THM modelling of multiphase geomaterials in dynamics at high temperature

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ABSTRACT

This work presents the development of a fully coupled mathematical and numerical model for the analysis of the thermo-hydro-mechanical behaviour of non-isothermal multiphase porous materials in dynamics, with application to the finite element simulation of strain localisation in sands.

The model is developed within the Hybrid Mixture theory [1] following [2]. The porous medium is treated as a multiphase system composed of a solid skeleton with open pores, filled with liquid water and gas. The solid is considered as deformable and non-polar. All the fluids are in contact with the solid phase. The constituents are assumed to be isotropic, homogeneous, immiscible, except for dry air and water vapour and chemically non-reacting. Local thermal equilibrium between the solid matrix, gas and liquid phases is assumed. Heat conduction, vapour diffusion, heat convection, liquid water flow due to pressure gradients or capillary effects and water phase change (evaporation and condensation) inside pores are all taken into account. In the partially saturated zones, liquid water is separated from its vapour by a meniscus concave toward gas (capillary water). In order to analyse the thermo-hydro-mechanical behaviour of soil structures in the low frequency domain, e.g. under earthquake excitation, the u-p formulation is advocated [3].

The standard Bubnov-Galerkin method is applied to the governing equations for the spatial discretization, while the implicit and unconditionally stable generalized Newmark procedure is used for the time discretization. The final non-linear set of equations is solved by the Newton method with a monolithic approach. The model has been implemented in the finite element code COMES-GEO, [1], [4], [5], [6], [7]. The implemented model is validated through the comparison with analytical or finite element quasi-static or dynamic solutions. Application to the simulation of strain localisation in initially water saturated sand samples including the effects of frictional heating is shown.

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