Purdue University
Purdue e-Pubs

IUTAM Symposium Architectured Materials Mechanics | Symposium Contributions

Sep 17th, 12:00 AM - Sep 19th, 12:00 AM

Mechanics of Energy Absorbing Phase Transforming Cellular Materials

Yunlan Zhang
Purdue University, zhan1337@purdue.edu

Kristiaan Hector

Mirian Velay-Lizancos

David Restrepo

Follow this and additional works at: https://docs.lib.purdue.edu/iutam

Part of the Engineering Commons

Recommended Citation

Zhang, Y., Hector, K., Velay-Lizancos, M., & Restrepo, D. (2018). Mechanics of Energy Absorbing Phase Transforming Cellular Materials. In T. Siegmund & F. Barthelat (Eds.) *Proceedings of the IUTAM Symposium Architectured Materials Mechanics, September 17-19, 2018* , Chicago, IL: Purdue University Libraries Scholarly Publishing Services, 2018. https://docs.lib.purdue.edu/iutam/presentations/abstracts/83

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.

IUTAM Symposium Architectured Material Mechanics,
T. Siegmund, F. Barthelat, eds
September 17-19, 2018, Chicago, IL, USA, , Chicago, IL, USA

Mechanics of Energy Absorbing Phase Transforming Cellular Materials

Yunlan Zhang[1], Kristiaan Hector[2], Mirian Velay-Lizancos, David Restrepo, Nilesh D. Mankame, and Pablo Zavattieri.

(1) Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, zhan1337@purdue.edu
(2) Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, hectork@purdue.edu

KEYWORDS:

Energy absorption, Phase transformation, and Cellular materials

Phase Transforming Cellular Materials (PXCM's) are architectured materials composed of a matrix of repeated unit cells that can dissipate energy while maintaining their base material within the elastic regime. Each unit cell can be designed with either a bistable or metastable mechanism. A PXCM can dissipate energy when a unit cell transitions between different stable configurations (phases). In addition, the amount of energy that a PXCM can dissipate depends upon the direction of the applied load and the material symmetry. The 1-Dimensional PXCM (1D PXCM), can successfully exhibit phase transformation and energy dissipation in response to a load applied along its principle axis of symmetry [1]. However, in real world scenarios, loading directions are arbitrary. Therefore, the design and fabrication of materials that can dissipate energy in response to a load applied along any arbitrary direction is crucial for real world applications. Here, two concepts of a 2-Dimensional PXCM (2D PXCM), that can dissipate energy and exhibit auxetic behavior in response to a load applied along several axes of symmetry, are presented. The two concepts of the 2D PXCM include the square 2D PXCM and the triangular 2D PXCM. Finite element analysis and cyclic loading tests were conducted on the square 2D PXCM (four axes of symmetry) and the triangular 2D PXCM (six axes of symmetry). The Poisson's ratio and the energy dissipated by the material from different loading angles were calculated, both of which were influenced directly by the choice of the loading angle, which is defined by the angle between an axis of symmetry and the loading direction. As more axes of symmetry were added to the 2D PXCM designs, the more uniform the energy dissipation became between various loading angles. However, the energy dissipated from 2D PXCM's with more axes of symmetry was observed to be less that that dissipated by 2D PXCM's with fewer axes of symmetry. The ability of a 2D PXCM to dissipate energy and exhibit auxetic and recoverable behavior in response to a load applied from any arbitrary direction makes it applicable to a vast range of fields that demand large deformations and energy absorption such us armors, car bumpers, medical stents, and helmets.

References

[1] Restrepo, D., Mankame, N.D., Zavattieri, P.D., 2015. Phase transforming cellular materials. *Extreme Mechanics Letters*, *vol.4, pp. 52-60.*