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Introduction

CATIA Version 5 Composites

Upon completion of this course, the student should have a full understanding of the following topics:

- Defining composite parameters
- Designing with the manual ply method
- Designing with the zones method
- Designing with the solid slicing method
- Designing with the grid method
- Generating solids and IML surfaces based off of zones or plies
- Analyzing and inspecting composite parts
- Creating manufacturing models
- Swapping definition surfaces and ply boundaries for manufacturing
- Creating flat patterns
- Splicing and darting plies
- Exporting ply definitions for ply nesting, cutting and laser projection
- Incorporating manufacturing modifications for automated fiber placement
- Creating ply books

Composites

This course will cover all of the options found in the Composites Design and Composite Grid Design workbenches. The first portion of the book will focus on the design options available within the two workbenches. The second portion of the book will delve into the manufacturing side of composite parts and how they will be created.

Please note that some additional environment variables have been activated for the Composite Design and Composite Grid Design workbenches. These environment variables provide additional functionality and visualizations within the two workbenches. If these environment variables are not activated in your CATIA load, your workbenches may look slightly different.

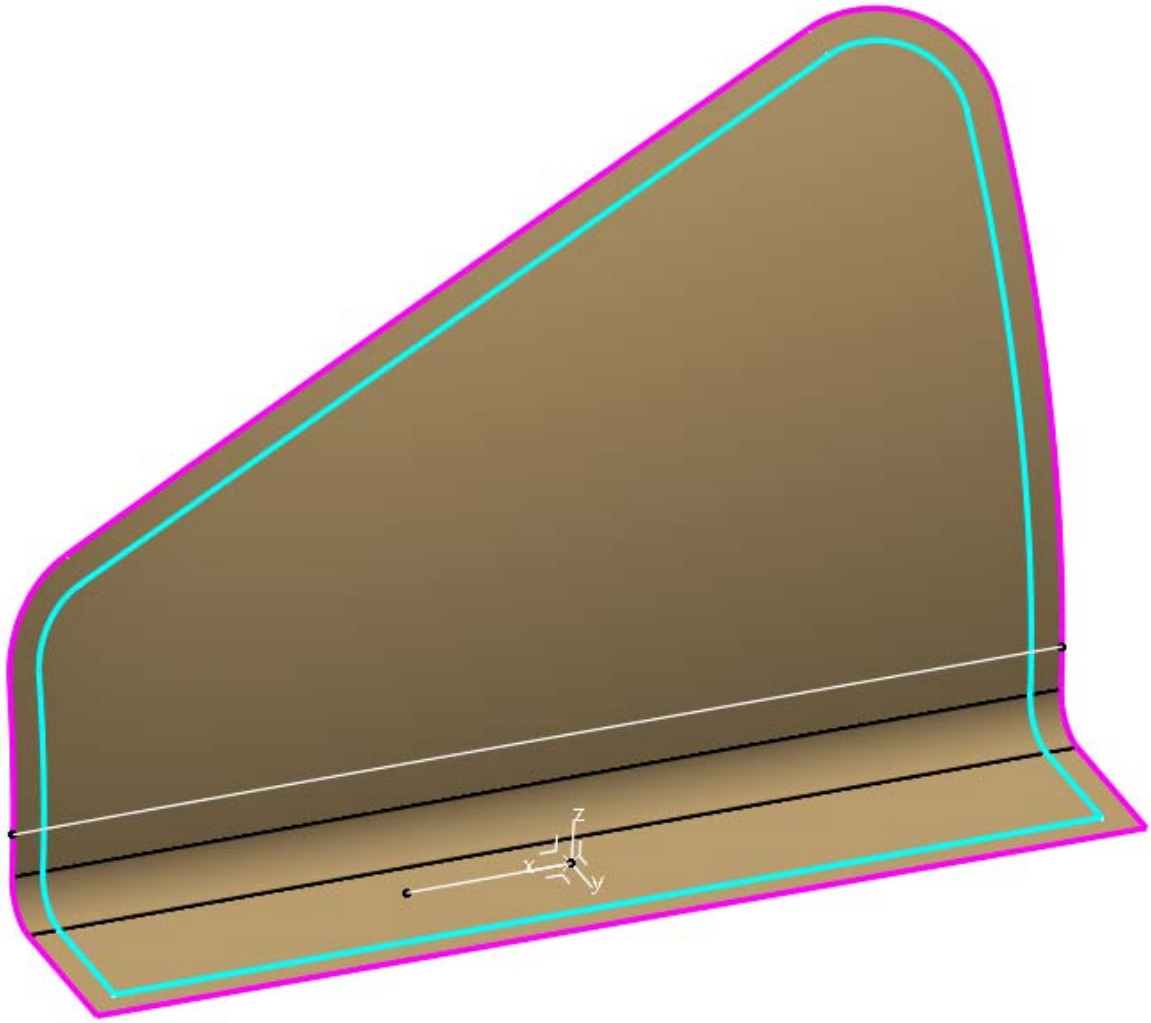
Review Exercises

This section will review the concepts and operations discussed in the previous sections of this manual.

Manual Ply Creation Review Exercise

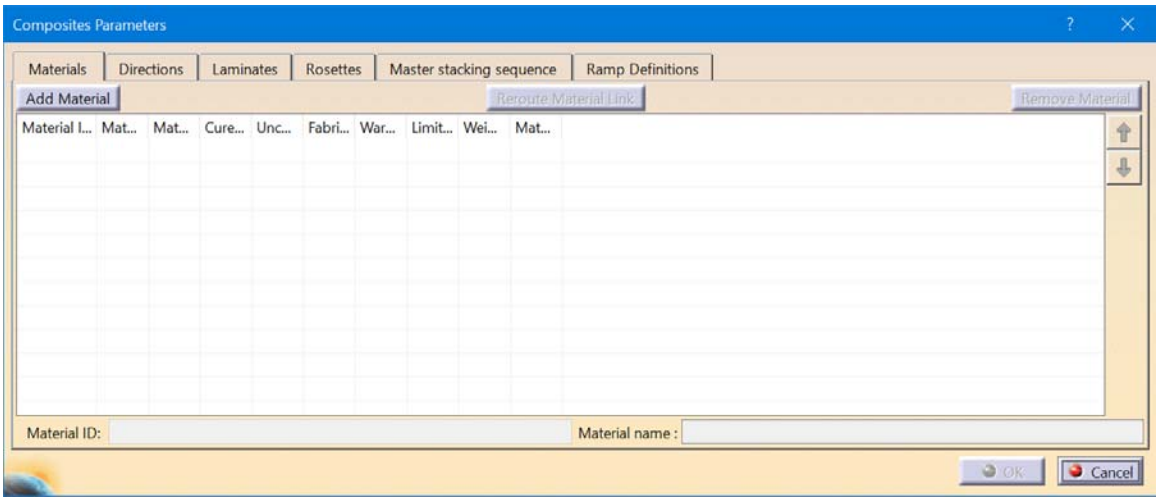
In this section, manual plies will be created to define a composite part. The plies for the first half of the laminate will be created manually. Next, the user will create the plies for the top half of the laminate by creating symmetric plies. Finally, the user will rename the plies using the interactive ply table.

Open the Manual Ply Creation model. The model contains wireframe and surface geometry for the initial definition of the composite part.

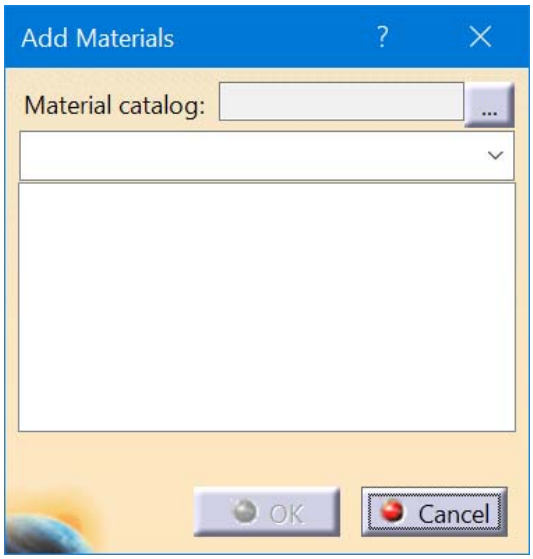


Switch to the Composites Design workbench if you are not already there.

Select the Composite Parameters icon.  The *Composites Parameters* window appears.



Select the *Add Materials* button. The *Add Materials* window appears.

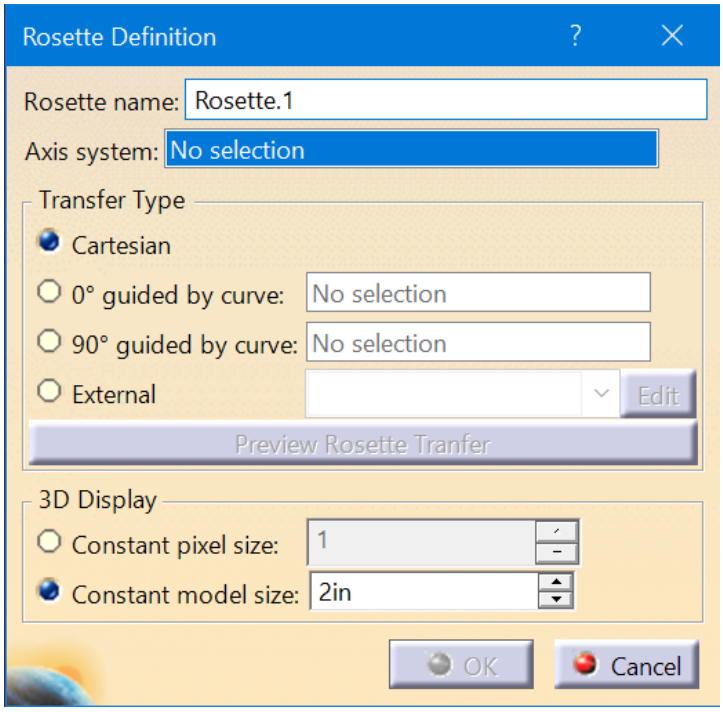


Select the Browse icon in the window.  A *File Selection* window appears.

Browse to the models directory and select the WSU Composite Materials document to define the *Material Catalog*. Select *Open*. The catalog is defined.

Select *Fiberite Graphite Fabric* from the list and select *OK*. Only one material will be used in this exercise.

Select the *Rosettes* tab and select the *Add Rosette* button. The *Rosette Definition* window appears.

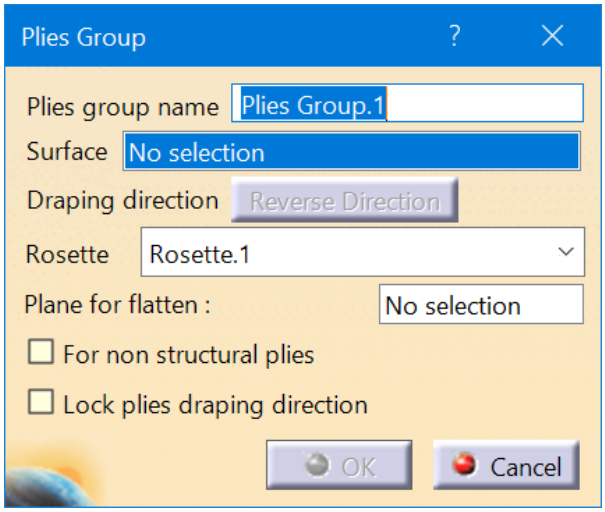


Select the axis system from the display to define the *Axis system* for the rosette and select *OK*. The rosette is created.

Select *OK* to the *Composite Parameters* window. The parameters are defined.

First a ply group will need to be created to define the location for the plies to be stored.

Select the Plies Group icon.  The *Plies Group* window appears.



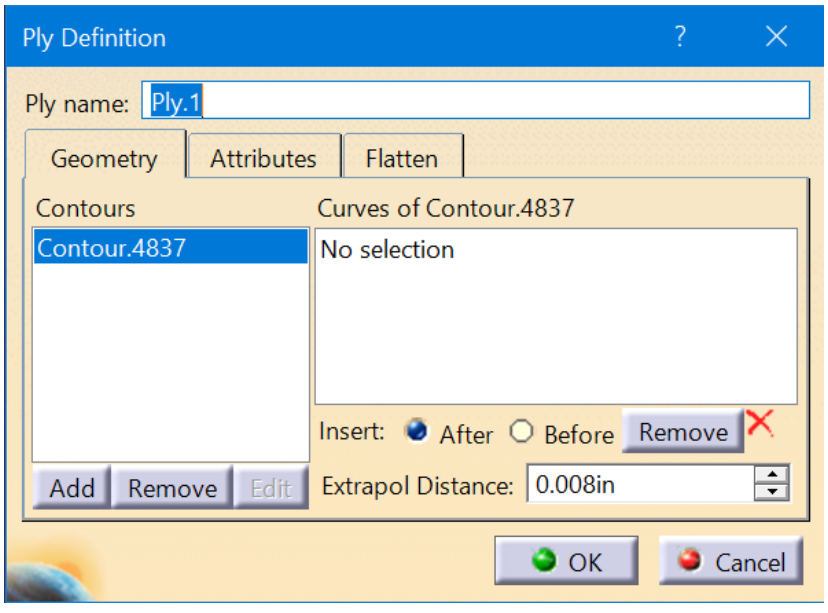
Select the surface from the display to define the *Surface* option. The draping direction should be pointing upwards.

Select *Rosette.1* to define the *Rosette*.

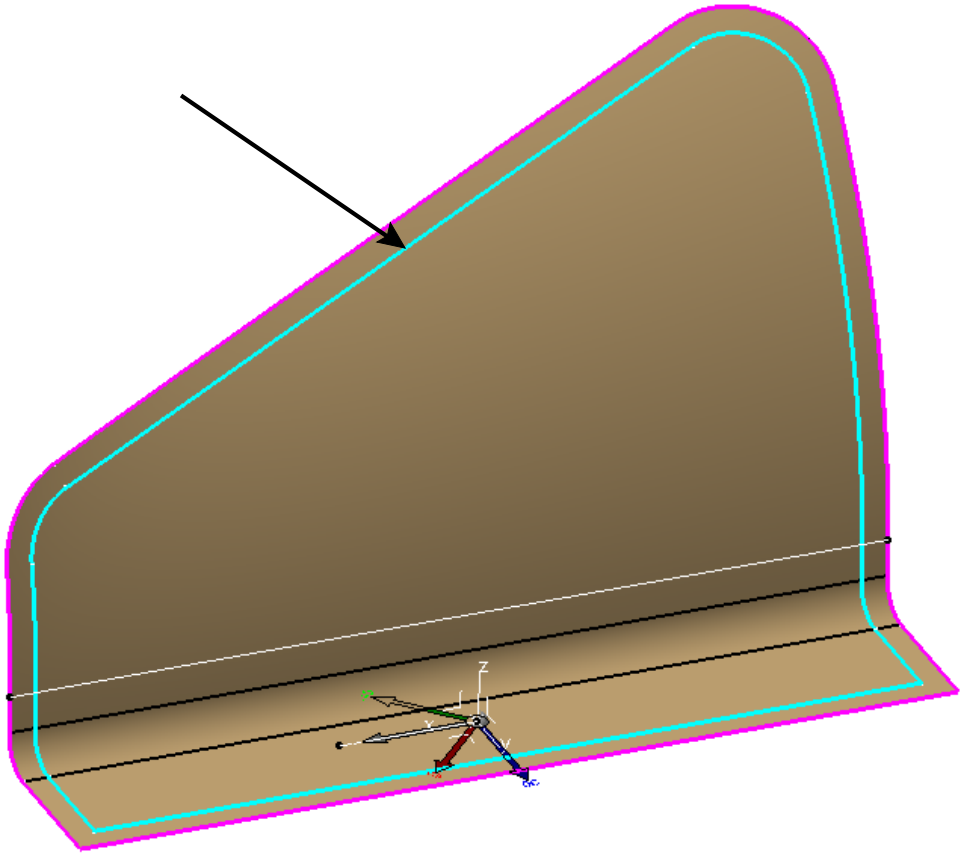
Select *OK*. The plies group is created.

Now the plies will be created for the composite part.

Select the Ply icon and select the *Plies Group.1* branch in the specification tree. 
The *Ply Definition* window appears.

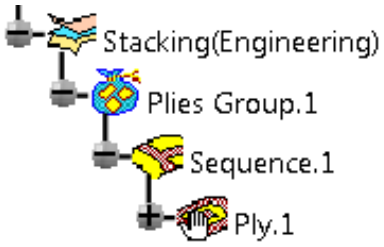


Select the curve in the display to define the contour. A green checkmark should appear in the *Contour* window, specifying it is a closed contour.



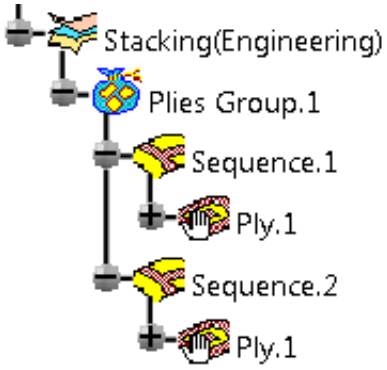
Select the *Attributes* tab and set the *Material* to be *Fiberite Graphite Fabric* and the *Direction* to be 0. This will define the first ply.

Select *OK*. The ply is created.



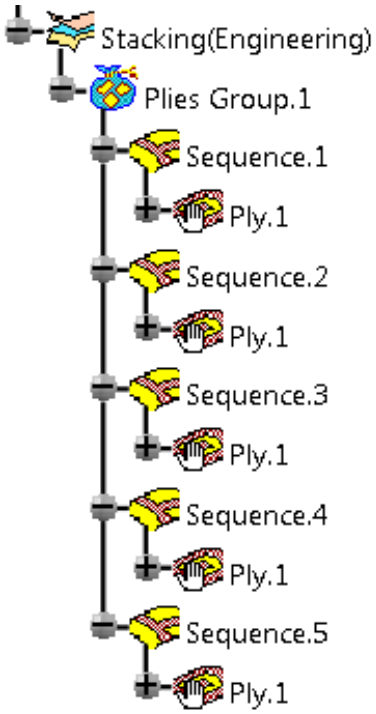
Right select on *Sequence.1* in the specification tree and select *Copy* from the contextual menu.

