

A New High Order Theory for Buckling Temperature Analysis of Functionally Graded Sandwich Plates Resting on Elastic Foundations

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(Received 12 April 2022; revised manuscript received 23 June 2022; published online 30 June 2022)

Using a high order theory (HSDT), this work presents a study of thermal buckling of functionally graded (FG) sandwich plates subjected to various temperature rises across their thickness and resting on a two-parameter elastic foundation. The mechanical properties of the FG sandwich plates are supposed to change gradually through the thickness according to a power law (P-FGM). The intermediate layer is homogeneous and made of a purely ceramic material. The principle of virtual works is used to obtain stability equations, and their solutions are obtained based on Navier's solution technique. The obtained results are compared with other studies in the literature. Then, a parametric study is conducted to investigate the influence of geometric and mechanical characteristics such as the ratios of dimensions (width, length, and thickness), the material index (k), and the effect of the elastic foundation on the critical buckling temperature.

Keywords: FG sandwich plates, Thermal buckling, Elastic foundation, Virtual works, Navier's solution.

DOI: [10.21272/jnep.14\(3\).03028](https://doi.org/10.21272/jnep.14(3).03028)

PACS numbers: 46.32. + x, 81.70.Pg

1. INTRODUCTION

Functionally graded materials (FGM) are a class of composites, in which the properties of the material gradually change over one or more Cartesian directions [1], the combination of which results in an assembly with higher performance than components taken separately. This class of composite materials has gained considerable attention in the engineering community, especially in high-temperature applications such as nuclear reactors, aerospace, and power generation industries [2]. The advantages of continuously varying volume fraction of the constituent phases are eliminating high-stress concentrations and separating layers encountered in other composites such as sandwiches and laminates. Over the last two decades, there has been a significant number of reports on thermal stresses, fracture, thermo-mechanical response, buckling, free vibration, etc. of FGM structural elements [3].

Zenkour [4] investigated the response and bending, buckling, and free vibration of the simply supported sandwich plate using the plate theory of sinusoidal shear strain. Zhao [5] studied the buckling behavior of FG plates under mechanical and thermal loads with arbitrary geometry. Bourada [6] presented a novel theory of refined four-variable plates for the thermal buckling analysis of FG sandwich plates. Kettaf [7] examined the thermal buckling response of FG sandwich plates by proposing a new model of hyperbolic displacement. Bouiadjra [8] proposed a refined four-variable plate theory to analyze buckling of FG plates subjected to thermal loads. Maiche [9] using the refined hyperbolic shear strain plate theory had four variables for the study of buckling and vibration of FGM plates.

This work analyzes a new displacement model for sandwich plates on an elastic foundation under various thermal loads. Analytical solutions are presented using a New High Order Theory (HSDT).

2. GEOMETRY OF A FUNCTIONALLY GRADED PLATE

A simply supported FGM sandwich plate of length a , width b , and thickness h is referred to the rectangular cartesian coordinates (x, y, z) , as shown in Fig. 1. The face layers of the FG sandwich plate are made of an isotropic material with material properties varying smoothly in the z direction only (FGM). The core layer is made of an isotropic homogeneous material (ceramic).

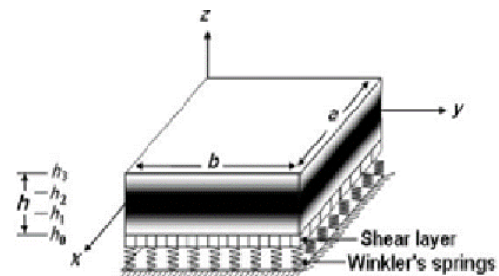


Fig. 1 – Geometry and coordinate system of the FGM sandwich plate resting on a two-parameter elastic foundation [10]

The effective material properties of FGM sandwich plates are expressed by [11]:

$$P^{(n)}(z) = P_m + (P_c - P_m)V^{(n)}. \quad (2.1)$$

The volume fraction of FGM is supposed to obey a power-law function along the thickness direction

$$\begin{aligned} v^{(1)} &= (z - h_0 / h_1 - h_0)^k & h_0 \leq z \leq h_1 \\ v^{(2)} &= 1 & h_1 \leq z \leq h_2 \\ v^{(1)} &= (z - h_3 / h_2 - h_3)^k & h_2 \leq z \leq h_3 \end{aligned} \quad (2.2)$$

where $V^{(n)}$ ($n = 1, 2, 3$) denotes the volume fraction

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