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THM analysIs of natural and engineered barriers for large excavations in deep nuclear waste repository

Matias Alonso[1,2], Jean Vaunat[1,2], Minh-Ngoc Vu[3], and Antonio Gens[1,2]
[1]Universitat Politècnica de Catalunya (UPC), Spain
[2]International Centre for Numerical Methods in Engineering (CIMNE), Spain
[3]French National Radioactive Waste Management Agency (ANDRA), France

Argillaceous rocks have great potential as possible geological host medium to store radioactive waste. Andra is leading the design of a deep geological nuclear waste repository to be located in the Callovo-Oxfordian formation. In the framework of this project, excavations of large diameter galleries are contemplated to access and to store intermediate-level long-lived nuclear waste at repository main level. The closure of the repository will be realized by building sealing structures of expansive material.

The response of such structures is affected by several thermo-hydro-mechanical coupled processes taking place in the near and far field of the argillaceous formations. They include the formation of an excavation induced damaged zone around the galleries, the impact of the thermal load on host rock pressures and deformations, the long-term interaction with support concrete structural elements and the hydration and swelling of sealing materials. As a result, the study of their performance requires to perform simulation works of increasing complexity in terms of coupling equations, problem geometry and material behaviour. As well, challenging computational aspects, as the ones related to fractures creation and propagation, have to be considered for a representative analysis of the problem.

This work presents advanced large scale THM numerical models to provide keys about the response of the host rock around large diameter galleries during excavation and further thermal load as well as to analyse the performance of large diameter sealing structures. Particular features of the models include on one hand advanced constitutive laws to capture the development of the fractured zone around excavations, the behaviour of host rock/gallery support interfaces and the multi-scale response of bentonitic backfill. On the other hand, simulations consider geometries including constructive details of interest at decimetre scale within large discretization domain covering the whole formation stratigraphic column.

These challenging simulations provided qualitative and quantitative results on key aspects for natural and engineered barrier integrity, like extension of the damaged zone, impact of the thermal load and water pressure variations in the surrounding geological layers, duration of natural hydration phase, swelling pressure development and seals global stability.