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An efficient approach to investigate the post-buckling behaviors of sandwich structures

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Abstract

In this paper, we propose an efficient and accurate approach to investigate the post-buckling behavior of sandwich structures. In this framework, a novel one-dimensional layer-wise model using Euler-Bernoulli beam theory in the skins and higher-order kinematics in the core is proposed. The resulting nonlinear governing equations are then solved by the Asymptotic Numerical Method (ANM) with a bifurcation indicator, which is more reliable and efficient than the classical iterative methods, e.g., Newton-Raphson method, in terms of detecting critical points and computing bifurcated branches. Several numerical tests, i.e., global buckling, local wrinkling and global-local-coupling instability phenomena of sandwich beams, are performed and the results show that the proposed approach is able to efficiently and precisely characterize the critical loads and the post-buckling behaviors of sandwich structures. Finally, the effect of three aspects, i.e., kinematics, strain-displacement relationships and interpolation functions on the computational accuracy of predicting these instability phenomena are investigated.

Keywords: Buckling; Post-buckling; Sandwich; Asymptotic Numerical Method; Bifurcation indicator.

1 Introduction

Sandwich structures are generally made of two high-strength skin layers and a low-density core layer, which thus possess the advantages of lightweight and high flexural stiffness. They have been widely used in practical engineering such as aeronautics, astronautics, automotive industry, etc. One of the most important problems when designing such kind of structures is to precisely predict the buckling and post-buckling behaviors such as global buckling and local wrinkling.

Many efforts have been devoted to the instability analysis of sandwich structures over the past few decades [1]. A unified model for global buckling and local wrinkling was proposed by Léotoing et al. [2]. They provided the analytical solutions for antisymmetric and symmetric buckling critical loads of sandwich beams under compressive loads. Another analytical linear elastic isotropic model was proposed by Ji and Waas [3] for the instability analysis of sandwich beams. Ji and Waas [4, 5] further presented benchmark solutions for buckling phenomena of the sandwich structures with orthotropic materials in the 2D plane strain and general 3D state. Recently, Le Grognec et al. [6–8] analytically investigated the critical loads and the corresponding patterns for global buckling and local wrinkling

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