# Zukunft Bau

# Short report

## Title

Research project: Studies of the load bearing behavior of small elastomer bearings for glass constructions

## Motive/ status quo

The stiffness of rubber pads, which are used for clamped glass panes affect the stresses and deformations of glass. In the DIN 18008 standard only imprecise numbers are given to be used for stress calculation. For an accurate, economical and resource-friendly design of glass panes the exact stiffness of the rubber pads must be known.

## Objective of the Research Project

The aim of the research project was to determine realistic stiffness values of the synthetical interlayers of clamps of glass fixing to enable an accurate, economical and resource friendly design of clamped glass panes. Thus Glass panes can be made thinner and the use of resources and embodied energy can be reduced.

Ethylen-Propylen-Diene-Monomer (EPDM), silicone, thermoplastic elastomers and thermoplastic polyurethanes were investigated. The hardness of all materials has lien between ShA 40 and ShA 80. Experimental studies included uniaxial tension and compression tests, periodic tension tests and a dynamic mechanical thermal analysis. To reduce the experimental expense, a pilot test series was executed beforehand.

The results of the uniaxial tension and compression tests were used to develop hyperelastic material models. A new approach was developed which allows the same energy input for different experimental tests which is important for strain-rate-dependent materials such as EPDM. This new approach was verified by accompanying finite element method studies. Cyclic uniaxial tension tests were performed to measure the material softening. The dynamic mechanical thermal analysis enabled to capture thermal dependence.

For the uniaxial compression tests three different test specimen (circle, quadrat, rectangle) and different thicknesses of samples were used.
The investigated different test specimen showed that the shape factor by BATTERMANN and KÖHLER had no influence on the results.

Besides the experimental studies a procedure was developed which allows a preparation and verification of numerical models. This includes a curve fitting of the stress strain behavior from the uniaxial tension and compression tests to generate hyperelastic material models. All common hyperelastic material models were created und their goodness of fit evaluated. To verify the curve fitting results, many of the tension and compression test were simulated with the finite element method.
The results showed that the models and the experimental tests matched very well.

## Summary of Results

The gained results were combined in a design approach, specifically construed for an engineering point of view. All the complex hyperelastic material models were simplified, so that they can be used in common structural analysis software (e.g. RFEM, SOFiSTiK, SJ-Mepla). By using a multilinear, isotropic elasto-plasto model (MISO-model) it is possible to include the nonlinear behavior of plastics. The developed MISO-model was verified by many comparative calculations and showed only small variations compared to the hyperelastic material models. Therefore a simple and precise model is available to design clamped glass panes.

## Key data

Short title: elastomer bearing

Researchers: University of Stuttgart (applicant), Institute for Lightweight Structures and Conceptual Design (ILEK),
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Michael Drass M.Eng.

Total costs: 346.455,30 €

Federal subsidy: 243.959,00 €

Project duration: 24 months

## Figures:

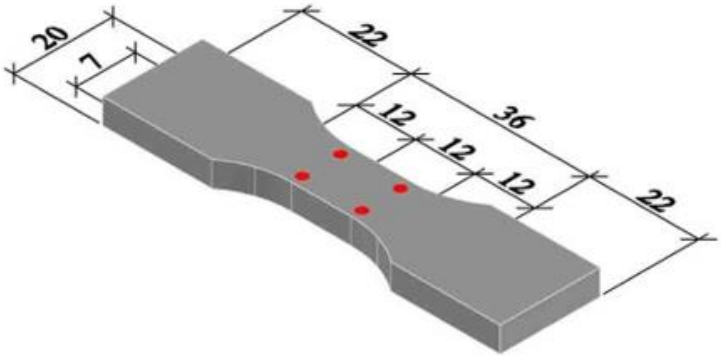


Bild 1: uniaxiale Zugprobe.png
Specimen for uniaxial tension test with optical measure points

