Vibration of a Cantilevered Beam (Turner's Problem), Nastran Optimization

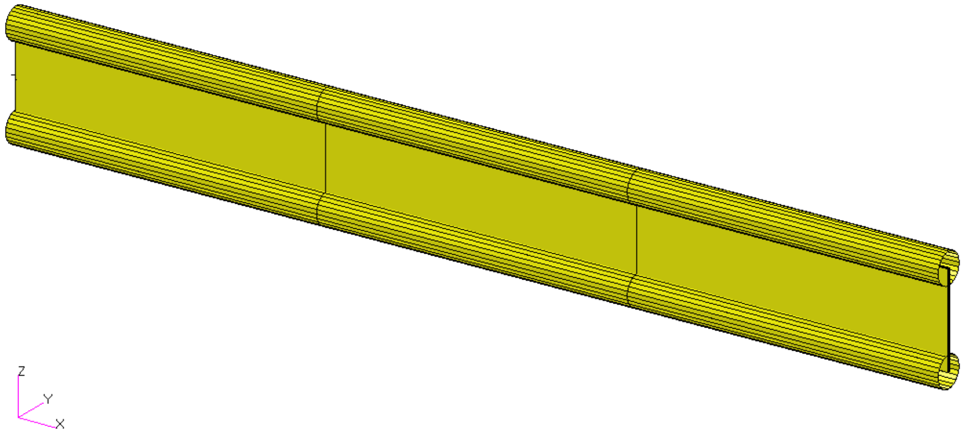
PRESENTED BY CHRISTIAN APARICIO

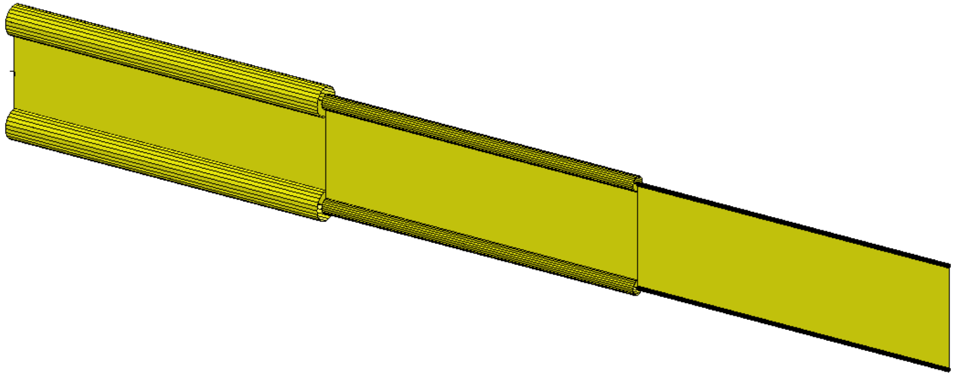
Goal: Use Nastran SOL 200 Optimization

Minimize the weight of this structure while constraining the 1st natural frequency

Before Optimization
- Weight: 19.2 lbs.
- 1st Natural Frequency: 26 Hz

After Optimization
- Weight: 6.97 lbs.
- 1st Natural Frequency: 20 Hz





MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 – Example Problems - Vibration of a Cantilevered Beam (Turner's Problem)

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 optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

Details of the structural model

Vibration of a Cantilevered Beam (Turner's Problem)

This problem was originally published by M.J. Turner (see Reference 13.). The problem is to design a minimum weight structure while constraining the fundamental natural frequency to be at or above 20 Hz. The beam is symmetric about Z = 0 and made up of a shear web having top and bottom caps that are modeled with rod elements. Turner's original design model consisted of piecewise linear bar cross-sectional areas and web thicknesses; however, we will just approximate this as a step function model with uniform cross-sectional rod elements and uniform thickness shear elements within each of three bays.