Right select on *Plies Group.1* and select *Paste* from the contextual menu. A second sequence and ply has been created.



Notice the name of the ply matches the original ply. This will be fixed eventually. The new ply will use the same contour and the same attributes as the original. The attributes will also need to be adjusted eventually.

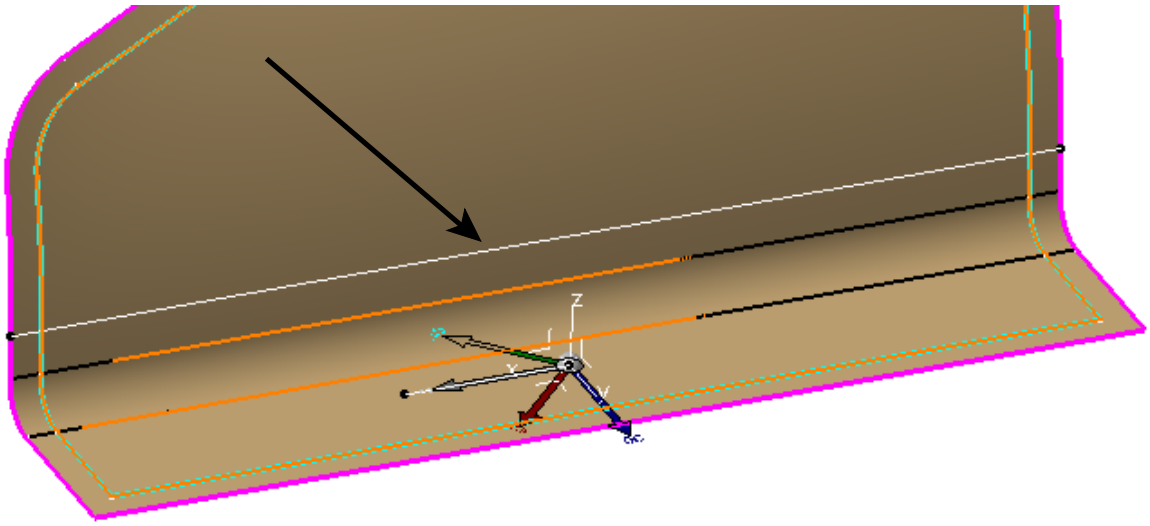
Create three more copies as shown.



Select the Limit Contour icon.  The *Limit Contour* window appears.

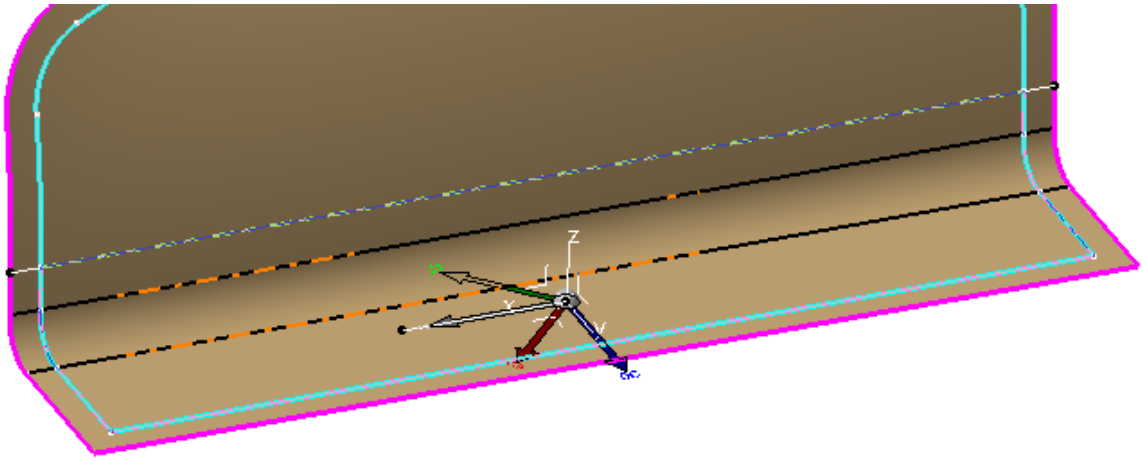
Select *Sequence.5* to define the *Entity*. This ply will be relimited.

Select the curve as shown to define the *Relimiting Curve*.



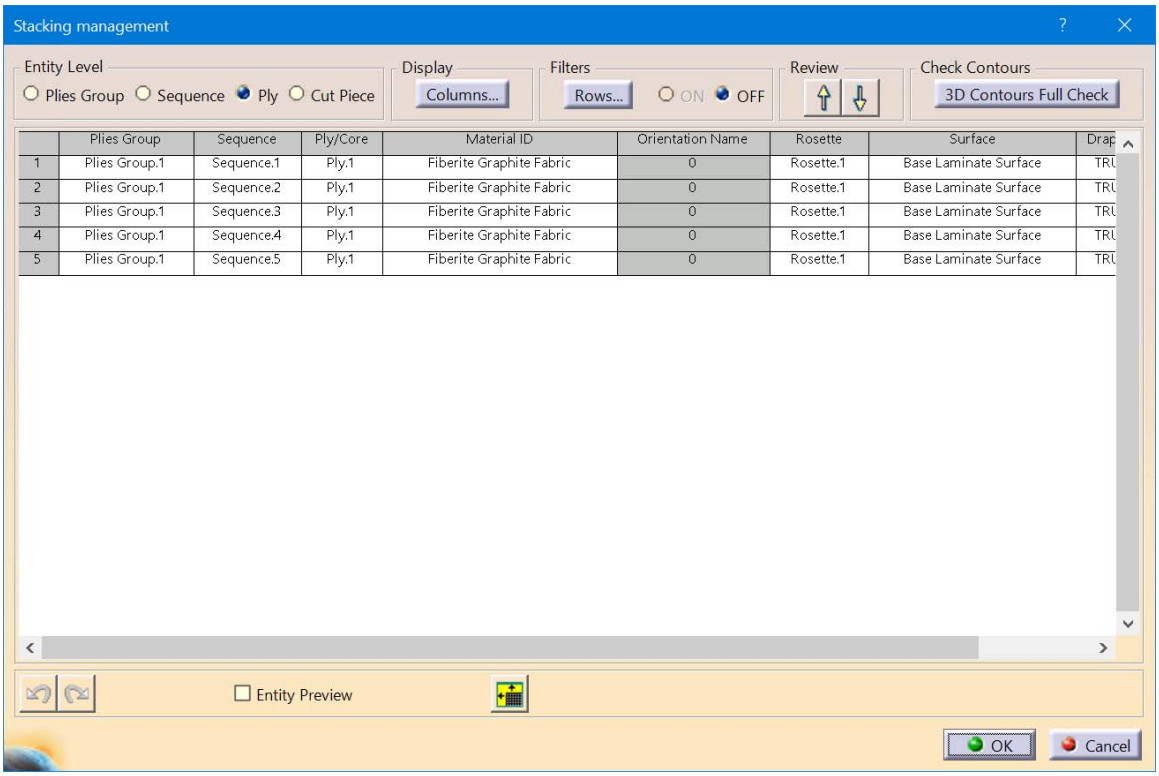
Be sure the arrow is pointing towards the lower portion of the surface and select *OK*. This specifies the lower side of the ply will be kept.

The ply should appear as shown now.



Now the attributes of the plies need to be updated.

Select the Stacking Management icon.  The *Stacking Management* window appears. You may have to adjust the options in the *Column* button to get the window to appear exactly the same.



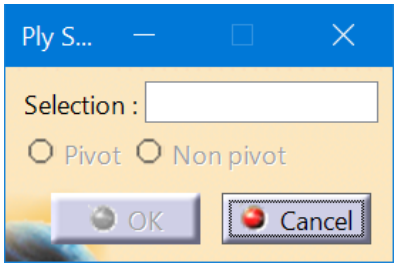
Modify the *Orientation Name* for each ply as shown. You will use the Multiple Row Edition icon or the contextual menu. 

Sequence	Ply/Core	Material ID	Orientation Name
Sequence.1	Ply.1	Fiberite Graphite Fabric	0
Sequence.2	Ply.1	Fiberite Graphite Fabric	45
Sequence.3	Ply.1	Fiberite Graphite Fabric	90
Sequence.4	Ply.1	Fiberite Graphite Fabric	-45
Sequence.5	Ply.1	Fiberite Graphite Fabric	90

Select *OK*. This defines the bottom half of the laminate.

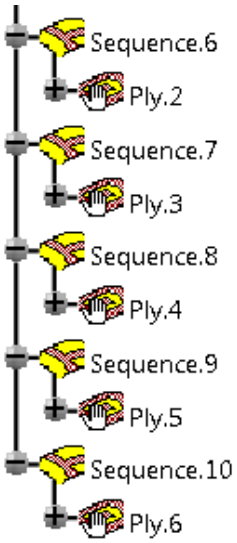
Now the plies will be symmetried to create the other half of the laminate.

Select the Symmetric Plies Stacking icon.  The *Ply Symmetry* window appears.



Select the *Plies Group.1* to define the *Selection* for the operation.

Be sure the *Non pivot* option is selected and select *OK*. The plies are symmetried as shown.



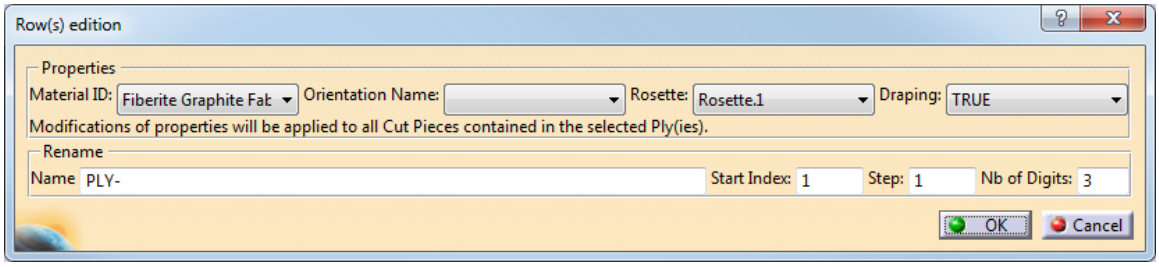
Now the names of the plies need to be fixed.

Select the Stacking Management icon.  The *Stacking Management* window appears.

Select the *Ply* option for the *Entity Level* and select all of the plies in the window. You will want to use the Shift key.

Right select on the selected plies in the window and select *Multiple Row Edition*. The *Rows Edition* window appears.

In the *Rename* section, set the *Name* to be <u>PLY-</u> and the *Nb of Digits* to be 3 as shown.

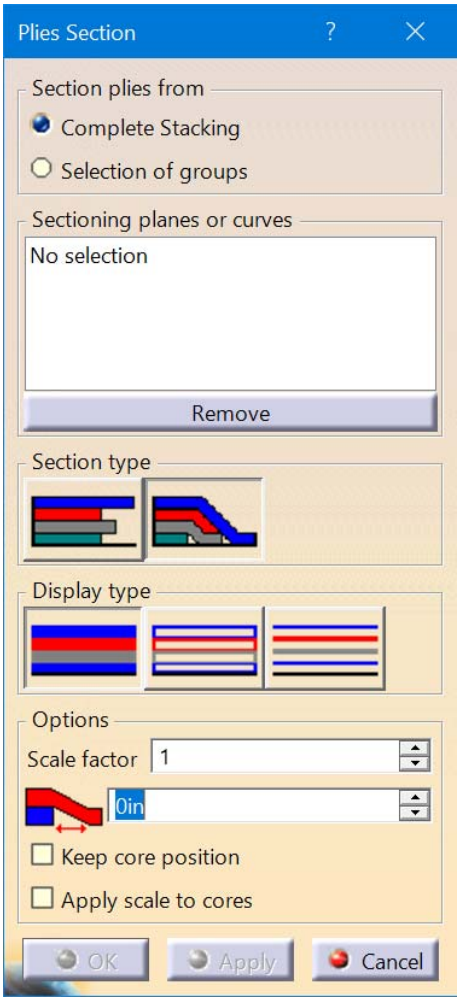


Select *OK*. The plies are renamed as shown.

Sequence	Ply/Core
Sequence.1	PLY-001
Sequence.2	PLY-002
Sequence.3	PLY-003
Sequence.4	PLY-004
Sequence.5	PLY-005
Sequence.6	PLY-006
Sequence.7	PLY-007
Sequence.8	PLY-008
Sequence.9	PLY-009
Sequence.10	PLY-010

Select *OK*. The laminate is finished. Now we will take a quick look at the cross section.

Select the Plies Sectioning icon.  The *Plies Section* window appears.

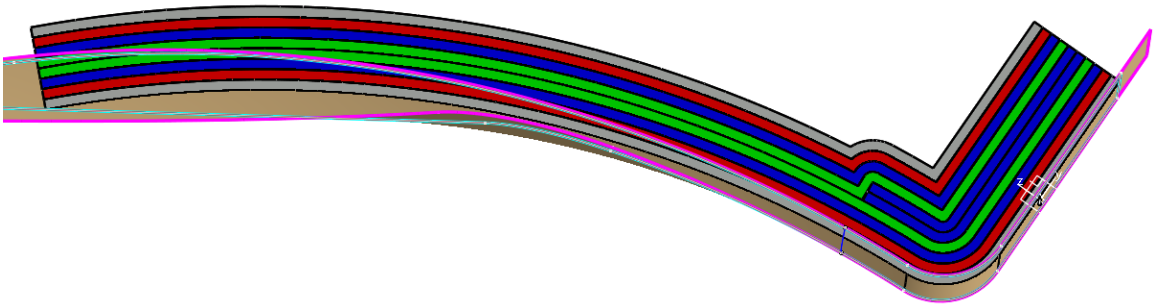


Select the *Complete Stacking* option.

Select the *Cross Section Plane* from *Geometrical Set.1* to define the *Sectioning planes or curves*.

Select the Realistic and Surfacic types.

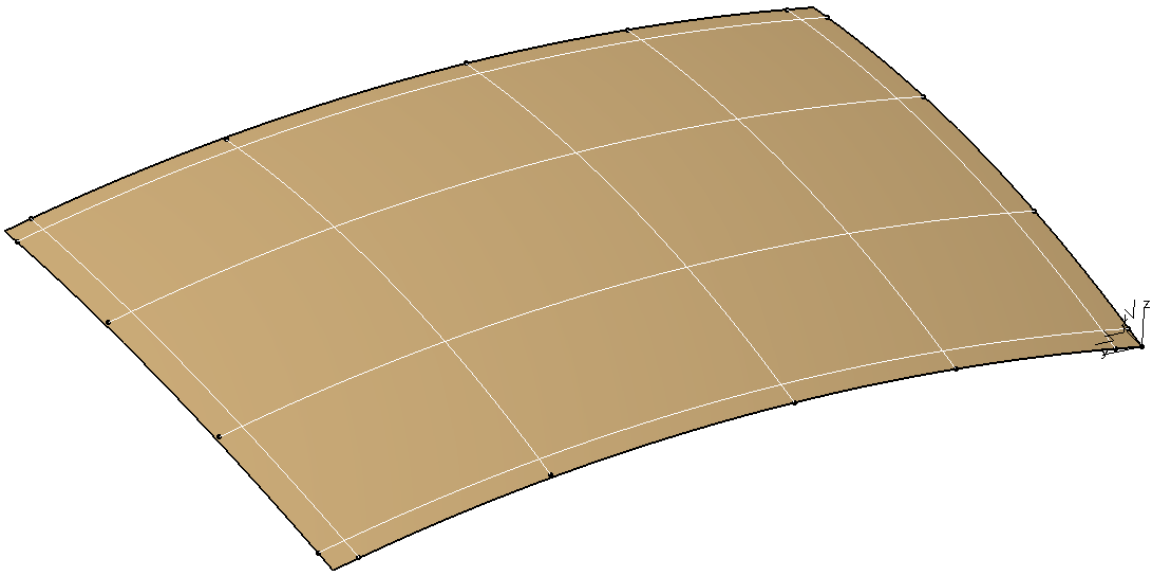
Set the *Scale factor* to be 5 and select *OK*. The cross section should appear as shown if you rotate the model around.



Composite Grid Design Review

This exercise will review the grid design method in more of a process based manner.

Open the Grid Design Review document. The model contains a surface and wireframe elements.



Select the Composites Parameters icon.  The *Composites Parameters* window appears.

Be sure the WSU Composite Materials catalog is defined for the *Material catalog* and *Graphite Unitape* is the selected material.

