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Digitale Zwillinge zum Schutz kritischer Infrastruktur

Virtual Twins Of Cold-Poured Liquid Adhesives For Glass Construction Using Viscoelastic Material Models

Research on the material behavior of polymeric adhesive materials

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Motivation

- Until today, the use of adhesives in structural glass applications is subject to stringent conditions, due to the brittle failure of the material glass, the insufficient properties of certain adhesive materials, and the limited availability of data on polymeric adhesive materials
- The use of cold-poured liquid adhesives (CPLA) allows for the establishment of a three-dimensionally cross-linked molecular structure which enables the assurance of infinity stiffness, crucial for adhesives under permanent loading
- To effectively calculate the material behavior of the adhesives and bridge the data gap, an extensive test program must be conducted, which includes various loading scenarios and environmental conditions, to get the basis for detailed and robust material models
- Thereof, the virtual twin is created through the development of these material models, and their use in e.g. Finite Element Method (FEM) software. With the subsequent advancement towards the hybrid digital twin incorporating monitoring by sensor data, a contribution can be made to a higher safety level and redundancy, thus increasing the spectrum of applications of bonded joints in glass construction.

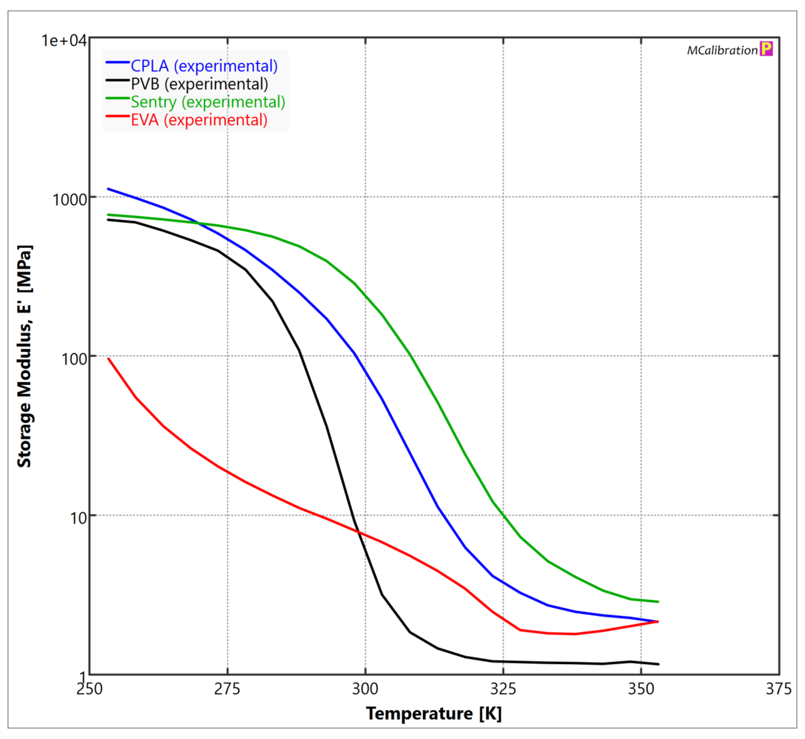
Simulation Models

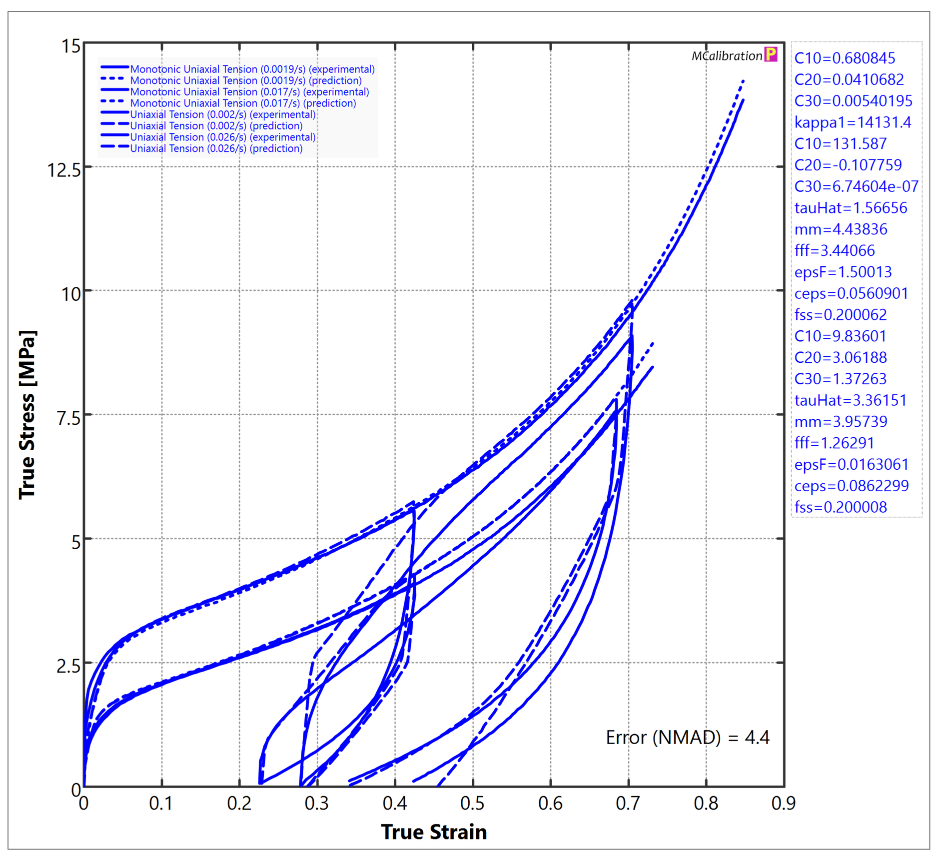
VIRTUAL TWIN

DIGITAL TWIN

Sensors and real data

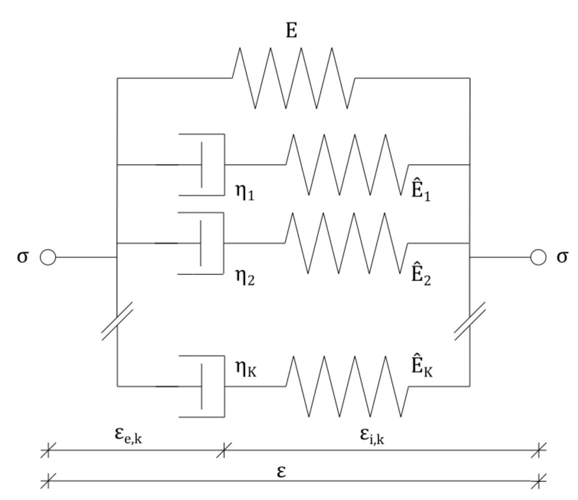
Material Tests and Modeling





Material Model Theory - Generalized Maxwell Model

The model is built by combining a single hyperelastic spring to guarantee a residual stiffness when time goes to infinity with a specific number of Maxwell elements giving the viscoelastic stress response.
It can be extended by various parameters, for example, to include a temperature dependency and to cover arbitrary loading scenarios.



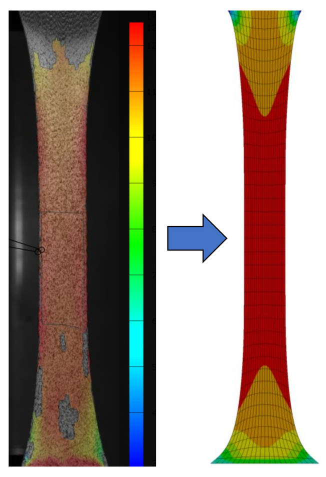
Elastic response: Hyperelastic springs – Cauchy stress according to Yeoh model

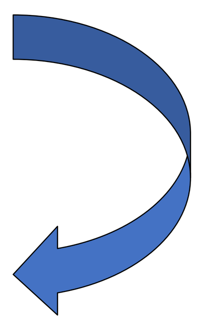
$$\boldsymbol{\sigma} = \frac{2}{J}\{C_{10} + 2C_{20}(I_1 - 3) + 3C_{30}(I_1 - 3)^2\}dev[\boldsymbol{b}] + \kappa(J-1)\boldsymbol{I}$$