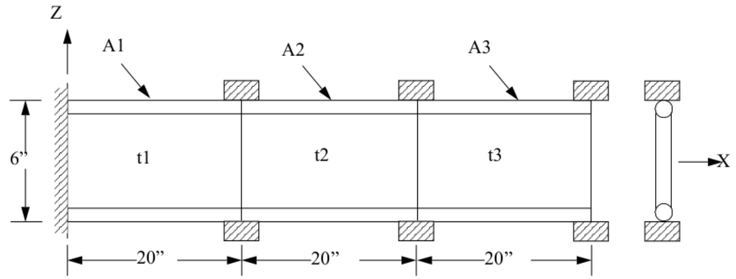


Figure 8-17 Cantilever Beam Vibration Model

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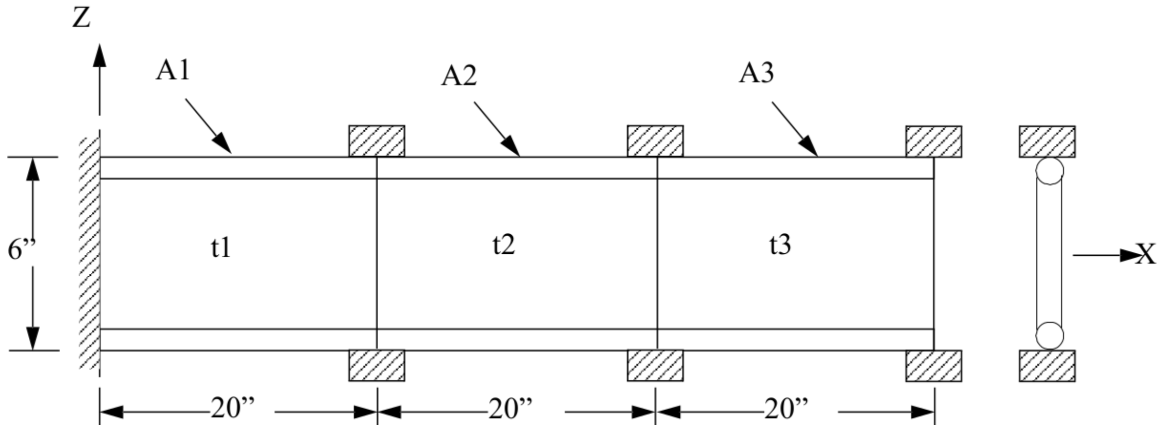
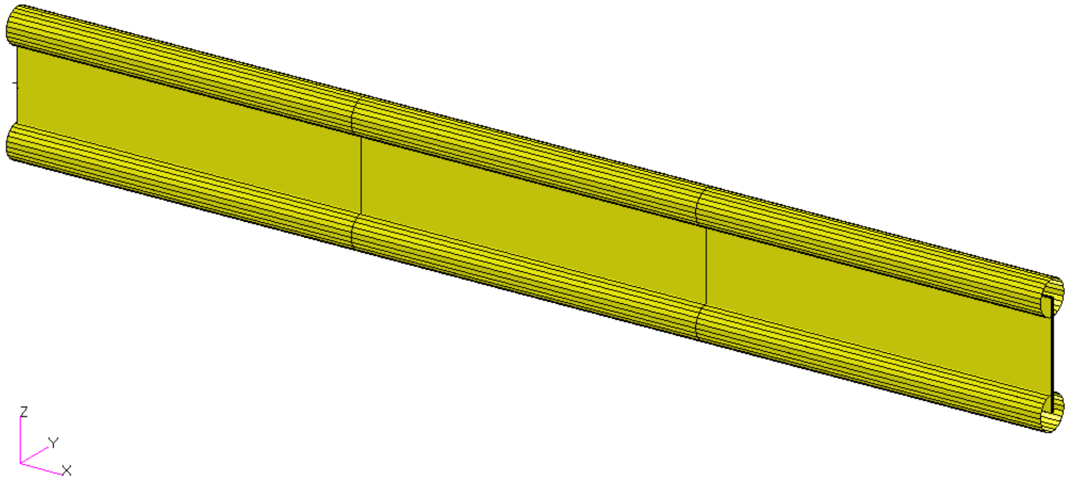




