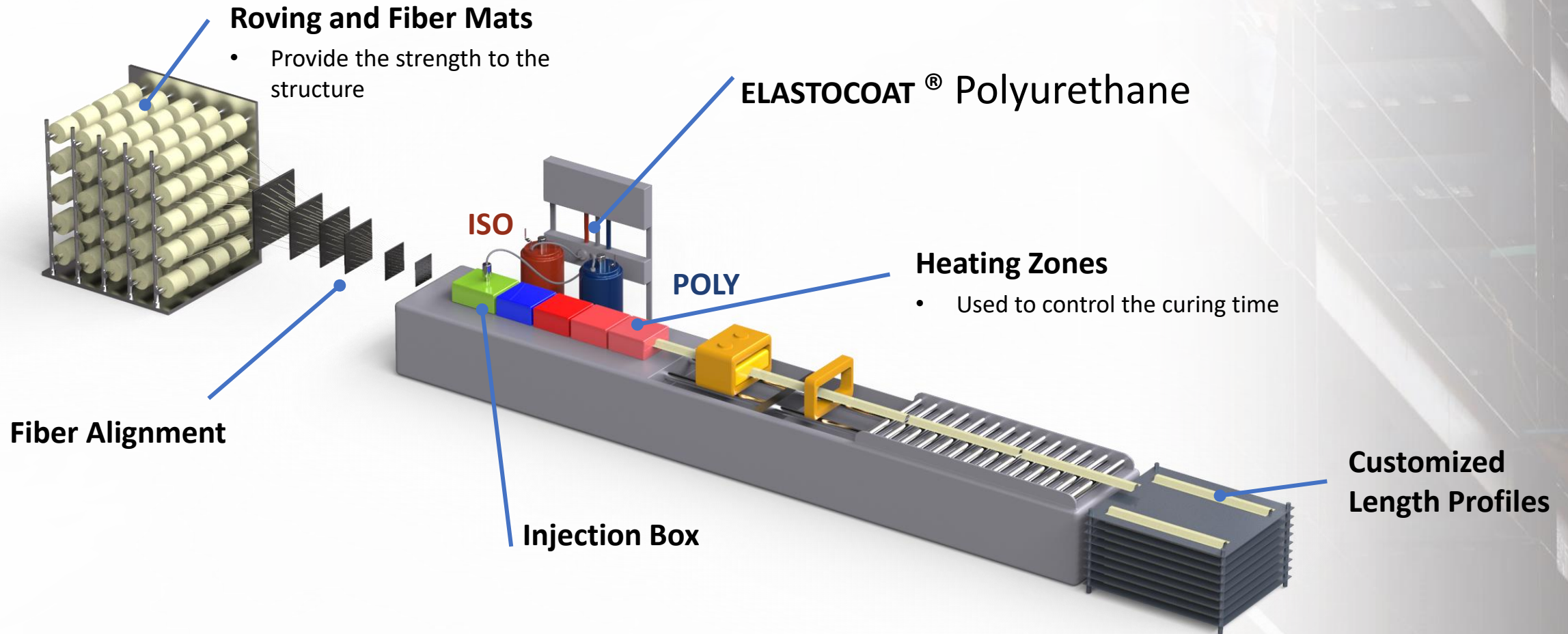


# Advanced Dynamic Simulation Capabilities in Pultrusion for Automotive Applications

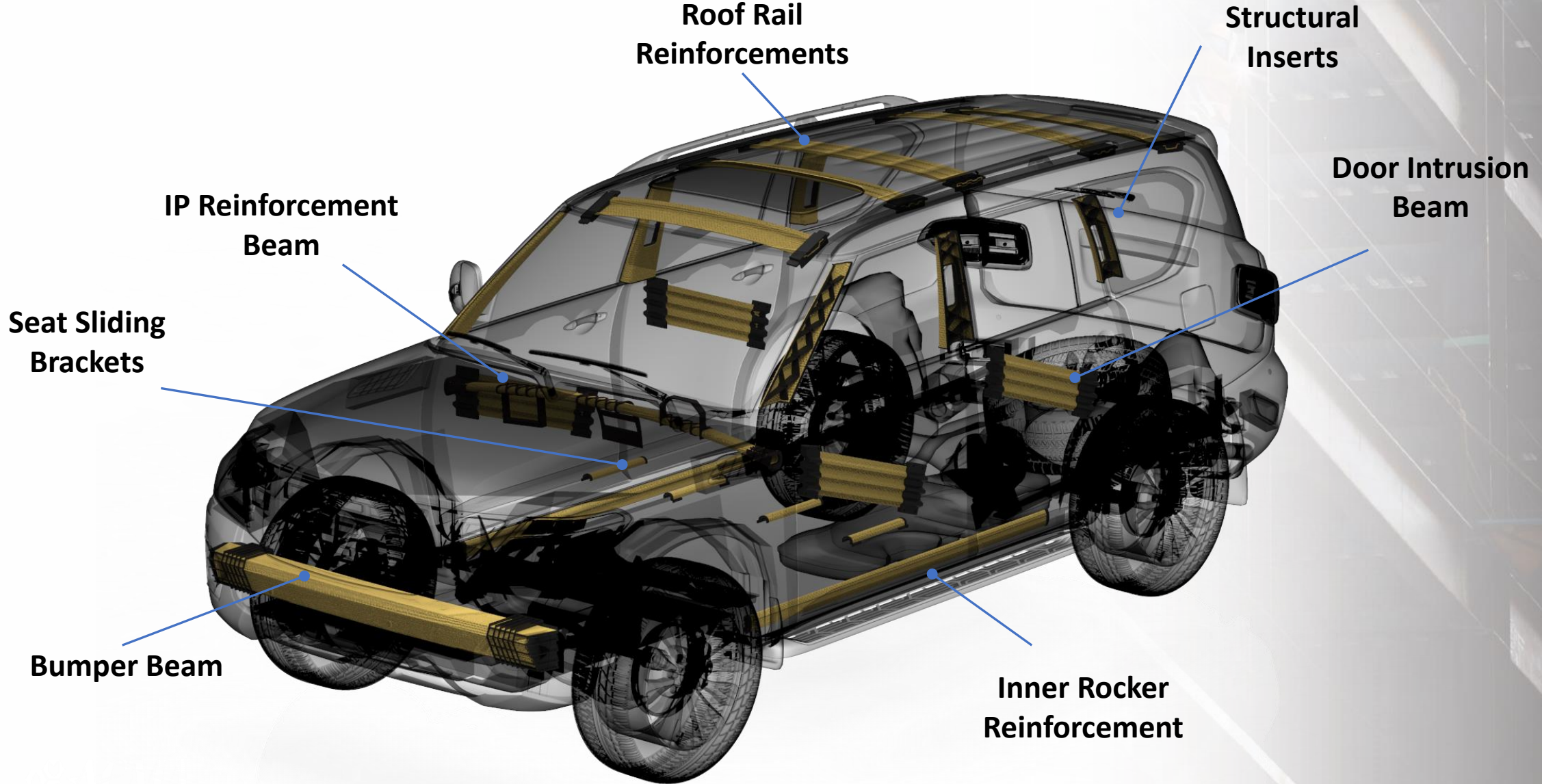
Elias Shakour Ph.D., Praphulla Chandra ,Ricardo Mercado, Chris Korson

