Vibration Characteristics of Fibrous Composites with Damage

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Abstract: A micromechanical model is developed in order to study the vibration characteristics of fibrous composites with damage. Damage is taken in the form of either a broken fiber or a matrix crack normal to the fiber direction. The unidirectionally reinforced periodic composite, when vibrating in the longitudinal (fiber) direction, is modeled as a concentric cylindrical system subjected at its outer boundaries to vanishing radial displacement and shear stress. Guided by the symmetry and the fiber-matrix interface continuity conditions, an approximate radial dependence of some of the field variables is first assumed. The two-dimensional field equations that hold in both the fiber and the matrix, together with their interface conditions, are then reduced to a quasi-one-dimensional system which automatically satisfies all interface and boundary conditions. The simplified model is applied to the study of the vibration characteristics of the composite with and without damage. The cases of broken fibers and cracked matrix are treated by invoking stress-free conditions at the crack faces. The dependence of the resonance frequencies and mode shapes on the nature and location of the damage is exploited. Significant reduction in the values of resonance frequencies can be realized for damage located close to the center of the composite system.

Key Words: Vibration, composite materials, damage, analytical solution

1. INTRODUCTION

Before composite materials become viable competitors to metals in critical structural applications, their reliability and damage-resisting capabilities need to be fully established. Inherent manufacturing defects, together with the low degree of ductility encountered in most currently available composite materials, have often overshadowed their otherwise superior qualities, such as light weight and high stiffness. Nevertheless, researchers have continued to expend significant efforts on their modeling, testing, and analysis.

As far as the strength assessment is concerned, two important problems present themselves. The first is concerned with the detectability of pre-existing (*in situ*) defects, and the second is concerned with whether or not such defects will grow and lead to catastrophic failure upon loading of the structure. As a consequence of manufacturing processes, typical defects are created at the micro-scale level, and include fiber breaks, matrix cracks, and fiber-

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