No. Z-9 A METHOD OF DETERMINING THE RATE OF DEFORMATION IN SOIL MASS, BY MEANS OF ELECTRICITY

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In the laboratory of soil mechanics of the All-Union Institute of water supplies and hydrogeology the following methods for the determining of the rate of deformation of soil mass have been worked out. As experiments carried out with direct models on the soil mass under laboratory conditions present a series of difficulties and are somewhat inaccurate, it therefore appeared rational to exchange the hydraulic system, which the soil mass represents, to an equivalent electrical system on the basis of the following considerations:

Let q_x, q_y, q_z be the components of the velocity of water in the soil mass upon squeezing out of this water under pressure and a_x, a_y, and a_z the corresponding velocities of the displacements of the given soil skeleton. Then taking the soil skeleton and water as non-compressible we can write down:

$$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z} + \frac{\partial a_x}{\partial x} + \frac{\partial a_y}{\partial y} + \frac{\partial a_z}{\partial z} = 0$$

as the rate of the diminishing of the volume of the skeleton v is equal to:

$$-\frac{dv}{dt} = \iiint\left(\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z}\right)dx\,dy\,dz$$

we may then write down:

$$\frac{dv}{dt} = \iiint\left(\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z}\right)dx\,dy\,dz \qquad (1)$$

In case of direct current electricity travelling in a conductive medium, in the body of which are distributed continuous sources of energy, we can write down on the basis of the first rule of Kirchhoff

$$\frac{\partial i_x}{\partial x} + \frac{\partial i_y}{\partial y} + \frac{\partial i_z}{\partial z} + \varphi = 0$$

where i_x, i_y, i_z - the components of the densities of the current forces along the axis of the coordinates, φ the voluminous density of the current derived from the above-mentioned distributed by volume sources. In general:

$$\varphi = f(x, y, z) \qquad (2)$$

consequently we can write

$$-\iiint \varphi\, dx\,dy\,dz = \iiint\left(\frac{\partial i_x}{\partial x} + \frac{\partial i_y}{\partial y} + \frac{\partial i_z}{\partial z}\right)dx\,dy\,dz \qquad (3)$$

on the basis of Darcy's law we have:

$$q_x = K\frac{\partial p}{\partial x}; \quad q_y = K\frac{\partial p}{\partial y}; \quad q_z = K\frac{\partial p}{\partial z}$$

Here K the coefficient of permeability and p the pressure acting on the water. In this way:

$$\frac{dv}{dt} = K\iiint\left(\frac{\partial^2 p}{\partial x^2} + \frac{\partial^2 p}{\partial y^2} + \frac{\partial^2 p}{\partial z^2}\right)dx\,dy\,dz \qquad (4)$$

On the basis of Ohms law we get:

$$i_x = \frac{1}{\rho}\cdot\frac{\partial V}{\partial x}; \quad i_y = \frac{1}{\rho}\cdot\frac{\partial V}{\partial y}; \quad i_z = \frac{1}{\rho}\frac{\partial V}{\partial z}$$

Here ρ the specific resistance and V the electrical potential. Therefore:

$$-\iiint \varphi\, dx\,dy\,dz = \frac{1}{\rho}\iiint\left(\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}\right)dx\,dy\,dz$$

Let us allow that experimentally under laboratory conditions such a distribution of electrodes in an electrically conductive medium and, of electric potentials on these electrodes, is attained so that with a sufficient degree of accuracy we attain the demands

$$P = cV \qquad c = \text{a constant} \qquad (6)$$

In that case it is of course necessary to determine beforehand by means of a theoretical calculation, or by means of experiment, the following function

$$P = f(x,y,z)$$

for the given moment of time. On the basis of equation (4 and 6) we can write down:

$$\frac{dV}{dt} = Kc\iiint\left(\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}\right)dx\,dy\,dz$$

or taking into consideration equation (5)

