



# ANTEC® 2024

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## Cost-Effective Automotive Body Structures

Christopher Oberste, Ph.D.

WEAV3D Inc.

**#ANTEC24**



- About WEAV3D® and Rebar for Plastics®
- Composite Door Design Challenge and Redesign Objectives
- Project Overview
  - Material Benchmarking
  - FEA Optimization
  - Parametric Cost Modelling
  - Prototype Manufacturing
- Experimental Results
- FEA Validation
- Summary



Manufacturer of composites lattice materials for automotive and construction applications

2014

Technology  
invented

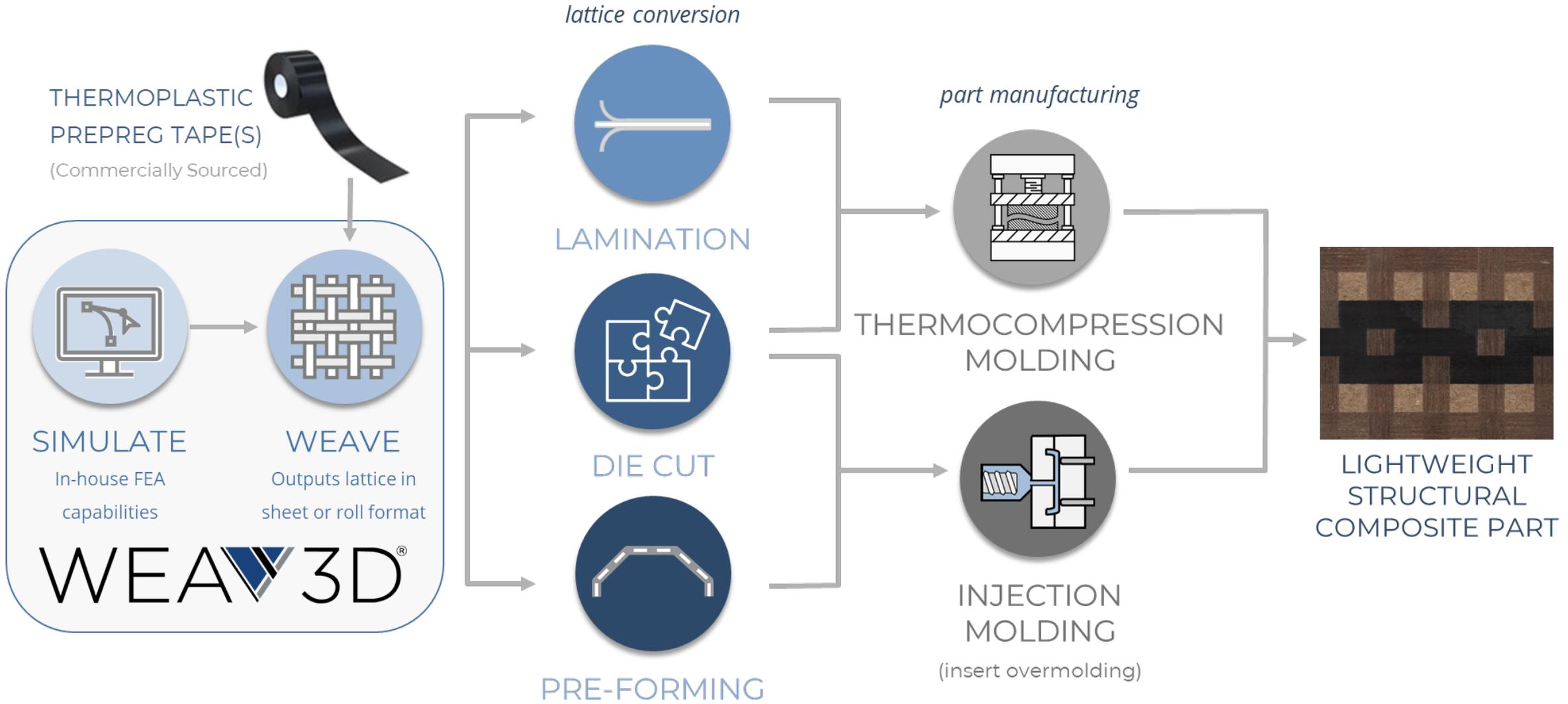
2017

WEAV3D founded  
out of Georgia Tech

TODAY

Headquartered in  
metro Atlanta, Georgia

**WEAV3D's** patented **Rebar For Plastics®** solution enables cost-effective,  
scalable, locally tunable composite lattices for mass production.





Excerpt from 2021 DoE Vehicle Technologies Office Annual Merit Review

## Background

- Clemson University led a Department of Energy funded project to design an ultralightweight composite door, based on the 2016 Acura MDX.
- Carbon fiber/PA6 organosheet used for the inner frame and inner beltline stiffener, augmented with metal
- Clemson design achieved 45% weight reduction and 64% parts consolidation



- Inner frame**
  - Manufacturing: *Thermoforming*
  - Material: *PA 6 + 50 % wt. Woven CF*
- Anti-intrusion beam assembly**
  - Manufacturing: *Hot Stamped and Welded*
  - Material: *Ultra high strength steel*
- Inner beltline stiffener**
  - Manufacturing: *Thermoforming*
  - Material: *PA 6 + 50 wt % Woven CF*
- Outer beltline stiffener**
  - Manufacturing: *Extrusion and Welded*
  - Material: *Aluminum 6061*
- Lower Reinforcement**
  - Manufacturing: *3D Printing Dies + Stamping*
  - Material: *Aluminum 6061*

Despite meeting performance and weight objectives, the cost of the composite door assembly was twice that of the original steel door, driven by the high cost of the carbon fiber organosheet.



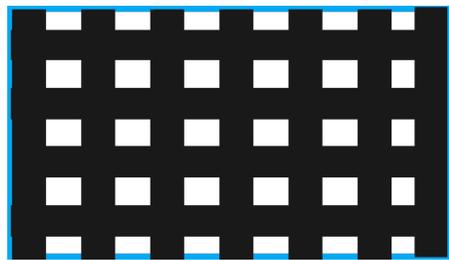
## Beltline Stiffener Demonstrator Goals

1. Reduce cost from current CF/PA6 organosheet design
2. Achieve comparable performance under side impact load case
3. Maintain weight savings
4. Maintain organosheet part geometry and thickness to utilize existing tooling

