Temporary research position (post-doctoral) at Andra R&D Division

Coupled thermo-hydro-mechanical modeling of large-scale *in situ* heating experiments

Andra (French national radioactive waste management agency) performs a wide range of *in situ* experiments at its Underground Research Laboratory (MHM URL). The main goal of the experiments is the study of the feasibility of a radioactive waste repository in a Callovo-Oxfordian claystone formation (COx). The MHM URL contains more than 1500 m of densely instrumented drifts excavated essentially at 490 depth, with about 30 on-going *in situ* experiments.

Thermo-Hydro-Mechanical (THM) behavior of the COx is of great importance in what concern the design and safety study of the high-level waste disposals. Indeed, the heat emitted from the wastes provokes a pore-pressure increase within the surrounding rock due to the differential thermal expansion of the pore water and the solid skeleton. The low permeability of the COx and its relative rigidity prevents the discharge of the induced pressure build-up. Moreover, thermal loading may provokes thermomechanical stresses in the media due to boundary conditions.

An important research program has been conducted at Andra since 2005 in order to investigate THM response of the COx to a thermal loading through laboratory and *in situ* experimentations. The *in situ* experimental program consists in a step-by-step approach started by small scale heating boreholes to full-scale experiments (Fig. 1).

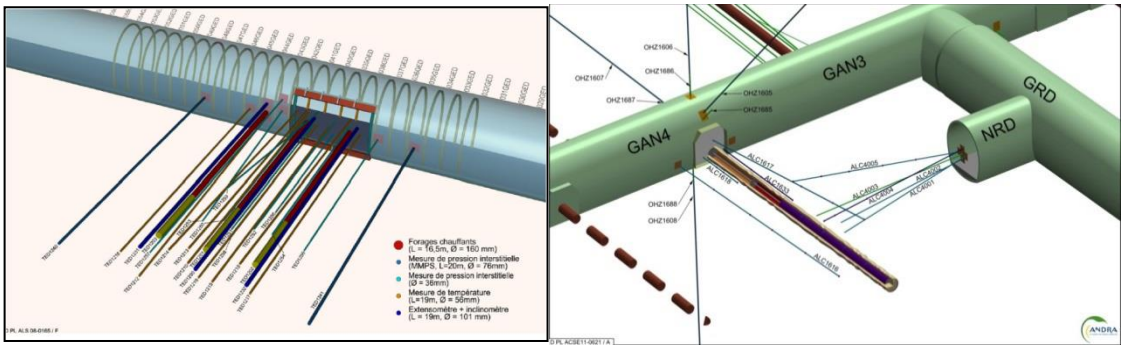

Fig. 1 – left: TED experiment (three heating boreholes); right: Heating micro-tunnel (a full-scale heating test)

A benchmark program is organized by Andra within DECOVALEX[1] international program. The objective of the program is the interpretation and modeling of full scale heating experiments on the basis of model calibrations performed at a smaller scale. The interaction between the surrounding rock mass and the support (steel casing in this case) will be closely investigated through one-to-one scale experiment to assess the effect of the thermal loading on the steel structure. The extent of the behavior of one single cell to the repository scale (many parallel cells) will be also approached.

Five research teams participate in the task (Task E: http://decovalex.org/task-e.html). In this framework, a small scale in situ heating test (TED) has been already back-analyzed and gave the reference values for the rock mass parameters. These values are used to model a full-scale in situ heating test.

The proposed research consists in:

- Providing a critical review on the numerical modeling already provided on TED experiment.

[1] DEvelopment of COupled models and their VALidation against EXperiments - http://www.decovalex.org/

- Modeling a full-scale experiment. The model calibration performed in the first part will be used to interpret the results of the full scale heating test. A particular attention must be paid to the scale-change effects. Modeling the THM behavior of the near-field, including excavation induced fracture network around the cell and its possible evolution is of major interest.

- A High-level repository consists of several parallel cells distributed within several hundreds of meter area. Technical challenges remain regarding the variability of THM parameters on such area. Other challenges concern setting appropriate boundary conditions when 2D modeling must be used to represent the behavior of a series of parallel cells. A sensitivity analysis will be conducted in view of providing recommendations for large-scale modeling of the repository.

Currently, the numerical simulations are performed within code-aster and COMSOL Multiphysics. An active interaction with other research teams involved in the program is expected. The successful candidate will be involved also within inter-comparison tasks of the benchmark program.

Profile requirements

A recently obtained PhD in civil engineering or a related discipline will be required. Good knowledge of non-linear behavior of materials including plasticity and continuum damage mechanics and finite element method are needed. Knowledge of multi-physics coupled phenomena in porous media is appreciated. Excellent oral and writing English skills are needed.

Duration

The position is planned for 18 months starting from January 1st 2018 and is based at the Andra's R&D Division located in Châtenay-Malabry (about 9 km south of Paris). The successful candidate is expected to present the results at the project's workshops (2 per year).

Contact

For any further information please contact Darius Seyedi (darius.seyedi@andra.fr) or Gilles Armand (gilles.armand@andra.fr).

Application procedure

The applications containing a cover letter, a detailed Curriculum Vita must be addressed to Darius Seyedi (darius.seyedi@andra.fr) and Gilles Armand (gilles.armand@andra.fr).