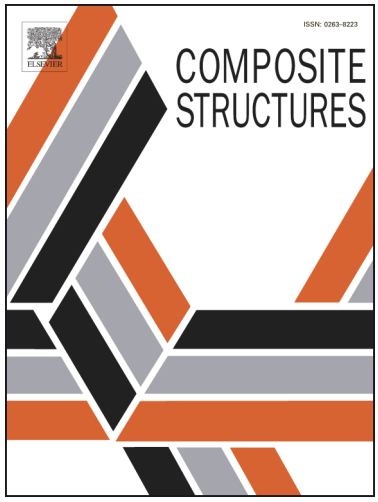

Computational and experimental study on dynamic instability of extended bistable carbon/epoxy booms subjected to bending

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Computational and experimental study on dynamic instability of extended bistable carbon/epoxy booms subjected to bending

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Abstract

Bistable reeled composite booms (BRCs) constructed from braided carbon/epoxy plies are suitable candidates for use as extendible booms or as elements of large deployable space structures. However, without modification, BRCs have an open section which limits their torsional stiffness, and makes them prone to collapse under low bending moments. In this study a "roll-up" deployable photovoltaic (PV) solar array with two side-by-side extendible BRCs is used as a case study to analyse the dynamic behaviour of BRCs on spacecraft undergoing rotational manoeuvres numerically. The BRCs have rotational accelerations applied to their roots to simulate the effect of being attached to a manoeuvring spacecraft. Budiansky-Hutchinson criterion is used to define an instability failure point based on a change in cross-sectional shape. This was used to estimate the maximum angular acceleration. While it is extremely difficult to replicate the behaviour of a large flexible lightweight structure in microgravity on the ground, an experiment to determine the point of collapse of BRCs under gravity were used to verify the simulation results.

Keywords:
Bistable composites, Dynamic stability, Numerical analysis, Solar array

1. Introduction

In their extended stable state, BRCs look like carpenter's tapes (see Fig. 1 (b)), however, they can also be stable in a coiled configuration as illustrated in Fig. 1 (a). BRCs constructed from lightweight braided carbon/epoxy plies have a naturally high packing efficiency, which makes them excellent candidates for space applications that require structures to be very large in space but as small as possible when launched.

As a result of their potential applications in space, many researchers have contributed to a substantial body of work on bistable cylindrical shells [1, 2, 3, 4, 5, 6, 7, 8]. Iqbal [1, 2] generated an approximate equation of strain energy due to bending and stretching in terms of transverse and longitudinal curvatures for a composite slit tube under pure bending. Galletly [4] developed this further using both beam and shell models with consideration

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