



Effective properties of UD lamina using SwiftComp-Patran GUI

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Multiscale
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Problem Statement

We study the properties of a simple fiber reinforced lamina using MSG solid model as shown in Figure 1. The fiber properties are $E_1 = 276\text{GPa}$, $E_2 = E_3 = 19.50\text{GPa}$, $G_{12} = G_{13} = 70\text{GPa}$, $G_{23} = 5.73\text{GPa}$, $\nu_{12} = \nu_{13} = 0.28$, $\nu_{23} = 0.70$, the matrix properties are $E = 4.76\text{GPa}$, $\nu = 0.37$. The fiber volume fraction is 0.6.

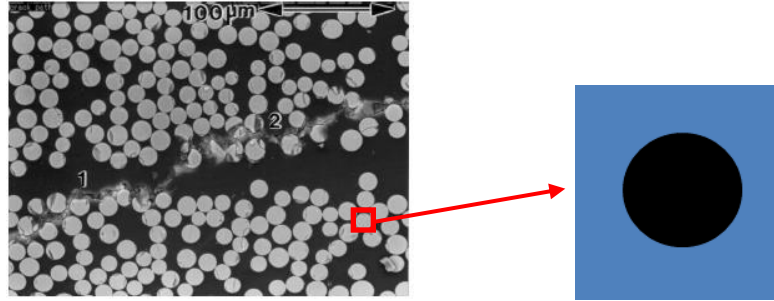


Figure 1. SG for composite lamina

Homogenization

We first need to build the SG model in Patran and use SwiftComp to carry out the homogenization. Open Patran and start a new database named SP as shown in Figure.2. Click *Geometry->Surface->XYZ*, then input the parameters shown in Figure. 3 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->2D Circle*. Input the radius of fiber circle 0.437 as the volume fraction is 0.6 and click apply as shown in Figure. 4. 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)

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

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 Figure. 5. Click “Yes” to finish the geometry generation of this SG.

