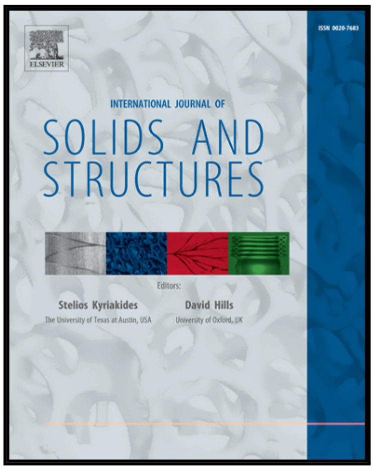

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The two-dimensional elasticity of a chiral hinge lattice metamaterial

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ABSTRACT

We present a lattice structure defined by patterns of slits that follow a rotational symmetry (chiral) configuration. The chiral pattern of the slits creates a series of hinges that produce deformation mechanisms for the lattice due to bending of the ribs, leading to a marginal negative Poisson's ratio. The engineering constants are modelled using theoretical and numerical Finite Element simulations. The results are benchmarked with experimental data obtained from uniaxial and off-axis tensile tests, with an overall excellent agreement. The chiral hinge lattice is almost one order of magnitude more compliant than other configurations with patterned slits and - in contrast to other chiral micropolar media - exhibits an in-plane shear modulus that closely obeys the relation between Young's modulus and Poisson's ratio in homogeneous isotropic linear elastic materials.

Keywords: lattice; metamaterial; chiral; elasticity; tension; shear

1. Introduction

Lattice metamaterials are currently being developed to create unusual deformation mechanisms and multifunctional capabilities [1][2] in a vast range of applications, from energy absorption through microbuckling instabilities [3][4] to wave propagation and vibration transmissibility reduction effects [5][6]. A subset of lattice metamaterials is constituted by solids with negative Poisson's ratio, also known as auxetic [7][8][9]. The unusual auxetic behavior is essentially achieved using specific cell topologies as re-entrant units, rotating rigid/semi rigid units, as well as chiral systems. Wojciechowski [10] has first suggested an auxetic chiral configuration based on rotating disks and nearest neighbor inverse n^{th} power interactions. Prall and Lakes [11] have formally developed a chiral structural honeycomb providing a theoretical and experimental in-plane Poisson's ratio of -1. This configuration consists in ligaments connecting two cylinders located on the opposite sides and ends, with each cylinder having 6 tangent ligaments at regular 60^o intervals. Chiral cellular solids have shown some peculiar features over conventional hexagonal honeycombs, because of the out-of-plane partial decoupling between compressive and transverse shear behavior

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