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MODELLING OF A DEEP EXCAVATION IN A STIFF CLAY

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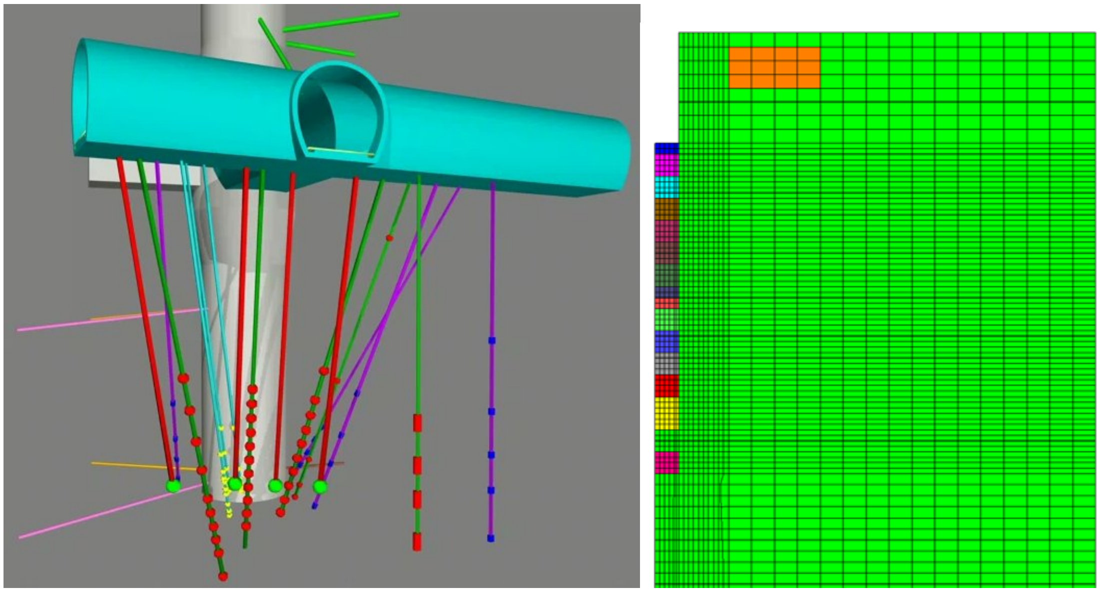
Summary. This extended abstract presents an interpretation of the response of a mudstone during the excavation of a shaft at high depths (500m). Instrument layout and numerical model are described. A very good agreement is observed between the field measurements and computed values.

1 INTRODUCTION

Within the research program developed to study the safety of storing radioactive waste at large depth in the underground, a laboratory has been built at a depth of 500 m in a formation of stiff clay located in Northern France. For a better understanding of material field behaviour, the response of the formation has been followed during the works realized to build the laboratory. Particularly, the excavation of the main access shaft has been followed by an intense instrumentation between depth 460 and 480 m[1].

2 FIELD MEASUREMENTS

A layout of the instrumentation is shown in Figure 1.a. Three boreholes equipped with extensometers (red points), one borehole with inclinometer (red squares), four boreholes with pore pressure transducers (blue points) and four boreholes with strain gauge cells (green points) were installed from a lateral niche previous to the excavation of the shaft at the considered depth. Instrumentation campaign is completed by wave velocity survey, hydraulic conductivity measurement by means of pulse tests and installation of radial extensometers after excavation[1].



a) b)

Figure 1: a) experimental shaft and instrumentation layout ; b) Geometry and spatial discretization considered in the numerical model.

3 MODEL DEVELOPED

Excavation of the access shaft has been modelled using Code_bright, a Finite Element code that solves 3D thermo-hydro-mechanical problems in geological media. In the analyses presented, the equations for stress equilibrium, water mass balance and solid mass balance were solved simultaneously, resulting in a hydro-mechanical coupled formulation of a Biot type. The mesh used is depicted in Fig. 1.b: it consists of a 2D axisymmetric mesh where the shaft and the lateral niche are represented (the latter in an approximate manner due to the assumption of axisymmetry). A damage/elastoplastic law that couples degradation of both elastic modulus and strength with increasing load has been implemented and the resulting parameters have been calibrated using laboratory tests[2].

