Numerical stress initialization in Geo-mechanics via the FEM and a two-step procedure.

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ABSTRACT

The knowledge of the in-situ stress field in rock masses is in general of crucial importance in various areas of geo-engineering, such as mining or civil underground excavations, hydrocarbon extraction, CO2 storage, hydraulic fracture operations, etc. [1,2].

In the context of the Finite Element Method, the in-situ stress conditions should be incorporated in the analysis following the generation of the FE mesh and prior to the consideration of the actions due to the engineering design [3]. An accurate evaluation of the in-situ stress field could be in principle achieved by modelling the detailed geologic history of the rock mass. However, although some work has been developed along this line, the geological history may be in general very complex, many details of geological processes often uncertain. This is why a number of methods have been developed in order to obtain directly a final picture of the in-situ stress state based on the known in-situ information (basically vertical stresses and K_0) plus some basic equilibrium considerations.

The method described in this paper involves basically two steps. In the first one a first estimate of the stress state at each Gauss point is proposed, and in a second one global equilibrium is verified and re-balanced nodal forces are applied as needed. While the re-equilibration step is a closed procedure based only on statics, the first estimate of the stress state can be done in a variety of ways to incorporate all the information available, aside of course from the most basic method consisting of using vertical stresses due to gravity and horizontal due to K_0. In this paper, the various options available are discussed and compared, and one new alternative procedure is developed based on Airy stress function [4]. The performance of the various procedures is illustrated with some application examples, both academic and real field.

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