3D THERMO-HYDRO-MECHANICAL MODELING OF THE IN-SITU FEBEX EXPERIMENT FOR RADIOACTIVE WASTE DISPOSAL.

I. CAÑAMÓN*, F.J. ELORZA**, R. ABABOU***

* Departamento de Ingeniería Civil: Infraestructura del Transporte, E.U.I.T. Obras Públicas,
Universidad Politécnica de Madrid (UPM)
** Departamento de Matemática Aplicada y Métodos Informáticos, E.T.S.I. Minas,
Universidad Politécnica de Madrid (UPM)
*** Institut de Mécanique des Fluides de Toulouse, Institut National Polytechnique de Toulouse (INPT)

Abstract

This work presents a fully coupled Thermo-Hydro-Mechanical (T-H-M) model of a fractured granite formation located at the Grimsel Test Site (GTS, Switzerland), in the work frame of the FEBEX experiment [2]. FEBEX is an experiment to test the T-H-M behavior of a high-level nuclear waste repository in crystalline host-rock [3].

The aim of the preliminary simulations presented below is to reproduce the thermo-hydro-mechanic behavior of the fractured rock due to the heating caused by the radioactive waste disintegration. The macroscale continuum equations and coefficients are obtained by upscaling from the local conservation equations up to block scale, where each homogenized block contains ideally many fractures [1].

In this research we focus on the T-H-M rather than in the fractured medium simulation [2] and upscaling [1]. A set of 3D numerical experiments with different material conditions are presented. The simulations are performed using the Comsol Multiphysics® software.

The coupled continuum equations resulting from this model can be summarily described as a combination of Darcy's law and of Biot's poro-elasticity equations for saturated medium, together with the classical conservation equations for mass, momentum and energy, with the Darcy and Biot laws cast in their most general, anisotropic form. Compressibility and thermal expansion of fluid are also considered [4]. The continuum coefficients involved in these constitutive laws come from the homogenization or upscaling approach mentioned above.

The simulation domain is a block with the Geographic North oriented towards –X. The dimensions of the block are 70m x 100m x 70m, with the origin of coordinates in the center of block. There are three connected drifts: the Main tunnel, the Laboratory tunnel and the FEBEX drift, the last one being centered in the origin of coordinates. In the test zone of the FEBEX drift there exist a heating process defined here by a temperature gradient from 100ºC at r=0m to 35ºC at r=1.14m, where r is the radial direction in the FEBEX drift.

The FEBEX experiment has been simulated with this model, with a good agreement between measured and simulated values of the main variables.

The advantage of the continuum approach is that it can be used for modeling coupled T-H-M processes in the presence of many, variously oriented fractures, while a discrete fractures approach would become rapidly untractable as the number of fractures and their geometrical complexity increases.

References

1. Ababou R., A. Millard, E. Treille, M. Durin, and F. Plas : Continuum Modeling of Coupled Thermo-Hydro-Mechanical Processes in Fractured Rock. Comput. Methods in Water Resources, Kluwer Academic Publishers, A. Peters et al. eds. Vol.1, Ch.6, pp.651-658 (1994).
2. Cañamón, I. Analysis and modeling of coupled thermo-hydro-mechanical phenomena in 3D fractured media. Ph.D. Thesis. Universidad Politécnica de Madrid and Institut National Polytechnique de Toulouse (2006).
3. Huertas F. et al. Full Scale Engineered Barriers Experiment for a High-level Radioactive Waste in Crystalline Host Rock (FEBEX Project). Final Report. European Commission. Report EUR 19147 EN. 2000.
4. Noorishad, J., et al. Coupled thermo-hydro-elasticity phenomena in variably saturated fractured porous rocks: Formulation and numerical solution. Dev. in Geot. Eng.: Coupled T-H-M Proc. of Fract. Media (O. Stephansson, L. Jing & C-F. Tsang, eds.) 79: pp. 93-134. Elsevier. 1996.