INJECTION MEASURES TO STABILISE THE EXCAVATION DAMAGED ZONE IN CLAYSTONE

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Introduction

Presently, the Konrad Repository for low- and intermediate-level radioactive waste is under construction. It is situated in a former iron ore mine that is covered by a thick clay cover. Although the emplacement level is excavated in the Middle Coral Oolite (Oxfordian), the claystone is present in the shafts and in the Konrad 2 shaft landing station. Due to the low strength of claystone, the shaft landing station is stabilised by an anchor-shotcrete lining. Furthermore, as a precautionary measure, injections were planned to stabilise the excavation damaged zone in case the mined cavities' convergence exceeds a threshold limit value and that the lining may be damaged as a consequence.

Laboratory and Pilot Tests

(1) To select an adequate injection grout, 11 series of test specimens with an artificial weakness plane glued by injection grout were investigated in order to check their compressive, shear, and tensile strengths. Lab test results of these glued specimens compared with existing data of intact claystone showed that the strength of the claystone itself was decisive for failure and not the glued plane.

(2) Based on numerical calculations, representative locations were selected to perform pilot injection tests in situ. First, the test series focused on weakness planes, then, the excavation damaged zone was investigated (Figure 1).

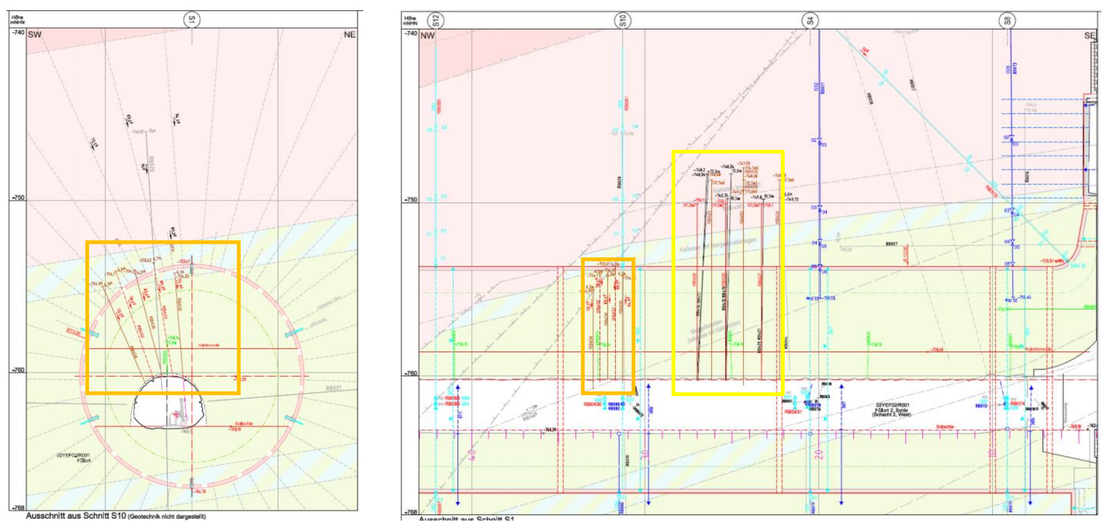

Figure 1. Pilot tests performed in claystone (light green) on weakness planes (yellow rectangle) and EDZ (orange rectangle) – The dimension of the future excavation and the (outer) shotcrete lining is also given. Note the gaps in the shotcrete liner!

In the case of weakness planes, the volumes of injection grout were limited to a few liters. In the EDZ, the volumes showed a range of 133 – 300 l per borehole (Fig. 2) agreeing with mining experience previously gained at Konrad.

Figure 2. Core samples from pilot tests – claystone (gray) and injection grout (ochery)

Industrial Scale Realisation

(1) Injections were performed before excavation in order to solidify weakness planes in advance (Figure 3).

