

Workshop - Automated Structural Optimization of a Stiffened Plate

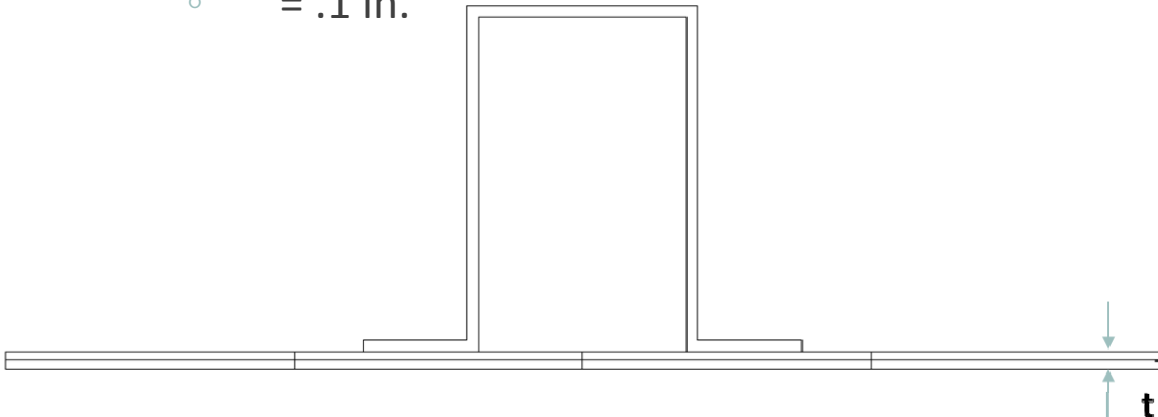
AN MSC NASTRAN SOL 200 TUTORIAL

Goal: Use Nastran SOL 200 Optimization

Optimize the weight of this structure while constraining stress and displacement

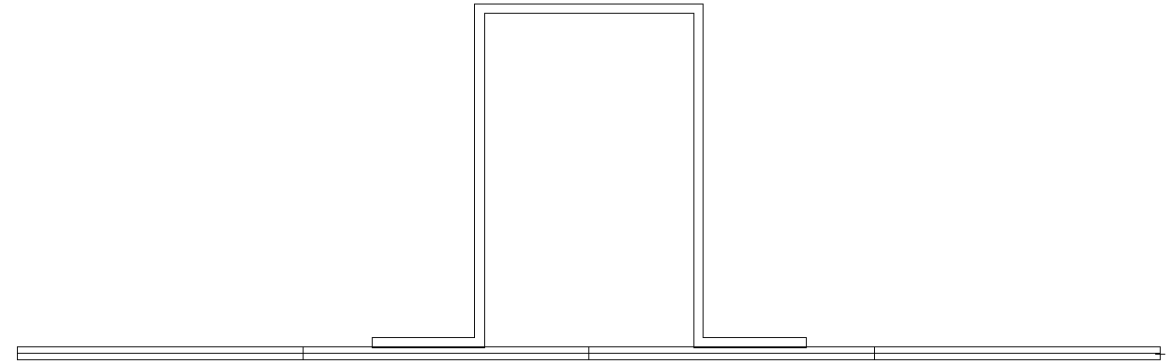
Before Optimization

- Weight: 6.962
- $x1 = T$, thickness of shell
- $= .15$
- $x2 = DIM2$
- $= .1$ in.



After Optimization

- Weight: 5.477
- $x1 = T = .113$ in.
- $x2 = DIM2 = .0839$ in.



Details of the Structural Model

Stiffened Plate

An effective way to keep the number of independent design variables to a minimum is by grouping designed elements by property type. A smaller set of independent design variables decreases the cost associated with the sensitivity analysis, allows the optimizer to perform more efficiently, and makes interpretation of the final results much easier.

A simple example is shown in Figure 8-20 and includes a plate with a hat stiffener. The design goal is to reduce the weight of the stiffened panel subject to stress and displacement constraints under two separate static load conditions. The thickness of the plate and the thickness of the hat stiffener are allowed to vary. The boundary condition creates a simply supported condition with the plate also restrained in the x direction along $x=0.0$. The first load case includes both uniaxial tension in the x-direction and a vertical pressure load in the z-direction. The second load case is a concentrated load applied in the +z direction at grid 10203, which is directly under the hat. The example illustrates how the beam library can be utilized to simplify the modeling and design tasks and how the beam offset relations can be adjusted as the structural properties change.

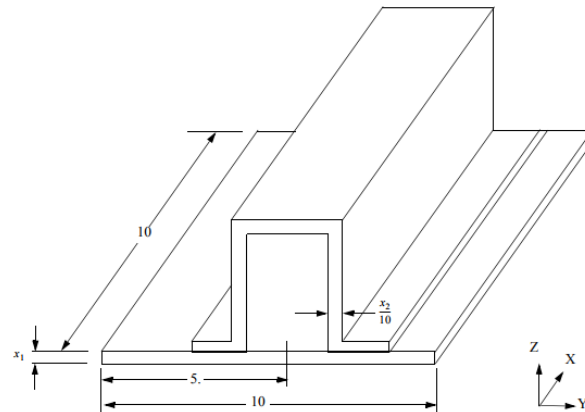
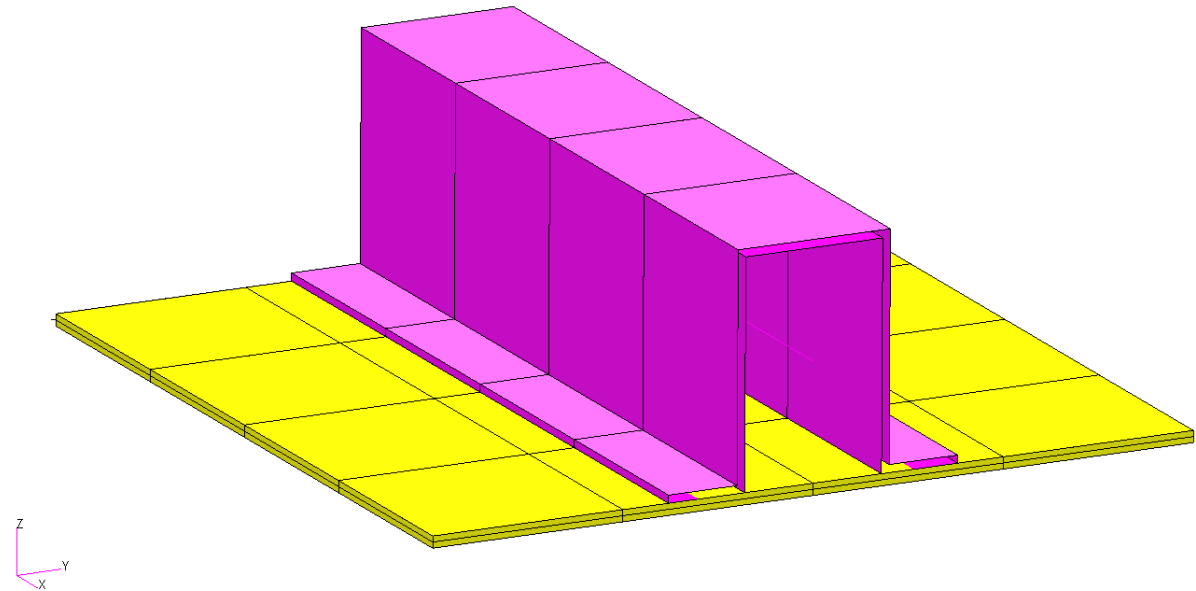


Figure 8-20 Plate with a HAT Stiffener



MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 - Example Problems - Stiffened Plate

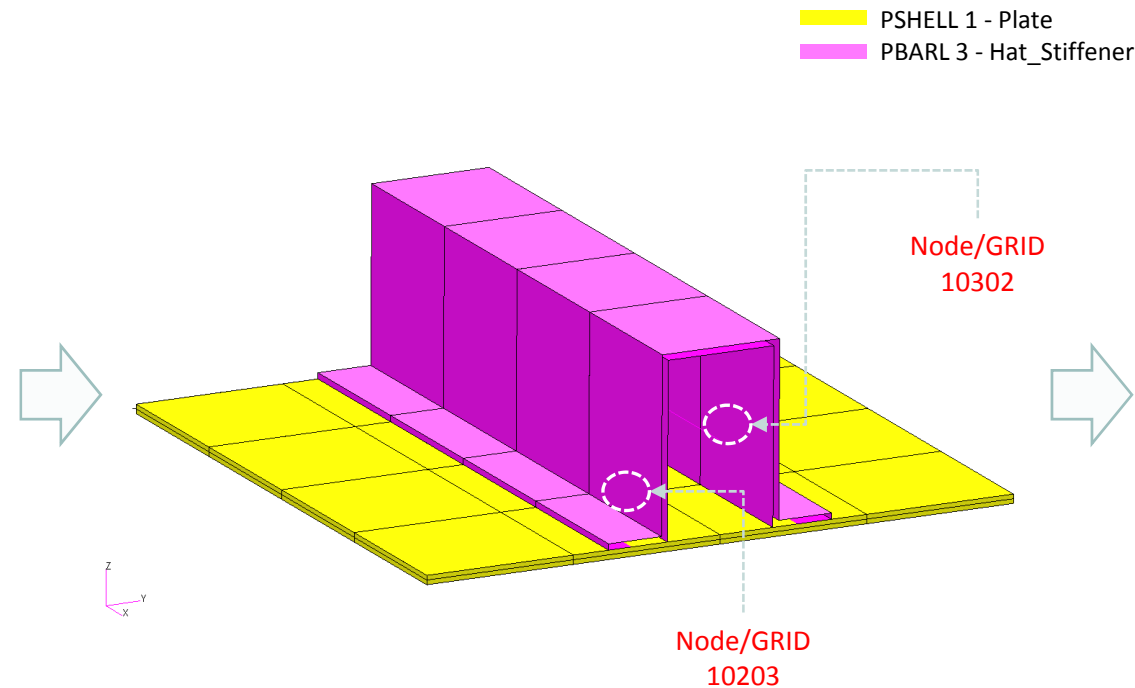
Optimization Problem Statement

Design Variables

x1: T1 of PSHELL 1 | $.01 < x1 < 1$.

x2: DIM2 of PBARL 3 | $.01 < x2 < 1$.

