North American Pultrusion Conference

Laminate Design Considerations & Tools for Lower Mass and Cost, with Higher Performance

Toby Jacobson

Vectorply Corporation

ACMA American Composites Manufacturers Association | EPTA

Uncertainty of Laminate Design Optimization

<u>So Many Options!</u>

Type of fabric construction
Fiber Type
Orientation
Areal Weight
Fiber Fraction
Layer Sequence

<u>Get It Right</u>

Win the Business
Good Margins
Happy Customers
Smooth Launch
Good Performance
Achieve Mass Targets

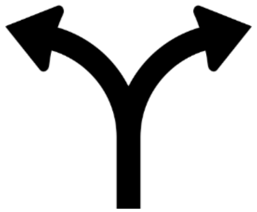
<u>Get It Wrong</u>

Lose the Business
Low Margins
Frustrated Customers
Stressful Launch
Miss Performance Targets
Part is too heavy

Preview

1. Show a tool to quickly develop and compare different materials and laminate designs

2. Low Cost / Low Performance Materials
   OR
   Higher Cost / High Performance Materials

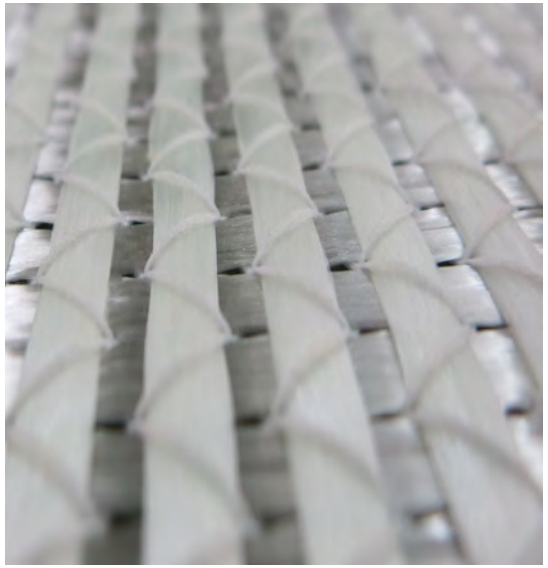


3. Material Selection Methodology that you can consider applying to your own products

Continuous Filament Mat vs Non-Crimp Fabric

CFM

NCF



Lower cost (per lb.)

Lower performance

Use more for equal performance

Higher cost (per lb.)

Higher performance

Use less for equal performance

Why so much uncertainty in the material selection process?

1. It is very difficult and time-consuming to adequately compare alternative laminates and materials.

2. There is a possibility that engineers did a thorough study in the past and applied the same conclusion to all similar products.

    -A comfort level with existing material may be present.

3. Some people may be under the impression that NCF's are too expensive.

Fabrics for Pultrusion

	Continuous Filament Mat (CFM)	Non-Crimp Fabric (NCF)
Method to hold fibers together	Chemical Binder	Stitching
Fiber Type	Typically Glass Only	Nearly any fiber can be used R-Glass, S-Glass, E-Glass, Carbon, Aramid, Natural Fibers, and others
Standard Areal Weight Units	oz / ft^2	oz / yd^2
Areal Weight Ranges	3/4 oz/ft^2 - 3 oz/ft2	6 oz/yd^2 - 100+ oz/yd2
Fiber Orientation	Random	Unidirectional Plies in "Zeros only", [+/- 45], [+/- 60], [0/90], [45/90/45], [0/45/45], [0/45/90/45]
Fiber Length	Continuous	Continuous and Oriented
Cost (for E-Glass)	X	X + (0% - 30%) with some scenarios where NCF is less than CFM
Fiber Volume Fraction	20-50%	50-60%
Mechanical Properties	X	X + (10%-200%)

When does it make sense to use CFM?

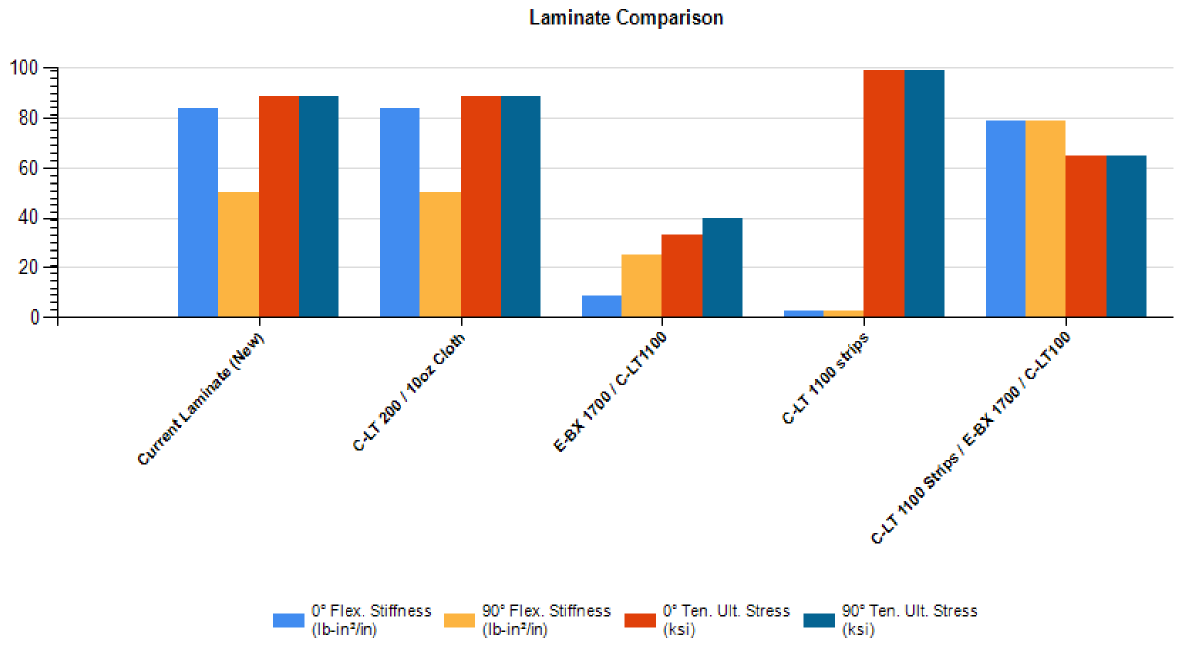
When is it better to use NCF?

VectorLam Introduction

- VectorLam is a tool to quickly compare alternative laminates.
- This is a FREE online tool that is available to anyone with an internet connection.
- Virtually, you can design and compare several laminates per project and layers per laminate.
- Use the existing database of materials or create your own “My Materials” database from a global list of fibers, fabrics, cores, and other materials.
- Analyze laminates with graphical comparisons, customizable laminate comparison tables, or ABD matrices.

