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Salvatore Brischetto*

Abstract

This new work proposes a three-dimensional (3D) exact shell model for the static analysis of simply-supported structures embedding Functionally Graded Material (FGM) layers when they are subjected to harmonic transverse normal loads. Results are proposed in terms of displacement and stress amplitudes through the thickness direction. One-layered FGM plates and cylinders, and sandwich cylindrical and spherical shell panels embedding an internal FGM core and external classical skins have been analyzed. Proposed results give a complete 3D description of FGM structures in terms of displacement and stress states. Such results can be used to validate new refined 2D shell models proposed in numerical or analytical form. Different geometries, lamination schemes, thickness ratios, materials and FGM laws through the thickness have been analyzed in order to have a general overview of the problem. The proposed 3D shell model uses the spherical 3D equilibrium equations developed in general orthogonal curvilinear coordinates. These equations automatically degenerate in those for cylindrical and plate structures via opportune considerations made about the radii of curvature. Equilibrium equations are solved in closed form considering simply supported boundary conditions and harmonic applied loads. The exponential matrix method has been employed to solve the second order partial differential equations in z. These equations have constant coefficients because of the introduction of opportune mathematical layers for the FGM description and for the curvature evaluation. A layer-wise approach has been identified with the direct imposition in the 3D shell model of equilibrium conditions for transverse stresses and compatibility conditions for displacements.

Keywords: functionally graded materials; sandwich plates and shells; 3D equilibrium equations; static analysis; 3D stress and displacement states; layer-wise approach.

1 Introduction

Functionally Graded Materials (FGMs) are a specific type of composite materials where two or more constituent phases have a continuous variation of elastic and thermal properties through different directions [1], [2]. A metallic and a ceramic phase are usually considered. In general, the related structure is full ceramic where refractory features are requested and it is full metallic where high mechanical properties are necessary. One of the main advantages of a monotonous variation of the volume fraction of the constituent phases is the elimination of physical interfaces in related multilayered structures. This feature means the elimination of the stress discontinuity and the consequent suppression of delamination-related problems [3]. FGMs have a lot of advantages and they are very attractive in those

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