Hydro-mechanical modeling of backfill homogenization

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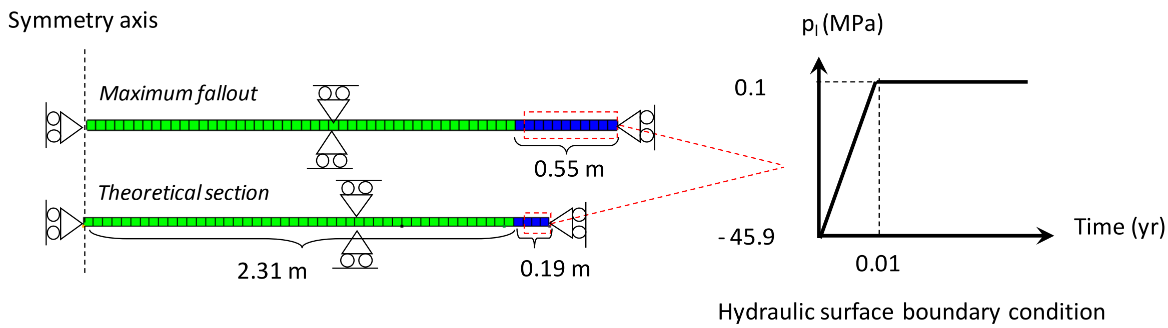

Figure 1. Geometries, mesh and boundary conditions of backfill homogenization models.

Background and objective: The KBS-3 tunnels are planned to be backfilled with bentonite blocks and bentonite pellets after the emplacement of the canisters and the buffer. This means that the bentonite dry density distribution in the tunnels will be significantly heterogeneous at the time of the installation. The differences in dry density will be reduced as an effect of the water-uptake and the build-up of swelling-pressure in the bentonite, and the extent of this homogenization process was investigated through hydro-mechanical modelling with the Code_Bright finite element code. This work was part of the THM modelling of buffer, backfill and other system components performed for the SR-Site (SKB TR-10-11).

General description: The backfill was represented with one-dimensional axisymmetric geometries with different outer radii, corresponding to different tunnel section areas (Figure 1). The central parts and the peripheral parts of the geometries consisted of materials representing the blocks and the pellets filling, respectively. Water-uptake was enabled through a hydraulic surface boundary in the pellets-filling. Internal radial displacements were allowed, whereas the outer boundaries were confined.

The water transport was modelled with Darcy's law for unsaturated conditions with adopted parameter values for the intrinsic and the relative permeability, as well as for the water retention curve. The mechanical processes were modelled with elasto-plastic constitutive laws which are based on the Barcelona Basic Model. In addition, these laws were modified by Clay Technology through incorporating a void ratio dependent swelling pressure relation into the pressure dependence of the used swelling modulus (SKB TR-10-44).

Main results: The model results can be evaluated as stress paths in the e-p plane (void ratio vs. net mean stress), see Figure 2. These paths illustrate that the net mean stress in the inner parts of the blocks ends up on the swelling pressure relation, incorporated in the swelling modulus. Pellets and the outer parts of block, in contrast, are compressed "beyond" the swelling pressure relation, and instead governed (at least to a large extent) by the adopted plastic stress-strain modulus.

The final states of all nodes are also presented in Figure 2, and the models indicate that the material will not be completely homogenised. The remaining heterogeneity is of such an extent that the difference between the inner and the outer parts is slightly more than 0.2 in terms of void ratio, and the main reason for this appears to be the hysteretic swelling/compression cycles. This is generally in agreement with the experimental findings from the Canister retrieval tests (SKB IPR 07-16).

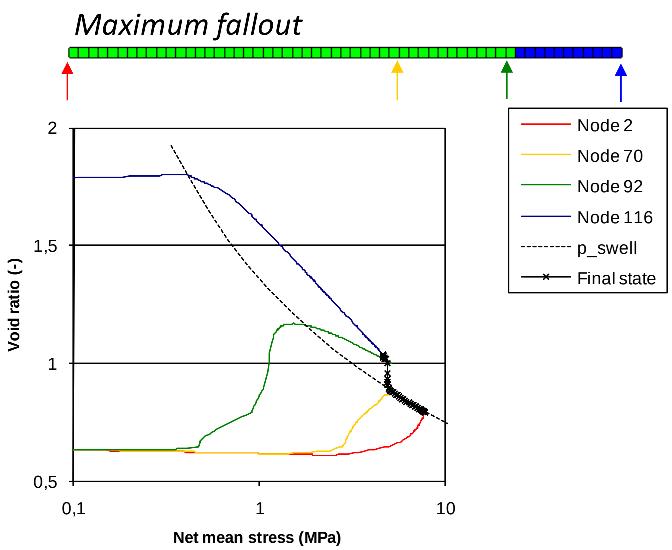

Figure 2. Stress paths in e-p plane for nodes in one of the investigated geometries, as well as final state and swelling pressure relation.