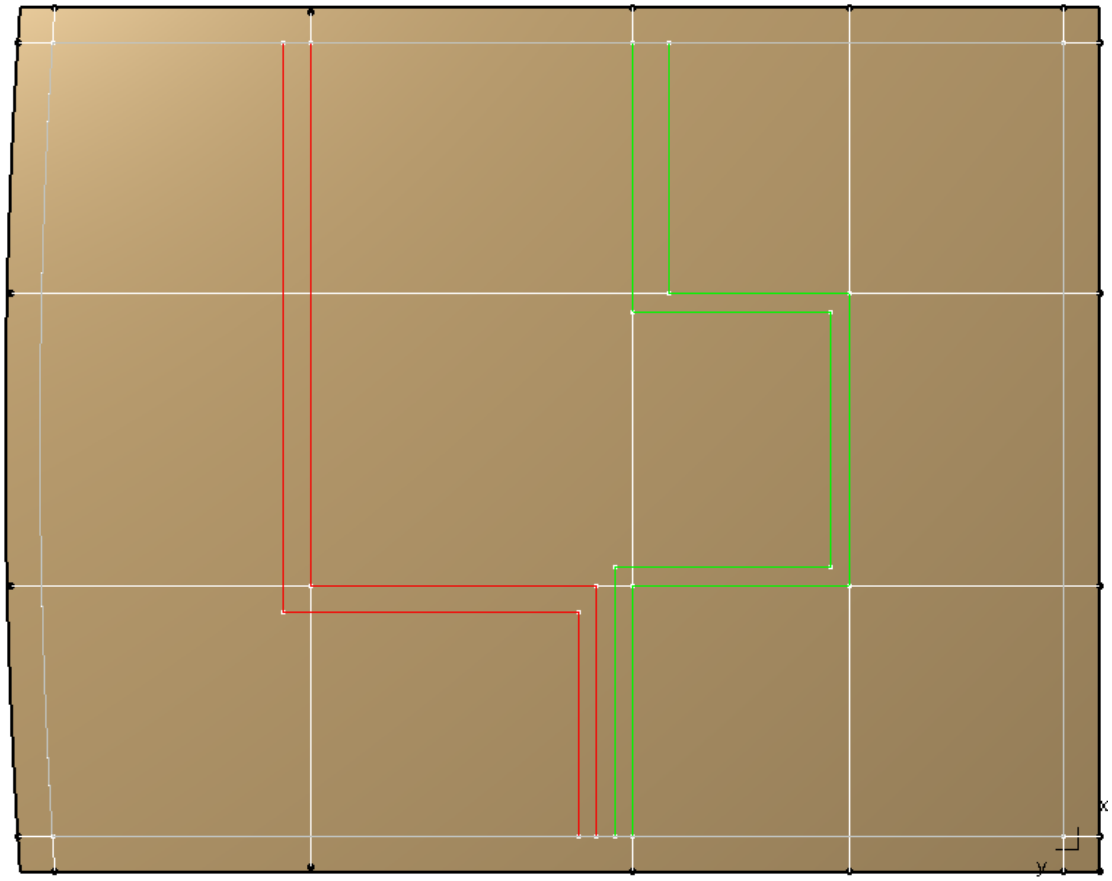
Create a rosette using the axis system in the display.

Select *OK* to finalize the parameters.

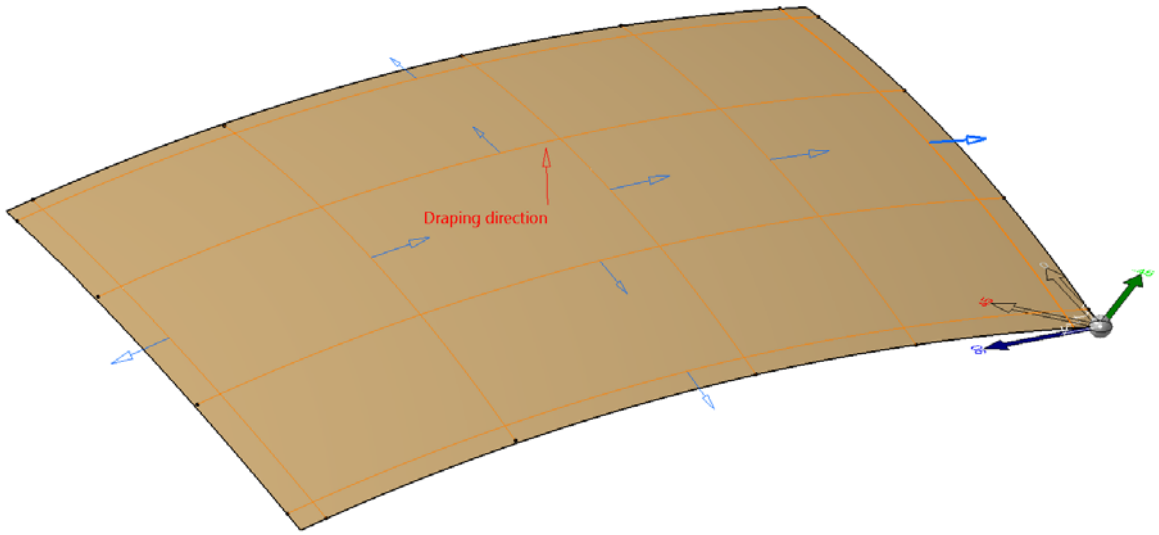
Select the Grid Panel Definition icon and define the *Surface* option with the surface in the display. Select *Rosette.1* for the *Rosette*.  Be sure the *Draping direction* is pointing upward.

Next, the reference elements will be defined with the necessary default offsets and staggering.

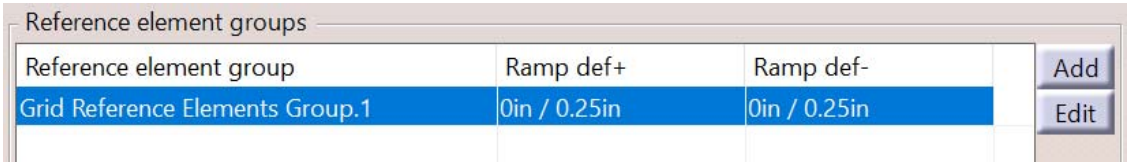
The following picture explains how the plies should eventually drop off. Three different drop off values will be used: 0.25in, 0.375in and 0.5in. In this case, a default drop off will be set to begin with for all structural elements and then eventually the individual structural elements will be modified to obtain the correct drop offs at each location.



Select all of the curves from the display as shown to define the first reference element group. The curves could be split into multiple reference element groups if necessary. In this case, only one group will be used.

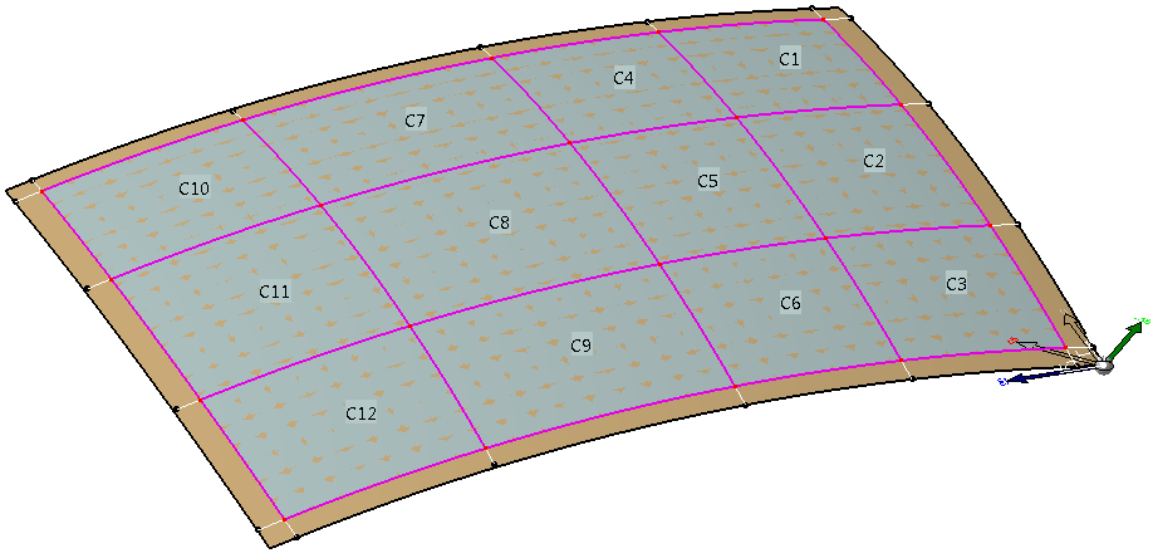


Edit the group and create a new ramp definition with the *Offset* set to 0 and the *Step* set to 0.25 for both the positive and negative directions. This will not work for all of the ply drops, but since it is the most common for this model, it will be used as the default. The other drops will be individually modified later. The window should appear as shown.



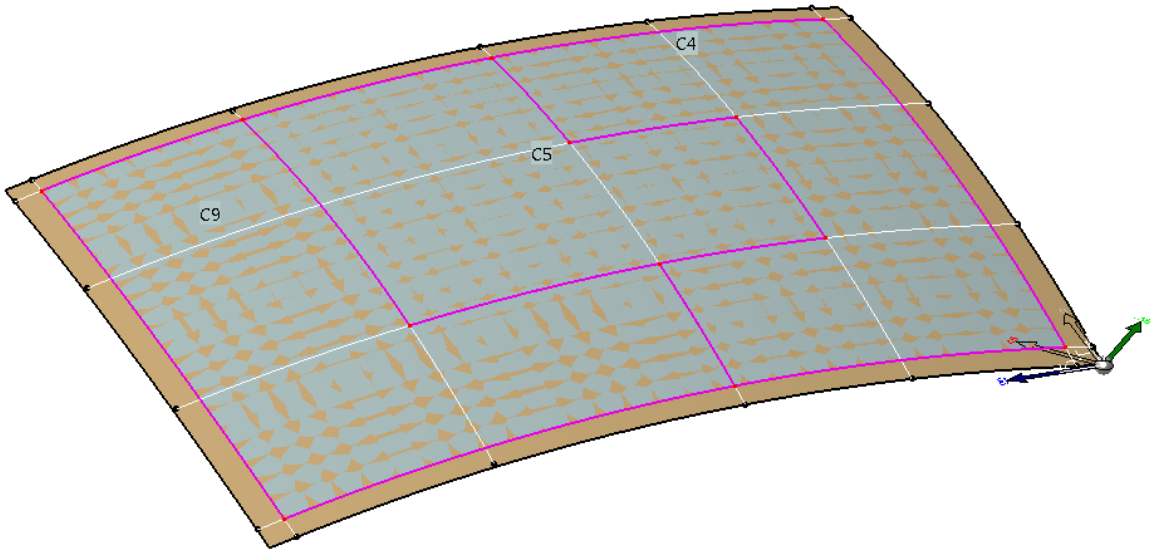
Select *OK*. The grid panel definition is completed.

Select the Grid Definition icon.  The *Grid Definition* window appears. The computed cells should appear in the display as well. Keep in mind the cell names may be different based on the order the reference elements were selected in. This shouldn't matter.

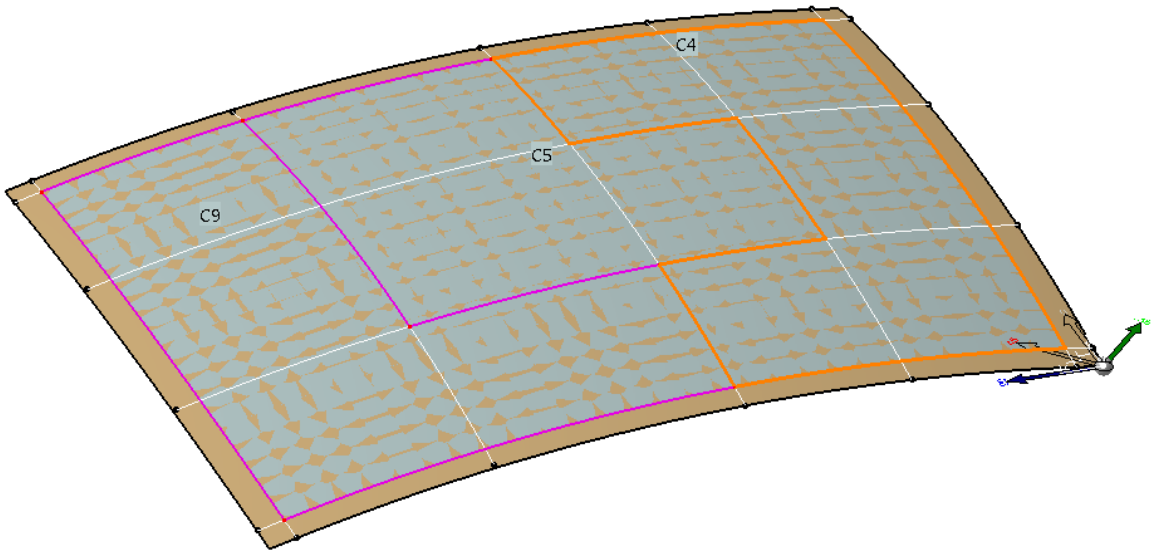


First, the cells that will be a common thickness will be merged together to simplify the panel definition. Keep in mind this is typically not recommended. Leaving the cells in their default definition will yield more robustness to the design.

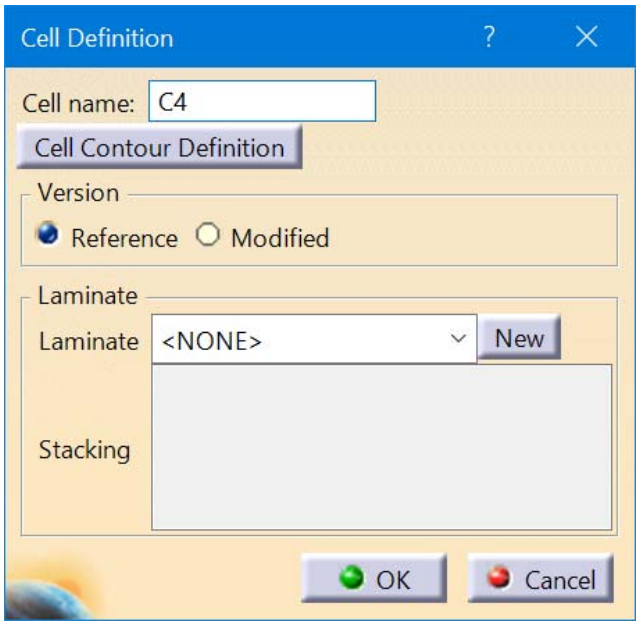
Merge the cells together as shown to define the three constant thickness areas. Keep in mind that your cell names may not match.



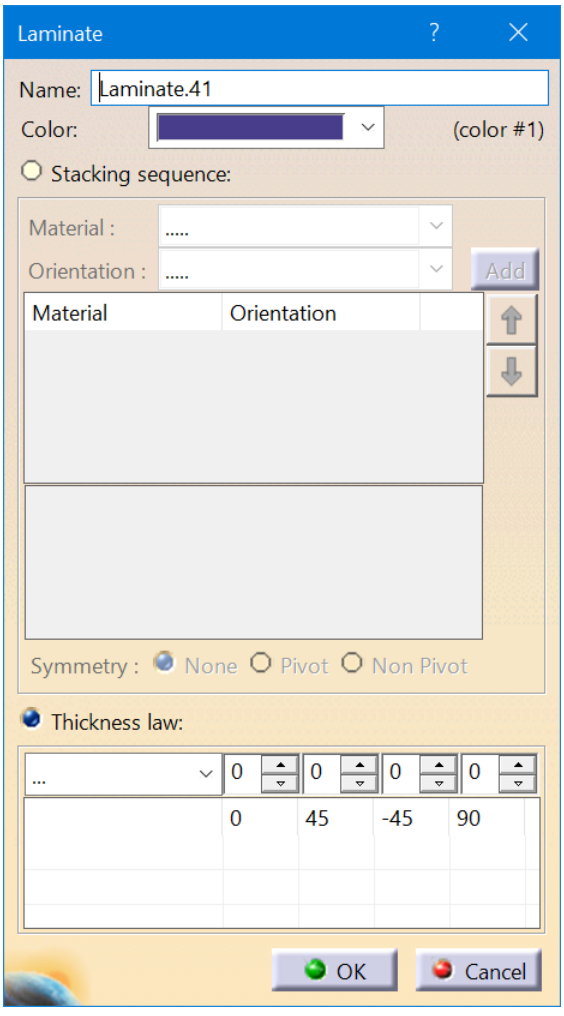
Select the cell as shown and select the *Edit* button. The name and stacking sequence for the cell will be modified.



The *Cell Definition* window appears.

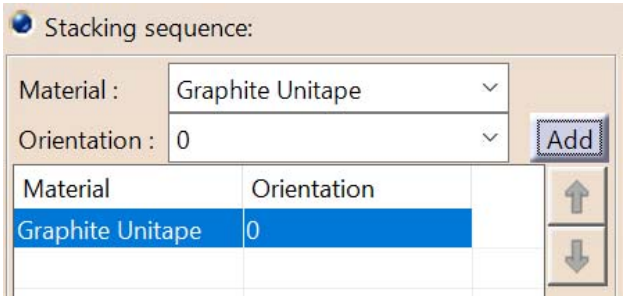


Change the *Cell name* to be 9 Ply Zone and select the *New* button for the *Laminate* option. The *Laminate* window appears.

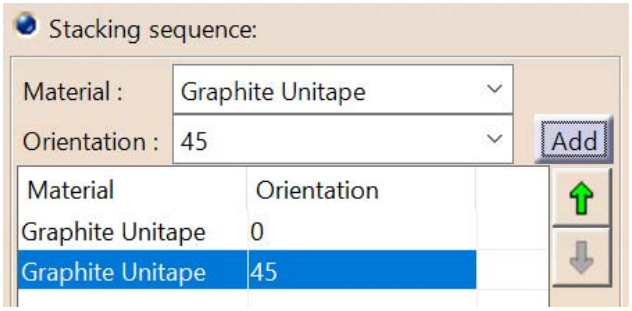


Change the *Name* to be LAM001 and select the *Stacking sequence* option.

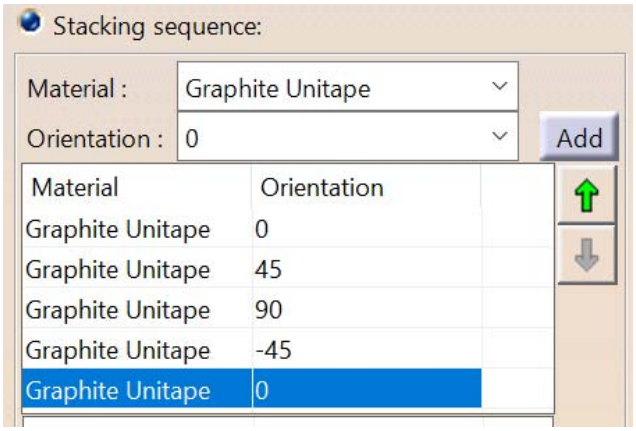
Set the *Material* drop down to be *Graphite Unitape* and the *Orientation* to be 0 and select the *Add* button. The first ply will be a 0 degree ply.



