Simulering av kolfiberkonstruktioner

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Enhetschef- Strukturanalys och Modellering
Polymera material och kompositer

Composite simulation areas at RISE

Structural analysis and Modelling – *Christopher Cameron*
Process Simulation and Manufacturing Technology- *Daniel Berglund*

2 units (ca 20 persons) focussed on simulation of Composites

Failure propagation models

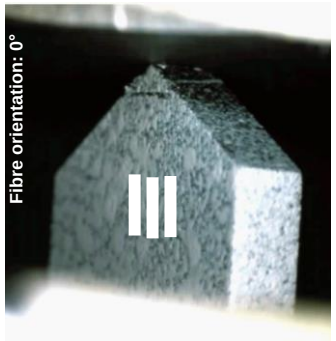
Material degradation/evolution models

Loading rate sensitive material models

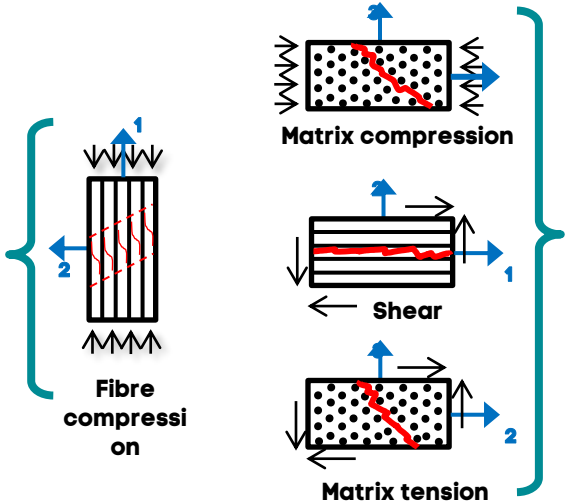
Failure propagation models

- The mechanisms of damage growth in composites are complex

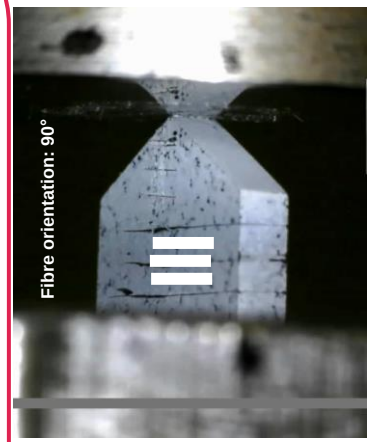
Fibre kinking & **shear**



$[0°]_{10}$ arrow



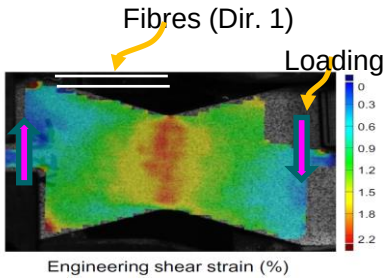
Matrix compression & **shear**



$[90°]_{10}$ arrow

3D damage model → SICOMP High Fidelity (SHF)

