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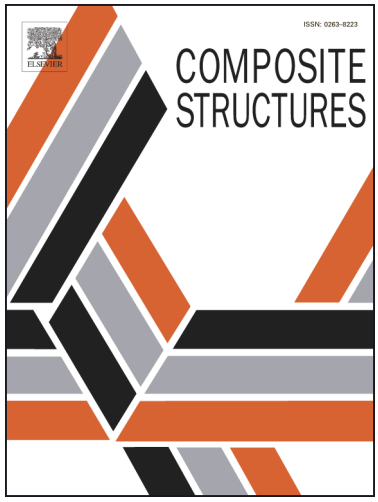

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The second strain gradient functionally graded beam formulation

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Abstract

A size-dependent formulation for the Euler-Bernoulli nano- and micr-beams made of functionally graded materials (FGMs) is presented. The formulation is developed on the basis of the second strain gradient theory (SSGT). This theory is a powerful non-classical continuum theory capable of capturing the small-scale effects in the mechanical behavior of small-scale structures. To drive the governing equations of motion along with the general form of boundary conditions, the Hamilton principle is utilized. Due to the inhomogeneity through the thickness of functionally graded beams, the two equations which govern the axial and flexural deformations are coupled. In two case studies with different boundary conditions, the system of coupled equations is analytically dealt with, and the size-dependent response of FG beams in free-vibration and static behavior is numerically investigated. This investigation shows a significant difference between results of SSG theory and other non-classical and classical theories for very thin beams.

Key words: The Second Strain Gradient Theory, functionally graded materials, small-scale structures, non-classical continuum theories

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1 .Introduction

Functionally graded materials (FGMs) are a class of inhomogeneous materials which their properties vary through some specific direction(s). This variation of properties can be regarded as a continuous function of position. FG materials are typically made of two different constituents, so that these materials would have advantages of both the constituents.

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