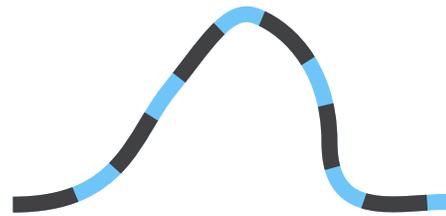


**In Partnership with:**

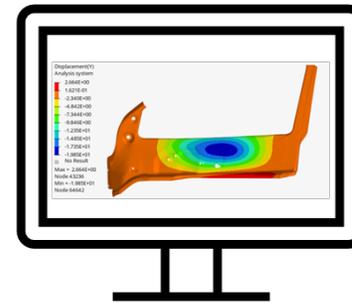




Flat Panels



Complex Shape



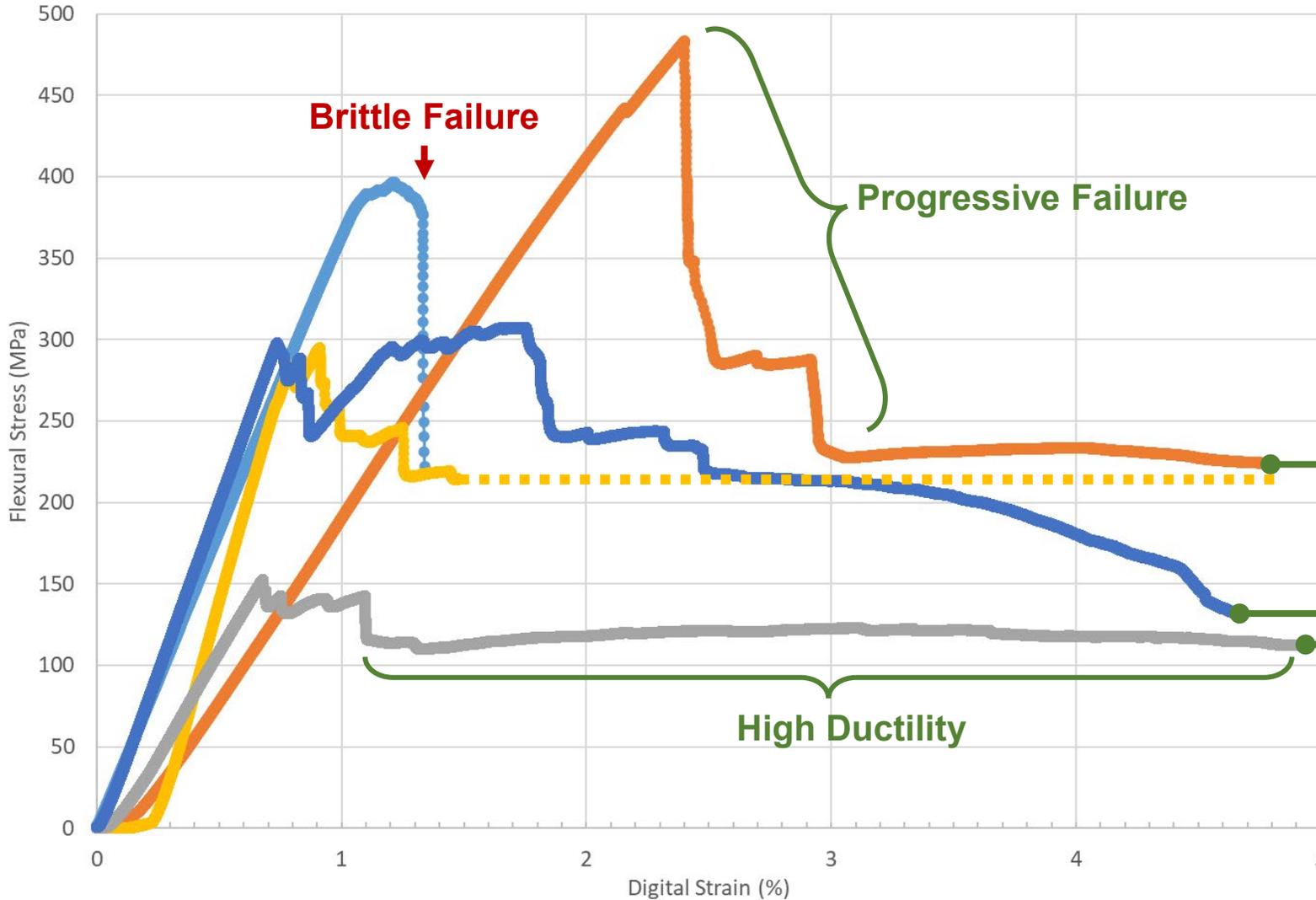
FEA Optimization



Part Prototyping

**Material Benchmarking**

# Material Benchmarking

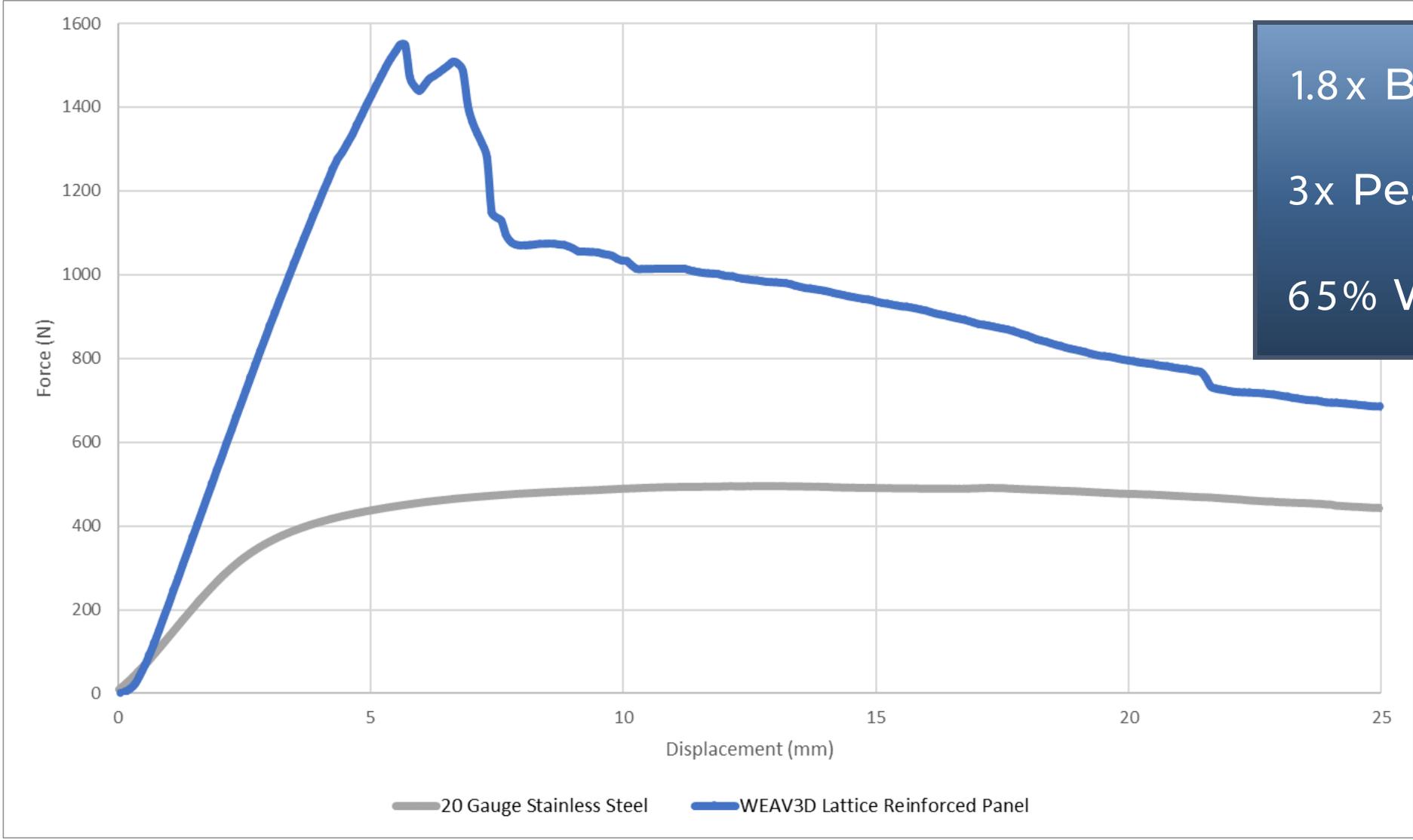


	Material
Organosheet	2/2 Twill Laminate – CF/PA6

	Bulk	Lattice
Design A	Unfilled T14003F PP	GF/PP
Design B		CF/PP
Design C		CF/PP
Design D		GF/CF/PP

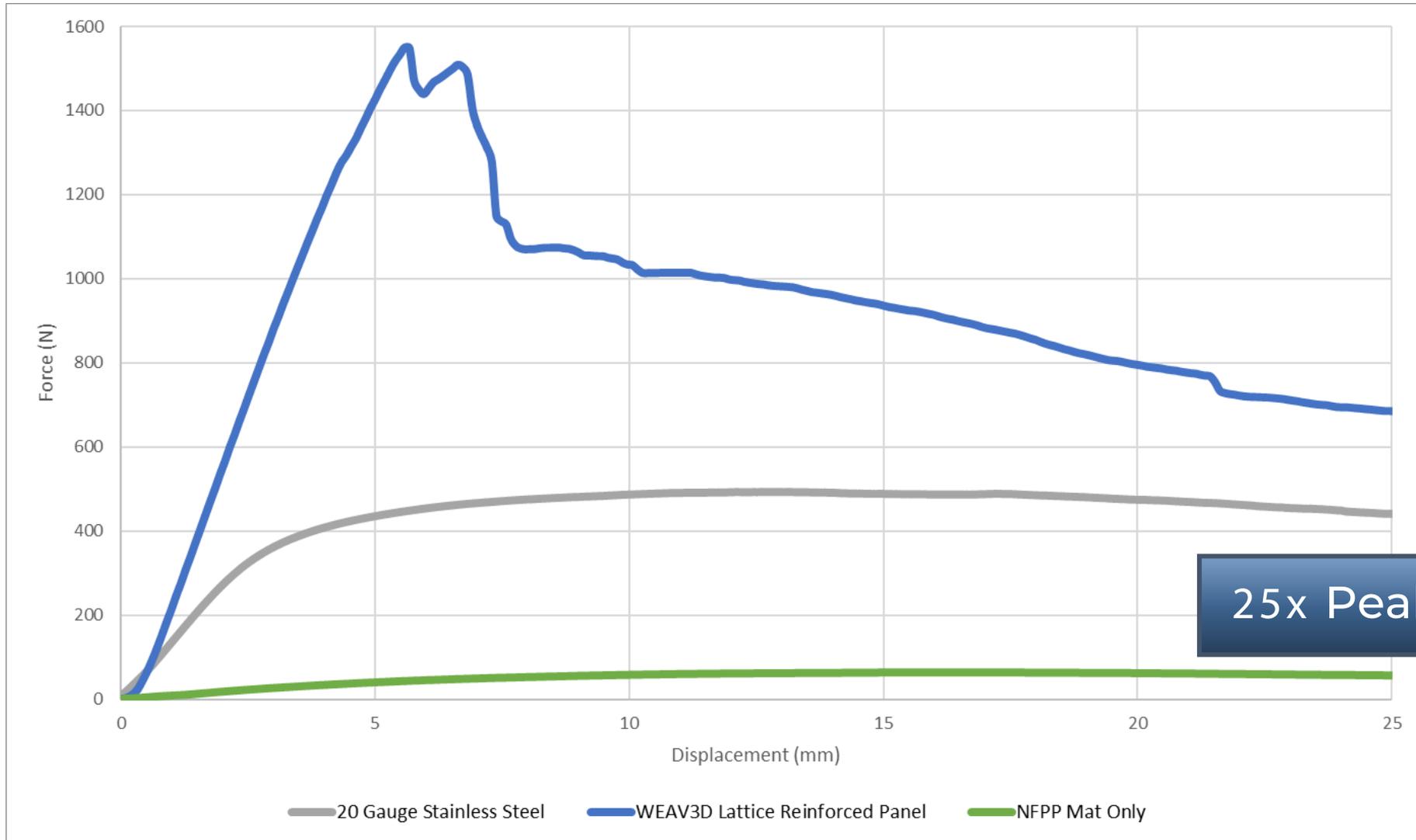
— Organosheet — Design A — Design B — Design C — Design D

