The Movement of Water in Soil Columns and the Theory of the Control Section

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THIS paper will present the results of an experiment on the movement of water downward in confined 6-foot soil columns of undisturbed structure; it will show the infiltration curves from the beginning of application of water until percolation began at the bottom, and the percolation curves for an extended period thereafter; and it will give data on the degree to which the columns had become saturated at the end of the period of wetting. All of this will constitute part I of the paper.

Part II will deal with the theory of percolation; a formula will be developed for the percolation of a heterogenous column which will involve the percolation coefficients of all the layers that comprise it; data will be presented to illustrate the validity of this formula, and the application to problems of impervious layers within the profile or at the surface will be discussed.

PART I — EXPERIMENTAL

PROCEDURE

The soil used in this study was Marshall silt loam from a moderately sheet-eroded field in Douglas County, Neb. In profile characteristics it was reasonably typical of the Marshall silt loam, friable subsoil phase, that is so prominently and widely distributed over the loess hill section of eastern Nebraska. The upper 4 feet at the time the columns were taken were medium moist except at the immediate surface, which was dry. The lower 2 feet were extremely dry.

At the site chosen for isolating the columns, two heavy anchor augers were sunk, and a heavy beam was attached across from one to the other. Alongside the beam and about 10 inches away from it, an excavation was started, and beneath the beam a sharpened 4-inch brass cylinder of 1/3-inch wall thickness and 6-inch length was sunk to its exact full length by the pressure of a hydraulic jack. After excavating around it, the cylinder was cut loose at its exact bottom with a fine steel wire. Then a second cylinder was set on the same spot and sunk its full length, and cut loose, and so on down as the excavation was deepened, until 12 cylinders per column had been removed, capped, and labeled. Two columns 4 feet apart were isolated simultaneously. The cylinders all had been previously coated smoothly inside and out with paraffin. This allowed sinking without friction or compaction as evidenced by the fact that the total depth of excavation was 6 feet to within 1/2 inch. Another advantage of the paraffin in experiments such as this is that soil becomes bedded into it on standing, and thus wall cracks are eliminated.

At the laboratory, any imperfections in the cut ends of the sections were repaired with bits of crushed soil from the various levels involved, samples having been taken at those levels for this specific purpose. Imperfections that required repair were never serious. Also, all indications of sealing of the surface as a result of cutting with the wire were carefully trimmed or brushed away. At this stage all cylinders were weighed. Then the column was rebuilt to its original length. Starting with the lower section, the bottom was fitted with a rigid screen and a cap of muslin, and this stood in a funnel. Then the top was dusted with powdered, dry soil from its own depth in the pit; the next section was set upon it and attached to it with a binder (a section of auto-tube) and metal bands secured tightly with screws, and so on upward until the top had been attached. Finally, the top was fitted with a reservoir for water and with a pad of wet cloth to prevent drying at the surface.

The procedure of watering was as follows: at early intervals, distilled water was applied by hand as it would soak away. Later the water was continuously from an inverted graduate fitted at the small, short-stem funnel with a wick through the graduate being supported with its funnel barely in contact with the surface of the cloth pad. Thus the graduate would be read and refilled as necessary. When the water began to drip from the bottom of the column, readings were made simultaneously — intake at the top of percolate at the bottom.

At the conclusion of watering, a period of overflow was allowed; then each column was divided into an upper 4-foot section, and later on the 4-foot sections were divided into two 2-foot sections. This was for purposes which will be discussed in part II. Finally, after moderate periods of jointed drainage to facilitate handling, the columns were watered to the point of drip, weighed, oven dried, reweighed, and emptied, and then the cylinders were weighed and volume determined. Thus, all the data were obtained for computing the original and final conditions of weight, moisture, and volume.

RESULTS

Fig. 1 shows the infiltration graphs (A), percolation graphs (C) for the periods of discharge from the bottom of percolation graphs (B), that is, the excesses over percolation.

Considering that the two columns were simultaneously from apparently uniform soil from the same pit, and only 4 feet apart, and practically identical in volume weight, initial and void capacity, either total or free (Table 1), the extreme dissimilarity in the moisture movement is unexpected and remarkable. The only reason is that the infiltration and repletion graph are linear and the percolation graphs are strongly curved. Column 1 absorbed and retained a total of 15.13 inches; it began to drip after absorption of 15.13 inches at 19.0 hours. Column 2 absorbed a total of 15.77 inches, and began to drip after absorption of 15.13 inches after 41.6 hours.