W3A,B for each element = $1.5 + x1 / 2.0$



Design Objective

r0: Minimize weight

Design Constraints

r1: The max stress at end A of elements related to PBARL 3

r2: The max stress at end B of elements related to PBARL 3

$$-25000 < r1, r2 < 25000$$

r3: The von Mises stress of elements related to PSHELL 1

r4: The von Mises stress of elements related to PSHELL 1

$$r3, r4 < 25000$$

r5: The z component of displacement for node 10302

$$-.1 < r5 < .1$$

r6: The z component of displacement for node 10203

$$-.03 < r6 < .03$$

Optimization Problem Statement

Design Variables

Design Variables

- $x_1 = T$, thickness of shell

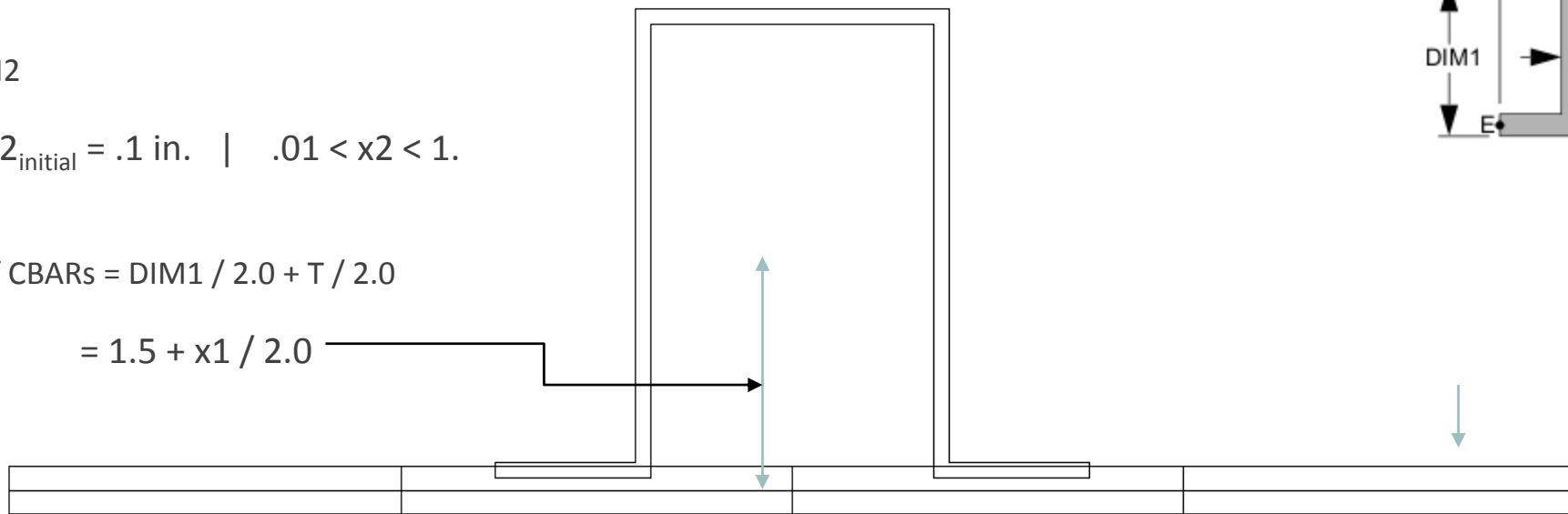
$$x_{1\text{initial}} = .15 \text{ in.} \quad | \quad .01 < x_1 < 1.$$

- $x_2 = \text{DIM2}$

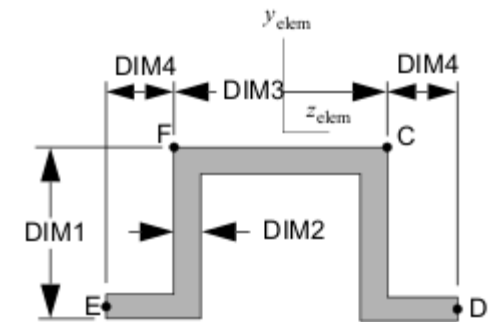
$$x_{2\text{initial}} = .1 \text{ in.} \quad | \quad .01 < x_2 < 1.$$

- Offset of CBARs = $\text{DIM1} / 2.0 + T / 2.0$

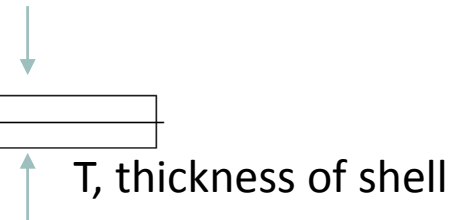
$$= 1.5 + x_1 / 2.0$$



DIM1: 3 in.
DIM2: .1 in
DIM3: 2 in.
DIM4: .9in



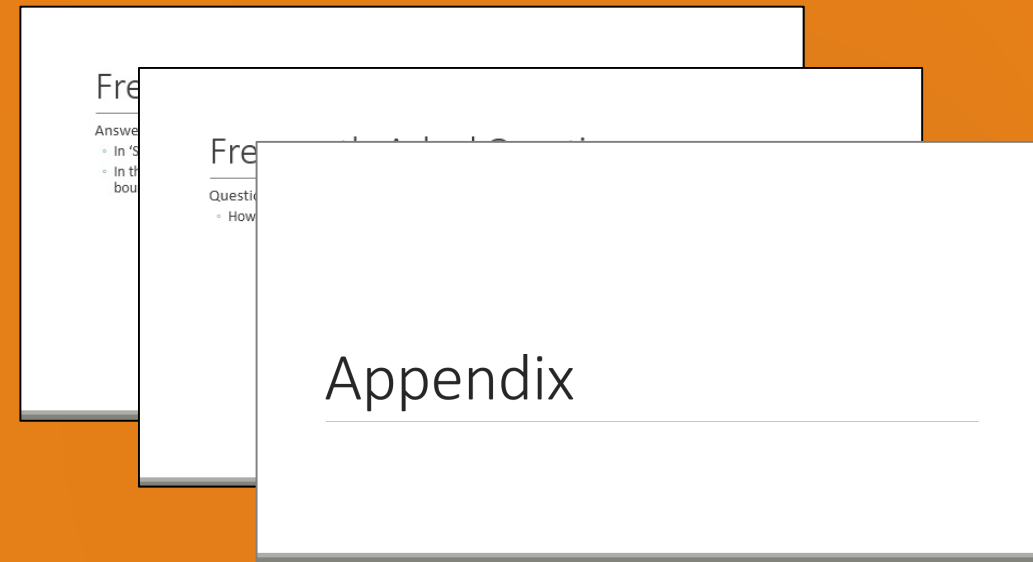
TYPE="HAT"



More Information Available in the Appendix

The Appendix includes information regarding the following:

- Frequently Asked Questions
 - How do I avoid the scenario where the offset causes the cross section to interfere with the plate?



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

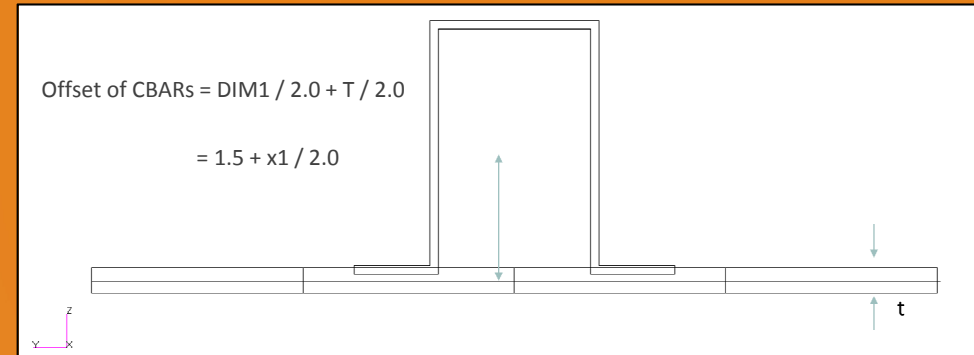
Tutorial

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
 - Design Constraints
 - Perform optimization with Nastran SOL 200
3. Plot the Optimization Results
4. Update the original model with optimized parameters

Special Topics Covered

Creating Hundreds of Equation Driven Parameters - Certain parameters of the Finite Element Model may need to be adjusted as certain design variables change. For example, as the thickness of a plate changes, an attached stiffener's offset will depend on the thickness. This tutorial describes the process for automatically generating dozens or hundreds of these equation driven parameters.



SOL 200 Web App Capabilities

The Post-processor Web App and HDF5 Explorer are free to MSC Nastran users.

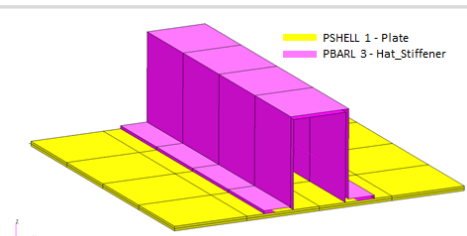
Compatibility

- Google Chrome, Mozilla Firefox or Microsoft Edge
- Windows and Red Hat Linux
- Installable on a company laptop, workstation or server. All data remains within your company.

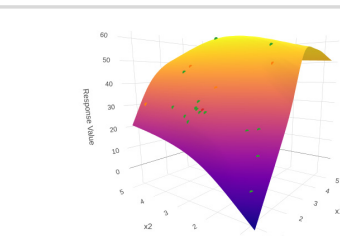
Benefits

- REAL TIME error detection. 200+ error validations.
- REAL TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials

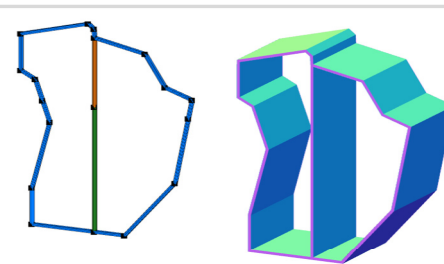
Web Apps



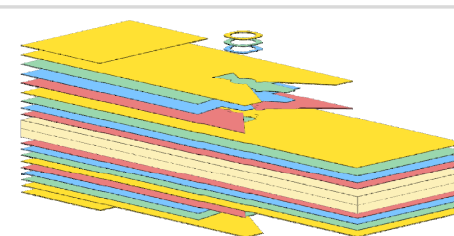
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200.
Support for size, topology, topometry, topography, multi-model optimization.



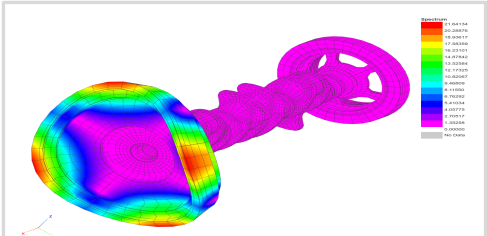
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



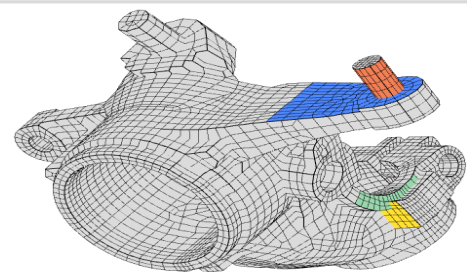
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



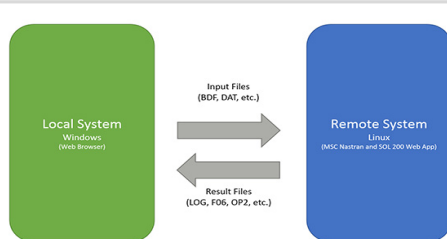
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMP entries



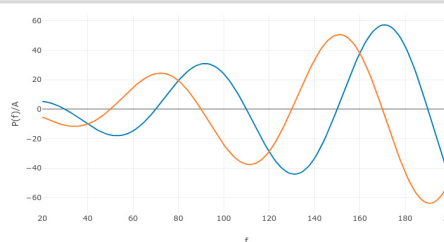
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



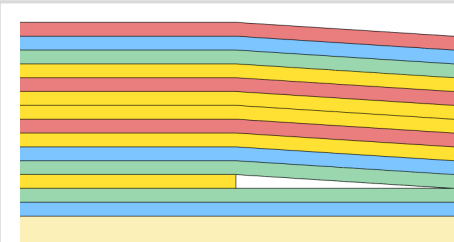
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



