

# Workshop - Arbitrary Beam Cross Section Optimization

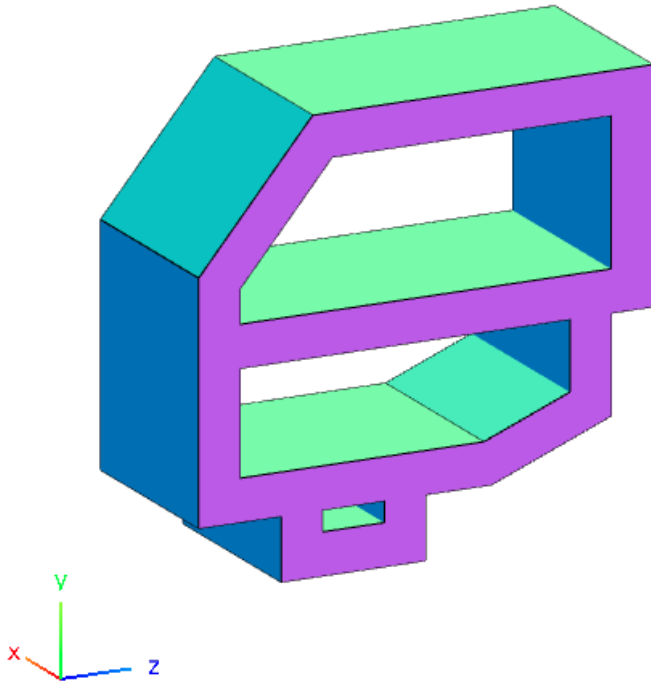
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A PBMSECT/PBRSECT AND SOL 200 WEB APP TUTORIAL

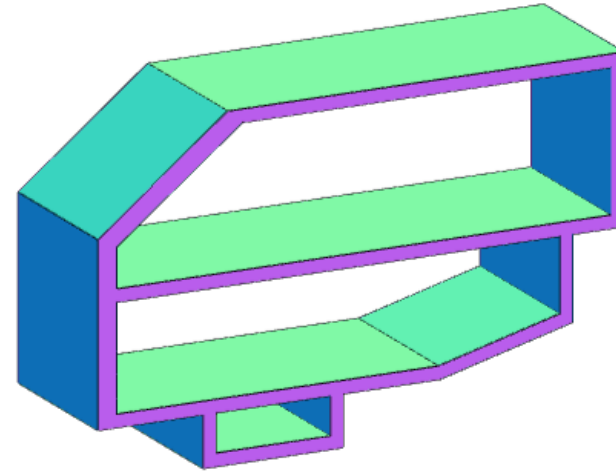
# Goal: Create a PBMSECT entry and optimize the arbitrary beam cross section with MSC Nastran SOL 200

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Before



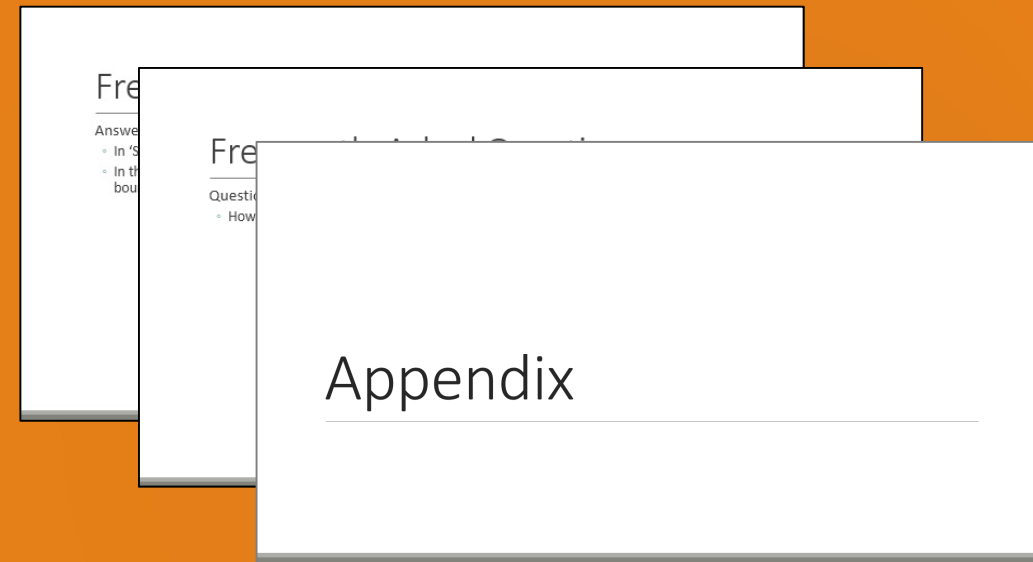
After



# More Information Available in the Appendix

The Appendix includes information regarding the following:

- Procedure to Create PBMSECT/PBRSECT Entries
- Comment on Critical Points
- Supported PBMSECT/PBRSECT Keywords
- UFM 2012
- UFM 7201 - Cause 1
- UFM 7201 - Cause 2
- UFM 7733
- What if the arbitrary cross section is not visible in the Viewer?



# 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

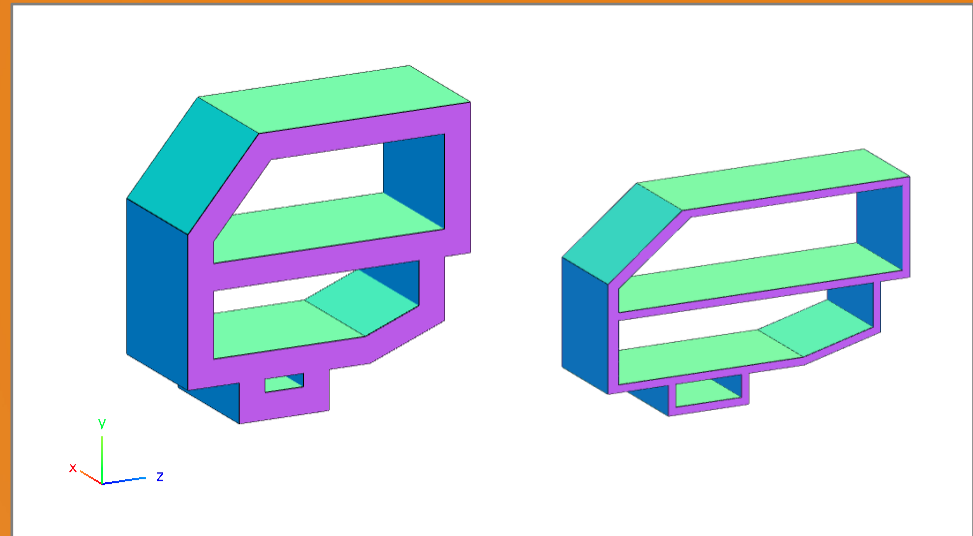
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# Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the PBMSECT Web App to:
  - Create a new arbitrary beam cross sections (ABCS)
  - Run MSC Nastran to confirm the ABCS is created properly
  - Download an updated BDF file
3. 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
4. Plot the Optimization Results
5. Update the original model with optimized parameters
6. Use the Viewer to view the updated beam elements with the newest ABCSs

## Special Topics Covered

**Arbitrary Beam Cross Section Optimization** - The width, height and 2 wall thicknesses of the ABCS are set as design variables and MSC Nastran SOL 200 is used to perform the optimization. After the optimization, the Viewer is used to post process the beam's forces.



# SOL 200 Web App Capabilities

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

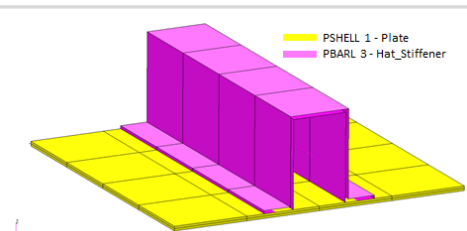
## Compatibility

- 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.

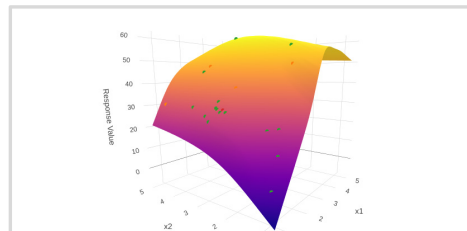
## Web Apps

## Benefits

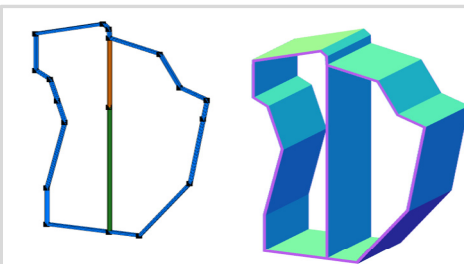
- REAL TIME error detection. 200+ error validations.
- REAL TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials



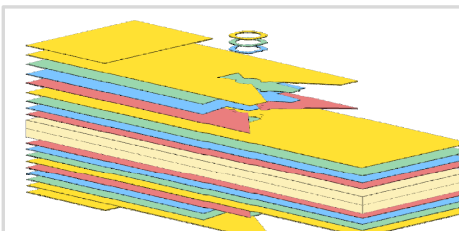
**Web Apps for MSC Nastran SOL 200**  
Pre/post for MSC Nastran SOL 200.  
Support for size, topology, topometry, topography, multi-model optimization.



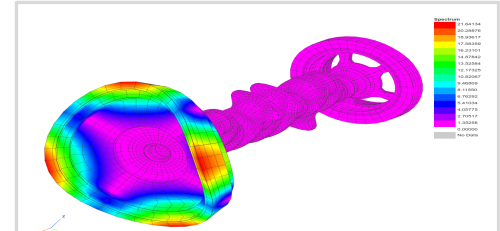
**Machine Learning Web App**  
Bayesian Optimization for nonlinear response optimization (SOL 400)



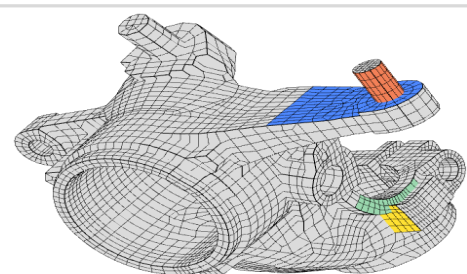
**PBMSECT Web App**  
Generate PBMSECT and PBRSECT entries graphically



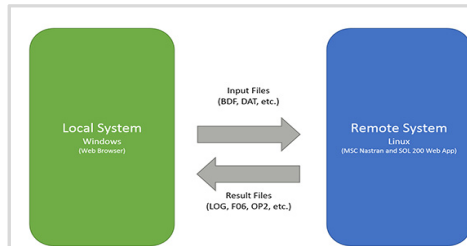
**Ply Shape Optimization Web App**  
Optimize composite ply drop-off locations, and generate new PCOMPG entries



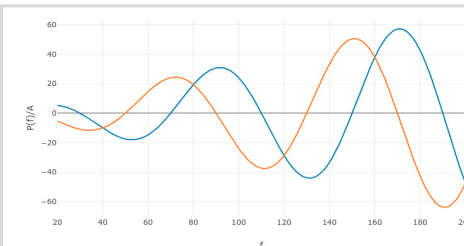
**Post-processor Web App**  
View MSC Nastran results in a web browser on Windows and Linux



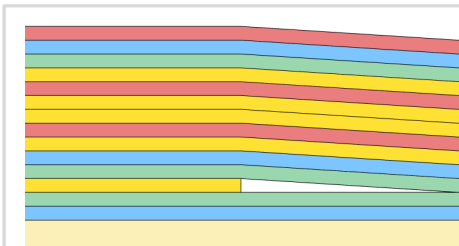
**Shape Optimization Web App**  
Use a web application to configure and perform shape optimization.



**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



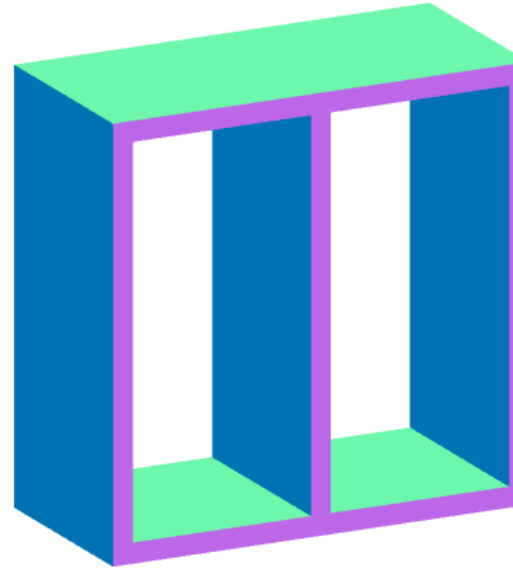
**HDF5 Explorer Web App**  
Create graphs (XY plots) using data from the H5 file

# Before Starting

- When creating an arbitrary cross section (ABCS), there are many different configurations of the entries that will yield the same ABCS.
- For the ABCS shown on the right, 4 different configurations of the PBMSECT, POINT and SET1 entries are displayed. Each configuration yields the same ABCS with these properties.
  - Area: 9.9000E+01
  - I1: 5.9182E+03
  - I2: 5.3482E+03
  - I12: 0.0
  - J: 8.2246E+03
- When you go through this tutorial, expect to get different IDs and sequences of entries. This is OK as long as your final arbitrary cross section matches what is shown in this tutorial.

```
PBMSECT 1      0888      CP
          OUTP=101,BRP(1)=102,T=1.0
POINT 1000001      0.0      -10.
POINT 1000002      0.0      10.
POINT 1000003      10.      10.
POINT 1000004      10.      -10.
POINT 1000005      -10.      10.
POINT 1000006      -10.      -10.
SET1 101      1000001 1000002 1000003 1000004
SET1 102      1000002 1000005 1000006 1000001
```

```
PBMSECT 1      0888      CP
          OUTP=101,BRP(1)=102,T=1.0
POINT 1000001      0.0      10.
POINT 1000002      -10.      10.
POINT 1000003      -10.      -10.
POINT 1000004      0.0      -10.
POINT 1000005      10.      -10.
POINT 1000006      10.      10.
SET1 101      1000001 1000002 1000003 1000004 1000005 1000006
SET1 102      1000004 1000001
```



```
PBMSECT 1      0888      CP
          OUTP=101,BRP(1)=102,T=1.0
POINT 1000001      -10.      10.
POINT 1000002      0.0      10.
POINT 1000003      0.0      -10.
POINT 1000004      -10.      -10.
POINT 1000005      10.      -10.
POINT 1000006      10.      10.
SET1 101      1000001 1000002 1000003 1000004
SET1 102      1000003 1000005 1000006 1000002
```

```
PBMSECT 1      0888      CP
          OUTP=101,BRP(1)=102,T=1.0,T(1)=[1.0,PT=(1000001,1000001)],T(2)=[
1.0,PT=(1000001,1000004)]
POINT 1000001      0.0      10.
POINT 1000002      -10.      10.
POINT 1000003      -10.      -10.
POINT 1000004      0.0      -10.
POINT 1000005      10.      -10.
POINT 1000006      10.      10.
SET1 101      1000001 1000002 1000003 1000004 1000005 1000006
SET1 102      1000001 1000004
```



# Part A - Locating the Web Apps

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# Locating the Web Apps

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Throughout this tutorial the following web apps will be used

- Size web app
- Viewer
- PBMSECT web app

The following slides detail where to locate these web apps

# Viewer and PBMSECT Web App

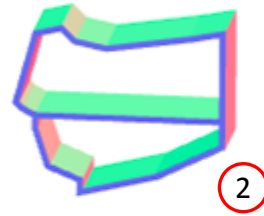
1. Navigate to the homepage
2. Click on the indicated link



## Viewer and PBMSECT Web App

1. Click the icon titled Viewer to open the Viewer
2. Click the icon titled PBMSECT to open the PBMSECT web app

## Beams

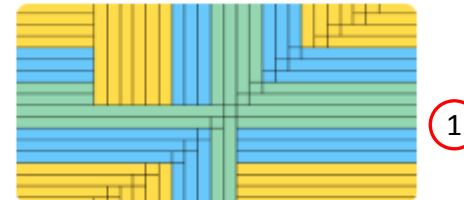


PBMSECT

## Composites

Ply	Theta [°]	PLY ID
1	45	121001
2	-45	131001
3	0	141001
4	90	111001
5	0	141002
6	90	111001
7	0	141002
8	45	121002
9	-45	131002

Stacking Sequence

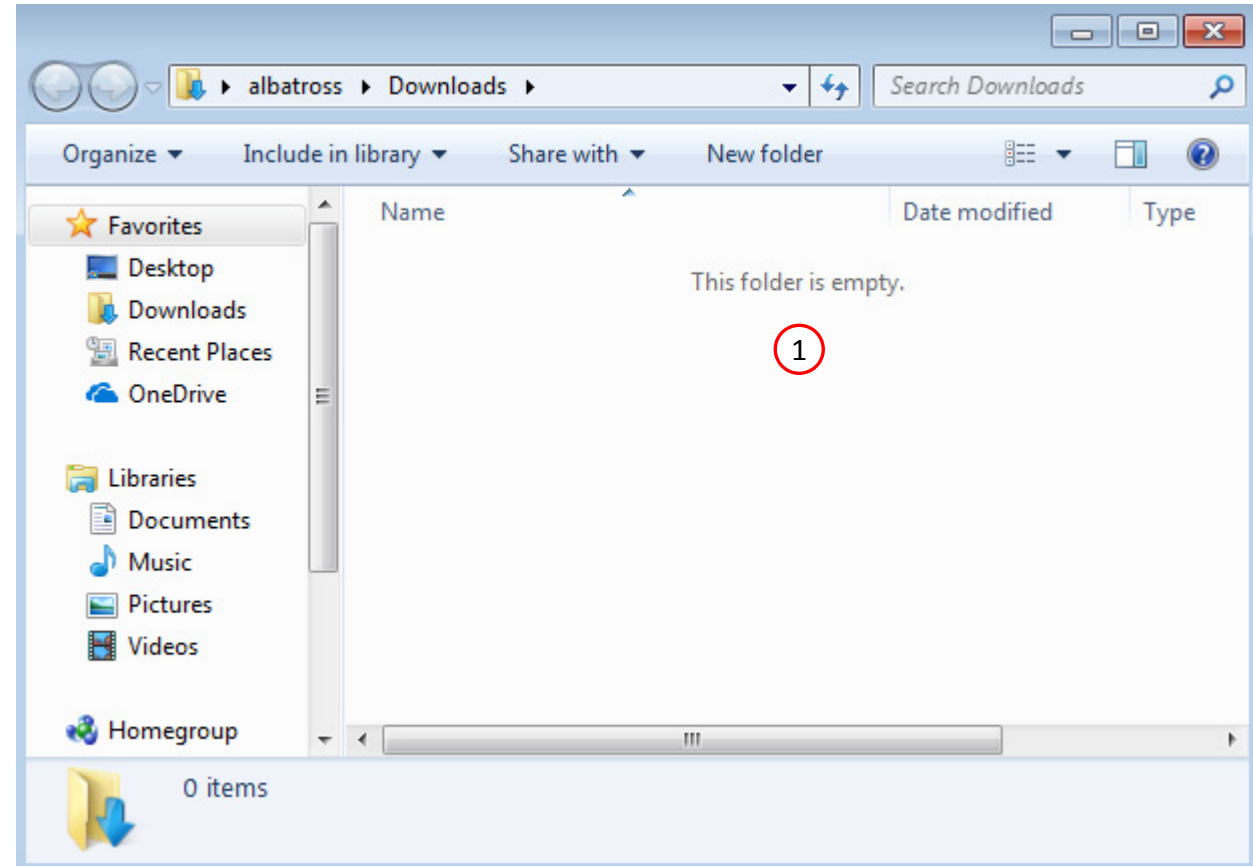


Viewer (.des, .ply000i)

# 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

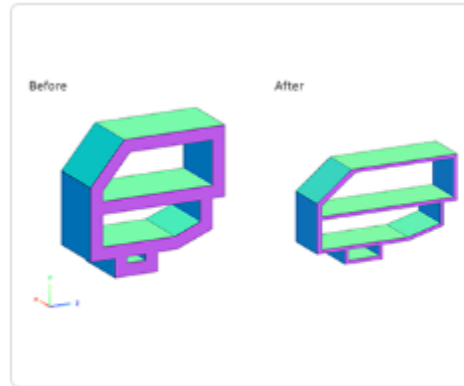
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



# 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

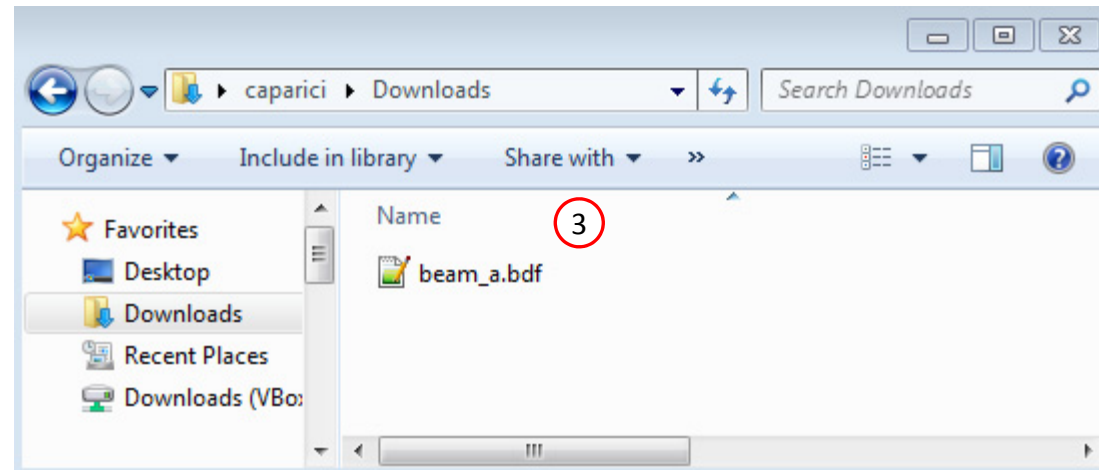
## Arbitrary Beam Cross Section Optimization

MSC Nastran SOL 200 supports varying the width, height and wall thickness of arbitrary beam cross sections (ABCS) defined by the PBRSECT or PBMSECT entries. This tutorial walks you through the process of generating an ABCS via the PBMSECT entry, configuring an optimization for MSC Nastran SOL 200, and reviewing the optimization results.

