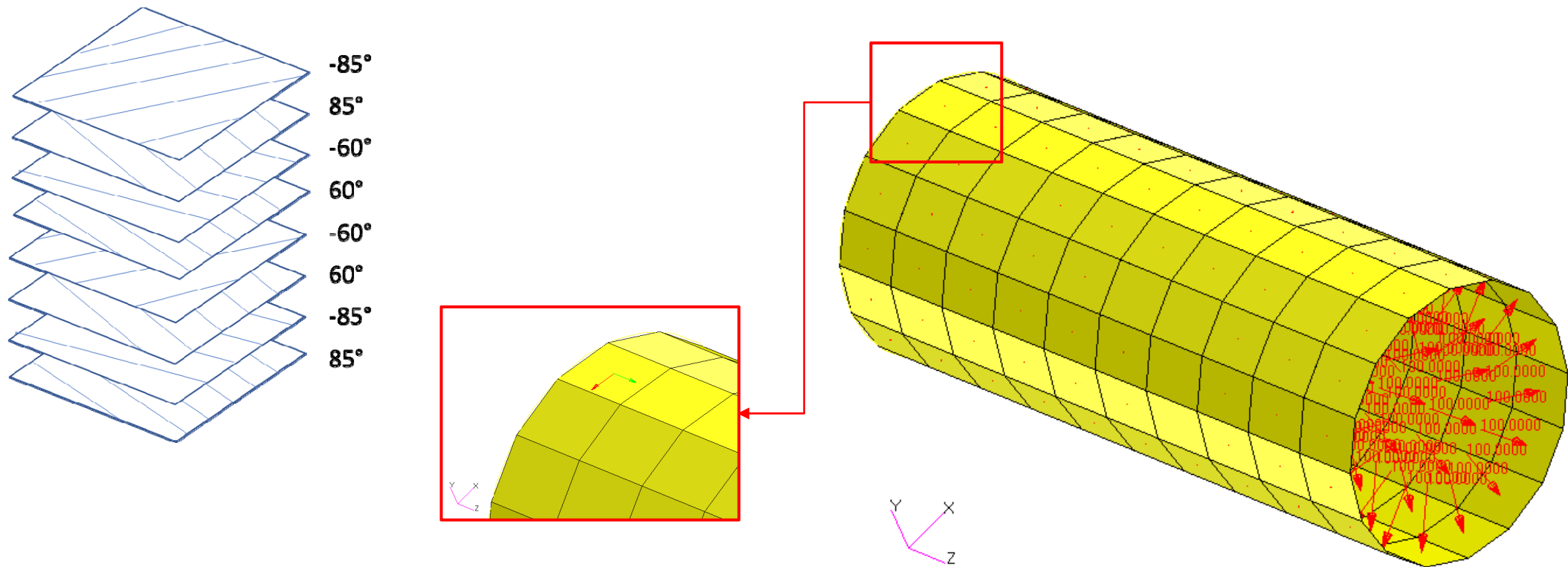


Automated Optimization of a Composite Laminate

PRESENTED BY CHRISTIAN APARICIO

Goal: Use Nastran SOL 200 Optimization



Goal: Use Nastran SOL 200 Optimization

Before Optimization

- Weight: $1.60 \text{ lb}_f \cdot \text{s}^2/\text{in}$
- Layup: [85/-85/60/-60/60/-60/85/-85]
- Thickness: .0100 in
- Plies are initially in failure

After Optimization

- Weight: $1.04 \text{ lb}_f \cdot \text{s}^2/\text{in}$
- Layup: [90/-90/0/0/0/0/90/-90]
- Thickness: .0065 in

Agenda

Details of the structural model

Optimization Problem Statement

Steps to use Nastran SOL 200 (Optimization)

- Convert a .bdf file to SOL 200
- Create:
 - Design Variables
 - Design Objective
 - Design Constraints
- Perform optimization with Nastran SOL 200