BASF Corporation

# Process Description



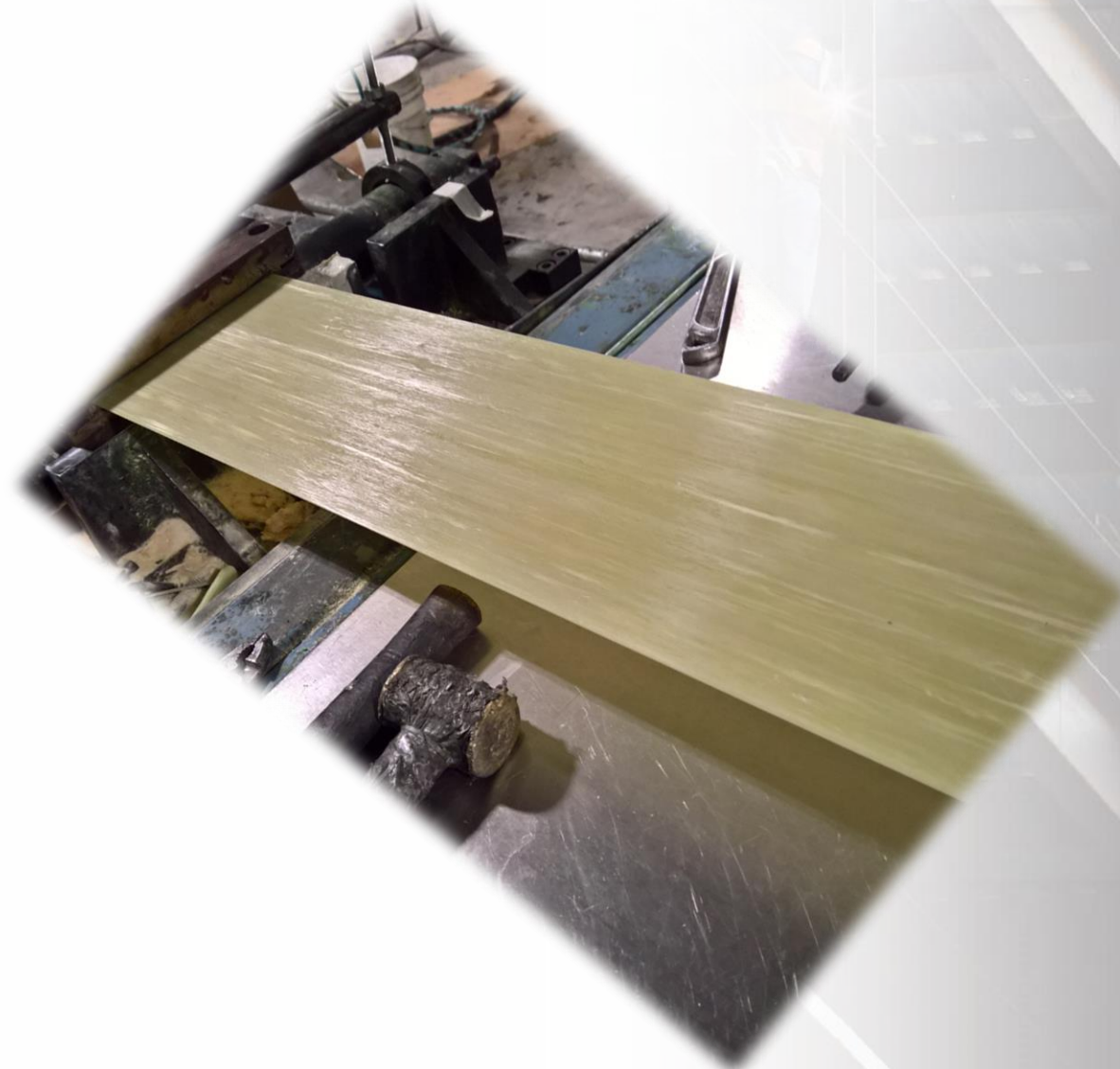
# Target Applications



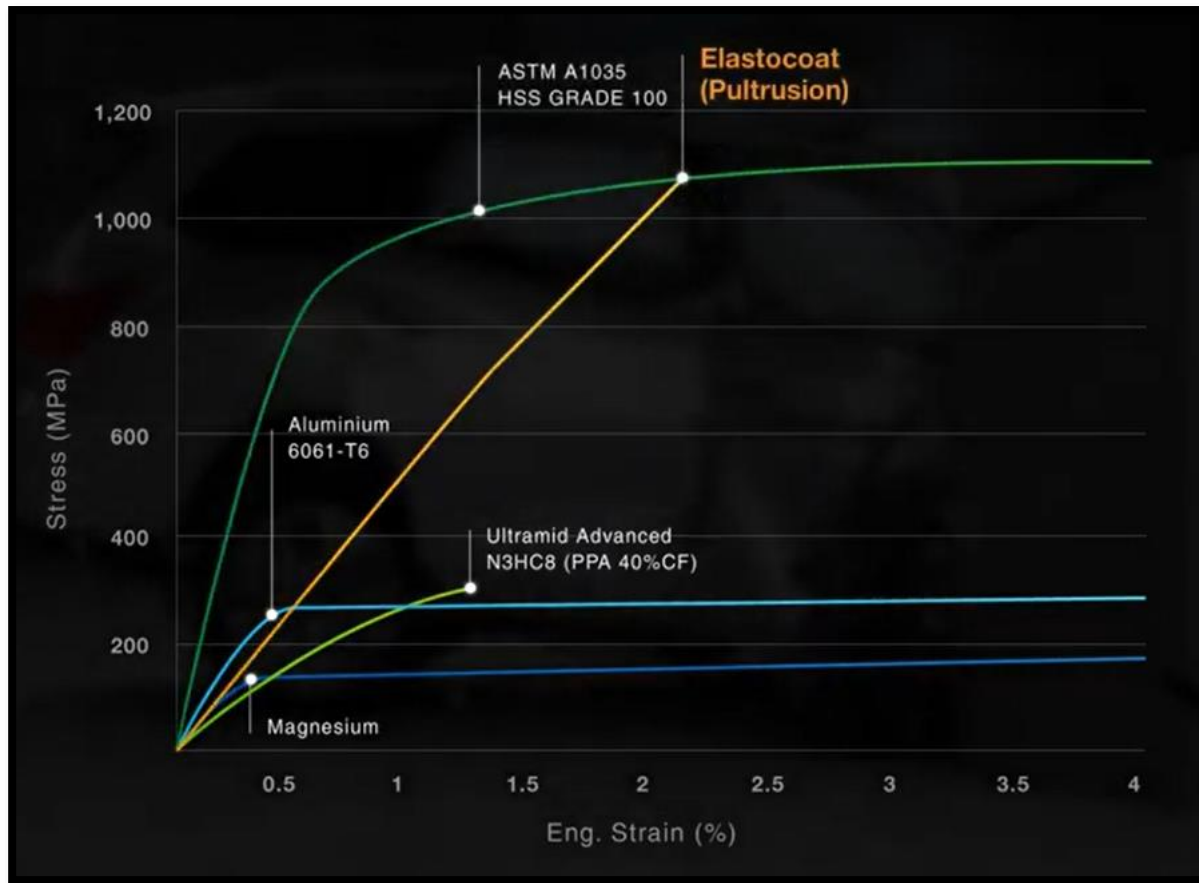


# Polyurethane Systems Used for the Study

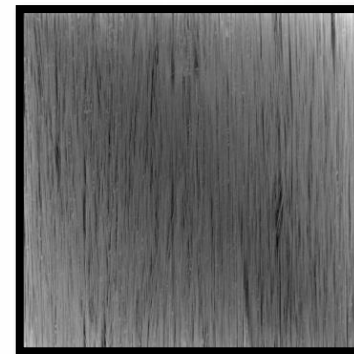
- Elastocoat® 74850:
  - Good wetout
  - Good mechanical performance
  - Line speed 1.5 m/min
- Elastocoat® 74830
  - Low viscosity
    - Suitable for carbon fiber
  - Low pull force
  - Good mechanical performance
  - Line speed 2.5 m/min
- Elastocoat® Hi-Tg
  - High tg up to 200C
  - Good mechanical performance
  - Line speed 1.5 m/min



# Why Offering Pultrusion - Performance



- Pultrusion strength is comparable to Steel grades (fiber direction)
- Pultrusion elastic modulus is comparable to Magnesium

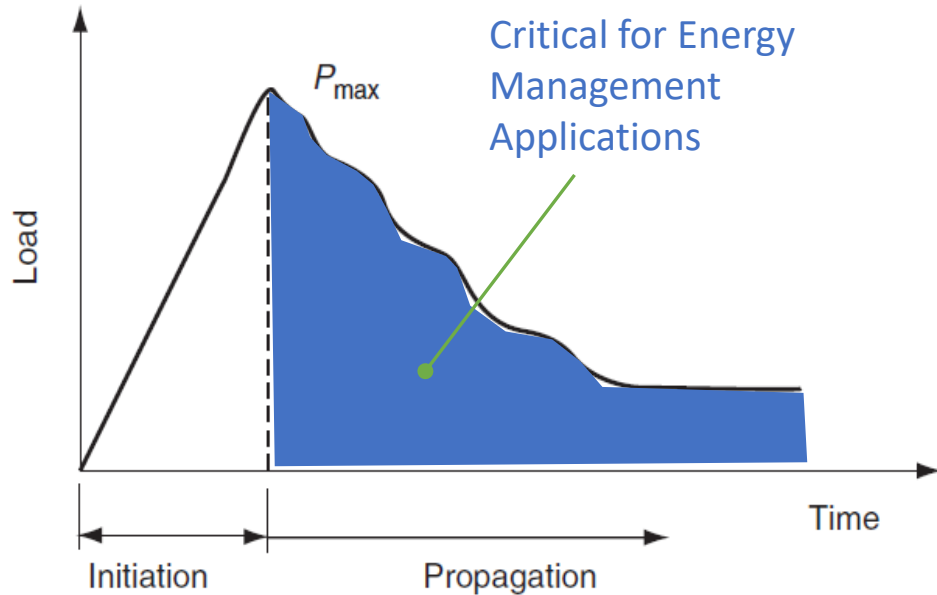


**All Roving  
Architecture**



**Tensile Test**

# Problem Statement

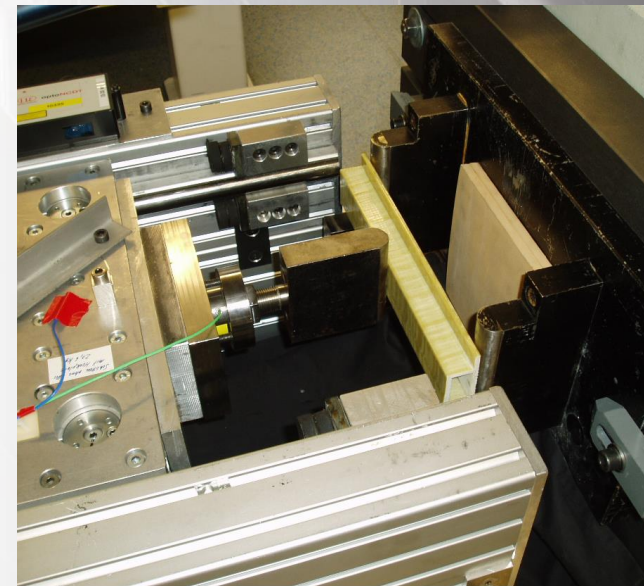
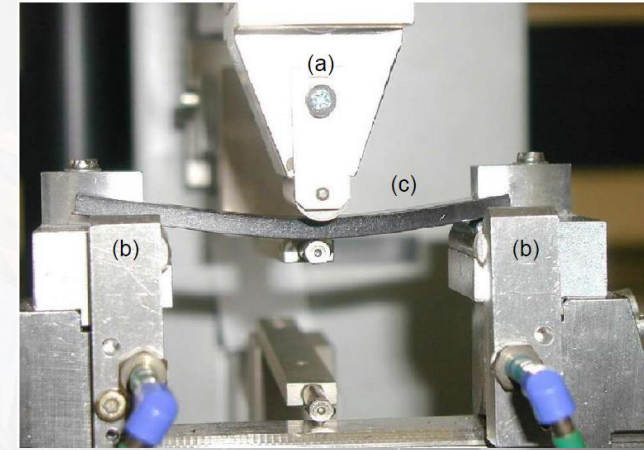


- Post-Impact deformation needs to be accounted for full performance evaluation
- Post-Impact need to be predicted using Finite Element Analysis (FEA)
- Need to build a material card for post failure



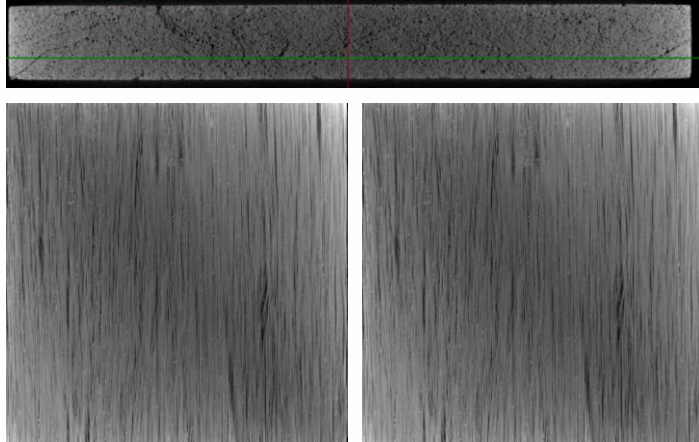
# Development Process of This Study

- Select PU for this development
- Identified four types of fiber architecture
- Developed two types of profiles:
  - 20cm flat die, with 2.2 mm thickness for coupon testing
  - Close box die with a mandrel for part demonstration testing
- Ran battery of tests to identify the material properties
  - Static
  - Dynamic
- Built Computer Aided Engineering ( CAE) material card
- Ran part-level tests
- Compared results with Finite Element Analysis ( FEA) and new card model

