Numerical analysis of desiccation, shrinkage, and cracking in low plasticity clayey soils

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ABSTRACT

This paper focuses on the numerical study of the desiccation processes of low-plasticity clayey soils that usually result in shrinkage and often in cracking.

For the theoretical development of the numerical model on which this paper is based, Unsaturated Soils Mechanics, classic Strength of Materials and concepts of Linear Elastic Fracture Mechanics (LEFM) are used to establish the necessary framework for formulating various phenomena such as water flow in deformable porous medium and cracking.

The mathematical formulation of the model and its implementation in a hydro-mechanical (HM) coupled model [1], based on the Finite Element Method (FEM) and Finite Difference Method (FDM) in a MATLAB environment are presented. The ultimate goal of this code is the numerical simulation of the flow and cracking in soils, for which the HM model and the node release technique is combined.

The code developed in this paper has been used to perform several numerical analyses on radial sections of cylindrical soil specimens subjected to drying processes. Simulations are made to reproduce numerically the process observed in the laboratory on soil specimens in cylindrical containers [2]. The objective of these simulations is to determine the mechanisms by which the soil shrinks and cracks during desiccation.

The results obtained with the model proposed show the capabilities of the approach to reproduce the main characteristics of this complex problem. The desiccation, shrinkage, and cracking are reproduced consistently during a desiccation cycle.

The model shows the crucial role of the boundary conditions in terms of displacement and suction for the development of a crack as a consequence of a tensile stress field in specific locations on the section analysed.

Finally, the model has revealed the necessity of further research in the study of the soil-container and soil-atmosphere interaction in order to reproduce with more accuracy the changes in the main variables.

Keywords: cracking, desiccation, shrinkage, flow in deformable porous media, fracture, numerical simulation.

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