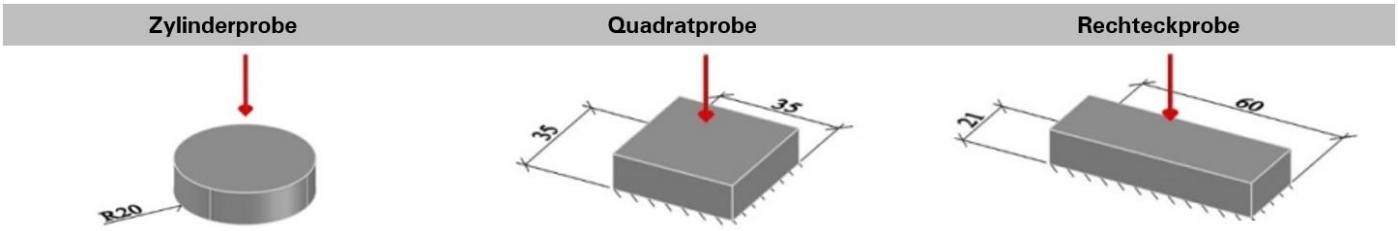


Bild 2: uniaxiale Druckproben.png
Specimens for uniaxial compressen test

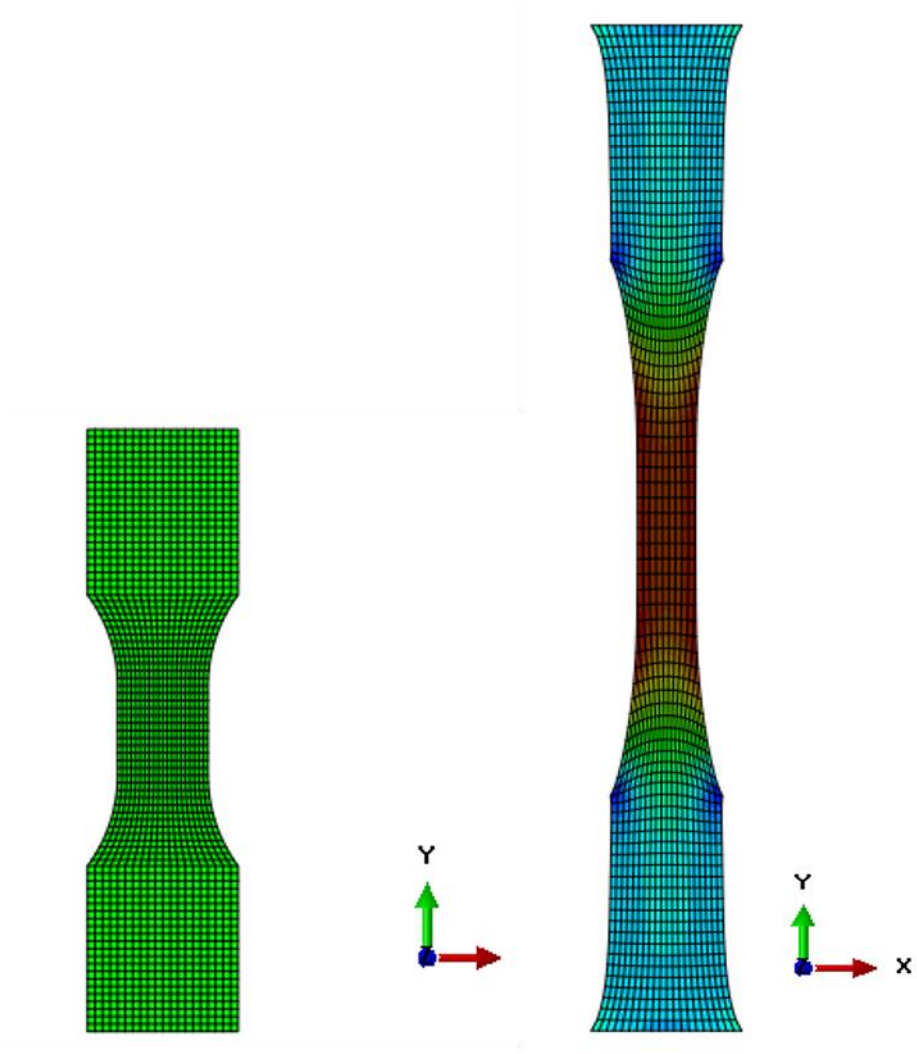


Bild 3: FEM Zugprobe.png
FEM-model of tension test unloaded (load) with load (right)

