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Prediction of Compressibility Characteristics of Marine Clay from Index Properties

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***Abstract*— Compression index is one of the important parameters in obtaining consolidation characteristics of cohesive soil. This parameter can be determined by carrying out laboratory oedometer test on undisturbed samples. However, the test is quite time consuming and expensive. Therefore, this study aims to correlate this parameter with the index properties. For this purpose, compression index and index properties values for the analysis and calculations were sought out from existing journals. Simple and multiple linear regression analysis were performed in SPSS software for the prediction. Compression index shows a good linear relationship between liquid limit, plastic limit and specific gravity**

***Keywords*— Marine clay, Compression index, Index properties, Regression analysis**

I. INTRODUCTION

Geotechnical investigation is an integral part of the construction process which is done to obtain information about the physical characteristics of soil around a site. These investigations form the basis for planning, designing, and constructing the structures. The soil properties once established, such as settlement can be used by engineers and builders to determine the strength and suitability of soil. Magnitude of settlement is dependent on many variables, but the most important factor for primary settlement are the compression indexes [11]. Lack of knowledge about the compressibility of soil that is important in the design of building and infrastructure may lead to construction faults which is costly in materials and efforts. Compressibility of soil is its capacity to decrease in volume under pressure and is indicated by soil characteristics called Compression Index (C_C).

Marine clay is a type of clay found both in the coastal and in several offshore areas spread over many parts of the world. Normally the soil exists in a soft consistency. Marine clay is microcrystalline in nature and clay minerals like chlorite, kaolinite and illite and non-clay minerals like quartz and feldspar are present in the soil. The soils have higher proportion of organic matters that acts as a cementing agent. Marine clay soils in particular can present great problems in foundation design due to its high compressibility, which represents a significantly problematic engineering property [9].

The consolidation theory deals with the prediction of magnitude and the rate of consolidation settlements which is primary for serviceability of structure founded on a compressible soil layer. One dimensional consolidation test using oedometer apparatus makeup the consolidation characteristics and the results can be influenced from quality of samples used in the tests. Although the compressibility parameters must be obtained from careful oedometer test measurements based on good quality undisturbed samples, conventional oedometer test comprises major disadvantages such as costliness, unwieldiness and time consuming. In addition, the other important disadvantage of the estimation of the compressibility parameters is that the graphical method directly depends on the personal experience [12]. As a result, several efforts are in progress to predict the value of compression index from empirical correlation linked with the index properties which is easier and faster.

II. OBJECTIVES

- To introduce an easy and effortless method for predicting the compressibility characteristics of marine clay.
- To establish relationship between the compressibility characteristics and index properties of the soil.

III. MATERIALS AND METHODS

3.1 Data collection :

In the present study, compression index and various index properties of marine clay have been collected and studied. Around 105 datas that are available from various journals were collected and consolidated in an excel sheet. The index properties included were liquid limit, plastic limit, plasticity index, specific gravity and maximum dry density. The Liquid limit of the collected samples ranges from 29% to 140%, Plastic limit ranges from 21% to 63%, Plasticity Index ranges from 8% to 90%, specific gravity ranges from 2.1 to 2.8 and maximum dry density ranges from 819 to 1600 Kg/m^3. Index properties are correlated with Cc to determine the best correlated parameter using linear as well as multiple linear regression.

3.2 Statistical analysis :

It has always been the endeavour of geotechnical engineers to simplify the rigorous testing and the complex data interpretation for better comprehension of soil parameters using statistical techniques by establishing prediction model with basic soil parameters. A Statistical method like regression analysis is best suited for establishing relationship between dependent and one or more independent variables. In this study an attempt has been made to establish

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relationship among the basic parameters of marine clay for prediction of compressibility using statistical measure called Regression Analysis using statistical package SPSS Version 26. The relationship between Compression index and index properties parameters of marine clay is found out by using multiple regression analysis and method adopted is stepwise regression. In this method, we specify which predictor we would like to include and SPSS then inspects which of these predictors really contribute to predicting the dependent variable and excludes those who don't. Correlation Coefficient (R^2) and root mean square error were used as an evaluation criterion in order to check the calculated empirical correlation equation**.**

