Structural Enhancement of Sustainable Materials

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WEAV3D®

SPE DETROIT CONFERENCE
TPO AUTOMOTIVE ENGINEERED POLYOLEFINS

Outline

- Tradeoffs of Sustainable Materials
- Hybrid Overmolding/Comolding – Rebar for Plastics®
- Benefits of Hybrid Material and Hybrid Length-Scale Composites
- Structural Enhancement of Sustainable Materials
- Conclusions
- Upcoming Publications

Tradeoffs of Sustainable Materials

BENEFITS
OF SUSTAINABLE MATERIALS

- LOW DENSITY
- GOOD NVH DAMPING
- LOW EMBODIED CARBON

DRAWBACKS
OF SUSTAINABLE MATERIALS

- HIGH VARIABILITY
- LOWER PERFORMANCE
- HIGHER COST

Natural fiber reinforced plastics will be the primary focus of this presentation

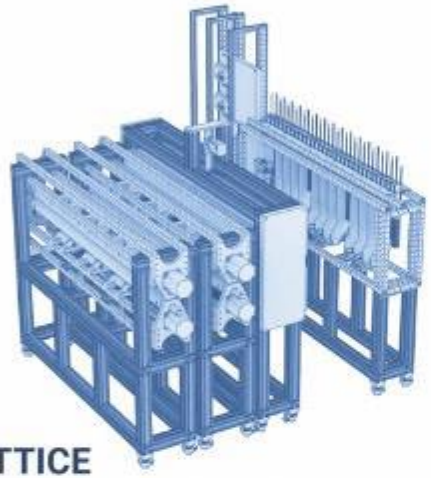
Rebar for Plastics®

Process Overview

THERMOPLASTIC PREPREG TAPE
Commercially Sourced

LIGHTWEIGHT STRUCTURAL COMPOSITE PART

US Pat 11,473,223 and International

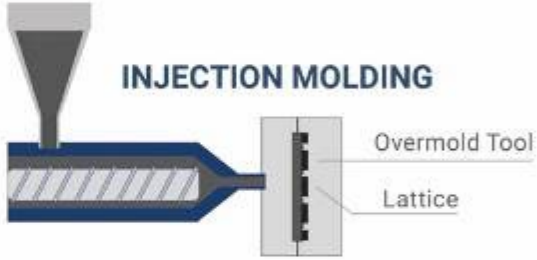


LATTICE WEAVING & CONSOLIDATION

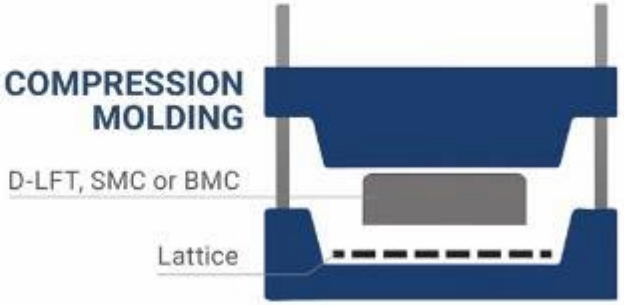
WEAV3D Process

Standard Molding Processes

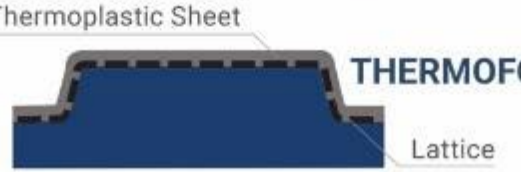
INJECTION MOLDING



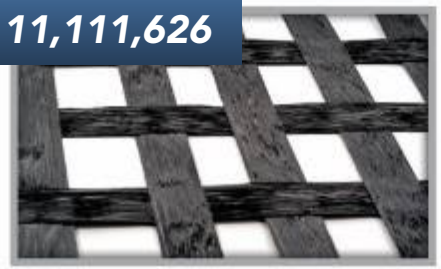
COMPRESSION MOLDING



THERMOFORMING



WEAV3D Product US Pat 11,111,626



TRIMMED COMPOSITE LATTICE

Why WEAV3D Composite Lattice?

LIGHTWEIGHT

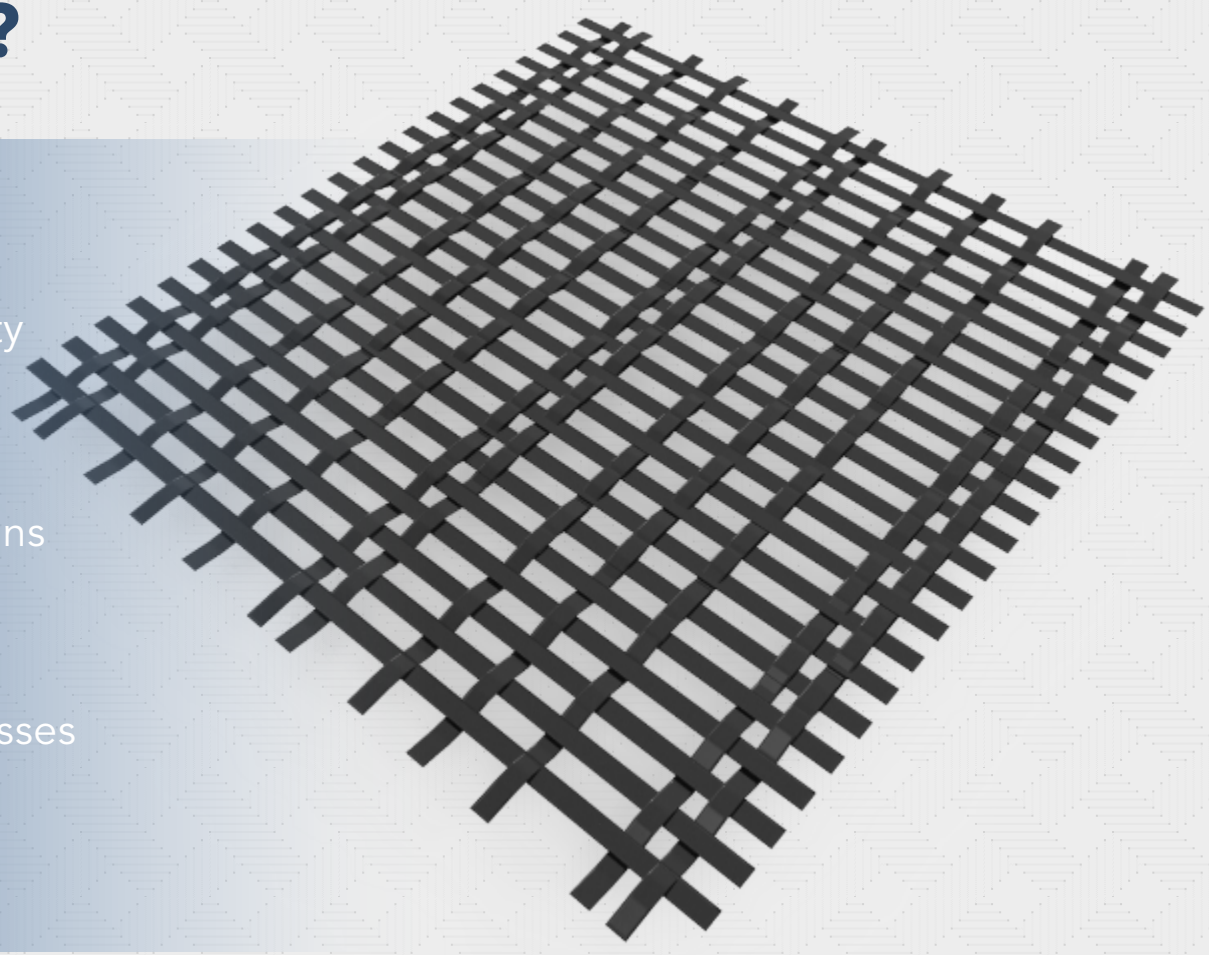
- 30% + weight reduction vs. existing solutions
- Locally optimized lattice density

COST-EFFECTIVE

- Automated continuous process
- Cost neutral vs. existing solutions
- Ability to mix tape types

