

Thermo-Hydro-Mechanical simulation of a full-scale steel-lined micro-tunnel excavated in the Callovo-Oxfordian Argillite

Tourchi, S.* , Vaunat, J.* , Gens*, A., Vu, M.N.† , Bumbieler, F. †

* Department of Geotechnical Engineering and Geosciences
Universitat Politècnica de Catalunya (UPC)
Campus Norte UPC, 08034 Barcelona, Spain

† National Radioactive Waste Management Agency (Andra),
1 rue Jean Monnet, 92290 Châtenay-Malabry

ABSTRACT

The paper presents an interpretation of the full-scale HA-ALC1604 in situ heating test carried out on Callovo-Oxfordian claystone (COx) in the Meuse/Haute-Marne underground research laboratory (MHM-URL) (Armand et al. 2017). The MHM-URL is a site-specific facility planned to study a radioactive waste disposal in the COx (Armand et al. 2016). The thermo-hydro-mechanical (THM) behaviour of the host rock is significant for the design of the underground radioactive waste disposal facility and for its long-term safety. When subjected to thermal loading, the claystone COx of low permeability ($\sim 10^{-20}$ - 10^{-21} m²) exhibits a strong pore pressure response that significantly affects the hydraulic and mechanical behaviour of the material (Gens et al. 2007, 2013). The observations gathered in the in situ test have provided an opportunity to examine the integrated thermo-hydro-mechanical (THM) response of this sedimentary clay.

Coupled THM numerical analyses have been carried out to provide a structured framework for interpretation, and to enhance understanding of THM behaviour of COx. Numerical analyses have been based on a coupled theoretical formulation that incorporates a constitutive law especially developed for this type of material. The law includes a number of features that are relevant for a satisfactory description of the hydromechanical behaviour: anisotropy of strength and stiffness, behaviour nonlinearity and occurrence of plastic strains prior to peak strength, significant softening after peak, time-dependent creep deformations and permeability increase due to damage.

By performing the numerical analysis, it has been possible to incorporate anisotropy of material parameters and of in situ stresses. The performance and analysis of the in situ test have significantly enhanced the understanding of a complex THM problem and have proved the capability of the numerical formulation to provide adequate predictive capacity. A sensitivity analysis has also been carried out to examine the potential effect of various key or uncertain parameters.

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