Dynamic Loads Web App
Generate RLOAD1, RLOAD2 and DLOAD entries graphically



Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies

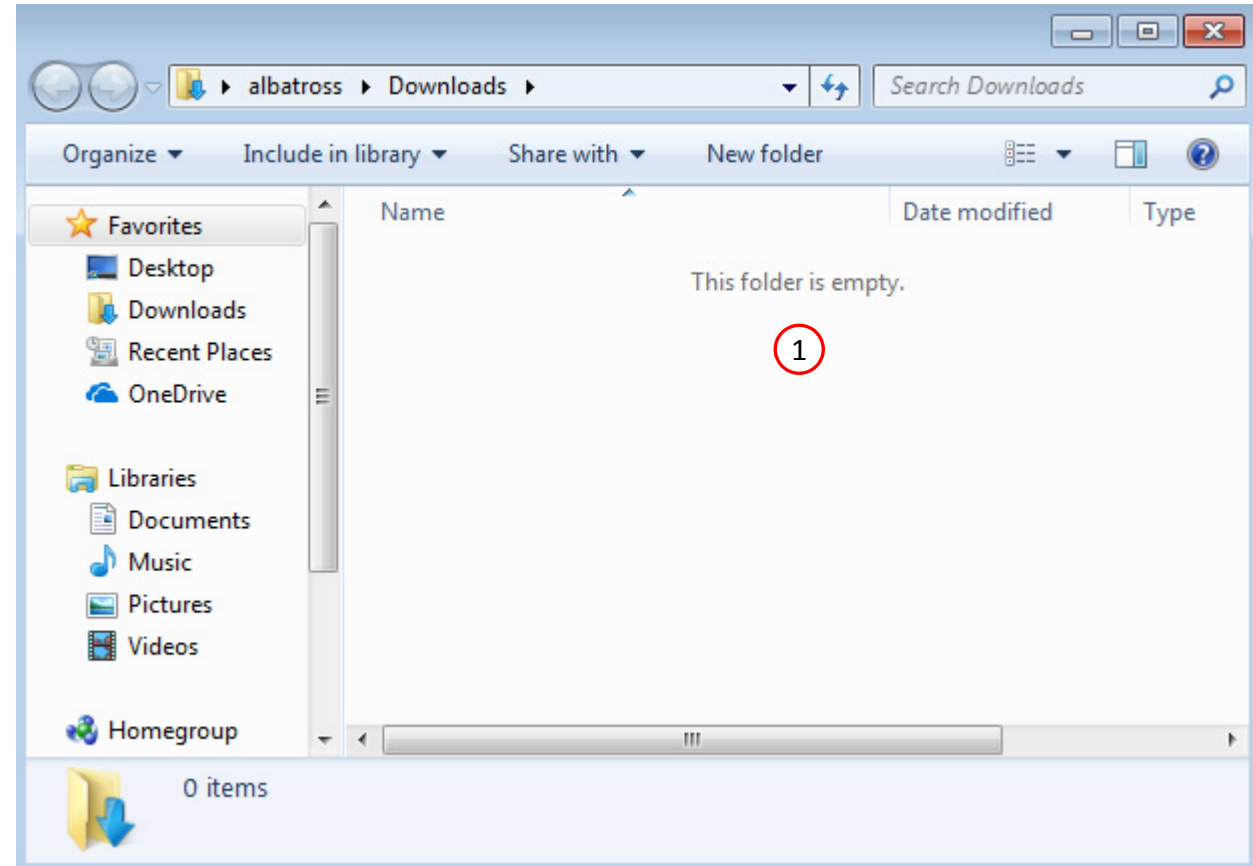


HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

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

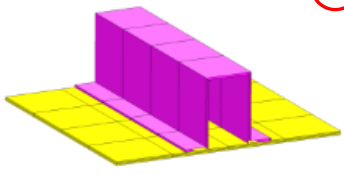
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

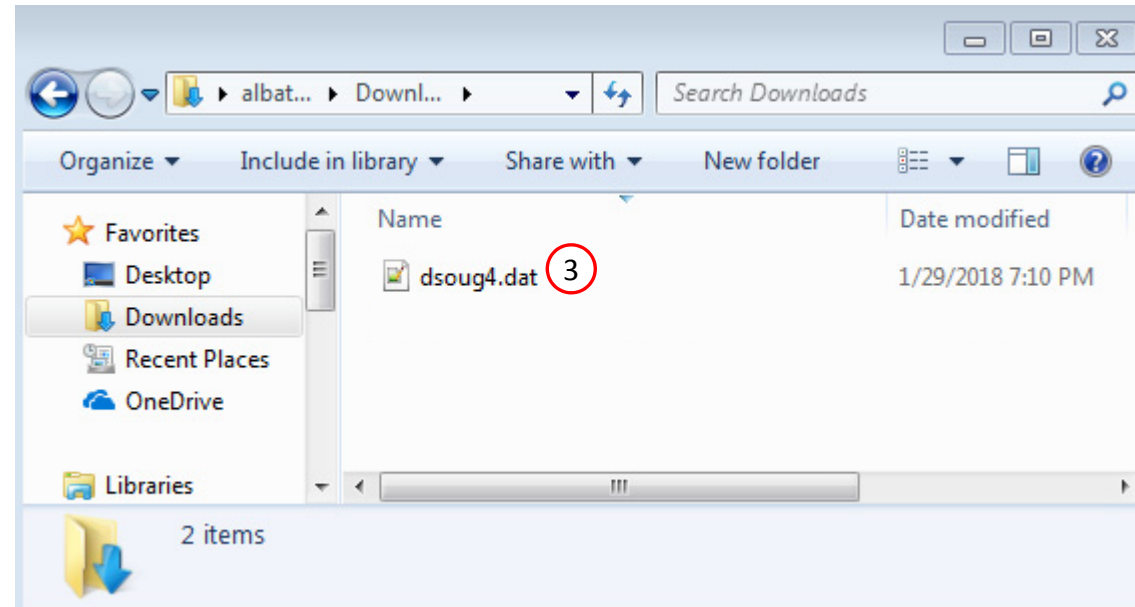


Obtain Starting Files

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.

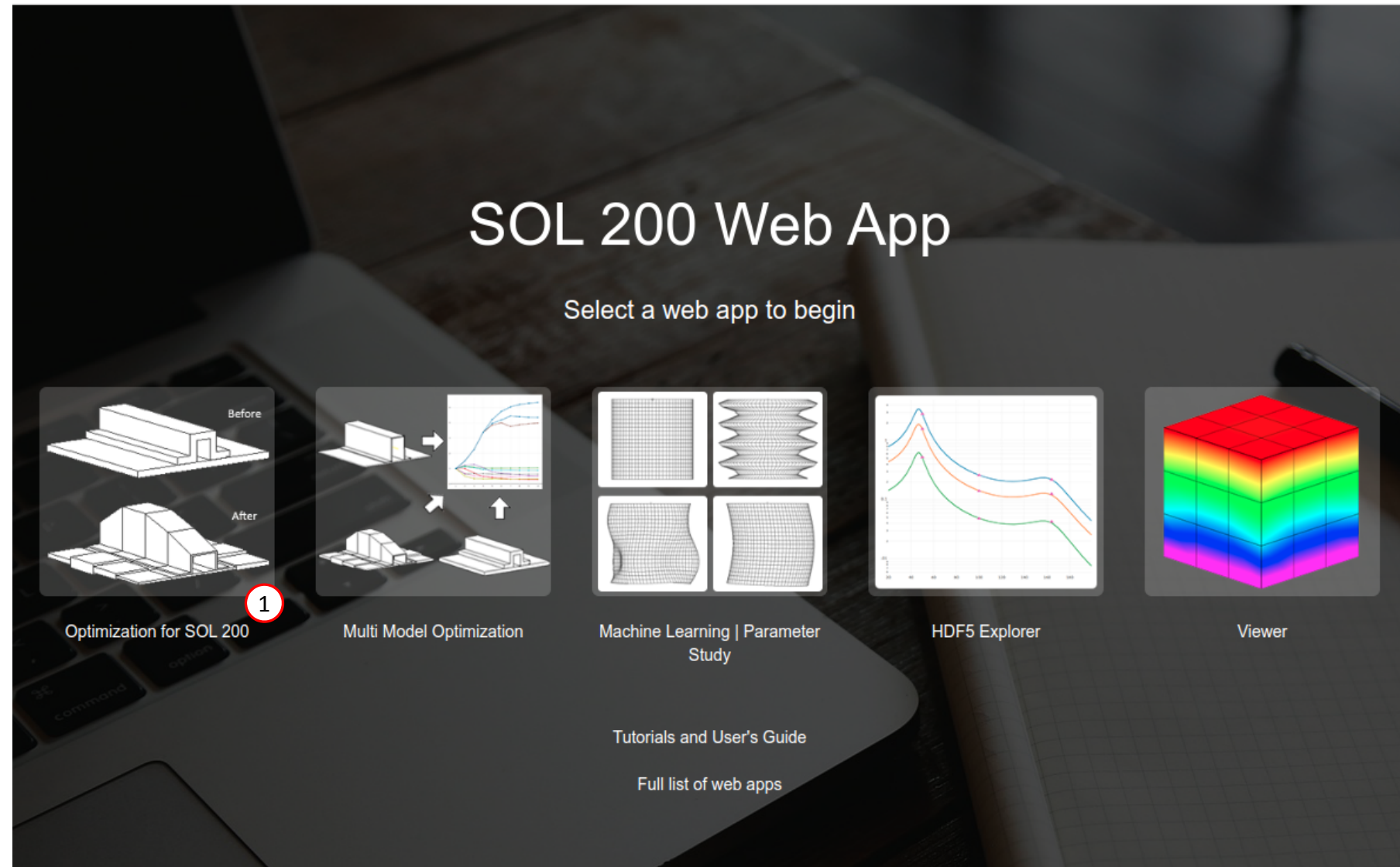
	<p>1 Automated Structural Optimization of a Stiffened Plate with MSC Nastran SOL 200/Design Optimization Link</p> <p>This example demonstrates the use of MSC Nastran to optimize the thickness of the plate and the thickness of a beam section to minimize weight. Constraints are imposed on the stresses in the shell and beam elements. Additional constraints are imposed on deflections.</p> <p>Starting BDF Files: Link 2 Solution BDF Files: Link</p>
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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.



Upload BDF Files

1. Click 1. Select Files and select dsoug4.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 BDF files. Step 1, '1. Select files', is highlighted with a blue button and shows the file 'dsoug4.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 dsoug4.dat

Inspecting: 100%

2. Upload files

Uploading: 100 %

☐ List of Selected Files

Create Design Variables

1. In the search box, type 't'
2. Click on the plus (+) icons to set the thickness as a design variable
3. In the search box, type 'dim'
4. Click on the plus (+) icons to set DIM2 as a design variable
5. Specify the lower bound as .01 for design variables x1, x2
6. Specify the upper bound as 1. for design variables x1, x2

- The necessary design variables, as detailed in the optimization problem statement, are created.
- The search boxes are used to filter the tables for the T and DIM2 properties.
- Each step has hidden functionality for advanced users. The visibility is controlled by clicking [+ Options](#).

Step 1 - Select design properties

+ Options

Create DVXREL1	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Current Value ⇅
	t 1	Search	Search	Search	Search
2 +	T	Thickness	PSHELL	1	0.15
+	T	Thickness	PSHELL	2	0.2

Step 1 - Select design properties

+ Options

Create DVXREL1	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Current Value ⇅
	dim 3	Search	Search	Search	Search
+	DIM1	HAT - Height of beam	PBARL	3	3.0
4 +	DIM2	HAT - Thickness of flange, web and li...	PBARL	3	0.1
+	DIM3	HAT - Width of flange, top	PBARL	3	2.0
+	DIM4	HAT - Width of lip	PBARL	3	0.9

Step 2 - Adjust design variables

✕ Delete Visible Rows

+ Options

	Label ⇅	Status ⇅	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Initial Value ⇅	Lower Bound	Upper Bound	Allowed Discrete Values
	Search	Search	Search	Search	Search	Search	Search	5	6	Search
✕	x1	✓	T	Thickness	PSHELL	1	0.15	.01	1.	Examples: -2.0, 1.0, THRU, '
✕	x2	✓	DIM2	HAT - Thickness of flange, web and li...	PBARL	3	0.1	.01	1.	Examples: -2.0, 1.0, THRU, '

Create Design Variables

1. In the search box, type 'w3'
2. Select '10' in the pagination bar
3. Click +Options
4. Check the DVXREL2 option
5. Type in this equation:
 - $1.5 + x1 / 2.0$
6. Click on Create

- In order to avoid interference between the beam cross section and thickness of the plate, a relationship is created between the beam offsets (W3A,B) and the variable representing the plate thickness (x1). A DVXREL2 entry defines this relationship.
- Design variables (DVXREL1) and DVXREL2 relationships can be individually created by clicking the blue plus (+) icons.
- If dozens or hundreds of variables or relationships must be created, the table can be used create these entries in one click by clicking the yellow icons named Create. In addition, the bounds, discrete values or equation can be configured rapidly.

