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New method for ageing resistant storage of argillaceous rock samples to achieve reproducible experimental results even after long intermediate storage times

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ABSTRACT

In case of radioactive waste confinement indurated clays are potential host rocks as well as barrier rock formations. Therefore, laboratory tests on indurated clays together with physical modelling as well as numerical calculations are important topics of today's international research work. Lots of laboratory experiments have been carried out in the past years at the Professorship for Waste Disposal and Geomechanics to determine the mechanical and hydraulic characteristics of argillaceous rocks, in particular with cylindrical samples. Due to increasing storage time, the properties of the rock exhibited at the time of the laboratory tests might not necessarily be reflective of the actual properties of the rock in situ that the sample is supposed to represent. Within long-term plastic bag storage of claystone core samples macroscopic damage was observed that negates the development of laboratory tests. This contribution deals with the experience of more than one year using a new method for ageing resistant storage of argillaceous rock samples to achieve reproducible experimental results even after long intermediate storage times. Investigated material properties are strength and deformability. A comparison between different types of storage with respect to mechanical properties is given, demonstrating the basic advantage of using pressure cells in the future to get reproducible data independent of storage times.

1. Introduction

In case of radioactive waste confinement indurated clays are potential host rocks as well as barrier rock formations. Therefore, laboratory tests on indurated clays together with physical modelling as well as numerical calculations simulating the EDZ development and long-term behaviour are important topics of today's international research work. There are many results of laboratory tests with indurated clays available in the literature now, e.g. investigations with indurated clays from the well-known sites of Mont Terri, Bure or Tournemire, Blümling et al. (2005), Dossier (2005), Rejeb et al. (2006), Tsang et al. (2005).

Nevertheless, the development of advanced computer codes for numerical simulation of hydro-mechanical coupled processes demands improved and specialized constitutive laws and this demand requires additional knowledge about mechanisms and parameters to understand, describe and model the rock mass behaviour sufficient realistic.

In this case here the constitutive model *Hou/Lux-T* will be used to model the rock mass behaviour in the EDZ. This constitutive model has been originally developed some years ago for salt rock mass and is now being modified to describe the mechanical behaviour of indurated clays, Hou (2002), Lux and Czaikowski (2005), Lux et al. (2005a,b,2006a,b), Czaikowski and Lux (2006).

The Opalinus clay from Mont Terri site has been well investigated in recent years at various institutes with respect to its mechanical and hydraulic properties and parameters, Popp and Salzer (2007), Schulze and Hunsche (2005) and Zhang et al. (2007). Nevertheless there is no complete and consistent *Hou/Lux-T* data base existing up to now to describe the complex hydro-mechanical behaviour of this rock. With respect to these experiences, it should be mentioned that lots of laboratory experiments have been carried out in the past years at our institute to determine the mechanical and hydraulic characteristics of argillaceous rocks, in particular with cylindrical samples.

The samples required for laboratory investigations are extracted from the rock mass by means of core drilling. In order to ensure that the material behaviour determined in the laboratory experiments for the different properties will sufficiently represent that of the on-site rock, it is necessary to appropriately protect the drill cores against ageing effects subsequent to their extraction and up to carrying out the rock mechanical experiments in the laboratory. Generally, for this purpose, sensitive core material with respect especially to water induced fabric alteration (predominately clay,

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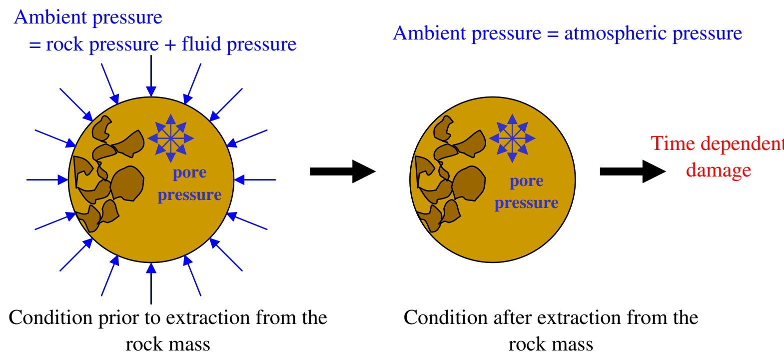

Fig. 1.1. Schematic representation of the pore water pressure effect on rock samples after extraction of the core material from the rock mass.

claystone) is protected against drying-out or the uptake of moisture from the ambient air by sealing it in a plastic bag and storing it under climatically suitable ambient conditions.

Subsequent to the extraction of the core material from the rock mass, a pore water pressure in the pore space of the rock is still effective because of the low hydraulic conductivity, but both the mechanical rock mass stress and the hydraulic pressure that have been active at the extraction location are reduced to the level of the atmospheric pressure at the boundaries of the samples, Fig. 1.1.

The result of this process may be that tangentially oriented tensile stresses originate within the rock structure of the sample. Another effect with fundamental impact may be the volume increase of the rock sample as a consequence of unloading and a related decrease of pore pressure.

Furthermore rocks that are additionally subjected to pore water pressure exhibit, despite storage under air-conditioning and protection against drying-out or moisture-uptake, a change in their mechanical properties that may increase significantly with storage time (structural weakening). According to the rock structure, and with increasing storage time, desaturation, geochemical reactions with oxygen as well as pore water pressures will lead to more or less strongly pronounced changes in the mechanical and hydraulic properties of the rock matrix (e.g. strengthening due to capillary forces and weakening due to microcracking), Delage et al. (2007).

Based on these complex processes, the laboratory test results show a high influence of the kind of interim storage conditions on the material properties. According to Lux et al. (2006a) in case of sample sealing with plastic bags for interim storage of six month the following influences on the material properties could be interpreted due to:

– an increase in the shear strength of the rock samples (increase of the effective stress because of a reduced pore water pressure or desaturation (suction)),
– increasing damage and destrengthening of the rock microstructure resulting from the actual pressure difference, e.g. the difference between the internal pore water pressure and the ambient pressure that has now been reduced to the atmospheric pressure, as well as
– increasing damage of the rock microstructure by further desaturation which leads to the formation of contraction cracks (shrinkage, enlarged suction), Fig. 1.2.

In case of Fig. 1.2 it is obvious that weakening of rock fabric predominantly occurs following the bedding planes which are usually planes of relative low strength compared to the strength of the rock matrix.

Fig. 1.2. Ageing cracks inplastic bag sealed sample.

2. Materials and methods

A successful method to avoid or minimize the mechanically, hydraulically as well as geochemically based ageing effects outlined above is the interim storage of the drill cores in special sample storage containers (pressure cells) directly after their extraction, Fig. 2.1 (Patent specification 10 2005 053 360).

Following the extraction of the drill core from the rock mass, segments of defined length are prepared from it, sealed in coated film and encased with a rubber jacket. Pressure plates are then positioned one on the top and the other on the bottom of the rock core. The locking of the pressure plates to the rubber jacket is made with metal clamps or a tensioning wire to give a form and force closed connection between the rubber jacket and the pressure plates. This is followed by the installation of the jacketed rock core in the storage container to which the bottom cover plate has been fitted. The bottom pressure plate makes positive connection to the bottom cover plate. The top cover plate is put on and this centres the sample in the storage container. The loading of isotropic pressure is made by filling the annular space between the sample jacket and the inner wall of the storage container with hydraulic oil. Bores in the top and bottom pressure plates ensure that the hydraulic oil can also penetrate throughout the area between the