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Free vibration analysis of FG nanoplates using quasi-3D hyperbolic refined plate theory and the isogeometric approach

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Abstract

In this paper, quasi three-dimensional (quasi-3D) hyperbolic shear deformation theory is used for the free vibration analysis of functionally graded nanoplates by using the isogeometric analysis (IGA) approach and nonlocal elasticity theory. The quasi-3D theory using five independent unknowns satisfies the free transverse shear stress conditions on the top and bottom surfaces of plate and so a shear correction factor is not needed. The displacement field takes into account both shear deformation and thickness stretching effect and the equations are derived based on physical neutral surface position. The IGA approach can easily formulate C^1 continuous elements by using Non-Uniform Rational B-Spline (NURBS) functions. Numerical results are compared with other solutions.

Keywords: Free vibration analysis, Functionally graded materials, Isogeometric approach, Nonlocal elasticity theory, Quasi-3D hyperbolic refined plate theory.

1. Introduction

In recent years, many researches have been studied to predict the behavior of nanostructures. The continuum mechanics approach which provides more simplicity and efficiency than molecular dynamics approach, is widely used to study the mechanical behavior of nanostructures. The local (classical) continuum theories do not model the behavior of nanoscale structures properly. In order to consider small scale effects in nanoscale structures, different size-dependent continuum mechanics models have been developed such as the couple stress theory [1,2], gradient theory [3], nonlocal elasticity theory [4-6], strain gradient theory [7,8], modified couple stress theory [9], modified strain gradient theory [10] and surface energy theory [11]. Many publications show that the nonlocal elasticity theory considering small scale effects can well predict the behavior of nanostructures. Aghababaei and Reddy [12] used third order shear deformation plate theory for the bending and vibration of nanoplates. Ansari and