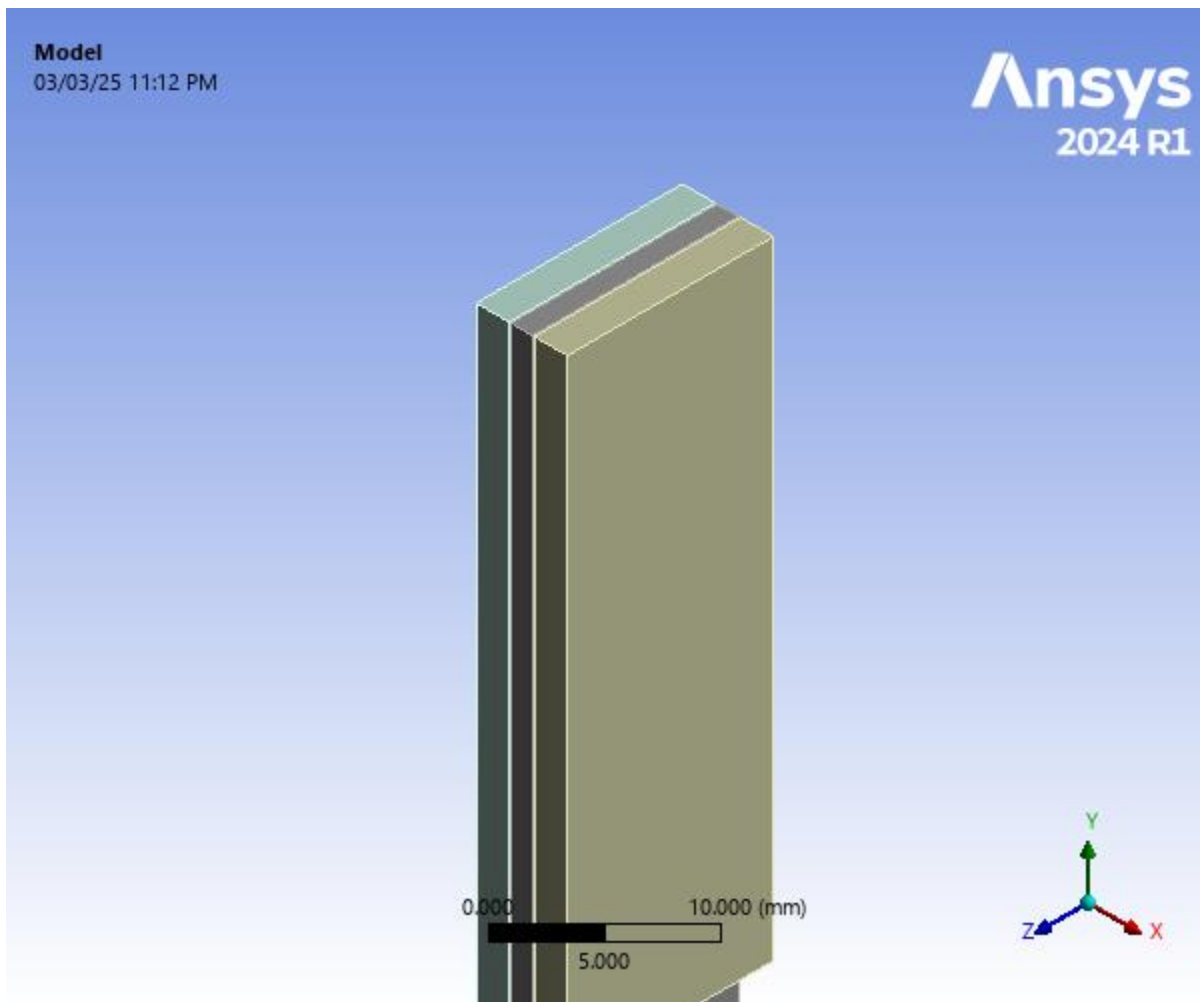




## Project\*

First Saved	17/Nov/2024
Last Saved	05/Dec/2024
Product Version	2024 R1
Save Project Before Solution	No
Save Project After Solution	No



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## Units

TABLE 1

Unit System	Metric (mm, t, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

## Model (C2)

**TABLE 2**  
**Model (C2) > Import Summary**

Object Name	<i>Import Summary</i>
State	No State

**TABLE 3**  
**Model (C2) > Geometry Imports**

Object Name	<i>Geometry Imports</i>
State	Solved

**TABLE 4**  
**Model (C2) > Geometry Imports > Geometry Import (B3)**

Object Name	<i>Geometry Import (B3)</i>
State	Solved
<b>Definition</b>	
Source	C:\Users\Mr. P\Documents\Simulation Files\Tensile Test Simulation\4 Layer Tensile\4 Layer Tensile Test_files\dp0\global\MECH\SYS-3\AssembledModel\SYS-3.pmdb
Type	Model Assembly
<b>Basic Geometry Options</b>	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS
Attributes	No
Named Selections	No
Material Properties	No
<b>Advanced Geometry Options</b>	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

## Geometry

**TABLE 5**  
**Model (C2) > Geometry**

Object Name	Geometry
State	Fully Defined
<b>Definition</b>	
Source	C:\Users\Mr. P\Documents\Simulation Files\Tensile Test Simulation\4 Layer Tensile\4 Layer Tensile Test_files\dp0\global\MECH\SYS-3\AssembledModel\SYS-3.pmdb
Type	Model Assembly
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
<b>Bounding Box</b>	
Length X	5.5221 mm
Length Y	200. mm
Length Z	12.5 mm
<b>Properties</b>	
Volume	7177.8 mm <sup>3</sup>
Mass	1.4439e-005 t
<b>Statistics</b>	
Bodies	5
Active Bodies	5
Nodes	36885
Elements	6456
Mesh Metric	None
<b>Update Options</b>	
Assign Default Material	No
<b>Advanced Geometry Options</b>	
Analysis Type	3-D

## Tabs

**TABLE 6**  
**Model (C2) > Geometry > Tabs > Parts**

Object Name	Solid(Tabs)	Solid(Tabs)	Solid(Tabs)	Solid(Tabs)
State	Meshed			
Graphics Properties				
Visible	Yes			
Transparency	1			
Definition				
Suppressed	No			
Stiffness Behavior	Flexible			
Coordinate System	Global Coordinate System(Tabs)			
Reference Temperature	By Environment			
Treatment	None			
Material				

Assignment	PCB laminate, PTFE			
Nonlinear Effects	Yes			
Thermal Strain Effects	Yes			
Bounding Box				
Length X	2. mm			
Length Y	40. mm			
Length Z	12.5 mm			
Properties				
Volume	975. mm³			
Mass	2.3888e-006 t	2.3887e-006 t		
Centroid X	-1.427 mm		2.078 mm	
Centroid Y	80.496 mm	-80.496 mm		80.496 mm
Centroid Z	-5.4792e-016 mm	2.121e-016 mm	1.7675e-017 mm	-1.7675e-017 mm
Moment of Inertia Ip1	3.3428e-004 t·mm²			
Moment of Inertia Ip2	3.1899e-005 t·mm²			
Moment of Inertia Ip3	3.0397e-004 t·mm²			
Statistics				
Nodes	5998			
Elements	1014			
Mesh Metric	None			
Transfer Properties				
Source	D4::Tabs			
Read Only	Yes			