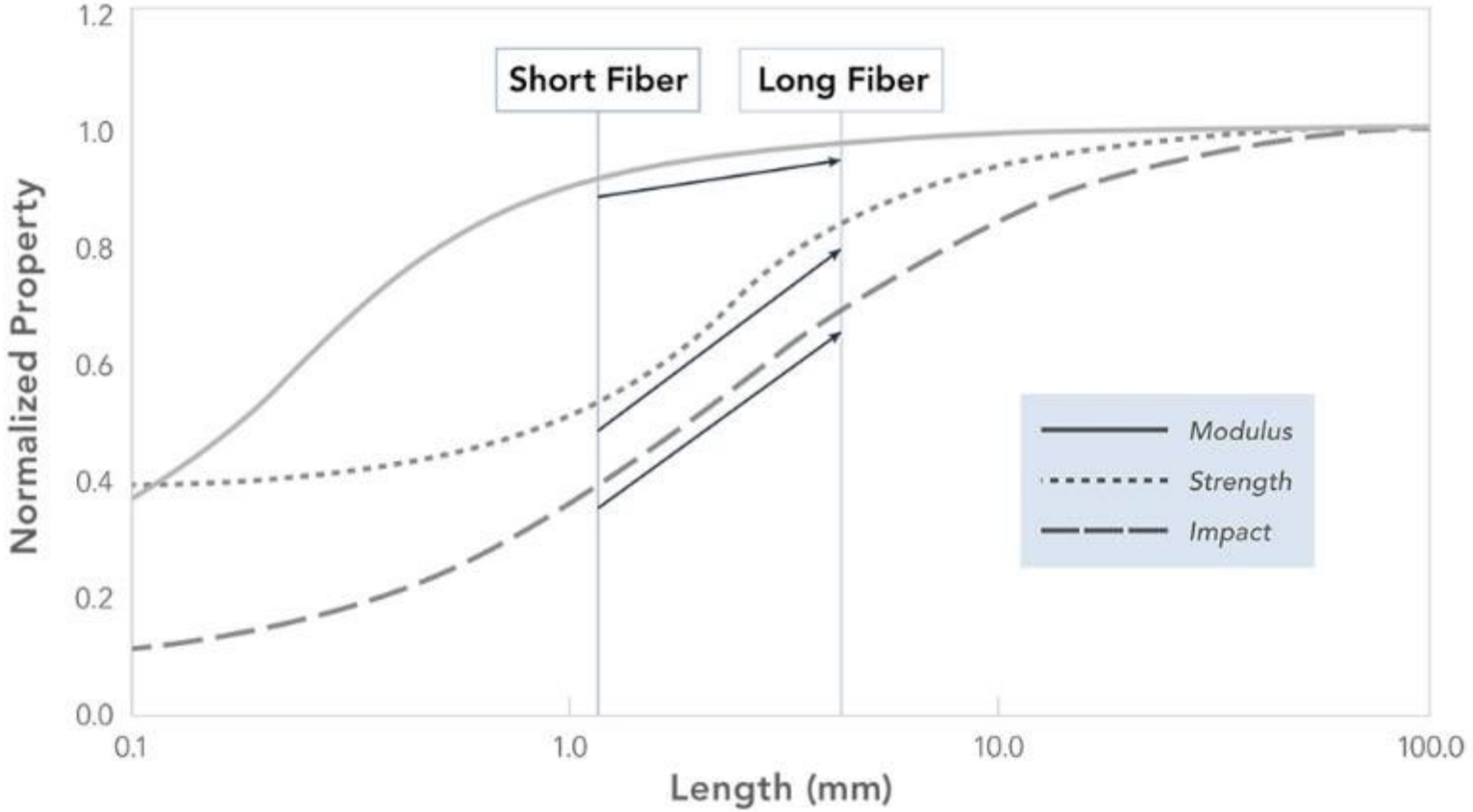
COMPATIBLE

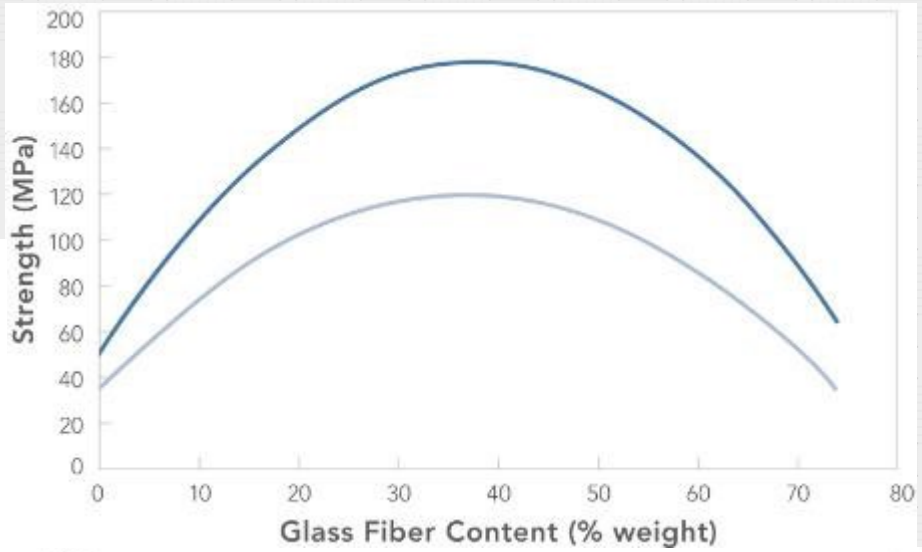
- Utilizes existing molding processes
- Sheet or roll format
- Choice of composite tape

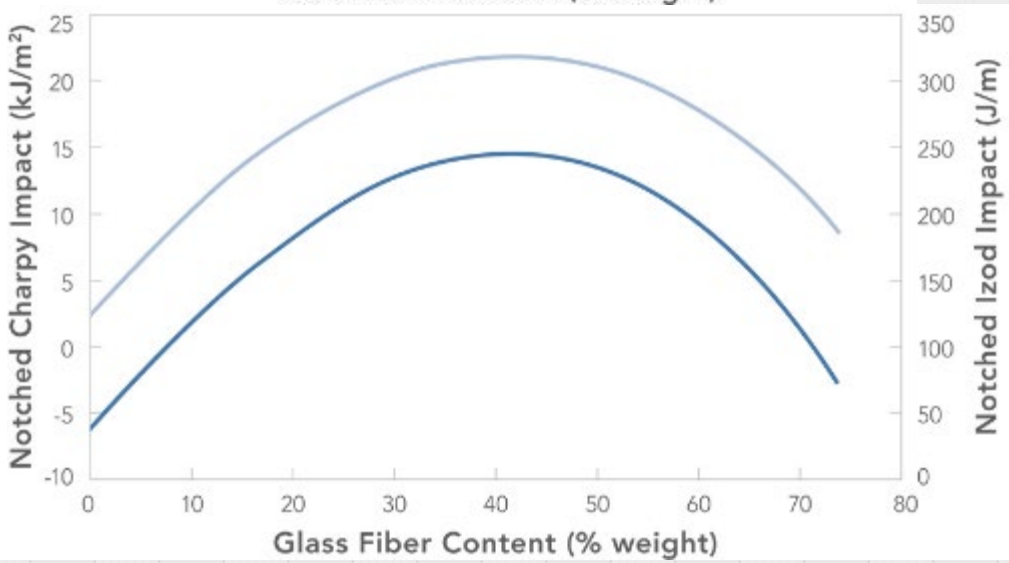


Strategic use of UD tapes in lattice provides a cost-effective and adaptable solution

Why Hybrid Materials?



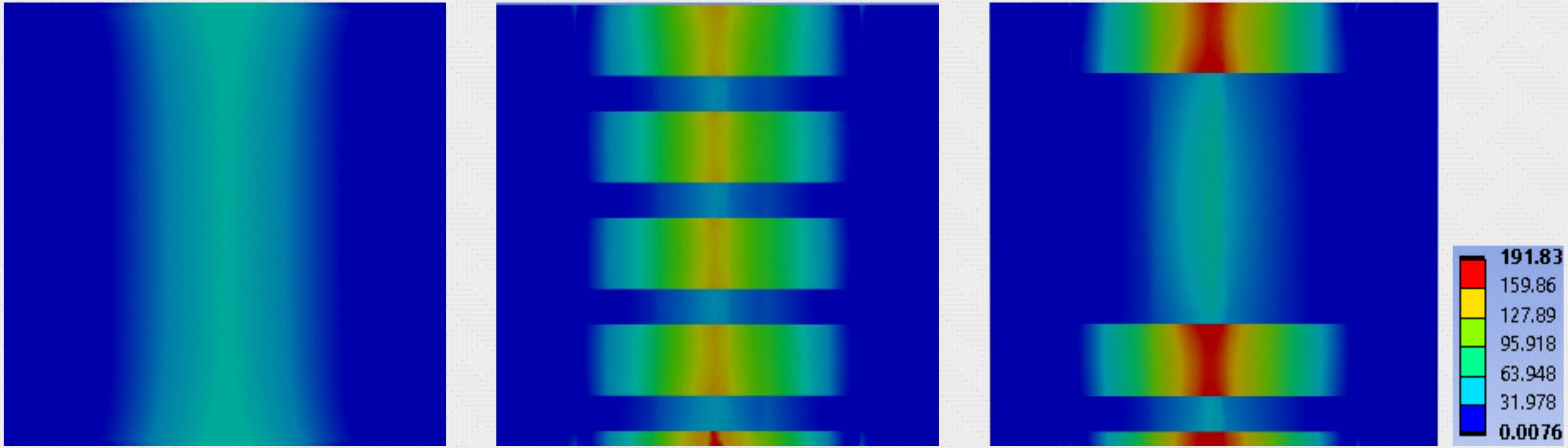




Independently tailorable modulus, strength, and impact performance

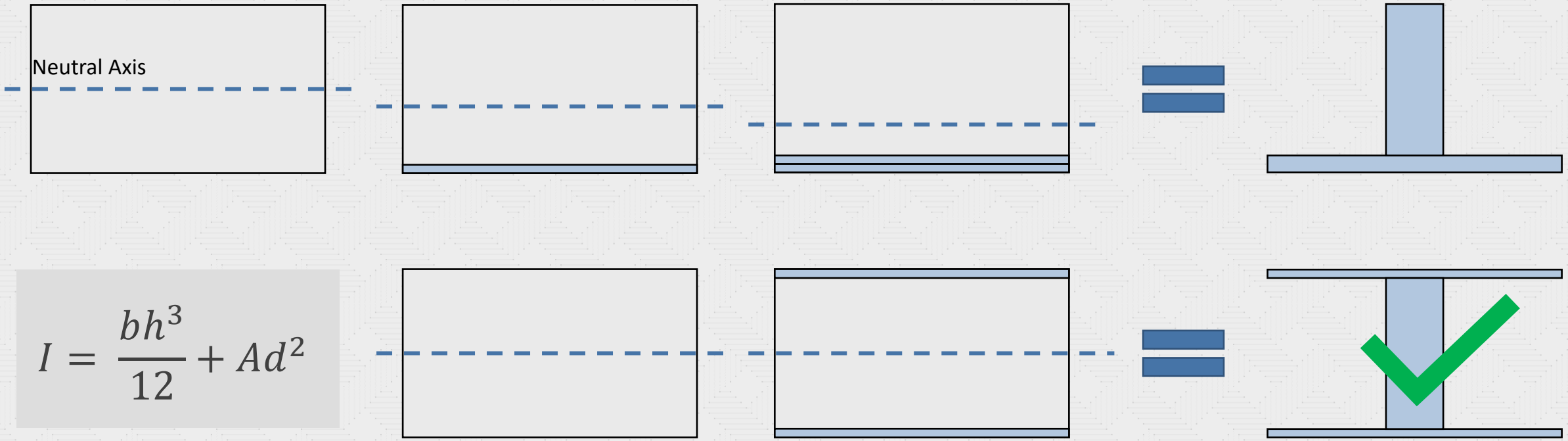
Ref: Thomason (2002, 2005) – Studies on Long Glass Fiber PP and PA6