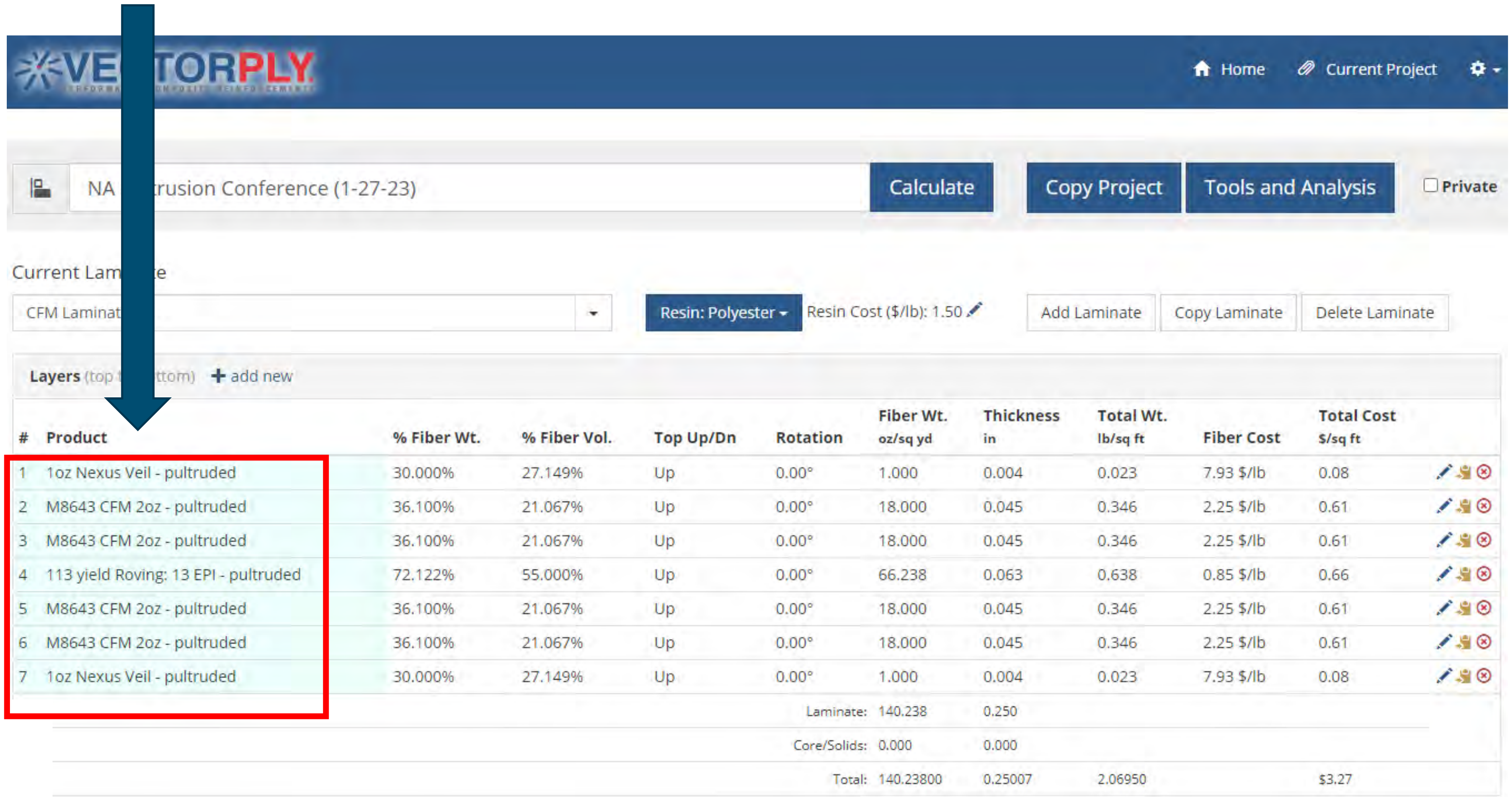
Layers (top to bottom) + add new

#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27



VectorLam Inputs

Layers of the Laminate: Including
Layers of direct roving



#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

Layer sequence – drag and drop to change the order of the layers.

VECTORPLY

Home | Current Project

NA Pultrusion Conference (1-27-23)

Calculate | Copy Project | Tools and Analysis | Private

Current Laminate

CFM Laminate #2

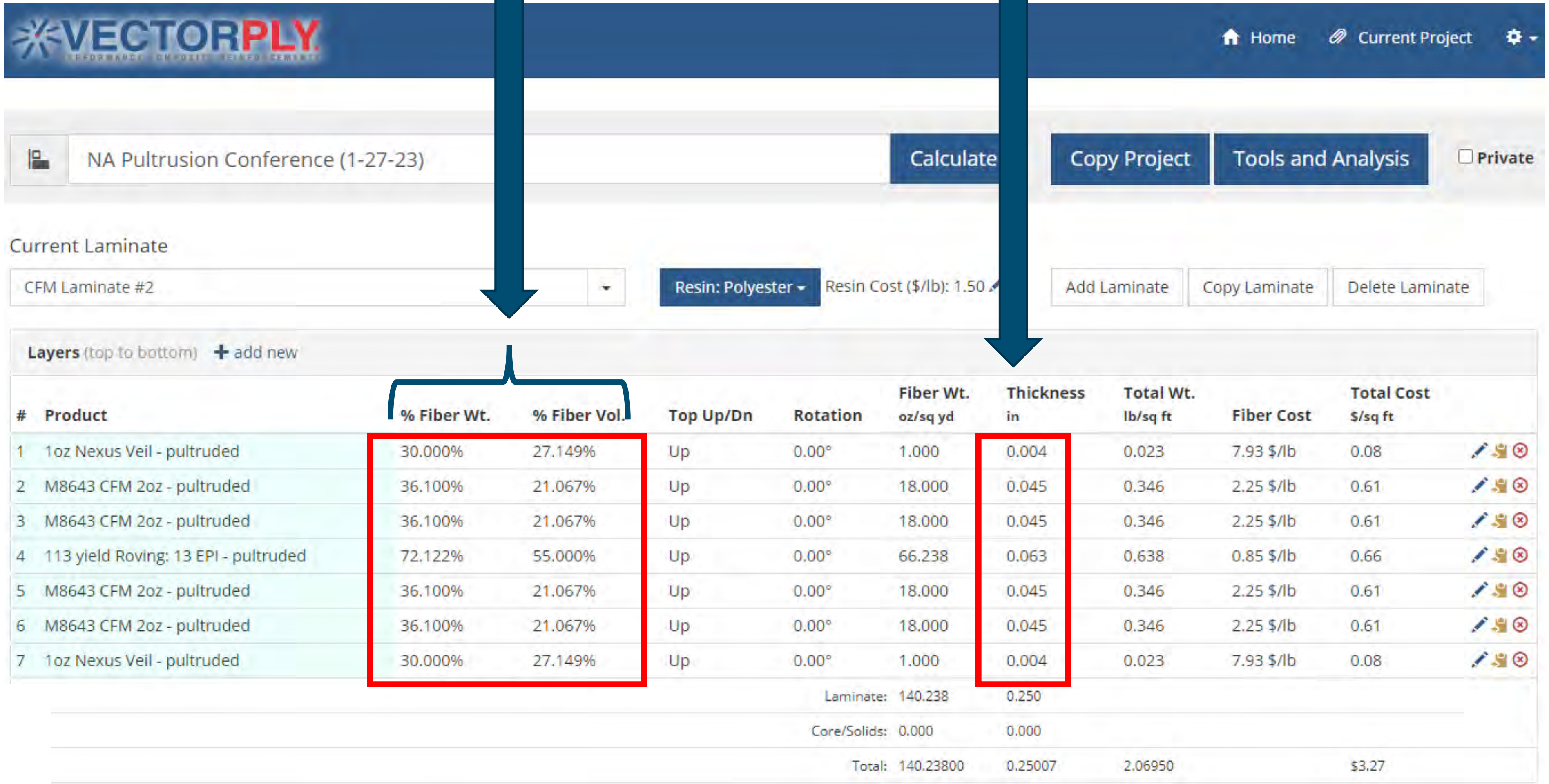
Resin: Polyester | Resin Cost ($/lb): 1.50 | Add Laminate | Copy Laminate | Delete Laminate