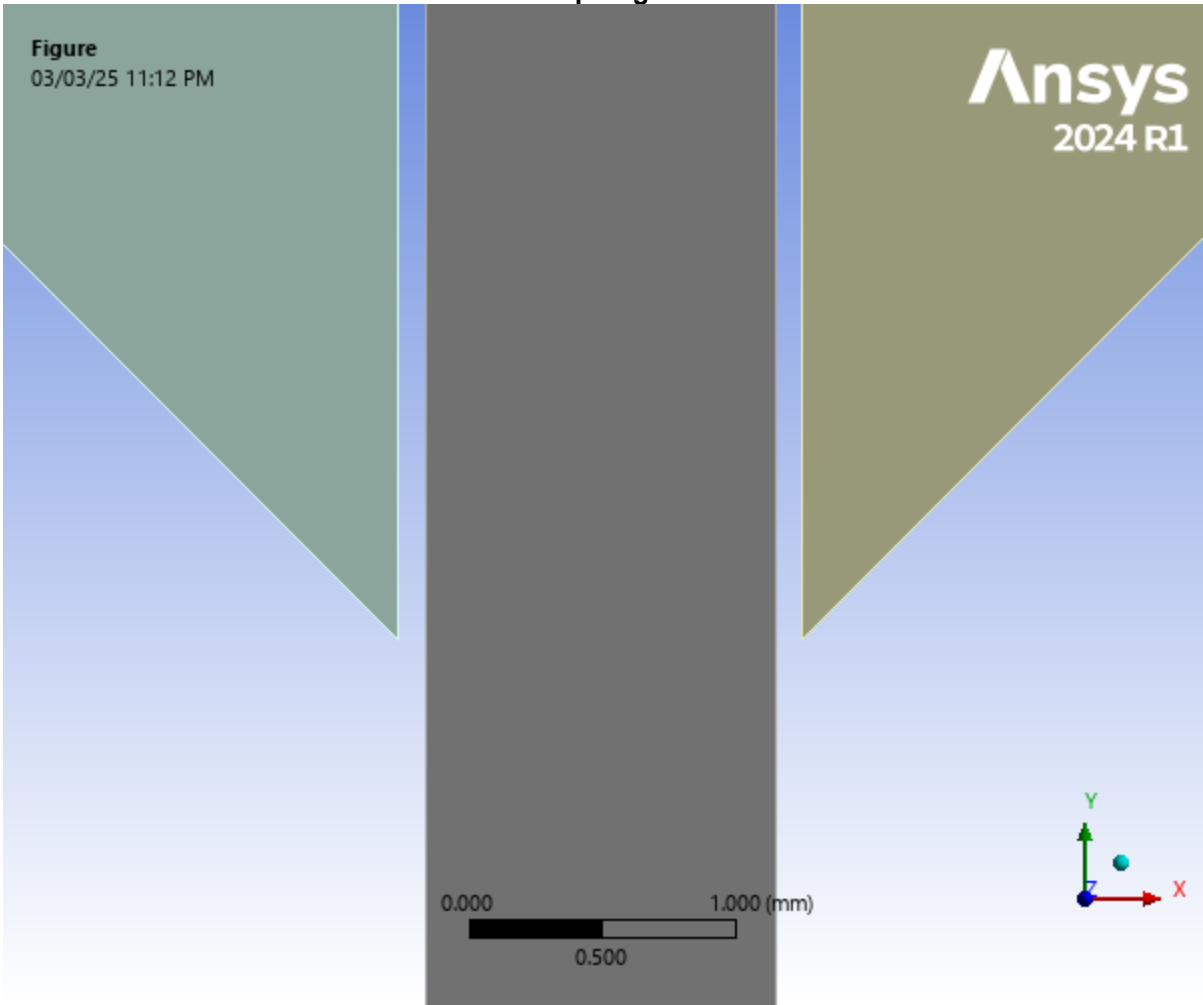
## ACP (Pre)

**TABLE 7**  
**Model (C2) > Geometry > ACP (Pre) > Parts**

Object Name	<i>Solid Body 1(ACP (Pre))</i>
State	Meshed
<b>Graphics Properties</b>	
Visible	Yes
Transparency	1
<b>Definition</b>	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Treatment	None
<b>Material</b>	
Assignment	Composite Material
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
<b>Bounding Box</b>	
Length X	1.3111 mm
Length Y	200. mm
Length Z	12.5 mm
<b>Properties</b>	

Volume	3277.8 mm <sup>3</sup>
Centroid X	0.32779 mm
Centroid Y	8.4645e-016 mm
Centroid Z	-1.2549e-015 mm
<b>Statistics</b>	
Nodes	12893
Elements	2400
Mesh Metric	None
<b>Transfer Properties</b>	
Source	B5::ACP (Pre)

**FIGURE 1**  
**Model (C2) > Geometry > Figure**  
**Shap Edges**



**TABLE 8**  
**Model (C2) > Materials**

Object Name	<i>Materials</i>
State	Fully Defined
<b>Statistics</b>	
Materials	4

Material Assignments	0
----------------------	---

## Coordinate Systems

### Tabs

**TABLE 9**  
**Model (C2) > Coordinate Systems > Tabs > Coordinate System**

Object Name	<i>Global Coordinate System(Tabs)</i>
State	Fully Defined
<b>Definition</b>	
Type	Cartesian
Coordinate System	Program Controlled
APDL Name	
Suppressed	No
<b>Origin</b>	
Define By	Global Coordinates
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Location	Defined
<b>Principal Axis</b>	
Axis	X
Define By	Fixed Vector
<b>Orientation About Principal Axis</b>	
Axis	Y
Define By	Fixed Vector
<b>Directional Vectors</b>	
X Axis Data	[ 1. 0. 0. ]
Y Axis Data	[ 0. 1. 0. ]
Z Axis Data	[ 0. 0. 1. ]
<b>Transfer Properties</b>	
Source	D4::Tabs
Read Only	Yes
<b>Transformations</b>	
Base Configuration	Absolute
Transformed Configuration	[ 0. 0. 0. ]

**TABLE 10**  
**Model (C2) > Coordinate Systems > Coordinate System**

Object Name	<i>Global Coordinate System</i>
State	Fully Defined
<b>Definition</b>	
Type	Cartesian
Coordinate System ID	0.
<b>Origin</b>	
Origin X	0. mm
Origin Y	0. mm

Origin Z	0. mm
<b>Directional Vectors</b>	
X Axis Data	[ 1. 0. 0. ]
Y Axis Data	[ 0. 1. 0. ]
Z Axis Data	[ 0. 0. 1. ]
<b>Transfer Properties</b>	
Source	
Read Only	No

## Connections

**TABLE 11**  
**Model (C2) > Connections**

Object Name	<i>Connections</i>
State	Fully Defined
<b>Auto Detection</b>	
Generate Automatic Connection On Refresh	Yes
<b>Transparency</b>	
Enabled	Yes
<b>Statistics</b>	
Contacts	4
Active Contacts	4
Joints	0
Active Joints	0
Beams	0
Active Beams	0
Bearings	0
Active Bearings	0
Springs	0
Active Springs	0
Body Interactions	0
Active Body Interactions	0

**TABLE 12**  
**Model (C2) > Connections > Contacts**

Object Name	<i>Contacts</i>
State	Fully Defined
<b>Definition</b>	
Connection Type	Contact
<b>Scope</b>	
Scoping Method	Geometry Selection
Geometry	All Bodies
<b>Auto Detection</b>	
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	0.50117 mm
Use Range	No
Face/Face	Yes



Face-Face Angle Tolerance	75. °
Face Overlap Tolerance	Off
Cylindrical Faces	Include
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Assemblies
<b>Statistics</b>	
Connections	4
Active Connections	4

