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MODELLING OF SEEPAGE THROUGH EMBANKMENTS OF EARTH-FILLED RECAHRGE DAMS IN OMAN: STEADY AND TRANSIENT REGIMES

A.R.Kacimov[1], A. Al-Maktoumi[1], Yu.V.Obnosov[2]
[1]Department of Soils, Water and Agricultural Engineering, Sultan Qaboos University, Oman
anvar@squ.edu.om
[2]Institute of Mathematics and Mechanics, Kazan Federal University, Kazan, Russia

Abstract

Recharge dams in Oman, which so far have been operated in intermittent seepage regimes after flash floods, are currently considered for a permanent storage of tertiary treated waste water, with the reservoirs potentially filled more regularly. Consequently, we consider both steady state and transient Darcian seepage through an earth-filled embankment with a clay core, sandwiched by two highly permeable shoulders, from an upper reservoir towards a horizontal, constant head drain. For steady seepage we assume a homogeneous isotropic capillarity-free core and shoulders and for sudden fillings or drawdowns of reservoirs we implement the Green-Ampt model of capillarity. Following the analytic element approach, we consider seepage through the core conjugated with flow through the downstream (right) shoulder to compute a steady flow rate and the shape of the phreatic surface. As a collateral benefit of this solution, we show that the see water intrusion problem in a confined aquifer is mathematically identical with the dam problem, modulo rescaling of the physical sizes and complex potential function. We illustrate that the decrease of the core permeability causes a strong decrease of the flow rate, drop of the free surface position in the right shoulder and reduction of the "active" length of the drain, which has to intercept water seeped through the core. The drain gets clogged with time. The corresponding rise and downstream propagation of the phreatic surface is assessed. For a sudden emptying of the reservoir we used the Toth 2-D model of an instantaneous pore pressure field and the Lembke model of a parametrized phreatic surface draining through a seepage face and spreading laterally in an opposite direction along an impermeable levee bed. For a sudden filling of the dam, we study imbibition of a wetting front with the Nelson-Skornyakov limiting steady regime. Refraction of seepage at a wedge (conjugation zone of the core, shoulder and levee's base) is analyzed. Suffusion, colmatage, heaving, piping and other seepage-triggered phenomena affecting the embankment stability are discussed.

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