Universität Stuttgart

Baustatik und Baudynamik

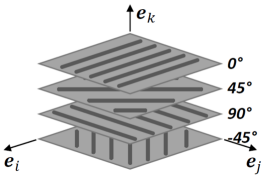
Master Thesis

# Investigation of the Suitability of Higher-Order 3D-Shell Elements for the Simulation of Laminate Structures

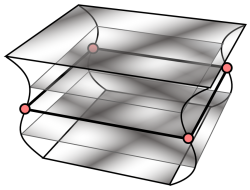
Dimensionally reduced shell models are particularly suitable for the efficient simulation of thin-walled laminate structures. However, state-of-the-art modeling approaches with classic shell elements are limited in their prediction quality, as they can only represent a reduced stress state. Especially for thick laminates, such as those found in hydrogen tanks, it is necessary to consider a three-dimensional stress state in order to obtain more realistic results.

In this thesis, the suitability of so-called higher-order 3D-shell elements for the efficient simulation of laminate structures is to be investigated. These elements are capable of representing a three-dimensional stress state as well as cross-sectional warping. The results are compared with simulations using standard shell elements. Experimental data from the literature (where possible) and fully three-dimensional simulations with linear solid elements will be used as references. These reference solutions will be used to conduct a systematic comparative study on the quality of the results. The simulation of the laminate structures will be performed in the commercial finite element software LS-DYNA, neglecting delaminations.


H2 tank made of fiber laminate




Layers of a fiber laminate



3D-shell element with layers

H2 tank from Claus Ableiter, CC BY-SA 4.0,
source: https://upload.wikimedia.org/wikipedia/commons/6/69/Linde-Wasserstofftank.JPG

## The specific tasks are

- Literature review on fiber reinforced polymers and modeling approaches.
- Familiarization with explicit finite element simulations with LS-DYNA.
- Simulation of selected benchmarks with different modeling approaches.
- Systematic comparison and evaluation of the results.

## Recommended fields of interest

Commercial finite element software, fiber reinforced polymers.

## Literature

Willmann, T. et al.: *Cross-Sectional Warping in Sheet Metal Forming Simulations*, 13th European LS-DYNA Conference, 2021.

Czichos, R. et al.: *Comparison of Numerical Modelling Approaches for the Residual Burst Pressure of Thick Type IV Composite Overwrapped Pressure Vessels Related to Low-Velocity Impact*, Internat. Journal on Pressure Vessels and Piping 199, 2022.