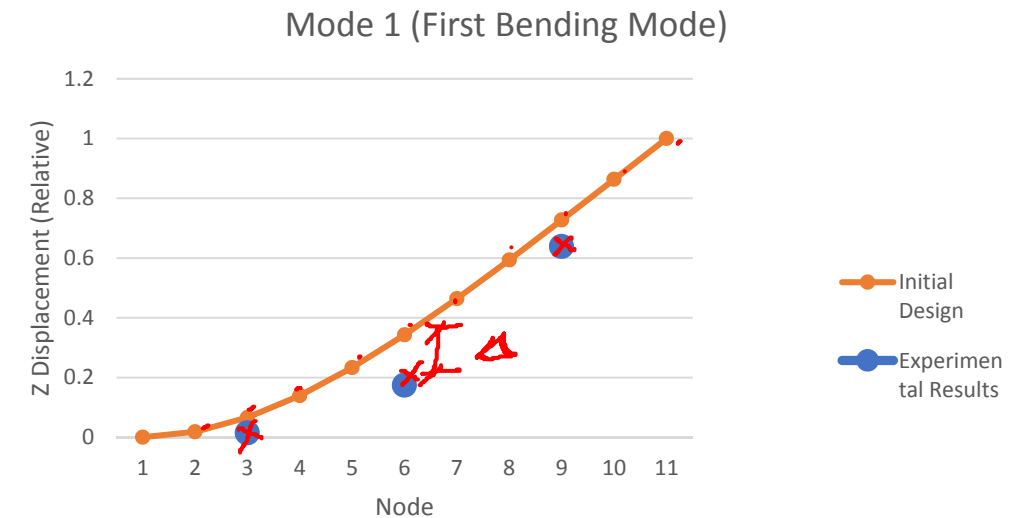
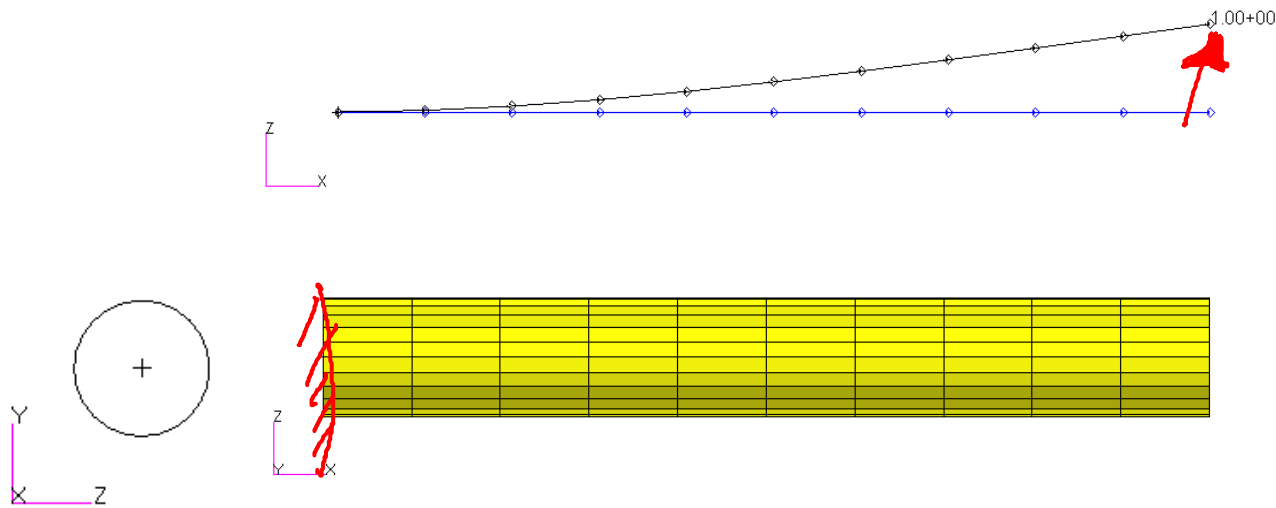


Model Matching / System Identification

PRESENTED BY CHRISTIAN APARICIO

Goal: Use Nastran SOL 200 Optimization

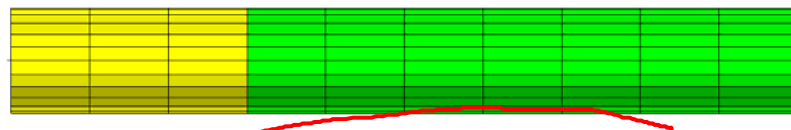
Modes analysis reveals discrepancy between FEM and experiment



