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Anti-plane elastodynamic analysis of a cracked orthotropic strip

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ABSTRACT

Stress analysis is carried out in an orthotropic strip containing a Volterra-type screw dislocation. The distributed dislocation technique is used to construct integral equations for an orthotropic strip weakened by multiple smooth cracks under time-harmonic anti-plane deformation. These equations are of Cauchy singular type at the location of dislocation, which are solved numerically to obtain the dislocation density on the faces of the cracks. The dislocation densities are employed to determine stress intensity factors for multiple smooth cracks under anti-plane deformation. Several examples are solved and the stress intensity factors are obtained. The effects of the geometric parameters, cracks location and orientation on the stress intensity factors of cracks are investigated.

1. Introduction

Orthotropic materials are vulnerable to cracking. The defects may initiate during the manufacturing process or in the regions subjected to steep stress gradient in the course of service life of a mechanical component. Multiple cracks with any shape and direction may exist in the material making the analytical stress analysis of a body intractable. The stress analysis in elastic regions weakened by cracks subject to dynamic loading has drawn the attention of several researchers. Apparently, the first study dealing with dynamic crack problems was conducted by Maue [1]. He analyzed a semi-infinite crack in an infinite plane under time-harmonic stress wave by means of the Wiener-Hopf technique. The dynamic stress intensity factor for a finite crack in the infinite plane under anti-plane deformation was determined by Loeber and Sih [2]. Xiao et al. [3] considered the interaction between a penny-shaped crack and a spherical inhomogeneity in an infinite solid under uniaxial tension. Results show the effects of the configuration and elastic properties of the matrix and inhomogeneity upon the stress intensity factors. The stress analysis for the problem of a penny-shaped crack located above the pole of a spherical particle in 3D elastic solid under tension was determined by Xiao [4]. The diffraction problem by two collinear cracks located in an orthotropic medium subjected to time-harmonic stress waves was investigated by Itou [5]. Itou et al. [6] considered the diffraction of incident harmonic stress waves by two parallel cracks in an infinite orthotropic medium. Dos et al. [7] considered the diffraction of shear waves by Griffith crack in an infinite transversely orthotropic medium. Meguid and Wang [8] investigated the failure behavior of fiber reinforced composites involving cracked matrix and imperfectly bounded fibers under dynamic anti-plane excitation. Results show the effect of the frequency of the incident wave upon the dynamic stress intensity factors of the cracked matrix and interaction between a main crack and a completely debounded fiber, which can be modeled as a cavity. Ma et al. [9] investigated the scattering of anti-plane harmonic waves by a finite crack in the functionally graded orthotropic medium. By utilizing the Fourier transformation the problem reduced to a pair of dual integral equations, which were solved by a series expansion method. Results show the effect of material properties upon the dynamic fracture behavior of functionally graded materials. The solution procedures devised in all the above studies are neither capable of handling curved cracks among multiple cracks with arbitrary arrangement. Fotuhi et al. [10] investigated the distributed dislocation technique for the stress analysis of multiple cracks in an elastic isotropic strip under static load. Moharrami and ayatollahi [11] investigated the scattering of anti-plane harmonic stress waves by multiple cracks in an orthotropic plane.

The primary objective of this study is to apply the distributed dislocation technique for the stress analysis of multiple cracks with arbitrary patterns in an orthotropic strip. The Fourier sine transform is employed and two solutions in series and integral forms are obtained for the stress fields. The solutions are then used to obtain singular integral equations for the dislocation density on the face of multiple cracks. These equations are solved numerically and the solutions are employed to determine stress intensity factors for cracks with different configurations and arrangements.

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