Comparison of Calibration Strategies for Material Models of Polymers, Foams, and Composite Materials

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About Applus+ DatapointLabs

Experience

- 30 years of experience in materials testing and characterization
- 20 years average experience of our test engineers and technicians

Expertise

- Deep understanding of physical properties and behavior of materials
- Deep understanding of complexities of test instrumentations, protocols and standards
- High degree of scientific precision in the measurement of materials properties
- Requirements for CAE: test data directly represents the material under simulation

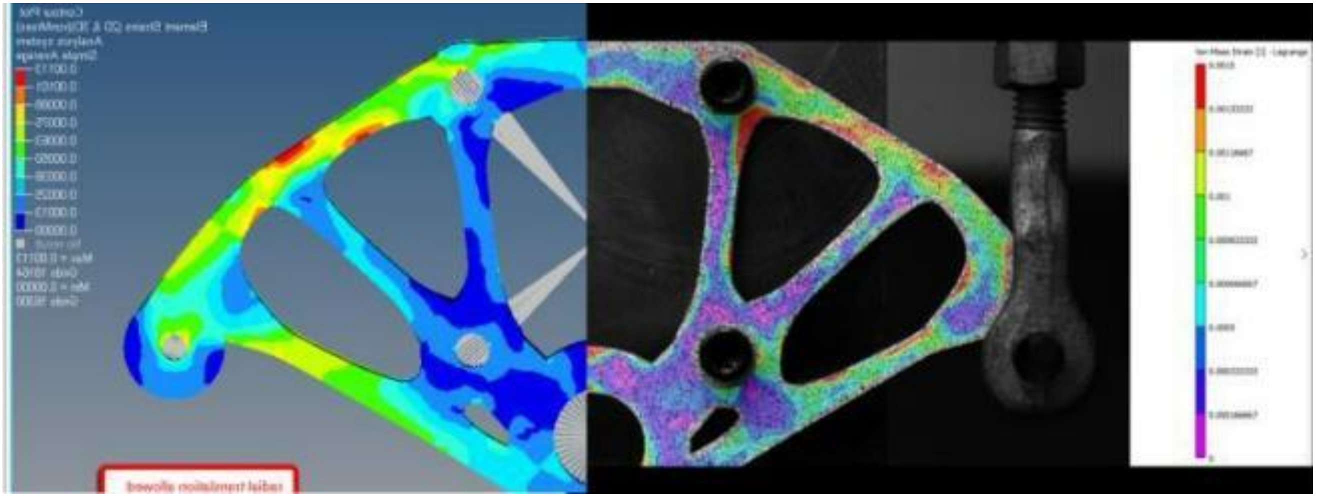
Clientele

- Global clientele of more than 1,800 companies in 49 countries
- Including 100+ Fortune 500 manufacturing-based companies
- Market leader in materials testing for CAE simulation
- Recognized as an approved materials test lab by leading OEMs

ISO 17025

Why material models matter

- Tailored material models are essential to ensure simulation results closely match real-world material behavior
- Untailored models can lead to inaccurate predictions → costly design failures or over-engineering
- Reduced need for physical testing → faster product development

