Hydro-mechanical behaviour of compacted bentonite-sand mixture used as sealing materials in radioactive waste disposal

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HYDRO-MECHANICAL BEHAVIOUR OF COMPACTED BENTONITE-SAND MIXTURE USED AS SEALING MATERIALS IN RADIOACTIVE WASTE DISPOSAL

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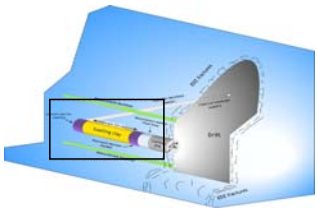
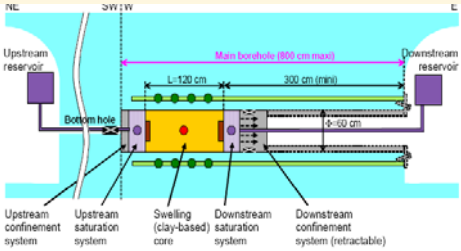
Concept

- In order to verify the safety of the geological high-level radioactive waste disposal, IRSN has undertaken the SEALEX research project to control the long-term performance of swelling clay-based sealing systems. Compacted bentonite-sand mixture is one of the most appropriate sealing material studied in this project because of its low permeability and good swelling capacity.





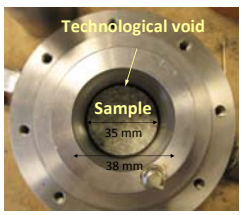
Phenomenon studied

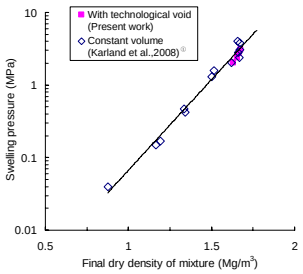
- Once installed, this material will be in contact with the host-rock pore water and start swelling to close all the gaps in the system (internal pores, rock fractures and technological voids) and then, swelling pressure develops. In parallel with the in-situ **SEALEX** project, laboratory experiments are performed to investigate the sealing properties under this complex hydro-mechanical condition taking into consideration the effect of technological voids.

Two Approaches

Studying the buffer as a homogeneous material

Swelling pressure



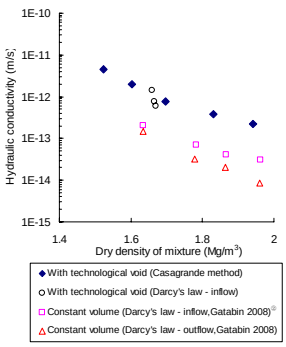


- No effect of technological void on the swelling pressure
- The final dry density controls the swelling pressure

Saturated hydraulic conductivity

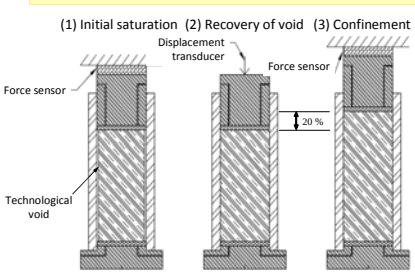
Obvious effect of technological void

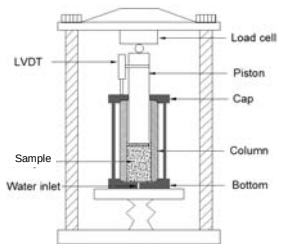
- The hydraulic conductivities with technological void are higher than those determined in constant volume condition
- That evidences the preferential pathway of water in the zone of technological void (filling material is more permeable)



Mock up test

- Objective:
  - Investigate the recovery capacity of compacted bentonite-sand mixture when considering a 14% of technological void
  - Provide useful information about the effectiveness of field design
- Methodology: Design a small scale (1/10) of the in situ **SEALEX** experiment model test

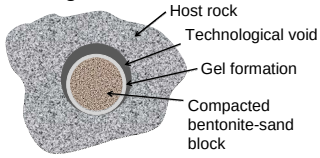




Studying the buffer as a non-homogeneous material

Blocks start being saturated from their surface and swell forming a loose gel that will grow to fill the technological void.

The state of the gel formation is changing with time in parallel with a constant evolution of the hydro-mechanical conditions.

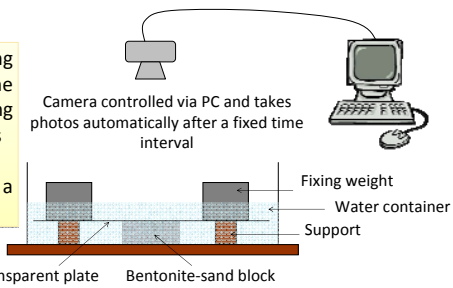


A better understanding of this changing gel formation is essential in assessing the performance of the total sealing structure.

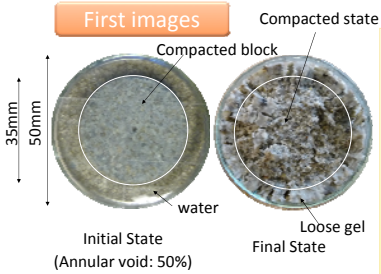
Methodology

Follow the swelling of a block immersed in water by time-lapse photography

- Image processing to investigate the kinetics of swelling and its limitations
- Compare with a free swell test



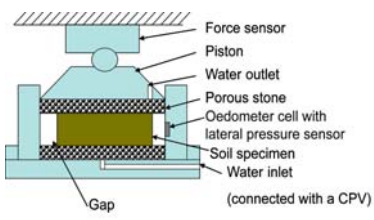
First images



- The annular void have been filled in 2h30min
- The filling material has different state than the central material
- The filling material is a loose gel which state is changing with time
- Generation of lateral swelling pressure

Perspectives

- From a mechanical point of view, due to this non homogeneity, the swelling pressure generated radially will be compared to the axial one
- Investigation of an anisotropic behavior



① Karnland, O., Nilsson, U., Weber, H., and Wersin, P., 2008. Sealing ability of Wyoming bentonite pellets foreseen as buffer material-Laboratory results. Physics and Chemistry of the Earth, Parts A/B/C, 33:S472–S475.

② Gatabin C. 2008. ESDRED Project Module1 Selection and THM Characterisation of the Buffer Material, ESDRED International Conference, 16-18 June 2008, Czech Technical University – Prague, Czech Republic