

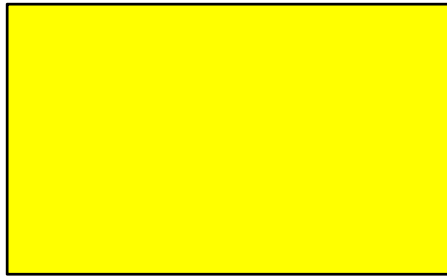
Workshop - MSC Nastran Topometry Optimization of a Composite Panel

AN MSC NASTRAN SOL 200 TUTORIAL

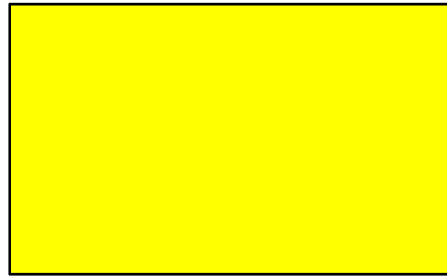
Goal: Use Nastran SOL 200 Optimization

Use Topometry optimization to determine ply shapes

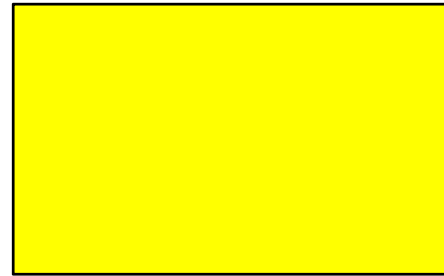
Initial Ply
Shapes



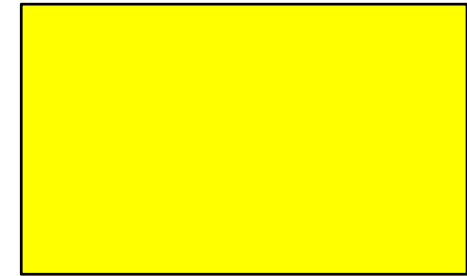
Ply 1 and 8
80°



Ply 2 and 7
-65°



Ply 3 and 6
80°

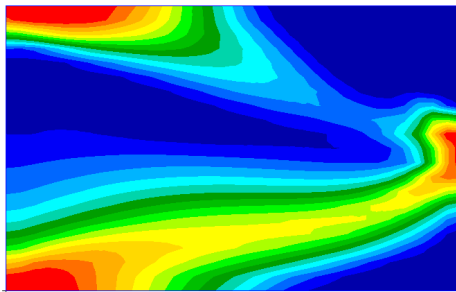


Ply 4 and 5
-65°

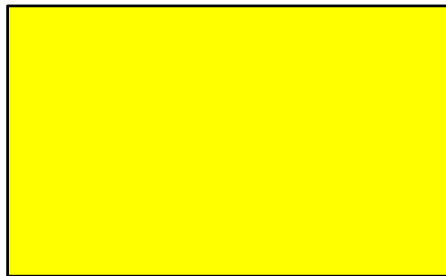
Goal: Use Nastran SOL 200 Optimization

Use Topometry optimization to determine optimal ply shapes

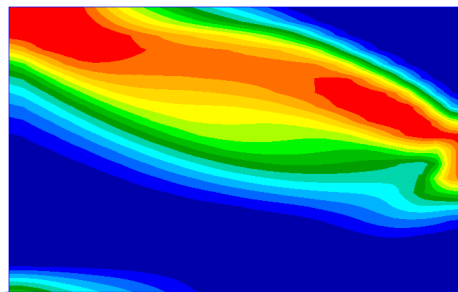
Topometry
Results



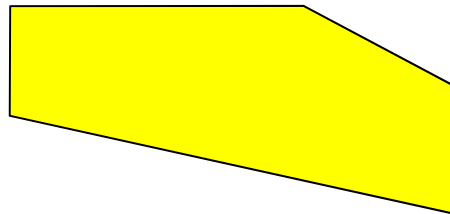
Ply 1 and 8
80°



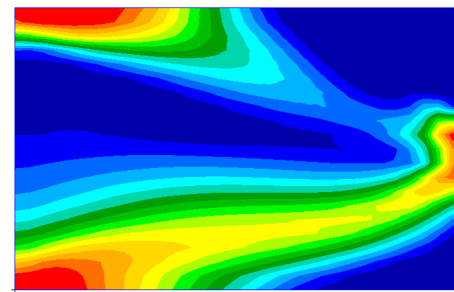
Ply 1 and 8
80°



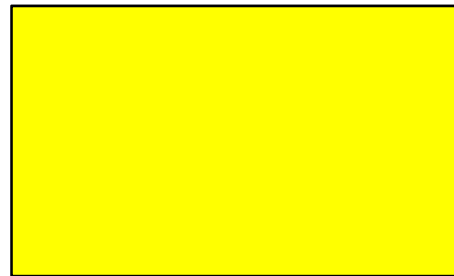
Ply 2 and 7
-65°



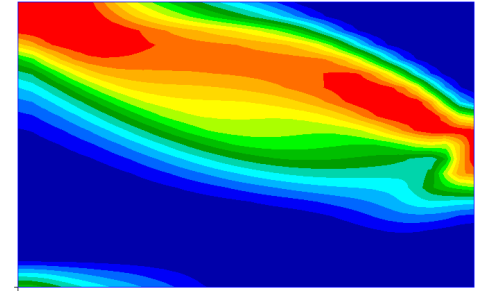
Ply 2 and 7
-65°



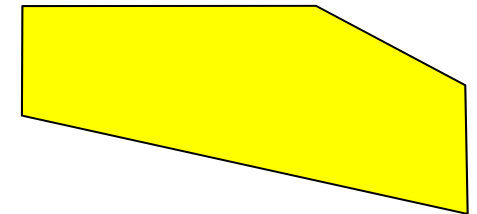
Ply 3 and 6
80°



Ply 3 and 6
80°



Ply 4 and 5
-65°



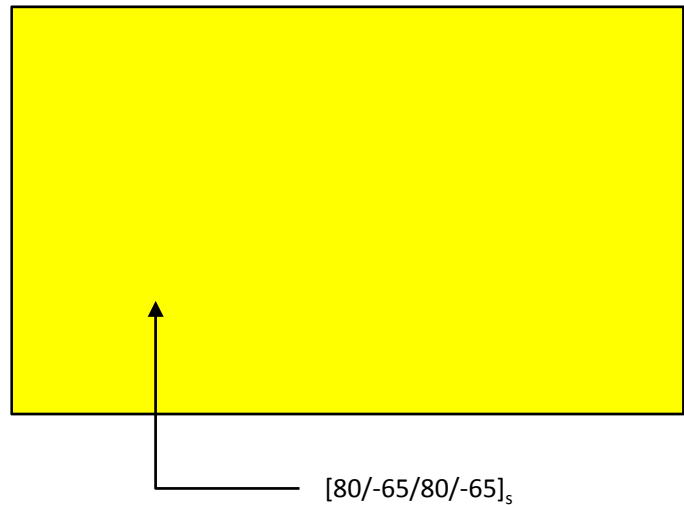
Ply 4 and 5
-65°

Proposed Ply
Shapes

Goal: Use Nastran SOL 200 Optimization

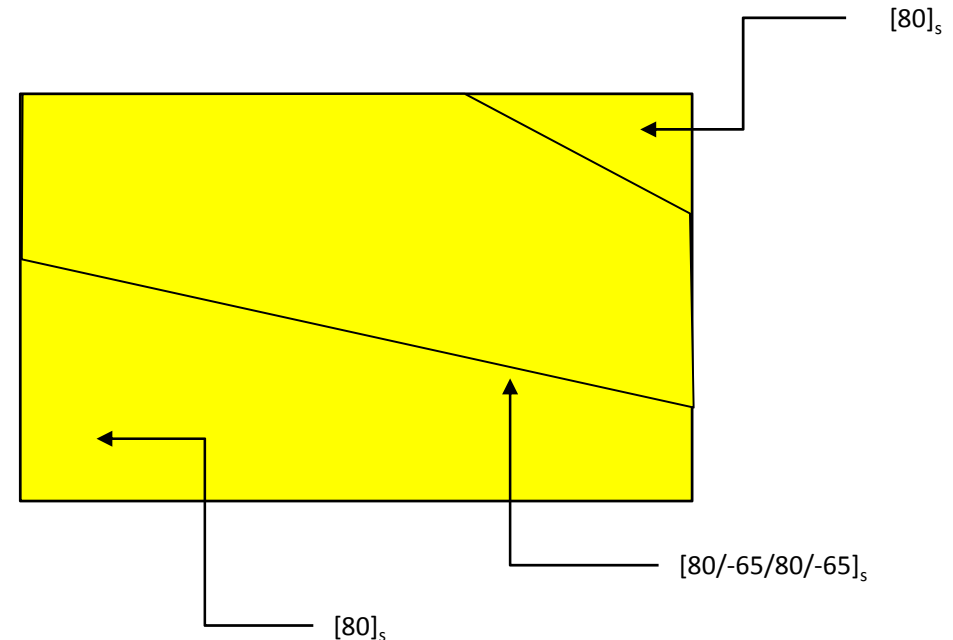
Before Optimization

- Panel of initial layup

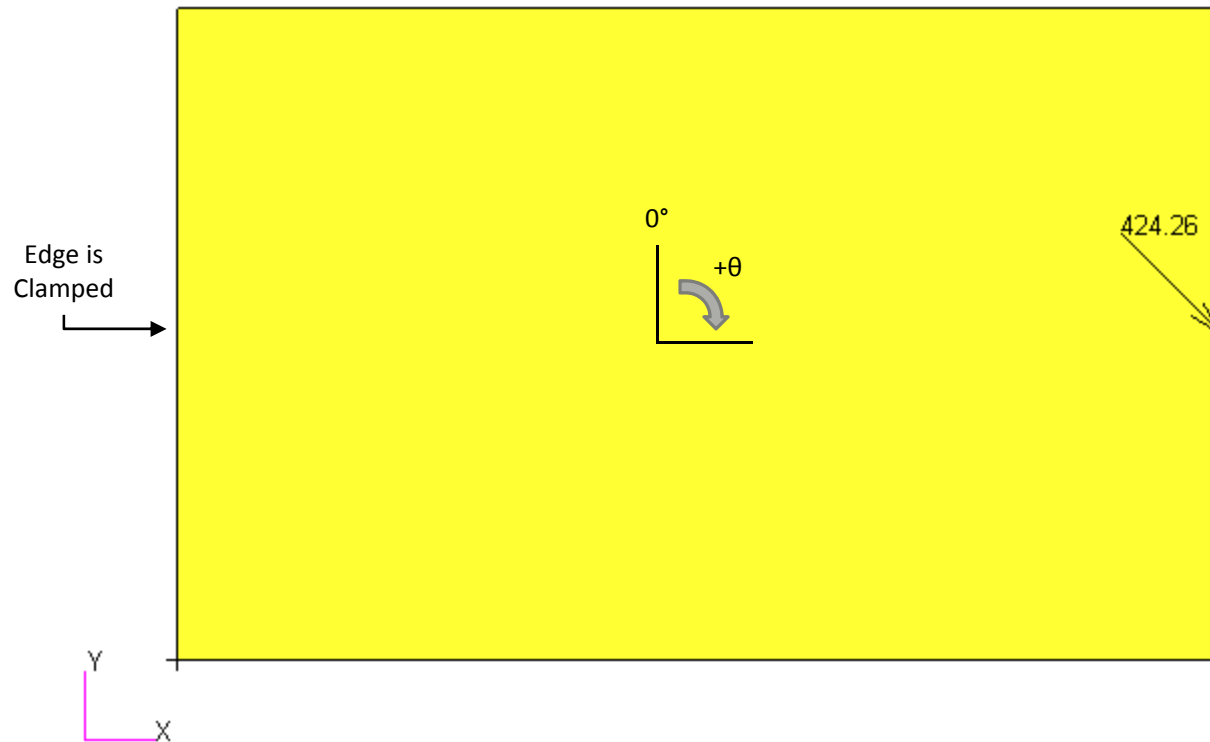


After Optimization

- Panel of updated layups
- The weight is reduced



Details of the structural model



Panel: 16in. x 10in.
Layup: $[80/-65/80/-65]_s$

Optimization Problem Statement

Design Region (Topometry)