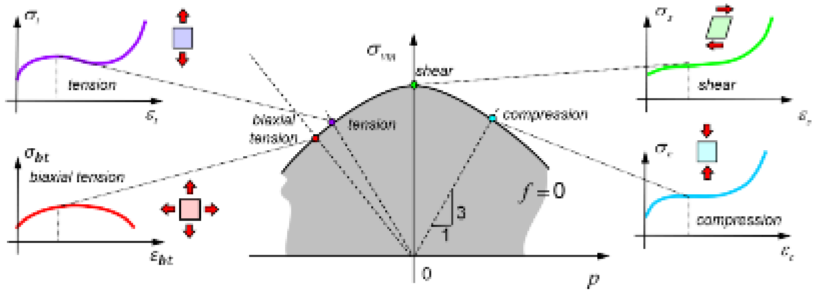


The Three Material Classes

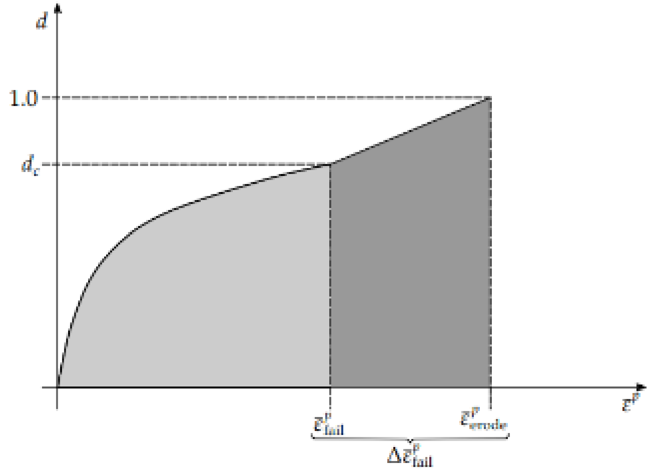
Material	Key properties	Simulation Challenges	Applications
Polymers 	Lightweight Ductile Viscoelastic Temperature Strain-rate sensitive	Nonlinear deformation Strain-rate dependency Damage evolution	Car bumpers, packaging, medical devices
Foams 	Compressible Energy-absorbing Elastic region Plateau region Densification region	Capturing large Deformations Rate sensitivity Low Poisson's ratio	Helmet padding, vehicle interiors
Composites 	Anisotropic High strength-to-weight ratio Layered structure Brittle failure	Multi-directional stiffness Damage progression Delamination	Aircraft fuselages, drone arms, blades

Material Models

MAT187 SAMP

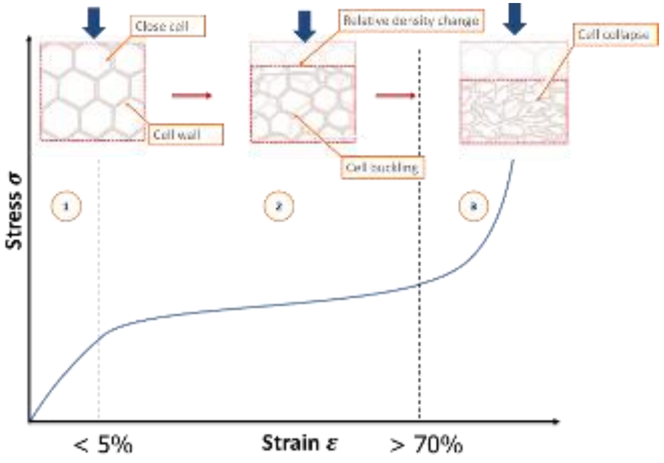


Yield surface as function of pressure



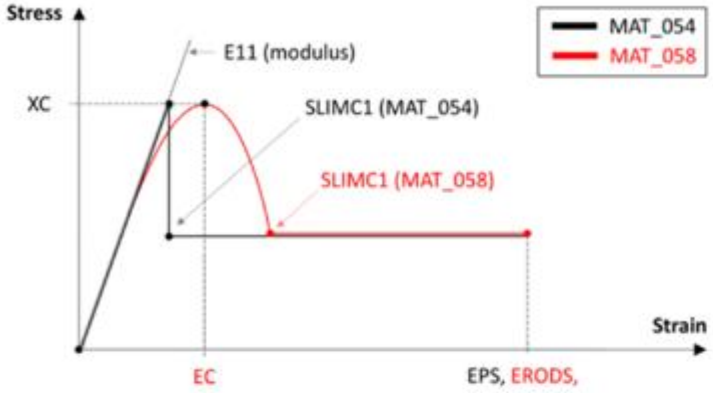
Plastic strain threshold criteria for damage evolution

