

Workshop – Composite Coupon – Phase C – Data Preparation for Ply Shape Optimization

AN MSC NASTRAN SOL 200 TUTORIAL

Composite Workshop

This workshop is phase C of a 5-phase workshop.

Phase A

Workshop – Composite Coupon – Phase A – Determination of the optimal 0° direction of a composite

- Perform an optimization on the angle of ply 1 to maximize stiffness
- Tools Used: MSC Nastran and SOL 200 Web App

Phase B

Workshop – Composite Coupon – Phase B – Baseline Ply Number Optimization

- Perform a ply number optimization with full and continuous ply shapes
- Tools Used: SOL 200 Web App (Viewer and Optimization web apps) and MSC Nastran

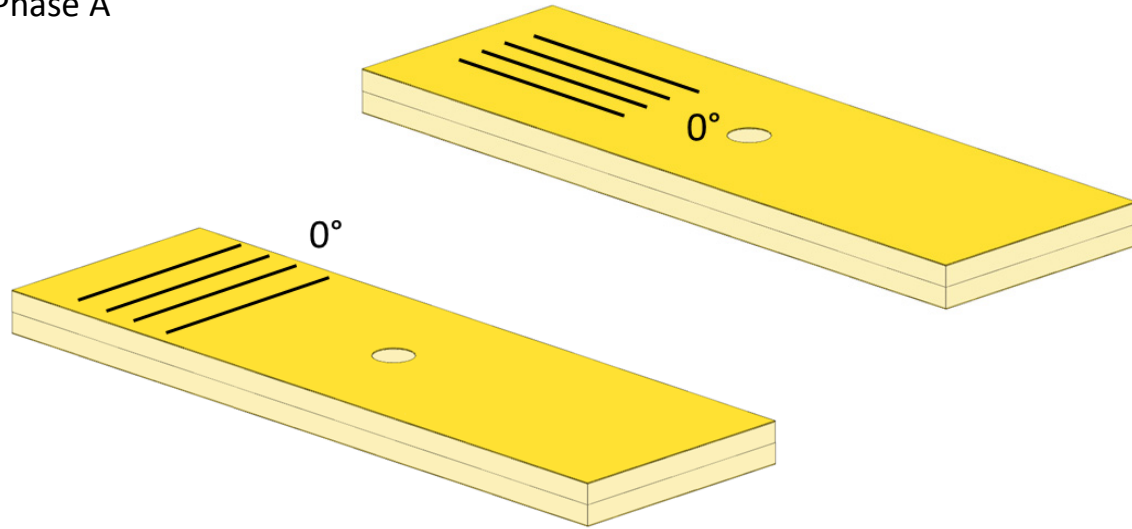
0° Direction Optimization

Baseline Ply Number Optimization

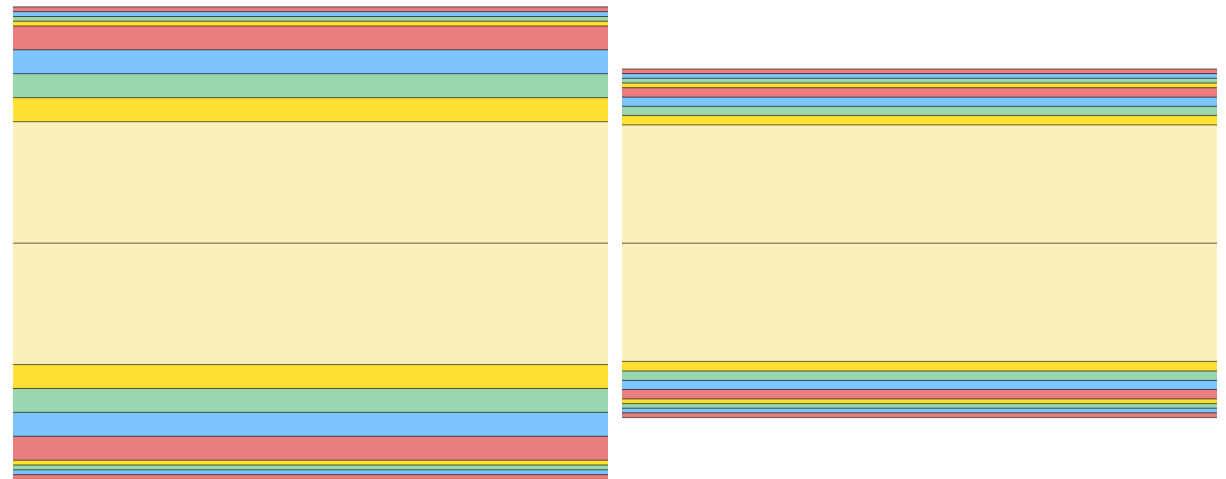
Composite Workshop

This workshop is phase C of a 5-phase workshop.

Phase A



Phase B



0° Direction Optimization

Baseline Ply Number Optimization

Composite Workshop

This workshop is phase C of a 5-phase workshop.

Phase C

Workshop – Composite Coupon – Phase C – Data Preparation for Ply Shape Optimization

- Manually create PLY000i Files
- Tools Used: Patran, MSC Nastran and SOL 200 Web App

Phase D

Workshop – Composite Coupon – Phase D – Ply Shape and Ply Number Optimization

- Input BDF and PLY000i Files
- Create Ply Shapes
- Perform Ply Number Optimization
- Inspect Plies
- Tools Used: SOL 200 Web App (Viewer and Optimization web apps) and MSC Nastran

Phase E

Workshop – Composite Coupon – Phase E – Stacking Sequence Optimization

- Input BDF
- Perform Stacking Sequence Optimization
- Validate Performance
- Inspect Plies
- Tools Used: SOL 200 Web App (Stacking Sequence and Viewer web apps) and MSC Nastran

Ply Shape Optimization

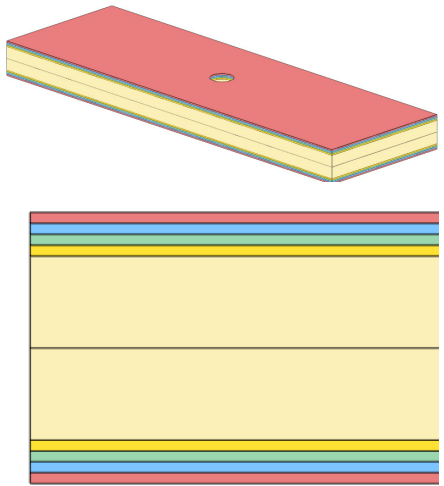
Ply Number Optimization

Stacking Sequence Optimization

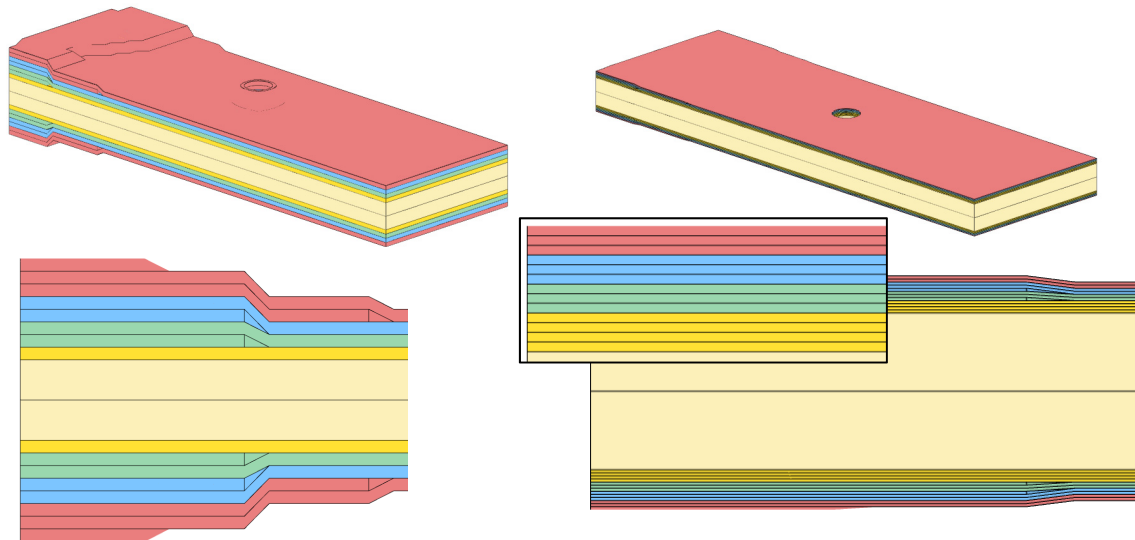
Composite Workshop

This workshop is phase C of a 5-phase workshop.

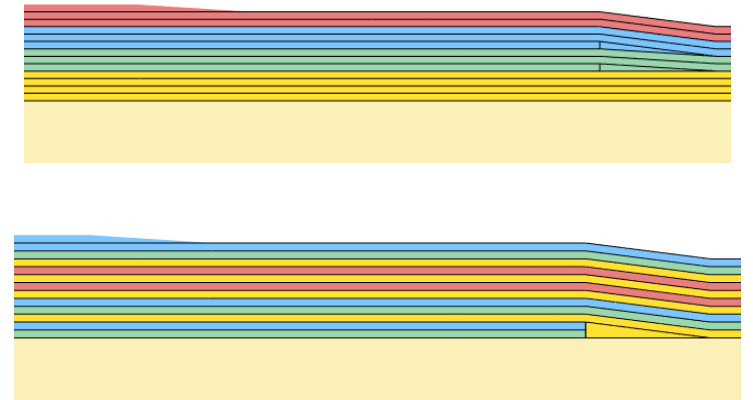
Phase C



Phase D



Phase E



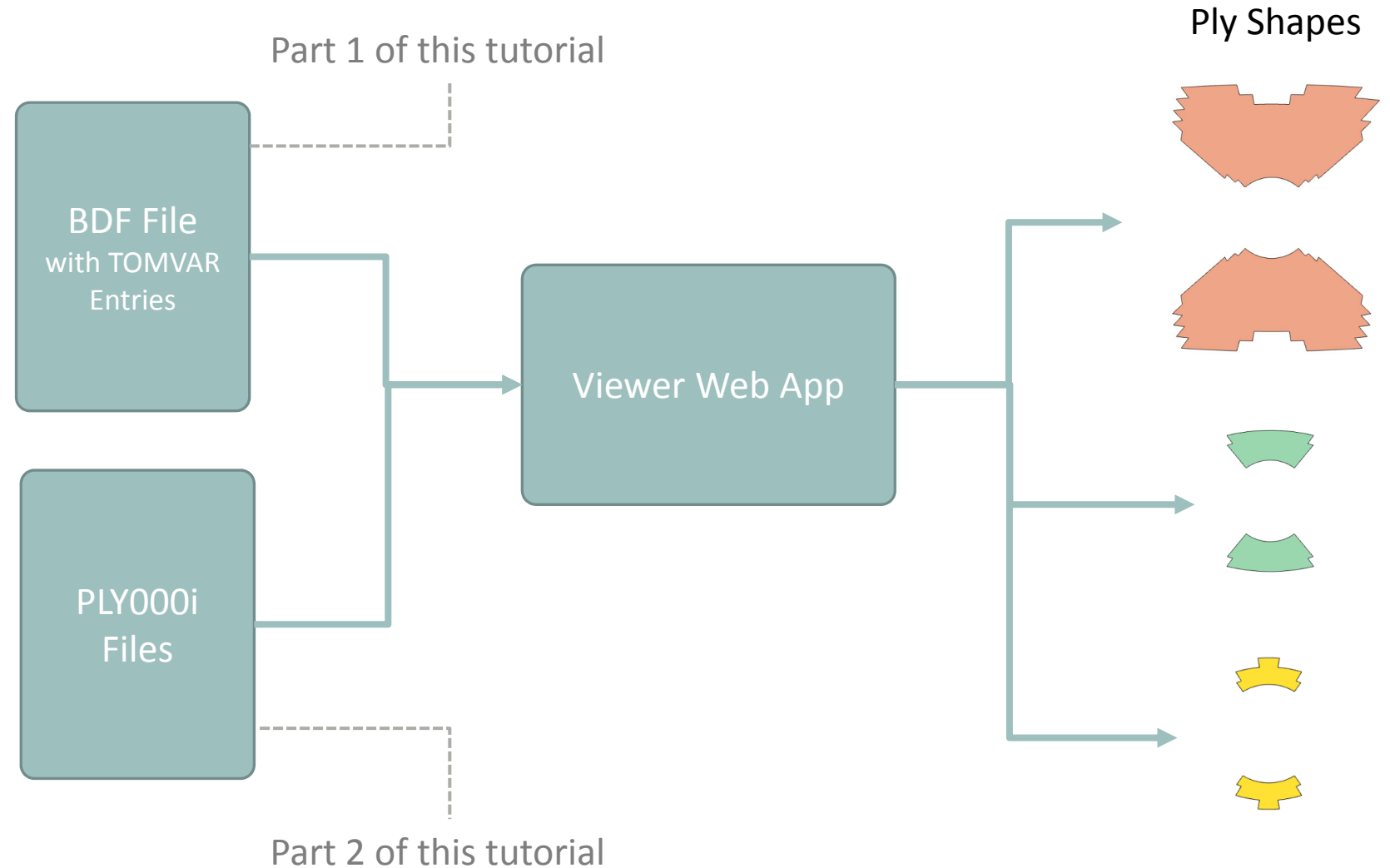
Ply Shape Optimization

Ply Number Optimization

Stacking Sequence
Optimization

Goal: Prepare Data for Ply Shape Creation

- The goal is to construct ply shapes that produce a lightweight composite but satisfy failure index constraints.
- The Viewer web app will be used to construct new ply shapes, but first, BDF and PLY000i files must be prepared.
- This tutorial discusses how to prepare the BDF and PLY000i files. A separate tutorial discusses how to upload these files to the Viewer web app and how to construct new ply shapes.



Summary of Optimized Designs

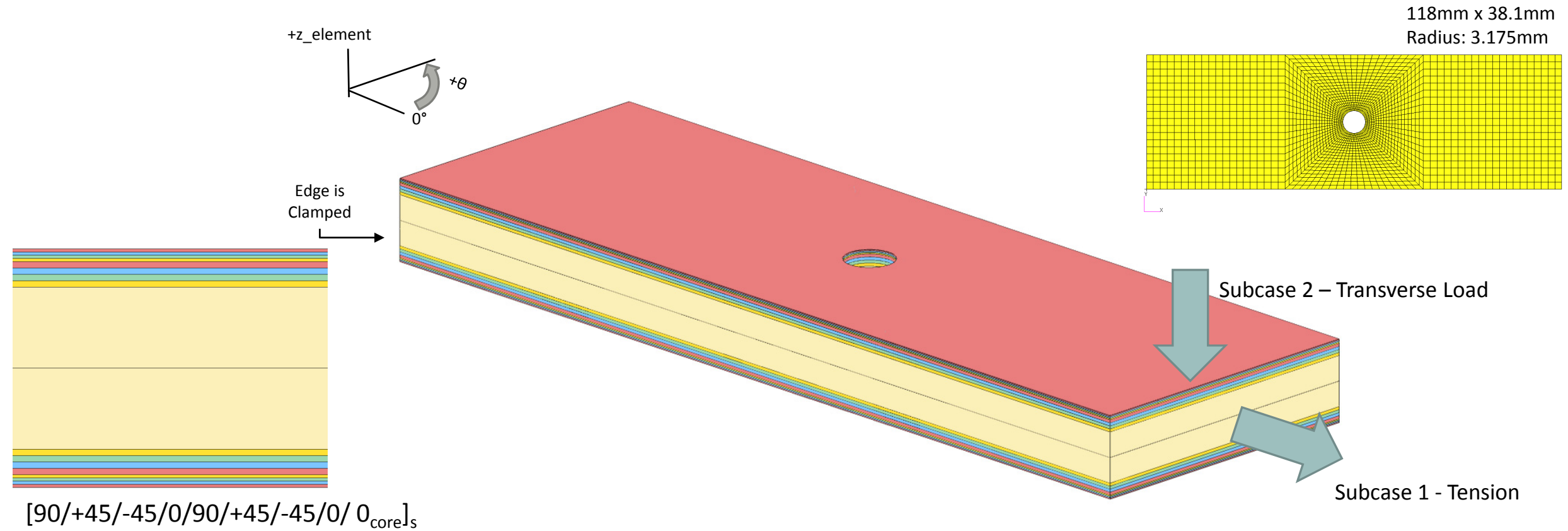
This tutorial is part of a 5-phase tutorial. Phase D and E yield optimized composites.

A comparison is made between the starting and final composite designs from phase D and E. Observe the following:

1. ~21% mass savings. The mass of the plies was reduced from 2.229851E-05 to 1.76E-05.
2. For the final composite, after stacking sequence optimization, the maximum failure index is .838 and is well under the upper allowed limit of .95.

