Forecasting of Compression Index

by

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Introduction

EMPIRICAL approaches for prediction of Compression Index have been advanced by Skempton (1944), Hough, and Cozzolino (1961). A study was taken up at the Central Building Research Institute also and formulae have been developed [Sengupta and Juneja (1965)].

Consolidation tests were carried out on remoulded samples prepared from seven different cohesive soils with different compressibilities, collected from various parts of India. Samples were prepared to possess different initial void ratio ranging from 0.5 to 1.0. Liquid, plastic and shrinkage limits of the soils were also determined.

Relationship of C_c with e_o

The correlation between C_c and e_o for the various soils is shown in Figure 1. For all practical purposes, the C_c-e_o relationship for a soil was found to be linear and the seven soils produced a set of parallel straight lines with the same slope leading to the equation of the form :

$$C_c = 0.21\ e_o + C \qquad \ldots(1)$$

where, C is the intercept of the C_c-e_o line produced to meet the 'Y' axis. It may be mentioned here that 'C' does not represent C_c at zero voids ratio, but it merely defines the C_c-e_o line between the limits of void ratio (0.5 to 1.0) used in this investigation.

Relationship between the Intercept 'C' and a Soil Property

Attempt was made to correlate the intercept 'C' with liquid limit, plastic limit, etc., of the respective soil. The plastic limit showed the best relationship (Figure 2), which could be expressed by the equation :

$$C = 0.0111\ PL - 0.17 \qquad \ldots(2)$$

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This paper (modified) was received on 6 June 1974. It is open for discussion up to January 1975.

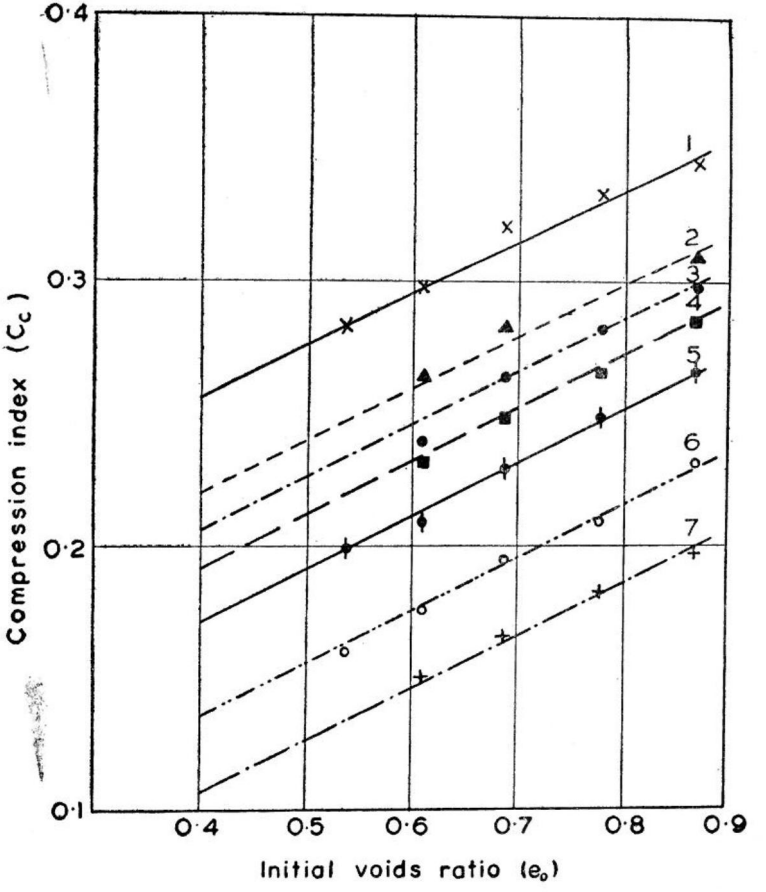

FIGURE 1 : Correlation between voids ratio (e_o) and compression index (c_c) [Sources of soils :

