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Numerical simulations on the fracture behavior of concrete material by particle method

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ABSTRACT

Finite Element Method (FEM) has been developed to simulate the failure behavior of elasto-plastic material. However, it has been exhibited that it was not easy to reproduce the discontinuity of fracture behavior and the post-peak behavior of concrete by general FEM because FEM is derived based on continuum mechanics. Recently meshless method such as element free galerkin method and particle method [1-3] have been developed and challenging to simulate inelastic behavior through elastic region.

This paper presents the applicability of the particle method on the failure and fracture analyses of brittle material such as concrete. In this paper, Moving Particle Semi-Implicit (MPS) method [4] proposed by Koshizuka is employed. In the early studies by the authors [5], original MPS method was improved so that the method could simulate elastic and elasto-plastic behavior. However, particle size and influence area, which are very essential in MPS, were not discussed.

First, in order to examine elastic behavior, the effects of particle size and influence area used in the weighted averaging are discussed. Also, the relationship between local spring constants and macro elastic constants such as young's modulus and poisson's ratio are investigated.

Then, simple constitutive model is considered as follows. In the normal spring between particles, the bilinear model is used. Mohr-Coulomb yield criteria is applied in the shear spring. To validate these constitutive model, analyses of uni-axial tension and compression tests of concrete plate are conducted. These results indicate that the model mentioned above enables us to reproduce brittle failure/fracture behavior of concrete, and the weighted avaraging operation in MPS method is very suitable to describe the strain gradient and strain localization of concrete material.

After that, the failure and fractre behavior of concrete under more complicated stress state are simulated and the applicability and issue of particle method is discussed.

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