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Dynamic Cohesive Crack Propagation Analysis of Concrete by Particle Discretized FEM

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Summary

In this study, 2D static and dynamic problems of cohesive crack propagation in concrete are analyzed by Particle Discretized FEM [1].

Particle Discretized FEM allows discontinuous displacement fields to be discretized into Voronoi blocks by using non-overlapping characteristic functions. Failures are then easily expressed as a separation of two adjacent Voronoi blocks. Average stress fields and average strain fields are discretized in each Delaunay triangle using Gauss divergence theorem, instead of using the differential form of displacement fields. Delaunay triangulation is conjugate of Voronoi tessellation. The relationship between the displacement fields and the strain field is equivalent to that of ordinary FEM with constant strain triangle elements.

For modeling concrete, we simply implemented the concrete constitutive law in the particle discretized FEM [2]. Concrete has high compressive strength but significantly lower tensile strength. Due to this characteristic, principal tensile stress is usually used as the fracture criterion. On the other hand, in the particle discretized FEM, failures always occur at the boundaries of the Voronoi blocks and the spring between two adjacent Voronoi Blocks is cut. Therefore instead of the principal tensile stress, the magnitude of normal tensile force of the boundaries of Voronoi blocks is used as the fracture criterion.

In order to validate our approach, we benchmarked it against problems with discontinuity in crack propagation in a single-edge and double-edge notched shear beams without considering cohesive cracks [3]. Although Particle Discretized FEM depends on mesh divisions, the results showed that different meshes gave almost identical crack propagation if a mesh division was finer enough. Finally, dynamic cohesive crack propagation analysis of concrete is carried out to show the potential abilities of our Particle Discretized FEM.

keywords: Finite Element Method, Crack Propagation, Cohesive Crack, Particle Modeling, Voronoi and Delaunay Tessellation, Concrete, Single-edge notched Shear Beam

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