If allowance were made for some consolidation settlement taking place concurrently, an even higher value of E would be obtained. It is therefore clear that ordinary 'undisturbed' samples of these unsaturated residual soils of silty sand and sandy silt texture can yield values of E which are grossly unreliable in settlement calculations. The calculations err on the safe side.

Lumb's Paper is of value to everybody who has to work in areas of deeply weathered acid rocks. These comments are offered merely to clarify and supplement his excellent work.

Yours faithfully,
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The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

A NON-LINEAR THEORY OF CONSOLIDATION

by E. H. Davis and G. P. Raymond (*Géotechnique*, 15:2:161–173)

The theory presented by the Authors in which compressibility and permeability vary during a consolidation process so as to maintain a sensibly constant coefficient of consolidation applies to a wide variety of normally and lightly overconsolidated clays, and their solution for instantaneous loading and a thin layer of clay is welcome. The theory predicts settlement–time behaviour identical to the linear Terzaghi theory regardless of the load increment ratio. This can be rapidly checked by deriving the equations in terms of strain f as done by Mikasa (1965) rather than in terms of effective stress and pore pressure as done by the Authors.

Starting with equation (14),

$$\frac{\partial v}{\partial z}dz = \frac{\partial f}{\partial t}dz$$

$$\frac{\partial f}{\partial t} = \frac{\partial}{\partial z}\cdot\frac{k}{\gamma_w}\cdot\frac{\partial u}{\partial z} = \frac{\partial}{\partial z}\cdot\frac{k}{\gamma_w}\cdot\frac{\partial \sigma'}{\partial z} = \frac{\partial}{\partial z}\cdot\frac{k}{\gamma_w m_v}\cdot\frac{\partial f}{\partial z}$$

Thus if

$$\frac{k}{\gamma_w m_v} = c_v = \text{constant},$$

$$\frac{\partial f}{\partial t} = c_v\frac{\partial^2 f}{\partial z^2}.$$

Hence the rates of settlement which are obtained by integration of the strains f are identical to those given by Terzaghi. Knowing the effective stress–strain relation the pore pressure behaviour could then be calculated. However, the Authors' solution for u is more elegant and direct.

The greatest divergence from the Terzaghi theory is in the pore pressure behaviour at large load increment ratios. The theory is therefore of particular interest in estimating the stability of embankments on a soft foundation, where it can be used to calculate the allowable rate of construction. Presumably, since the theory is non-linear, the principle of super-position is not strictly applicable; nevertheless it should provide a safer design than the simple linear Terzaghi theory.

The experimental evidence presented was mainly for large values of load increment ratio when the results exhibited the predicted behaviour. There was however some doubt about the effects of side friction. Tests at Manchester University (Barden and Berry, 1965) in a new consolidation cell, which sensibly eliminated the effects of side friction, gave pore pressures which very clearly support the Authors' theory at large load increment ratios.

For small load increment ratios the theory predicts that the pore-pressure behaviour will approach that of the Terzaghi theory. Laboratory tests by a number of workers, including Leonards and Girault (1961), Barden and Berry (1965), have shown that the pore pressure dissipates much more quickly than in the Terzaghi theory when the load increment ratio is small. The reason for this is probably in the structural viscosity or creep behaviour of the soil (Barden, 1965) which has been neglected by the Authors. However, there is indication that at the field scale the large thickness of the clay 'sample' will greatly reduce the rates of strain and hence minimize the importance of structural viscosity effects which tend to dominate tests on small laboratory samples. In this case small load increment ratios may indeed result in Terzaghi behaviour in agreement with the proposed theory. This point will remain speculative until very thick samples of undisturbed clay can be tested accurately under small load increment ratios.

Yours faithfully,
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The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

BEDDING-PLANE SLIP, RESIDUAL STRENGTH AND THE VAIONT LANDSLIDE

Stability analyses of the Vaiont landslide show that the angle of friction ϕ' acting along the slip surface before failure must have had an average value of not more than about 20°, even if cohesion was negligible. Thus, with rather different assumptions concerning piezometric levels and the shape and position of the slip surface, Mencl (1964) obtains $\phi'=19°$ and Kenney (1966) calculates $\phi'=20\frac{1}{2}°$. Non-circular methods of analysis were used by both authors. Mencl adopted two wedges joined by a Prandtl zone and Kenney employed Janbu's method.

Now according to investigations summarized by Müller (1964) it is reasonably certain that the slide occurred on bedding planes somewhere within the Malm formation, and that the various strata were arranged in a synclinal form as sketched in Fig. 1. The main slip surface was located at an average depth of the order 100 m. It is also known from geological evidence