	Starting Design	Design After Ply Shape and Ply Number Optimization	Design After Stacking Sequence Optimization
	Tutorial Phase B	Tutorial Phase D	Tutorial Phase E
Total Mass	2.825148E-05	2.356787E-05	2.356787E-05
Mass of Non-design Region (Core)	5.952966E-06	5.952966E-06	5.952966E-06
Mass of Design Region (Plies)	2.229851E-05	1.76E-05	1.76E-05
Max Failure Index , Subcase 1	.905 (OK)	.838 (OK)	.838 (OK)
Max Failure Index, Subcase 2	.934 (OK)	.856 (OK)	.654 (OK)

Details of the structural model

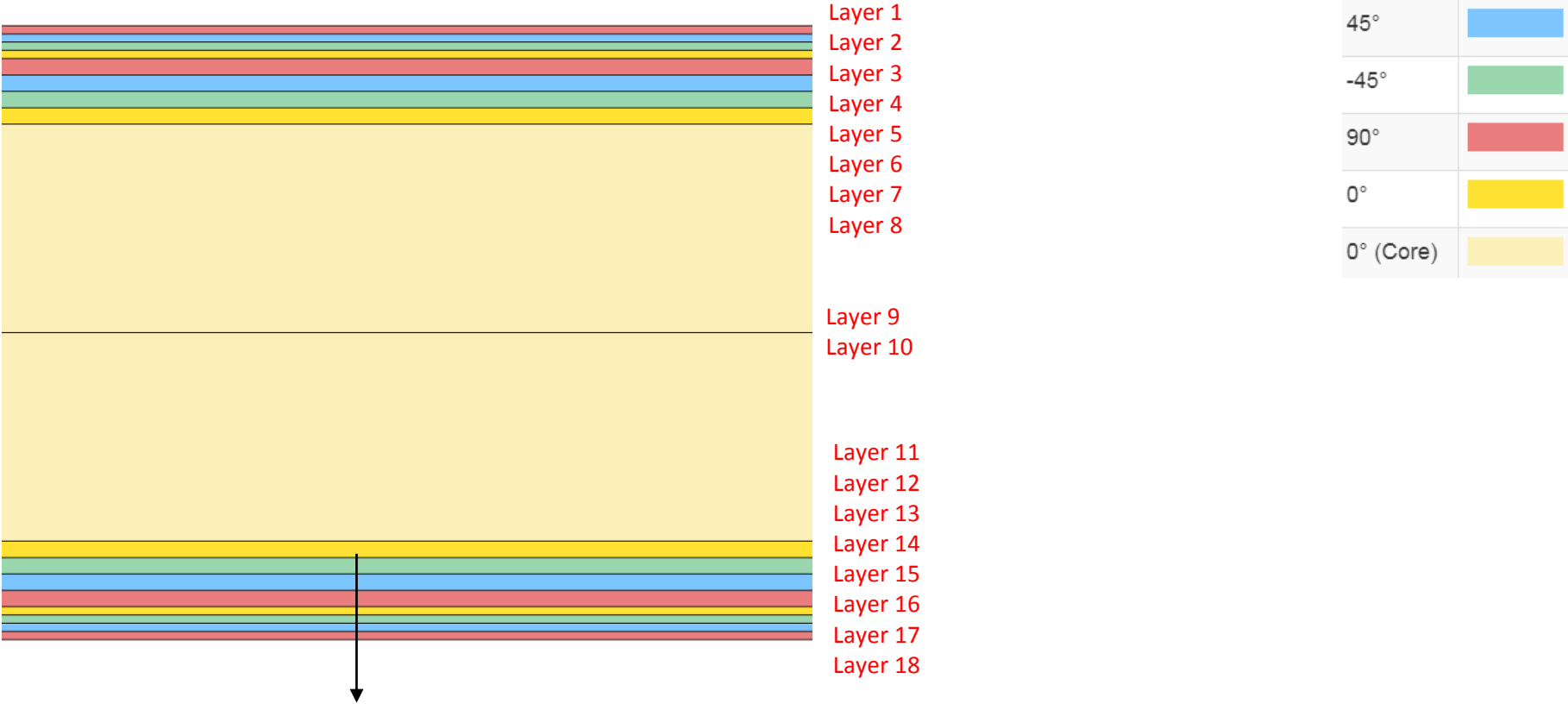


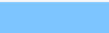



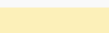
Details of the Composite Layers

This composite consists of 18 layers.

The PCOMP entry defines only 9 layers, but the LAM=SYM option indicates that the composite is symmetric. Internally, layers 10, 11, ..., 18 are generated and stored.

- Layers 9 and 10 correspond to the core.
- These layers are NOT optimized.
 - Layers 1 and 18 correspond to 90° layers.
 - Layers 2 and 17 correspond to 45° layers.
 - Layers 3 and 16 correspond to -45° layers.
 - Layers 4 and 15 correspond 0° layers.
- These layers are optimized.
 - Layers 5 and 14 correspond to 90° layers.
 - Layers 6 and 13 correspond to 45° layers.
 - Layers 7 and 12 correspond to -45° layers.
 - Layers 8 and 11 correspond 0° layers.



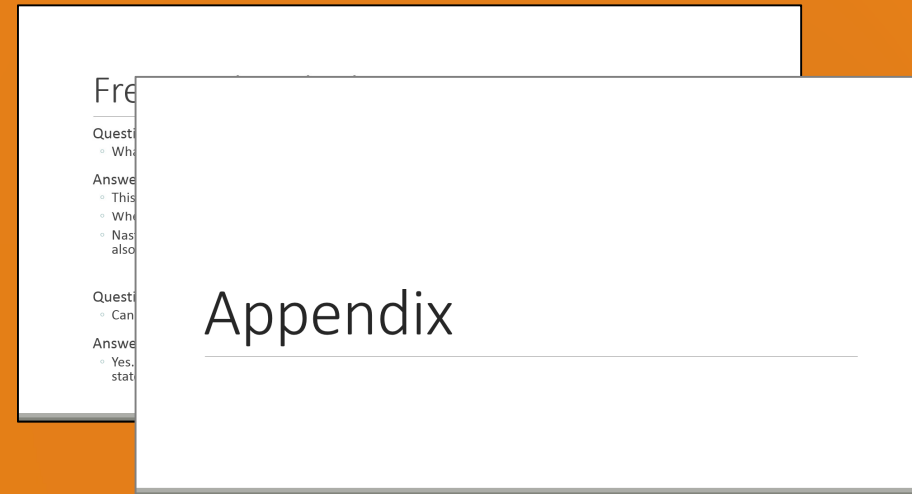
45°	
-45°	
90°	
0°	
0° (Core)	

		+z_element				
PCOMP	1			90.	HILL	SYM
	101	.125	90.	YES	Layer 1	
	101	.125	45.	YES	Layer 2	
	101	.125	-45.	YES	Layer 3	
	101	.125	0.	YES	Layer 4	
	101	.25	90.	YES	Layer 5	
	101	.25	45.	YES	Layer 6	
	101	.25	-45.	YES	Layer 7	
	101	.25	0.	YES	Layer 8	
	501	3.175	0.	YES	Layer 9	

More Information Available in the Appendix

The Appendix includes information regarding the following:

- Comments on bulk data entries compatible with ply shape optimization
- Why is a topometry optimization skipped?
- Methods to Create PLY000i Files



Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

Tutorial

Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
 - Convert the .bdf file to SOL 200
 - Design Variables
 - Design Objective
3. Manually create PLY000i files

Special Topics Covered

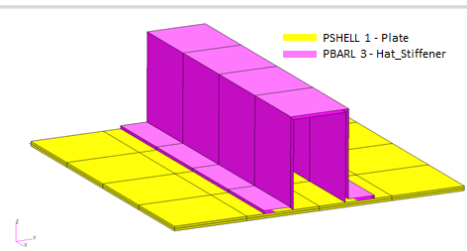
PLY000i Files - The PLY000i files contain information that is used to construct ply shapes. This tutorial discusses how to manually create PLY000i files.

SOL 200 Web App Capabilities

Benefits

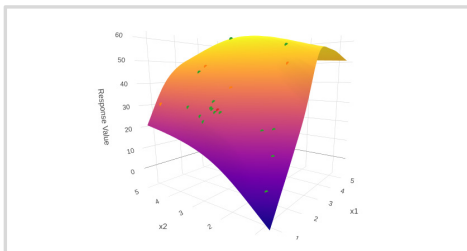
- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 76 tutorials

Capabilities



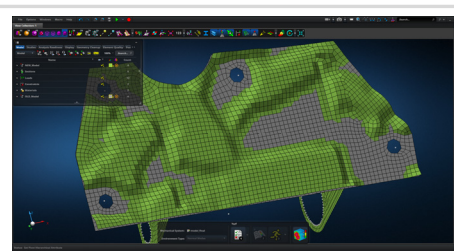
Web Apps for SOL 200

Pre/post for MSC Nastran SOL 200.
Support for size, topology, topometry, topography and multi-model.



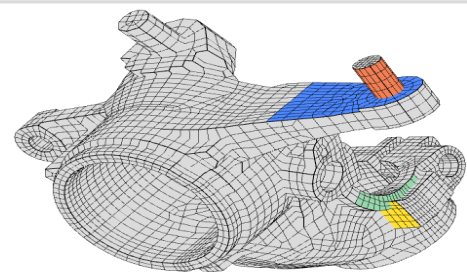
Machine Learning Web App

Bayesian Optimization for nonlinear response optimization (SOL 400)



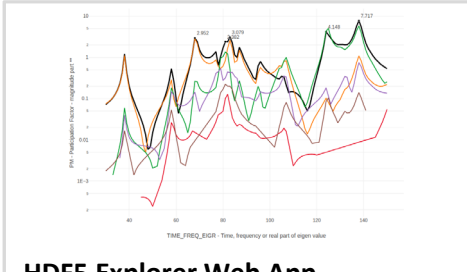
MSC Apex Post Processing Support

View the newly optimized model after an optimization



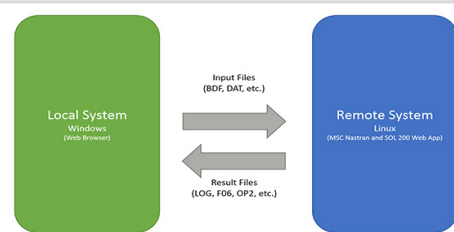
Shape Optimization Web App

Use a web application to configure and perform shape optimization.



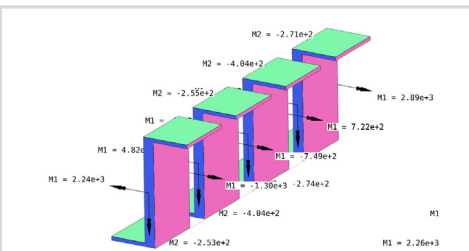
HDF5 Explorer Web App

Create XY plots using data from the H5 file



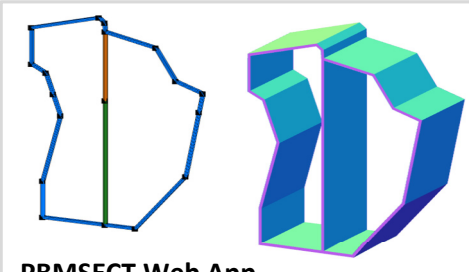
Remote Execution Web App

Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



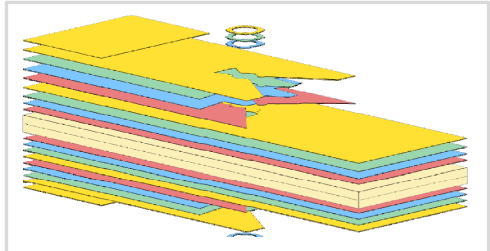
Beams Viewer Web App

Post process 1D element forces, including shear forces, moments, torque and axial forces



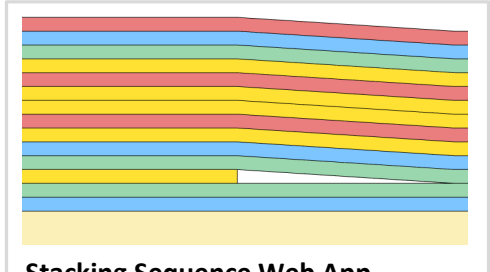
PBMSECT Web App

Generate PBMSECT and PBRSECT entries graphically



Ply Shape Optimization Web App

Spread plies optimally and generate new PCOMPG entries



Stacking Sequence Web App

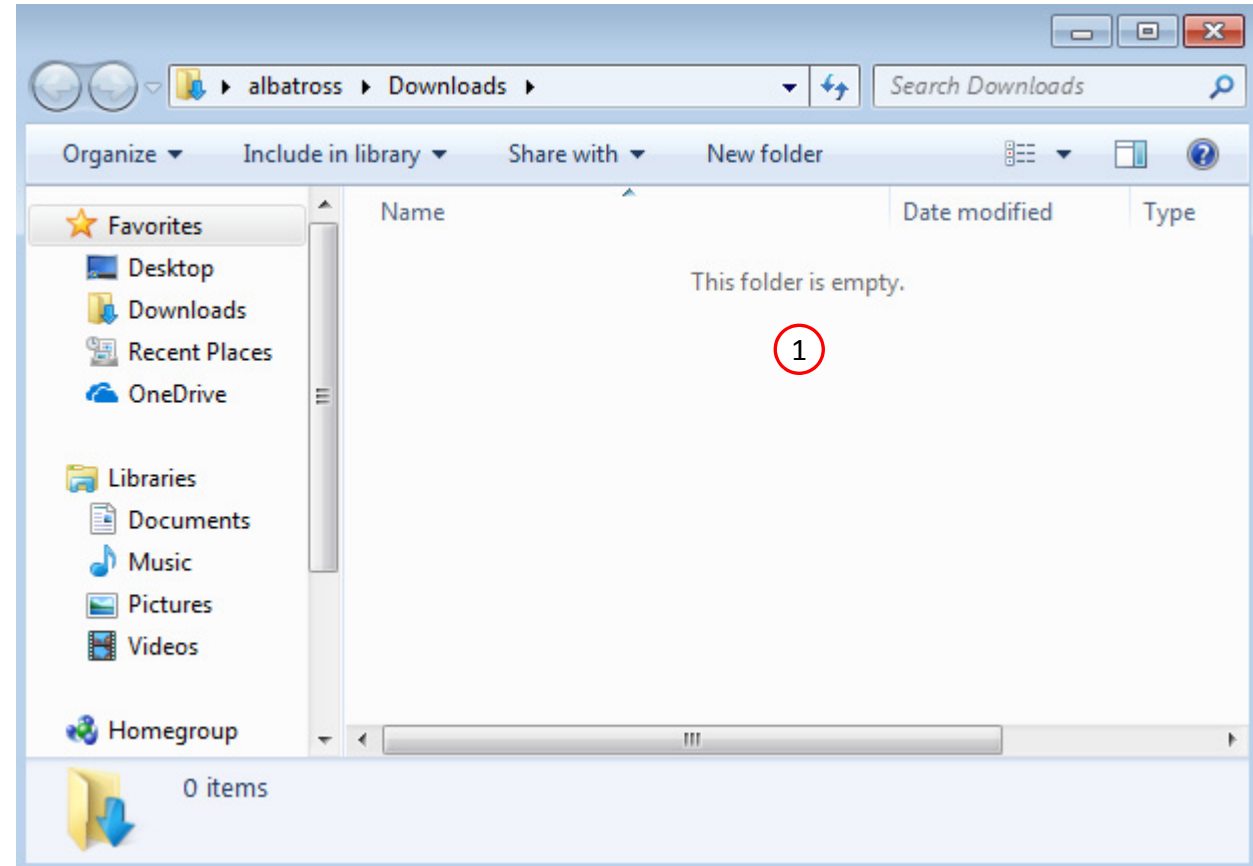
Optimize the stacking sequence of composite laminate plies

Part 1 - BDF File with TOMVAR Entries

Before Starting

1. Ensure the Downloads directory is empty in order to prevent confusion with other files

- Throughout this workshop, you will be working with multiple file types and directories such as:
 - .bdf/.dat
 - nastran_working_directory
 - .f06, .log, .pch, .h5, etc.
- To minimize confusion with files and folders, it is encouraged to start with a clean directory.



Go to the User's Guide

1. Click on the indicated link

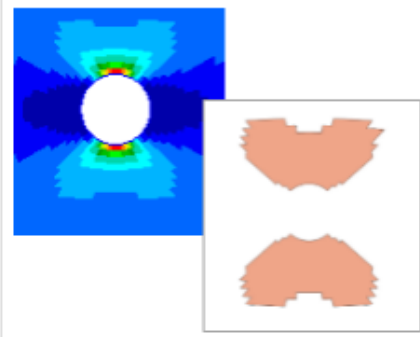
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



Obtain Starting Files

1. Find the indicated example
2. Click Link
3. The starting file has been downloaded

- When starting the procedure, all the necessary BDF files must be collected together.



1

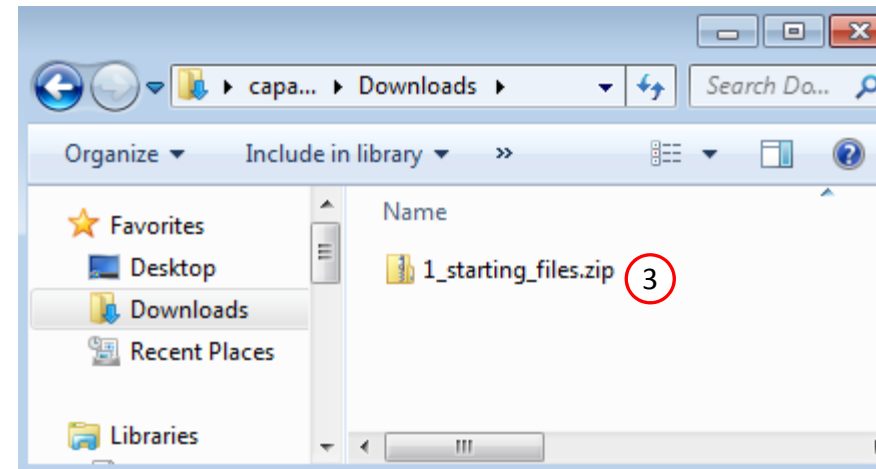
Composite Coupon – Phase C – Data Preparation for Ply Shape Optimization

This tutorial is a guide to preparing data for ply shape optimization in a subsequent tutorial. The maximum failure index values of the outer plies of the composite are determined and saved to specially formatted PLY000i files. The PLY000i files will be used to construct optimal ply shapes in a subsequent tutorial.

This is the third phase in a 5-phase tutorial series.