View optimization results

- Online Plotter
- Structural Results

Update the original structural model with optimized parameters

Contact me

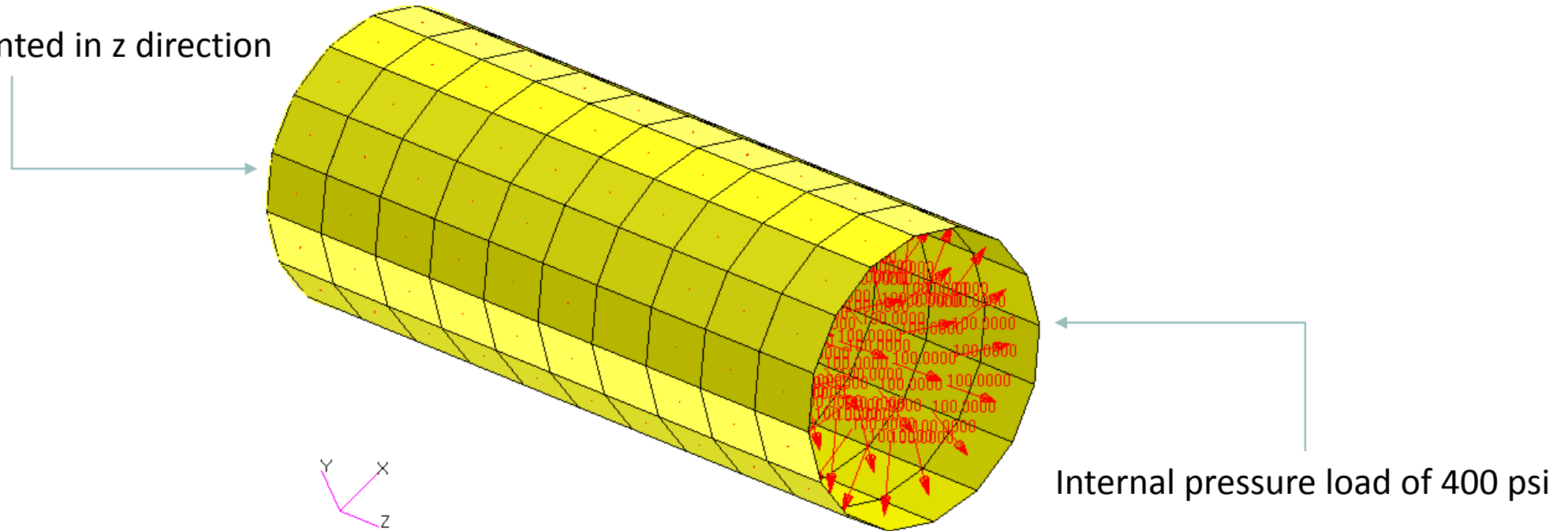
- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