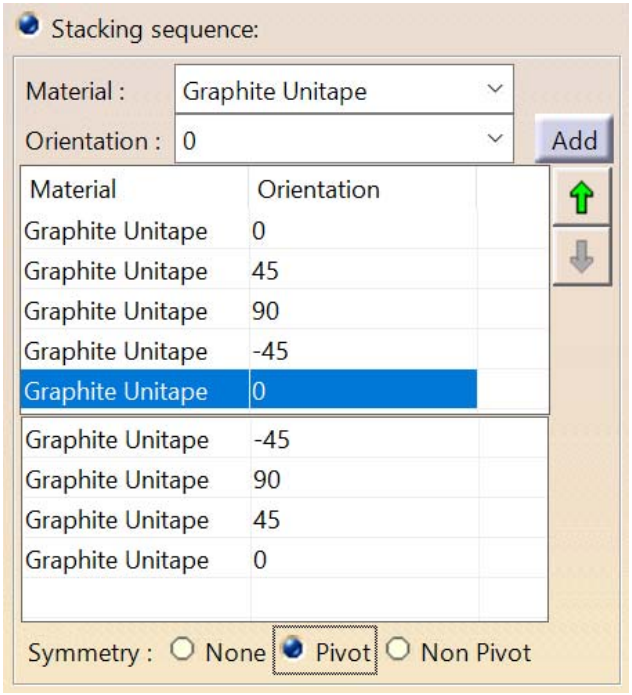
Change the *Orientation* to be 45 and select the *Add* button again. The second ply is defined.



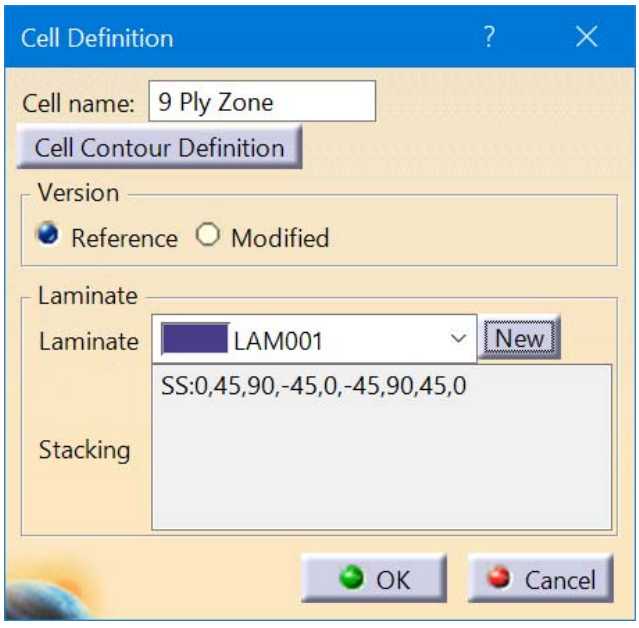
Define three more plies as shown. This will complete half of the laminate.



Set the *Symmetry* option to be *Pivot*. The final 0 degree ply will be the center of the laminate. The stacking should appear as shown.

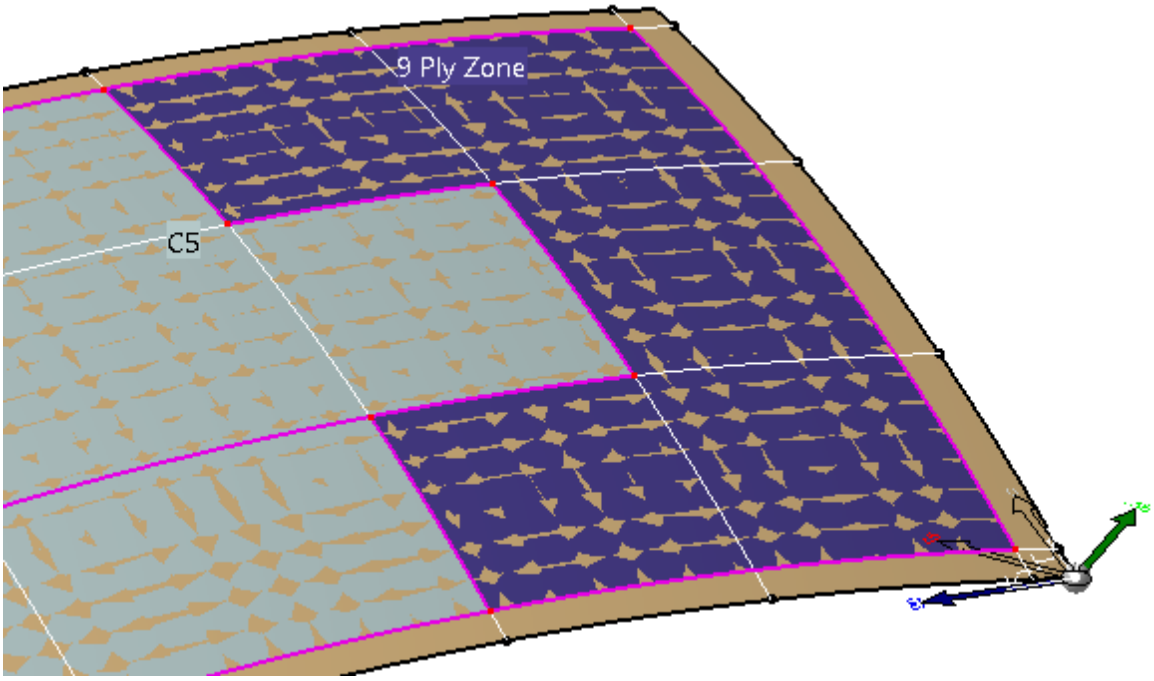


Select *OK*. This defines the thickness law as well as the actual order of the stacking for constant area. The Cell definition should appear as shown.



Select *OK*.

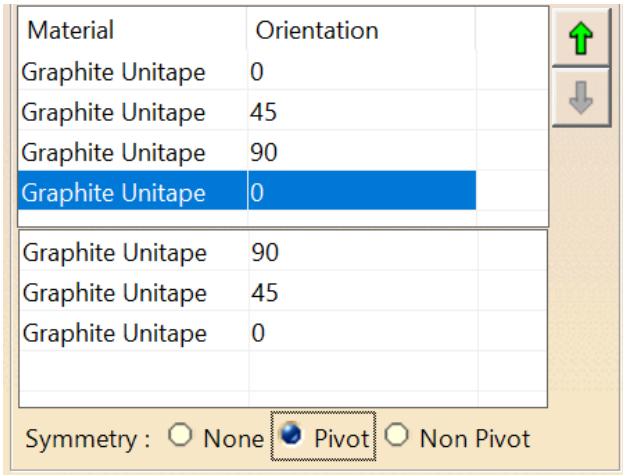
The cell should appear as shown.



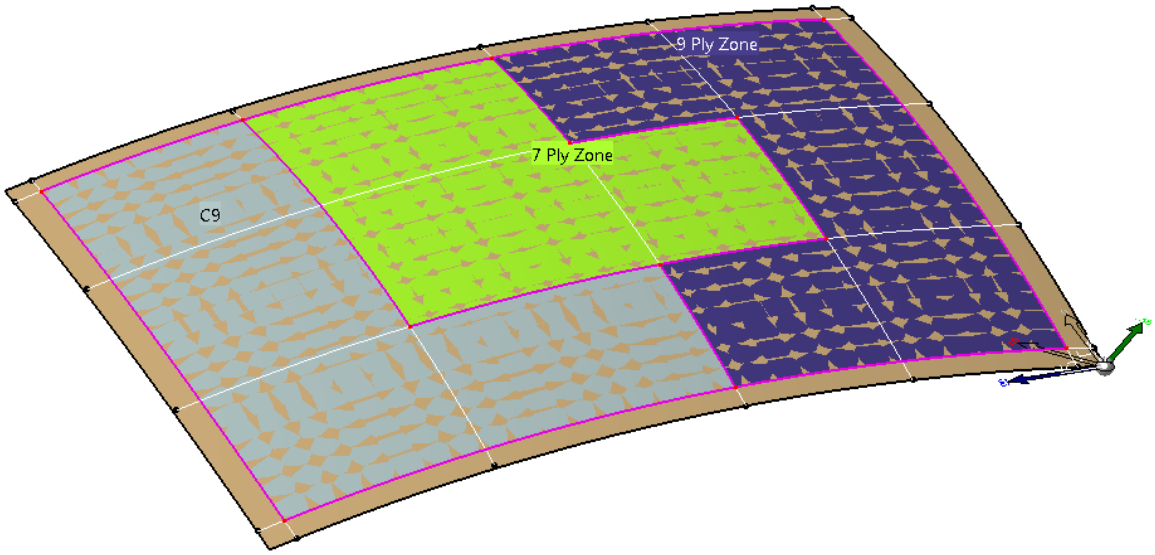
Select the center cell and select the *Edit* button. The *Cell Definition* window appears.

Change the *Cell name* to be 7 Ply Zone.

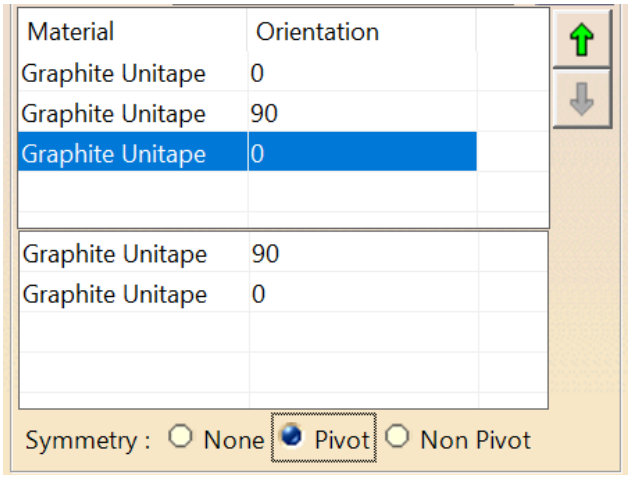
Create a new laminate called LAM002 with the following stackup.



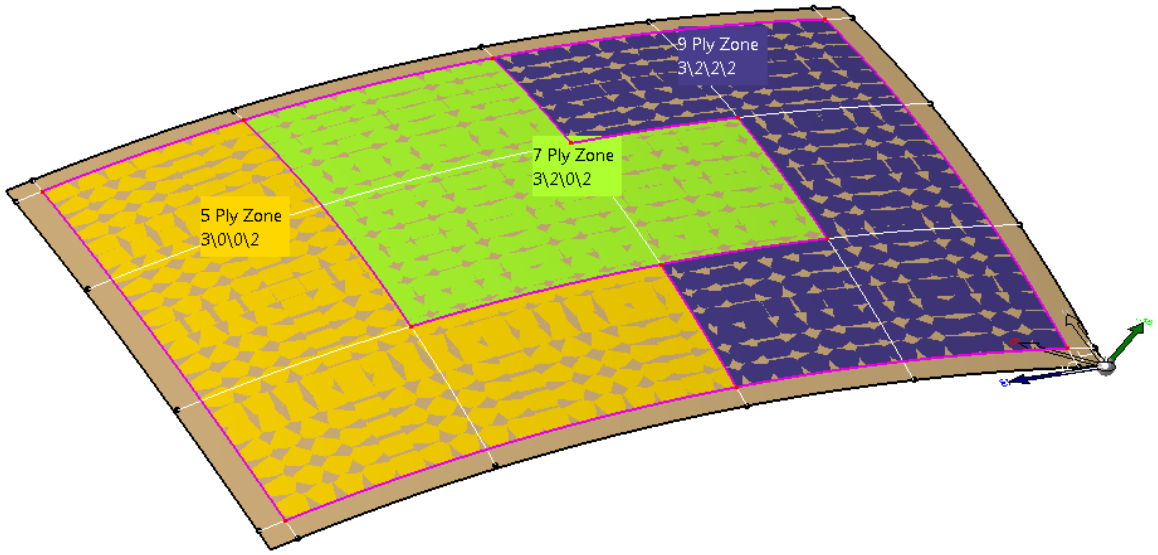
Select *OK*. The cell should appear as shown.



Set the name of the final cell to be <u>5 Ply Zone</u> with a new laminate called <u>LAM003</u> with the following stackup.



Set the *3D text labels* to display the *Cells name* and *Thickness law*. The panel should appear as shown.



Select the *Reference* option under *Import/Export Management* and select the Browse icon for the *Export to file* option.  A *File Selection* window appears.

Browse to your area, key in SS Export for the *File name* and select *Open*. This will define where to create the spreadsheet.

Select the *Export* button. The file is created.

Open the file from your area. It should appear as shown.

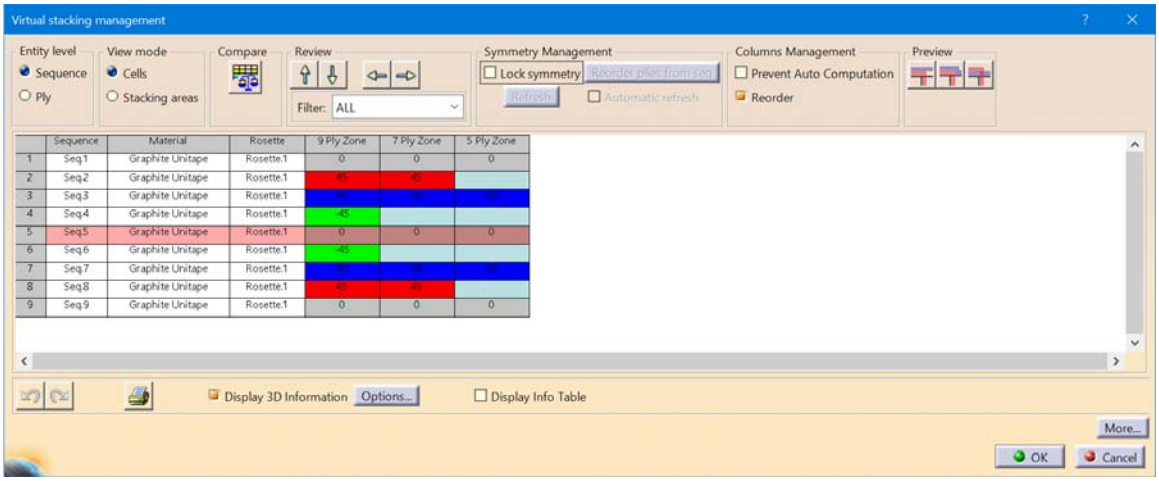
	A	B	C	D	E	F	G	H	I	J	K	L
1	Cells	Laminate	1	2	3	4	5	6	7	8		
2	9 Ply Zone	LAM001	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Reference Element.7		
3	7 Ply Zone	LAM002	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Reference Element.4				
4	5 Ply Zone	LAM003	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Refer	Grid Reference Element.5				
5	#											
6	Name	LAM001										
7	ColorIdx	1										
8	Type	SS										
9	Stacking											
10	Graphite Unitape	0										
11	Graphite Unitape	45										
12	Graphite Unitape	90										
13	Graphite Unitape	-45										
14	Graphite Unitape	0										
15	Graphite Unitape	-45										
16	Graphite Unitape	90										
17	Graphite Unitape	45										
18	Graphite Unitape	0										
19	#											
20	Name	LAM002										
21	ColorIdx	2										
22	Type	SS										
23	Stacking											
24	Graphite Unitape	0										
25	Graphite Unitape	45										
26	Graphite Unitape	90										
27	Graphite Unitape	0										
28	Graphite Unitape	90										
29	Graphite Unitape	45										
30	Graphite Unitape	0										
31	#											
32	Name	LAM003										
33	ColorIdx	3										
34	Type	SS										
35	Stacking											
36	Graphite Unitape	0										
37	Graphite Unitape	90										
38	Graphite Unitape	0										
39	Graphite Unitape	90										
40	Graphite Unitape	0										

This is the format for using the stacking sequence option rather than the thickness law. In this case, the full stacking sequence definition was defined in CATIA so the spreadsheet may not really be necessary. However, the spreadsheet could be used to make changes in the future.

Close the spreadsheet. You should be back to the *Grid Definition* window in CATIA.

Select *OK*. The grid definition is created.

Select the Virtual Stacking Management icon and select *Grid.1* from the tree. 
The *Virtual Stacking Management* window appears.



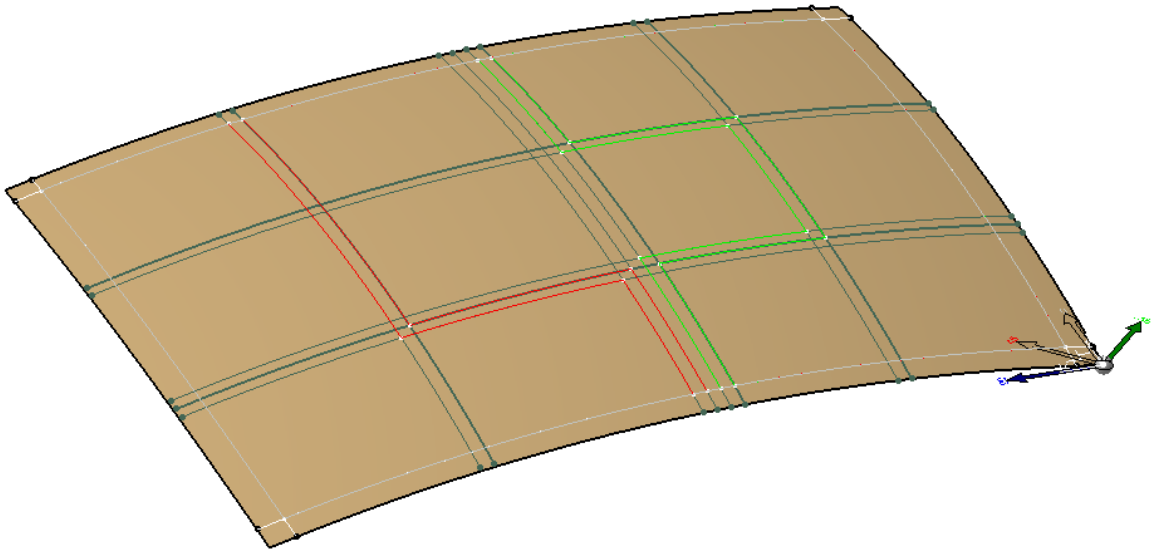
Since the stacking sequences were already defined for the cells, it is not necessary to rearrange the rows in this window. If any changes were needed, they could be made though.