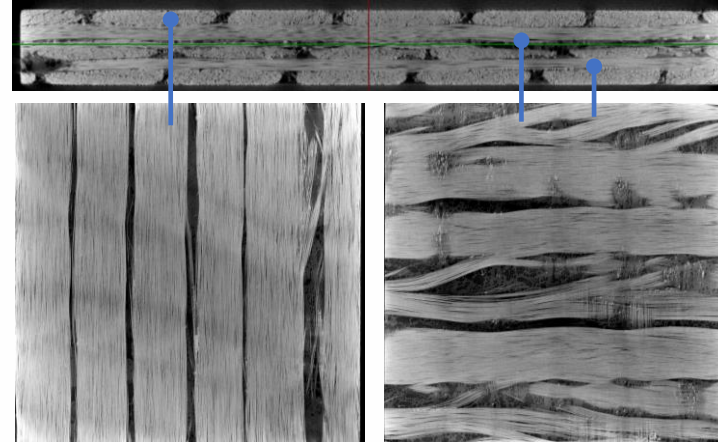


# Fiber Architecture (CT Scan Pictures)

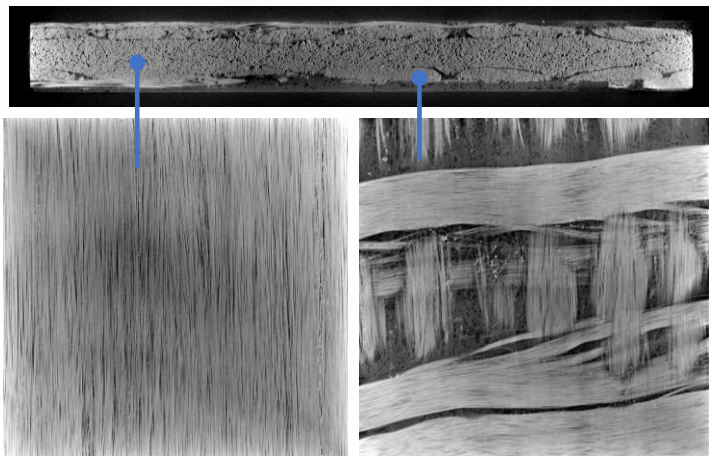
ALL ROVING



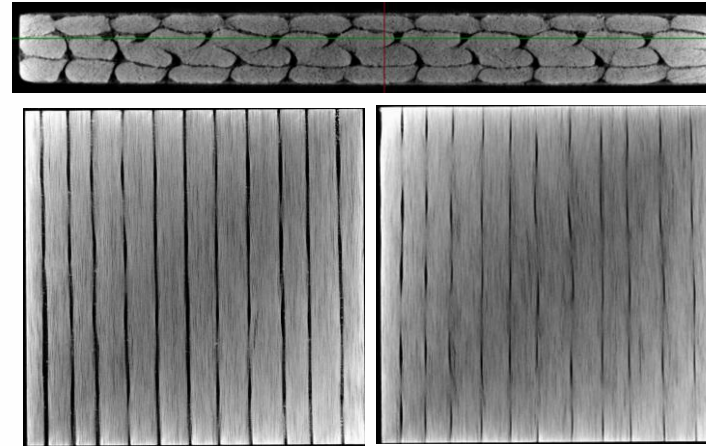
BIAXIAL



HYBRID



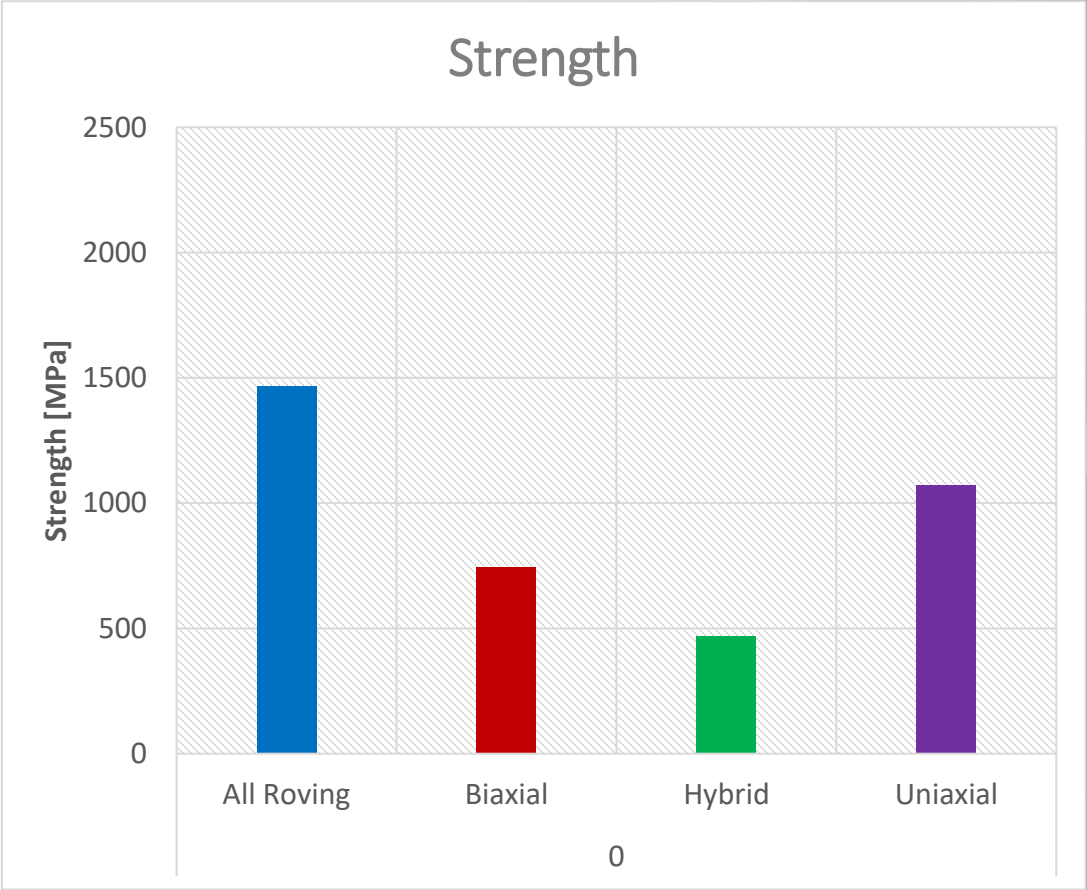
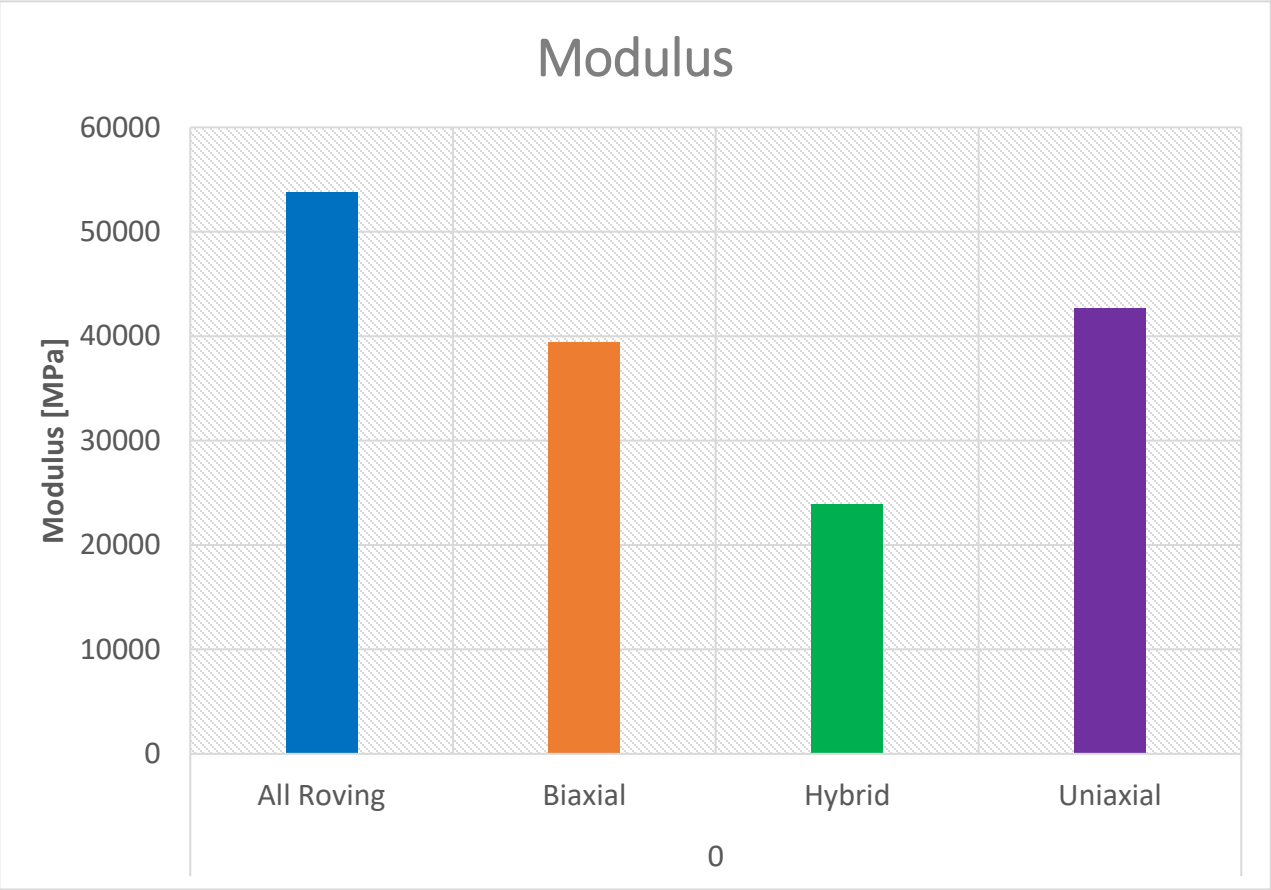
UNI-AXIAL



- Arrangement of fibers, influence properties and processing
- Determines void content, fiber wetting, fiber distribution, dry area
- Opportunity to tailor the structural performance of the composite
- 1- and 2- dimensional fiber layout

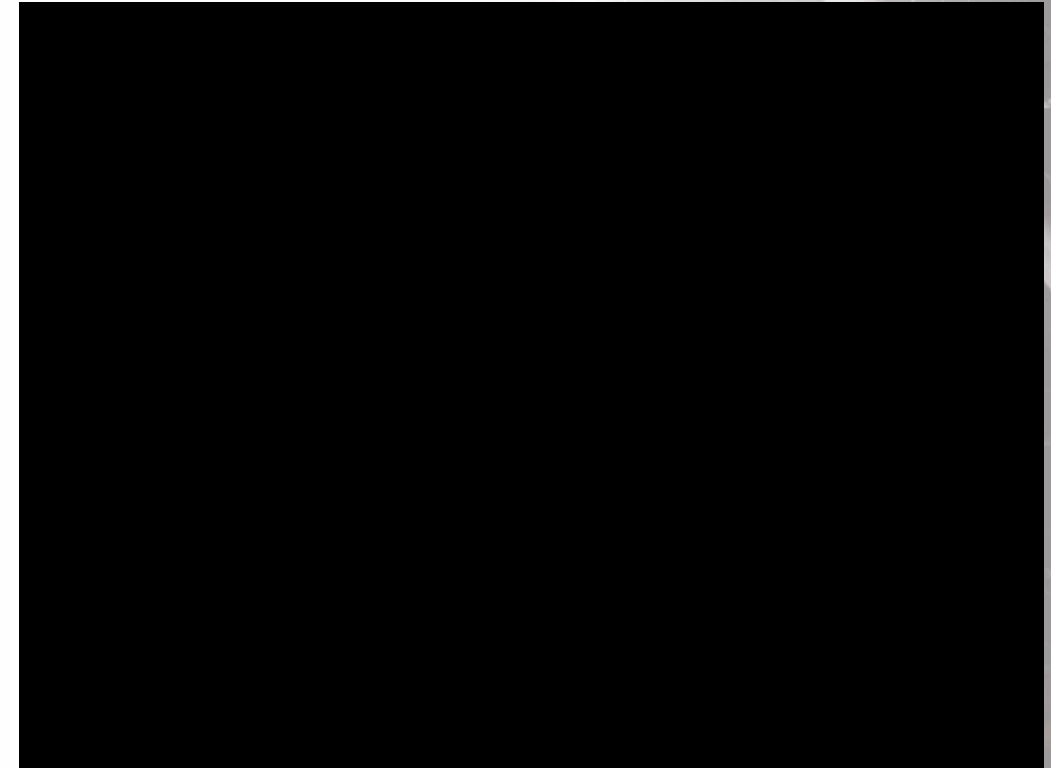
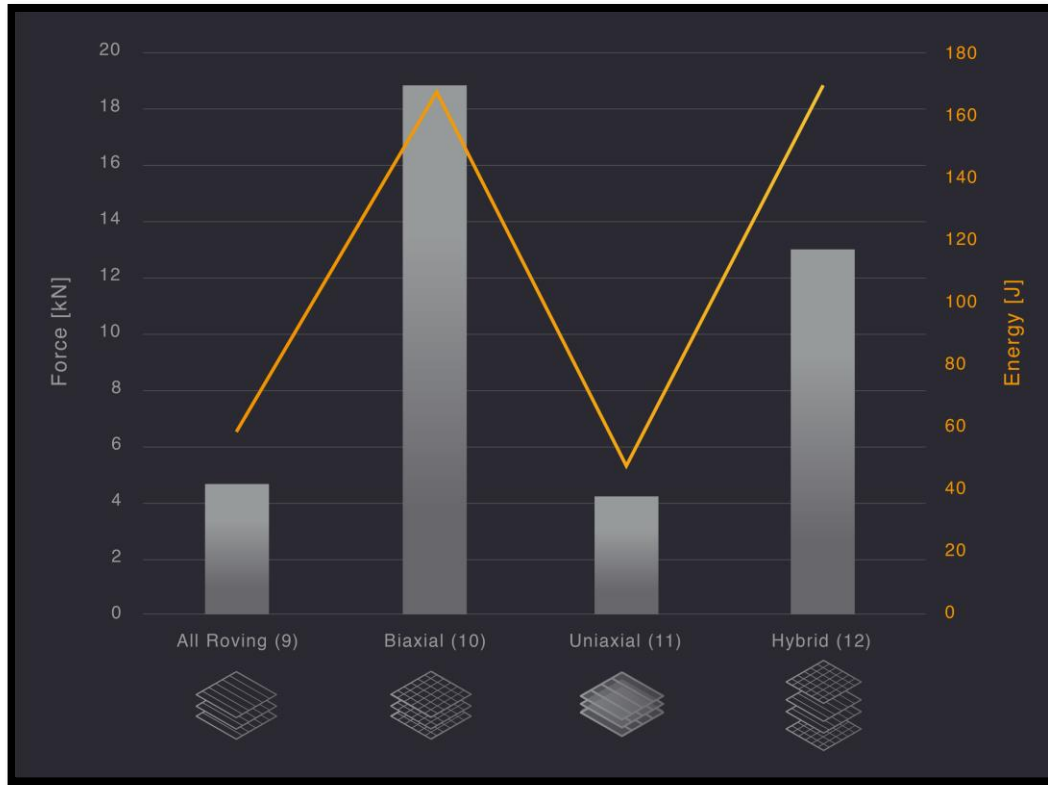