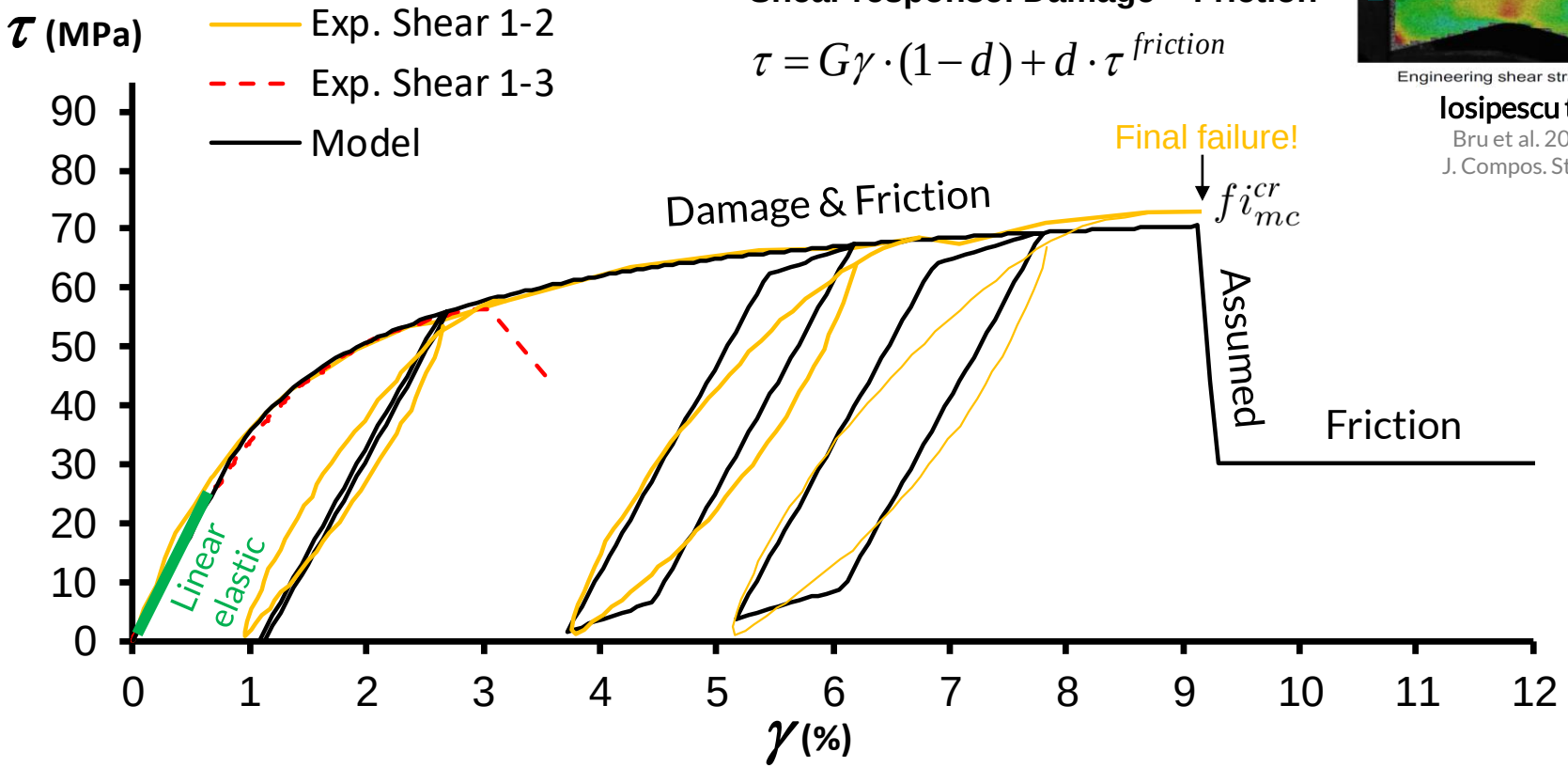
Failure propagation models



Iosipescu test
Bru et al. 2017
J. Compos. Struct

Shear response: Damage + Friction

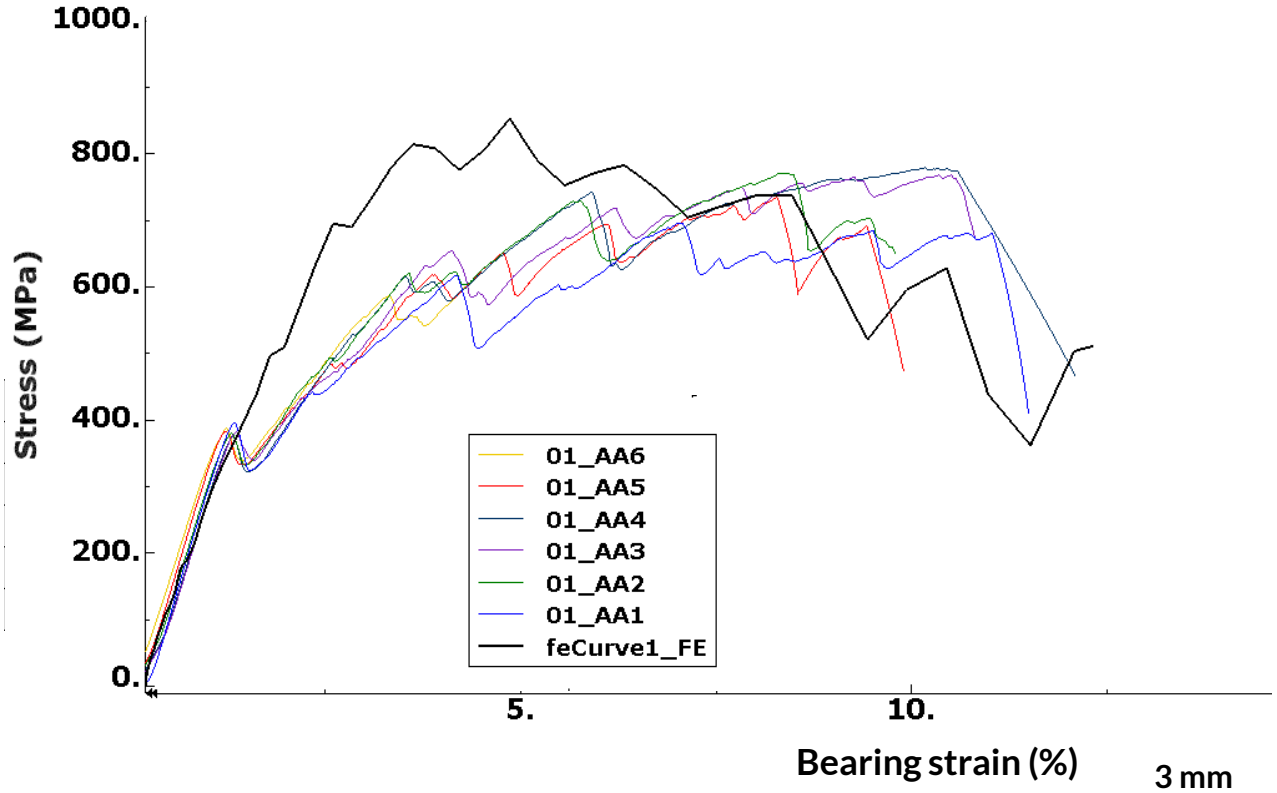