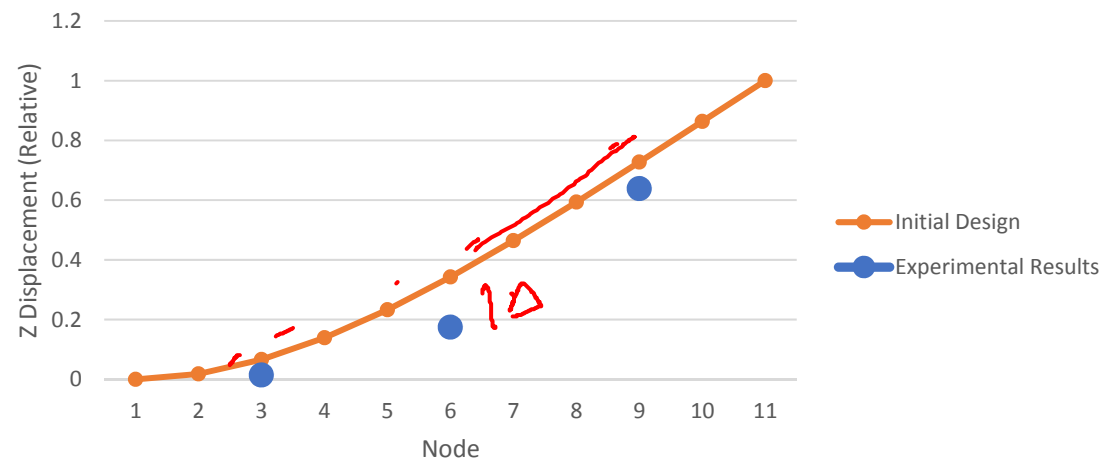
Goal: Use Nastran SOL 200 Optimization

Correlate test data and analysis results

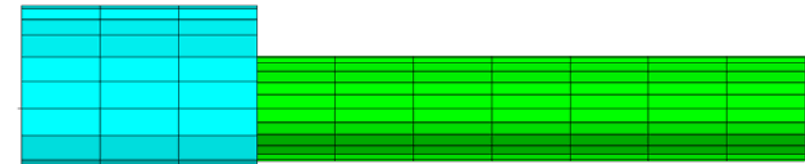
Before Optimization
Radius: 2 in



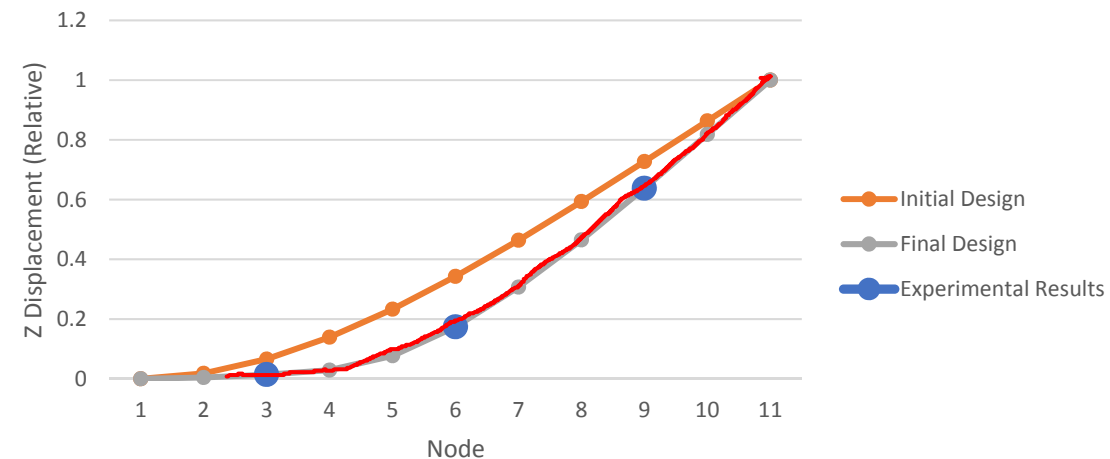
Mode 1 (First Bending Mode)



After Optimization
Radius 3.93 in



Mode 1 (First Bending Mode)



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 MSC Nastran SOL 200 Web App

christian@ the-engineering-lab.com

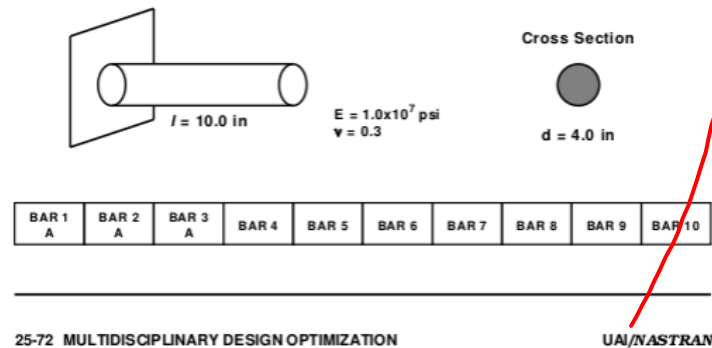
Details of the structural model

25.6.6 System Identification

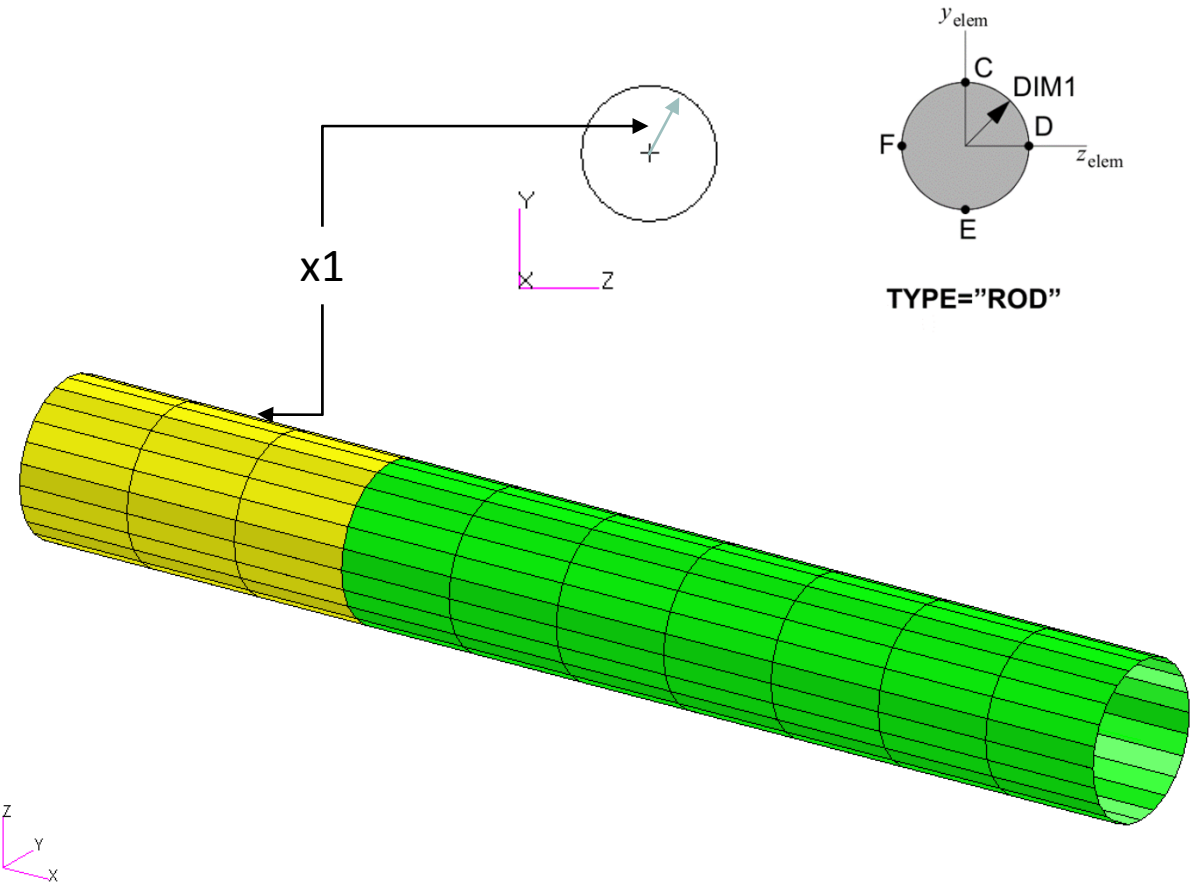
An important area of research is the tuning of finite element models to experimental test results. This is often called system identification. This example problem illustrates how optimization may be used to address these requirements. It features:

- Normal modes optimization
- Constraints on RMS error in mode shapes
- Frequency constraints
- Using an analytical response as the objective

Figure 25-13. SYSTEM ID — SIMPLE BEAM MODEL

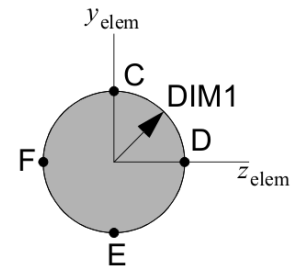
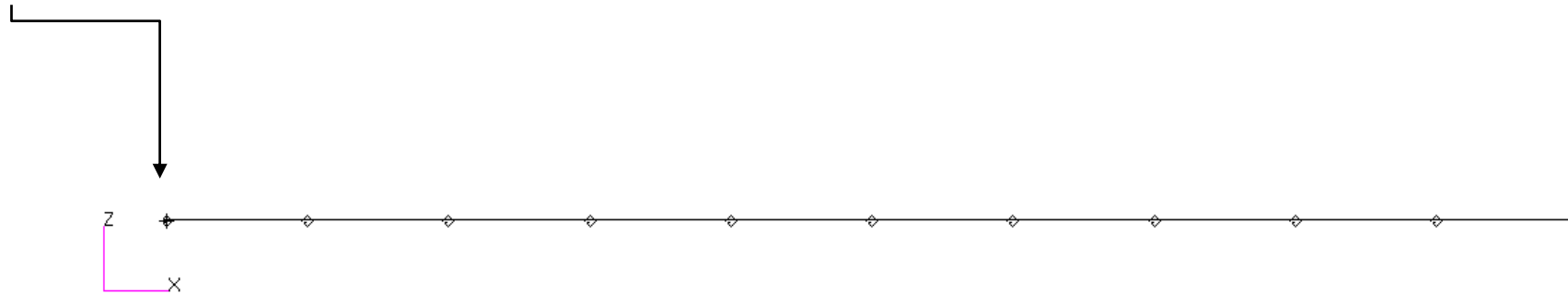


