table has a run-off.

Numerous tests carried out in pumping in isolated wells show that:

1) The water-table in the wells at the start of pumping coincides with the extreme end of the saturarion level, of the soil. That coincidence seems to remain, until the line of saturation makes an angle of 45° with the horizontal at its meeting-point with the well.

If the rise is increased above that point the level of the water in the well is lower than the extreme end of the saturation line.

2) If the soil is of low permeability, the flow may be such that the upper limit of the laminar regime is reached, before the extreme end of the saturation line is at an angle of 45° with the horizontal. There is on the inner sides of the well a difference of level comparable to the former. The outflow limit of wells sunk in captive waters is due exclusively to that cause.

3) The radius of pumping action seems to depend only on precision of measurement. But close to the well, Dupuit's formula gives a true picture of what happens, causing to appear a fictitious radius of action.

This latter decreases slightly as the flow increases, but it can practically be considered as a constant. It satisfies the relation :

$$R = 550 \sqrt[4]{H K i}$$

the units being meter and seconds.

H = Depth of the groundwater
K = Coefficient of permeability
i = Gradient of the sheet before pumping

4) The coefficient of permeability computed according to Dupuit's formula varies between narrow limits in terms of strong or feeble flows.

Jaeger's method covers a greater scale of flows with the same coefficient which is comparable to that of Dupuit.

It is therefore possible to apply Dupuit's formula for the computation of filter-wells. Nevertheless, the notion of range, has yet to be defined as far as level-lowerings by means of several wells are concerned.

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FLOW OF FLUIDS THROUGH POWDERY MEDIAE

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The flow of fluids through powdery mediae should obey the general laws governing the flow of fluids. Consequently, according to Reynold's number characterising this flow, it should be possible to arrive at the laminary flows, the turbulent flows and the transitory regimen separating the two.

In fact, permeability tests, carried out with considerable variation of the hydraulic gradient, bring into evidence the laminary regimen, corresponding to the law of Darcy, and, beyond that, the transitory regimen. The experiments carried out by ZUNKERS and LINDQUIST are almost entirely confined to this latter field. Moreover it can be ascertained, that for gradients very close to zero, Darcy's law does not seem to be applicable any longer.

The upper limit of Darcy's law, that is to say the starting point of the transitory regimen, is given with a close approximation by SICHART'S relation

$$i = \frac{I}{15\sqrt{k}}$$

Flow in transitory regimen becomes easier and easier as the coefficient of permeability of Darcy's law increases. It seems that when the latter is inferior to 1 x 10^{-3} and 5 x 10^{-3} m/sec (3.048 x 10^{-3} ft/sec and 15.240 x 10^{-3} ft/sec.) the transitory flow can no longer take place in nature.

As Darcy's law corresponds to a laminary flow it should be possible to determine "a priori" the coefficient of permeability K, of the medium.

To that effect, the grading curve of soil should be determined by plotting the logarithm of the diameter of the grains against the quantity

$$\frac{1}{\sqrt{\pi}} \int e^{-z^2} dZ$$

with $Z = a \log (D - D_0) + b$
a,b and D_0 being three constarts determined so as to have a linear representation. By assimilating the grains to spheres, it is possible to calculate mathematically the specific surface of the medium. Moreover it can be ascertained that its index of voids ε depends on the constants of Z. Thus, all elements necessary to establish the hydraulic radius ρ are available since,

$$\rho = \frac{\varepsilon V}{S}$$

V being the volume of the spheres the surface of which is S. Hence K is given by the relation

$$K = \frac{g \rho^2}{A \nu}$$

g = acceleration due to gravity
ν = kinematic viscosity of the fluid
A = a constant equal to 13 for spheres and comprised between 140-350 for analysed sands.

This constant is a form-coefficient, which it should be possible to determine by comparing the actual volume of a certain number of grains to the volume of the same number of spheres of the same diameter. This determination is facilitated by the use of gausso-logarithmical paper.

The eventual result is of course not absolutely precise from a mathematical point of view, but is quite sufficient for practical needs.

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ON THE LAWS OF SEEPAGE FLOW

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SYNOPSIS OF THE FRENCH REPORT

The knowledge of the laws of the flow of water through porous masses is essential in several engineering problems. They are notably required for the study of the stability of slopes, for the determination of the seepage through the body of embankments and under the foundation of dams; they are the basis of the theory of consolidation of clay layers. So, ever since, Boussinesq who seems to have been the first to draw theoretical inferences from the fruitful observations of Darcy, the expounding and the study of the implications of these laws have given rise to important developments. We only refer to:

Darcy et Ritter - Les fontaines publiques de la Ville de Dijon; 1856.

Boussinesq - Recherches théoriques sur l'écoulement des nappes d'eau infiltrées dans le sol; C.R. Académie des Sciences 1903.

Sauvage de St. Marc - Ecoulement en milieux poreux-; Houille blanche 2.1947.

J. Mandel - Note cur le calcul des infiltrations; Annales des Ponts-et-Chaussées Juillet 1939.

For the greater part the authors have applied themselves to determine the velocity field assuming that the filter material may, on macroscopic scale, be considered as homogeneous and isotropic. The application of Darcy's law leads under this twofold condition to interesting conclusions, permitting in the particular case of two-dimensional planes the use of the attractive tool of the theory of analytic functions and giving rise to striking hydrodynamic or electric analogies.

The aim of the present paper is different. Starting from the law of Poiseuille we intend in fact to determine the nature of the physical coefficients upon which depend both the field of velocities and that of the hydrodynamic forces acting on the solid particles of the filter material, and to establish the general laws to which these two fields are subjected.

The absence of any particular assumptions regarding the nature of the filter material concerned - in general we suppose this to be heterogeneous and anisotropic on macroscopic scale - leads us to make use of the theory of matrices (1) by means of which the results obtained appear in a very simple shape and are easily applicable to practicle problems.

(1) Following the notations of the course of mechanics at the Ecole Polytechnique given by M.Ch. Patrier (years 1945-1946 and 1946-1947) and used by the various sections of this school.

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