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EFFECT OF A VERTICAL FRACTURE ON HORIZONTAL UNSATURATED SEEPAGE FLOW*

HUANG Yong, ZHOU Zhi-fang
School of Earth Science and Engineering, Hohai University, Nanjing 210098, China, E-mail: hyong@hhu.edu.cn
YU Zhong-bo
State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Nanjing 210098, China
NICHOLL M. J.
University of Nevada, Las Vegas, NV, 89154-4010, USA

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Abstract: The movement of water flow in unsaturated fractured rock was investigated with the sandstone sample through experimental research and numerical simulation. The experimental results show that the arriving time of wetting front is delayed by the fracture, resulting in the increase of water saturation in the domain on the upstream side of the fracture, which will locally enhance water flow through the matrix. The numerical simulation with the finite volume method captures effectively these characteristics. The comparison between simulated and observed travel time and arriving time of wetting front shows that their difference are very small and the simulated results are in agreement with the observed results, which implies calibrated parameters are reliable and effective. Then according to the calibrated parameters, fractured models were established to examine how the change of large fractured aperture would affect the arriving time of wetting fronts, pressure heads and water saturation on the upstream and downstream sides of fracture.

Key words: vertical fracture, unsaturated flow, finite volume method, wetting front, water saturation

Introduction

Flied measured data show that there exist many fractures with large angle of dip in fractured rocks, whose angles are usually greater than 75°. These approximately vertical fractures have important effect on the groundwater and solute transport and often generate prevalent pathway in fractures, which makes the velocity of water flow higher than that of in rocks matrix. Hence, experimental and numerical studies on the impact of vertical fracture on hydrodynamics properties in variable saturated fractured rocks are of considerable significance.

There were some researches on groundwater and solute transport in single fracture, fractured network and fractured rocks with the experimental and numerical methods. An experimental model was designed by Zhan[1] to determine the relationship on capillary pressure-saturation and unsaturated hydraulic conductivity-capillary pressure in single fracture according to the experimental results in unsaturated porous medium. Glass et al.[2] provided two meso-scale experiments to study the hydraulic properties of fracture-matrix system in unsaturated fractured rocks, and obtained prevalent pathway of water flow. Hydraulic characteristics of single fracture in unsaturated flow was investigated by Vandersteen et al.[3] using the network theory with limestone sample. Movement of water flow in unsaturated fractured rocks was researched by Grace and John[4] with the sandstone sample. Results showed that fracture can enhance the velocity of water flow. Tan et al.[5,6] proposed new methods for calculating the concentration of solute and compared to experimental

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Biography: HUANG Yong (1974-), Male, Ph, D., Associate Professor