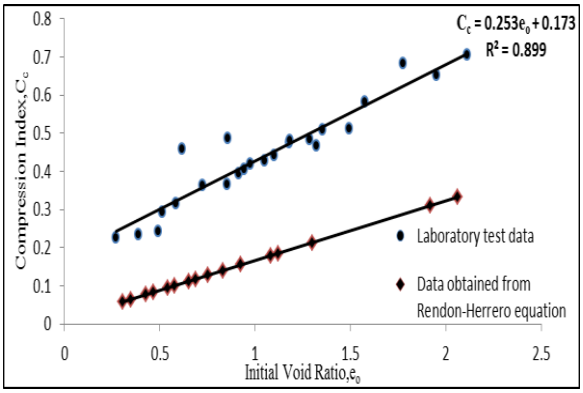

Figure 6*: Correlation between compression index and initial void ratio*

3.4.7 Correlation between Recompression Index and Plasticity Index

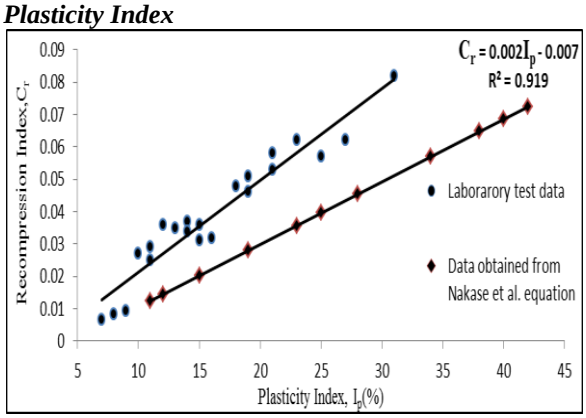

Figure 7*: Correlation between recompression index and plasticity index*

3.4.8 Correlation between Recompression Index and initial void ratio

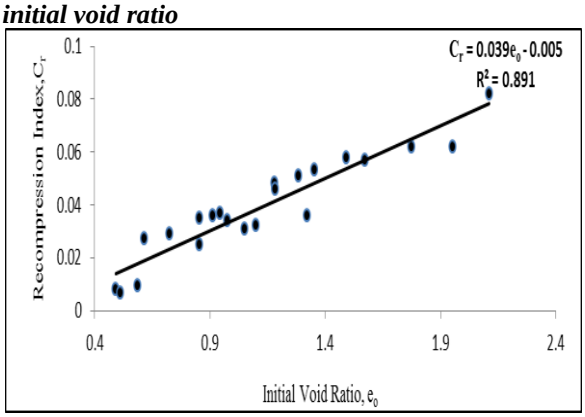

Figure 8*: Correlation between recompression index and initial void ratio*

3.4.9 Correlation between Coefficient of Consolidation and Liquid Limit

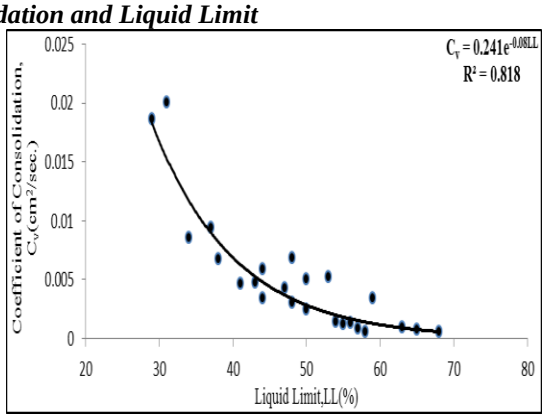

Figure 9: *Correlation between coefficient of consolidation and liquid limit*

3.4.10 Correlation between Coefficient of Consolidation and Plasticity Index

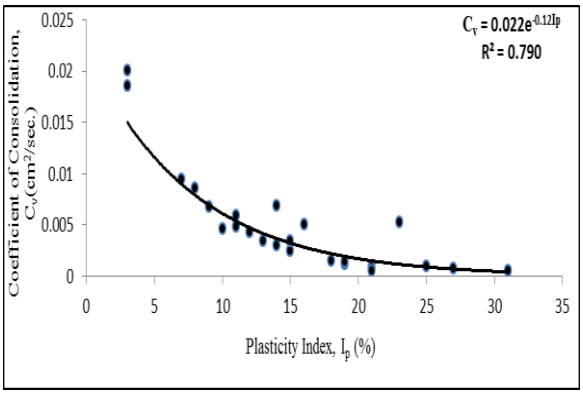

***Figure 10**: Correlation between coefficient of consolidation and plasticity index*

3.5 Results Outline

The following results are found in study area:

i. Liquid limit ranges in between 29% to 68%
ii. Plasticity index ranges in between 3% to 31%
iii. Initial void ratio in ranges between 0.271 to 2.112
iv. Compression index in ranges between 0.243 to o.705
v. Recompression index in ranges between 0.00678 to 0.082
vi. Coefficient of consolidation in ranges between 0.000714 cm^2/sec. to 0.0201 cm^2/sec.
vii. Unconfined compressive strength in ranges between 20 kPa to 128 kPa
viii. Undrained shear strength in ranges between 10 kPa to 64 kPa
ix. N-value in ranges between 2 to 13

The following correlations are obtained among different parameters:

a) S_u = -1.159LL +84.16
b) S_u= -23.62e_o+52.62
c) q_u=7.948N+1.723
d) C_c=0.011LL -0.102
e) C_c=0.017I_p +0.180
f) C_c=0.253e_o+0.173
g) C_r=0.002I_p - 0.007
h) C_r=0.039e_o-0.005
i) $C_v = 0.241\ e^{-0.08LL}$
j) $C_v = 0.022\ e^{-0.12I_p}$

4. Conclusions and Recommendations:

4.1 Conclusions:

The value of unconfined compressive strength, undrained shear strength, N-value, compression index , recompression index and coefficient of consolidation of cohesive soil of the study area were found in ranges between 20 kPa to128 kPa, 10 kPa to 64 kPa, 2 to 13, 0.243 to 0.705, 0.00678 to 0.082, 0.000714 cm^2/sec. to 0.0201 cm^2/sec. respectively. Although soil types and its distribution is very complex and are usually heterogeneous both in vertical and horizontal direction, the results and findings of this project work can play a significant role for planning and design of structure in study area of Khulna city. The graphical representation of some soil parameters and the relationships established for soils of study area may help the design engineer in finding out one unknown parameter when other is known in the study area.

4.2 Recommendations:

For detail information regarding soils of the respective area further investigation is necessary. To establish more genuine relationship between different soil parameters and to characterize them, more area and soil samples should be included for further study.

References:

[1] Rafizul et. al. (2006); "Compressibility Properties of Reconstituted organic soils at Khulna Region of Bangladesh", Proceedings of the 4th ICSSE, 367-372, Canada.