Strain localization patterns during hole fluid pressurization of an anisotropic Vosges Sandstone under true triaxial conditions

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Résumé

Tensile fracturing of porous rocks induced by fluid pressure is an important process, encompassing both natural and artificial phenomena, including the formation of dike, vein growth and subsequent mineralization; the extraction of hydrocarbon through hydraulic fracturing or gas outbursts in underground mines. A particular concern during engineered tensile fracturing of rock mass through fluid pressure (such as hydraulic fracturing) is generating passive seismic events. Hence, it is necessary to monitor the evolution of this kind of engineered deformation and localization pattern of the deformation to demarcate the damage zone of the subsurface.
In this study, fluid driven tensile fracturing experiments were performed on anisotropic Vosges sandstone blocks retrieved from a quarry near the city of Hangviller,. Prismatic samples of volume 50 × 50 × 30 mm3 were prepared. A hole of diameter 10 mm and length 30 mm was then bored within the samples, with its axis intersecting the centre of the 50 × 50 mm2 face. A white and black random speckled pattern was then applied on the 50 × 50 mm2 face of the specimen. The high pressure true triaxial apparatus (TTA) used for the loading experiment has been designed at Laboratory 3SR, Grenoble with the unique feature of a transparent sapphire glass window in contact with the specimen's speckled surface allowing to photograph the face of the specimen during deformation so as to a posteriori reconstruct the surface strain field using Digital Image Correlation (DIC) (1). DIC computation was performed in the SPAM (2) software by computing the correlation function between many subset (correlation windows) of corresponding images taken at two successive time steps. DIC algorithm includes rigid displacement and rotation and linear distortion of the correlation windows.

Specimen is prevented from fluid invasion thanks to an external soft jacket all around the specimen and by an internal one inside the cylindrical hole. Loading experiments were conducted in the specimens with two different orientations; one in which the applied axial load was perpendicular to the bedding plane of the sandstone and another in which the axial load was applied parallel to the bedding plane. In either of the situations, isotropic loading was applied with a rate of 0.4 MPa/min to 8 MPa followed by the application of vertical load at a rate of 0.2 MPa/min to 10 MPa. Internal fluid pressurization in the circular cavity was achieved by injecting water with a pump at a rate of 0.2 MPa/min until visible fracture

*Intervenant

occurred in the specimen.
The evolution of the volumetric and deviatoric component of surfacic strain tensor with loading and fluid pressurization up to post failure was correlated with macroscopic stress-strain curves. Local zones of compaction and dilatancy around and away from the cavity are presented. Monitoring the advancement of strain concentration from early stages to failure, and how these high deformation zones control the post failure behavior is reported. The study thus establishes a correlation between the mechanical response with the development and evolution of kinematic structures during fracturing of porous sandstone with fluid pressure.