Stress Concentration of Lattice Reinforcement



Lattice concentrates stress away from molded plastic

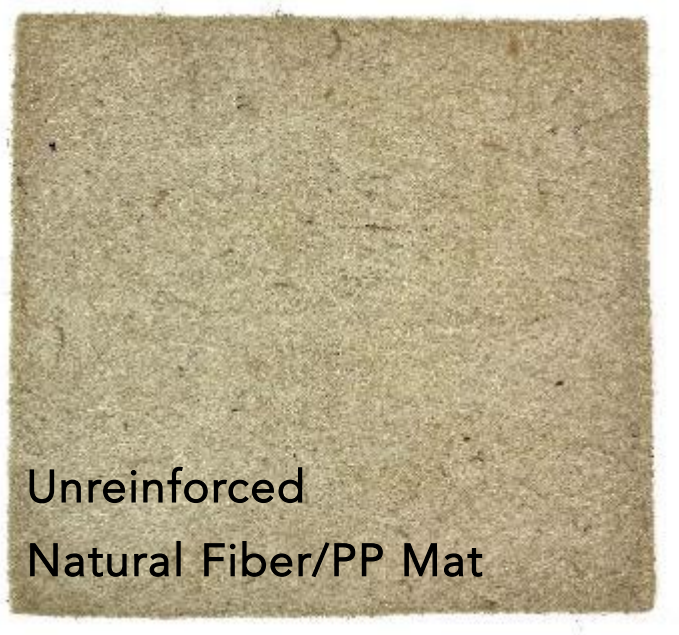
Single vs. Double Sided Panels



$$I = \frac{bh^3}{12} + Ad^2$$

Double sided designs yield better performance for the same material cost

Lattice Reinforcement for Natural Fiber Panels



2-Sided Lattice Reinforced Panel

357% STIFFNESS

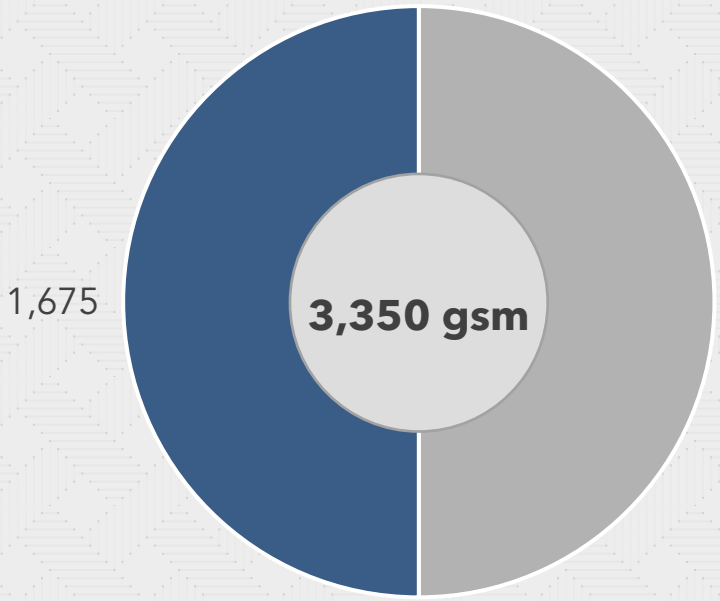
226% STRENGTH

	Unreinforced Panel	WEAV3D Reinforced: 1-Sided	WEAV3D Reinforced: 2-Sided	50% Long Glass-Filled PP
Flex Stiffness	2.88 GPa	**5.55 Gpa**	**13.2 GPa**	**13 GPa**
Flex Strength	50 Mpa	**83 Mpa**	**164 MPa**	**191 MPa**
Weight	1,600 gsm	1,900 gsm	2,300 gsm	**3,350 gsm (2.5mm panel)**

Sustainable Substitution: Long-glass performance with 30%+ weight savings

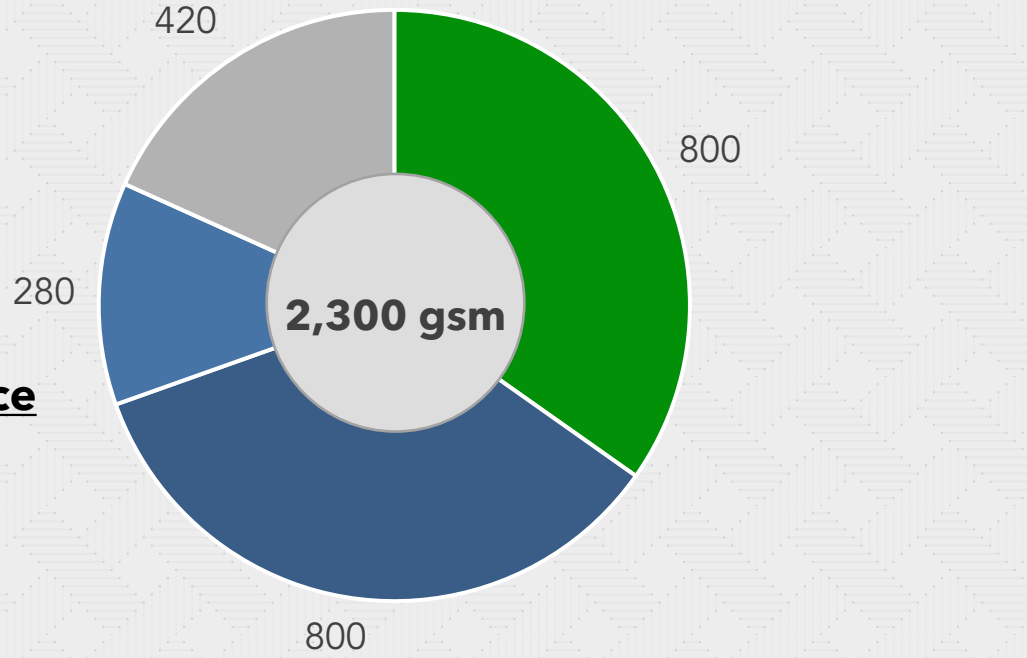
Reduction in Nonrenewable Content

50% GFPP



Equivalent Performance

WEAV3D 2-Sided NFPP



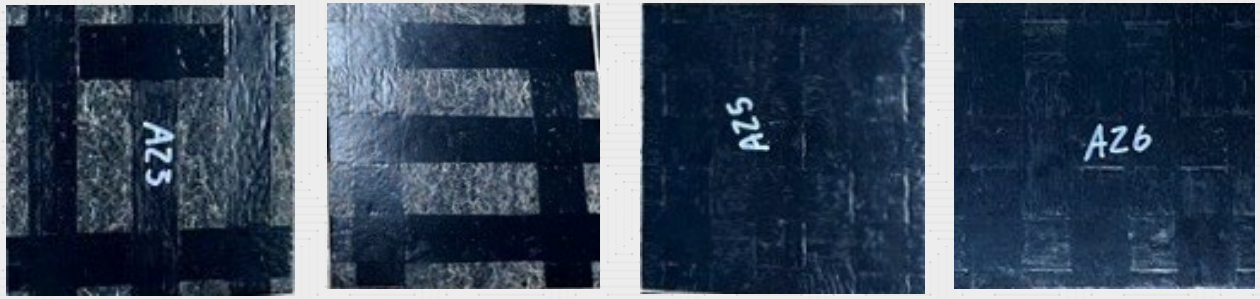
75% reduction in synthetic fiber reinforcement, 36% reduction in PP usage (by mass)