z1: Thickness of ply 1 and 8
z2: Thickness of ply 2 and 7
z3: Thickness of ply 3 and 6
z4: Thickness of ply 4 and 5

$$.001 < z1, z2, z3, z4$$

Variable Linking

z3 = z1
z4 = z2



PCOMP 1 - Panel



Design Objective

r0: Minimize compliance
This is equivalent to maximizing stiffness

Design Constraints

r1: Weight
 $r1 < 38.0$ (~50% of original weight 75.0)

Contact me

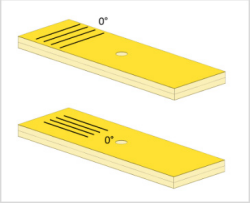
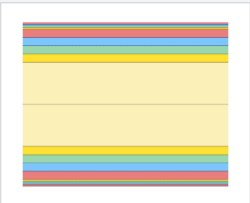
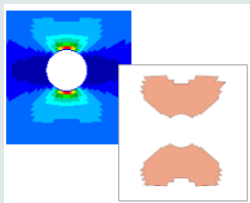
- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

Before Continuing

Consider the New Composite Laminate Optimization Tutorials – Composite Coupon

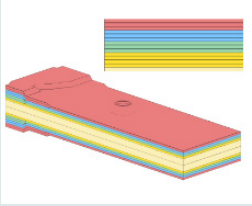
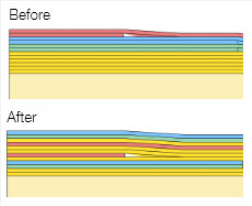
Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	<p>Composite Coupon – Phase A – Determination of the optimal 0° direction of a composite</p> <p>The goal of this 5-phase tutorial series is to optimize a composite coupon, with a core, and produce a lightweight composite that satisfies failure index constraints. The optimal ply shapes (ply drop-offs) and ply numbers are determined for 0°, ±45°, and 90° plies. A stacking sequence optimization is performed to satisfy manufacturing requirements. One important part of optimizing composites is visualizing the composite plies. This tutorial series also demonstrates the visualization of ply drop-offs, tapered plies and core layers.</p> <p>This first phase involves determining the optimal 0° direction of a composite. It is best practice to align the 0° plies in the direction of the load. Not doing so will more than likely produce a suboptimal composite that is heavier than necessary. This tutorial demonstrates the use of MSC Nastran's optimizer to determine the optimal 0° direction of a composite. An optimization is performed to maximize the stiffness of the composite for multiple load cases and while varying the angle of the 0° plies. Ultimately, the best 0° direction is determined.</p> <p>This is the first phase in a 5-phase tutorial series.</p>	Link	Link
	<p>Composite Coupon – Phase B – Baseline Ply Number Optimization</p> <p>This tutorial demonstrates how to configure a basic ply number optimization of continuous plies that span the entire model. The goal of this tutorial is to demonstrate basic actions such as creating variables, a weight objective and constraints on failure index. The results of this ply number optimization serve as a baseline for future comparisons. In a subsequent tutorial, the ply shapes will be optimized to minimize weight.</p> <p>This is the second phase in a 5-phase tutorial series.</p>	Link	Link
	<p>Composite Coupon – Phase C – Data Preparation for Ply Shape Optimization</p> <p>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.</p> <p>This is the third phase in a 5-phase tutorial series.</p>	Link	Link

Before Continuing

Consider the New Composite Laminate Optimization Tutorials – Composite Coupon, Continued

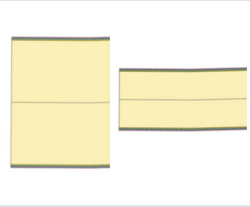
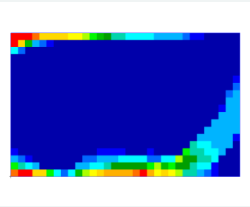
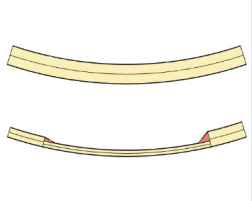
Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	Composite Coupon – Phase D – Ply Shape and Ply Number Optimization This tutorial details the process to build optimal ply shapes and perform a ply number optimization. The optimal ply shapes are constructed to follow the contours of the failure indices. The ply number optimization involves minimizing weight and constraining the failure indices of plies. The PLY000i files and BDF files from the previous tutorial, phase C, are used in this tutorial. This is the fourth phase in a 5-phase tutorial series.	Link	Link
	Composite Coupon – Phase E – Stacking Sequence Optimization This tutorial involves performing a stacking sequence optimization and is a continuation of the previous tutorial, phase D. A final statics analysis is performed to confirm the optimized composite satisfies failure index constraints. This is the fifth phase in a 5-phase tutorial series.	Link	Link

Before Continuing

Consider the New Composite Laminate Optimization Tutorials – Sandwich Composite Panel

Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	<p>Sandwich Composite Panel – Phase B – Baseline Core Thickness Optimization</p> <p>The goal of this 3-phase tutorial series is to optimize a curved composite panel, with a core, and produce a lightweight composite that satisfies constraints on the buckling load factor. This tutorial series focuses exclusively on optimizing the thickness of the core. The methods detailed in the tutorial series are applicable to both foam and honeycomb cores.</p> <p>This tutorial demonstrates how to configure a basic core thickness optimization where the core has a constant thickness throughout the entire model. The goal of this tutorial is to demonstrate basic actions such as creating variables, a weight objective and constraints on the buckling load factor. The results of this core thickness optimization serve as a baseline for future comparisons. In a subsequent tutorial, the core will be allowed to have a variable thickness throughout the model and will be optimized to minimize weight.</p> <p>This is the first phase in a 3-phase tutorial series.</p>	Link	Link
	<p>Sandwich Composite Panel – Phase C – Topometry Optimization to Determine Optimal Core Shape</p> <p>This tutorial is a guide to preparing data for core shape and core thickness optimization in a subsequent tutorial. A topometry optimization is performed in this tutorial to determine the ideal thickness distribution of the core throughout the entire composite panel while satisfying constraints on the buckling load factor and minimizing weight. The results of a topometry optimization are contained in the PLY000i files and will be used to construct optimal core shapes in a subsequent tutorial.</p> <p>This is the second phase in a 3-phase tutorial series.</p>	Link	Link
	<p>Sandwich Composite Panel – Phase D – Core Shape and Core Thickness Optimization</p> <p>This tutorial details the process to build optimal core shapes and perform a core thickness optimization. The optimal core shapes are constructed to follow the contours of thickness results generated by a topometry optimization. The core thickness optimization involves minimizing weight and constraining the buckling load factor. The PLY000i files and BDF files from the previous tutorial, phase C, are used in this tutorial. Comparisons are made between this optimization in phase D and the baseline optimization performed in phase B.</p> <p>This is the third phase in a 3-phase tutorial series.</p>	Link	Link

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 Regions/Variables
 - Design Objective
 - Design Constraints
 - Perform optimization with Nastran SOL 200
3. Review optimization results
 - .f06
 - Topometry Optimization and Structural Results

Special Topics Covered

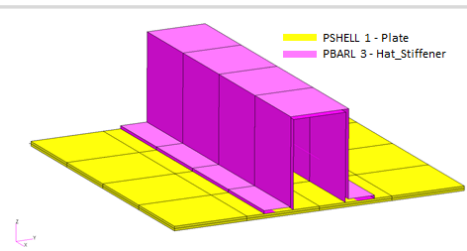
Linked Properties in Topometry Optimization – When configuring a size optimization, there is an option to link variables, i.e. one variable is dependent on the change of another variable. A similar option exists for the thickness properties on the PCOMP entry, enabling users to link ply thicknesses of a composite laminate during a topometry optimization.

SOL 200 Web App Capabilities

Benefits

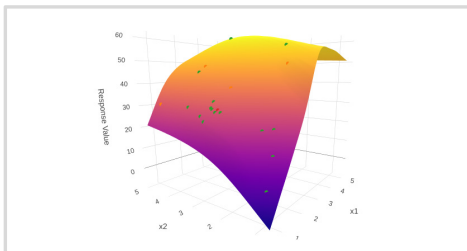
- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 76 tutorials

Capabilities



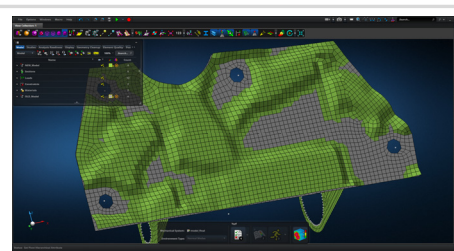
Web Apps for SOL 200

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



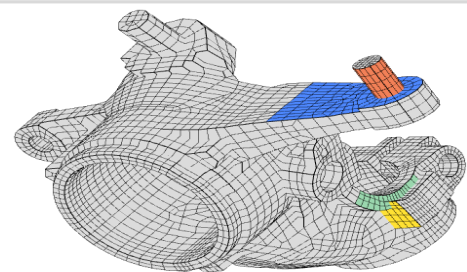
Machine Learning Web App

Bayesian Optimization for nonlinear response optimization (SOL 400)



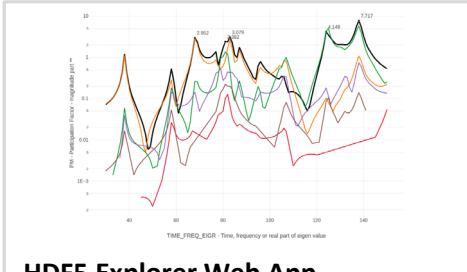
MSC Apex Post Processing Support

View the newly optimized model after an optimization



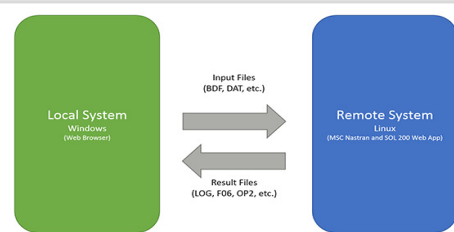
Shape Optimization Web App

Use a web application to configure and perform shape optimization.



