

# Multiscale Analysis of woven plate using SwiftComp-Patran GUI

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## **Problem Statement**

In this example, a 2 by 2 twill woven laminated plate is analyzed using SwiftComp-Patarn GUI. In order to use PCOMP card in Nastran, the effective properties of woven laminar must be obtained from multiscale analysis. At micro-scale, yarn effective properties are obtained from fiber and matrix using SwiftComp solid model, and woven laminar properties are obtained from yarns and matrix using SwiftComp solid model.

The layup of the laminated plate is [45/0/0/45/0/0/45]s, and the ply thickness is 0.2 mm. Assume the plate has dimensions Length \* Width = 50mm \* 50mm. The plate is subjected to fixed-free boundary conditions, and a uniform pressure is applied at free end with magnitude 10 MPa along x-direction (Fig. 1).

The fiber properties are  $E_1 = 276$  GPa,  $E_2 = E_3 = 19.50$  GPa,  $G_{12} = G_{13} = 70$  GPa,  $G_{23} = 5.73$  GPa,

 $v_{12} = v_{13} = 0.28$ ,  $v_{23} = 0.70$ , the matrix properties are E = 4.76GPa, v = 0.37. The fiber volume fraction is 0.6.

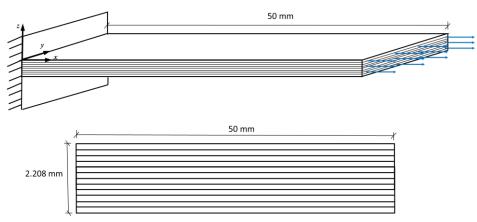


Fig. 1 The clamped structure

### Microscale homogenization

In order to obtain the effective properties of yarns, homogenization analysis is needed by considering fibers and matrix. The microstructure of the yarn is usually idealized a square pack and the SG is shown in Figure 2.

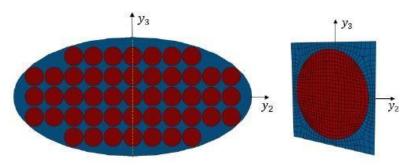


Fig. 2 Yarn cross-section and its SG

Open Patran and start a new database named yarn\_SG as shown in Fig.3. Click *Geometry*>*Surface*->*XYZ*, then input the parameters shown in Fig. 4 to center the SG at the origin so that the reference surface is located in the mid-plane of the structure, and click apply. Next select *Curves*->2*D Circle*. Input the radius of fiber circle 0.437 as the volume fraction is 0.6 and click apply as shown in Fig. 5. If we define the length of each edge is *a*, the radius of fiber is *r* and the fiber volume fraction is  $v_f$ . The relation of radius and fiber volume fraction is given in Eq. (1)

$$\frac{S_f}{S} = \frac{\pi r^2}{a^2} = v_f \Longrightarrow r = \sqrt{\frac{v_f \times a^2}{\pi}}$$
(1)

Now the geometry of the SG is still not ready, we need to break the entire domain to be matrix and fiber. Select *Action: Edit, Object: Surface and Method: Break* in the Geometry control window and select the corresponding surface and curve as shown in Fig. 6. Click "Yes" to finish the geometry generation of this SG.

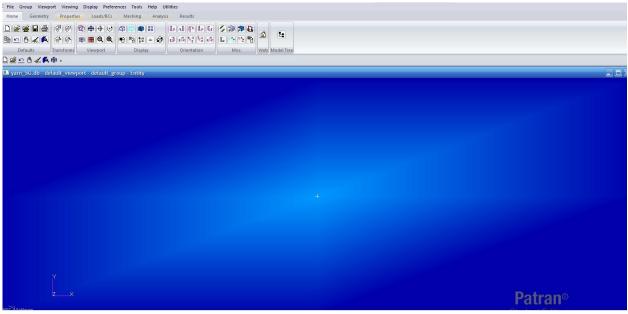


Fig. 3 New Patran database named Laminar\_SG

Action:	Create 🔻
Object:	Surface 🔻
Method:	XYZ 🔻
Surface ID	) List
4	
Refer. Co	ordinate Frame
Coord 0	
Vector Co	oordinates List
<110>	
Auto Ex	ecute
Origin Cou	ordinates List
Ungin Cu	

