Stress measurements with the under excavation technique

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The aim of the IS experiment (In situ stress measurements) is to test and validate one or several methods of stress investigations for argillaceous materials. One can distinguish two types of in situ methods. The first category is based on the principle of the partial or total stress release and stresses are calculated by the means of strain measurements. The second category consists in a mechanical or hydraulic stimulation of the rock. In this case, the measured parameters are pressures and there is no need to have a hypothesis of the constitutive law of the rock.

The undercoring technique belongs to the first category and consists in measuring strains at borehole walls due to a stress change provoked by the excavation of a volume of rock mass in the vicinity of the cells. The instrumentation is placed in neighbouring boreholes before the starting of its excavation.

Several rock samples from these small boreholes were taken and tested in order to estimate the local elastic parameters of the rock fabric.

During the excavation process, strains induced by the dynamic stress regime are recorded for different geometries of the excavation. First, a back-analysis procedure allows an estimate of the stress changes while the excavation is passing by, based on elastic parameters determined in laboratory conditions. A second step level of back analysis permits the estimation of the far-field pre-existing stresses in the rock mass.

The test was designed to conduct simultaneously an undercoring and overcoring experiment. An optimisation of the test design was first undertaken (modelling, experience from previous measurements) : a small vertical shaft (600 mm in diameter) was pre-surrounded with three boreholes at 120° each other all around. To avoid disturbances due to the niche or the tunnel, a minimum depth for measuring the induced stresses was assessed based on 3-D numerical modelling. Several steps (stabilisation periods) in the drilling of the principal shaft were marked. The strain cells used were CSIRO Hi cells which provide redundant information based on 12 strain gauges equipping each cell.

The responses of the CSIRO cells were recorded and were back analysed as globally good. Stabilisation of the strains while the boring process stopped appears clearly on the graphs. Unfortunately, during the last phase of boring, cable of the fourth CSIRO cell placed in an overcoring position was hurt, introducing a sudden, random shift in its data that could not be corrected. Those data could not be used for an independent, direct in situ stress estimate.

Nevertheless, a step by step analysis of all intermediate results and associated statistics were conducted, using the stress change analysis of the collected strain data, in order to estimate the in situ stresses. The back-analysis procedure consists in providing a ëbest-fití solution of the far-field stress tensor that minimises the difference between the measured and the predicted strains.

This study demonstrates both advantages of a new technique to measure what is usually difficult to obtain, i.e. dynamic stress changes and natural field 3D stress estimate of the studied rock mass, and very new strategies in characterising rock mass behaviour in the frame of further research work to be conducted in the future.