Champs sur Marne, February 15, 2017

PhD project

Modeling the time-dependent behavior of the fractured Excavation Damage Zone around deep underground galleries in claystone

Context

The excavation of deep underground galleries for the storage of radioactive waste in claystone (quasi-brittle rocks) induces a fractured zone around these galleries called EDZ (Excavation Damage Zone). The presence of the EDZ strongly affects the hydromechanical properties of the formation around the gallery and so the safety of storage. Therefore, both the genesis mechanisms of the fractures and their effects on the behavior of the formation are studied and analyzed in depth.

To model the EDZ behavior, the fractures must be represented both discretely, in order to make possible the analysis of their initiation and propagation, and globally in a homogenized or equivalent continuous model, in order to analyze their overall effect on the structure. The short-term behavior of the EDZ has been approached by experimental, theoretical and numerical methods. Equivalent continuous models of the fractured EDZ have been established based on numerical and theoretical approaches. But these models do not include the time-dependent effects that determine the long-term behavior of the structure. The time-dependent behavior of the EDZ results from both the viscous deformation mechanisms of the clay matrix and the viscous sliding on between the fracture surfaces. The viscous sliding on the fracture surfaces can have a significant contribution to the overall properties of the EDZ.

There is very little knowledge about the mechanical properties of fractures in claystone and less on their time-dependent behavior. Moreover, the analysis of the viscous propagation of fractures and the formulation of a homogenized model for a viscous and fractured medium pose both theoretical and numerical challenges.

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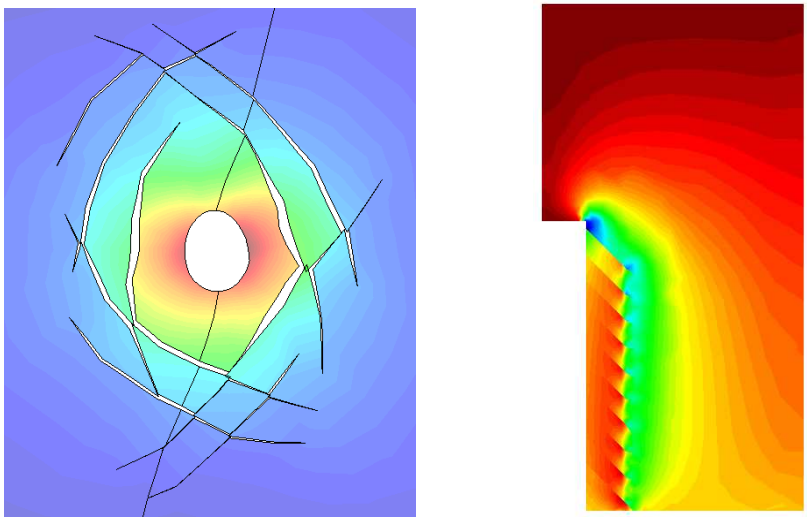
Research project

The proposed research project is mainly numerical but also includes an experimental part.

Experimental characterization of the fracture behavior will be carried out on samples in which a discontinuity has been created by mechanical fracturing. Creep tests under different loading conditions will be carried out. The sample will be instrumented in order to follow its global deformation as well as and its local deformation by field measurements. In particular, attempts will be made to identify and separate the contribution of glide along the fracture surfaces in the overall deformation of the sample.

The establishment of an equivalent continuous model for time-dependent behavior will be based on numerical simulation and theoretical approaches. Numerical tools for the simulation of viscous fracture media are available but an appropriate homogenization method based on relevant theoretical approaches using numerical simulation results has to be established.



Fractured EDZ around the opening, (left): view in the plane of the section, (right): in the radial plane

The final objective of this thesis will be to provide a predictive model of the time-dependent and especially the long-term deformation processes of the fractured EDZ. In particular, in the light of this model, the evolution of the loads applied to the lining support of the gallery will be examined to draw conclusions for its design.

The thesis will take place at Laboratoire Navier and will be supervised by Amade Pouya as a team with Jean Sulem, Siavash Ghabezloo and Michel Bornert. It will be financed by ANDRA (National Agency for Radioactive Waste Management). The PhD student will be an employee of ANDRA.
ANDRA requires that the doctoral student be of ***European nationality***.

The application must be submitted before 24 March 2017.

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