

A tunable architected core material exhibiting auxetic behaviour for sound transmission control

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Metamaterials, exhibiting exotic properties by artificial geometry design, have received increasing attention in the past decades. In this contribution, a tunable mechanical metamaterial exhibiting three-dimensional (3D) auxetic (negative Poisson's ratio) properties is proposed. The negative Poisson's ratio arises from the chirality of the cellular microstructures, which also leads to anisotropic elastic material properties to be characterised by an inverse estimation method developed by the authors. The results show that the anisotropic mechanical properties and the Poisson's ratios in all three dimensions are tunable by simply adjusting the cellular geometry. These adjustable properties offer broad potential for applications in the fields of sensors, tissue engineering, or vibro-acoustics. The paper mainly illustrates an application on sound transmission loss of a sandwich panel in the low frequency range. The simulated results highlight the potential of the proposed approach to control the design of structures with exceptional noise insulation properties.

1 3D auxetic cell and material modelling

An isometric Kelvin cell (KC) arrangement exhibiting cubic material symmetry is chosen as the reference micro-structure, see Fig. 1a. The geometrical modifications applied to the reference KC geometry are in the form of rigid body rotations of the square faces, while keeping these square undeformed during the rotation [2]. Fig. 1b shows an auxetic cell generated from twisting all six square faces with an angle of 90° . Topologically, the cell is not modified and all vertices remain connected through the same struts (with altered lengths) as in the KC geometry. The rotational angles applied on each pair of square faces are anti-symmetric, *i.e.* rotated with opposite angles, equal in absolute value. The twisted cell exhibits chirality with respect to each middle plane parallel to the pairs of twisted faces, see Fig. 1b. When a load is applied to the chiral structure, the non-centered force or non-affine deformation induce auxetic behavior where the lateral squares from any chosen pair of squares contract laterally under compression of the cell applied to the chosen pair.

The anisotropic elastic material properties associated with this KC geometry with rotated faces are characterised by an inverse estimation method developed by the authors [3]. The corresponding results show that the estimated Poisson's ratio of the twisted cell vary as a function of the twisting angle and geometry size. A negative Poisson's ratio is found for a twisting angle in the range $35^\circ - 90^\circ$ when twisting all six square faces anti-symmetrically with a same angle.

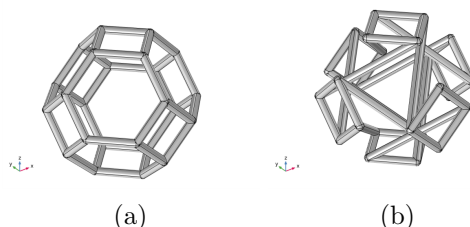


Figure 1: a) Kelvin cell, b) twisted auxetic cell (90°).

2 Applications: an example in vibro-acoustics

In connection with the specific auxetic and chiral properties previously introduced, multiple applications are currently under study. Here we focus on an application in vibro-acoustics for sound insulation