1. Indore ; 2. Madras ; 3. Dudhwa ; 4. Bhopal ;

5. Roorkee ; 6. Durgapur ; and 7. Bhagalpur].

With liquid limit the following relationship could be drawn (Figure 3) :

$$C = 0.00314\ LL - 0.07 \qquad \ldots(3)$$

The Final Formulae

Combining Equations (1), (2) and (3), the following equations could be established for prediction of C_c :

$$C_c = 0.21\ e_o + 0.0111\ PL - 0.17$$

and

$$C_c = 0.21\ e_o + 0.00314\ LL - 0.07$$

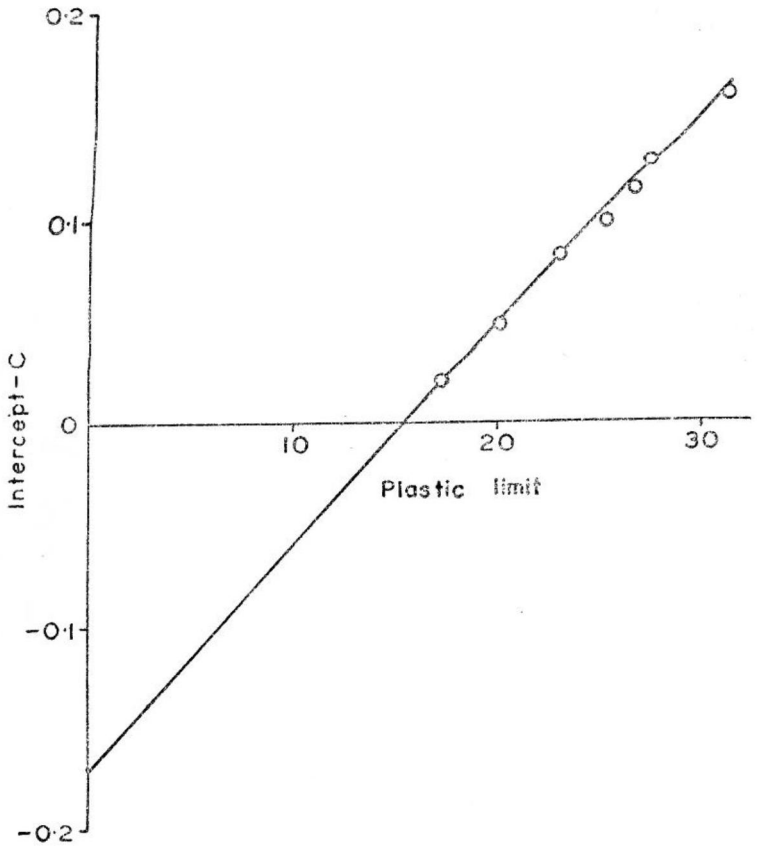

FIGURE 2 : Relationship between C and plastic limit [C represents the intercepts of C_c—e_o plots on C_c axis].

Application of the Formulae

In Table I, the predicted values of C_c using Skempton's, Hough's and Sengupta's equations are given. It can be noticed from the table that Skempton's equation gives the same value of C_c for a particular soil for all values of e_o. Hough's equation gives the same value of C_c for all soils for a particular value of e_o. The Sengupta's equations take into account both the variations and the predicted values show good agreement with the values obtained from consolidation tests (Table I).

It was now intended to check up the agreement of the predicted values from the present equations with actual results of consolidation tests carried out on undisturbed samples of soil.

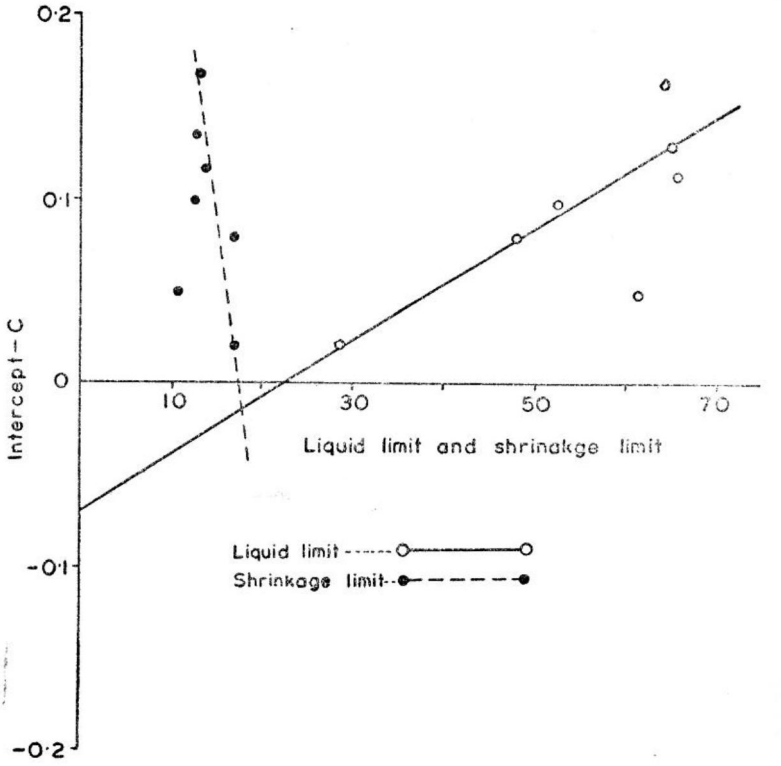

FIGURE 3 : **Relationship between C and liquid limit and shrinkage limit.**

TABLE I

Compression Index obtained by Different Methods.

