Soil Compression Index Prediction Model for Fine Grained Soils

Amardeep Singh
Scientist 'C', Central Soil and Materials Research Station
Ministry of Water Resources, Government of India

Shahid Noor
Scientist 'B', Central Soil and Materials Research Station
Ministry of Water Resources, Government of India

Abstract - Compressibility of a soil mass is its susceptibility to decrease in volume under pressure and is indicated by soil characteristics like coefficient of compressibility, compression index and coefficient of consolidation. However, the determination of soil compressibility characteristics in the labs is a cumbersome and time consuming process, especially in the case of fine grained soils. In the present study, an attempt has been made to estimate compression index as a function of soil index properties. Soil samples were collected from different Indian hydropower projects. The collected samples were subjected to laboratory investigations for the determination of geotechnical parameters namely liquid limits, plastic limits and compression indices. Based on experimental results, correlations between the soil index properties (liquid limit & plasticity index) and compression index were evaluated. An empirical model was developed to estimate the compression index as a function of liquid limit and plasticity index. The model results were compared with the actual compression index values, as determined by laboratory tests, and were found to be in good agreement. The compression index values for the collected samples were also determined using the available models in literature, and the results indicate that the present model can predict the soil compressibility more accurately.

Keywords: soil compressibility characteristics, plasticity index, liquid limit, specific gravity, compression index, fine grained soils.
Disclaimer: The views expressed in this paper are strictly individual views of the authors and do not, in any way, represent the views of the department/organization where they are presently working.

I. Introduction

Shear strength, compressibility and permeability are considered to be the three most important properties of a soil mass applicable in areas such as in the design and analysis of dams, retaining walls, soil foundation systems and in other applications pertaining to geotechnical engineering practice. Among these three, compressibility is the most significant parameter while evaluating the settlement of soil under the load of an infrastructure constructed on that soil mass (Tiwari and Ajmera, 2012). Compressibility of a soil mass is its susceptibility to decrease in volume under pressure and is indicated by soil characteristics like coefficient of compressibility, compression index and coefficient of consolidation. Although coefficient of volume compressibility is the most suitable, and most popular, of the compressibility coefficients for the direct calculation of settlement of structures, its variability with confining pressure makes it less useful when quoting typical compressibilities or when correlating compressibility with some other property. For this reason, the compression index of soils is generally preferred as its value does not change with the change in confining pressure for normally consolidated clays (Carter and Bentley, 1991; Gulhati and Datta, 2005). However, the determination of compression index in the labs is a cumbersome and time consuming process. Hence several attempts have been made in the past to correlate the value of compression index of soils with index properties of soil which are relatively easier to determine and take lesser time.

II. LITERATURE REVIEW

In the literature several correlations have been proposed whereby compressibility characteristics like compression index have been evaluated using liquid limit, natural moisture content, initial void ratio, plasticity index, specific gravity, void ratio at liquid limit, and several other properties of soil. Skempton (1944) and Terzaghi and Peck

(1967) have given equations correlating compression index with the liquid limit of soils. Wroth and Wood (1978) used critical state soil mechanics concepts to deduce a relationship between compression index, plasticity index and specific gravity of remoulded clays. Nagaraj and Murthy (1983) proposed equations to evaluate the value of compression index with specific gravity and void ratio at liquid limit of soils. Di Maio et al. (2004) conducted one dimensional consolidation tests on the mixtures of bentonite and kaolin as well as other natural clays and observed a good correlation between compression index and void ratio at liquid limit of soils. Tiwari and Ajmera (2012) prepared 55 different soil specimens in the laboratory by mixing various proportions of montmorillonite, illite, kaolinite, and quartz at initial moisture contents equal to the liquid limit and proposed two different equations to estimate the compression indices of remoulded clays with liquid limit, one for soils with activities less than one and the other for soils with activities greater than one. Based upon the past study, it can be concluded that compression index can be related with index properties (Liquid limit(LL) and Plasticity Index(PI)) of soil. The model proposed by Skempton (1944), Terzaghi and Peck (1967) and Wroth and Wood (1978) are presented below.