Starting BDF Files: [Link](#) 2

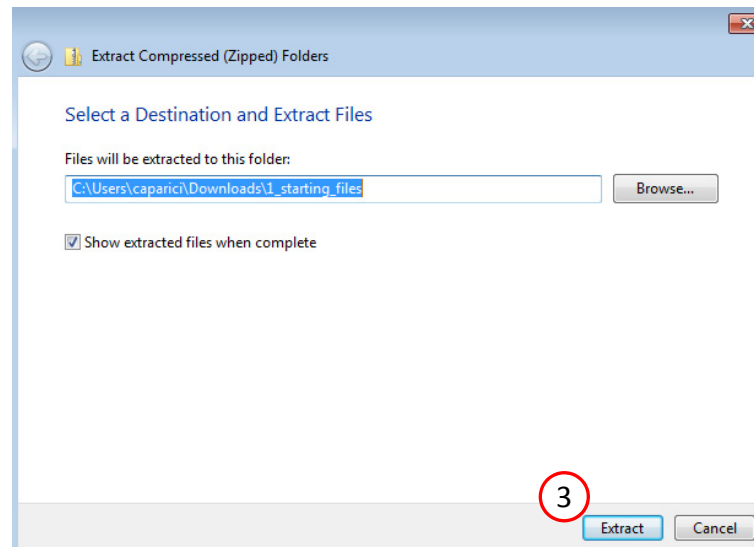
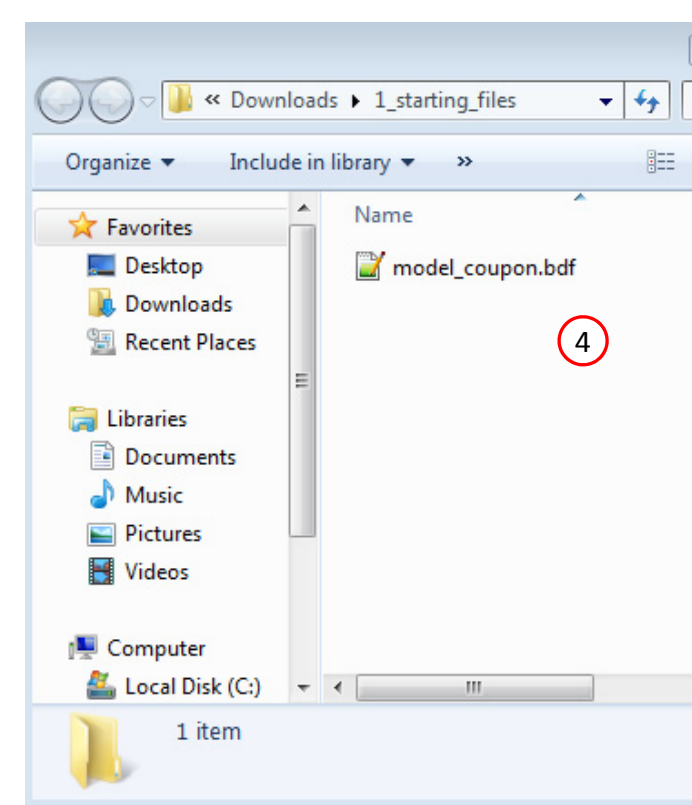
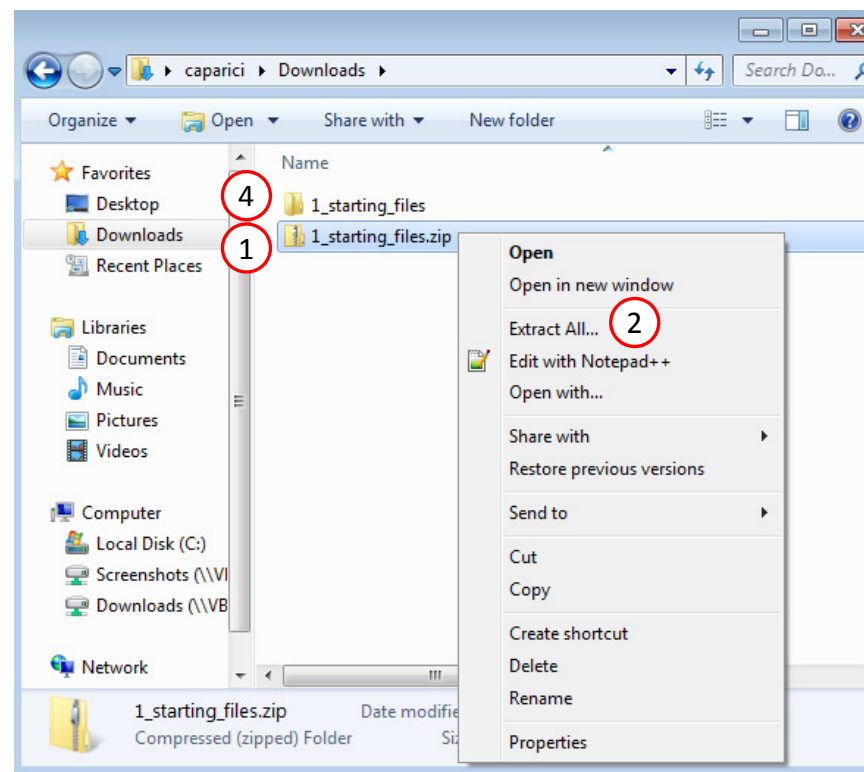
Solution BDF Files: [Link](#)



Obtain Starting Files

1. Right click on the zip file
2. Select Extract All...
3. Click Extract
4. The starting files are now available in a folder

- This workflow works best when the BDF has the following configuration:
 - PCOMP entries are used
 - The Ti fields on the 2D element entries, e.g. CQUAD4 and CTRIA3, are NOT used
- See the appendix for more information



Open the Correct Page

1. Click on the indicated link

- MSC Nastran can perform many optimization types. The SOL 200 Web App includes dedicated web apps for the following:
 - Optimization for SOL 200 (Size, Topology, Topometry, Topography, Local Optimization, Sensitivity Analysis and Global Optimization)
 - Multi Model Optimization
 - Machine Learning
- The web app also features the HDF5 Explorer, a web application to extract results from the H5 file type.

The screenshot displays the SOL 200 Web App interface. At the top, it says "SOL 200 Web App" and "Select a web app to begin". Below this, there are five main categories of web apps, each with a representative image:

- Optimization for SOL 200**: Shows a 3D model of a mechanical part with "Before" and "After" states. A red circle with the number "1" is placed over this icon.
- Multi Model Optimization**: Shows a 3D model and a line graph.
- Machine Learning | Parameter Study**: Shows four small plots representing different data sets or models.
- HDF5 Explorer**: Shows a line graph with multiple colored curves.
- Remote Execution**: Shows a diagram of data flow between a "Remote System" and a "Local System", with "Input Files" going up and "Results Files" coming down.

At the bottom of the interface, there are two links: "Tutorials and User's Guide" and "Full list of web apps".

Upload BDF Files

1. Click 1. Select Files and select model_coupon.bdf
2. Click Upload Files

- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.

Step 1 - Upload .BDF Files

The screenshot shows a web interface for uploading BDF files. It consists of two main steps, each with a progress bar.

Step 1: Select files

- A button labeled "1. Select files" is highlighted in blue.
- Next to it, the file "model_coupon.bdf" is listed.
- Below this, a green progress bar is shown with the text "Inspecting: 100%".

Step 2: Upload files

- A button labeled "2. Upload files" is highlighted in green.
- Below this, a green progress bar is shown with the text "Uploading: 100 %".

At the bottom, there is a checkbox labeled "List of Selected Files" which is currently unchecked.

Variables

1. Click Topometry
2. In the search box, search for: thickness
3. Click 10 on the pagination bar
4. Click the indicated plus (+) icons to create a TOMVAR entry for layers 5, 6, 7 and 8
5. Four new TOMVAR entries have been created

- Each ply shape that will be optimized requires a TOMVAR entry. In this example, optimal ply shapes will be created for the 90°, ±45° and 0° layers, i.e. T5, T6, T7 and T8, so a total of 4 TOMVAR entries are created.
- Additional TOMVAR entries may be defined for other layers in different PCOMP entries.

Step 1 - Select design properties

+ Options

Create TOMVAR	Property	Property Description	Entry	Entry ID	Current Value
	<input type="text" value="Search"/>	<input type="text" value="thickness"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	T1	Thickness of layer 1 (90°)	PCOMP	1	.125
	T2	Thickness of layer 2 (45°)	PCOMP	1	.125
	T3	Thickness of layer 3 (-45°)	PCOMP	1	.125
	T4	Thickness of layer 4 (0°)	PCOMP	1	.125
	T5	Thickness of layer 5 (90°)	PCOMP	1	.25
	T6	Thickness of layer 6 (45°)	PCOMP	1	.25
	T7	Thickness of layer 7 (-45°)	PCOMP	1	.25
	T8	Thickness of layer 8 (0°)	PCOMP	1	.25
	T9	Thickness of layer 9 (0°)	PCOMP	1	3.175

5 10 20 30 40 50

Step 2 - Adjust TOMVAR Entries

+ Options

✕ Delete Visible Rows

	Label	Status	Property	Property Description	Entry	Entry ID	Initial Value	Lower Bound	Upper Bound	Allowed Discrete Values
	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	z1		T5	Thickness of layer 5 (90°)	PCOMP	1	.25	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
	z2		T6	Thickness of layer 6 (45°)	PCOMP	1	.25	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
	z3		T7	Thickness of layer 7 (-45°)	PCOMP	1	.25	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
	z4		T8	Thickness of layer 8 (0°)	PCOMP	1	.25	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'

TOMVAR Entries

1. The indicated TOMVAR entries have been created for the thicknesses of layers 5, 6, 7 and 8

It is expected that files model.ply0005, model.ply0006, model.ply0007 and model.ply0008 are available to construct optimal ply shapes. The creation of the PLY000i files is covered in part 2 of this tutorial.

1	\$TOMVAR	ID	TYPE	PID	PNAME	XINIT	XLB	XUB	DELXV
	TOMVAR	3000001	PCOMP	1	T5	.25	.001		
	TOMVAR	3000002	PCOMP	1	T6	.25	.001		
	TOMVAR	3000003	PCOMP	1	T7	.25	.001		
	TOMVAR	3000004	PCOMP	1	T8	.25	.001		

Objective

1. Click Objective
2. Click the plus (+) icon for Weight
3. An objective to minimize weight has been created

SOL 200 Web App - Optimization Upload Variables **Objective** Constraints Subcases Exporter Results Settings Match Other User's Guide Home

Objective Equation Objective **1**

Step 1 - Select an objective

Select an analysis type

SOL 101 - Statics

Select a response

	Response Description	Response Type
	<input type="text" value="Search"/>	<input type="text" value="Search"/>
2	Weight	WEIGHT
	Volume	VOLUME
	Displacement	DISP
	Strain	STRAIN
	Element Strain Energy	ESE

« 1 2 3 4 5 » 5 10 20 30 40 50

Step 2 - Adjust objective

+ Options

	Label	Status	Response Type	Maximize or Minimize	Property Type	ATTA	ATTB	ATTI
	r0		WEIGHT	MIN		3	3	

3 5 10 20 30 40 50

BDF Output - Design Model

```
$
$
$----- Design Objective -----
$
$
$ DRESP1 8000000 r0 WEIGHT 3 3
$
```

Developed by The Engineering Lab

Export New BDF Files

1. Click on Exporter
2. Click on Download BDF Files

- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”

1

BDF Output - Model

```
assign userfile = 'optimization_results.csv', status = unknown,
form = formatted, unit = 52
$ MSC.Nastran input file created on March    08, 2023 at 12:46:53 by
$ Patran 2022.2
$ Direct Text Input for Nastran System Cell Section
$ Direct Text Input for File Management Section
$ Direct Text Input for Executive Control
$ Linear Static Analysis, Database
SOL 200
CEND

$ Direct Text Input for Global Case Control Data
ECHO = NONE
  DESOBJ(MIN) = 8000000
  $ DESGLB Slot
  $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1
  ANALYSIS = STATICS
  $ DESSUB Slot
  $ DRSPAN Slot
  SUBTITLE=Load Case 1
  SPC = 2
  LOAD = 2
  DISPLACEMENT(PLOT,SORT1,REAL)=ALL
  SPCFORCES(PLOT,SORT1,REAL)=ALL
  STRESS(PLOT,SORT1,REAL,VONMISES,BILIN)=ALL
$ Direct Text Input for this Subcase
SUBCASE 2
  ANALYSIS = STATICS
```

Download BDF Files

Download BDF Files

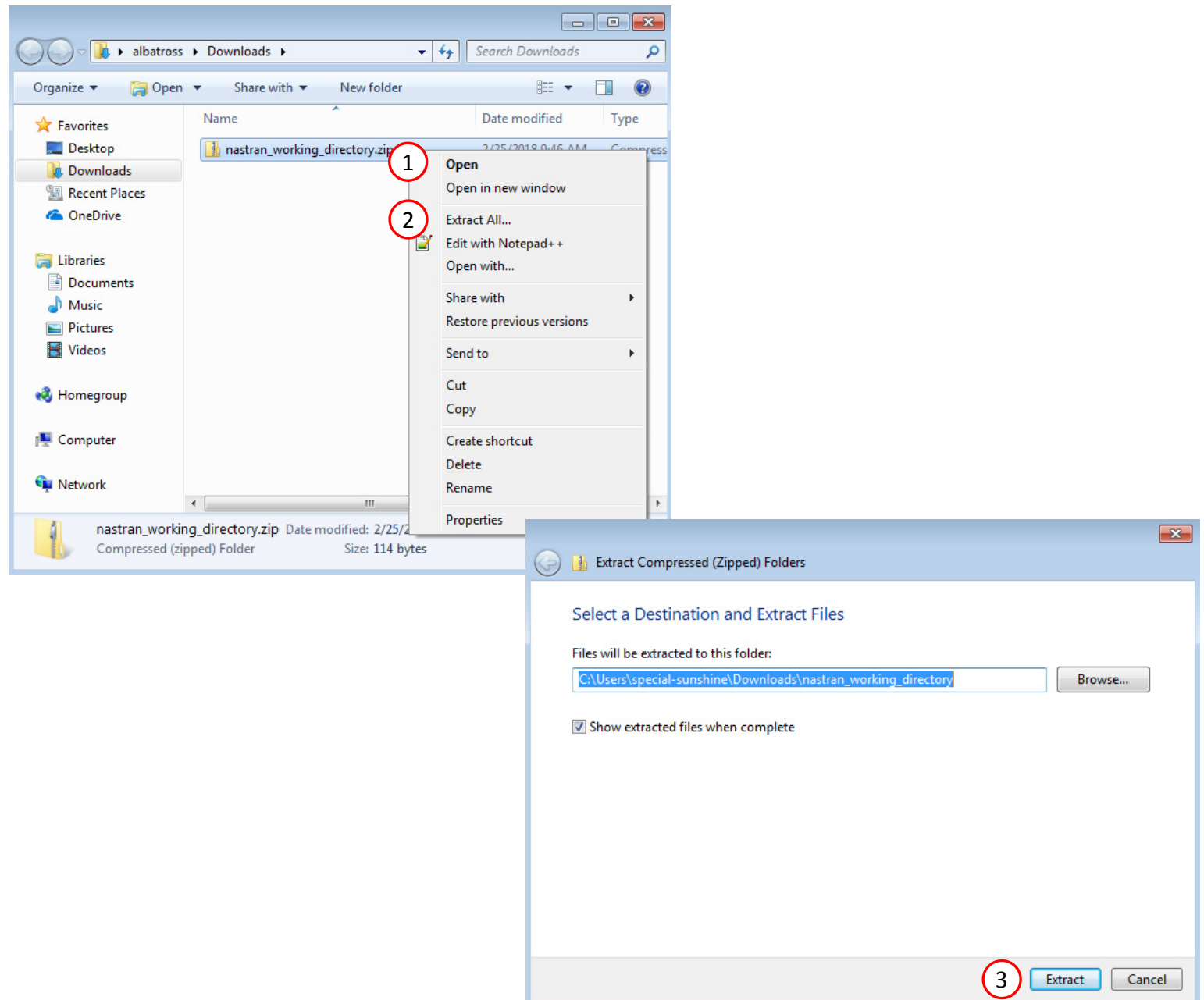
2

Extract the Contents of the ZIP File

A new .zip file has been downloaded

1. Right click on the file
2. Click Extract All
3. Click Extract on the following window

- Always extract the contents of the ZIP file to a new, empty folder.



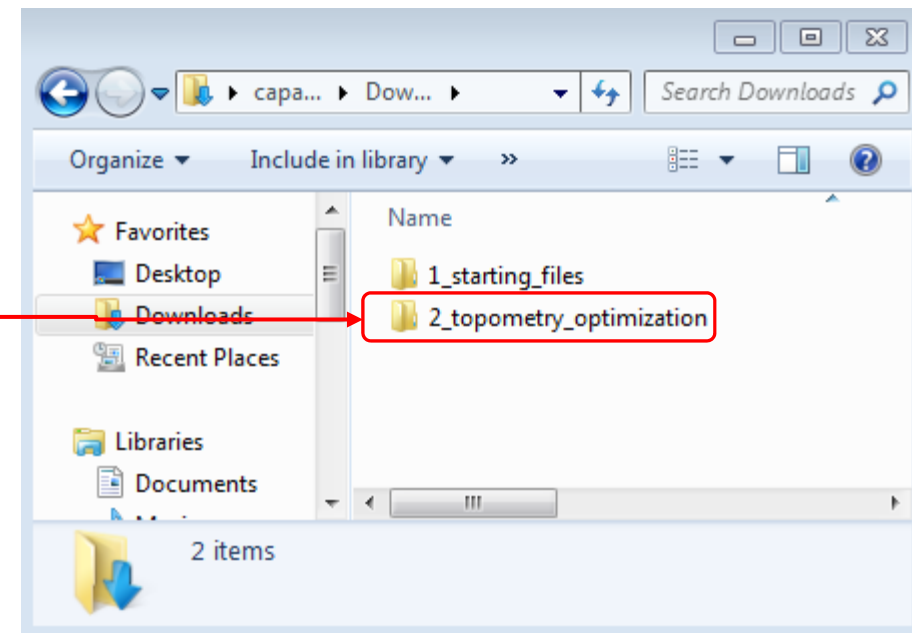
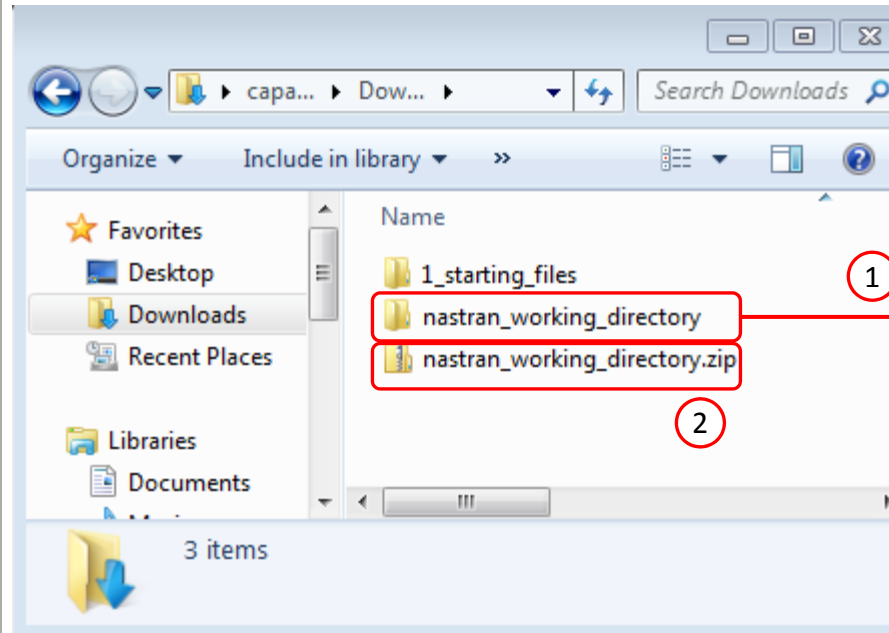
Extract the Contents of the ZIP File

1. Rename directory nastran_working_directory as 2_topometry_optimization
2. Delete the indicated ZIP file

A topometry optimization is NOT performed in this exercise. Do NOT perform a topometry optimization. The BDF files with TOMVAR entries are required by the Viewer web app in order to construct ply shapes.