Step 1 - Select design properties

+ Options **3**

Display Type	% Lower Bound	% Upper Bound	Lower Bound	Upper Bound	Allowed Discrete Values or Equation	Bulk Create
	<input type="checkbox"/>	<input checked="" type="checkbox"/>				
<input checked="" type="checkbox"/> DVXREL1	Lower	Upper	Lower	Upper	Allowed discrete values, example: -2.0, 1.0, THRU, 10.0, BY, 1.0	
<input type="checkbox"/> DVXREL1 Unity	Lower	Upper	Lower	Upper	Allowed discrete values, example: -2.0, 1.0, THRU, 10.0, BY, 1.0	
4 <input checked="" type="checkbox"/> DVXREL2	Lower	Upper	Lower	Upper	$1.5 + x1 / 2.0$ 5	6

Display Columns

☒ Create DVXREL1 ☐ Create Unity DVXREL1 ☒ Create DVXREL2 ☐ Entry Name

Settings for row filtering in tables

☒ Contains ☐ Starts with ☐ Ends with

Create DVXREL1	Create DVXREL2	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Current Value ⇅
		w3 1	Search	Search	Search	Search
		W3A	Component of offset vector wa at poi...	CBAR	31	1.575
		W3B	Component of offset vector wb at poi...	CBAR	31	1.575
		W3A	Component of offset vector wa at poi...	CBAR	32	1.575
		W3B	Component of offset vector wb at poi...	CBAR	32	1.575
		W3A	Component of offset vector wa at poi...	CBAR	33	1.575
		W3B	Component of offset vector wb at poi...	CBAR	33	1.575
		W3A	Component of offset vector wa at poi...	CBAR	34	1.575
		W3B	Component of offset vector wb at poi...	CBAR	34	1.575

5 10 20 30 40 50
Num **2** of Visible Rows 10

Create Design Variables

1. Click 10 on the pagination bar
2. 8 DVXREL2 entries have been created

- These entries define relationships between the beam offsets (W3A,B) and the plate thickness variable (x_1). As the thickness variable changes, the offset is also updated and will avoid the situation where the beam cross section interferes with the plate thickness.

Step 5 - Adjust DVXREL2

✕ Delete Visible Rows

+ Options

	Label ▾	Status ▾	Property ▾	Property Description ▾	Entry ▾	Entry ID ▾	Initial Value ▾	Lower Bound	Upper Bound	Equation
	<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"/>
✕	C1	✓	W3A	Component of offset vector wa a...	CBAR	31	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C2	✓	W3B	Component of offset vector wb a...	CBAR	31	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C3	✓	W3A	Component of offset vector wa a...	CBAR	32	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C4	✓	W3B	Component of offset vector wb a...	CBAR	32	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C5	✓	W3A	Component of offset vector wa a...	CBAR	33	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C6	✓	W3B	Component of offset vector wb a...	CBAR	33	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C7	✓	W3A	Component of offset vector wa a...	CBAR	34	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$
✕	C8	✓	W3B	Component of offset vector wb a...	CBAR	34	1.575	Minimum	Maximum	$1.5 + x_1 / 2.0$

5 10 20 30 40 50

1

Create Design Objective

1. Click Objective
2. Select the plus (+) icon for weight
3. The objective has been set to minimize the weight, no further modification is necessary






- The objective must always be a single and global response. A response such as weight and volume are single responses, are independent of load case, 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 103 - Normal Modes

Select a response



	Response Description ▾	Response Type ▾
	<input type="text" value="Search"/>	<input type="text" value="Search"/>
2 	Weight	WEIGHT
	Volume	VOLUME
	Eigenvalue	EIGN
	Frequency	FREQ
	Displacement	DISP

« 1 2 3 »

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 ▾	

Create Design Constraints

1. Click Constraints
2. In the search box, type 's'
3. Select the plus(+) icon 4 times for Stress to create 4 stress constraints
4. Select the plus(+) icon 2 times for Displacement to create 2 displacement constraints
5. Select '10' in the pagination bar
6. Configure the constraints as shown to the right

- Example: Configure the following for r1
 - Property Type: PBARL
 - ATTA: 7 - End A maximum
 - ATTi: 3 (PID 3)
 - Lower Allowed Limit: -25000.
 - Upper Allowed Limit: 25000.

- The r1 label is configured as follows: A stress constraint is created for all elements associated with the entry PBARL 3, for component 7 (End A Maximum). PBARL 3 has 4 elements associated, so 4 stress quantities are constrained.

- The r3 label is configured as follows: A stress constraint is created for all elements associated with PSHELL 1 for component 9 (von Mises). PSHELL 1 has 16 elements associated, so 16 stress quantities are constrained.

1

Step 1 - Select constraints

Select an analysis type

SOL 101 - Statics

Select a response

	Response Description	Response Type
	s	Search
4	+	Displacement
	+	Strain
	+	Element Strain Energy
3	+	Stress
	+	Fatigue, pseudo-static fatigue analysis
		DISP
		STRAIN
		ESE
		STRESS
		FATIGUE

Step 2 - Adjust constraints

+ Options

	Label	Status	Response Type	Property Type	ATTA	ATTB	ATTi	Lower Allowed Limit	Upper Allowed Limit
	Se	Seal	Search	Search	Search	Search	Search	Search	Search
	r1	+	STRESS	PBARL	7 - End A maximum		3	-25000.	25000.
	r2	+	STRESS	PBARL	14 - End B maximum		3	-25000.	25000.
	r3	+	STRESS	PSHELL	9 - von Mises or maximum shear a		1	Lower	25000.
	r4	+	STRESS	PSHELL	17 - von Mises or maximum shear i		1	Lower	25000.
	r5	+	DISP		3 - T3 (Rectangular z, Cylindrical z		10302	-.1	.1
	r6	+	DISP		3 - T3 (Rectangular z, Cylindrical z		10203	-.03	.03

5 10 20 30 40 50

5

Assign Constraints to Load Cases (SUBCASES)

1. Click Subcases
2. Click Check visible boxes
3. Unmark the indicated checkboxes

- The following constraints have been applied to SUBCASE 1: r1, r2, r3, r4, r5
- The following constraints have been applied to SUBCASE 2: r1, r2, r3, r4, r6
- When hundreds of SUBCASEs must be configured, the following options expedite the process:

Uncheck visible boxes

Check visible boxes

1

Step 1 - Assign constraints to subcases

Display Columns

Global Constraints
SUBCASE 1
SUBCASE 2

☐ Uncheck visible boxes

☒ Check visible boxes

2

+ Options

	Status	Label	Response Type	Description	Global Constraints	SUBCASE 1	SUBCASE 2
		<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>			
	<input checked="" type="checkbox"/>	r1	STRESS	Stress, item code 7, of elements associated with PBARL 3		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	<input checked="" type="checkbox"/>	r2	STRESS	Stress, item code 14, of elements associated with PBARL 3		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	<input checked="" type="checkbox"/>	r3	STRESS	Stress, item code 9, of elements associated with PSHELL 1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	<input checked="" type="checkbox"/>	r4	STRESS	Stress, item code 17, of elements associated with PSHELL 1		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	<input checked="" type="checkbox"/>	r5	DISP	T3 component(s) of displacement at grid 10302		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	r6	DISP	T3 component(s) of displacement at grid 10203		<input type="checkbox"/>	<input checked="" type="checkbox"/>

3

Configure Settings

1. Click Settings
2. Scroll to section Result Files
3. Select one of the following H5 output options
 - Create the H5 file with MDLPRM
 - Create the H5 file with HDF5OUT

- The H5 file is used by the Post-processor web app to display MSC Nastran results.
- The H5 file is used by the HDF5 Explorer to create graphs (XY Plots) of MSC Nastran results.

The screenshot shows the 'SOL 200 Web App - Optimization' interface. The 'Settings' tab is selected, indicated by a red circle with the number '1'. Below the navigation bar, the 'Result Files' section is highlighted with a red circle and the number '2'. Within this section, the 'H5 Output Option' dropdown menu is open, showing three options: 'Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)', 'Create the H5 file with MDLPRM (supported in MSC Nastran 2016.1 or newer)', and 'Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)'. The third option is selected and highlighted in blue, with a red circle and the number '3' next to it. On the right side of the interface, there is a 'BDF Output' section with a list of parameters including '\$', '\$', '\$', '\$', '\$', 'DOPTPRM', 'DESM', '\$ Parameter t', and 'HDF5OUT INPUT'.

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 **Exporter** Results

Settings Match Other User's Guide Home

BDF Output - Model

```
assign userfile = 'optimization_results.csv', status = unknown,
form = formatted, unit = S2
$
$ Automated Structural Optimization of a Stiffened Plate with
$ MSC Nastran SOL 200/Design Optimization
$
$ field entries left justified for clarity
$ cbar entry line 1: vector v is z direction
$ cbar entry line 2: w3a and w3b that is fields 6 and 9
$ rename t-box as hatdim2
$
ID MSC DSOUG4 $ v2004 ehj 15-Jun-2003
$ Modified 31-May-2007 v2007 S_NATARAJAN
TIME 10
SOL 200
CEND

$
TITLE = STATIC ANALYSIS OF A STIFFENED PLATE DSOUG4
ECHO = NONE
DISP = ALL
STRESS = ALL
SPC = 1
DESOBJ(MIN) = 8000000
$ DESGLB Slot
$ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1
ANALYSIS = STATICS
DESSUB = 40000001
```

BDF Output - Design Model

```
$*****
$*
$* Design Model
$*
$*****
$
$ Design Variables - Type 1
$-----
$
$
$
DVPREL1 1000001 PSHELL 1 T
100001 1.0
DVPREL1 1000002 PBARL 3 DIM2
100002 1.0
$
$
DESVAR 100001 x1 0.15 .01 1.
DESVAR 100002 x2 0.1 .01 1.
$
$
$
$
$ Design Variables - Type 2
$-----
$
$
$
DVCREL2 2000001 CBAR 31 W3A 5001
DESVAR 100001
DVCREL2 2000002 CBAR 31 W3B 5001
DESVAR 100001
DVCREL2 2000003 CBAR 32 W3A 5001
DESVAR 100001
DVCREL2 2000004 CBAR 32 W3B 5001
DESVAR 100001
DVCREL2 2000005 CBAR 33 W3A 5001
DESVAR 100001
DVCREL2 2000006 CBAR 33 W3B 5001
DESVAR 100001
DVCREL2 2000007 CBAR 34 W3A 5001
DESVAR 100001
```