Skempton (1944) model,

$$Cc = 0.007(LL-10) \qquad (1)$$

Terzaghi and Peck (1967) model,

$$Cc = 0.009(LL-10) \qquad (2)$$

Wroth and Wood (1978) model,

$$Cc = 0.50 \times PI \times Gs \qquad (3)$$

III. METHODOLOGY OF THE PRESENT STUDY

As per earlier research work, some of the researchers correlated the compression index with liquid limit only (Skempton (1944) and Terzaghi and Peck (1967)) while the some researchers correlated the compression index with plasticity index (Wroth and Wood (1978)) only. So to overcome the shortcoming of earlier models, in the present study the compression index is related to all basic and index properties of soil. In the present study, an attempt has been made to estimate compression index as a function of soil index properties. Soil samples were collected from different Indian hydropower projects. A total number of 23 soil samples were taken. The values of liquid limits of the samples varied from 29.3 to 85.9 and IS classification of soil varied from CL to CH i.e. Clays having low compressibility to Clays with high compressibility. The collected samples were subjected to laboratory investigations for the determination of geotechnical parameters namely liquid limits, plastic limits and compression indices. Based on experimental results, correlation between the compression index and soil index properties was attempted.

IV. PROPOSED MODEL

To predict the compression index (Cc), several regression analyses were carried out using the different variables of soil index and basic properties and accuracy of each model was tested by comparing the predicted values with actual values and calculating the statistical parameter root mean squared error (RME). The following proposed models were the best fit to the data.

Compression Index,

$$(Cc)p = 0.002\times LL + 0.0025\times PI - 0.005 \quad \text{------------------------------------} \quad (4)$$

Fig. 1 (a), (b) & (c) plot the predicted values of compression index (Cc)p versus actual values of compression index (Cc) using proposed model, model predicted by Skempton (1944) and Terzaghi and Peck (1967).

V. DISCUSSIONS

The proposed models were developed by correlating the compression index with liquid limit (LL) and plasticity Index (PI). The accuracy of proposed models was checked by comparing the actual values of Cc with predicted values of Cc. It was found that for mean target value for input data was 0.15128 whereas the mean target value by the proposed model was 0.15163. While the mean target value by the models proposed by Skempton (1944) and Terzaghi & Peck model (1967) were 0.2679 & 0.3445 respectively. The accuracy of proposed model was also checked by calculating the statistical parameter Root Mean Squared Error (RME) and it was found that for the proposed model RME was 0.035 whereas for the models proposed by Skempton's and Terzaghi & Peck's were 0.131 & 0.211 respectively. The values of compression index predicted using the present model and the model proposed by Skempton (1944) and Terzaghi & Peck (1967) were plotted on graph, Fig. 1, and it was found that compression index values predicted using the present model has better distribution around the equality line in comparison of other models. Thus it evident that compression index (Cc) values predicted using the proposed model are much closer to the actual values in respect of other models and can be concluded that proposed models are much accurate and are in good agreement with actual values.

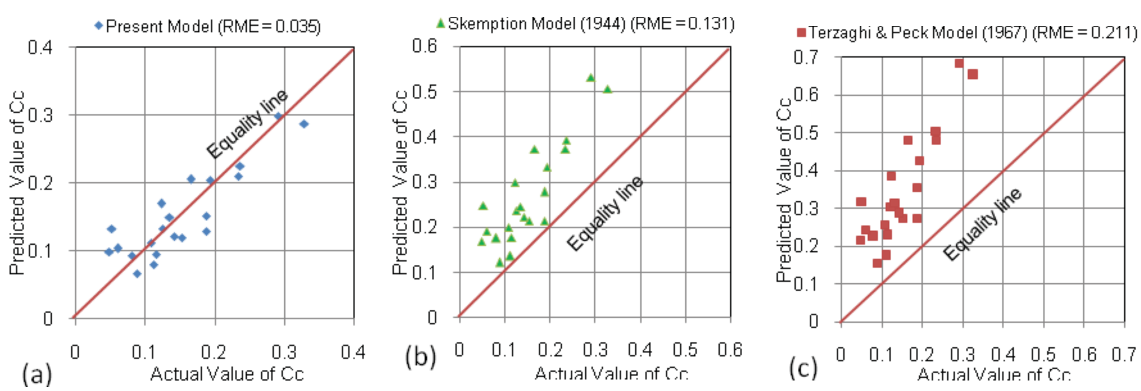

Fig. 1 Actual Compression Index, C_c versus predicted Compression Index, $(C_c)_p$ obtained by (a) proposed model, Equ. (4), (b) model proposed by Skempton (1944), Eqa. (1) and (c) model proposed by Terzaghi & Peck model (1967), Eqa. (2).

VI. CONCLUSIONS

The paper presents the method to predict the compression index (Cc) for fined grained soils based on index properties (LL and PI). Regression analysis was carried out to develop the predictive models for estimation of compression index (Cc). The results show that compression index (Cc) correlated well with liquid limit and plasticity. The model results were compared with the actual compression index values, as determined by laboratory tests, and were found to be in good agreement. The compression index values for the collected samples were also determined using the available models in literature. The results indicate that the model can predict the soil compressibility values more accurately.

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