This tutorial only discusses the creation of the BDF file, with TOMVAR entries, and the PLY000i files.

- Refer to the appendix to answer this question: Why is a topometry optimization skipped?

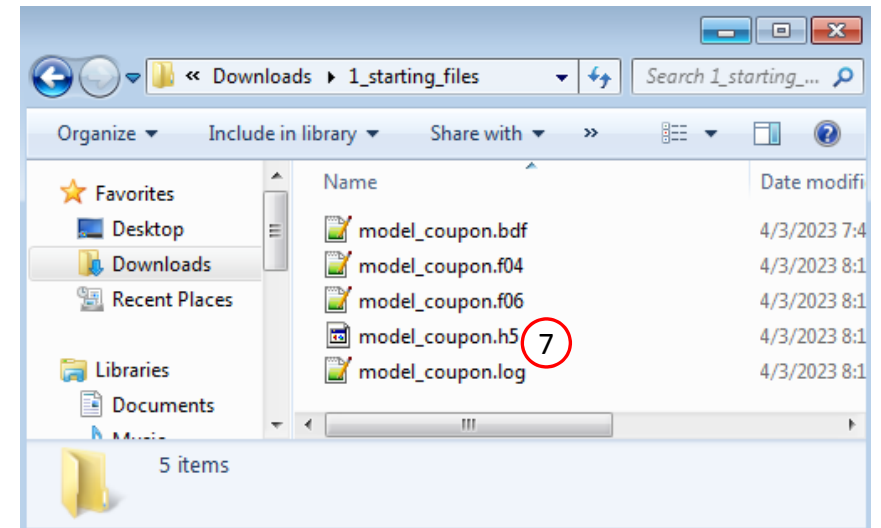
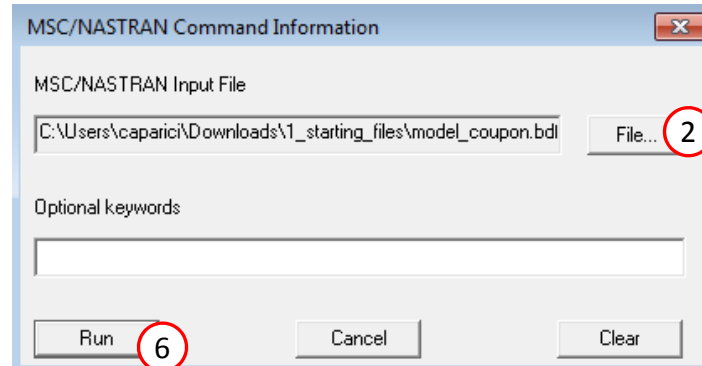
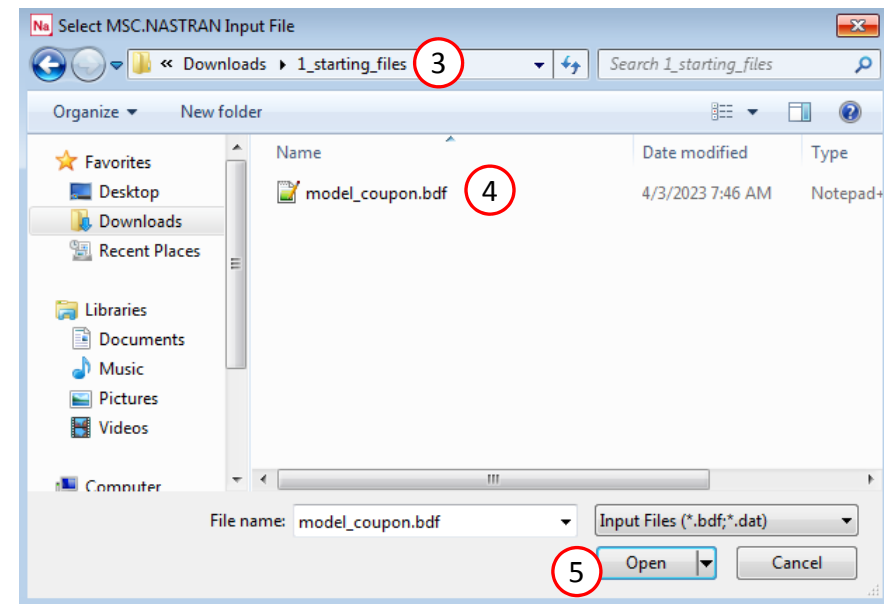


Part 2 - PLY0000i Files

Create the H5 File

1. Double click the MSC Nastran desktop shortcut
2. Click File
3. Navigate to directory 1_starting_files
4. Select file model_coupon.bdf
5. Click Open
6. Click Run
7. The file model_coupon.h5 is now available

- The results of the statics analysis are contained in the H5, including the ply failure indices. The failure indices are required in the following steps, so the H5 file is generated.

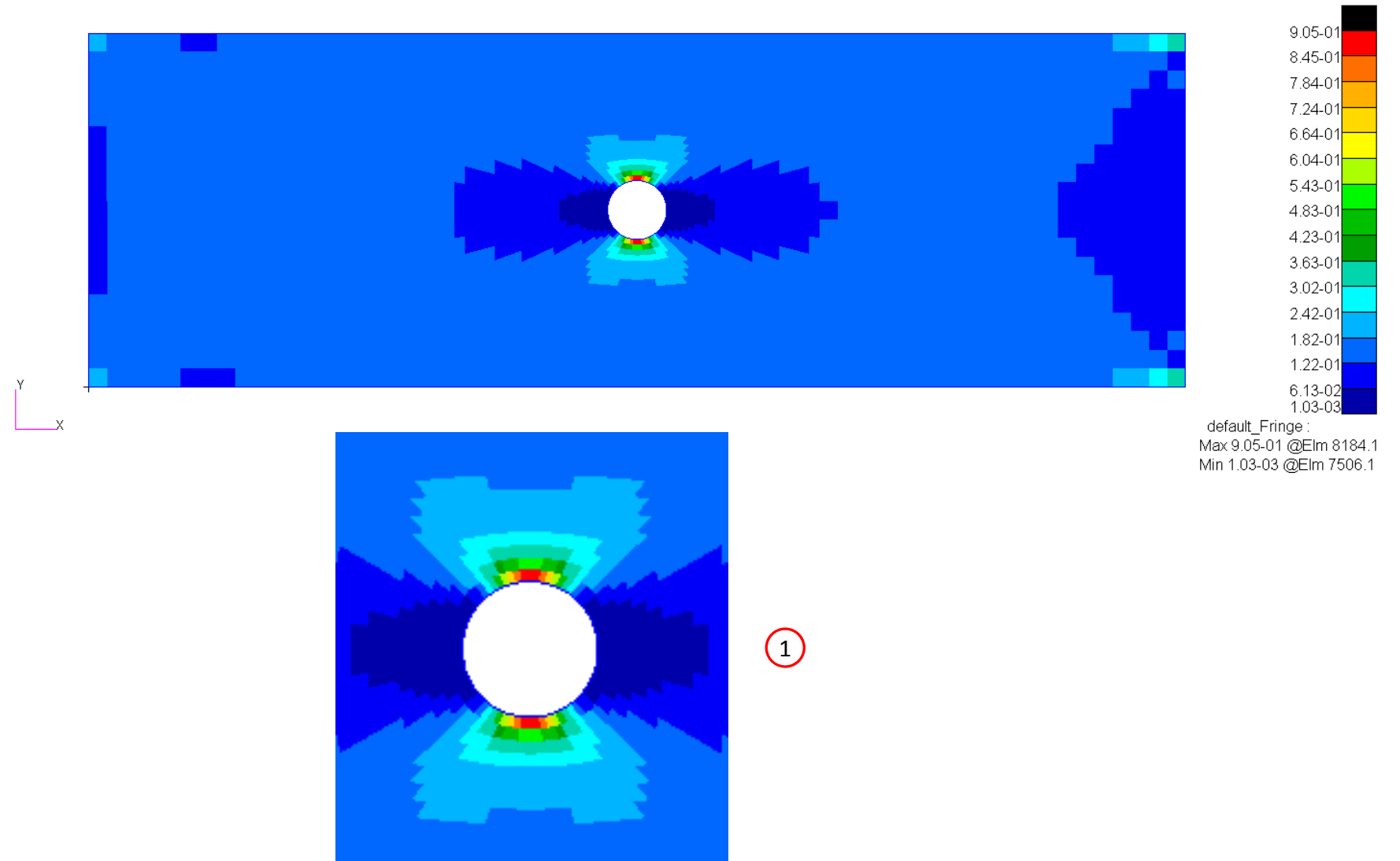


Ply Shape Strategy for Failure Indices

A strategy is necessary to create ply shapes for failure index responses.

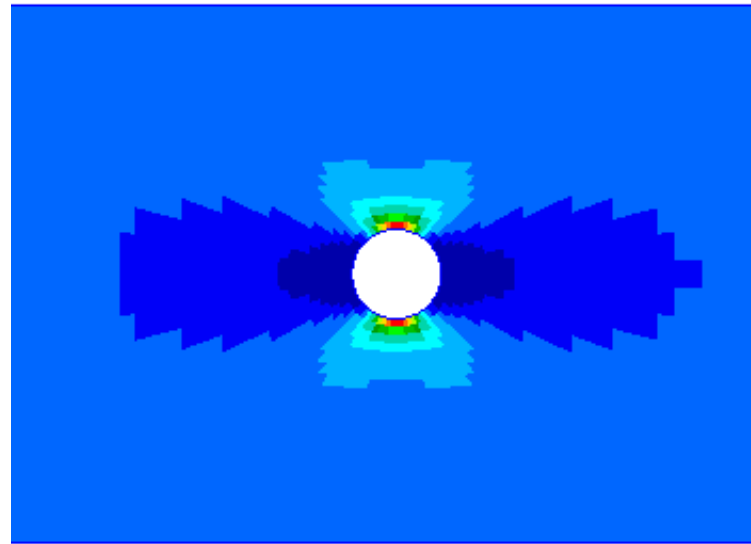
1. To the right, a plot created by Patran is displayed of failure indices for layer 1 of subcase 1. Notice that the highest failure index values are at the hole.

Failure index of layer 1, subcase 1

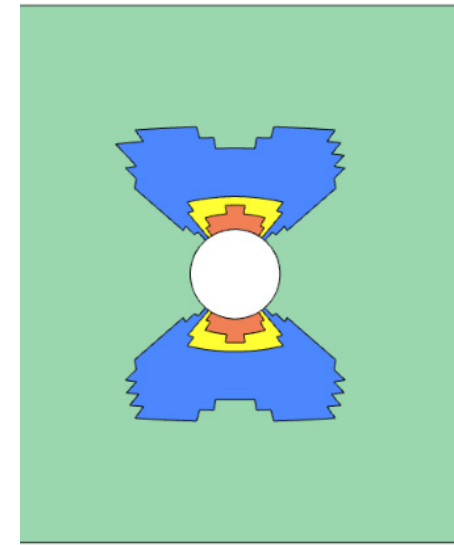


Ply Shape Strategy for Failure Indices

An effective strategy is to build ply shapes that follow the contours of the failure index fringe plot.



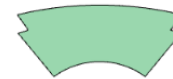
Fringe Plot: Failure indices of layer 1 for subcase 1



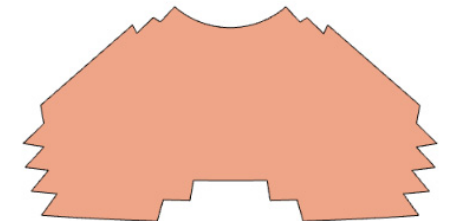
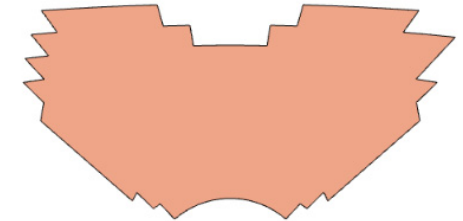
Overlapped ply shape candidates



Ply Shape Candidate 1



Ply Shape Candidate 2

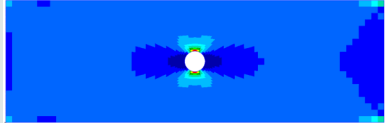
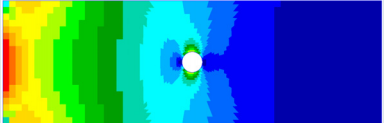
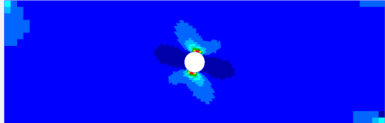
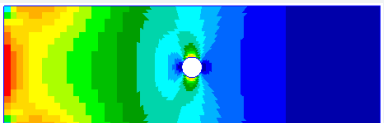
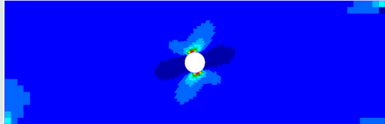
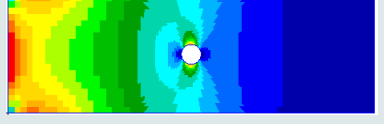
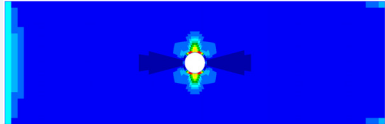
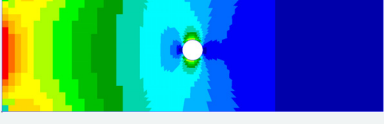
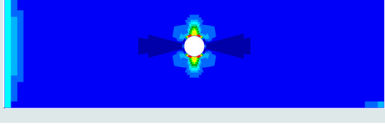

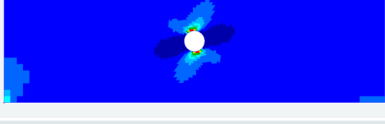
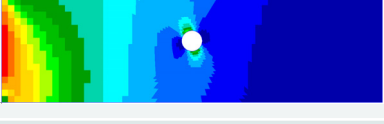
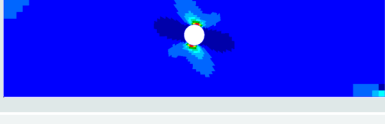
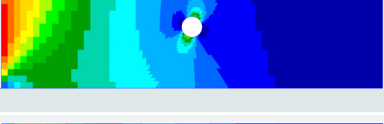
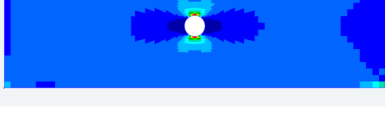
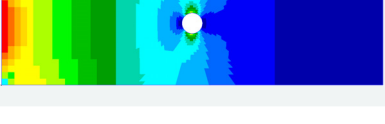


Ply Shape Candidate 3

Ply Shape Strategy for Failure Indices

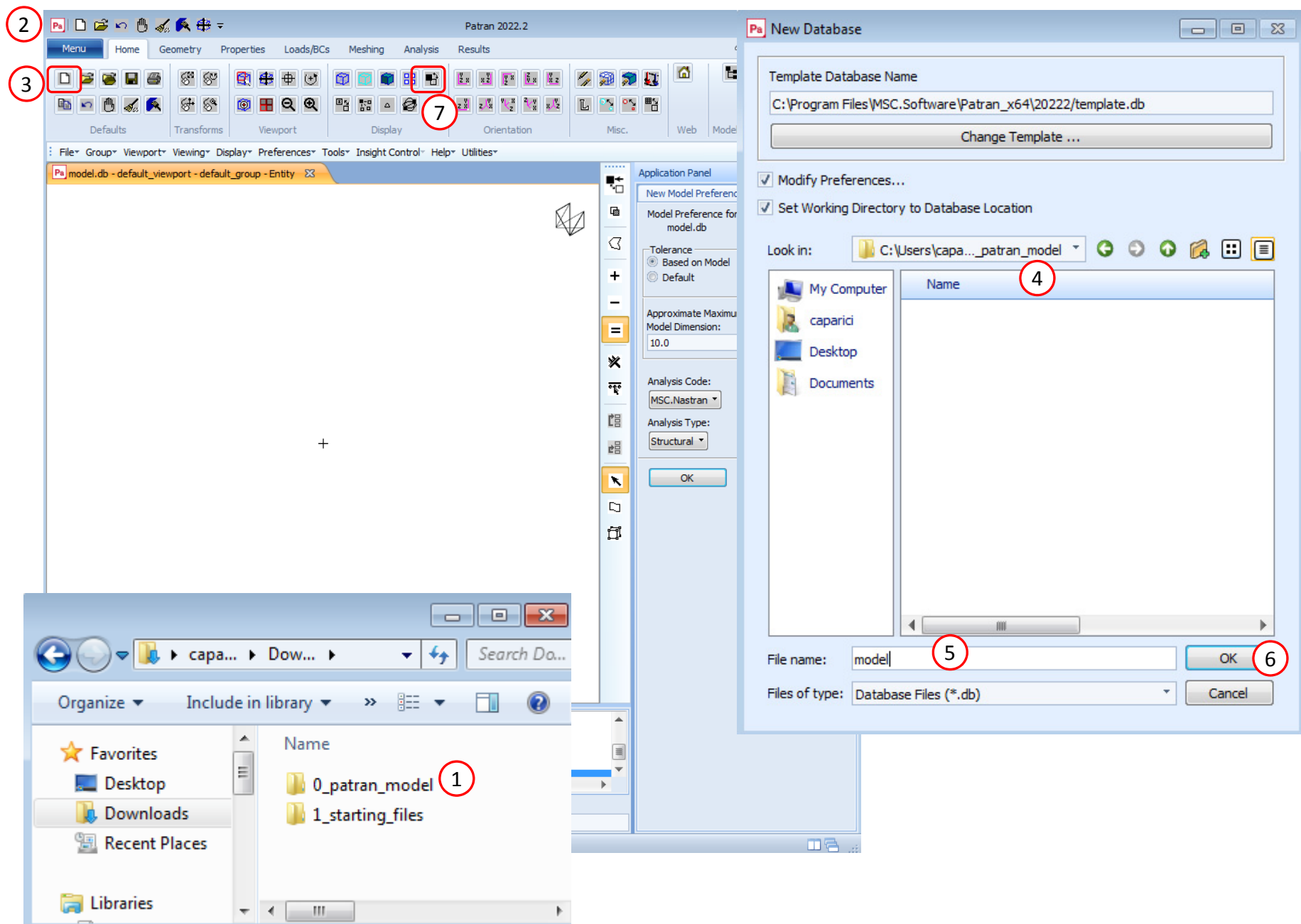
- This analysis model involves two subcases and multiple layers.
- A procedure is necessary to build ply shapes for each layer and for each subcase.

