EXPERIMENTAL STUDIES ON TRANSIENT BEHAVIOR OF CAPILLARY ZONE*

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ABSTRACT

In the analysis of the groundwater flow problems in unconfined aquifers, by considering the water table as the upper boundary of the flow system, the flow above the water table including the capillary zone was neglected until very recent years. On the other hand, when analyzing the unsaturated flow problems, the soil physicists consider the water percolation in the vadose zone (including the capillary zone) in vertical direction. Beside these problems, in subsurface flow studies, it is usually observed that the discharge rate and the water table position fluctuate during the rainfall events.

To investigate these problems, laboratory experiments were performed on Toyoura standard sand. The models for these experiments consist of a sand tank model, rainfall simulator and the ponding equipments. To analyze the behavior of flow in the capillary zone due to the water table movements, initial drying and boundary wetting experiments were conducted. For the investigations of the behavior of flow in the capillary zone due to the infiltration process, the rainfall and ponding infiltration experiments were carried out.

While performing the experiments under the water table movement, it was observed that with the development of suction in the outlet zone of the flow system, the upper bondary of the saturated capillary zone was acting as the upper boundary of the flow region. Moreover, during these experiments, it was found that the saturated capillary zone acts as a siphon for the water movement above the water table. Thus the capillary siphon flow concept was realized as a physically existing phenomenon.

On the other hand, when the behavior of capillary zone in response to infiltration was studied, it was found that the water in the vadose zone moved vertically down to the upper boundary of the saturated capillary zone. Therefore, the upper boundary of saturated capillary zone carries significant characters in subsurface flow studies.

Further it was clearly noticed that if the entrapped pore-air is compressed downward by the infiltrating water, the entrapped pore-air pressure gradually builds up to the air entry value of that soil material. At the final pressure build-up stage, the entrapped pore-air escapes from the soil profile and thereafter the flow system acts as an unconfined one with regard to the pore-air pressure build-up. During the entrapped pore-air pressure build-up, the water table and the discharge rate rise temporarily. This leads to understand that the entrapped pore-air is one of the main causes of pulsation in the discharge rate, the water table position and in the pressure head of the soil water systems. To reveal such a transient behavior, certain time is required for the displaced pore-air to become continuous in the soil profile. Eventually the time required for this purpose depends on the soil type, the boundary conditions of the flow system, the rainfall intensity and its duration.

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