# Steel Equivalence Comparison



1.8x Bending Stiffness  
3x Peak Load  
65% Weight Reduction

# Steel Equivalence Comparison

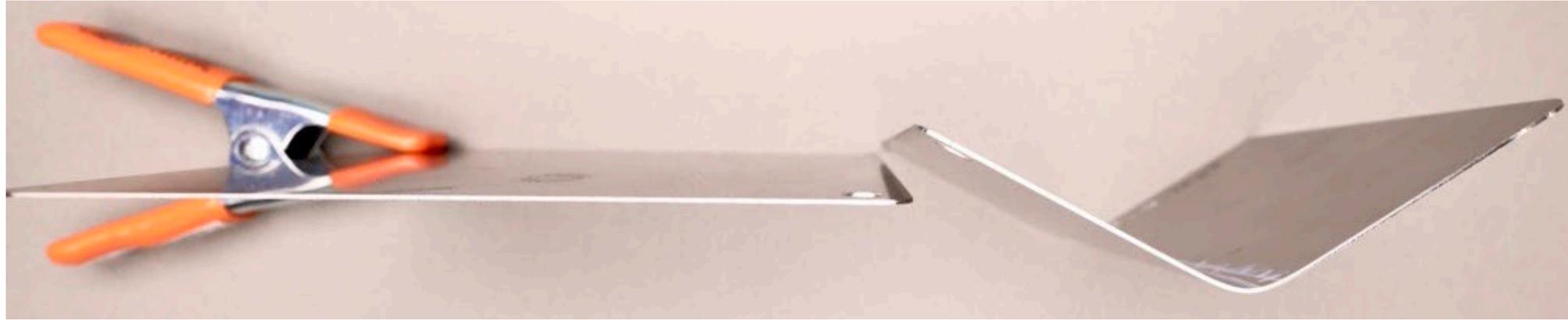


25x Peak Load vs. NFPP

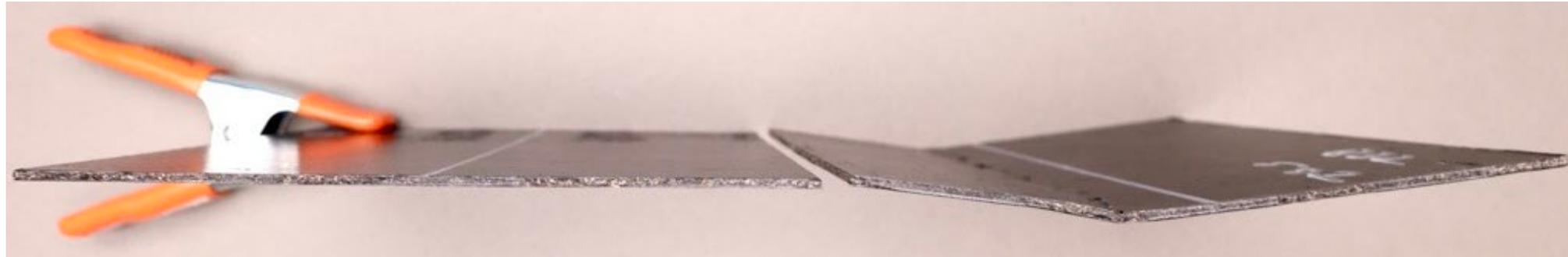
# Steel Equivalence Comparison



**20 Gauge  
Stainless Steel  
(0.95mm)**



**WEAV3D Reinforced  
(2.1 mm)**



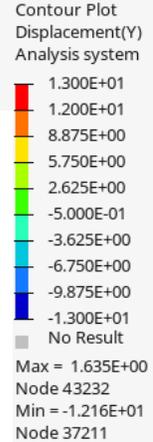
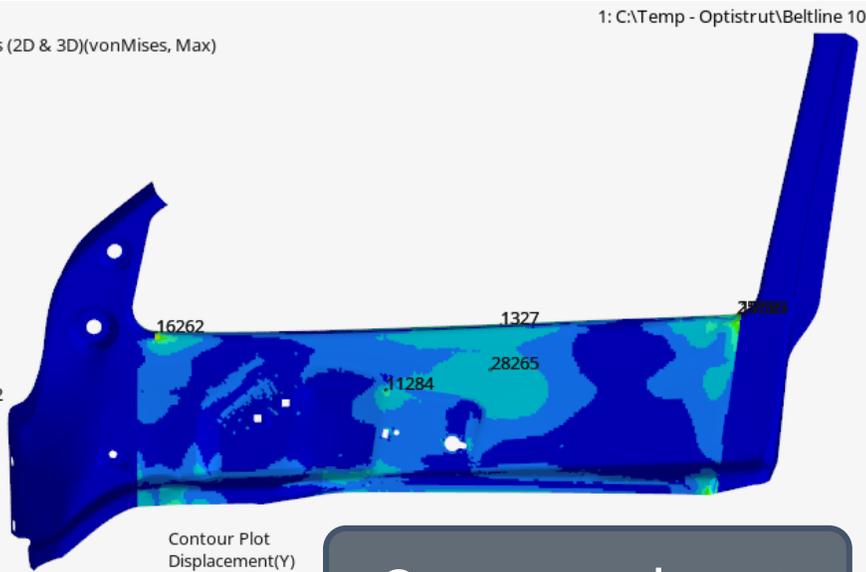
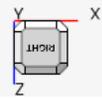
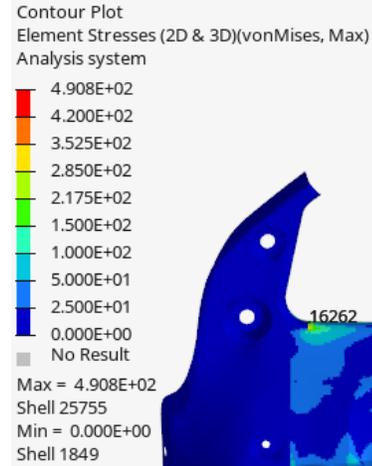
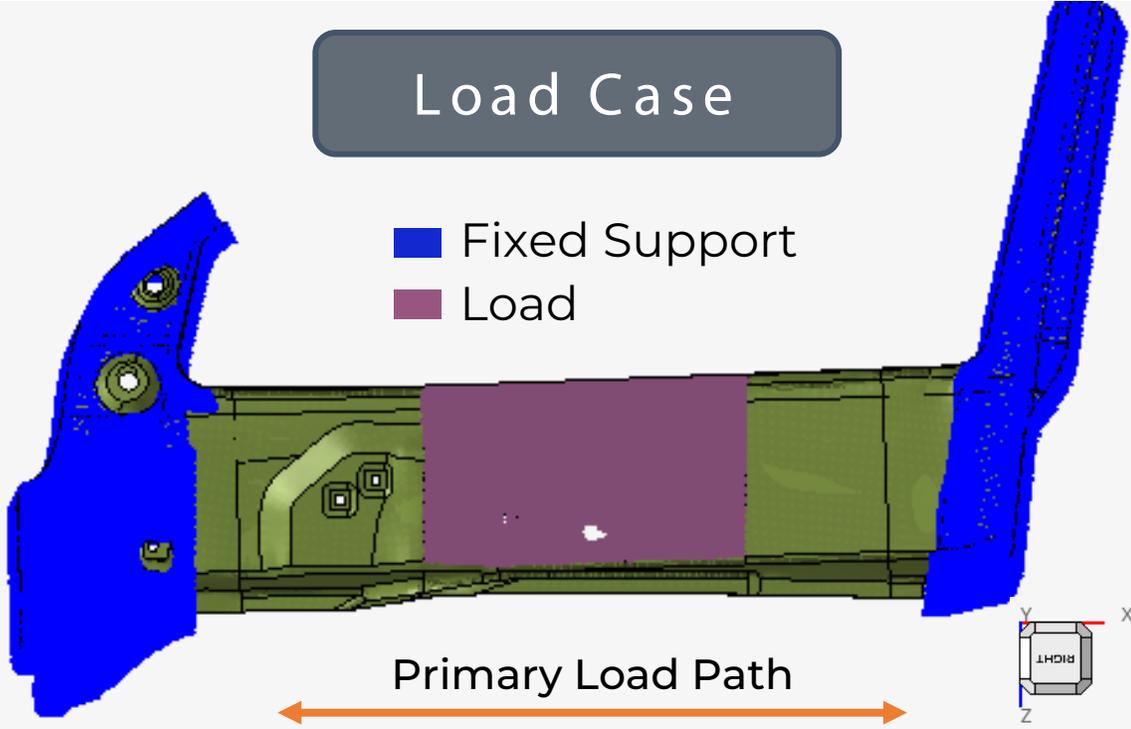
Before Test