- Layers 5 and 6 are purposely ignored during this optimization exercise and are not listed in this table. Layers 5 and 6 correspond to the core of the composite and the core is not modified during this optimization procedure.

Layer	Theta	Subcase 1	Subcase 2
1	90		
2	45		
3	-45		
4	0		
15	0		
16	-45		
17	45		
18	90		

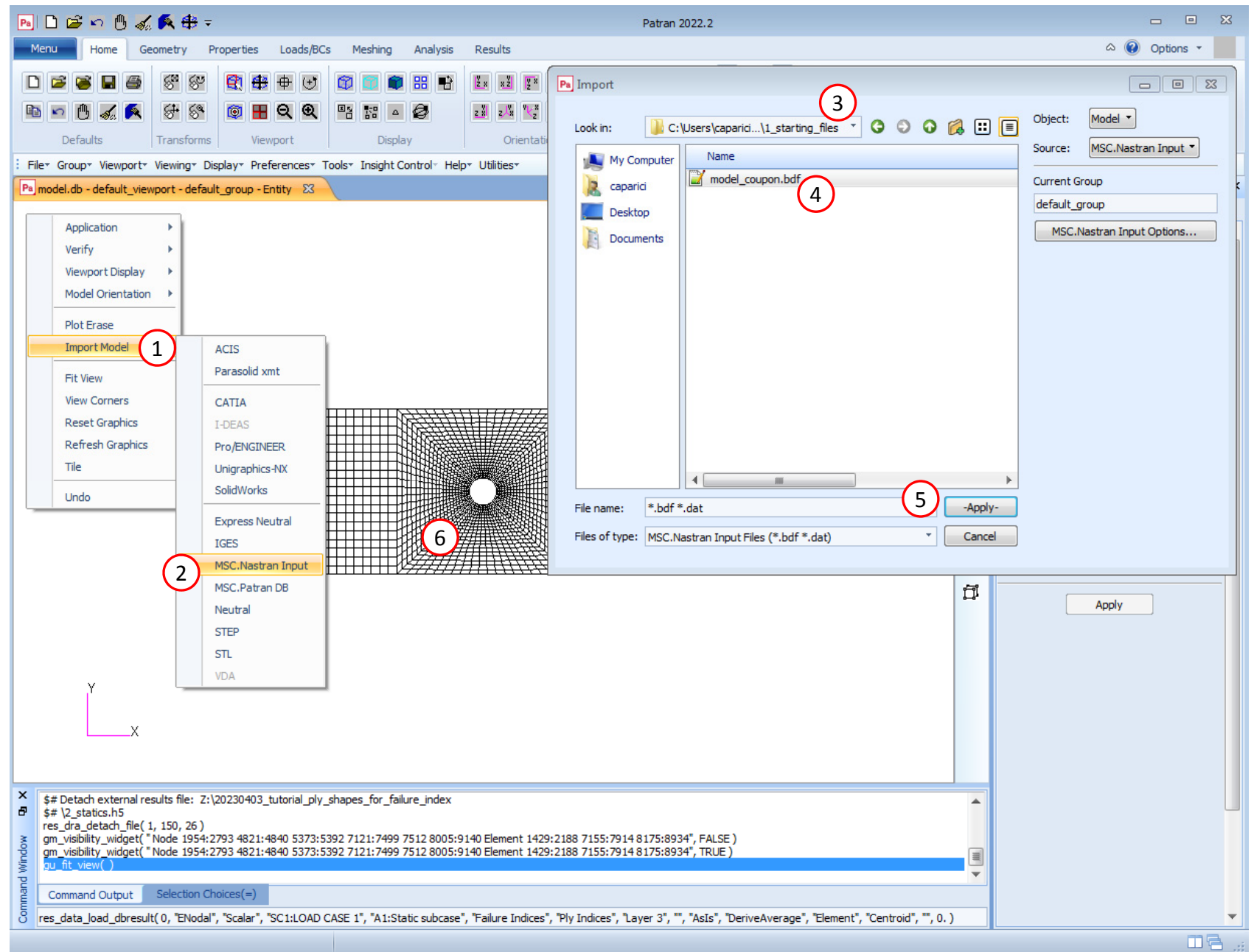
Open Patran

1. Create a new directory named 0_patran_model in your Downloads directory
2. Open Patran
3. Click New
4. Navigate to the directory 0_patran_model
5. Set File name to model
6. Click OK
7. Click the indicated icon 2 times to change the background to white



Import the BDF

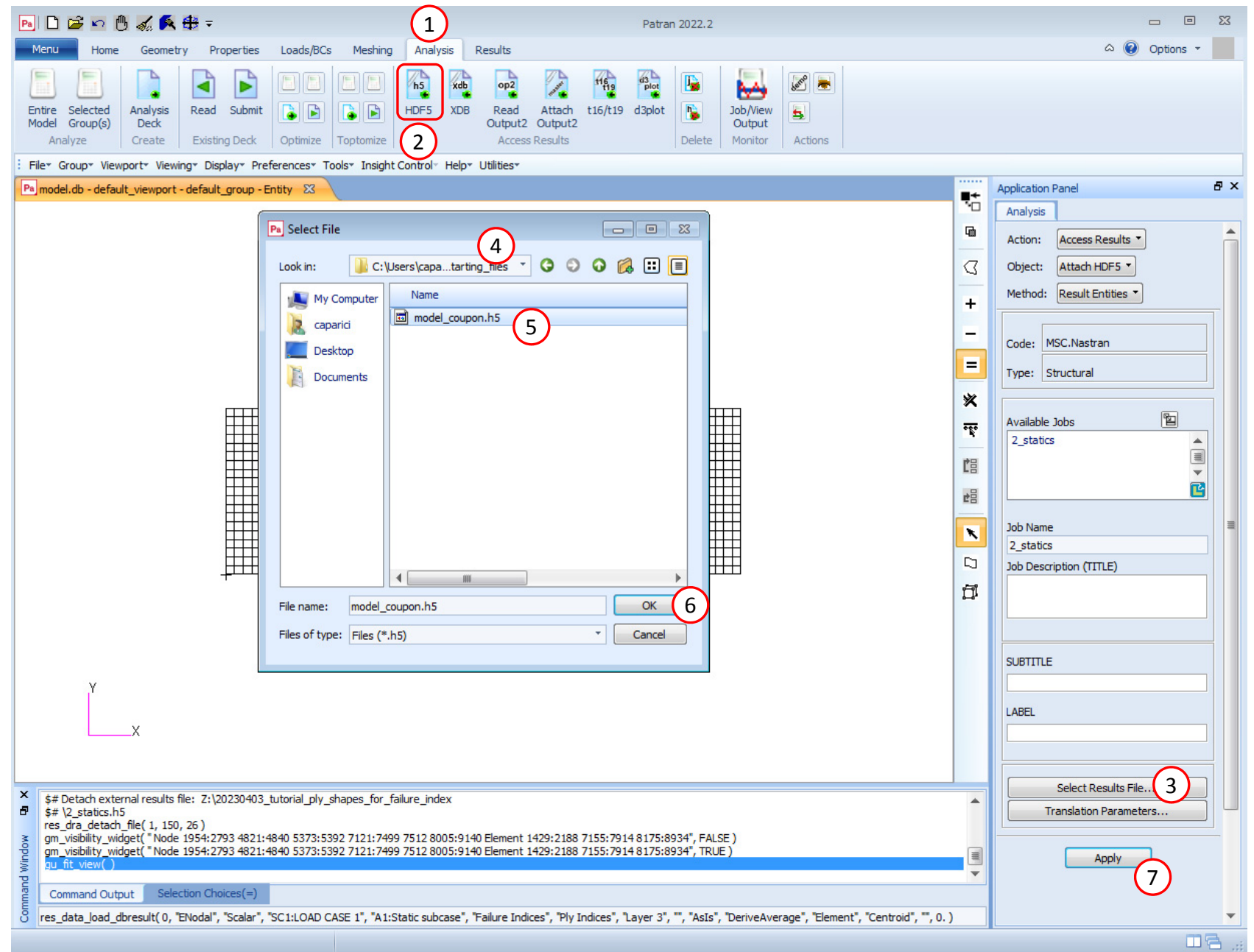
1. Right click in the viewport and click Import Model
2. Click MSC.Nastran Input
3. Navigate to directory 1_starting_files
4. Select the file model_coupon.bdf
5. Click Apply
6. The model has been imported
7. Click OK on the window Nastran Input File Summary if it is visible (not shown)



Import the Results

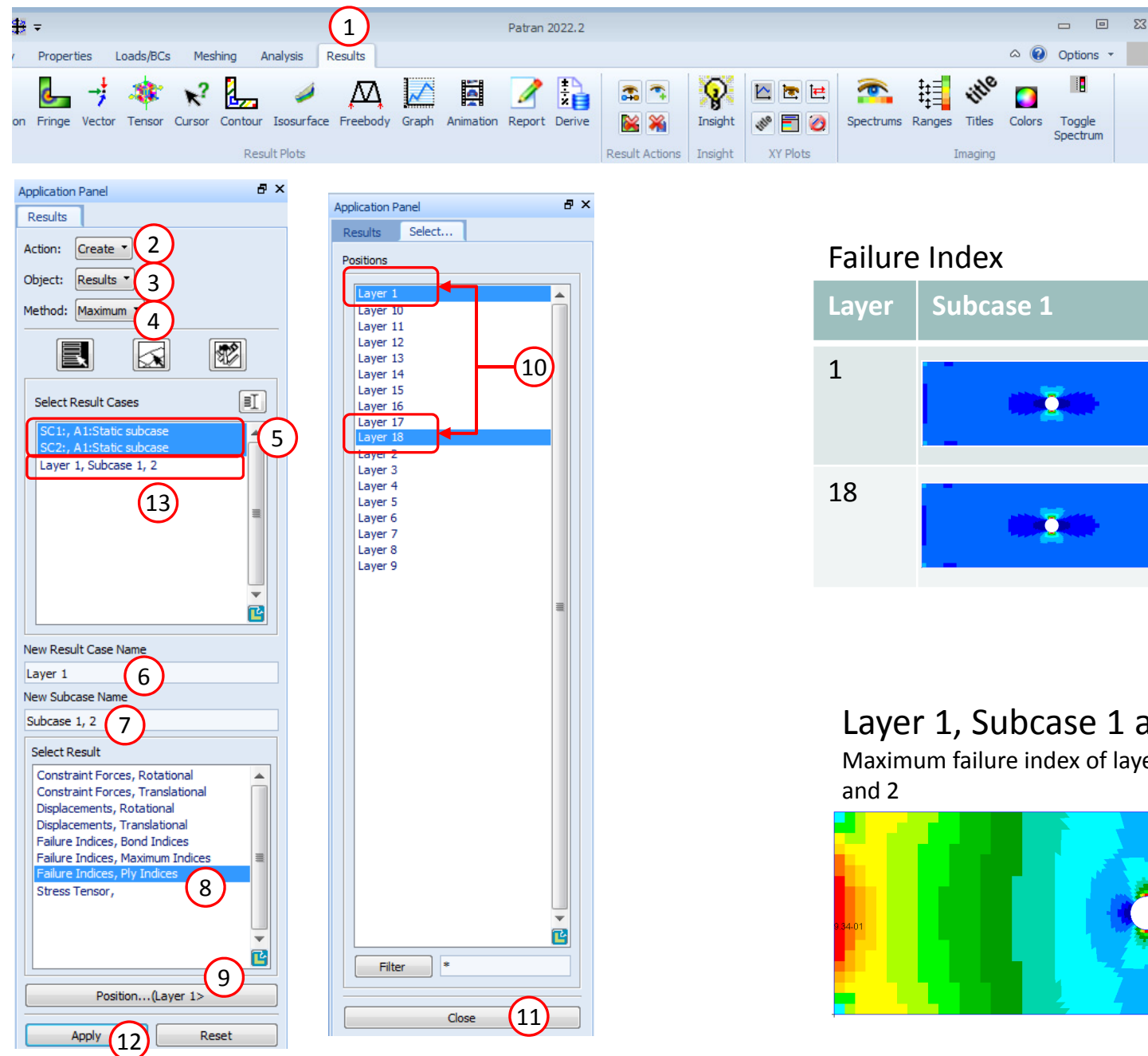
1. Click Analysis
2. Click HDF5
3. Click Select Results File
4. Navigate to 1_starting_files
5. Select model_coupon.h5
6. Click OK
7. Click Apply

The results from the H5 file has been imported to Patran.

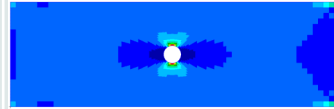
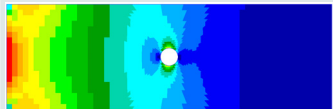
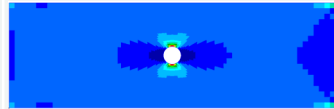
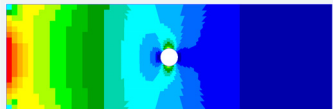


Create a New Subcase: Layer 1, Subcase 1, 2

1. Click Results
2. Set Action: Create
3. Set Object: Results
4. Set Method: Maximum
5. Select both subcases
6. Set the name to Layer 1
7. Set the subcase name to Subcase 1, 2
8. Select Failure Index, Ply Indices
9. Click Position
10. Select Layer 1 and Layer 18
11. Click Close
12. Click Apply
13. A new subcase is created and is named Layer 1, Subcase 1, 2

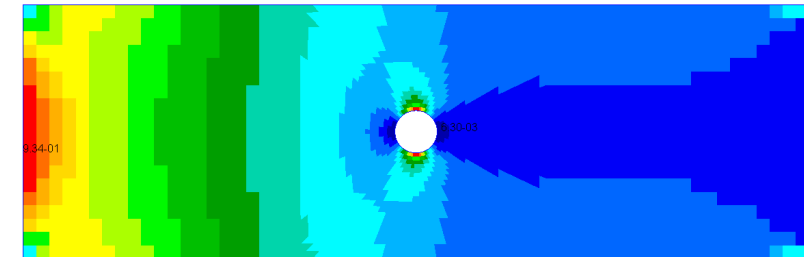


Failure Index

Layer	Subcase 1	Subcase 2
1		
18		

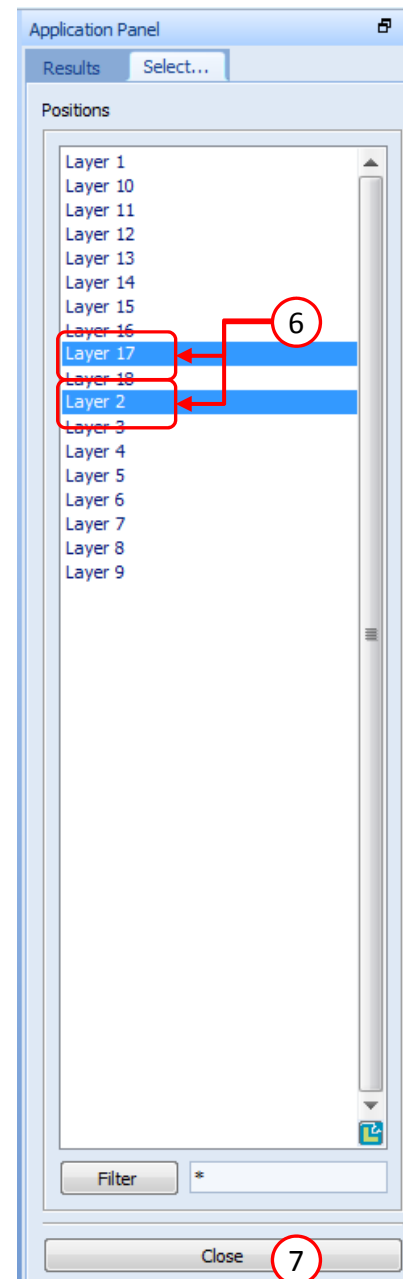
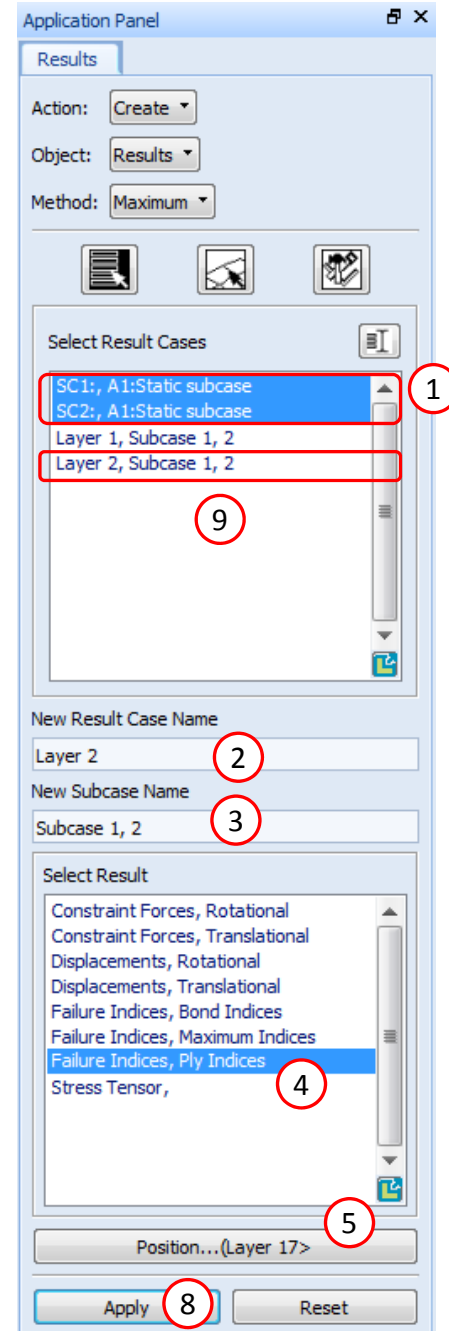
Layer 1, Subcase 1 and 2

