

## **Development of a damage propagation analysis system based on XFEM using CZM and application to fracture problems**

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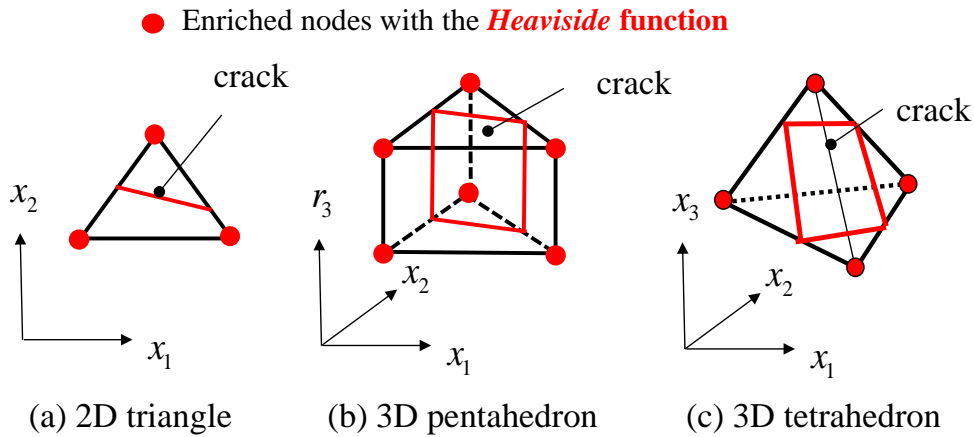
*Key Words:* XFEM, Cohesive zone model, Damage propagation, Delamination, Crack.

### **ABSTRACT**

Damage propagation simulation of engineering structures is one of the greatest challenges in the field of the computational fracture mechanics. In the present study, the extended finite element method (XFEM) [1] using the cohesive zone model (CZM) is applied to damage propagation analyses of rock mass and Carbon Fiber Reinforced Plastics (CFRP) composite. As CZM [2][3] can consider both a stress-based crack initiation and an energy-based crack propagation, it is expected to have a potential for providing practical crack propagation analyses. Moreover, if it is utilized in conjunction with XFEM, the cohesive crack can be modeled independently of finite elements, and therefore the crack propagation analysis can be performed much more effectively without remeshing.

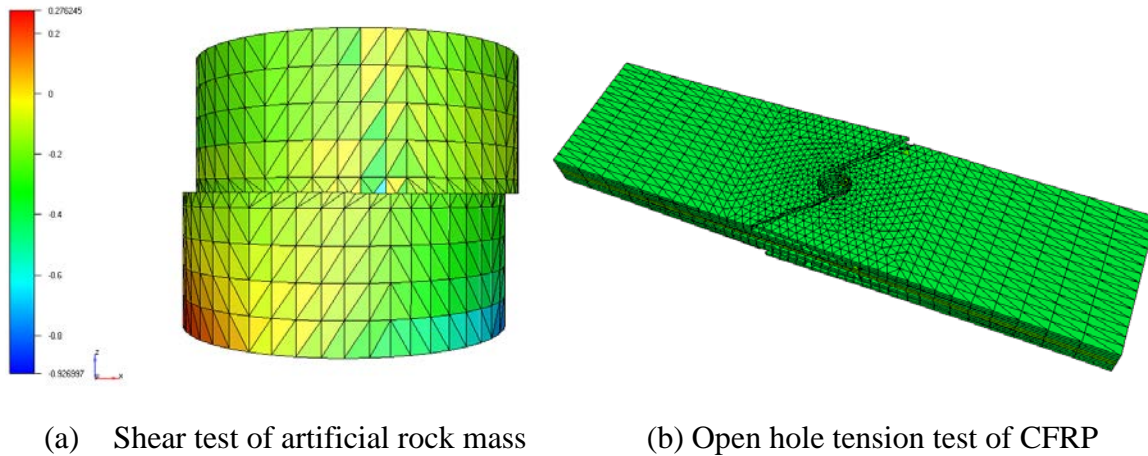
In this study, a crack propagation analysis systems based on XFEM using CZMs for two-, quasi- three-, and three-dimensional fracture problems were developed. In two- and quasi three-dimensional analyses, only the Heaviside function is utilized as the enrichment functions, and in three-dimensional analysis both the Heaviside function and the asymptotic basis functions are used. In all the analyses, the constitutive equations for CZMs are considered at the evaluation point on the discontinuous line and plane included by elements. In the developed system, the explicit method is also implemented in order to solve the problems, where converged solution cannot be obtained by the implicit method.

A finite element is classified as one of three types of elements according to the signed distance function with respect to the crack surface for each node. Specifically, the nodal value of it may be classified as one of three levels, i.e., positive, negative, or zero, and consequently the element can be classified as one of three types of elements: a normal element, a cut element, or a zero element. Cut elements for 2D triangle, 3D pentahedron, and 3D tetrahedron are shown in **Figure 1**.



**Figure 1:** Cracked elements by XFEM

The developed system was applied to test specimens of artificial rock mass and CFRP composite laminate as shown in **Figure 2**. The developed code can consider various cohesive zone models. The results including static/implicit dynamic/explicit dynamic analyses were verified through comparison with those by the conventional FEM. It was shown that the developed system can provide the appropriate results.



**Figure 2:** Numerical results obtained by the developed system.

## REFERENCES

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