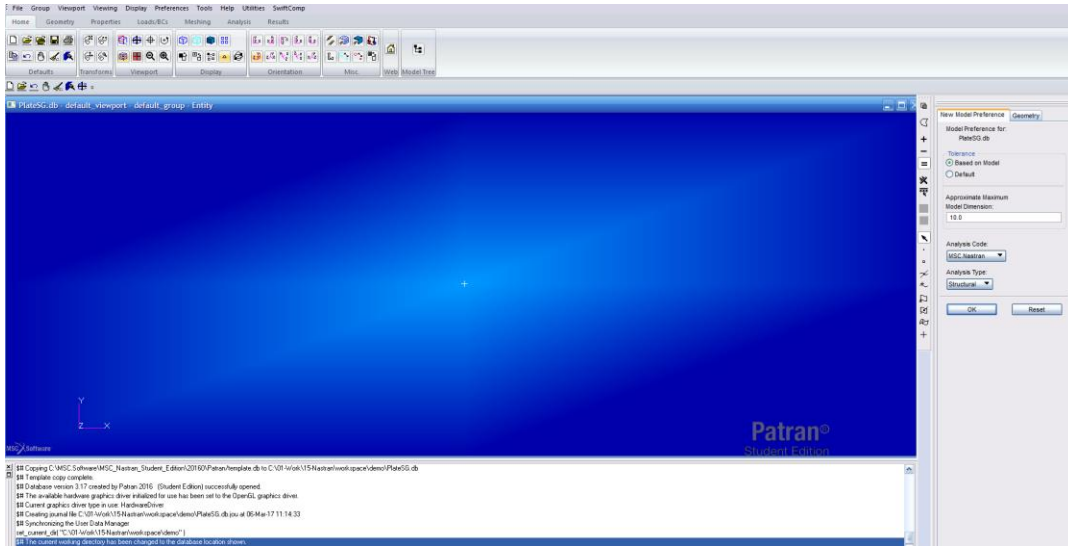


Figure 2. New Patran database named SP

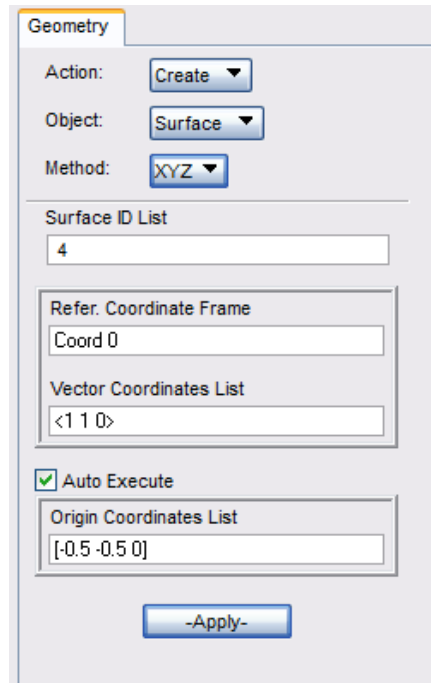


Figure 3. Parameters for generating matrix of the SG

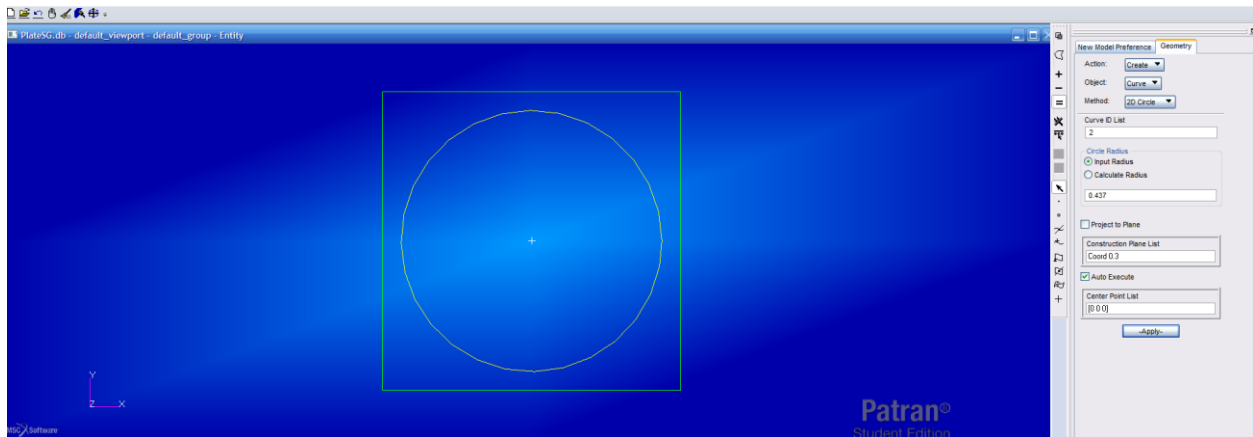


Figure 4. Generating fiber inside the matrix

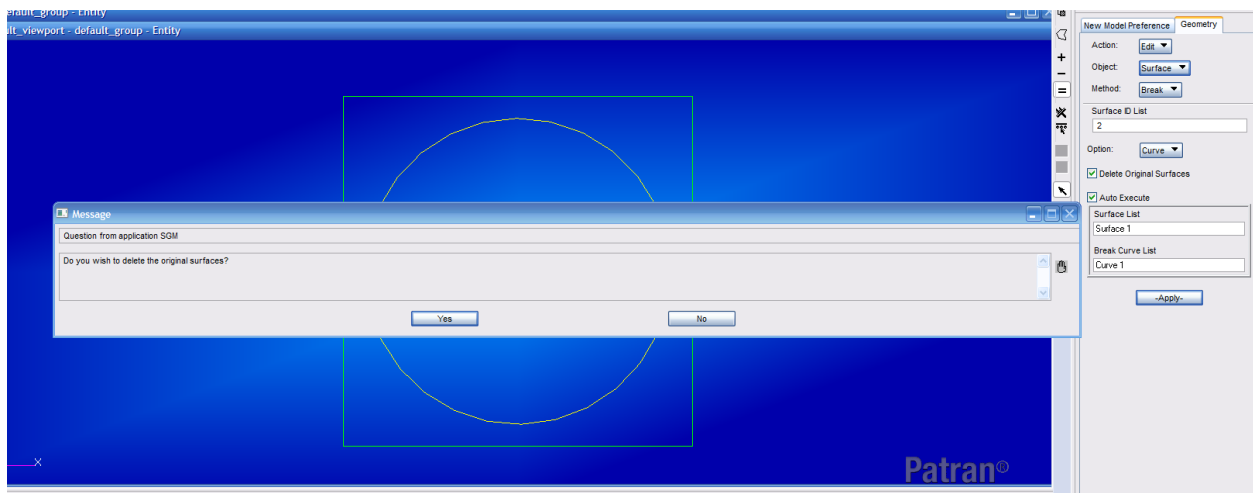


Figure 5. Divide surface into fiber surface and matrix surface

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 Figure 6 and click Apply. Click *Materials->3D Orthotropic*, input Fiber as material name and click *Input Properties* and input parameters as shown in the Figure 7 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.