After Test

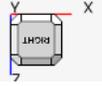
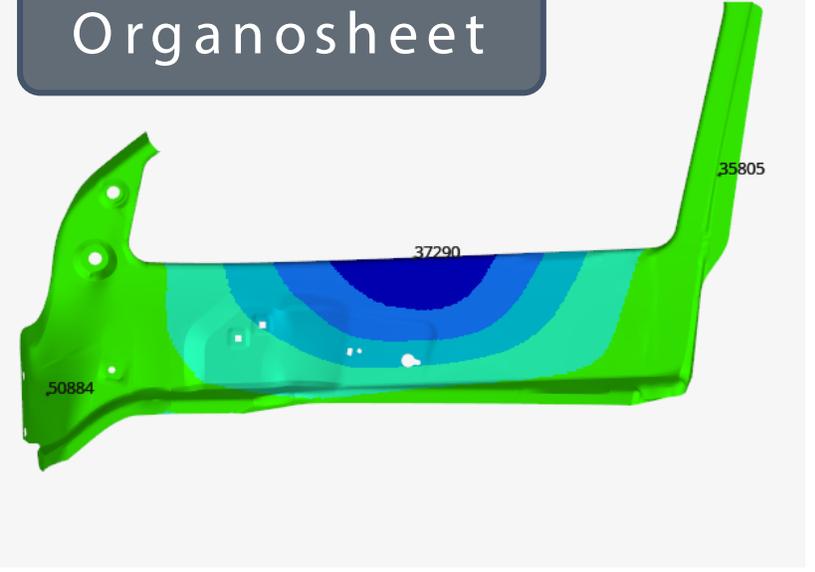


## Load Case

- Fixed Support
- Load



## Organosheet





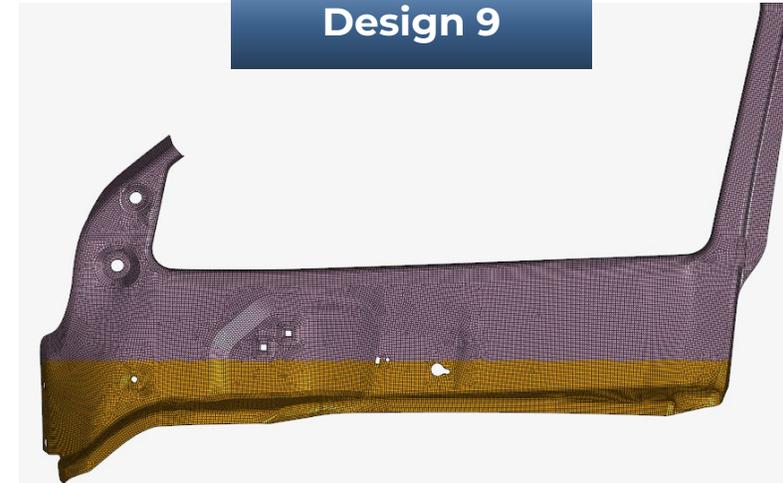
Design 7



Design 8



Design 9

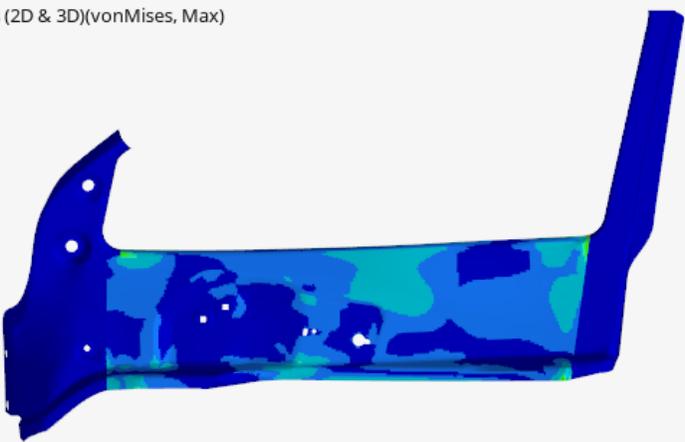
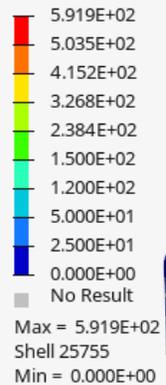


**2-Layer 100% Dense (Alternating)  
Glass and Carbon**

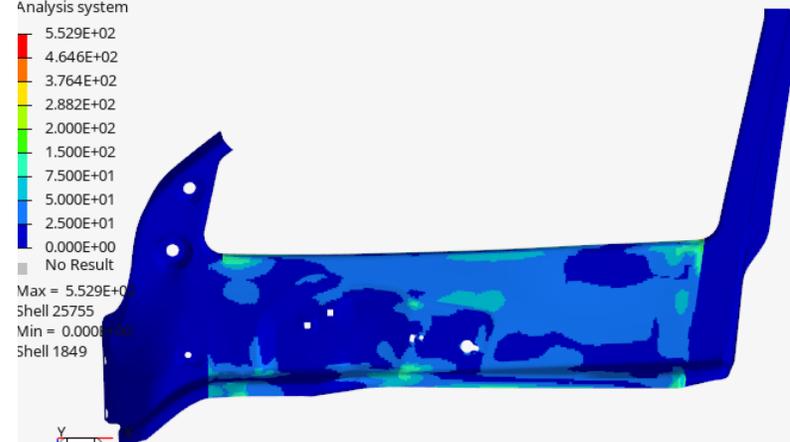
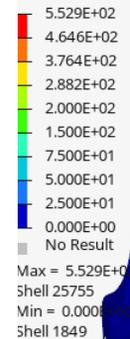
**2-Layer 100% Dense  
Carbon Inner, Glass Outer**