$$\tau = G\gamma \cdot (1-d) + d \cdot \tau^{friction}$$

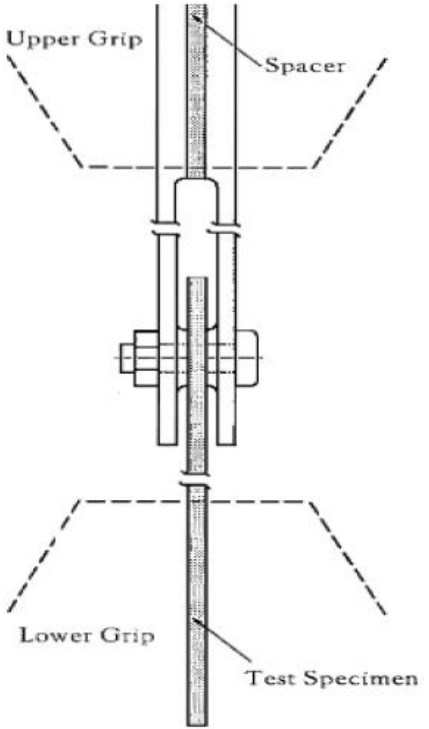


Failure propagation models

Application: bolted joints

- The SICOMP damage model shows promising results for the challenging bearing damage



