Institute of Structural Mechanics and
Dynamics in Aerospace Engineering

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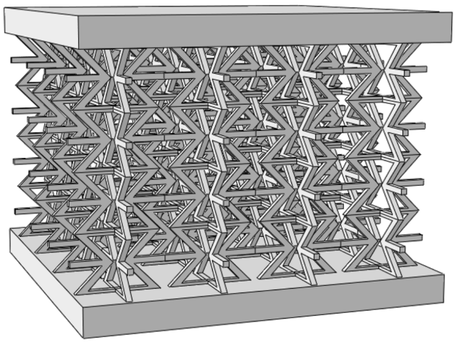
Master thesis

Analysis of the linear and nonlinear buckling behavior in auxetic structures

2024-06-11



Auxetic structures are a special class of metamaterials that are mainly known for the unintuitive deformation behaviour, that leads to a negative Poisson's ratio. Compared to conventional materials, auxetic structures exhibit great properties such as high energy absorption, increased indentation resistance and highly tuneable mechanical properties. They are therefore of great interest in many applications all over the engineering field.

Since the distinguishing attributes of auxetic structures are mainly geometrically driven, it is important to understand the properties in every aspect of these structures. Experimental testing of uniaxial tension showed that under certain conditions localized parts of the lattice structure experience buckling. This behaviour of course has to be avoided for load bearing structures, but can be beneficial for other applications, such as impact absorption.

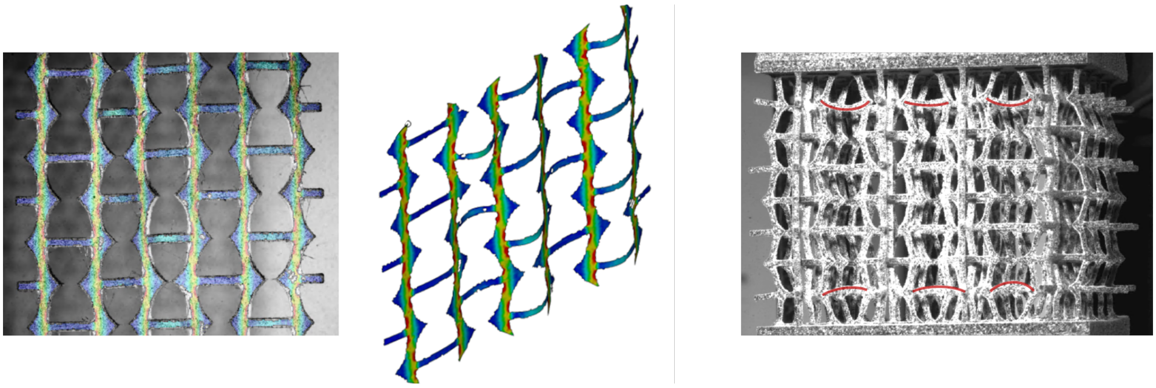


Figure 1: Buckling effect on planar structures (left-middle) and on 3D lattice structures (right)

The main objective of this thesis is to investigate and simulate the linear and nonlinear buckling behaviour of auxetic structures under one dimensional quasi-static loading conditions. The results will be used to find a set of rules that define a border for buckling in an lattice structure. Additionally the potentials of the tuneable behaviour in regards to buckling should be identified. In order to achieve this goal, the proposed investigation will focus on the use of two and three-dimensional, reentrant lattice structure (see Fig. 1). This lattice design will be investigated and simulated using Abaqus Python scripting.

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

1) Conduct a thorough literature review on auxetic structures and linear and nonlinear buckling.
2) Learn Abaqus and Python scripting for FEA and lattice structure simulation.
3) Understand the 3D reentrant lattice structure, its geometry, and mechanical behavior.
4) Implement buckling simulation models with Abaqus Python scripting.
5) Linear and nonlinear buckling simulations with regards to experimental Data.
6) Localization of Imperfections and their effect on the results.
7) Deriving of buckling threshold with respect to geometry, boundary conditions and loads.
8) Draw conclusions on the buckling in auxetic structures as well as the possible areas of application where buckling could be useful.

This thesis will be a cooperation and supported by the Institute for Structural Mechanics (IBB).

If you are interested in this thesis topic or you have your own interesting ideas in this area, we look forward to hearing from you. Please contact us by email to nicolas.gruenfelder@isd.uni-stuttgart.de or berta.pi-savall@isd.uni-stuttgart.de.

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