3.3 Compressibility Characteristics :

In this study, compression index was considered as the Compressibility parameter of marine clay. 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 Index Properties :

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

- **Liquid Limit**
- **Plastic Limit**
- **Plasticity Index**
- **Specific Gravity**

IV RESULTS

4.1 Simple Linear Regression

Simple linear regression was performed in SPSS software and results are obtained. A total of 105 samples were used for analysis. Fig 2,3 and 4 shows the plot between compression index and index properties. All of the results show the increase of C_C with the increase of index properties. From the simple linear regression analysis, the liquid limit was best correlated with compression index. The equation obtained for correlation of compression index with Liquid limit, Plastic limit and Specific gravity respectively from regression analysis are shown in table 1.

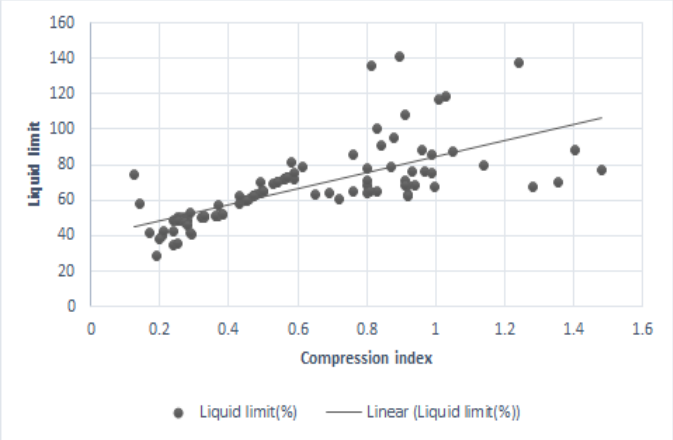

Fig 2. Correlation of C_C with LL

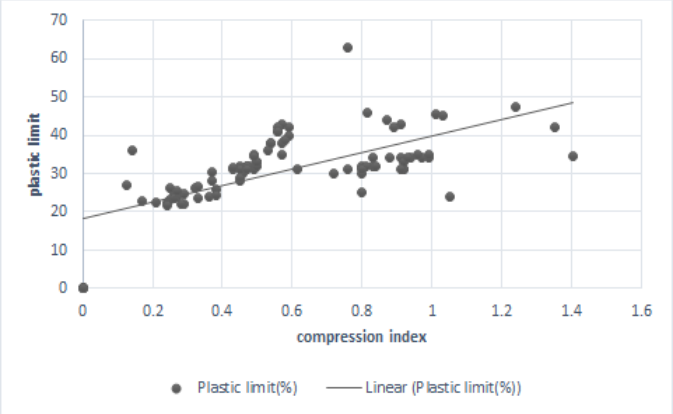

Fig 3. Correlation of C_C with PL

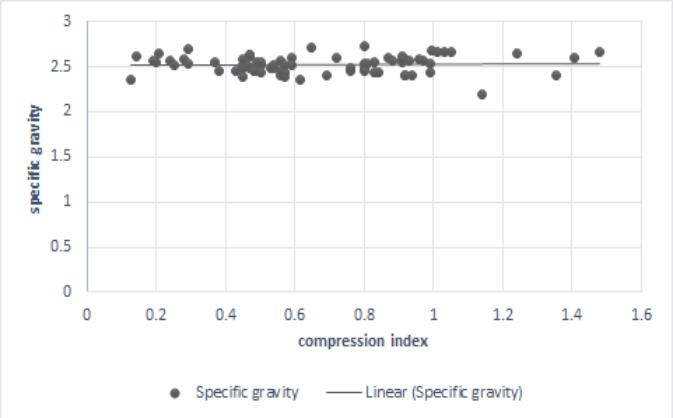

Fig 4. Correlation of C_C with Specific gravity

TABLE 1. EQUATIONS OF SIMPLE LINEAR REGRESSION

PARAMETER	EQUATION	R^2
LIQUID LIMIT	C_C=0.01 LL- 0.096	0.741
PLASTIC LIMIT	C_C=0.034 PL -0.158	0.682
SPECIFIC GRAVITY	C_C=0.45 S_G- 0.167	0.566