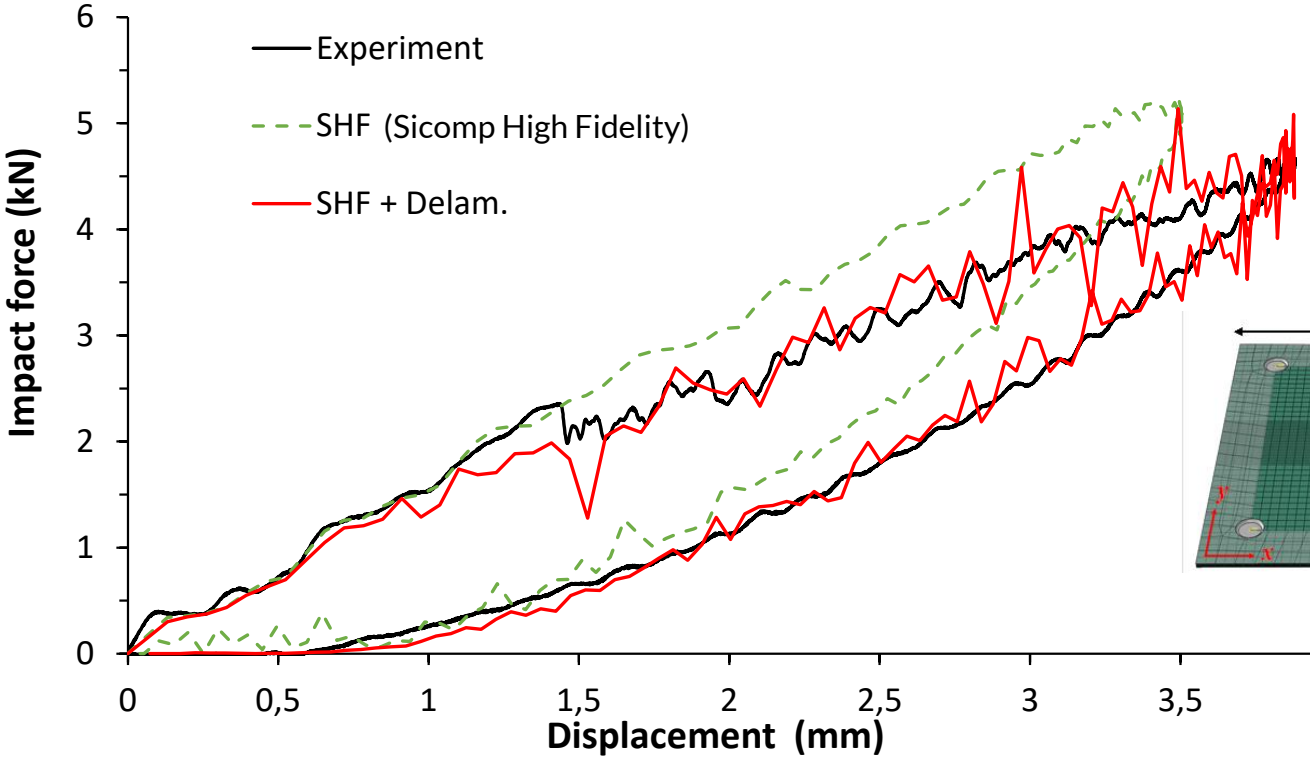


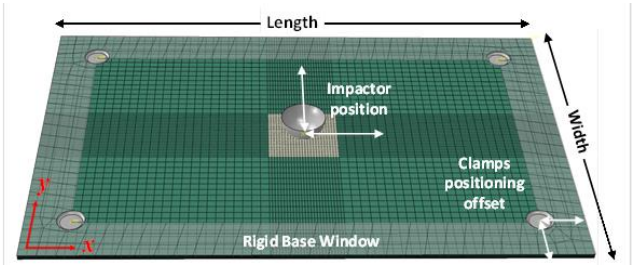
3 mm

Failure propagation models

Application: panel impact

- The SICOMP damage model shows good coorrelation in impact simulations

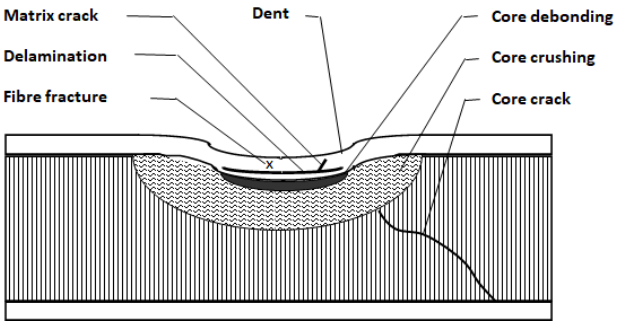




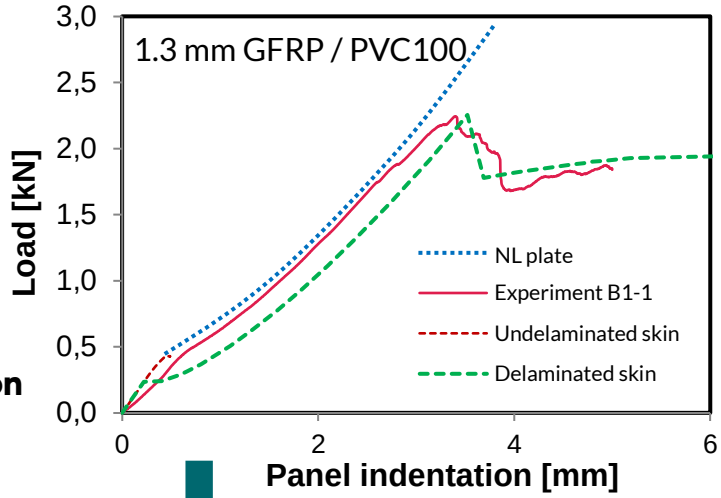
Failure propagation models

Application: sandwich panel impact

Impact damage