UAI/NASTRAN User's Guide for Version 20.1
Chapter 25 — MULTIDISCIPLINARY DESIGN OPTIMIZATION —
25.6.6 System Identification



Details of the structural model

Fixed



TYPE="ROD"

Length: 30 in

$E = 1 * 10^7$ psi

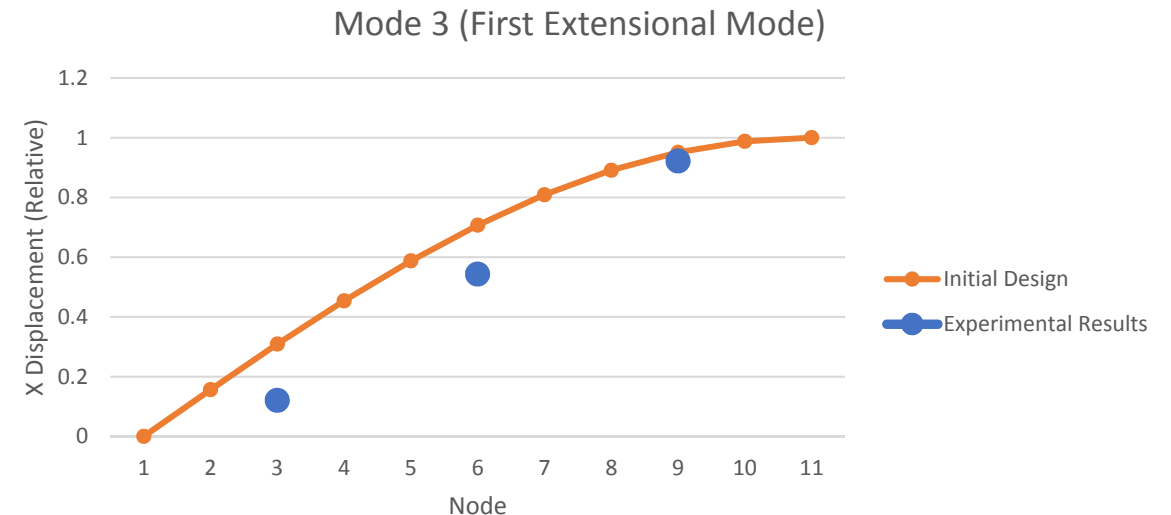
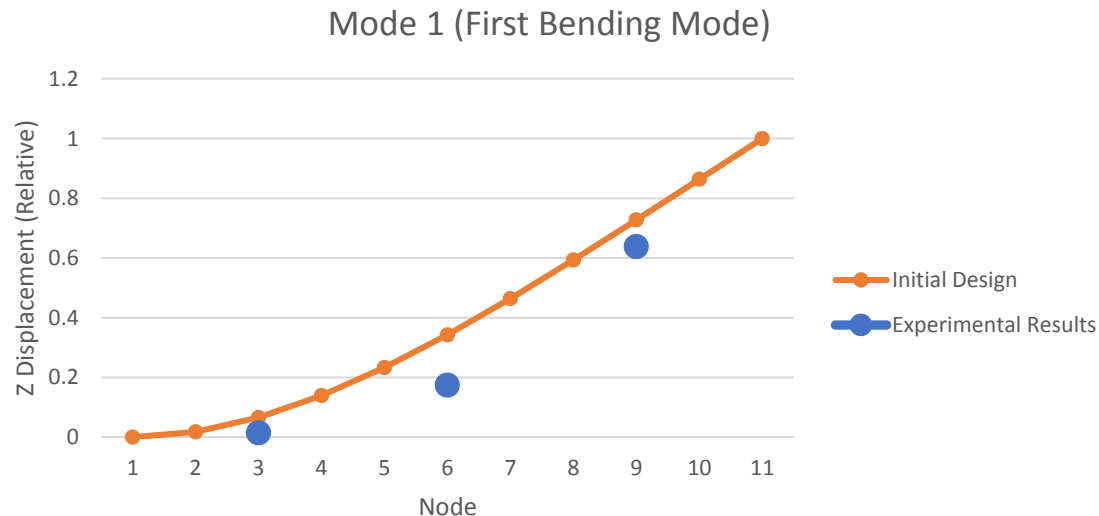
$\nu = .3$

Density = $.01 \text{ lb}_f * \text{s}^2 / \text{in}^4$

Details of the structural model

Experimental Results

	Mode 1			Mode 3	
Node	Component	Experimental Value		Component	Experimental Value
3	z or 3 direction	0.0143		x or 1 direction	0.1204
6	z or 3 direction	0.1741		x or 1 direction	0.5431
9	z or 3 direction	0.6381		x or 1 direction	0.9216

