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PII: S0263-8223(16)32795-7
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.03.022
Reference: COST 8343

To appear in: *Composite Structures*

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Abstract

In this paper, a simple beam theory accounting for shear deformation effects with one unknown is proposed for static bending and free vibration analysis of isotropic nanobeams. The size-dependent behaviour is captured by using the nonlocal differential constitutive relations of Eringen. The governing equation of the present beam theory is obtained by using equilibrium equations of elasticity theory. The present theory has strong similarities with nonlocal Euler-Bernoulli beam theory in terms of the governing equation and boundary conditions. Analytical solutions for static bending and free vibration are derived for nonlocal beams with various types of boundary conditions. Verification studies indicate that the present theory is not only more accurate than Euler-Bernoulli beam theory, but also comparable with Timoshenko beam theory.

Keywords: Nanobeam, Nonlocal elasticity theory, Shear deformation beam theory, Bending, Vibration

1. Introduction

In recent years, the emergence of nanotechnology in high-tech devices requires a proper understanding of the mechanical behaviours of small-scale structures, which are considerably influenced by the size effects [1]. In general, the classical continuum theories failed to accurately predict the responses of such structures as they dismiss the size effects. In order to capture these effects, two different approaches have been proposed including atomistic and high-order continuum mechanics. Comparing to the former, the later approach is more popular in practice due to its simplicity and computational efficiency. Currently, there are are various high-order continuum theories developed to describe the size-dependent phenomenon. Among those, the nonlocal elasticity theory proposed by Eringen [2] is widely used in the literature to

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