4 RESULTS AND INTERPRETATION

Values of convergence, displacements and pore pressure computed by the model at a number of points are compared with field measurements in Figure 2, 3, 4 and 5, respectively. A very good agreement can be observed. The examination of a number of modelling features demonstrate the importance of the following points to achieve a good reproduction of field data: vertical and horizontal values of permeability, value of Young modulus, low damage threshold, damage evolution controlled by the energy input to the material (which takes into account the damage in both compression and shear), increase of permeability with damage, and modelling of the upward drainage due to the presence of the lateral niche.

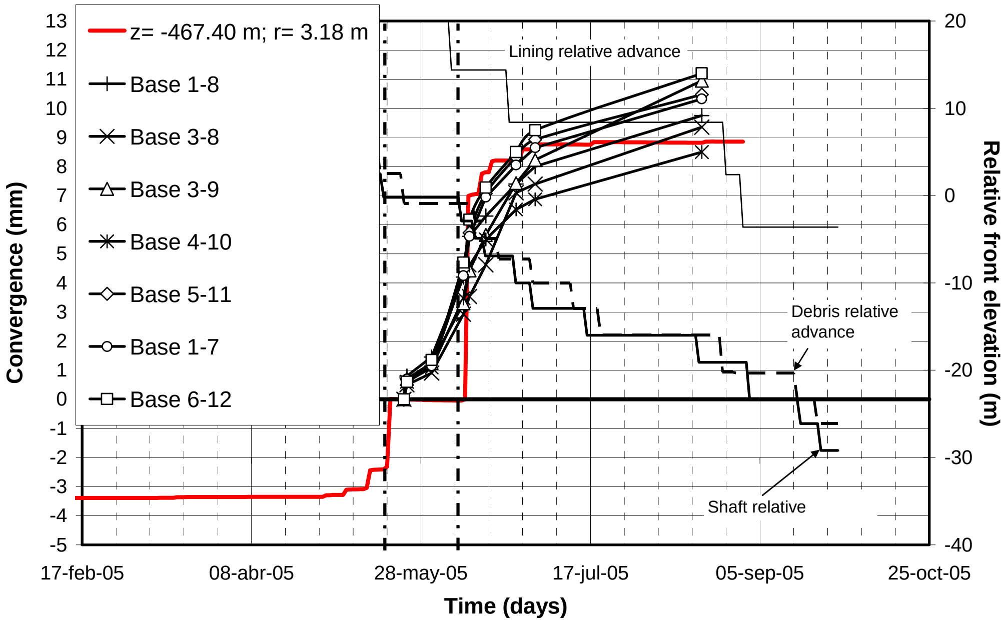


Figure 2: Shaft convergence: comparison between measurements and numerical results.

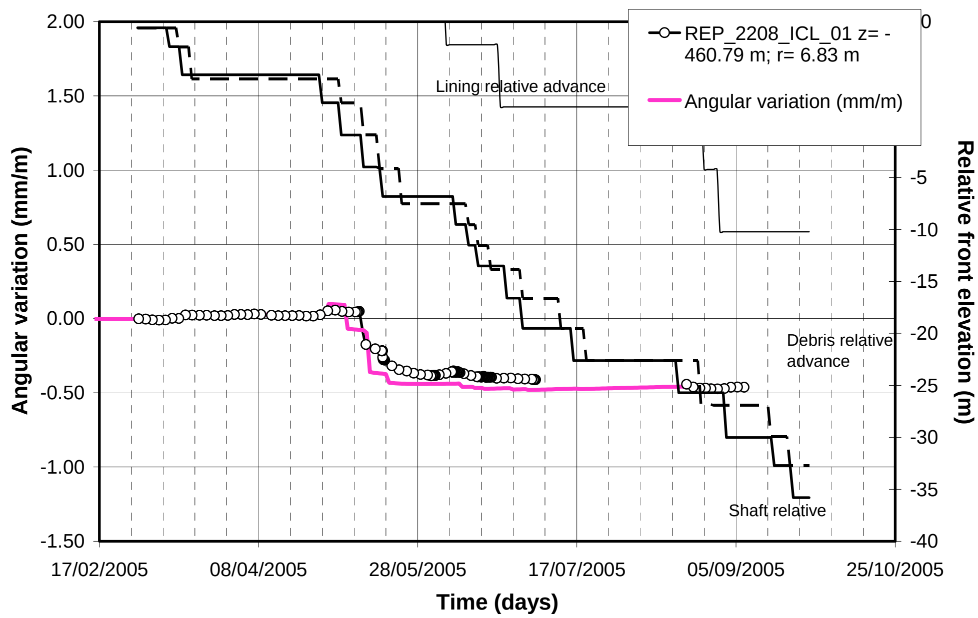


Figure 3: Deformation close to the shaft: comparison between measurements and numerical results.