Fig. 4 Parameters for generating matrix of the SG

File Group Viewport Viewing Display Preferences Tools Help Utilities	
Home Geometry Properties Loads/BCs Meshing Analysis Results	
Select       Disassociate       Disassociate       Select       S	
<u>] 🖻 🖻 🖞 🐇 🏟 🗧 👘 👘 👘 👘</u>	
🖬 yarn_SG.db - default_viewport - default_group - Entity	
	<b>Patran</b> <sup>®</sup>

Fig. 5 Generating fiber inside the matrix

enan_group = Ennty IL_viewport - default_group - Entity	с Ц	New Model Preference Geometry
A Message Question from application SQM	2 + - = × · · · · · · · · · · · · · · · · · ·	Actor: Edw Object: Surface Surface D Lat 2 Opton: Curve Opton: Curve Surface D Lat 2 Opton: Curve Surface Lat Surface Lat Surface Lat Curve List Curve 1 - Apply-
Patran®		J

Fig. 6 Divide surface into fiber surface and matrix surface

Next, we need to define the material properties for fiber and matrix respectively. Click *Materials->Isotropic*, input Matrix as material name and click *Input Properties* and input parameters as shown in the Fig. 7 and click Apply. Click *Materials->3D Orthotropic*, input Fiber as material name and click *Input Properties* and input parameters as shown in the Fig. 8 and click Apply.

Select Element Properties Action: Create, Object: 2D and Type: 2D Solid. Give Matrix as Property Set Name, click *Input Properties* and select *matrix* properties click Ok. The click select *Application Region* and click on the surface corresponding to matrix material, click Ok and apply. Follow the same procedure to define fiber properties.

📔 Input Options			Act	ion: Create
Constitutive Model:	Linear Elastic 🔻			ject: Isotropic▼
Property Name	Value		Me	thod: Manual Input
Elastic Modulus =	4760.			sting Materials 🛛 🖺
Poisson Ratio =	0.37		m	atrix
Shear Modulus =				
Density =			-	
Thermal Expan. Coeff =				
Structural Damping Coeff =				
Reference Temperature =				
			<u>ب</u> ابا	
				Filter *
			I	
				aterial Name
			m	natrix
Current Constitutive Models:	-1			scription
Linear Elastic - [,,,,] - [Activ	e]			ate: 17-Mar-19 Time: 1:04:58
ок	Clear	Cancel		
				Input Properties
				Change Material Status
	t Edition			Apply

Fig. 7 Input matrix material properties

P Input Options			
Constitutive Model:	Linear Elastic 🔻		RHS Window
Property Name	Value		Materials
Elastic Modulus 11 =	276000.		Action: Create -
Elastic Modulus 22 =	19500.		Object: 3d Orthotropic▼
Elastic Modulus 33 =	19500.		Method: Manual Input
Poisson Ratio 12 =	0.28		
Poisson Ratio 23 =	0.69999999		Existing Materials
Poisson Ratio 31 =	0.02		fiber
Shear Modulus 12 =	70000.		
Shear Modulus 23 =	5730.		
Shear Modulus 31 =	70000.		
Density =			
Thermal Expan. Coeff 11 =			
Thermal Expan. Coeff 22 =			
Thermal Expan. Coeff 33 =			Filter *
Structural Damping Coeff =			
Reference Temperature =			Material Name
			fiber
,			
			Description
			Date: 17-Mar-19 Time: 11:04:58
Current Constitutive Models:			
Linear Elastic - [,,,,] - [Activ	e]		
			Input Properties
			Change Material Status
ОК	Clear	Cancel	Apply

Fig. 8 Input fiber material properties

Next, we need to mesh the SG. Go to Mesh and assign mesh seed to each edge to make sure that a periodic mesh will be generated. In this example, each edge contains 20 seeds, and the circle contains 80 seeds. Go to Finite elements *Action: Create, Object: Mesh and Type: Surface*. Choose *Elem Shape: Tria, Mesher: Paver and Topology: Tria3* and select the surfaces corresponding to matrix and fiber. Keep all the other parameters as default values. Click apply, then the SG is meshed as shown in Fig. 9.