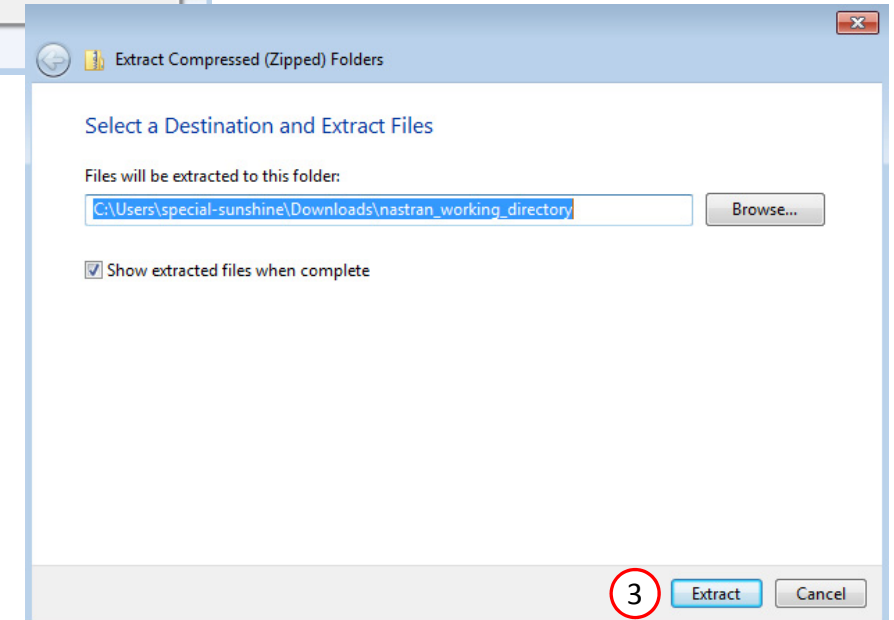
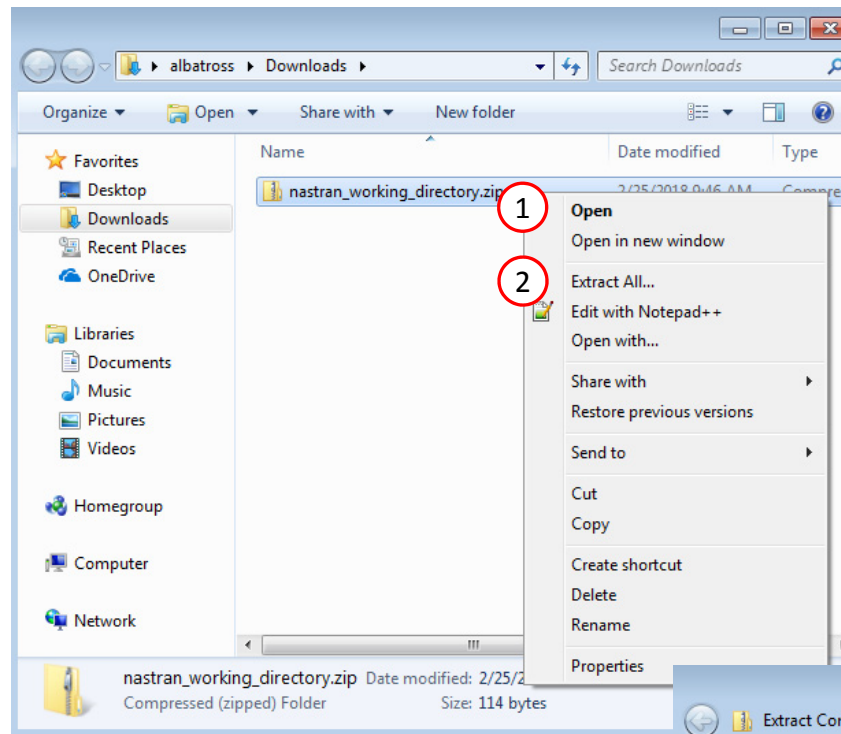
Developed by The Engineering Lab

[Download BDF Files](#)

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.

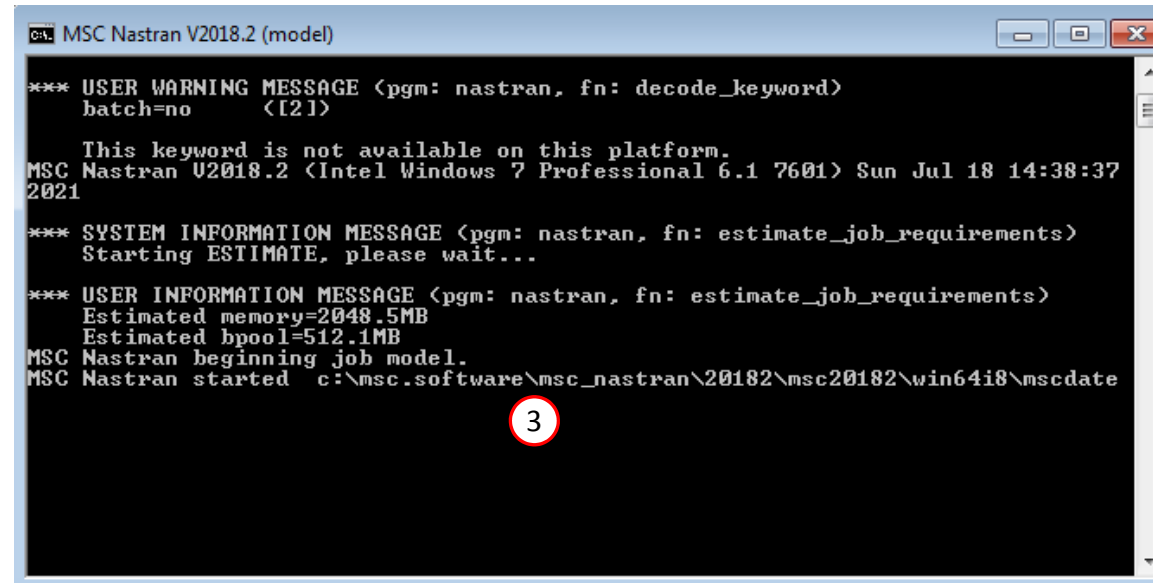
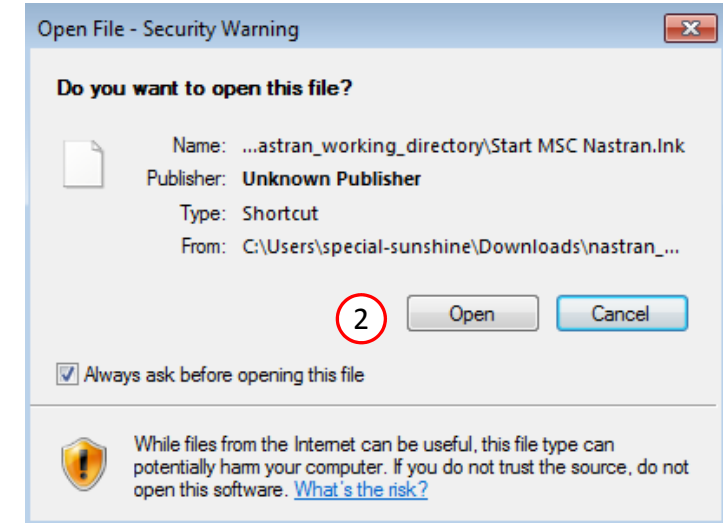
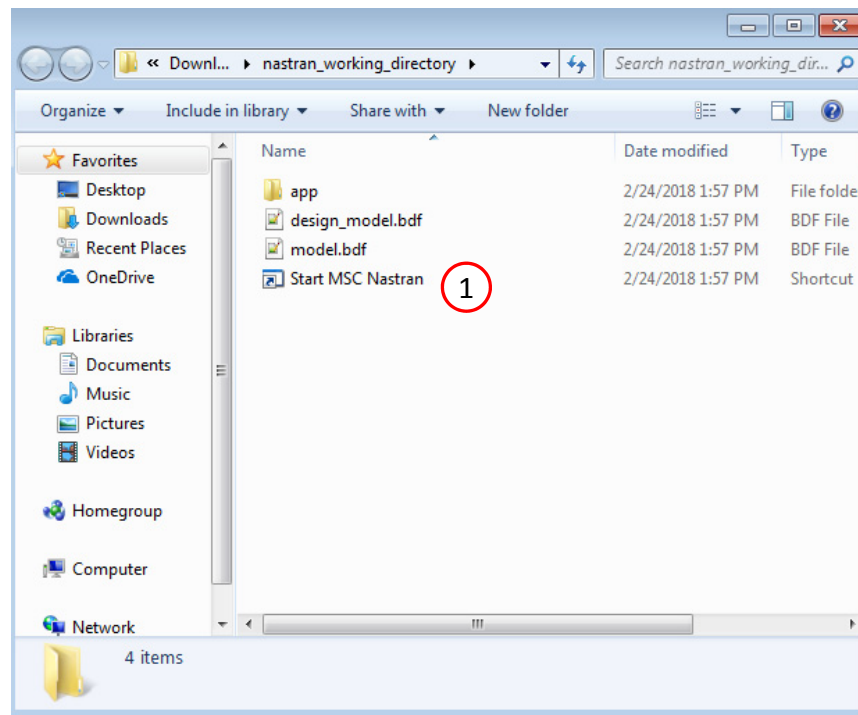
Using Linux?

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) and design variables can be reviewed.

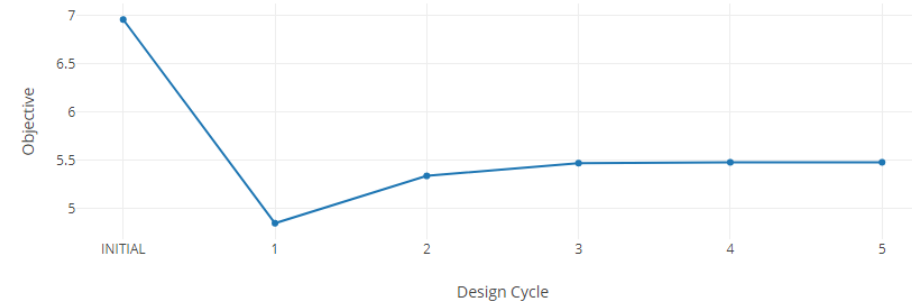
- After an optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- After the first design cycle, the weight is minimized from 7 to ~4.8, but after the second design cycle, the weight increases to ~5.4. This drop in weight, then slight increase is sometimes an indication a constraint was violated or near violation when minimizing weight, but then corrected by increasing weight. The normalized constraint at the initial design, after design cycle 1 and 2 are, -.164, .654 and .087, respectively, note the increase to .654, then drop to .087. The normalized constraint plot is not shown on this page but is visible to you when viewing the web app.

Final Message in .f06

1

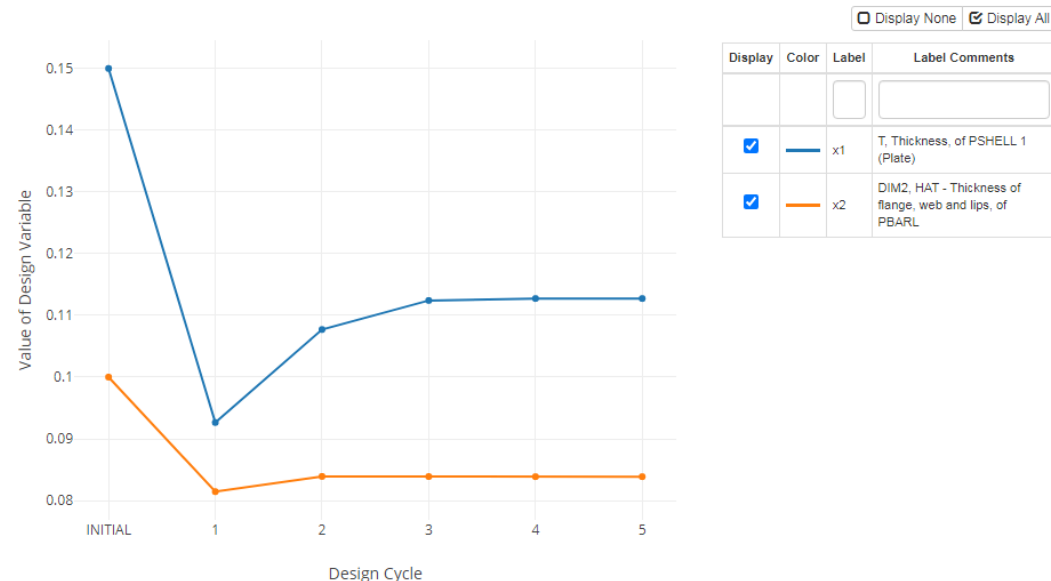
 RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 5.