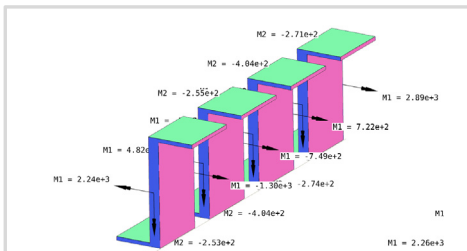
HDF5 Explorer Web App

Create XY plots using data from the H5 file



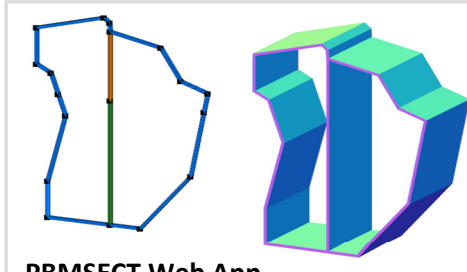
Remote Execution Web App

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



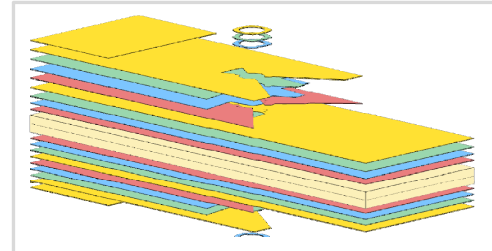
Beams Viewer Web App

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



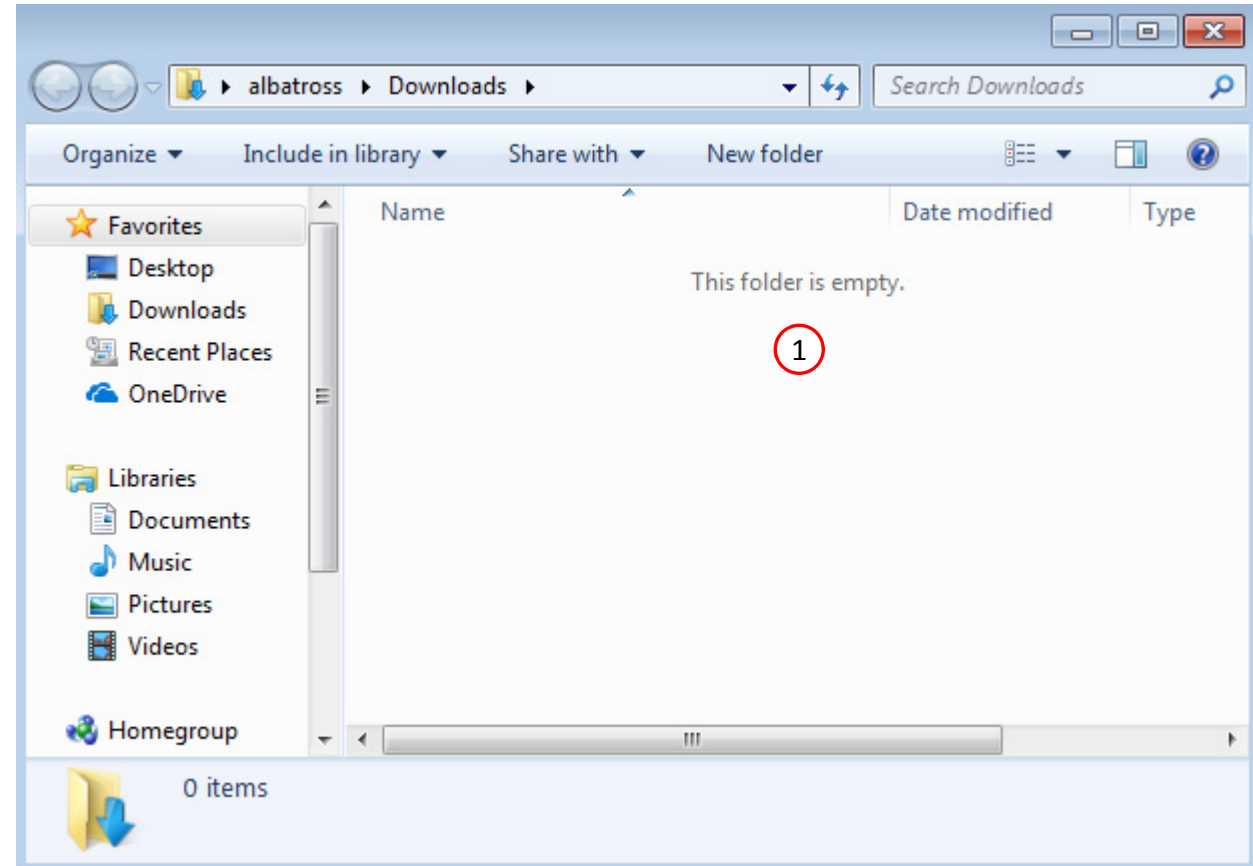
Stacking Sequence Web App

Optimize the stacking sequence of composite laminate plies

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

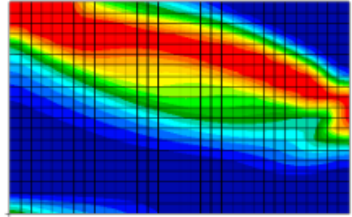
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



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.



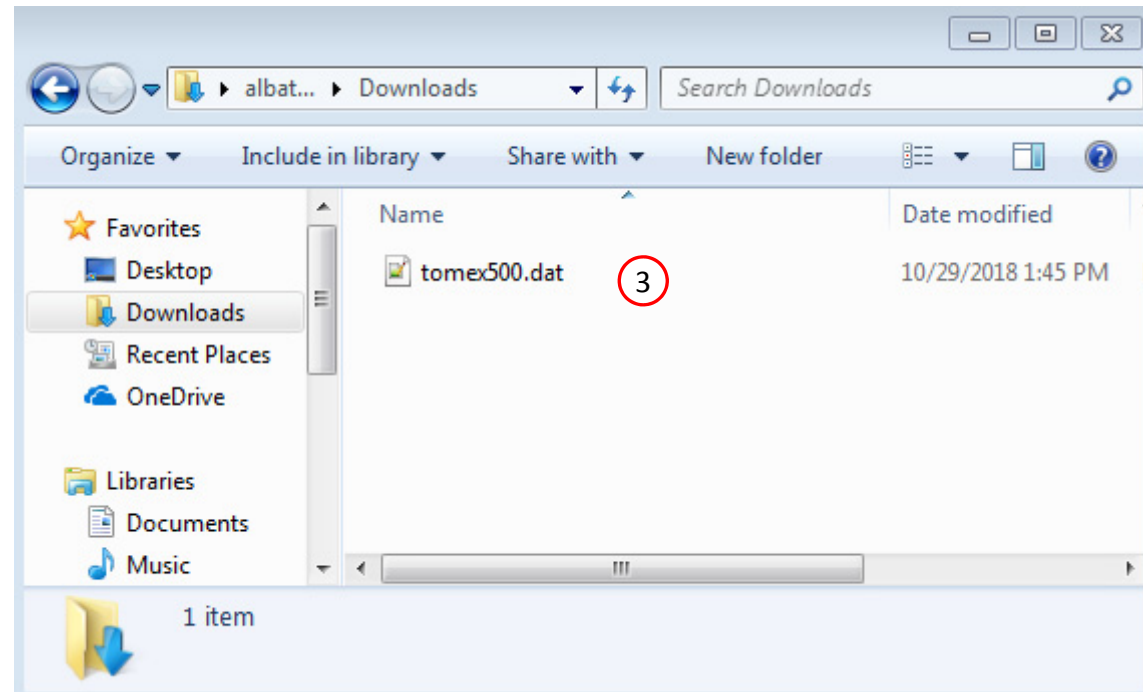
1

MSC Nastran Topometry Optimization of a Composite Panel

This tutorial covers the use of Topometry Optimization to determine ply shapes.

Starting BDF Files: [Link](#) **2**

Solution BDF Files: [Link](#)



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.

SOL 200 Web App

Select a web app to begin

Optimization for SOL 200

Multi Model Optimization

Machine Learning | Parameter Study

HDF5 Explorer

Remote Execution

Tutorials and User's Guide

Full list of web apps

Upload BDF Files

1. Click 1. Select Files and select tomex500.dat
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 two-step process for uploading files. Step 1, '1. Select files', is highlighted with a blue button and shows a file named 'tomex500.dat' selected. Below it is a green progress bar labeled 'Inspecting: 100%'. Step 2, '2. Upload files', is highlighted with a green button and shows a green progress bar labeled 'Uploading: 100 %'. At the bottom, there is a checkbox labeled 'List of Selected Files' which is currently unchecked.

1. Select files tomex500.dat

Inspecting: 100%

2. Upload files

Uploading: 100 %

☐ List of Selected Files

Create Design Region

1. Click Topometry
2. In the search box, type 'thickness'
3. Click on the plus (+) icons to set the thickness (Ti) of Plies 1-4 as Design Regions
4. Scroll to the section titled Step 2 – Adjust TOMVAR entries
5. The new Design Region is added to the table, no further edit is necessary

- Suppose the goal is to vary the thickness. In traditional Size optimization, the thickness can be a set a single design variable. With Topometry optimization, when the design region is set, each element in the region is given its own independent thickness design variable.
- If PSHELL 1 has 500 elements associated and is configured as a design region, then there will be 500 design variables created.
- Each step has hidden functionality for advanced users. The visibility is controlled by clicking +Options .
- If the property entry, e.g. PSHELL, was given a name in Patran, e.g. Car Door, the name can be shown by marking the checkbox titled Entry Name.

Size Topology **Topometry** **1** ography

Step 1 - Select design properties

+ Options

Create TOMVAR	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Current Value ⇅
	<input type="text" value="Search"/>	<input <b="" type="text" value="thickness"/> 2	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
3 <input type="checkbox"/>	T1	Thickness of ply	PCOMP	1	1.000
<input type="checkbox"/>	T2	Thickness of ply	PCOMP	1	1.000
<input type="checkbox"/>	T3	Thickness of ply	PCOMP	1	1.000
<input type="checkbox"/>	T4	Thickness of ply	PCOMP	1	1.000

5 10 20 30 40 50
Number of Visible Rows 5

4 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"/>
<input checked="" type="checkbox"/>	z1	<input checked="" type="checkbox"/>	T1	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
<input checked="" type="checkbox"/>	z2	<input checked="" type="checkbox"/>	T2	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
<input checked="" type="checkbox"/>	z3	<input checked="" type="checkbox"/>	T3	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
<input checked="" type="checkbox"/>	z4	<input checked="" type="checkbox"/>	T4	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'

Create Design Region

1. Scroll to the section titled Step 3 – Optional – Create variable links for TOMVARs
2. Click 2 times on +Create DLINK
3. Create design variables links for the thickness of ply 1 and 3
 1. Dependent Design Variables: z3
 2. Equation: z1
4. Create design variables links for the thickness of ply 2 and 4
 1. Dependent Design Variables: z4
 2. Equation: z2

- It is important to verify the Equation is configured properly. For example, the variable z3 is initially equal to 1.0. When the Equation is configured, it should also produce an initial value of 1.0. The resulting value of the Equation is displayed on the column titled Value of Equation and can be used to validate the Equation is configured properly.

