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MULTI-PHYSICS MODELLING OF THE CONSOLIDATION PROCESSES IN VARIABLY SATURATED ELASTO-PLASTIC SOILS DUE TO HIGH TEMPERATURE

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The aim of this work is a numerical study of the consolidation processes in soils due to high temperature, performed in the framework of Porous media mechanics for fully coupled multi-phase porous media.

In recent years, increasing interest in thermo-hydro-mechanical analysis of variably saturated porous materials is observed, because of a wide spectrum of their engineering applications. An area of particular interest is Environmental Geomechanics, where some challenging problems are of interest.
In this area, soils and rocks need to be considered as multi-phase porous media in isothermal or non-isothermal conditions, in which the interaction between the components cannot be neglected. In case of liquid and gaseous fluids, capillary effects have to be considered, and phase change for liquid water and its vapour can play a role.
For enabling significant predictive simulations to be carried out, suitable physical and mathematical models have to be developed. Then, coupled Thermo-Hydro-Mechanical (THM) finite element codes are of paramount importance.

A step in the development of a suitable physical, mathematical and numerical model for the simulation of geo-environmental engineering problems is presented here.
In particular, a mathematical and finite element model for soils at high temperature [1] is developed and implemented in the finite element code COMES-GEO [2], [3], [4], [5] for the analysis of non-isothermal variably saturated deformable porous materials. The general ACMEG-TS thermo-elasto-plastic constitutive model for variably saturated soils [6] is adopted for the analysis of the THM behavior of the solid skeleton.
The numerical model results to be a fully coupled heat and multiphase flow model for elasto-plastic porous media. The porous medium is assumed to be a multiphase system where interstitial connected voids of the solid matrix may be filled with liquid water, water vapor and dry air. The general frame of averaging theories has been used in deriving the governing equations, [2]. Phase changes of water (evaporation-condensation, adsorption-desorption) and

heat transfer through conduction and convection, as well as latent heat transfer are considered. The governing equations are discretized in space and time by means of the finite element method.

The non-isothermal elasto-plastic consolidation processes in a Boom clay column [7] due to the temperature rise of the top surface from 30 to 150 °C is studied in detail, aiming to analyse the coupled thermo-hydro-mechanical behaviour of the material when the temperature in the column is above the boiling value and water phase change develops inducing variably saturated conditions.
The numerical results reveal the temperature increase over time in the column; desaturation starts from the top surface, triggered by a water vapour mass exchange with the ambient at a RH=95%. Then, when the temperature reaches the boiling value, phase change for the liquid water occurs and desaturation proceed much faster, developing high capillary pressures and inducing plastic strains, swelling and finally settlements reaching the steady state conditions.

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