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ACCEPTED MANUSCRIPT

Interpretation of boundary conditions in the analytical and numerical shell solutions for mode analysis of multilayered structures

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Abstract

The paper proposes the first 18 vibration modes for plates, and the first 14 vibration modes for cylinders and cylindrical shells. All the edges of these structures are simply supported and the free frequencies are calculated using an exact three-dimensional shell model. A comparison is proposed using two different numerical models such as a classical two-dimensional finite element model and a refined two-dimensional generalized differential quadrature model. The 3D exact model gives all types of vibration modes, when the four edges are simply supported, changing the imposed half-wave numbers m and n in the two in-plane directions α and β. Some of these modes have one of the two half-wave numbers equals zero. When this condition is simultaneously combined with the condition of transverse displacement different from zero, the resulting vibration mode is defined as cylindrical bending mode. The cylindrical bending case has all the derivatives made in the direction where $m = 0$ or $n = 0$ equal zero. This feature means that the vibrational behavior does not change along this particular direction. The numerical models with the simply supported boundary conditions for all the edges do not achieve these results. These cylindrical bending numerical results are obtained modifying the boundary conditions. Proposed results will demonstrate the validity of this idea and how to modify the mathematical models in order to obtain and improve the cylindrical bending solutions.

Keywords: 3D exact shell model; 2D finite element model; 2D generalized differential quadrature model; vibration modes; cylindrical bending; simply supported edges; free edges; boundary conditions.

1 Introduction

A comparison in terms of free frequencies between classical two-dimensional (2D) finite elements (FEs), classical and refined 2D generalized differential quadrature (GDQ) models and an exact three-dimensional method has been proposed by authors in [1] and [2] for single-layered and multilayered isotropic, composite and sandwich structures, and in [3] and [4] for single-layered and sandwich functionally graded structures. The proposed analyses considered plates, cylinders, and cylindrical and spherical panels. Low and high order frequency values were investigated for simply supported thick and thin structures. Vibration mode investigation was fundamental to understand how to compare

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