Now we will use the SC functions. Users need to install SC-Patran GUI as described in the installation manual, copy SwiftComp license file to the working directory, and type "!!input sc.pcl" in Patran command window to invoke all the SC related functions. Go to SwiftComp icon in the menu bar, and choose *Homogenization->Solid* as shown in Fig. 10 and select analysis type to be ThermoElastic, and keep all the other default parameters click apply. Note if the working directory contains a file with the same name, a warning message will be popup to ask if users want to overwrite the existed file. The results will be automatically popup as shown in Fig. 11.

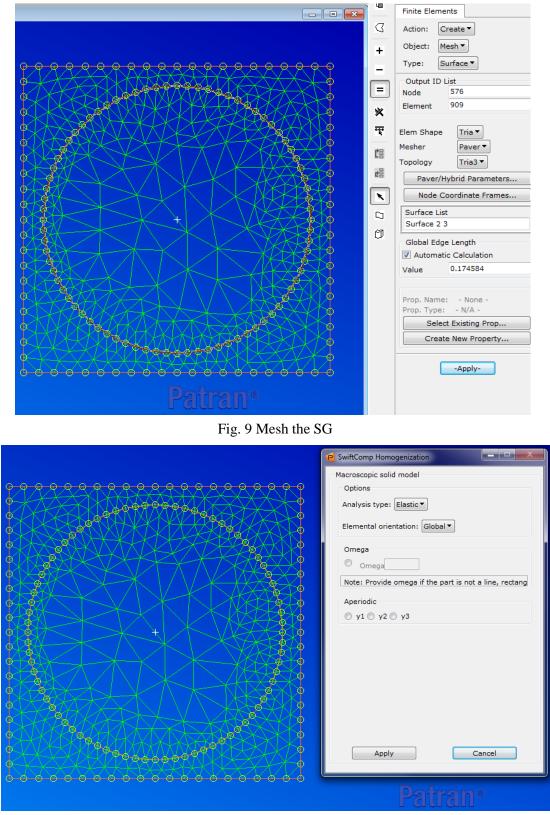


Fig. 10 Select SiwftComp homogenization solid model

Microscale.sc.k - Notepad			
File Edit Format View Help			
The Effective Stiffness Matrix			
1.7277296E+05 8.6862739E+03 8.6862739E+03 1.7523062E+04 8.7033387E+03 1.0280137E+04 -2.9516874E-02 -1.2792928E-01 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00	1.0280137E+04 -1.2792928E-01 1.7524516E+04 1.3074564E-02 1.3074564E-02 3.1003707E+03 0.0000000E+00 0.0000000E+00	0.000000E+00	
The Effective Compliance Matrix	x		
-1.8619673E-06 8.7592778E-05 -1.8756708E-06 -5.0458482E-05 -1.2025185E-11 3.8093651E-09 0.0000000E+00 0.0000000E+00		0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 1.4691774E-04 6.5752174E-10	0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 6.5752174E-10 1.4691408E-04
The Engineering Constants (App	roximated as Orthotropic)		
E1 = 1.6733489E+05 E2 = 1.1416466E+04 E3 = 1.1416290E+04 G12 = 6.8066997E+03 G13 = 6.8065300E+03 G23 = 3.1003707E+03 nu12= 3.1157209E-01 nu13= 3.1386516E-01 nu23= 5.7605756E-01			

Fig. 11 Results of solid homogenization analysis

#### Mesoscale homogenization

Once the effective yarn properties are obtained, we are ready for performing homogenization at macro-scale to get effective properties of woven laminar. The SG of 2 by 2 twill woven laminar is shown in Figure 12. The yarn width is 0.8 mm, yarn thickness is 0.1 mm and yarn spacing is 1 mm. The fabric thickness is 0.2 mm.

