ABSTRACT

Author: Yunlan, Zhang. PhD
Institution: Purdue University
Degree Received: December 2019
Title: Architected Material-Based Shape Memory Alloys
Committee Chair: Pablo Zavattieri

Architected materials are a class of materials with novel properties that typically consist of numerous periodic unit cells. In past investigations, researchers have demonstrated how architected materials can achieve these novel properties by tailoring the features of the unit cells without changing the bulk materials. Here, a group of architected materials called Phase Transforming Cellular Materials (PXCMs) are investigated with the goal of mimicking the novel properties of shape memory alloys. A general methodology is developed for creating 1D PXCMs that exhibit temperature-induced reverse phase transformations (i.e., shape memory effect) after undergoing large deformations. During this process, the PXCMs dissipate energy but remain elastic (i.e., superelasticity). Next, inspired by the hydration-induced shape recovery of feathers, a PXCM-spring system is developed that leverages the superelasticity of PXCMs to achieve shape recovery. Following these successes, a real-world application in seismic-resisting systems is evaluated. A single degree of freedom-PXCM system is subjected to a series of simulated ground motions to evaluate how 1D PXCMs respond in a dynamic environment. Lastly, the concept of PXCMs is extended into two dimensions by creating 2D PXCMs that achieve superelasticity in multiple directions. Overall, the findings of this investigation indicate that PXCMs: 1) can achieve shape memory and recovery effects through temperature changes, 2) offer a novel alternative to traditional building materials for resisting seismic demands, and 3) can be expanded into two dimensions while still exhibiting superelasticity.