**2-Layer 100% Dense Carbon Upper  
2-Layer 100% Dense Glass Lower**

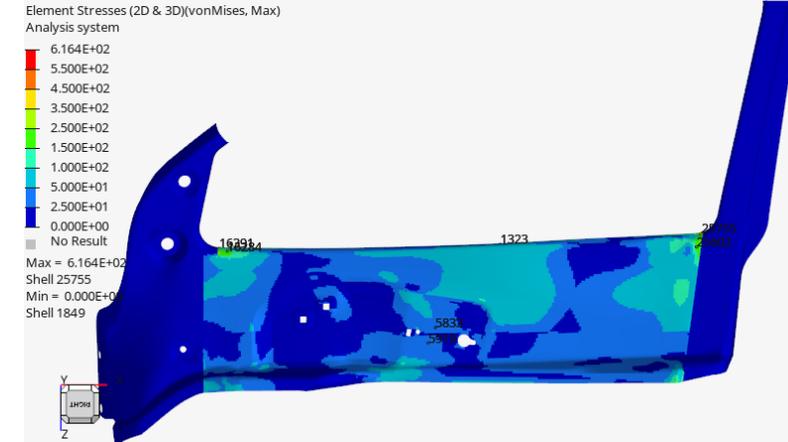
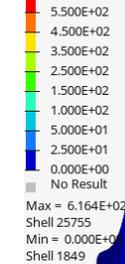
Element Stresses (2D & 3D)(vonMises, Max)  
Analysis system



Analysis system



Element Stresses (2D & 3D)(vonMises, Max)  
Analysis system





## Organosheet Cost Model

- **Materials Cost**
- Tooling Cost
- Equipment Cost
- Labor Cost
- Energy Cost
- Overhead + Profit



## Lattice Reinforced Beltline Cost Model

### Polypropylene Sheet

- Materials Cost
- Extrusion Cost

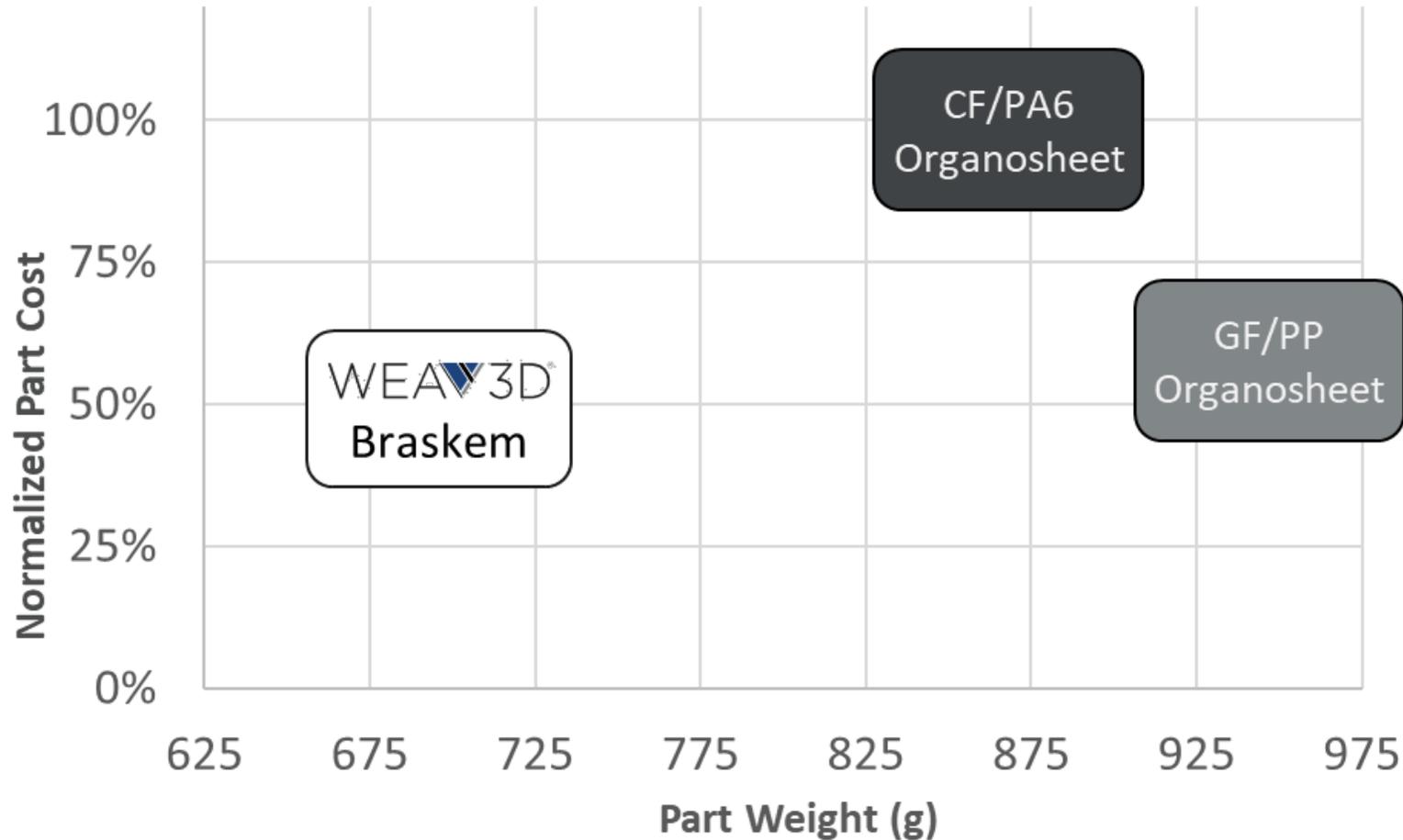


### Lattice Forming

- Materials Cost
- Lamination Cost

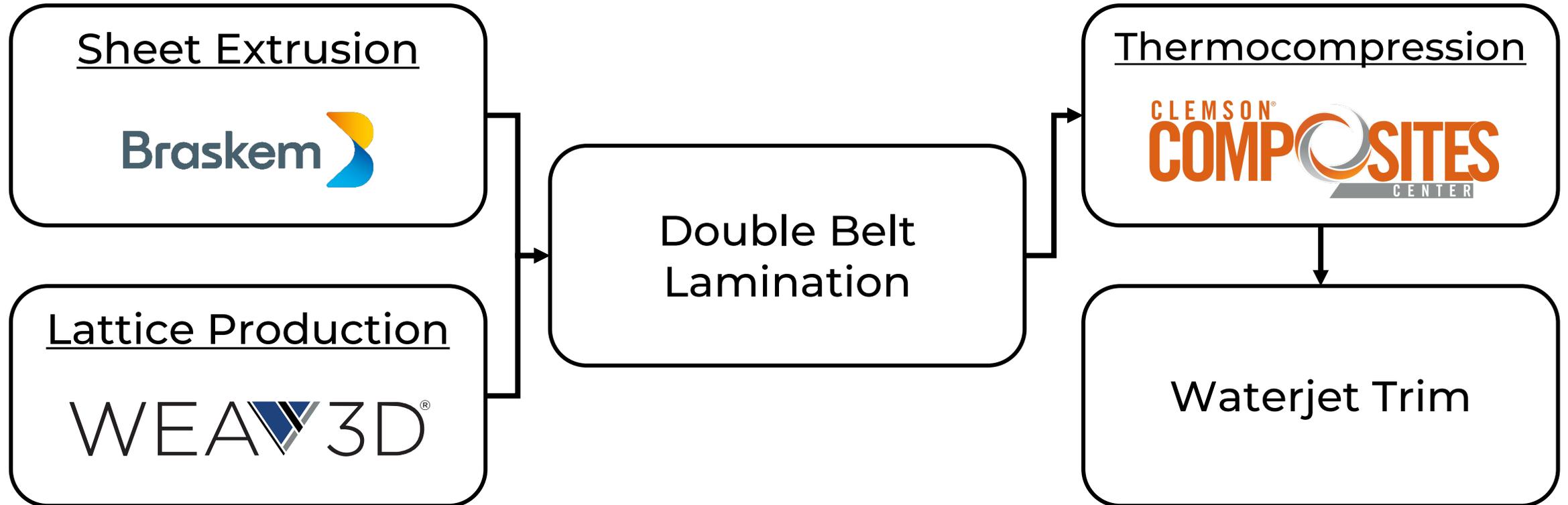


# Cost Advantages over Organosheet



Relative to CF/PA6 baseline, WEAV3D lattice optimization:

- Reduced part weight (-23%)
- Reduced cost (-50%)
- Increased trim yield from 27% to 44% by weight
- Reduced trim waste (-62%)