Starting BDF Files: [Link](#)

2

Solution BDF Files: [Link](#)



# Part B – Creating an Arbitrary Beam Cross Section (ABCS) with the PBMSECT Web App

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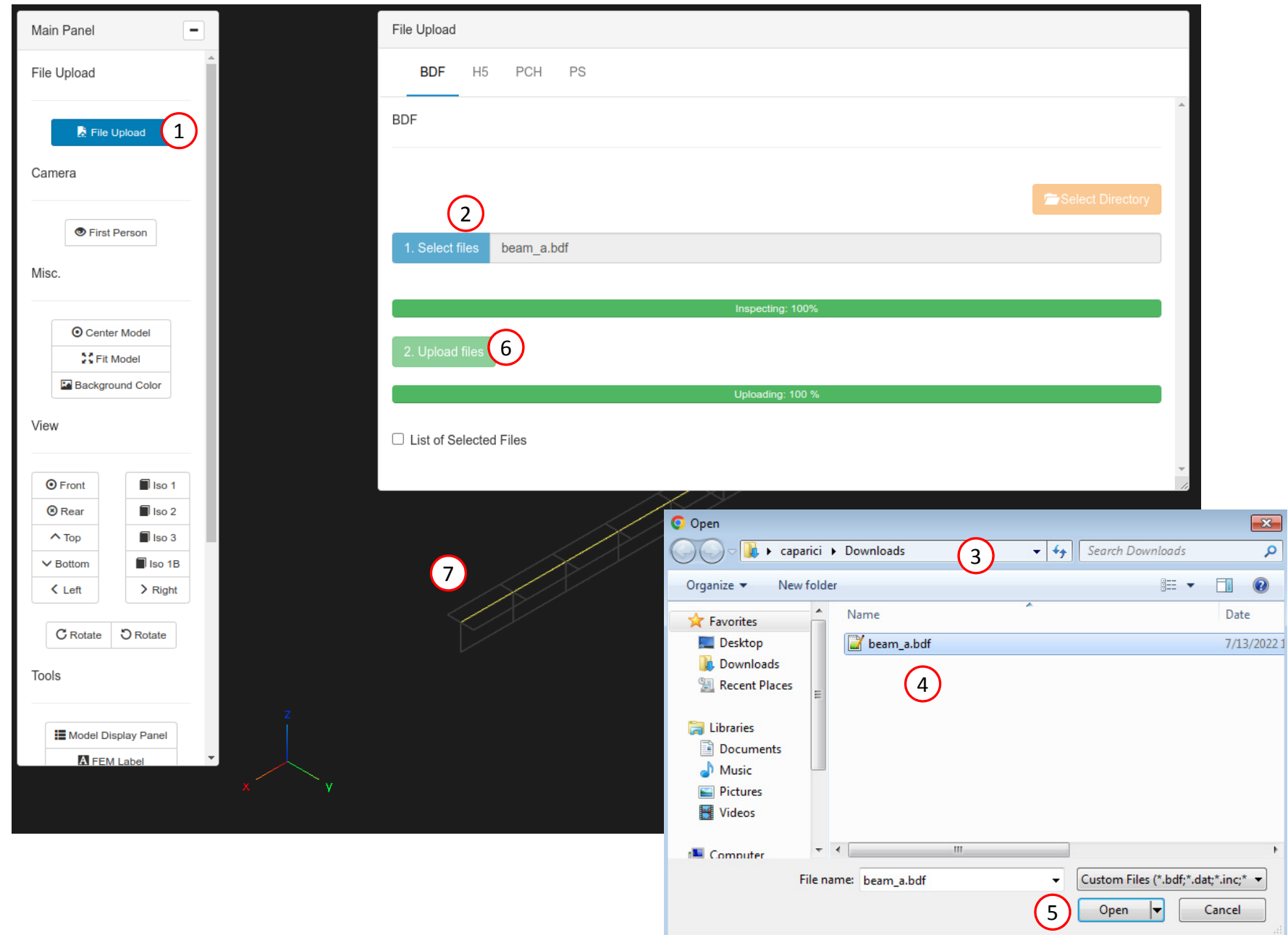


# Viewer

Open the Viewer

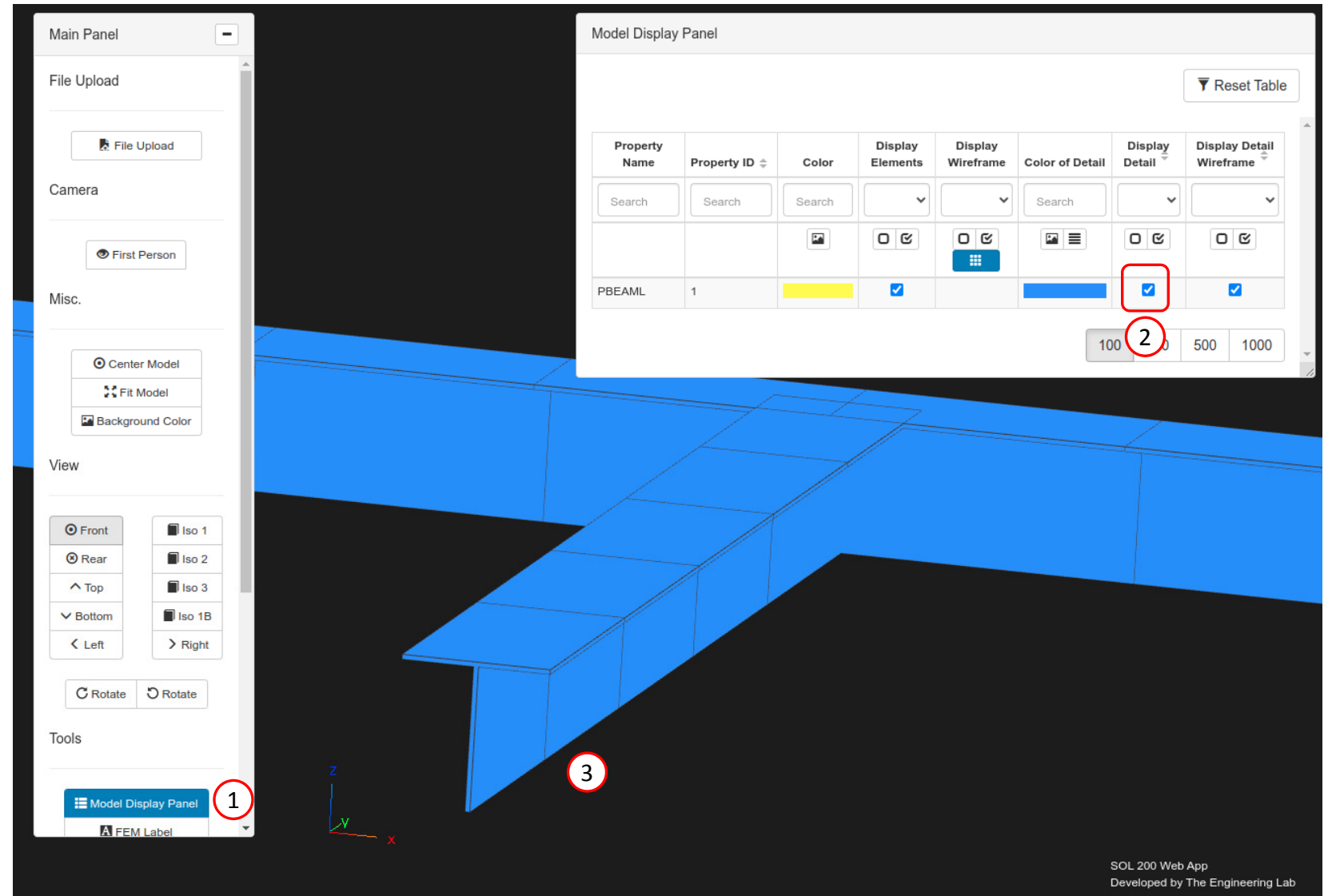
1. Click File Upload
2. Click Select files
3. Navigate to the directory Downloads
4. Select beam\_a.bdf
5. Click Open
6. Click Upload files
7. The MSC Nastran model has been uploaded to the Viewer

- The selected BDF file was created by a separate pre processor.



# Viewer

1. Click Model Display Panel
  - In the future, click this button again to close the Model Display Panel
2. Mark the indicate checkbox to display the beam cross section
3. Press and hold the left mouse button, then move the mouse to rotate the model
  - This model consists of 15 CBEAM elements and their cross section is defined by a PBEAML entry, which defines a T cross section



# PBMSECT Web App

The PBMSECT web app will be used to define an arbitrary beam cross section by defining a PBMSECT, POINT and SET1 entries

1. Open the PBMSECT web app
2. Click Select files
3. Select beam\_a.bdf
4. Click Open
5. Click Upload files

- The selected BDF file was created by a separate pre processor. The PBMSECT Web App only generates the following entries: PBMSECT, PBRSECT, POINT and SET1.

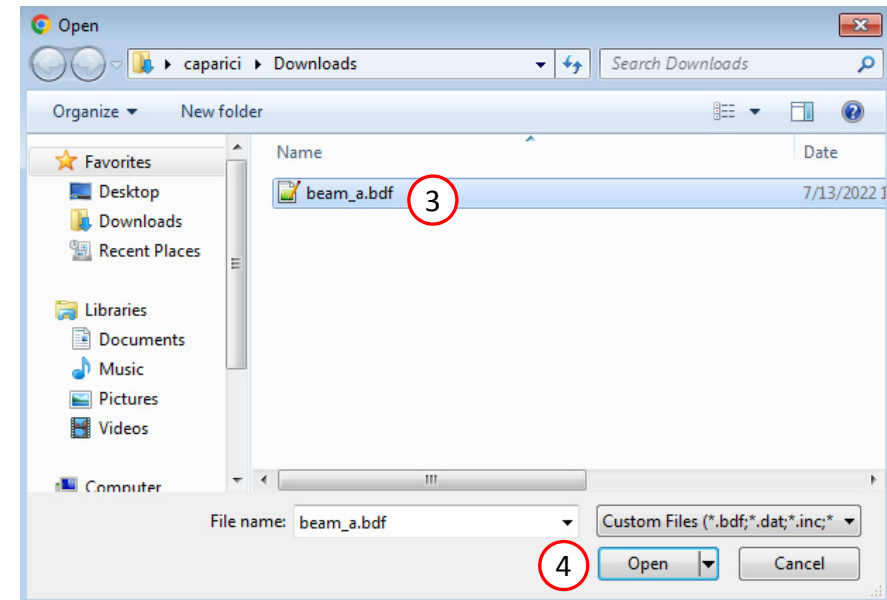
## Select BDF Files

- 2 1. Select files beam\_a.bdf

Inspecting: 100%

- 5 2. Upload files

Uploading: 100 %



# Create a New PBMSECT Entry

1. Click Create New Entry
2. Configure the Cross Section Options follows:
  1. Entry: PBMSECT
  2. PID: 1
  3. MID: 1, MAT1
  4. FORM: CP Closed Profile
  5. CORE: No
  6. NSM: Leave blank
3. If you have multiple PBMSECT or PBRSECT entries, you may use the select box to switch between entries
4. Refer to the section Custom IDs
5. The Status icon is red and indicates an ID conflict between the PBMSECT ID and another entry
6. Inspect the beam\_a.bdf file. There is an existing PBEAML entry with ID=1 and will conflict with the newly created PBMSECT ID=1 entry. Later in this tutorial, the PBEAML entry will be renumbered to ID=99 to avoid the conflict.

## Existing PBMSECT/PBRSECT Entries

Select a PBMSECT/PBRSECT ID to edit

1

**+ Create New Entry** **✕ Delete Selected Entry**

## Cross Section Options

Entry: PBMSECT

PID: 1

MID: 1, MAT1

FORM: CP Closed Profile

CORE: No - Do not use CORE

NSM:

## Custom IDs

☒ Renumber Lines and Points

Entry	Custom ID	Status	IDs Used by this PBMSECT/PBRSECT	IDs Used by other entries
PBMSECT/PBRSECT	1	!	1	1
SET1	201	✓		
POINT	2000001		! Check separately to ensure POINT IDs do not conflict with GRID IDs	

```

40      LOAD = 2
41      BEGIN BULK
42      $ Direct Text Input for Bulk Data
43      MDLPRM   HDF5      0
44      PARAM    PRTMAXIM YES
45      $ Elements and Element Properties for region
46      PBEAML   1         1         .003      .003      T2
47      .1       .1       .003      .003
48      $ Pset: "Beam_Assignment_A" will be imported
49      CBEAM    1         1         1         2         0
  
```

# Points

1. Click Create Points (The button should be blue)
2. Adjust the Grid Helper as follows
  1. Width and Height: 0.1
  2. Number of Divisions: 20
3. Click Fit Model
4. Click on the points on the Grid Helper to create 13 white points approximately in the same locations as shown in the image.

## Points

### Actions

1. ☒ Create Points
- ☐ Create Points on Line
- ☐ Remove Points

### Settings - Grid Helper

Width and Height

0.1

Number of Divisions

20

Max allowable divisions: 50

### Controls

#### Tools

☒ Center Model

☒ Fit Model

☐ Isometric View 1

☐ ZY View

☐ Background Color

☐ Label Color

#### Display

☒ Labels

☐ Cross Section Preview

☐ Cross Section Actual

☐ Size Controls

#### Demos

☒ Clear Demo

☐ Demo 1

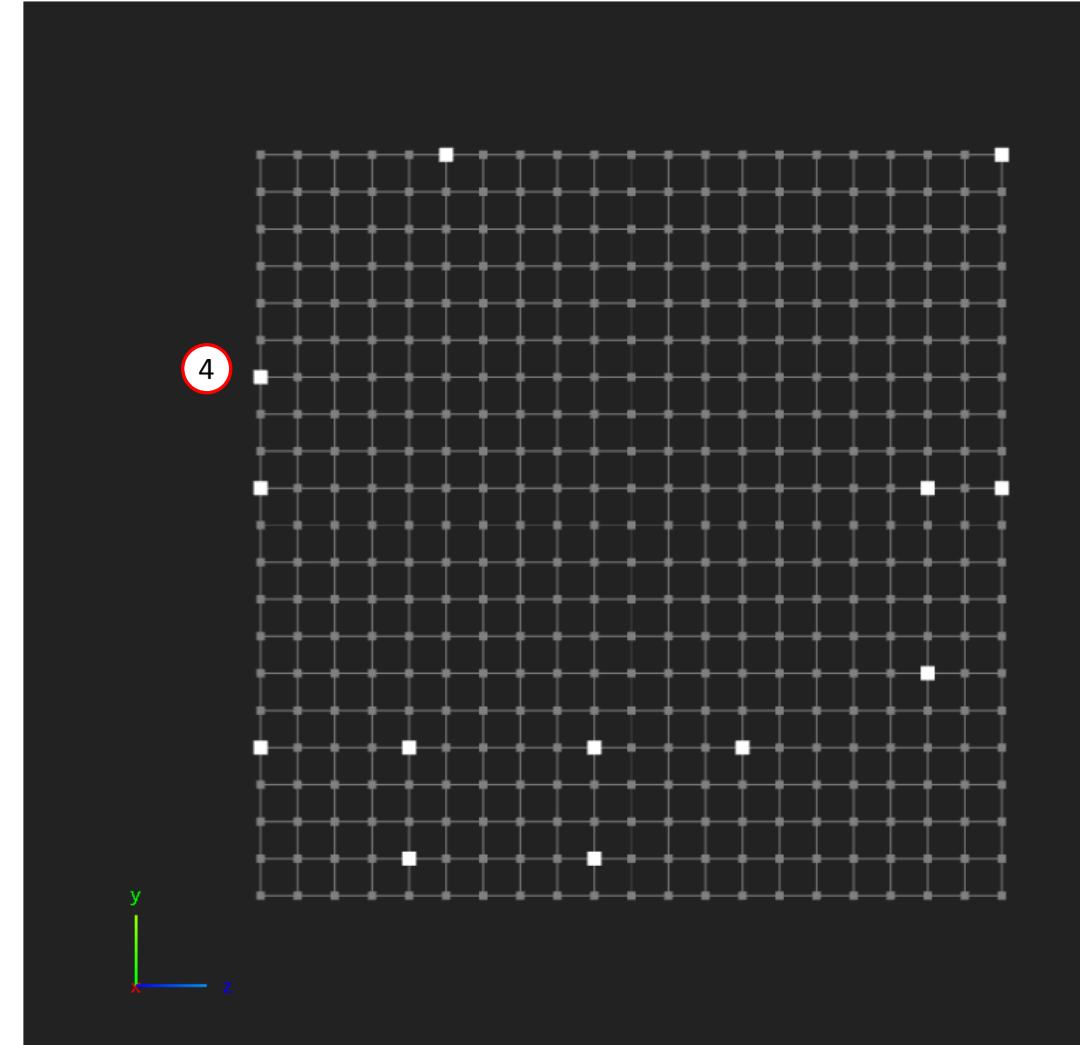
☐ Demo 2

☐ Demo 3

☐ Demo 4

☐ Demo 5

### Editing PBMSECT 1



# Lines

1. Click Create Lines
2. Click on 2 points at a time to create the 3 indicated lines
3. Repeat the process to create 15 lines in total

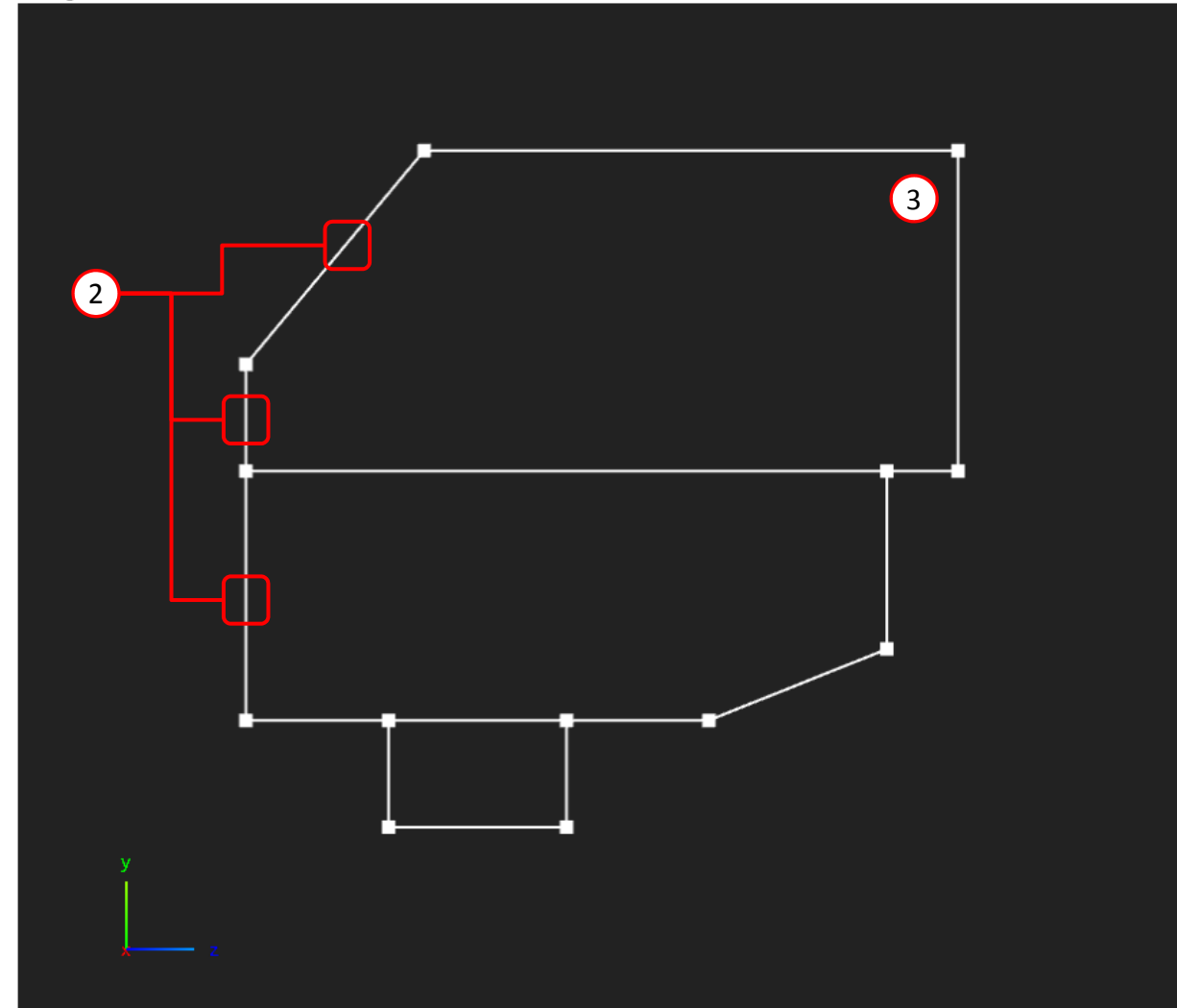
## Lines

### Actions

1

— Create Lines
✕ Remove Lines
☞ Select Lines of Outer Perimeter
☞ Deselect Lines of Outer Perimeter

Editing PBMSECT 1



# Outer Perimeter

On this slide, the outer perimeter is defined, which corresponds to the OUTP keyword on the PBMSECT entry

1. Click Select Lines of Outer Perimeter
2. Click on the 3 indicated lines to select the lines as part of the Outer Perimeter. Successful selection is indicated by a blue color.
3. Repeat the process by selecting the other 8 lines as indicated.
4. In most cases, the outer perimeter should connect all critical points (orange points)

## IMPORTANT!

Defining the outer perimeter is the most critical step in defining the PBMSECT/PBRSECT entry. Constantly inspect the outer perimeter. Only one continuous outer perimeters is valid.

