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Nonlinear vibration of functionally graded carbon nanotube-reinforced composite beams with geometric imperfections

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ABSTRACT

The nonlinear vibration of imperfect shear deformable functionally graded carbon nanotube-reinforced composite (FG-CNTRC) beams is studied in this paper based on the first-order shear deformation beam theory and von Kármán geometric nonlinearity. A one-dimensional imperfection model in the form of the product of trigonometric and hyperbolic functions are used to describe the various possible geometric imperfections such as sine type, global, and localized imperfections. The governing equations are derived by employing the Ritz method and then solved by an iteration procedure. Special attention is given to the influences of imperfection mode, location, and amplitude on the nonlinear behaviour. The linear vibration is also discussed as a subset problem. Numerical results in tabular and graphical forms show that the nonlinear vibration behaviour of imperfect FG-CNTRC beams is considerably sensitive to sine type and global imperfections (except for G2-mode), whereas the effect of localized imperfection is much less pronounced. It is also observed that whether the FG-CNTRC beam exhibits the "hard-spring" or "soft-spring" vibration behaviour is largely dependent on the initial imperfection mode, its amplitude as well as the vibration amplitude.

Keywords: B. Mechanical properties; B. vibration; C. Analytical modelling; Functionally graded beam; Carbon nanotube; Geometric imperfection.

1. Introduction

Functionally graded carbon nanotube-reinforced composites (FG-CNTRCs) in which carbon nanotubes (CNTs) are distributed nonuniformly in the matrix have attracted

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