Step 3 - Create variable links for TOMVARs

					2	+ Create DLINK
	Status ▾	Dependent Design Variables ▾	Equation (Independent Design Variables) ▾	Value of Equation ▾		
	Search	Search	Search	Search		
✖	✔	z3 3.1	z1 3.2	1.		
✖	✔	z4 4.1	z2 4.2	1.		

Create Design Objective

1. Click on Objective
2. Type 'comp' in the search box
3. Select the plus(+) icon for Compliance
4. The objective with label r0 is created.
The objective is to minimize (MIN)


• The objective must always be a single scalar response. A response such as weight and volume are single responses and can be used as an objective. Other responses require special care when set as an objective. For example, if the objective is stress, only the stress of a single component, e.g. von Mises, of a single element, of a single load case may be used.

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="comp"/>
3 	Compliance (Product of displacement and the applied load)	COMP

5 10 20 30 40 50

Step 2 - Adjust objective

+ Options

	Label	Status	Response Type	Maximize or Minimize	Property Type	ATTA	ATTB	ATTI
	r0		COMP	4 MIN ▾				

Create Design Constraints

1. Click Constraints
2. Click on the plus (+) icon for Weight
3. Configure the following for r1:
 - Upper Allowed Limit: 38.0

- The constraints are defined normally as would be done in a size optimization.

Step 1 - Select constraints

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 constraints

+ Options

	Label ▾	Status ▾	Response Type ▾	Property Type ▾	ATTA ▾	ATTB ▾	ATTi ▾	Lower Allowed Limit	Upper Allowed Limit
	<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"/>
x	r1	✓	WEIGHT		3 ▾	3 ▾		Lower	38.0

Configure Optimization Settings

1. Click Settings
2. Set P2 to 12 – Print constraints and responses

- The P2 setting controls the output of the following information to the F06 file: objective, constraints, responses, properties and design variables.
- This is a topometry optimization and will generate a large amount of property and design variable data in the F06 file. To make the F06 file size manageable, the design variable information is omitted by using the P2=12 option. When the results are viewed, note that the objective and constraint information is plotted, but the design variable history is not plotted due to the P2=12 option.
- If this is a combined size and topometry optimization, P2 should be set to 15. If this is a pure size optimization, P2 should be set to 15.

1

Optimization Settings

Parameter ▾	Description ▾	Configure ▾
Search	Search	Search
APRCOD	Approximation method to be used	<input type="checkbox"/> 2 - Mixed Method ▾
CONV1	Relative criterion to detect convergence	<input type="checkbox"/> Enter a positive real number
CONV2	Absolute criterion to detect convergence	<input type="checkbox"/> Enter a positive real number
DELX	Fractional change allowed in each design variable during any optimization cycle	<input type="checkbox"/> Enter a positive real number
DESMAX	Maximum number of design cycles to be performed	<input checked="" type="checkbox"/> 20
DISBEG	Design cycle number for discrete variable processing initiation	<input type="checkbox"/> Enter a positive integer
GMAX	Maximum constraint violation allowed at the converged optimum	<input type="checkbox"/> Enter a positive real number
P1	Print items, e.g. objective, design variables, at every n-th design cycle to the .f06 file	<input checked="" type="checkbox"/> 1
P2	Items to be printed to the .f06 file	<input checked="" type="checkbox"/> 12 - Print constraints and responses ▾
TCHECK	Topology Checkerboarding	<input type="checkbox"/> -1 - Automatic selection (Default) ▾
TDMIN	Minimum diameter of members in topology optimization	<input type="checkbox"/> Enter a positive real number
TREGION	Trust Region	<input type="checkbox"/> 1 - Trust Region On ▾

2

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"

SOL 200 Web App - Optimization Upload Variables Objective Constraints Subcases **1** Exporter Results Settings Match Other User's Guide Home

BDF Output - Model

```
assign userfile = 'optimization_results.csv', status = unknown,
form = Formatted, unit = S2
$ id msc, tomex.dat $ xmy 3-Mar-2009 mdr4
$ PCOMP PLY-BY-PLY TOPOMETRY OPT
SOL 200
CEND

SEALL = ALL
SUPER = ALL
TITLE = PCOMP PLY-BY-PLY TOPOMETRY WITH IPOPT
ECHO = NONE
MAXLINES = 999999999
  DESOBJ(MIN) = 8000000
  DESGLB = 40000000
  $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1
  ANALYSIS = STATICS
  $ DESSUB slot
  $ DRSPAN slot
  SUBTITLE=Default
  SPC = 1
  LOAD = 3
  displacement(plot,sort1,real)=all
  spcforces(plot,sort1,real)=all
  stress(plot,sort1,real,vonmises,center)=all
BEGIN BULK
INCLUDE './design_model.bdf'
```

Download BDF Files

[Download BDF Files](#) **2**

BDF Output - Design Model

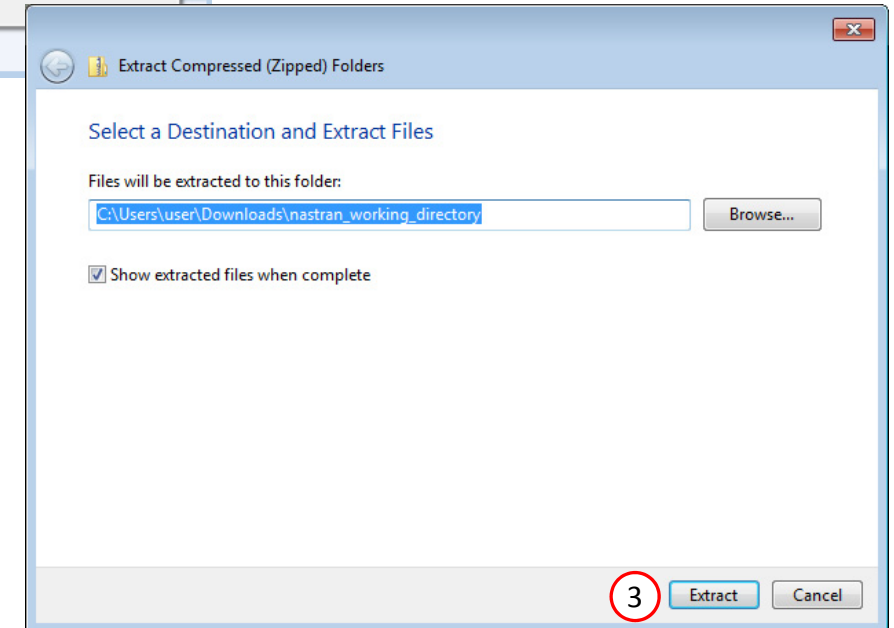
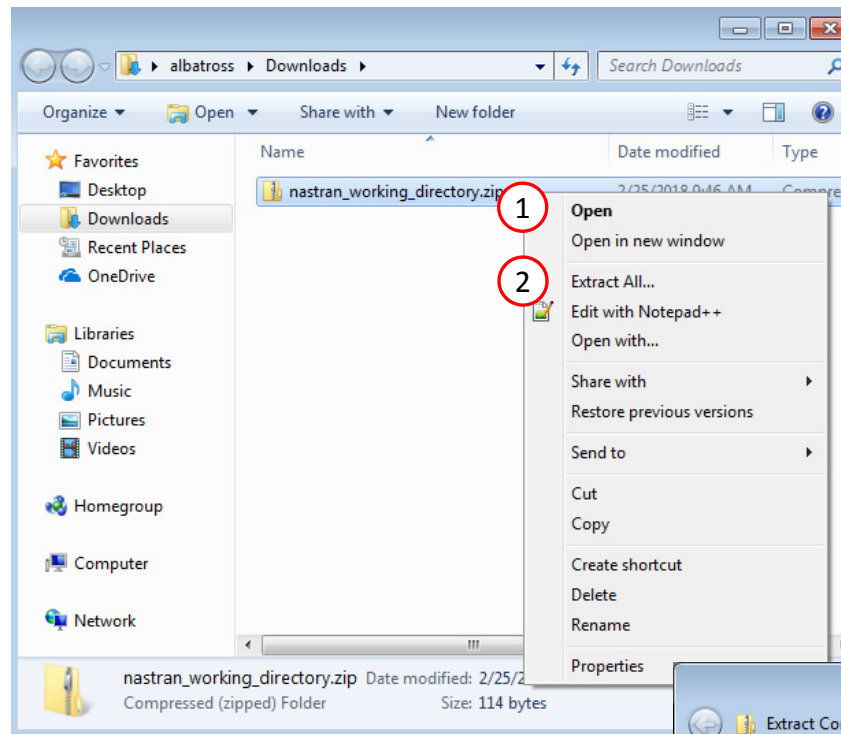
```
$*****
$
$          Design Model
$
$*****
$
$          Design Regions/Variables
$-----
$
$
TOMVAR 3000001 PCOMP 1 T1 1.000 .001
TOMVAR 3000002 PCOMP 1 T2 1.000 .001
TOMVAR 3000003 PCOMP 1 T3 1.000 .001
      DLINK 3000001 1.0
TOMVAR 3000004 PCOMP 1 T4 1.000 .001
      DLINK 3000002 1.0
$
$
$
$          Design Objective
$-----
$
$
DRESP1 8000000 r0 COMP
$
$
$          Design Constraints
$-----
$
$
DRESP1 8000001 r1 WEIGHT 3 3
$
$
$
DCONSTR 30001 8000001 30.
$
$          Design Equation Constraints
$-----
$
$
$
$
```

Developed by The Engineering Lab

Perform the Optimization with Nastran SOL 200

1. A new .zip file has been downloaded
2. Right click on the file
3. Click Extract All
4. Click Extract on the following window

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



Perform the Optimization with Nastran SOL 200

1. Inside of the new folder, double click on Start MSC Nastran
2. Click Open, Run or Allow Access on any subsequent windows
3. MSC Nastran will now start

- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
 - 1) Copy the BDF files and the INCLUDE files to a remote machine.
 - 2) Run the MSC Nastran job on the remote machine.
 - 3) After completion, copy the BDF, F06, LOG, H5 files to the local machine.
 - 4) Click "Start MSC Nastran" to display the results.

