NEW 3D ANALYSTICAL SOLUTION FOR MODELING TRANSIENT UNSATURATED FLOW DUE TO WETTING AND DRYING

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Abstract: This study presents a novel three-dimensional (3D) analytical solution to the Richards equation, which takes as a basis a linear unsaturated model that was previously proposed. Specifically, the partial differential equation governing the transient, unsaturated flow phenomenon could be solved when using specific constitutive hydraulic functions that linearize the problem. The new 3D analytical solution could also be simplified to two-dimensional (2D) and one-dimensional (1D) analytical solutions, which make possible the evaluation of water flow using the constraints relevant for field and experimental settings. Two general cases of transient moisture movement are simulated using the new analytical solutions. The first case involves a wetting process, in which the flow within the soil mass is triggered by the initial presence of a specific region within the domain that had been subjected to an increased volumetric water content (e.g., because of precipitation or irrigation). In this case, water flows under unsaturated conditions from the region of increased moisture to the surrounding soil mass. The second case involves the recovery of an unconfined soil mass (e.g., an aquifer) within which a limited region had been subjected to a decreased volumetric water content (e.g., because of a localized drying process). In this case, water flow occurs from the soil mass into the region characterized by an initially low moisture content. The solutions presented in the study can be implemented to address a broad range of applications, providing insight into the complex phenomenon of soil wetting and drying. In particular, the solutions highlight the relative impact of the advective and diffusive components of unsaturated flow processes in multidimensional transient problems.

Full reference:

Cavalcante, A.L.B., Borges, L.P.F., and Zornberg, J.G. (2019). “New 3D Analytical Solution for Modeling Transient Unsaturated Flow Due to Wetting and Drying.” International Journal of Geomechanics, ASCE, Vol. 19, No. 7, July.

Link to file*:

https://doi.org/ 10.1061/(ASCE)GM.1943-5622.0001461