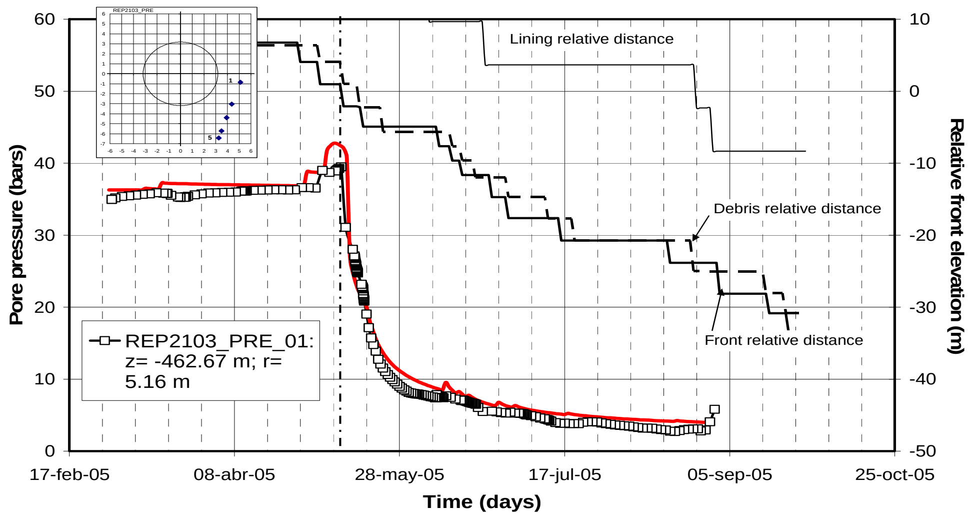


Figure 4: Pore pressure close to the shaft: comparison between measurements and numerical results.

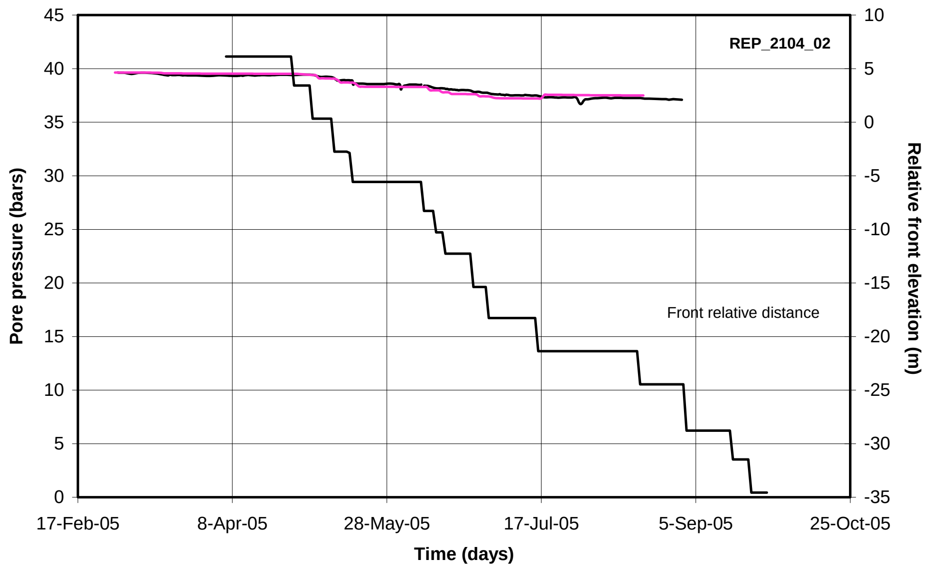


Figure 5: Pore pressure far from the shaft: comparison between measurements and numerical results.

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[2] K. Su. "Development and validation of the constitutive hydromechanical models for Callovo-Oxfordian Argillites: the MODEX-REP Project". *ANDRA report, Paris, France*. (2007).