ICCES, 2026, vol.36, no.1

DOI: 10.32604/icces.2026.013709

PROCEEDINGS

An Analytical and Experimental Investigation on the Dynamic Response of Bistable Deployable Composite Booms with Several Cross-Sectional Profiles

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ABSTRACT

As a novel kind of deployable structures, the bistable deployable composite booms (Bi-DCBs) have attracted extensive attentions for space applications in recent years, they are favorable when a low energy requirement for the folded state is imposed and have more controllable deployment when compared to monostable booms. However, the quietly high speed of Bi-DCBs may cause chaos and even give the structure a big impact in practical applications, and the deployment process is generally affected by multiple factors, so it is significant to have an overall understanding for the mechanical behavior of deployment process, such as releasing strain energy, full deployed time, deployment velocity et al. Based on the urgent requirement, this study proposes an analytical model to predict the deployment dynamics, inspired from classical Archimedean spiral and conic section equation, to construct a unified computational framework for different cross sections satisfied with eccentricity no more than 1. The model of accuracy and effectiveness were validated through experiments with maximum relative error no more than 10%, and the parametric study was used to investigate the influence of geometric parameters and stacking schemes on deployment behavior. This model confirmed that these factors are conducive to increasing the curvature variation and the material bending stiffness often store more strain energy when flattened, therefore producing a higher driving force and faster dynamic response. This work attempts to formulate the full analytical framework from first principles to predicting deployment behaviors of Bi-DCBs with various cross-sections, further revealing the underlying essence, and providing a practical methodology for exploring deployment mechanisms and engineering designs of Bi-DCBs.

KEYWORDS

Bistable deployable composite booms; deployment dynamics; full deployed time; conic section

Acknowledgement: Funding from the National Natural Science Foundation of China is gratefully acknowledged.

Funding Statement: The work was supported by the National Natural Science Foundation of China (52275231).

Conflicts of Interest: The authors declare that they do not have any commercial or associative interest that represents a conflict of interest in connection with this study.

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