## Lines

### Actions

1




— Create Lines

✕ Remove Lines

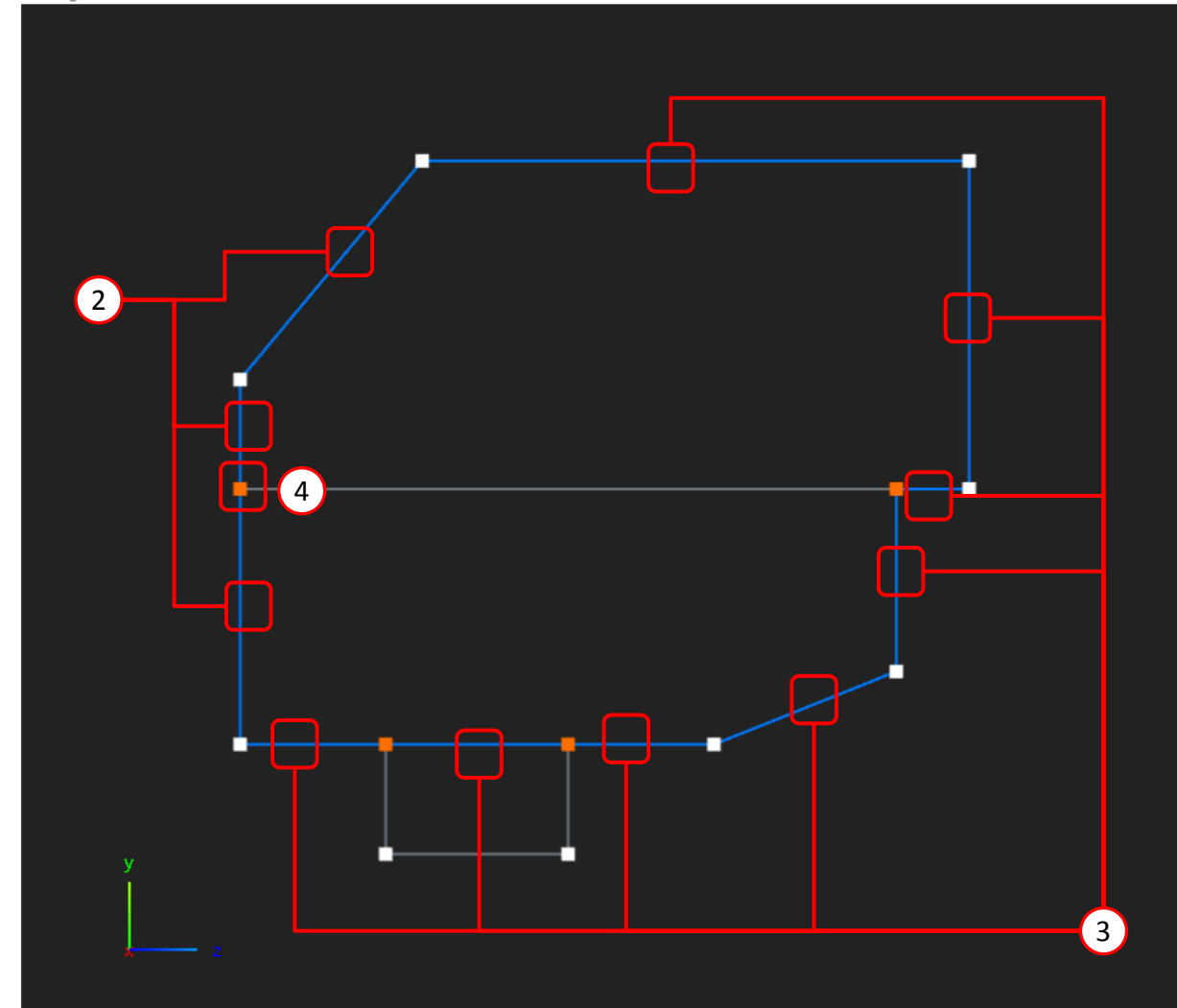
Select Lines of Outer Perimeter

⌵ Deselect Lines of Outer Perimeter

### Legend

Color	Description
	Outer Perimeter (OUTP)
	Possible lines for OUTP
	Critical Points

Editing PBMSECT 1



# Cross Section Preview

1. Click Cross Section Preview
2. A preview of the arbitrary beam cross section is displayed
3. Set the Default Thickness to .010
4. Set the Thickness of lines 1, 2 and 3 to .0101
5. Refer to the section Corresponding Bulk Data Entries
6. In the PBMSECT entry, a new T keyword has been created which corresponds to the 3 line segments. Later in this tutorial, the Default Thickness (keyword T=) and the thickness of the 3 line segments (T(1)=) will be set as design variables for the optimization.

## Lines

### Actions

- Create Lines
- ✕ Remove Lines
- Select Lines of Outer Perimeter
- Deselect Lines of Outer Perimeter

Status:

### Legend

Color	Description
	Outer Perimeter (OUTP)
	Possible lines for OUTP
	Critical Points

### Adjustments

#### Default Thickness

.010 3

#### Line Segments

Line ID	Type	Thick
1	OUTP	.0101 <span>4</span>
2	OUTP	.0101
3	OUTP	.0101
4	OUTP	
5	OUTP	
6	OUTP	
7	OUTP	
8	OUTP	
9	OUTP	
10	OUTP	

### Controls

#### Tools

- Center Model
- Fit Model
- Isometric View 1
- ZY View
- Background Color
- Label Color

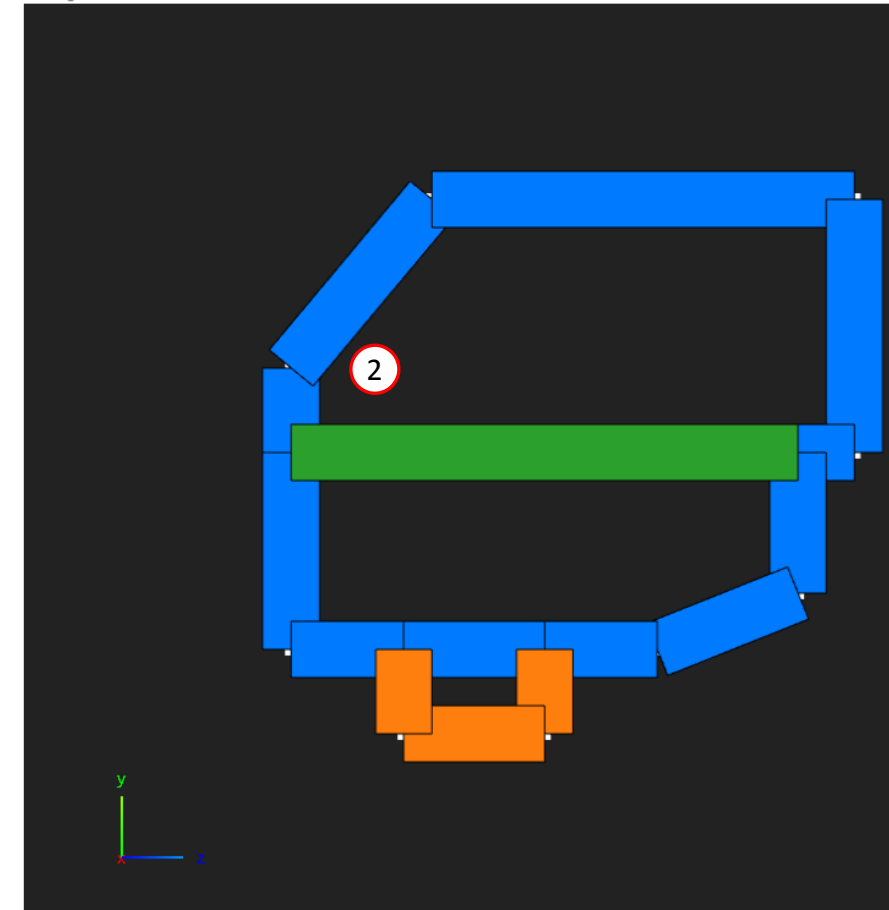
#### Display

- Labels
- Cross Section Preview 1
- Cross Section Actual
- Size Controls

#### Demos

- Clear Demo
- Demo 1
- Demo 2
- Demo 3
- Demo 4
- Demo 5

Editing PBMSECT 1



## Corresponding Bulk Data Entries 5

```

$ 1 || 2 || 3 || 4 || 5 || 6 || 7 || 8 || 9 || 10 |
PBMSECT 1      1      CP
          OUTP=201, BRP=202, BRP=203, T=.010, T(1)= [.0101, PT=(2000012, 2000007)
          ]
  
```



# Run MSC Nastran to Generate the Cross Section

The following requires MSC Nastran to be installed on the same machine as the SOL 200 Web App.

1. The respective entries that define the arbitrary beam cross section are displayed
2. Click Run MSC Nastran
  - The web app will run MSC Nastran in the background and determine the cross section generated by MSC Nastran. This MSC Nastran run should take no more than 10 seconds. MSC Nastran must be installed on the machine as the SOL 200 Web App.
3. If the run is successful, the MSC Nastran generated cross section is displayed
4. Inspect the F06 file to inspect the result of the run
5. The test BDF file used for this test run may be downloaded by clicking Download Test BDF File

## Run MSC Nastran and Bulk Data Entries

5

Download Test BDF File

Run MSC Nastran

2

Complete

Corresponding Bulk Data Entries

```
$ 1 || 2 || 3 || 4 || 5 || 6 || 7 || 8 || 9 || 10 |
```

```
PBMSECT 1      1      CP
      OUTP=201,BRP=202,BRP=203,T=.010,T(1)=[.0101,PT=(2000012,2000007)
      ]
POINT  2000007      -0.025000,0.050000
POINT  2000008      0.050000,0.050000
POINT  2000012      -0.050000,-0.029999
POINT  2000013      -0.029999,-0.029999
POINT  2000014      -0.004999,-0.029999
POINT  2000015      0.014999,-0.029999
POINT  2000016      -0.029999,-0.045000
POINT  2000017      -0.004999,-0.045000
POINT  2000018      -0.050000,0.019999
POINT  2000019      -0.050000,0.004999
POINT  2000020      0.039999,0.004999
POINT  2000021      0.050000,0.004999
POINT  2000022      0.039999,-0.019999
SET1    201      2000012 2000019 2000018 2000007 2000008 2000021 2000020
2000022 2000015 2000014 2000013
SET1    202      2000013 2000016 2000017 2000014
SET1    203      2000020 2000019
```

1

F06

4

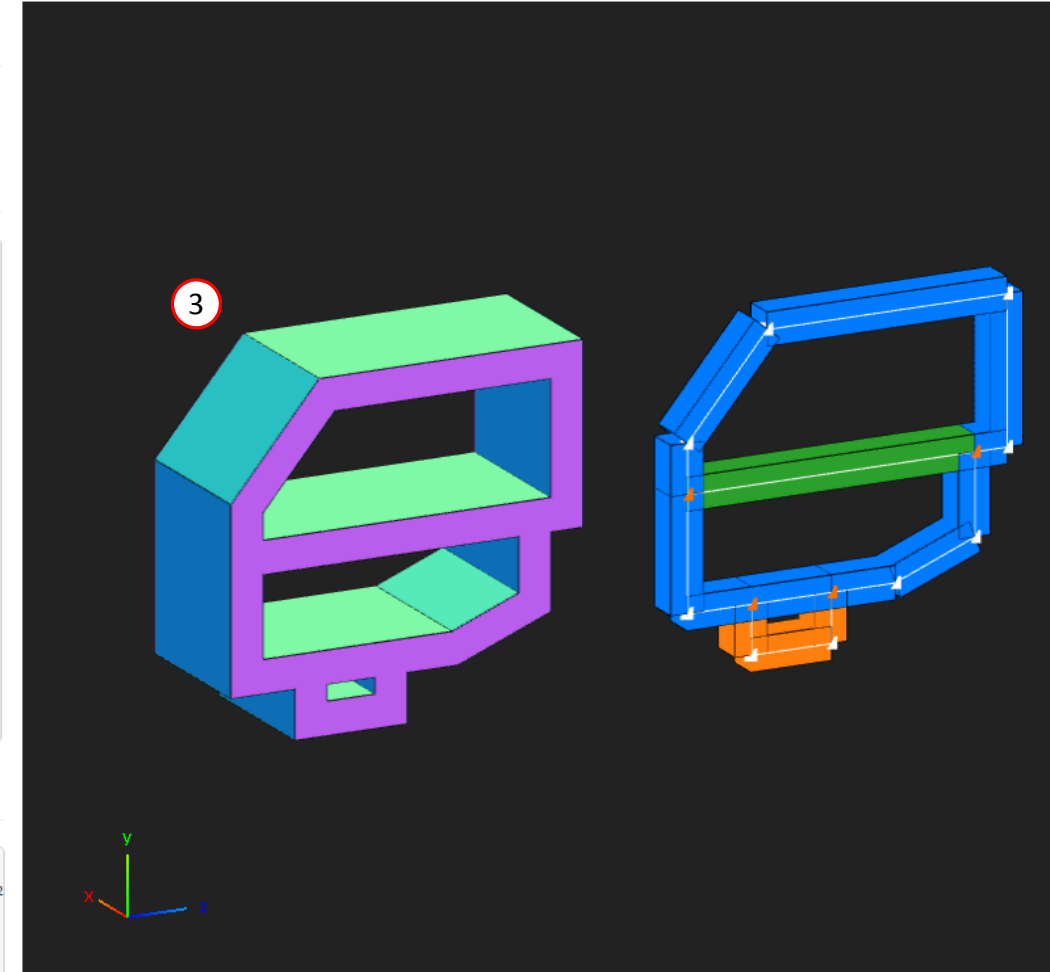
```
Command executed: /msc/MSC_Nastran/2022.1/bin/msc20221 nastran ./tmp/854e82ee40045005a441ff1e2

1

Warning: This computer program is protected by copyright law and interna
Unauthorized use, reproduction or distribution of this computer program, or
result in severe civil and criminal penalties.
Copyright (C) 2022 Hexagon AB and/or its subsidiaries. All rights res

*****
*****
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*****
Hexagon AB
**
```

Editing PBMSECT 1



# Inspect F06 Output

1. If the MSC Nastran run was a success, an equivalent PBEAM entry is generated and listed in the F06 file. This PBEAM entry displays cross section information such as the cross sectional area and moments of inertia.
  - If a PBRSECT entry is created, a PBAR entry is generated.
  - If a PBMSECT is created with the CORE keyword, which is used for a composite section, a PBEAM3 entry is generated.
  - If a regular PBMSECT entry is created, a PBEAM entry is generated.

```

*** USER INFORMATION MESSAGE 4379 (IFP9A)
      THE USER SUPPLIED PBEAML/PBMSECT BULK DATA ENTRIES ARE REPLACED BY THE FOLLOWING PBEAM EN
      CONVERSION METHOD FOR PBARL/PBEAML FINITE ELEMENT METHOD.
PBEAM      1      1  4.6182E-03  4.5635E-06  5.3515E-06  1.1963E-06  7.2492E-06
      4.9952E-02  6.0074E-02 -5.5048E-02 -2.9916E-02 -5.0487E-03  6.0074E-02 -2.8423E-02
      3.1567E-01  6.2217E-01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.1989E-10
      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -1.1396E-03  3.0214E-03 -1.1396E-03
1  CONFIRMATION TEST OF PBMSECT/PBRSECT ENTRY                                     JUNE  6, 2022
  
```

## PBEAM

### Beam Property

Defines the properties of a beam element (CBEAM entry). This element may be used to model tapered beams.

#### Format:

1	2	3	4	5	6	7	8	9	10
PBEAM	PID	MID	A(A)	I1(A)	I2(A)	I12(A)	J(A)	NSM(A)	
	C1 (A)	C2 (A)	D1 (A)	D2 (A)	E1 (A)	E2 (A)	F1 (A)	F2 (A)	

# Download BDF Files

1. Navigate to the Download section
2. The Download Information section provides details regarding how the original BDF files will be edited and downloaded
3. Click Download BDF Files

## Download Information

2

The following PBMSECT/PBRSECT entries, and respective POINT and SET1 entries, have been edited in this web app and will be updated in the downloaded BDF files.

Changes will be made at BEGINBU LK or near lines [41] in file beam\_a.bdf.

