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Cohesive fracture simulations on polygonal finite element meshes

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ABSTRACT

The partial differential equations governing the hydraulic fracture propagation in partially saturated, porous media involve the linear momentum balance equation for the whole mixture and the continuity equation for fluid flow inside the fracture and in the porous medium surrounding the fracture. The spatial discretization using XFEM and the time domain discretization applying the generalized Newmark scheme yield the final system of fully coupled nonlinear equations, which involves the hydro-mechanical coupling between the fracture and the porous medium surrounding the fracture. Because of the nonlinearity of the coupled problem, an iterative procedure is implemented to linearize the nonlinear system of equations. As a result, solid displacement and fluid pressure fields are obtained simultaneously together with the fracture length and the fracture process zone length. More importantly, the fluid leak-off from the fracture into the surrounding porous medium is obtained directly as a part of the solution without introducing any simplifying assumption. Moreover, the possibility of the fluid lag formation is determined as a result of the analysis, and the fluid lag size and the pressure within it are obtained directly in case that the fluid lag develops. The proposed approach is successfully applied to examples involving a fracture driven hydraulically in a partially saturated, poroelastic medium because of the fracture injection. Apart from proving the applicability and efficiency of the proposed model in simulating fluid-driven fractures, the numerical simulations illustrate the capability of the method to predict the influence of the fluid injection rate, the fracturing fluid, and formation properties, such as the fracturing fluid viscosity and formation permeability, and the in-situ stress field on the hydraulic fracture response, e.g., time history of the fracture opening profile.