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Transient analysis of multiply interacting cracks in orthotropic layers

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Abstract

The solution to an edge dislocation with time-dependent Burgers vector is obtained in the orthotropic layers. Structural energy dissipation is taken into account and it is modeled by viscous damping. Furthermore, stress analysis is carried out in the intact layer subjected to dynamic self-equilibrating point forces. These solutions are utilized to derive singular integral equations for the layer containing cracks parallel/perpendicular to its boundary. The equations are solved numerically to obtain dislocation density functions on a crack surface. These functions are used to determine dynamic stress intensity factors for cracks. Moreover, it is shown that the formulation may be used for the analysis of cracked rectangular regions under dynamic in-plane excitation.

Keywords: orthotropic layer, multiple cracks, impact load, mixed mode, viscous damping, rectangular region

1. Introduction

The knowledge of stress distribution in mechanical components is essential for their durability assessment. The widespread application of composite materials, in various industries, is due to their superior material properties over metals. Delamination of constituents in composite materials, however, is the major cause of failure in composites. In general, stress analysis of cracked composite structures under dynamic loads is complicated and only those with simple geometries may be handled analytically. An orthotropic infinite-plane with a crack under time-harmonic load was studied by Ohyoshi (1973) and under transient condition by Kassir and Bandyopadhyay (1983). Transient mode I stress analysis of a central crack perpendicular to the boundary of a layer was carried out for an isotropic layer by Itou (1980) and in an orthotropic layer by Shindo et al. (1986). The same crack but, in an orthotropic layer under in-plane impact shear load, i.e., mode II, was solved by Xialiu and Huang (1995). The response of a central crack in an anisotropic strip under impact load was dealt with by Ang (1987). Orthotropic layers, weakened by an edge crack subjected to dynamic loads, were considered by Shindo et al. (1992). The same problem wherein a layer was functionally graded was tackled by Guo et al. (2005). Itou and Haliding (1997) obtained modes I and II stress intensity factors (SIFs) for two coaxial cracks in an orthotropic plane subjected to a time-harmonic plane wave normal to a crack surface. The dependency of SIFs on material properties of the media, distance between cracks, and the ratio of crack lengths were illustrated. Rubio-Gonzales and Mason (1999) and Das (2006a), considered a crack in an orthotropic plane under impact shear loads. The same problem subjected to normal load was solved by Das (2006b). Closed form solutions were derived for dynamic SIFs of a semi-infinite crack in orthotropic planes under different modes of fracture by Rubio-Gonzales and Mason (2000). Dynamic mode I deformation of an orthotropic functionally graded layer with a crack which is normal to the boundary was investigated by Chen et al. (2002). Anti-plane dynamic deformation of a crack perpendicular to the boundary of an orthotropic functionally graded layer was studied by Chen and Liu (2005). The latter problem for isotropic functionally graded layer under in-plane impact load was solved by Li-Cheng et al. (2005). Wang and Mai (2006) were

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