Hydro-mechanical behavior of Boom clay host-rock in interaction with a deep excavated gallery's lining

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Keywords: Boom clay, Strain localization, Excavation Damaged Zone, Pore water pressure distribution, Interfaces

Abstract

In the framework of the long-term management of the high-level nuclear waste, storing them in deep stable geological formations is considered as an acceptable solution. Geological disposal facilities (GDFs) combine a suitable system of engineered barriers with an host rock with favourable confinement properties, among which is a low hydraulic conductivity, at a depth that ensures adequate isolation from man and the environment. Boom clay, plastic clay formation located in the north of Belgium, is a candidate host-rock [1] for this purpose.

Due to the underground excavation process, a damaged zone with significant irreversible deformations and important host rock's properties modifications is expected to be created around the openings resulting to the macro and microfracturing and a rearrangement of rock structures. This zone is called as Excavation Damaged Zone (EDZ). Our study is firstly focused on numerical modelling of this zone around a gallery excavated in Boom clay host-rock through the framework of a strain localization approach in shear band mode. The initial anisotropic stress and cross-anisotropy of the elasto-plastic properties of the material are considered for a more realistic simulation. Additionally, to properly model the localization phenomenon and post-peak shear strength behavior, the coupled second gradient method is applied [2]. The development of the shear strain localization and extension of EDZ is analyzed numerically in comparison with the in-situ evidences while the both consist in an eye-shape extension of EDZ (Fig. 1). Besides, with regard to the long-term coupled hydro-mechanical behaviour of the rock, the pore water pressure evolution measured through some in-situ boreholes are analyzed compared to the corresponding numerical predictions. A good agreement is found between the simulated results and site measurements (Fig. 2).

Moreover, given the essential need to a lining while excavating in the plastic Boom clay formation in order to minimize the extension of the damaged zone and the convergence of the rock [3,4], the interaction of the rock with the gallery' lining is analyzed. Our study demonstrates that there is a fundamental relation between the development pattern of strain localization within the clay in the galley's proximity, and the pressure excreted by the clay on its interface with the lining upon contact (Fig. 3) [5]. Furthermore, the long-term strain evolution in the gallery's lining recorded through some installed instrumentation is analyzed. To reproduce realistically the latter results in the lining, we propose modelling of a discontinuous lining, making of the concrete blocks (like the

real case), while the interface elements are introduced between them to address their contact phenomena [3].

References

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Figures

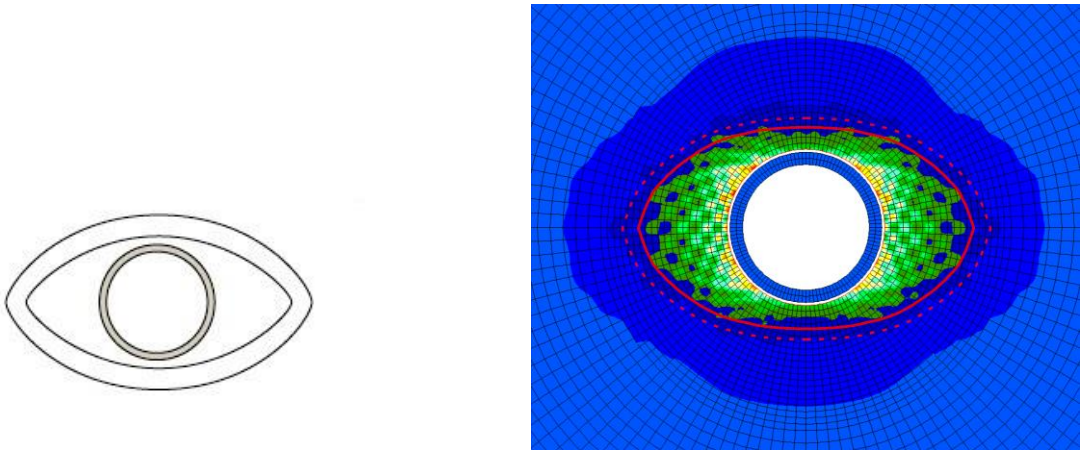

Figure 1 : *Schematic representation of the eye-shape fractures pattern observed around the gallery [1] (left side), and the similar numerical prediction of an eye-shape extension of the EDZ (right side) [3].*

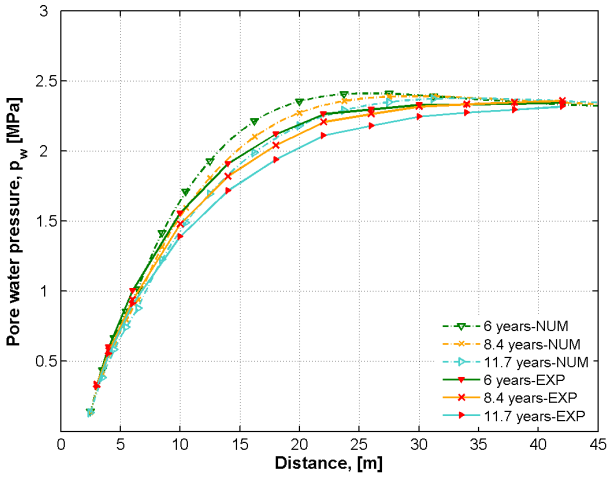

Figure 2 : *In-situ measurements through an eastward borehole R55E, compared to the numerical results [3].*

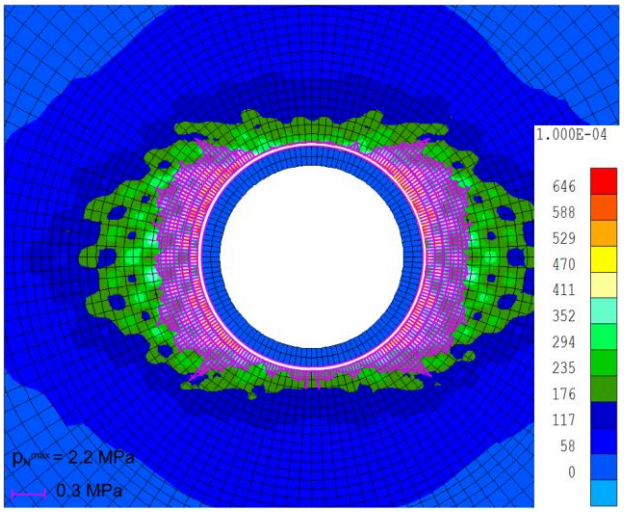

Figure 3 *: Superposition of the localized shear bands and normal contact pressure on the interface [5].*