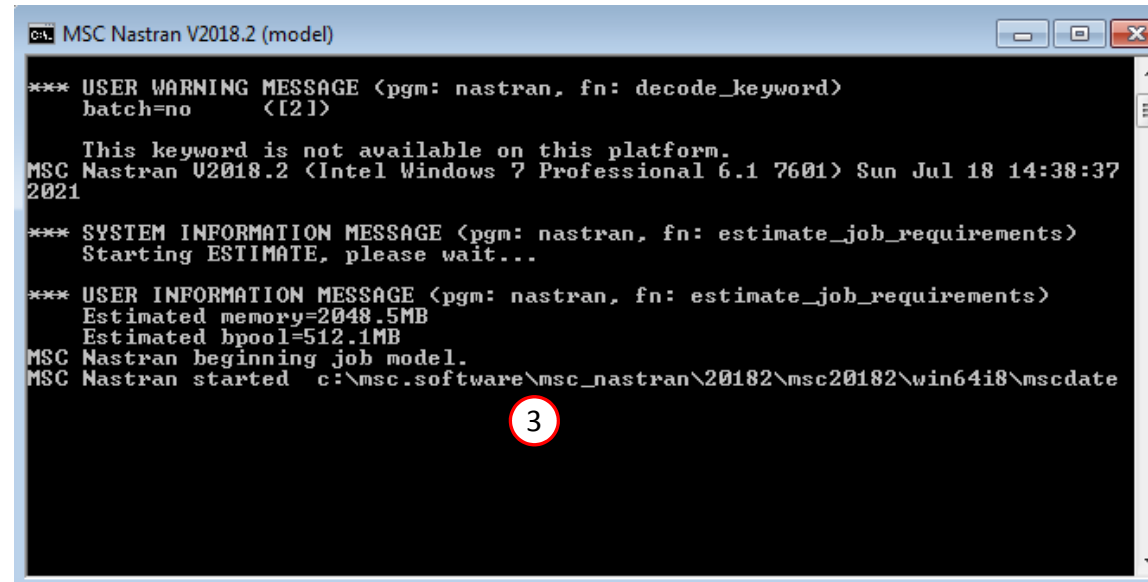
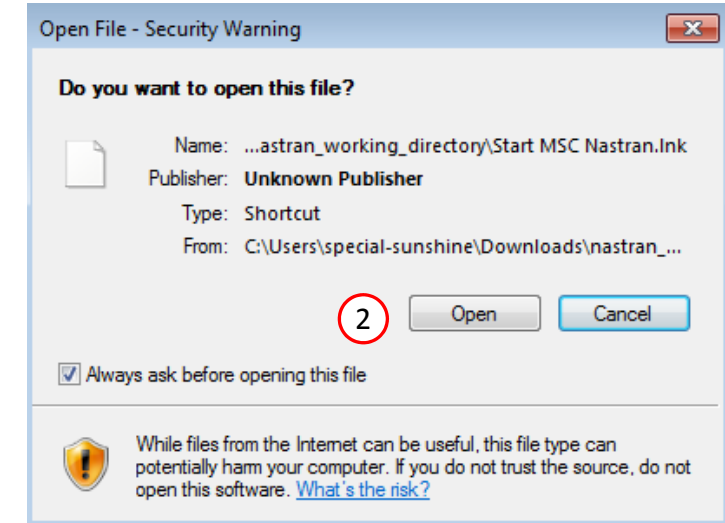
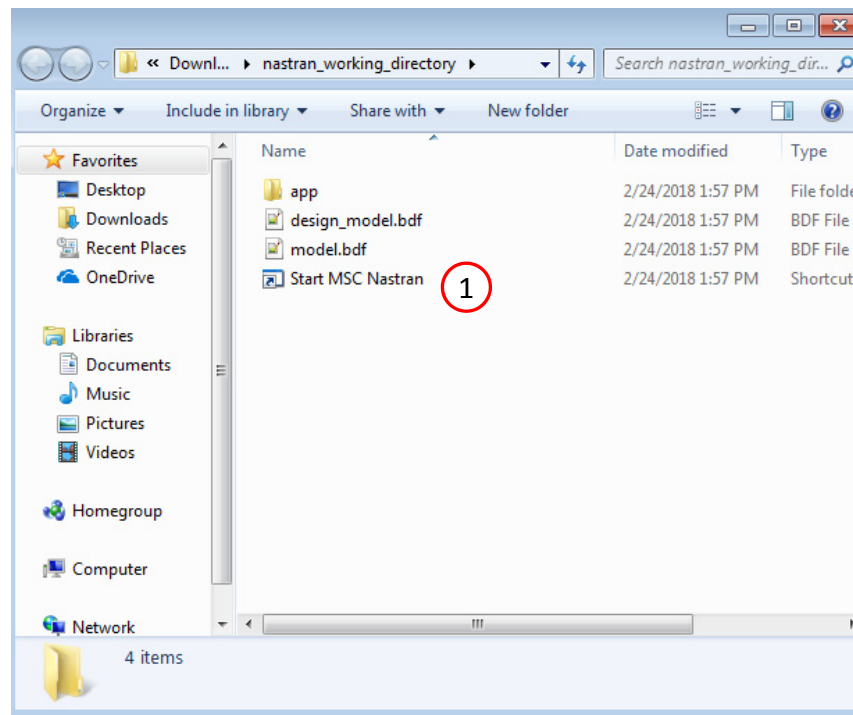
Using Linux?

Follow these instructions:

- 1) Open Terminal
- 2) Navigate to the nastran_working_directory
`cd ./nastran_working_directory`
- 3) Use this command to start the process
`./Start_MSC_Nastran.sh`

In some instances, execute permission must be granted to the directory. Use this command. This command assumes you are one folder level up.

```
sudo chmod -R u+x ./nastran_working_directory
```



Status

1. While MSC Nastran is running, a status page will show the current state of MSC Nastran

- The status of the MSC Nastran job is reported on the Status page. Note that Windows 7 users will experience a delay in the status updates. All other users of Windows 10 and Red Hat Linux will see immediate status updates.

SOL 200 Web App - Status

 Python

 MSC Nastran

Status

Name	Status of Job	Design Cycle	RUN TERMINATED DUE TO
model.bdf	Running	None	

Review Optimization Results

After MSC Nastran is finished, the results will be automatically uploaded.

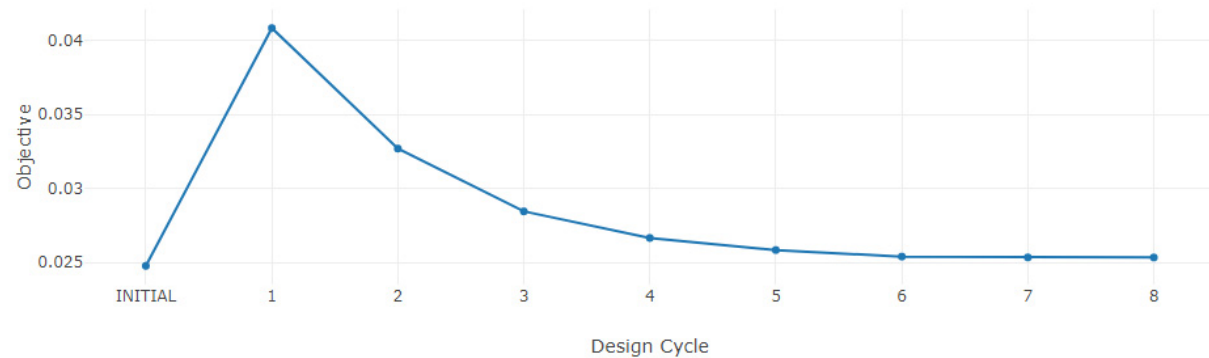
1. Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
2. The final value of objective, normalized constraints (not shown here) and design variables can be reviewed.

- Note that in a Topometry optimization, hundreds or thousands of design variables can be created. In this situation, the Design Variables are not plotted and displayed. Instead, the Objective and Normalized Constraints are displayed. It is recommended that a traditional post-processor be used to review the design variable results.

1 Final Message in .f06

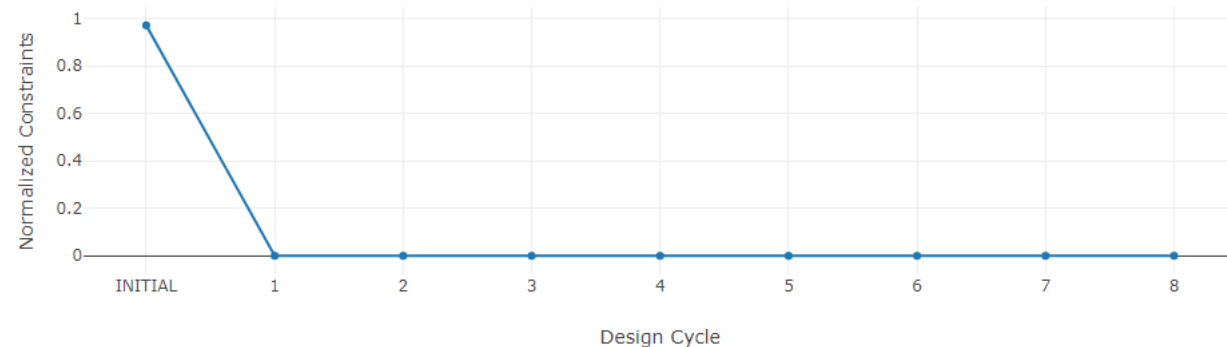
✓ RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 8.

