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Research Paper :

Study of subsurface drainage of two layered soil with exponentially declining replenishment rate

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ABSTRACT

The transient drainage for two layered soil, when the initial water level in the ditches is 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 exponentially declining 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 were found to be in good agreement for the entire duration of the experiments for exponentially declining 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

Subsurface drainage has a very important effect on agriculture productivity because of draining the excessive water on time. It provides aeration, and prevents water logging and salinization of the plant root zone. Subsurface drainage is a measure, which controls the rise of water table as a function of time and quantity of water to be removed and plays an important role in lowering of water table in case of excess irrigation and recharge due to rainfall..

Most of the drainage theories available in literature attempt to describe water table behaviour in response to uniform percolation related to flat lands and have been developed by obtaining the solution of partial differential equations derived by Boussinesq's equation (1877 and 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 (1987a) 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 exponentially declining replenishment rate with time.

Many investigator such as Chieng and Uziak (1991), Sharma *et al*. (1991), Shiv Kumar and Chauhan (1999), and 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. Some of these are Khan *et al*. (1989), and Yognedra Kumar (1998).

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

Problem formulation:

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

– The soil consisted of two layers that were unconfined, homogeneous and isotropic within themselves.

– The phreatic surface lied over a flat impermeable bed.

– Dupuit-Forchheimer assumptions were valid.

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

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

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

The flow system in the drains under unsteady state condition was taking place due to variable replenishment