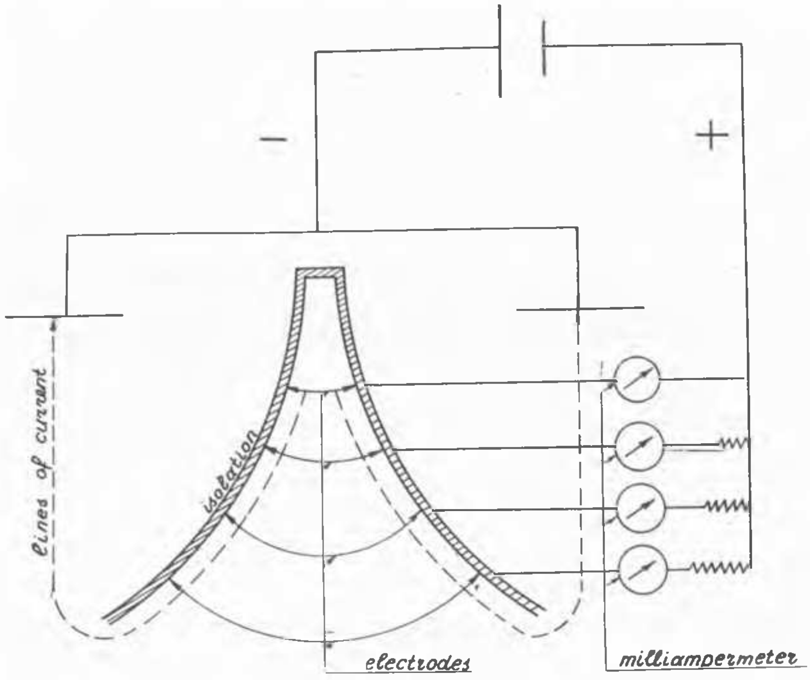

Fig 1.

$$\frac{dv}{dt} = -Kc\rho\iiint\varphi\,dx\,dy\,dz \qquad (7)$$

If on the experimental set up, the electrodes which are feeding the system with current are broken up into certain sections, then we can with a certain approximation determine the value of φ in various parts of an electrically conductive medium.

If we determine the value φ for a series of separate volumes, we can then substitute equation (7) going over to the method of final differences, with the approximate formula:

$$\frac{dv}{dt} = c\sum\varphi \qquad (8)$$

Here:

$$c = -Ko\rho v_o$$

(v_o = the value of a separate discreet element into which the volume under investigation is divided, during experiment).

If the question resolves itself into the determination of the settlement of the centre of a symetrically loaded symetrical surface, then the summation can be carried out along the central, vertically situated current path, which may be separated out by means of insulated walls running parallel to the lines of the current and without reproducing all the rest of the medium. (See Fig. 1)

We can also under any experiments whatsoever instead of deducting the value c determine it by means of experiments with such a configuration of the deformed medium and with such a distribution of stresses, by which it would be possible to carry out an experiment, parallel with the theoretical calculation of the value dv/dt.

From the preceding it is plain, that the herein described method makes possible the further development of the method of hydroelectrodynamical analogy as suggested by Pavlovski (N. N. Pavlovski, The Theory of the Movement of Subsoil Water under Hydraulic Structures, Petrograd, 1922) for the investigation into the movement of subsoil waters. What is new about this is the construction of the voluminous feeding of the whole system with current.

This may be more simply accomplished by distributing the electrodes along the surfaces of equal pressure previously determined by one means or other. The more the electrodes and the closer they are placed inside of the conducting medium, (electrolytic liquid) the nearer will the laboratory test correspond to the theoretical demands.

No. Z-10 THE CONSOLIDATION OF MARINE CLAY DEPOSITS DURING AND AFTER THE SEDIMENTATION PERIOD

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The problem of the determination of the excess hydrostatic pressures existing in clay or mud deposits during their sedimentation period and thereafter has been dealt with by K. Terzaghi (1), A. Ortenblad (2) and the writer (3) on the following assumptions:

1) The sedimentation takes place on an impervious base.
2) The excess water contained in the deposit escapes only in a vertical upward direction.
3) The average coefficient c of consolidation may be considered constant over the whole thickness of the deposited layer.
4) The speed of sedimentation v is constant during the whole period of sedimentation.

This problem is governed by a partial differential equation, which is formally identical with the Fourier equation relating to the one-dimensional, non-stationary flow of heat through plan-parallel plates of homogeneous materials. (4) Let be:

w .... the excess hydrostatic pressure at a point of the layer characterized by
z .... the depth under its surface, and
t .... the time, elapsed since the beginning of the flow phenomena;
ε .... the voids-ratio at t = 0,
k .... the coefficient of permeability,
a .... the coefficient of compression,
s .... the specific weight of the liquid (water) filling the voids of the clay,
$c = \frac{k}{s.a}(1+\varepsilon)$ ..... the definition equation of the coefficient of consolidation,