On the anisotropy and hydromechanical properties of intact/jointed rocks

S. Pietruszczak

McMaster University, Canada

This paper deals with description of hydromechanical response of intact rocks as well as discontinuous rock mass. In the former case, the focus is on the notion of anisotropy, which is addressed in the context of argillaceous Cobourg limestone. For a rock mass containing discontinuities, the average hydro-mechanical properties are established in a domain that comprises the intact material and the pre-existing and/or newly developing fracture zones.

The anisotropy of Cobourg limestone stems from heterogeneity of its fabric. In this work, an approach that incorporates a fabric tensor is developed for the description of strength and deformation characteristics of this rock. The quantification of fabric is carried out by employing the basic principles of stereology and the specific fabric descriptor used is the so-called 'mean intercept length'. The results demonstrate that the material may be perceived as transversely isotropic and the mechanical response is affected by the volume fraction of argillaceous partings. The latter are spatially variable, so that the notion of Representative Elementary Volume (RVE) is not, in general, applicable. A numerical study is included involving simulation of triaxial tests conducted on differently oriented samples of Cobourg limestone.

For a rock mass containing discontinuities, the formulation employs the averaging of the field operators within the referential volume adjacent to macrocrack. This leads to an enriched form of Darcy's law, which incorporates the notion of equivalent hydraulic conductivity. The latter is defined as a symmetric second-order tensor whose components are function of hydraulic properties of constituents (viz. intact material and fractured region) as well as the internal length parameter. Such an approach does not require any additional degrees of freedom to account for the presence of discontinuities, which significantly improves the computational efficiency.

The mechanical analysis is based on an enhanced embedded discontinuity approach, which is conceptually similar to that employed for specification of equivalent hydraulic conductivity. It incorporates the same internal length parameter related to geometry of fractures and enables a discrete tracing of the propagation of new cracks.

The formulation is illustrated by a numerical study involving 3D simulation of an axial splitting test carried out on a saturated sample under displacement and fluid pressure-controlled conditions. The finite element analysis incorporates the PPP stabilization technique and a fully implicit time integration scheme.