Prediction of the excavation damaged zone in Callovo-Oxfordian claystone using a coupled second gradient model

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Abstract

The solution currently studied in France for long-term management of radioactive waste is the repository in deep argillaceous geological media with low permeability. The drilling of underground galleries in these clayey rocks induces damage propagation in the surrounding medium. This excavation process creates a damaged zone, in which the material properties are modified. The prediction of the fracture structure and material properties evolution within this zone is a major issue especially in the context of underground disposal.

Experimental works have highlighted that the damage around galleries in Callovo-Oxfordian claystone is localized and develops mainly as extensional and shear fractures. We propose to model these shear fractures as a strain localisation process in the mode of a shear band. In order to properly represent the shear strain localisation behaviour, an enhanced model introducing a regularization method and an internal length scale is needed. Among the different regularization methods, the coupled second gradient local model is chosen.

To illustrate the development of the damaged zone, a two-dimensional plane strain state hydro-mechanical modelling of a gallery excavation is performed (Lagamine code, ULg) for two orientations of the gallery in the Callovo-Oxfordian claystone. Firstly, a gallery oriented along the minor horizontal principal stress is considered. In this direction, the anisotropy of the stress state in the plane perpendicular to the gallery is the predominant factor leading to the elliptical shape of the damaged zone, with a significantly larger extent in the vertical direction. Secondly, a gallery oriented along the major horizontal principal stress is modelled. The stress state in the plane perpendicular to the gallery is quasi-isotropic and does not lead to shear strain localisation unless the material anisotropy is considered. Moreover, the modelling provides information about the fracture structure and evolution around the gallery. It exhibits a chevron fracture pattern corresponding to *in situ* experimental measurements of shear fractures for both considered gallery orientations.

About the speaker

After obtaining a PhD in geomechanics for his work on the thermo-hydro-mechanical coupling in partially saturated soils and soft rocks, Frédéric Collin became Associate Professor at the Université de Liège, where he got his master's degree in civil engineering. His main research topics are the finite element modeling of multiphysics phenomena as well as strain localization modeling in geomaterials. Dr Collin has been developing the Lagamine Finite Element code for more than 20 years. This code has been used for applications in the context of nuclear waste deep geological disposal. In the vicinity of the storage galleries, THM phenomena are of paramount importance as well as fracturing processes. Since his post-doctoral stay in Laboratoire 3S-R in Grenoble (France), Frédéric Collin is developing numerical methods in order to model properly the post-localization path. The enriched continuum theory is used to predict the localization pattern in partially saturated argillaceous rocks.