Optimization Problem Statement

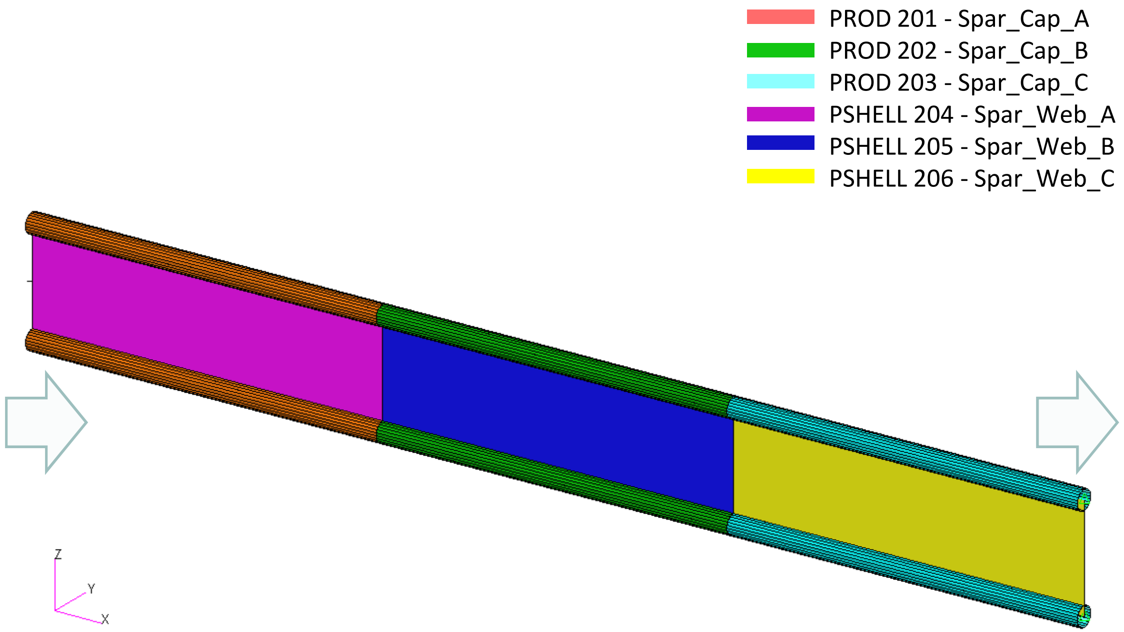
Design Variables

x1: A of PROD 201
x2: A of PROD 202
x3: A of PROD 203

.01 < x1, x2, x3 < 100.

x4: T of PSHELL 204
x5: T of PSHELL 205
x6: T of PSHELL 206

.0002 < x4, x5, x6 < 2.



Responses (Outputs)

- Frequencies
- Mode shapes
- ....

Optimization Problem Statement

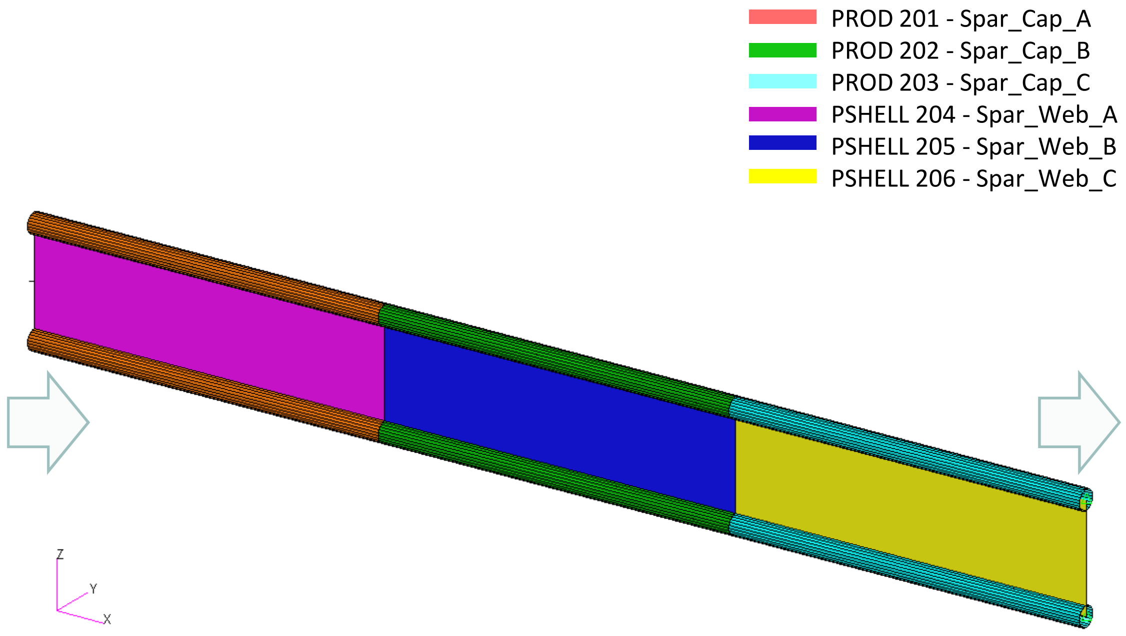
Design Variables

x1: A of PROD 201
x2: A of PROD 202
x3: A of PROD 203

.01 < x1, x2, x3 < 100.

x4: T of PSHELL 204
x5: T of PSHELL 205
x6: T of PSHELL 206

.0002 < x4, x5, x6 < 2.