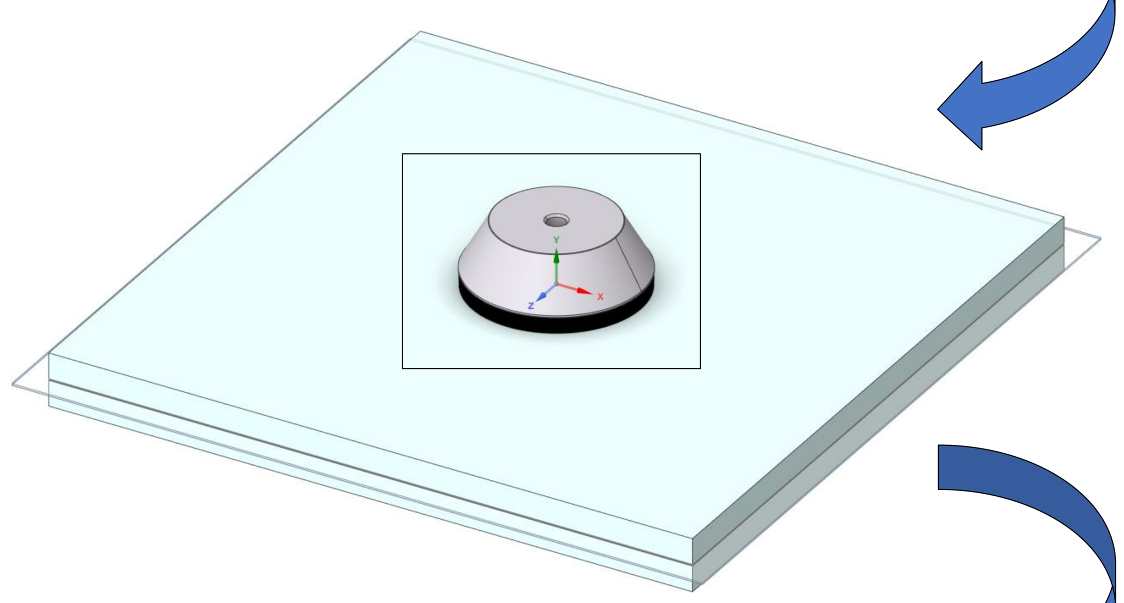
Flow Response: Dampers – Flow rate according to power-flow

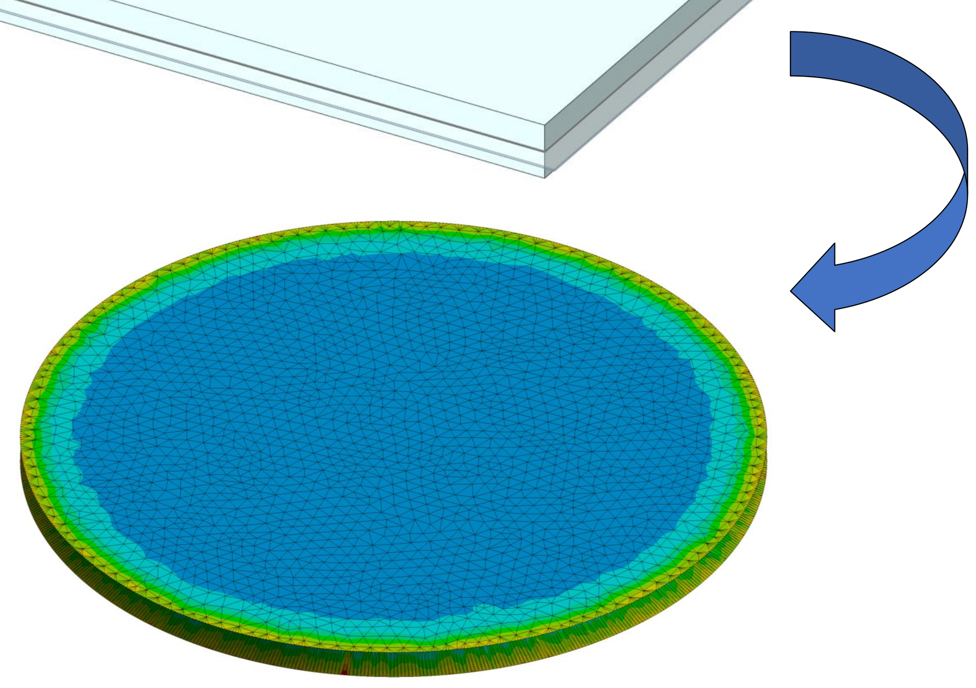
$$\dot{\gamma} = \dot{\gamma}_0 \cdot \left(\frac{\tau}{\hat{\tau} + aR(p)}\right)^{m_A} \cdot \left(\frac{\theta}{\theta_0}\right)^{n}$$

Finite Element Method Analysis









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