SIMILARITIES IN THE HYDROMECHANICAL RESPONSE OF CALLOVO-OXFORDIAN CLAY AND BOOM CLAY DURING GALLERY EXCAVATION

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INTRODUCTION
The coupled hydromechanical response and the fracture pattern around excavations are of much interest in the feasibility studies of high-level and long-lived radioactive waste repository. This response was characterised during recent excavation works performed at the Meuse/Haute-Marne URL in the indurated Callovo-Oxfordian clay and at the HADES URL in the plastic Boom clay.

THE OBSERVATIONS PERFORMED IN CALLOVO-OXFORDIAN CLAY
Two major experiments were carried out in order to understand the rock response in the Meuse/Haute-Marne URL: the REP experiment, during shaft sinking (Armand et al., 2006), and the SUG-SMR1.1 experiment (Wileveau et al., 2006)) at the main level (-490 m depth).

For both experiments, the impact of the excavation on the hydromechanical response was clearly identified. As expected, the amplitude of the pore water pressure jumps increased with the proximity of the working face. In REP experiment, a strong hydromechanical coupling was observed for the two directions of principal horizontal stress. In the SUG-SMR1.1 experiment, the piezometer chambers installed far away in the rock mass showed a smooth over pressure 20 meters ahead the front face.

The excavation of the horizontal drifts induced shear fractures herringbone shaped ahead of the excavation front. The shear fractures are symmetrical to the horizontal plane crossing the gallery at the middle. The pattern is oriented towards the front face with a dip of approximately 40-45°. They extent around the galleries between 2 and 2.5 m at the vault and at the floor for the galleries oriented parallel to the maximum horizontal stress (fig. 1). They are generally less pronounced when the galleries are parallel to \( s_h \). Herringbone shaped fractures were also observed on drill-cores from one horizontal borehole parallel to \( s_h \) (fig. 1).

THE OBSERVATIONS PERFORMED IN BOOM CLAY
The characterization of the hydromechanical behaviour of the Boom clay has been undertaken mainly using data from in situ measurements. Major progresses were made during the construction of the connecting gallery excavated using a tunnelling machine in 2002. The EC CLIPEX instrumentation programme provided a unique opportunity to monitor the hydromechanical response of Boom clay during the excavation (Bernier & al. 2002).

Figure 1: Similararities of fracture patterns of Boom clay (at left) and of Callovo-Oxfordian claystone.
All piezometers installed ahead of the excavation front registered a similar regular evolution of the pore water pressure with the approach of the excavation front: a progressive increase followed by a sharp drop as the excavation front approached closely. The pressure response and mechanical displacement were strongly coupled. An unexpectedly extended disturbed zone (both hydraulic and mechanical) due to excavation was observed. The pore pressure and displacement sensors began to register regular variation when the excavation front was still more than 60 metres (i.e. 12.5 tunnel diameters) distant.

Evidences of fractures induced by the excavation have been gathered during the construction of the connecting gallery. The systematic observations of the front and the sidewalls allowed the characterisation of the fracture pattern in the surrounding formation. The orientation of the encountered fractures is consistent along most of the excavation. It consisted of two conjugate fracture planes: one in the upper part, dipping towards the excavation direction, the other in the lower part, dipping towards the opposite direction. The two planes were curved and intersected at mid height of the gallery. Some cored borings indicated a radial fracture extent of about 1 m. It is interesting to note that the observed herringbone fracture pattern is similar to the fracture pattern observed on a smaller scale along cores as a result of the drilling of these cores (Figure 1).

DISCUSSION

Despite the important difference in the characteristics between the Callovo-Oxfordian clay and the Boom clay (especially in terms of water content, uniaxial compression strength and hydraulic conductivity), the observed hydromechanical response and the fracture pattern around excavation are quite similar (Blümling et al., 2005). For both clays, the pore pressure evolved regularly during excavation of a gallery with the coming excavation front. Important findings were the unpredicted hydraulic perturbation at large distance from the excavation inside the formation, and the herringbone fracture pattern ahead of the excavation front. The clear difference of fracture pattern can be correlated with the ratio between in situ stress state and compressive strength of rock mass.

Taking note that two different research teams, working separately and using different instrumentation devices, are able to point out similar hydromechanical processes, built our confidence in the reliability of our results.

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References