Layers (top to bottom) + add new

#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

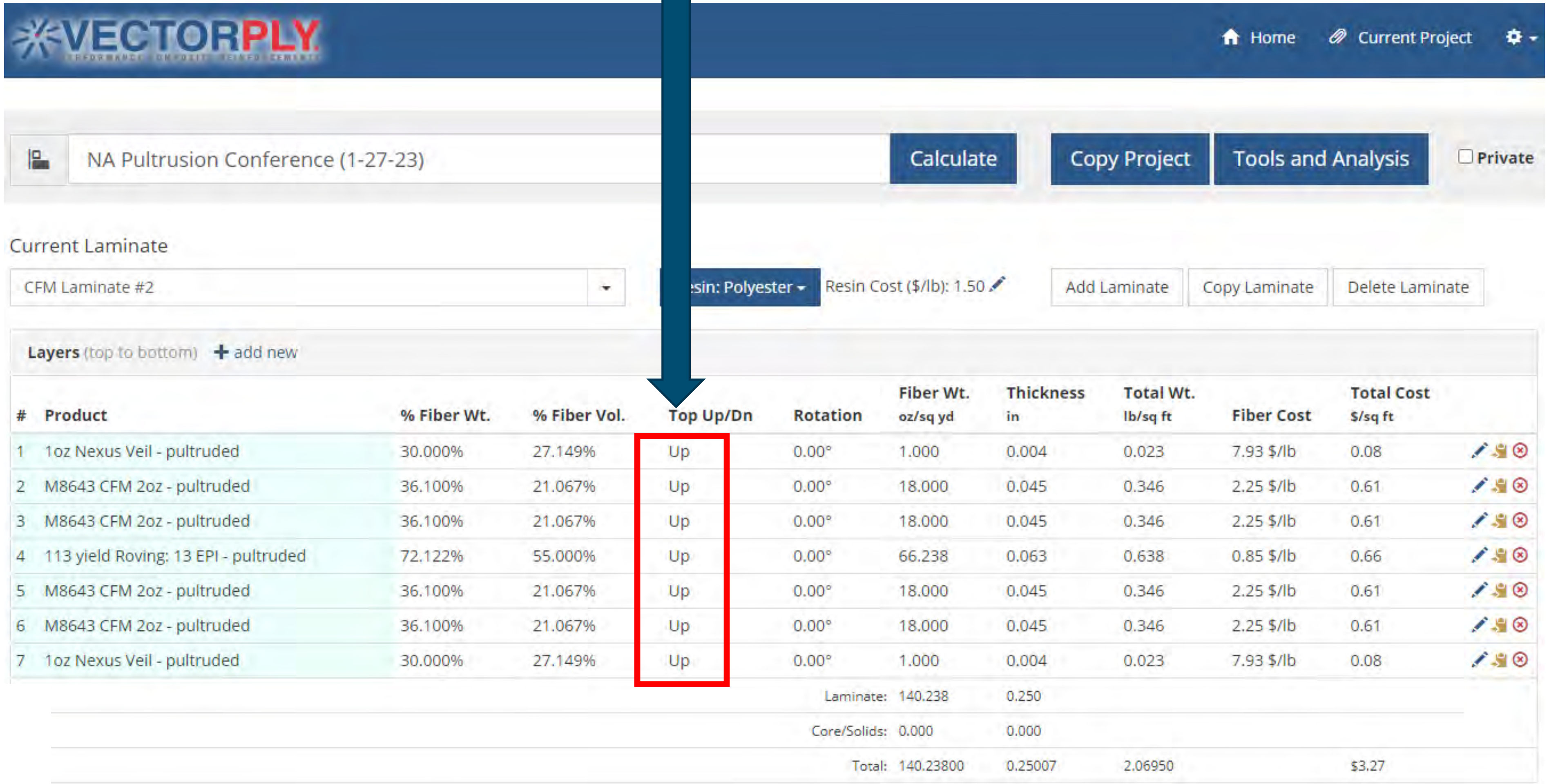
Fiber Volume Fraction OR Weight Fraction. Thickness is auto updated as a dependent variables



#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

UP / Down Orientation for each layer



#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

Rotation for each layer

VECTORPLY

Home | Current Project

NA Pultrusion Conference (1-27-23)

Calculate | Copy Project | Tools and Analysis | Private

Current Laminate

CFM Laminate #2

Resin: Polyester | Resin Cost ($/lb): 1.50

Add Laminate | Copy Laminate | Delete Laminate

Layers (top to bottom) + add new

#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

Areal Weight for each layer (populated directly by material selection)

VECTORPLY

Home | Current Project

NA Pultrusion Conference (1-27-23)