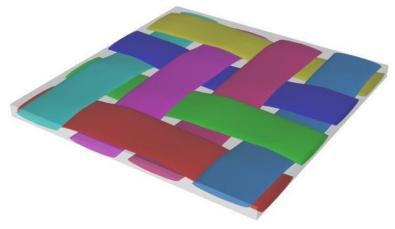


Fig. 12 2 by 2 twill woven SG

SwiftComp solid model is used for macro-scale homogenization, then import scmat (PCOMP+MAT8) function is used to create MAT8 properties in Patran. Tutorial #2 Page 7 Create a new database named Mesoscale, select *SwiftComp->Create woven composites->2 by 2 twill woven SG* as shown in Figure 13. The woven SG is created by TexGen4SC in the background, and users only need to input some parameters to define the SG as shown in Figure 14. The geometric information is given in this example. The woven composites using TexGen4SC is meshed using voxel mesh method to avoid distorted elements, and the voxel count needs to be defined for each direction in woven SG. In this example, we can keep all the default parameters, and click apply. TexGen4SC will be invoked in the background, and users will see the windows prompt as shown in Figure 15. Once the woven composites are generated, the prompt will be automatically closed. Note the woven SG is created in the sc file, and users need to use import sc file function to import the woven SG into Patran.

Sw	iftComp		7
	Homogenization	•	
	Dehomogenization	•	
	Failure-Input failure constants	•	<u><u><u>×</u></u> x <u>×</u> <u>×</u> <u>×</u> z z z z z z z z z z z z z z z z z z z</u>
	Failure-Initial failure	•	×
	Failure-Failure index/Strength ratio	•	
	Failure-Failure envelope	•	
	Import scmat	•	
	Create woven composites	•	Import yarn properties
	Import SC file		plain woven SG
			2 by 2 twill woven SG
			Run script

Fig. 13 Select woven type

2 by 2 twill woven	2 by 2 twill woven textile composites				
- Geometric param	eters				
Yarn width 0.8	Yarn spacing 1.0				
Yarn thickness 0.1	Number of layers				
Gap size 0.0					
Mesh size					
X voxel count	Y voxel count				
20	20				
Z voxel count					
10					
Woven SG name					
woven_sc					
Apply	Cancel				

Fig. 14 Define woven geometric, material and mesh parameters

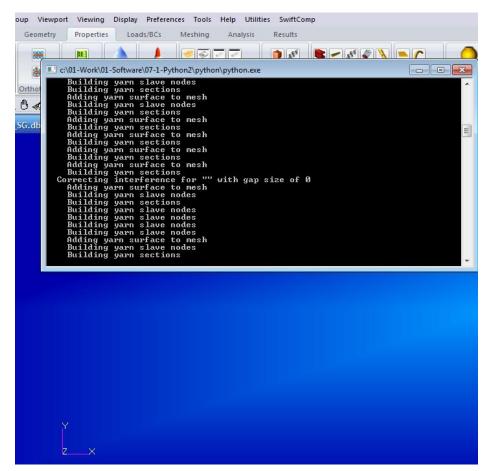


Fig. 15 Woven SG creation

Select *SwiftComp->Import SC file* as shown in Figure 16, the default sc file name is woven\_sc.sc. The geometry and material properties of woven SG are imported into Patran database. The yarns of this SG is shown in Figure 17. Matrix and individual yarns are defined in different groups. In this case, there is one matrix group and 8 yarn groups as shown in Fig. 18. The multiple groups enable users to define different properties for different yarns. In this example, we will only consider just one set of yarn properties which are obtained from microscale analysis. The matrix properties are predefined, and users need to change the corresponding default properties to the user-define one.

