Rock mechanics model for simulation of fracture propagation based on embedded discontinuities

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ABSTRACT

Numerical model presented here [1-2] is based upon embedded discontinuity concept [3-5]. It is capable of representing the evolution of cracks propagating through the rock mass until complete localized failure. The proposed model takes into account the grainy structure of rocks and thus the heterogeneities that occur due to its geological formation. The rock grainy structure is represented by Voronoi cells which are held together by cohesive forces (links) represented by Timoshenko beams.

Embedded strong discontinuities have been added to cohesive links leading to failure modes I, II (2D case) and I, II, III (3D case). The important aspect of the model is a possibility to simulate mixed-mode fracture propagation. The heterogeneities of the rock mass are considered through the Gaussian distribution of the material parameters.

The main advantage of the proposed failure model is in successful representation of full set of failure modes, starting with micro-crack initiation and their accumulation to forming larger macro-cracks. The progressive failure of rock material is characterized by the growth of discontinuities, which can initiate and propagate under the external load and form the macro-cracks that will lead to total failure.

Upon reaching the failure point, the cohesive link (Timoshenko beam of length l) is cut by half by the crack and further experiences the jump in the displacement field leading to heterogeneous displacement field within the finite elements. Embedded strong discontinuity serves for latter representation. Such a task includes addition of the appropriate discontinuous shape function to the standard beam kinematics. The proposed model has been validated by a set of experimental results.

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