Objective



2

Design Variables



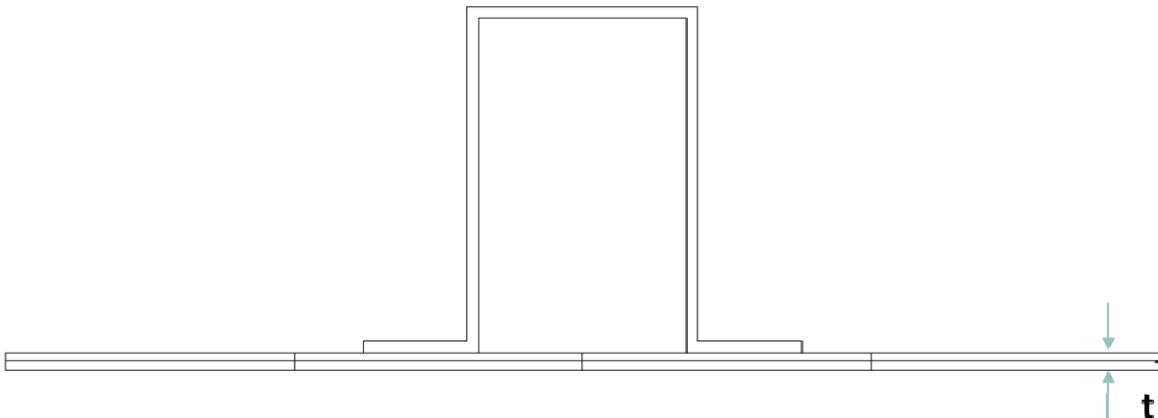
☐ Display None ☒ Display All

Display	Color	Label	Label Comments
<input checked="" type="checkbox"/>	Blue	x1	T, Thickness, of PSHELL 1 (Plate)
<input checked="" type="checkbox"/>	Orange	x2	DIM2, HAT - Thickness of flange, web and lips, of PBARL

Results

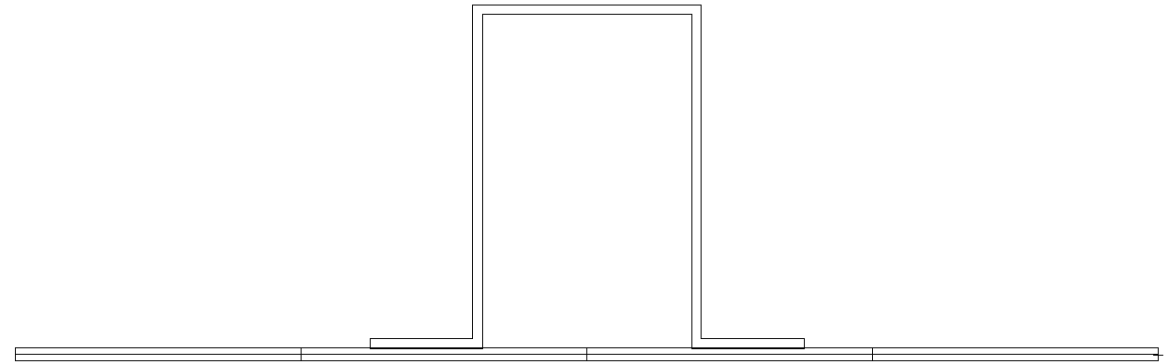
Before Optimization

- Weight: 6.962
- $x_1 = T$, thickness of shell
- $= .15$
- $x_2 = \text{DIM2}$
- $= .1 \text{ in.}$



After Optimization

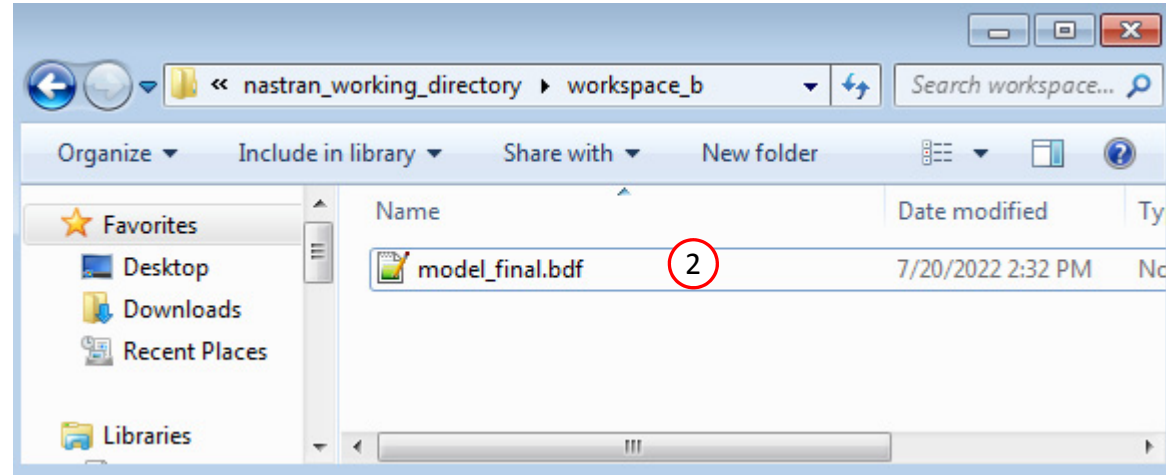
- Weight: 5.477
- $x_1 = T = .113 \text{ in.}$
- $x_2 = \text{DIM2} = .0839 \text{ in.}$



Update the Original Model

1. The original input files, e.g. DAT, BDF, etc., contains the original values for the designed properties. These original values must be updated to use the new and optimized values.
2. A new BDF file has been created in `nastran_working_directory/workspace_b/model_final.bdf`.
3. The file `model_final.bdf` is a copy of the original input files but the original values for the designed properties have been updated to use the optimized values.

- If you were using multiple INCLUDE files, model_final.bdf is a combination of all INCLUDE files. The next few slides discuss an alternative method of using the PCH to BDF web app to update the values for the designed properties while preserving separate INCLUDE files.



Original Input Files

```

CBAR      31      3      10200      10201      0.0      0.0      1.0
1.575      1.575
CBAR      32      3      10201      10202      0.0      0.0      1.0
1.575      1.575
CBAR      33      3      10202      10203      0.0      0.0      1.0
1.575      1.575
CBAR      34      3      10203      10204      0.0      0.0      1.0
1.575      1.575

$
$ Elements and Element Properties for region : Plate
PSHELL  1      1      0.15      1
$ Elements and Element Properties for region : Plate_2
PSHELL  2      1      0.2      1
$1111111222222333333333333444444455555555666666677777777788888889999999
$ Elements and Element Properties for region : Hat_Stiffener
PBARL   3      1      hat
3.0      0.1      2.0      0.9

$

```

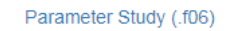
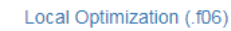
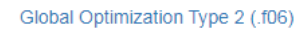
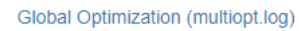
Updated BDF File (model_final.bdf)

```

CBAR      31      3      0      10201      0.0      0.0      1.0      1
      0      0      0.0      0.0      1.55637      0.0      0.0      1.55637
CBAR      32      3      10201      10202      0.0      0.0      1.0      1
      0      0      0.0      0.0      1.55637      0.0      0.0      1.55637
CBAR      33      3      10202      10203      0.0      0.0      1.0      1
      0      0      0.0      0.0      1.55637      0.0      0.0      1.55637
CBAR      34      3      10203      10204      0.0      0.0      1.0      1
      0      0      0.0      0.0      1.55637      0.0      0.0      1.55637
$
$ Elements and Element Properties for region : Plate
PSHELL    1      1      .112735      0      1      1.0      0 .833333      0.0
$ Elements and Element Properties for region : Plate_2
PSHELL    2      1      0.2      1
$111111122222223333333334444444455555556666666777777778888888899999999
$ Elements and Element Properties for region : Hat_Stiffener
PBARL      3      1MSCBML0 HAT
      3.      .083866      2.      .9      0.0

```

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: dsoug4.dat
- 3. A summary of updates that will be performed are shown
- 4. Click Download and a new updated BDF file is downloaded

Step 1 - Select PCH File

Select files

model.pch

1

Inspecting: 100%

☐ List of Selected Files

PCH Entries

CBAR	31	3	10200	10201	0.0	0.0	1.0	1
	0	0	0.0	0.0	1.55637	0.0	0.0	1.55637
CBAR	32	3	10201	10202	0.0	0.0	1.0	1
	0	0	0.0	0.0	1.55637	0.0	0.0	1.55637
CBAR	33	3	10202	10203	0.0	0.0	1.0	1
	0	0	0.0	0.0	1.55637	0.0	0.0	1.55637
CBAR	34	3	10203	10204	0.0	0.0	1.0	1
	0	0	0.0	0.0	1.55637	0.0	0.0	1.55637
PSHELL	1	1	.112735	1	1.0	0	.833333	0.0
			0					
PBARL	3	1	MSCBML0	HAT				
	3.	.083866	2.	.9	0.0			

Step 2 - Select BDF Files

Select files

dsoug4.dat

2

Inspecting: 100%

☐ List of Selected Files

BDF Entries

CBAR	31	3	10200	10201	0.0	0.0	1.0	1.575
					1.575			1.575
CBAR	32	3	10201	10202	0.0	0.0	1.0	1.575
					1.575			1.575
CBAR	33	3	10202	10203	0.0	0.0	1.0	1.575
					1.575			1.575
CBAR	34	3	10203	10204	0.0	0.0	1.0	1.575
					1.575			1.575
PSHELL	1	1	0.15	1				
PBARL	3	1		hat				
	3.0	0.1	2.0	0.9				

3



Step 3 - Download New BDF Files

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

Download

4

1. Note the entries have been updated with the optimized properties

Downloaded BDF/DAT File

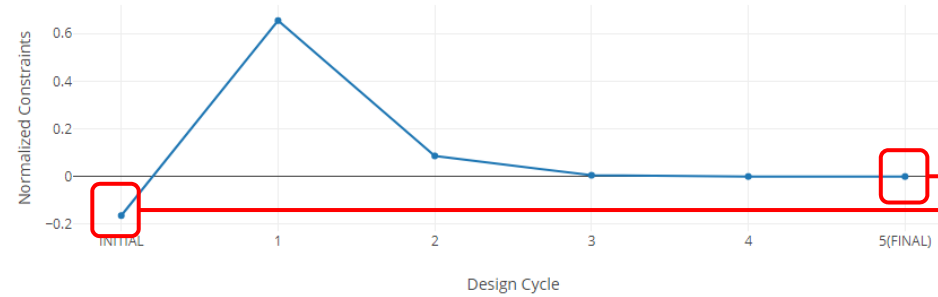
Inspection of MSC Nastran Results with the Post-processor Web App

Normalized Constraints

- All constraints are normalized. For each design cycle, the maximum normalized constraint (NC) is reported in the Normalized Constraints plot.
- The Responses web app is used to inspect the corresponding response for each maximum normalized constraint value.
 - For the initial design, the maximum NC is -.16392 and corresponds to a beam stress of 20,902.
 - For the final design, the maximum NC is .000024418 and corresponds to a von Mises stress of 25,001.

Normalized Constraints

+ Info



SOL 200 Web App - Responses

Home

Responses

Reset view Violated constraints Active constraints Maximum constraint for each design cycle

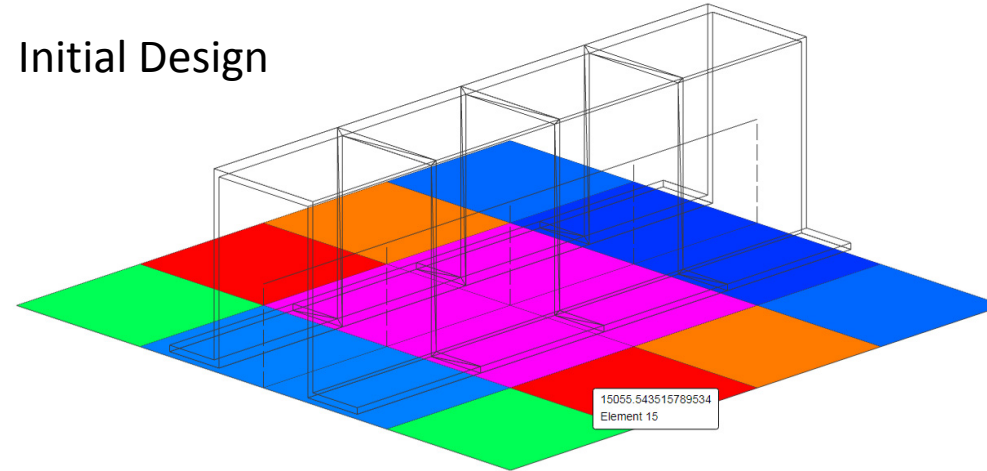
Design Cycle	Subcase	Label	Response Type	Normalized Constraint	Lower Bound	Value	Upper Bound	Normalized Constraint	Show More Information	designCycleNumber	ELEMENT ID	COMPONENT NO.
Search	Search	Search	Search	Search	Search	Search	Search	Search				
INITIAL	2	r1	STRESS		N/A	2.0902E+04	2.5000E+04	-1.6392E-01**		0	34	7
1	1	r5	DISPLACEMENT		N/A	1.6545E-01	1.0000E-01 V	6.5446E-01**		1		3
2	1	r3	STRESS		N/A	2.7165E+04	2.5000E+04 V	8.6588E-02**		2	3	9
3	1	r3	STRESS		N/A	2.5133E+04	2.5000E+04 V	5.3229E-03**		3	3	9
FINAL - 5(FI	1	r3	STRESS		N/A	2.5001E+04	2.5000E+04 A	2.4418E-05**		5	15	9