Maximum failure index of layers 1 and 10 for subcase 1 and 2



Create a New Subcase: Layer 2, Subcase 1, 2

1. Select both subcases
2. Set the name to Layer 2
3. Set the subcase name to Subcase 1, 2
4. Select Failure Index, Ply Indices
5. Click Position
6. Select Layer 2 and Layer 17
7. Click Close
8. Click Apply
9. A new subcase is created and is named Layer 2, Subcase 1, 2

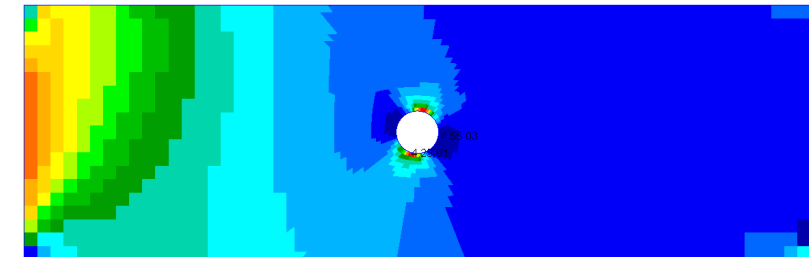


Failure Index

Layer	Subcase 1	Subcase 2
2		
17		

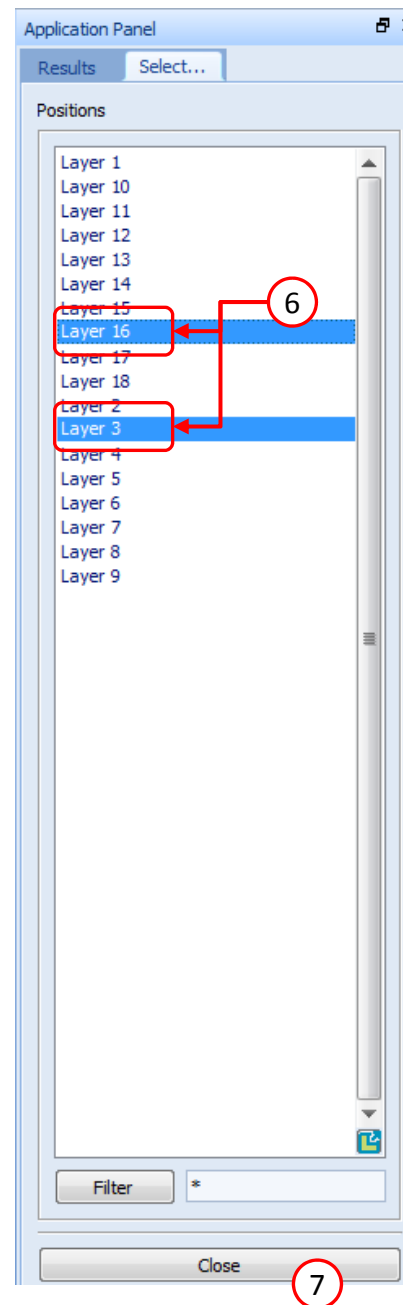
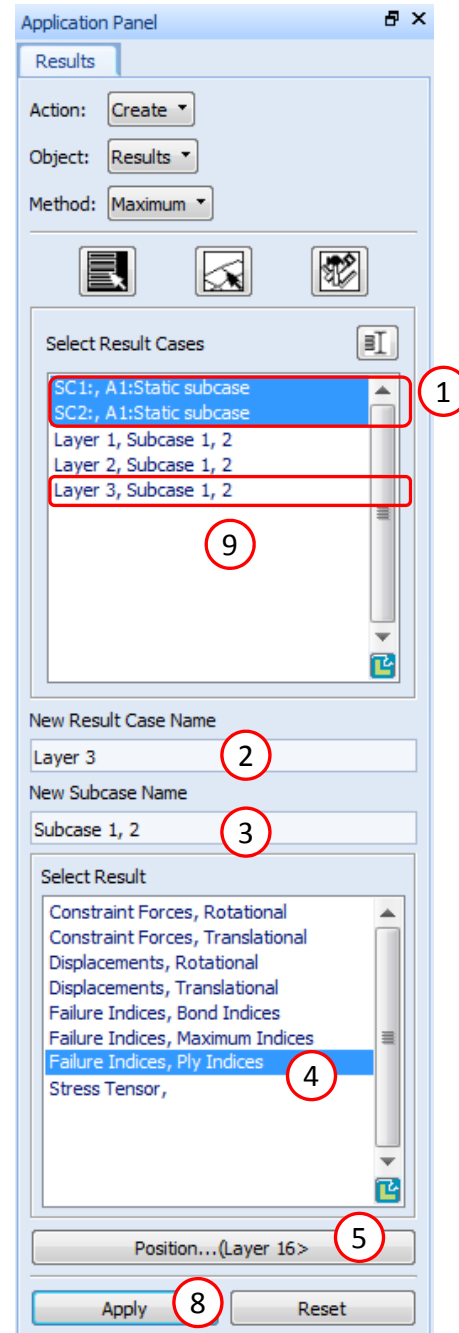
Layer 2, Subcase 1 and 2

Maximum failure index of layers 2 and 9 for subcase 1 and 2

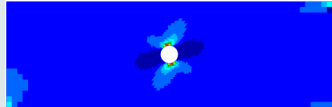
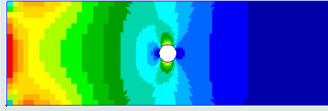
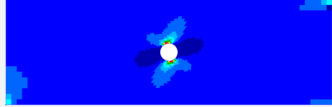
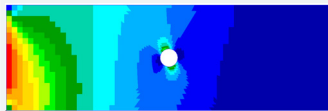


Create a New Subcase: Layer 3, Subcase 1, 2

1. Select both subcases
2. Set the name to Layer 3
3. Set the subcase name to Subcase 1, 2
4. Select Failure Index, Ply Indices
5. Click Position
6. Select Layer 3 and Layer 16
7. Click Close
8. Click Apply
9. A new subcase is created and is named Layer 3, Subcase 1, 2

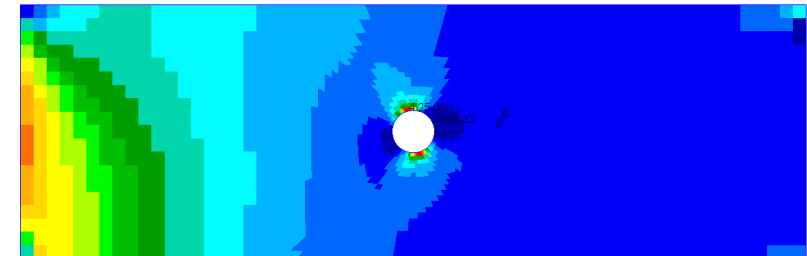


Failure Index

Layer	Subcase 1	Subcase 2
3		
16		

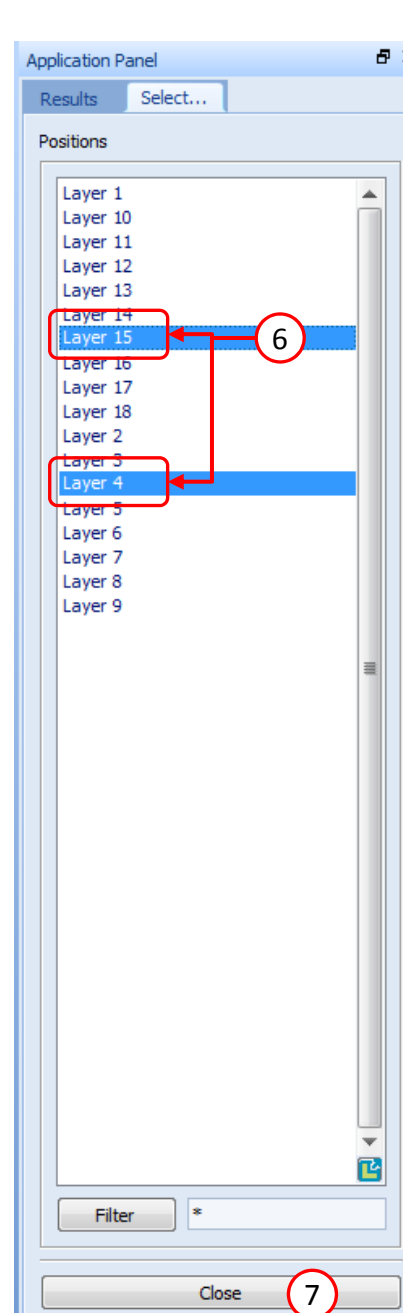
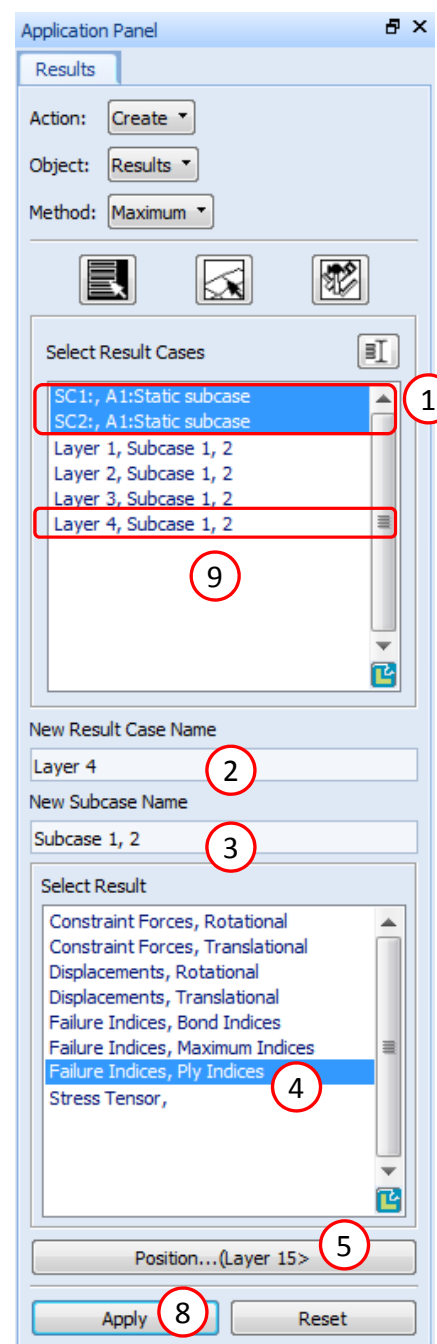
Layer 3, Subcase 1 and 2

Maximum failure index of layers 3 and 8 for subcase 1 and 2



Create a New Subcase: Layer 4 Subcase 1, 2

1. Select both subcases
2. Set the name to Layer 4
3. Set the subcase name to Subcase 1, 2
4. Select Failure Index, Ply Indices
5. Click Position
6. Select Layer 4 and Layer 15
7. Click Close
8. Click Apply
9. A new subcase is created and is named Layer 4, Subcase 1, 2

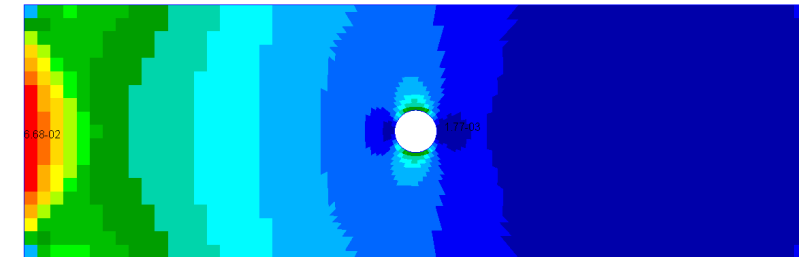


Failure Index

Layer	Subcase 1	Subcase 2
4		
15		

Layer 4, Subcase 1 and 2

Maximum failure index of layers 4 and 7 for subcase 1 and 2



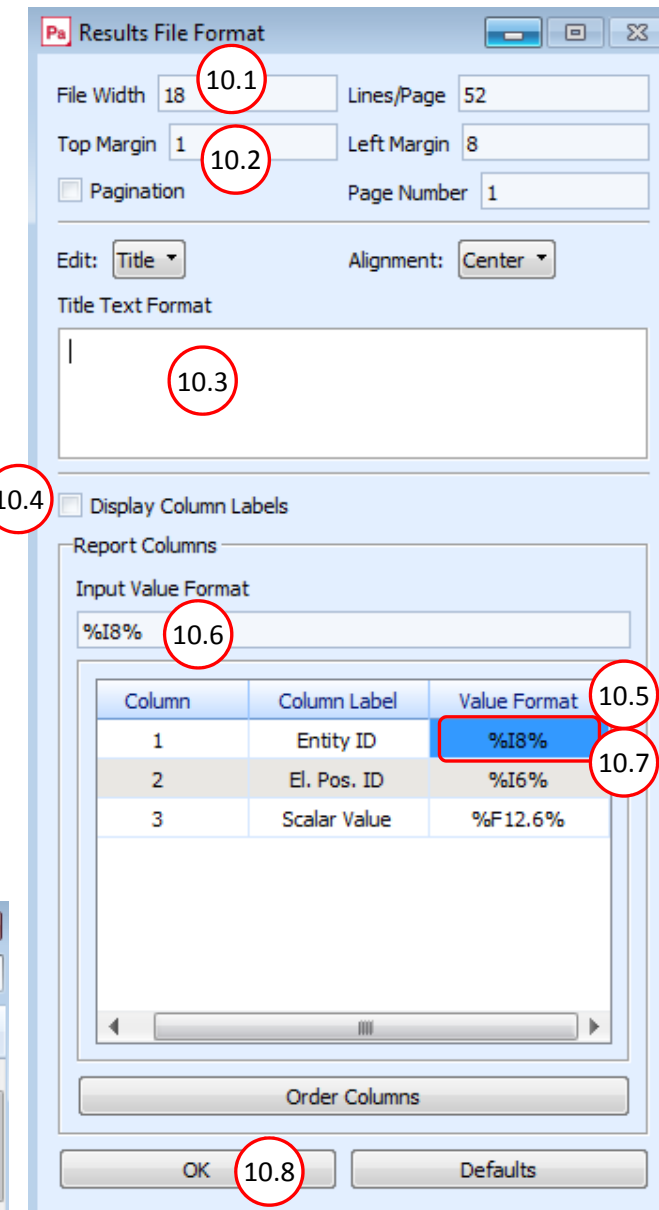
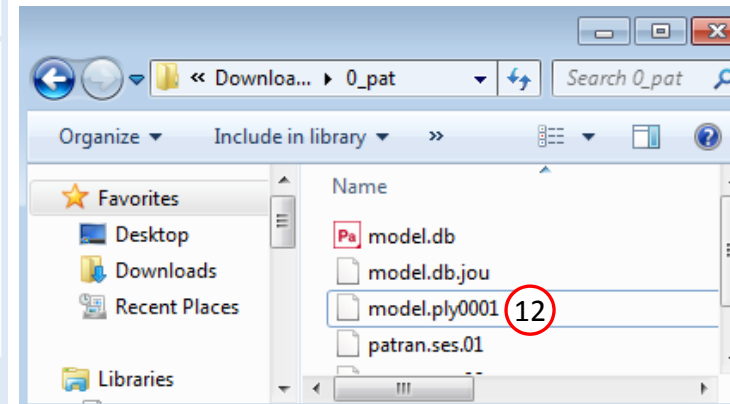
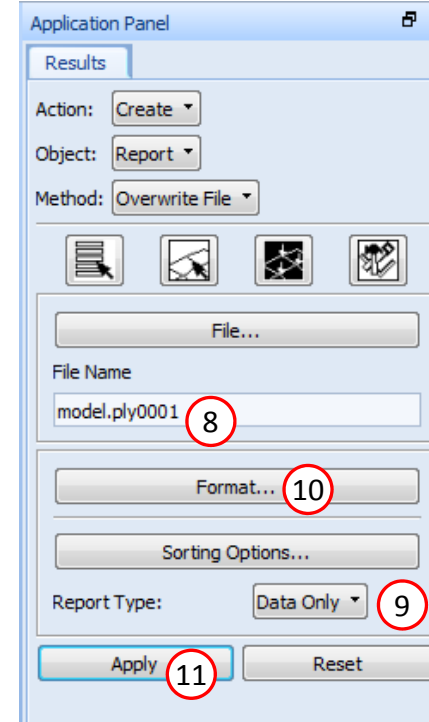
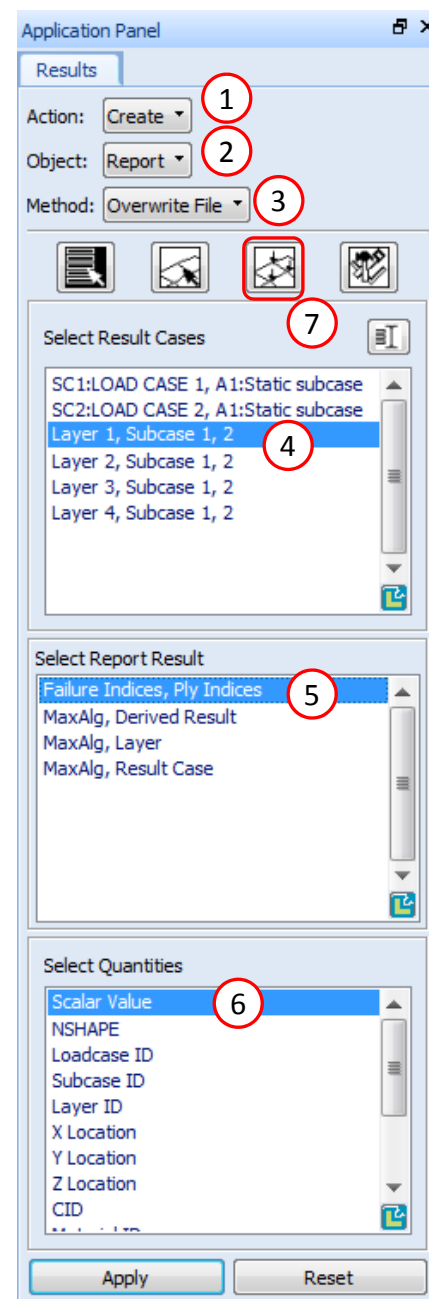
Create model.ply0001

1. Set Action: Create
2. Set Object: Report
3. Set Method: Overwrite File
4. Select Layer 1, Subcase 1, 2
5. Select Failure Indices, Ply Indices
6. Select Scalar Value
7. Click Display Attributes
8. Set File Name: model.ply0001
9. Set Report Type: Data Only
10. Click Format

1. Set File Width: 18
2. Top Margin: 1
3. Set Title Text Format: blank
4. Unmark the checkbox Display Column Labels
5. Select the indicated cell, which previously reads: %I6%
6. For the indicated input box, type in this text : %I8%
7. Press Enter on the keyboard to commit the new text, the indicated cell should now read: %I8%
8. Click OK

11. Click Apply

12. A new file model.ply0001 has been created



Create model.ply0001

1. The files .ply000i are typically created by a topometry optimization. This tutorial manually creates the .ply000i files.
2. Open file model.ply0001 in a text editor. Note that the format of the manually created model.ply0001 is similar to the format created by a topometry optimization.