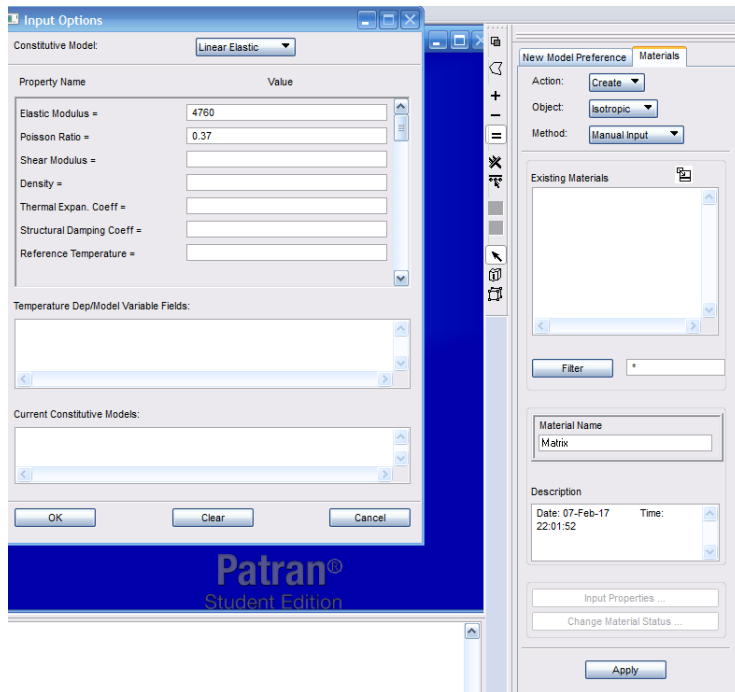


Figure 6. Input matrix material properties

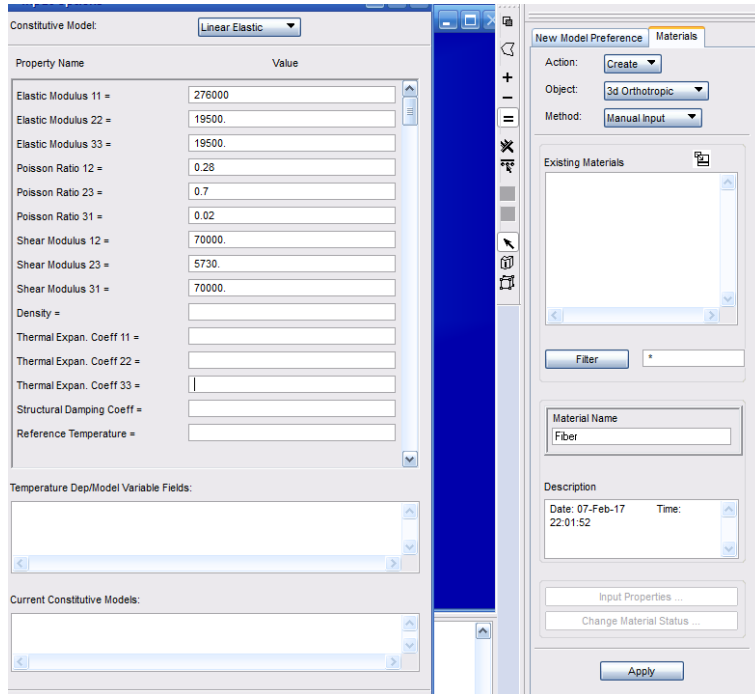


Figure 7. Input fiber material properties

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 Figure 8.

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 Figure 9., and keep all the 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 Figure 10.