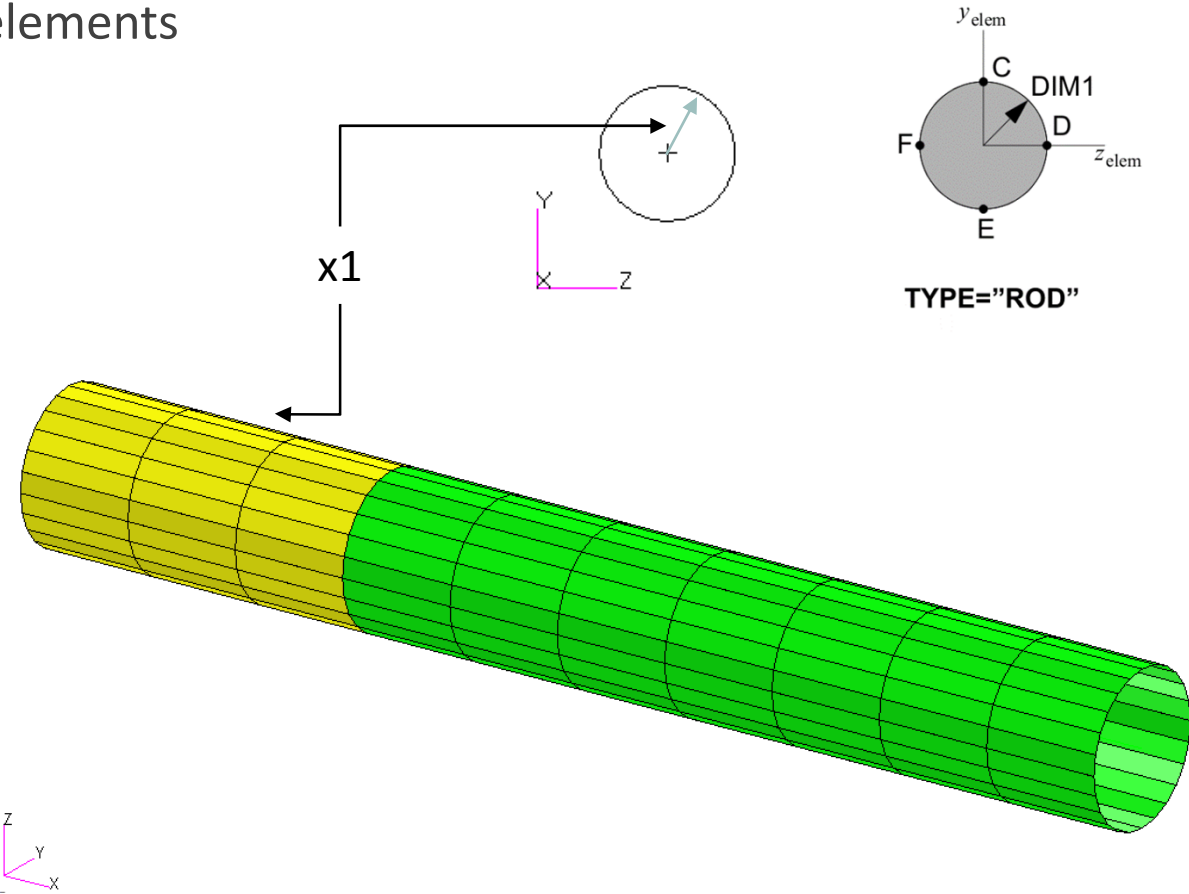


Optimization Problem Statement

Design Variables

x1: Radius of cross section for first 3 elements

- $.1 < x1 < 10$.

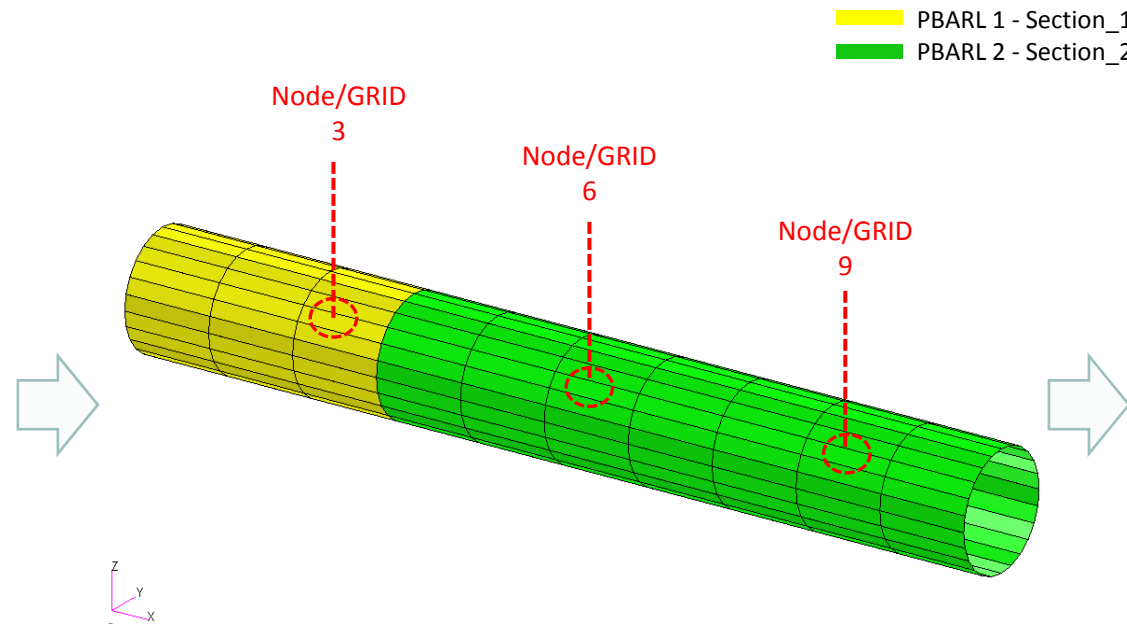


Optimization Problem Statement

Design Variables

x1: Radius of cross section (DIM1 of PBARL 1)

$.1 < x1 < 10.$



Responses (Outputs)

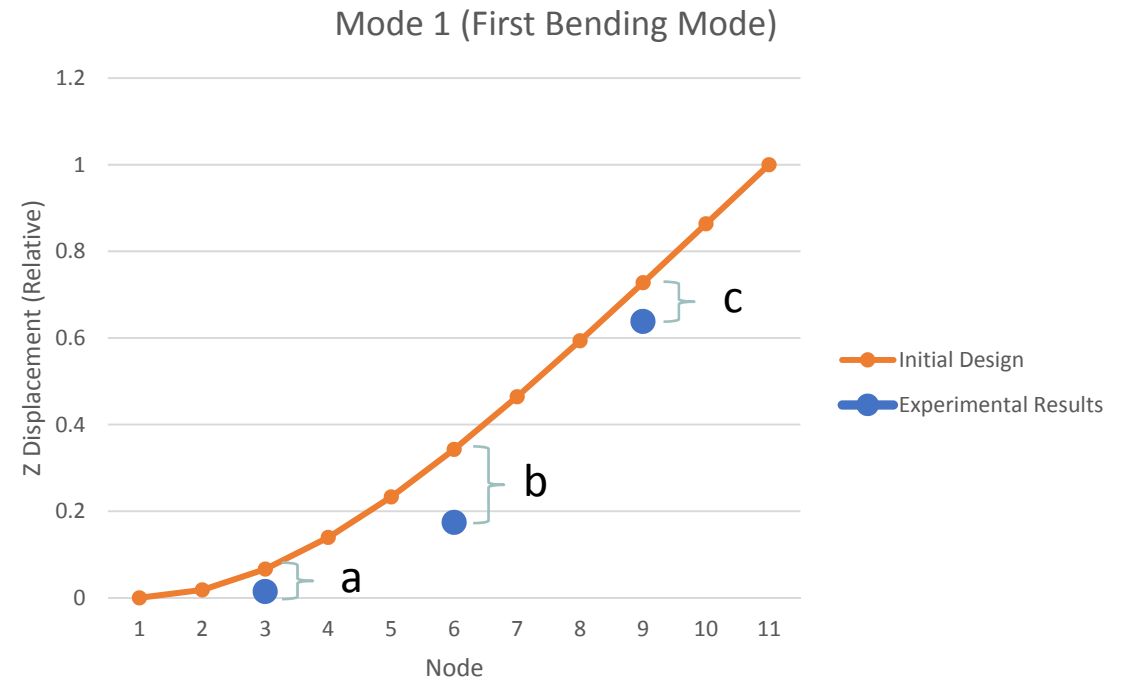
- Frequencies
- Mode shapes
-

Optimization Problem Statement

Design Objective

For mode 1, minimize least squares

- Minimize $R0$
 - $R0 = a + b + c$
 - $a = \left(\frac{a1 - .0143}{.0143}\right)^2$
 - $b = \left(\frac{a2 - .1741}{.1741}\right)^2$
 - $c = \left(\frac{a3 - .6381}{.6381}\right)^2$
 - $a1, a2, a3$ are the z displacements at nodes 3, 6, 9, respectively, for mode 1