MAT083 Fu Chang Foam



Compression response of foam materials

MAT058 model for CFRP



Damage evolution of MAT058 vs MAT054

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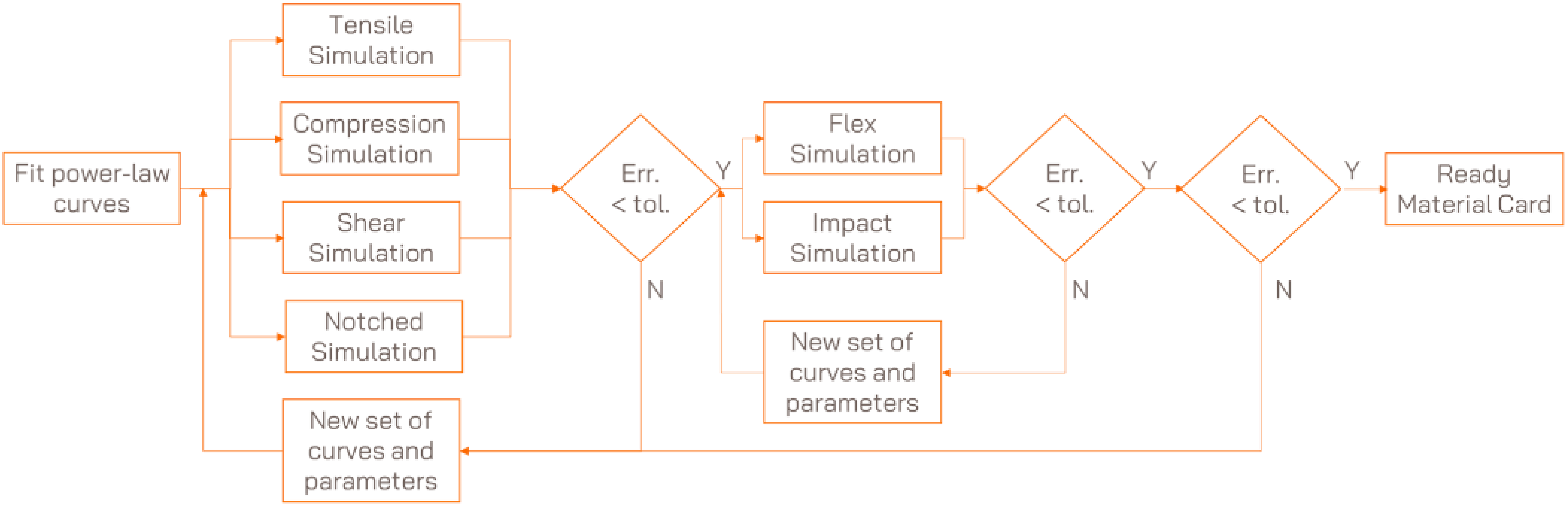
Calibration workflow: Polymers

Optimization process required

Strain-rate Model

Calibration of the yield surface

Material card formatting



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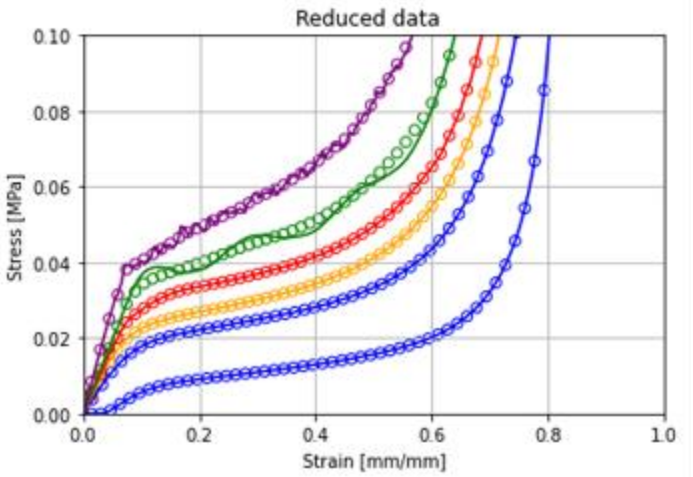
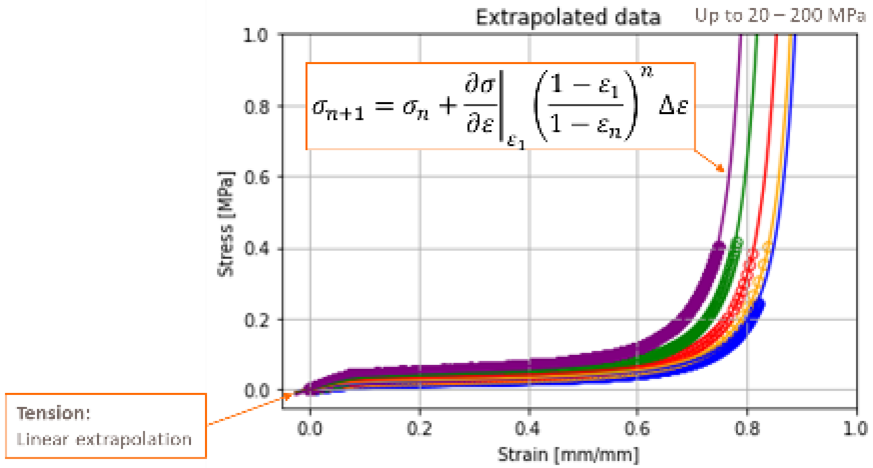
Calibration workflow: Foams

