PROPOSED METHOD FOR FIELD MEASUREMENT OF PERMEABILITY OF SOIL BELOW THE WATER TABLE

Don Kirkham

In the design of a drainage system for waterlogged land, the most important soil constant required is that governing the rate of flow of water through the soil, the permeability constant. Among other factors that should be known are knowledge of the rainfall rate, surface runoff, infiltration capacity, the location of impermeable layers, underground drain passages, and underground sources of water.

Present laboratory methods used in measuring soil permeability require that a soil sample be taken from the field and placed in one of several kinds of apparatus for test (1, 7, 14, 17, 18). The disadvantages of the laboratory methods are that the soil sample is of necessity relatively small and that, in obtaining the sample from the field and preparing it for the apparatus, its properties may be considerably changed (2) due to entrapped air alone by as much as 3,000% (5). The change in properties occurs especially in samples which must be obtained in the region below the water table, the very region in which the permeability measurement is desired.

Certain field methods have been proposed for determining soil permeability (1). For example, a long ditch may be cut alongside a pond and the seepage to the ditch measured to determine the permeability of the soil between the pond and ditch; or a system of drain lines may be installed and the rate of discharge measured. The disadvantage of these methods, assuming that correct theoretical formulas are at hand to relate the permeability to measured quantities, is the labor involved. Further, such installations should ordinarily not be made without first making permeability measurements.

In the search for a practical method to determine the permeability of soil in the field, the use of circular cylinders sunk vertically into the soil suggests itself. Such cylinders have been used in infiltration measurements (3, 11). In the present method, use of a cylinder is also proposed, but the method differs from the infiltration tests cited in that the cylinder is sunk below the water table and that the soil normally enclosed within the cylinder is removed. The region of capillary flow is thus eliminated, and when water is passed through the cylinder it flows outside into saturated soil, a region where Darcy's law is valid and hence established potential theory is applicable. Recognizing that definite boundary conditions are at hand, a theoretical solution relating the permeability to the measured rate of water flowing through the cylinder is determined.

The proposed method is illustrated in Fig. 1. A cylindrical pipe of inside radius \( R \) is inserted snugly in an augur hole bored vertically into the soil to a depth \( d \) below the water table, the pipe extending a suitable distance above the bottom of the test hole. The pipe is filled with water to a level \( l_1 \). Two cases are to be distinguished. Case I: The level \( l_1 \) is maintained by supplying water at a constant measured rate through a water meter \( M \). Case II: The source of water is shut off by a cock and the length of time for the water level to fall to a height \( l_2 \) is observed. The levels \( l_1 \) and \( l_2 \) are both measured from the bottom of the test hole.

The formula applicable in case I is

\[
k = \frac{M \mu}{\gamma g A(R, d)(l_1 - d)}
\]

where

- \( k \) = permeability of the soil,
- \( M \) = rate at which water flows through the water meter to maintain the water level in pipe to a height \( l_1 \),
- \( \mu \) = viscosity of the soil water at the soil-water temperature in question.