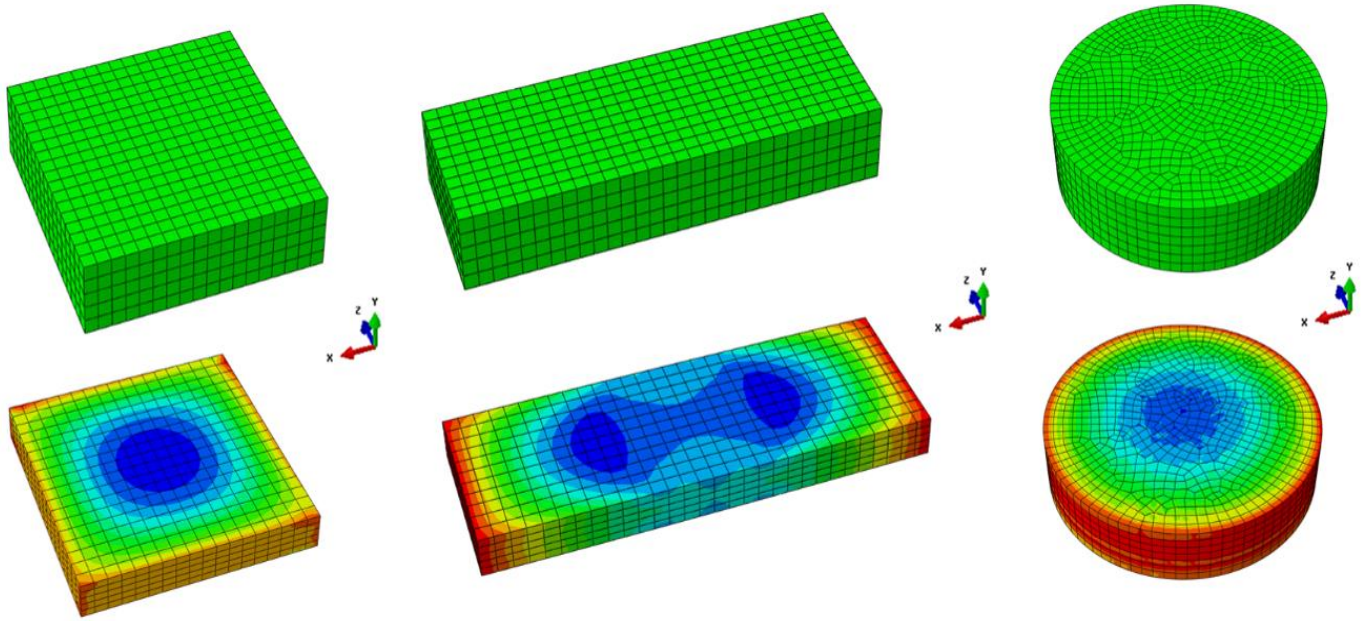

Bild 4: FEM Druckprobe.png
FEM-model of compression test unloaded (top) loaded (below)

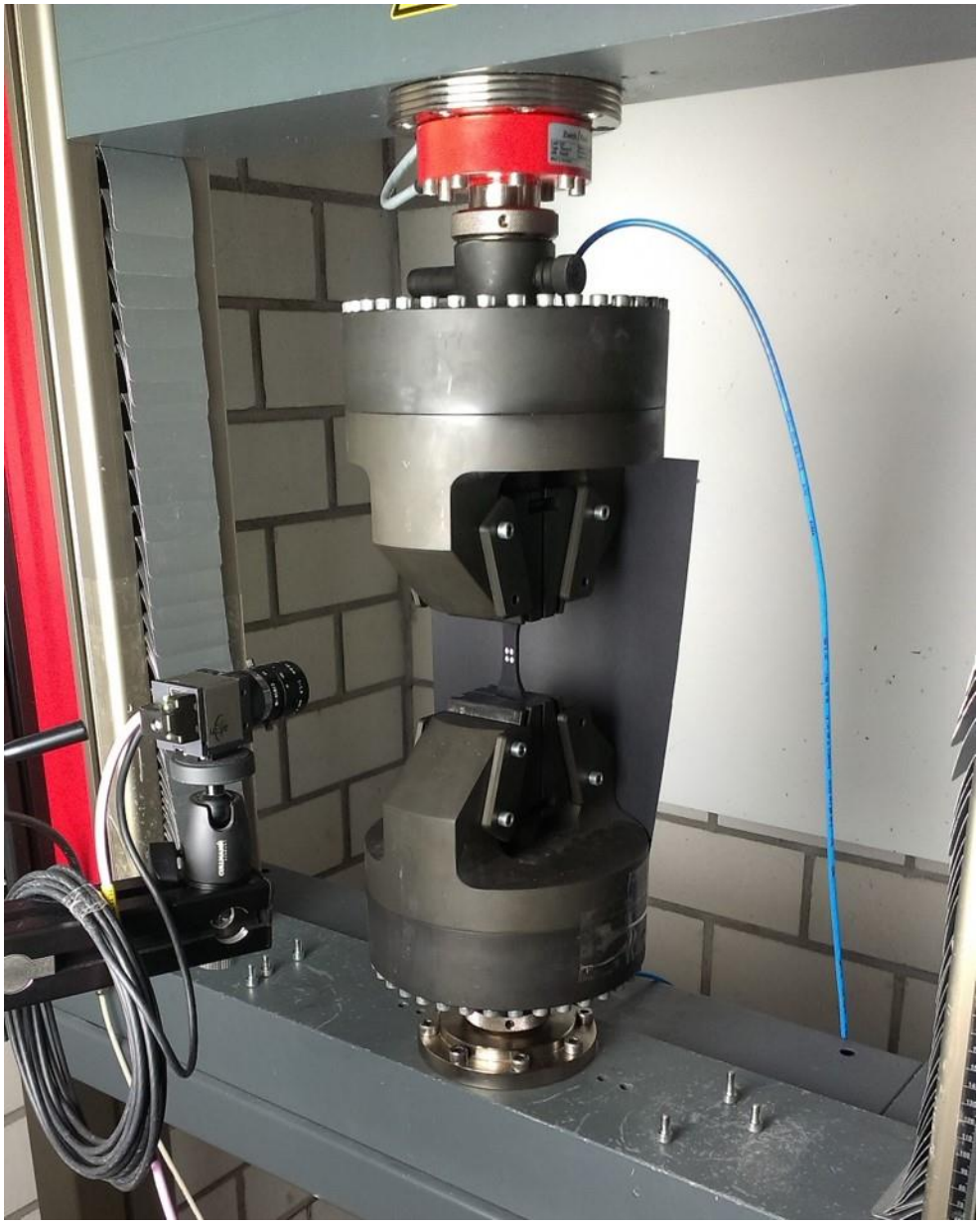

Bild 5: uniaxiale Zugprobe.jpg
Experimental setup of tension test with optical measurement system