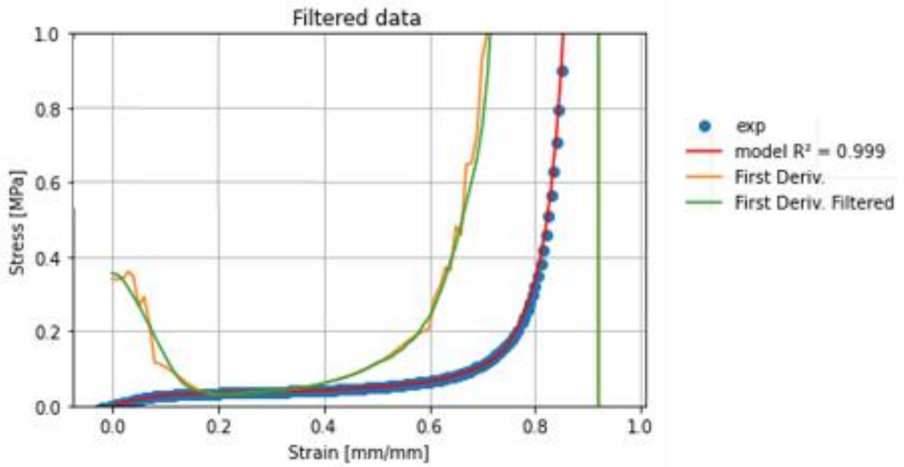
Reduce the data



Extrapolation



Filtering the first derivative



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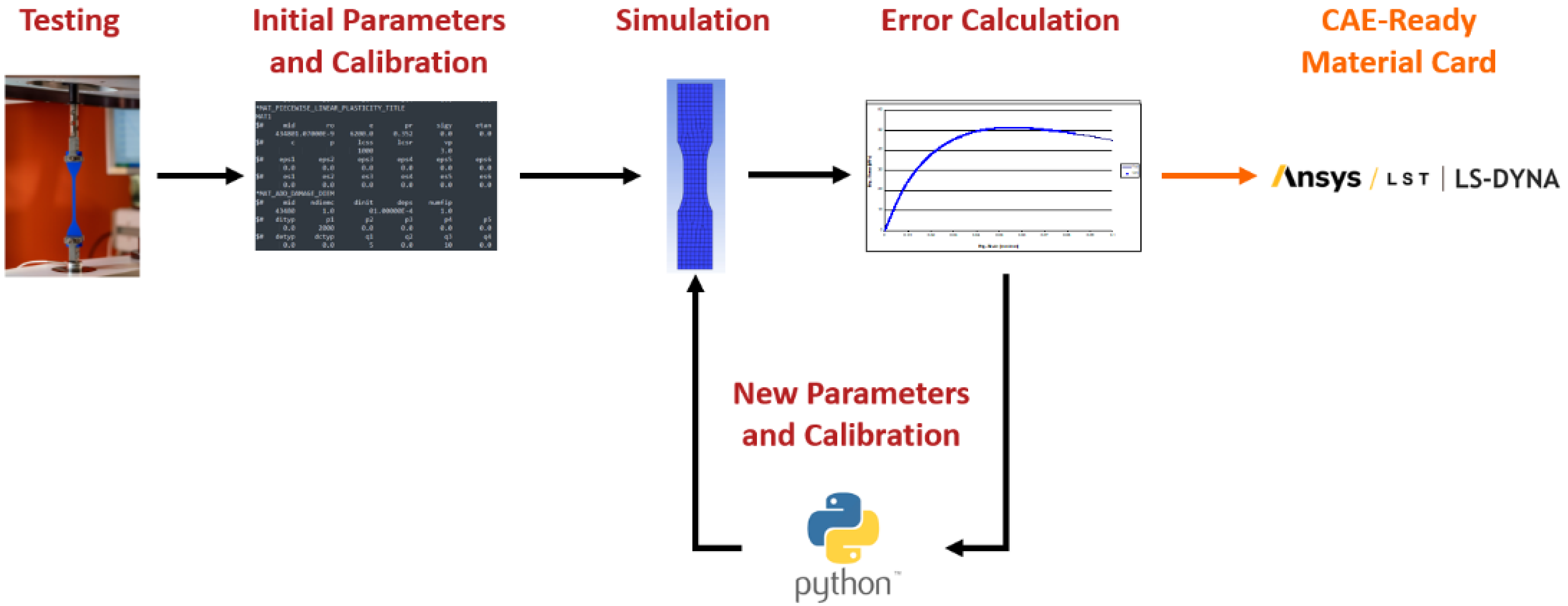
Calibration workflow: Composites

