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SUBTERRANEAN EROSION IN CLAY

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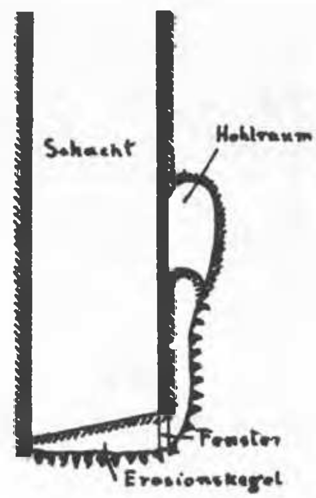
The mechanics of subterranean erosion in quicksand are well-known and have already been described, 2) whereby it was shown that in the case of underground water springs the individual grains of sand are washed away so that subterranean cavities are formed in retrogressive direction. However, analogous effects take place occasionally in clay, i.e. whenever the clay by nature contains fissures or this becomes the case as the result of some previous influence as e.g. lowering of the ground in mining sites, landslides, or building work. In such cases the originally coherent clay layers may dissolve into a mass of small clay cubes without any coherence, within which erosion is possible,which takes place in a manner similar to that in the case of quicksand.
When sinking a shaft in the coal district of Moravska Ostrava a layer of meagre clay 380 m thick was to be penetrated, within which there were very thin layers of sand and "mo". As soon as a depth of about 80 m was reached, the ring of the shaft was not closed but a crevasse was left open in order to house a pump. When the next ring was being excavated, the walling of the shaft gave way towards the interior, and a pulpy mass of clay oozed slowly from the window, until the bottom of the shaft was filled up to the upper edge of the window. In the course of this process the individual clay cubes were severed from the wall and after they had fallen to the ground it was possible to see the reflection of the water on the walls, which slowly trickled down the walls. The hollow formed behind the walling of the shaft began to move in an upward direction along the walling, after the process had been completed by filling up the window, so that when closed by injection of cement it was located by means of drilling aper-



tures through the walling and was located in a height of 15 to 20 m above the upper edge of the window. (See illustration).
Such erosions are found also at the foot of clay layers formed as the result of a slide, in which case mostly springs emerge having considerable hydraulic gradients, which may lead to the formation of hollows if the deposits of eroded material is continually removed as e.g. by a river.

REFERENCES

1) Bernatzik: Baugrund und Physik, Zürich 1947
2) Bernatzik: Beitrag zut Frage der unterirdischen Erosion im Sand Deutsche Wasserw. 1938 H. 4.

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FILTER WELLS AND DUPUIT'S FORMULA

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SUMMARY OF THE FRENCH REPORT

The calculation of the flow of a filter-well is very easy if Dupuit's formula is used. The latter gives very precise results in the case of captive groundwater; in the case of ordinary groundwater however, the results are only approximate. As this approximation is not very well known, several authors like MUSKAT, VIBERT and JAEGER have written against the use of this formula.

The methods they advocate are much more complicated and this prevents them from being used in the calculations aimed at lowering the water table by means of several filter-wells, whereas Dupuit's method remains still easily applicable. There only remains to determine the conditions under which it can be applied, taking as starting point pumping from a single well-point.

It is possible to establish this latter formula, assuming the free surface of the water-table to be horizontal, that is to say a groundwater with no run-off.

The potential theory gives us a definite right to apply this formula when the water-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 1×10^{-3} and 5×10^{-3} m/sec (3.048×10^{-3} ft/sec and 15.240×10^{-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.