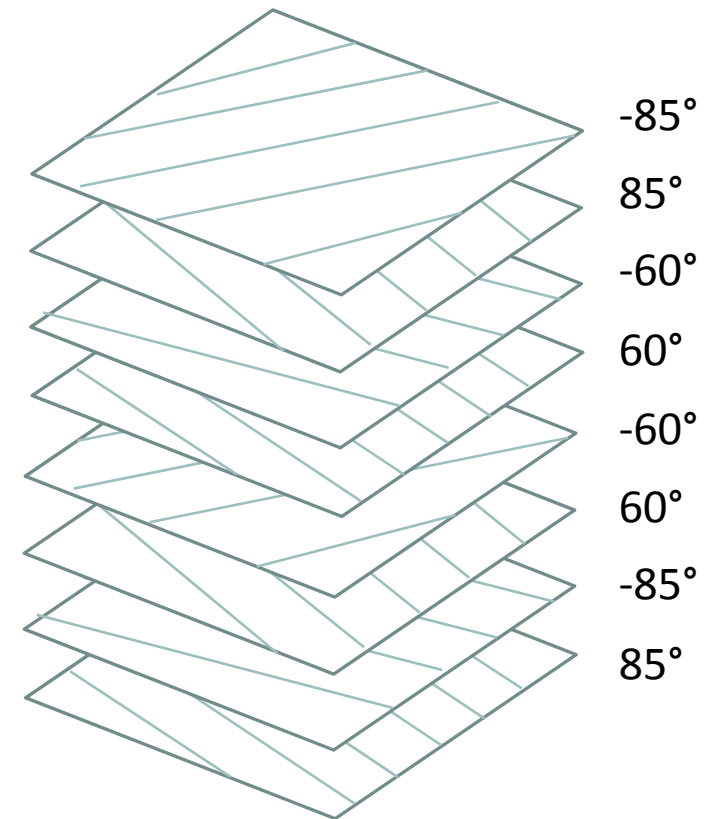
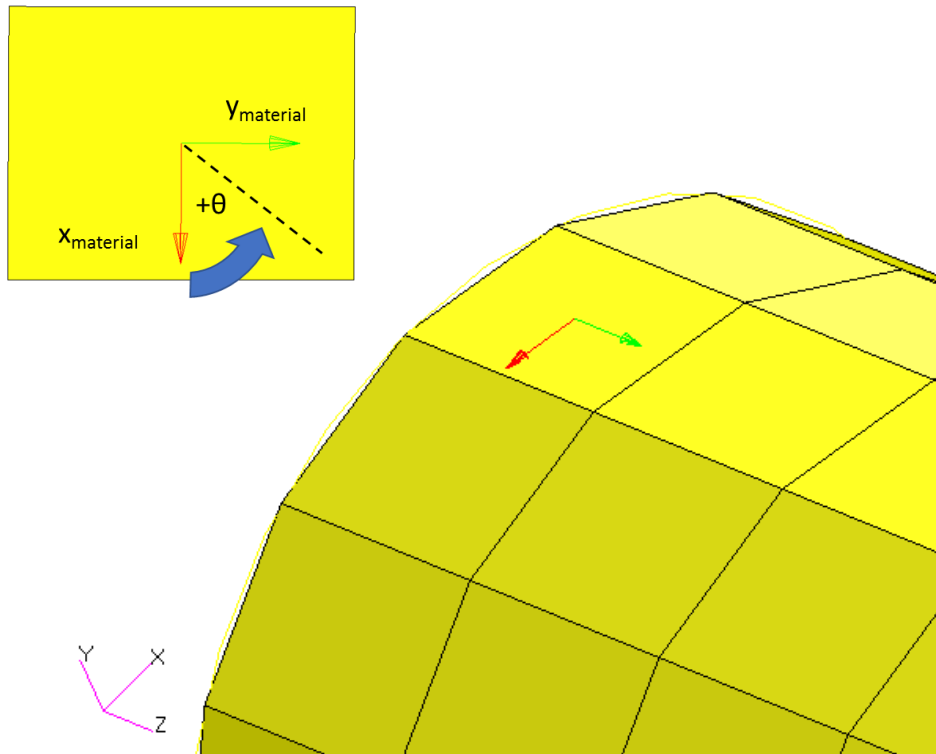
Details of the structural model

