Modelling the excavation damaged zone using a hydro-mechanical double-scale model

A.P. van den Eijnden[1], P. Bésuelle[2,3], F. Collin[4], R. Chambon[2], J. Desrues[2]

[1]*Delft University of Technology, Section of Geo-Engineering, Delft, Netherlands*

[2]*Univ. Grenoble Alpes, 3SR, 38000 Grenoble, France*

[3]*CNRS, 3SR, 38000 Grenoble, France*

[4]*ArGEnCo dept, Univ. of Liège, 4000 Liège, Belgium*

Abstract

The principle of deep geological repositories for the disposal of radioactive waste relies among others on the low permeability of the host rock. As the permeability is influenced by mechanical damage of the material, the coupling between hydraulic and mechanical behaviour of the host rock is of importance in the study of radioactive waste repositories. In this context an approach is investigated for the modelling hydro-mechanical coupled behaviour of Callovo-Oxfordian claystone, a potential host rock for repositories in France. The presented approach is a double-scale finite element method (FE^2) using a representative elementary volume (REV) to model the material behaviour at the micro-scale. The global response of this REV serves as a homogenised numerical constitutive law for the macro-scale, to be used in the modelling of the excavation damaged zone (EDZ) around the repository galleries.

The double-scale model

On the macro-scale, a poro-mechanical continuum is defined with fully coupled hydro-mechanical behaviour. Boundary value problems (BVP) are solved using the finite element method, regularized using a local second gradient model [1].

On the micro-scale, the microstructure of the material in the REV contains elastic deformable solids separated by cohesive interfaces, thereby allowing material softening with deformation. Additionally, the interfaces form a porous network allowing fluid transport prescribed by the variation in interface opening. With fluid pressure acting on the solid parts, this gives a coupled hydro-mechanical system at the micro level.

The two scales are linked in the framework of computational homogenization [4,2]. This technique provides a consistent scale transition, taking into account the homogenization of a granular microstructure to a macroscale continuum (Figure 1).

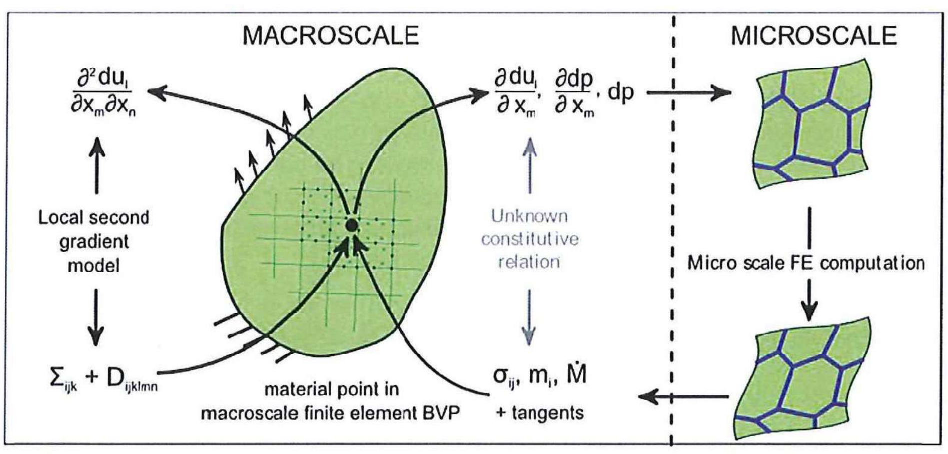

Figure 1: Outline of the double-scale model for hydro-mechanical coupling in the framework of computational homogenization with a poro-mechanical continuum at the macroscale and a granular microstructure with pore channels at the microscale [2].

[2] A.P. van den Eijnden, "Multiscale modelling of the hydromechanical behaviour of argillaceous rocks", *PhD Thesis*, Université Grenoble Alpes, France, 2015.

[3] A.P. van den Eijnden, P. Bésuelle, F. Collin, J. Desrues, "Modeling the strain localization around an underground gallery with a hydro-mechanical double scale model; effect of anisotropy", *under review*

[4] V. Kouznetsova, W.A.M. Brekelmans, F.P.T. Baaijens, 2001. "An approach to micro-macro modeling of heterogeneous materials". *Computational Mechanics* 27 (1), 37–48.

[5] D. Seyedi, G. Armand, A. Noiret, 2016. "'Transverse action' - a model benchmark exercise for numerical analysis of the Callovo-Oxfordian clay-stone hydromechanical response to excavation operations", *under review*