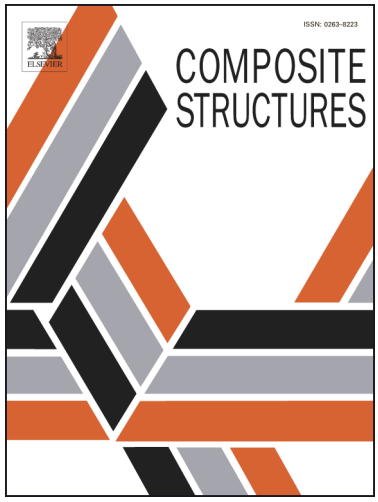

Snapthrough and Free Vibration of Bistable Composite Laminates Using a Simplified Rayleigh-Ritz Model

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Snapthrough and Free Vibration of Bistable Composite Laminates Using a Simplified Rayleigh-Ritz Model

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Abstract

The snapthrough and free vibration response of bistable cross-ply $[90_n/0_n]$ composite laminates is investigated. Thin unsymmetric composite laminates possess more than one equilibrium position when cooled to room temperature due to the difference in thermal expansion of the plies. Bistable cross-ply laminates have cylindrical shapes at room temperature provided appropriate side-length-to-thickness ratio is used. The laminate is modelled according to the classical lamination plate theory taking into account the von Karman geometric nonlinearity. The strains and displacements are approximated via a simplified Rayleigh-Ritz model that depends on only four time-dependent parameters for the general dynamic response. The simplified model is validated against experimental and finite element results and an acceptable agreement is obtained. The laminate's length-to-thickness ratio is key to assess the existence of bistability. The model is used to investigate the snapthrough response of an 8-ply $[90_4/0_4]$ laminate that is subjected to three loading schemes: concentrated moments, normal forces, and tangential forces. The variations of the principal curvatures and the lateral displacement of the laminate with the applied forces are shown. The significance of the force location is also found a crucial element in finding the snapthrough force. The free vibration that takes place in the vicinity of a stable equilibrium position is studied and the variation of the fundamental frequency with the laminate size is presented.

Keywords: Snapthrough, bistable laminates, free vibration, Rayleigh-Ritz method.

1. INTRODUCTION

Bistable composite laminates have attracted attention in recent years due to their ability to switch from one stable equilibrium position to another with an appropriate triggering action. Moreover, the bistable laminate does not need external power to maintain a stable configuration since it is a self-equilibrated equilibrium position. This feature gives bistable laminates the potential for