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Combined influence of porosity and elastic foundation parameters on the bending behavior of advanced sandwich structures

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Abstract. Elastic bending of imperfect functionally graded sandwich plates (FGSPs) laying on the Winkler-Pasternak foundation and subjected to sinusoidal loads is analyzed. The analyses have been established using the quasi-3D sinusoidal shear deformation model. In this theory, the number of unknowns is condensed to only five unknowns using integral-undefined terms without requiring any correction shear factor. Moreover, the current constituent material properties of the middle layer is considered homogeneous and isotropic. But those of the top and bottom face sheets of the graded porous sandwich plate (FGSP) are supposed to vary regularly and continuously in the direction of thickness according to the trigonometric volume fraction's model. The corresponding equilibrium equations of FGSPs with simply supported edges are derived via the static version of the Hamilton's principle. The differential equations of the system are resolved via Navier's method for various schemes of FGSPs. The current study examine the impact of the material index, porosity, side-to-thickness ratio, aspect ratio, and the Winkler-Pasternak foundation on the displacements, axial and shear stresses of the sandwich structure.

Keywords: elastic bending; FG sandwich plate; Navier's method; porous plate; trigonometric-law; winkler-pasternak foundation

1. Introduction

Sandwich structures have high structural effectiveness through their exceptional properties: lower density, sound absorption capability, higher stiffness, higher strength, good energy, and often-low production cost compared to aluminum or steel. These features have led sandwich plates to find wide applications in mechanical, civil constructions, and many other engineering fields (Sobhy and Alakel Abazid 2022). FGMs are commonly used in different areas in civil and mechanical structures subjected to thermal fields. As an example, Aerospace panels to support high thermal loading such as rocket nozzle, spacecraft trusses, diesel, Polyurethane Pipe, engine pieces, Aerotech, Seebeck generators etc.). Automotive applications like the diesel engine piston and engine cylinder liners … etc.). In the biomedical field, the reasons for using a gradient material are more important. It is possible, for example, to use a gradient material to combine mechanical properties and wear resistance on a hip prosthesis.

Over the past several decades, these structures have experienced significant difficulties with durability due to the stress concentration at the face sheet-core interfaces (Funari *et al.* 2018, Meksi *et al.* 2019, Burlayenko and Sadowski 2020, Van Vinh 2021, Swaminathan *et al.* 2022). Consequently, a local separation through delamination often occurs between the core and face sheets. Additionally, sandwich materials do not provide high operating temperatures. These disadvantages are resolved using functionally graded materials (FGMs) of two or more phases with different material properties varying smoothly and continuously in one or more directions. They are introduced to exploit the desired material properties of each constituent material without interface complications. The major inconvenience of such materials is the stress concentrations along the interfaces between layers, specifically in high temperatures. This can cause delamination, matrix cracks, and other damage mechanisms resulting from sudden changes in mechanical properties between layers. Therefore, increasing the sandwich's resistance to these types of failures, the concept of a

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