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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 value problem given by equations (9), (9a), and (9b) for, say, Case I, i.e.:

$$h\ (r,\,0,\,t) = h\ (r,\,2\alpha,\,t) = H,$$

as $t \rightarrow \infty$. By physical reasoning or by actually solving the problem, one obtains the result that:

$$\lim_{t\to\infty} h\ (r,\,\theta,\,t) = H \qquad r > 0,\ 0 < \theta < 2\alpha.$$

That is, h goes to H everywhere in the wedge. This equality must hold, in particular, on the "free surface", given by (8), so that the latter reduces to:

$$H = r \sin\,(\alpha - \theta)$$

or

$$H = r\,[\sin\alpha\cos\theta - \cos\alpha\sin\theta] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

and since $r = \sqrt{x^2 + y^2}$, $\cos\theta = \dfrac{x}{\sqrt{x^2+y^2}}$, $\sin\theta = \dfrac{y}{\sqrt{x^2+y^2}}$ (2) becomes:

$$H = x\sin\alpha - y\cos\alpha$$

so that the "free surface" ultimately becomes a straight line parallel to the sloping surface and a distance H above it (?).

Obviously something is wrong since from physical considerations it is known that the water surface in the embankment ultimately approaches the horizontal. The correct boundary conditions should be step functions as follows:

$$h = \begin{cases} H \text{ for } 0 \leqslant \mathrm{r} \leqslant H/\sin\alpha \\ 0 \text{ for } \qquad r > H/\sin\alpha \end{cases} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6b)$$

and

$$h = \begin{cases} \sigma\mathrm{t} \text{ for } 0 \leqslant \mathrm{r} \leqslant \sigma\mathrm{t}/\sin\alpha \\ 0 \text{ for } \qquad r > \sigma t/\sin\alpha, \end{cases} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (7b)$$

indicating that the water level in the reservoir is rising at some predetermined rate and on this basis the water surface in the embankment must be below this surface. Condition (8) of the Paper is not used.

The agreement of the Authors' form of solution with that of Polubarinova-Kochina for the case of $\alpha = 90°$ is quite accidental. Polubarinova-Kochina employs a one-dimensional approach to obtain a solution for the problem of flow out of a ditch. When the Authors' solution is specialised for $\alpha = 90°$ the extraneous co-ordinate drops out altogether also yielding the transient heat equation in one dimension. However, Polubarinova-Kochina's variable is definitely the height to the free surface, and nowhere does she employ an auxiliary condition of the type (8) since, as indicated, this is superfluous. It is noted, moreover, that Polubarinova-Kochina states that the use of this equation in the first place ". . . is permissible (only) if we want to obtain crude results as a guidance," which agrees with the Writer's earlier comments.

Most of the shortcomings discussed, I believe, are caused by the unfortunate representation of h as a "head" rather than as the height to the free surface. With the proper definition of h the analysis presented may be applicable to the "long time" solution of this problem, i.e. when the free surface is nearly horizontal. For this case I believe the one-dimensional approach should be valid. A similar problem involving long-time behaviour has been presented by De Wiest (see reference) for a two-dimensional flow field (flow in a vertical plane). Here the final (steady state) free surface was not horizontal but, in fact, parabolic so that a two-dimensional analysis had to be employed.

Yours faithfully,

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BOOK REVIEWS

The measurement of soil properties in the triaxial test by A. W. Bishop and D. J. Henkel

Published by Edward Arnold Ltd, 2nd edition, 1962. 223 pp., 141 illustrations.

The authors and the publishers of this well-known but highly specialized book must be congratulated on having to produce a second edition at 60*s*. only 5 years after it first appeared, particularly as the price of the first edition at 70*s*. must have been an embarrassment to many purchasers.

The present edition is produced by an off-set process and the first 180 pages are identical with the first edition except that 5-pointed stars have been added after certain section headings to indicate that further discussion is to be found in a new Appendix of 31 pp. entitled "Developments in the period 1957/61". These stars should not be confused with the original 8-pointed asterisks used within the text to refer to the footnotes. The bibliography, the list of equipment manufacturers, and the index contain the additional information associated with the new Appendix.

This Appendix is concerned with several recent modifications in testing equipment and techniques at Imperial College, but particularly with investigations into the measurement of pore–air and pore–water pressure in partly saturated soil and the important effects of rate of testing on pore pressures in saturated undrained tests. The testing of partially saturated soils is clearly still in its early stages of development, for example, no attention seems to have been given to the question of non-uniform air pressures within the sample or to the rates of solution and diffusion of air in the pore-water.

This edition is better value for money than the first edition since it is cheaper. The binding is exactly the same and the paper is more serviceable. Those who refrained from buying the earlier edition will be attracted to the second edition.

W.H.W.