Variable stiffness and damping components for semi-active vibration control and inflatable rigidization

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Abstract
The paper explores the potential applications of adaptive components based on shape memory polymer (SMP) composites in vibration control of plate/shell structures and rigidization of inflatable structures. These components achieve stiffness and damping variation by thermally actuating SMP between its glassy and rubbery states. In CASE A, steel-SMP sandwich plates of a truss bridge are actuated to glass transition temperature (Tg), where material damping reaches the peak to mitigate dynamic responses. CASE B proposes a simple and reversible rigidization method for inflatable structures, creating high compaction ratio and design flexibility. Converting the SMP layer between its glassy and rubbery states, inflatable structures achieve multiple functions during transportation, construction, and service life. SMP-based adaptive components enhance structural performance and mitigate dynamic effects in demanding environments for various structures.

Keywords: adaptive components; shape memory polymer (SMP); variable stiffness and damping; vibration control; plate/shell structures; inflatable structures; physical rigidization; construction in extreme environments

1 Introduction

1.1 Vibration control
Structural control strategies optimize performance in adaptive structures under changing loading conditions, categorized as passive, active, semi-active, and hybrid [1]. Passive systems, e.g. base isolation, require no control power but have limited capabilities. Active control effectively reduces structure responses, especially in seismic- [2] and wind-excited [3] buildings, but can be unstable due to high power density and control uncertainties. Semi-active control systems, like magnetorheological dampers, perform better than passive systems and offer reliability and energy efficiency over fully active systems. Hybrid control combines passive, semi-active, and active

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