International Journal of Agricultural Engineering, Vol. 3 No. 1 (April, 2010) : 77-82

Research Paper :

Rise and decline of water table in response to linearly decreasing replenishment rate

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Accepted : ***February, 2010***

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ABSTRACT

The transient drainage for two layered soil, when the initial water level in the ditches was at interface of the layers has been studied. The flow system in the layered soils has been described by Boussinesq's equation in the form of the Girinsky potential. The analytical solutions were derived to describe rise and decline of water table in response to time varying replenishment rate for linearly decreasing replenishment rate. The Laplace transformation was used to obtain the solution with initial and boundary conditions. The two layered drainage problem was also investigated on a simulated vertical Hele-Shaw model for the validation of theoretical solutions. The comparison of results of observed and computed water table at mid point was found to be in good agreement for the entire duration of the experiments for linearly decreasing replenishment rate. From the comparison, it was also revealed that the solution for layered soil gave more accurate results as compared to homogeneous soil with weighted average hydraulic conductivity (WAHC). Hence, the proposed solutions can be used for the design of drainage system or flow through the aquifer of two layered soil.

Key words : Subsurface drainage, Two layered soil, Drainage, Replenishment rate, Water table

Most of the drainage theories available in literature attempt to describe water table behaviour in response to uniform percolation related to flat lands have been developed by obtaining the solution of partial differential equations derived by Boussinesq's equation (1877, 1904), which is based on Dupuit-Forchheimer assumptions and potential theory. Massland (1959) analysed the problem of water table fluctuation in response to constant recharge, intermittent constant recharge and intermittent instantaneous recharge. Sewa Ram and Chauhan (1987 a and b) obtained transient solutions for water table rise in a sloping aquifer receiving time varying recharge and lying between two parallel ditches reaching up to impermeable layer. The solution was obtained for linearly decreasing replenishment rate with time.

Many investigators such as Chieng and Uziak (1991), Sharma *et al.* (1991), Kumar and Chauhan (1999), Sharma *et al.* (2000) presented analytical solutions for steady or unsteady state condition of layered soil. Some earlier cited workers also conducted experiments on Hele-Shaw model to verify their theoretical investigations. Khan *et al.*, 1989 and Kumar, 1998.

Thus, the objective of the present paper is to develop analytical solution for unsteady state rise and decline of water table under linearly decreasing replenishment rate for two layered soil, when the initial water level in the interface of layers.

Problem formulation:

The assumptions considered for formulating the mathematical problem are given below:

– The soil consists of two layers that are unconfined, homogeneous and isotropic within themselves.

– The phreatic surface lies over a flat impermeable bed.

– Dupuit-Forchheimer assumptions are valid.

– The generalized Boussinesq equation is valid for a stratified aquifer.

– The drainage system consists of equally spaced open ditch drain reaching upto impervious layer.

–The initial water table is at h_0 for t = 0 and $0 \leq x \leq L$.

The flow system in the drains under unsteady state condition is taking place due to variable replenishment rate. The Boussinesq's equation for unsteady state flow, in the form of Girinsky potential is written as below:

$$\frac{\partial^2 \theta}{\partial x^2} = \frac{1}{k'}\frac{\partial \theta}{\partial t} - R \qquad (1)$$

where,

R = Recharge rate per unit surface area

$$k' = \frac{1}{f}\int_0^h K(Z) \cdot dz \qquad (2)$$