Homogenization	•	P Import	SwiftComp input	, me			
Dehomogenization Failure-Input failure constants	+ +	Look	in: 🚺 C:	\Patra\sc_data 🔻 🔾	0	) 🛤 🗉	
Failure-Initial failure Failure-Failure index/Strength ratio	•		My Computer	Name	Size		Dat
Failure-Failure envelope	•	2	liu1512pc	View woven_sc.sc		sc File sc File	3/1
Import scmat	•		Desktop	SP.sc	57 KB	sc File	3/1,
Create woven composites	-		Documents				

Fig. 16 Import woven SG into Patran

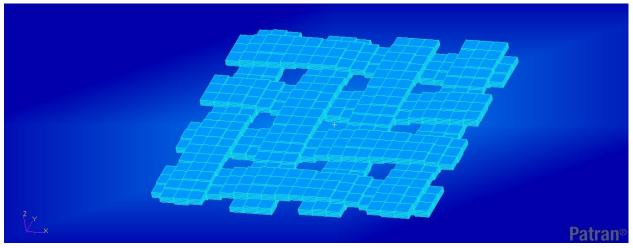


Fig. 17 Yarns of the woven SG in Patran

Action: Post 🕶
Current Viewport
default_viewport
Select Groups to Post
default_group
matrix
yarn1
yarn2
yarn3
yarn4
yarn5
yarn6
yarn7
yarn8

Fig. 18 Groups of matrix and yarns

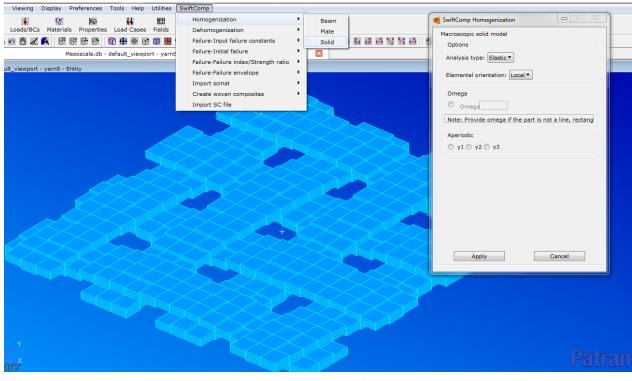
The matrix properties are given in Fig.7. Note that the convention of the constitutive equation in Nastran and SwiftComp is different which means users cannot directly input the 6 by 6 stiffness in Fig. 11 into Patran. If we define  $G_{ij}$  as the stiffness matrix in Nastran and  $C_{ij}$  as the stiffness matrix in SwiftComp, we have the following relations in Table 1. Therefore, the yarn properties are changed to the properties given in Fig. 19.

Table 1. Relation between Nastran and SwiftComp in constitutive equation							
$G_{11} = C_{11}$	$G_{12} = C_{12}$	$G_{13} = C_{13}$	$G_{14} = C_{16}$	$G_{15} = C_{14}$	$G_{16} = C_{15}$	$G_{22} = C_{22}$	
$G_{23} = C_{23}$	$G_{24} = C_{26}$	$G_{25} = C_{24}$	$G_{26} = C_{25}$	$G_{33} = C_{33}$	$G_{34} = C_{36}$	$G_{35} = C_{34}$	
$G_{36} = C_{35}$	$G_{44} = C_{66}$	$G_{45} = C_{46}$	$G_{46} = C_{56}$	$G_{55} = C_{44}$	$G_{56} = C_{45}$	$G_{66} = C_{55}$	

Constitutive Model:	Linear Elastic▼	
Property Name	Value	
Stiffness 11 =	172772.95	-
Stiffness 12 =	8686.2695	
Stiffness 13 =	8686.2695	
Stiffness 14 =		
Stiffness 15 =		
Stiffness 16 =		
Stiffness 22 =	17523.061	
Stiffness 23 =	10280.14	
Stiffness 24 =		
Stiffness 25 =		
Stiffness 26 =		
Stiffness 33 =	17523.061	Ε
Stiffness 34 =		
Stiffness 35 =		
Stiffness 36 =		
Stiffness 44 =	6806.7002	
Stiffness 45 =		
Stiffness 46 =		
Stiffness 55 =	3100.3701	
Stiffness 56 =		
Stiffness 66 =	6806.7002	
Density =		
Thermal Expan. Coeff 11 =		
Thermal Expan. Coeff 22 =		
Thermal Expan. Coeff 33 =		
Thermal Expan. Coeff 12 =		-

Fig. 18 Yarn properties

Select *SwiftComp->Homogenization->Solid* as shown in Figure 20, and click apply. Then, the effective constitutive information of solid model is automatically pop up.