SOURCE	COMPRESSION INDEX VALUES—C_c									
	From Consolidation Test			Predicted Values						
				Sengupta's Eqn. $0.21e_o+0.0111\ PL-0.17$			Skempton's Eqn. $0.007\ (LL-10)$	Hough's Eqn. $0.31e_o-0.081$		
	Void Ratio—e_o			Void Ratio—e_o				Void Ratio—e_o		
	0.87	0.69	0.61	0.87	0.69	0.61		0.87	0.69	0.61
ROORKEE	0.27	0.23	0.21	0.27	0.23	0.21	0.27	0.18	0.13	0.10
INDORE	0.35	0.32	0.30	0.36	0.32	0.29	0.38	,,	,,	,,
DURGAPUR	0.23	0.20	0.18	0.23	0.20	0.18	0.36	,,	,,	,,
MADRAS	0.31	0.28	0.26	0.32	0.28	0.26	0.39	,,	,,	,,
BHAGALPUR	0.20	0.17	0.15	0.21	0.17	0.15	0.13	,,	,,	,,
DUDHWA	0.30	0.27	0.24	0.31	0.27	0.25	0.39	,,	,,	,,
BHOPAL	0.29	0.25	0.23	0.29	0.25	0.24	0,30	,,	,,	,,

Agreement of Predicted Values with Test Results

Results of site investigations were collected from various agencies dealing in soil exploration. The comparison was limited to cases in which the initial voids ratio of the samples ranged between 0.5 to 1.0. In Table II, the predicted values from the present formulae and estimated values of C_c are entered. In Figures 4 and 5, the relationships between the pair of values are shown and it can be noticed that the agreements are good.

To check the level of significance of the agreement, 't' test was carried out in the case of prediction from plastic limit according to the following formula :

$$t = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{1}{n_x} + \frac{1}{n_y}} \sqrt{\frac{\sum_{t=1}^{n_x} (x-\bar{x})^2 + (y-\bar{y})^2}{n_x + n_y - 2}}}$$

Where,

1st Series of random variables are $x_1, x_2, x_3, \ldots\ldots x_n$ (up to n_x terms)

2nd Series of random variables are $y_1, y_2, y_3, \ldots\ldots y_n$ (up to n_y terms)

$$\bar{x} = \frac{\sum_{t=1}^{n_x} x_1}{n_x} \quad \text{and} \quad \bar{y} = \frac{\sum_{t=1}^{n_y} y_1}{n_y}$$

In Table III, the various parameters in the present case are entered and the 't' value works out to 0.8.

For the given degree of freedom, the values of 't' at 1 percent and 5 percent levels of significance being approximately 2.4 and 1.7 respectively, the difference between the predicted and estimated values is found to be insignificant at both the levels in the present case ('t'=0.8). In other words, the hypothesis of agreement has been found to hold good with a very high degree of probability.

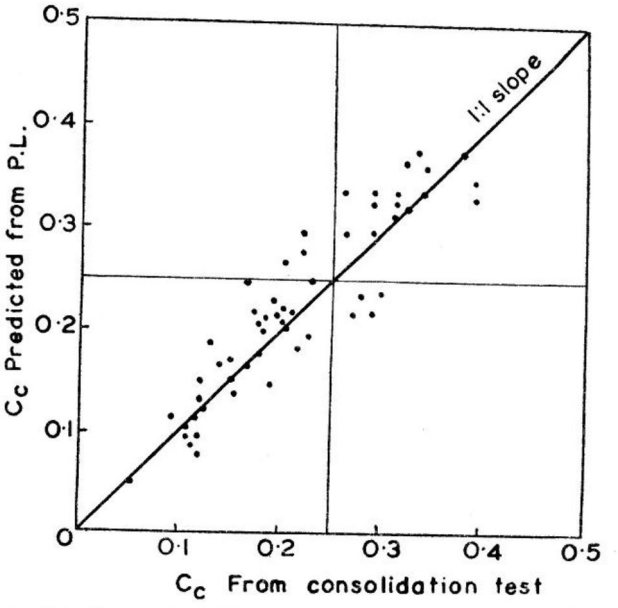

FIGURE 4: C_c predicted from P L versus C_c from consolidation test.

