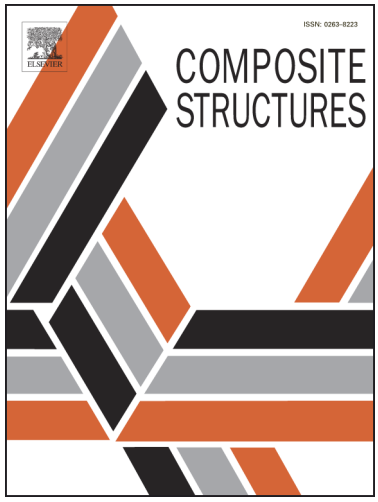

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Frequency and mode veering phenomena of axially functionally graded non-uniform beams with nonlocal residuals

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Abstract

A Timoshenko beam model for axially functionally graded (FG) non-uniform nanobeams with nonlocal residuals is developed. Eringen's nonlocal theory of linear elasticity is used to model the effects of the nonlocal residuals on the natural frequencies and mode shapes of the FG nanobeam. The derived model is numerically solved using Chebyshev spectral collocation method. With the Chebyshev method, the discretization of a system of partial differential equations with variable coefficients can be easier performed and implemented. The derived model and solution are harnessed to study, for the first time, the eigenvalue loci veering and mode veering phenomena for axially functionally graded non-uniform nanobeams with nonlocal residuals. It is demonstrated that there is a threshold value for the beam size at which frequency veering and mode shape veering may take place. This veering behavior is discovered in graded beams due to the material and geometry grading and the nonlocal residuals. In addition to these contributions, a parametric study on the beam size, material, and geometry effects on the natural frequencies and mode shapes of axially FG non-uniform nonlocal-beams is performed. This study can be used for design and optimization of different nano-devices made of FG materials.

Keywords: functionally graded materials, nanobeams, nonlocal theory, mode veering, eigenvalue loci veering, Chebyshev collocation method.

1. Introduction

Nanostructures have gained appreciated consideration due to their significant role in different engineering and modern technology fields, such as aerospace, communications, electronics,