On Fracture Mechanics Analysis

using B-spline Wavelet Galerkin Method

*Satoyuki Tanaka[1], Hiroshi Okada[2], Shigenobu Okazawa[3], Masahiko Fujikubo[4]

Graduate School of Engineering, Hiroshima University
4-1, Kagamiyama 1-chome, Higashi-Hiroshima, Japan, 739-8527
E-mail:
satoyuki@hiroshima-u.ac.jp

Graduate School of Science and Engineering, Kagoshima University
1-21-40, Korimoto Kagoshima, Japan, 890-0065
okada@mech.kagoshima-u.ac.jp

Graduate School of Engineering, Hiroshima University
4-1, Kagamiyama 1-chome, Higashi-Hiroshima, Japan, 739-8527
E-mail:
okazawa@hiroshima-u.ac.jp

Graduate School of Engineering, Hiroshima University
4-1, Kagamiyama 1-chome, Higashi-Hiroshima, Japan, 739-8527
E-mail:
fujikubo@naoe.hiroshima-u.ac.jp

Key Words: *B-spline, Wavelet Galerkin method, Fracture mechanics, eXtended FEM*

ABSTRACT

In this study, B-spline wavelet Galerkin method for the fracture mechanics analysis is carried out. B-spline scaling function and wavelets [1] are used as the basis functions in the Galerkin formulation. It is very easy to integrate and differentiate compared with other kind of wavelet basis functions, such as Daubechies wavelet basis function. Furthermore, they have the so called multiresolution properties. The spatial resolution of the basis functions can be enhanced in the regions of high stress and strain gradients by superposing finer wavelet basis functions.

The B-spline wavelet Galerkin method can be considered as a kind of fixed grid approach. A solid or structure is descretized equally spaced structured cell. Numerical integration are conducted based on them. The outer boundaries are represented by performing or not performing the integration. To accurately represent the boundary, a sub-cell approach is applied. Then, it is simple to generate an analysis model for a complex shaped structure. There are no finite element mesh in classical sense. Then, it can be classified to be a kind of meshfree method.

In this methodology, there are some difficulties in dealing with external boundaries. They are due to the loss of linear independence of the basis functions. To circumvent these problems, we introduce the modified scaling function/wavelets or eliminate particular basis functions that can be expressed by the linear superposition of the other basis functions [2][3]. Furthermore, to carry out the analyses efficiently, an adaptive strategy based on the posteriori error estimation is developed. The error estimation are carried out in each integration cells and the different wavelets of finer length scales are added where numerical error is large [4].

Fracture mechanics analyses using B-spline wavelet Galerkin method are able to add enrichment functions to the original wavelet basis functions which contains a discontinuous displacement field [5][6]. The stress concentration region around the crack tip can represent by superposing diffelent length scale wavelets. Equivalent domain integral method [7] are adopted to calclate energy release rate. In this presentation, mathematical formulation and numerical examples for the two dimensional elastic crack problems are adopted.

REFERENCES

[1] C. K. Chui, "An Introduction to Wavelets", Academic Press, (1992).

[2] S. Tanaka and H. Okada, "On the Analysis of Stress Concentration Problems using Wavelet Galerkin Method (1st Report, Mathematical Formulations and Treatments on External Boundaries)", Trans. JSME Series A, Vol. **72**-718, pp.856-863, (2006).

[3] S. Tanaka and H. Okada, "On the Analysis of Stress Concentration Problems using Wavelet Galerkin Method (2nd Report, Using Higher Degree B-splines as the Basis Functions)", Trans. JSME Series A, Vol. **72**-719, pp.982-989, (2006).

[4] S. Tanaka and H. Okada, "On the analysis of stress concentration problems using wavelet Galerkin method (3rd Report, Adaptive Analysis)", Trans. JSME Series A, Vol. **73**-725, pp.42-49, (2007).

[5] T. Belytschko, T. Black, "Elastic Crack Growth in Finite Elements with Minimal Remeshing", Int. J. Num. Methods Eng., Vol. **45**, pp. 602-620, (1999).

[6] N. Moës, J. Dolbow, "A Finite Element Method for Crack Growth without Remeshing", Int. J. Num. Methods Eng., Vol. **46**, pp. 131-150, (1999).

[7] B. Moran, C. F. Shih, "Crack tip and associated domain integrals from momentum and energy balance", Engng. Frac. Mech., Vol. **27**, pp. 615-642, (1987).