

TRANSIENT CHANGES DURING INTERMITTENT SURFACE PONDING IN A POROUS MEDIUM

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The phenomenon of water movement in fine and coarse soils has been explained either on the basis of laboratory experiments (Watson, 1967; Staple, 1970), or on the basis of numerical analysis using digital computers (Watson, 1971; Watson and Curtis, 1975; Banerjee, 1983). These workers studied the manner in which water moved through the soils in simulated conditions restricted to single infiltration event followed by a redistribution event. The present paper deals with the vertical soil water movement in a porous material (sand) during intermittent surface ponding condition.

The vertical soil water movement was studied for the 'zero head' ponding condition with magnitude of the applied surface flux either greater than or equal to the hydraulic conductivity at saturation. The water movement during intermittent surface ponding was recorded in a semi-infinite profile with a uniform initial water content. The intermittency extending over two cycles (including $2\frac{1}{2}$ min infiltration and $3\frac{1}{2}$ min redistribution events) was found to be sufficient to demonstrate the water content profile development in the porous material.

The basis of the numerical analysis was to solve the flow equation by a finity difference scheme under suitable initial and boundary conditions. The flow equation can be expressed as

$$\bar{C}(h) \frac{\partial h}{\partial t} = \frac{\partial}{\partial z} \left[K(h) \frac{\partial h}{\partial z} \right] + \frac{\partial K(h)}{\partial z} \quad (1)$$

where $\bar{C}(h)$ is the specific wate capacity, h the soil water pressure, t is the time, z is the depth (measured positive upwards), and $K(h)$ is the unsaturated hydraulic conductivity.

The values of $\bar{C}(h)$ and $K(h)$ are accounted from the soil water characteristic curves the $h(\theta)$ and $K(\theta)$ relationships. The details of the numerical solution of the flow equation have been described by Watson (1971) and Banerjee (1986).

The top boundary condition for sand was specified as that of 'zero head' ponding of water, hence, at the surface $h=0$, $t=0$. Implicit in this boundary condition formulation is the assumption of an adequate supply of water such that the infiltration demands of the sand were always met. The ponding condition was initiated three times. The profile was assumed to be semi-infinite with an initial water content value as $0.055 \text{ cm}^3/\text{cm}^3$ and an initial soil water pressure value as -90 cm .

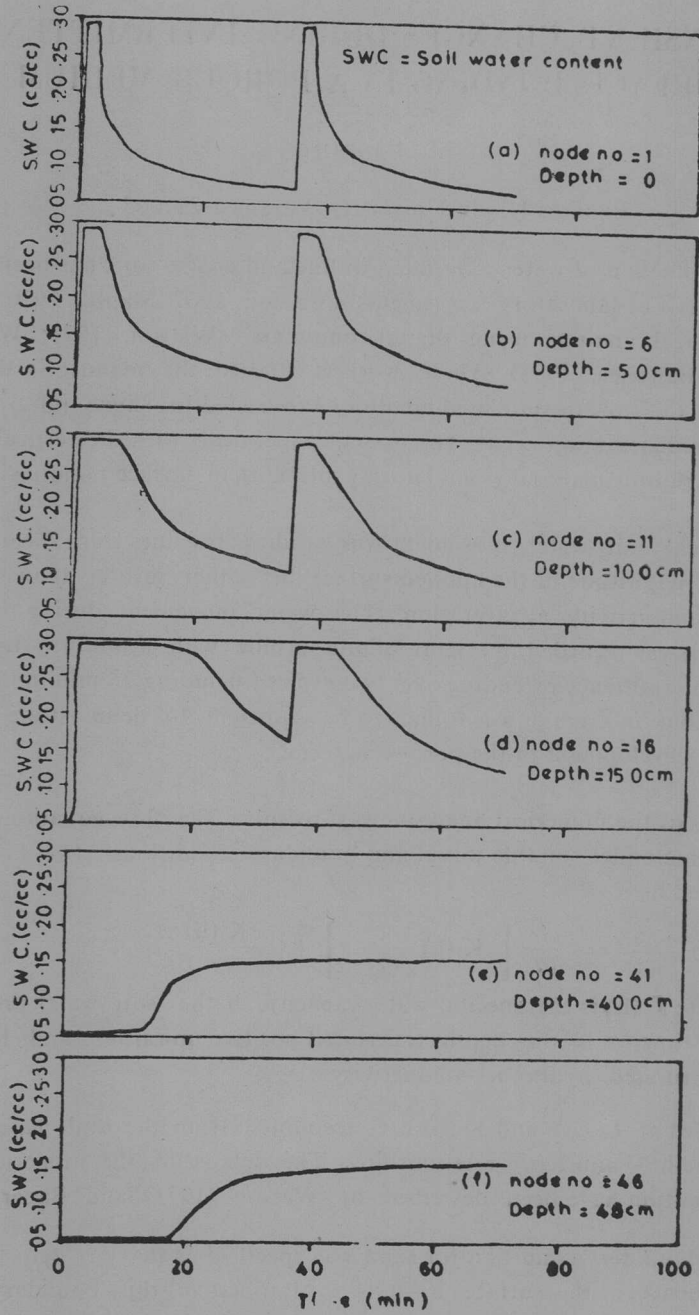


Fig. 1. The $O(Z, t)$ variations for intermittent 'zero head' ponding condition.