Design Objective, Equation

R0: Minimize a1 - 90.

where,

a1: weight of entire structure

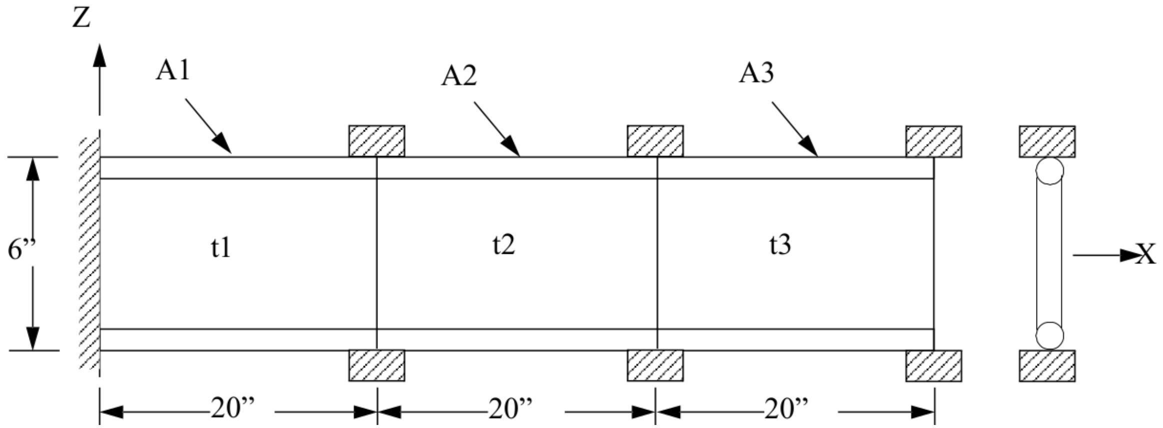
Design Constraints

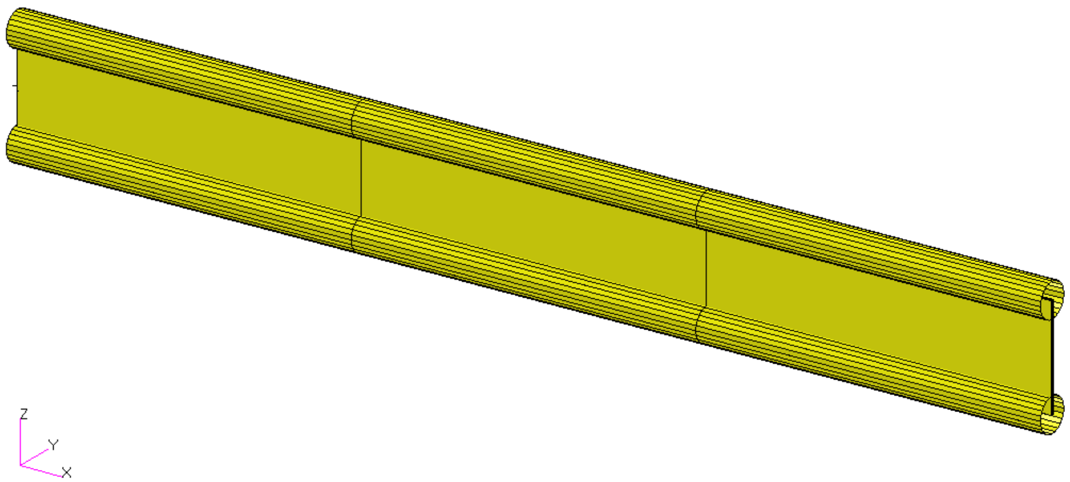
r1: 1st Natural frequency

20 Hz < r1

Optimization Problem Statement

1. Design Variables
   - x1: A1 | .01 < x1 < 100.
   - x2: A3 | .01 < x2 < 100.
   - x3: A3 | .01 < x3 < 100.
   - x4: T1 | .0002 < x4 < 2.
   - x5: T3 | .0002 < x5 < 2.
   - x6: T3 | .0002 < x6 < 2.
2. Design Objective, Equation
   - Minimize R0
     - R0: a1 - 90. lbs.
     - a1: Weight
3. Design Constraints
   - r1: 1st Natural Frequency
     - 20. Hz < r1



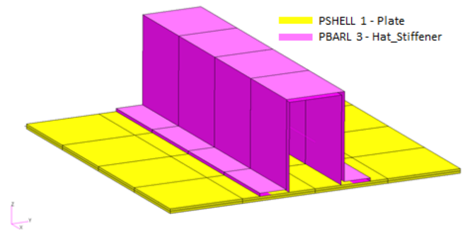


Steps to use Nastran SOL 200 (Optimization)

