A benchmark exercise to investigate the thermal effects on the Excavated Damage Zone

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Abstract

Deep geological disposal with multi-barriers confinement is considered as one of the most reliable solutions for long-term management of radioactive wastes. Thermal-Hydro-Mechanical (THM) effects are likely to alter the confining function of clay host rock during the construction and lifetime of repository [1]. Specifically, the heat generated by the waste must not affect the favourable properties of the clay host rock for containment, especially its transport properties. In the vicinity of the drift, the excess pore pressure generated by the thermal expansion of pore water could induce fracture re-opening or propagation. In the far-field, the zone subjected to thermal loading from two neighbor galleries could induce tensile or even shear failure and/or reactivate old fractures. The above processes could potentially alter the permeability of host rock. The present work aims to reproduce the development of strain localization bands induced by multi-physical couplings associated with thermal effects.

A 2D plane strain generic model is built from the benchmark exercise within the European joint programme EURAD HITEC [2]. The geometry of this model is a cross-section of a heating drift and host rock. Only a quarter of the full drift is modelled thanks to the symmetry of the problem and the boundary conditions. The full computation is characterised by three phases: excavation (0 ~ 24 h), waiting (24 h ~ 6 months) and heating (6 months ~ 10 years), conducted by adjusting boundary conditions of drift wall. The elasto-plastic mechanical law with hardening and softening is used, and a local THM second gradient model including microstructure effects allows a robust modelling of the post peak regime. The Callovo-Oxfordian claystone (COx) is selected as a candidate host formation due to its low permeability and good plasticity [3]. All the numerical modelling is performed with the finite element code Lagamine developed at University of Liège.

During the tunnel excavation, the strain localisation was not triggered at the end with a radial stress reduction to 5% of initial confining pressure. At the beginning of the waiting phase, Figure 1 shows that the initiation of shear band is located at around 45°. Due to the progressive drainage (elastic unloading) during the waiting phase, the development of shear bands gradually weakens. Once the heating phase is activated, the plasticity develops rapidly. The THM couplings at the drift wall are evidenced by excess pore pressure, that induces distinct growth of shear bands. Thermal effect has a leading role in the development of strain localisation, and the shear bands occur preferably along with the minor principal stress direction.

Acknowledgements

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References

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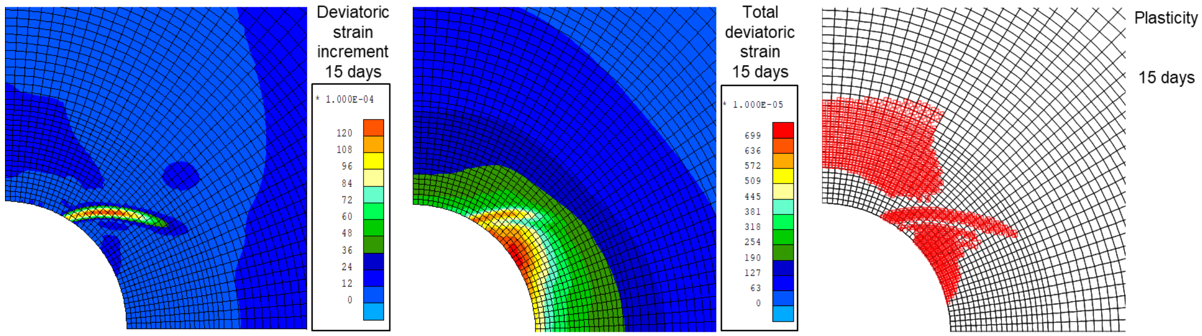

Figure 1: Evolution of strain localisation at the start of waiting phase (14th day of waiting)

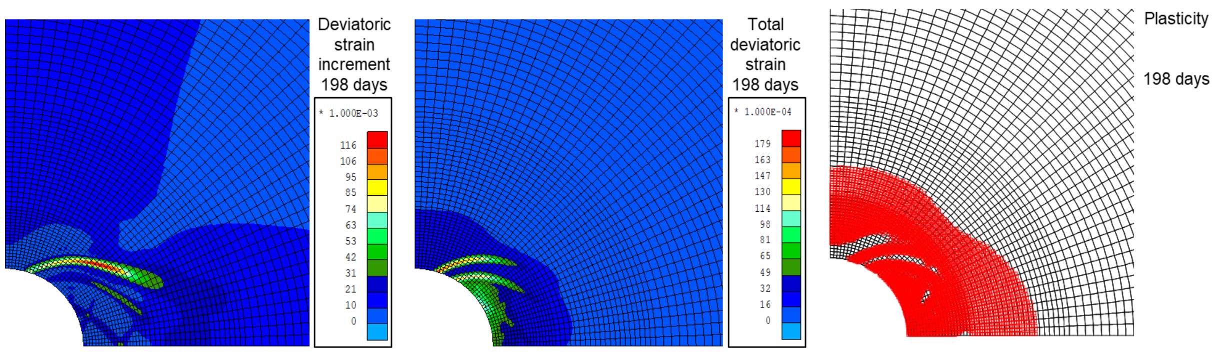

Figure 2: Evolution of strain localisation at the start of heating phase (18th day of heating)