# Sample of Coupon Testing- Flexural Testing



All Roving has the highest modulus and the highest ultimate strength of all tested materials followed by Uniaxial, Biaxial and Hybrid

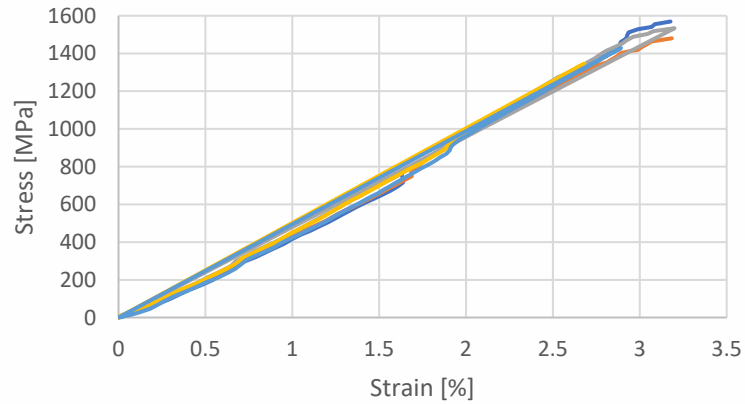
# Dart Impact Performance



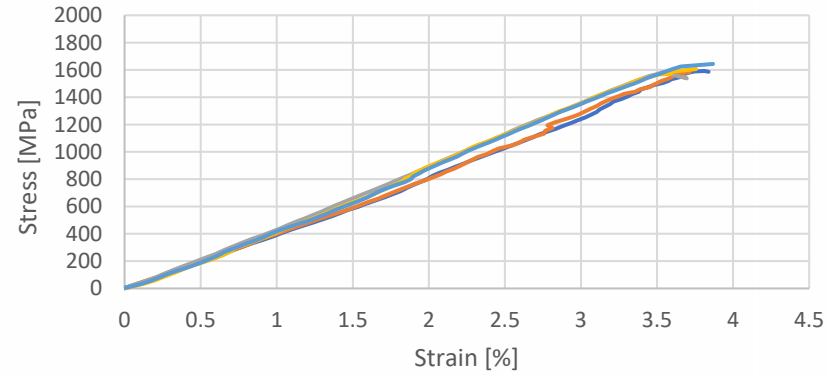
- The impact properties of a material represent its capacity to absorb and dissipate energy under impact or shock loading

# Coupon testing- High Speed Tensile Test

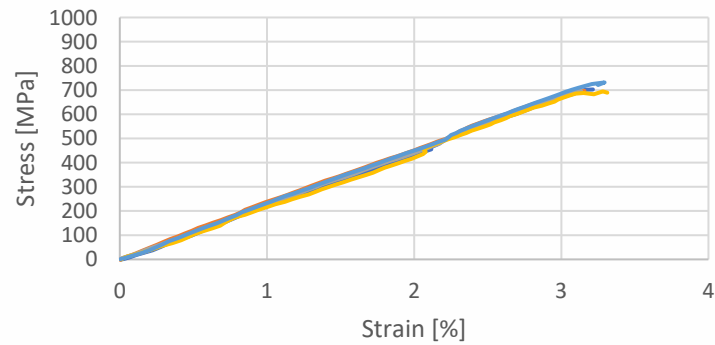
All Roving Temp:23°C Orient:0° SR:0.1/s



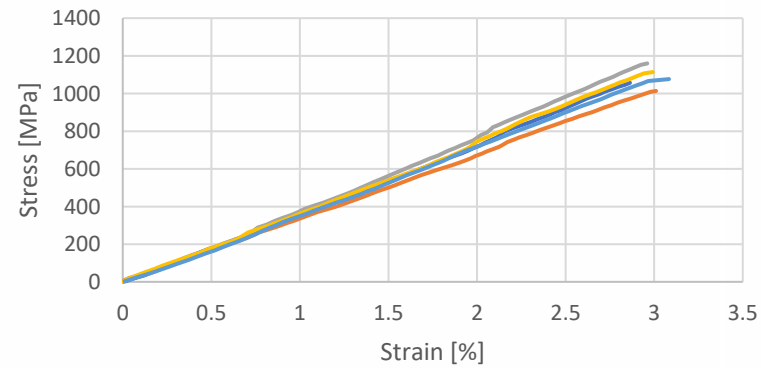
Uniaxial Temp:23°C Orient:0° SR:0.1/s



Biaxial Temp:23°C Orient:0° SR:0.1/s



Hybrid Temp:23°C Orient:0° SR:0.1/s





# Flexural impact tests on a part

All Roving



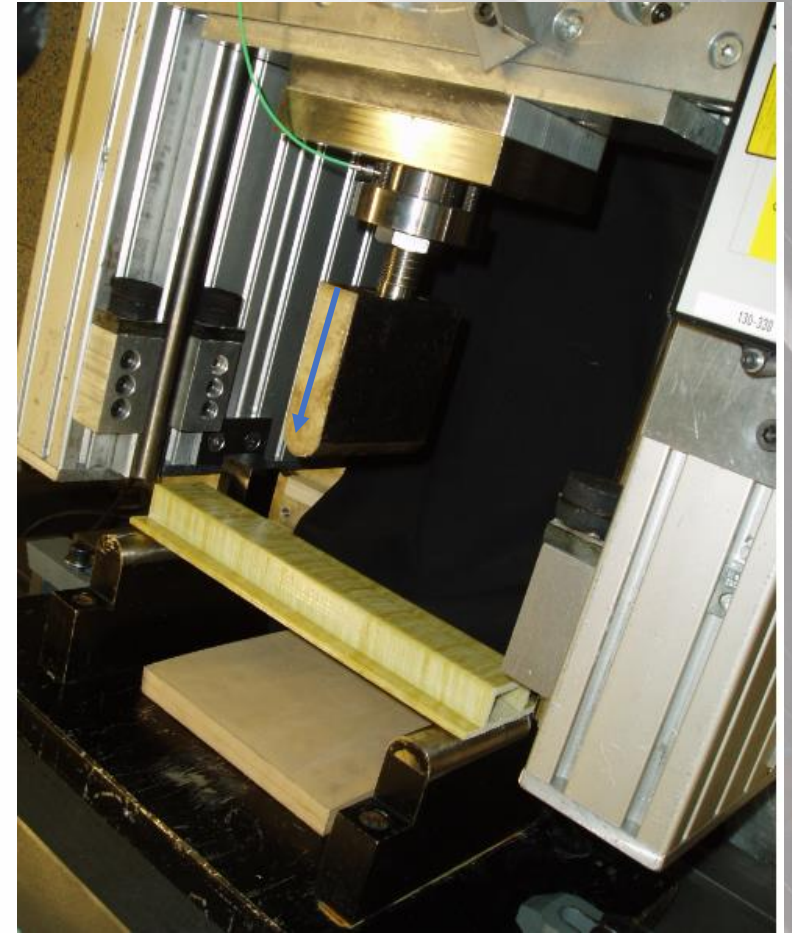
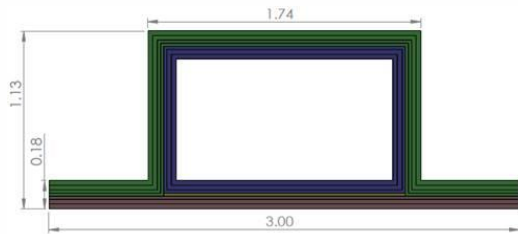
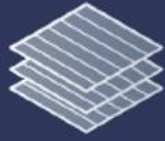
Biaxial