Select *OK*. Now you are ready to create the plies.

Select the Plies From Virtual Stacking icon.  The *Plies Creation* window appears.

Select the Minimum Crossing & Weight Savings algorithm and the *Backslash* pattern and select *OK*. The plies are created.

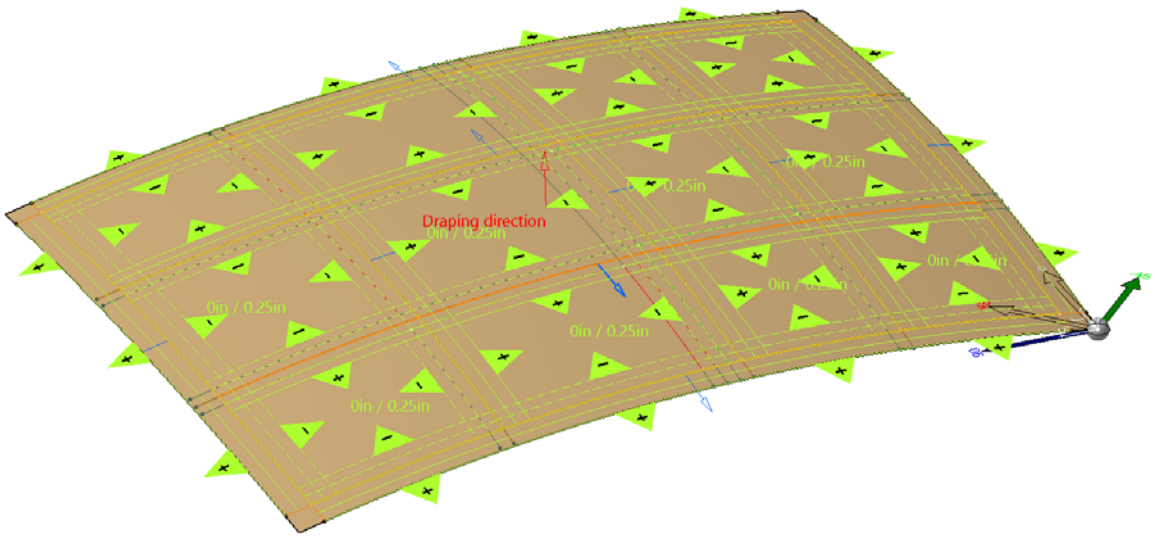
Hide the *Grid.1* and *Grid Virtual Stacking.1* and show the grid ramp supports in the tree. The plies should appear as shown.



Most of the drop offs are correct, but a few need to be modified to have the correct staggering. Fortunately, the original grid panel definition can be modified and the plies will automatically update.

Double select on *Grid Panel.1* from the tree. The *Panel Definition* window appears.

Select the reference element group and select *Parallel.7* in the window. It should highlight as shown in the display.

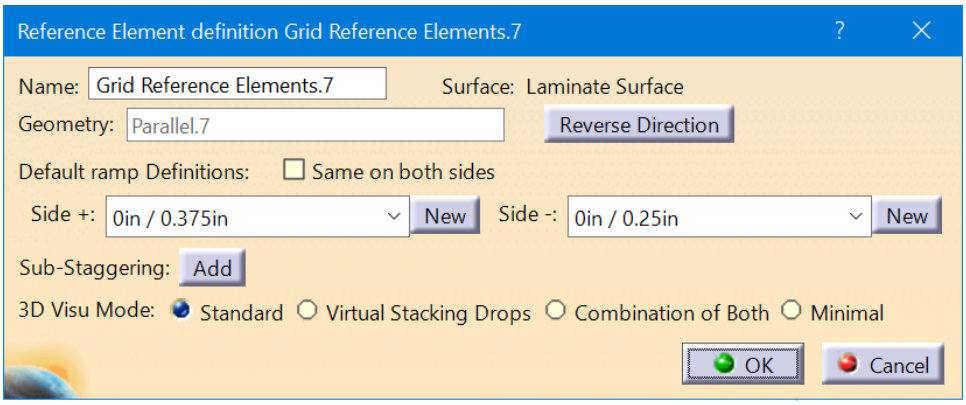


This curve should have a drop off staggering of 0.375 in the negative X direction instead of 0.25. This will be fixed now.

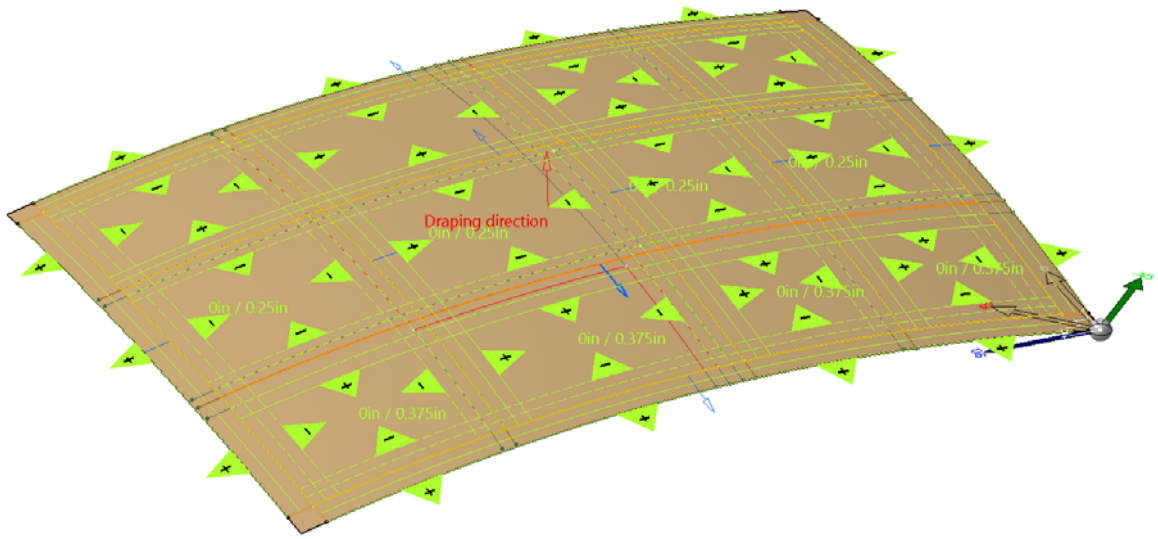
Select the *Edit* button in the *Reference elements* area. The *Reference Element Definition* window appears for the curve.

Turn off the *Same on both sides* option and create a new ramp definition for the positive side.

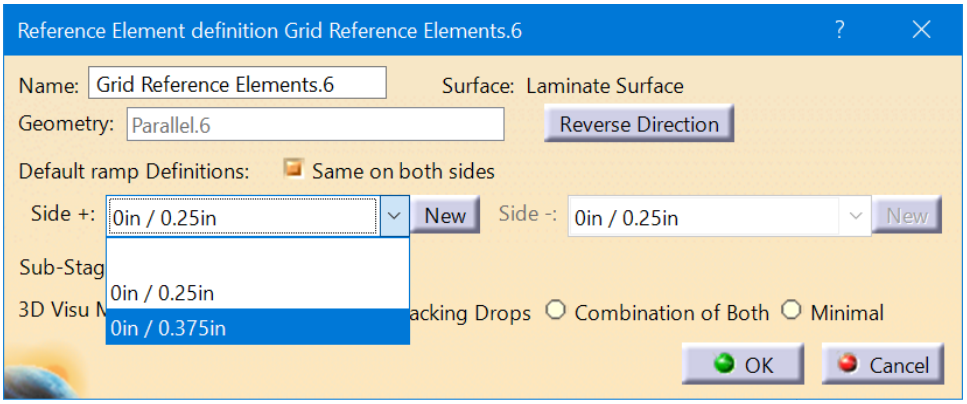
Set the *Step* to be 0.375 for the new ramp support. It should appear as shown.



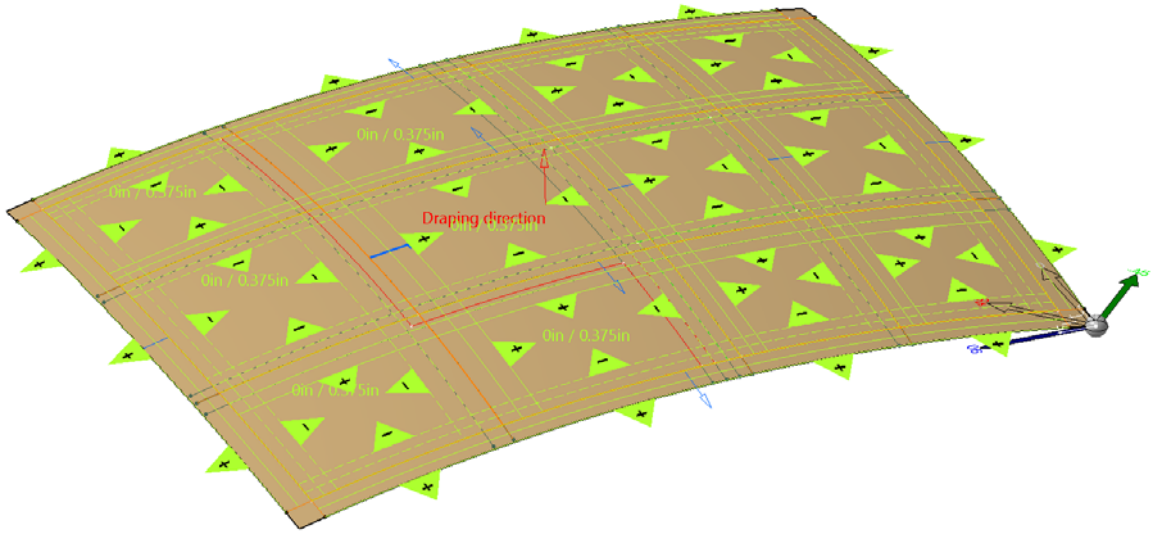
Select *OK*. Notice the representation in the display updates.



Change the ramp definition for *Parallel.6* to use the *0in / 0.375in* ramp definition in both directions. You can simply select the 0in / 0.375in ramp definition from the drop down to reuse the one you just created.



Select *OK*. The representation should update in the display.

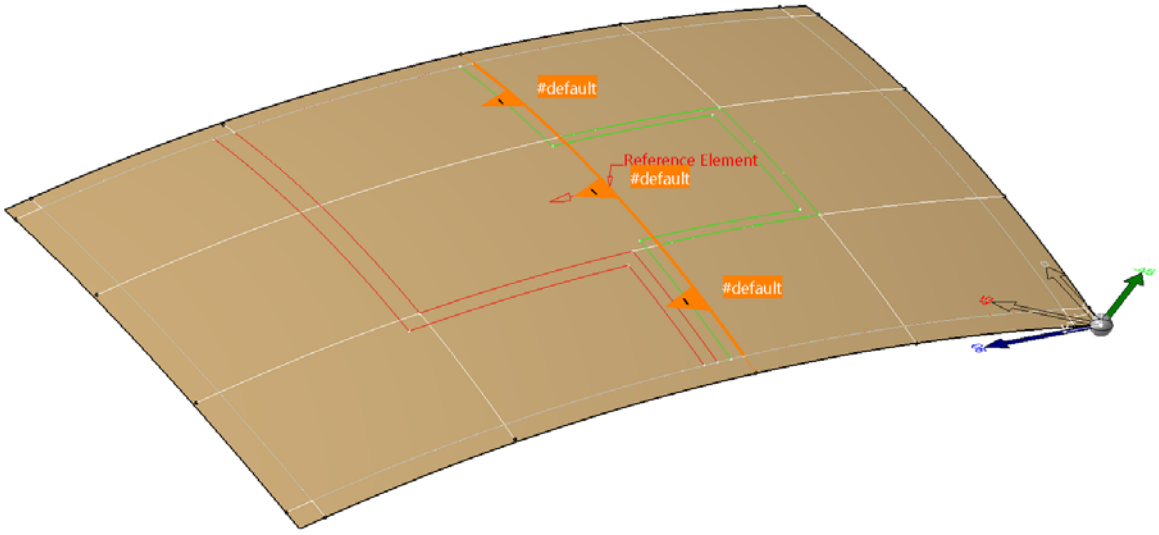


Select *OK*.

Select the Update icon.  The plies should update. The final ply manipulation will require a new grid ramp support.

Select the Grid Ramp Support Definition icon.  The *Grid Ramp Support Definition* window appears.

Select the curve as shown.

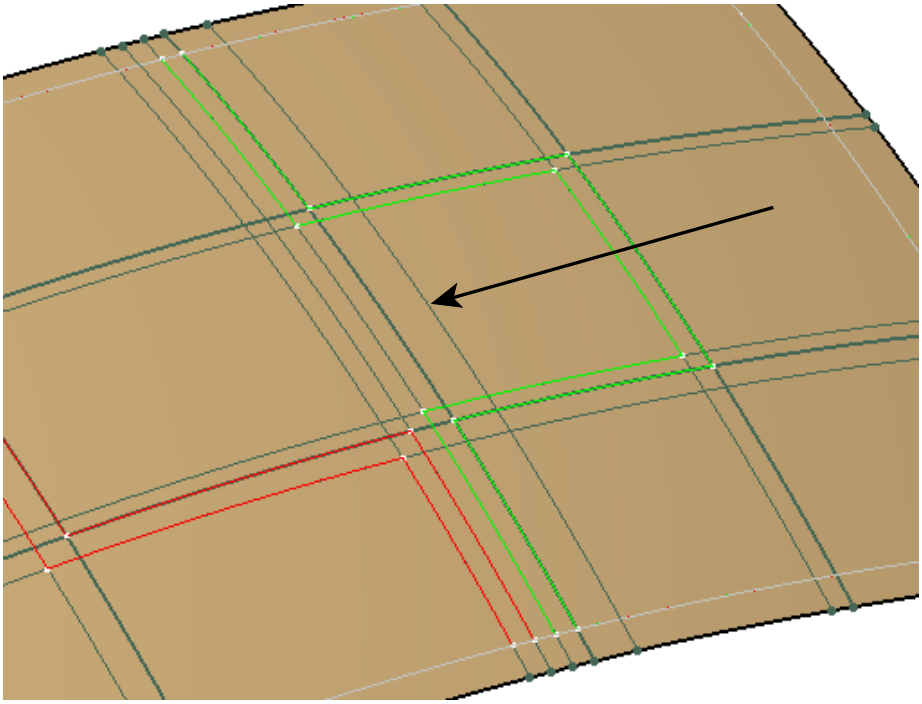


Select the *Side* + option and set the *Curves count* to be 3. This specifies which side of the reference element and the number of curves to be created.

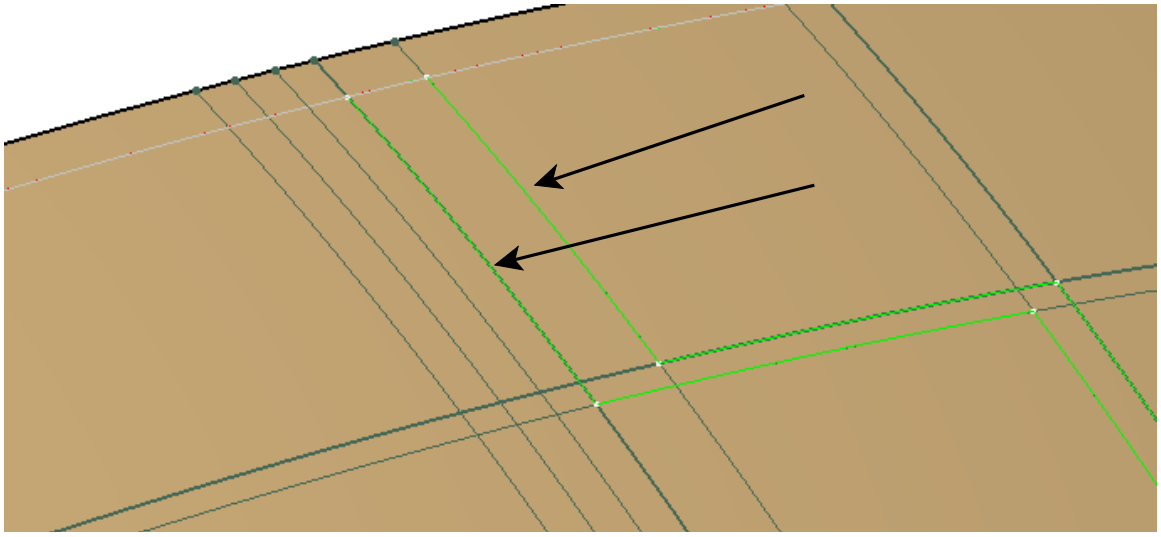
Select the *Override reference element spec with* option and select the *New* button. The *Ramp Definition* appears.

Change the *Step* to be 0.5 and select *OK*.

Select *OK*. The new grid ramp supports are created.