lculate | Copy Project | Tools and Analysis | Private

Current Laminate

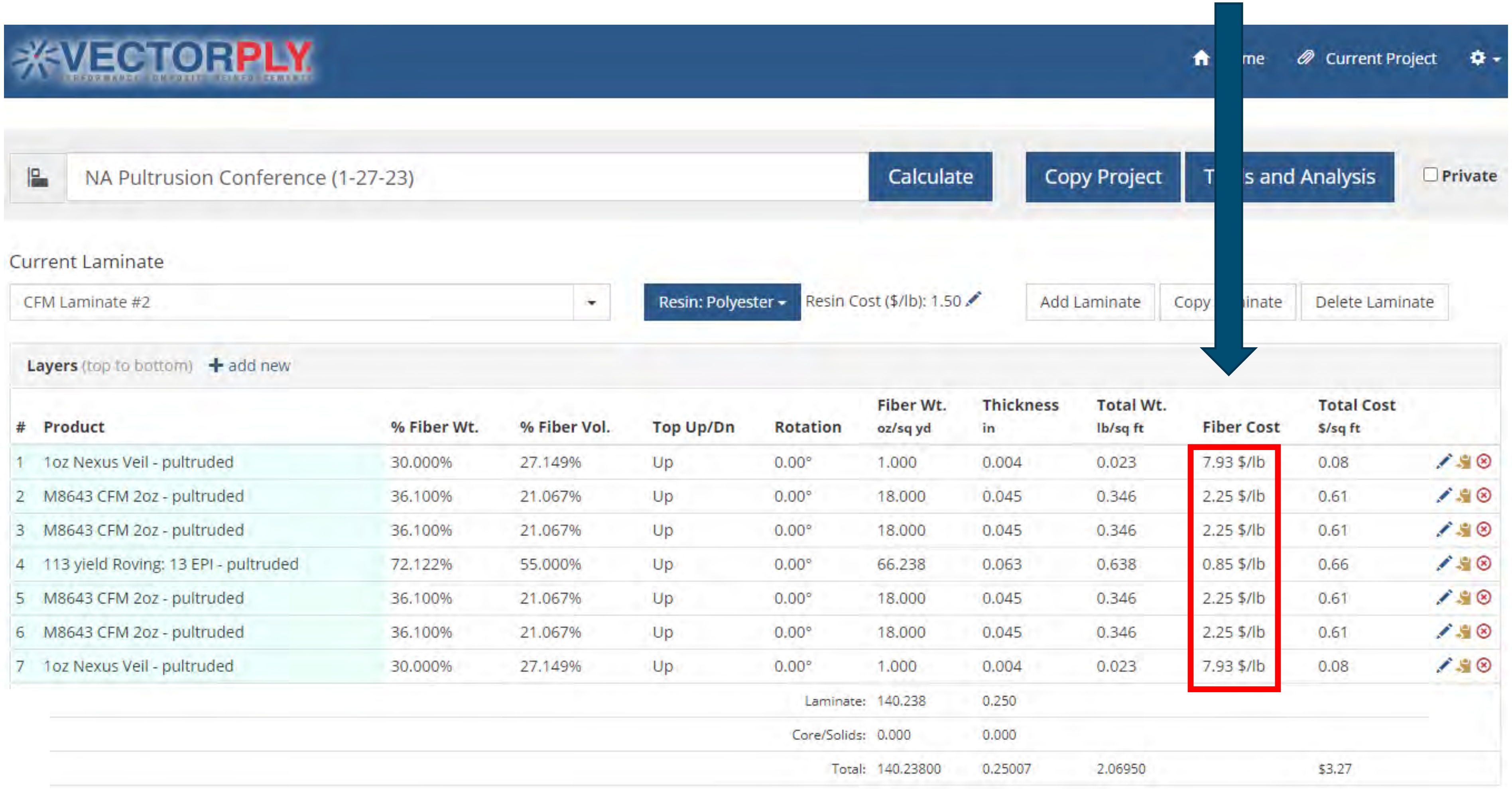
CFM Laminate #2 | Resin: Polyester | Resin Cost): 1.50 | Add Laminate | Copy Laminate | Delete Laminate

Layers (top to bottom) + add new

#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Inputs

Cost Per Pound



#	Product	% Fiber Wt.	% Fiber Vol.	Top Up/Dn	Rotation	Fiber Wt. oz/sq yd	Thickness in	Total Wt. lb/sq ft	Fiber Cost	Total Cost $/sq ft
1	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
2	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
3	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
4	113 yield Roving: 13 EPI - pultruded	72.122%	55.000%	Up	0.00°	66.238	0.063	0.638	0.85 $/lb	0.66
5	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
6	M8643 CFM 2oz - pultruded	36.100%	21.067%	Up	0.00°	18.000	0.045	0.346	2.25 $/lb	0.61
7	1oz Nexus Veil - pultruded	30.000%	27.149%	Up	0.00°	1.000	0.004	0.023	7.93 $/lb	0.08
					Laminate:	140.238	0.250			
					Core/Solids:	0.000	0.000			
					Total:	140.23800	0.25007	2.06950		$3.27

VectorLam Outputs

Laminate Comparison Table

- 20 different metrics shown in this table
- Total Weight
- Laminate Cost
- Density
- Thickness
- Fiber Volume and Weight Fraction
- Tensile Modulus
- Flex Modulus
- Thickness
- Ultimate Tensile
- 0 and 90 Degree Properties

VECTORPLY — Home | Current Project

Laminate Comparison Table — **Unit:** US — **Add Property:** Add Property — Compare | Graph | ABD Matrix | Data Sheet

Laminate # »	**11**	**12**	
Laminate	CFM Plate Laminate #3	NCF Plate Laminate #3	
Total Wt.	1.839	1.765	lb/ft²
Thickness	0.236	0.177	in
0° Modulus, Ex	1.132	3.640	Msi
90° Modulus, Ey	1.132	3.640	Msi
Shear Modulus, Gxy	0.435	0.731	Msi
0° Flex. Stiffness	1,260.346	1,388.281	lb-in²/in
90° Flex. Stiffness	1,260.346	1,507.074	lb-in²/in
0° Ten. Ult. Stress	18.560	59.691	ksi
90° Ten. Ult. Stress	18.560	59.691	ksi
0° Comp. Ult. Stress	22.634	68.907	ksi
90° Comp. Ult Stress	22.634	68.907	ksi
Shear Ult. Stress	14.284	23.989	ksi
Vf	22.847	54.304	%
Wf	38.132	71.359	%
Poisson Ratio, PRxy	0.299	0.155	
0° Ult. B. Moment	194.287	304.838	in lb/in
90° Ult. B. Moment	194.287	330.922	in lb/in

VectorLam Outputs

Comparing only selected laminates

VECTORPLY | Home | Current Project

Laminate Comparison Table | Unit: US | dd Property: Add Property | Compare | Graph | ABD Matrix | Data Sheet

Laminate # »	11	12		
Laminate	CFM Plate Laminate #3	NCF Plate Laminate #3		
Total Wt.	1.839	1.765	lb/ft^2	☐
Thickness	0.236	0.177	in	☐
0° Modulus, Ex	1.132	3.640	Msi	☐
90° Modulus, Ey	1.132	3.640	Msi	☐
Shear Modulus, Gxy	0.435	0.731	Msi	☐
0° Flex. Stiffness	1,260.346	1,388.281	lb-in^2/in	☑
90° Flex. Stiffness	1,260.346	1,507.074	lb-in^2/in	☑
0° Ten. Ult. Stress	18.560	59.691	ksi	☐
90° Ten. Ult. Stress	18.560	59.691	ksi	☐
0° Comp. Ult. Stress	22.634	68.907	ksi	☐
90° Comp. Ult Stress	22.634	68.907	ksi	☐
Shear Ult. Stress	14.284	23.989	ksi	☐
Vf	22.847	54.304	%	☐
Wf	38.132	71.359	%	☐
Poisson Ratio, PRxy	0.299	0.155		
0° Ult. B. Moment	194.287	304.838	in lb/in	☐
90° Ult. B. Moment	194.287	330.922	in lb/in	☐

