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Flexural vibrations of discontinuous layered elastically bonded beams

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Abstract

This paper addresses the dynamic flexural behavior of layered elastically bonded beams carrying an arbitrary number of elastic translational supports and rotational joints. The beams are referred to as *discontinuous* for the discontinuities of response variables at the application points of supports/joints. The Euler-Bernoulli hypothesis is assumed to hold for each layer separately, and a linear constitutive relation between the horizontal interlayer slip and the interlaminar shear force is considered. Based on the theory of generalized functions to handle the discontinuities of response variables due to supports/joints, exact beam modes are obtained from a characteristic equation built as determinant of a 6 x 6 matrix, regardless of the number of supports/joints. On using pertinent orthogonality condition for the deflection modes, the dynamic response of the beam is derived in time domain. Remarkably, all response variables are presented in a closed analytical form. Two numerical applications illustrate the efficiency of the proposed method.

Keywords: Layered beams, Interlayer slip, Translational supports, Rotational joints.

1. Introduction

In engineering applications, beams composed of two or more layers are widely used to increase the strength-to-weight and stiffness-to-weight ratio of structural components. If bonded by strong adhesives, the layers can be assumed to be rigidly interconnected, and a full composite action between the layers is developed. During the last decades a large amount of studies has been devoted to static and dynamic analysis of rigidly bonded composite structures for various engineering problems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14], providing engineers with various well established methods.

However, in certain structural components such as composite steel-concrete beams and layered wood beams with flexible shear connectors, a rigid bond between the layers cannot be achieved. The deformation of the connectors results in an interlayer slip, which affects both strength and deformation of the structure. Existing literature has focused on static and dynamic analysis of layered elastically bonded beams. For instance, linear static analysis is performed in [15, 16, 17, 18, 19, 20, 21, 22, 23, 24], and vibration problems are addressed in [25, 26, 27, 28, 29, 30, 31, 32, 33]. In general studies in [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33] have considered layered beams in a simple configuration, with uniform cross section and constraints at the beam ends only.

In practical applications, beams often have one or several in-span elastic supports, and in-span local flexibility may arise from cracks and imperfections [34, 35, 36, 37, 38, 39, 40, 41]. In this case, the corresponding structural model is a multi-span beam with elastic translational supports, and elastic rotational

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