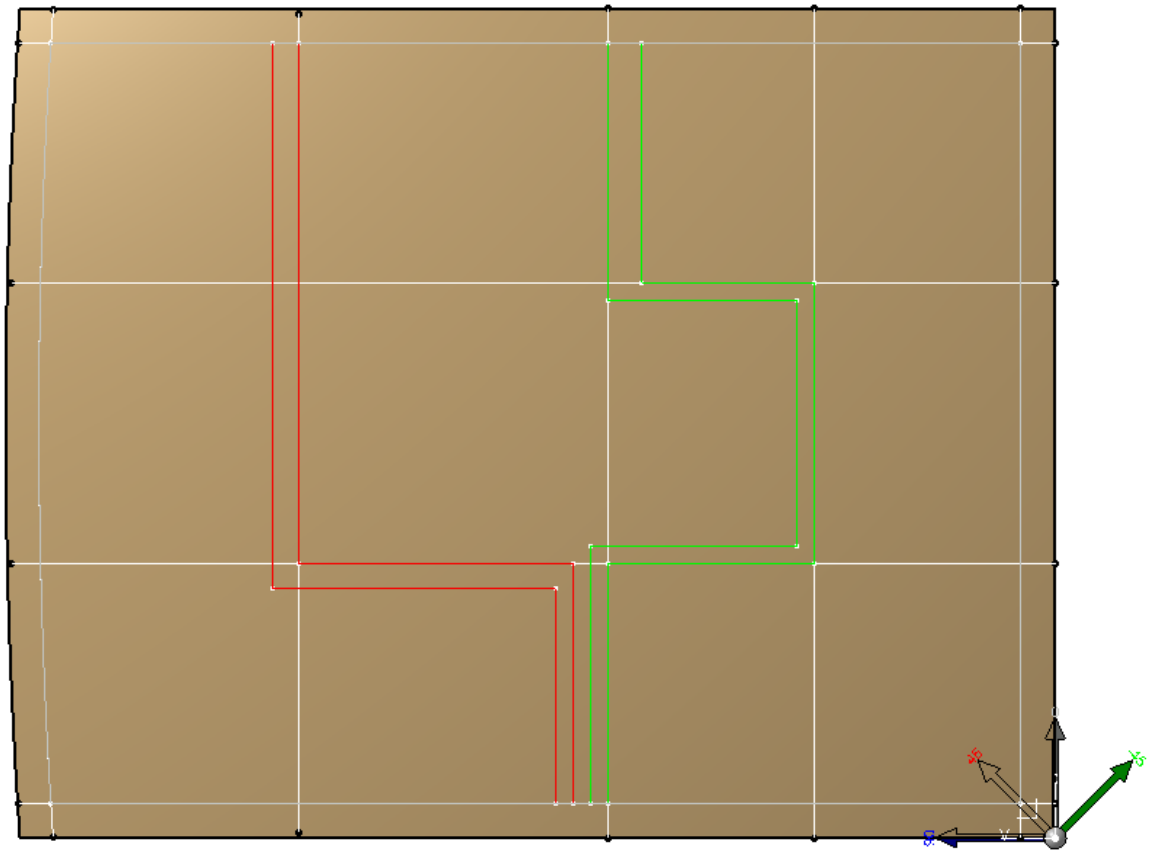


Use the Swap Edge icon to modify the plies as shown. 

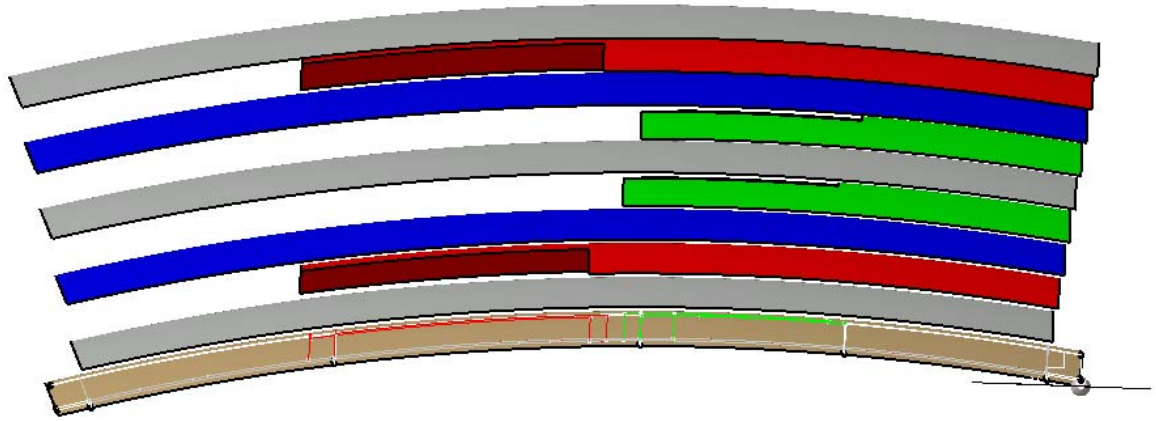


This should have all of the ply drops in the correct direction and with the correct staggering.

Hide the ramp supports in the tree. The plies should appear as shown.



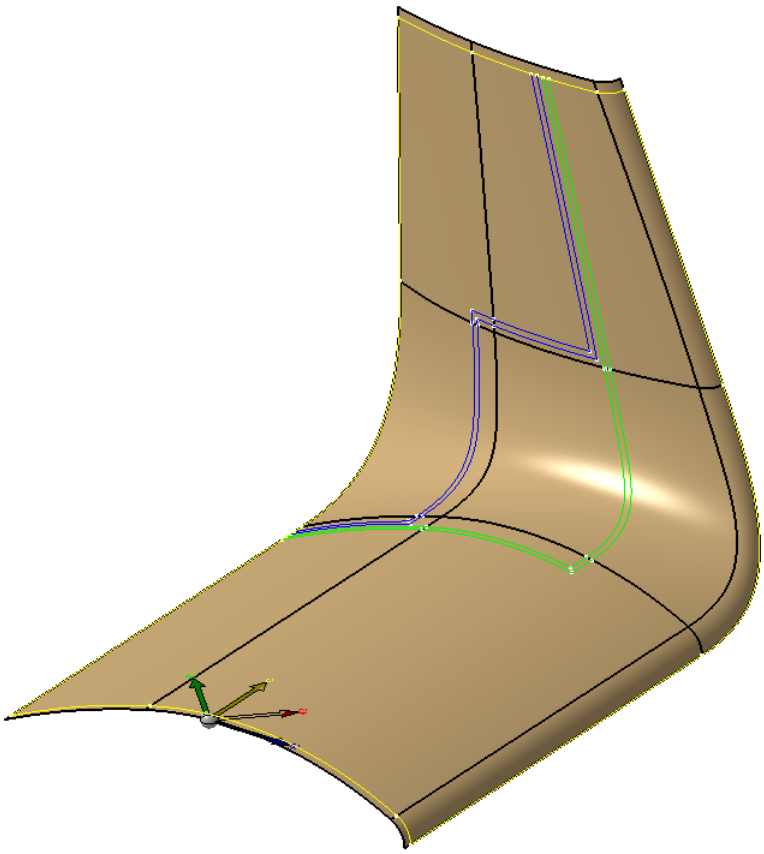
Explode the plies with the Shell Constant Offset option and a Scale of 10.  They should appear as shown. The plies should be symmetric.



Remove the exploded surfaces and save and close the document.

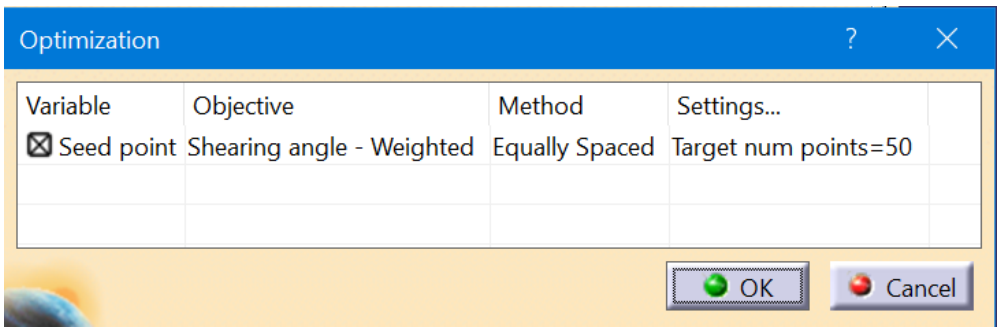
Now the producibility optimization option will be investigated.

Open the Producibility Optimization document. It should appear as shown.



Select the Producibility for Hand Layup icon.  The *Producibilty for Hand Layup* window appears.

Select the first ply in the tree and select the *Optimize* button next to the *Seed point* definition. The *Optimization* window appears.



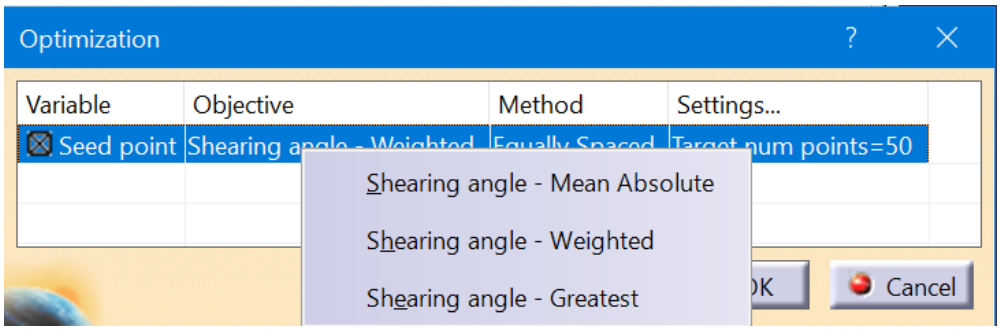
Variable Specifies whether the seed point locations for the selected plies can vary

Objective Specifies the optimization criteria: Mean Absolute, Weighted or Greatest for the shearing angle

Method Specifies the method for distributing points over the ply area

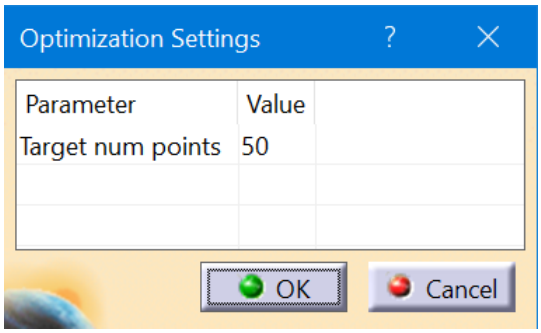
Settings Specifies the number of points to be analyzed over the ply during the optimization

Select *Shearing angle - Weighted* in the window, then right select on it. The contextual menu will appear as shown.



This is how you can edit the various options for the optimization.

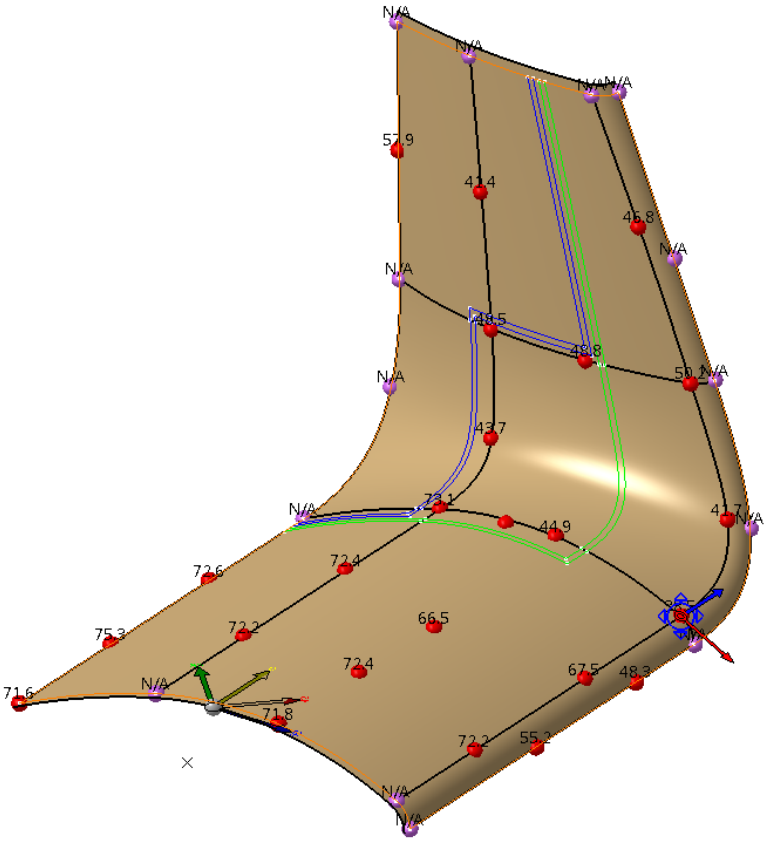
Right select under the *Settings* column and select *Edit*. The *Optimization Settings* window appears. This would allow you to modify the number of points to be included in the optimization.



Select *Cancel*.

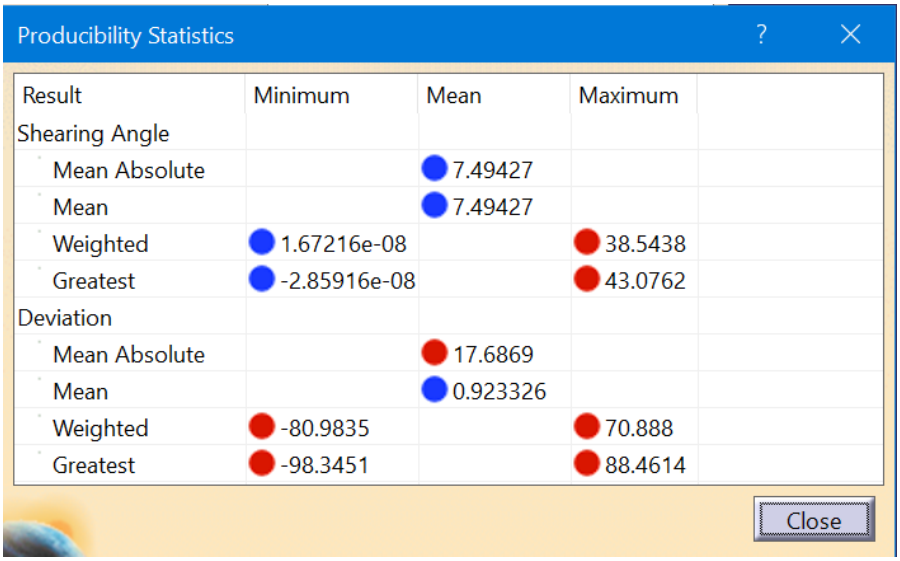
Select *OK*. The optimization is run.

The display should appear as shown.



Notice 50 locations were analyzed for producibility. The location yielding the lowest maximum shearing angle was selected.

Select the *Results* tab and turn on the *Statistics* option. The *Producibility Statistics* window appears.

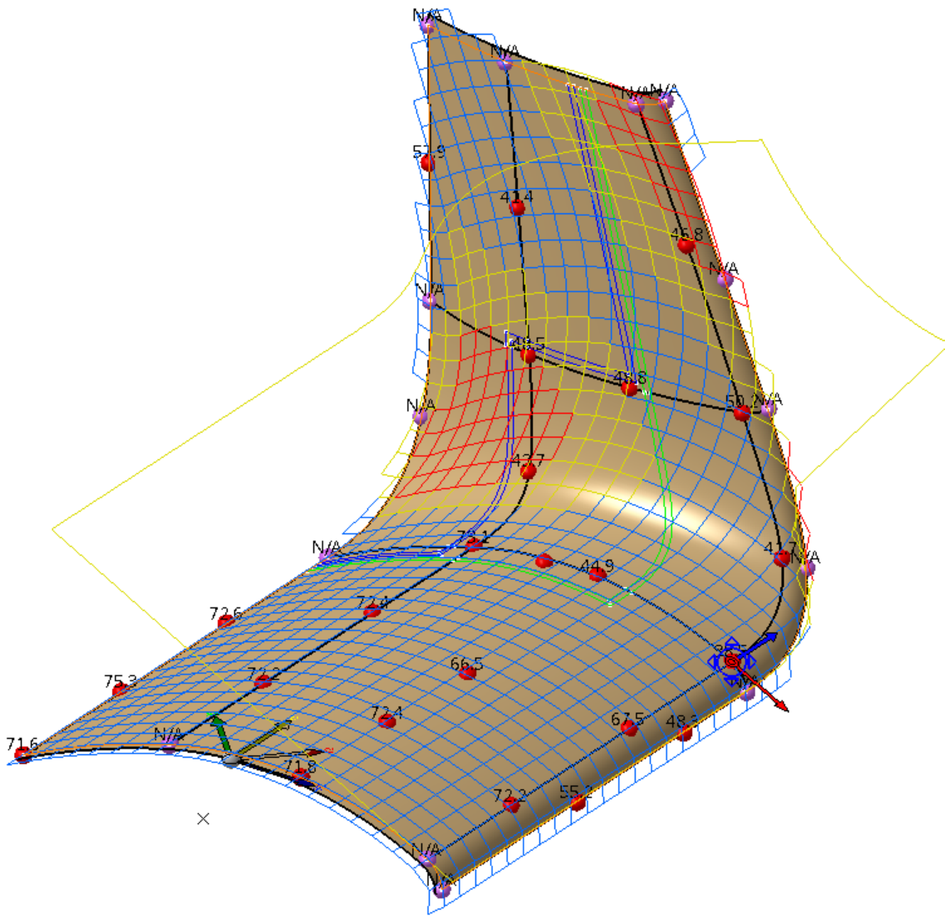


Notice the maximum shearing angle for the weighted computation is 38.5 degrees.

