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Numerical modelling of shear banding around openings in clayey rocks. Application to URL dedicated to nuclear waste disposals

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Drilling galleries in clayey rocks creates generally EDZ – Excavated Damaged Zone. A number of experimental evidences have been proposed during the last 15 years, concerning URL of Mol, Bure or Mont Terri. The EDZ is generally composed of strain localised bands, partly in mode I, opening, partly in mode II, shearing.
Measurements of permeability in EDZ is not an easy task. However, they are clear evidences of permeability variation of several orders of magnitude.

The presentation deals with numerical modelling of EDZ development in Bure and Mol URL.

Strain localisation induces an ill-posed problem when using classical finite elements: shear bands thickness is mesh depending. Following Chambon and Collin (1998 & 2001), problem regularisation is achieved through a second grade model, adding in the virtual power principle micro-strain and micro-stress contribution. At micro scale, the constitutive law is linear elastic. The micro elasticity modulus is related to the band thickness. Thanks to this regularisation, the band thickness is now perfectly controlled.

Drilling numerically a gallery in Bure rock shows progressive shear banding and evolution through time of the EDZ size, reproducing a number of observed features (figure 1).

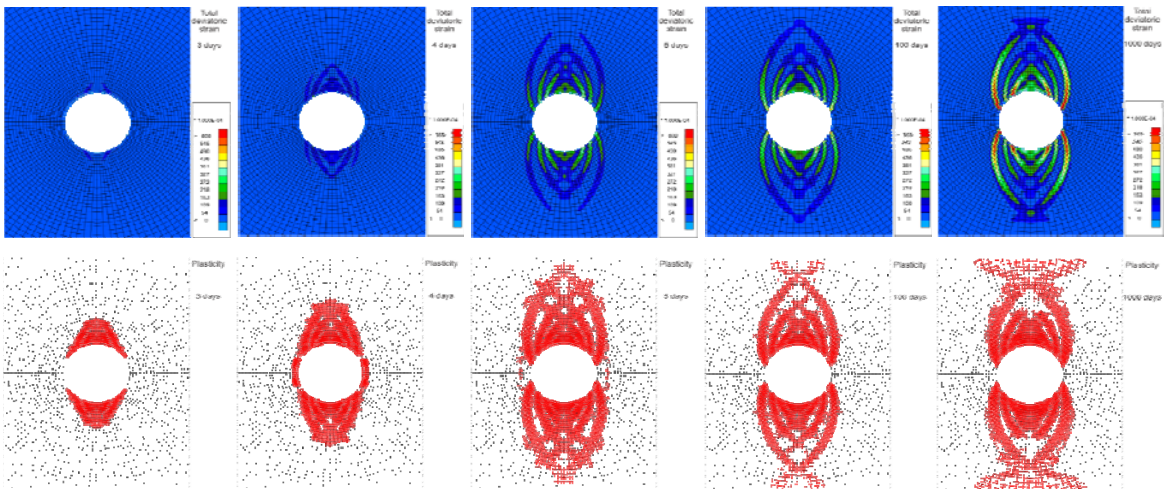

Figure 1: EDZ development for a Bure gallery

Water flow in rock mass and in EDZ depends on boundary conditions. Gallery wall is in contact with air, and ventilation is partly controlled in underground opening during operational phase. Boundary condition will be discussed and unilateral conditions may be a good compromise.

Permeability in EDZ evolves with strain localisation. Phenomenological laws may be used to model the permeability evolution with straining. They allow to better reproduce experimental observations. There is a clear evidence of water pressure variations between band and intact rock, showing the band effect on water transmissivity.

A second example deals with the connecting gallery in Mol URL. Similar results may be obtained. However, due to the differences in material (COX stiffer for Bure URL, Boom Clay smother for Mol URL), the gallery convergence is much higher and a liner is absolutely needed. Experimental measurement of strain or stress in liner elements is not simple and interpretation shows surprisingly oscillations. It is shown that shear banding explains the observed oscillations. Shear bands start before contact of clay rock with the liner. The contact pressure at the liner and rock interface (figure 2) is directly related with the shear bands scheme.

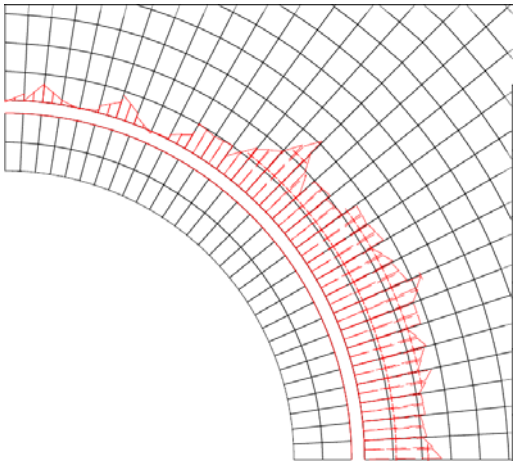

Figure 2: pressure at the interface rock – liner

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