GRANULAR MX-80 BENTONITE AS BUFFER MATERIAL: A FOCUS ON SWELLING CHARACTERISTICS

M. Rizzi[1]*, L. Laloui[1], S. Salager[1], P. Marschall[2]

1. Soil Mechanics Laboratory, École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland (marta.rizzi@epfl.ch)
2. NAGRA, CH-5430 Wettingen, Switzerland (Paul.Marschall@nagra.ch)

The Swiss High Level Waste (HLW) disposal concept envisages the emplacement of the waste canisters in horizontal tunnels excavated at a depth of several hundred meters in an overconsolidated claystone formation. After waste emplacement the disposal tunnels are backfilled with MX-80 granular bentonite.

Research activities are presented in this paper, aimed at characterising the geomechanical behaviour of the MX-80 granular bentonite and at providing the theoretical framework for modelling its response to thermo-hydro-mechanical (THM) perturbations. From the experimental point of view, a series of tests has been designed in order to extract constitutive data and to assess the temperature and suction effects on the mechanical behaviour of the bentonite, paying particular attention in the investigation to the swelling behaviour of the material. As for the theoretical framework an elasto-plastic constitutive model has been developed to take into account those coupled processes of stress, capillary pressure, and temperature to which the bentonite will be submitted,.

Bentonite is mainly composed of the smectite mineral montmorillonite with a high swelling capacity which may provide sufficient sealing properties to seal the tunnel without gaps and to restore the buffer continuity. In fact, as bentonite hydrates in the repositories it will expand in those areas where it is allowed and will exert a swelling pressure where the material is confined. The results of both confined and free swelling tests are presented. Confined tests are aiming at determining the pressure applied by the material during complete saturation under isochoric conditions, whereas in the free swelling tests the strain on hydration is measured. Figure 1 presents some results from confined swelling tests at ambient temperature. The specimen is compacted uniaxially directly in the cells, the initial dry density being chosen in the range between 1.6 and 1.8 g/cm^3. The bottom of the sample is in contact with a porous stone connected to a graduated burette which allows control the pore water pressure while the material saturates. The air in the pores escapes from the upper part of the cell through the opportunely pierced piston. Tests have been carried out for about 4 months and confirm, in line with other literature data (e.g. Karnland *et al.* 2006), the remarkable swelling capacity the MX-80 granular bentonite. For instance, a swelling pressure of about 7 MPa is exerted by a specimen characterized by an initial dry density of 1.67 g/cm^3.

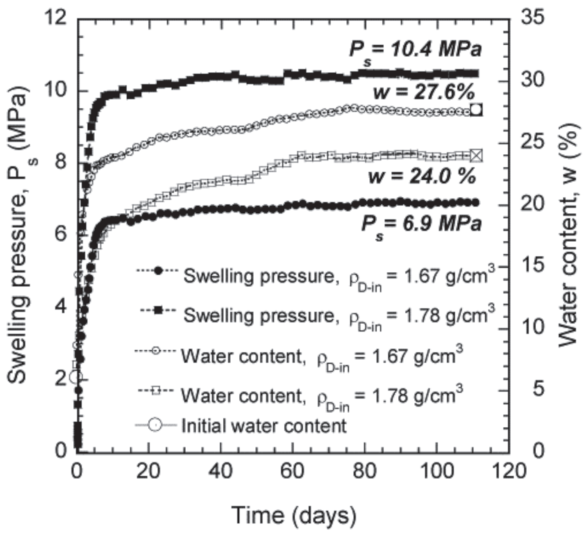

Figure 1: Confined swelling test: evolution of swelling pressure and water content with time for two different initial dry densities.

In order to be able to understand correctly the swelling behaviour of the material, it is essential, in addition to the fundamental basic characterisation, to investigate its retention properties and their evolution with temperature. In general, the water retention behaviour of unsaturated soils is presented through the Soil Water Retention Curve (SWRC). The SWRC plays a significant role within the constitutive framework and has therefore to be precisely defined. In detail, the required parameters are the air entry value, the slope of retention curve and the extension of the hysteresis for different temperatures. Specific experimental tools have to be developed for this purpose (Salager *et al.* 2008). In particular, our sorption bench allows determining different points of the SWRC simultaneously and for accurately set thermal conditions. Finally, thanks to the possibility of weighing regularly the samples without disturbing the equilibrium of the system, the water content kinetics can be precisely drawn (Figure 2).

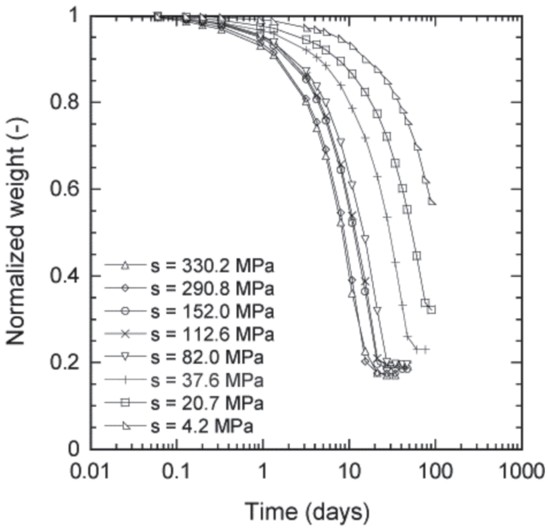

Figure 2: Evolution of the normalized weight of the sample of MX-80 bentonite during the main drying path at ambient temperature (s – suction pressure).

The final goal is indeed to catch the geomechanical behaviour of the bentonite, mainly in terms of swelling capability, in a high pressure – high temperature – high suction coupled context.

Thanks to the fact that within the reference model both suction and temperature influence the size of the elastic domain, the physics of coupled processes is captured. In detail, the model considers, in an elastoplastic framework, multiple mechanisms of plasticity and is extended to partial saturated and non-isothermal conditions. A new model for the soil water retention curve, considering hysteresis and effect of void ratio, is also implemented. The stress-strain model and the retention one are coupled together by means of the generalized effective stress formulation and key parameters such as preconsolidation pressure (Nuth and Laloui, 2008).

References:

Karnland, O., Olsson, S. & Nilsson, U., 2006. Mineralogy and sealing properties of various bentonites and smectite-rich clay materials. *SKB Technical Report*, TR, 06-30.

Nuth, M. & Laloui, L., 2008. Effective stress concept in unsaturated soils: Clarification and validation of a unified framework. *International journal for numerical and analytical methods in Geomechanics, 32*, 771-801.

Salager, S., El Youssoufi, M.S. & Saix, C., 2008. Temperature effect on hydraulic behaviour for unsaturated deformable soils. *E-UNSAT*, Durham, UK.