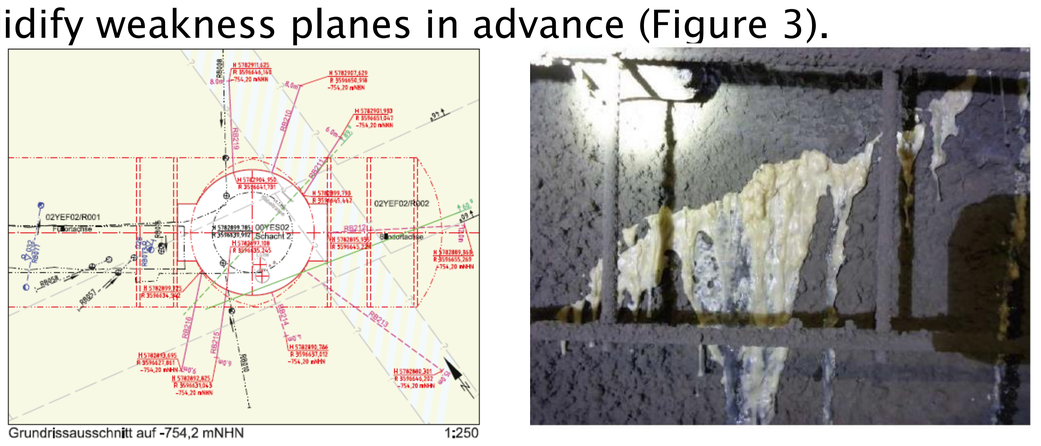

Figure 3. Injections before excavation – Example of planning (left) and leakage of injection grout during realization (right)

(2) Injections after excavation, anchoring, and implementation of the outer slotted shotcrete liner when the threshold limit value of convergence was exceeded (Fig. 4). The amount of grout volume effectively injected (difference between borehole volume and injected volume) lies within the range of -10.5 l and 48.6 l (0 % to 780 % of borehole volume). The "-" indicates that the borehole was already closed. Stability of boreholes in claystone is short-term.

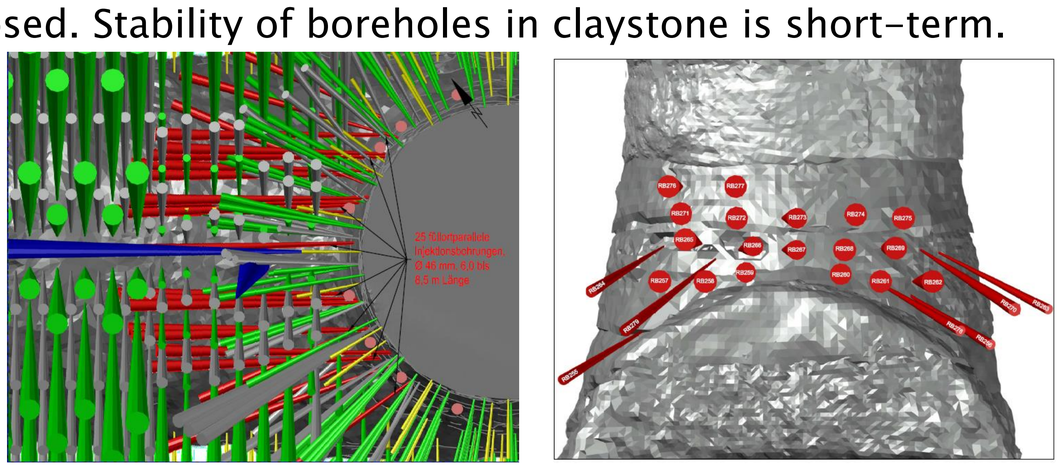

Figure 4. Injections after excavation – Position of injection boreholes (red) between the rock bolts (left) and injection boreholes related to the contour of the excavated shaft landing station (right)

(3) Injection of the top heading after detecting some deterioration at the slotted shotcrete liner. After closing the gaps in the liner, injections were performed in short (2 m) boreholes. The packer was fixed in the shotcrete liner. The injected volumes were significantly higher than in step (2). The maximum grout volume effectively injected was 92 l, which is equivalent to 3124 % of the borehole volume.

Conclusion and Lessons Learnt

Within this project, the process chain to inject claystone in order to improve stability of mine openings was developed and implemented at an industrial scale. One lesson learnt is that injection measures in claystone do not solely stabilise planes of weakness and the EDZ. Furthermore, the injection data – pressure versus time and volume rate of injection – supply valuable information on the state of claystone close to the mine excavations. If high injection pressures are realised at low grouting volumes the claystone is mainly intact. If high grouting volumes are realised, the solidification of the damaged claystone is successful.

Acknowledgements

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