VectorLam Outputs

You Select US or Metric Units

Laminate Comparison Table

Units: US

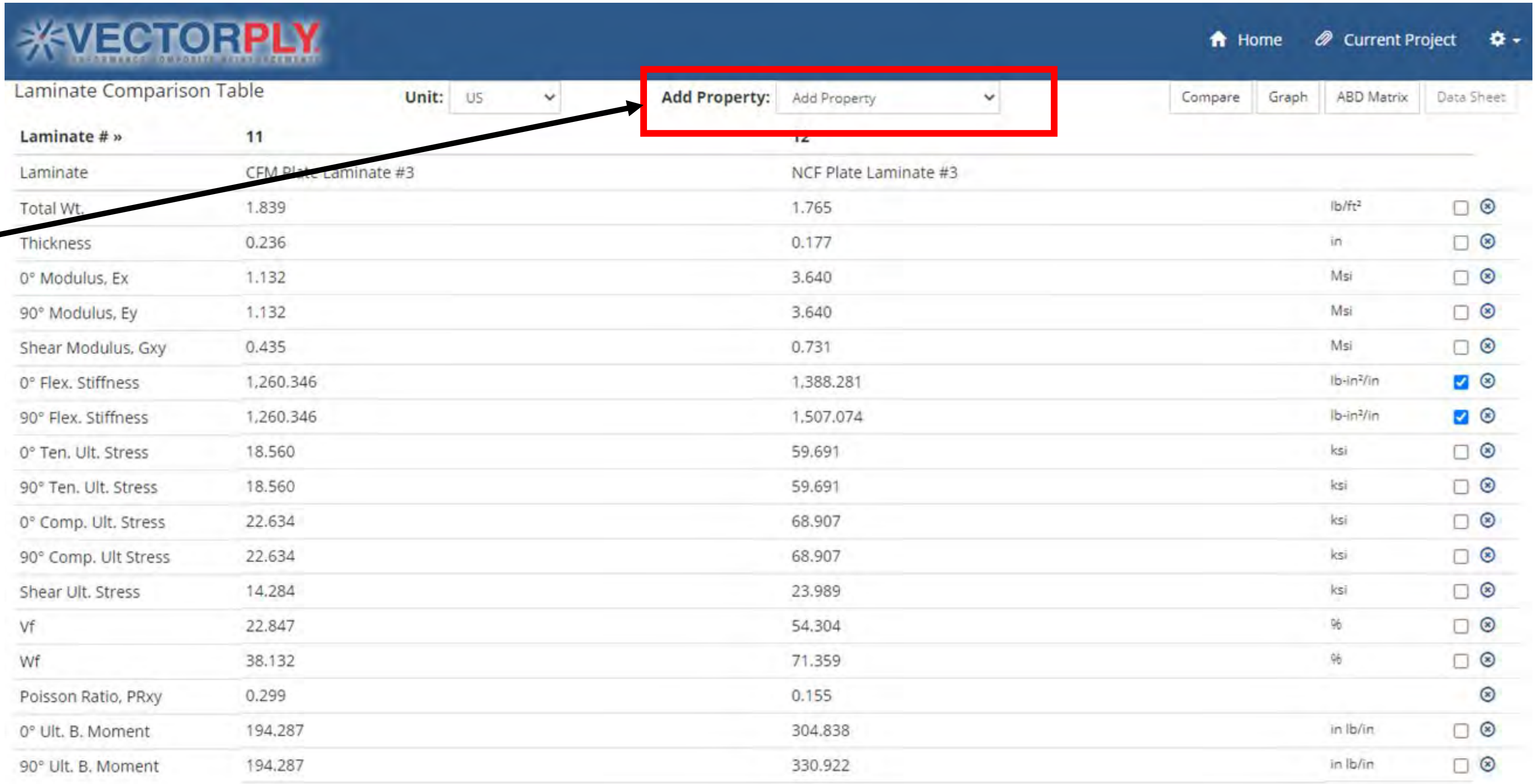
Add Property: Add Property

Compare | Graph | ABD Matrix | Data Sheet

Laminate # »	11	12	
Laminate	CFM Plate Laminate #3	NCF Plate Laminate #3	
Total Wt.	1.839	1.765	lb/ft²
Thickness	0.236	0.177	in
0° Modulus, Ex	1.132	3.640	Msi
90° Modulus, Ey	1.132	3.640	Msi
Shear Modulus, Gxy	0.435	0.731	Msi
0° Flex. Stiffness	1,260.346	1,388.281	lb-in²/in
90° Flex. Stiffness	1,260.346	1,507.074	lb-in²/in
0° Ten. Ult. Stress	18.560	59.691	ksi
90° Ten. Ult. Stress	18.560	59.691	ksi
0° Comp. Ult. Stress	22.634	68.907	ksi
90° Comp. Ult Stress	22.634	68.907	ksi
Shear Ult. Stress	14.284	23.989	ksi
Vf	22.847	54.304	%
Wf	38.132	71.359	%
Poisson Ratio, PRxy	0.299	0.155	
0° Ult. B. Moment	194.287	304.838	in lb/in
90° Ult. B. Moment	194.287	330.922	in lb/in