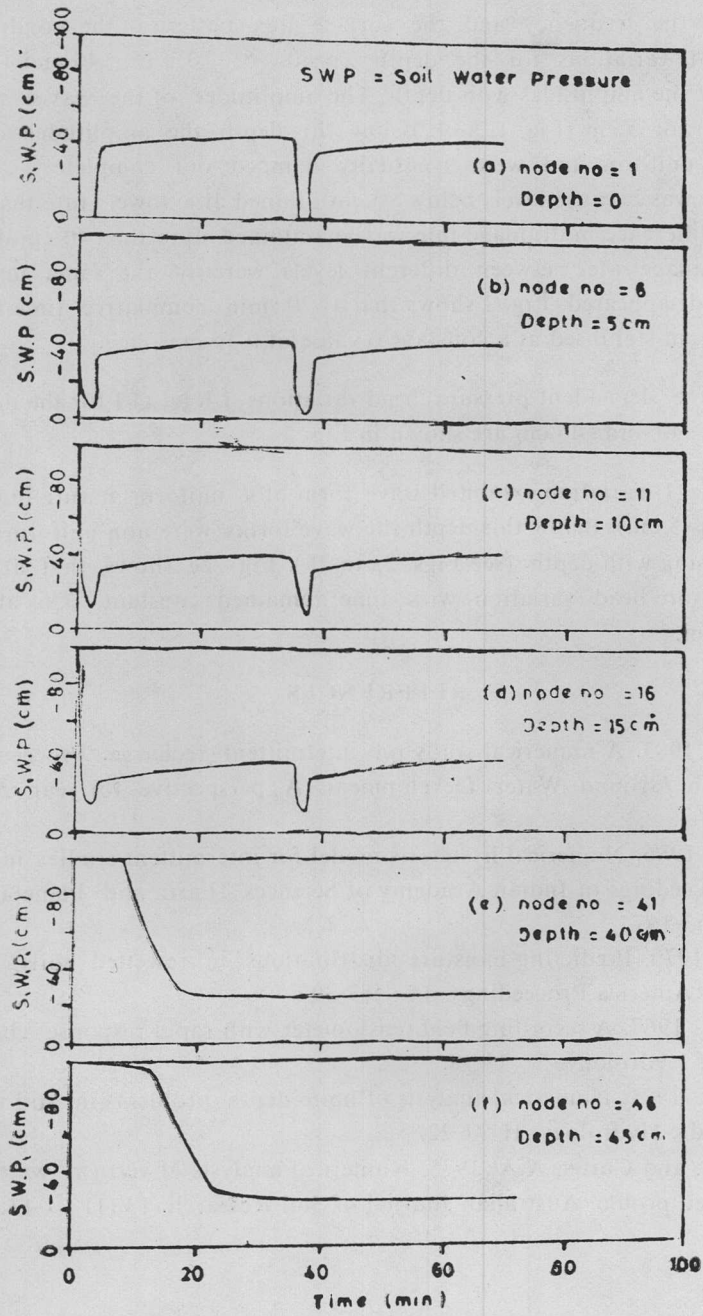


Fig. 2. The $h(Z, t)$ variations for intermittent 'zero head' ponding condition.

The transient water content variations $\theta(z, t)$ show a particular wave form governed by the frequency and the surface flux pattern of the ponding condition (Fig. 1). $\theta(z, t)$ variations for the depth $z = 0, -5, -10, -15, -40$ and -45 cm show a damping of the amplitudes with depth. The amplitudes of the waves were uniform upto a depth of -5 cm (Fig. 1, a-c). Below this depth the amplitudes of the waves became non-uniform and were eventually damped out completely at a depth of -40 cm. This was because levels below -5 cm drained at a lower rate than the upper levels. This difference in drainage rate was maintained upto the -40 cm depth. Thereafter, the drainage rates between different levels were of the same magnitude and hence waves disappeared. Fig. 1 shows that at 20 min cumulative time the level at a depth of -45 cm stabilised at a constant θ value of $0.16 \text{ cm}^3/\text{cm}^3$.

The time dependent pressure head variations [$h(z, t)$] for the depths $z = 0, -5, -10, -15, -40$ and -45 cm are shown in Fig. 2.

The $h(z, t)$ variation exhibited wave form of a uniform nature but for shallow depths (upto -5 cm). Below this depth the wave forms were non-uniform with amplitudes decreasing with depth (see Figs. 2a to 2f). Fig. 2e shows that at a depth of -40 cm, pressure head variation with time remained constant. This also occurred for $z = -45$ cm.

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