Allowed to translate in x and y

Translation prevented in z direction



Details of the structural model

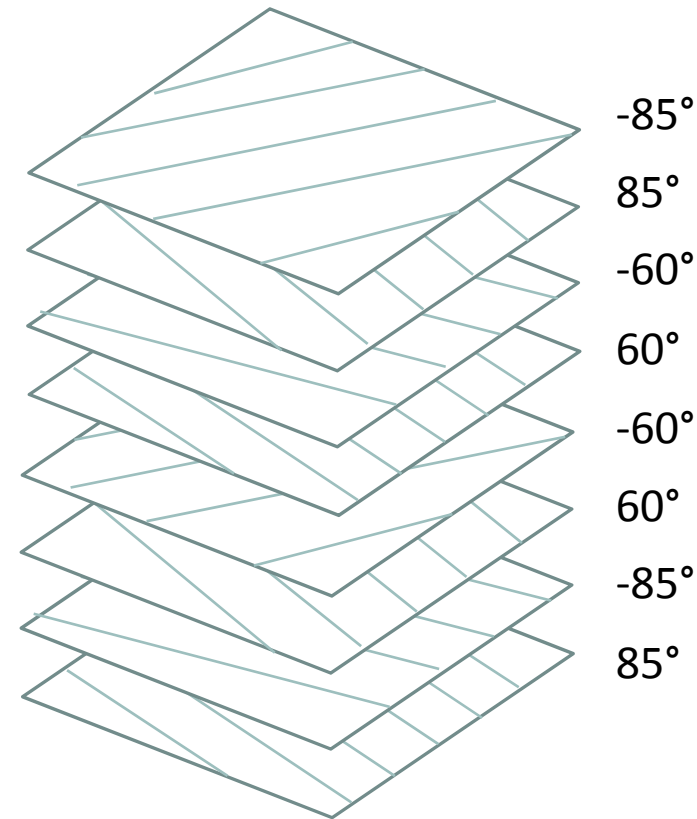


Optimization Problem Statement

Design Variables

Design Variables

- x_1 : thickness of lamina 1
 - $.001 < x_1 < 10$.
- ...
- x_8 : thickness of lamina 8
 - $.001 < x_8 < 10$.
- x_9 : orientation of lamina 1
 - $-90 < x_9 < 90$
- ...
- x_{16} : orientation of lamina 8
 - $-90 < x_{16} < 90$
- Allowed angles: -90, -85, -80.... 80, 85, 90

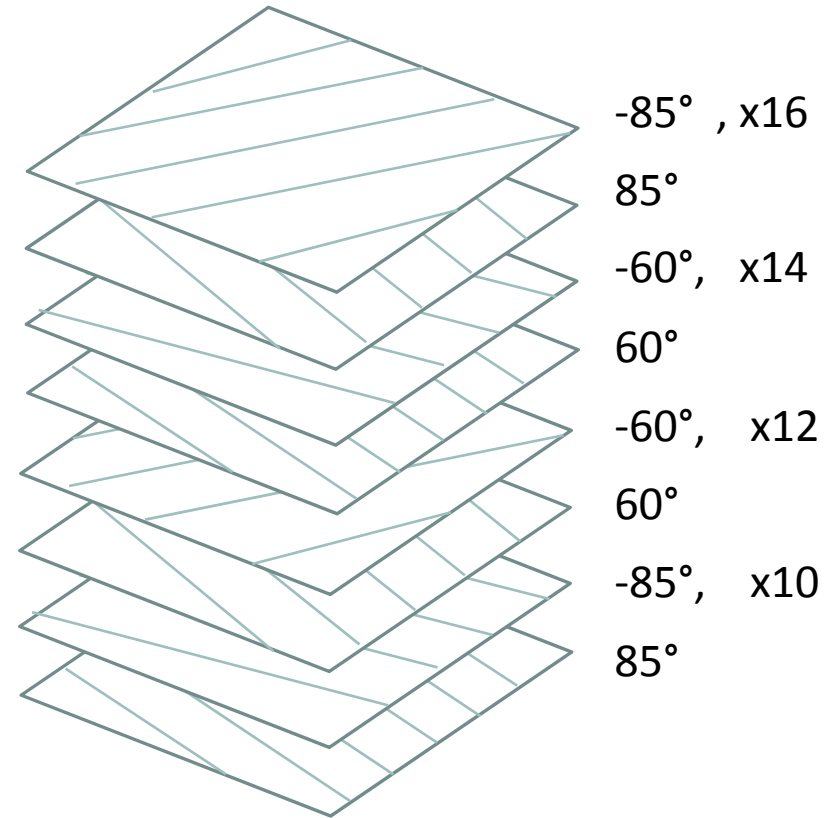


Optimization Problem Statement

Design Variable Linking

Design Variables

- All thicknesses will be equal
 - $x_2 = x_1$
 - $x_3 = x_1$
 - ...
 - $x_8 = x_1$
- The absolute value of laminas 1, 2, 7 and 8 will be equal
 - $x_{15} = x_9$
 - $x_{10}, x_{16} = x_9 * -1$
- The absolute value of laminas 3, 4, 5, 6
 - $x_{13} = x_{11}$
 - $x_{12}, x_{14} = x_{11} * -1$