Optimization process required



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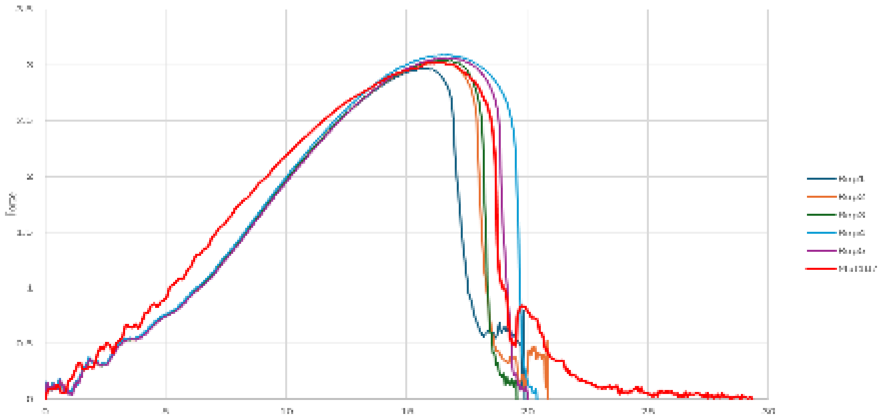
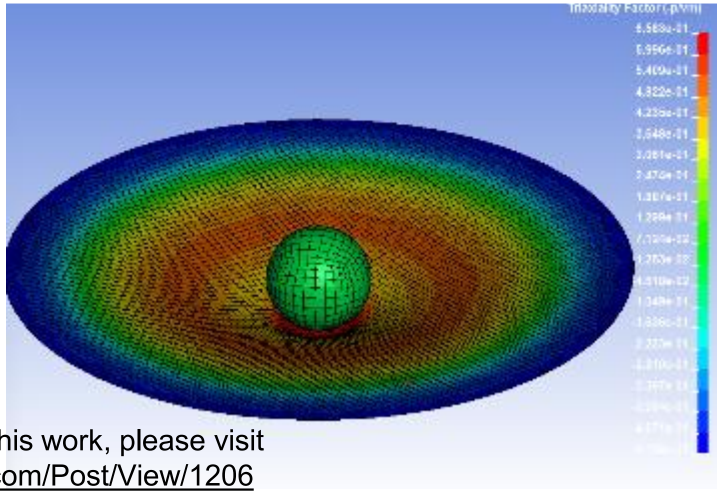
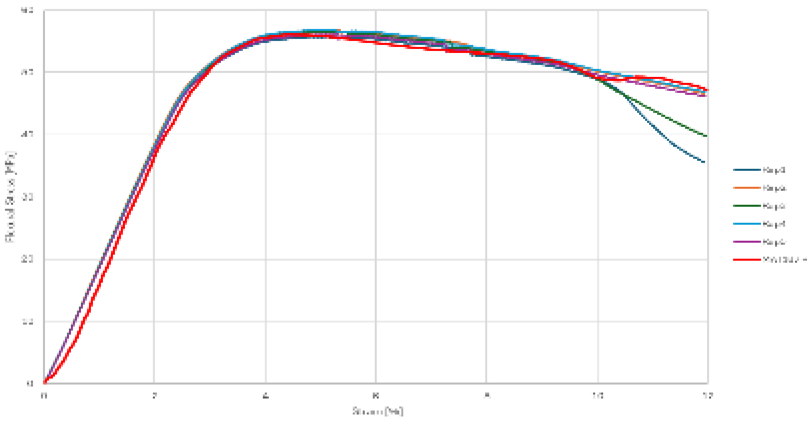
Validation: Polymers

