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DYNAMIC RESPONSE ANALYSIS OF INTERFACIAL CRACKS IN 2D ANISOTROPIC BI-MATERIALS USING A TIME-DOMAIN BEM

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ABSTRACT

Dissimilar or bonded materials such as ceramic-metal, polymer-composite and composite-metal have been widely used in engineering applications for the purpose of strengthening or lightening. In these materials, interfacial failure often becomes the principal mode in the process of manufacture or in-service application from the viewpoint of materials strength. Additionally, many materials are either intrinsically anisotropic or anisotropic on some length scale of the deformation and often subjected to dynamic loading in service. As a result, dynamic interfacial failure in dissimilar anisotropic materials is becoming an important and promising subject of materials science and fracture mechanics.

In this paper, the time-domain BEM developed by Zhang (2000) and García-Sánchez et al (2007) in conjunction with the sub-region technique is applied to analyze the dynamic response of interfacial cracks in dissimilar anisotropic bi-materials. The bi-material system is divided into two homogeneous sub-regions along the interface and the traditional displacement boundary integral equations (BIEs) are applied on the boundary of each sub-region. The present time-domain BEM uses the quadrature formula of Lubich (1988a,b) for the temporal discretization to approximate the convolution integrals and a collocation method for the spatial discretization. Quadratic quarter-point elements are implemented at the interfacial crack-tips. An extrapolation technique proposed by Cho et al (1992) is used to compute the complex dynamic stress intensity factors (SIFs). Numerical examples for computing the SIFs are presented and discussed to demonstrate the accuracy and the efficiency of the present time-domain BEM.

As an example, we consider two bonded rectangular plates which are subjected to an impact tensile loading $\sigma_0 \cdot H(t)$ as shown in Fig. 1. An edge crack on the interface is considered. Here the geometric parameters are selected as a=5mm, W=30mm and H=20mm. A Graphite-epoxy composite with a composition of 65% graphite and 35%

epoxy is investigated, which has a mass density of $\rho^1 = \rho^2 = 1500 \mathrm{kg} \cdot \mathrm{m}^{-3}$ and the elastic constants are given as

$$C_{ij} = \begin{bmatrix} 155.43 & 3.72 & 0.0 \\ 3.72 & 16.34 & 0.0 \\ 0.0 & 0.0 & 7.48 \end{bmatrix} \mathrm{GPa} \, . \tag{1}$$

Fully anisotropic material properties in plane stress are investigated by using different inclination angles θ between the principal material-axis 1 and the crack-line. The elastic constants of Eq. (1) are transformed by the rotation of the angles $\theta_1 = -30^\circ$ and $\theta_2 = -60^\circ$. Each plate is discretized into 39 elements, where 18 elements for the external boundary and 21 elements for the interface including 10 for the crack-face. A time-step of $\Delta t = 0.2 \mu s$ is chosen. The numerical results of the present time-domain BEM and the FEM using ANSYS are shown in Fig. 2. The corresponding real part K_1 and the imaginary part iK_2 of the complex stress intensity factors show a very good agreement between our time-domain BEM and the FEM.

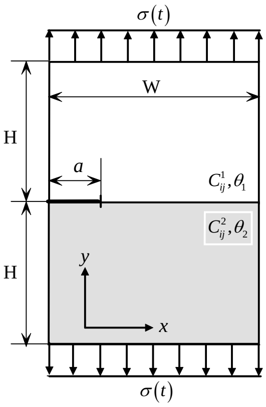

Fig. 1: An edge interfacial crack in a layered rectangular plate

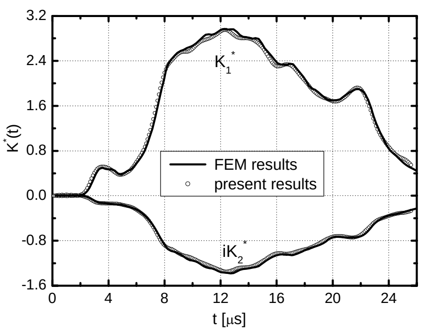

Fig. 2: Normalized dynamic complex SIFs for an edge interfacial crack

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