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Free vibration of axially loaded composite beams using a four-unknown shear and normal deformation theory

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Abstract

This paper presents free vibration of composite beams under axial load using a four-unknown shear and normal deformation theory. The constitutive equation is reduced from the 3D stress-strain relations of orthotropic lamina. The governing differential equations of motion are derived using the Hamilton's principle. A two-node C^1 beam element is developed by using a mixed interpolation with linear and Hermite-cubic polynomials for unknown variables. Numerical results are computed and compared with those available in the literature and commercial finite element software (ANSYS and ABAQUS). The comparison study illustrates the effects of normal strain, lay-ups and Poisson's ratio on the natural frequencies and load-frequency curves of composite beams.

Keywords: Composite beams; normal strain; Poisson effect; shear and normal deformation theory

1. Introduction

Due to the attractive properties of strength, stiffness, and lightness, composite structures become popular in several applications of aerospace, automotive, civil engineering, etc. In particular, composite beams are widely used and thus many beam theories have been proposed to predict their free vibration and dynamic response. Finite element models originally developed for solid mechanics and mainly for isotropic beams have been extended to laminated composite ones by many authors and only some of them are referenced here ([1–6]). More details can be found in recent review by Sayyad and Ghugal [7]. These models provide reasonably accurate results for the structural response of thin to moderately thick composite beams. Because of the low shear moduli of composite materials, the effect of shear deformation is expected to be much more pronounced in composite beams than in the

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