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On three-dimensional nonlocal elasticity: Free vibration of rectangular nanoplate

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Abstract:

Ritz and Galerkin methods based on local theory of elasticity employ polynomials as their approximating functions, however these methods in their common form are not suitable to be used in three-dimensional nonlocal analysis. The potential functions for Helmholtz displacement vector representation of three-dimensional free vibration analysis of simply-supported nanoplate and wave propagation in three-dimensional infinite nonlocal solid were presented. In addition, novel trigonometric series were developed as approximating functions in Galerkin approach to analyze three-dimensional nanoplates with other boundary conditions. Furthermore, the effects of length to thickness ratio, aspect ratio, nonlocal parameter, and different boundary conditions on the non-dimensional natural frequencies of nanoplates were studied. It can be shown that nonlocal theory of elasticity and Aifantis' strain gradient theory are equivalent, therefore, the results of this investigation can be extended to that theory. The research showed that in nonlocal theory of elasticity, the difference between two- and three-dimensional results is more noticeable.

Keywords: Three-dimensional; Nonlocal Elasticity; Nanoplate;

1. Introduction

Due to their Superior mechanical, chemical and electrical properties, nanomaterials are used as the building blocks for ultrasensitive and ultrafine resolution applications in the field of nano-electro-mechanical systems (NEMS). Vibration of nanostructures such as nanoplates is of great importance, and various theories and approaches have been developed to describe the effects of scale on the vibration behavior of nanoplates. Experimental and molecular analysis of nano-structures are expensive and time-consuming therefore many researchers employ continuum based models such as nonlocal theory of elasticity or strain gradient elasticity theories in nano-structure analysis. Conventional tools in classic theory of elasticity such as FEM and energy methods needs some modifications to be used in analysis based on nonlocal theory of elasticity.

Eringen, (1983) presented a differential form of constitutive equations in nonlocal elasticity. Later, Polizzotto, (2001) proved that the principal of minimum potential energy is also applicable to static problems in nonlocal elasticity. Nonlocal vibration analysis of plates with simply-supported (SS)