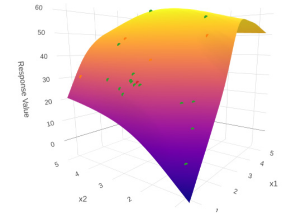
1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
   - Convert the .bdf file to SOL 200
     - Design Variables
     - Design Objective
     - Design Constraints
   - Perform optimization with Nastran SOL 200
3. Review optimization results
   - Online Plotter
   - Optimized structural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

SOL 200 Web App Capabilities

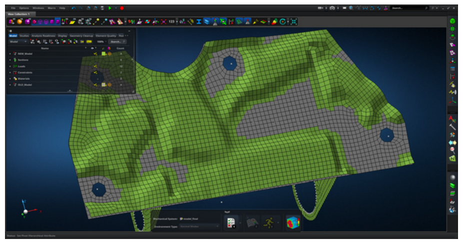
Capabilities



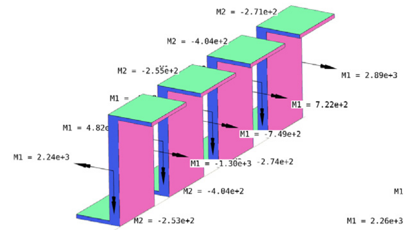
Web Apps for SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry and topography.



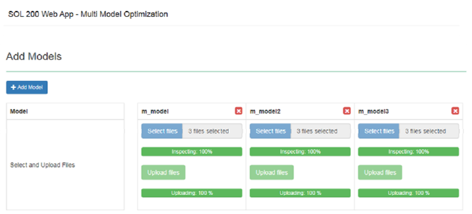
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



MSC Apex Post Processing Support
View the newly optimized model after an optimization

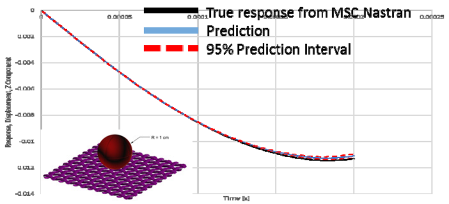


Beams Viewer Web App
Post process 1D element forces, including shear forces, moments, torque and axial forces

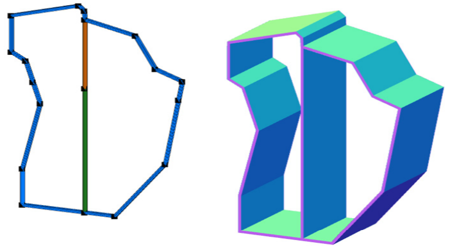


Multi-model Optimization Web App
Pre/post for multi model optimization

HDF5 Explorer Web App
Create XY plots using data from the H5 file



Prediction Analysis Web App
Gaussian process regression to predict output of MSC Nastran without time consuming analyses



PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically

Benefits

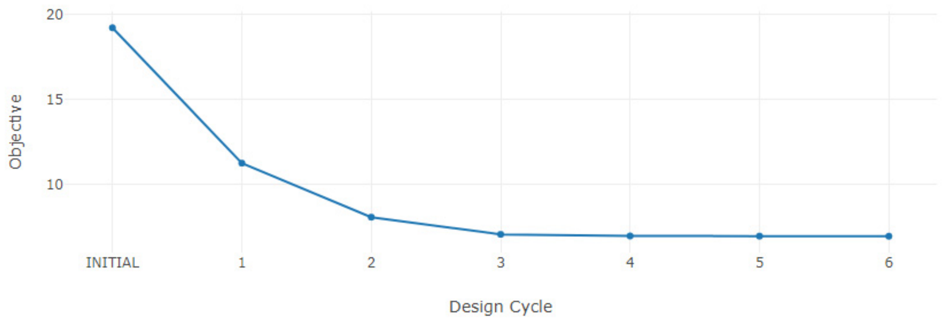
- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 50+ tutorials

