

DISCUSSION

KENNETH PEAKER AND DONALD H. SHIELDS¹—When considering the tests on clays, the writers wonder if too much is concluded from the results. The plot of $\frac{1}{2} q_u$ versus T in Fig. 2 has been replotted on an arithmetic scale, Fig. 8, and the scatter of results is more readily apparent. The ratio of maximum to minimum values of $\frac{1}{2} q_u$, which corresponds to a particular value of T , is commonly 2 to 1. When it is remembered that these tests were performed with remolded soils, one hesitates to predict the scatter of results for intact clay.

The author fails to state the depth of penetration of the vane into the clay and the allowances made for shaft friction.

A better appreciation of the work on sand and silt would result if the author would specify the method for controlling the pore pressure in these tests. The comment that Fig. 3 (b) does not conform to the theory of effective stress is puzzling, since a decrease in pore pressure should, according to this theory, result in the higher torque shown by the results.

It appears to the writers that, in view of the scatter of the results of the clay tests, a logical step would be to review both the method of test and the apparatus with the object of decreasing this scatter. A direct comparison of T and $\frac{1}{2} q_u$ can be made without the intermediate step of measuring the moisture content. This requires thoroughly mixed batches of clay and high humidity conditions during the tests. The author is referred to

a paper by Crawford in this same conference for a detailed discussion on the problems of measuring pore pressure with probes. One also wonders whether the optimum size of bin was attained in these tests.

Field vane results in clay have often been compared with other methods of determining shear strength. The correlation of results in some instances has been good, while in others the correlation was questionable. These differences may arise from the fact that, for some clays, the path of maximum shear in the soil at failure is not necessarily that imposed after failure by the mechanics of the vane's rotation.

NYAL E. WILSON (*author*)—The tests on remolded clay were conducted for the purpose of checking the applicability of the vane to cohesive soils. This work was done following some preliminary work in sand and silts which showed that the vane test in coarse-grained soils assumed the characteristics of a drained test.

Messrs. Peaker and Shield refer to the scatter of results on the $\log q_u/2$ versus $\log T$ plot (Fig. 2, middle left). This plot was drawn as a key diagram to show the steps in the construction of the main diagram. The torque is related to the shear strength using the equation $q_u/2 = 1.00 T^{1.23}$.

Some scatter of results can be expected as the tests were related to a common parameter, water-content, and number of blows. The scatter does appear to be significant on the $\log q_u/2$ versus $\log T$ plot, but the final judgment of statisti-

¹ Lecturer and research student, respectively, Manchester University, Manchester, England.

cal fit should be based on the main diagram in Fig. 2, where the actual experimental values rather than the key diagram (synthetic data) are plotted.

The tests were conducted at constant depth, 3 in., and no allowance was made

magnitude of induced pore-water pressure is variable, due to the variable degree of drainage of the surface water. The value of negative pore-water pressure is dependent on the formation of the meniscus at the surface of the soil, and various

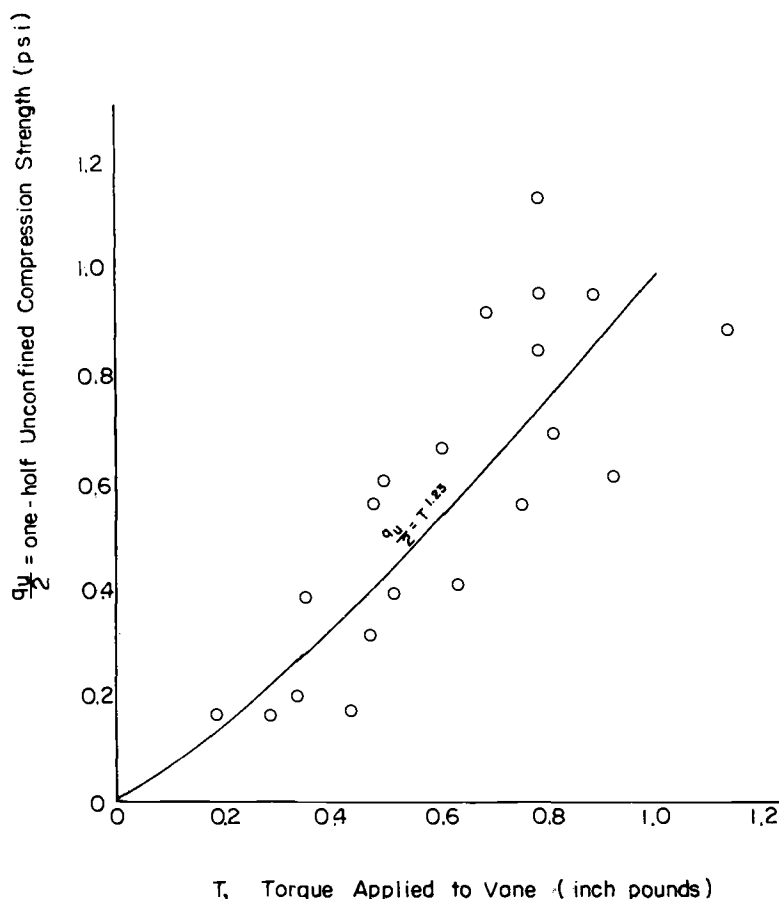


FIG. 8—Unconfined Compression Strength Versus Torque.

for shaft friction. If Cadling's equation is applicable, the correction for shaft friction is negligible

The discussers' comments on the control of pore-pressure are most important. In this research, the induced pore-pressure was not controlled, but was generated by the rotation of the vane. The

initial states of wetness of the surface provide various degrees of formation of the meniscus. In the region of applied pore-water pressure, the applied pressure was controlled by the Norwegian pore-pressure instrument.

