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DYNAMIC STABILITY OF A SIZE-DEPENDENT MICRO-BEAM

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Abstract

The effect of variation of the geometrical dimensions on dynamic instability regions (DIRs) of a rectangular cross-sectioned micro-beam with simply supports is discussed in this study based on modified coupled stress theory. A set of linear equations are derived on basis of the Lagrange method and trial series expansions for vertical displacement and rotation of the Timoshenko micro-beam model while longitudinal displacement is neglected due to the stretching effect of the micro-beams mid-plane. The first approximation of the dynamic stability analysis is done by the application of the Bolotin method besides obtaining the Mathieu-Hill equations. The numerical results demonstrate how the cross section's height and micro-beams length are the only effective parameters on DIRs somehow that when the geometrical dimensions are increased the DIRs are going to coincide.

Keywords: Dynamic stability, modified couple stress theory, Timoshenko beam, Lagrange method, natural frequency, buckling load.

Introduction

The behaviour of micro-elements such as micro-beams which are used for instance as an airbag sensor in the vehicle industry depends on their mechanical properties and dimensions. In Micro-Electro-Mechanical Systems (MEMS) while a structure's geometrical dimensions are miniaturized, the size effect (length scale parameter) has to be brought into account as far as the classical continuum mechanic models are not capable enough to describe this size-dependency effect. In recent years several studies have been done in this field by application of some general theories to describe either micro- or nano-structures performance i.e. Cosserat elastic theory, gradient elasticity theories, modified coupled theory and nonlocal elastic theories (Mühlhaus et al., 1995). Some research such as (Dai et al., 2015; Dehrouyeh-Semnani et al., 2016; Dehrouyeh-Semnani et al., 2015; Ghayesh et al., 2013; Ghayesh et al., 2016; Li and Pan, 2015) – among a massive number of