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Continuous-discontinuous coupling model for crack initiation and propagation analysis

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Abstract

The analysis of crack initiation and propagation is essential for predicting the service life of engineering structure. A continuous-discontinuous coupling model is proposed and applied to simulate the progressing cracking problems. In continuous calculation, element is denoted by a discrete spring system which has specific physical meaning and its deformation and stress are directly calculated by the spring stiffness obtained from the energy functional. Using the penalty method, a group of mathematical springs are placed between two elements to ensure displacement compatibility condition. The continuous calculation results of the new model demonstrate a satisfactory agreement with the traditional finite element method. In addition, Mohr-Coulomb criterion is implemented into the new model to specify the failure state and fracture direction. Double paths including element boundary and element interior are adopted to realize the crack propagation. In this way, the fracture may be inserted along the boundary of elements or within the intact element. The two elements would separate or slide away from each other when inter-element fracturing occurs. In the case of intra-element fracturing, the intact element will be divided into two elements by means of cutting block. A set of element nodes are established on the crack tip at the same time, and the elements on two sides of the crack are set to two different nodes, causing the displacement to be discontinuous. To obtain a more accurate fracture direction, a preliminary judgement is simultaneously employed in this model. Finally, the rationality of numerical results is approved by several intense examples with crack propagation. The numerical results show that this method can satisfactorily simulate the progressing cracking problems under tensile, compressive and shear conditions. The continuous- discontinuous coupling model has been shown to be insensitive to quality of elemental mesh and thus has the potential to simulate crack initiation and propagation.

Keywords: continuous-discontinuous coupling model; crack propagation; intra-element fracturing; numerical experiment