Hybrid

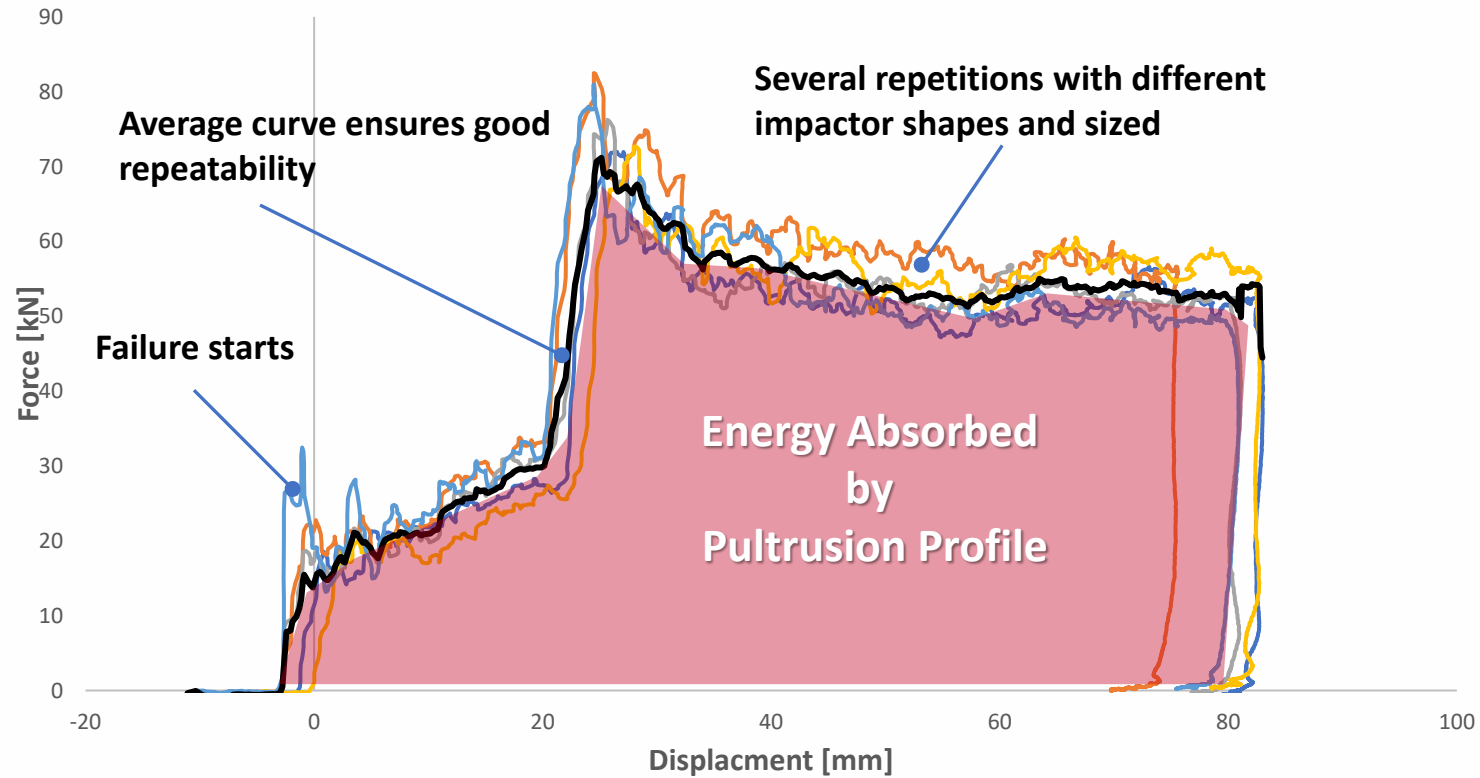


Uniaxial

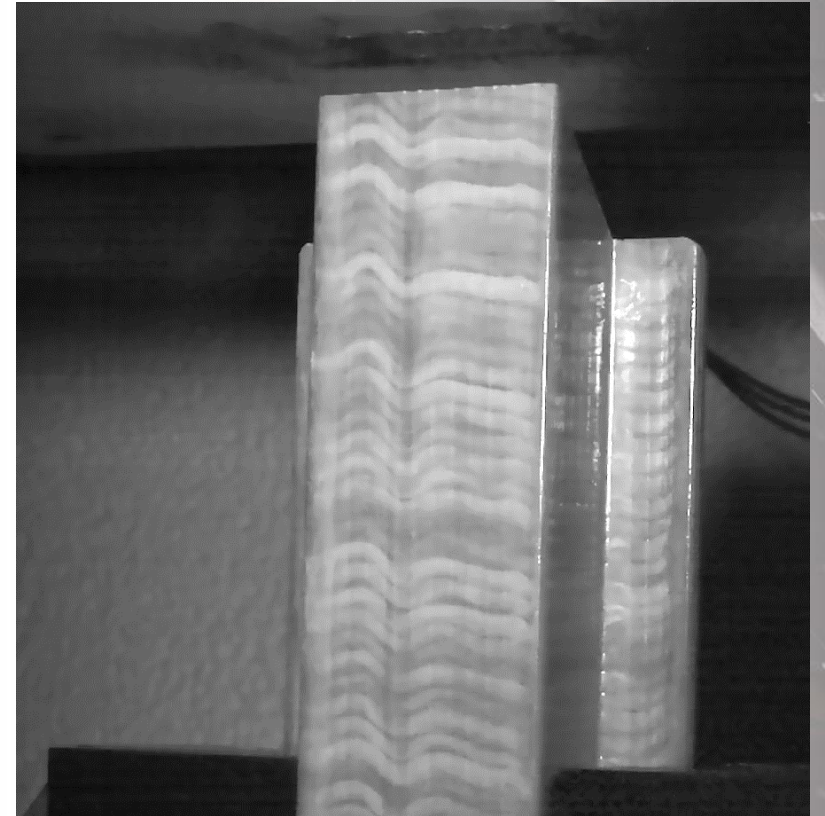


- Impact energy 613 J
- Total mass impactor 35.7 kg
- Impact speed 5.9m/sec.
- ~1200fps

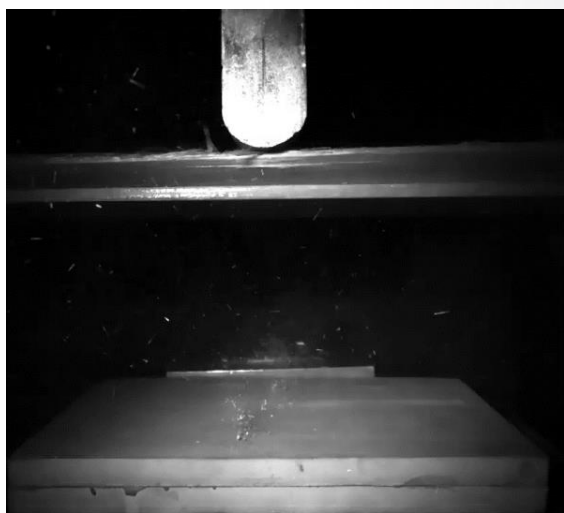
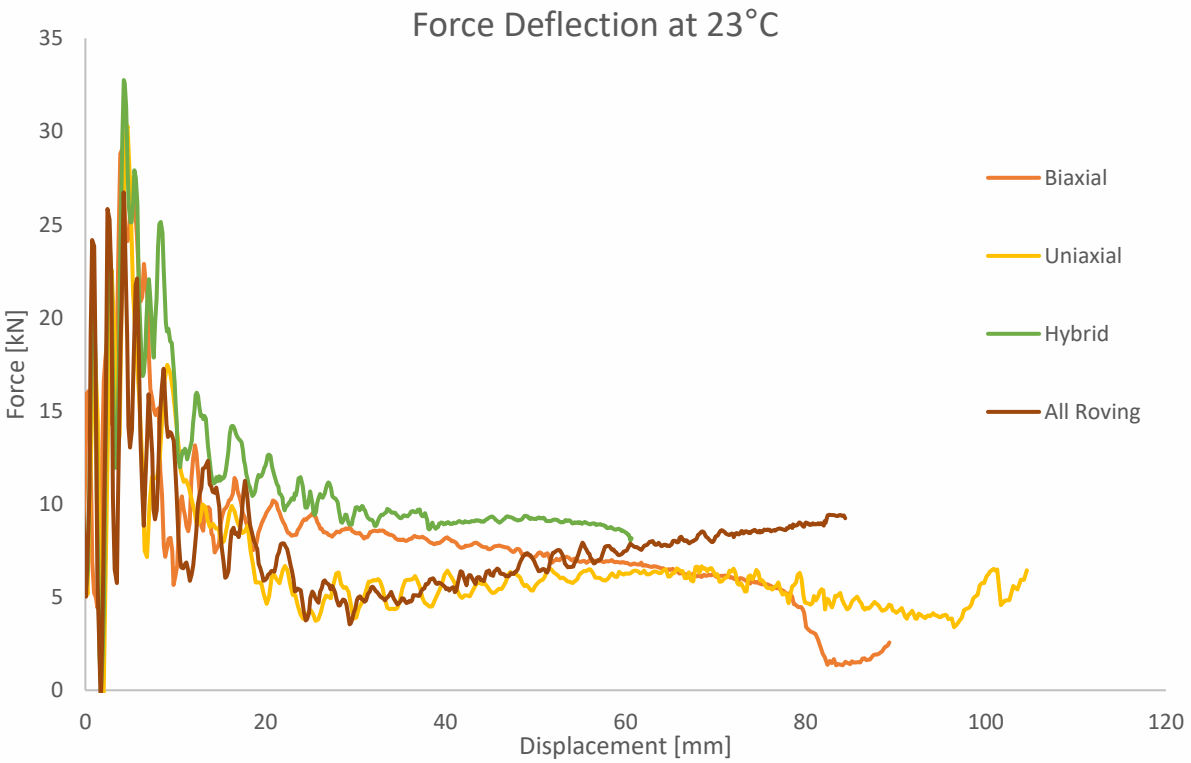
# Impact Measurements- on a part



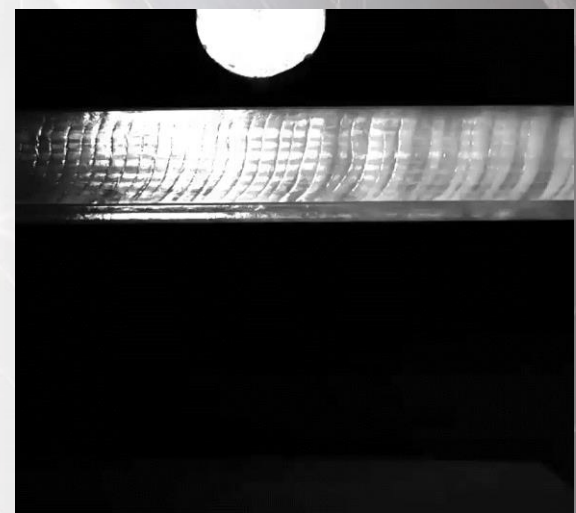
- Axial Crush Impact measurements
- ULTRATEST® for maximum accuracy



