Three-dimensional bending and vibration analysis of functionally graded nano-plates by a novel differential quadrature-based approach

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Abstract. In this paper, the three dimensional (3D) nonlocal bending and vibration analyses of functionally graded (FG) nanoplates are presented using a novel numerical solution method which is called variational differential quadrature (VDQ) due to its numerical essence and the framework of implementation. Through this approach, a quadratic weak formulation of 3D nonlocal elasticity for the considered phenomena is presented. Two types of the distribution of functionally graded materials (FGMs) namely power law distribution and exponentially varied along the thickness of the plate are considered. The energy quadratic representation of the problems is first obtained based on the 3D theory of elasticity. A weak form of local governing equations is then derived from this representation by a variational approach. To incorporate the effects of small size into the local model, a size-dependent energy functional based on the nonlocal elasticity theory is developed. By introducing this functional into Hamilton's principle, the discretized equations of motion including size effects are derived. By the VDQ method, the need for derivation of strong statement of the problems through minimizing the energy functional in the differential quadrature formulation is bypassed. In several numerical examples, the obtained results are compared with the available solutions in the literature, and the validity and high accuracy as well as fast convergence rate of the VDQ are indicated. It is also found that the small scale has a decreasing effect on the stiffness of nanoplates.

Keywords: FG nanoplate; 3D nonlocal elasticity theory; Bending; Vibration; Variational differential quadrature method

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