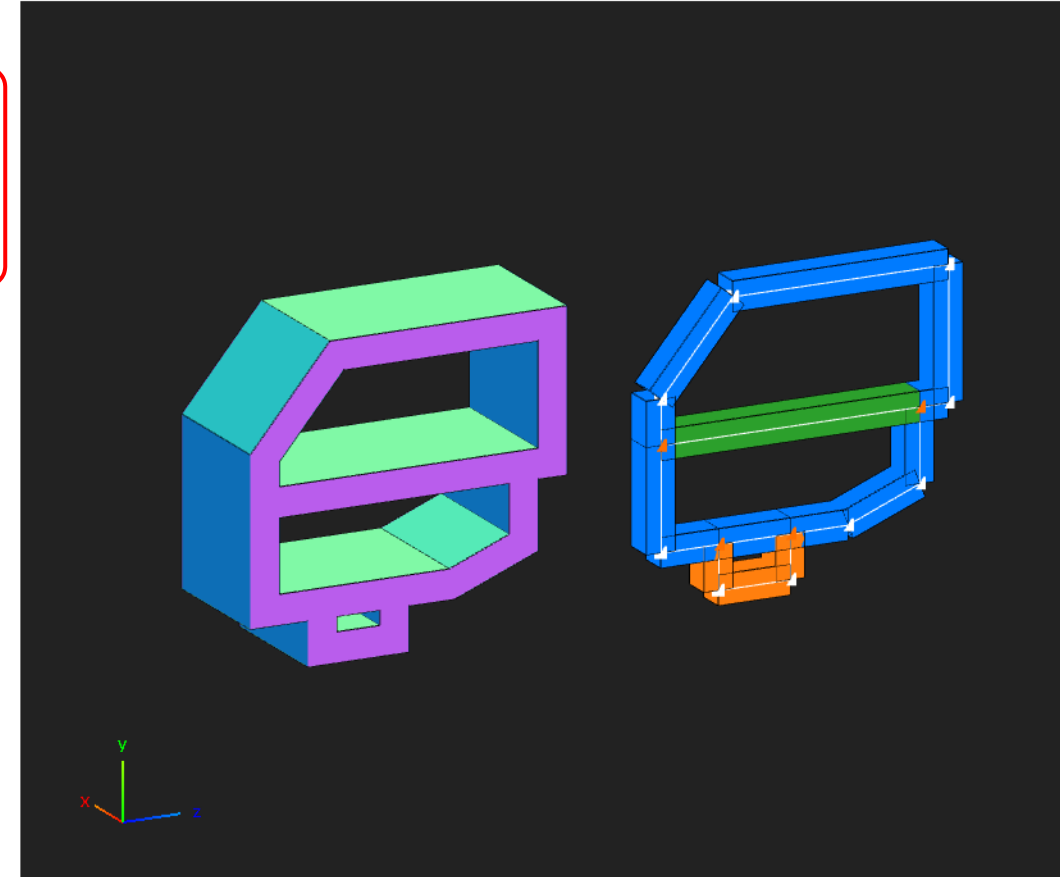
Entry	PID
PBMSECT	1

## Download 1

Download BDF Files

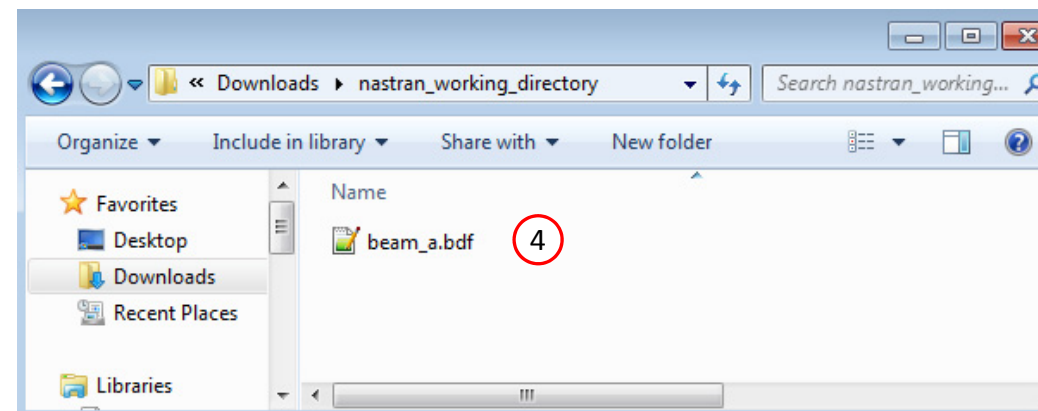
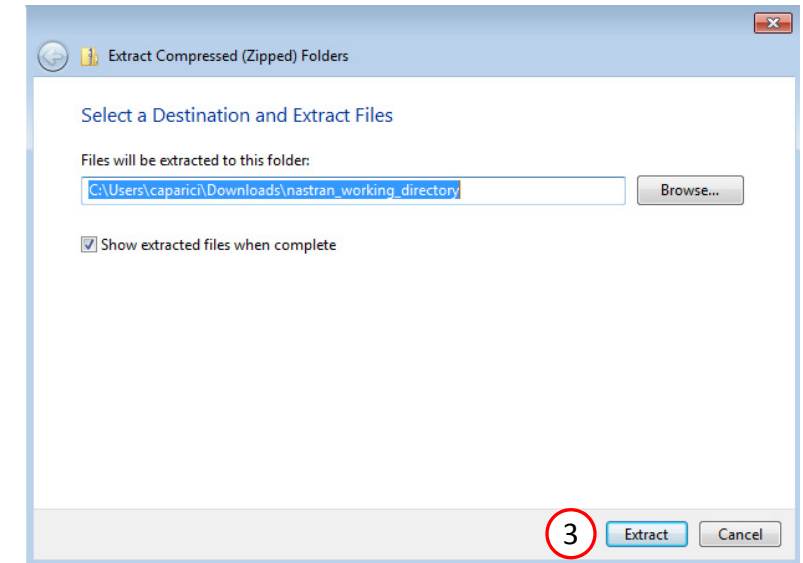
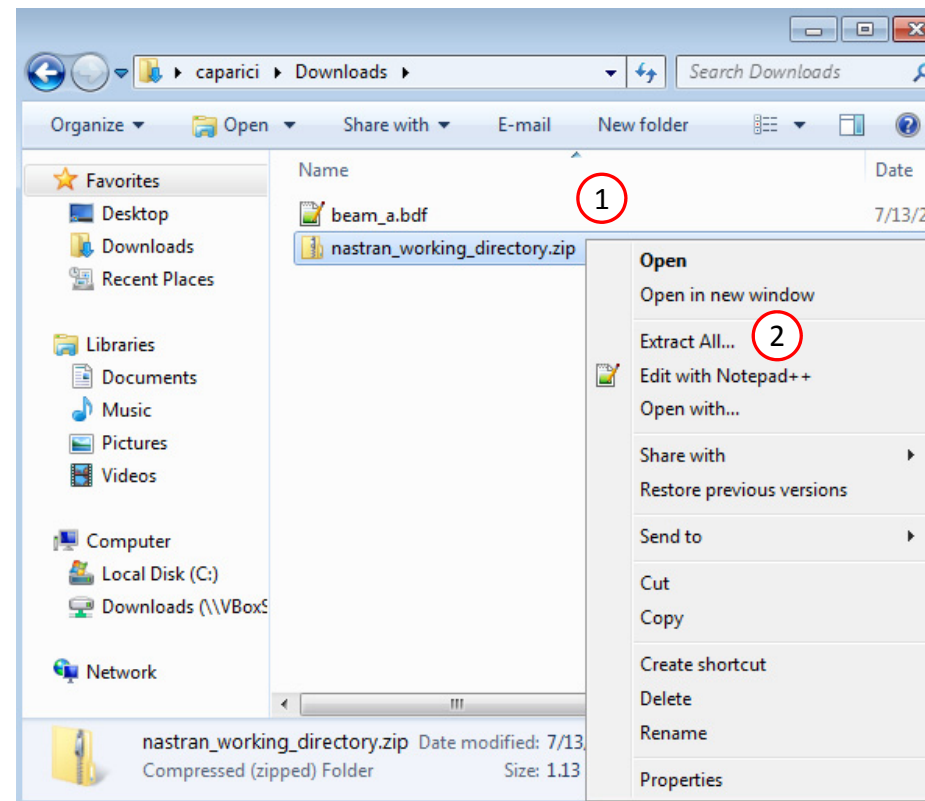
3

Editing PBMSECT 5



# Extract the ZIP File

1. A new file `nastran_working_directory.zip` has been downloaded
2. Right click on the ZIP file and click Extract All
3. Click Extract
4. A new folder `nastran_working_directory` is created and inside is the updated `beam_a.bdf` file



# Compare the Original and New BDF Files

1. Open file Downloads/beam\_a.bdf and nastran\_working\_directory/beam\_a.bdf in a text editor
2. The entries PBMSECT, POINT and SET1 that define the ABCS have been inserted into the BDF file
3. Renumber PBEAML 1 to PBEAM 99 so that the PBEAML entry does not conflict with PBMSECT 1
4. Click save to save the edits to the BDF file

The image shows two Notepad++ windows side-by-side, comparing two BDF files. The left window is titled "C:\Users\aparcic\Downloads\nastran\_working\_directory\model.bdf - Notepad++" and the right window is titled "C:\Users\aparcic\nastran\_working\_directory\beam\_a.bdf - Notepad++".

On the left window, the file content includes:

```

41 BEGIN BULK
42 $ Direct Text Input for Bulk Data
43 MDLPRM HDF5 0
44 PARAM PRTMAXIM YES
45 $ Elements and Element Properties for region : Beam_Assignment_A
46 PBEAML 1 1 .1 .003 T2
47
48 $ Pset: "Beam_Assignment_A" will be imported as:
49 CBEAM 1 1 2 0.
50 CBEAM 2 1 3 0.
51 CBEAM 3 1 4 0.
52 CBEAM 4 1 5 0.
53 CBEAM 5 1 6 0.
54 CBEAM 6 1 8 0.
55 CBEAM 7 1 9 0.
56 CBEAM 8 1 10 0.
57 CBEAM 9 1 11 0.
58 CBEAM 10 1 12 0.
59 CBEAM 11 1 14 0.
60 CBEAM 12 1 15 0.
61 CBEAM 13 1 16 0.
62 CBEAM 14 1 17 0.
63 CBEAM 15 1 18 0.
64 $ Referenced Material Records
65 $ Material Record : aluminum
66 $ Description of Material : Length: m

```

On the right window, the file content includes:

```

41 BEGIN BULK
42 PBMSECT 1 1 CP
43 OUTP=201, BRP=202, BRP=203, T=.010, T(1)=[.0101, PT=(2000012,2000007)]
44
45 POINT 2000007 -0.025000 .050000
46 POINT 2000008 0.050000 .050000
47 POINT 2000012 -0.050000 -0.029999
48 POINT 2000013 -0.029999 -0.029999
49 POINT 2000014 -0.004999 -0.029999
50 POINT 2000015 0.014999 -0.029999
51 POINT 2000016 -0.029999 -0.045000
52 POINT 2000017 -0.004999 -0.045000
53 POINT 2000018 -0.050000 .019999
54 POINT 2000019 -0.050000 .004999
55 POINT 2000020 0.039999 .004999
56 POINT 2000021 0.050000 .004999
57 POINT 2000022 0.039999 -0.019999
58 SET1 201 2000012 2000019 2000018 2000007 2000008 2000021 2000020
59
60 SET1 202 2000022 2000015 2000014 2000013
61 SET1 203 2000020 2000019
62 $ Direct Text Input for Bulk Data
63 MDLPRM HDF5 0
64 PARAM PRTMAXIM YES
65 $ Elements and Element Properties for region : Beam_Assignment_A
66 PBEAML 99 .1 .003 T2
67
68 $ Pset: "Beam_Assignment_A" will be imported as:
69 CBEAM 99 99 100 0.
70
71 $ Referenced Material Records
72 $ Material Record : aluminum
73 $ Description of Material : Length: m

```

Red annotations highlight the changes:

- Circle 1: The "File" menu in the right window.
- Circle 2: The "Save" icon in the right window's toolbar.
- Circle 3: The new PBEAML entry "99" in the right window.
- Circle 4: The "Save" icon in the left window's toolbar.

The status bar at the bottom of the right window shows: "length: 4,326 lines: 118 Ln: 69 Col: 39 Pos: 2,152 Windows (CR LF) UTF-8 INS".

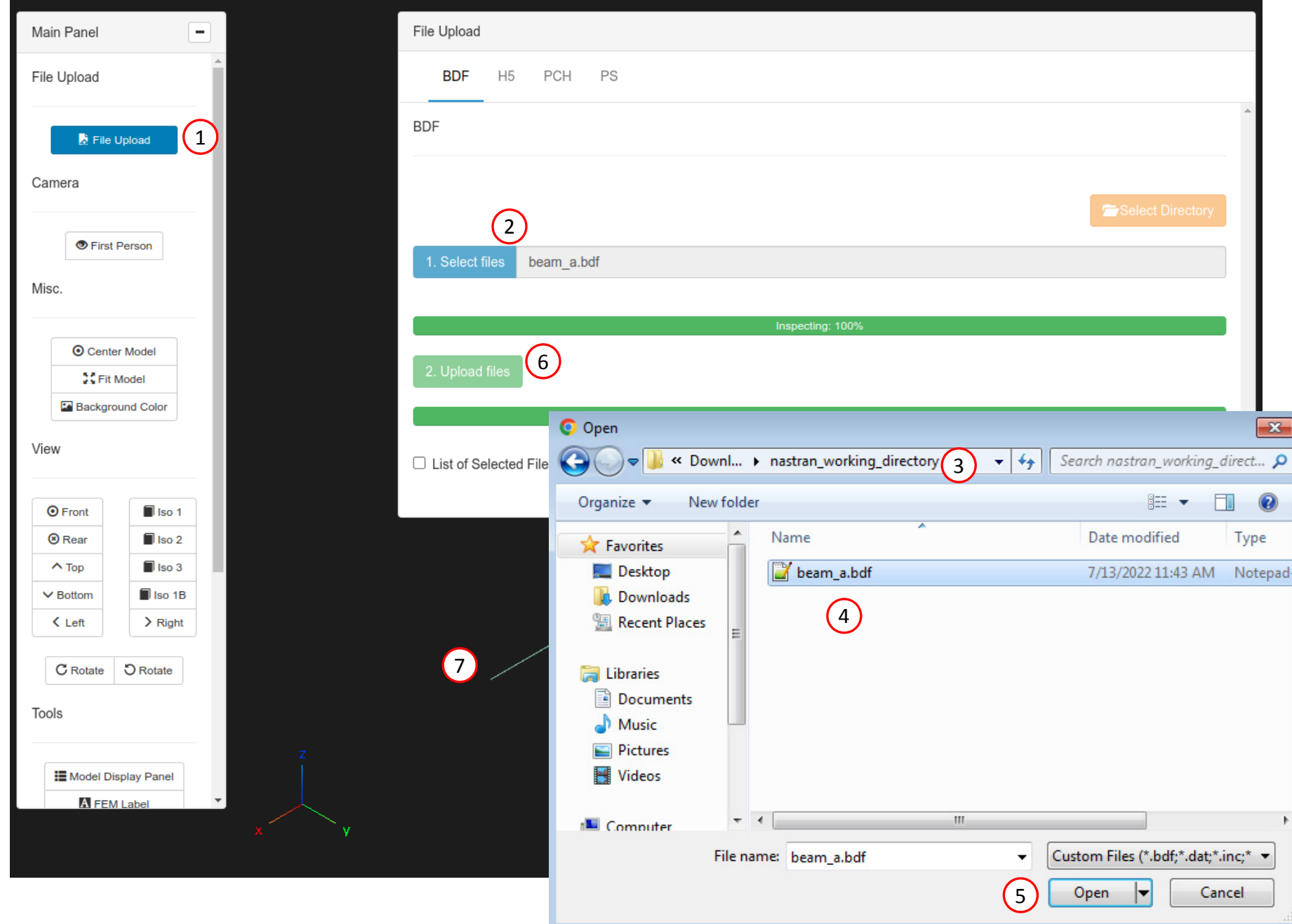
Downloads/beam\_a.bdf

nastran\_working\_directory/beam\_a.bdf

# View the Model in the Viewer

Open the Viewer in a new web browser tab or window (Not shown)

1. Click File Upload
2. Click Select files
3. Navigate to the directory nastran\_working\_directory
4. Select beam\_a.bdf
5. Click Open
6. Click Upload files
7. The MSC Nastran model has been uploaded to the Viewer





# View the Model in the Viewer

1. Click Model Display Panel
  - In the future, click this button again to close the Model Display Panel
2. Mark the indicate checkbox to display the beam cross section
3. Press and hold the left mouse button, then move the mouse to rotate the model
  - Notice the cross section is now the ABCS that was defined in the PBMSECT web app

The screenshot displays the SOL 200 Web App interface. On the left is the 'Main Panel' with sections for File Upload, Camera (First Person), Misc. (Center Model, Fit Model, Background Color), View (Front, Rear, Top, Bottom, Left, Right, Rotate), and Tools (Model Display Panel, FEM Label). The 'Model Display Panel' on the right contains a table with columns: Property Name, Property ID, Color, Display Elements, Display Wireframe, Color of Detail, Display Detail, and Display Detail Wireframe. The table lists two properties: PBEAML\* (Property ID 99, Yellow) and PBMSECT (Property ID 1, Green). The 'Display Detail' checkbox for PBMSECT is checked and circled with a red '2'. Below the table, a note states '\* There are no elements using the indicated property' and a range of values (100, 2, 500, 1000) is shown. The central 3D viewer shows an orange beam cross-section, with a red circle '3' indicating the rotation point. A coordinate system (X, Y, Z) is visible at the bottom left of the viewer. The bottom right corner of the interface reads 'SOL 200 Web App Developed by The Engineering Lab'.

Property Name	Property ID	Color	Display Elements	Display Wireframe	Color of Detail	Display Detail	Display Detail Wireframe
PBEAML*	99	Yellow			Blue		
PBMSECT	1	Green	<input checked="" type="checkbox"/>		Orange	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

\* There are no elements using the indicated property

100 2 500 1000

# Part C – Using MSC Nastran SOL 200 To Optimize the ABCS

---



# Optimization Problem Statement

## Design Variables

x1: Width of arbitrary cross section (ABCS)

x2: Height of ABCS

x3: Thickness of segments 4-15

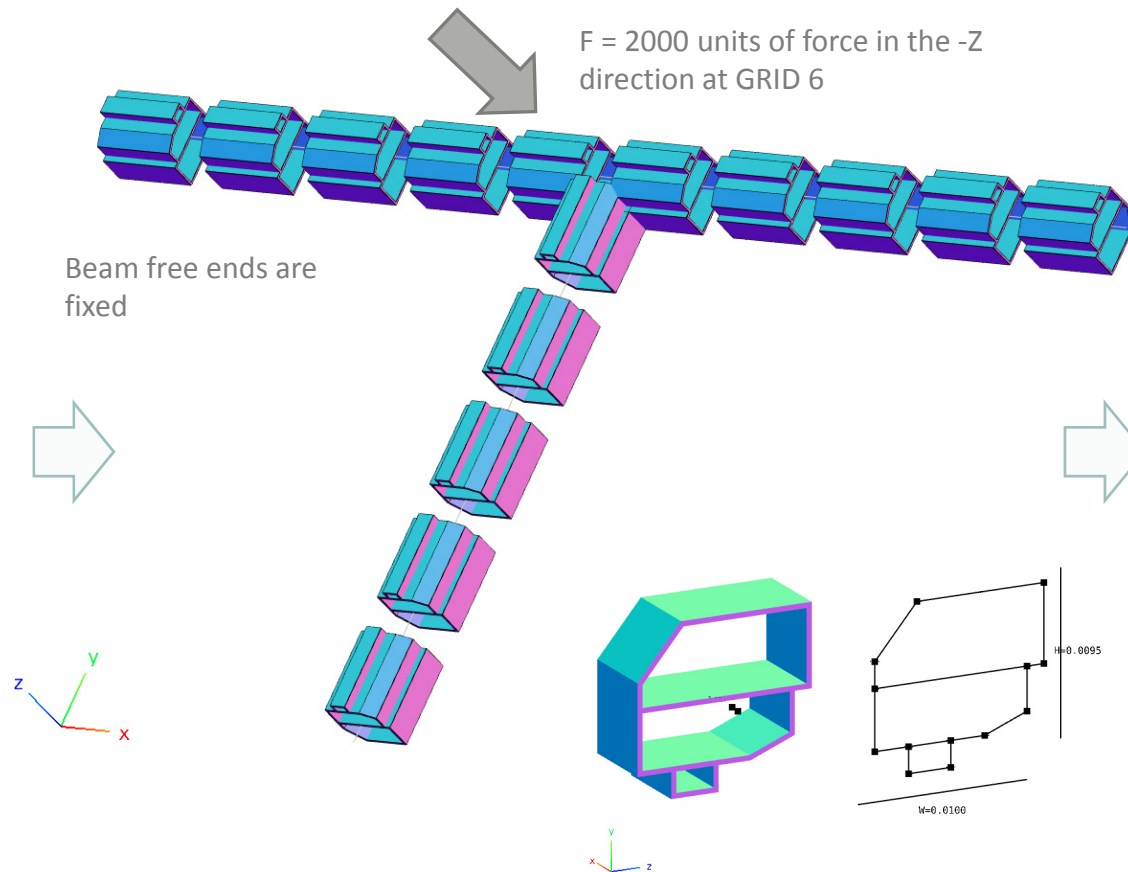
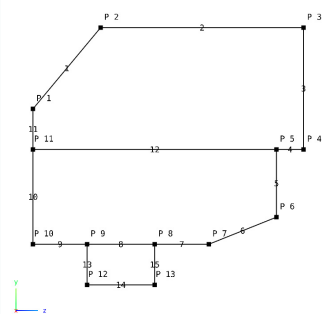
x4: Thickness of segments 1, 2 and 3

$$.08 < x1 < .2$$

$$.05 < x2 < .2$$

$$.002 < x3 < .02$$

$$.003 < x4 < .02$$



## Design Objective

r0: Minimize weight

## Design Constraints

r1: The displacement, z component, at GRID 6

$$-.01 < r1 < .01$$

# Open the Correct Page

1. Navigate to the homepage
2. 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 nastran\_working\_directory/beam\_a.bdf
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 web interface for uploading BDF files. It consists of two main steps, each with a progress bar.

**Step 1: Select files** (indicated by a red circle with the number 1). The progress bar is labeled "1. Select files" and "beam\_a.bdf". Below it, a green progress bar shows "Inspecting: 100%".

**Step 2: Upload files** (indicated by a red circle with the number 2). The progress bar is labeled "2. Upload files". Below it, a green progress bar shows "Uploading: 100 %".

At the bottom, there is a checkbox labeled "List of Selected Files" which is currently unchecked.

# Create Design Variables

1. Click the 4 plus icons to create 4 design variables for the width, height, overall thickness and thickness of line segment 1 of the ABCS
2. Configure the bounds for the variables as using the values in the table below

Variable	Lower Bound	Upper Bound
x1	.08	.2
x2	.05	.2
x3	.002	.02
x4	.003	.02

## Step 1 - Select design properties

+ Options

Create DVXREL1	Property	Property Description	Entry	Entry ID	Current Value
	<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"/>
<div>+</div>	W	Overall width	PBMSECT	1	.1
<div>+</div>	H	Overall height	PBMSECT	1	.095
<div>+</div>	T	Overall thickness	PBMSECT	1	.010
<div>+</div>	T(1)	Thickness of segment	PBMSECT	1	.0101
<div>+</div>	DIM1(A)	T2 - Width of flange	PBEAML	99	.1

« 1 2 3 4 5 6 7 ... 12 »

5 10 20 30 40 50

Number of Visible Rows 5

## 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
	<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"/>
<div>✕</div>	x1	<div>✓</div>	W	Overall width	PBMSECT	1	1.000E-1	<input type="text" value=".08"/>	<input type="text" value=".2"/>	Examples: -2.0, 1.0, THRU, 10.0,
<div>✕</div>	x2	<div>✓</div>	H	Overall height	PBMSECT	1	9.500E-2	<input type="text" value=".05"/>	<input type="text" value=".2"/>	Examples: -2.0, 1.0, THRU, 10.0,
<div>✕</div>	x3	<div>✓</div>	T	Overall thickness	PBMSECT	1	.010	<input type="text" value=".002"/>	<input type="text" value=".02"/>	Examples: -2.0, 1.0, THRU, 10.0,
<div>✕</div>	x4	<div>✓</div>	T(1)	Thickness of segment	PBMSECT	1	.0101	<input type="text" value=".003"/>	<input type="text" value=".02"/>	Examples: -2.0, 1.0, THRU, 10.0,

# 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 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 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. Click the plus(+) icon for Displacement to create 1 displacement constraint
3. Configure the constraints as shown to the right
  - Configure the following for r1
    - ATTA: 3 – T3
    - ATTi: 6 (GRID 6)
    - Lower Allowed Limit: -.01
    - Upper Allowed Limit: .01

1

## 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"/>
	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="St"/>	<input type="text" value="Seal"/>	<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"/>
	r1		DISP		3 - T3 (Rectangular z, Cylindrical z ▾)		6	-.01	.01

3

# 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, 3 and 5: r1
- 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  
SUBCASE 3  
SUBCASE 4  
SUBCASE 5

2

☐ Uncheck visible boxes

☒ Check visible boxes

+ Options

	Status	Label	Response Type	Description	Global Constraints	SUBCASE 1	SUBCASE 2	SUBCASE 3	SUBCASE 4	SUBCASE 5
		<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>						
		r1	DISP	T3 component(s) of displacement at grid 6		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<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. The right sidebar shows a 'BDF Output' section with a list of parameters.

