CONTINUUM EQUIVALENT MODEL FOR THE FRACTURED EDZ AROUND UNDERGROUND GALLERIES IN CLAYSTONE

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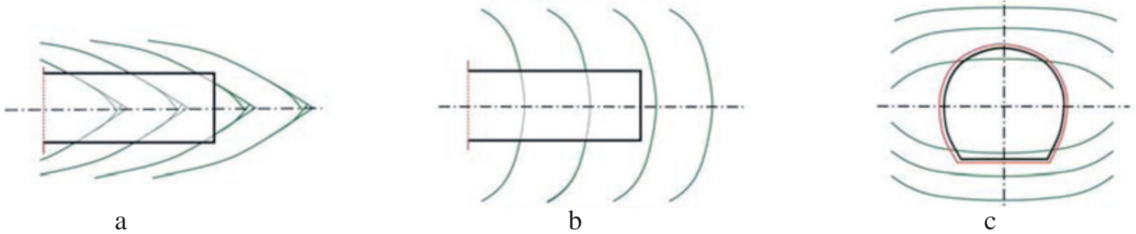
The Excavation Damaged Zone (EDZ) around the underground galleries excavated in claystone for the CMHM project, includes several zones showing different types of cracking and/or fracturing. In the vicinity of the wall, a fractured zone is observed that spreads out on a distance of about 1 m from the wall; at a larger distance from the wall one observes another zone with micro-cracks. The first zone, called 'fractured EDZ', includes different families of fractures with different geometries and origins. The main one consists of a family of shear fractures called 'chevron', that have approximately the shape of conical surfaces slightly flattened with respect to the horizontal plane (Figure 1, ANDRA 2008). The 'chevrons' observed in the galleries at 490 m depth in LMSMH are regularly spaced of about 50 cm to 1 m along the gallery's axis, make an angle of about 45° with this axis and extend to about 2 or 3 m beyond the wall depending of the size and orientation of the gallery. The fractures have a significant effect on the hydromechanical properties of the EDZ. The present work is focused on the effect of the 'chevron' fractures on the mechanical behaviour of the EDZ.



a b c

Figure 1: Geometry of the 'chevron' fractures : cut in vertical plane parallel (a) and perpendicular (c) the axis of the galeri and in a horizontal plane (b) (ANDRA 2008)

Due to the large number of fractures, introducing them individually to the modelling leads to heavy and not easy to handle numerical models and to long calculations. One is led to find some Continuum Equivalent Material (CEM) for the EDZ including the fractures' effect. The EDZ is not very large compared to the fractures, so that it may not be fully justified to apply a homogenization approach; however, this is the approach we have used to define the behaviour of CEM. The geometry of the fractures is first simplified and assumed to correspond to conical surfaces with axial symmetry around the gallery's axis (Figure 2a). The local behaviour of the CEM is deduced from the model of an infinite medium containing a family of planar, parallel and equidistant fractures perpendicular to $\underline{n}$, the vector normal to the local fractures surface. This behaviour has thus the axial symmetry around the axis $\underline{n}$. We have studied this problem first for a linear elastic behaviour of the intact rock and of fractures and then extended it to more complex behaviours. In this case, the local elastic behaviour of the CEM is defined by a tensor which has the transversal isotropy around n , given by the following expression:

$$C_{ijkl} = b_1\delta_{ij}\,\delta_{kl} + b_2\,(\delta_{ik}\,\delta_{jl} + \delta_{il}\,\delta_{jk}) + b_3\,(\delta_{ij}\,n_k\,n_l + \delta_{kl}\,n_i\,n_j) + b_4\,(\delta_{ik}\,n_j\,n_l + \delta_{il}\,n_j\,n_k + \delta_{jk}\,n_i\,n_l + \delta_{jl}\,n_i\,n_k) + b_5\,n_i\,n_j\,n_k\,n_l \quad (1)$$

where b_1 to b_5 are five parameters depending on the Young's modulus E and Poisson ratio ν of the intact rock, the normal and tangent stiffnesses k_n and k_t of the fractures and their spacing D. Because of the finite size of the studied domain, the assumption of uniform stress or uniform strain at the boundary leads to different CEM models called 1 and 2 in the following.

