THERMO-MECHANICAL CEMENTATION EFFECTS IN BENTONITE INVESTIGATED BY UNCONFINED COMPRESSION TESTS

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BACKGROUND

Mechanical properties of buffer material are included in the model used for predicting the physical behaviour of saturated buffer in the final disposal of spent nuclear fuel. One simple test where the mechanical properties can be quantified is the unconfined compression test. In this type of test the relation between stress and strain are determined from axial compression of a cylindrical specimen.

In the project LOT (Karnland *et al.*, 2009) the unconfined compression test was used to study the mechanical properties on field exposed buffer material. The results from these test series showed that specimens exposed to warm conditions had a significantly reduced strain at failure compared to reference material. Changes in mechanical properties may be due to incipient chemical changes in the material. However, the present study focuses on other possible sources for brittle failure behaviour.

OBJECTIVE

In this study the objective was to experimentally investigate if deviating stress-strain behaviour measured after temperature exposure could be explained by Thermo-Hydro-Mechanical processes. The word cementation is used as a general term for the process involving a change in mechanical properties including brittleness at failure.

MATERIAL AND METHODS

A relatively large number of specimens were tested representing sodium dominated and calcium dominated bentonites. Cylindrical specimens were compacted from air dry powder to a height and diameter of 20 mm. The main part of the specimens was put in a saturation device prior to the tests in order to ensure full saturation. After the saturation each sample was placed in a mechanical press where a constant rate of strain was applied axially to the specimens having no radial confinement. During the test the deformation and the applied force were measured by means of force and strain transducers. After failure the water content and density were determined.

Test series were carried out for investigating the influence of for example exposure to 200C, stress path, initial water content, initial degree of saturation, friction during shearing and gypsum content.

RESULTS

The deviator stress q and the strain e were derived from the test results according to Equations 1 and 2 where F is the applied vertical load, A_0 is the original cross section area, l_0 is the original length and Dl the change in length. Examples of results are shown in Figure 1.

$$q=\frac{F}{A_0}\cdot\left(\frac{l_0-\Delta l}{l_0}\right) \tag{1}$$

$$\varepsilon=\frac{\Delta l}{l_0} \tag{2}$$

In Figure 1a the impact of increased temperature is shown. The colours blue, yellow and red denote the temperatures 20C, 150C and 200C, respectively. In Figure 1b the influence of initial water content is

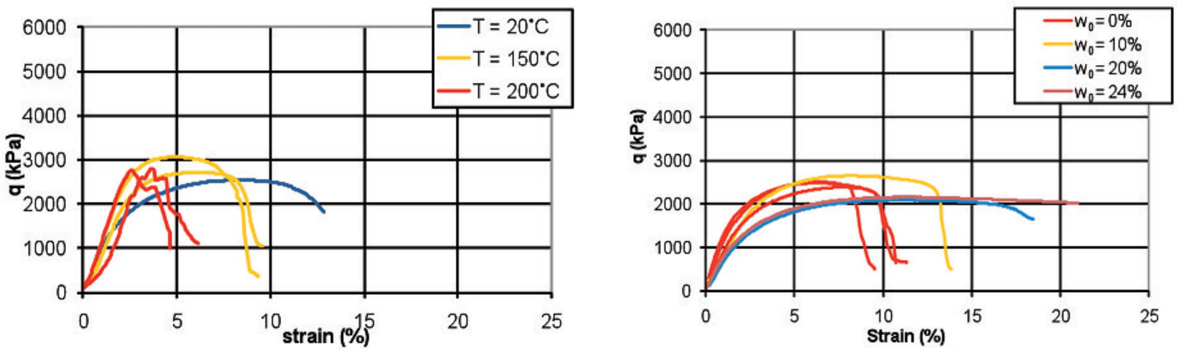

Figure 1: Resulting axial stress vs. strain from unconfined compression tests. **a.** Influence of temperature (left). **b.** Influence of initial water content (right).

shown. The colours red, yellow, blue and brown denote the initial water contents 0%, 10%, 20% and 24%, respectively. All specimens were water saturated and had a bulk density of approximately 2.00 g/cm^3.

The appearance of a marked brittle failure can be seen in the test series on specimens exposed to 200C during a relatively short time period. A similar behaviour was also seen on specimens exposed to room temperature but with very high densities or low degree of saturation. Decreased strain at failure was also seen for example when the preparation involved compression before shearing although the failure was not brittle in those cases.

One conclusion is that increased brittleness, in terms of decreased strain at failure, can be caused by conditions not necessarily involving chemical alteration. However, the results do not exclude that the brittleness seen on some field exposed material is caused by chemical alteration.

Reference:

Karnland, O., Olsson, S., Dueck, A., Birgersson, M., Nilsson, U., Hernan-Håkansson, T., 2009. Long Term Test of Buffer material at the Äspö HRL (LOT project), Report on the A2 test parcel. In preparation.