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Unsaturated Flow in Two-Dimensional Fracture Networks

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Abstract

Although considerable progress has been made in understanding unsaturated flow processes in a single fracture, our knowledge of unsaturated flow in fracture networks remains incomplete. In this study, we present a numerical investigation of steady flow behavior in two-dimensional fracture networks containing thousands of fractures within a 10 m × 10 m domain. Simulation results indicate that flow paths are generally vertical (as a result of gravity-dominated flow behavior), with subhorizontal fractures providing pathways for communications between vertical flow paths, inducing horizontal spreading of these paths. Although many fractures with small trace lengths do not contribute to the global flow through a fracture network, some of them are still connected to the major flow paths and thus contribute to the overall connectivity of the network. They may also considerably affect the interaction between fractures and the matrix. Based on our simulation results, we hypothesize that average spacing between flow paths in a layered system tends to increase with depth as long as flow is gravity-driven. We also discuss the concept of a capillary-barrier influence zone to describe seepage from fracture networks to underground openings (drifts). Our simulation results imply that three-dimensional fracture network models are needed for providing a more realistic evaluation of capillary-barrier effects.

Keywords: vadose zone, fracture network modeling, seepage