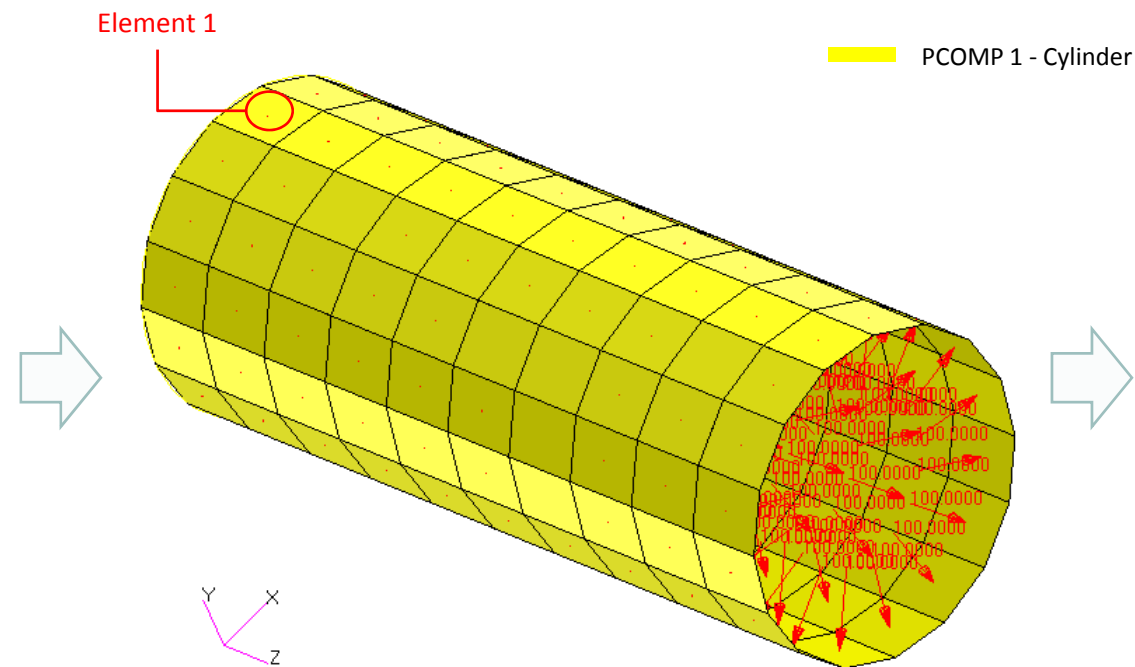
Optimization Problem Statement

Design Variables

x1: T of lamina 1 of PCOMP 1
x2: T of lamina 2
x3: T of lamina 3
x4: T of lamina 4
x5: T of lamina 5
x6: T of lamina 6
x7: T of lamina 7
x8: T of lamina 8
 $.001 < x_i < 10.$
x9: Orientation of lamina 1 of PCOMP 1
x10: Orientation of lamina 2
x11: Orientation of lamina 3
x12: Orientation of lamina 4
x13: Orientation of lamina 5
x14: Orientation of lamina 6
x15: Orientation of lamina 7
x16: Orientation of lamina 8
 $-90. < x_i < 90.$

Variable Linking

x2, x3, ..., x8 = x1
x15 = x9
x10, x16 = -1.0 * x9
x13 = x11
x12, x14 = -1.0 * x11



Responses

Displacements
Strains
Stresses
...

