The Summer Undergraduate Research Fellowship (SURF) Symposium
3 August 2017
Purdue University, West Lafayette, Indiana, USA

Cylindrical Shell based Phase Transforming Cellular Materials: Designing a Recoverable Energy Dissipating Material

Gordon F. Jarrold, David Restrepo
Lyles School Civil Engineering, Purdue University
Nilesh Mankame
Smart Materials and Structures, General Motors Global Research & Development
Pablo Zavattieri
Lyles School Civil Engineering, Purdue University

ABSTRACT

Energy dissipating materials are used in a variety of impact events to protect more important parts of a system; one example of this is a football player's helmet protecting a brain. A major drawback to classic energy dissipating materials however is that they dissipate energy through plastic deformation, meaning that after a single use, permanent deformations will prevent the material from being reusable to the same capacity as initially. We have designed a 1D cellular material in which geometric phase transformations in cylindrical shell elements are the primary energy dissipating mechanism, allowing for recoverability after use while keeping high energy dissipation functionality. Finite element analysis was used to evaluate cylindrical shell ligaments of differing lengths and angle of inclination, after which key parameter combinations were identified. Physical samples were manufactured and tested in loading and unloading cycles. It was found through simulations that ligaments with high length and high angle of inclination gave the greatest amount of energy dissipation. Mechanical tests have shown key similarities in deformation modes with the simulations, and verified that there is significant energy dissipation due to phase transformations. This concept could improve design in many fields, such as car bumper design and earthquake damage control, by adding recoverable elements to structural design. This would mean that energy dissipation mechanisms could be implemented in places not utilized before, as well as reducing the recovery effort post impact.

KEYWORDS

Energy Dissipation, Snapback, Cellular Materials, Geometric Phase Transformation, Finite Element Analysis