FINITE ELEMENT METHOD FOR SINGLE-PHASE AND MULTI-PHASE PARTLY SATURATED SUBSURFACE FLOW

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Climate change may result in a reduction of integrity and reliability of engineered slopes in general and dikes specifically, and can even lead to failure of the soil structures caused by pore pressure changes. This article addresses the saturated-unsaturated subsurface flow process and compares a single-phase flow formulation with a multi-phase flow formulation. The Richards single-phase model, which describes the flow of water only and assumes the gas phase to be stagnant, has been generalized to a multi-phase model, which describes the flow of the water phase and the gas phase simultaneously and computes pressure distributions in both phases. The effect of entrapped air under increased wetting conditions, the transport of water vapor in the air phase during longer periods of drought and the effects of gas production in engineered slopes, can then be simulated more accurately. Simulation of pore water pressure for a number of column tests show the differences in both modeling approaches. The examples indicate that for most cases, the single-phase formulation gives results that are very similar to the two-phase results, with less computational work. However, for some cases the multi-phase formulation is more robust.