Steel and Composite Structures, *Vol. 35, No. 5 (2020) 635-640*
DOI: https://doi.org/10.12989/scs.2020.35.5.635

Buckling analysis of smart beams based on higher order shear deformation theory and numerical method

Pouyan Talebizadehsardari[1,2a], Arameh Eyvazian[3], Mojtaba Gorji Azandariani[4], Trong Nhan Tran[5], Dipen Kumar Rajak[6] and Roohollah Babaei Mahani*[7,8]

[1]*Metamaterials for Mechanical, Biomechanical and Multiphysical Applications Research Group, Ton Duc Thang University, Ho Chi Minh City, Vietnam*
[2]*Faculty of Applied Sciences, Ton Duc Thang University, Ho Chi Minh City, Vietnam*
[3]*Mechanical and Industrial Engineering Department, College of Engineering, Qatar University, P.O. Box 2713, Doha, Qatar*
[4]*Structural Engineering Division, Faculty of Civil Engineering, Semnan University, Semnan, Iran*
[5]*Faculty of Automobile Technology, Van Lang University, Ho Chi Minh City, Vietnam*
[6]*Department of Mechanical Engineering, Sandip Institute of Technology and Research Centre, Nashik 422213, MH-India*
[7]*Institute of Research and Development, Duy Tan University, Da Nang 550000, Vietnam.*
[8]*Faculty of Civil Engineering, Duy Tan University, Da Nang 550000, Vietnam*

(*Received April 1, 2020, Revised May 17, 2020, Accepted May 26, 2020*)

Abstract. The buckling analysis of the embedded sinusoidal piezoelectric beam is evaluated using numerical method. The smart beam is subjected to external voltage in the thickness direction. Elastic medium is simulated with two parameters of spring and shear. The structure is modelled by sinusoidal shear deformation theory (SSDT) and utilizing energy method, the final governing equations are derived on the basis of piezo-elasticity theory. In order to obtaining the buckling load, the differential quadrature method (DQM) is used. The obtained results are validated with other published works. The effects of beam length and thickness, elastic medium, boundary condition and external voltage are shown on the buckling load of the structure. Numerical results show that with enhancing the beam length, the buckling load is decreased. In addition, applying negative voltage, improves the buckling load of the smart beam.

Keywords: smart beam; buckling; SSDT; numerical method; elastic medium

1. Introduction

Nanocomposite structures are made from a matrix reinforced with nanoparticles for improving the property of the material. Recently, the properties of nanocomposite structures have encouraged researchers to investigate about these materials. These structures have many applications such as producing batteries with greater power output, speeding up the healing process for broken bones, producing structural components with a high strength-to-weight ratio, structures and so on.

Buckling analysis of composite structures has been presented by many researchers. Bending and local buckling of a nanocomposite beam reinforced by a single-walled carbon nanotube (SWCNT) were studied by Vodenitcharova and Zhang (2006) based on the Airy stress-function method. Buckling analysis of nanocomposite Timoshenko beams reinforced by SWCNTs resting on an elastic foundation was investigated by Yas and Samadi (2012) using the generalized differential quadrature method (GDQM). Kolahchi *et al.* (2015) investigated nonlocal nonlinear buckling analysis of temperature-dependent microplates reinforced with FG-SWCNT resting on an elastic matrix as orthotropic temperature-dependent elastomeric medium. Based on harmonic differential quadrature (HDQ), Mehri *et al.* (2016) analyzed buckling and vibration responses of a composite truncated conical shell with embedded SWCNTs subjected to an external pressure and axial compression simultaneously. Buckling and vibration analysis of cantilever functionally graded (FG) beam that reinforced with carbon nanotube (CNT) were presented by Nejati *et al*. (2016). In this paper, an equivalent continuum model based on the Eshelby–Mori–Tanaka approach was obtained. Based on DQM and Bolotin's method, Kolahchi et al. (2016a,b) investigated nonlinear dynamic buckling analysis of embedded temperature-dependent viscoelastic plates reinforced by SWCNTs. Mosharrafian and Kolahchi (2016) presented buckling analysis of classical piezoelectric polymeric cylindrical shell reinforced by armchair double walled boron nitride nanotubes (DWBNNTs). The free vibration and linearized buckling analysis of laminated composite plates were studied using the Isogeometric approach (IGA) and Carrera's Unified Formulation (CUF) (Alesadi *et al.* 2017). Yang *et al.* (2017) studied buckling and postbuckling behaviours of functionally graded multilayer nanocomposite beams reinforced with a low content of graphene platelets (GPLs) resting on an elastic foundation. It was assumed that GPLs are randomly oriented and uniformly dispersed in each individual GPL-

*Corresponding author, Ph.D.
E-mail: roohollahbabaeimahani@duytan.edu.vn
[a] E-mail: ptsardari@tdtu.edu.vn".

ISSN: 1229-9367 (Print), 1598-6233 (Online)