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4.2 Multiple Linear Regression

Multiple linear regression was performed in SPSS software and results are shown in the figure 5. Compression index shows a good linear relationship with PL, LL, and Specific Gravity. The equation obtained from regression is represented as eq:5.2 with high correlation coefficient of 0.994.

$$CC=6.118- 0.007LL+0.095PL- 3.218\ SG \qquad (5.2)$$

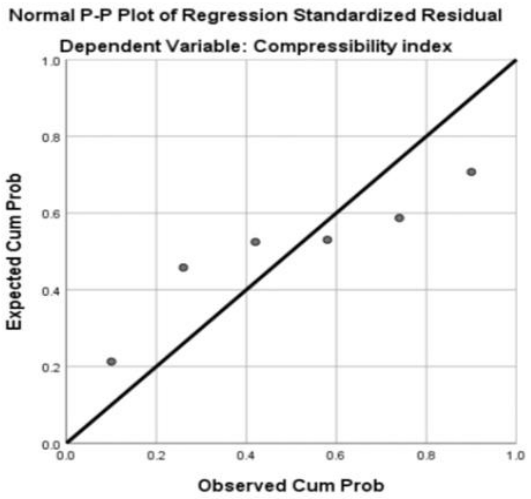

Fig 5: Correlation of C_c with LL, PL and G_s

V. VALIDATION OF RESULT

For validating the equation obtained from multiple linear regression, soil properties of various marine clay have been selected and checked. Table 2 shows the validation of result obtained from the prediction. It is seen that the difference between observed compression index and predicted compression index was very negligible. Fig 3. represents the variation in predicted data.

TABLE 2. VALIDATION OF RESULT

Liquid Limit	Plastic Limit	Specific Gravity	Observed Compression index	Predicted Compression index
69	35	2.54	0.92	0.8
28	14	2.2	0.44	0.21
85	32	2.4	0.85	0.88
166	72	2.5	4.5	4.1
79	39	2.53	0.628	0.65
73	37	2.5	0.9	1.07

Fig 3 shows a graph showing the variation in predicted data.

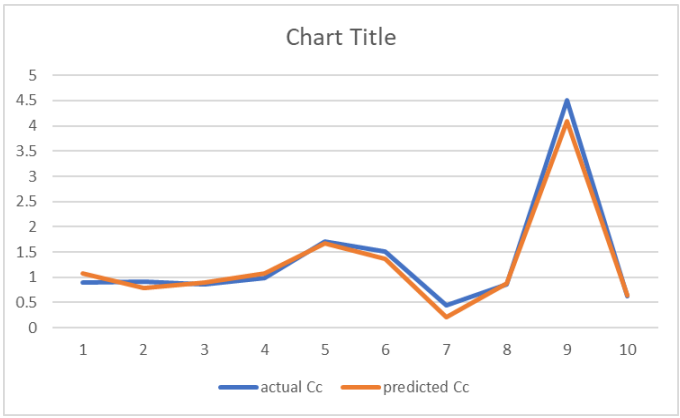

Fig 3. Variation in predicted data

VI. CONCLUSIONS

The project presents an attempt to predict compression index (C_C) of marine clay with basic soil properties such as plastic limit, liquid limit, plasticity index, specific gravity and maximum dry density. For this, simple and multiple linear regression were performed in SPSS. The correlation coefficients obtained for simple linear regression were not satisfactory. Multiple linear regression was performed to improve the prediction. And the result shows a good linear relationship between C_C and index properties. Compression Index was well correlated with plastic limit, liquid limit and specific gravity and yielded an equation:

$$CC = 6.118 - 0.007\ WL + 0.095\ WP - 3.218\ SG$$

The equation has a high correlation coefficient of 0.994. The equation was applied for marine clay in different locations and compression index was predicted.

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