Tutorial #5

Fig. 20 Homogenization using SwiftComp solid model

```
The Effective Stiffness Matrix
    _____
 5.0738030E+04 8.1656367E+03 7.0391837E+03 -1.6845505E-12 -6.0641416E-13 3.0170204E+01
 8.1656367E+03 5.0738049E+04 7.0391832E+03 1.6845115E-12 8.8408731E-13 3.0154597E+01
 7.0391837E+03 7.0391832E+03 1.2427646E+04 2.6487478E-13 3.4096543E-13 4.8598720E+00
 -1.6845505E-12 1.6845115E-12 2.6487478E-13 2.8959011E+03 1.3272589E+01 -2.8308591E-13
-6.0641416E-13 8.8408731E-13 3.4096543E-13 1.3272589E+01 2.8959012E+03 4.8039996E-13
 3.0170204E+01 3.0154597E+01 4.8598720E+00 -2.8308591E-13 4.8039996E-13 3.7365480E+03
The Effective Compliance Matrix
                      _____
_____
 2.1562272E-05 -1.9271279E-06 -1.1121550E-05 1.4637755E-20 6.3698368E-21 -1.4408408E-07
-1.9271279E-06 2.1562263E-05 -1.1121544E-05 -1.2634723E-20 -5.5950225E-21 -1.4398590E-07
-1.1121550E-05 -1.1121544E-05 9.3064522E-05 -8.4614185E-21 -9.8620206E-21 5.8509471E-08
 1.4637755E-20 -1.2634723E-20 -8.4614185E-21 3.4532292E-04 -1.5826953E-06 2.6360393E-20
 6.3698368E-21 -5.5950225E-21 -9.8620206E-21 -1.5826953E-06 3.4532291E-04 -4.4510785E-20
 -1.4408408E-07 -1.4398590E-07 5.8509471E-08 2.6360393E-20 -4.4510785E-20 2.6762895E-04
The Engineering Constants (Approximated as Orthotropic)
E1 = 4.6377301E+04
E2 = 4.6377322E+04
E3 =
       1.0745233E+04
G12 =
       3.7365166E+03
G13 =
       2.8958403E+03
G23 = 2.8958402E+03
nu12= 8.9374989E-02
nu13=
       5.1578748E-01
nu23= 5.1578743E-01
Effective Density = 0.000000E+00
```

Fig. 21 Homogenization constitutive information for solid model

### Macroscale analysis

This is the third step of using MSG to analyze woven laminated plate structures. We will perform macroscopic structural analysis. Open a new database and create a woven laminated plate structure as shown in Fig. 21. The user shall use consistent units in the SG and in the structural level database.

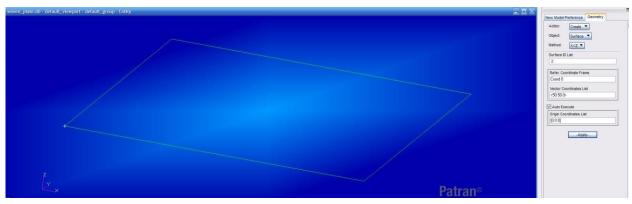


Fig. 22 Geometry of the laminated plate structure

In order to use PCOMP card in Nastran, we need to import MAT8 card from SwiftComp results. Users can import SC results file as shown in Fig. 23. The MAT8 import function can be found under Import scmat/Plate/PCOMP+MAT8. Then users can go to Material Properties, and check the homogenized 2D orthogonal material properties shown in Figure 24.

Users need to go to *Composite->Lamination* to define the layup and thickness of this laminated plate as shown in Figure 25, then users need to go to define Shell properties with laminate options as shown in Figure 26.