WEAV3D®

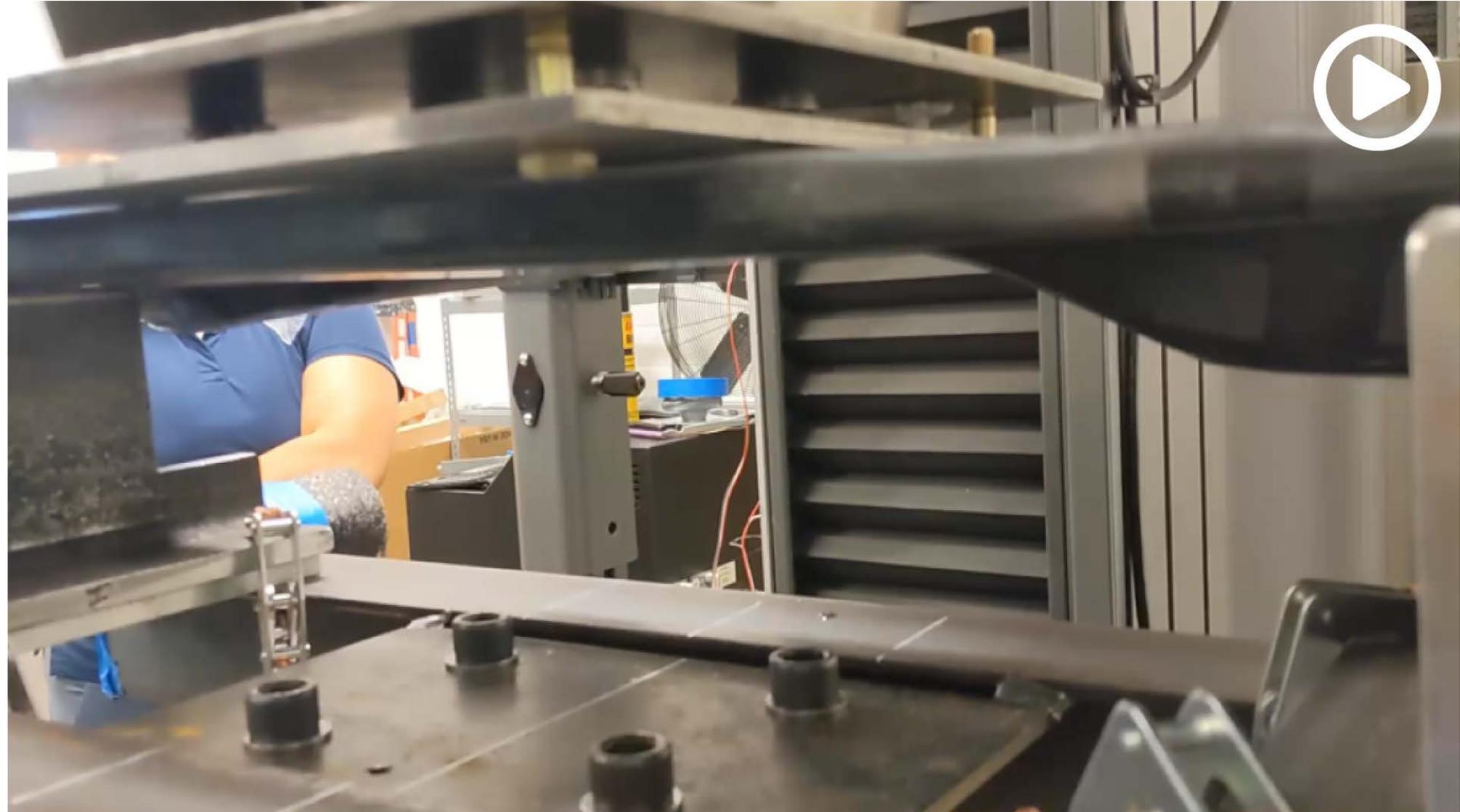
Cost-Effective Automotive Body Structures  
Beltline Stiffener Door Component