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

Result Files **2**

**H5 Output Option**

Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer) ▼

-- Select an Option --

Create the H5 file with MDLPRM (supported in MSC Nastran 2016.1 or newer)

Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)

**Result Files**

**H5 Output Option**

Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer) ▼

-- Select an Option --

Create the H5 file with MDLPRM (supported in MSC Nastran 2016.1 or newer)

Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)

BDF Ou

\$

\$

\$

\$

\$

DOPTPRM DESMA

\$ Parameter t

HDF5OUT INPUT



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”

Download BDF Files

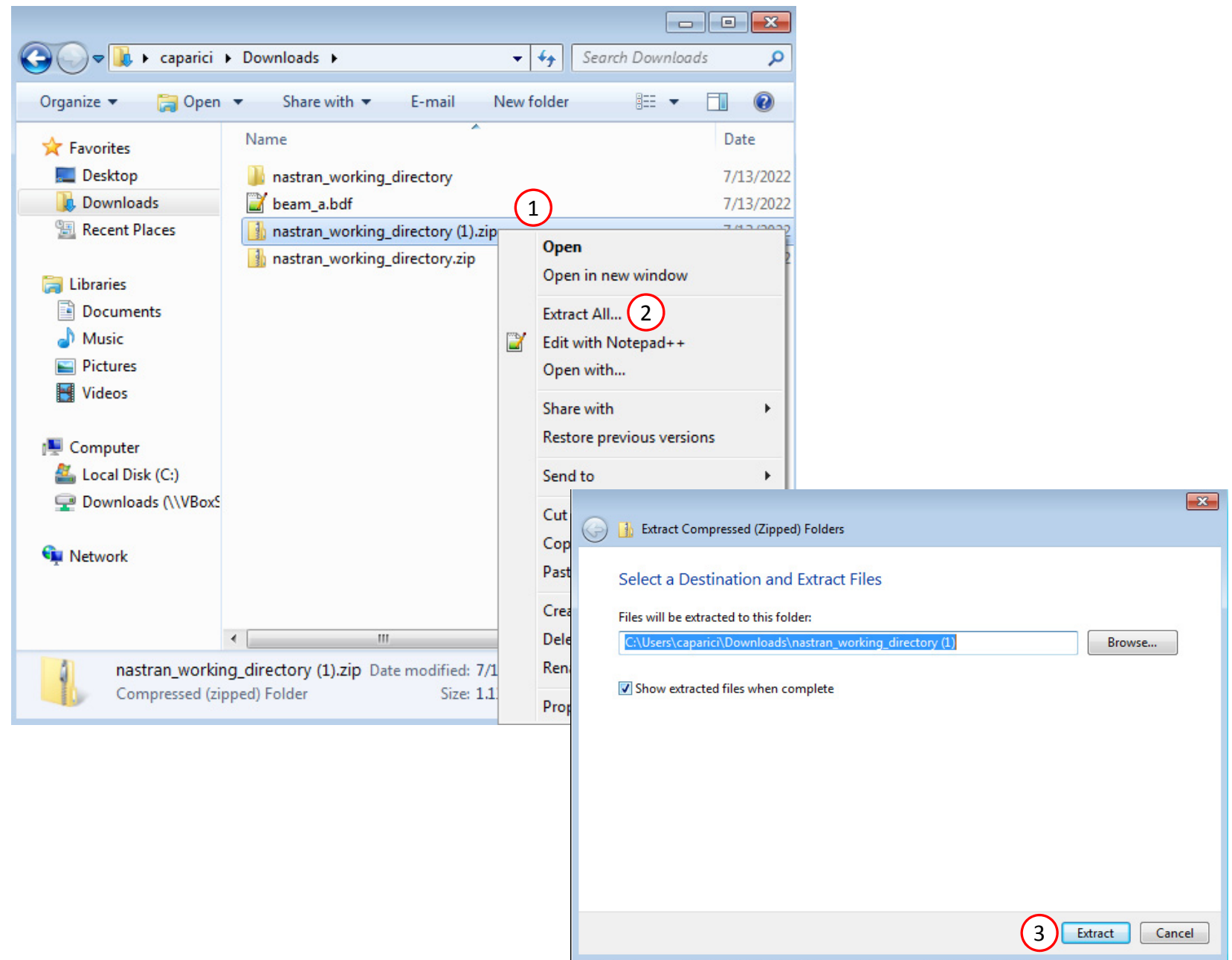
[Download BDF Files](#)

2

# Perform the Optimization with Nastran SOL 200

1. A new file nastran\_working\_directory (1).zip 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.

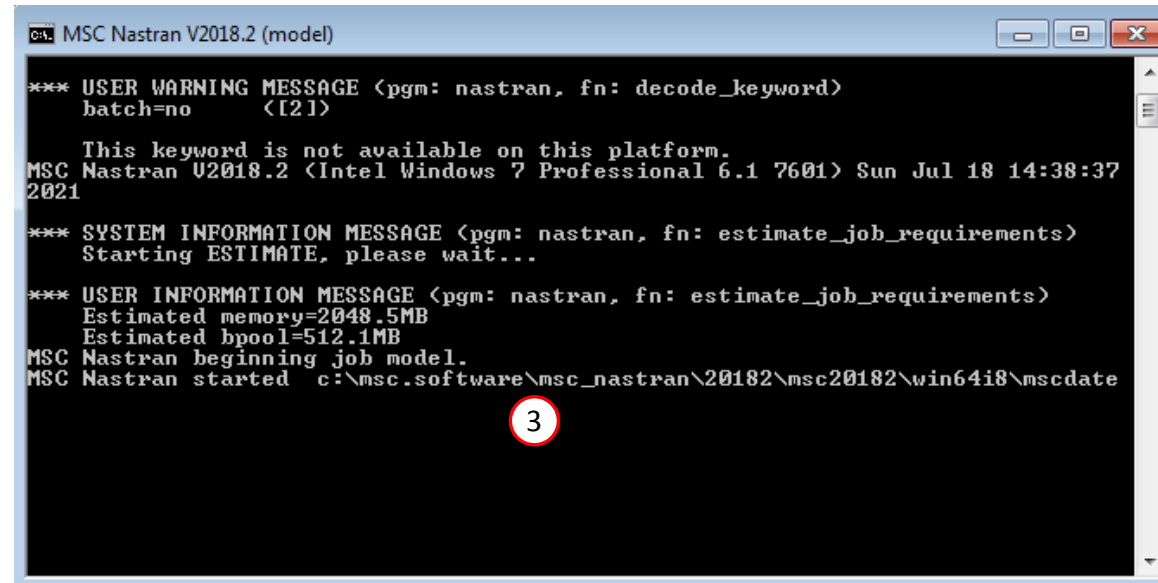
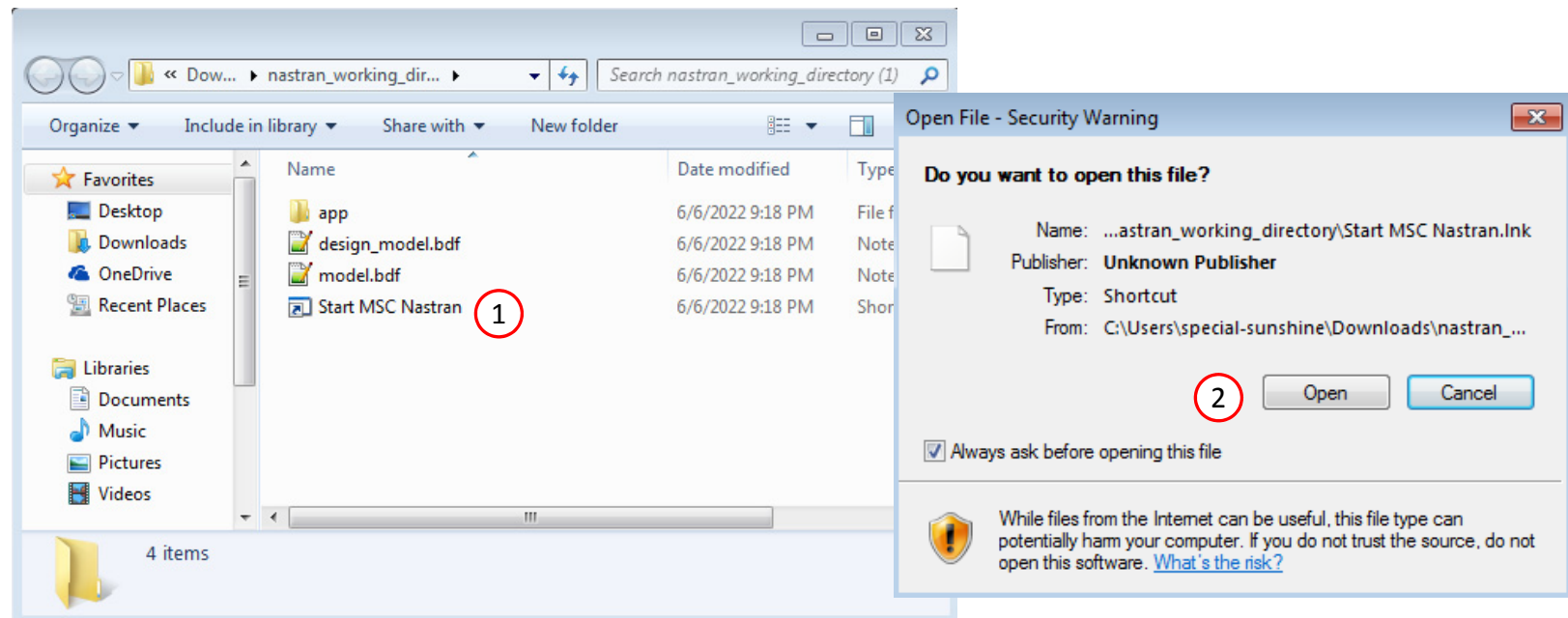
## Using Linux?

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

1. After MSC Nastran is finished, the results will be automatically uploaded.
2. Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
3. The final value of objective, normalized constraints (not shown) and design variables can be reviewed.

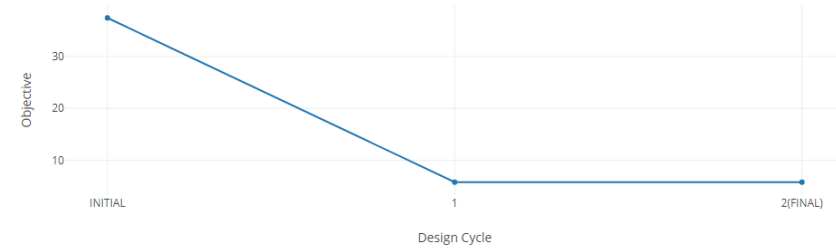
- After an optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- For this optimization, each variable has been reduced. On close inspection, each variable has been reduced to its lower bound.

Final Message in .f06

1

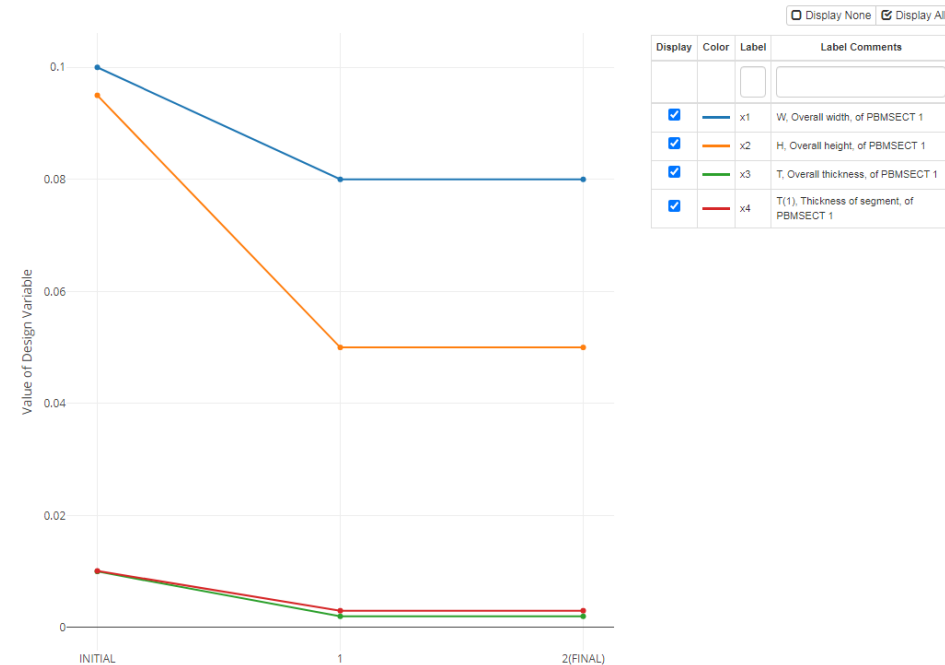
 RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 2.

Objective



Design Variables

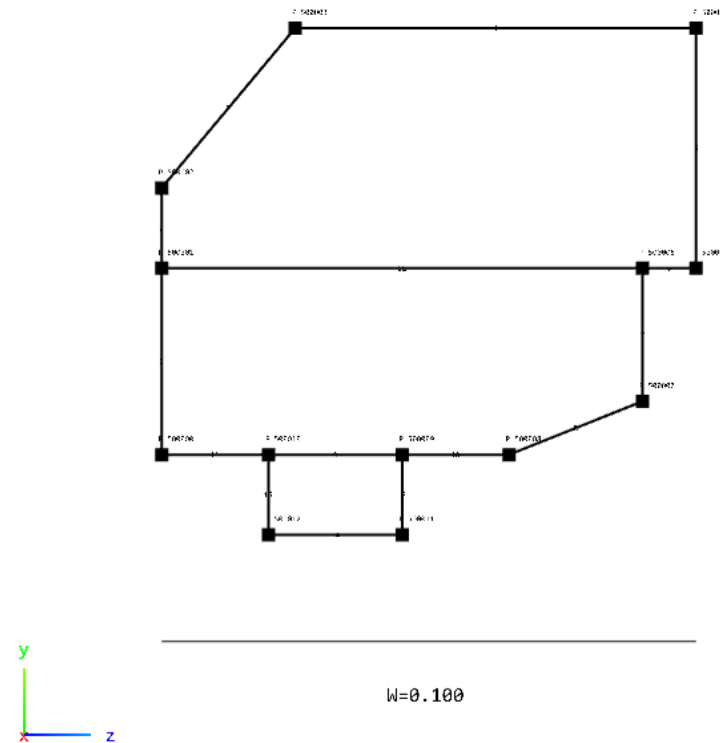
2



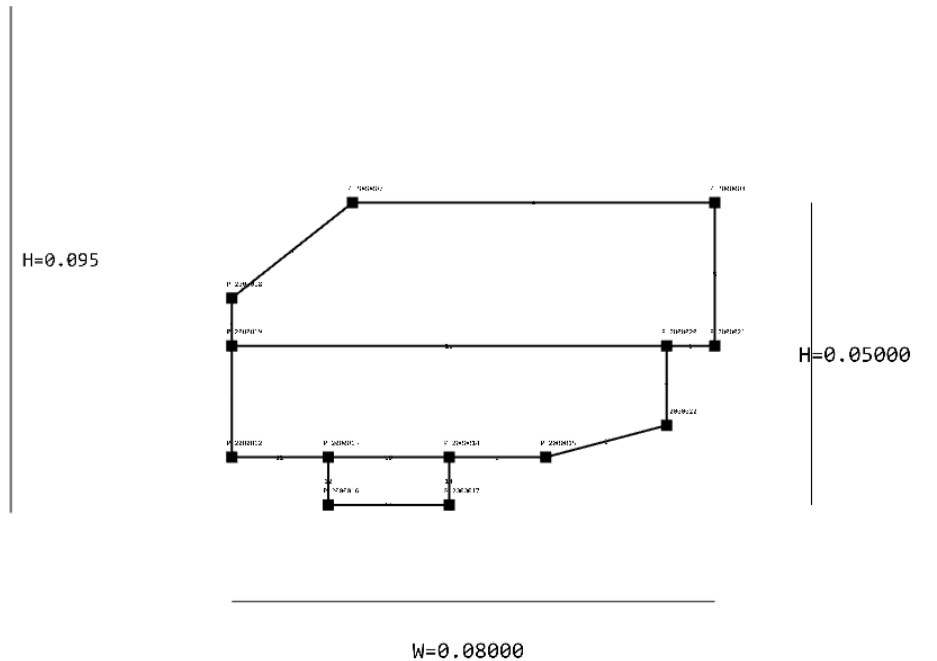
# Comparison of Original and New Arbitrary Beam Cross Section

This slide show a comparison of the original and new cross section after optimization

Before Optimization

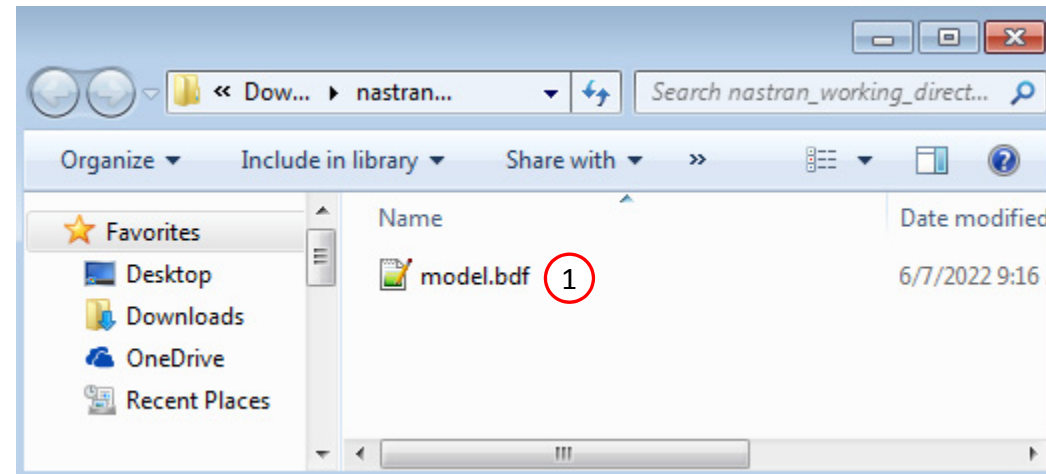
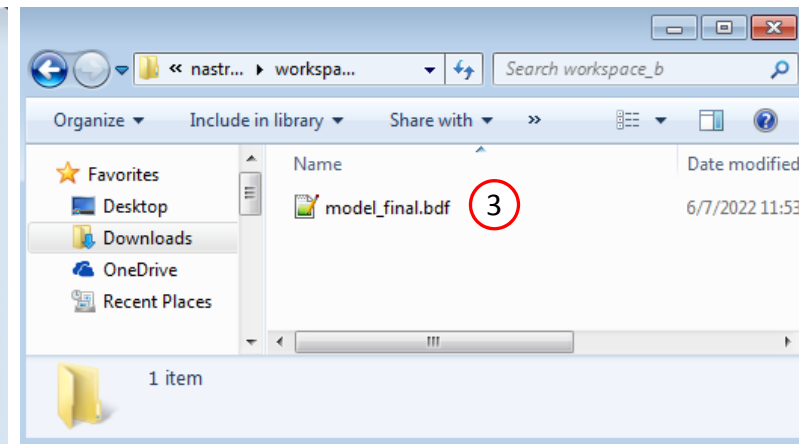
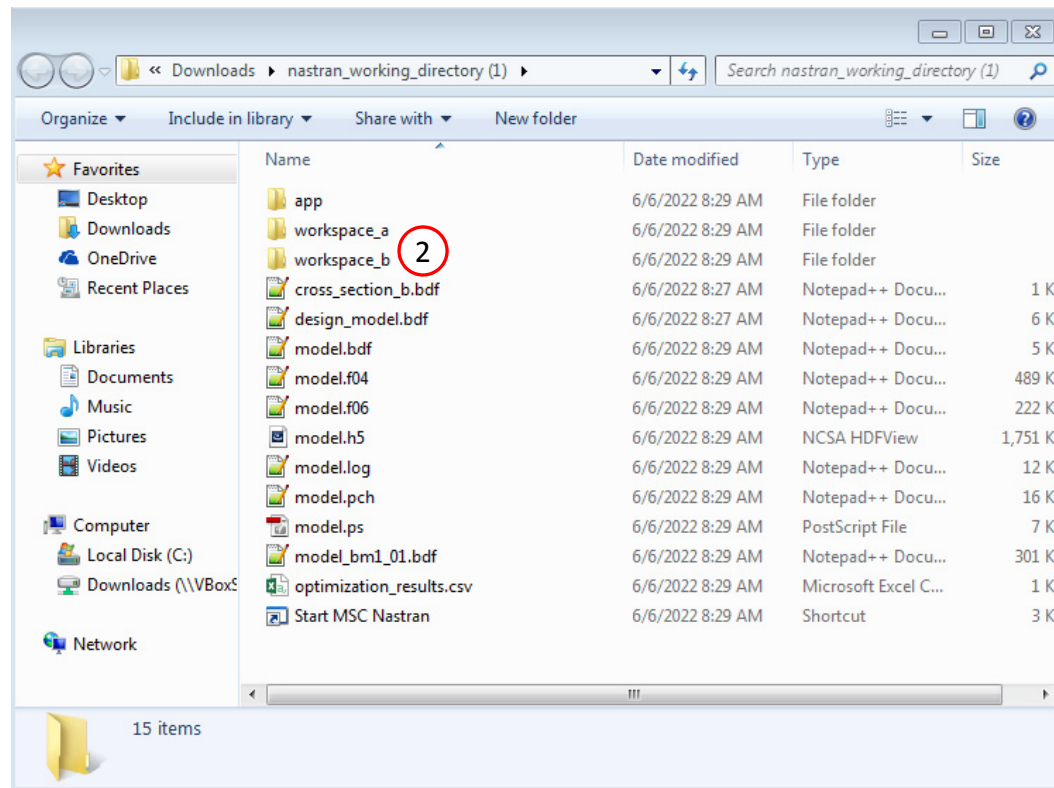


