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Experimental data of the influence of the degree of saturation on physical and mechanical properties of shale rocks

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In addition to direct mechanical perturbations, an excavation influences rock conditions (mechanical, hydraulic and chemical properties) due to ventilation conditions. The internal fluids are drastically modified and in particular, the presence of water in the rock with regard to hydration and desiccation, as described in recent study on similar rocks [1]. The aim of the present study is to investigate the influence between the degree of saturation and the physical/mechanical properties for shale rock. Anisotropy effects are also studied to identify hydro-mechanical behaviour.

The studied shale rock is collected from Bure site (ANDRA-France); shale rock is bedded-indurated-argillaceaous rock with predominant clay fraction (40-50%), carbonate (20-30%) and quartz (20-30%). Native water content is close to 8 % and the total porosity is between 10 and 12%.

The different degrees of saturation are imposed by controlled suctions with continuous measurement of physical parameters such as weight and deformations (different suctions are imposed from 2.8MPa (or 98% RH) to 143MPa (or 36% RH) in order to cover the disposal site conditions). Deformation are correlated with mass evolution; for the driest suction, shrinkage deformation perpendicular to the bedding could reach 8.10^{-3} and 4.10^{-3} in the bedding plane for 5.8%-mass loss. The volume variations (swelling or shrinkage behaviour) would result principally from the opening or closing of the inter-layers space. Ultrasonic wave propagation properties have been investigated before and after suctions: the decrease of the ultrasonic wave velocity versus the degree of saturation is quasi linear.

Uniaxial compressive tests are carried out in order to attempt to correlate different mechanical parameters (elastic, damage and failure data) to the sample saturation. The mechanical behaviour is sensitive to the saturation state of the rock with an important part of the stratification and its relative orientation to the mechanical stress; for example, between the saturated state and the driest state (143MPa-suction), Young modulus in the direction normal to the isotropic bedding plane, increases from close to 5000MPa to 11000MPa, and strength from 20 MPa to 50MPa. During the mechanical test, acoustic emission (AE) are recorded to estimate volume damage. Acoustic emission activity occurs in four principal steps: i) initial activity due to the closing of existent micro-fractures, ii) no activity during the elastic phase, iii) for 60 to 80% of the strength, important activity is recorded with energetic wave; this phase can be correlated to development of micro-fractures, iiii) beyond 80-90% of the strength, the number and energy of AE activity decreases; this seems to be related with the propagation of the fractures created in the precedent phase.

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