THM Modelling of Onkalo – Final Disposal of Radioactive Spent Nuclear Fuel

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The preliminary analyses of coupled THM processes in ONKALO have been published by POSIVA Oy (Toprak et al. 2013). In that report, the time required for the buffer to reach full saturation, the maximum temperature reached in buffer, deformations at the buffer-backfill interface and the buffer and backfill homogenization were analyzed.

In this paper, an additional modelling work on the backfill material is included. The backfill material refers to granular material used to fill the drift mainly. At present, Friedland clay is considered as one of the candidates. In order to investigate the hydro-mechanical behavior of Friedland clay, a series of laboratory tests are in progress at B+TECH laboratories. Two types of tests have been performed: oedometer tests and infiltration tests. These tests have been simulated using the finite element code Code_Bright using the constitutive model BBM (Alonso et al., 1990).

With regard to the hydraulic part of the analyses, the time required for full saturation is sensitive to vapor diffusion, advective water flow which depends on intrinsic permeability and retention curve of the various elements. Another fundamental issue is to determine relevant hydraulic boundary conditions at boundaries that are not far enough. This is also de case of temperature which was already identified in the previous simulations. In short, both temperature and liquid pressure cannot be fixed on relatively close boundaries.

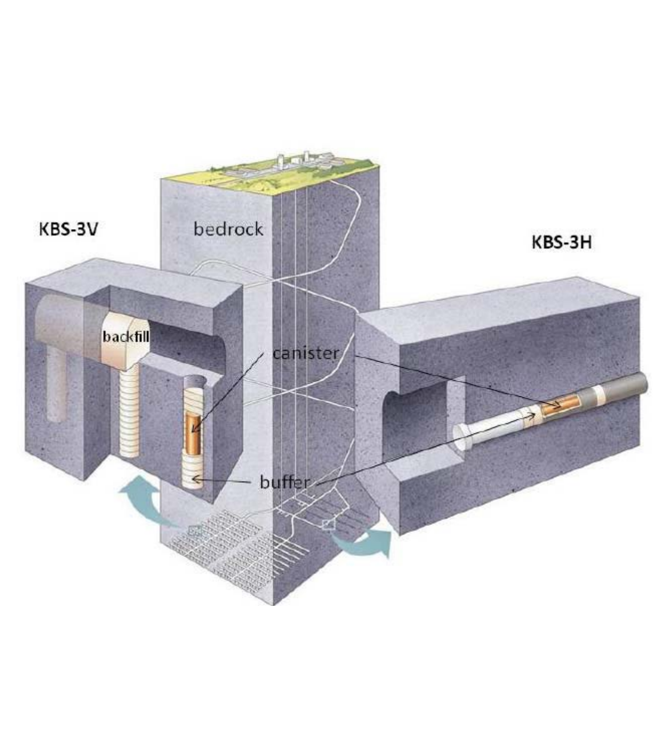

Figure 1-A. Alternative designs of the KBS-3 concept for the nuclear spent fuel disposal(In this study, it has been modeled vertical concept, KBS-3V)

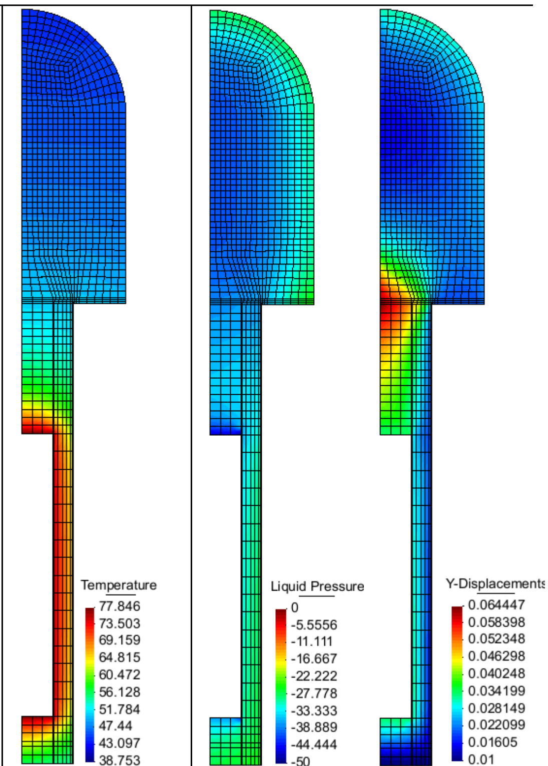

Figure 1-B. Evolution of temperature (ºC) (30 years), liquid pressure(MPa) (3 years) and vertical displacements (m) (100 years)

The study presented in this paper consists of the simulation of a disposal scheme which includes several clay based components of the EBS as it is shown in Figure 1-A. These components are referred to as: buffer components (bentonite blocks and pellets), backfill (several types of components), host rock and interfaces. The complete understanding of the THM response of the system requires calibration of the most appropriate constitutive equations for each of the components. These constitutive equations should cover not only mechanical effects but also hydraulic and thermal effects. For instance, an air gap between the canister (heat source) and the clay buffer may require the inclusion of the thermal radiation term as this element is initially full of air which has very low thermal conductivity. Double structure concept will be necessary to accurately model the clay based elements but these elements have different nature. In addition, the response to changes in water salinity should be accounted for. 3D response of the vertical boreholes is also discussed.

Distribution of temperature, liquid pressure and vertical displacement are shown in Figure 1-B. The modeling process of buffer-backfill interface is an important part of tunnel backfill design. The calculations will aim to find out deformations at this intersection whose behavior is important for the buffer swelling. In order to investigate the hydro-mechanical behavior of MX-80 bentonite (buffer material), a series of laboratory tests are in progress at the laboratories of B+Tech Oy (Pintado et al., 2013) and modelling results of these tests have been given in Pintado and Rautioaho (2013) and Toprak et al. (2013). According to new data for backfill and pellets, the THM results achieved for buffer will be updated. To evaluate the influence of different parameters over system components, sensitivity analysis will be performed. Other analysis in KBS-3V concept can be found in Åkesson et al. (2010).

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