ABSTRACT

Carbon nanotubes (CNTs) are advanced materials known for their remarkable mechanical properties, including high strength, stiffness, and durability. These exceptional features have led to their widespread use as reinforcement in composites. The mechanical performance of carbon nanotube reinforced composites (CNTRC) is influenced by several factors, such as the volume fraction of CNTs, their orientation, the properties of the matrix, the loading conditions, and the length-to-thickness ratios. Additionally, understanding the complex interaction between the soil and the structure is essential, as it plays a crucial role in the structural analysis of these materials. Further, it is essential to model these complicated effects correctly. Hence this work investigates the static, buckling, and free vibration behavior of carbon nanotube reinforced composite (CNTRC) beams resting on a Pasternak elastic foundation using various non-polynomial shear deformation theories. The used non-polynomial shear deformation theories are based on the secant function and inverse hyperbolic sine function, which naturally satisfies the traction-free boundary conditions at the top and bottom surfaces of the beam, eliminating the need for a shear correction factor. Hamilton's principle is utilized to derive the governing differential equations and boundary conditions, while Navier's solution method is applied to obtain the closed-form solutions. The analytical method is used to examine the deflection, stress distribution, critical buckling load, and natural frequencies of functionally graded (FG)-CNTRC beams on a Pasternak elastic foundation that includes a shear layer and Winkler springs. The material properties of the CNTRC beams are determined using the Rule of Mixtures. The analysis considers various carbon nanotube (CNT) reinforcement distributions, including uniform distribution (UD), FG-X, FG-O, and FG-V beams. The structural responses are predicted based on different span-to-thickness ratios, various loading conditions, CNT volume fractions and distributions, as well as the Winkler spring and shear layer constants. The results show that the present theory accurately predicts the structural behavior of FG-CNTRC beams compared to other existing theories. Further, several new results are presented as benchmark solutions for future research.

Keywords: Non-polynomial shear deformation theory; Analytical method; Navier's solution; Elastic foundation; Static; Free vibration; Buckling analysis.