Towards a mesh independent fracture modeling method using cohesive elements

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Abstract

Prediction and understanding of material failure is of major importance for different industrial and natural processes. Linear Elastic Fracture Mechanics (LEFM) is a very useful tool when dealing with brittle and quasi-brittle materials. Indeed, LEFM approach enables to identify a characteristic length where the fracture process will take place. It is well known that the softening experienced by materials once the failure process has started leads to an ill-posed problem if no regularization technique is used. Many different techniques have been developed in order to overcome this issue. It is possible to distinguish three main categories, namely, gradient-enhanced models, non-local models and cohesive zone models (CZM). Among these numerical techniques, CZM represents a very interesting alternative regarding the modeling of fracture processes since it allows to control in a very accurate way the fracture energy while keeping a rather low computational cost. They also allow to represent sharp cracks (in contrast to non local models), but their numerical implementation can be complex, especially within a parallel computing framework. In order to avoid the change on the macroscopic response of the material (in particular while the fracture has not yet started) dynamic insertion of cohesive elements is often used. Although it is possible to obtain a macroscopic behavior that is in agreement with experiments, the main drawback of CZM is related to the fact that obtained fracture patterns are mesh dependent since the cohesive elements are present at the facets between two bulk elements.

We will address this issue by using advanced remeshing techniques. Within the context of fracture modeling at microscopic scale, we have developed a numerical approach that allows to perform constrained remeshing steps during the resolution of the mechanical problem. These constrained remeshing steps consist in automatically generating a conforming mesh that suits the matrix and the inclusions of the material. This constrained remeshing tool has been enhanced in order to allow the dynamic insertion of cohesive elements (also known as extrinsic cohesive elements). We will present the numerical approach and its validation by looking into the convergence of the fracture pattern for different prescribed crack paths. Finally we will compare the results obtained for different crack propagation criteria for 2D problems in terms of fracture pattern and energy dissipation.
References


