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Saeid Sahmani, Mohammad Mohammadi Aghdam, Timon Rabczuk

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Nonlinear bending of functionally graded porous micro/nano-beams reinforced with graphene platelets based upon nonlocal strain gradient theory

Saeid Sahmani[a*], Mohammad Mohammadi Aghdam[a], Timon Rabczuk[b]

[a] *Department of Mechanical Engineering, Amirkabir University of Technology, 15875-4413 Tehran, Iran*

[b] *Institute of Structural Mechanics, Bauhaus Universität-Weimar, Marienstr 15, D-99423 Weimar, Germany*

Abstract

Fast improvements in technology causes to provide the ability to manipulate porous graded materials for using in directed design of micro/nano-structures. The prime objective of the current study is to anticipate the size-dependent nonlinear bending of functionally graded porous micro/nano-beams reinforced with graphene platelets, and subjected to the uniform distributed load together with an axial compressive load. Via the nonlocal strain gradient theory of elasticity, two entirely different features of size effects are incorporated in the third-order shear deformable beam model. In addition to the uniform distribution of porosity, three different functionally graded porosity distributions along the thickness of micro/nano-beams are supposed in such a way that the relationship between coefficients related to the relative density and porosity is considered for an open-cell metal foam. On the basis of Hamilton's principle, the non-classical governing differential equations of motion are established. After that, the Galerkin method in conjunction with an improved perturbation technique is utilized to attain explicit analytical expressions for nonlocal strain gradient load-deflection paths of the functionally graded porous micro/nano-beams reinforced with the graphene nanofillers. It is observed that the type of porosity dispersion pattern has no considerable influence on the significance of size effects. However, by approaching the axial compressive load to the critical buckling value, the significance of the both nonlocality and strain gradient size dependencies on the nonlinear bending behavior of functionally graded porous micro/nano-beams increases, and this increment in the nonlocal small scale effect is more considerable than in the strain gradient one.

Keywords: Nanomechanics; Porous materials; Nanocomposites; Nonlinear bending; Size dependency.

*Corresponding author. Tel.: +98 21 66405844, Fax: +98 21 66419736.

E-mail addresses: sahmani@aut.ac.ir (S. Sahmani), aghdam@aut.ac.ir (M.M. Aghdam), timon.rabczuk@uni-weimar.de (T. Rabczuk).