Institute of Structural Mechanics and
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Simulation and Optimization of Auxetic Metamaterials under Quasi-Static Loading Conditions

Final thesis

Auxetic materials are a special class of structured mateamaterials that are characterised by their unique property of negative transverse contraction. Compared to conventional materials, auxetic structures exhibit superior properties such as high energy absorption, increased indentation resistance and self-defined mechanical properties. The main objective of this thesis is to research and develop and simulate auxetic structures under one dimensional quasi-static loading conditions. Both beam and shell structures will be investigated in detail to enable a comprehensive analysis of their individual advantages and disadvantages.

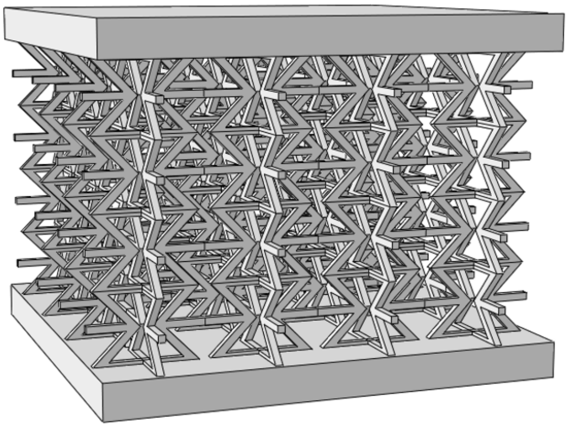

Figure 1: 3D Lattice structure with reentrant unit cells.

In order to achieve this goal, the proposed investigation will focus on the use of a three-dimensional, reentrant lattice structure, which is an outstanding example of auxetic architecture (see Fig. 2). This lattice design will be investigated and simulated using Abaqus Python scripting.

The comparison between simulations with shell and beam elements and in comparison with brick elements is of utmost importance to determine the optimal structural configuration that balances efficiency and effectiveness. Ultimately, the results of this comparative analysis will inform possible changes to the lattice structure to make it a more practical and efficient design by using either shells or beams.

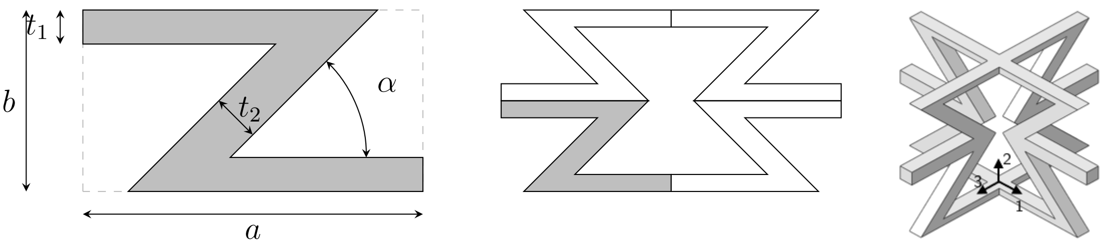

Figure 2: Schematic illustration of a quarter cell (left), as part of a two-dimensional auxetic unit cell (middle), and a three-dimensional auxetic unit cell (right).

To achieve this goal, the following steps will be carried out:

1) Conduct a thorough literature review on auxetic structures, their applications, and advancements.
2) Master Abaqus and Python scripting for FEA and lattice structure simulation.
3) Understand the 3D re-entrant lattice structure, its geometry, and mechanical behavior.
4) Implement simulation models using Abaqus, using shell and beam elements.
5) Perform FEA of the lattice structure under various loading scenarios.
6) Compare simulation results of shell and beam models, analyzing structural stability, stress distribution and calculate the Poisson's ratio.
7) Draw conclusions on the suitability of shell or beam elements for lattice representation.

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