The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

COMPUTING ELASTIC SETTLEMENT IN SOILS

The application of a load to the surface of the ground causes an immediate settlement which can be estimated from elastic theory. The elastic settlement, ρ, at the corner of a rectangular uniform load, q, of width, B, placed on the surface of a homogeneous soil of infinite depth was given by Schleicher (1926) to be:

$$\rho = q \frac{B\,(1 - \mu^2)}{E} J \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where E = modulus of elasticity of the soil,

μ = Poisson's ratio (the original text utilizes a Poisson's number m which is $\frac{1}{\mu}$),

J = influence value which is mainly dependent upon the dimensions of the loaded area and is independent of Poisson's ratio.

For a homogeneous soil of finite depth, Steinbrenner (1934) computed the elastic settlement at the corner of a rectangular uniform load. Terzaghi (1943) transformed his equation into the form:

$$\rho = \frac{qB}{E} . I_\rho \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where the influence value I_ρ is dependent upon the size and shape of the loaded area, depth of subsoils, and upon Poisson's ratio and is given by:

$$I_\rho = (1 - \mu^2)\, F_1 + (1 - \mu - 2\mu^2)\, F_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where F_1 and F_2 depend upon the dimensions of the loaded area and depth of the subsoils.

In his analysis of equations (1) and (2), Terzaghi (1943) denoted the respective influence values by I_ρ, which led some authors to assume that the influence values are the same for both equations. Consequently, equation (1) has been used with the I_ρ from the charts published by Steinbrenner (1934) or Terzaghi (1943). An analysis of Steinbrenner's original Paper shows that if the depth $= \infty$, $F_2 = 0$ in equation (3) and $I_\rho = (1 - \mu^2)\, F_1$. Equations (1) and (2) then have the same form with F_1 corresponding to J. Substituting this I_ρ for J in equation (1), however, can cause the elastic settlements to be underestimated by as much as 25%.

For soils of finite depth, F_1 and F_2 may be evaluated by means of a length and depth factor from the formulae or charts given by Steinbrenner (1934). These formulae and charts were reproduced by Terzaghi (1943) but, the first term of his equation for F_1 gives $\frac{l}{\pi}$ [... + ...] instead of $\frac{1}{\pi}$ [... + ...] as found in Steinbrenner (1934) which is probably a printer's error. Otherwise they are the same.

The elastic settlement can be determined from equations (1) and (2) for a soil of infinite depth provided the appropriate influence values are used, and from equation (2) for a soil of finite depth.

Yours faithfully,
MICHAEL BOZOZUK,*
Soil Mechanics Section.

National Research Council,
Ottawa, Canada.
15 May, 1963.

* Mr Bozozuk is Research Officer, Soil Mechanics Section.

REFERENCES

SCHLEICHER, F., 1926. "Zur Theorie des Baugrundes" ("The theory of foundations"). *Bauingenieur*, 7:931–935 and 949–952.

STEINBRENNER, W., 1934. "Taflen zur Setzungsberechnung" ("Tables for the calculation of settlement"). *Die Strasse*, 1:121–124. Also in *Proc. Int. Conf. Soil Mech., Cambridge, Mass.*, 1936.

TERZAGHI, K., 1943. Theoretical soil mechanics. *John Wiley, NY.*, pp. 382–384, 423–425.

The Secretary,
The Institution of Civil Engineers.

DEAR SIR,

TRANSIENT DEVELOPMENT OF THE FREE SURFACE IN A HOMOGENEOUS EARTH DAM, by Suresh P. Brahma and Milton E. Harr, *Géotechnique* 12:4:283–302

There are several points in the above Paper which the Writer feels require discussion. The Authors use as their governing differential equation the linearized version of the Dupuit-Forchheimer or Boussinesq equation:

$$\frac{\partial h}{\partial t} = \frac{k\bar{h}}{n}\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and cite as their reference source Muskat's "Flow of homogeneous fluids". Muskat, however, goes to great lengths to point out the shortcomings of this equation (pp. 359–365). In the derivation the assumption is made that the slope of the free surface is everywhere small, and to linearize the resulting differential equation requires the additional assumption that h be not too different from $\bar{h}$. For the class of problems considered by the Authors neither of these assumptions holds.

Of greater importance, however, is the fact that in the derivation h is not a "head" but merely the height of the free water surface measured up from some datum. The vertical co-ordinate is eliminated as a consequence of the assumption that the vertical velocity component is zero. Hence the co-ordinates x, y which appear in the equation lie in a horizontal plane and not in a vertical plane, as supposed by the authors.

The "exact" theory for this problem includes Laplace's equation as the governing differential equation, together with an *a priori* unknown boundary location as part of the boundary conditions. The purpose of the approximations described is to allow the recasting of this fairly complicated problem into a much simpler form whereby the unknown boundary location itself becomes the variable in the differential equation. Hence, once these approximations are made nothing further needs to be said about the free surface, so that the first phrase of condition (3c) on p. 284 appears to be redundant.

In the formulation of the boundary value problems the condition (6b) on p. 285 implies that $h = H$ everywhere along the rays:

$$\theta = 0 \text{ and } \theta = 2\alpha,$$

and similarly, condition (7b) implies that $h = \sigma t$ everywhere along the same lines. With these conditions the problem is solved. To obtain the "free surface" from the solution above, condition (8) is then imposed. That the foregoing does not yield meaningful results can easily be seen from the following. Consider the behaviour of the solution of the boundary