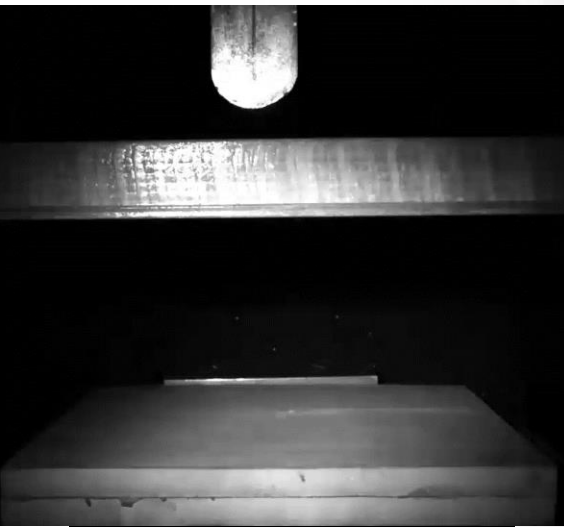
# 3Pt Bending Impact on part



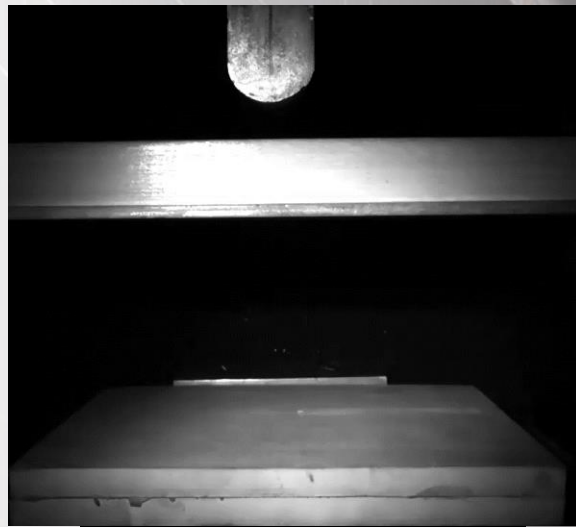
All Roving



Bi-Axial



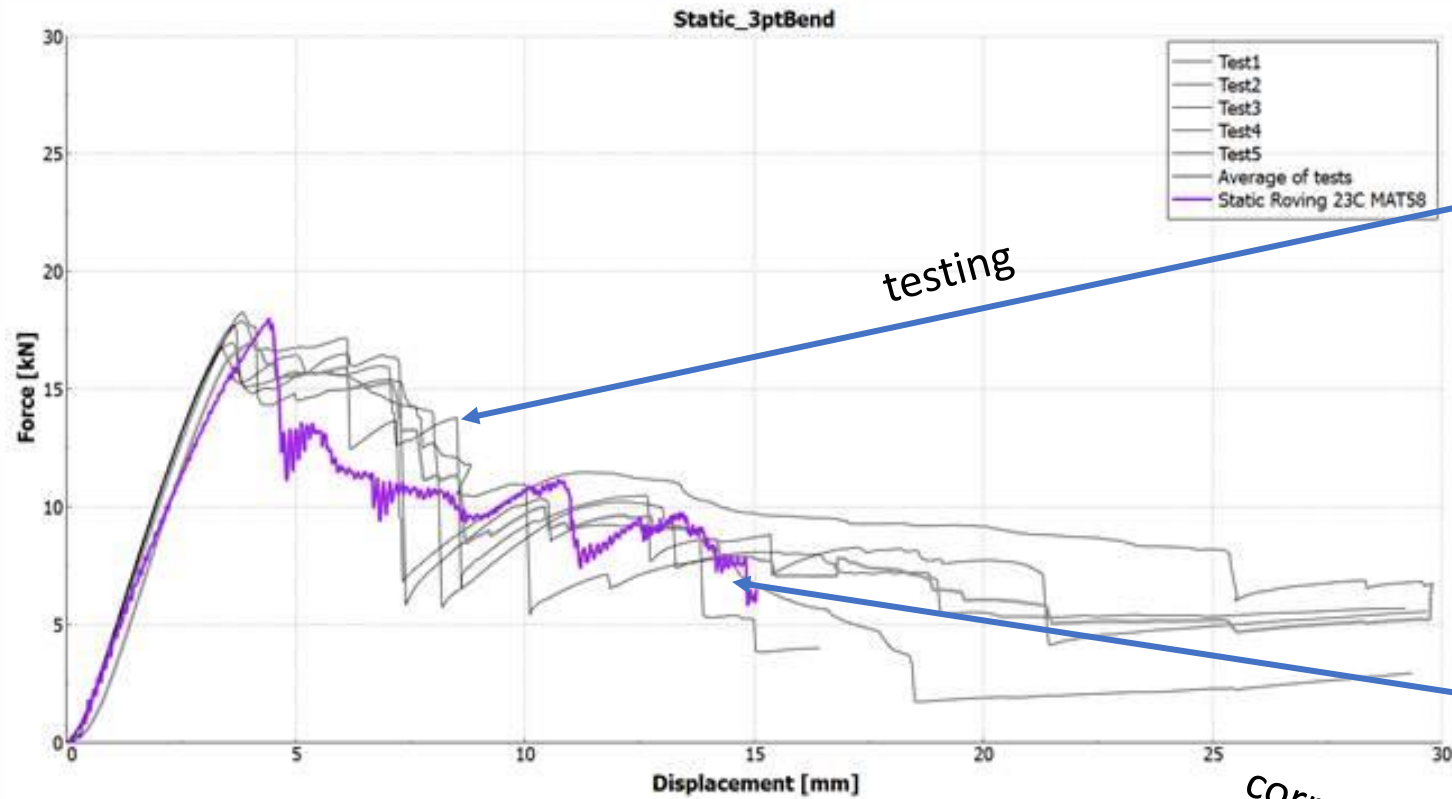
Hybrid



Uni-Axial

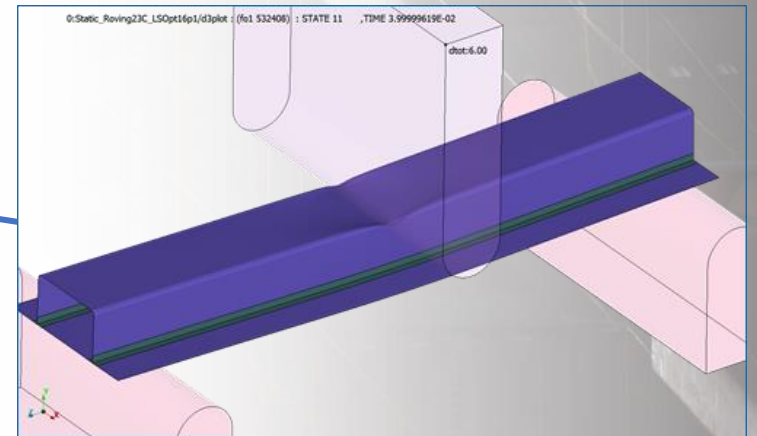
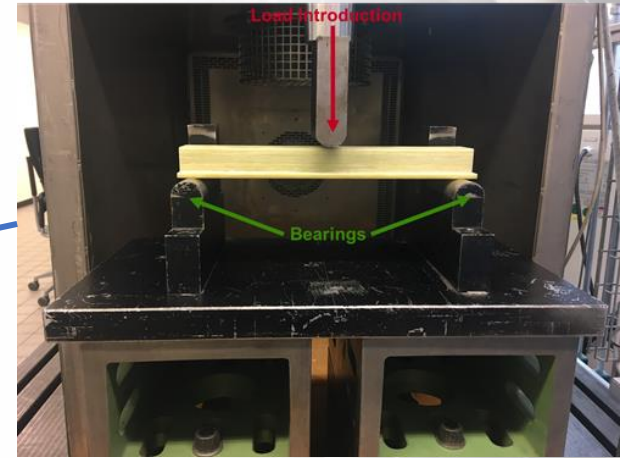


# How to Correlate test vs Simulation



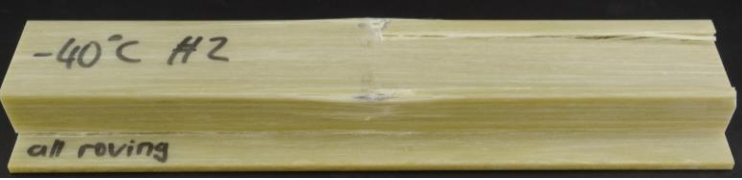
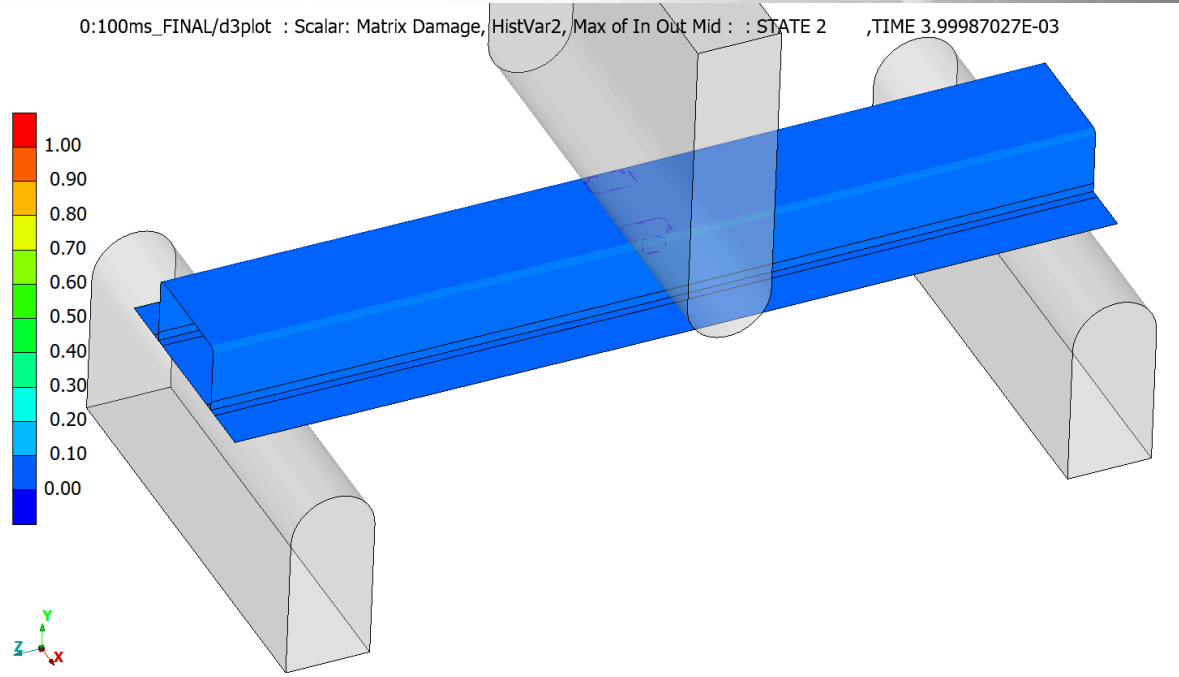
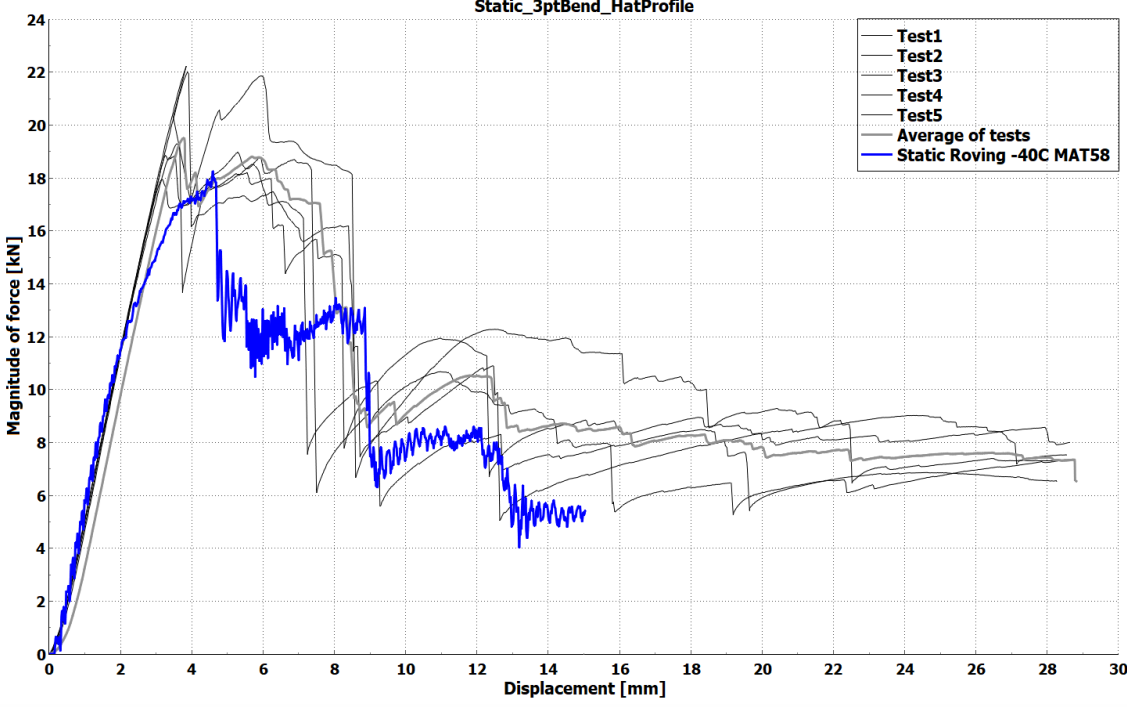
testing

correlation



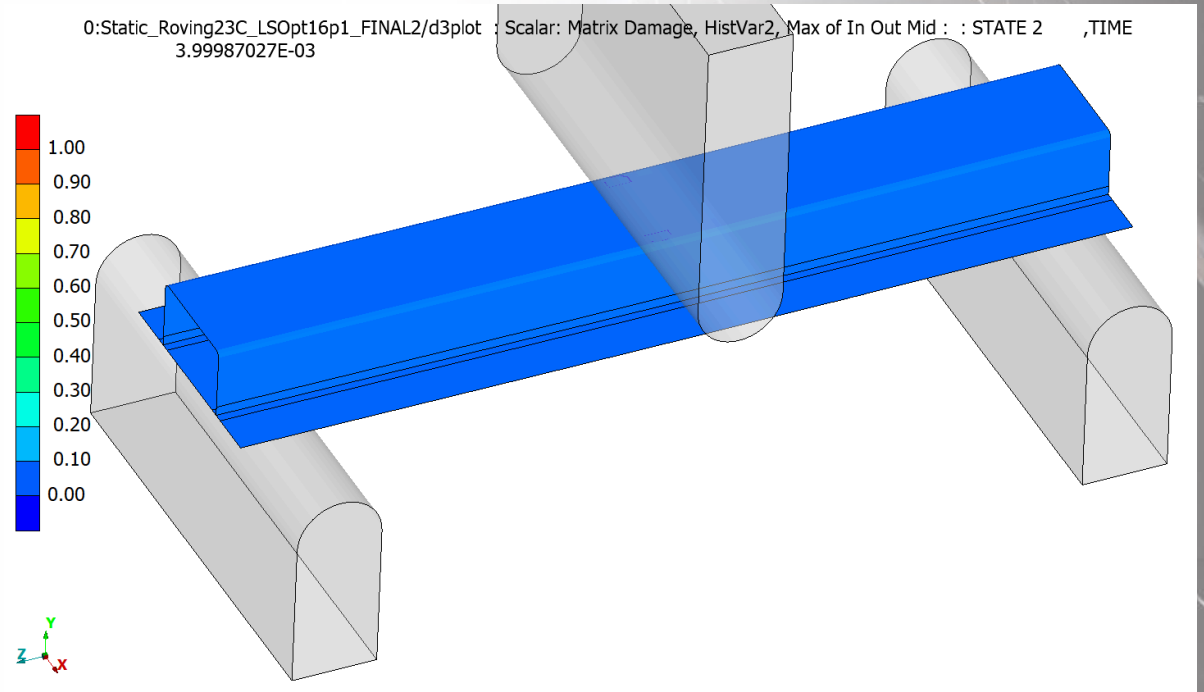
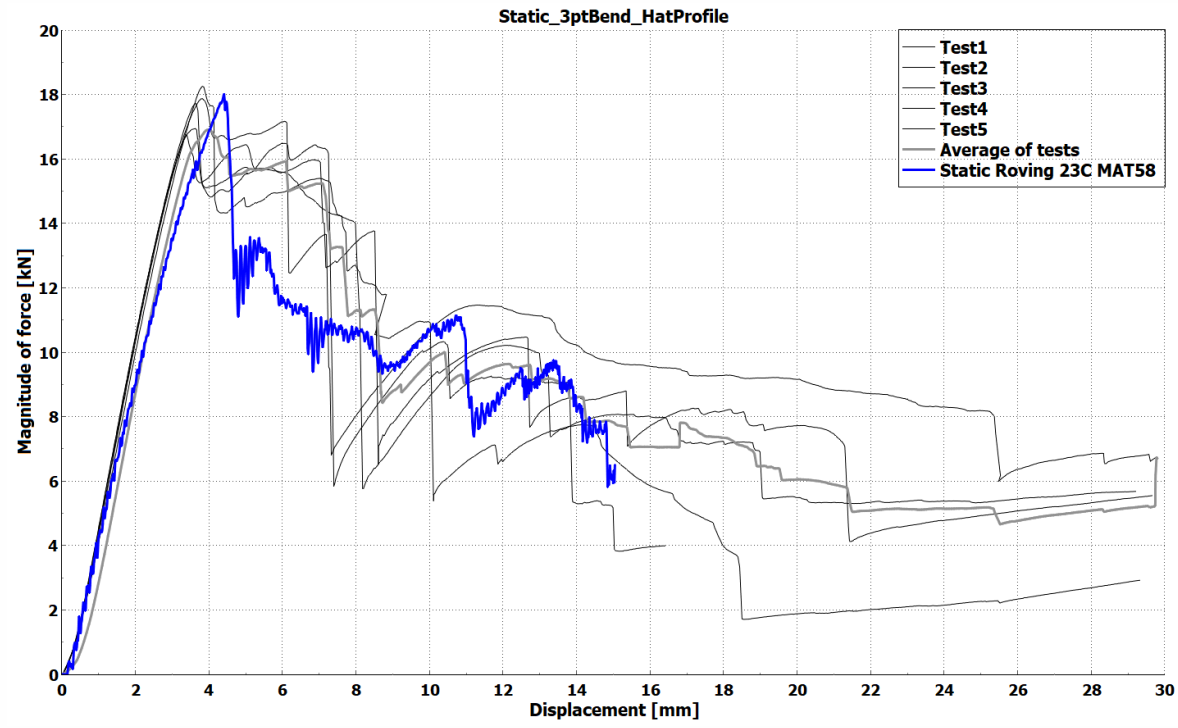
# Correlation of Static 3pt Bend Part