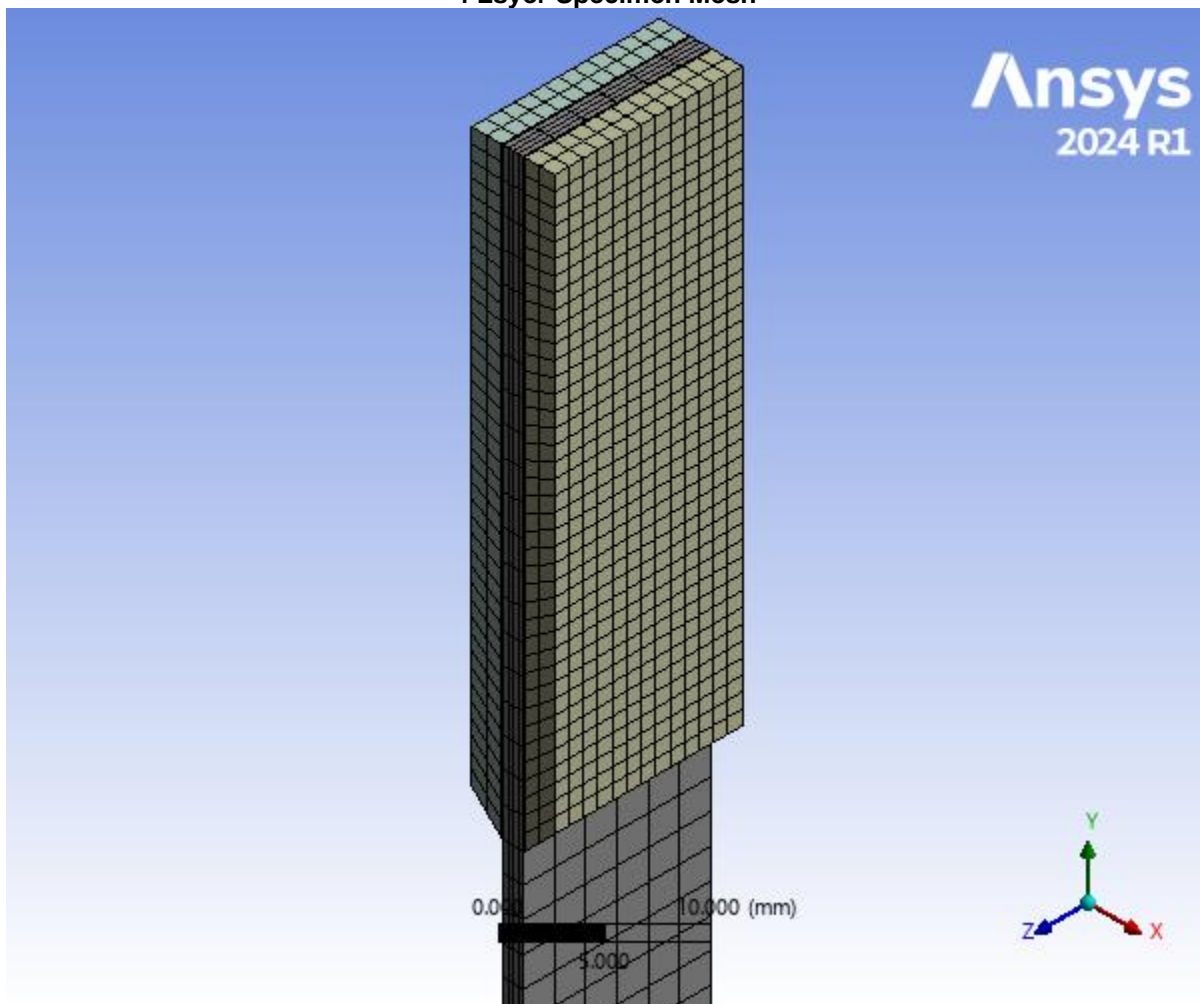
**TABLE 13**  
**Model (C2) > Connections > Contacts > Contact Regions**

Object Name	Contact Region	Contact Region 2	Contact Region 3	Contact Region 4
State	Fully Defined			
Scope				
Scoping Method	Geometry Selection			
Contact	1 Face			
Target	1 Face			
Contact Bodies	Solid(Tabs)			
Target Bodies	SolidModel.1			
Protected	No			
Definition				
Type	Bonded			
Scope Mode	Automatic			
Behavior	Program Controlled			
Trim Contact	Program Controlled			
Trim Tolerance	0.50117 mm			
Contact APDL Name				
Target APDL Name				
Suppressed	No			
Display				
Element Normals	No			
Advanced				
Formulation	Program Controlled			
Small Sliding	Program Controlled			
Detection Method	Program Controlled			
Penetration Tolerance	Program Controlled			
Elastic Slip Tolerance	Program Controlled			
Normal Stiffness	Program Controlled			
Update Stiffness	Program Controlled			
Pinball Region	Program Controlled			
Geometric Modification				
Contact Geometry Correction	None			
Target Geometry Correction	None			

**TABLE 14**  
**Model (C2) > Mesh**

Object Name	<i>Mesh</i>
State	Solved
<b>Display</b>	
Display Style	Use Geometry Setting
<b>Quality</b>	
Check Mesh Quality	Yes, Errors
Error Limits	Aggressive Mechanical
Mesh Metric	None
<b>Statistics</b>	
Nodes	36885
Elements	6456
Show Detailed Statistics	No
<b>Model Assembly</b>	
Read Only	Yes

**FIGURE 2**  
**Model (C2) > Mesh > Figure**  
**4 Lsyer Specimen Mesh**



**TABLE 15**  
**Model (C2) > Imported Plies**

Object Name	<i>Imported Plies</i>
State	Solved
<b>Definition</b>	
Type	Imported Plies
Suppressed	No
<b>Material</b>	
Nonlinear Effects	Yes
Thermal Strain Effects	Yes

**ACP (Pre)**

**SolidModel.1.h5(ACP (Pre))**

**ModelingGroup.1(ACP (Pre))**

**ModelingPly.1(ACP (Pre))**

**P1\_\_ModelingPly.1(ACP (Pre))**

**TABLE 16**

**Model (C2) > Imported Plies > ACP (Pre) > SolidModel.1.h5(ACP (Pre)) > ModelingGroup.1(ACP (Pre)) > ModelingPly.1(ACP (Pre)) > P1\_\_ModelingPly.1(ACP (Pre)) > P1L1\_\_ModelingPly.1(ACP (Pre))**

Object Name	P1L1__ModelingPly.1(ACP (Pre))	P1L2__ModelingPly.1(ACP (Pre))	P1L3__ModelingPly.1(ACP (Pre))	P1L4__ModelingPly.1(ACP (Pre))
State	Fully Defined			
Definition				
Name in Source	P1L1__ModelingPly.1	P1L2__ModelingPly.1	P1L3__ModelingPly.1	P1L4__ModelingPly.1
ID in Source	P1L1__ModelingPly.1	P1L2__ModelingPly.1	P1L3__ModelingPly.1	P1L4__ModelingPly.1
Material	UD_ Carbon Fiber (90)			
Thickness	0.32778 mm			
Angle	0. °			
Number of Elements	600.			
Transfer Properties				
Source	B5::ACP (Pre)			

**Named Selections**

**ACP (Pre)**

**TABLE 17**  
**Model (C2) > Named Selections > ACP (Pre) > Named Selections**

Object Name	SOLIDMODEL.1_ALL_ELEMENTS_BOT(ACP (Pre))	SOLIDMODEL.1_ALL_ELEMENTS_TOP(ACP (Pre))	SOLIDMODEL.1_ALL_ELEMENTS(ACP (Pre))
State	Fully Defined		
Scope			
Scoping Method	Geometry Selection		
Geometry	1 Face	2400 Elements	
Definition			
Send to Solver	Yes		
Protected	Program Controlled		
Visible	Yes		
Program Controlled Inflation	Exclude		
Preserve During Solve			No
Statistics			
Type	Imported		
Total Selection	1 Face	2400 Elements	
Surface Area	2500. mm²		
Suppressed	0		
Used by Mesh Worksheet	No		
Transfer Properties			
Source	B5::ACP (Pre)		
Read Only			Yes

## Static Structural (C3)

**TABLE 18**  
**Model (C2) > Analysis**

Object Name	Static Structural (C3)
State	Solved
<b>Definition</b>	
Physics Type	Structural

Analysis Type	Static Structural
Solver Target	Mechanical APDL
<b>Options</b>	
Environment Temperature	22. °C
Generate Input Only	No