Objective



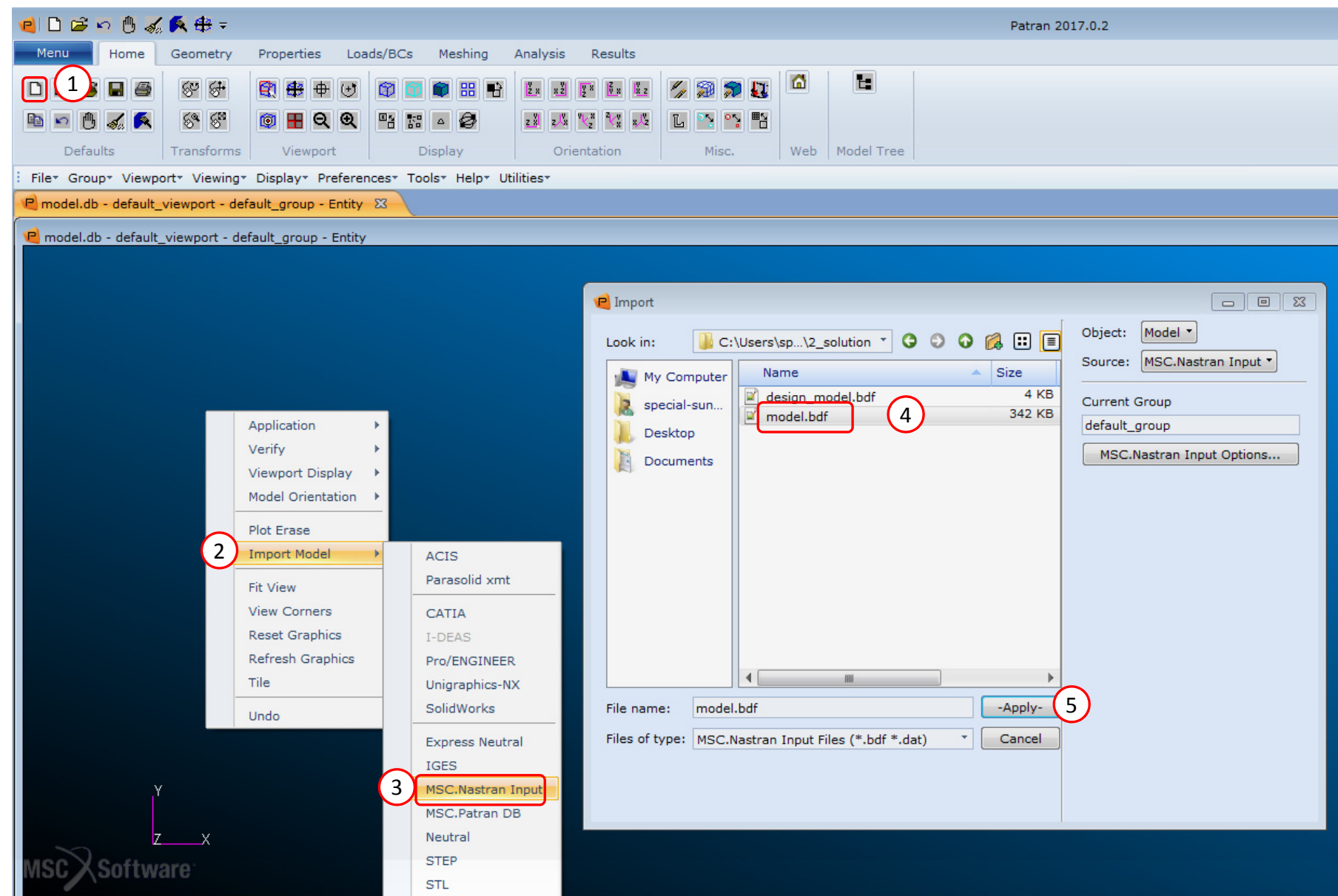
2 Normalized Constraints

+ Info



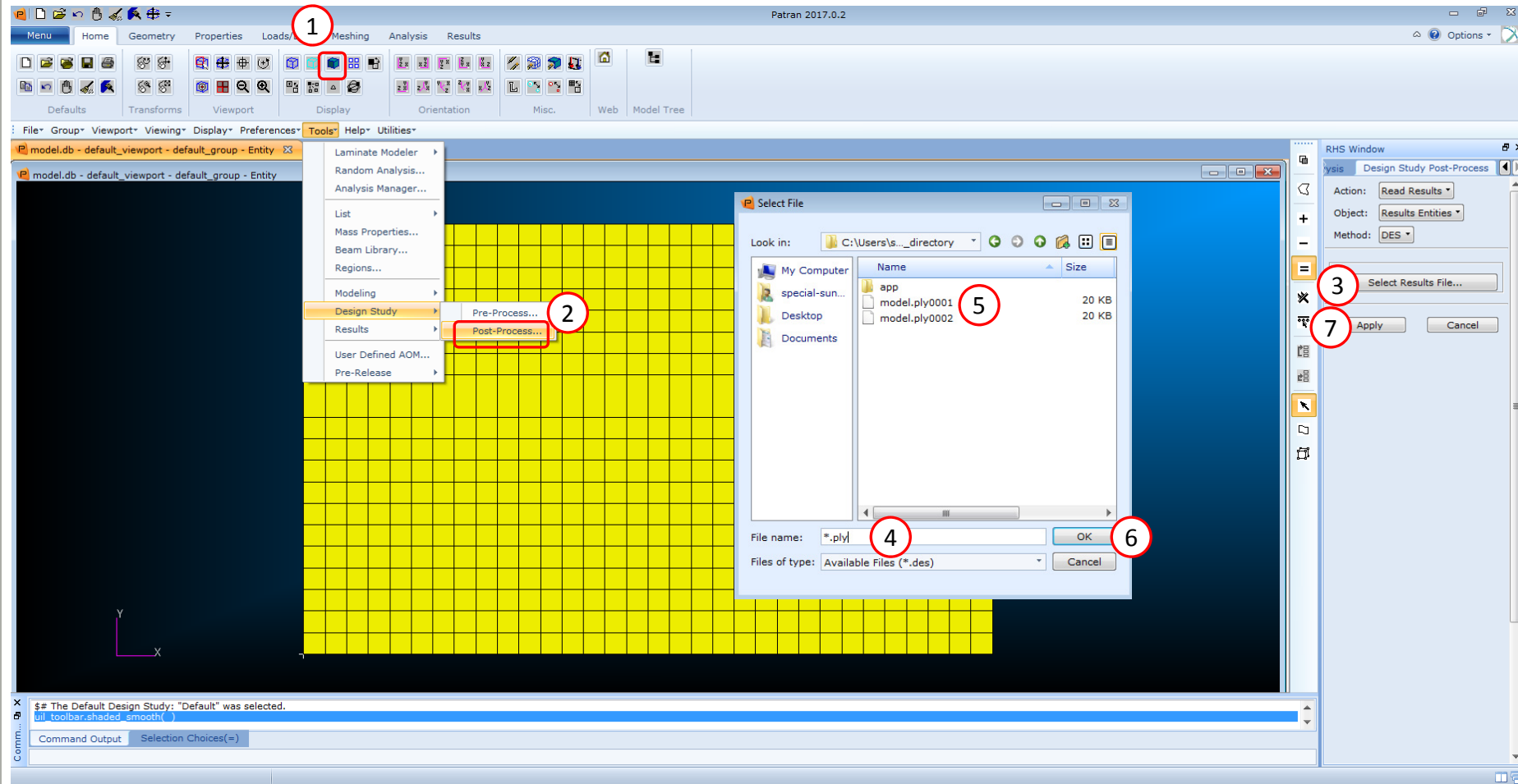
Review Optimization Results in Patran

1. Start a new Patran session
2. Right click to open a menu
3. Go to Import Model and click on MSC.Nastran Input
4. Select model.bdf (This file was used for the optimization)
5. Click Apply



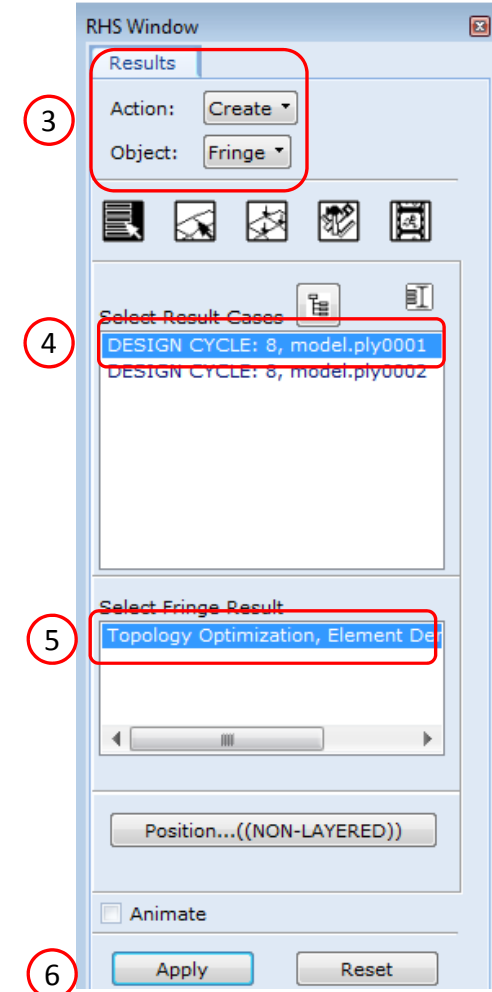
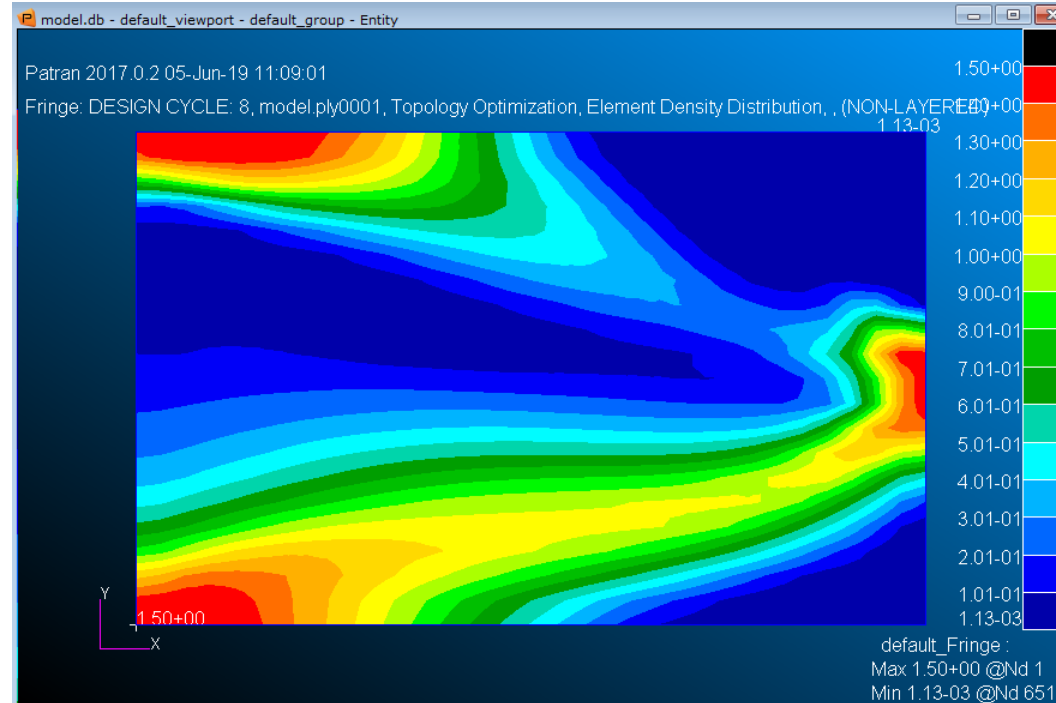
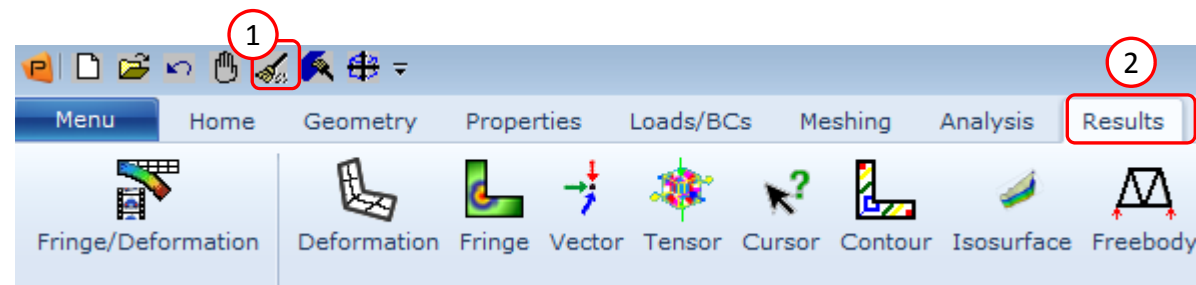
Review Optimization Results in Patran

1. Click Smooth Shading
2. Go to Tools > Design Study and click on Post-Process
3. Click Select Results File
4. Type "*.ply" and press the enter key to show all the files in the folder
5. Select model.ply0001 (This file was created during the optimization)
6. Click OK
7. Click Apply
8. Repeat steps 3-7 for the following files:
 1. model.ply0002

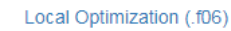
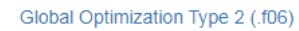
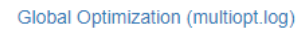


Review Optimization Results in Patran

1. Click the clear icon
2. Click Results
3. Set the following:
 - Action: Create
 - Object: Fringe
4. Select: DESIGN CYCLE: 8, model.ply0001
(The row should be highlighted blue)
5. Select Topology Optimization, Element D...
(The row should be highlighted blue)
6. Click Apply
7. Repeat steps 4-6 for the following:
 - DESIGN CYCLE: 8, model.ply0002



1. Click Results
2. Click PCH to BDF



Converter

PCH to BDF

Update the Original Model

The original .bdf/.dat file has old information about the properties. The properties will be updated.