-40°C



# Correlation of Static 3pt Bend Part

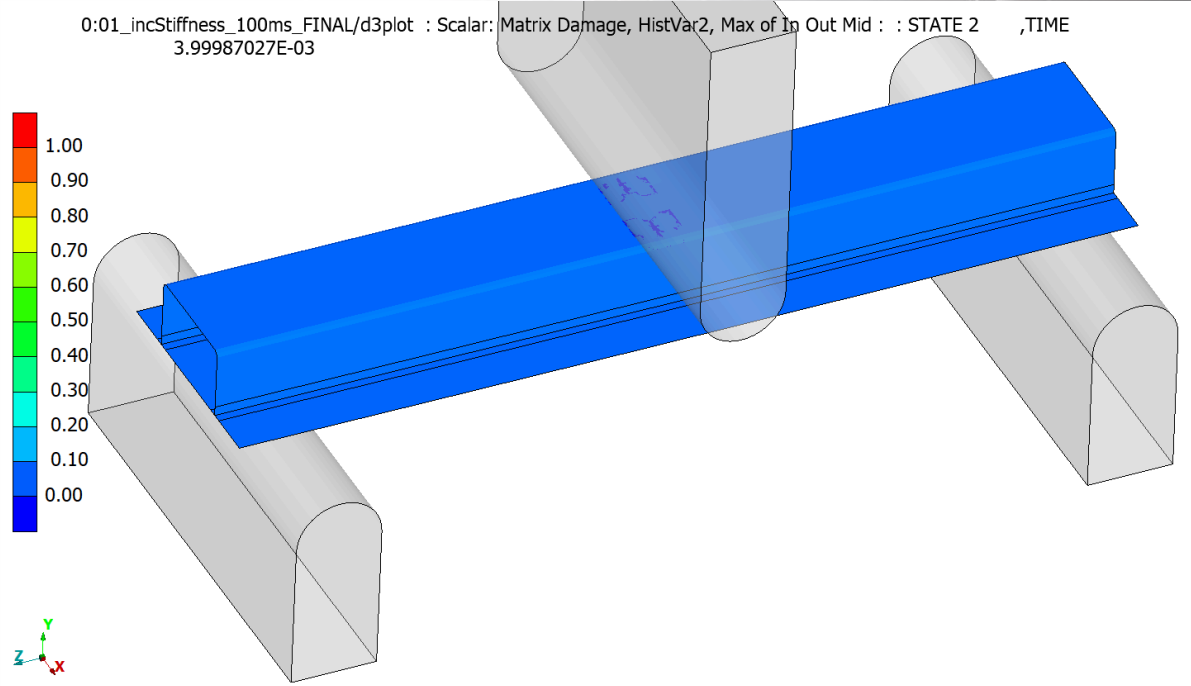
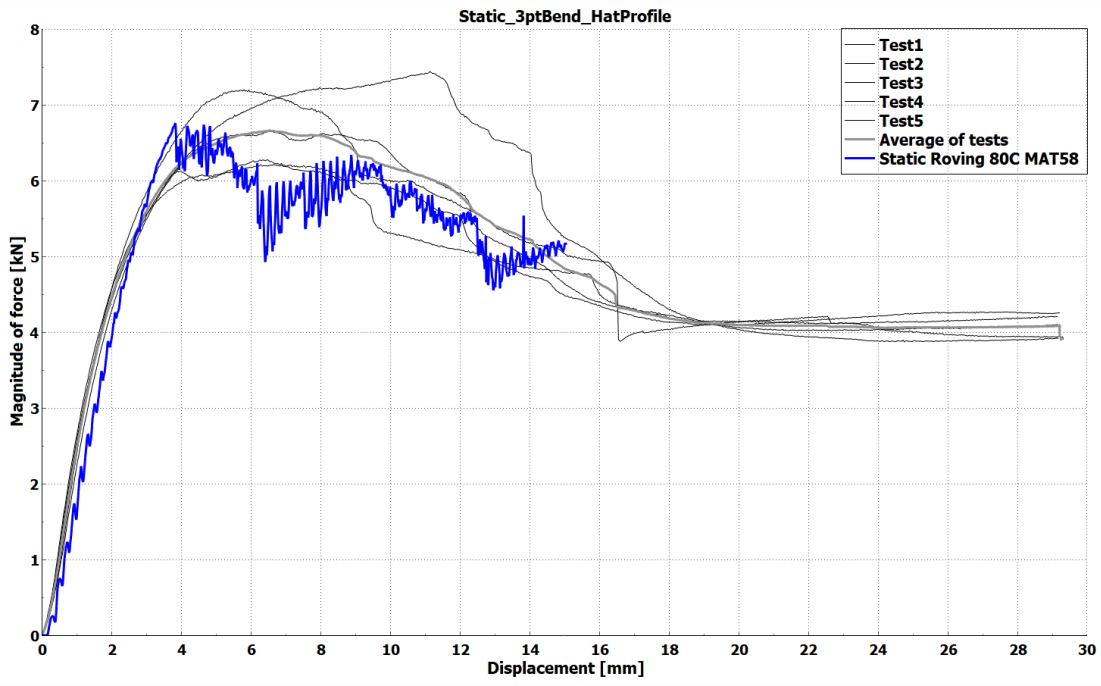
23°C





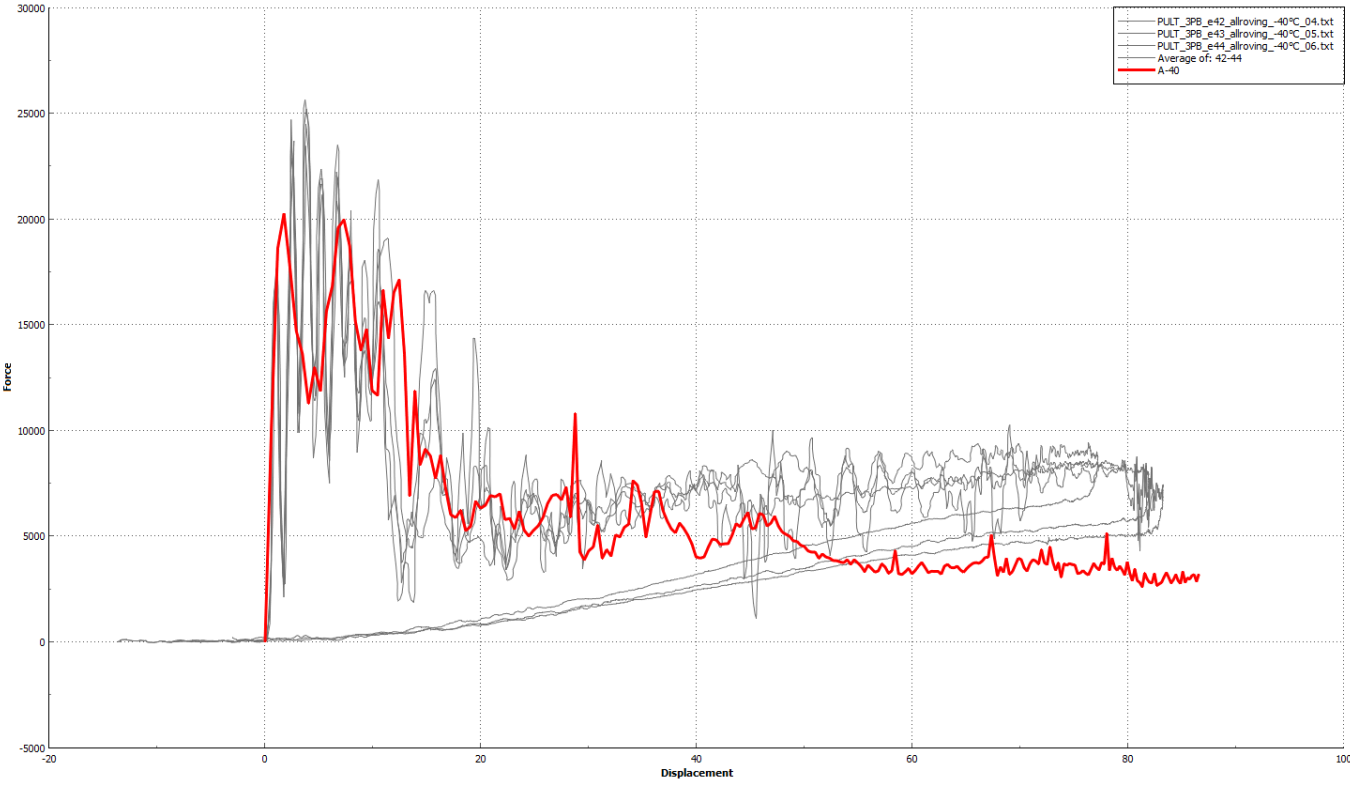
# Correlation of Static 3pt Bend Part

80°C

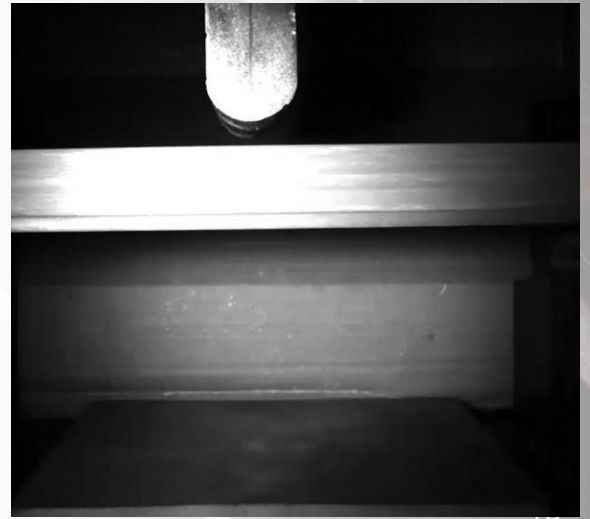
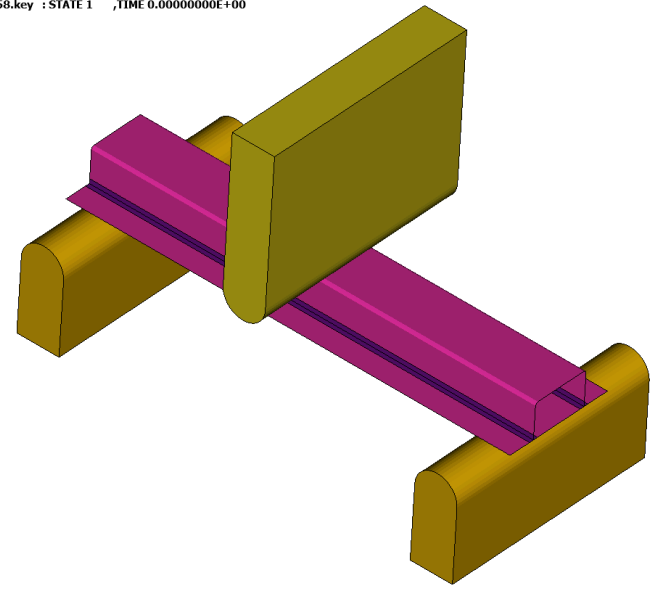