Figure 3(b) does not conform to the theory of effective stress regarding the

magnitude of the stresses, but does agree with the theory regarding the sign of the stresses. When values of effective stress are related to values of shear stress, it is found that the slope of the line is greater in the case of the vane test than in the case of the triaxial or direct shear tests.

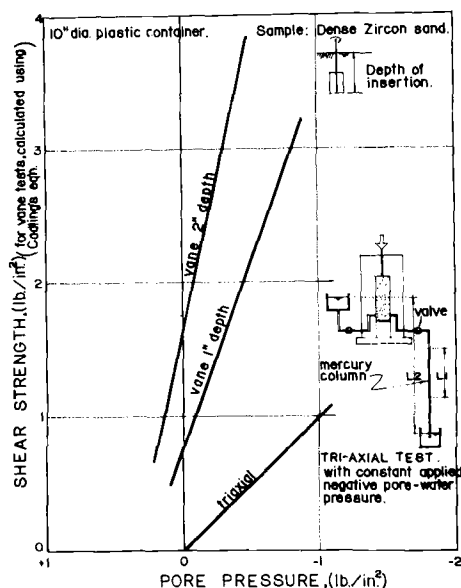
Messrs. Peaker and Shield have a comment of considerable importance when they discuss the path of maximum

layers of sand or silt occur, negative pore water pressures at the tips of the blades can increase the measured strength. Whereas local dilatancy at the vane temporarily increases strength in the test, the same varves can result in pore pressure migration when an embankment is placed. Consequently the use of a vane in varved or layered materials to predict performance can be dangerous, and reanalyses of failures on this basis do not appear to be fruitful.

Wilson observes that "some parameter, other than Terzaghi's theory of effective stress is involved." This probably arises from the use of Coulomb's equation, which does not include a treatment of volume change. Sands and silts tend to expand during shear, which, with partial drainage, leads in part to a decrease in pore pressure and its resultant increase in effective stress, and in part to a direct increase in effective stress to satisfy compatibility of displacements.

NYAL E. WILSON (*author*)—Professor Rowe, referring to the statement that "some parameter, other than Terzaghi's theory of effective stress, is involved," attributes this to dilatancy, which is not considered in Coulomb's equation. He may be correct in this hypothesis. The discrepancy is significant and can be readily shown by a comparison of the results of laboratory vane tests and triaxial tests. Figure 9 shows these comparative results relating shear stresses to pore-water stresses and indicates that pore-water stresses have a greater influence on vane tests than triaxial tests.

E. C. W. A. GEUZE²—The author deserves credit for drawing attention to the phenomenon of stress concentrations in soils imposed by discontinuities of the probing body, that is a four-bladed rotary vane.



Dependence of shear strength on pore-water pressure using different testing procedures.

FIG. 9—Shear Tests in Dense Zircon Sand.

shear. The stress distribution around the vane or along the vane blades is unknown, and the research work using the vane in silt has confirmed the complexity of the mechanics of failure.

P. W. ROWE²—N. E. Wilson has drawn attention to the fact that the use of the Cadling and Odenstad equation for undrained shear strength based on vane tests is only applicable to intact homogeneous clays. Where varves or

² Professor of soil mechanics, Manchester University, Manchester, England.

³ Professor of soil mechanics and foundation engineering, chairman of the Department of Civil Engineering, Rensselaer Polytechnic Inst., Troy, N. Y.

This phenomenon is most clearly demonstrated in tests on sands. The stresses in the radial planes are mostly concentrated near the edges of the blades. The directions of the initial failure planes are at an angle with the normal to the blades, that is, the tangential direction of the rotating movement. The friction along the blades is of unknown magnitude, and its distribution strongly affects the direction of initial failure. The stress conditions are comparable to those occurring near the edge of the loading plates in a triaxial test.

The identical behavior of dense sands in the vane tests and in undrained triaxial tests are indicative of similar stress and strain patterns.

The major objections against the vane-test are shared by a number of other *in situ* testing methods.⁴ The inherent shortcomings of the methods can be ascribed

to the fact that rigid bodies with discontinuous contours and indeterminate surface properties cause stress concentrations of unknown magnitude and extent.

NYAL E. WILSON (*author*)—Professor Geuze has commented on one of the most important factors in soil mechanics testing—the distribution of stresses on the boundary between the soil and the testing device. Very little is known of the distribution of these stresses, which are a combination of both compression and sliding friction stresses. In the case of the triaxial tests, some consideration of the effects has been given by using sectional caps and bases; this solution is not possible for vane tests.

⁴ E. C. W. A. Geuze, "Techniques of Field Measurement and Sampling," *Proceedings, Fourth International Conference on Soil Mechanics and Foundation Engineering*, London, Vol. 3, 1957, p. 128.