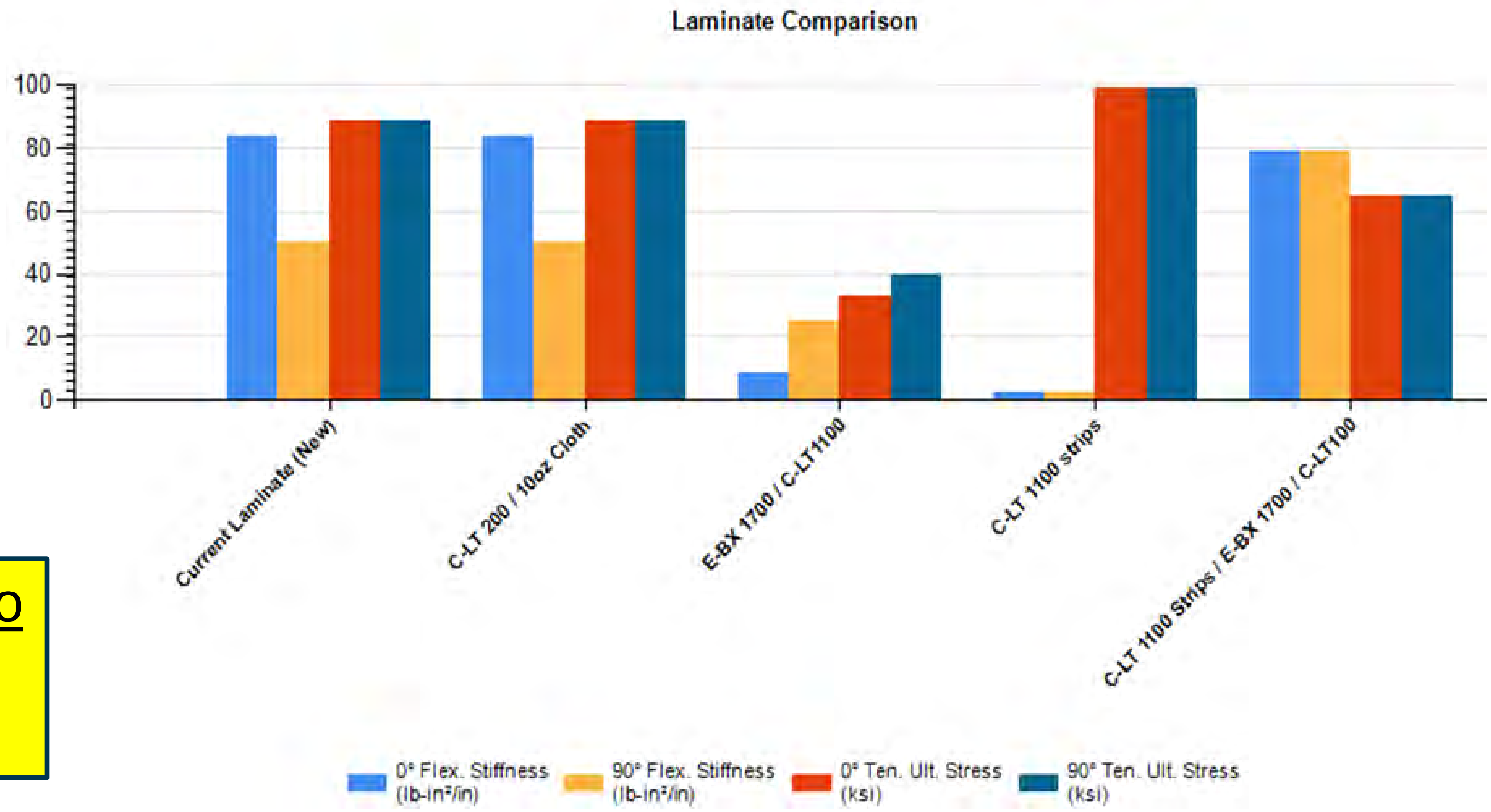
VectorLam Outputs

20+ other properties to choose from



Laminate # »	11	12		
Laminate	CFM Plate Laminate #3	NCF Plate Laminate #3		
Total Wt.	1.839	1.765	lb/ft²	☐
Thickness	0.236	0.177	in	☐
0° Modulus, Ex	1.132	3.640	Msi	☐
90° Modulus, Ey	1.132	3.640	Msi	☐
Shear Modulus, Gxy	0.435	0.731	Msi	☐
0° Flex. Stiffness	1,260.346	1,388.281	lb-in²/in	☑
90° Flex. Stiffness	1,260.346	1,507.074	lb-in²/in	☑
0° Ten. Ult. Stress	18.560	59.691	ksi	☐
90° Ten. Ult. Stress	18.560	59.691	ksi	☐
0° Comp. Ult. Stress	22.634	68.907	ksi	☐
90° Comp. Ult Stress	22.634	68.907	ksi	☐
Shear Ult. Stress	14.284	23.989	ksi	☐
Vf	22.847	54.304	%	☐
Wf	38.132	71.359	%	☐
Poisson Ratio, PRxy	0.299	0.155		
0° Ult. B. Moment	194.287	304.838	in lb/in	☐
90° Ult. B. Moment	194.287	330.922	in lb/in	☐

VectorLam Outputs



You can also export to Excel

How does VectorLam work?

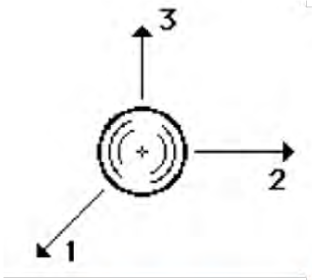
1. Uses Classical Laminate Theory & Hooke's Law

2. SQL Language is used in Cloud Based platform

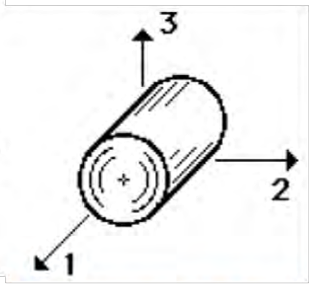
3. The Lamina "Ply"
   a) Made from Uni continuous fiber and matrix
   b) This is the building block of the "Laminate"

4. Required ply properties for classical Lamination
   a) Mechanical Properties along the fiber direction
   b) Mechanical Properties transverse to fiber direction
   c) Shear Modulus
   d) Poisson's Ratio
   e) Minor Poison's Ratio

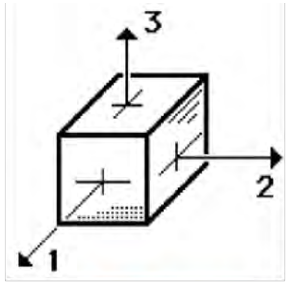
5. We have done correlation and correlate well to physical testing



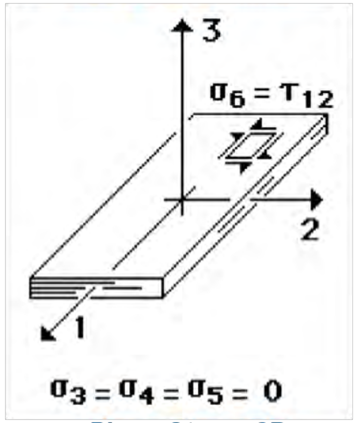
Isotropic:
Metals, Plastics



Transversely Isotropic:
Wood, Uni Lamina



Orthotropic:
Special Case
Laminates

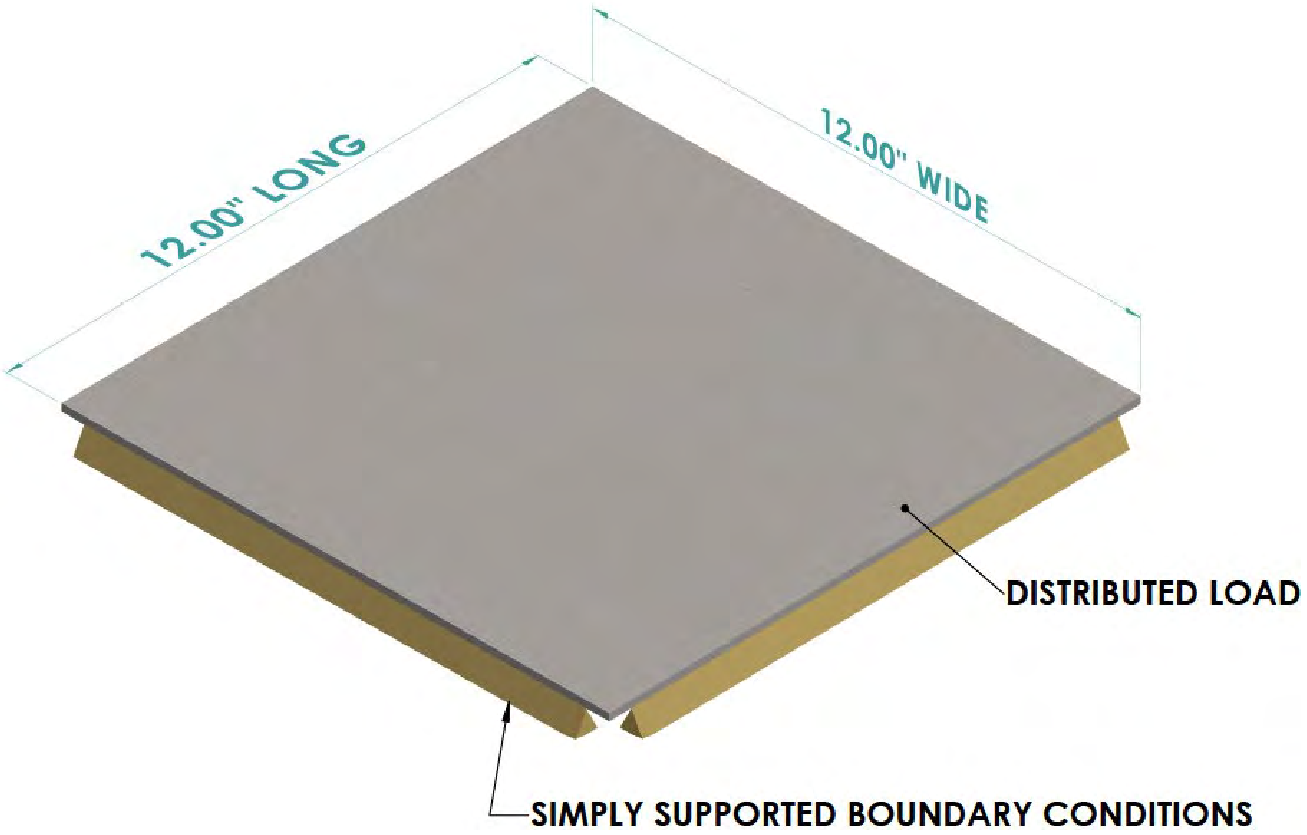


Plane Stress 2D
Idealization

Theory of Composites Design (Tsai, 2008)

