Effect of imperfect bonding on the dynamic response of a pre-stressed sandwich plate-strip with elastic layers and a piezoelectric core

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Effect of imperfect bonding on the dynamic response of a pre-stressed sandwich plate-strip with elastic layers and a piezoelectric core

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Abstract: In this paper, we consider the dynamic response of a pre-stressed sandwich plate-strip with a piezoelectric core and elastic layers under the action of a time-harmonic force resting on a rigid foundation. The investigation is carried out within the framework of the piecewise homogeneous body model by utilizing the exact equations of motion and relations of the linear theory of electro-elasticity. It is assumed that there is a shear-spring-type imperfect contact between the layers, but a complete contact between the plate-strip and the rigid foundation. A mathematical model of the problem is constructed, and the governing equations of motion are solved by employing the Finite Element Method (FEM). Numerical results illustrating the influence of a change in the value of the shear-spring parameter on the dynamic response of the plate-strip are then presented.

Keywords: Sandwich plate-strip; Shear-spring-type imperfection; Piezoelectric materials; Initial stress; Frequency response.

MSC 2010 Subject Classification: 74A40; 74H45

1. Introduction

Composite materials have multi-layered structures. For example, a sandwich is a type of composite material that consists of three layers, where the materials used for the layers can either be the same or different. Composite materials are used in many engineering applications, such as building and civil infrastructure construction, and the aerospace and nuclear industries. This has recently encouraged intense research and drawn considerable attention to the subject. Problems regarding nonlinear effects in the dynamics of multi-layered elastic systems involve many factors, two of which are (a) the static initial stresses in each layer that exist before the external dynamic force is applied and (b) the contact characteristics on the interface planes between the layers.

The first factor, namely the static initial stresses that exist in the composite structure's layers before the dynamic force is applied, is important for many engineering applications, due to either their technical requirements or the temperature of the environment. Note, however, that the influence of these initial stresses cannot be investigated within the classical linear theory of elasticity since it is nonlinear. When the amplitudes of the deformations superimposed on a pre-stressed medium by external forces are significantly smaller than those of the initial deformations, they can be investigated using the three-dimensional linearized theory of elastic waves in initially stressed bodies (TLTEWISB); see [1] for more detailed information on the subject. Many interesting problems have been investigated using the fundamental principles of the TLTEWISB and its variants. For example, Cilli and Ozturk analyzed the propagation of torsional waves in a pre-stressed multi-layered circular cylinder [2]. Zamanov and Agasiyev considered the propagation of Lamb waves in a three-layer plate made from compressible materials with finite initial deformations [3]. Wen-tao et al. analyzed