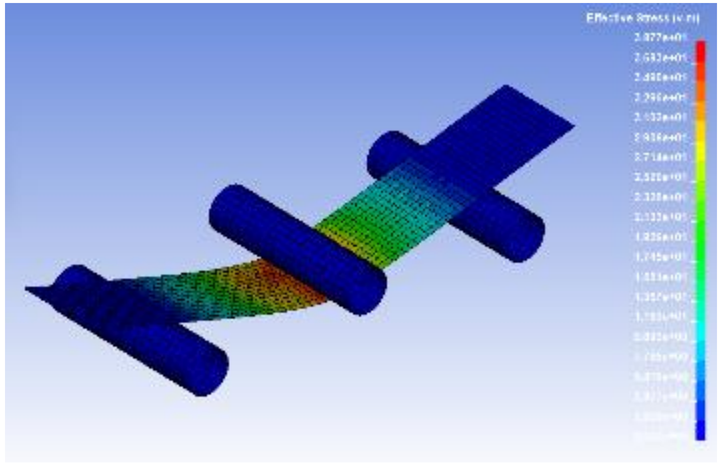
Impact Test





Flexural Test





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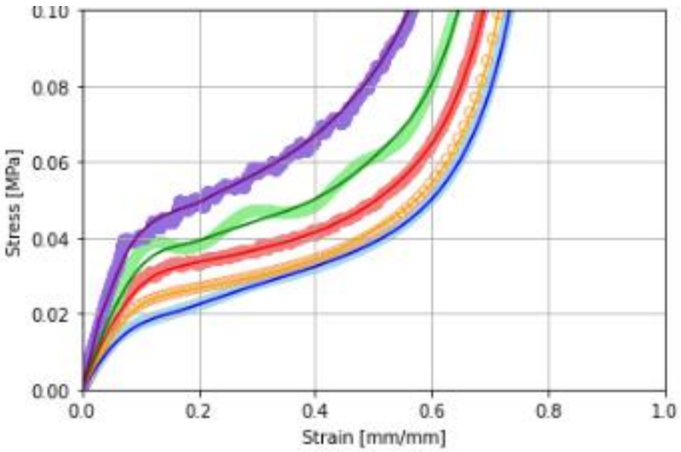
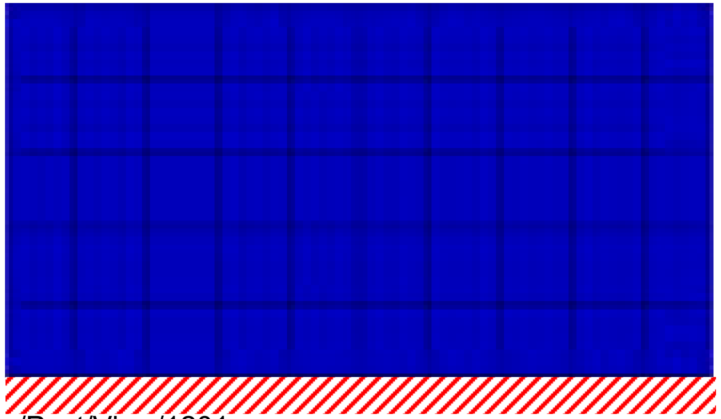
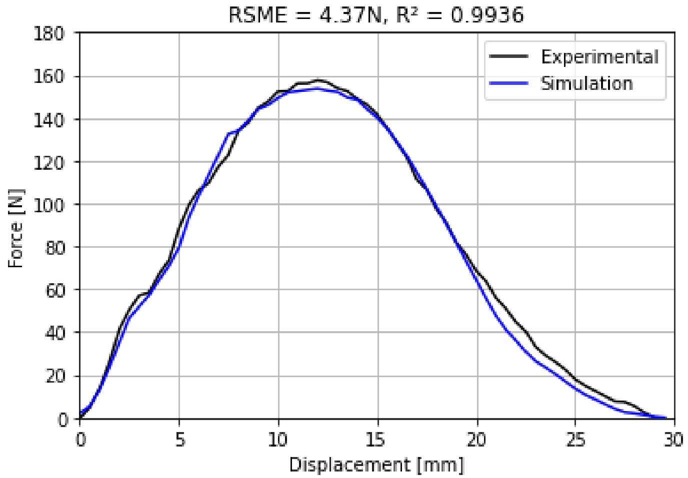
Validation: Foams