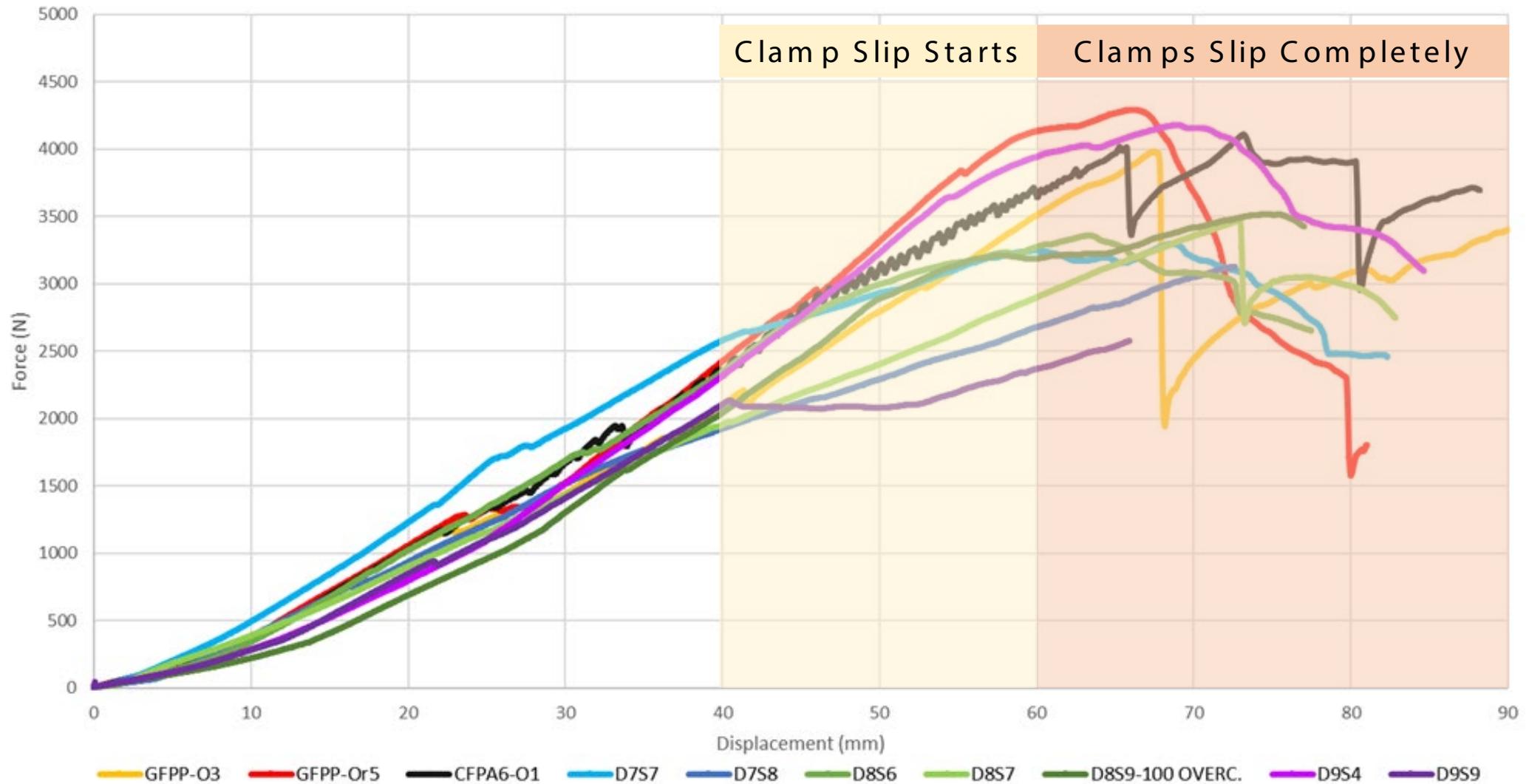
**B-Pillar Clamping**



**A-Pillar Clamping**



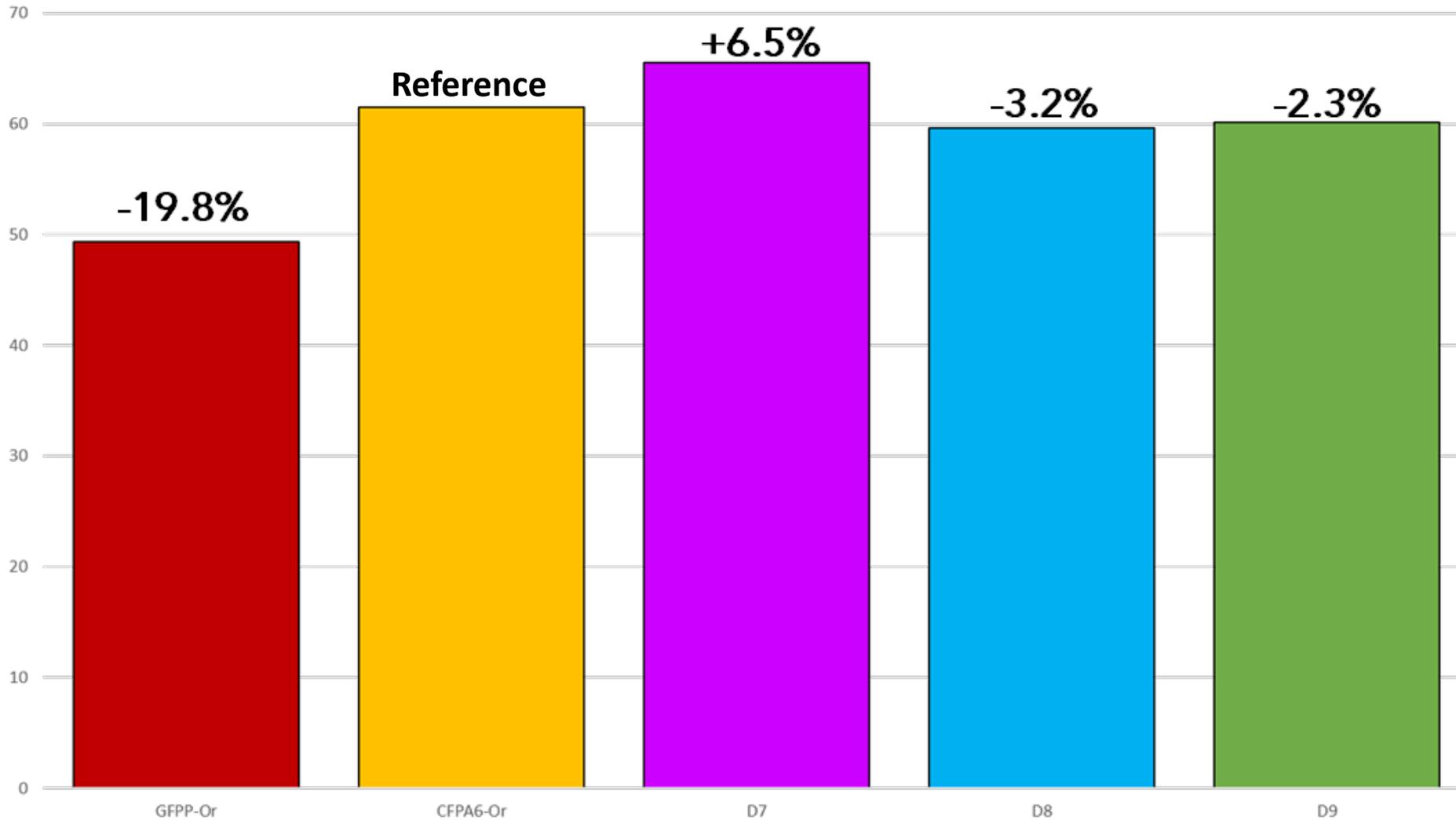
# Experimental Results



# Experimental Results

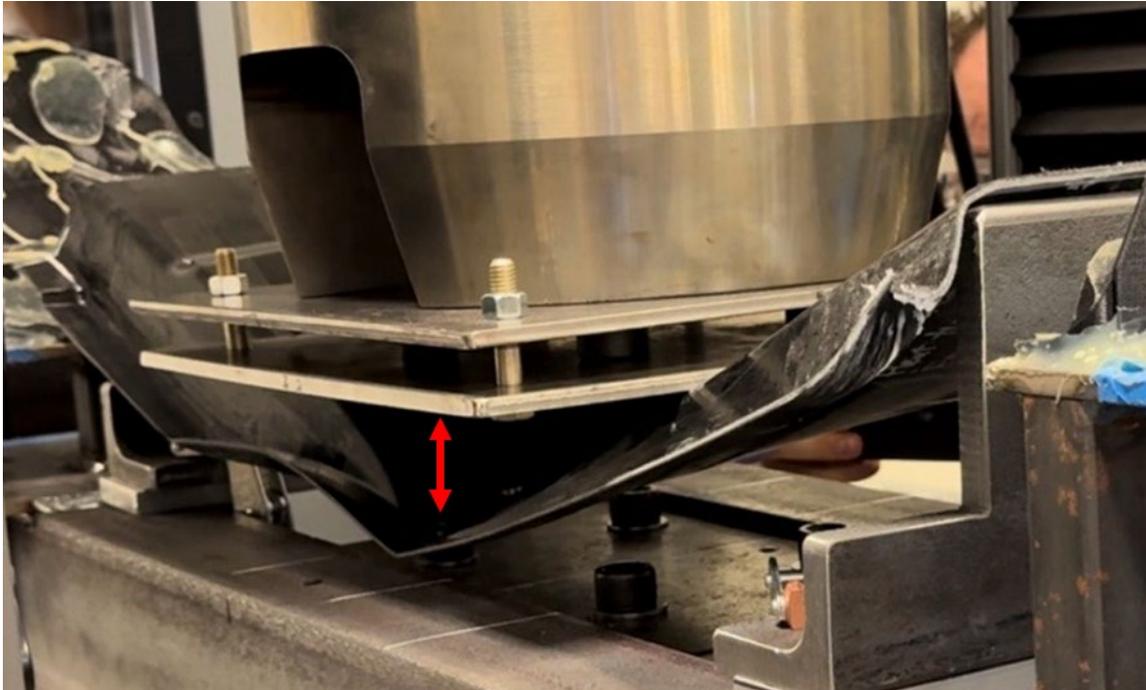


Full Size - Slope Averages (15-30mm)





## Boundary Conditions Simplified to Reduce Error



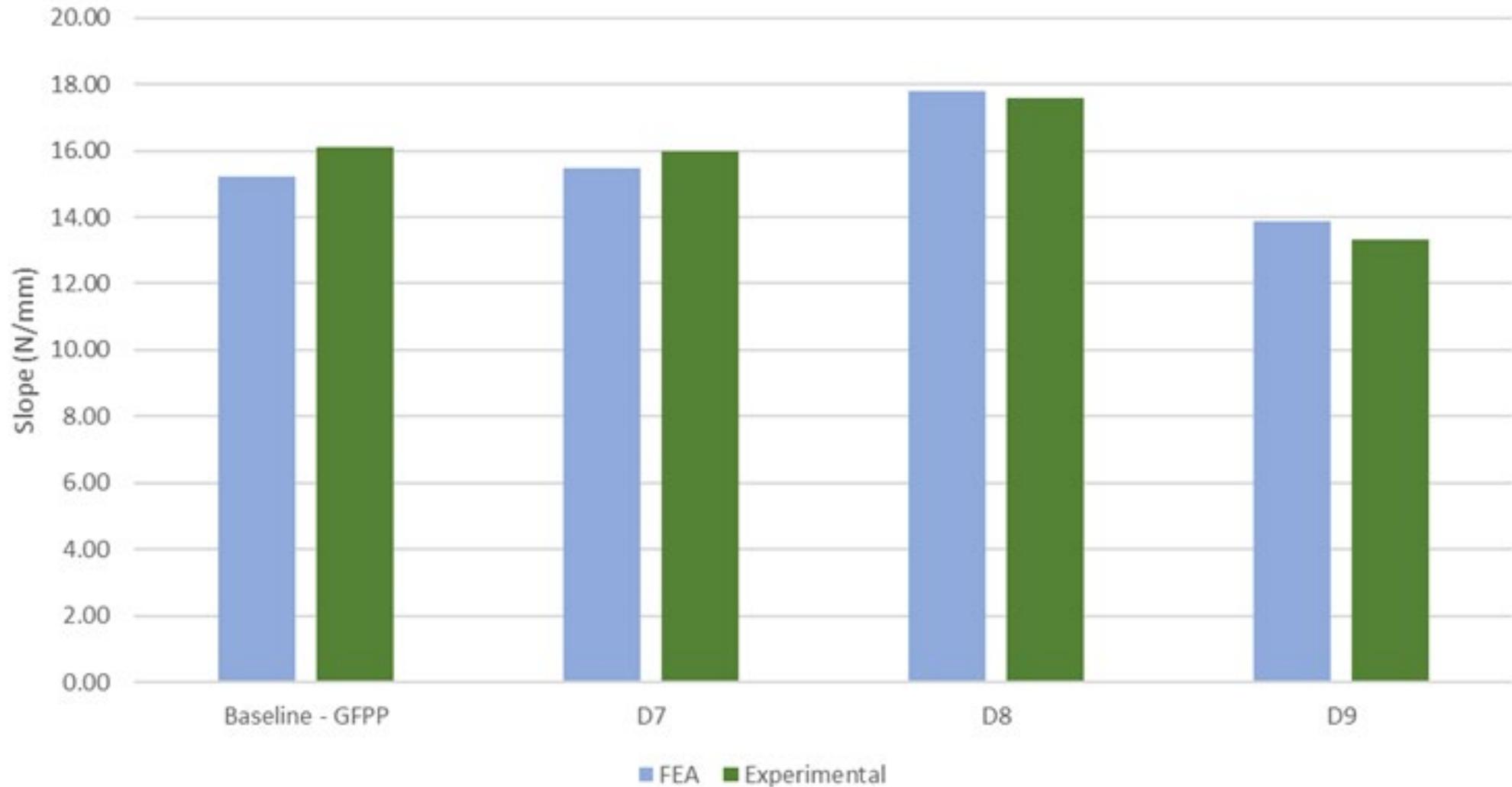
Simply Supported Load Case -  
Original Load Applicator

