Correlation of Unconfined Compressive Strength of Soil with Size of Test Specimen*

by

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Author's Reply

The author thanks Shri S.K. Shukla for his kind comments on the paper. The following clarifications are submitted :-

(*a*) The height to diameter ratio was kept constant as 2:1.

(*b*) The water content ranges from 36.5 percent to 43 percent in case of a standard specimen of 3.81 cm. diameter, whereas the ranges of water content in other specimens are as follows :

Specimen diameter (in cm)	Range of Water Content (in %)	
	From	To
6	36.5	45
7.62	35	42
10.2	34	41
12.9	32.5	45
17.0	41	44.5
20.35	40	43.5

2. From Figure 1 of the paper, the range of water content in case of 12.9 cm diameter specimen is fairly large, which is between 32.5 per cent and 45 per cent. In Figure 2, one point has been erroneously left out. Though the water content may be varying between 40 per cent and 44.5 per cent in case of 17 and 20.35 cm specimens, the slope (i.e., parameter m) obtained by least square method depended on a minimum 10 points. It is presumed that this would have given reasonably reliable data.

3. The testing programme was formulated to test a minimum of 20 specimens of each size. In actual practice the number of samples tested in each category varied between 10 and 33, which is considered suitable for any statistical analysis. However, these tests were conducted at varying

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moisture contents thereby restricting application of statistical approach rigidly. Hence, coefficient of variation and standard diviations would not serve any purpose.

4. Theoretically speaking, a specimen of the size of the foundation should be used, which is neither practically possible nor desirable. In the available literature varying diameters have been used in different countries. The aim of this paper has been basically to highlight the effect of any change in diameter on the unconfined strength. Since, all foundation design formulae have been based on 1½″ size specimen, for the time being 3.81 cm dia specimen as recommended by Indian Standard may be used till further work in this direction is completed to arrive at a rational and optimum size of the specimen which could be termed truely representative of the natural sub-soil conditions.

The author gratefully appreciates the comments offered by Prof Dinesh Mohan. The following points are submitted in clarification :—

(*a*) According to Terzaghi and Peck (1967) slightly over-consolidated soil usually have numerous cracks slickensides and fissures randomly scattered. The author had noticed in larger specimens appreciable amount of slickensides. The possibility and probability of having such discontinuities in 20.35 cm dia specimen having a cross-sectional area as high as 324.7 sq. cm is much more than in a 3.81 cm dia specimen having a cross-sectional area equal to nearly 11.32 sq. cm. Hence it is evident that in a larger specimen greater number of discontinuities would join together to develop a failure plane easily as compared to a smaller specimen and hence the UCS values of larger specimens would be low.

(*b*) It is further submitted that the strength would keep on decreasing, instead of increasing as mentioned by the writer, with increase in the size of the specimen. However, the author agrees with the writer that such relationship should have some limit. Theoretically when NMC is nearer to the liquid limit, the strength of the specimen is considered zero, since the soil sample will flow automatically indicating no shear strength. By substituting $W = 67$ per cent and $q_u = 0$ in equation (3) we get diameter of the speciman as small as as 0.0933 cm.

Taking into consideration practical aspects of sampling, it is recommended to use a specimen of atleast 10 cm diameter. This would be further useful since even pebbles of the size of 2 cm can be tolerated, thereby giving more reliable and realistic results, since closer to the natural conditions.

(*c*) The height to diameter ratio was kept constant as 2:1 for all specimen sizes.

The author thanks Shri R. J. Dave for his Comments.

The length to diameter ratio was kept constant as 2:1 to avoid any buckling of the specimen of failure plane cutting through the top and the bottom faces of specimens.

2. It may please be seen from Fig. 1 that the curves are hyperbolic, and would be asymptotic to X and Y axes. Therefore it is difficult to assign any maximum or minimum values to the specimen. The aim here is to use a standard size because any variation in the size of the specimen would result in errors. In different countries different sizes of specimens are used for UCS test. However, for arriving at a standard size it is submitted that a 10 cm size specimen be used to give realistic values of shear strength, even when the soil contains particle sizes as large as 2 cm. In nature it is rather difficult to get black cotton soil free from small stones and pebbles. So far it has been considered that the soil should be passing 4.75 mm sieve size for a standard specimen of 3.81 cm dia which is unrealistic.

3. The author agrees with the contention of the writer. It is an obvious conjucture that a little disturbance in smaller specimen with regards to its cross-sectional area and volume would affect UCS values considerably, whereas even moderate disturbance in larger specimen would not affect ulltimate results to that extent.

4. The author could not locate the formula $\log T_f = -(0.053) - 2.45\, I_L$ for the shear strength given by Prof Dinesh Mohan formula in his paper titled Consolidation and Strength Characteristics of Indian Black Cotton Soils" as reproduced in the IV International Conference on Soil Mechanics and Foundation Engineering (1957) held in London. However, the formula given by the writer is true for liquidity indices having negative values, i.e., when NMC is less than plastic limit. The soil samples tested in this case had natural moisture content greater than PL and less than liquid limit, thereby giving positive values of liquidity index. Hence, formula suggested by the writer cannot be strictly applied here.

5. The Y-ordinate should have begun with 31 per cent water content i.e., a figure of 0.31 and not 0.3 as printed in the paper in Fig. 2. The error is regretted.

6. Many authors have established relationship between water content and strength of the soil. The author invites attention of the writer to the papers referred at the end of paper under discussion with special emphasis on the papers by Henkel (1960), Hvorslev (1960) and Ladd (1964). Their contention has been confirmed during experimentation as represented by the graphs between water content (w) Vs UCS (g_u) given in Fig. 2 of the paper. The author agrees with the writer that the relationship suggested is only applicable to black cotton soil having properties as mentioned in the paper under discussion. However, it is for consideration that, if different types of soils are tested for UCS, by virtue of their established relationship between moisture content and UCS, they should also show similar trend. Hence further experimentation in this field would be useful, if such a generalised equation is obtained, thereby giving fairly accurate information to the soil engineer by just knowing the NMC and diameter of the specimen.