Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Agricultural Water Management 82 (2006) 210–222
Agricultural water management
www.elsevier.com/locate/agwat

Falling water tables in a sloping/nonsloping aquifer under various initial water table profiles

R.M. Singh [a], K.K. Singh [a,1], S.R. Singh [b,*]

[a] *Department of Irrigation and Drainage Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Dist. Udham Singh Nagar, India*
[b] *Department of Mathematics Statistics and Computer Science, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Dist. Udham Singh Nagar, India*

Accepted 4 June 2005

Abstract

An analytical solution for the Boussinesq equation using Werner method of linearization have been obtained to describe falling water table between two parallel drains installed at sloping/nonsloping aquifer for flat, parabola and elliptical initial water table profiles. Midpoints of falling water table between parallel drains obtained from proposed analytical solutions for these initial conditions were compared with both the laboratory and field data. Midpoint water tables obtained from various solutions for nonsloping aquifer were also compared with the result obtained from Boussinesq exact solution using parameters of a drainage experimental site. Tchebycheff norm was used to rank the performance of the proposed solutions. It was observed that the proposed analytical solution for elliptical initial water table profile provides a better result as compared to other solutions and found to be more realistic in modeling the falling water profile.

Keywords: Watertable; Sloping; Nonsloping; Aquifer; Boussinesq equation

* Corresponding author. Tel.: +91 5944 233343; fax: +91 5944 233473.
E-mail addresses: singhkeke@yahoo.com (K.K. Singh), singh_shivaraj@rediffmail.com (S.R. Singh).
[1] Tel.: +91 5944 233675 (R)/233307 (O)/233413 (O), fax: +91 5944 233473.

0378-3774/$ – see front matter © 2006 Published by Elsevier B.V.
doi:10.1016/j.agwat.2005.06.003

1. Introduction

Most of the subsurface drainage theories related to sloping or nonsloping land have been developed using Boussinesq equation (1904), based on the principle of continuity and Dupuit-Forchheimer assumptions. Further in most of the transient flow studies, the water table between drains was assumed to be a flat surface at the start of each drainage cycle between two drains except at the drains where the water table drops suddenly to zero, which occurs in the situation when the drains are put into operation for the first time or after a very long period of time.

Dumm (1964) obtained an analytical solution of linearized Boussinesq equation assuming the initial water table described by a fourth degree parabola. Moody (1966) obtained a numerical solution of the nonlinear Boussinesq equation considering drains to be lying some distance above the horizontal impervious layer with an initial water table profile that was described by fourth degree parabola. Dass and Morel-Seytoux (1974) obtained the solutions of one dimensional nonlinear Boussinesq equation by Galerkin finite element technique for three initial conditions: flat, and two types of parabola. Skaggs (1975) obtained numerical solution of Boussinesq equation for initially parabolic and elliptical conditions. Uzaik and Chieng (1989) presented a solution of linearized Boussinesq equation with initial condition in the form of an ellipse (approximated by the two negative exponential functions). Upadhyaya and Chauhan (2001) mentioned that initial shape of water table may be assumed flat, parabola or elliptical depending on soil characteristics. However, they obtained analytical solutions of the Boussinesq equation linearized by Baumann and Werner (1953, 1957) methods and numerical solutions for nonlinear form of the Boussinesq equation using finite difference, finite element and hybrid finite analytic methods, only for flat initial water table profile.

In real situation, a flat water table does not occur after the installation of parallel drains and thus a solution for initially parabolic or elliptical profile should be used for drain spacing. This is probably the case for drainage of irrigated lands and soils with higher hydraulic conductivity. Therefore, various initial water table profiles were being implemented for obtaining analytical solution of Boussinesq equation with Werner linearization for falling water table between drains in sloping/nonsloping aquifer. The objective of this study was to obtain analytical solutions of Boussinesq equation linearized by Werner method for different initial water table profiles to describe falling water tables between two drains lying on a sloping/nonsloping impermeable barrier. The midpoints of falling water tables for the above flow conditions obtained from various solutions were compared with laboratory and field data and the result obtained from Boussinesq exact solution.

2. Mathematical formulation of the problem

The physical problem of subsurface drainage considered for the present study is illustrated in Fig. 1. While formulating the boundary value problem for a falling water table between two parallel drains, it is assumed that due to previously recharge the water table has reached the land surface at the midpoint and it starts falling with drainage of the