**TABLE 19**  
**Model (C2) > Static Structural (C3) > Analysis Settings**

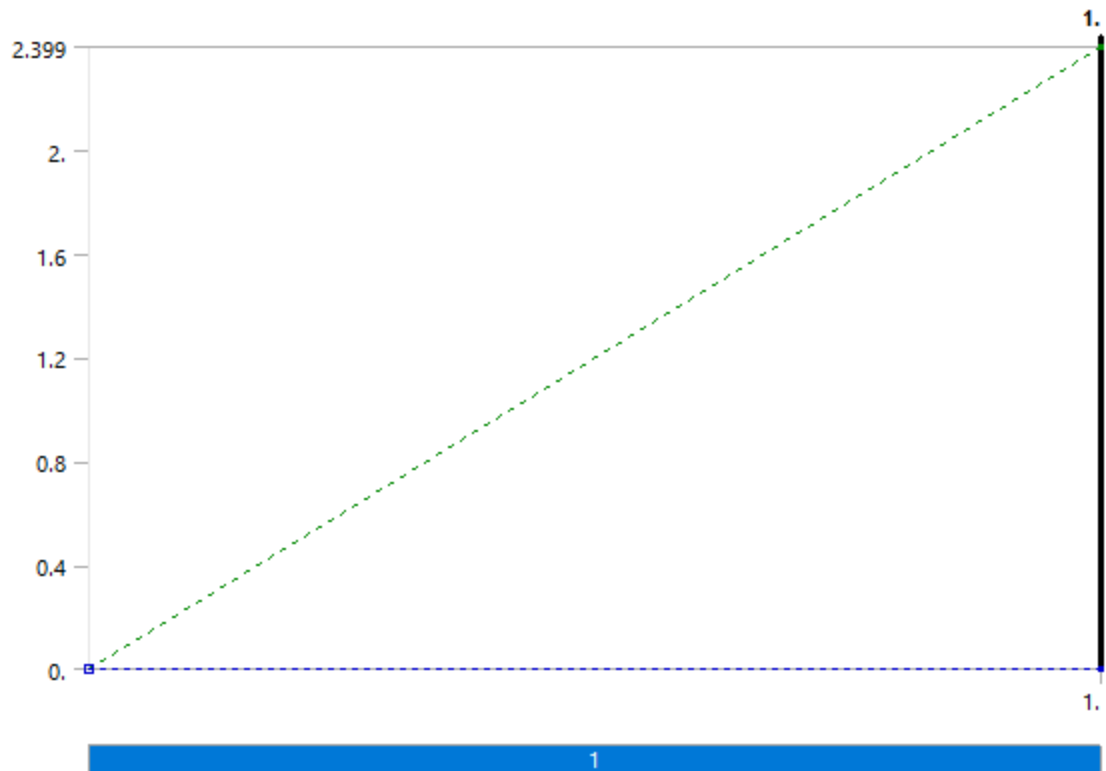
Object Name	<i>Analysis Settings</i>
State	Fully Defined
<b>Step Controls</b>	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
<b>Solver Controls</b>	
Solver Type	Program Controlled
Weak Springs	Off
Solver Pivot Checking	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Quasi-Static Solution	Off
<b>Rotordynamics Controls</b>	
Coriolis Effect	Off
<b>Restart Controls</b>	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Combine Restart Files	Program Controlled
<b>Nonlinear Controls</b>	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Program Controlled
<b>Advanced</b>	
Inverse Option	No
Contact Split (DMP)	Program Controlled
<b>Output Controls</b>	
Stress	Yes
Back Stress	No
Strain	Yes
Contact Data	Yes
Nonlinear Data	No

Nodal Forces	No
Volume and Energy	Yes
Euler Angles	Yes
General Miscellaneous	No
Contact Miscellaneous	No
Store Results At	All Time Points
Result File Compression	Program Controlled
<b>Analysis Data Management</b>	
Solver Files Directory	C:\Users\Mr. P\Documents\Simulation Files\Tensile Test Simulation\4 Layer Tensile\4 Layer Tensile Test_files\dp0\SYS-3\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Contact Summary	Program Controlled
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	nmm

**TABLE 20**  
**Model (C2) > Static Structural (C3) > Loads**

Object Name	Fixed Support		Displacement	
State	Fully Defined			
Scope				
Scoping Method	Geometry Selection			
Geometry	2 Faces			
Definition				
Type	Fixed Support		Displacement	
Suppressed	No			
Define By			Components	
Coordinate System			Global Coordinate System	
X Component			0. mm (ramped)	
Y Component			2.399 mm (ramped)	
Z Component			0. mm (ramped)	

**FIGURE 3**  
**Model (C2) > Static Structural (C3) > Displacement**



## Solution (C4)

**TABLE 21**  
**Model (C2) > Static Structural (C3) > Solution**

Object Name	<i>Solution (C4)</i>
State	Solved
<b>Adaptive Mesh Refinement</b>	
Max Refinement Loops	1.
Refinement Depth	2.
<b>Information</b>	
Status	Done
MAPDL Elapsed Time	9. s
MAPDL Memory Used	1.1055 GB
MAPDL Result File Size	9.4375 MB
<b>Post Processing</b>	
Beam Section Results	No
On Demand Stress/Strain	No

**TABLE 22**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Solution Information**

Object Name	<i>Solution Information</i>
State	Solved
<b>Solution Information</b>	
Solution Output	Solver Output
Newton-Raphson Residuals	0

Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
<b>FE Connection Visibility</b>	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

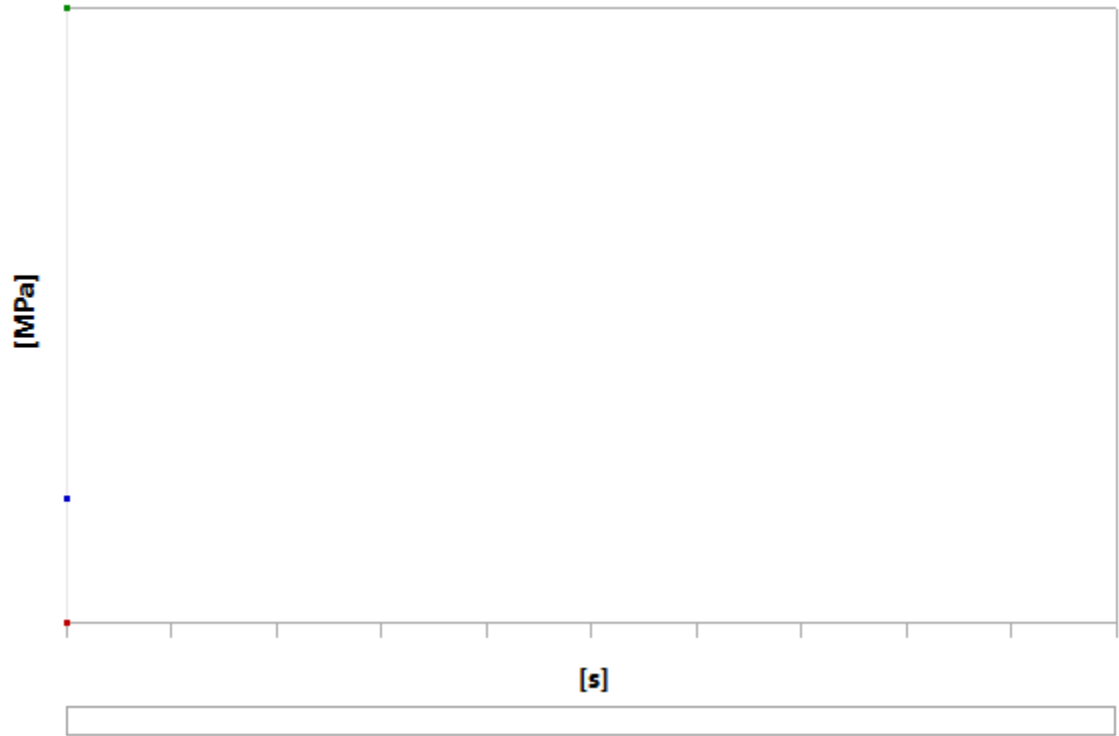
**TABLE 23**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Results**

Object Name	<i>Normal Stress</i>	<i>Normal Elastic Strain</i>	<i>Equivalent Stress</i>	<i>Equivalent Elastic Strain</i>	<i>Directional Deformation</i>
State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies				
Sub Scope By	Layer				
Layer	Entire Section				
Position	Top/Bottom				
Definition					
Type	Normal Stress	Normal Elastic Strain	Equivalent (von-Mises) Stress	Equivalent Elastic Strain	Directional Deformation
Orientation	X Axis				X Axis
By	Time				
Display Time	Last				
Separate Data by Entity	No				
Coordinate System	Solution Coordinate System				Global Coordinate System
Calculate Time History	Yes				
Identifier					
Suppressed	No				
Integration Point Results					
Display Option	Averaged				
Average Across Bodies	No				
Results					
Minimum	-350.83 MPa	-1.5183e-002 mm/mm	2.7533 MPa	5.9853e-004 mm/mm	-1.373e-002 mm
Maximum	2841.3 MPa	3.8512e-002 mm/mm	2878. MPa	0.17804 mm/mm	1.1514e-002 mm
Average	296.81 MPa	2.411e-003 mm/mm	332.52 MPa	1.3999e-002 mm/mm	-1.8382e-003 mm
Minimum Occurs On	SolidModel.1	Solid(Tabs)			SolidModel.1



Maximum Occurs On	SolidModel.1
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