To validate the 'homogenization' procedure, we compare the displacement and stress fields calculated around the galleries with two approaches : the first one uses a discrete model (with individual representation of the fractures) and the other one relies on the CEM model of the EDZ. Both models assume the same geometry with axial symmetry (shown in Figure 2b). In the first case, fractures are represented numerically by the Goodman (1966) 'joint elements' implemented in the finite element code CESAR (see Pouya *et al.* 2010), and in the second case, the special anisotropic and position depending elastic model (1) implemented in CESAR is used. Figure2c shows the total displacement at the wall obtained by the first method and the two CEM models given by the procedure described above.

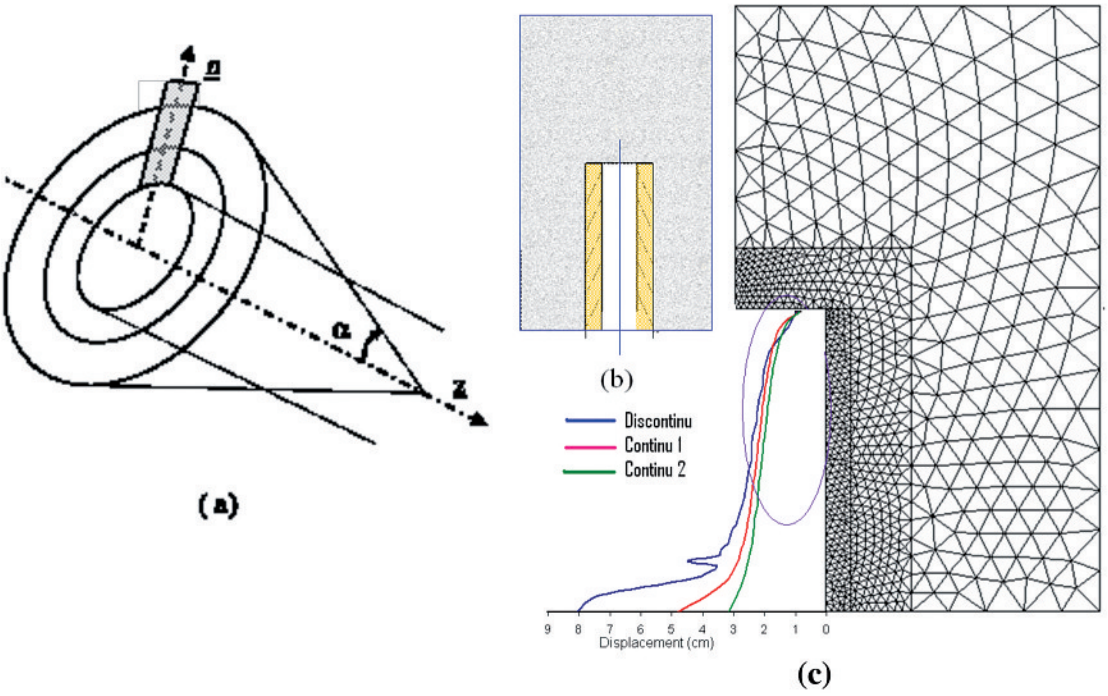


Figure 2: (a) Conical shape assumed for 'chevron' fractures, (b) geometry of the gallery model, (b), displacement obtained at the wall for discontinuous model and two continuum equivalent models.

Except for the beginning of the gallery where boundary effects are dominant, CEM models give nearly the same displacements that the discontinuous model. The comparison between the stresses leads also to a good agreement between the results. This approach was extended to the elastoplastic behaviour of the rock and of the fractures with also taking into account the curvature of the fractures. A good agreement between the discontinuous and CEM models could be obtained for these cases also. This shows the possibility of replacing effectively in the numerical models the fractured EDZ by a CEM determined by homogenization methods.

References:

ANDRA, 2008. Expertise sur la fracturation induite par le creusement des galeries au niveau -490m, LASALLE-BEAUVAIS, Rapport Andra n° D.RP.01LB.08.0005.A.

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