Post-processor Web App

- The Post-processor web app is used to inspect the MSC Nastran results.
- Consider the maximum von Mises stress for the top and bottom of the thickness and for subcase 1.
 - For the initial design, for element 15, the von Mises stress is 15,055.
 - For the final design, for element 15, the von Mises stress is 25,000.61 \approx 25,001.
- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

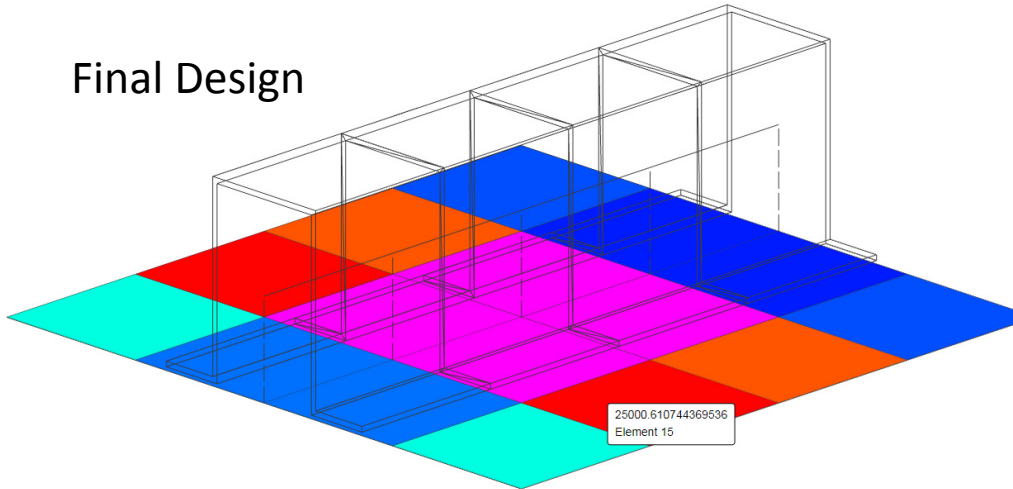
Main Panel

Initial Design

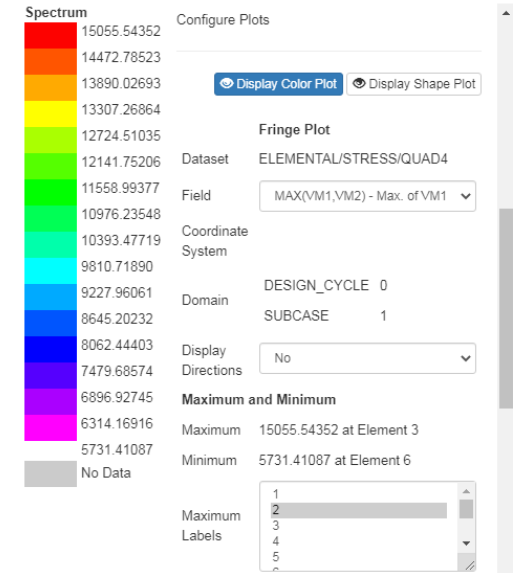


Main Panel

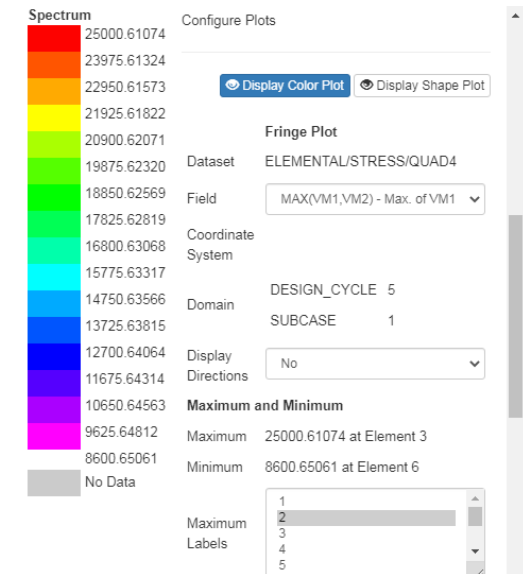
Final Design



Post-processor



Post-processor

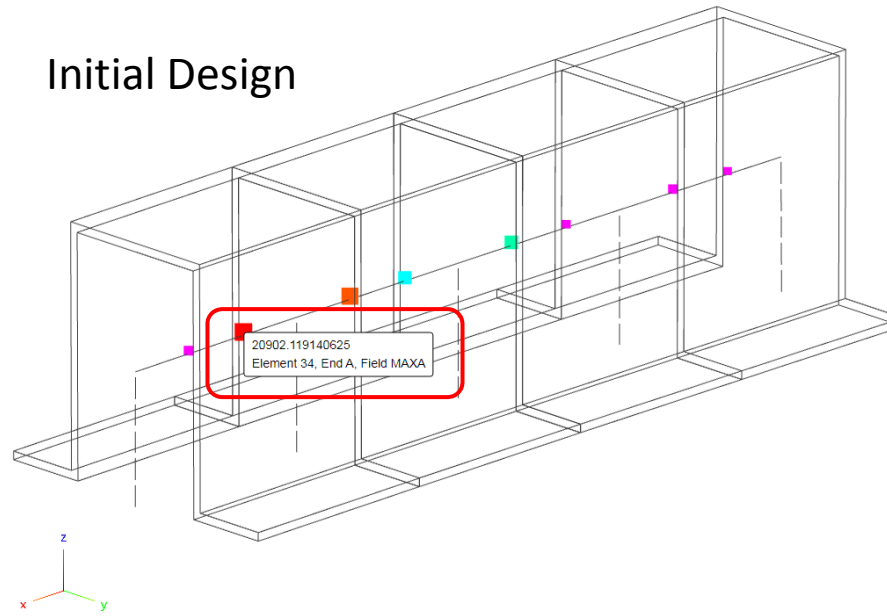


Post-processor Web App

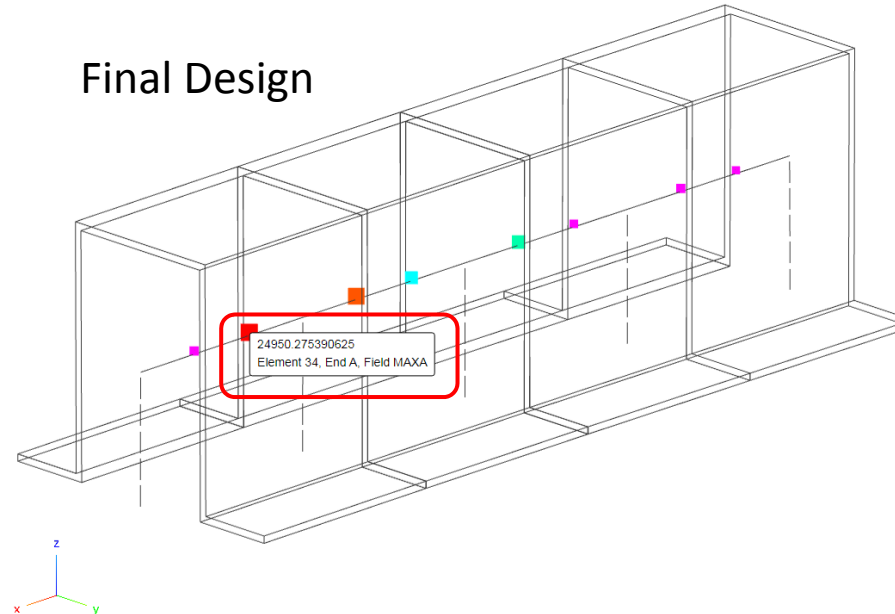
- The Post-processor web app is used to inspect the MSC Nastran results.
- Consider the maximum beam stress for the end A and B of the beam elements for subcase 2.
 - For the initial design, for element 34, the maximum beam stress is at end A and is 20,902.
 - For the final design, for element 34, the maximum beam stress is at end A and is 24,950.

Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

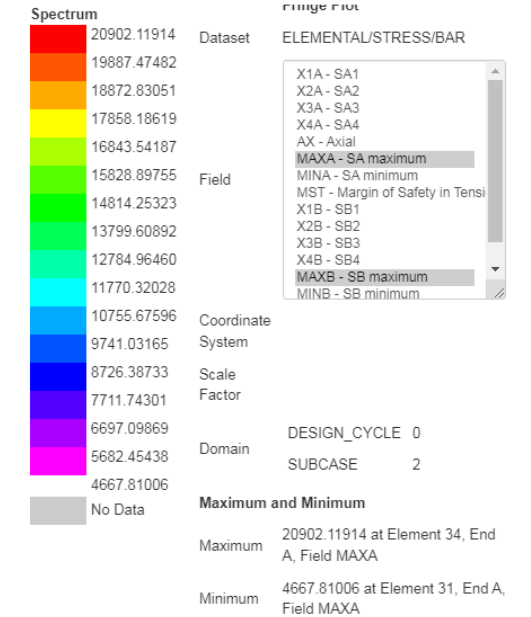
Initial Design



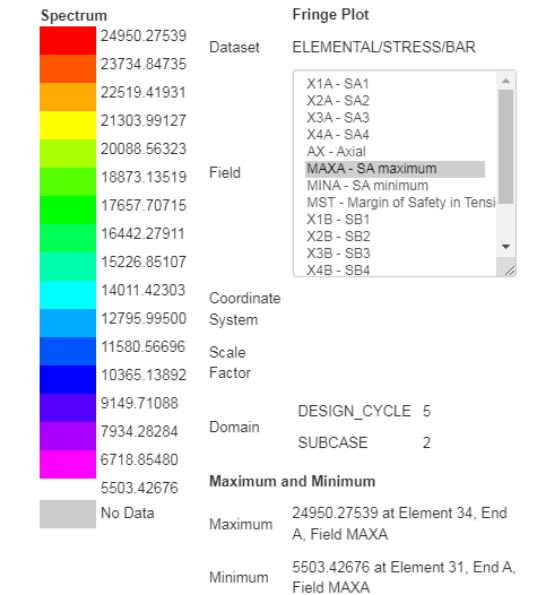
Final Design



Post-processor



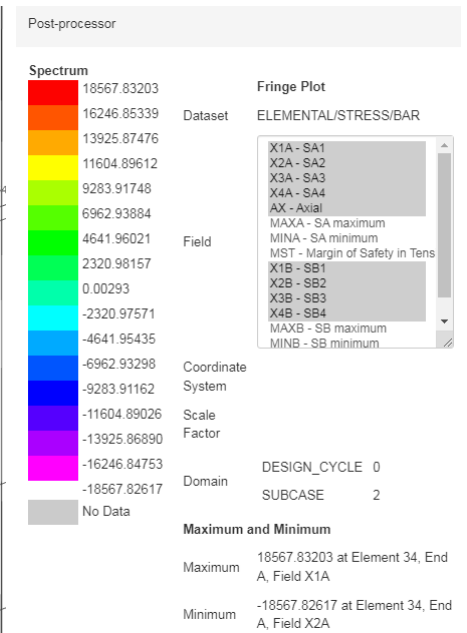
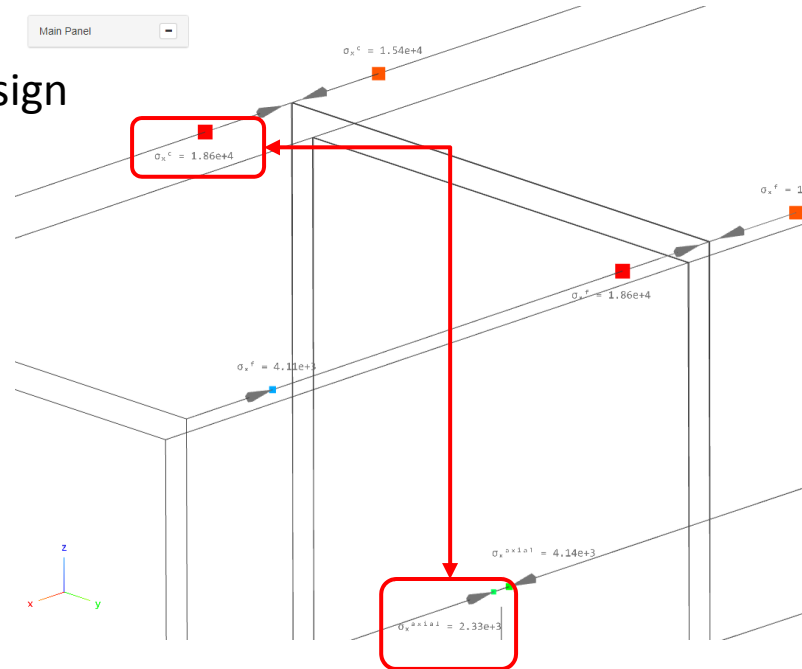
Post-processor