Analytical model vs experiments



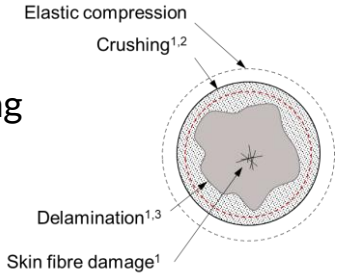
Effects

Compression:
dent, delamination, core crushing

Tension:
fibre fracture

Out-of-plane shear:
core shear cracks/debonding

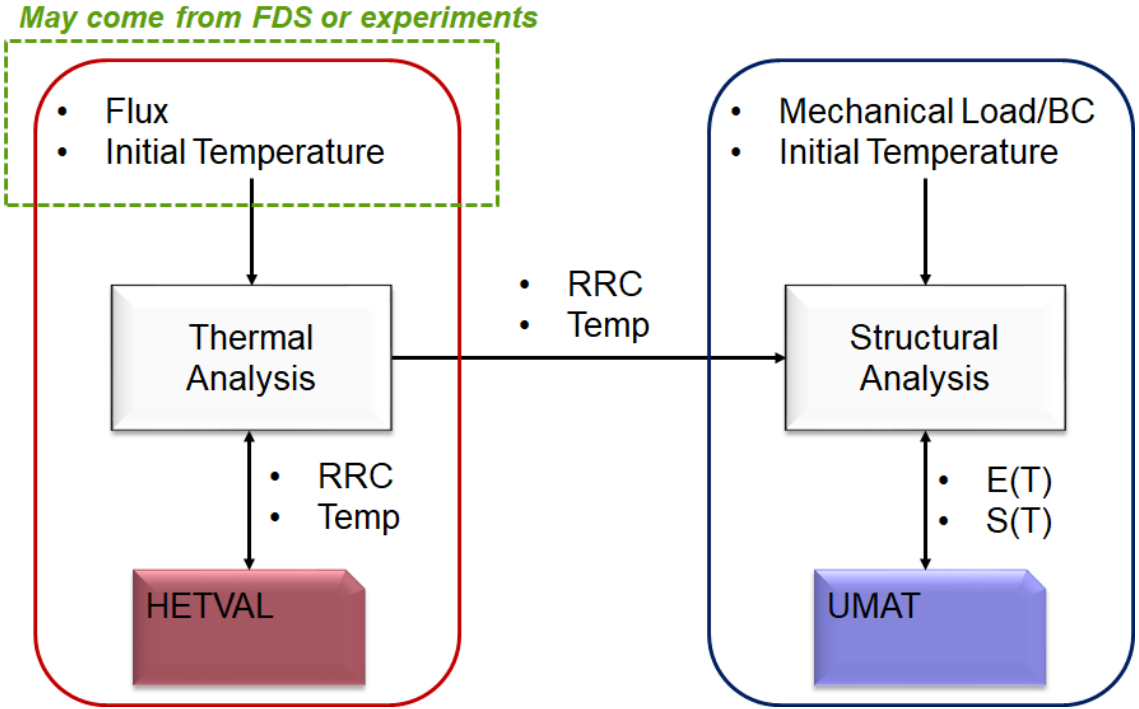
Damage prediction



- Membrane solution (”Delaminated skin”) provides simple lower bound
- Skin penetration accurately predicted