Methodology for a plate application

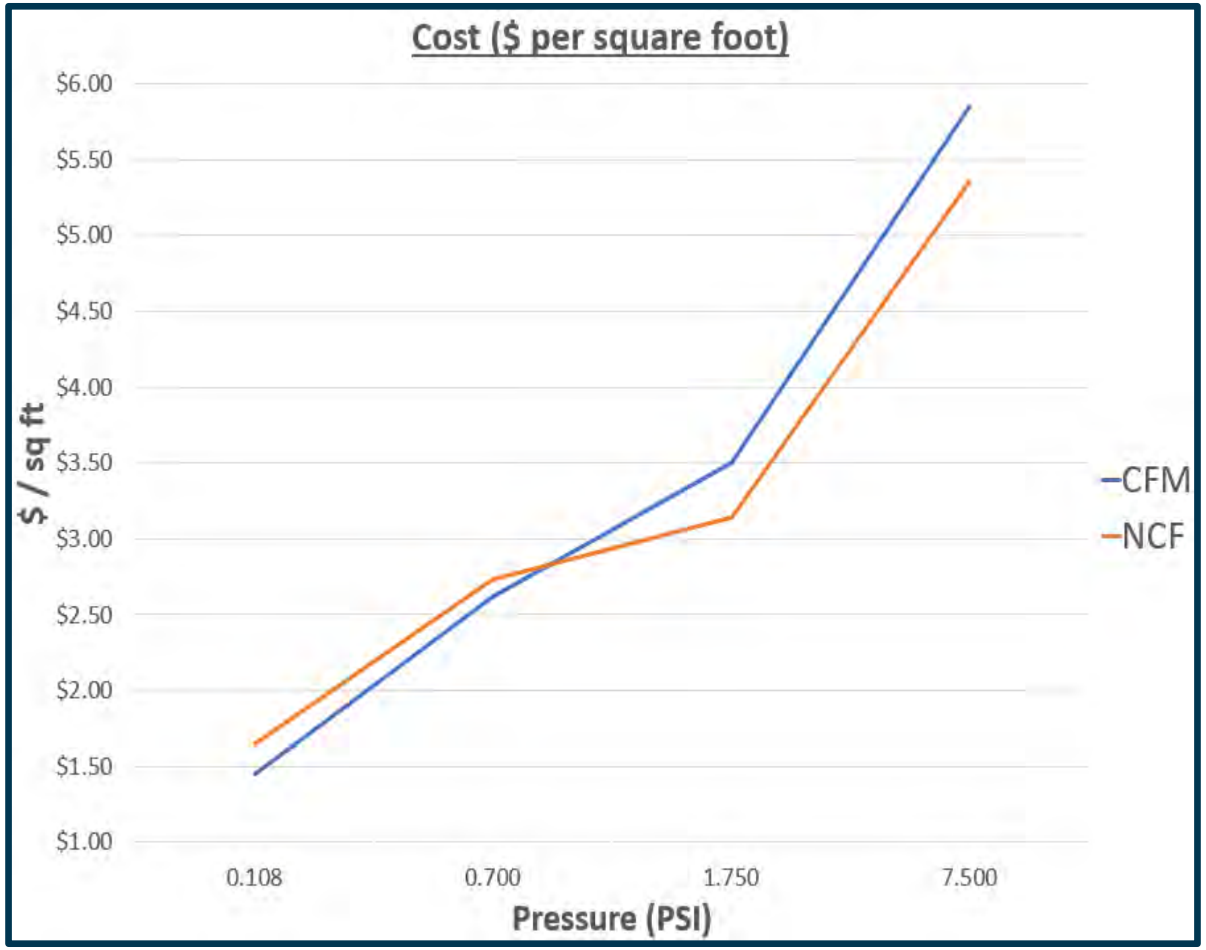
- Used VectorLam's Plate Tool to develop a laminate that would achieve a specified deflection at a given load.
- Goal: To Increase Load at several increments. Keep deflection the same by adding layers of fabric.
- We used a distributed load. Range from .108 psi to 7.5 psi
- Targeted Deflection for all loads = .110 inches
- We recognize that most pultruders would add direct rovings (zeros) to add thickness. For this analysis we added layers of either CFM or NCF to build thickness into the plate.

