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AN EXPERIMENTAL AND NUMERICAL STUDY OF BENTONITE SWELLING UNDER CONSTANT-VOLUME CONDITIONS

TOPIC 04: Hydro-mechanical properties

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Abstract

The swelling pressure developed by an engineered barrier upon saturation is a key aspect of the design and safety assessment of geological disposals for radioactive waste. The swelling pressure should indeed be sufficiently high to create a good seal and close fractures of the excavation-damaged zone, but it should not exceed the natural stress of the geological formation.

This contribution presents an experimental and numerical study of the swelling behaviour of compacted bentonite subjected to hydration under constant-volume conditions. For the sake of the experiment, a bentonite sample is compacted with an isostatic press and hydrated, under constant volume conditions, until full saturation of the sample is reached (14 months). The total axial pressure, total radial pressures at four different heights of the sample, and the injected water volume are recorded over time. The experimental data show a complex and non-uniform evolution of axial and radial stresses over time, as well as anisotropy of the total stresses, which persist at the saturated equilibrated state.

In order to help understand the test results, numerical simulations are performed using an advanced hydromechanical framework for partially saturated porous media, accounting for the evolving microstructure of the material. The complex evolution of the total axial and radial pressure sensors with time is explained by an advancing hydration and swelling front in the bentonite sample, and by the development of irreversible deformations. The good agreement between the numerical results and the experimental data enables validation of the developed framework. Implications for engineered barriers in deep geological disposal of radioactive waste are discussed.