Material degradation/evolution models

Structural thermal degradation

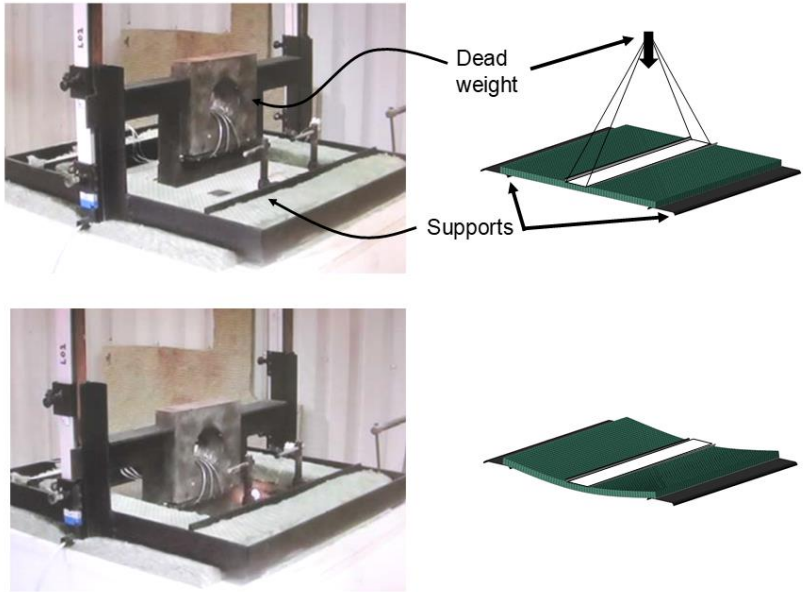


Goal: predict material response under fire exposure of composite structures

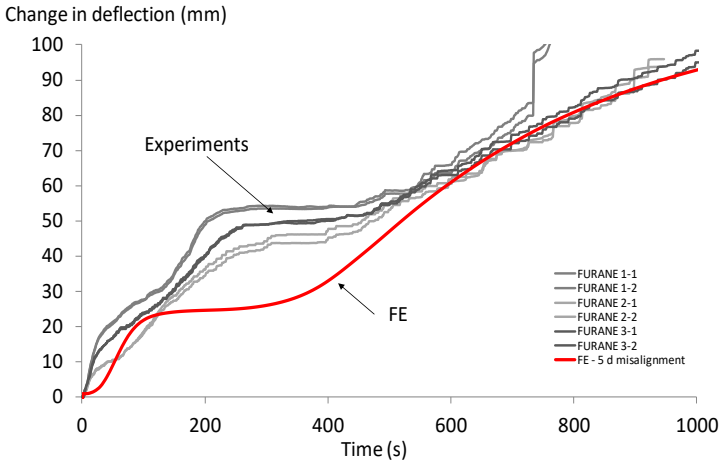
Method: Thermal degradation models implemented as Abaqus subroutines.

Thermomechanical and constitutive models separately.

Material degradation/evolution models
Structural thermal degradation



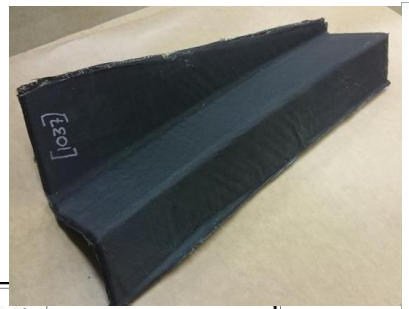
Loaded plate in mini-furnace before and after testing (at RISE Safety and Transport) and FE models in undeformed state and at maximum deflection