View Optimization Results
Online Plotter

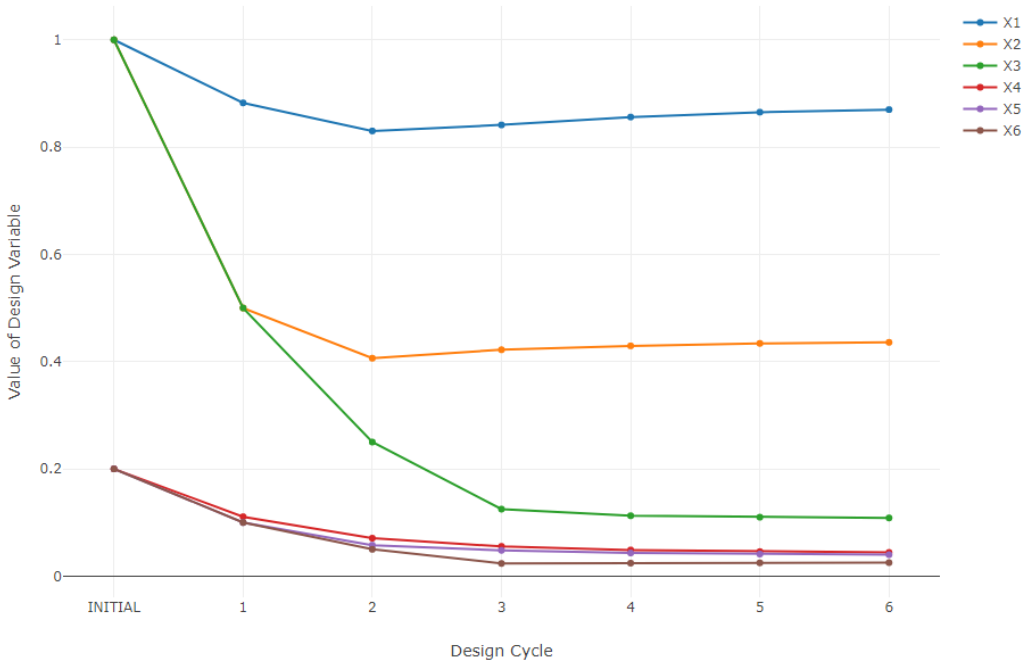
Final Message in .f06

RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER =   6.

Objective



Design Variables



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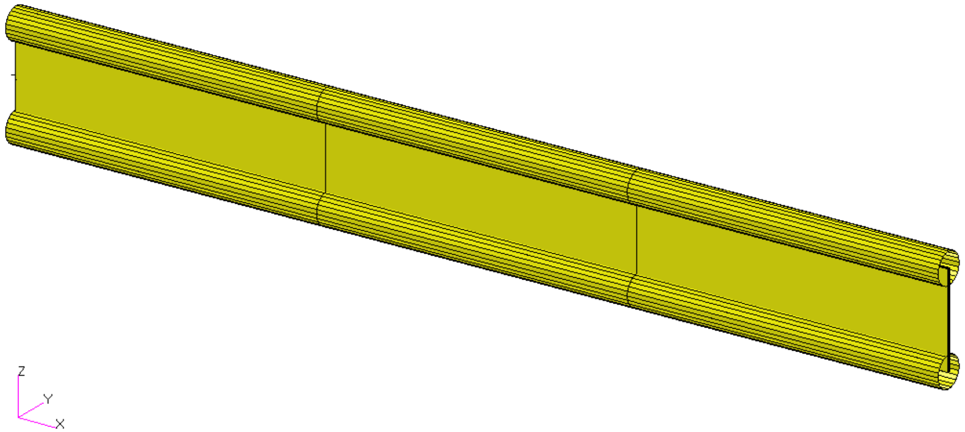

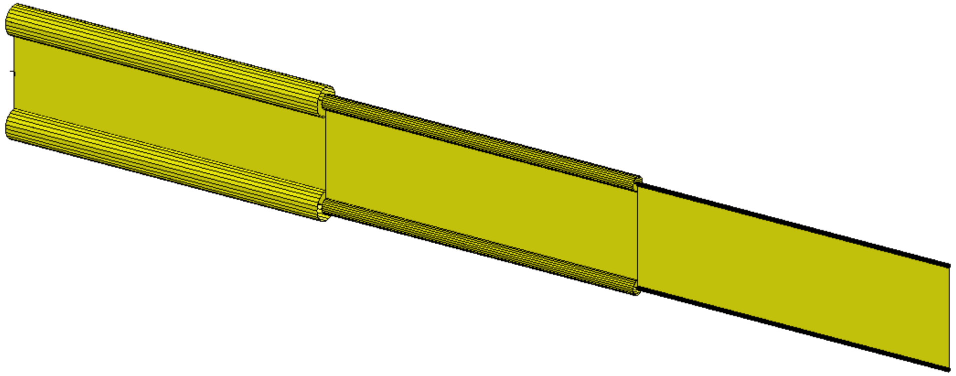

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Use the .pch file

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