Numerical simulation of dynamic brittle crack propagation using the singular edge-based smoothed finite element method

***Haodong Chen[1], †Qingsong Wang[1,2]**

[1] State Key Laboratory of Fire Science, University of Science and Technology of China, China
[2] Collaborative Innovation Center for Urban Public Safety, Anhui Province, China

*Presenting author: linghao@ustc.edu.cn
†Corresponding author: pinew@ustc.edu.cn

Abstract

Numerical prediction of dynamic crack propagation in brittle materials is much more difficult than that of static case. Therefore, effective computational techniques are needed. In recent years, the singular edge-based smoothed finite element method has been showed the high accuracy for the stationary dynamic crack problems in brittle materials [1]. In this work, the singular edge-based smoothed finite element method is extended to study the dynamic crack growth problems. The values of assumed displacements on the boundary of smoothing domains are only needed for forming the stiffness matrixes and mapping is not required by using the strain smoothing technique [2]-[4]. Five-node crack-tip elements are designed based on the base mesh for capturing the stress singularity near the crack tip [5]. A local refined mesh around the crack tip is used to enhance the accuracy of solutions. The consistent mass and the lumped mass are simultaneously developed as the standard finite element method and their accuracy is investigated numerically. The implicit Newmark time integration scheme is used to ensure the stability of this method. Dynamic stress intensity factors are computed using the domain-form formula of interaction integral. If dynamic crack initiation toughness is reached, crack will advance in the direction determined by the maximum hoop stress criterion.

Several typical examples were tested to verify the high accuracy of the proposed method. The numerical results are in good agreement with an analytical solution and the consistent mass offers smaller errors in the numerical results than that using the lumped mass.

Keywords: Edge-based smoothed finite element method, five-node crack-tip element, dynamic stress intensity factors, dynamic crack propagation

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