1. Select the model.pch file
2. Select the original file: tomex500.dat
3. Select the design_model.bdf file
4. A summary of updates that will be performed are shown
5. Click Download and a new updated BDF file is downloaded

In the V3.5 release, the PCH to BDF app supports updated PCOMP entries generated by a Topometry optimization. The associated 2D elements, e.g. CQUAD4, are also updated. All other properties generated by a Topometry optimization, such as PSHELL and PWELD properties are not supported. If performing Size optimization, the PCH to BDF app supports PCOMP, PSHELL and PWELD properties.

Nastran SOL 200 Web App - PCH to BDF

Step 1 - Select PCH File

Select files **1**

Inspecting: 100%

☐ List of Selected Files

Step 2 - Select BDF Files

Select files **2**

Inspecting: 100%

☐ List of Selected Files

Select design_model.bdf File

Select files **3**

Inspecting: 100%

☐ List of Selected Files

PCH Entries

CQUAD4	1	10000001	1	2	23	22
CQUAD4	2	10000002	2	3	24	23
CQUAD4	3	10000003	3	4	25	24
CQUAD4	4	10000004	4	5	26	25
CQUAD4	5	10000005	5	6	27	26
CQUAD4	6	10000006	6	7	28	27
CQUAD4	7	10000007	7	8	29	28
CQUAD4	8	10000008	8	9	30	29
CQUAD4	9	10000009	9	10	31	30
CQUAD4	10	10000010	10	11	32	31

\$ Only the first 10 element entries are previewed.
\$ The final download will include all the updated 2D element entries.

PCOMP	10000001-.0105	0.0	650000.	TSAI	0.0	0.0	SYM
	70 1.5	80.	YES	70 .774108-65.			YES
	70 1.5	80.	YES	70 .774108-65.			YES
PCOMP	10000002-.0105	0.0	650000.	TSAI	0.0	0.0	SYM
	70 1.39312	80.	YES	70 .052964-65.			YES
	70 1.39312	80.	YES	70 .052964-65.			YES
PCOMP	10000003-.0105	0.0	650000.	TSAI	0.0	0.0	SYM

4



BDF Entries

CQUAD4	1	1	1	2	23	22
CQUAD4	2	1	2	3	24	23
CQUAD4	3	1	3	4	25	24
CQUAD4	4	1	4	5	26	25
CQUAD4	5	1	5	6	27	26
CQUAD4	6	1	6	7	28	27
CQUAD4	7	1	7	8	29	28
CQUAD4	8	1	8	9	30	29
CQUAD4	9	1	9	10	31	30
CQUAD4	10	1	10	11	32	31

\$ Only the first 10 element entries are previewed.
\$ The final download will include all the updated 2D element entries.

ENDDATA 5c8b7a30

Step 3 - Download New BDF Files

On download, the PCH entries will replace older BDF entries.

Download

5

Update the Original Model

1. Since this was a topometry optimization, each element has been given its own PCOMP entry with updated thicknesses for plies 1, 2, 3 and 4. The PCH to BDF web app transfers the new PCOMP entries from the .pch file to the tomex500.dat file.
2. In addition, each CQUAD4 element must be updated to point to its new respective PCOMP entry, e.g.

tomex500.dat	tomex500 (1).dat
24 CQUAD4 1	24 CQUAD4 1 10000001
25 CQUAD4 2	25 CQUAD4 2 10000002
26 CQUAD4 3	26 CQUAD4 3 10000003
27 CQUAD4 4	27 CQUAD4 4 10000004
28 CQUAD4 5	28 CQUAD4 5 10000005
29 CQUAD4 6	29 CQUAD4 6 10000006
30 CQUAD4 7	30 CQUAD4 7 10000007
31 CQUAD4 8	31 CQUAD4 8 10000008
32 CQUAD4 9	32 CQUAD4 9 10000009
33 CQUAD4 10	33 CQUAD4 10 10000010
34 CQUAD4 11	34 CQUAD4 11 10000011
35 CQUAD4 12	35 CQUAD4 12 10000012
36 CQUAD4 13	36 CQUAD4 13 10000013
37 CQUAD4 14	37 CQUAD4 14 10000014
38 CQUAD4 15	38 CQUAD4 15 10000015
39 CQUAD4 16	39 CQUAD4 16 10000016
40 CQUAD4 17	40 CQUAD4 17 10000017

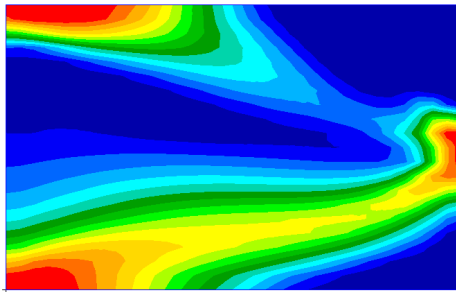
tomex500.dat	tomex500 (1).dat
1386 \$ Ultimate transverse compressive strength: 35.68E3 PSI	1384 \$ Ultimate longitudinal compressive strength: 217.56E3 PSI
1387 \$ Ultimate in-plane shear strength: 9.863E3 PSI	1385 \$ Ultimate transverse tensile strength: 5.802E3 PSI
1388 \$	1386 \$ Ultimate transverse compressive strength: 35.68E3 PSI
1389 \$ Source: Tsai, S.W. and Hahn, H.T., Introduction to Composite Materi	1387 \$ Ultimate in-plane shear strength: 9.863E3 PSI
1390 \$ FL, Table 1.7, p. 19; Table 7.1, p.292; Table 8.3, p. 342.	1388 \$
1391 \$ 1 2 3 4 5 6 7 8 9	1389 \$ Source: Tsai, S.W. and Hahn, H.T., Introduction to Composite Mate
1392 MAT8 70 26.25e6 1.49e6 .28 1.04e6 .0585	1390 \$ FL, Table 1.7, p. 19; Table 7.1, p.292; Table 8.3, p. 342.
1393 ENDDATA 5c8b7a30	1391 \$ 1 2 3 4 5 6 7 8 9
1394	1392 MAT8 70 26.25e6 1.49e6 .28 1.04e6 .05
1395	1393
1396	1394 PCOMP 10000001-.0105 0.0 650000. TSAI 0.0 0.0
1397	1395 70 1.5 80. YES 70 .774108-65.
1398	1396 70 1.5 80. YES 70 .774108-65.
1399	1397 PCOMP 10000002-.0105 0.0 650000. TSAI 0.0 0.0
1400	1398 70 1.39312 80. YES 70 .052964-65.
1401	1399 70 1.39312 80. YES 70 .052964-65.
1402	1400 PCOMP 10000003-.0105 0.0 650000. TSAI 0.0 0.0
1403	1401 70 .946061 80. YES 70 .011974-65.
1404	1402 70 .946061 80. YES 70 .011974-65.
1405	1403 PCOMP 10000004-.0105 0.0 650000. TSAI 0.0 0.0
1406	1404 70 .713549 80. YES 70 .001135-65.
1407	1405 70 .713549 80. YES 70 .001135-65.
1408	1406 PCOMP 10000005-.0105 0.0 650000. TSAI 0.0 0.0
1409	1407 70 .534361 80. YES 70 .001135-65.
1410	1408 70 .534361 80. YES 70 .001135-65.
1411	1409 PCOMP 10000006-.0105 0.0 650000. TSAI 0.0 0.0
1412	1410 70 .399395 80. YES 70 .001142-65.
1413	1411 70 .399395 80. YES 70 .001142-65.
1414	1412 PCOMP 10000007-.0105 0.0 650000. TSAI 0.0 0.0
1415	1413 70 .317016 80. YES 70 .00312 -65.
1416	1414 70 .317016 80. YES 70 .00312 -65.

