8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

EFFECTS OF FRICTIONAL SLIP BETWEEN CRACK INTERFACES TO CRACK PROPAGATION IN QUASI-BRITTLE ROCKS

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Key Words: *Crack Propagation, Frictional Slip, Rock, Finite Cover Method (FCM).*

ABSTRACT

Failure processes of quasi-brittle rocks generally involve not only cracking within rocks but also slippage between crack interfaces, especially when they are subjected to compressive loading. But, it is not clear exactly how the crack propagations are affected by the slippages between the crack interfaces. In this study, these processes under uni-axial compressive loading are simulated by means of the numerical analysis method based on the finite cover method (FCM) [1].

The FCM, which is one of the generalized versions of the finite element method (FEM), brings a slightly different understanding of the mathematical domain for approximation from the standard FEM. The domain for approximation is composed of the finite number of covers of differentiable geometry and also endowed with the partition of unity conditions for weight functions (that corresponding to shape functions in the FEM). Then, the important feature of the FCM is that it admits into the FE approximation the arbitrary representations of crack propagation regardless of mesh topologies.

Additionally, the fracture behavior on craking surfaces is represented by the cohesive crack model [2], which realizes smooth transition from continuity to discontinuity in the fracture process zone near the crack-tip. When internal interfaces correspond to closed cracks, the mortar approximation techniques [3] are applied to satisfy the contact conditions on these surfaces which is analyzed by using the augumented Lagrangian method [4]. However, surprisingly few studies have so far been made at integrating those methodologies for different types of non-linearities involved in the failure. In this study, the numerical examples are simulated by those detailed algorithms for dealing with opening and closing interfaces in the light of cohesive and frictional contact behaviors.

The simulated numerical examples are uni-axial compressive loading tests on the rectangular plane structure with a single inclined pre-formed crack. the prepared pre-formed cracks have following different surface properties. (i) the pre-formed crack is open, and its surfaces of discontinuity not expected to contact each other, (ii) the surfaces of discontinuity of the pre-formed crack contact each other, but are assumed to be frictionless, (iii) frictional-contact behavior is assumed on the surfaces of discontinuity of the pre-formed crack.

The above-mentioned numerical tests demonstrate the effects of frictional slippage between the crack interfaces to crack propagations within quasi-brittle solids. These results show the fundametal mechanisms of crack propagations within brittle rocks.

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