Sample Variables

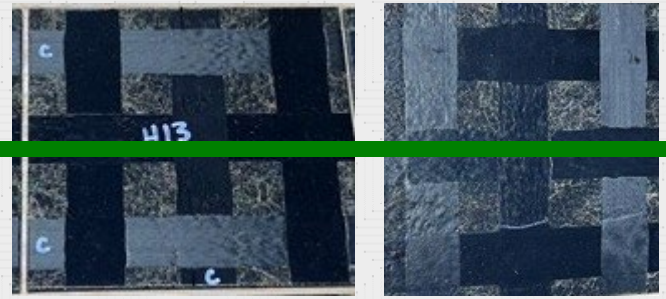
Control NFPP

Low Density | **Crimp Angle** | **High Density**

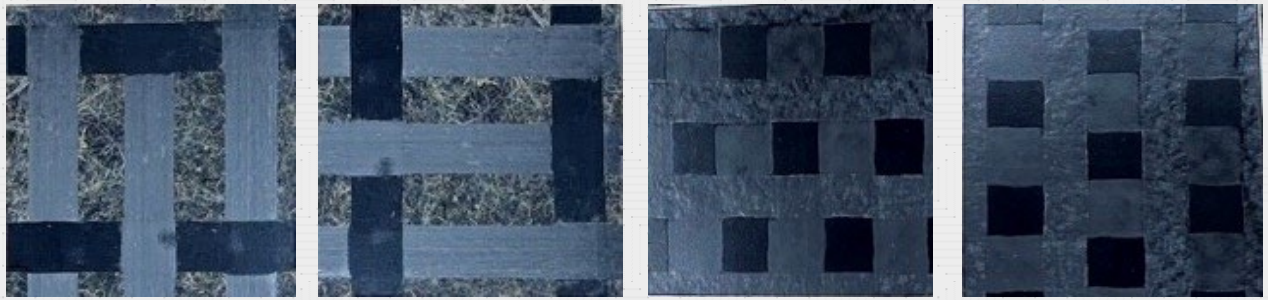
Glass Fiber



Flex Load Path



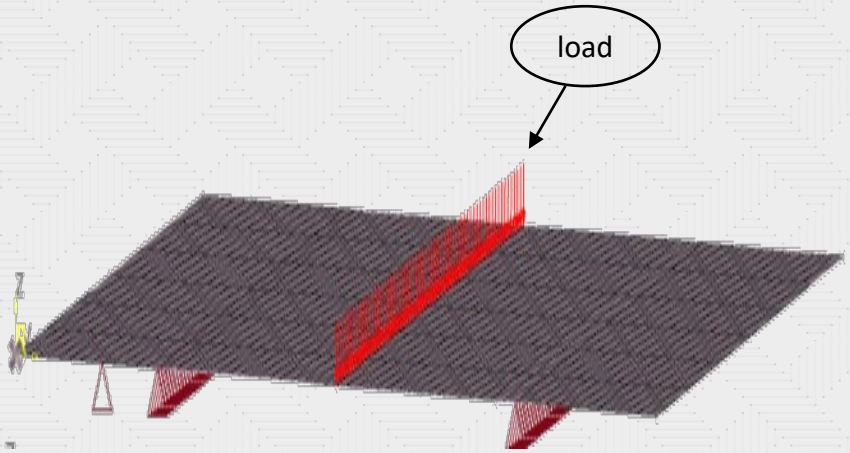
Carbon Fiber

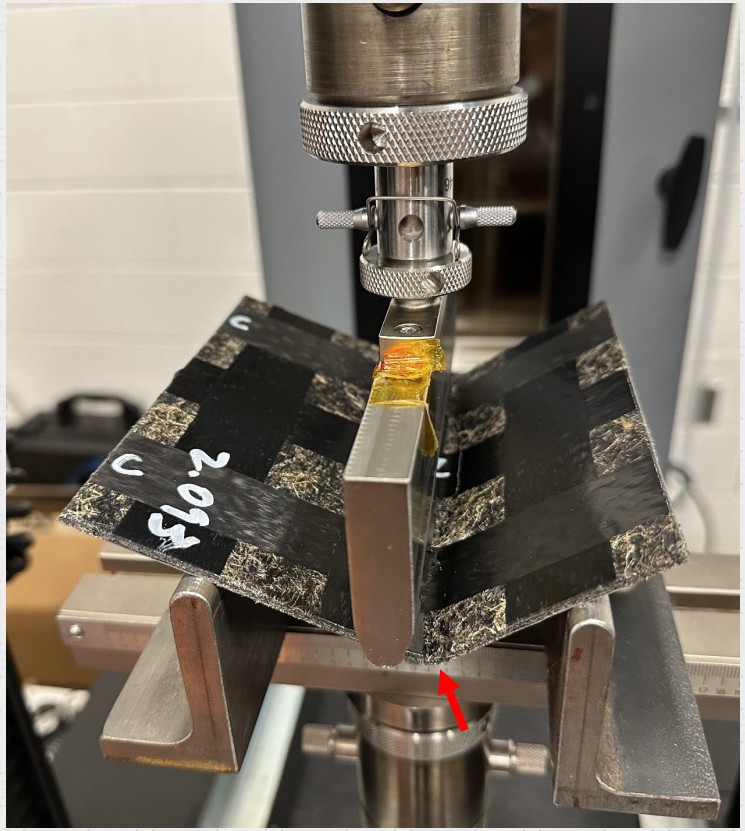


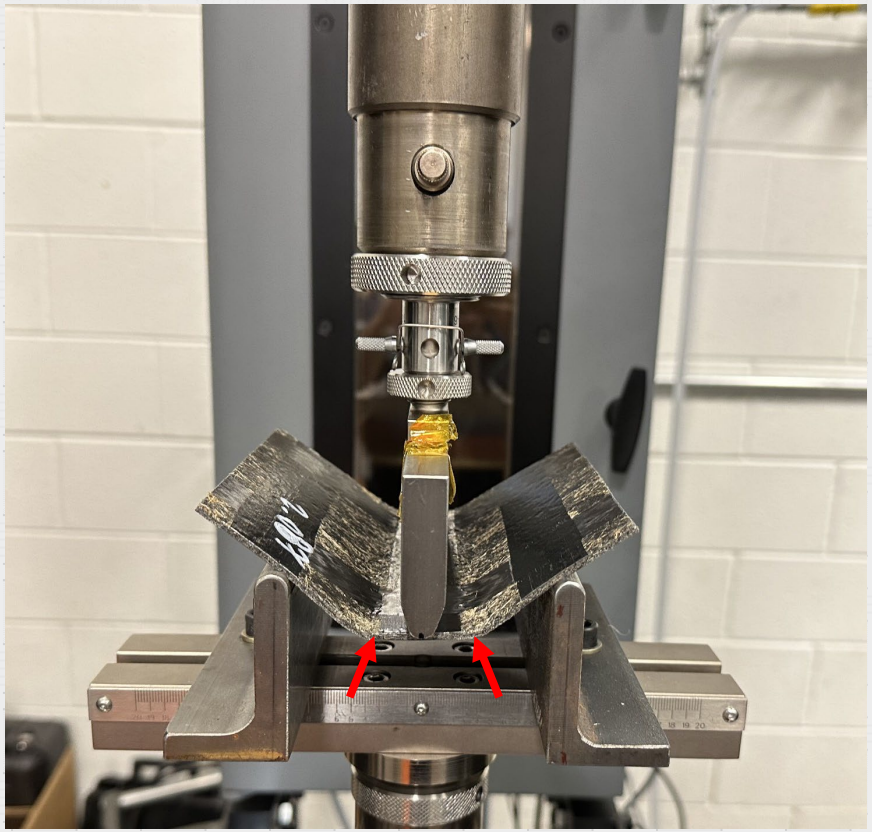
Hybrid CF/GF