After Optimization



# Comparison of the Original and New PBMSECT Entries

1. Open the following file in a text editor:  
nastran\_working\_directory/beam\_a.bdf
2. Open the directory named  
workspace\_b
3. Open the following file in a text editor:  
nastran\_working\_directory  
(1)/workspace\_b/model\_final.bdf





# Comparison of the Original and New PBMSECT Entries

1. model\_final.bdf contains updated POINT entries that describe the new ABCS

```
42 PBMSECT 1 1 CP
43 OUTP=201, BRP=202, BRP=203, T=.010, T(1)=[.0101, PT=(2000012, 2000007)
44 ]
45 POINT 2000007 -0.025000 .050000
46 POINT 2000008 0.050000 .050000
47 POINT 2000012 -0.050000 -0.029999
48 POINT 2000013 -0.029999 -0.029999
49 POINT 2000014 -0.004999 -0.029999
50 POINT 2000015 0.014999 -0.029999
51 POINT 2000016 -0.029999 -0.045000
52 POINT 2000017 -0.004999 -0.045000
53 POINT 2000018 -0.050000 .019999
54 POINT 2000019 -0.050000 .004999
55 POINT 2000020 0.039999 .004999
56 POINT 2000021 0.050000 .004999
57 POINT 2000022 0.039999 -0.019999
58 SET1 201 2000012 2000019 2000018 2000007 2000008 2000021 2000020
59 2000022 2000015 2000014 2000013
60 SET1 202 2000013 2000016 2000017 2000014
61 SET1 203 2000020 2000019
62 $ Direct Text Input for Bulk Data
63 MDLPRM HDF5 0
64 PARAM PRTMAXIM YES
65 $ Elements and Element Properties for region : Beam_Assignment_A
66 PBEAML 99 1 T2
67 .1 .1 .003 .003

159 PBMSECT 1 1 CP
160 OUTP=201, BRP=202, BRP=203, T=.002, T(1)=[.003, PT=(2000012,
161 2000007) ]
162 POINT 2000007 -0.03 .005
163 POINT 2000008 0.03 .005
164 POINT 2000012 -0.05 -.0371
165 POINT 2000013 -.033992 -.0371
166 POINT 2000014 -.013992 -.0371
167 POINT 2000015 0.001999 -.0371
168 POINT 2000016 -.033992 -.045
169 POINT 2000017 -.013992 -.045
170 POINT 2000018 -0.05 -.01079
171 POINT 2000019 -.05 -.018685
172 POINT 2000020 -.021999 -.018685
173 POINT 2000021 0.03 -.018685
174 POINT 2000022 -.021999 -.031837
175 SET1 201 2000012 2000019 2000018 2000007 2000008 2000021 2000020
176 + 2000022 2000015 2000014 2000013
177 SET1 202 2000013 2000016 2000017 2000014
178 SET1 203 2000020 2000019
179 $ Direct Text Input for Bulk Data
180 $! MDLPRM HDF5 0
181 PARAM PRTMAXIM YES
182 $ Elements and Element Properties for region : Beam_Assignment_A
183 PBEAML 99 1 T2
184 + .1 .1 .003 .003
```

Original BDF/DAT File

Updated BDF/DAT File



# Part D – Inspecting the new ABCS in the PBMSECT Web App

---

# PBMSECT Web App

1. Open the PBMSECT web app
2. Click Select files
3. Select nastran\_working\_directory (1)/workspace\_b/model\_final.bdf
4. Click Open
5. Click Upload files
6. Select PBMSECT 1 from the list of available entries

1 SOL 200 Web App - PBMSECT

Existing PBMSECT/PBRSECT Entries

Cross Sec

Select BDF Files

2 1. Select files

model\_final.bdf

Inspecting: 100%

3 2. Upload files

Uploading: 100 %

☐ List of Selected Files

Existing PBMSECT/PBRSECT Entries

Select a PBMSECT/PBRSECT ID to edit

1 6

+ Create New Entry

✕ Delete Selected Entry

Open

<< nastran\_working\_dir... >> workspace\_b

Search workspace\_b

Organize New folder

★ Favorites

Desktop

Downloads

OneDrive

Recent Places

Libraries

Documents

Music

Pictures

Videos

Name

Date modified

Type

model\_final.bdf 4 6/7/2022 11:53 AM Notepad+

File name: model\_final.bdf

Custom Files (\*.bdf;\*.dat;\*.inc;\*)

5 Open

Cancel

# View the New Cross Section

The following requires MSC Nastran to be installed on the same machine as the SOL 200 Web App.

1. Click Run MSC Nastran
  1. The web app will run MSC Nastran in the background and will determine the cross section generated by MSC Nastran. This MSC Nastran run should take no more than 10 seconds. MSC Nastran must be installed on the machine as the SOL 200 Web App.
2. If the run is successful, the MSC Nastran generated cross section is displayed.
3. Click Labels
4. Click Fit Model

SOL 200 Web App - PBMSECT Existing PBMSECT/PBRSECT Entries Cross Section Options Points Lines Custom IDs Run MSC Nastran and Bulk Data Entries Download Home

### Run MSC Nastran and Bulk Data Entries

Download Test BDF File Run MSC Nastran **1** Complete

Corresponding Bulk Data Entries

```
PBMSECT 1 1 CP
OUTP=201,BRP=202,BRP=203,T=.002,T(1)=[.003,PT=(2000012,2000007)]
POINT 2000007 -.03 .005
POINT 2000008 .03 .005
POINT 2000012 -.05 -.0371
POINT 2000013 -.033992-.0371
POINT 2000014 -.033992-.0371
POINT 2000015 .001999 -.0371
POINT 2000016 -.033992-.045
POINT 2000017 -.033992-.045
POINT 2000018 -.05 -.01079
POINT 2000019 -.05 -.010685
POINT 2000020 .021999 -.010685
POINT 2000021 .03 -.010685
POINT 2000022 .021999 -.031037
SET1 201 2000012 2000019 2000018 2000007 2000008 2000021 2000020
2000022 2000015 2000014 2000013
SET1 202 2000013 2000016 2000017 2000014
SET1 203 2000020 2000019
```

F06

```
Command executed: /msc/MSC_Nastran/2022.1/bin/msc20221 nastran -./tmp/92628fab09b109fae6aa87b2
1

Warning: This computer program is protected by copyright law and interna
Unauthorized use, reproduction or distribution of this computer program, or
```

Controls

Tools

- Center Model
- Fit Model** **4**
- Isometric View 1
- ZY View
- Background Color
- Label Color

Display

- Labels** **3**
- Cross Section Preview
- Cross Section Actual
- Size Controls

Demos

- Clear Demo
- Demo 1
- Demo 2
- Demo 3
- Demo 4
- Demo 5

Editing PBMSECT 1

Developed by The Engineering Lab

# Part E – Inspecting the new ABCS in the Viewer

---

# Viewer

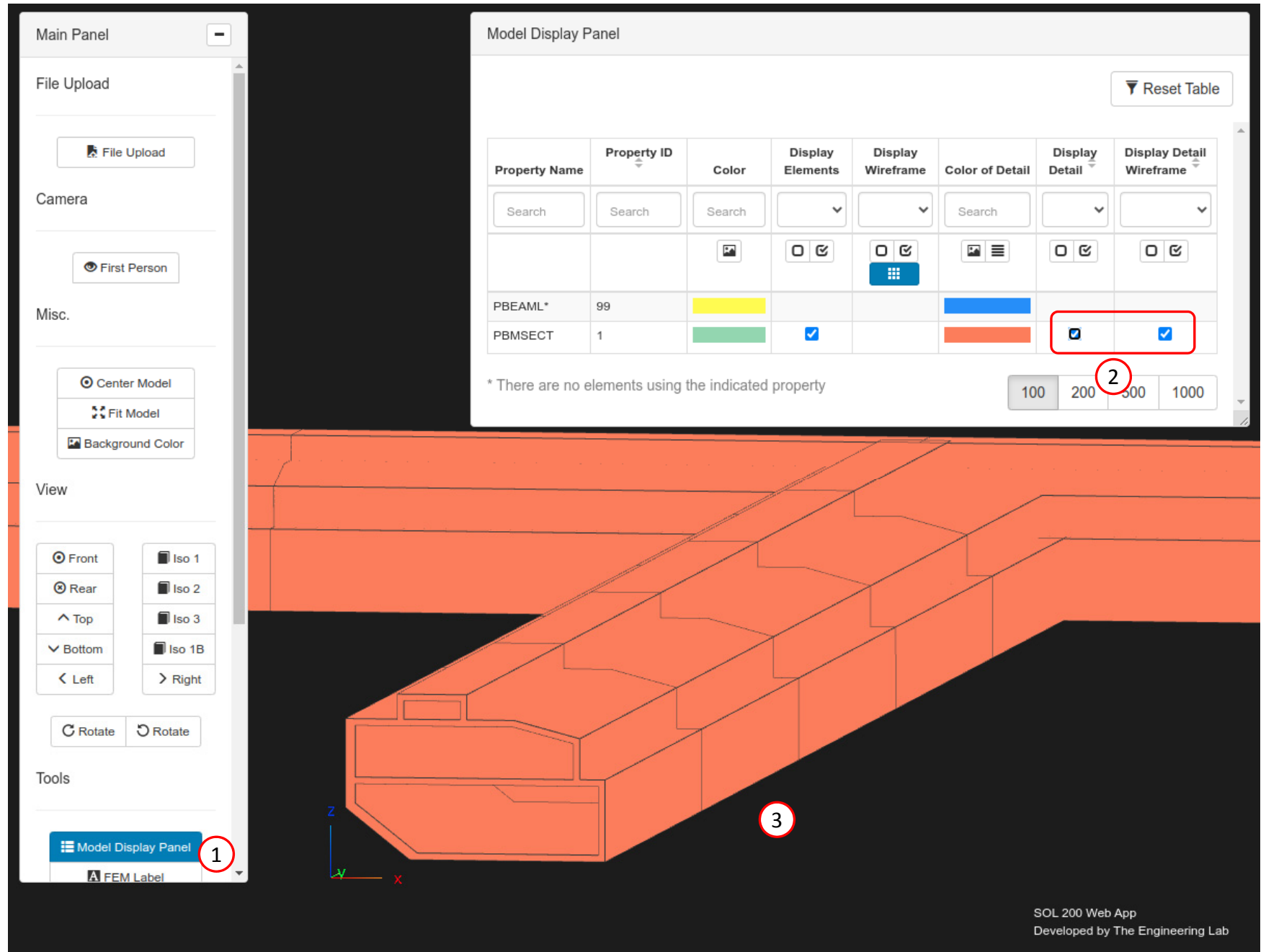
Open the Viewer

1. Click File Upload
2. Click Select files
3. Navigate to the directory workspace\_b
4. Select model\_final.bdf
5. Click Open
6. Click Upload files
7. The MSC Nastran model has been uploaded to the Viewer

The screenshot displays the SOL 200 Web App interface, which is divided into a Main Panel on the left and a central workspace. The Main Panel contains sections for File Upload, Camera, Misc., View, and Tools. The File Upload section has a 'File Upload' button (1). The Camera section has a 'First Person' button (2). The Misc. section has buttons for 'Center Model', 'Fit Model', and 'Background Color'. The View section has buttons for 'Front', 'Rear', 'Top', 'Bottom', 'Left', 'Right', 'Iso 1', 'Iso 2', 'Iso 3', and 'Iso 1B'. The Tools section has a 'Model Display Panel' and a 'FEM Label' button. The central workspace shows the 'File Upload' process. It has tabs for 'BDF', 'H5', 'PCH', and 'PS'. The 'BDF' tab is selected. Below the tabs, there is a 'Select files' button (2) and a text input field containing 'model\_final.bdf'. A green progress bar indicates 'Inspecting: 100%'. Below the progress bar, there is an 'Upload files' button (6). A 'List of Selected Files' checkbox is also present. An 'Open' dialog box is open, showing the file 'model\_final.bdf' (4) in the 'workspace\_b' directory (3). The 'File name' field contains 'model\_final.bdf' and the file type is set to 'Custom Files (\*.bdf;\*.dat;\*.inc;\*)'. The 'Open' button (5) is highlighted. The 3D model of the Nastran structure is visible in the workspace (7).

# Viewer

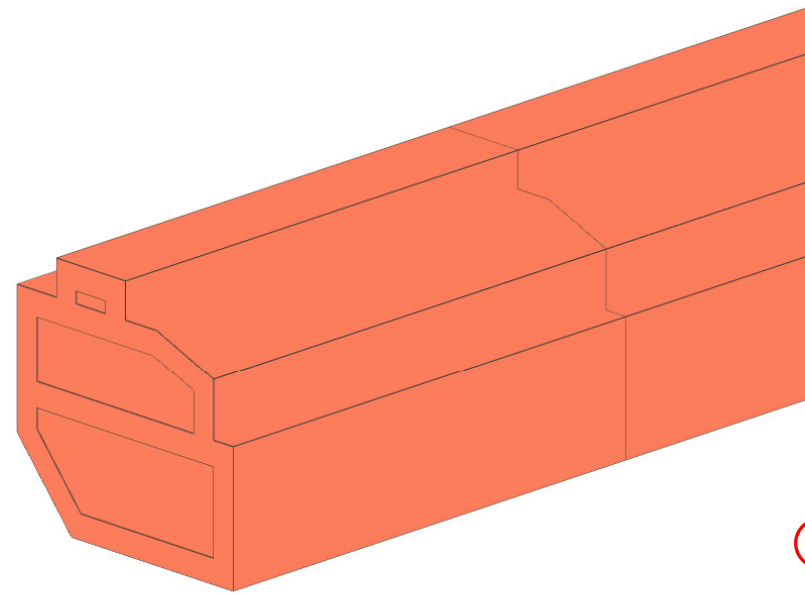
1. Click Model Display Panel
  - In the future, click this button again to close the Model Display Panel
2. Mark the indicate checkbox to display the beam cross section
3. The new, optimized ABCS is displayed



# Viewer

1. Two separate web browser tabs are used to open the Viewer web app. The initial and final BDF files are uploaded, so a side-by-side comparison is done on the arbitrary cross sections.

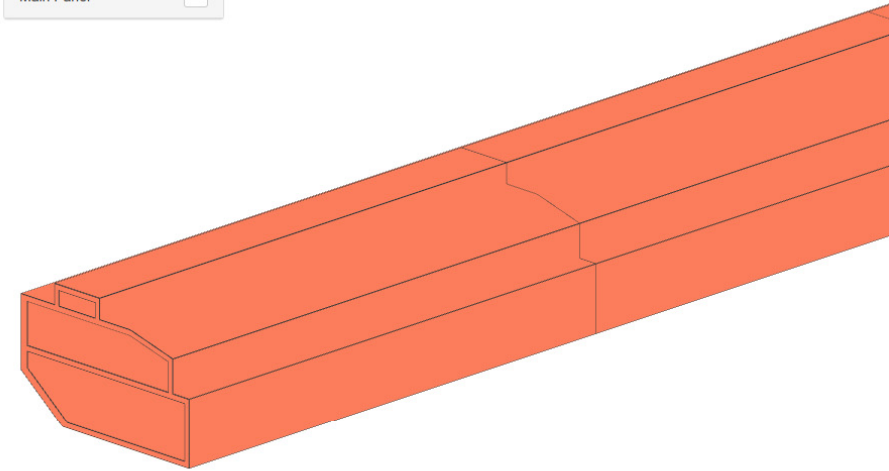
Main Panel



SOL 200 Web App  
Developed by The Engineering Lab

Initial Design  
model.bdf

Main Panel



1



SOL 200 Web App  
Developed by The Engineering Lab

Final Design  
model\_final.bdf

# Part F – Inspecting the PBMSECT and CBEAM Results

---



# Upload the H5 File

1. Click File Upload
2. Click H5
3. Click Select files
4. Select file nastran\_working\_directory (1)/model.h5
5. Click Open
6. Click Upload files

Main Panel

File Upload

File Upload

Camera

First Person

Misc.

Center Model

Fit Model

Background Color

View

Front

Rear

Top

Bottom

Left

Right

Iso 1

Iso 2

Iso 3

Iso 1B

Rotate

Rotate

Tools

Model Display Panel

FEM Label

File Upload

BDF

H5

PCH

PS

H5

Upload .h5 File

1. Select files

model.h5

2. Upload files

Uploading

Loading

Acquire Dataset

Select Dataset

Specify Entities

Open

File name: model.h5

NCSA HDFView (\*.h5)

Open

Cancel

SOL 200 Web App  
Developed by The Engineering Lab

# Display Internal Element Moments

1. Select dataset:  
ELEMENTAL/ELEMENT\_FORCE/BEAM
2. Select DESIGN\_CYCLE 2
3. Select the indicated checkbox

The screenshot displays the SOL 200 Web App interface, which is used for visualizing finite element analysis results. The interface is divided into several panels:

