A 2nd gradient Thermo-Hydro-Mechanical model to investigate gas transfer processes in low-permeable media

***G. Corman**[1], F. Collin[1] and S. Levasseur[2]*

[1]University of Liège, UEE research unit - Geomechanics and Engineering Geology, Quartier POLYTECH 1, Allée de la Découverte 9, 4000 Liège, Belgium

[2] Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS), Avenue des Arts 14, 1210 Brussels, Belgium

gilles.corman@uliege.be, f.collin@uliege.be

Keywords: Numerical Modelling, Excavation Damaged Zone, Strain localisation, Gas Migrations

Abstract

Nowadays, the deep geological disposal based on the multi-barriers confinement concept, is considered as one of the most promising solutions for the safe storage of radioactive wastes. Many Thermo-Hydro-Mechanical (THM) phenomena are likely to occur during the construction and the lifetime of the repository, which could alter the confining function of the different constituent layers.

Among these, the underground excavation process tends to create a so-called Excavation Damaged Zone (EDZ) in the surrounding of the storage galleries, where the mechanical and hydraulic properties are affected [1]. For instance, the hydraulic permeability is increased compared to the sound rock formation. Moreover, during the exploitation of the system, a certain amount of gases, such as hydrogen could actually be generated in the nearfield of the repository due to the anoxic corrosion of the metal components, and could potentially lead to the alteration of the host rock behaviour.

In light of this, the present work aims at developing a numerical tool within the finite element code LAGAMINE[1], able to reproduce simultaneously the development of strain localisation bands due to excavation and the multiphysical couplings associated with gas generation and migrations. This model includes on the one hand a THM part [2] to describe triphasic porous media under unsaturated and non-isothermal conditions. On the other hand, since the problem involving strain localisation is not well posed when modelled using classical medium, the local second gradient approach [3] is also integrated to the model. It helps avoiding the pathological mesh dependency by considering an enrichment of the continuum with microstructure effects through a regularizing internal length [4].

This model is subsequently used for reproducing two *in situ* gas injection tests[2] conducted in two distinct directions in the Boom Clay Formation, which is investigated by the Belgian National Radioactive Waste Management Agency (ONDRAF) as potential host rock for a deep geological disposal. The 2D plain strain simulations provide information about the fracture structure and permeability evolution due to the excavation (Figure 1), and about the stress state during a phase of pore pressures stabilization, and during a last phase of gas migrations (Figures 2 & 3).

[1] Developed at the University of Liège

[2] Experiments E4 and E5 performed in the framework of the MEGAS European project in the Underground Research Laboratory (URL) in Mol [5]

References

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Acknowledgement

The Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS), is gratefully acknowledged for its financial support of the work presented in this paper.

Figures

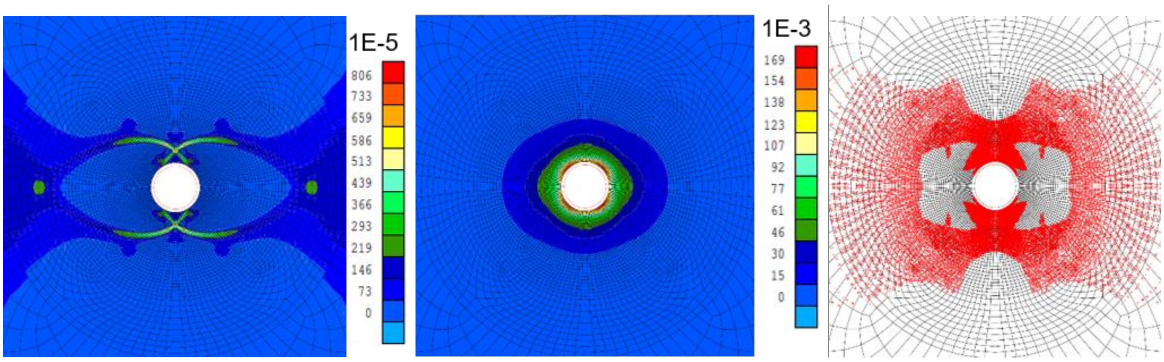

Figure 1 : *Evolution of total deviatoric strain (left), deviatoric strain increment (middle), and plasticity (right).*

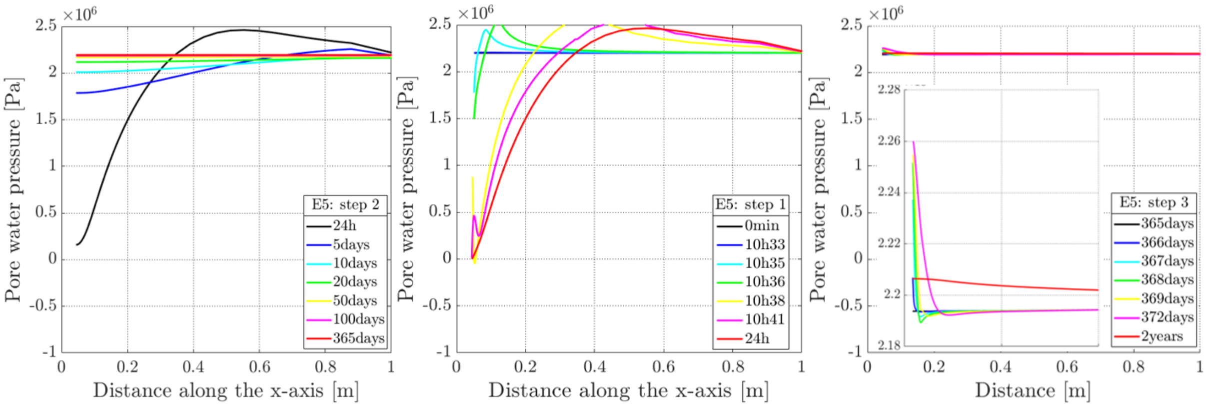

Figure 2: *Evolution of pore water pressures for excavation (left), stabilization (middle), and gas migrations (right).*

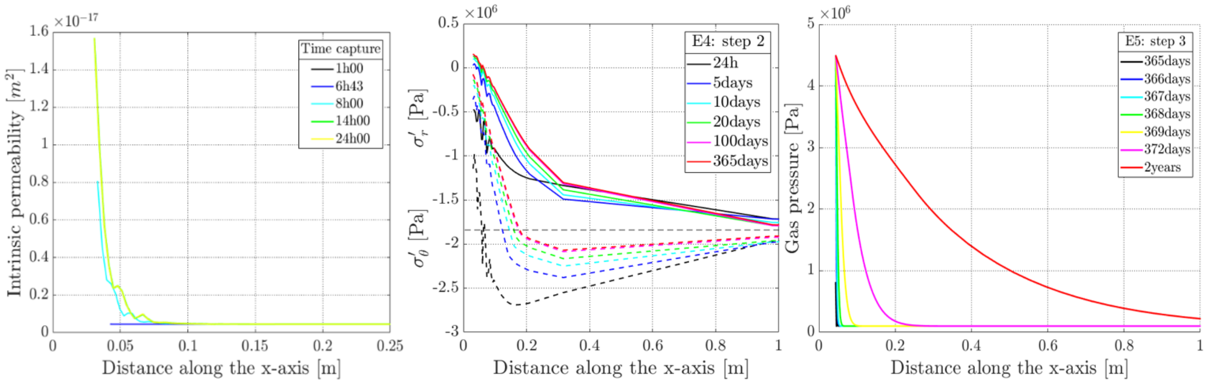

Figure 3: *Evolution of permeability (excavation - left), stresses (pressure stabilization - middle), ans gas pressures (gas migrations - right).*