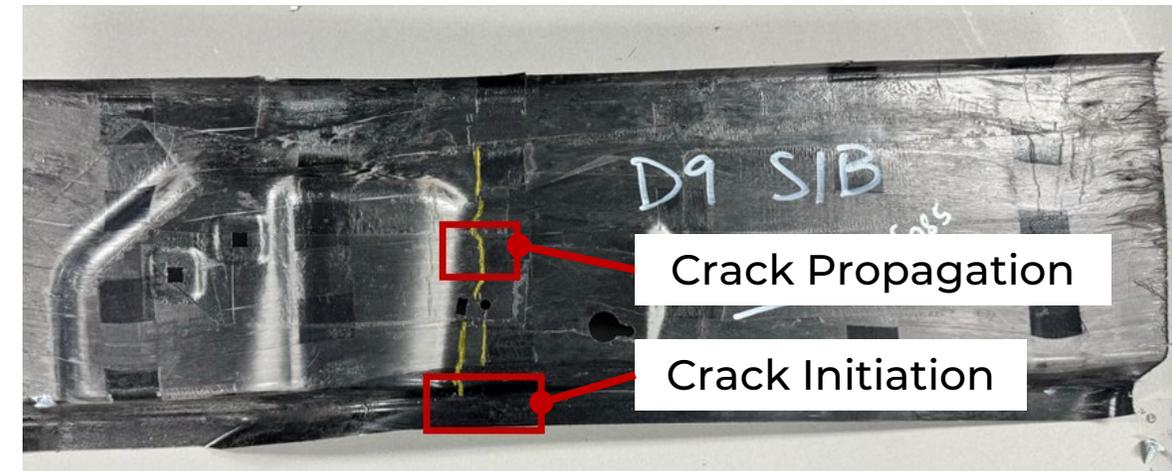
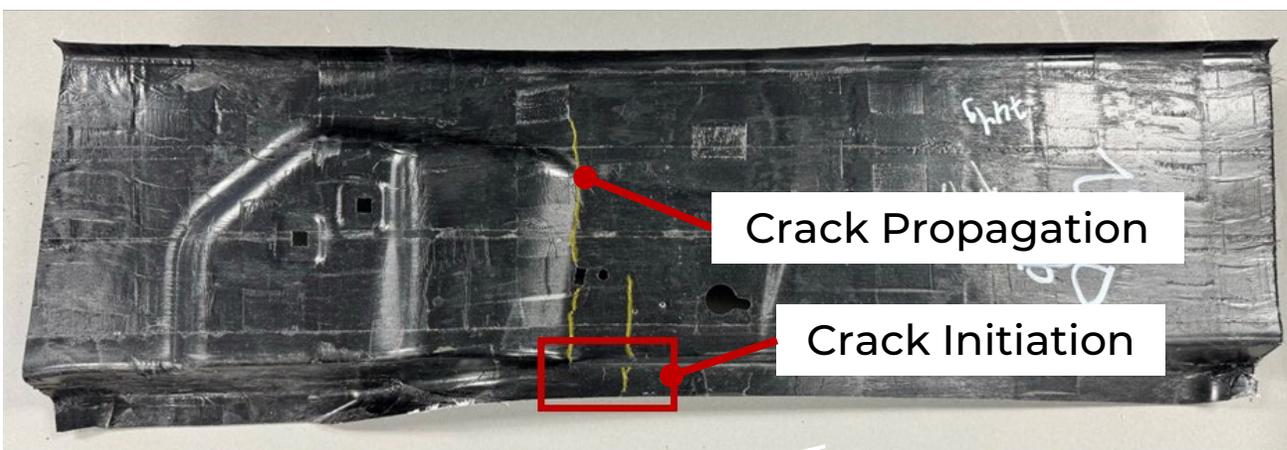
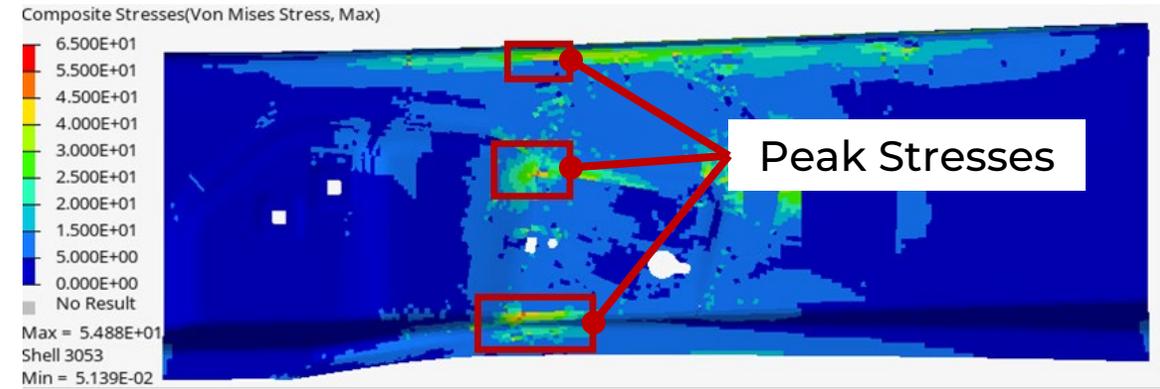
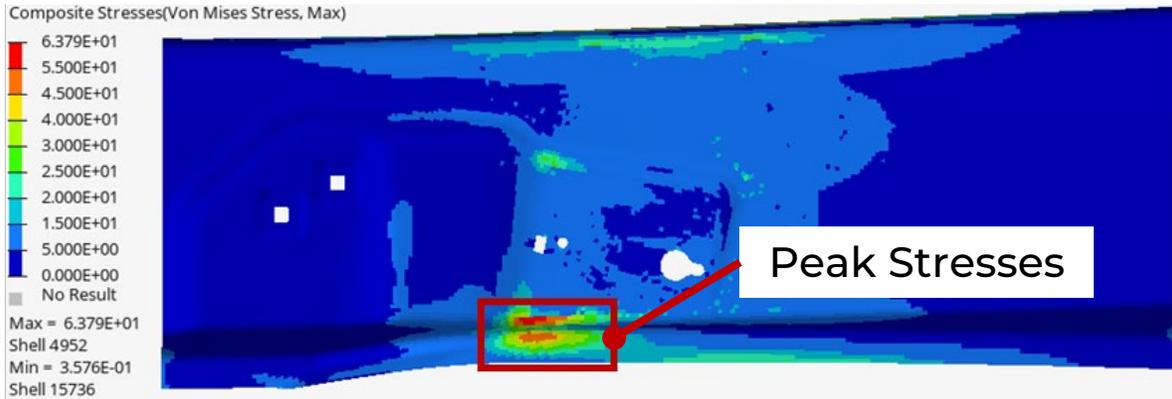


Simply Supported Load Case -  
Round Load Applicator

Reduce Part-Load Gap

# FEA Validation - Comparison





**Design 8**

2-Layer 100% Dense Carbon Inner, Glass Outer

**Design 9**

2-Layer 100% Dense Carbon Upper  
2-Layer 100% Dense Glass Lower



## Beltline Stiffener Demonstrator

1. 50% cost reduction from baseline (CF/PA6 organosheet)
2. Comparable performance in high-rate full-scale bending load case
3. 23% weight reduction from baseline
4. Good correlation between FEA and experiment in simplified load case

## Future Work

Partner with OEM to conduct crash test of full door assembly, with WEAV3D reinforced beltline stiffener



In Partnership with:

WEAV3D®

Braskem

CLEMSON®  
COMPOSITES  
CENTER

ALTAIR



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## CONTACT INFORMATION:

**Christopher Oberste**

WEAV3D Inc.  
info@weav3d.com  
770-759-1001

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