NFPP mat (1000gsm) and nominal panel thickness (2.1mm) held constant

Test Setup

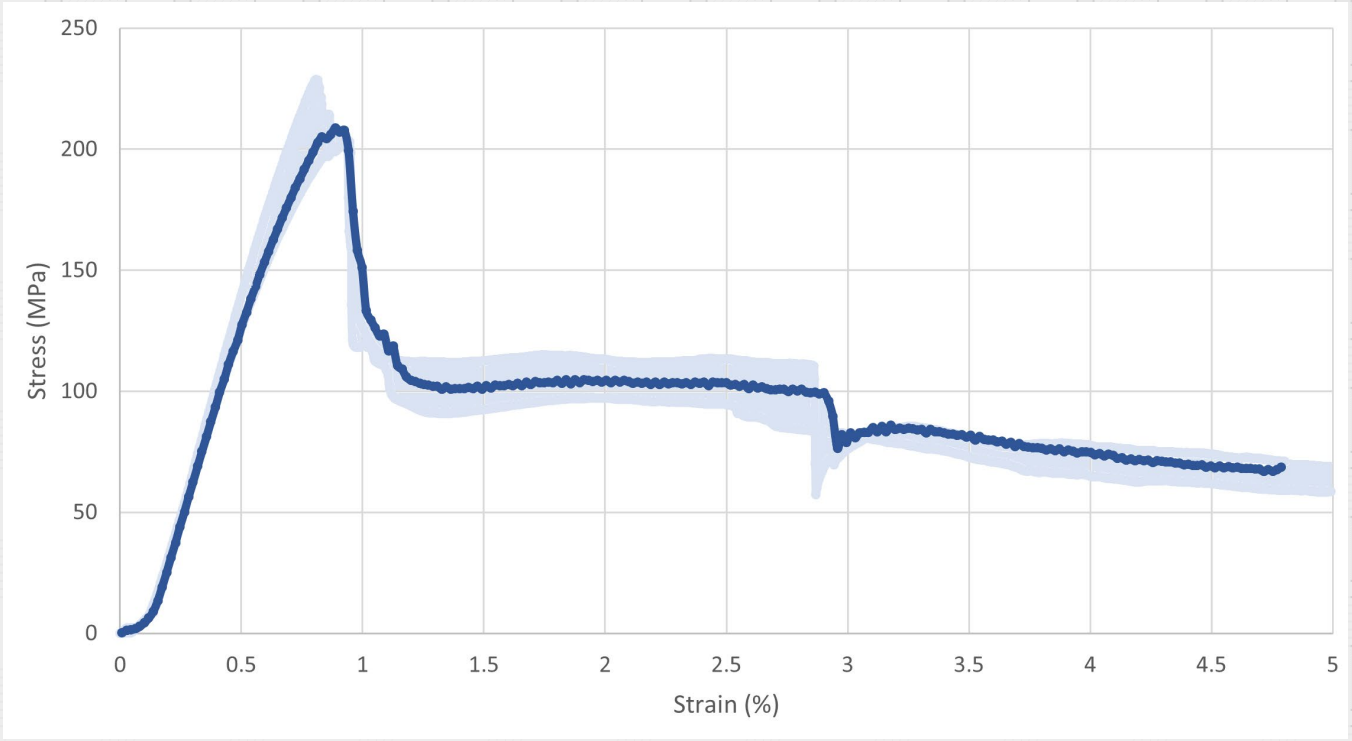




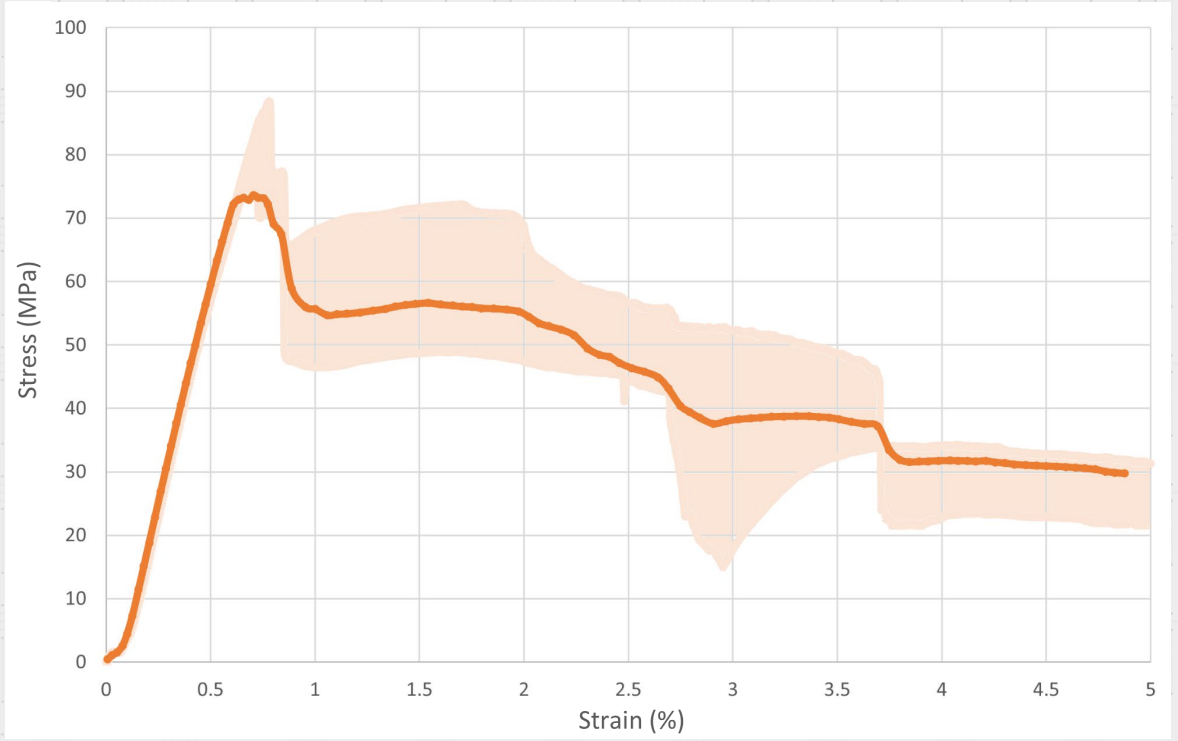


3pt Bend Load Case – Varying Failure Responses

Stress-Strain Curves – Averaging/Error



Example of consistent sample set

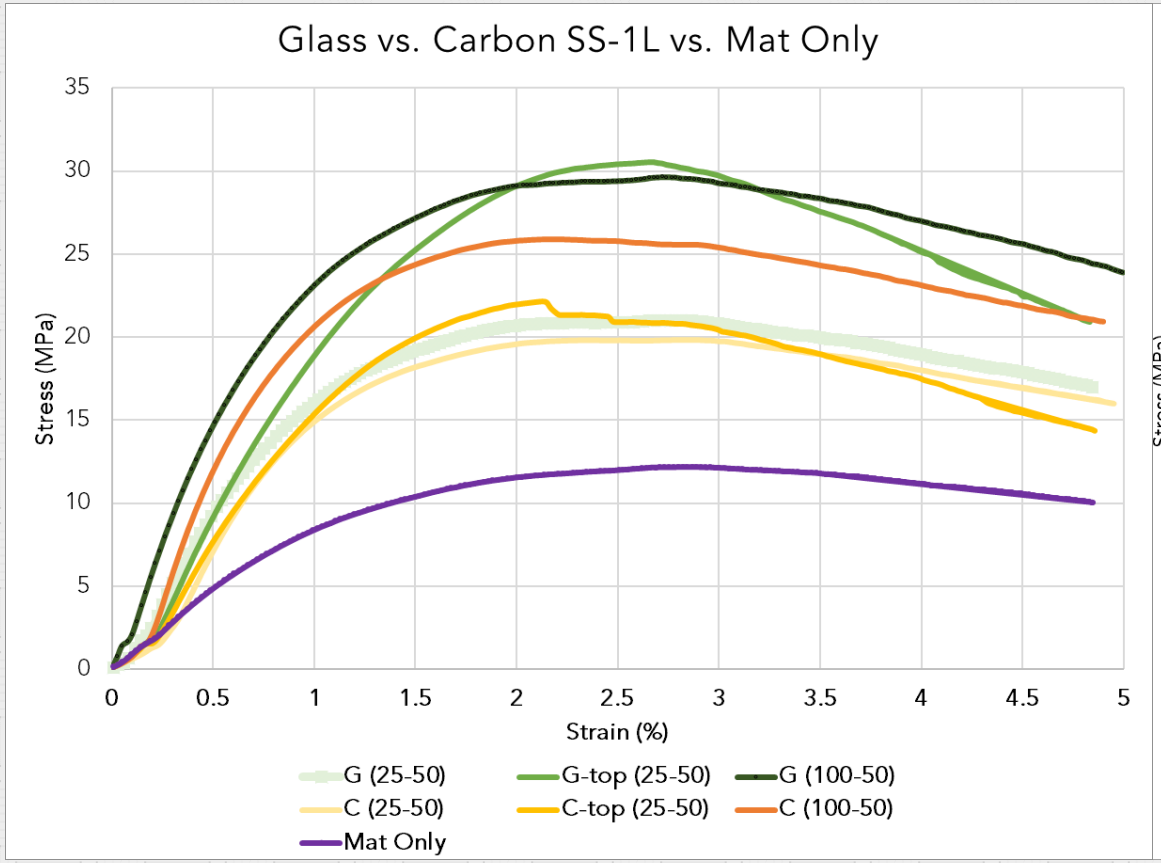


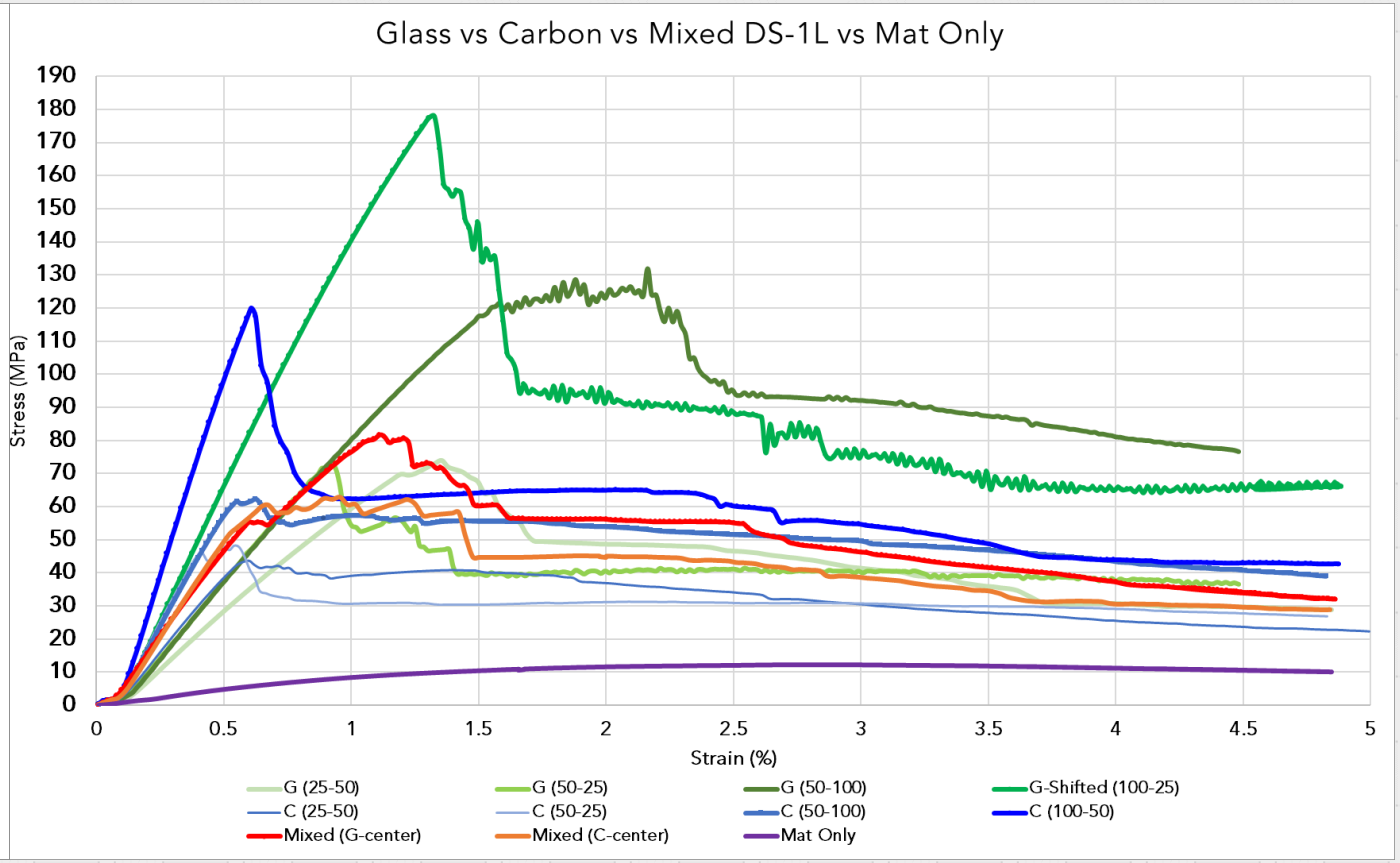
