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Non-linear dynamic thermo-mechanical buckling analysis of the imperfect laminated and sandwich cylindrical shells based on a global-local theory inherently suitable for non-linear analyses

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ABSTRACT

The available accurate shell theories satisfy the interlaminar transverse stress continuity conditions based on linear strain–displacement relations. Furthermore, in majority of these theories, either influence of the transverse normal stress and strain or the transverse flexibility of the shell has been ignored. These effects remarkably influence the non-linear behavior of the shells especially in the postbuckling region. Furthermore, majority of the buckling analyses performed so far for the laminated composite and sandwich shells have been restricted to linear, static analysis of the perfect shells. Moreover, almost all the available shell theories have employed the Love–Timoshenko assumption, which may lead to remarkable errors for thick and relatively thick shells. In the present paper, a novel three-dimensional high-order global-local theory that satisfies all the kinematic and the interlaminar stress continuity conditions at the layer interfaces is developed for imperfect cylindrical shells subjected to thermo-mechanical loads.

In comparison with the layerwise, mixed, and available global-local theories, the present theory has the advantages of: (1) suitability for non-linear analyses, (2) higher accuracy due to satisfying the complete interlaminar kinematic and transverse stress continuity conditions, considering the transverse flexibility, and releasing the Love–Timoshenko assumption, (3) less required computational time due to using the global-local technique and matrix formulations, and (4) capability of investigating the local phenomena. To enhance the accuracy of the results, compatible Hermitian quadrilateral elements are employed. The buckling loads are determined based on a criterion previously published by the author.

1. Introduction

Sandwich shell structures have been extensively used in various engineering applications. The cores of the mentioned shells that are usually fabricated from light and soft materials, beside their functional characteristics, serve as spacers. Therefore they may enhance the overall performance of the structure without increasing the total weight of the structure or complicating the manufacturing process considerably. Sandwich shells with stiff sheets and soft low strength cores have been widely used in construction of many components in automotive, aerospace, aeronautic, ship, underwater, and building structures. They may be utilized for many purposes, among them: dynamic or NVH (noise, vibration, and harshness) behaviors enhancement, thermal insulation, construction of lightweight structures with higher strength to weight ratios, and ease of manufacturing. In cases where severe differences between the material properties of the face sheets and the flexible cores exist, results of most of the available shell theories may become unreliable, especially when analyzing the local behaviors and failures. Majority of the available shell theories have either neglected the transverse flexibility or the transverse shear and normal stress continuity conditions at the layer interfaces. Therefore, these theories may encounter serious accuracy problems in predicting the mentioned local behaviors, especially for sandwich shells with flexible cores. Some researchers have assessed the accuracy of theories proposed for the sandwich and multilayered shells [1–3].

Although the theory of elasticity is a powerful tool for analyzing behaviors of the structures, only limited solutions with C^0-contintity in the transverse direction were proposed, based on the linear theory of elasticity, for simple loading and boundary conditions. In the

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