Digital Image Correlation experiments at the Tournemire Underground Rock Laboratory

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Clay rocks are considered in several industrial countries as potential repositories for high-level radioactive wastes. Among the critical issues related to the long-term safety assessment of such geological repositories, the study of the so-called excavation damaged zone (EDZ) is of particular importance. The initiation and extension of the EDZ are governed by many parameters: the material properties of the rock (e.g., material anisotropy), the initial stress field, the existence of natural fracture zones in the rock mass, the geometry of the gallery, and the hydric state existing in the gallery. With regard to the latter, fractures associated with the desaturation of argillaceous medium have been observed on gallery fronts in several underground research laboratories, e.g., in the experimental platform at Tournemire and in the Mont Terri laboratory. This hydric fracturing process is evidenced in situ by sub-horizontal cracks spaced at several decimeters on all vertical walls in contact with ambient air. In winter (dry state), the corresponding crack apertures can reach a few millimeters; in summer (wet state), these cracks are closed. These cracks induced by drying are parallel to the bedding planes, suggesting that they are partially controlled by sedimentological patterns (e.g., vertical differences in sediment granulometry and/or mineral composition).

These observations of clay-rock damage induced by drying have been obtained in the field using conventional crackmeters or jointmeters, and one may wonder whether similar observations could have been made using non-invasive optical methods, such as the digital image correlation (DIC) technique. This communication presents an application of the DIC method in the East1996 underground gallery at the experimental platform of Tournemire; during this study, the Relative Humidity (RH) and temperature (T) were measured for more than one year. The objectives of this experimental investigation were (a) to assess the ability of the DIC method to measure displacement (figure 1) and strain fields and crack apertures induced by climatic changes in an underground gallery, and (b) to correlate the measured strain fields and crack apertures with climatic fluctuations (here RH only) in the gallery.

Our results demonstrate the ability of the non-invasive DIC method to monitor (a) clay-rock strains for at least four months and (b) the opening and closure of desiccation cracks for more than one year. Moreover, our study provides the following phenomenological results. First, as observed in the laboratory, the hydric strains were anisotropic; the strains perpendicular to the desiccation cracks were almost homogeneous and much larger than those parallel to the same cracks. Second, the changes in crack apertures calculated from the displacement fields (at an accuracy of approximately 26.9 µm) and the strain fields were clearly correlated and concomitant with changes in RH and T (with $25\% < RH < 99\%$ and $6°C < T < 14°C$). Third, contrary to direct measurements acquired at the Mont-Terri site, the crack apertures of the desiccation cracks were reversible after one year of data acquisition. Moreover, although the main desiccation cracks were sub-horizontal and associated with the direction of bedding planes, our work demonstrated the existence of sub-vertical cracks.