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Nonlinear flexural and vibration response of geometrically imperfect gradient plates using hyperbolic higher-order shear and normal deformation theory

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Abstract

This paper investigates the sensitivity of nonlinear flexural and vibration response of shear deformable functionally graded material (FGM) plates to the initial geometrical imperfections. The formulations are based on recently developed non-polynomial higher-order shear and normal deformation theory by authors. The theory accounts for nonlinear variation in the in-plane and transverse displacement through the thickness. It also accommodates thickness stretching effect without employing shear correction factor. The novelty of this theory is that it contains only four unknowns, unlike several other shear deformation theories which contain five or more unknowns. The equations of motion are derived using variational principle. The initial geometric imperfections have been incorporated using generic imperfection function. Material properties of the FGM plates are assumed to be varying continuously in the thickness direction according to a simple power law and exponential law. Convergence and comparison studies have been carried out to establish the authenticity and reliability of the solution. The numerical results are highlighted with various geometric imperfections and system parameters.

Keywords: Non-polynomial higher-order shear and normal deformation theory, Von- Karman nonlinearity, Geometric imperfections, Voigt model, Mori-Tanaka model

1. Introduction

In recent years, functionally graded materials (FGMs) have received remarkable attention in many engineering applications. FGMs are microscopically inhomogeneous materials in which the properties change gradually from one surface to the other [1,2]. These materials facilitate the designer for tailoring the material properties according to their specific requirements in various engineering applications.

FGM structures are often prone to failure from large deflections or excessive stresses that are induced by severe environmental conditions such as high mechanical load or large temperature gradients. Therefore, it is of prime importance to explore the geometrically nonlinear (large amplitude) vibration and flexural response of FGM structures to confirm the authentic and realistic structural analysis.