5 Dynamic response of
dissimilar materials with
-cracks

5.1 Introduction

Composite materials are being developed for increased use in primary
structures subjected to time dependent loadings. Their nonhomogeneous
and anisotropic properties in addition to the presence of mechanical
imperfections such as voids or cracks can have a strong influence on the
dynamic response under different loadings. In particular, the various type
of initial flaws suggest a number of failure modes which include interface
delamination, matrix fracture, fiber breaking, etc. A knowledge of the
redistribution of stresses in the neighbourhood of initial flaws is essential
to achieving an in-depth understanding of the failure of composite
materials.

Only a few dynamic problems of composites with cracks have been
treated because of the complexities that arise from the interaction of
waves scattered by the crack with those reflected by the material interface
or free surface. The analytical method developed herein applies Fourier
transform to the space variable and Laplace transform to the time
variable. The boundary-value crack problem is formulated with stress and
displacement conditions specified on a half plane, a portion of which
represents the crack segment. These conditions reduce the problem to a
system of dual integral equations which is solved in the Laplace transform
plane for the transform of the dynamic stress intensity factor. The time
inversion is accomplished by a numerical scheme. In-plane, anti-plane,
axisymmetric and torsional deformation of the composite are considered.
Numerical results are presented for cracks subjected to suddenly applied
uniform loads. Stress intensity factor solution for the cases of applied
loads that vary with time may be obtained by superposing a sequence of
step load solutions.

G. C. Sih et al., Cracks in composite materials
5.2 Parallel crack in a sandwiched layer

The composite body under consideration is imagined to comprise of a number of layers each of thickness $2h$. One of the layers contains a through crack of length $2a$ attached to a system of rectangular cartesian coordinate axes $x$ and $y$ as shown in Figure 5.1. The number of layers surrounding the cracked layer is reasonably large so that the average shear modulus $\mu_2$, Poisson’s ratio $\nu_2$ and mass density $\rho_2$ can be used. The material properties of the cracked layer are designated by $\mu_1$, $\nu_1$ and $\rho_1$.

In-plane extension. Let the composite solid in Figure 5.1 be subjected to disturbances that are confined in two dimensions such that the solid undergoes no displacement in the direction normal to the $xy$-plane. A condition of plane strain thus prevails and the resulting displacement field can be expressed in terms of two scalar potentials $\phi_i(x, y, t)$ and $\psi_i(x, y, t)$:

\begin{align}
(u_x)_i &= \frac{\partial \phi_i}{\partial x} + \frac{\partial \psi_i}{\partial y} \\
(u_y)_i &= \frac{\partial \phi_i}{\partial y} - \frac{\partial \psi_i}{\partial x} \\
(u_z)_i &= 0
\end{align}

Figure 5.1. Cracked layer sandwiched between dissimilar media.