The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

In his reply to my earlier letter (*Géotechnique*, 14:1:68–71), Roscoe (*ibid.* 14:2:173–177) makes it clear that the justification for his equation (27) (Roscoe and Poorooshasb, 1963)[1] lies in a careful examination of certain test data. This is important, since it was not adequately explained in the original Paper. It appears in fact that the reference in the Paper to a "rigorous proof" by Poorooshasb is—as is now implied by Roscoe himself—unnecessary. The important stage in the argument is the *assumption* that the inequality:

$$(\epsilon_1)_{bcc'} > (\epsilon_1)_{bc} > (\epsilon_1)_{bb'c} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

is satisfied for *all* finite paths. The justification for equation (27) in the Paper by Roscoe and Poorooshasb depends on this assumption—as, therefore, does also the deduction in a subsequent Paper (Roscoe *et al.*, 1963) that the normality condition is applicable. The "rigorous proof" of Poorooshasb is seen to be trivial, and it is important to deny the conclusion—which could easily be reached by reading the original Papers only—that there has been in any sense a "rigorous proof" of the normality condition for soils within the conditions stated by Roscoe *et al.* This is not to imply that the assumption that inequality (A) is always satisfied is not reasonable—in view of the difficulty of establishing a stress-strain theory for clays, the hypothesis may well be acceptable, and appears to have been fruitful.

The *explicit* statement of experimental evidence which supports the premises on which "rigorous" arguments are based is usual in most branches of engineering science, and is not mere pedantry. The absence of such explicit statement is hardly to be explained by the assumption that readers are familiar with the subject, which may be the import of the final sentence of the author's letter. It is commonly assumed in the theory of plasticity that the normality law is satisfied for metals, but this has not been given any sort of rigorous proof. The arguments used by Drucker (1959) and referred to in the Paper by Roscoe, Schofield and Thurairajah constitute a re-definition of the normality law rather than a proof, since they depend on an unnecessarily restricted definition of stability. This lack of proof has not prevented the universal use of the normality law, the reasons for this being that:

1. within the limits of experimental error, the law is not unambiguously contradicted, and
2. the mathematical consequences of assuming the normality law are extraordinarily convenient.

There is a danger that mathematical convenience may prejudice rather than help physical interpretation if the rigour of the mathematical theory of plasticity is allowed to become attached to the experimental evidence. If this is allowed to happen, the idea may arise that something absolute and rigorous has been proved about the plastic behaviour of real materials. Such proof is certainly no more available for soils than it is for metals. The Author's letter is particularly valuable in that it states more clearly than the original Paper and at a crucial stage in the argument, the respective domains of experimental evidence, hypothesis and rigorous proof in relation to his theory and its development.

Yours faithfully,
M. R. HORNE

University of Manchester,
Simon Engineering Laboratories,
Manchester, 13
29 July, 1964.

[1] See references overleaf.

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ROSCOE, K. H., *and* H. B. POOROOSHASB, 1963. "A theoretical and experimental study of strains in triaxial compression tests on normally consolidated clays", *Géotechnique*, 13:1:21–38.

ROSCOE, K. H., A. N. SCHOFIELD, *and* A. THURAIRAJAH, 1963. "Yielding of clays in states wetter than *Géotechnique*, 13:3:211–240.

The Secretary,
The Institution of Civil Engineers,

DEAR SIR,

Bishop and Morgenstein define the factor of safety, on p. 132 of their Paper on "Stability Coefficients for Earth Slopes (*Géotechnique*, 10:4:129–150), as the ratio of shear strength to shear stress. Their equation (3) may be rearranged as follows:

$$F = \frac{C' + \bar{\sigma} \tan d'}{\tau}$$

where $\bar{\sigma}$ is the effective stress on a potential failure surface. This expression contains an implied assumption that the stress point A on the enclosed sketch may approach strength point B on a straight line vector curve. This can occur in a completely drained direct shear

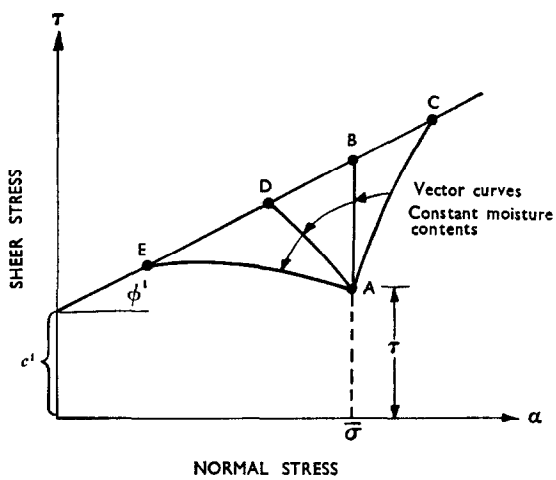

Fig. 1

test and appears reasonable for stability studies for steady seepage cases where the soil can adjust its moisture content to changed stress conditions.

For cases where a soil cannot change its moisture content the above definition may not apply. A soil which tends to dilate under shear will have a failure strength indicated by point C which is greater than that at point B and the safety factor as defined by equation (3) is conservative provided a problem of progressive failure does not exist. A soil which tends to consolidate during shear will have a strength indicated by point D and the safety factor