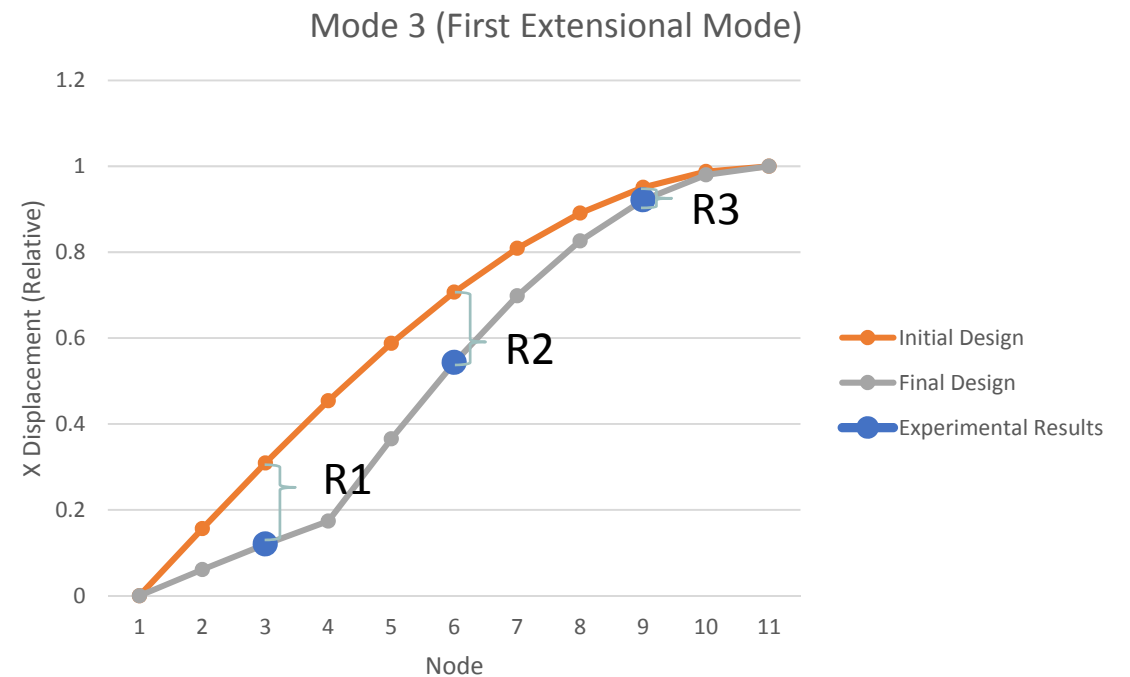
Optimization Problem Statement

Design Constraint

For mode 3,

$$\begin{aligned} \circ R1 &= \left(\frac{a4 - .1204}{.1204} \right)^2 & R1 &< .001 \\ \circ R2 &= \left(\frac{a5 - .5431}{.5431} \right)^2 & R2 &< .001 \\ \circ R3 &= \left(\frac{a6 - .9216}{.9216} \right)^2 & R3 &< .001 \end{aligned}$$

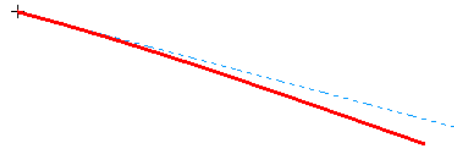
a4, a5, a6 are the x displacements at nodes 3, 6, 9, respectively, for mode 3



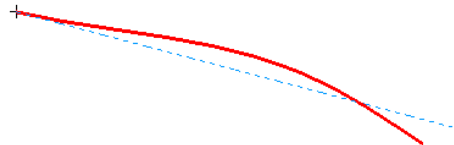
Mode Tracking

radius = 2 in.

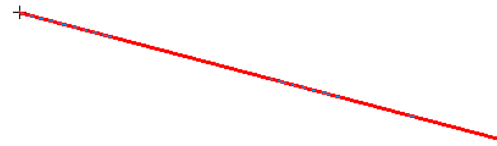
Mode 1
19Hz



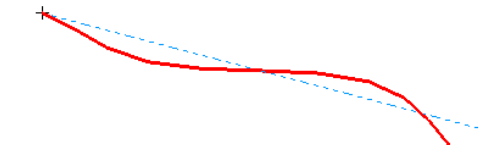
Mode 2
115Hz



Mode 3
263Hz

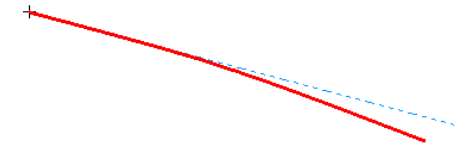


Mode 4
299Hz

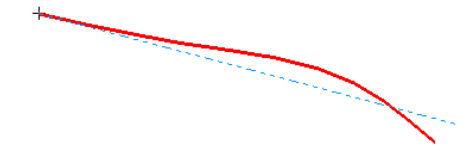


radius = 3.9 in.

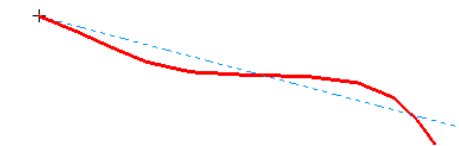
Mode 1
35Hz



Mode 2
174Hz



Mode 3
333Hz



Mode 4
334Hz



Mode Tracking

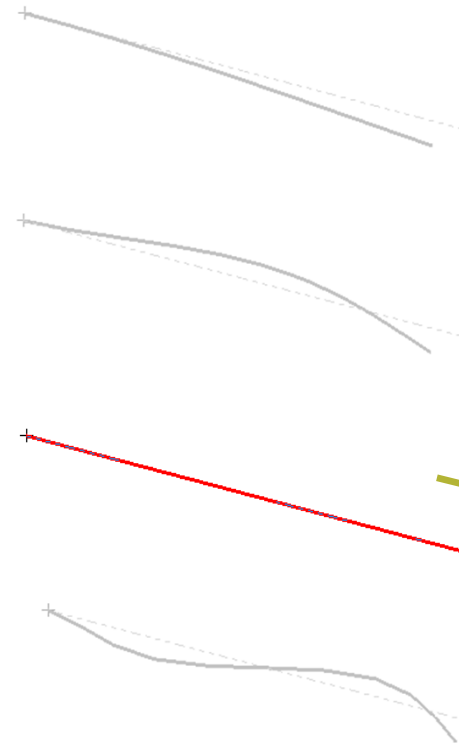
radius = 2 in.

Mode 1
19Hz

Mode 2
115Hz

Mode 3
263Hz

Mode 4
299Hz



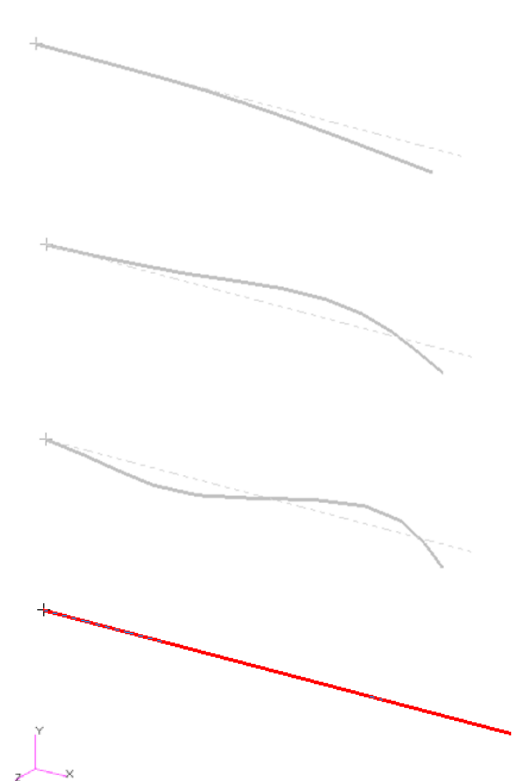
radius = 3.9 in.

