Fracture analysis with zero-thickness interface elements and crack re-orientation based on configurational forces

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ABSTRACT

The prediction of crack trajectory is one of the challenging problems in the modeling of solids in general, and in particular of quasi-brittle materials such as rocks or concrete. One approach described in the literature is to use a fixed mesh but allow cohesive cracks to develop along any of the initial mesh lines [1,2]. This approach is very convenient but the quality of the results depends very much on how well the original mesh layout includes (or not) the expected crack pattern. In the new approach described in this paper, it is proposed to decrease the initial mesh dependency by allowing a re-orientation of the fracturing lines during the analysis. The criterion used for this purpose is based on Configurational Mechanics theory [3], which defines configurational forces as indicating the direction in which the original position of each node would have to be moved in order to maximize (or minimize if taken with opposite direction) the overall elastic energy of the domain. These concepts lead to the material force method [4,5,6], which in this case is applied to the zero-thickness interface elements that have been pre-inserted in the FE mesh along major potential crack paths, as they start opening. This will be done in the context of an iterative process, which also involves a number of auxiliary techniques such as an energy-driven IDC control method, a mesh relaxation procedure to maintain mesh quality, a variable transport algorithm for the nodes changing location, etc. This methodology has been implemented and successfully tested in basic examples of fracture propagation in concrete specimens subject to simple loading. Extension to coupled analysis with saturated porous medium is currently under development.

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