DISCUSSION

C. B. CRAWFORD[1]—In his conclusion Mr. Simons acknowledges the importance of the influence of strain on shear strength parameters, but the stress-strain properties of the soils tested are not given. These would make a valuable addition to the paper and allow a more fruitful discussion of failure criteria. It is presumed that in these soil specimens the maximum principal stress difference was reached at a lower strain than the maximum principal effective stress ratio.

The point is made in the paper that the principal stress ratio failure criterion should be used in slope stability analyses ". . . since the results of undrained and drained triaxial tests will then agree." The writer has argued[2] against this criterion for undisturbed clays on the basis that, in order for drained and undrained tests to agree, the strain at failure is so large that the soil is remolded.

To apply a drained test result with axial stress increasing to an ordinary undisturbed clay that is not heavily overconsolidated is considered by the writer to be inappropriate because the laboratory specimen cannot fail until it is seriously distorted and consolidated. A drained test with lateral stress decreasing appears to be more satisfactory, but in this case, the effective stresses may simply follow the same path as in an undrained test.[3] It is questionable whether drained failure is possible on the shear plane of a clay in which negative dilation (volume decrease) occurs, except in a controlled strain laboratory test in which stresses and water can be redistributed. In controlled-stress laboratory tests of sensitive clays, the failure is catastrophic, as it is in natural slopes of these clays, and at the moment of failure the shear plane is undrained.

The writer is of the opinion that the principal effective stress ratio criterion of failure can be applied only to soils in which the effective stresses and the intergranular stresses are equal. If intrinsic stresses are significant, as they must be in most undisturbed clays, this criterion of failure must be open to question.

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[2] C. B. Crawford, Discussion in *Proceedings*, Am. Soc. Civil Engrs., Research Conference on Shear Strength of Cohesive Soils, Boulder, Colo., 1960, pp. 1080–1086.

[3] C. B. Crawford, "Cohesion in an Undisturbed Sensitive Clay," *Geotechnique*, Vol. 13, No. 2, June, 1963, pp. 132–146.