Mode 1
35Hz

Mode 2
174Hz

Mode 3
333Hz

Mode 4
334Hz

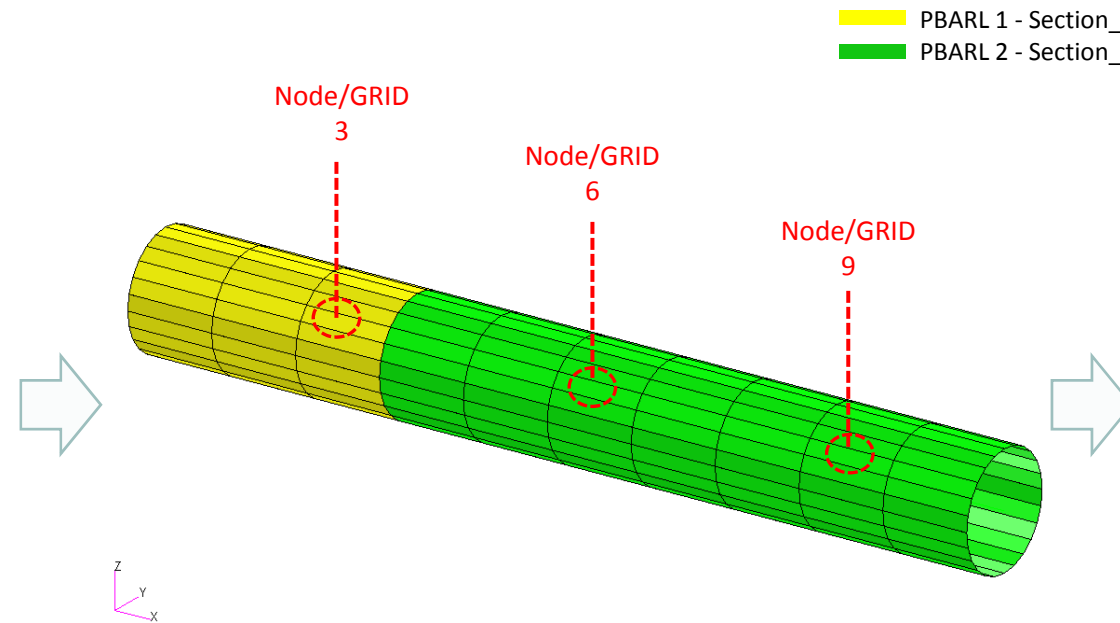


Optimization Problem Statement

Design Variables

x1: Radius of cross section (DIM1 of PBARL 1)

$$.1 < x1 < 10.$$



Design Objective, Equation

R0: Minimize

$$\left(\frac{a1-.0143}{.0143}\right)^2 + \left(\frac{a2-.1741}{.1741}\right)^2 + \left(\frac{a3-.6381}{.6381}\right)^2$$

- a1: 3rd component of relative displacement for mode 1 at grid 3
- a2: 3rd component of relative displacement for mode 1 at grid 6
- a3: 3rd component of relative displacement for mode 1 at grid 9

Design Constraints, Equation

$$R1 = \left(\frac{a4-.1204}{.1204}\right)^2 \quad R1 < .001$$

$$R2 = \left(\frac{a5-.5431}{.5431}\right)^2 \quad R2 < .001$$

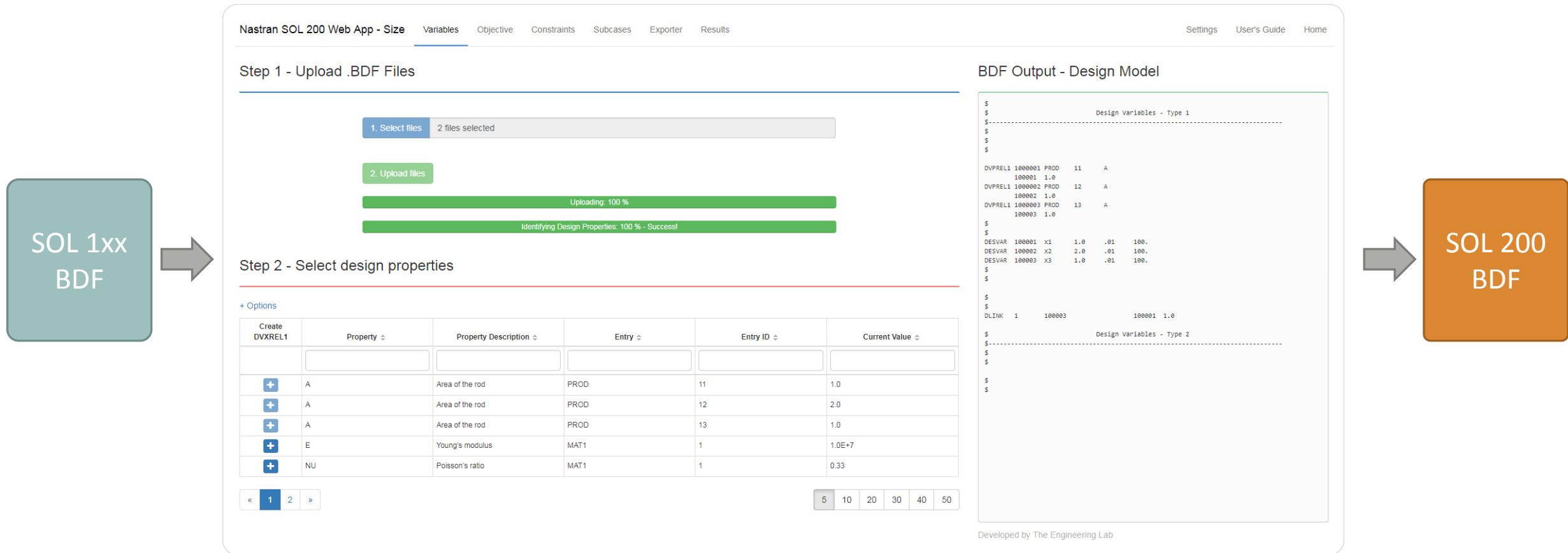
$$R3 = \left(\frac{a6-.9216}{.9216}\right)^2 \quad R3 < .001$$

- a4: 1st component of relative displacement for mode 3 at grid 3
- a5: 1st component of relative displacement for mode 3 at grid 6
- a6: 1st component of relative displacement for mode 3 at grid 9

Steps to use Nastran SOL 200 (Optimization)