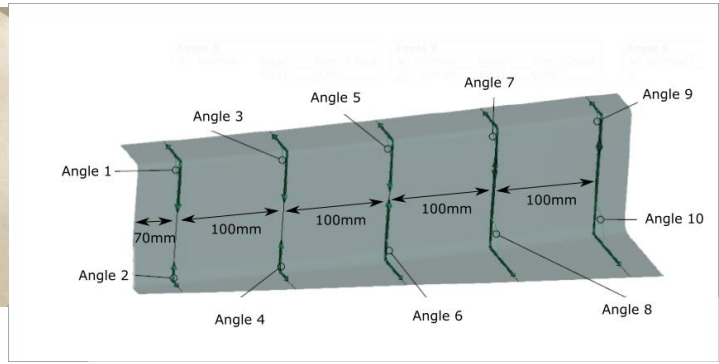


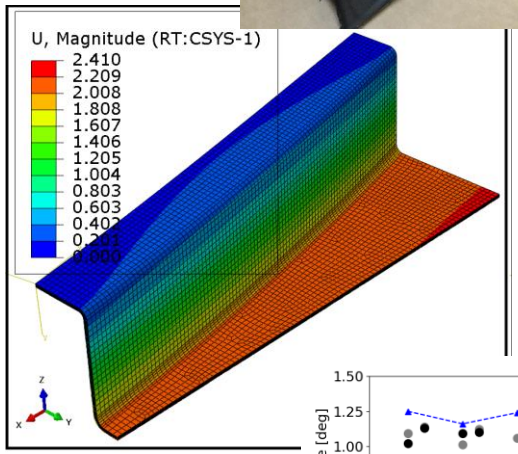
Material degradation/evolution models

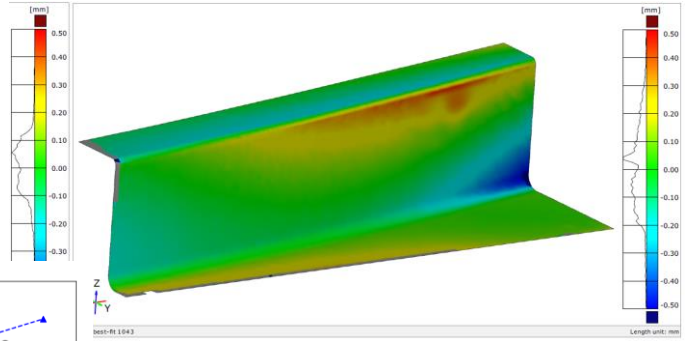
Residual stress/distortion analysis

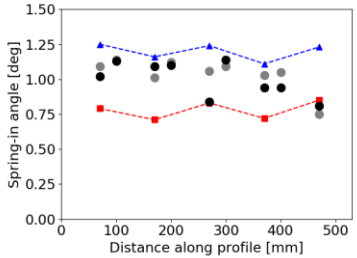
Simulate
Measure
Calibrate
Compensate
Optimize







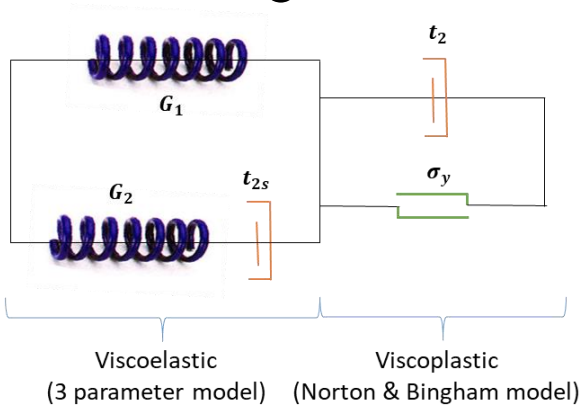




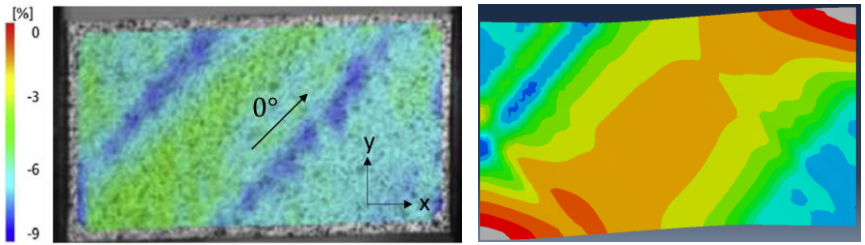
Loading rate sensitive material models

High strain rate loading material response

Polymer model



Strain in loading direction (x)