Example of inconsistent sample set

Solid line is average of 5 curves, shaded areas indicate max and min curves

Average curves used to show representative stress-strain behavior

Stress-Strain Curves – Multivariate Summary

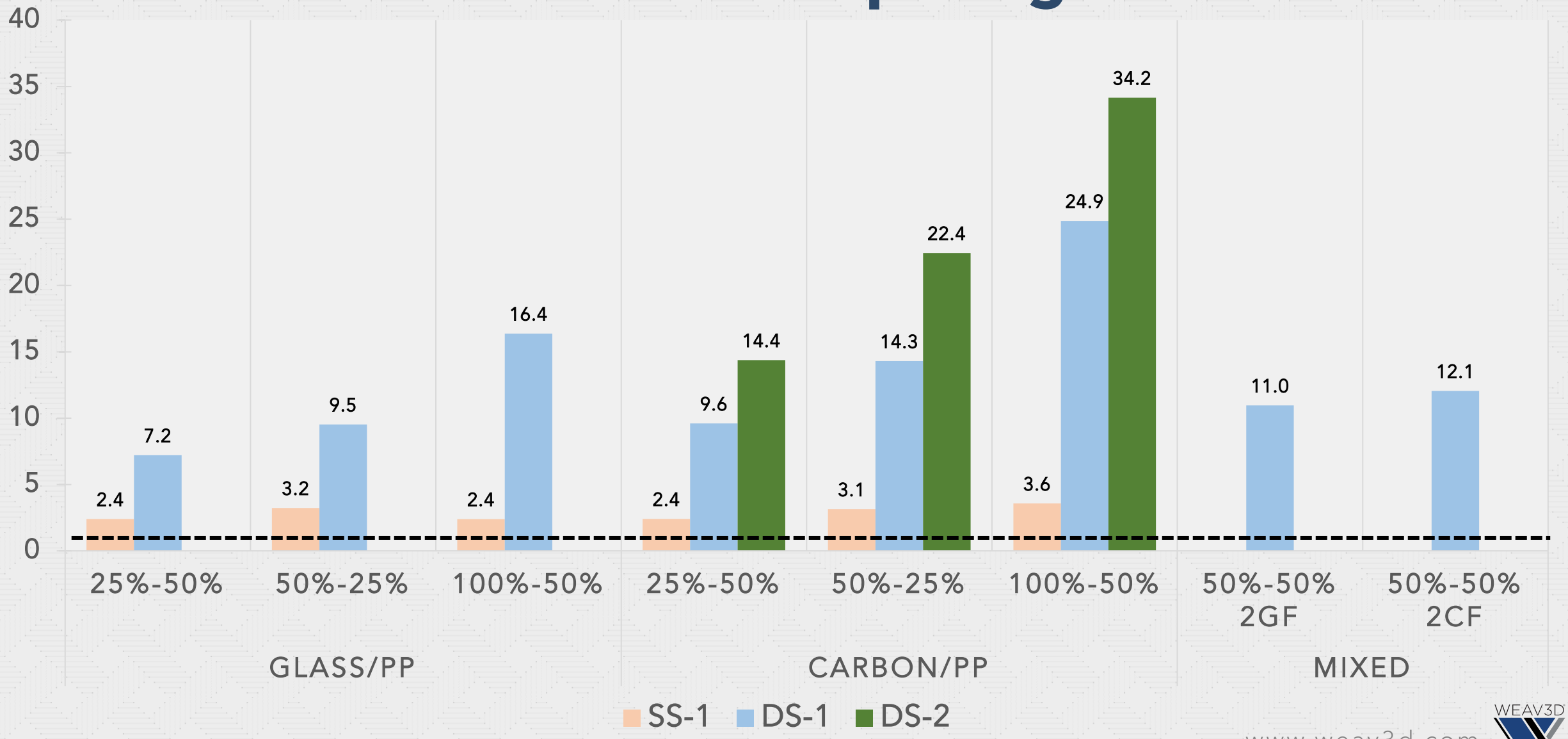




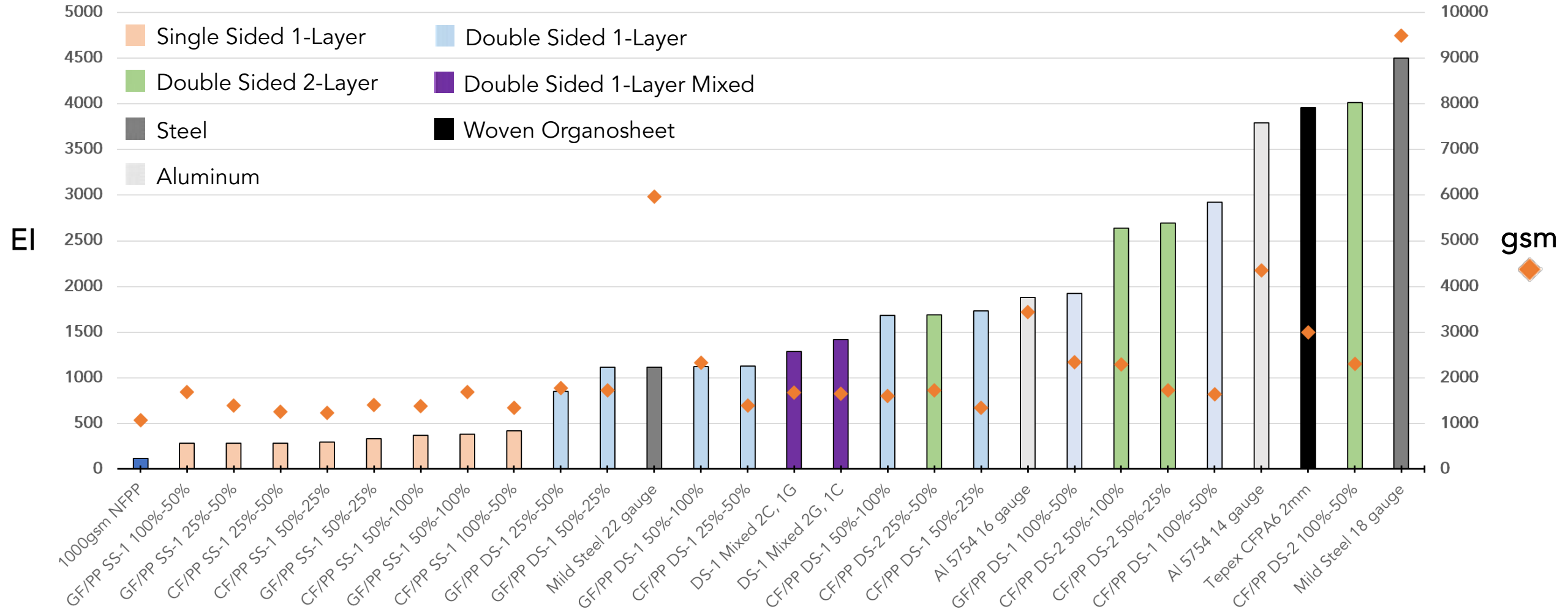
Strength improvements of 1.7x-2.5x (single-sided), 4x-15x (double-sided)