Optimization Problem Statement

Design Objective

r0: Minimize Weight

Optimization Problem Statement

Design Constraints

r1: failure index of lamina 1

- $r1 < .9$

...

r8: failure index of lamina 8

- $r8 < .9$

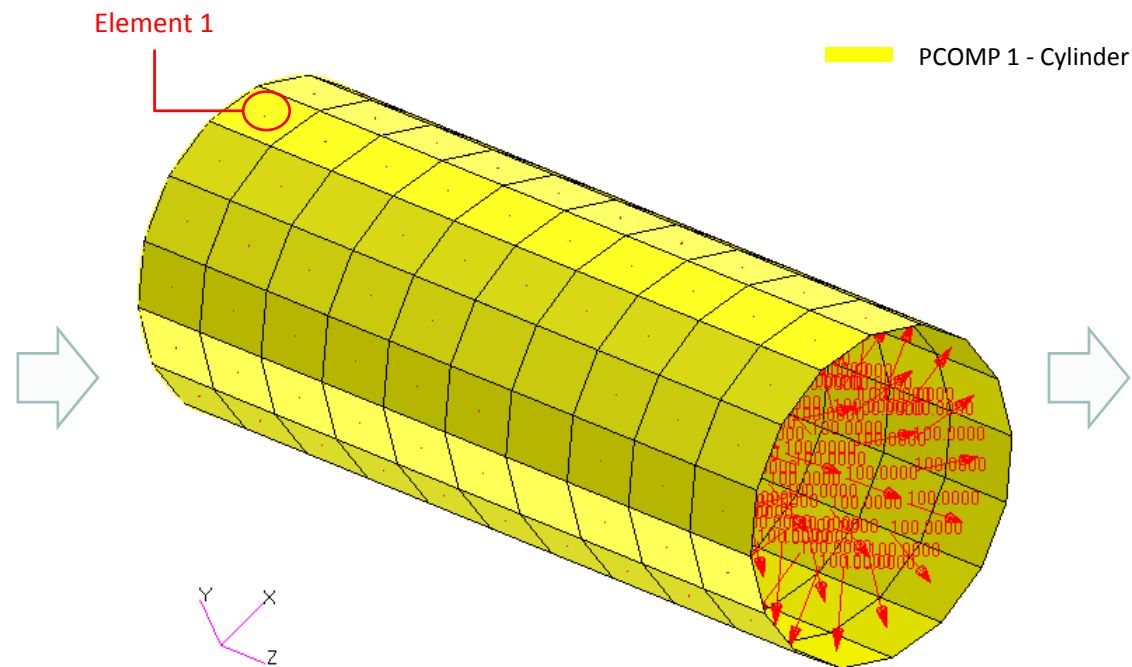
Optimization Problem Statement

Design Variables

x1: T of lamina 1 of PCOMP 1
x2: T of lamina 2
x3: T of lamina 3
x4: T of lamina 4
x5: T of lamina 5
x6: T of lamina 6
x7: T of lamina 7
x8: T of lamina 8
 $.001 < x_i < 10.$
x9: Orientation of lamina 1 of PCOMP 1
x10: Orientation of lamina 2
x11: Orientation of lamina 3
x12: Orientation of lamina 4
x13: Orientation of lamina 5
x14: Orientation of lamina 6
x15: Orientation of lamina 7
x16: Orientation of lamina 8
 $-90. < x_i < 90.$

Variable Linking

x2, x3, ..., x8 = x1
x15 = x9
x10, x16 = -1.0 * x9
x13 = x11
x12, x14 = -1.0 * x11



Design Objective

r0: Minimize weight

Design Constraints

r1: Failure index of lamina 1 of element 1
...
r8: Failure index of lamina 8 of element 1

$$r1, \dots, r8 < .9$$

Steps to use Nastran SOL 200 (Optimization)

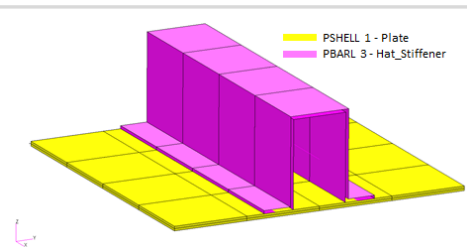
1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
 - Convert the .bdf file to SOL 200
 - Design Variables
 - Design Objective
 - Design Constraints
 - Perform optimization with Nastran SOL 200
3. Review optimization results
 - Online Plotter
 - Optimized structural results
4. Update the original model with optimized parameters