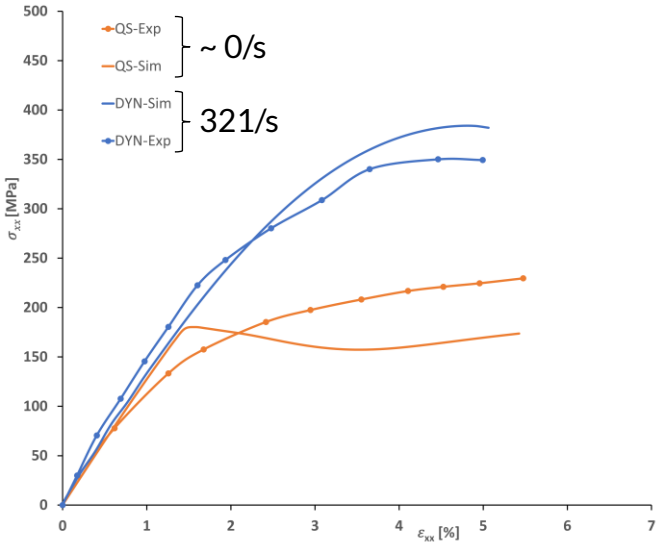
Fibre model Elastic fibres

Material model

Homogenised, piecewise constant strains

FE-implementation

Material subroutine in Abaqus

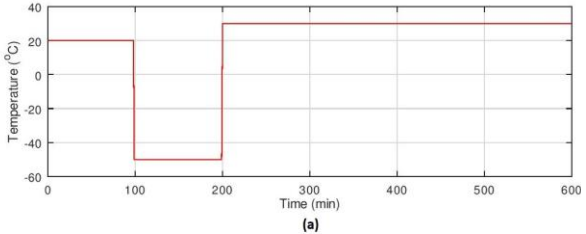


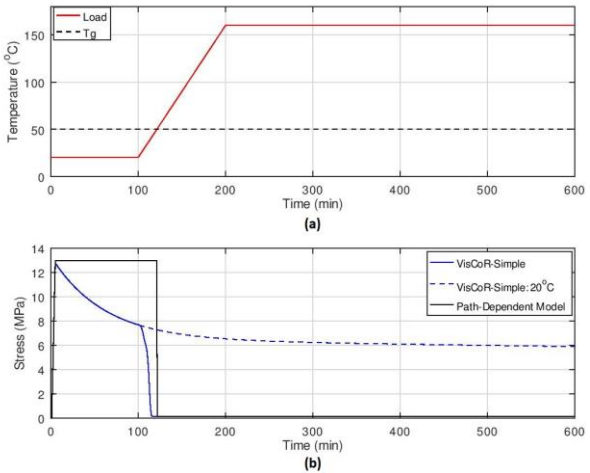
Experiments vs FE-simulation: 45° laminate

Loading rate sensitive material models

Fully viscoelastic material models

VisCoR vs. Path-dependent model





Captures stress relaxation@ arbitrary temperatures

High and low strain rate compatible

Captures hysteresis effects

Applications: Time dependent structural response @ elevated temp
Residual stress and cure distortion evaluation

Composite simulation areas at RISE Challenges and Future Research

Failure propagation models

- Sufficient material characterization
- Industrial implementation (TRL 8)
- Improving computational efficiency

Material *degradation* models

- Improvement of thermomechanical and degradation kinetics formulations
- Include stress-state dependency and concurrent analysis is e.g. “Fire simulation”
- Increase computational efficiency for industrial implementation (TRL 4)

RI.
SE

Composite simulation areas at RISE Challenges and Future Research

Material *evolution* models
- Industrial implementation (TRL 7-9)

Strain rate sensitivity models
- Material characterization facilities
- Improved micromechanical representations
- Improving computational efficiency

RI.
SE

Composite simulation areas at RISE
Challenges and Future Research

Goal: Fully industrially implemented failure progression models in industry.

Goal: Integrated material evolution + degradation + viscoelastic response model
→ time dependent mechanical response of structures @ temperature

RI.
SE

Questions?

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