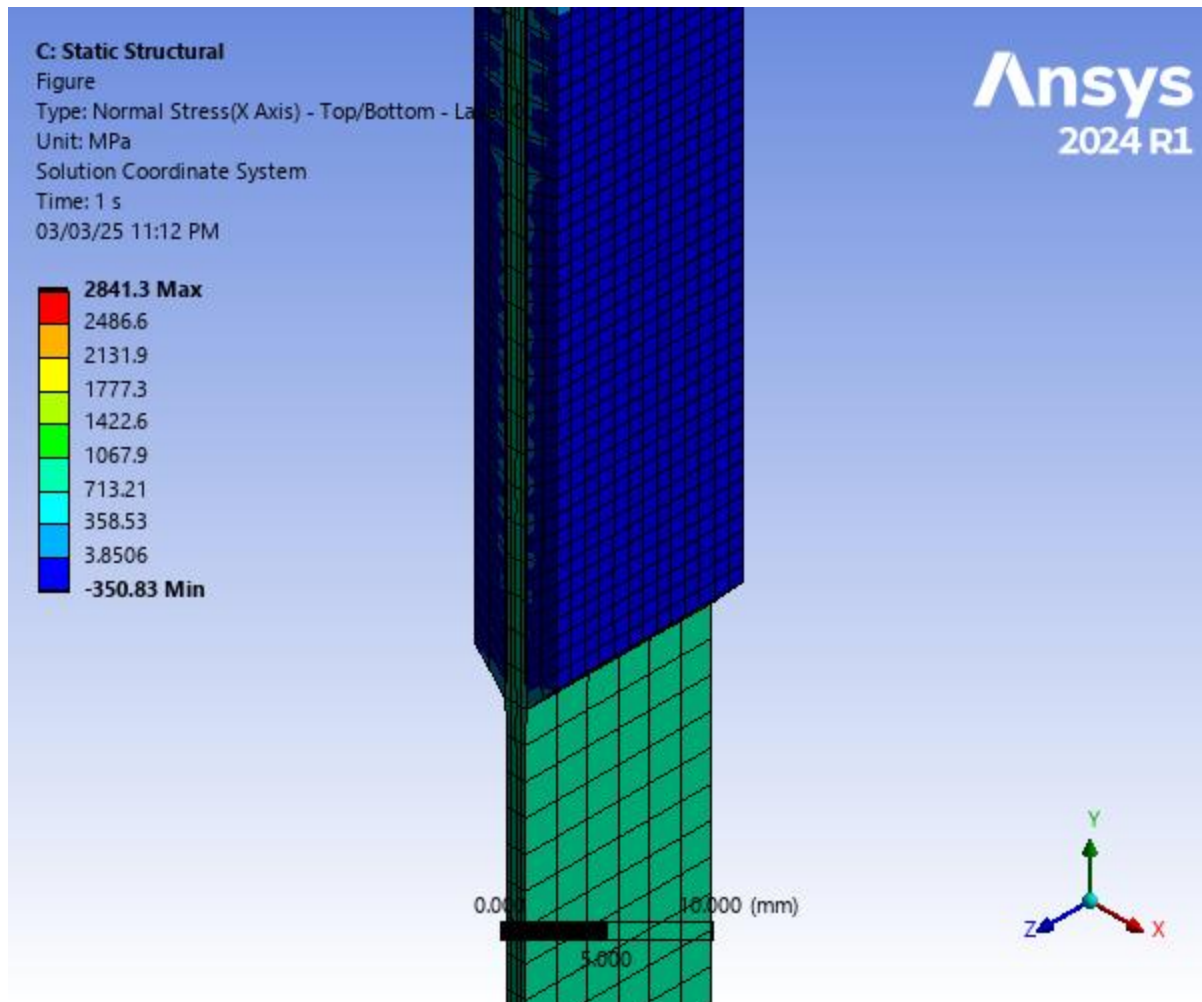
**FIGURE 4**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Stress**



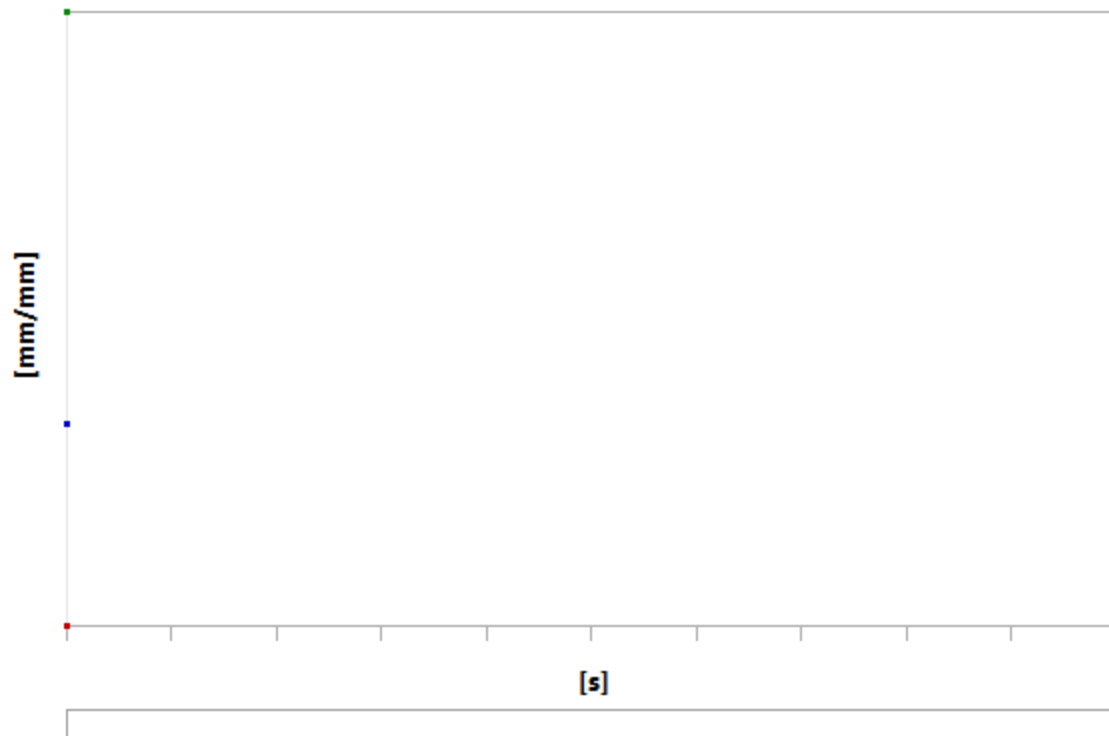
**TABLE 24**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Stress**

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	-350.83	2841.3	296.81

**FIGURE 5**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Stress > Figure 4 Layer specimen Normal Stress**



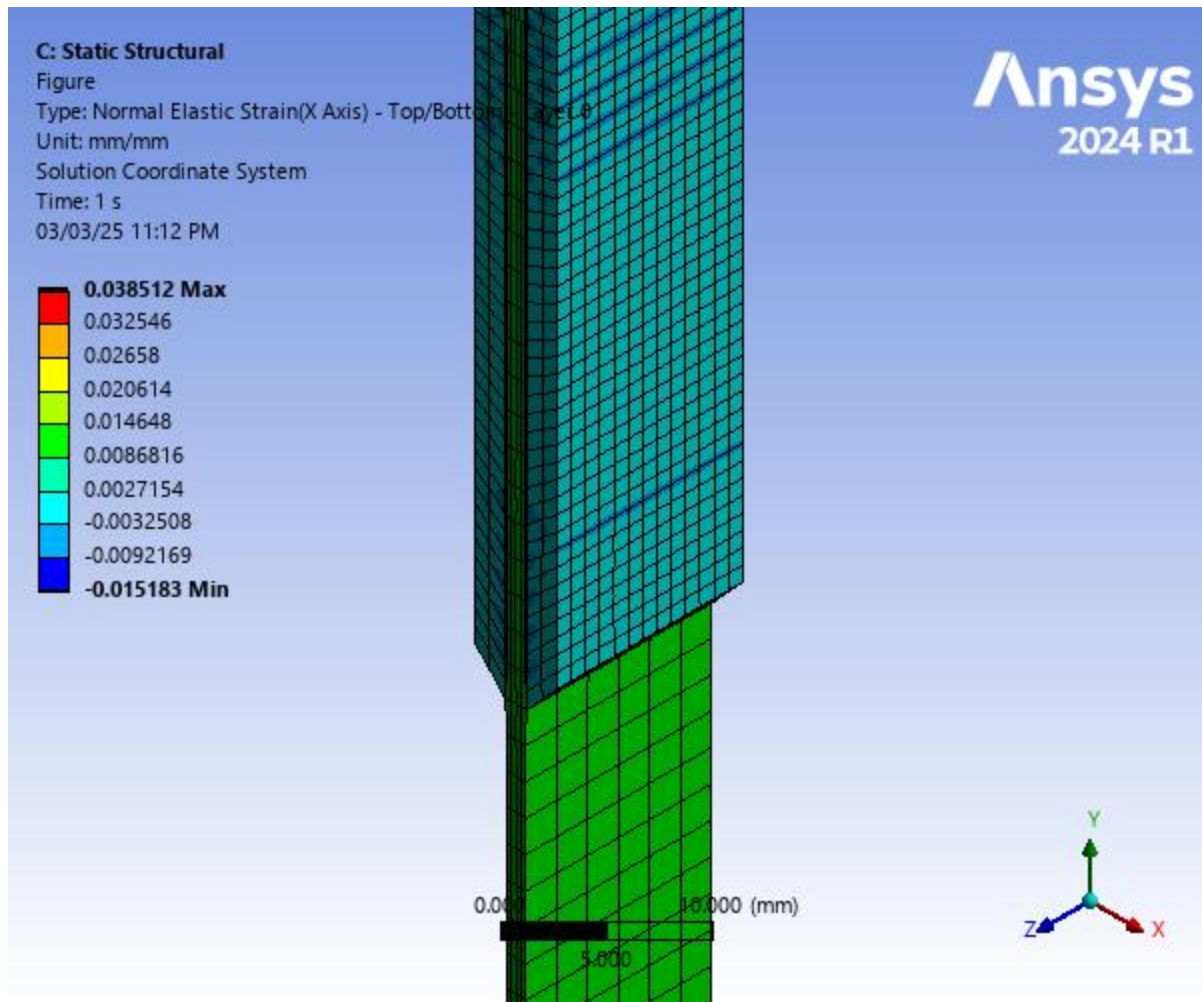
**FIGURE 6**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Elastic Strain**