The values next to the other locations in the display correspond to what the maximum shearing angle for the weighted computation would be if the seed point were positioned at each location.

Close the *Producibility Statistics* window.

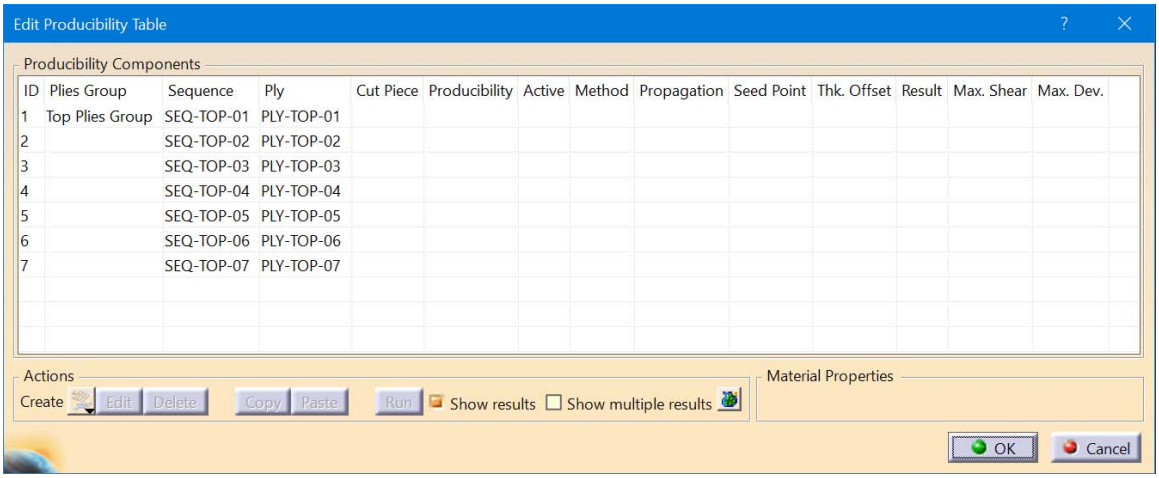
Select *Preview*. The producibility should appear as shown.



Feel free to select any of the other locations and preview their results.

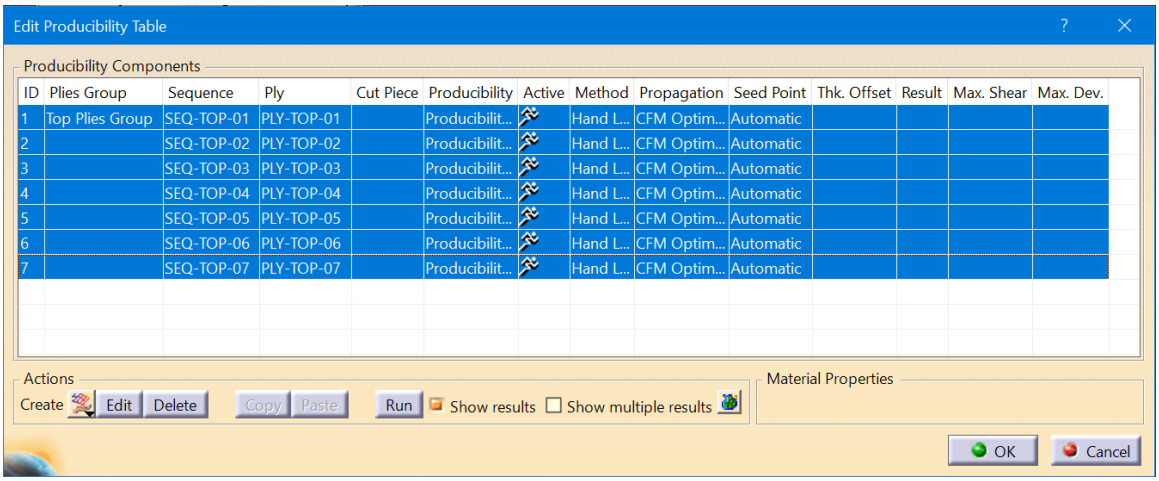
Select *Cancel* when you are done. The producibility will be computed and optimized for all plies now.

Select the Edit Producibility Table icon.  The *Edit Producibility Table* window appears.



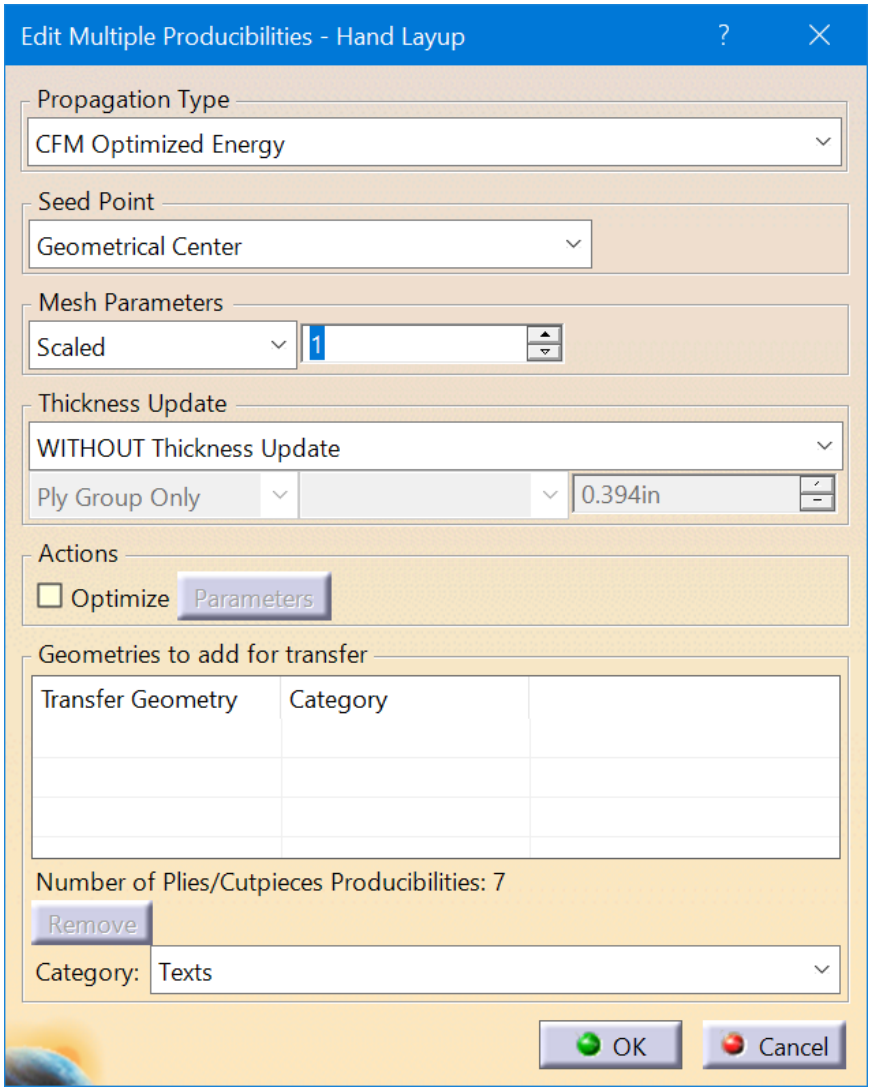
Select all of the plies in the window. You may use the Shift key.

Select the Producibility for Hand Layup icon in the window.  Many of the columns in the window will populate.

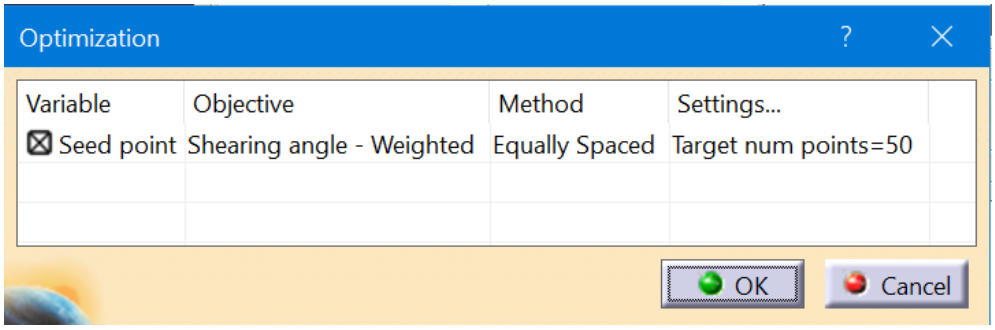


The producibility has been setup for all of the plies according to the last producibility analysis that you ran.

Select the *Edit* button. The *Edit Multiple Producibilities - Hand Layup* window appears.



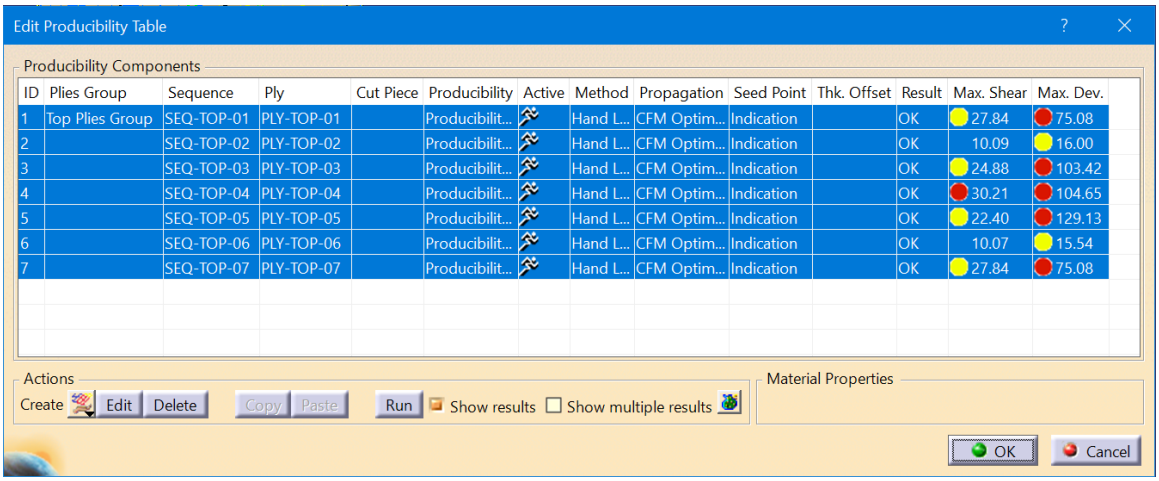
Turn on the *Optimize* option and select the *Parameters* button. The *Optimization* window appears.



Select *Cancel*. The default optimization settings will be used.

Select *OK*. The optimization begins and will be computed for each ply. When it is completed, the *Edit Producibility Table* will reappear.

Select *Run*. The producibilities will be computed for each ply.



Select each ply in the window to view it's producibility.

Select *OK* when finished.

The *Optimize* option can be very useful for determining the best position of the seed point without manually reviewing the producibility.

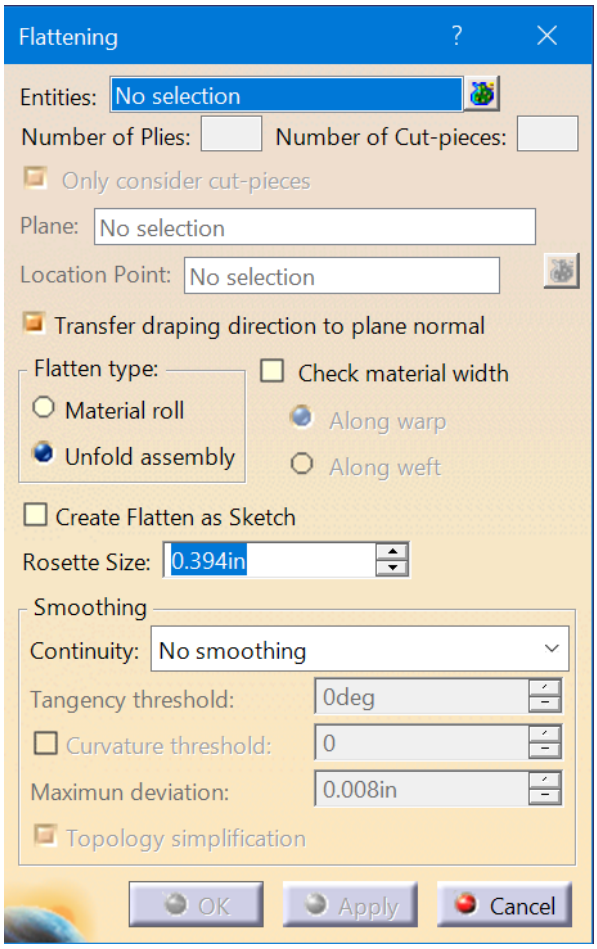
Save and close the document.

Flattening

The Flattening option allows you to generate a flat pattern for each of the plies.

Open the Flattening document. The producibility has already been computed for all of the plies.

Select the Flattening icon.  The *Flattening* window appears.

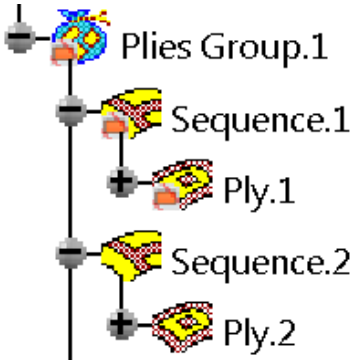


Entities	Specifies the plies to flatten
Only consider...	Specifies if cut-pieces exist, only they will be used
Plane	Specifies the plane to create the flat patterns on
Location Point	Specifies the location each flat pattern will be located at on the flattening plane
Transfer draping...	Allows you to flip the flat patterns on the flatten plane

Flatten type

Material roll	Flat patterns are positioned on the flattening plane according to the fiber directions of the ply and the axis of the plane
Unfold assembly	Flat patterns are positioned according to the 3D positioning of the ply

Check material... Performs a material width analysis to be sure the ply will fit on the specified material. If any ply ever fails this analysis, a mask will appear on the features in the tree as shown. In this case *Ply.1* is failing the material width check.

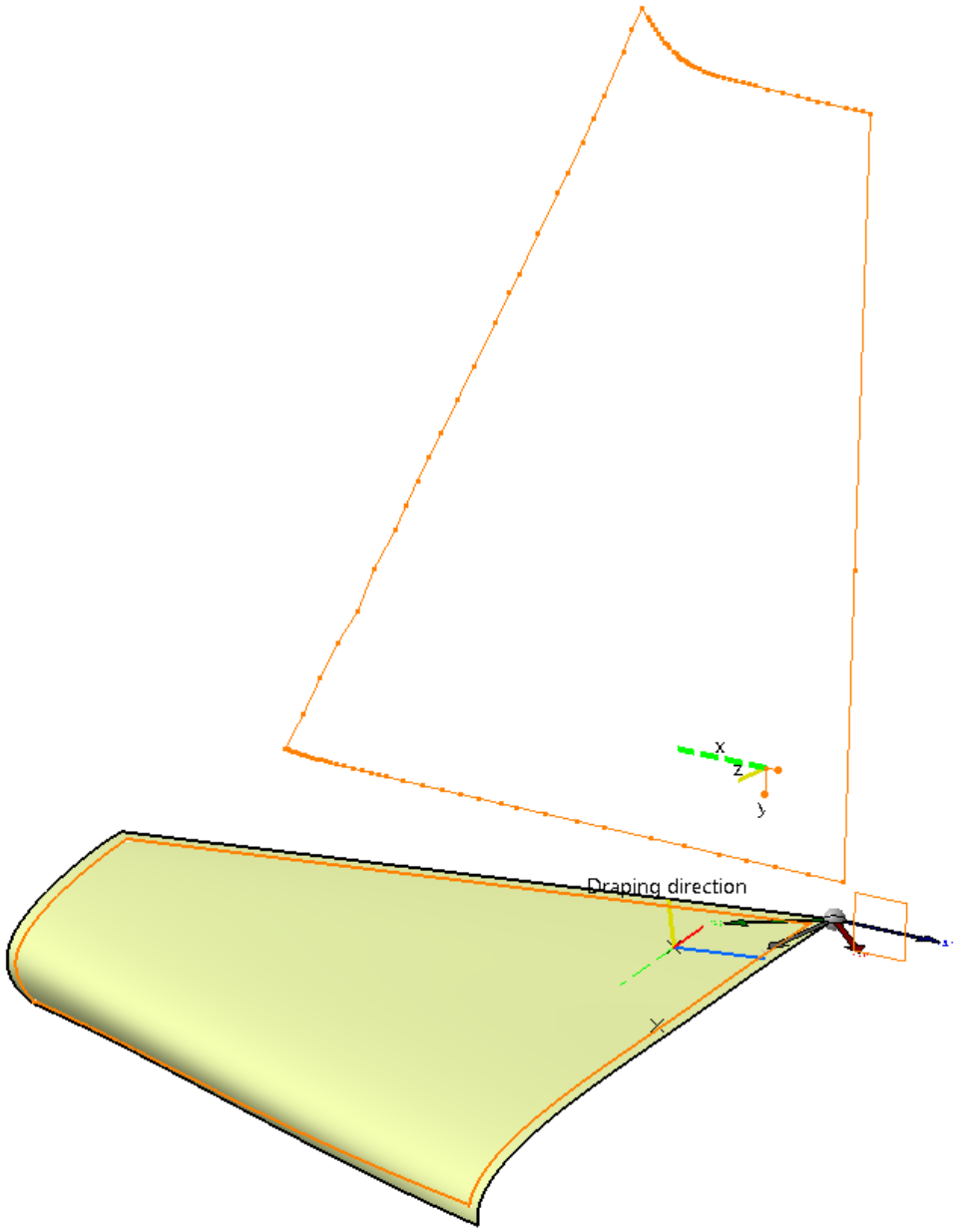


Create Flatten... Specifies the flat pattern will be created as a sketch rather than a wireframe curve

Smoothing Allows the flat patterns to be smoothed

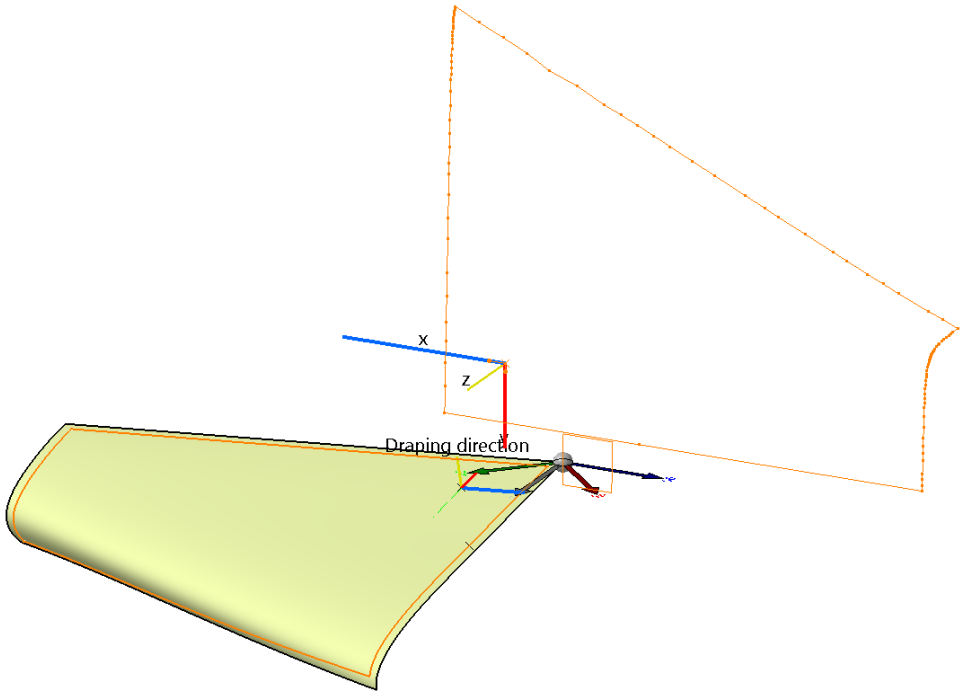
Select the *Sequence.1* to define the ply to flatten. Select the *Flattening Plane* from *Geometrical Set.1* and select the point from the *Flattening Points* geometrical set.

