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Phase Transforming Cellular Materials (PXCMs) Design and Assembly

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ABSTRACT

We introduce a new class of phase transforming cellular materials (PXCMs) based on locally bistable or metastable unit cells that form periodic microstructures, where the thermomechanical behavior of each unit cell exhibits snap-through type behavior. We propose to explore the capabilities of these new materials to improve structural resistance to damage caused by natural hazards including PXCM in structural members. The main benefits of this material are that it can absorb energy and is reusable. During the first part of this work, a fabrication method for PXCMs based on the assembly material slotted stripes was explored. The 1D unit cell of the PXCM was dis-assembled into six components. CAD models of these components were designed, 3D printed, and assembled together to allow us to explore the fabrication of PXCMs in different materials without relying on 3D printing. On the second part of this work, we explored the geometric design space of the PXCMs that exhibit phase transformation in two or more preferential directions. For this, 2D and 3D geometric designs where proposed and a parametric study was performed using 3D-printed models to explore the behavior of each individual cell. The 1D assembly design and the 2D models did not demonstrate expected PXCM behavior when subjected to compression. However, most of the 3D geometric models demonstrated the expected PXCM behaviors when subjected to compression — bistability/ metastability, energy absorption, and phase transformation capabilities. More testing needs to be done in the future to further determine the behavioral patterns for the PXCM models.

KEYWORDS

Cellular materials, phase transformation, energy absorption, compliant mechanism, geometric design