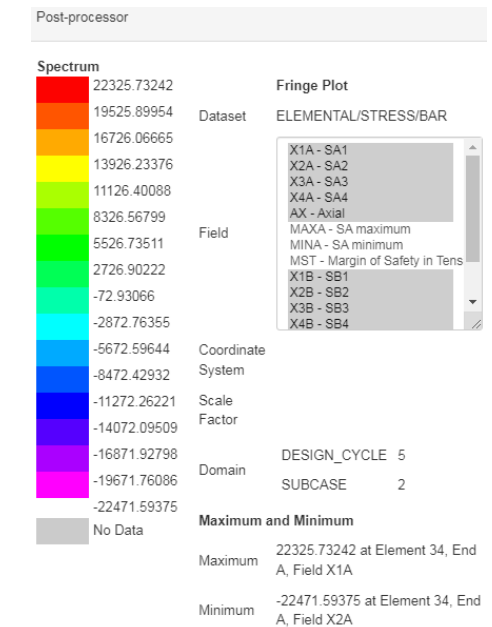
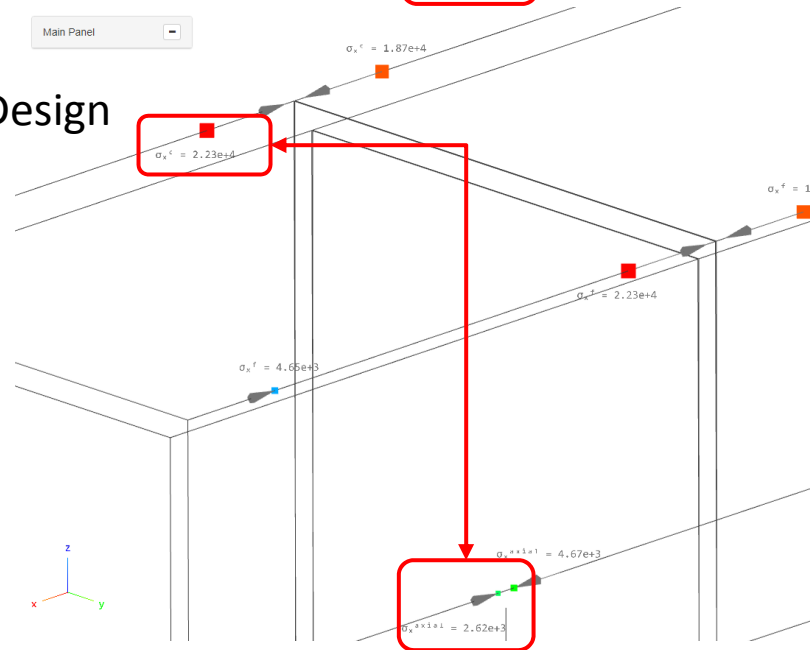
Post-processor Web App

- The maximum stress and end A and B was constrained during the optimization. What is the maximum stress?
 - The maximum stress is the sum of the bending stress and axial stress.
 - For subcase 2, element 34:
 - For the initial design, the max stress is $20,902 = 18,567.83 + 2,334.29$
 - For the final design, the max stress is $24,950 = 22,325 + 2,625$
- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

Initial Design



Final Design

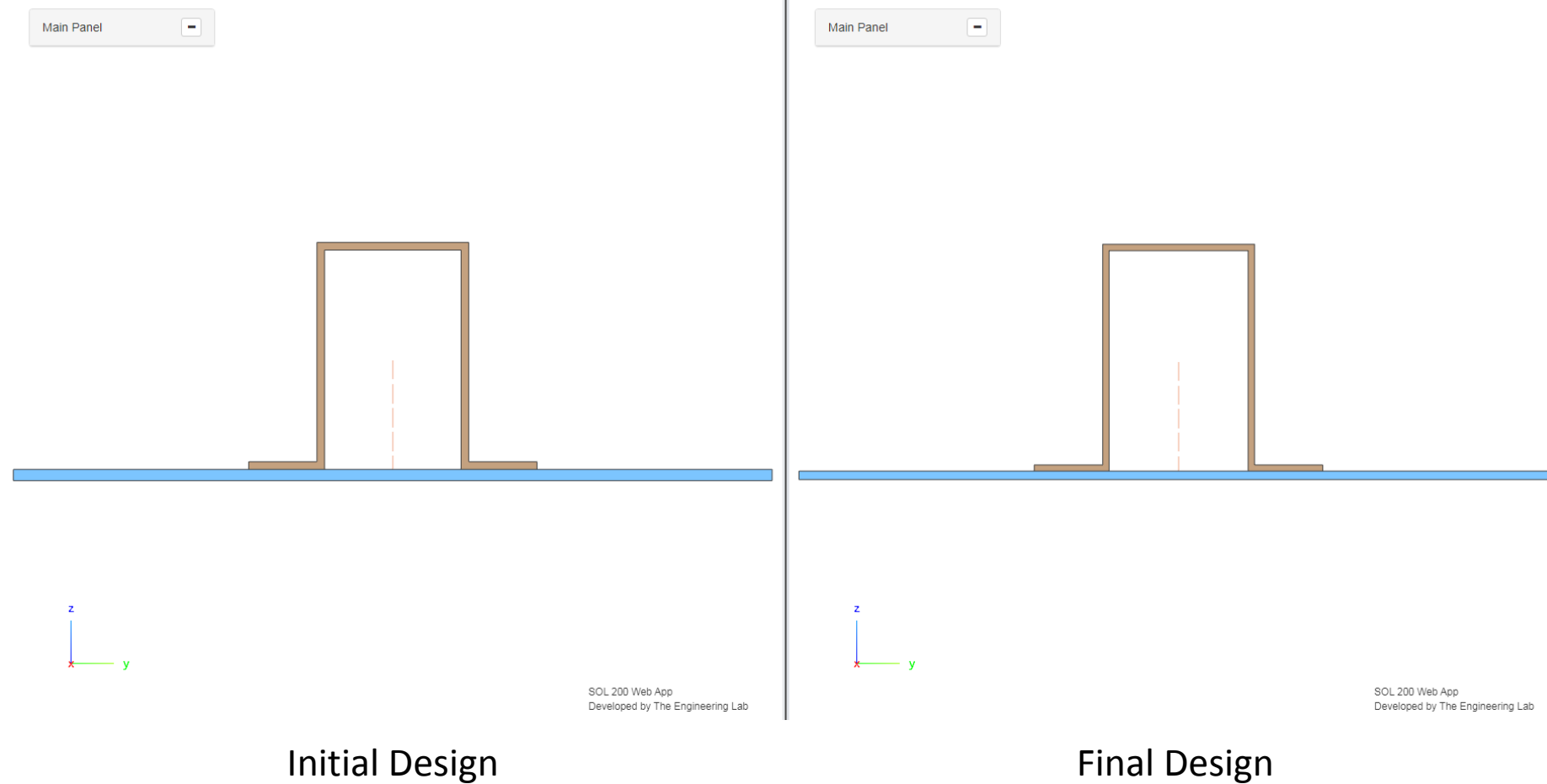


Post-processor Web App

- The CBAR cross sections of the initial and final design are compared.
- The CQUAD4 thicknesses of the initial and final design are compared

- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

Thickness of CQUAD4 elements
Beam cross section of CBAR elements



End of Tutorial

Appendix

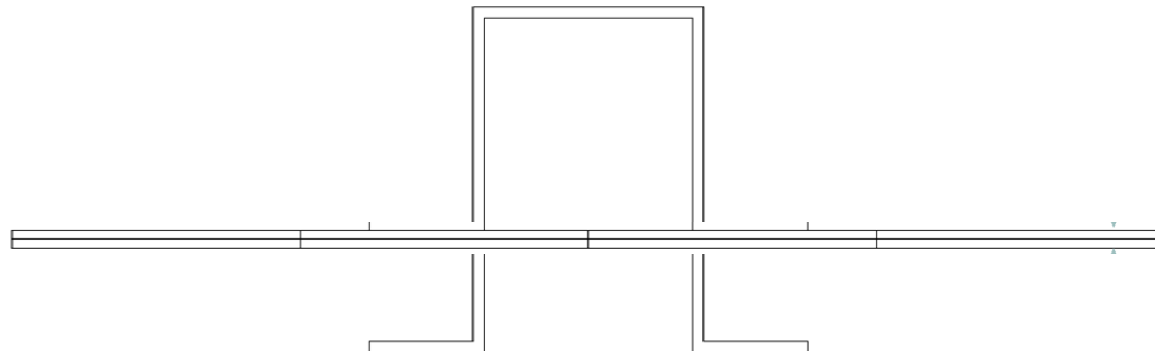
Appendix Contents

- Frequently Asked Questions
 - How do I avoid the scenario where the offset causes the cross section to interfere with the plate?

Frequently Asked Questions

Question:

- How do I avoid the scenario where the offset causes the cross section to interfere with the plate?



The offset (W3A and W3B) in this example causes the beam cross section to interfere with the plate

Frequently Asked Questions

Answer:

- In 'Step 4 - Adjust DVXREL2', specify bounds that the offset property can take
- In this tutorial, this step was not necessary because the offset is in terms of x1 and x1 already has bounds applied

Step 5 - Adjust DVXREL2

+ Options

Delete Visible Rows

	Label ▾	Status ▾	Property ▾	Property Description ▾	Entry ▾	Entry ID ▾	Initial Value ▾	Lower Bound	Upper Bound	Equation
	<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 type="checkbox"/>	C1	<input checked="" type="checkbox"/>	W3A	Component of offset vector wa a...	CBAR	31	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C2	<input checked="" type="checkbox"/>	W3B	Component of offset vector wb a...	CBAR	31	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C3	<input checked="" type="checkbox"/>	W3A	Component of offset vector wa a...	CBAR	32	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C4	<input checked="" type="checkbox"/>	W3B	Component of offset vector wb a...	CBAR	32	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C5	<input checked="" type="checkbox"/>	W3A	Component of offset vector wa a...	CBAR	33	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C6	<input checked="" type="checkbox"/>	W3B	Component of offset vector wb a...	CBAR	33	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C7	<input checked="" type="checkbox"/>	W3A	Component of offset vector wa a...	CBAR	34	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>
<input type="checkbox"/>	C8	<input checked="" type="checkbox"/>	W3B	Component of offset vector wb a...	CBAR	34	1.575	<input type="text" value=".1"/>	Maximum	<input type="text" value="1.5 + x1 / 2.0"/>