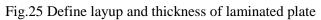
WiftComp Homogenization Dehomogenization Failure-Input failure constants	• • • •		Import Look	SC solid materia		MAT8 'a\sc_data ▼ 🔾	0 0		
Failure-Initial failure Failure-Failure index/Strength ratio Failure-Failure envelope				My Computer liu1512pc		Name Mesoscale.sc.k Microscale.sc.k	3 KB	Type k File k File	Date 3/17 3/17
Import scmat	<ul> <li>Be</li> </ul>	am		Desktop		SP.sc.k		k File	3/1/
Create woven composites Import SC file	pla So	ite 🔸		PSHELL+MAT2 PCOMP+MAT8					
					Γ				

Fig. 23 Import laminar properties

P Input Options				RHS Window
Constitutive Model:	Linear Elastic 🔻			Materials
Property Name	Value			Action: Create
Elastic Modulus 11 =	46377.301			Object: 2d Orthotropic▼
Elastic Modulus 22 =	46377.32			Method: Manual Input 🔻
Poisson Ratio 12 =	0.089374989		h	
Shear Modulus 12 =	3736.5166		J	Existing Materials
Shear Modulus 23 =	2895.8401			Mesuscale.sc
Shear Modulus 13 =	2895.8403			
Density =			-	
Thermal Expan. Coeff 11 =				
Thermal Expan. Coeff 22 =				
Structural Damping Coeff =			h	
Reference Temperature =			IJ	
				Filter *
				Material Name
				Mesoscale.sc
				Description
Current Constitutive Models:				This material comes from homogenization results by
Linear Elastic - [,,,,] - [Activ	e]			SwiftComp
ОК	Clear	Cancel		Input Properties
				Change Material Status
rai	lall <sup>~</sup>			

Fig. 24 Define material properties for PCOMP

1 1 1 2 1 3 1 4 1 5 1 7 1 8 1 9 1	laterial Name Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	Thickness 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01	Crientation 4.500000E+01 0.000000E+00 4.500000E+00 4.500000E+01 0.000000E+00 4.500000E+01	tighlight Import	ID	Materials Action: Object: Method: Existing *	Create  Composite Laminate Materials	
1 1 1 2 1 3 1 4 1 5 1 7 1 8 1 9 1	Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01 2.00000E-01	4.500000E+01 0.000000E+00 0.000000E+00 4.500000E+01 0.000000E+00 0.000000E+00	Global Ply	ID	Method: Existing	Laminate <b>•</b> Materials	•
2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11	Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01	0.000000E+00 0.000000E+00 4.50000E+01 0.00000E+00 0.000000E+00			Existing *	Materials	
3 11 4 11 5 11 6 11 7 11 8 11 9 11	Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01	0.000000E+00 4.500000E+01 0.000000E+00 0.000000E+00			*		Filter
4 11 5 11 6 11 7 11 8 11 9 1	Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.000000E-01 2.000000E-01 2.000000E-01 2.000000E-01	4.500000E+01 0.000000E+00 0.000000E+00			Mesosc	ale.sc	Filter
5 1 6 1 7 1 8 1 9 1	Mesoscale.sc Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.000000E-01 2.000000E-01 2.000000E-01	0.000000E+00 0.000000E+00			Mesosc	ale.sc	
6 1 7 1 8 1 9 1	Mesoscale.sc Mesoscale.sc Mesoscale.sc	2.000000E-01 2.000000E-01	0.00000E+00					
7 1 8 1 9 1	Mesoscale.sc Mesoscale.sc	2.000000E-01						
1 8 1 9	Mesoscale.sc		4.500000E+01					
9 1		2.00000E-01						
-		210000000 01	4.500000E+01					
10 1	Mesoscale.sc	2.000000E-01	0.000000E+00					
	Mesoscale.sc	2.000000E-01	0.000000E+00			Laminat	ted Composit	
11	Mesoscale.sc	2.000000E-01	4.500000E+01					Filter
12 1	Mesoscale.sc	2.00000E-01	0.000000E+00					
13	Mesoscale.sc	2.000000E-01	0.000000E+00					
14	Mesoscale.sc	2.00000E-01	4.500000E+01					
	n Spreadsheet = 2. n Stacking Sequen		for A ies in Spreadsheet = 14 ies in Stacking Sequence	ALL Layers of "M = 14	esoscale.sc"	Material		
te Selected	Rows Insert	1		Row	<ul> <li>Above</li> <li>Below</li> </ul>	Material	Description	
Sh	ow Laminate Prope	erties	Clear D	ataboxes				
		P	atran®					