SOL 200 Web App Capabilities

Benefits

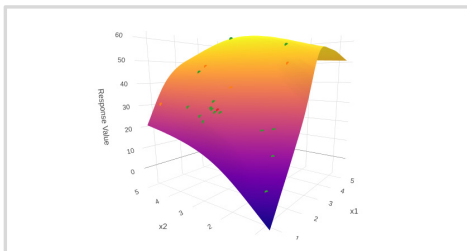
- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 76 tutorials

Capabilities



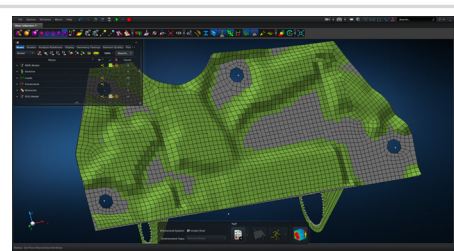
Web Apps for SOL 200

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



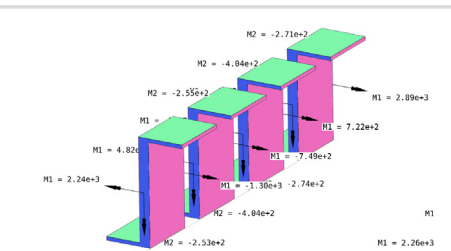
Machine Learning Web App

Bayesian Optimization for nonlinear response optimization (SOL 400)



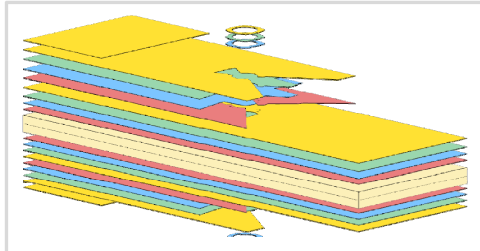
MSC Apex Post Processing Support

View the newly optimized model after an optimization



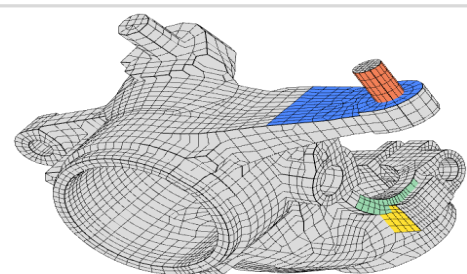
Beams Viewer Web App

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



Ply Shape Optimization Web App

Spread plies optimally and generate new PCOMP entries



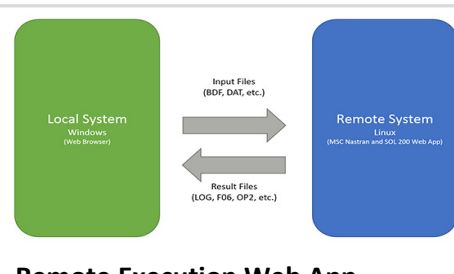
Shape Optimization Web App

Use a web application to configure and perform shape optimization.