# Correlation of Crash 3pt All roving

-40°C

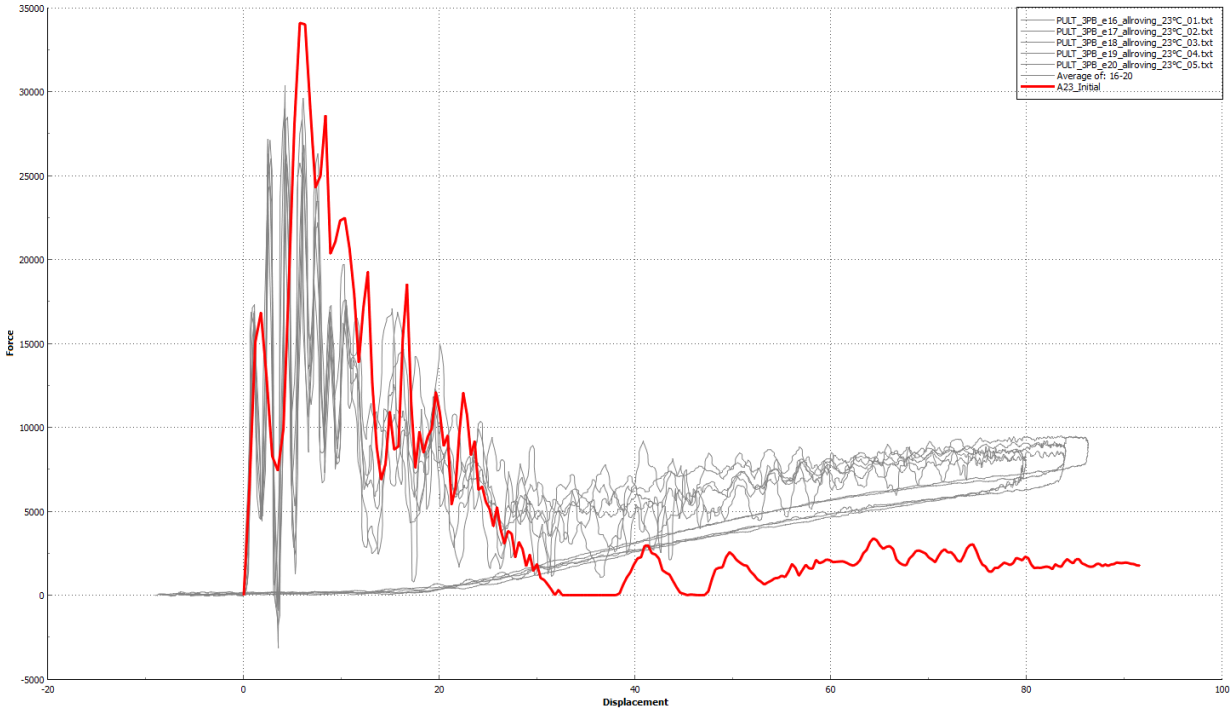


0:Crash3PTBend\_MAT58.key : STATE 1 ,TIME 0.00000000E+00

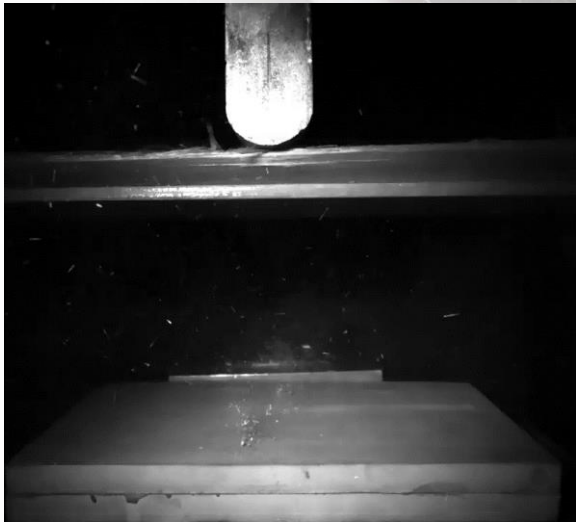
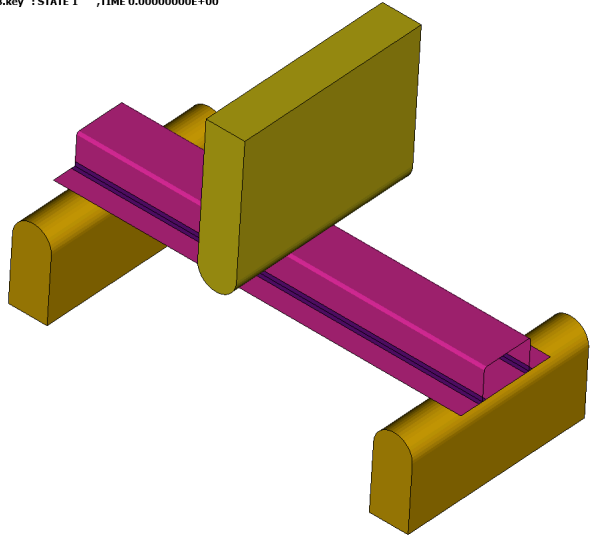


# Correlation of Crash 3pt Bend specimen

23°C



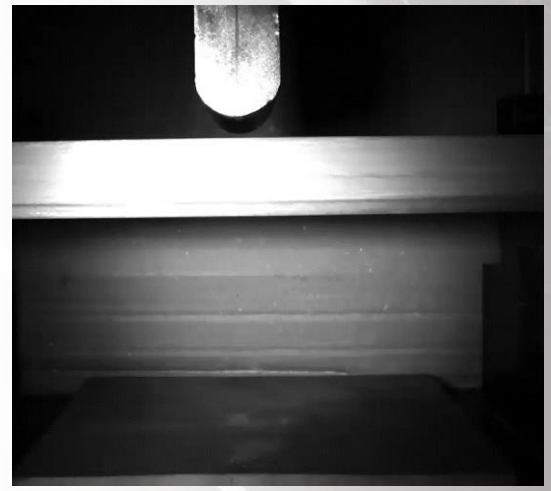
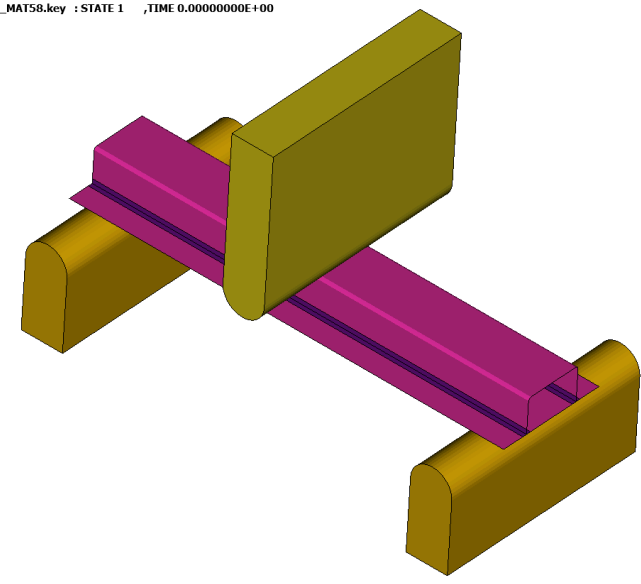
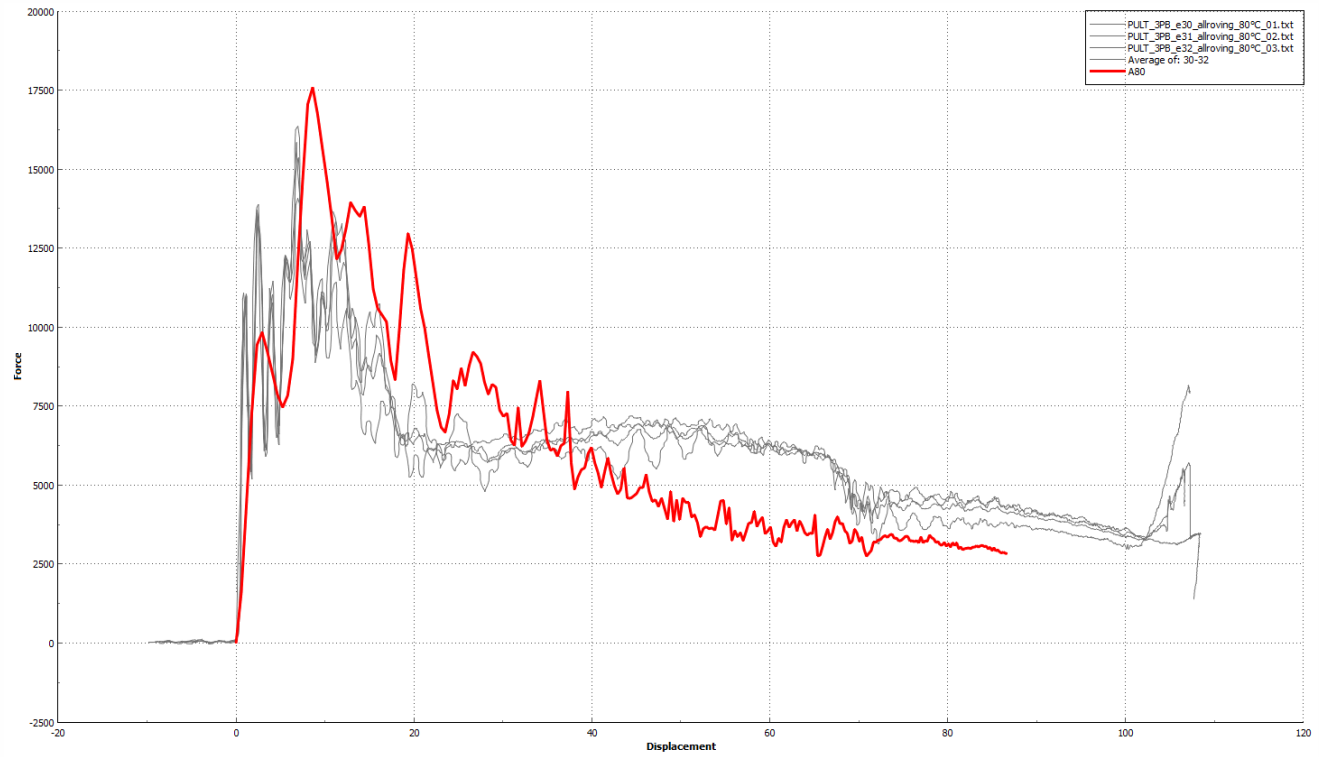
0:Crash3PTBend\_MAT58.key : STATE 1 ,TIME 0.0000000E+00



# Correlation of Crash 3pt Bend specimen

3:A80\_Crash3PTBend\_MAT58.key : STATE 1 ,TIME 0.0000000E+00

80°C





# Conclusions



- We were able to create a proprietary material card for the polyurethane system with high correlation accuracy
- The Material card captures well the post failure
- With the material card we have the know how to optimize the design and predict crash behavior
- Next step to build new material card for the other polyurethane system



# Thank you!

If you have any further question, please contact



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