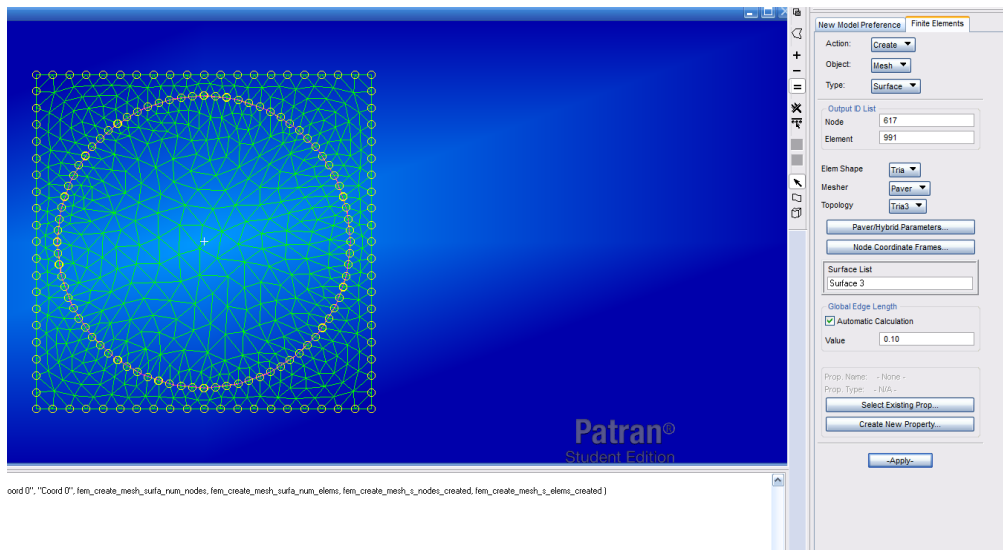


Figure 8. Mesh the SG

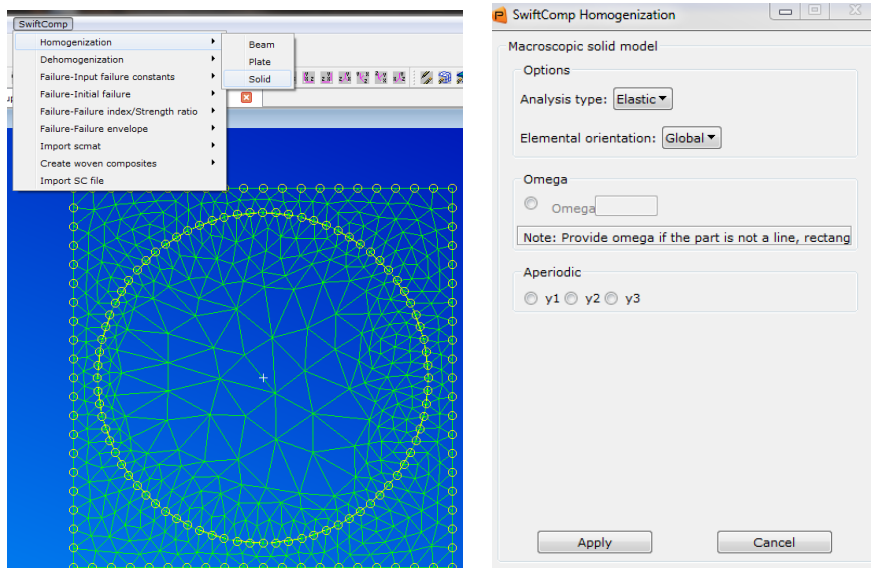


Figure. 9 Select SiwftComp homogenization solid model

The Effective Stiffness Matrix

```
-----  
 1.7277234E+05  8.6875567E+03  8.7057843E+03 -2.9448671E-02  0.0000000E+00  0.0000000E+00  
 8.6875567E+03  1.7526779E+04  1.0287075E+04 -1.2795400E-01  0.0000000E+00  0.0000000E+00  
 8.7057843E+03  1.0287075E+04  1.7537587E+04  1.3385890E-02  0.0000000E+00  0.0000000E+00  
-2.9448671E-02 -1.2795400E-01  1.3385890E-02  3.1003793E+03  0.0000000E+00  0.0000000E+00  
 0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00  6.8065300E+03 -3.0462985E-02  
 0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00 -3.0462985E-02  6.8066997E+03
```

The Effective Compliance Matrix

```
-----  
 5.9760384E-06 -1.8620641E-06 -1.8743120E-06 -1.1992995E-11  0.0000000E+00  0.0000000E+00  
-1.8620641E-06  8.7592273E-05 -5.0454922E-05  3.8151238E-09  0.0000000E+00  0.0000000E+00  
-1.8743120E-06 -5.0454922E-05  8.7546307E-05 -2.4780808E-09  0.0000000E+00  0.0000000E+00  
-1.1992995E-11  3.8151238E-09 -2.4780808E-09  3.2254118E-04  0.0000000E+00  0.0000000E+00  
 0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+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 (Approximated as orthotropic)

```
-----  
E1 = 1.6733493E+05  
E2 = 1.1416532E+04  
E3 = 1.1422526E+04  
G12 = 6.8066997E+03  
G13 = 6.8065300E+03  
G23 = 3.1003793E+03  
nu12= 3.1158837E-01  
nu13= 3.1363787E-01  
nu23= 5.7602024E-01
```

Effective Density = 0.0000000E+00

Figure 10. Effective properties