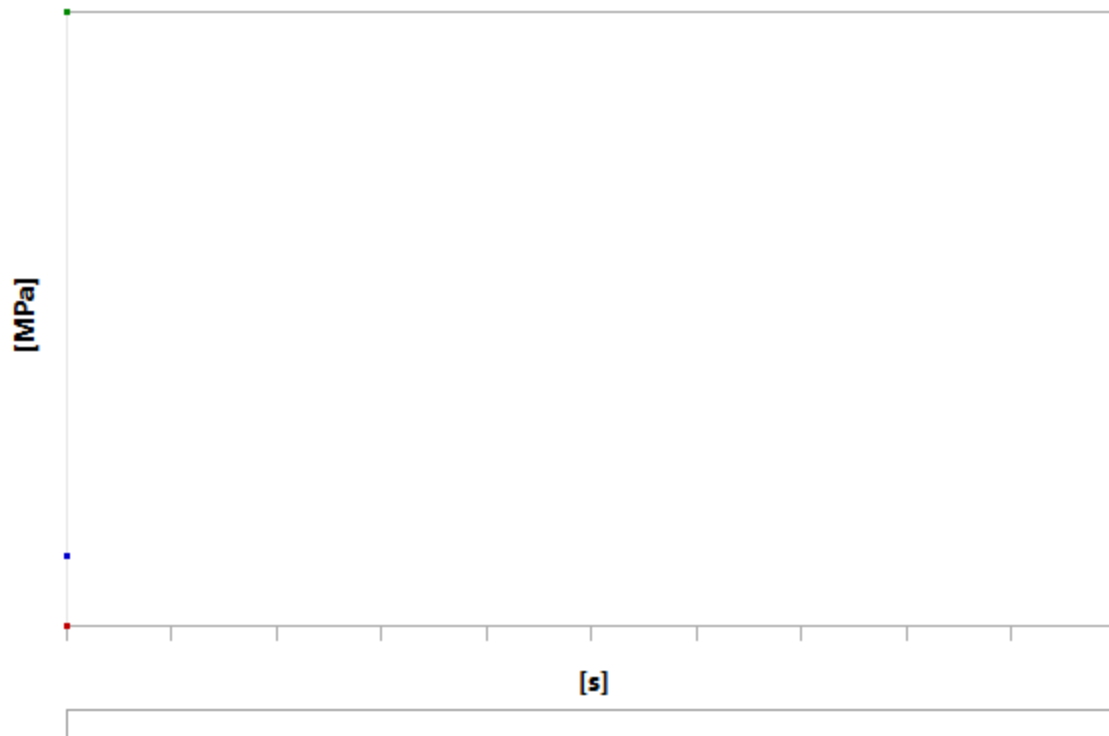
**TABLE 25**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Elastic Strain**

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.	-1.5183e-002	3.8512e-002	2.411e-003

**FIGURE 7**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Normal Elastic Strain > Figure**  
**4 Layer Specimen normal elastic Strain**



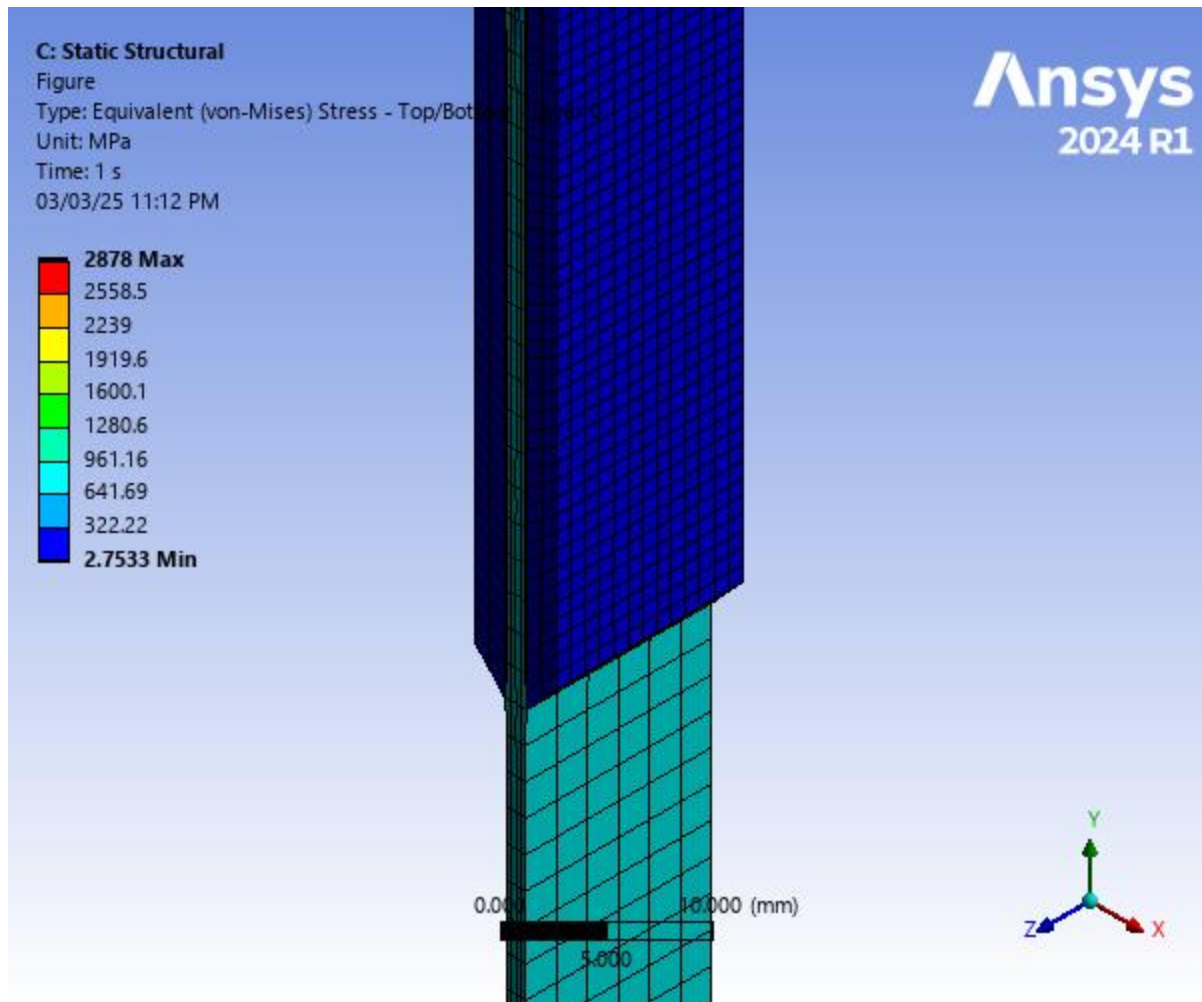
**FIGURE 8**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Stress**