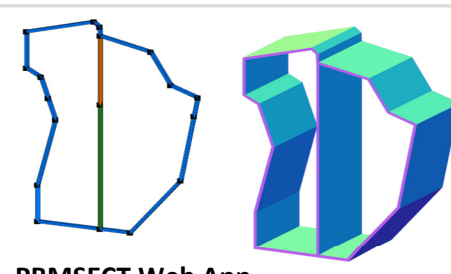
HDF5 Explorer Web App

Create XY plots using data from the H5 file



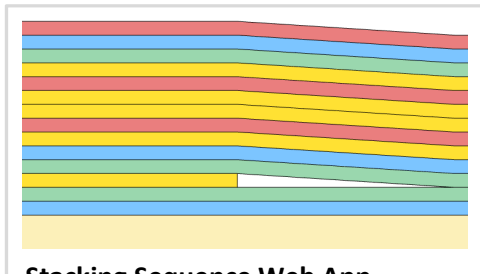
Remote Execution Web App

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



PBMSECT Web App

Generate PBMSECT and PBRSECT entries graphically



Stacking Sequence Web App

Optimize the stacking sequence of composite laminate plies

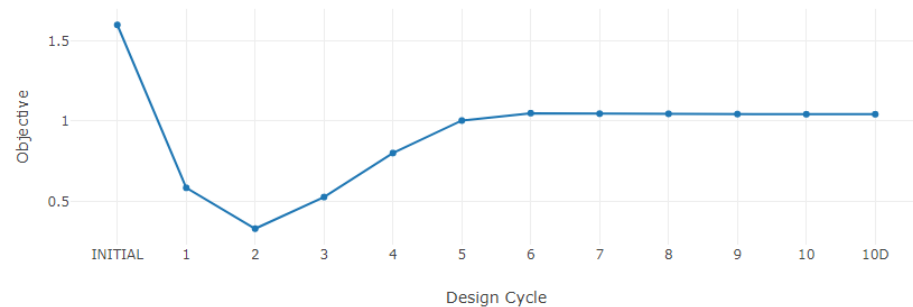
View Optimization Results

Online Plotter

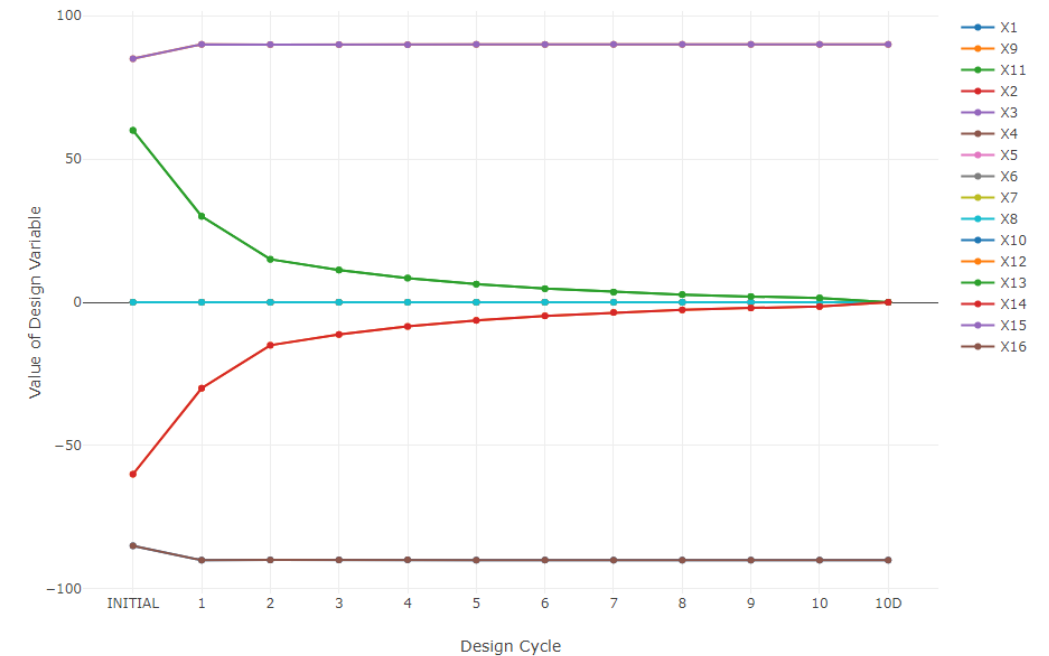
Final Message in .f06

✓ RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 10.
✓ AND HARD FEASIBLE DISCRETE DESIGN OBTAINED

Objective



Design Variables



Goal: Use Nastran SOL 200 Optimization

Initial Design

- Weight: $1.60 \text{ lb}_f \cdot \text{s}^2/\text{in}$
- Layup: [85/-85/60/-60/60/-60/85/-85]
- Thickness: .0100 in
- Plies are initially in failure

Optimized Design

- Weight: $1.04 \text{ lb}_f \cdot \text{s}^2/\text{in}$
- Layup: [90/-90/0/0/0/0/90/-90]
- Thickness: .0065 in

Update the original structural model with optimized parameters

Use the .pch file

Contact me

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