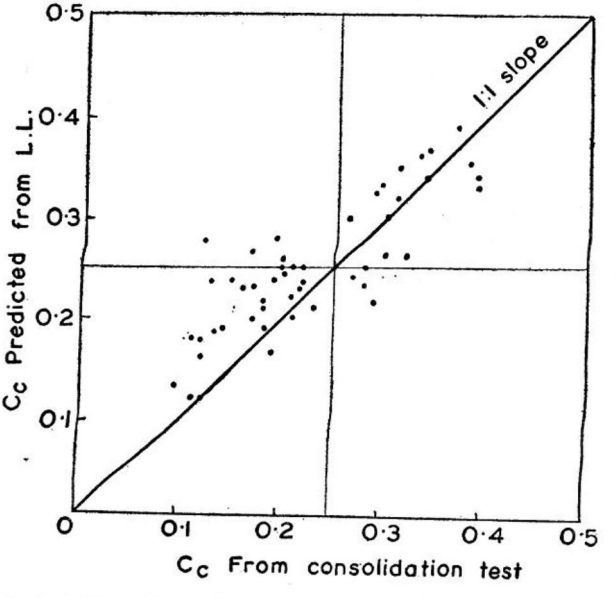

FIGURE 5: C_c predicted from L L versus C_c from consolidation test.

TABLE II

Application of the Present Formulae.

SOURCE	COMPRESSION INDEX—C_c			SOURCE	COMPRESSION INDEX—C_e		
	Tested Value	Predicted Value From			Tested Value	Predicted Value From	
		PL	*LL*			*PL*	*LL*
JOYPUR BELL —by— Jadavpur University 1968.	0.31	0.33	—	BUCKLAND *BRIDGE* —by— MSJ (ENGRS) & Co.	0.31	0.34	0.35
	0.21	*0.23*	*0.25*		*0.14*	0.16	0 19
	0.23	—	0.23		0.15	0.17	0.24
	0.28	—	0.25		0.29	0.30	0.33
	0.19	0.29	0.28		0.13	0.19	0.24
	0.32	0.37	0.26		0.22	0.19	0.23
	0.27	0.22	0.24		0.34	0.34	0.34
	0.29	0.34	—		0.12	0.10	0.12
	0.23	0.20	—		0.20	0.21	0.25
					0.18	0.18	0.19
					0.16	0.14	0.23
TELEPHONE BHAWAN, —by— Progressive Sub-Soil Survey (P) Ltd.	0.39	0.35	0.34	CARSHED, HOWRAH —by— MSJ (Engrs) & Co.	0.19	0.23	0.24
	0 20	0.27	0.26		0.29	0.29	0.30
	0.26	0.34	0.25		0.36	0.36	0.39
2 ND HOOGHLY CROSSING, —by— Cementation Co. Ltd.	0.19	0.15	—	ALLOY STEEL, DURGAPUR —by— MSJ (Engrs) & Co.	0.12	0.13	0.28
	0.12	0.13	—		0.13	0.13	0.19
	0.22	0.28	0 25		0.06	0.06	0.12
	0.12	0.15	0.16		0.11	0.10	0.18
	0.29	0.22	0.21		0.17	0.17	0.23
	0.26	0.30	0.30		0.12	0.08	0.18
	0.22	0.30	0.28				
	0.18	0.20	0.16				
	0.28	0.24	0.23	CENTRAL DRUG LABORATORY —by— Progressive Sub-Soil Survey (P) Ltd.	0.30	0.34	—
	0.31	0.32	0.32		0.20	0.22	—
	0.21	0.21	0.22		0.10	0.11	—
	0.30	0.24	0.26				
	0.21	0.22	0.20				
	0.20	0.22	0.19				
	0.23	0.25	0.21				
	0.17	0.25	0.20	BHILAI STEEL PROJECT —by— C. B. R. I.	0.10	0.13	0.14
	0.18	0.21	0.21				
	0.17	0.22	0.27				
	0.18	0.20	0.21				
	0.38	0.38	0.36				
	0.29	0.33	0.33				
	0.20	0.22	0.25				
	0.34	0.36	0.37				
	0.39	0.34	0.33				

TABLE III

't' Test on predicted and estimated values of C_c.

n_x	n_y	n_x+n_y-2	$\bar{x}$	$\bar{y}$	$\sum_{t=1}^{n_x} (x-\bar{x})^2$	$\sum_{t=1}^{n_y} (y-\bar{y})^2$
58	58	114	0.234	0.221	0.4002	0.4030

$$'t' = \frac{0.234-0.221}{\sqrt{\frac{1}{58}+\frac{1}{58}}\sqrt{\frac{0.4002+0.4030}{114}}}$$

$$=0.834$$

Acknowledgement

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