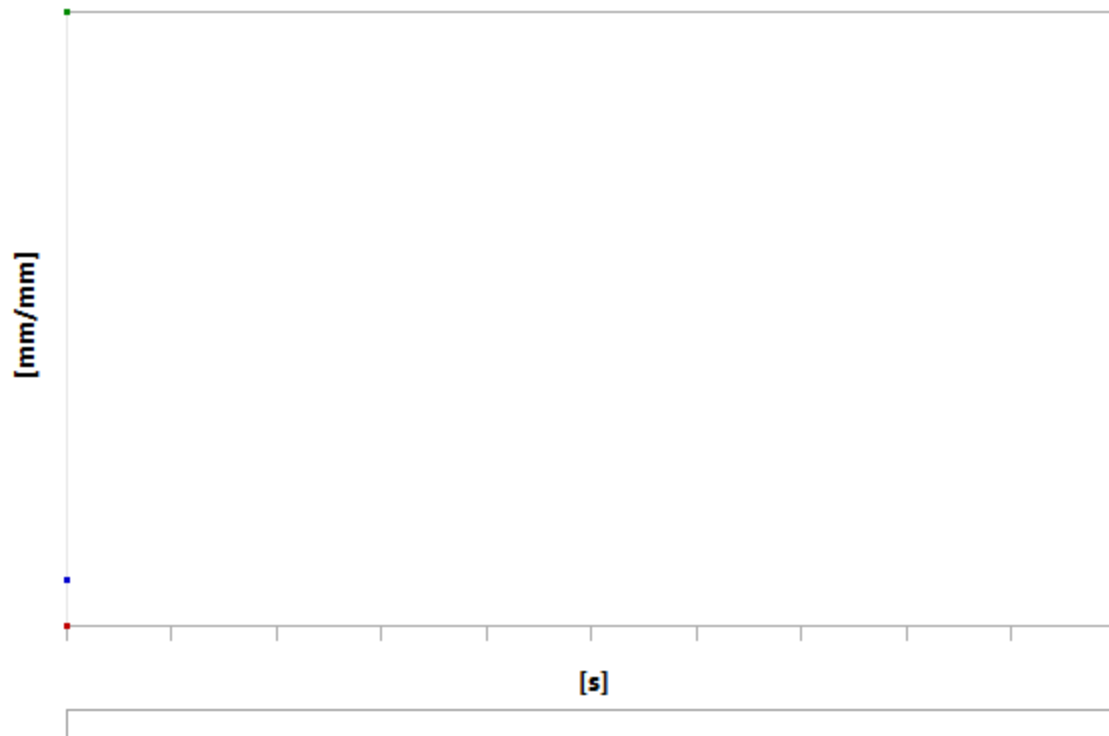
**TABLE 26**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Stress**

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	2.7533	2878.	332.52

**FIGURE 9**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Stress > Figure**  
**4 Layer Equivalent Stress**



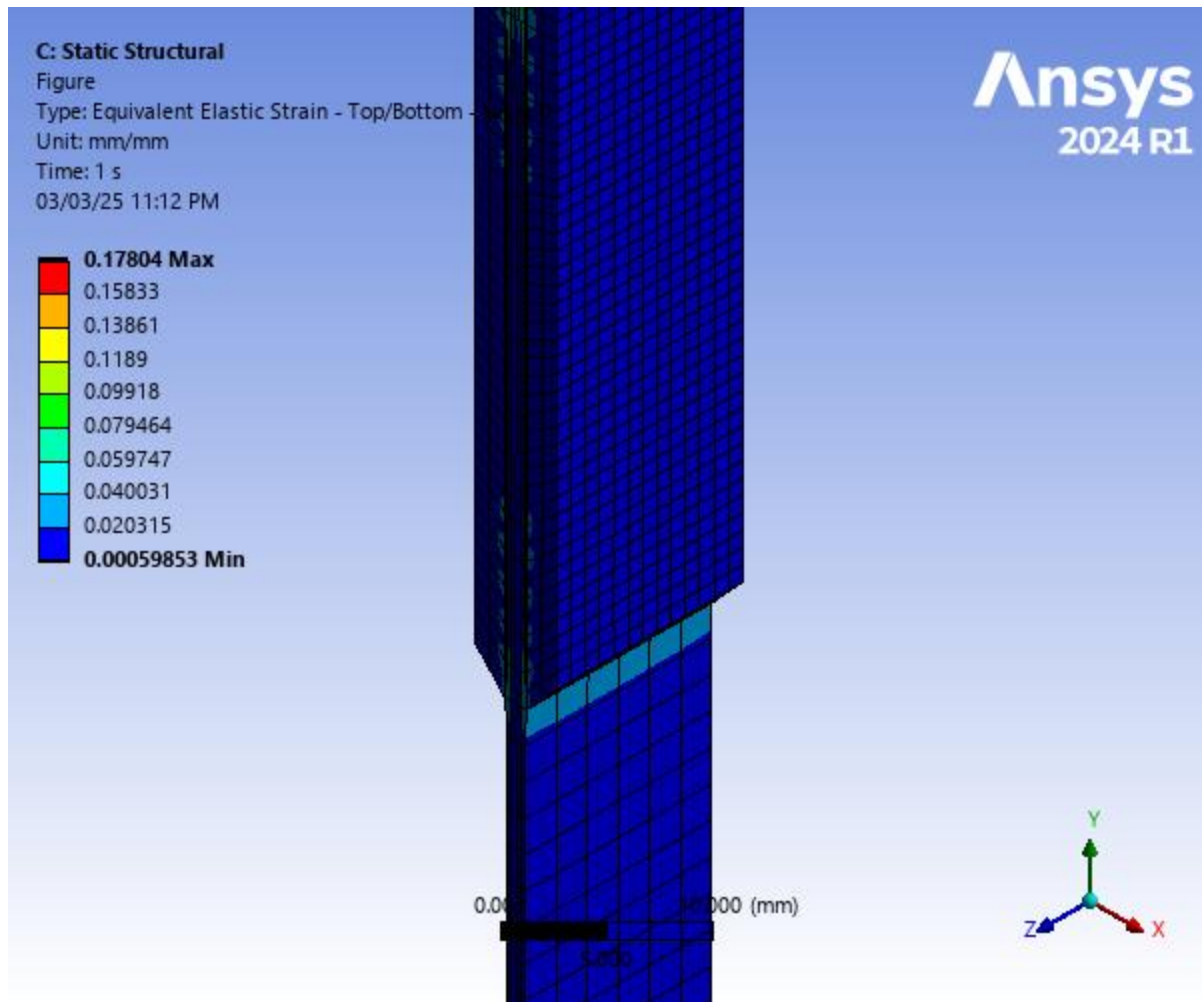
**FIGURE 10**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Elastic Strain**



**TABLE 27**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Elastic Strain**

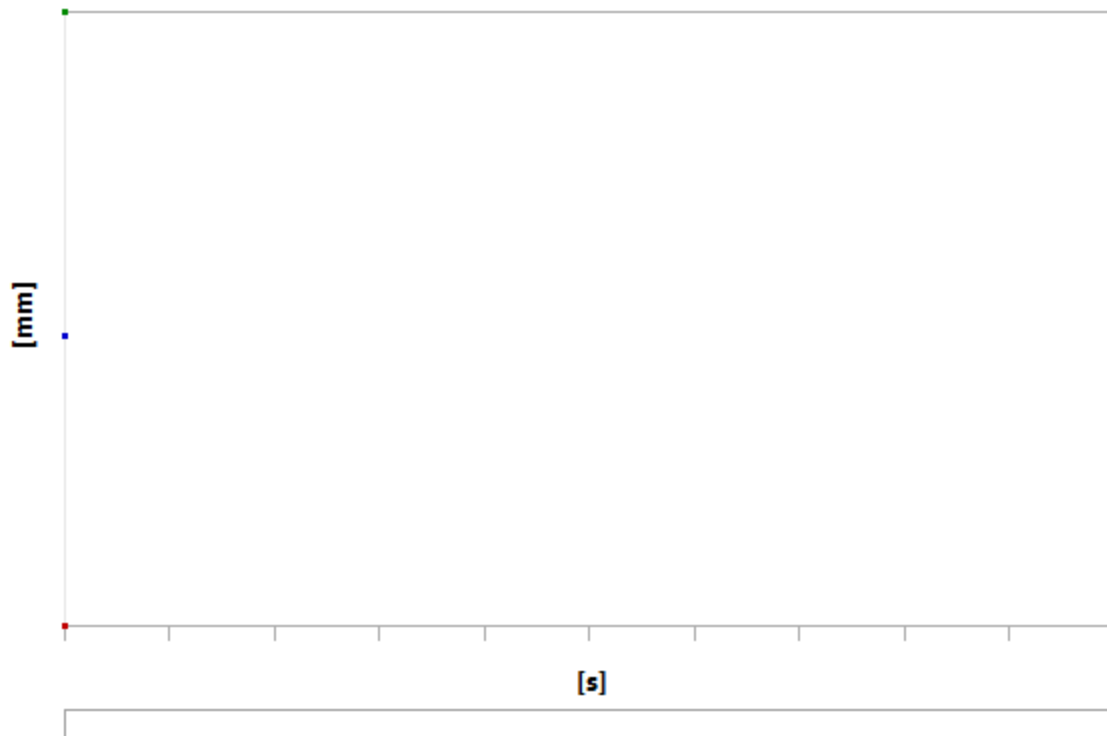
Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.	5.9853e-004	0.17804	1.3999e-002