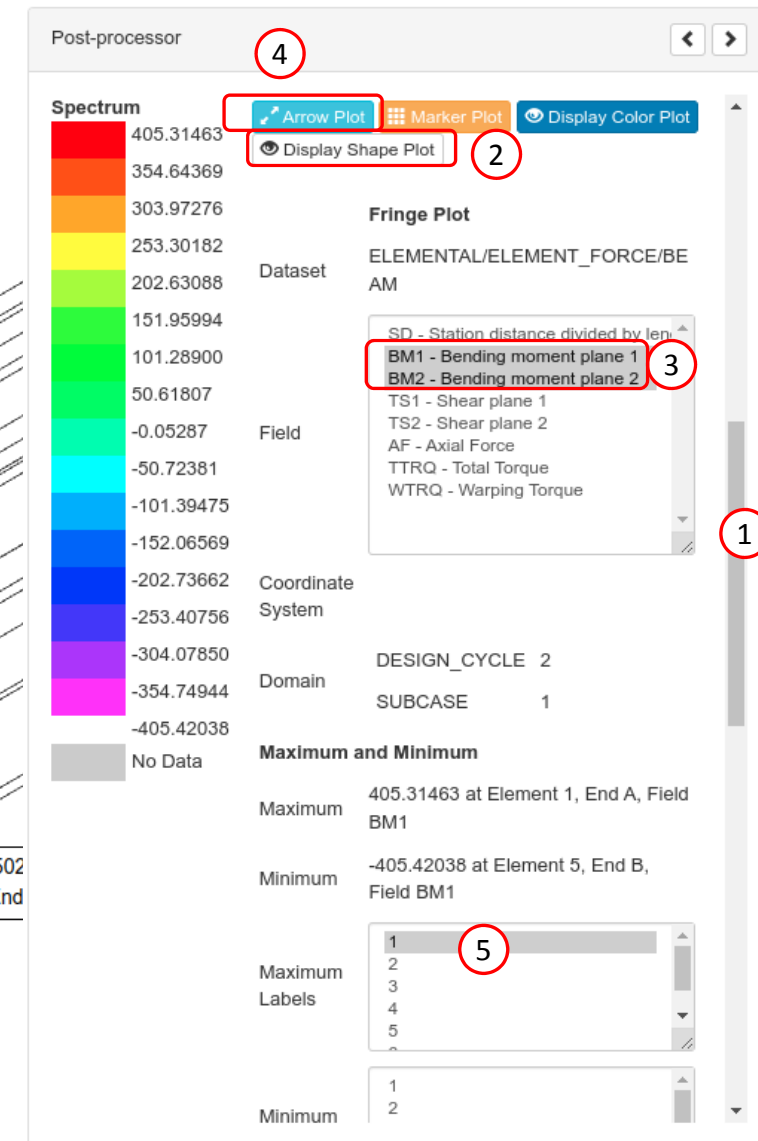
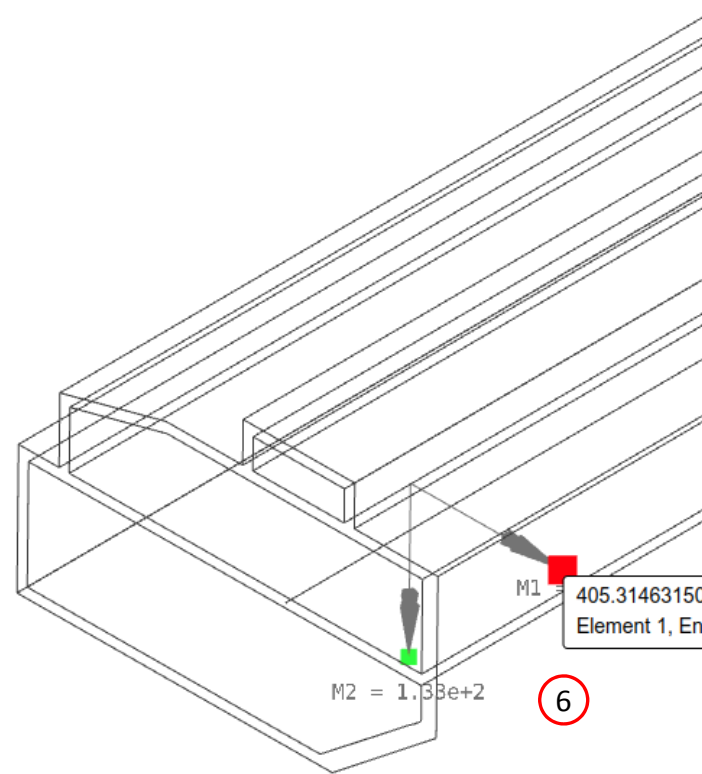
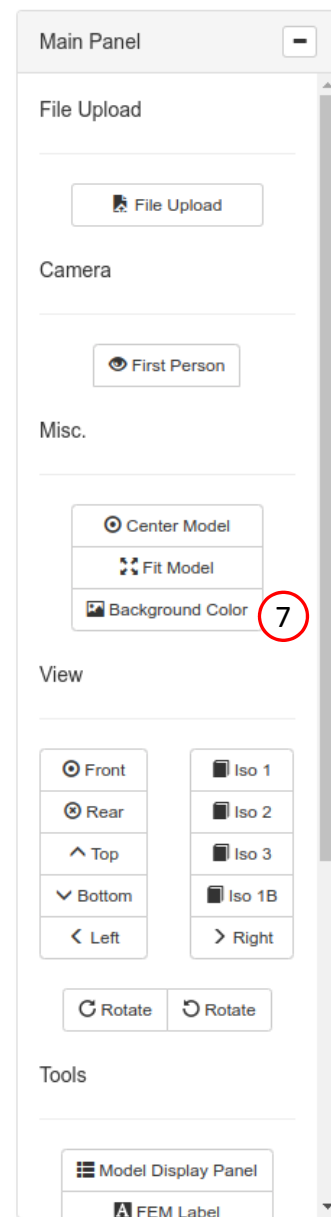
- Main Panel:** Contains controls for file upload, camera view (First Person), miscellaneous settings (Center Model, Fit Model, Background Color), view orientation (Front, Rear, Top, Bottom, Left, Right), and tools (Model Display Panel, FEM Label).
- Post-processor:** Contains a color scale for internal element moments, ranging from 0.00000 (blue) to 1.00000 (red). It also includes a table for selecting datasets and domains.
- Acquire Dataset:** A dropdown menu showing the selected dataset: ELEMENTAL/ELEMENT\_FORCE/BEAM (circled 1).
- Select Dataset:** A dropdown menu showing the selected design cycle: 2 (circled 2).
- Select Domain:** A table with columns: Selected, DOMAIN\_ID, DESIGN\_CYCLE, and SUBCASE. The table lists domains 15 through 19, all with DESIGN\_CYCLE 2. The checkbox for domain 15 is checked (circled 3).
- Configure Plots:** Includes buttons for Arrow Plot, Marker Plot, Display Color Plot, and Display Shape Plot.

The 3D model shows a beam structure with internal element moments visualized as a color gradient. A coordinate system (X, Y, Z) is visible at the bottom left.

SOL 200 Web App  
Developed by The Engineering Lab

# Display Internal Element Moments

1. Use scroll bar to move to the Fringe Plot section
2. Click Display Shape Plot
3. Select the indicated fields for moments M1 and M2
4. Click Arrow Plot
5. Display the first maximum label
6. Rotate and zoom in to the location of the first maximum label
7. Click Background Color



# Display Internal Element Moments

1. Click Model Display Panel
2. Deselect the indicated checkboxes

**Main Panel**

**File Upload**

File Upload

**Camera**

First Person

**Misc.**

Center Model  
Fit Model  
Background Color

**View**

Front  
Rear  
Top  
Bottom  
Left  
Right

Iso 1  
Iso 2  
Iso 3  
Iso 1B

Rotate  
Rotate

**Tools**

Model Display Panel **1**  
FEM Label

**Model Display Panel**

Reset Table

Property Name	Property ID	Color	Display Elements	Display Wireframe	Color of Detail	Display Detail	Display Detail Wireframe
Search	Search	Search			Search		
PBEAML*	99						
PBMSECT	1		<input checked="" type="checkbox"/>			<input type="checkbox"/> <b>2</b>	<input type="checkbox"/>

\* There are no elements using the indicated property

100 200 500 1000

**Spectrum**

M1 = 3.85e+1  
M2 = 2.41e+0

405.31463  
354.64369  
303.97276  
253.60182  
202.63088  
151.95994  
101.28900  
50.61807  
-0.05287  
-50.72381  
-101.39475  
-152.06569  
-202.73662  
-253.40756  
-304.07850  
-354.74944  
-405.42038  
No Data

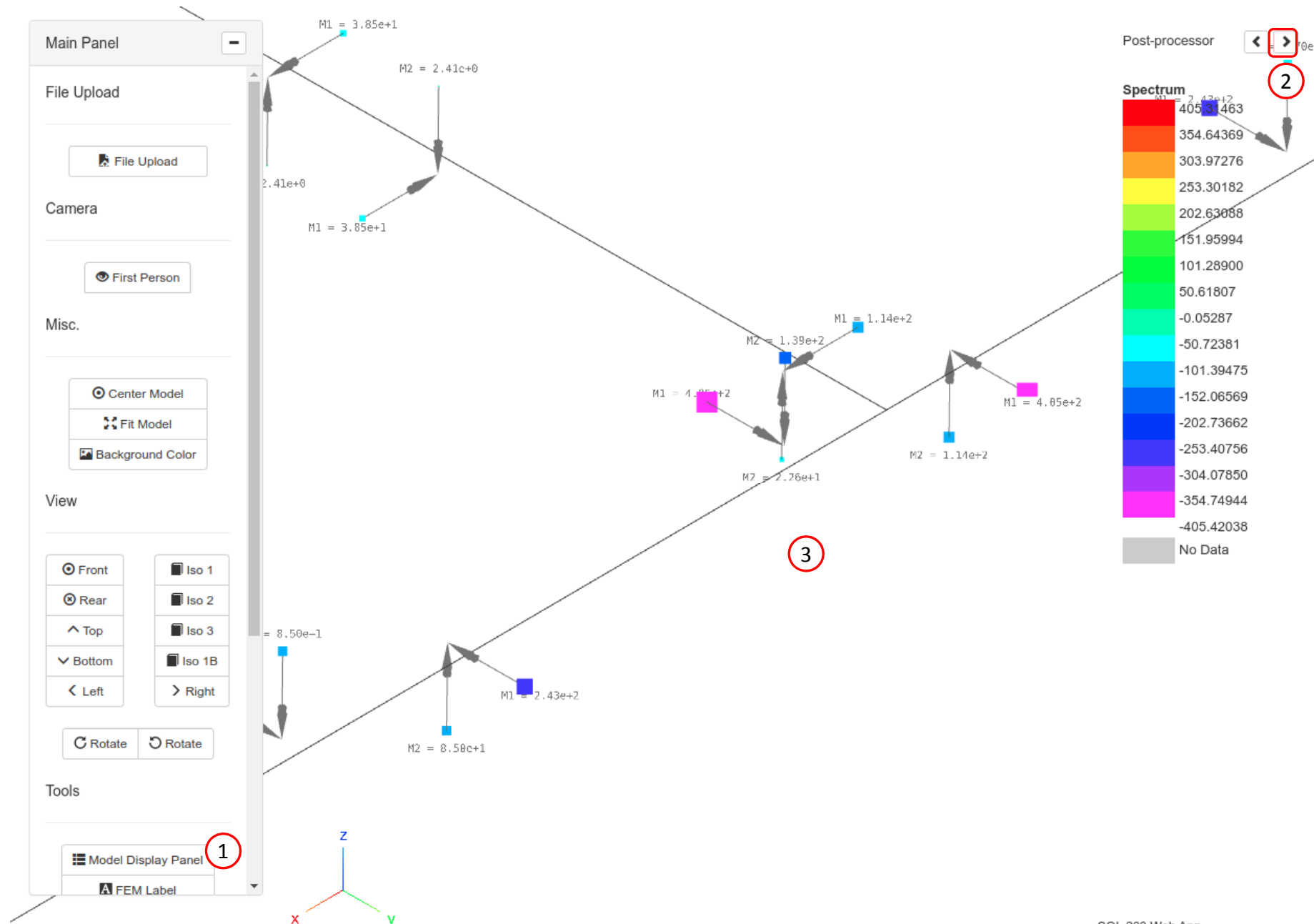
M1 = 2.43e+2  
M2 = 8.50e+1  
M2 = 1.14e+2  
M2 = 2.76e+1

8.50e-1

X Y Z

# Display Internal Element Moments

1. Click Model Display Panel to hide the Model Display Panel
2. Click the indicated button to hide the Post-processor panel
3. Inspect the moments in other beam elements

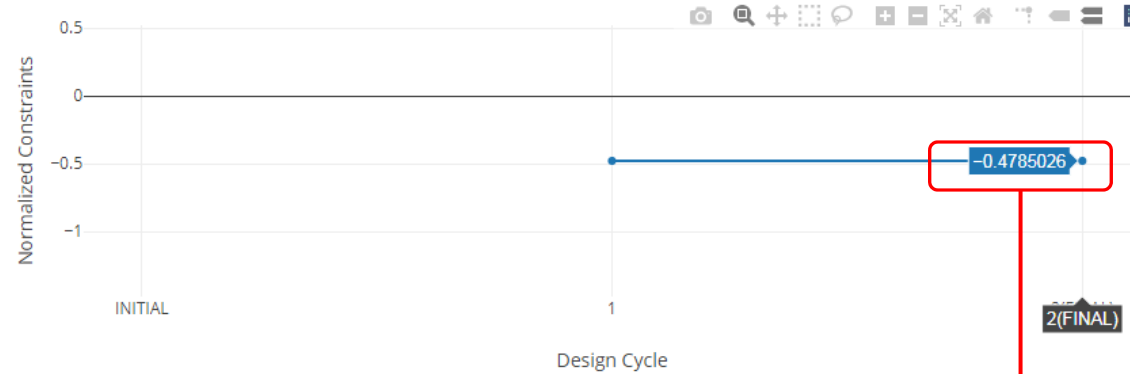


# Normalized Constraints

- 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 final design, the maximum NC is  $-0.4785026$  and corresponds to a displacement of  $-0.0052150$  (z component of displacement at grid 6 and subcase 5).

## Normalized Constraints

+ Info



## SOL 200 Web App - Responses

### Responses

<input type="button" value="Reset view"/> <input type="button" value="Violated constraints"/> <input type="button" value="Active constraints"/> <input type="button" value="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	GRID ID	COMPONENT NO.
<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"/>				
INITIAL	0	r0	WEIGHT		N/A	3.7407E+01	N/A			0		
FINAL - 2(FI	0	r0	WEIGHT		N/A	5.8078E+00	N/A			2		
FINAL - 2(FI	1	r1	DISPLACEMENT	$-4.7850E-01^{**}$	$-1.0000E-02$	$-5.2150E-03$	N/A			2	6	3
FINAL - 2(FI	3	r1	DISPLACEMENT	$-4.7850E-01^{**}$	$-1.0000E-02$	$-5.2150E-03$	N/A			2	6	3
FINAL - 2(FI	5	r1	DISPLACEMENT	$-4.7850E-01^{**}$	$-1.0000E-02$	$-5.2150E-03$	N/A			2	6	3

# Display Displacements

1. Click the indicated button to show the Post-processor panel
2. Move the scroll bar until the Acquire Dataset section is visible
3. Set Select Dataset to NODAL/DISPLACEMENT
4. Select DESIGN\_CYCLE 2
5. Select the indicated checkbox
  - Note the checkbox corresponds to design cycle 2, subcase 5
6. Move the scroll bar until the Fringe Plot section is visible
7. Set the Scale Factor to 40
8. Click Marker Plot
9. Set Field to Z – Z Component
10. Select the first minimum label

**Post-processor**

**Spectrum**

Acquire Dataset

Select Dataset: NODAL/DISPLACEMENT

Select Domain

Reset Table Uncheck visible boxes Check visible boxes

Selected	DOMAIN_ID	DESIGN_CYCLE	SUBCASE
		0	1
		2	2
		3	3
		4	4
<input type="checkbox"/>	15	2	1
<input type="checkbox"/>	16	2	2
<input type="checkbox"/>	17	2	3
<input type="checkbox"/>	18	2	4
<input checked="" type="checkbox"/>	19	2	5

10 20 50

Acquisition complete and successful

Configure Plots

Marker Plot Display Color Plot Display Shape Plot

**Post-processor**

**Spectrum**

Marker Plot Display Color Plot Display Shape Plot

**Fringe Plot**

Dataset: NODAL/DISPLACEMENT

Field: Z - Z component

Coordinate System: CID=0 (Basic)

Scale Factor: 40

Domain: DESIGN\_CYCLE 2 SUBCASE 5

**Shape Plot**

Dataset: NODAL/DISPLACEMENT

Field: X Y Z RX RY RZ

Coordinate System: CID=0 (Basic)

Scale Factor: 40

Domain: DESIGN\_CYCLE 2 SUBCASE 5

**Maximum and Minimum**

Maximum: 0.00000 at Grid 1

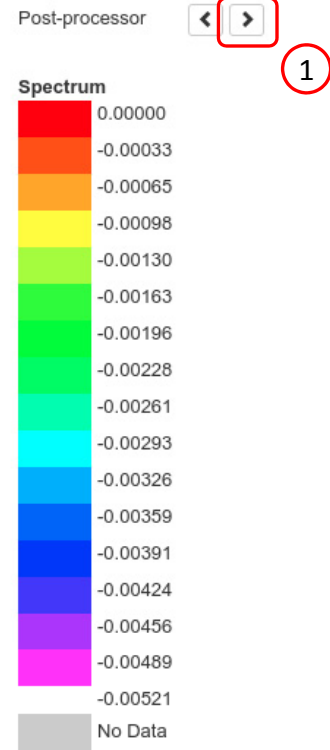
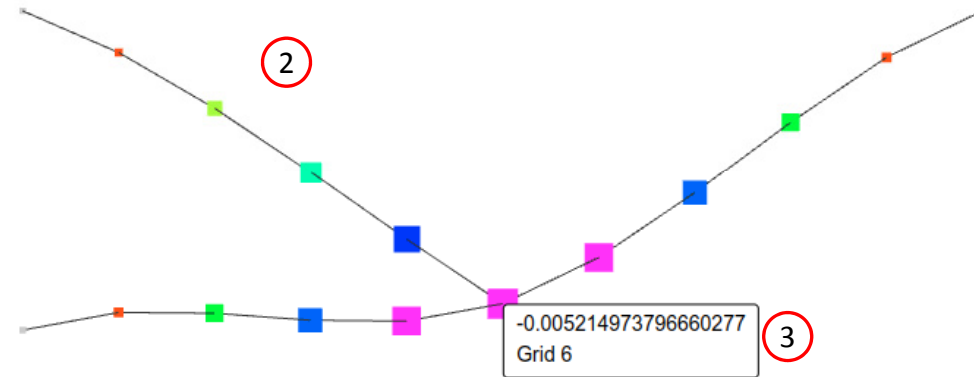
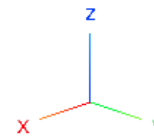
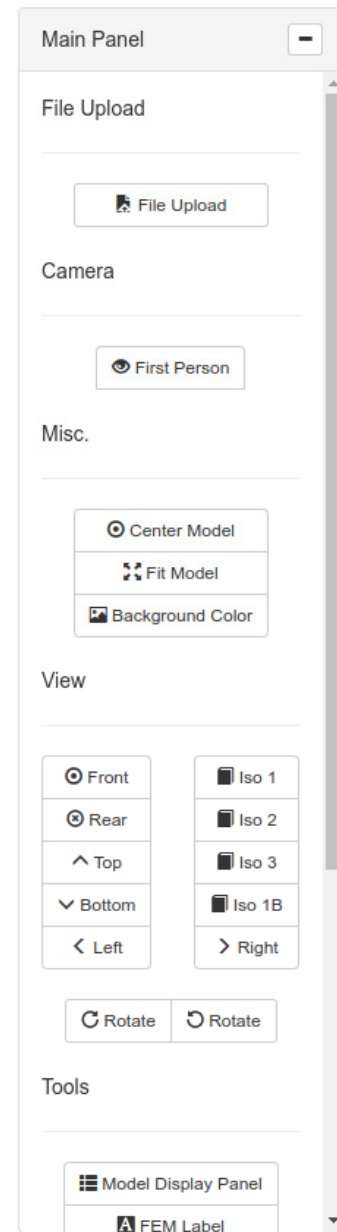
Minimum: -0.00521 at Grid 6

Maximum Labels: 1 2 3 4 5

Minimum Labels: 1 2 3 4

# Display Displacements

1. Click the indicated button until the Post-processor panel is hidden
2. Rotate and inspect the deformed shape
3. The displacement values matches the response value reported during the optimization





End of Tutorial

# Appendix

---

# Appendix Contents

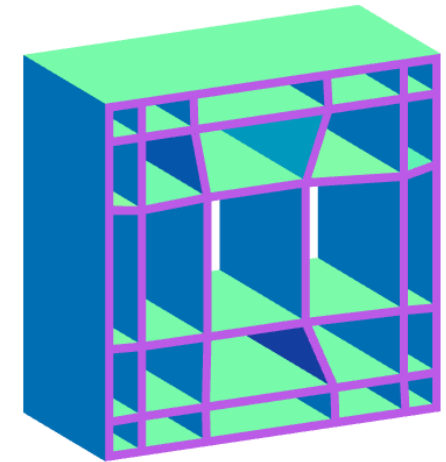
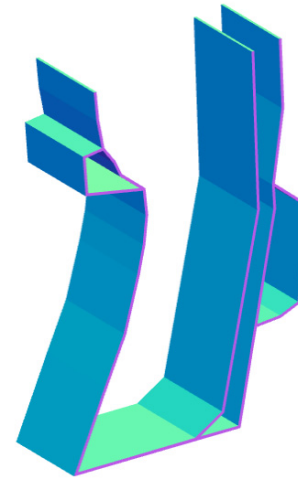
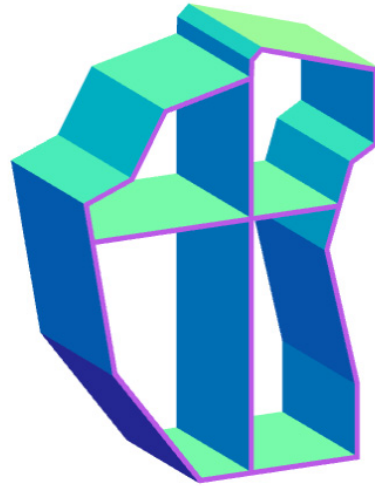
---

- Procedure to Create PBMSECT/PBRSECT Entries
- Comment on Critical Points
- Supported PBMSECT/PBRSECT Keywords
- UFM 2012
- UFM 7201 - Cause 1
- UFM 7201 - Cause 2
- UFM 7733
- What if the arbitrary cross section is not visible in the Viewer?

