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

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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

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