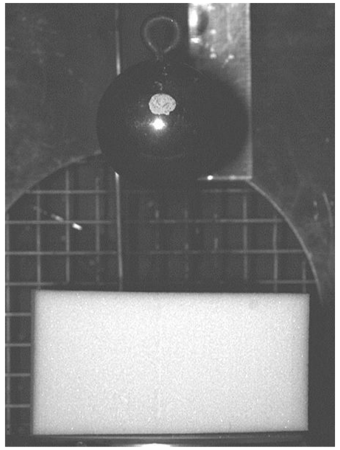
Compression Test

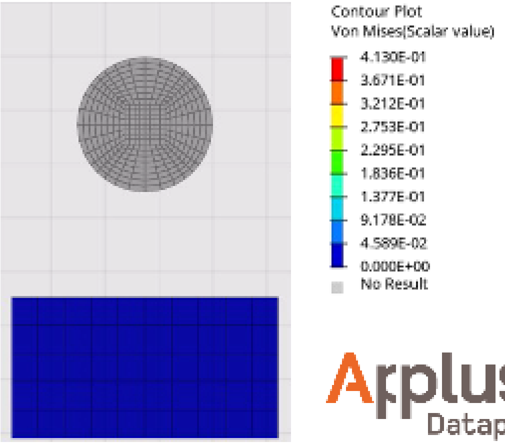




Impact Test







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For more details
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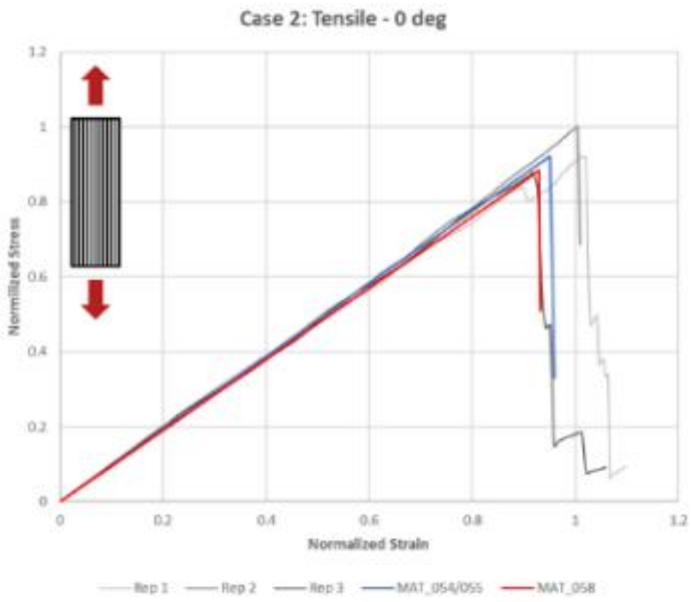
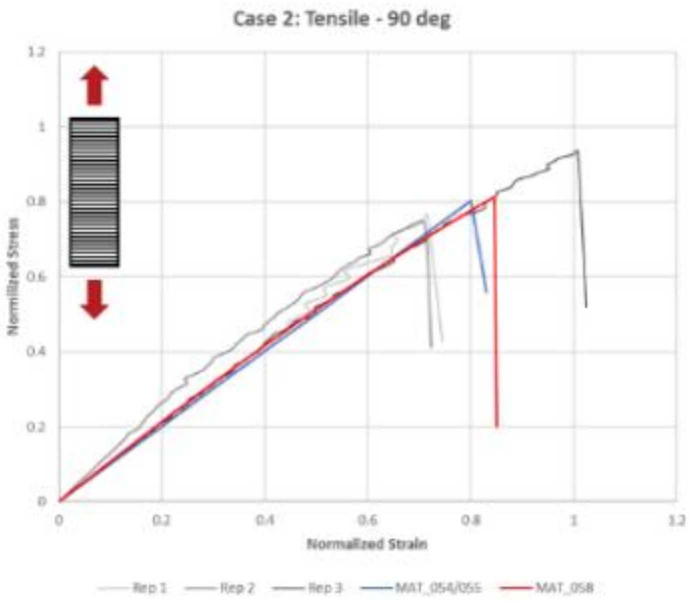
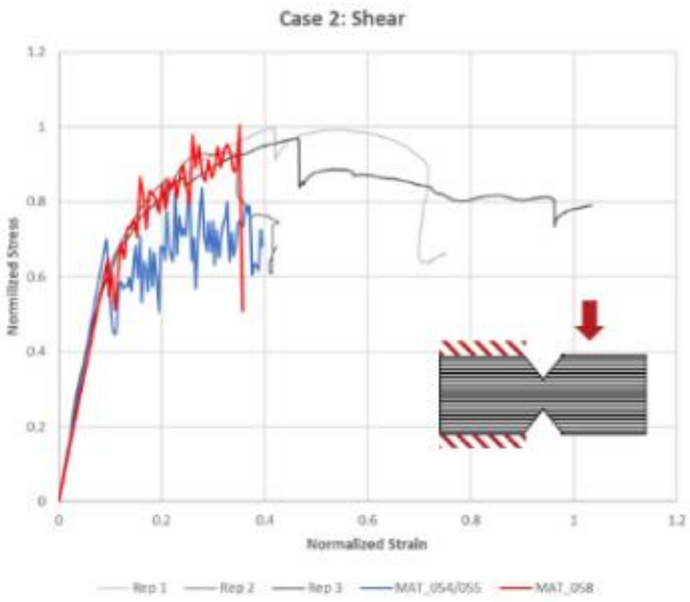
Validation: Composites

Pure modes validation for each orientation







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Summary of findings

Material	Key Calibration Challenges	Best Practices & Lessons Learned
Polymers 	Strong strain-rate dependence Damage evolves progressively Yield surface needs multi-axial data	Use DIC + high-speed cameras to capture full-field strain under dynamic load Include notched tests to define hydrostatic stress behavior Iteratively refine yield surface using inverse modeling
Foams 	Large deformations and densification behavior Rate sensitivity varies non-linearly Difficult to extract tension data	Focus on compressive and impact testing Fit rate-dependence with power/exponential laws Use extrapolation methods Use the first derivative filtering technic
Composites 	Anisotropic properties require directional testing Complex failure modes (fiber, matrix, delamination) Model needs ply-level & laminate-level accuracy	Perform tests in 0°, 90°, ±45° Use failure surface theories like Chang-Chang, Tsai-Wu Validate with impact & delamination-sensitive tests

Thank You!

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