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Effects of hygro-thermo-mechanical conditions on the buckling of FG sandwich plates resting on elastic foundations

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Abstract. In this research work, the hygrothermal and mechanical buckling responses of simply supported FG sandwich plate seated on Winkler-Pasternak elastic foundation are investigated using a novel shear deformation theory. The current model take into consideration the shear deformation effects and ensures the zero shear stresses on the free surfaces of the FG-sandwich plate without requiring the correction factors "*Ks*". The material properties of the faces sheets of the FG-sandwich plate are assumed varies as power law function "P-FGM" and the core is isotropic (purely ceramic). From the virtual work principle, the stability equations are deduced and resolved via Navier model. The hygrothermal effects are considered varies as a nonlinear, linear and uniform distribution across the thickness of the FG-sandwich plate. To check and confirm the accuracy of the current model, a several comparison has been made with other models found in the literature. The effects the temperature, moisture concentration, parameters of elastic foundation, side-to-thickness ratio, aspect ratio and the inhomogeneity parameter on the critical buckling of FG sandwich plates are also investigated.

Keywords: buckling; hygrothermal effect; elastic foundation; Hamilton's principle; Navier solution

1. Introduction

The sandwich plates are a structural element composed of two faces sheet and one core (Thai *et al*. 2014, Borsellino *et al*. 2004). Because of its low weight and high rigidity, this type of structure element has been widely employed in several sectors such as construction, aerospace, transport, aeronautic and marine and others engineering (Wang *et al*. 2010, Yeh 2013, Chakrabarti and Sheikh 2005, Pandit *et al*. 2008, Kant and Swaminathan 2002, Nayak *et al*. 2002, Mantari *et al*. 2012, Mehar *et al*. 2019, Rajabi and Mohammadimehr 2019).The three elements of the classical composite sandwich plates are adhesively bonded which increases the delamination risk. To avoid this problem, Japanese researches laboratories have created the new class of materials called FGMs which eliminate the interfaces areas that represents an area of accumulation and concentrations of stresses. Several researchers used this this kind of materials in the FG-sandwich structure (Li *et al*. 2008, Liu and Jeffers 2017, Xiang *et al*. 2011). For studying the various behaviors of the thick FG-sandwich plate, many analytical models are proposed.

Kiani and Eslami (2011) studied the stability of the porous FG-sandwich plate under thermal load using the first-shear deformation theory (FSDT). Mantari and Granados (2015) proposed a novel first shear deformation model based on the undetermined integral for studying the flexural analysis of the FG-sandwich plate with an FG core and isotropic skins. Sobhy (2013) investigated on the stability and dynamic behavior of the EFG-sandwich plates with various types of support using five variables shear deformation theory. Nguyen *et al*. (2014) developed an inverse-tangential higher-order shear-deformation theory for studying the bending, buckling and free-vibrational behaviors of the FG-sandwich plate with isotropic core and FG-faces sheets and FG-sandwich plate with FG-core and isotropic faces sheets. Based on HSDT theory, Natarajan and Manickam (2012) investigated on static and dynamic behaviors of the FG-sandwich plate using 8-noded quadrilateral plate element. Akavci (2016) developed a new hyperbolic warping function shape for the analyze of the various behaviors of the FG-sandwich plate seated on Winkler-Pasternak elastic foundation. Using the layerwise FE formulation based on the FSDT assumption, Pandey and Pradyumna (2015) have examined the free vibration of the FG-sandwich plate. The Natural frequencies of the rectangular sandwich plate with FG-face and homogeneous core has been computed by Xiang *et al*. (2011) by

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