tan. Lam. Plate (CQUAD4/PCC	JMP)			
operty Name	Value	Value Type		
laterial Name	m:laminate	Mat Prop Name	XX ^	
[Material Orientation]				Element Properties
lonstructural Mass]		Real Scalar		Action: Create
Plate Offset]		Real Scalar		Object: 2D
onding Shear]		Real Scalar		Type: Shell
Reference Temperature]		Real Scalar		Sets By: Name 🔻 🗳
amping Coefficient]		Real Scalar		
onlinear Formulation(SOL400	))	String 🔻	~	
				Filter * Property Set Name Woven
nter the Material Name or sele	act a material with the icon.		8	Property Set Name
	act a material with the icon.		<u>×</u>	Property Set Name woven Options: Thin
Iter the Material Name or sele	ect a material with the icon.	Can	<u> </u>	Property Set Name woven Options: Thin  Laminate

Fig. 26 Define shell elements with laminate options

Next, users can define the displacement boundary conditions and apply the pressure loading required in the problem statement. Mesh the model and submit the job. For those who are familiar with Patran/Nastran, these steps are very easy to complete, and therefore a detailed description of the modeling steps is not included in this manual. The screenshot for the model is given in Figure 27, and the typical displacements and stresses screenshots are given in Figure 28 and 29 just for reference.

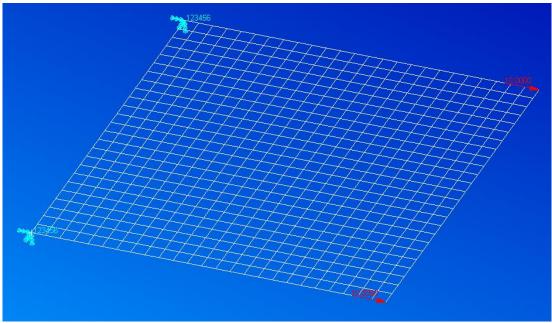


Fig. 27 Laminated plate model

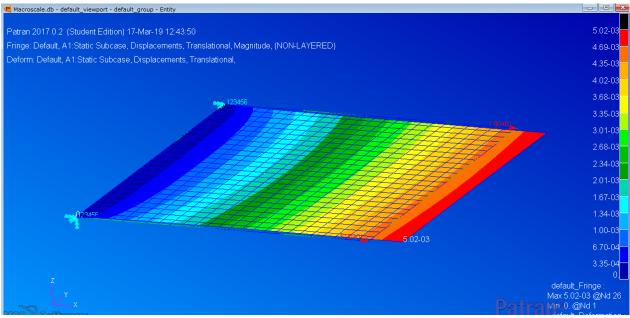


Fig. 28 Magnitude of displacement results

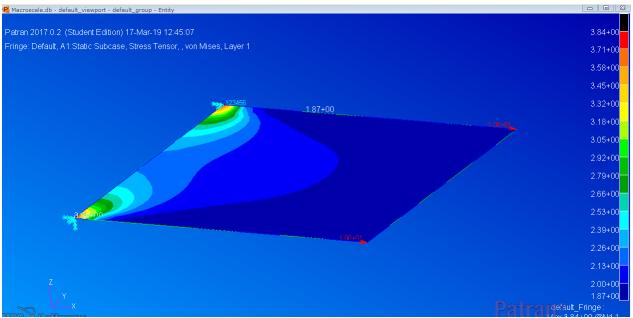


Fig. 29 von Mises stresses of layer 1