*Averaged stress-strain curve from multiple specimens

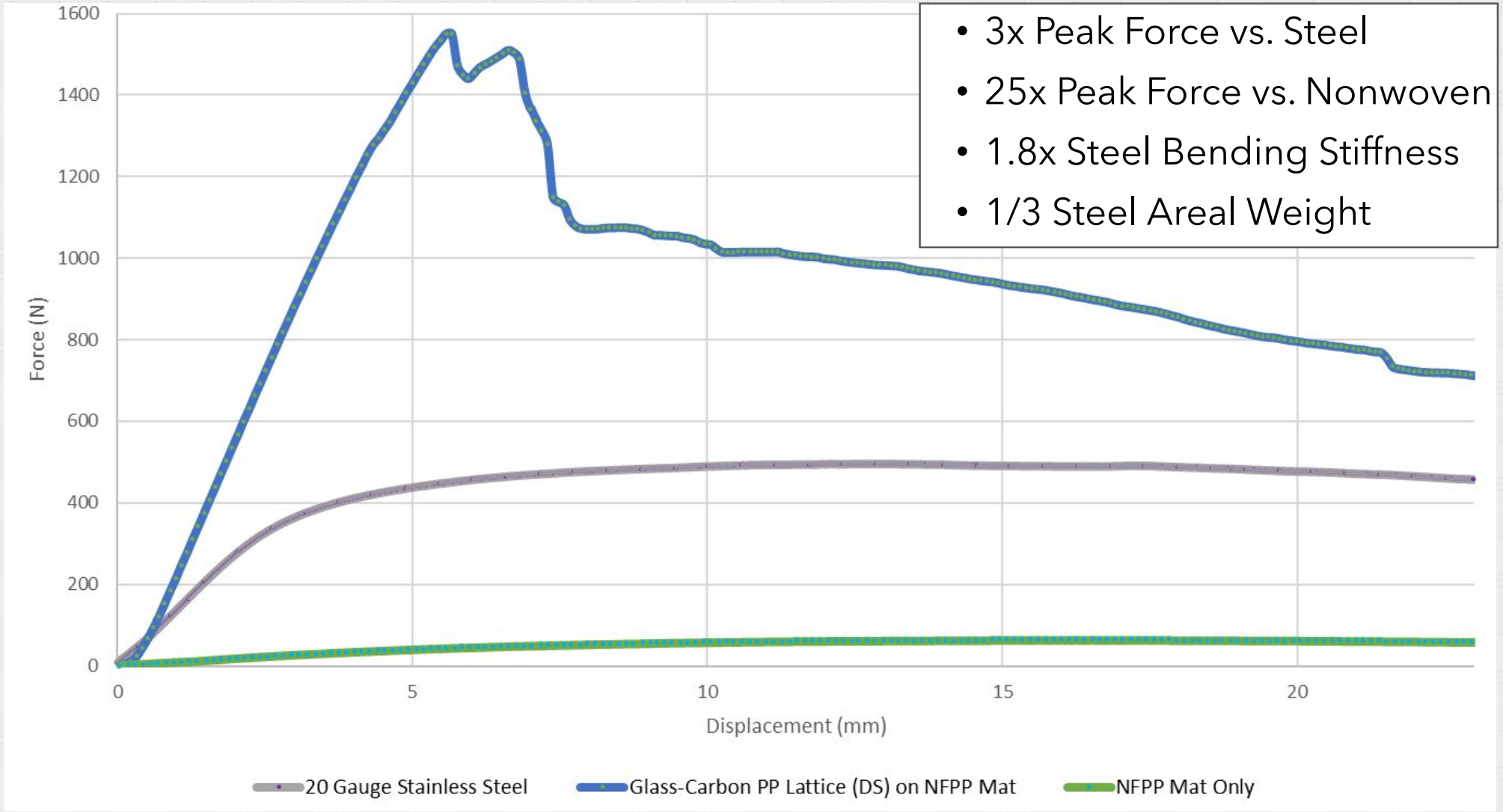
Effects of Orientation and Spacing on Flex Mod.



Bending Stiffness (EI) vs. Areal Density (gsm)



Steel Comparison: Force-Displacement

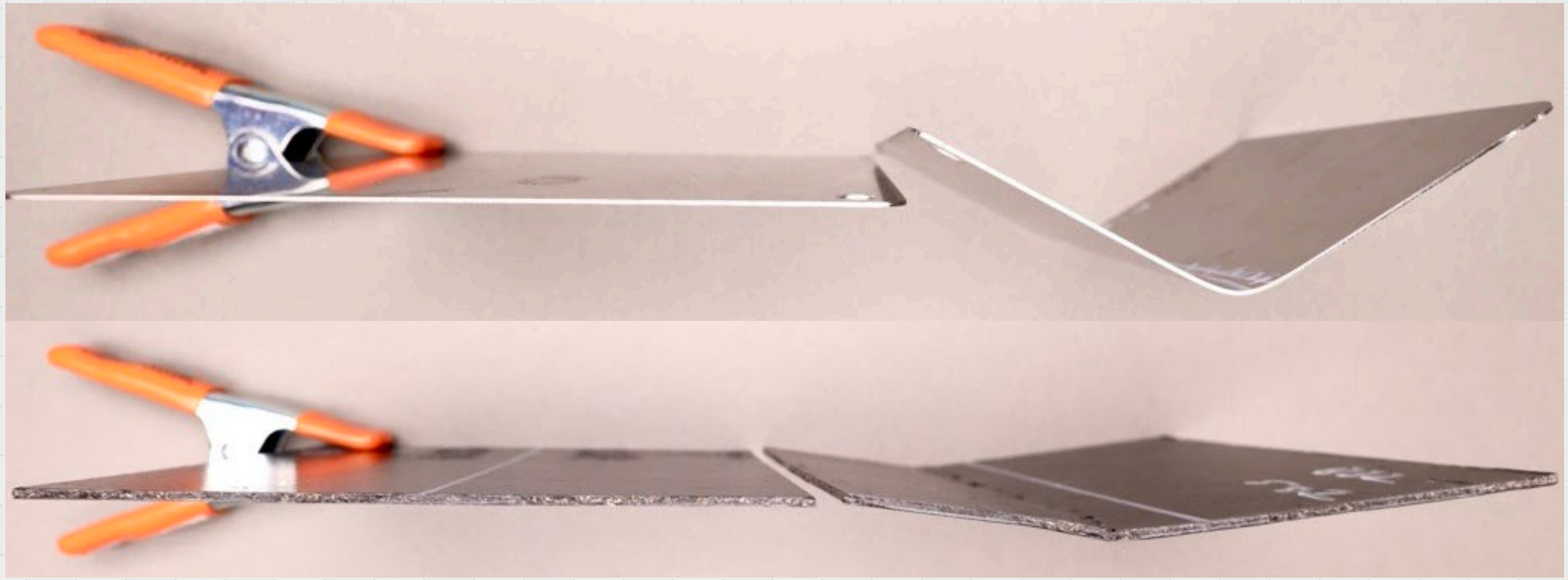


- 3x Peak Force vs. Steel
- 25x Peak Force vs. Nonwoven
- 1.8x Steel Bending Stiffness
- 1/3 Steel Areal Weight

Steel Comparison – Test Specimens

20 Gauge Stainless Steel (0.95mm)

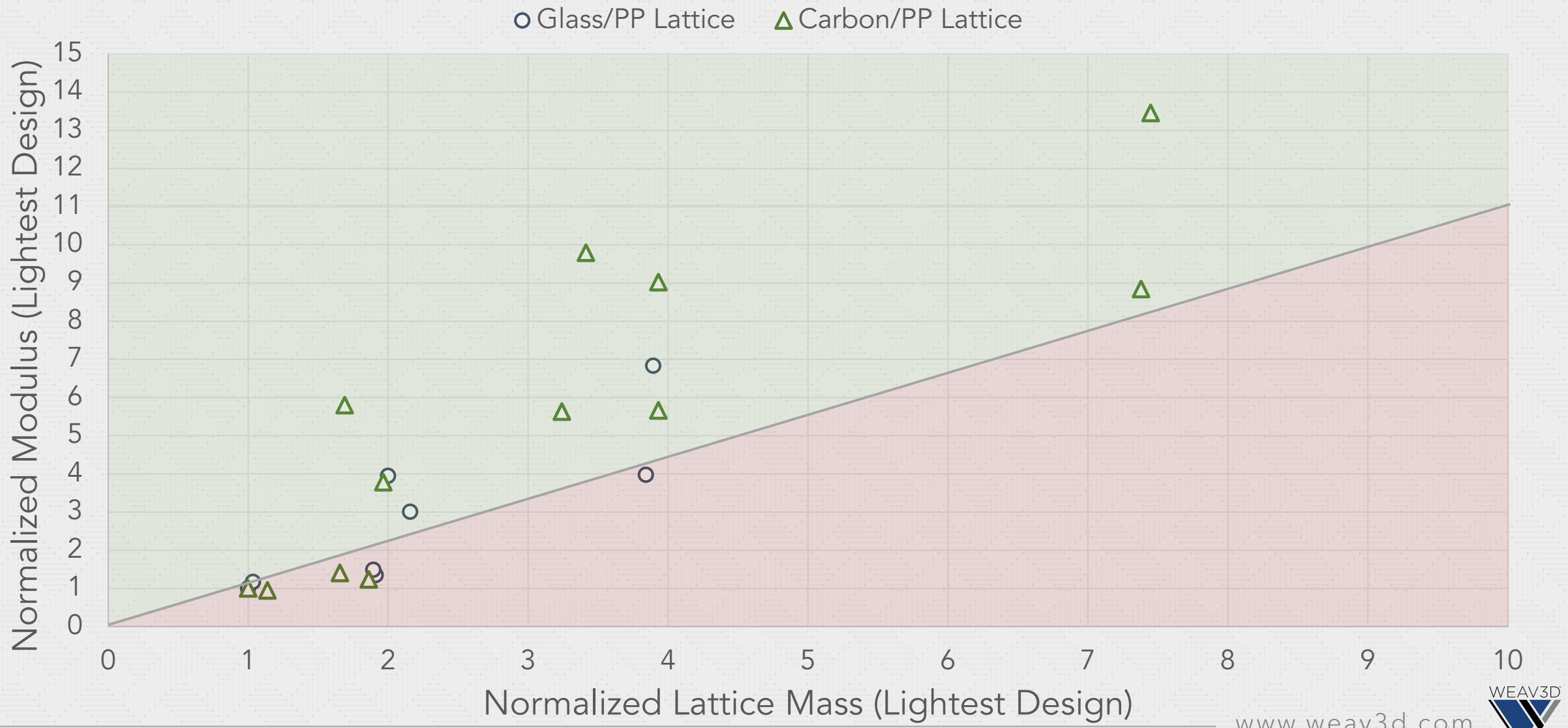
WEAV3D Reinforced Nonwoven (2.1 mm)