1. Start with a .bdf or .dat file
2. Use the MSC Nastran 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

MSC Nastran SOL 200 Web App



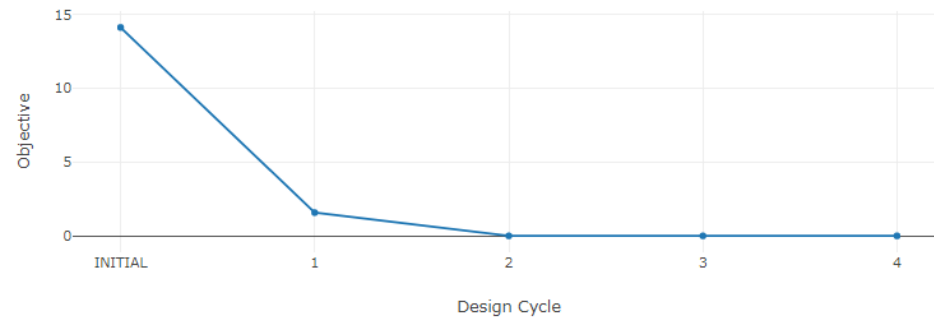
View Optimization Results

Online Plotter

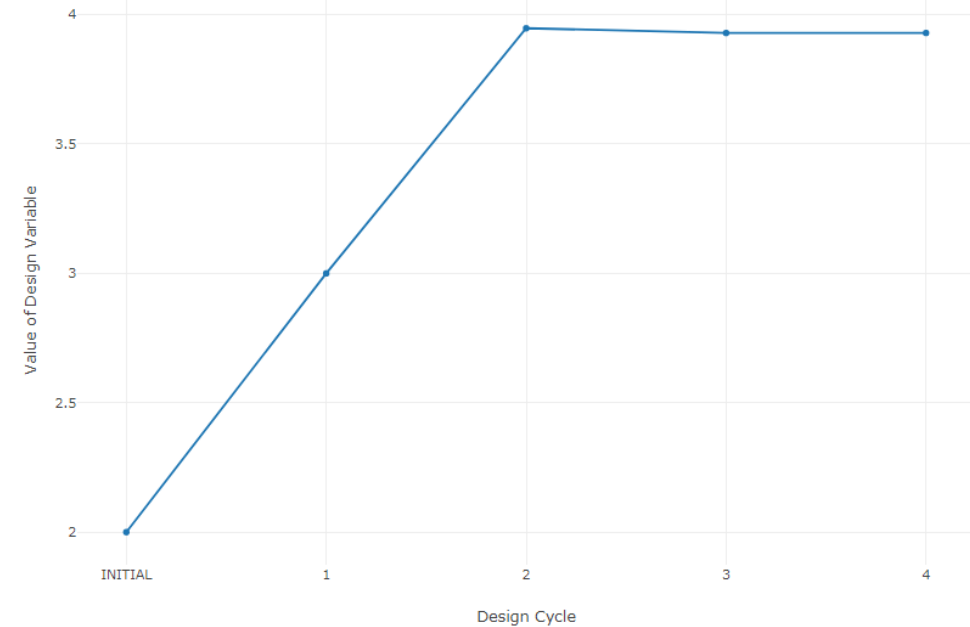
Final Message in .f06

✓ RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 4.

Objective



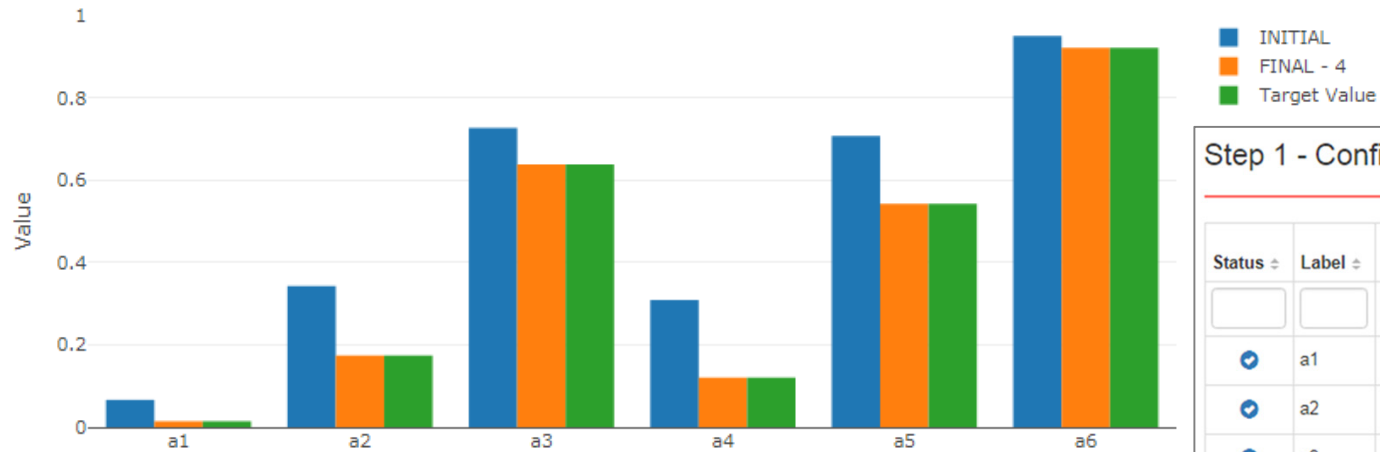
Design Variables



View Optimization Results

Comparison between FINAL and Target Values

Model Matching Bar Charts

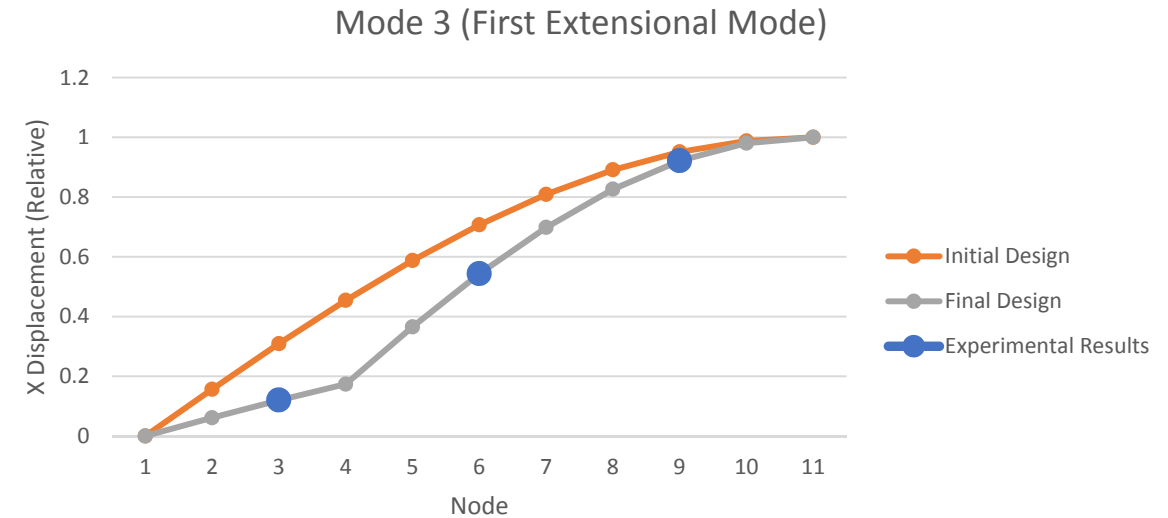
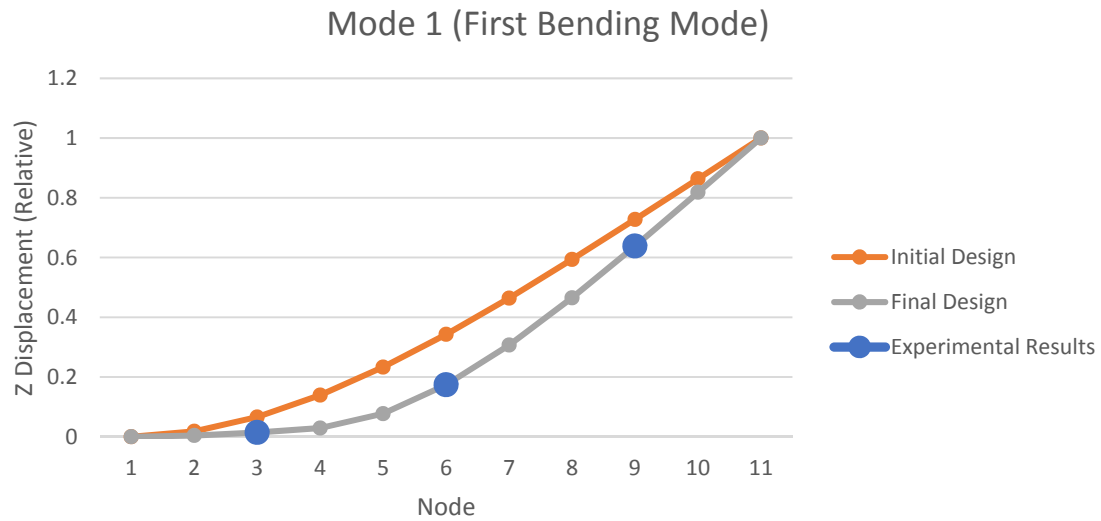


