Variational interface zone model for modeling of fluid induced fracture propagation

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ABSTRACT

A novel variational framework for aninterface zone model is developed and extended to poroelasticity. As was previously promoted in [1], the total energy of the system is composed by the bulk potential and fracture surface energy. In contrast to the phase-field method [2], the fracture surface is approximated directly along the edges of the finite elements in terms of the interface zero-thickness finite elements. With an introduction of new degree of freedom c (damage field) on the interface level, the solution is found by the minimization of the total potential energy with respect to the displacement and damage fields. An elastic interface constitutive law with the normal and tangential displacement opening formulation is adopted in the pre-fracture regime. Assuming, that a crack propagates according to the Griffith's criterion of brittle fracture, the damage occurs dominantly from the normal opening mode.

The Biot's theory is applied both to the bulk and interface elements for the simulation of fluid driven fracture. The pressure field within the interfaces is averaged between the pressures at the bulk element faces. The pressure continuity is enforced by means of a penalty functional. The flow within the fracture is modeled by the cubic law taking the displacement and damage variables into account

A number of numerical benchmark tests, which include comparisons with experimental results and analytical solutions, are performed to demonstrate the performance of the model.

Literature

[1] B. Bourdin, G.A. Francfort, J.J. Marigo. The variational approach to fracture. J. Elast. 91 (1-3) 2008 5-148.

[2] Miehe, C.; Welschinger, F. & Hofacker, M. Thermodynamically consistent phase-field models of fracture: Variational principles and multi-field FE implementations. International Journal for Numerical Methods in Engineering, John Wiley & Sons, Ltd., 2010, 83, 1273-1311.