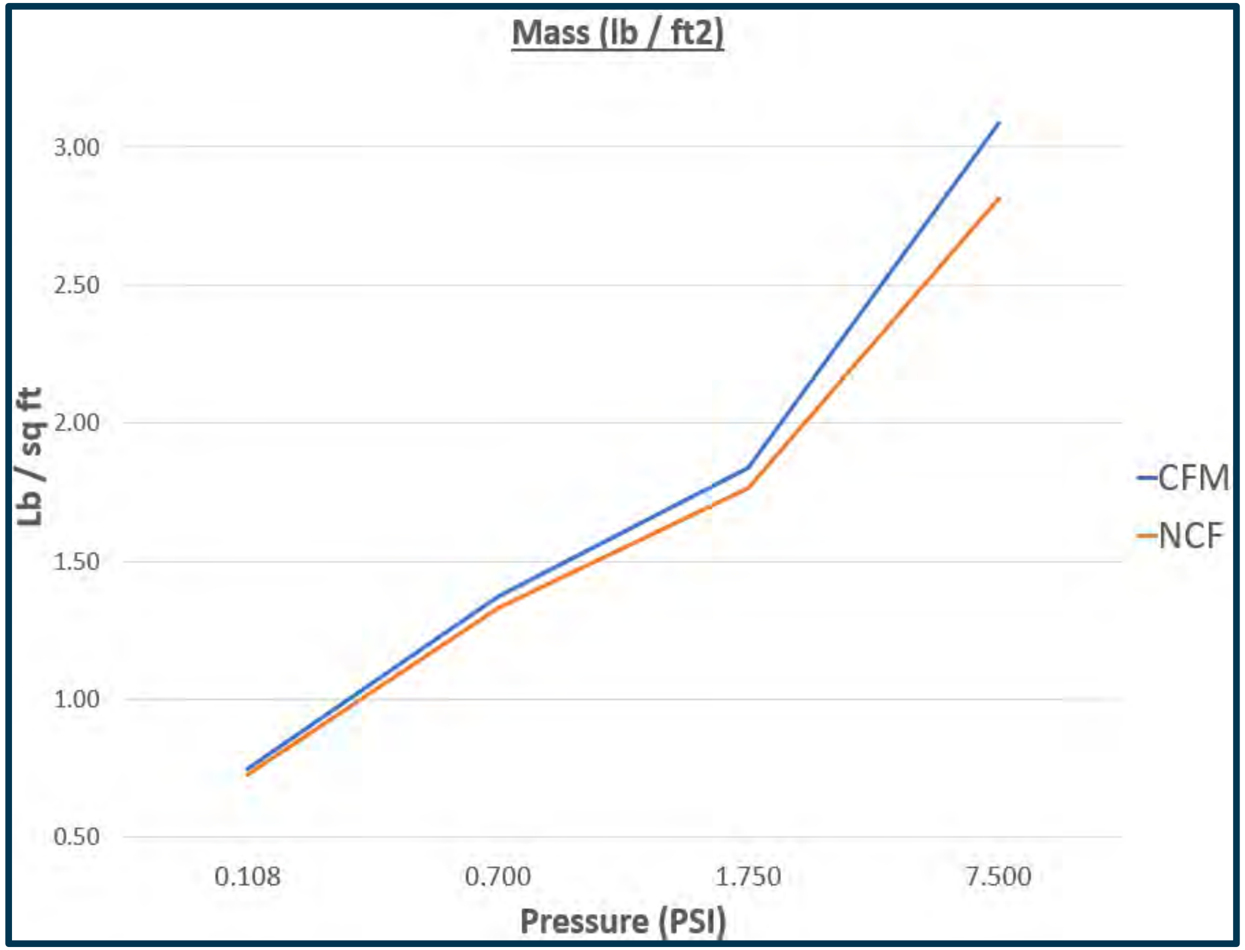


Laminate Construction

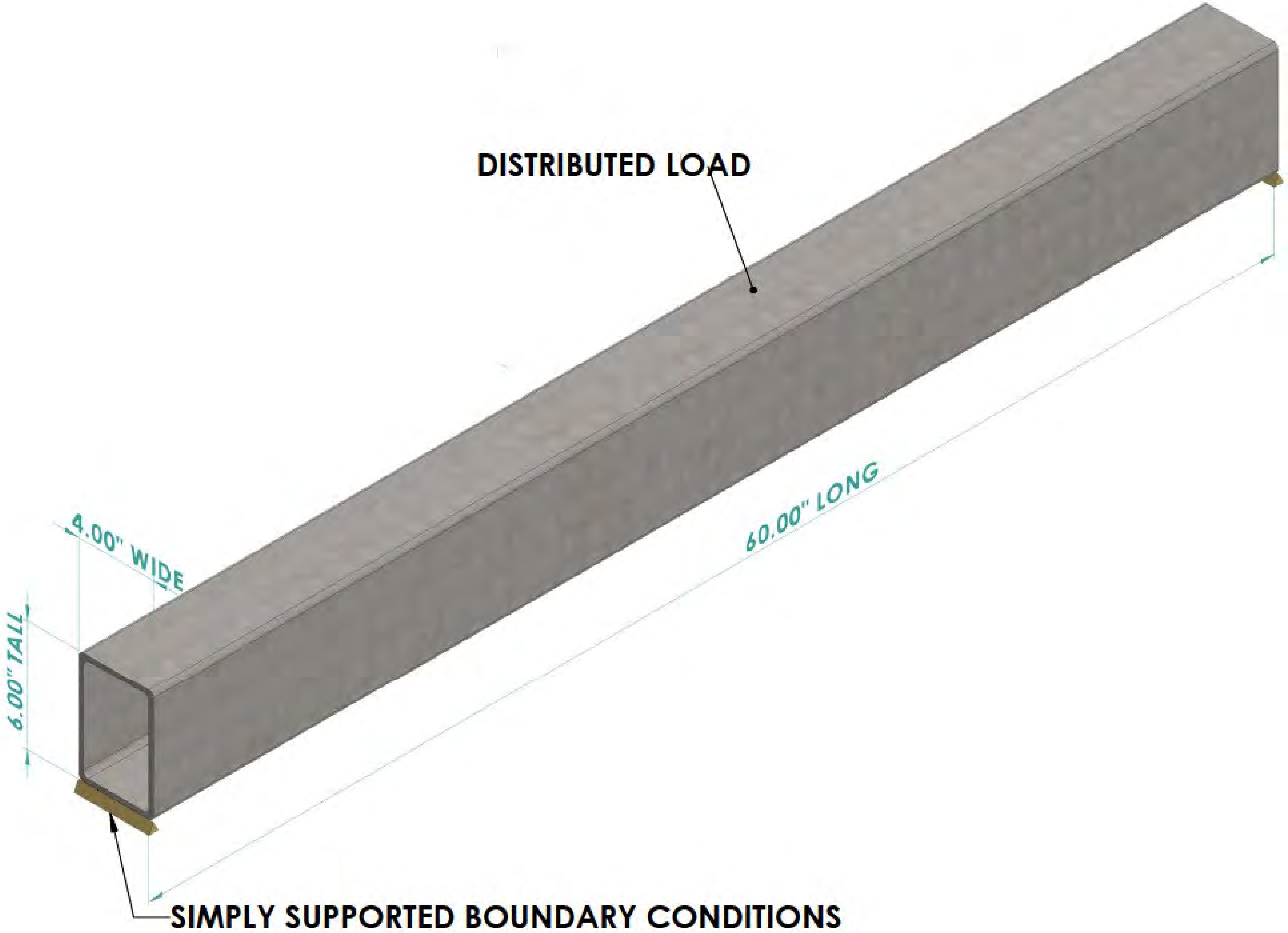
	Continuous Filament Mat (CFM)		Non-Crimp Fabric (NCF)	
Pressure	Layers	Thickness (inches)	Layers	Thickness (inches)
.11 psi	2	0.098	2	0.079
0.70 psi	4	0.177	4	0.138
1.75 psi	6	0.236	4	0.177
7.50 psi	10	0.394	4	0.295

Results / Outcome





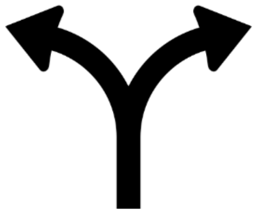
Beam Tool Option



Review

1. Show a tool to quickly develop and compare different materials and laminate designs

2. Low Cost / Low Performance Materials
OR
Higher Cost / High Performance Materials



3. Material Selection Methodology that you can consider applying to your own products

www.Vectorply.com

VECTORPLY®
PERFORMANCE COMPOSITE REINFORCEMENTS

Home | About Vectorply | Video Resources | **Technical Services** | Products | Markets | Contact

Vectorlam

You are here: Home / Vectorlam

VectorLam – The Next Evolution in Laminate Design and Analysis Software

VectorLam is the latest edition of Vectorply's proprietary laminate analysis software. VectorLam provides a cloud-based, multi-platform compatible approach to classical laminate theory and provides a suite of services across diversified market segments. This upgrade from the Excel-based version of VectorLam allows users to build and access laminates on nearly any internet connected device.

VectorLam helps achieve goals of stiffness, strength, weight and cost by allowing users to design the perfect laminate for their application. Whether it is comparing materials, resin, or even manufacturing processes, VectorLam offers the best solution and reports it in clear, concise language. It has never been easier for users to build, review, and adjust their laminates to meet their specific requirements.

Most importantly, VectorLam is free to all users. Just sign in by clicking the logo to the right and start creating!

Click Here to access VECTORLAM

www.Vectorply.com