With the *Unfold assembly* option selected, select *Apply*. The flattened ply appears in the display.

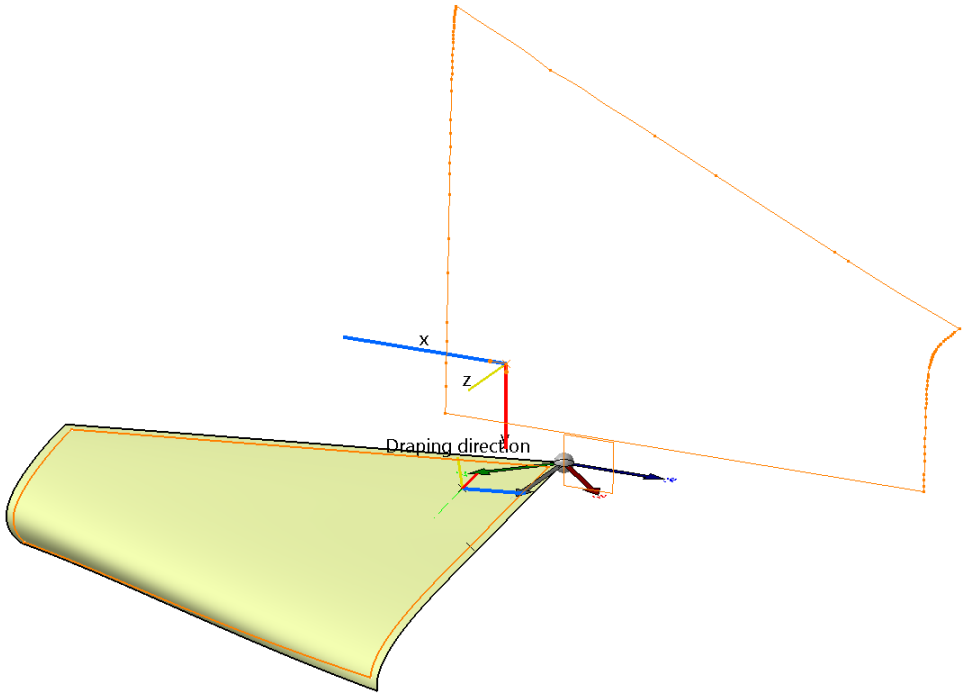


Notice the original point that was selected during the producibility operation is positioned at the specified point from the flattening operation.

Select the *Material roll* option in the *Flattening* window and select *Apply*. The flattened ply is repositioned on the plane.



In the *Smoothing* section, select *Threshold* for the *Continuity* and key in 10deg for the *Tangency threshold*. Select *Apply*. Notice the flat pattern is smoothed a bit and many of the vertices are removed.

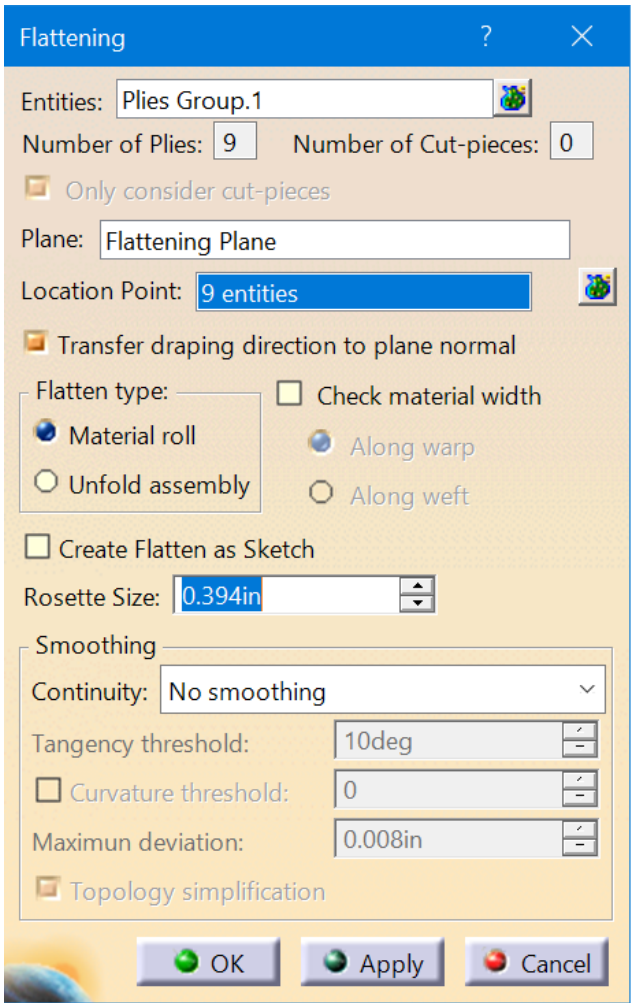


Select *Cancel* in the window. Since you want to create a flat pattern for all of the plies, you will do it all at once.

Select the Flattening icon.  The *Flattening* window appears.

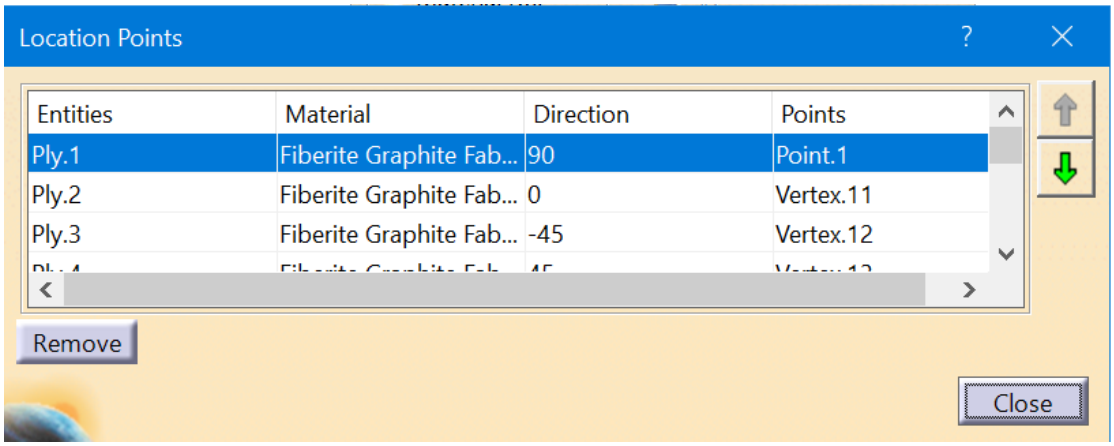
Select *Plies Group.1* to define the *Entities* to flatten.

Select the same *Flattening Plane* again and select the rectangular pattern in the *Flattening Points* geometrical set to define the *Location Point* for the operation. The *Flattening* window should appear as shown.



Notice there are 9 plies selected and 9 point locations as well.

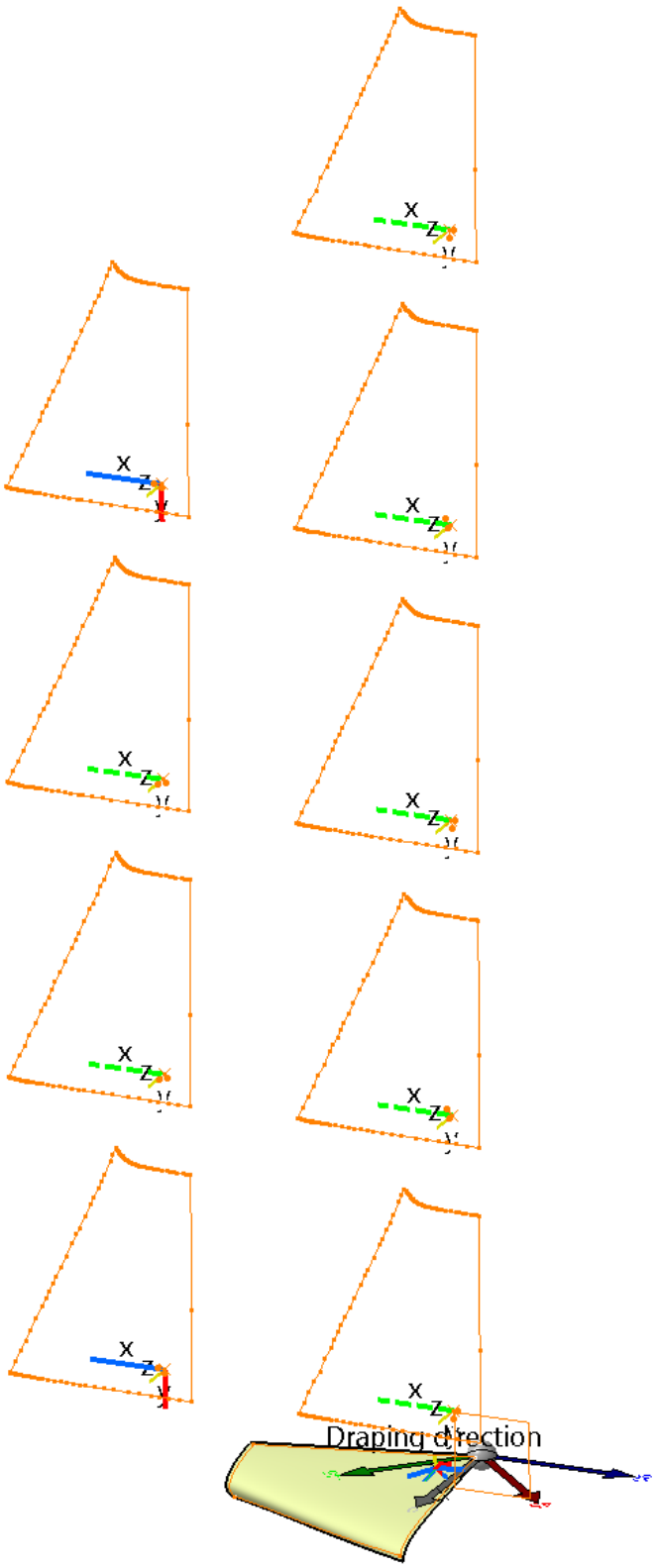
Select the Multi Selection icon for the *Location Point* option in the window.  The *Location Points* window appears.



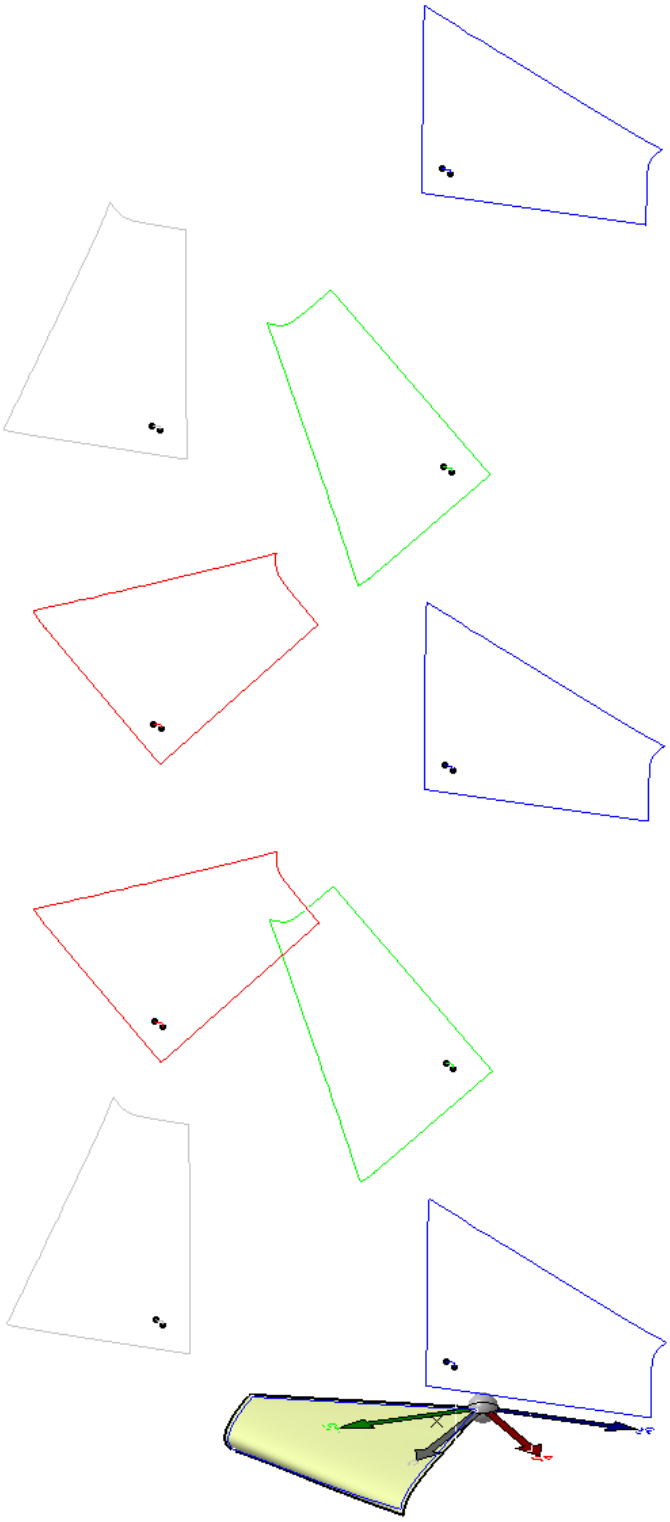
Notice all of the plies are listed and each ply was assigned a location point. You can manually specify which ply is assigned to which point from this window if you wanted to.

Select *Close*. You are returned to the *Flattening* window.

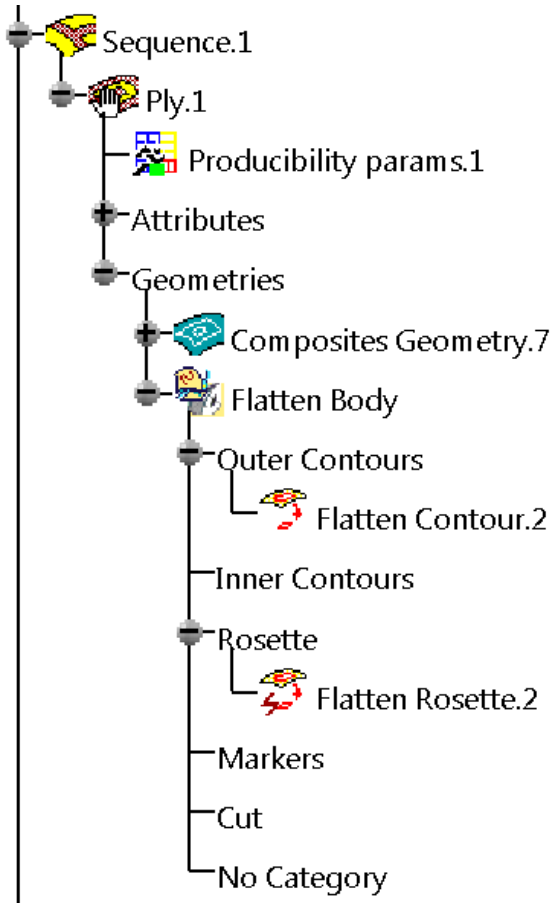
Select the *Unfold assembly* option and select *Apply*. The plies are positioned in a uniform manner. This is typically not what you want since the plies will normally need to be exported in their oriented position.



Select the *Material roll* option and select *OK*. The flattened plies are created in their specified orientations.



Expand the first ply in the tree as shown.



Notice the categories under the *Flatten Body* allow you to organize the contents of the flattening. This is important when it comes to exporting the flat patterns. This will be discussed in more detail in the Exporting section.