Before Test

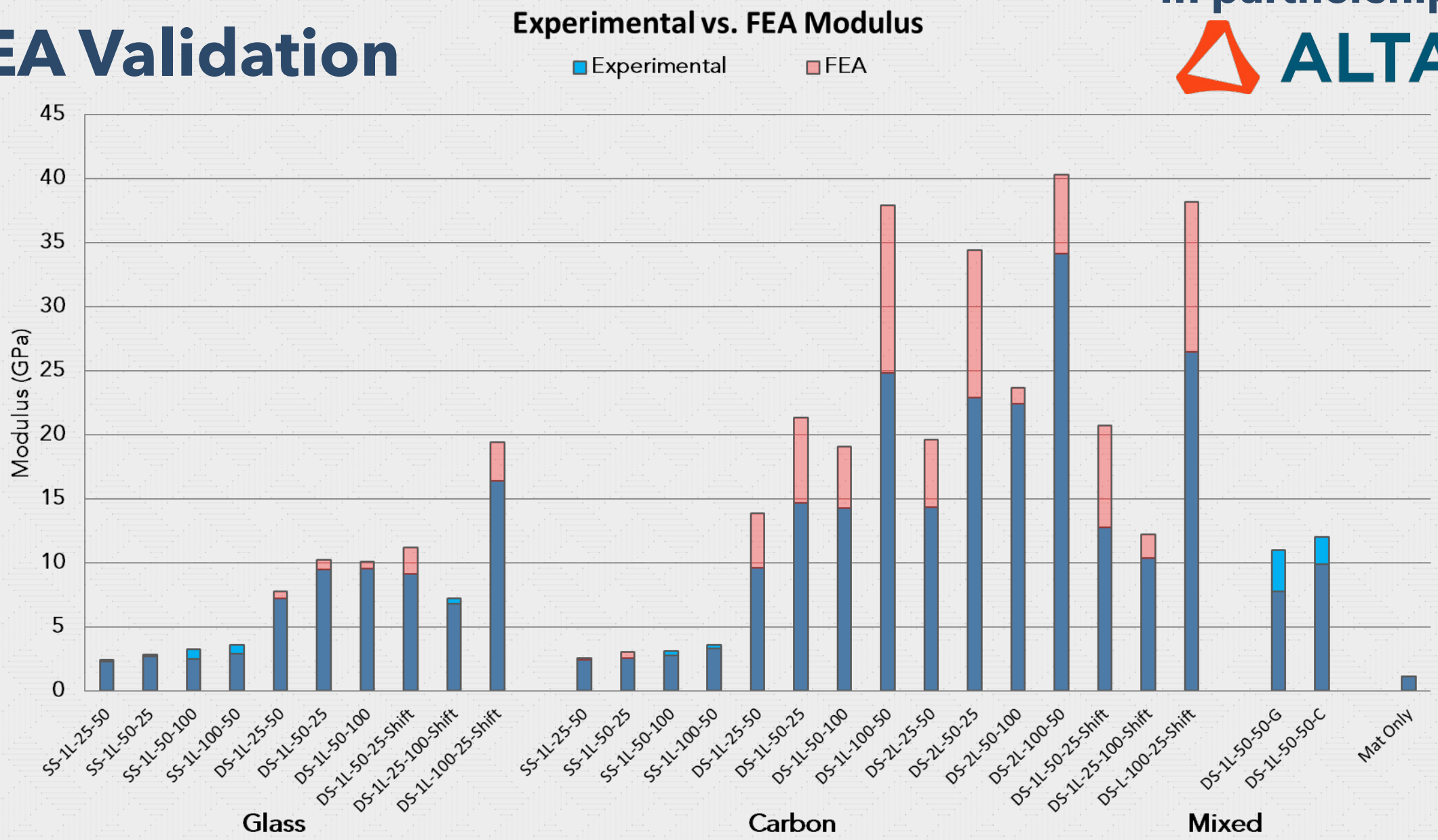
After Test

Cost-Mass Efficiency Tradeoffs



FEA Validation

In partnership with: ALTAIR



WEAV3D + Antolin IP Topper Pad Demonstrator

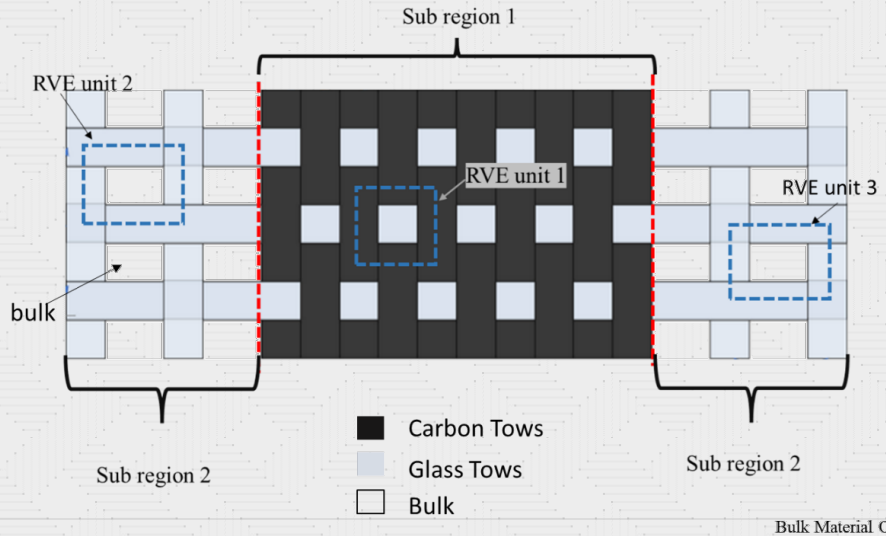
- IP topper pad made from NFPP nonwoven mat
- Original design utilized 1700gsm mat with back injected GFPP ribs
- Antolin produced WEAV3D lattice reinforced variants using 1200 gsm and 1000 gsm mat, eliminating the need for ribbing to enable a single step compression molding solution

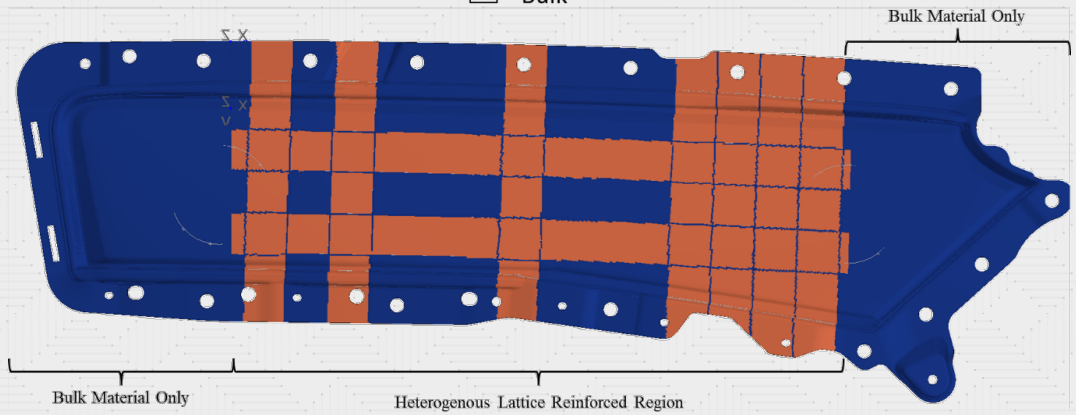
In partnership with:

ANTOLIN
Intelligent. Integrated. Inside.

Conclusions and Acknowledgements

- Single-sided panels can downgauge existing NFPP panel mat areal density, reducing part weight and trim scrap
- Double-sided panels are suitable for replacing structural long fiber plastics and metals
- Lattice pattern/material can be varied heterogeneously to change local strength and stiffness behavior





This work was funded by the National Science Foundation TIP Directorate, award #2036336. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Upcoming Publications

See it at the Braskem booth!

CAMX 2023 – Atlanta, GA – November 1st

1. Rebar for Plastics – A Novel Approach to Part Optimization with Composite Lattices
2. A Revised Finite Element Analysis Approach to Design and Optimize Composite Lattice Reinforcements and Simulate the Mechanical Properties of Composite Lattice Reinforced Plastics

Ongoing/Future Work

1. Guidelines for Forming WEAV3D Lattice-Reinforced NFPP Automotive Panels
2. Lattice Reinforced Structural Body Panels, in partnership with Braskem, Altair, and the Clemson Composites Center

To learn more about how WEAV3D can improve your products, contact us at info@weav3d.com