**FIGURE 11**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Equivalent Elastic Strain > Figure 4 Layer equivalent elastic Strain**



**FIGURE 12**  
**Model (C2) > Static Structural (C3) > Solution (C4) > Directional Deformation**





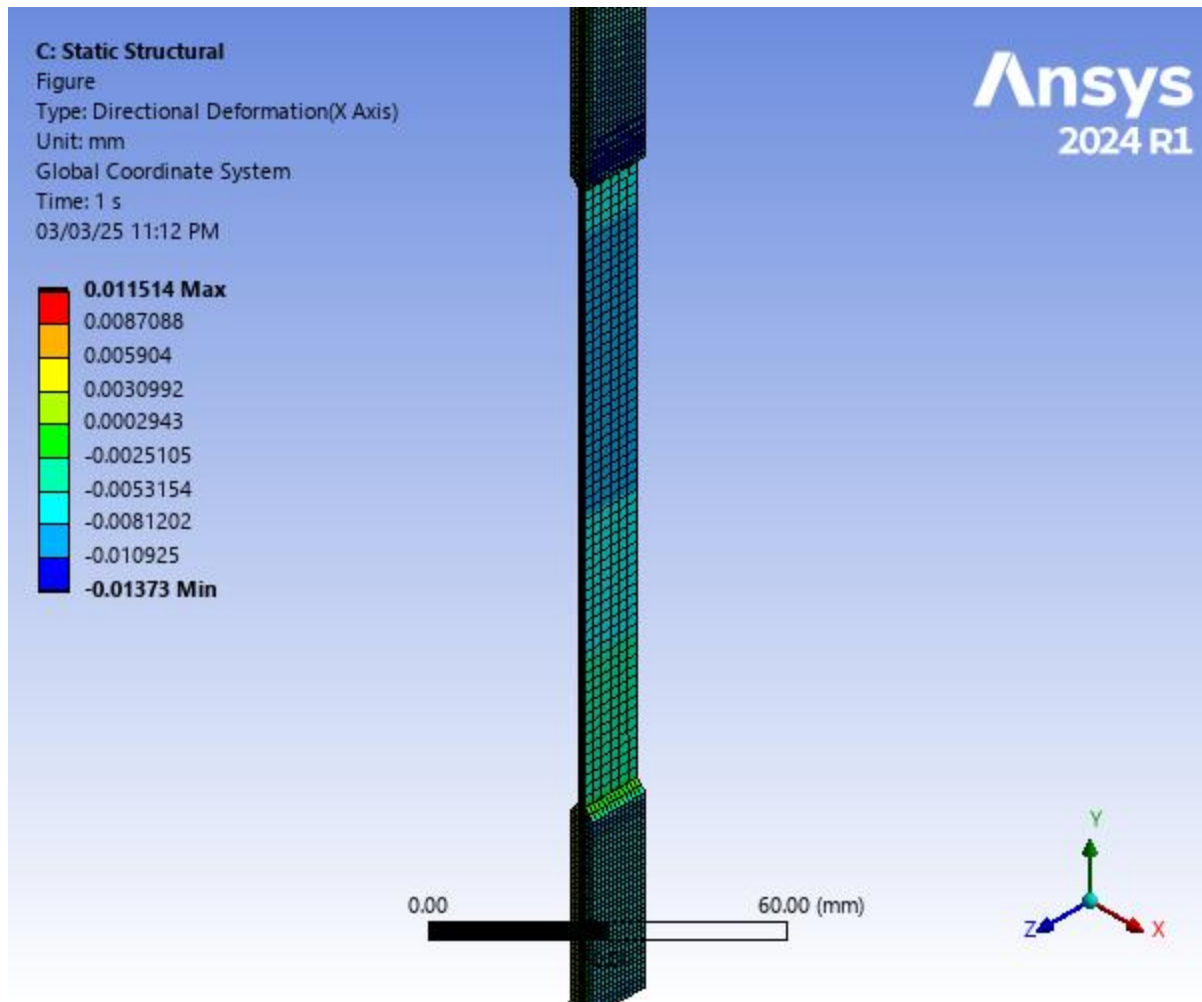
**TABLE 28**

**Model (C2) > Static Structural (C3) > Solution (C4) > Directional Deformation**

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	-1.373e-002	1.1514e-002	-1.8382e-003

**FIGURE 13**

**Model (C2) > Static Structural (C3) > Solution (C4) > Directional Deformation > Figure 4 Layer Directional Deformation**



## Material Data

### PCB laminate, PTFE

**TABLE 29**  
**PCB laminate, PTFE > Constants**

Density	2.45e-009 tonne mm <sup>-3</sup>
Tensile Yield Strength	80.1 MPa
Tensile Ultimate Strength	80.1 MPa
Coefficient of Thermal Expansion	1.59e-005 C <sup>-1</sup>
Thermal Conductivity	2.5e-004 W mm <sup>-1</sup> C <sup>-1</sup>
Specific Heat	8.06e+008 mJ tonne <sup>-1</sup> C <sup>-1</sup>
Resistivity	4.8e+015 ohm mm
Electric Loss Tangent	2.1e-003
Relative Permittivity	2.5

**TABLE 30**  
**PCB laminate, PTFE > Opacity**

Red	Green	Blue
-----	-------	------

80	130	80
Opacity		
0.9		
Metallic Finish		
0		

**TABLE 31**  
**PCB laminate, PTFE > Isotropic Elasticity**

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Temperature C
4600	0.25	3066.7	1840	23

**TABLE 32**  
**PCB laminate, PTFE > Isotropic Secant Coefficient of Thermal Expansion**

Zero-Thermal-Strain Reference Temperature C
23

**TABLE 33**  
**PCB laminate, PTFE > Embodied energy**

Embodied energy mJ tonne <sup>-1</sup>
5.718e+014

**TABLE 34**  
**PCB laminate, PTFE > Climate change CO2-eq**

Climate change CO2-eq dBA
35.95

**TABLE 35**  
**PCB laminate, PTFE > Recycle**

Recycle
1

## **UD\_ Carbon Fiber (90)**

**TABLE 36**  
**UD\_ Carbon Fiber (90) > Constants**

Density	1.49e-009 tonne mm <sup>-3</sup>
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**TABLE 37**  
**UD\_ Carbon Fiber (90) > Color**

Red	Green	Blue
130	181	143

**TABLE 38**  
**UD\_ Carbon Fiber (90) > Orthotropic Stress Limits**

Tensile X direction MPa	Tensile Y direction MPa	Tensile Z direction MPa	Compressive X direction MPa	Compressive Y direction MPa	Compressive Z direction MPa	Shear XY MPa	Shear YZ MPa	Shear XZ MPa	Temperature C
1253	16	16	-608	-56	-56	34	18	34	

**TABLE 39**  
**UD\_ Carbon Fiber (90) > Orthotropic Elasticity**

Young's Modulus X direction MPa	Young's Modulus Y direction MPa	Young's Modulus Z direction MPa	Poisson's Ratio XY	Poisson's Ratio YZ	Poisson's Ratio XZ	Shear Modulus XY MPa	Shear Modulus YZ MPa	Shear Modulus XZ MPa	Temperature C
72322	5140	5140	0.26	0.4	0.26	2809	1853	2809	

**TABLE 40**  
**UD\_ Carbon Fiber (90) > Tsai-Wu Constants**

Temperature C	Coupling Coefficient XY	Coupling Coefficient YZ	Coupling Coefficient XZ
	-1	-1	-1