Accepted Manuscript

Experimental and simulation investigation of the reversible bi-directional twisting response of tetra-chiral cylindrical shells

Chao Ma, Hongshuai Lei, Jian Hua, Yingchun Bai, Jun Liang, Daining Fang

PII: S0263-8223(18)31949-4
DOI: https://doi.org/10.1016/j.compstruct.2018.07.013
Reference: COST 9930

To appear in: *Composite Structures*

Received Date: 29 May 2018
Revised Date: 29 June 2018
Accepted Date: 3 July 2018

Experimental and simulation investigation of the reversible bi-directional twisting response of tetra-chiral cylindrical shells

Chao Ma[1,2], Hongshuai Lei[1,2,3,*], Jian Hua[4], Yingchun Bai[5], Jun Liang[1,2,*], Daining Fang[1,2]

1. Beijing Key Laboratory of Lightweight Multi-functional Composite Materials and Structures, Beijing Institute of Technology, Beijing 100081, PR China.
2. State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology, Beijing 100081, PR China.
3. State Key Laboratory for Strength and Vibration of Mechanical Structures, School of Aerospace Engineering, Xi'an Jiaotong University, Xi'an 710049, PR China.
4. State Key Laboratory of Mechanics and Control of Mechanical Structures, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, PR China.
5. National Engineering Laboratory for Electric Vehicles, School of Mechanical Engineering, Beijing Institute of Technology, Beijing 100081, PR China.

Abstract

Chiral-type cells consisting of rigid nodes and rotatable ligaments provide an opportunity to develop lightweight engineering structures with unique mechanical performances. For a 2D or 3D chiral-type cellular structure system with a periodic arrangement of chiral cells, a distinct rotational response will present because of the asymmetrical and geometrical configuration. In this article, a tetra-chiral cylindrical shell is proposed on the basis of natural plant architecture. This shell exhibits a reversible bi-directional twisting deformation in the axial compression and tension processes. A theoretical model is proposed via the geometrical parameters of cells to describe the relationship between twist angle and axial displacement. Two categories of tetra-chiral cylindrical shell specimens are fabricated utilizing additive manufacturing technique involving the application of nylon and AlSi10Mg materials. Uniaxial compressive tests and finite element simulation are conducted to reveal the twist deformation mechanism. Results verify that the twist characteristics of the chiral-type shell, which are adjustable in terms of the rotational direction and angle, are only related to the distribution and geometrical sizes of ligaments. The innovative chiral-type cylindrical shell provide a new design strategy which can be used in engineering applications as compress– or stretch–twist coupled smart actuators, biomechanical devices, and micro sensors.

Keywords: auxetic cellular structure, chiral cylindrical shell, twist response, deformation mechanism

Corresponding authors:
leihongshuai@bit.edu.cn (Hongshuai Lei); liangjun@bit.edu.cn (Jun Liang)