① model.ply0001 (Topometry Optimization)

```

model.ply0001
1 DESIGN CYCLE : 14
2 1
3 Topometry Optimization Mat
4 Total number of element
5 1429 0
6 0.1002350E-02
7 1430 0
8 0.1002253E-02
9 1431 0
10 0.1002049E-02
11 1432 0
12 0.1002280E-02
13 1433 0
14 0.1002328E-02
15 1434 0
16 0.1002254E-02
17 1435 0
18 0.1002217E-02
19 1436 0
20 0.1002244E-02
21 1437 0
  
```

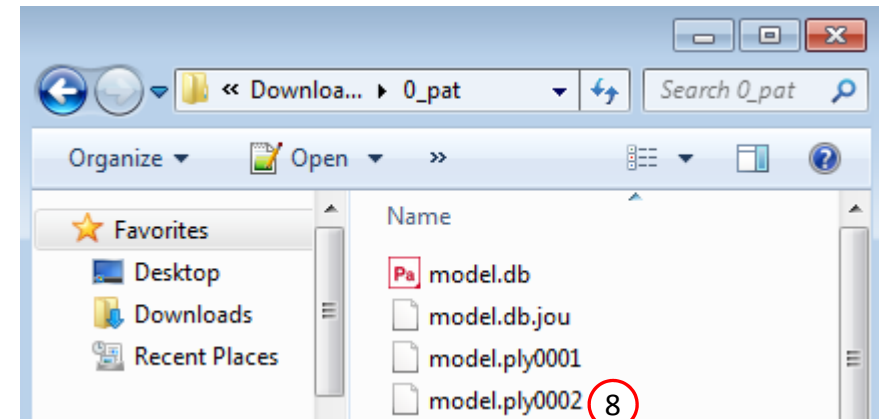
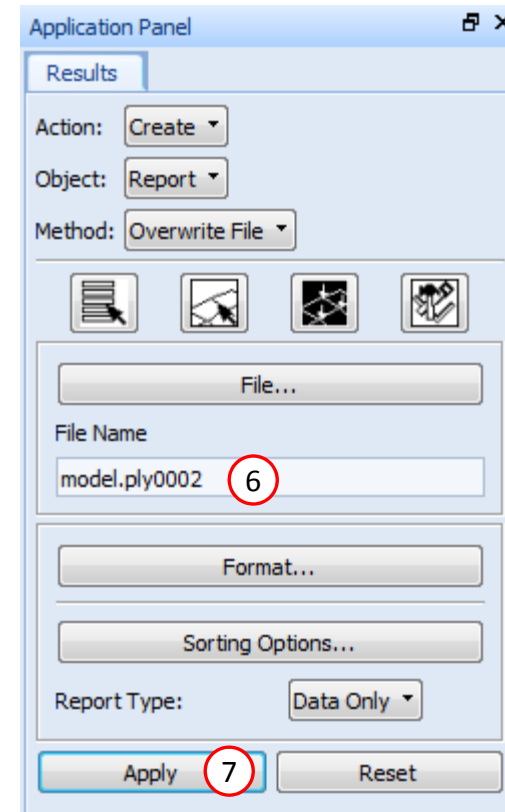
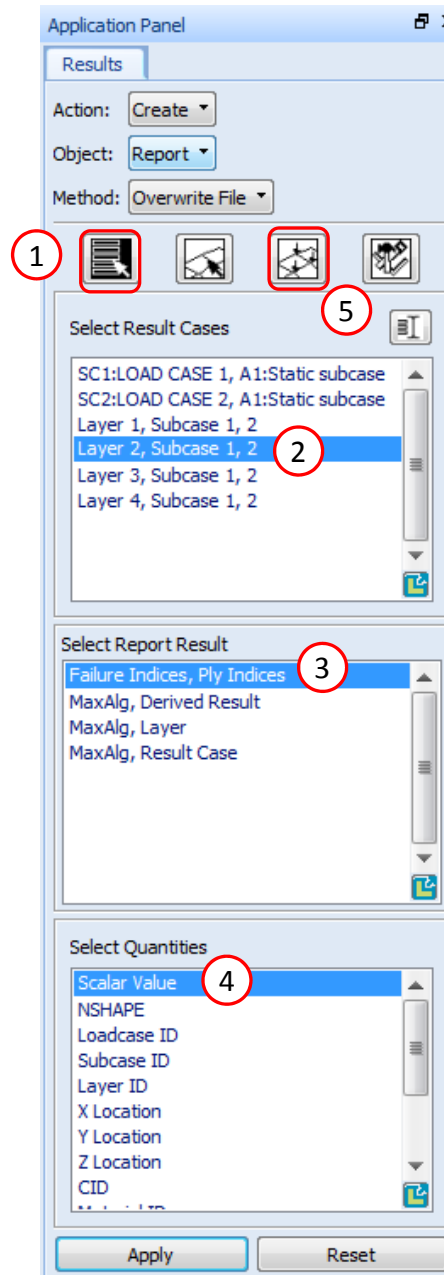
② model.ply0001

```

model.ply0001
1
2
3 1429 0
4 0.307122
5 1430 0
6 0.103824
7 1431 0
8 0.123881
9 1432 0
10 0.120190
11 1433 0
12 0.121350
13 1434 0
14 0.121152
15 1435 0
16 0.121225
17 1436 0
18 0.121206
19 1437 0
20 0.121206
21 1438 0
  
```

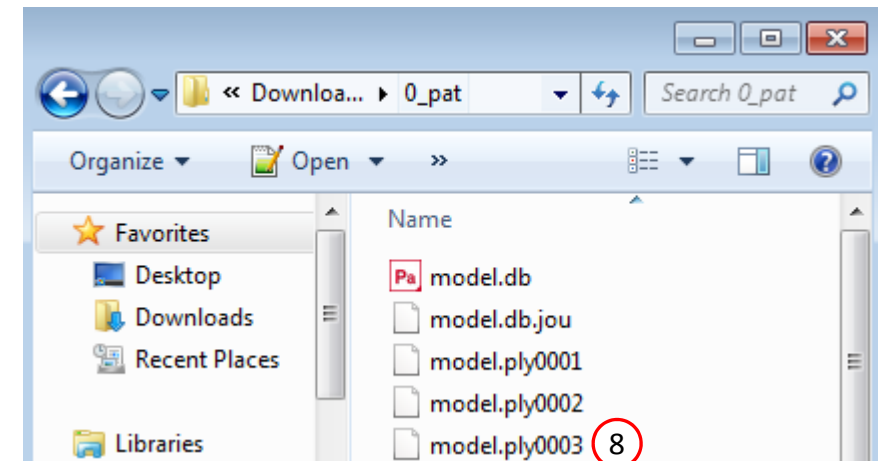
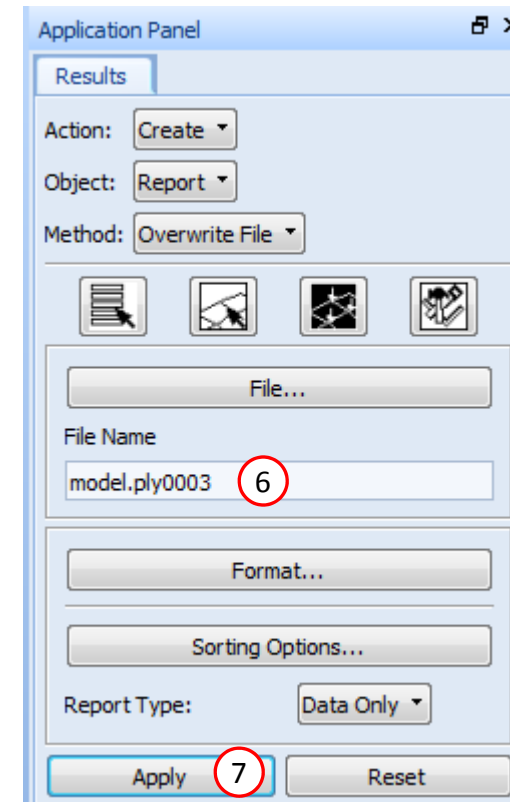
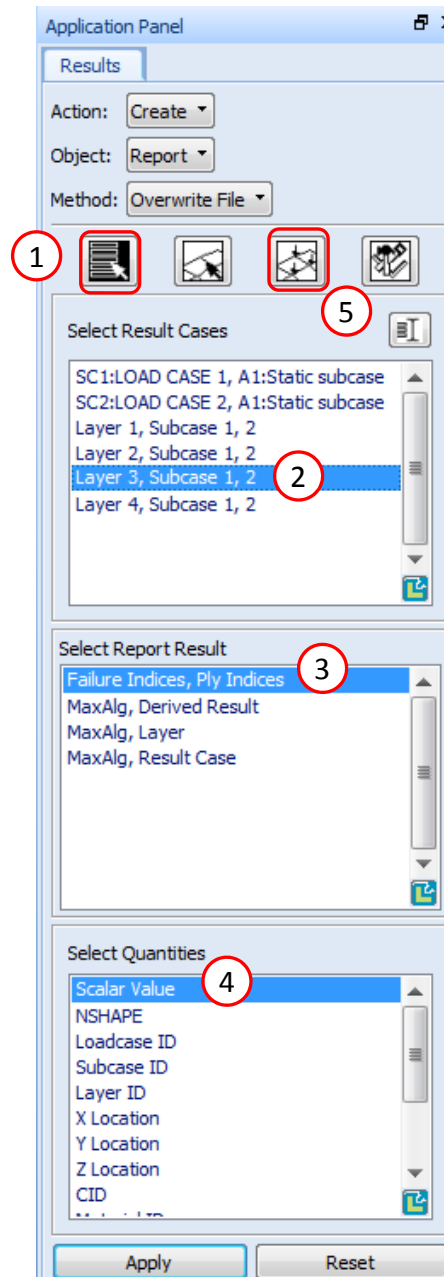
Create model.ply0002

1. Click Select Results
2. Select Layer 2, Subcase 1, 2
3. Select Failure Indices, Ply Indices
4. Select Scalar Value
5. Click Display Attributes
6. Set File Name: model.ply0002
7. Click Apply
8. A new file model.ply0002 has been created



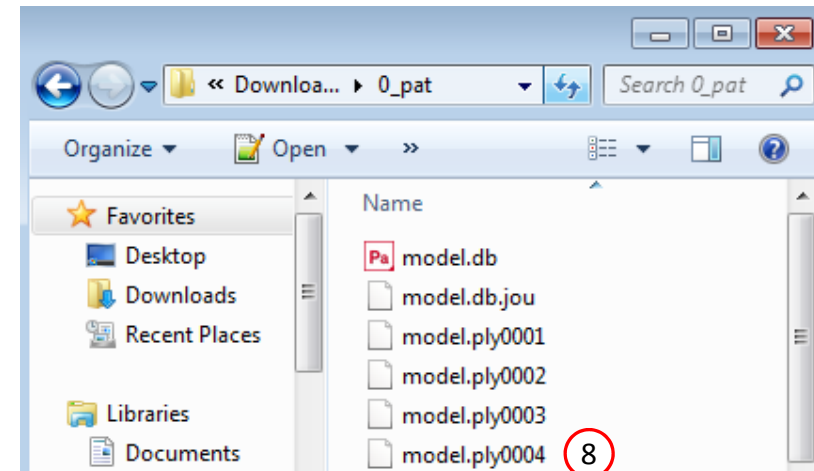
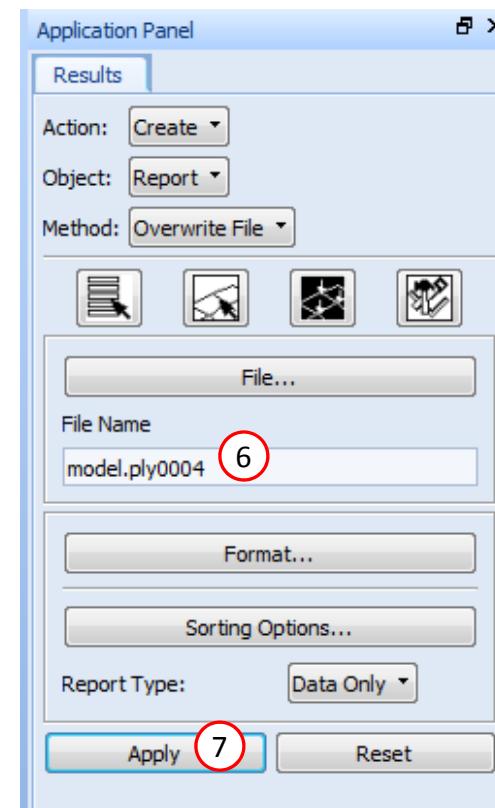
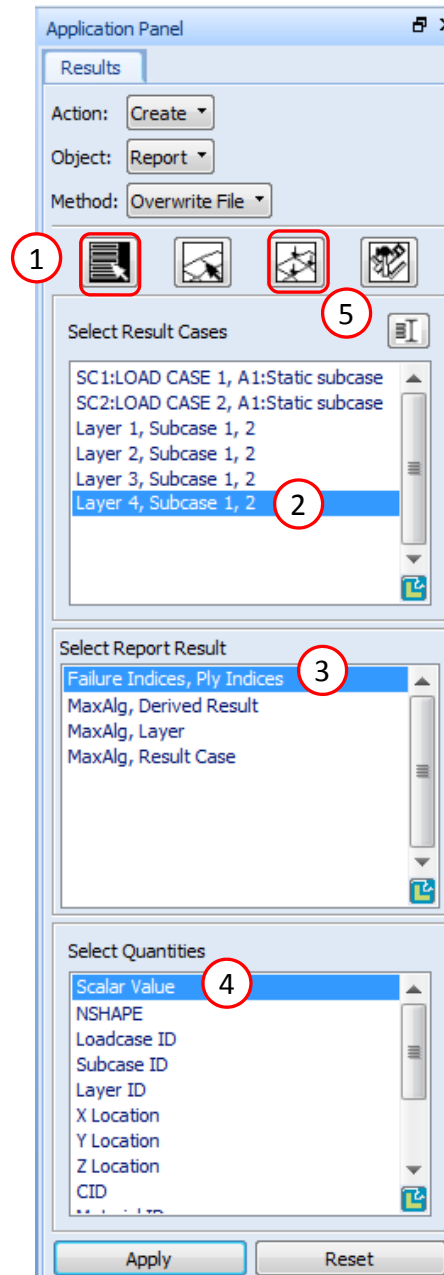
Create model.ply0003

1. Click Select Results
2. Select Layer 3, Subcase 1, 2
3. Select Failure Indices, Ply Indices
4. Select Scalar Value
5. Click Display Attributes
6. Set File Name: model.ply0003
7. Click Apply
8. A new file model.ply0003 has been created



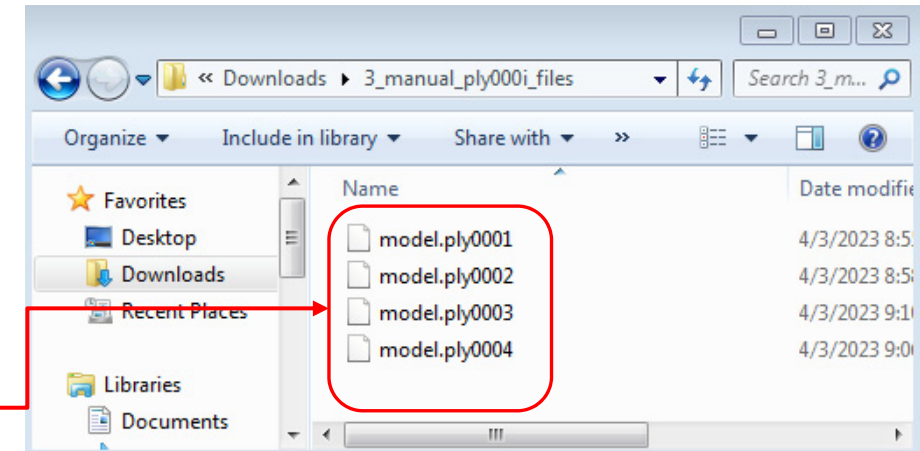
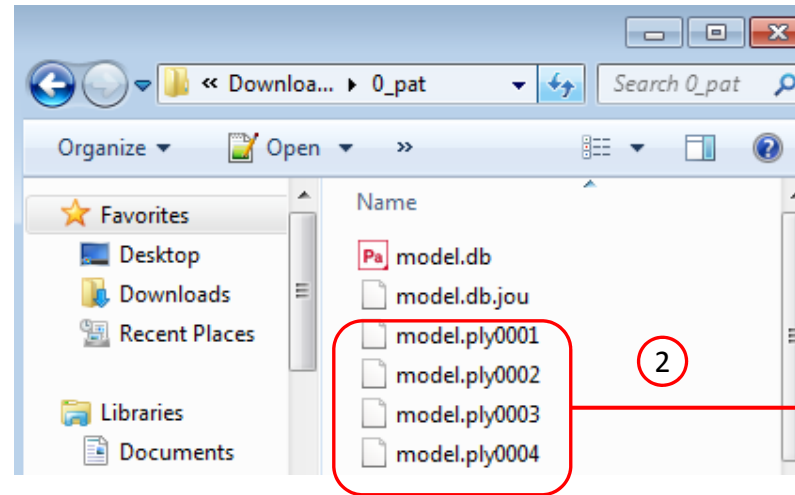
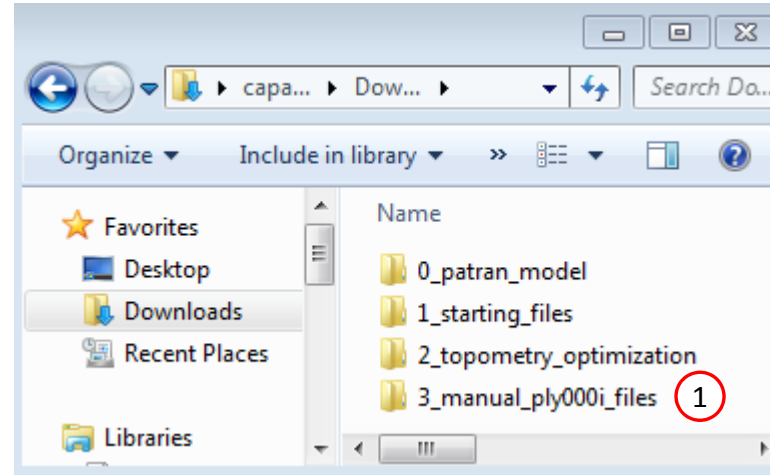
Create model.ply0004

