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Buckling behaviors of FG porous sandwich plates with metallic foam cores resting on elastic foundation

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Abstract. The main objective of this paper is to study the effect of porosity on the buckling behavior of thick functionally graded sandwich plate resting on various boundary conditions under different in-plane loads. The formulation is made for a newly developed sandwich plate using a functional gradient material based on a modified power law function of symmetric and asymmetric configuration. Four different porosity distribution are considered and varied in accordance with material propriety variation in the thickness direction of the face sheets of sandwich plate, metal foam also is considered in this study on the second model of sandwich which containing metal foam core and FGM face sheets. New quasi-3D high shear deformation theory is used here for this investigate; the present kinematic model introduces only six variables with stretching effect by adopting a new indeterminate integral variable in the displacement field. The stability equations are obtained by Hamilton's principle then solved by generalized solution. The effect of Pasternak and Winkler elastic foundations also including here. the present model validated with those found in the open literature, then the impact of different parameters: porosities index, foam cells distribution, boundary conditions, elastic foundation, power law index, ratio aspect, side-to-thickness ratio and different in-plane axial loads on the variation of the buckling behavior are demonstrated.

Keywords: buckling behavior; functionally graded materials; metal foam; porosity; sandwich plate

1. Introduction

Since 1972 Bever and Duwez proposed a new material technology able to support a high degrees of loading. (Bever and Duwez 1972). Then is developed by Japanese scientist in 1981s (Singh and Harsha 2019). Functionally graded materials basically are an advanced composite materials which retains the strengths and eliminates the weaknesses existing in traditional stratifies as the concentration of the stress between discrete materials, specifically under the high thermal loads (Daikh and Zenkour 2019a). FGMs present a homogonous structure made up by two different constituents, usually ceramic and metal, ceramic with its high thermal resistance and metal with high mechanical resistance in which final proprieties vary gradually across the thickness.

These kinds of materials are generally fabricated based on many known and disposable treatment techniques. chemical and physical vapor deposition, powder metallurgy and various methods of casting, are the frequently used since the first fabrication of FGM, but today a new technology called additive manufacturing (AM) has been established in this area in recent years using 3D printing to fabricate FGM, because of its advancement makes it easy to control the density and directivity of material sedimentation within a complex 3D distribution or to combine different materials to manufacture a smooth homogeneous structure by changing disposition density and orientations (Loh *et al.* 2018, Sinha and Kumar 2021, Zhang *et al.* 2022).

With the development in manufacturing process, the FGMs are considered in the sandwich structures industries when the problem of stress concentration between the layers is very important, so the key of this materials was the use of a smooth gradient between the two materials, this makes it capable of minimizing the concentration stress between two sandwich layers and the propagation of cracks. FG sandwich plate with designed three-layered forms, core layer combined with top and bottom designed face sheets. During the manufacturing process and due to the restriction in fabrication technique micro voids can scattered inside the FGM structure which perhaps can reduce the resistance of the material, so there are few papers focusing in this phenomenon of the effect of porosity on the behavior of FG

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