Step 1 - Configure model matching

Status	Label	Single Scalar?	Description	Target Value	Include in Objective	Max Allowed Error
<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>	
<input checked="" type="checkbox"/>	a1	Yes	T3 component(s) of displacement at grid 3 of mode 1	.0143	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a2	Yes	T3 component(s) of displacement at grid 6 of mode 1	.1741	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a3	Yes	T3 component(s) of displacement at grid 9 of mode 1	.6381	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a4	Yes	T1 component(s) of displacement at grid 3 of mode 3	.1204	<input type="checkbox"/>	.001
<input checked="" type="checkbox"/>	a5	Yes	T1 component(s) of displacement at grid 6 of mode 3	.5431	<input type="checkbox"/>	.001
<input checked="" type="checkbox"/>	a6	Yes	T1 component(s) of displacement at grid 9 of mode 3	.9216	<input type="checkbox"/>	.001

View Optimization Results

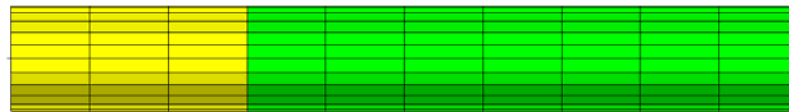
Comparison between analysis and experiment



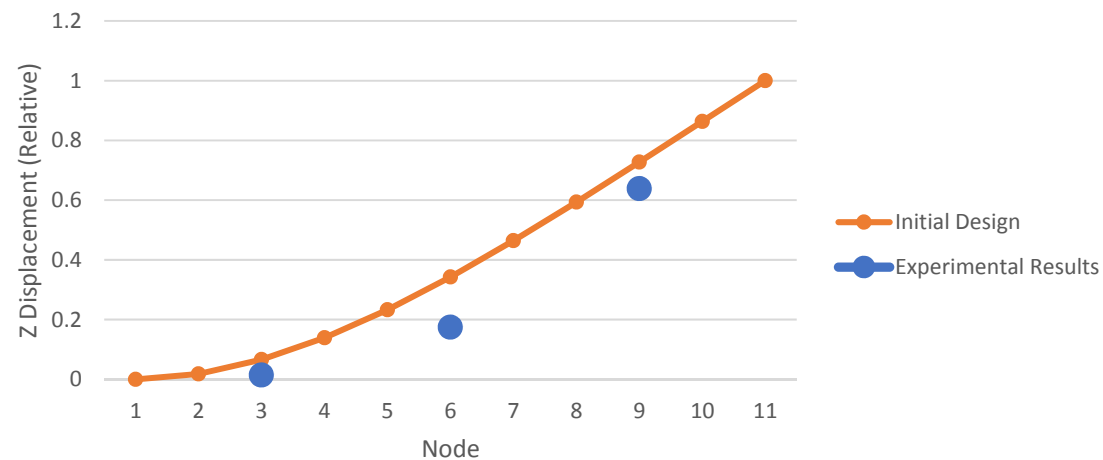
Goal: Use Nastran SOL 200 Optimization

Correlate test data and analysis results

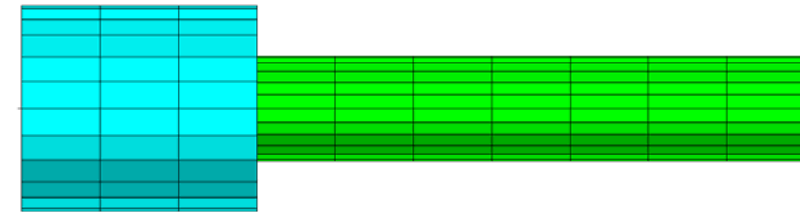
Before Optimization
Radius: 2 in



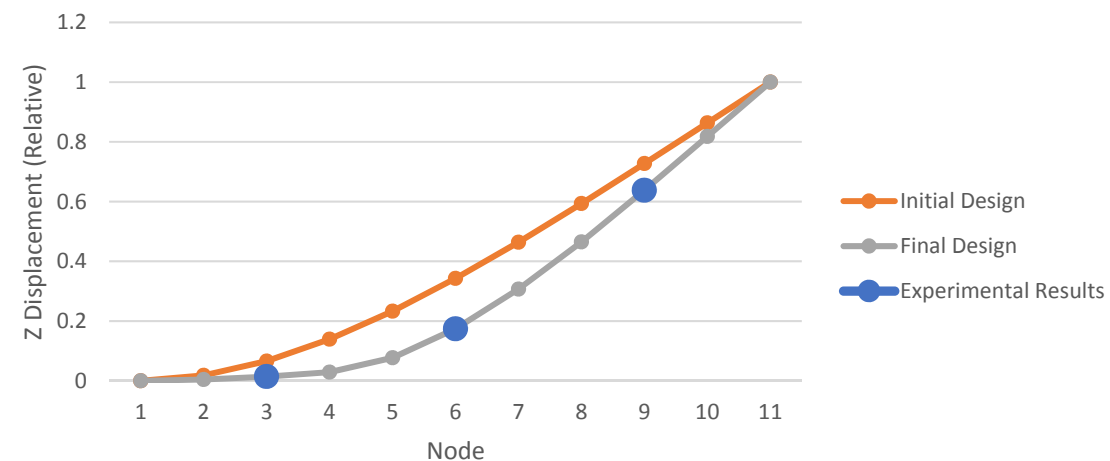
Mode 1 (First Bending Mode)



After Optimization
Radius 3.93 in



Mode 1 (First Bending Mode)



Update the original structural model with optimized parameters

Use the .pch file

Contact me

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christian@ the-engineering-lab.com