1. Click Select Results
2. Select Layer 4, Subcase 1, 2
3. Select Failure Indices, Ply Indices
4. Select Scalar Value
5. Click Display Attributes
6. Set File Name: model.ply0004
7. Click Apply
8. A new file model.ply0004 has been created



Store the PLY000i Files

1. Navigate to the Downloads directory and create a new directory named 3_manual_ply000i_files
2. Copy the PLY000i files to directory 3_manual_ply000i_files



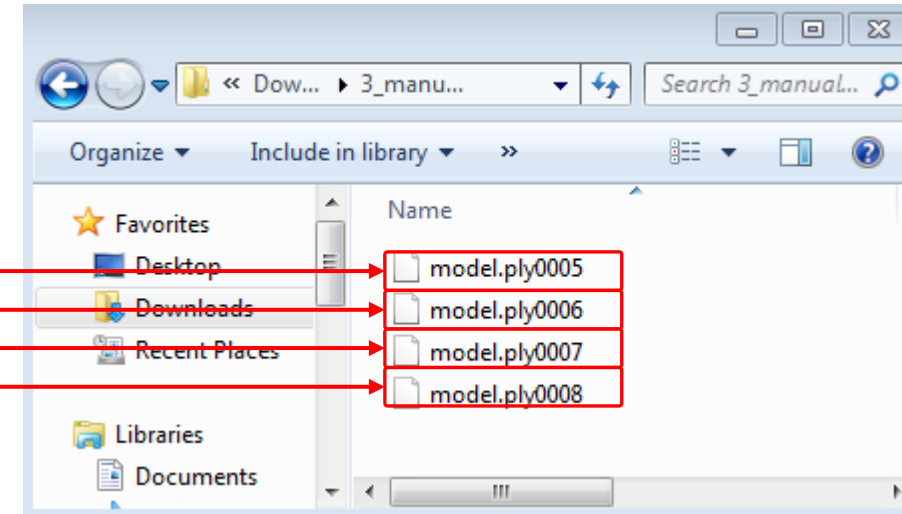
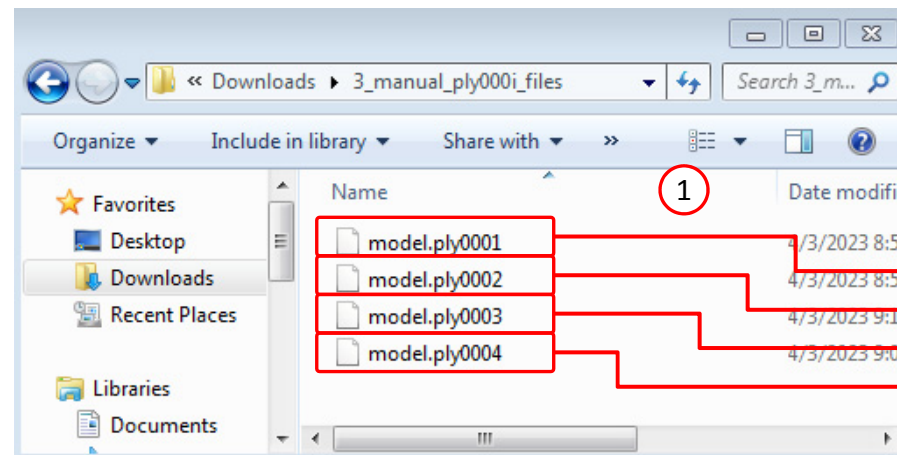
Store the PLY000i Files

1. Rename the following files
 - model.ply0001 => model.ply0005
 - model.ply0002 => model.ply0006
 - model.ply0003 => model.ply0007
 - model.ply0004 => model.ply0008
2. These file names align with the layer numbers referenced in the TOMVAR entries, e.g. T5, T6, T7 and T8.

- Layers 1-4 will remain fixed during the optimization. Only layers 5, 6, 7 and 8 will be change during this optimization procedure.

2

\$TOMVAR	ID	TYPE	PID	PNAME	XINIT	XLB	XUB	DELXV
TOMVAR	3000001	PCOMP	1	T5	.25	.001		
TOMVAR	3000002	PCOMP	1	T6	.25	.001		
TOMVAR	3000003	PCOMP	1	T7	.25	.001		
TOMVAR	3000004	PCOMP	1	T8	.25	.001		



Inspect the PLY000i Files

1. Open each PLY000i file in a text editor and ensure the values are similar to what is shown

model.ply0005

model.ply0005		
1		
2		
3	1429	0
4	0.307122	
5	1430	0
6	0.103824	
7	1431	0
8	0.123881	
9	1432	0
10	0.120190	
11	1433	0
12	0.121350	
13	1434	0
14	0.121152	
15	1435	0
16	0.121225	
17	1436	0
18	0.121206	
19	1437	0
20	0.121206	
21	1438	0

model.ply0006

model.ply0006		
1		
2		
3	1429	0
4	0.068311	
5	1430	0
6	0.033003	
7	1431	0
8	0.037165	
9	1432	0
10	0.035959	
11	1433	0
12	0.036363	
13	1434	0
14	0.036402	
15	1435	0
16	0.036498	
17	1436	0
18	0.036520	
19	1437	0
20	0.036492	
21	1438	0

model.ply0007

model.ply0007		
1		
2		
3	1429	0
4	0.128537	
5	1430	0
6	0.023576	
7	1431	0
8	0.032193	
9	1432	0
10	0.032717	
11	1433	0
12	0.034264	
13	1434	0
14	0.034998	
15	1435	0
16	0.035578	
17	1436	0
18	0.035959	
19	1437	0
20	0.036224	
21	1438	0

model.ply0008

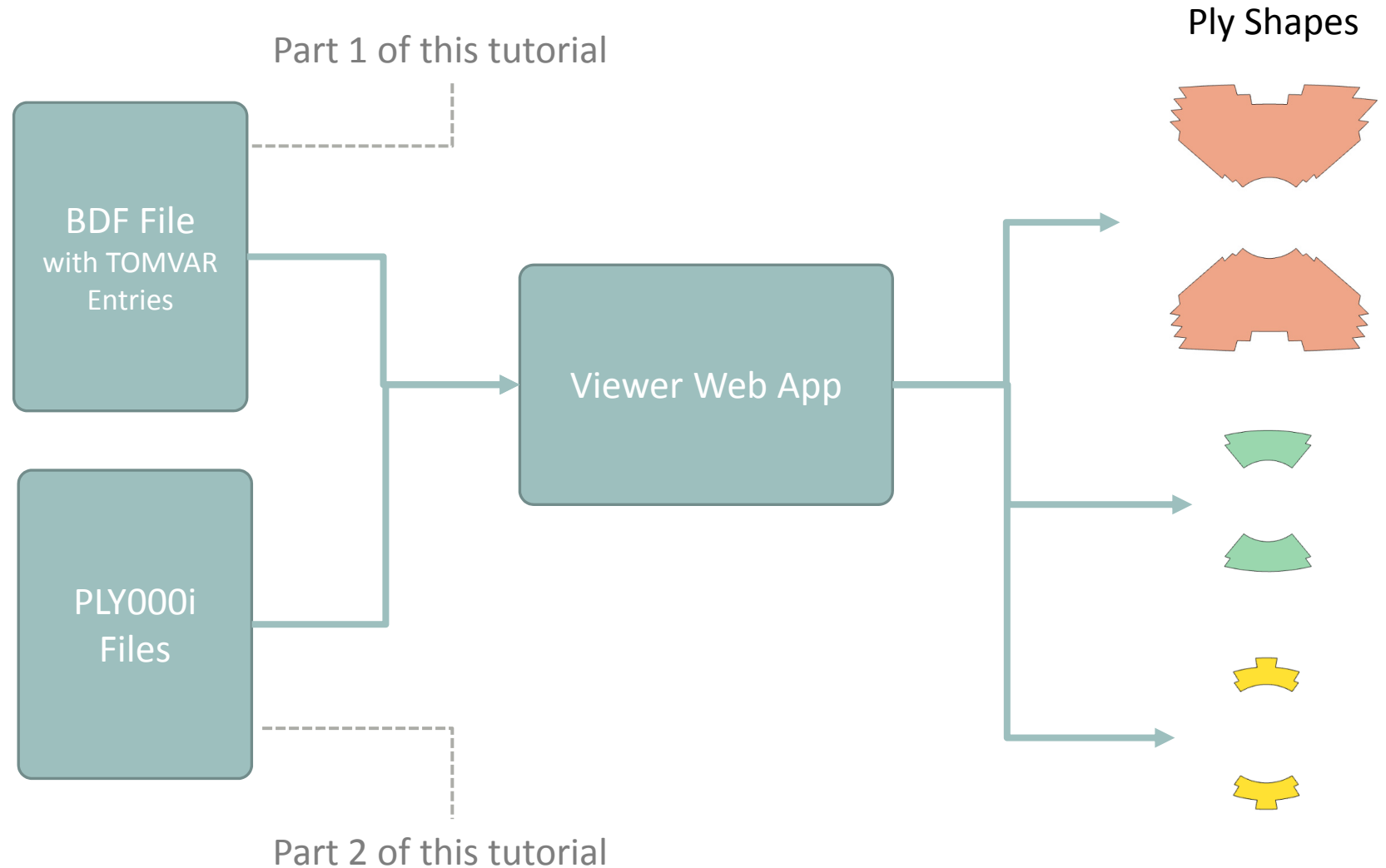
model.ply0008		
1		
2		
3	1429	0
4	0.008058	
5	1430	0
6	0.003148	
7	1431	0
8	0.003341	
9	1432	0
10	0.003091	
11	1433	0
12	0.003008	
13	1434	0
14	0.002936	
15	1435	0
16	0.002893	
17	1436	0
18	0.002865	
19	1437	0
20	0.002850	
21	1438	0

Conclusion

A future goal is to construct a lightweight composite with optimized ply shapes.

The Viewer web app may generate new ply shapes, but first, BDF files, with TOMVAR entries, and PLY000i files must be created. This tutorial detailed how to create the BDF and PLY000i files.

In a separate tutorial, instructions are provided to upload the BDF files and PLY000i files to the Viewer web app and how to create ply shapes.



End of Tutorial

Appendix

Appendix Contents

- Comments on bulk data entries compatible with ply shape optimization
- Why is a topometry optimization skipped?
- Methods to Create PLY000i Files

Comments on bulk data entries compatible with ply shape optimization

Certain configurations of bulk data entries should be avoided in ply shape optimization or in general optimization

1. The TOMVAR entry does NOT support PCOMPG entries, so use PCOMP entries.
2. The formatting of PCOMPG and PCOMP entries are very similar. A text editor may be used to convert PCOMPG to PCOMP entries.
3. The Ti fields corresponding to the membrane thickness of the element at the grid points should NOT be used in a weight optimization. Using these fields will fix the volume of the element, which will fix the mass of the model. During the weight optimization, the mass will remain constant but the goal is to minimize the mass.
4. Use 2D element entries that do NOT use the Ti fields in a weight optimization.

NOT OK

①	PCOMPG	1			90.	HILL
		1	101	.3755	90.	YES
		2	101	.3755	45.	YES
		3	101	.3755	-45.	YES
		4	101	.3755	0.	YES
		5	501	3.175	0.	YES

OK

②	PCOMP	1			90.	HILL
		101	.3755	90.	YES	
		101	.3755	45.	YES	
		101	.3755	-45.	YES	
		101	.3755	0.	YES	
		501	3.175	0.	YES	

NOT OK

③	CQUAD4	1429	1	2393	2374	2452	2411
				1.0	1.0	1.0	1.0
	CQUAD4	1430	1	2411	2452	2453	2410
				1.0	1.0	1.0	1.0

OK

④	CQUAD4	1429	1	2393	2374	2452	2411
	CQUAD4	1430	1	2411	2452	2453	2410

Why is a topometry optimization skipped?

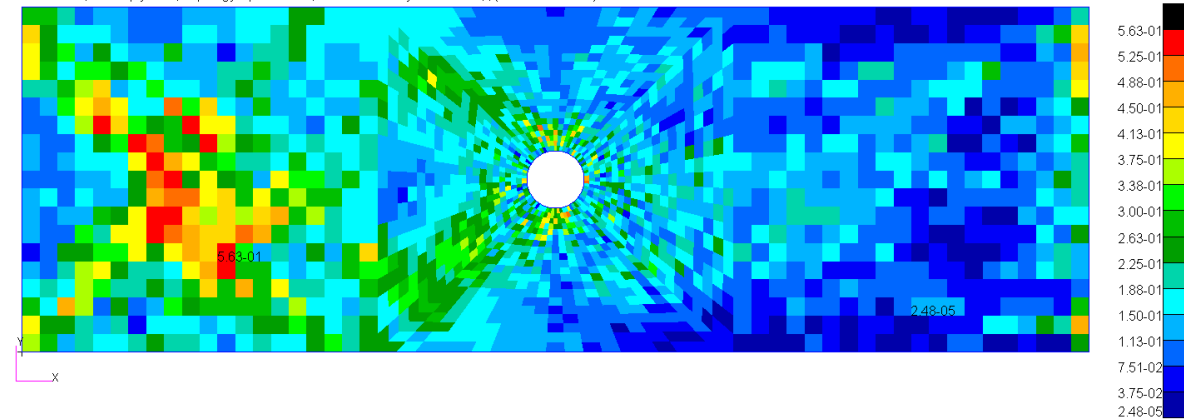
There are 2 reasons why topometry optimization is not performed.

1. Topometry optimization with failure index constraint does not yield good results. This is likely due to the many local optimization solutions that exist. One topometry optimization may yield a converged solution but is one solution of many solutions. A topometry optimization with failure index constraints is not performed. Instead, the failure index results are used to construct optimal ply shapes. The failure index results are stored in PLY000i files.
2. While a topometry optimization is not necessary, the BDF files do require TOMVAR entries to exist. For each layer that will have new optimized ply shapes, a TOMVAR entry must be defined.
3. If global responses, such as buckling load factors or natural frequencies, are to be optimized, a topometry optimization does yield good results and should be used to optimize composites.

Topometry Optimization Results

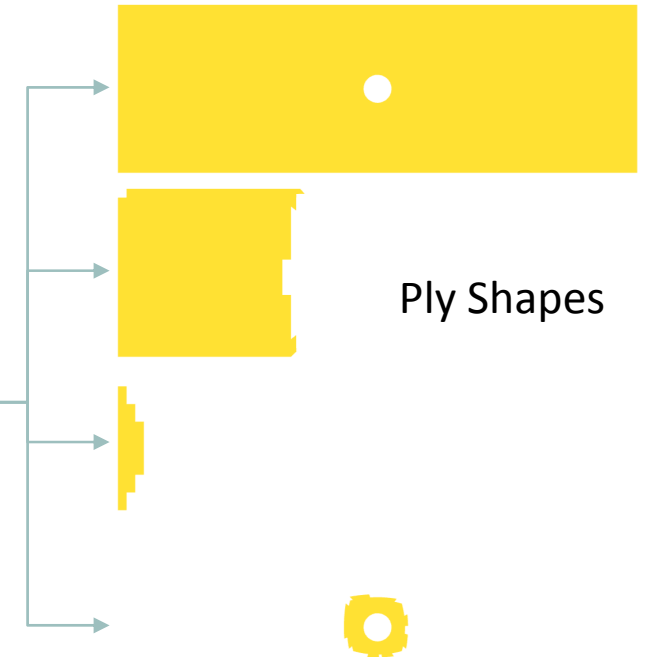
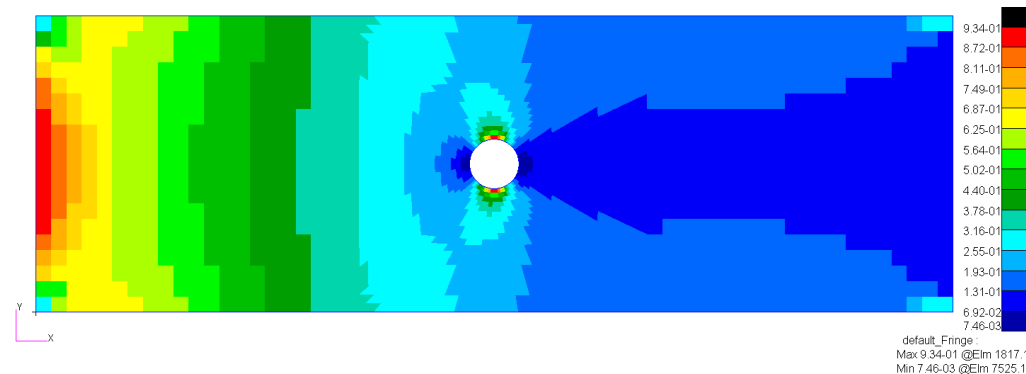
Patran 2022.2 11-Mar-23 17:18:09

Fringe: DESIGN CYCLE: 20, model.ply0001, Topology Optimization, Element Density Distribution, , (NON-LAYERED)



Best Approach

Failure index plot of 0-degree layers for the most critical subcase(s)



Methods to Create PLY000i Files

PLY000i files are required to perform ply shape optimization. There are various methods to create PLY000i files.

1. Manual Method – Manually combine fringe plots and create PLY000i files.
2. Topometry Optimization Method – Use Topometry optimization to generate PLY000 files.
3. Hybrid Method – Combine PLY000i files from the manual method and topometry optimization.

- This tutorial employs the Manual Method

Method to Create PLY000i Files	Primary Constrained Response
Manual Method	Element Quantities: Ply Stress, Ply Strain, Failure Index or Strength Ratio
Topometry Optimization Method	Non-element Quantities: Displacements, Natural Frequencies and Buckling Load Factors
Hybrid Method	Element AND non-element quantities