Original BDF/DAT File

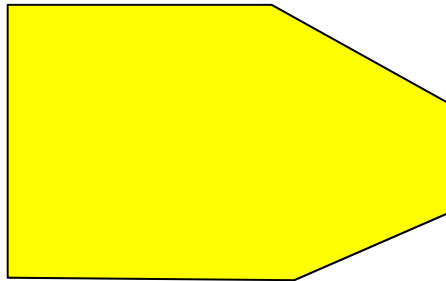
Downloaded BDF/DAT File

Results

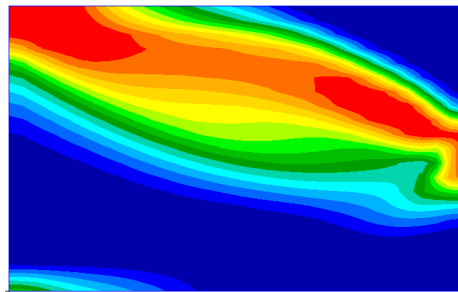
Topometry
Results



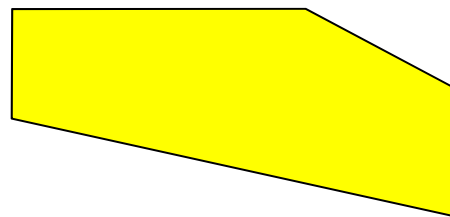
Ply 1 and 8
80°



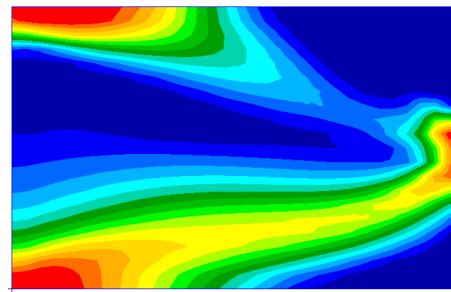
Ply 1 and 8
80°



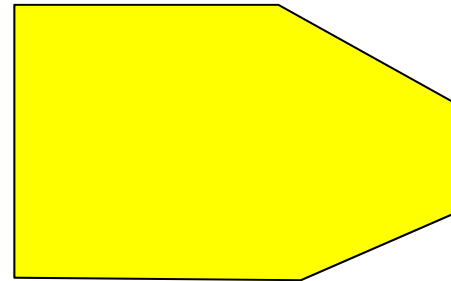
Ply 2 and 7
-65°



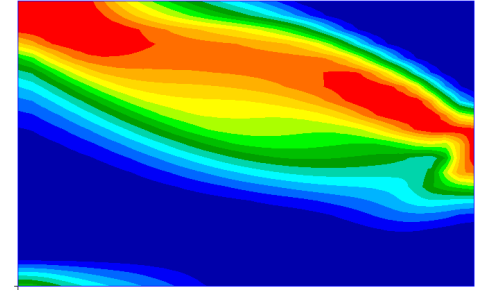
Ply 2 and 7
-65°



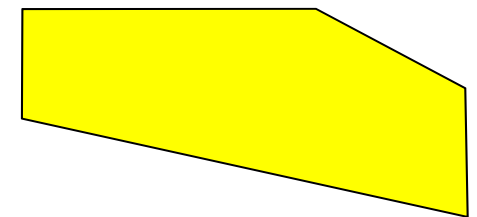
Ply 3 and 6
80°



Ply 3 and 6
80°



Ply 4 and 5
-65°



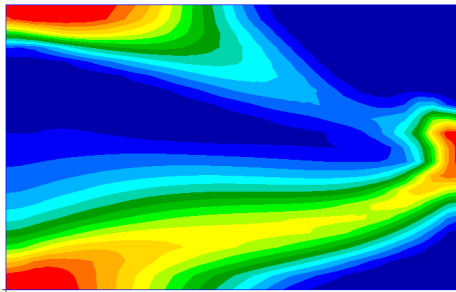
Ply 4 and 5
-65°

Possible Ply
Shapes

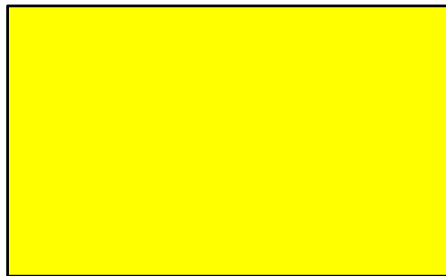
Results

Ply drop offs are employed for the -65 degree plies. In the interest of manufacturability, ply drop offs are not employed for the 80 degree plies.

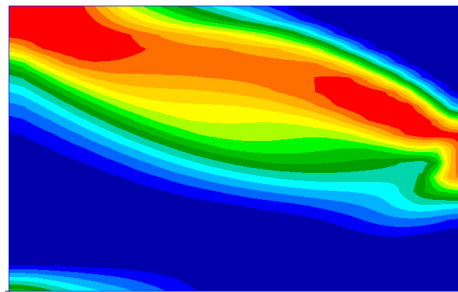
Topometry
Results



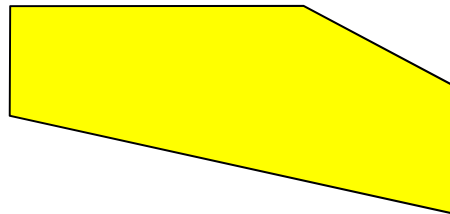
Ply 1 and 8
80°



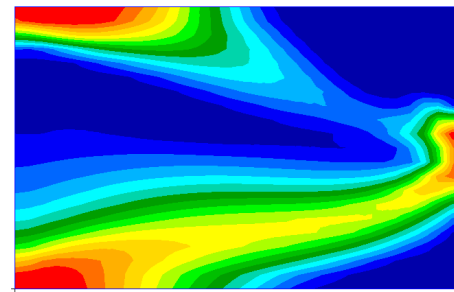
Ply 1 and 8
80°



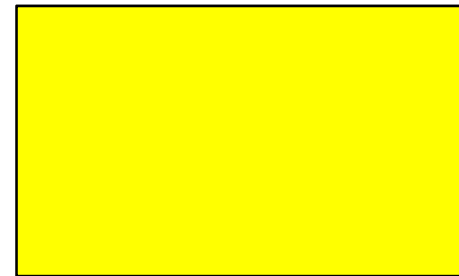
Ply 2 and 7
-65°



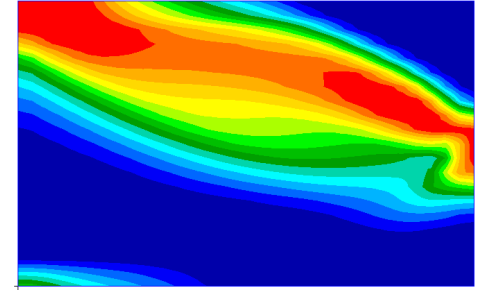
Ply 2 and 7
-65°



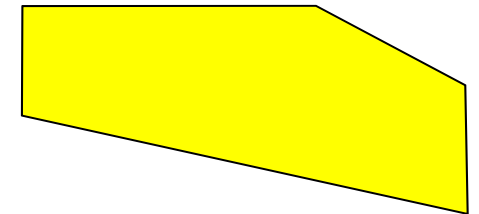
Ply 3 and 6
80°



Ply 3 and 6
80°



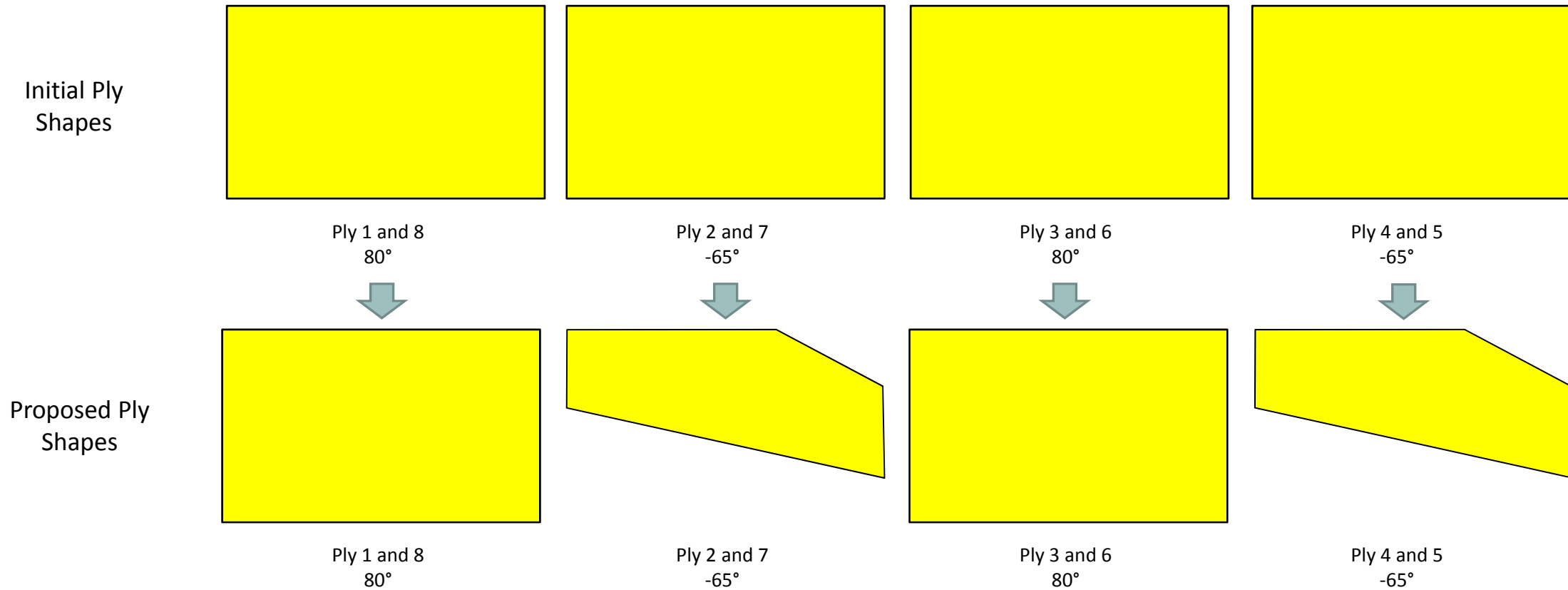
Ply 4 and 5
-65°



Ply 4 and 5
-65°

Proposed Ply
Shapes

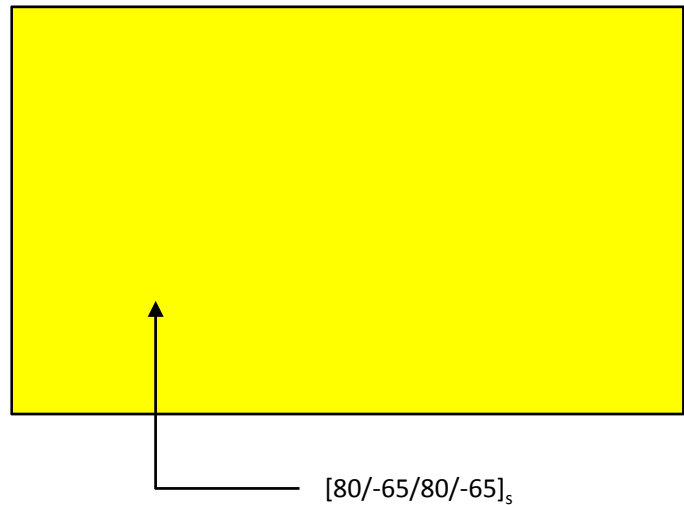
Results



Results

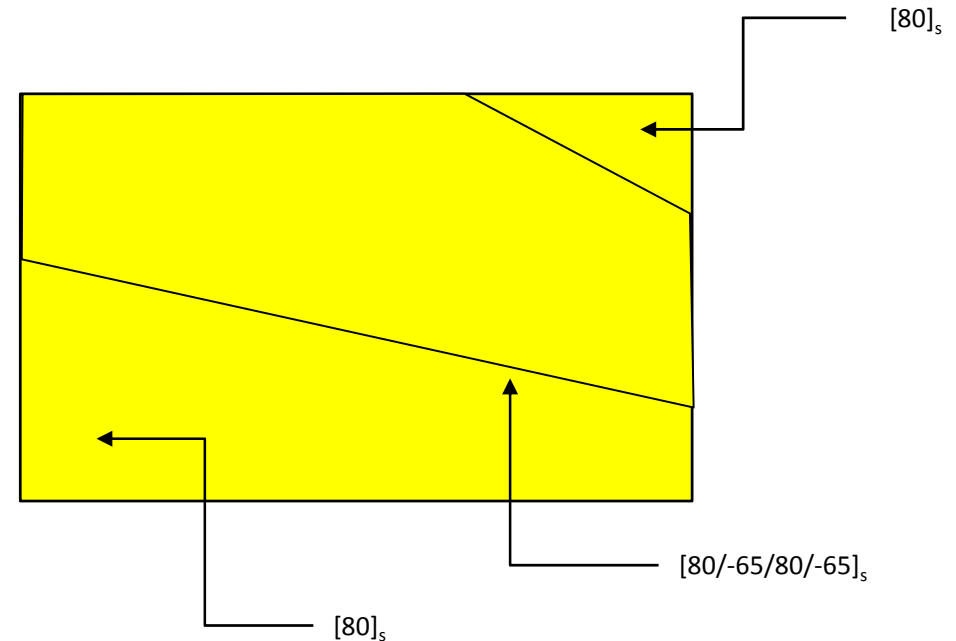
Before Optimization

- Panel of initial layup



After Optimization

- Panel of updated layups
- The weight is reduced



End of Tutorial