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A general nonlocal stress-strain gradient theory for forced vibration analysis of heterogeneous nanoporous plates

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Abstract

A new modeling of nanoplates constructed from porous heterogeneous materials is presented based on generalized nonlocal strain gradient theory (NSGT). In this model, both stiffness-softening and stiffness-hardening effects are considered for more reliable forced vibration analysis of nanoplates. The present nano-resonator is based on a vibrating higher order nanoscale plate subjected to transverse uniform dynamic load. Nano-pores or nano-voids are incorporated to the model based on a modified rule of mixture. According to the Hamilton's principle, the formulation of dynamically loaded nanoplate is derived. Applying Galerkin's method, the resonance frequencies and dynamic deflections are obtained. It is indicated that the forced vibration characteristics of the nanoplate are significantly influenced by the porosities, excitation frequency, nonlocal parameter, strain gradient parameter, material gradation, elastic foundation and dynamic load location.

Keywords: Nanoporous resonator, Forced vibration, Nonlocal strain gradient theory, Four-variable plate theory

1. Introduction

Porosities occurring inside the material structure during construction have a significant effect on mechanical performance of inhomogeneous structures [1]. In last years, fabrication and synthesis of porous nanoplates is performed by several researchers [2-4]. Functionally graded (FG) structures have an inhomogeneous nature, while their vibration behavior is affected by the porosity volume fraction [5]. These structures have excellent properties under environmental conditions such as thermal environments due to the gradation of material properties in the thickness direction which distinguishes them from conventional composites [6-8].