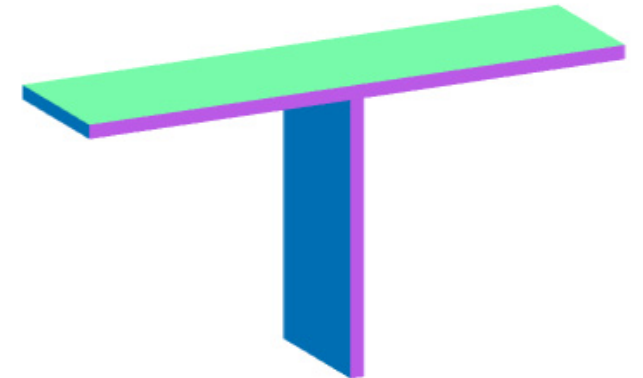
# Procedure to Create PBMSECT/PBRSECT Entries

1. Create points
2. Connect points and create Lines
3. Identify lines on the outer perimeter (**Critical Step**)
  - Guideline: If creating an open profile, the outer perimeter should connect all “critical points”
4. Fine tune the configuration
  - Select between PBMSECT and PBRSECT
  - Select general section, open profile or closed profile
  - Adjust the point's z and y positions
  - Adjust the line segment thicknesses
  - Specify custom IDs for POINT and SET1 entries
5. Run MSC Nastran to validate the PBMSECT/PBRSECT entry
  - This only works if MSC Nastran is installed on the same machine as the SOL 200 Web App

## Arbitrary Beam Cross Section Examples



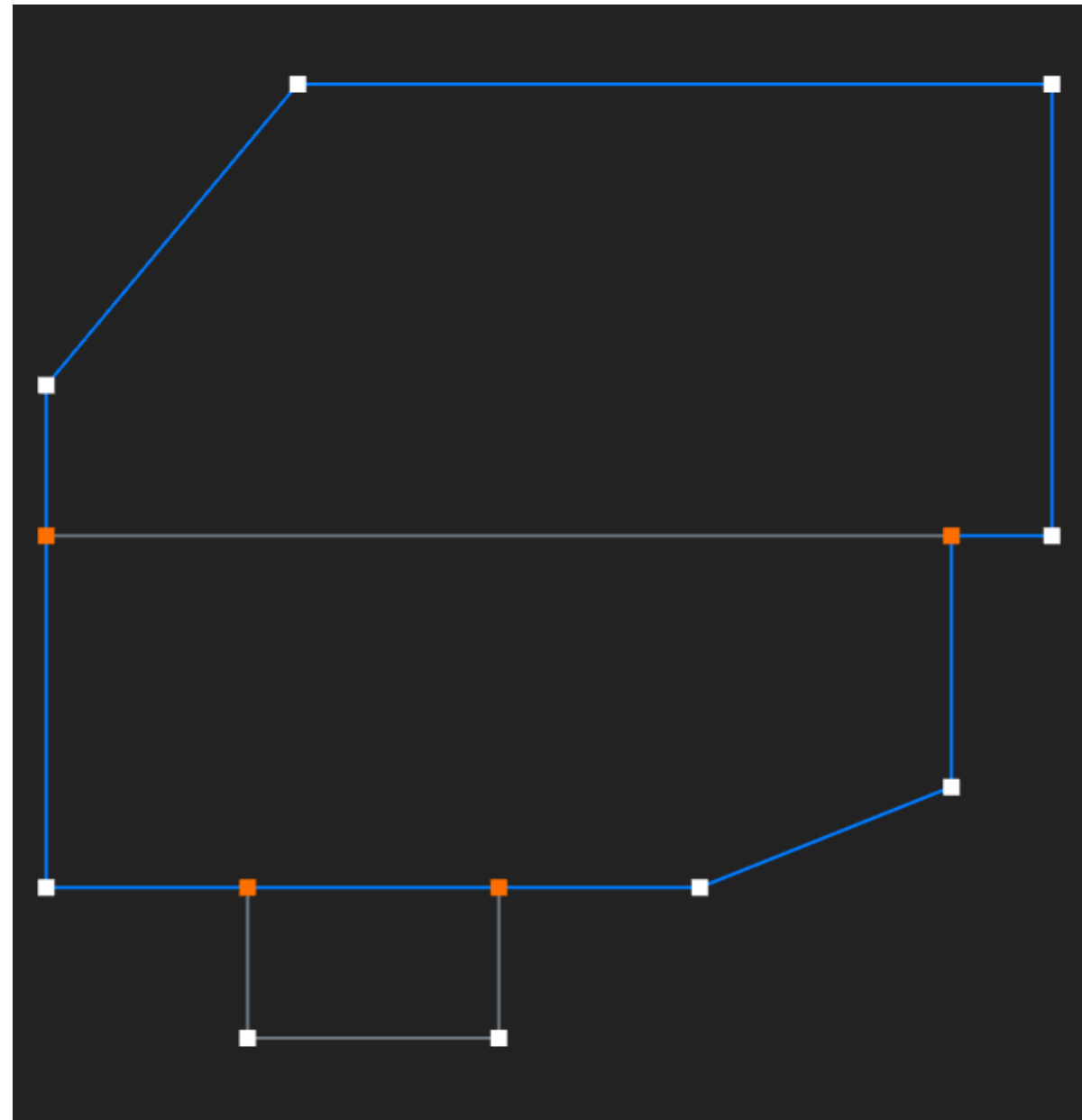
## Composite Arbitrary Beam Cross Section Examples






# Comment on Critical Points

A critical point is a point with 3 or more connecting lines.

1. For open profile (OP) cross sections, the outer perimeter should always cross the critical points.
2. For closed profile (CP) cross sections, it is recommended that the outer perimeter cross the critical points.

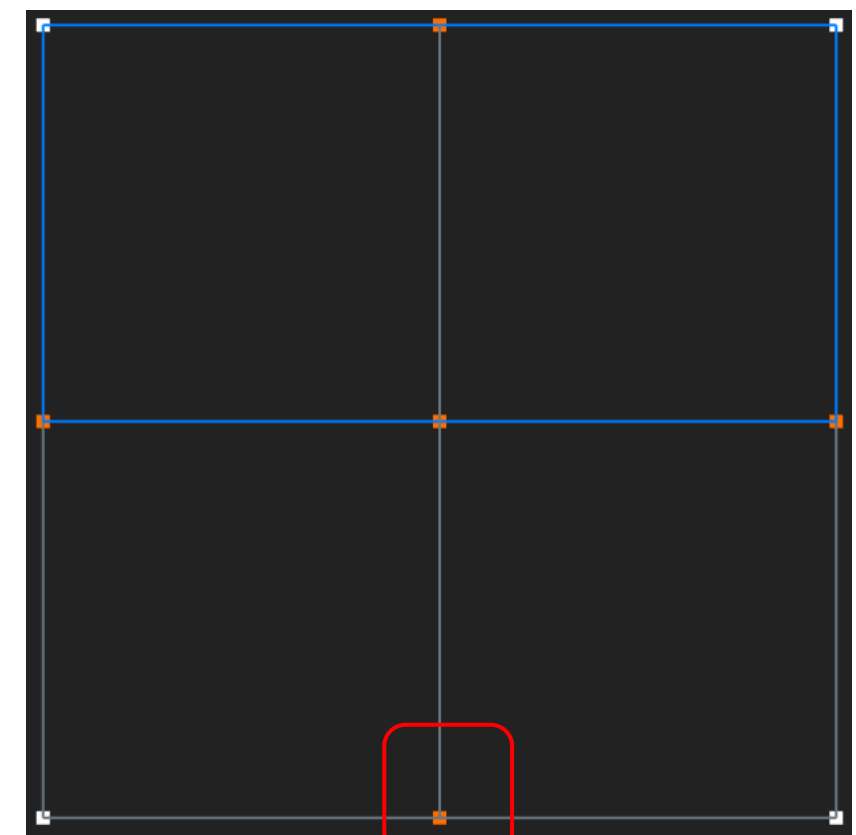
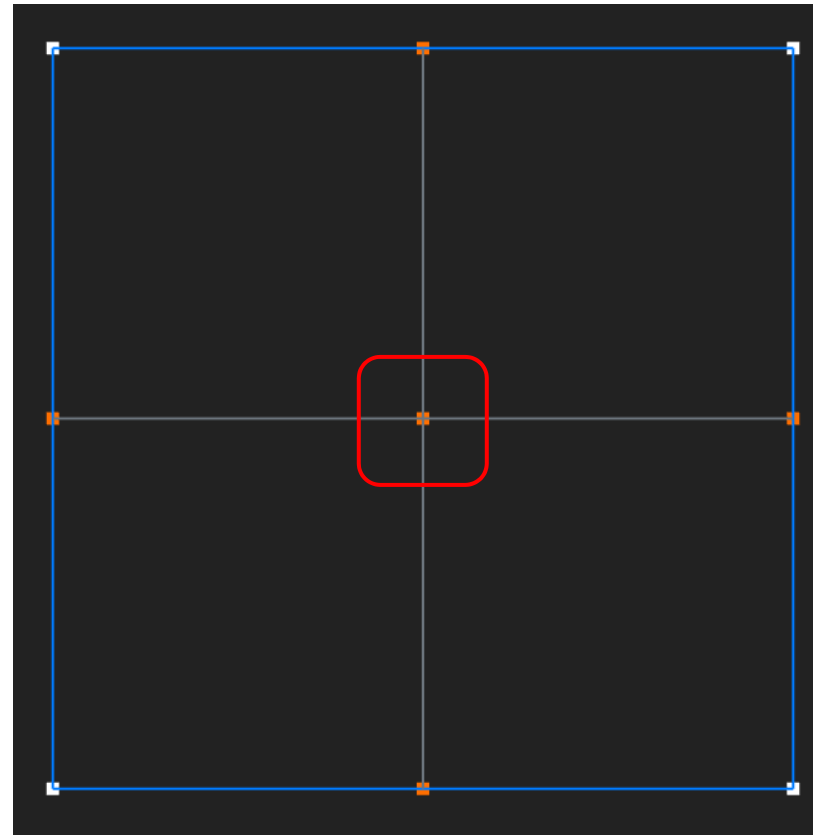





Legend

Color	Description
	Outer Perimeter (OUTP)
	Possible lines for OUTP
	Critical Points

# Comment on Critical Points

1. For closed profile cross sections, it is recommended that the outer perimeter cross the critical points.
  - This recommendation is NOT absolute. As shown in the examples to the right, certain cross sections provide flexibility where the outer perimeter does not need to cross all the critical points.



Legend	
Color	Description
	Outer Perimeter (OUTP)
	Possible lines for OUTP
	Critical Points

## Supported Bulk Data Entries and Keywords

- The PBMSECT Web App supports the keywords listed in the table

### Supported Bulk Data Entries

Entry	Import	Export
PBMSECT	YES	YES
PBRSECT	YES	YES
POINT	YES	YES
SET1	YES	YES
SET3	YES	NO

\*When uploading BDF files to the SOL 200 Web App, including the PBMSECT web app and Viewer, each entry listed in the table above must have a unique ID in all BDF files. The use of BEGIN MODULE allows for duplicate IDs for PBMSECT, POINT, SET1, etc. The following examples have duplicate IDs for POINT entries and are not supported by the SOL 200 Web App. All other DAT and BDF files are supported.

- /tpl/modules/mod\_vabcor2a.dat
- /tpl/modules/mod\_vabcore1.dat

### Supported Keywords

Keyword	Supported?
OUTP	YES
OUTM**	NO
INP	YES
BRP	YES
T	YES
CORE or C	YES
LAYER or L	YES
NSM	YES

\*\*OUTM and BEGIN BULK ARBMODEL are not supported.

### Supported Forms

- GS General Section
- OP Open Profile
- CP Closed Profile

# UFM 2012

1. The IDs for the POINT entries may be customized as shown and is done to avoid conflicts with existing GRID IDs

```
*** USER FATAL MESSAGE 2012 (GP1GSM)
      IDENTIFICATION 1 SAME BETWEEN GRID, SCALAR OR POINT OR
      AUTOMATICALLY GENERATED Q-SET SPOINT ID
*** USER FATAL MESSAGE 2012 (GP1GSM)
      IDENTIFICATION 2 SAME BETWEEN GRID, SCALAR OR POINT OR
      AUTOMATICALLY GENERATED Q-SET SPOINT ID
```

## Custom IDs

☒ Renumber Lines and Points

Entry	Custom ID	Status	IDs Used by this PBMSECT/PBRSECT	IDs Used by other entries
PBMSECT/ PBRSECT	<input type="text" value="78020"/>	<input checked="" type="checkbox"/>	78020	
SET1	<input type="text" value="2000"/>	<input checked="" type="checkbox"/>		
POINT	<input type="text" value="2001"/>	! Check separately to ensure POINT IDs do not conflict with GRID IDs		

1



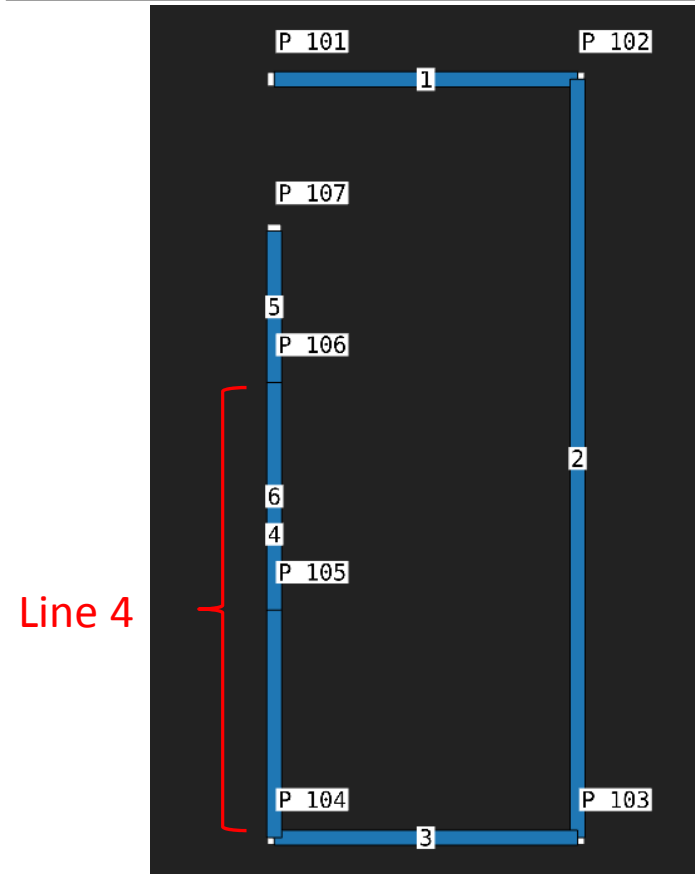
# UFM 7201 Cause 1

1. This UFM sometimes occurs if line segments overlap

```
*** USER FATAL MESSAGE 7201 (ARNFCK)
    PBRSECT/PBMSECT ENTRY ID=32, INTERSECTION OF SEGMENTS WITHIN A LOOP OR BETWEEN LOOPS FOUND.
    USER ACTION : IF FORM=CP OR OP, USE LESSER NUMBER OF POINTS TO DESCRIBE THE PROFILE. ESPECIALLY IN MERGING AREA OF TWO LINES.
                  IF FORM=GS, CHECK FOR OVERLAPPING POINTS AND/OR POINTS WITH SAME COORDINATES.

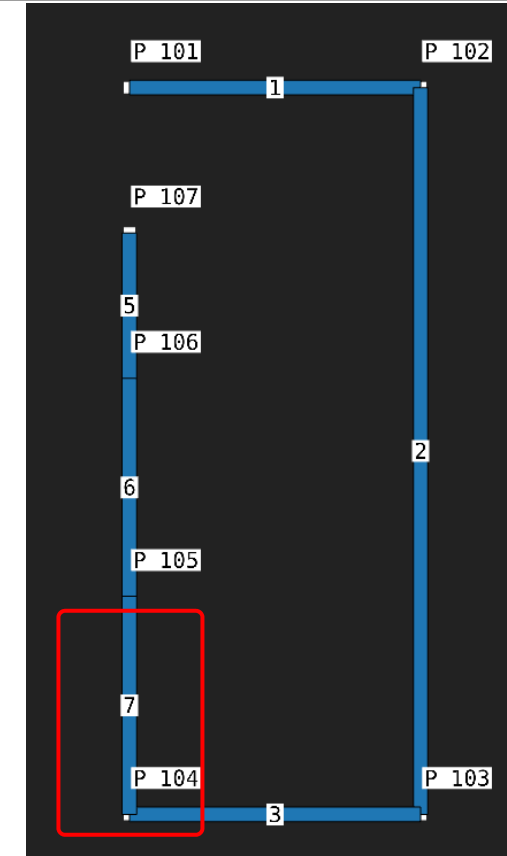
    INTERSECTION
    X-COOR      Y-COOR      PROXIMITY POINT ID
4.9407-324    0.0000E+00
    USER ACTION: MAKE SURE POINTS IN CLOSE PROXIMITY OF ABOVE COORDINATES ARE SEPARATED BY
                  A DISTANCE LARGER THAN THE THICKNESS OF THE SEGMENT.
    PLEASE NOTE THAT LIST OF PROXIMITY POINTS IS NOT EXHAUSTIVE. REVIEW OF ALL POINTS INVOLVED IS RECOMMENDED.
    POST-SCRIPT OUTPUT FILE MAY BE UTILIZED AS A TOOL TO LOCATE THE PROBLEM SPOT.

*** USER FATAL MESSAGE 6624 (IFP9)
    SEE INFORMATION MESSAGES ABOVE
```



Line 4

Not Correct: Line 4 overlaps line 6



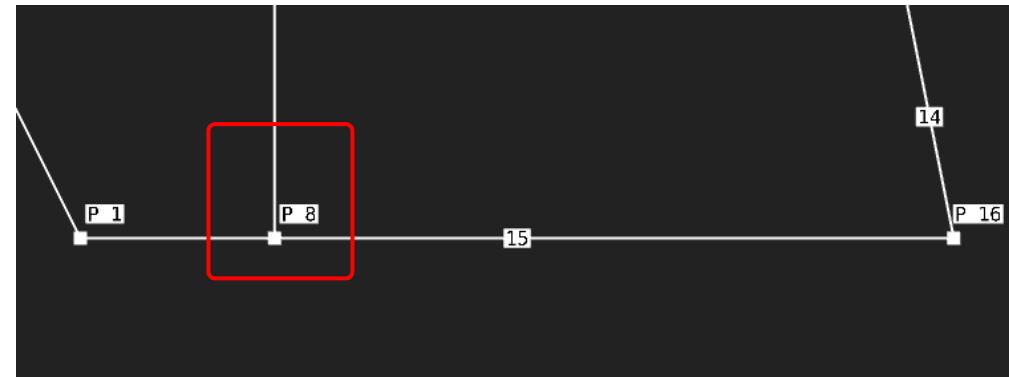
Correct: Line 4 is removed and line 7 is created.

# UFM 7201 Cause 1, Another Example

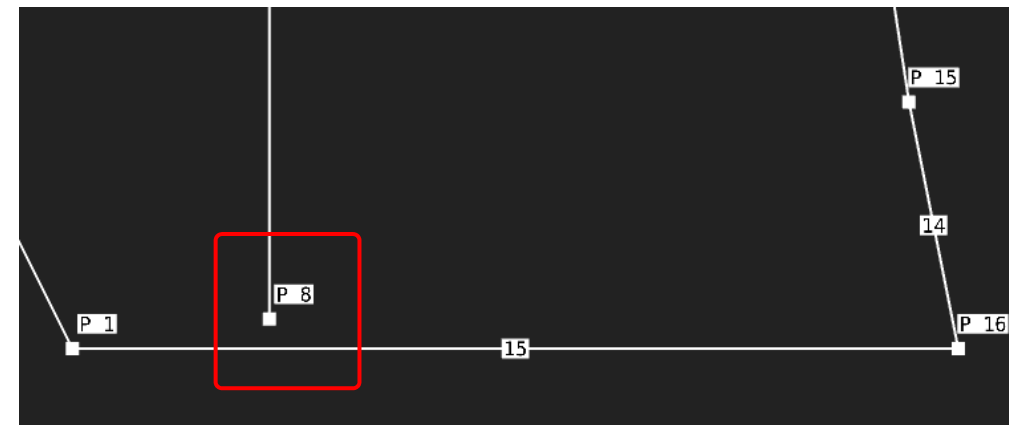
1. If a free end of a line is very close to another line, the overlapping sections will trigger this error

```
*** USER FATAL MESSAGE 7201 (ARNFCK)
PBRSECT/PBMSECT ENTRY ID=32, INTERSECTION OF SEGMENTS WITHIN A LOOP OR BETWEEN LOOPS FOUND.
USER ACTION : IF FORM=CP OR OP, USE LESSER NUMBER OF POINTS TO DESCRIBE THE PROFILE. ESPECIALLY IN MERGING AREA OF TWO LINES.
                IF FORM=GS, CHECK FOR OVERLAPPING POINTS AND/OR POINTS WITH SAME COORDINATES.
INTERSECTION
X-COOR      Y-COOR      PROXIMITY POINT ID
4.9407-324  0.0000E+00
USER ACTION: MAKE SURE POINTS IN CLOSE PROXIMITY OF ABOVE COORDINATES ARE SEPARATED BY
A DISTANCE LARGER THAN THE THICKNESS OF THE SEGMENT.
PLEASE NOTE THAT LIST OF PROXIMITY POINTS IS NOT EXHAUSTIVE. REVIEW OF ALL POINTS INVOLVED IS RECOMMENDED.
POST-SCRIPT OUTPUT FILE MAY BE UTILIZED AS A TOOL TO LOCATE THE PROBLEM SPOT.
*** USER FATAL MESSAGE 6624 (IFP9)
SEE INFORMATION MESSAGES ABOVE
```

Not Correct: Point 8 is too close to line 15



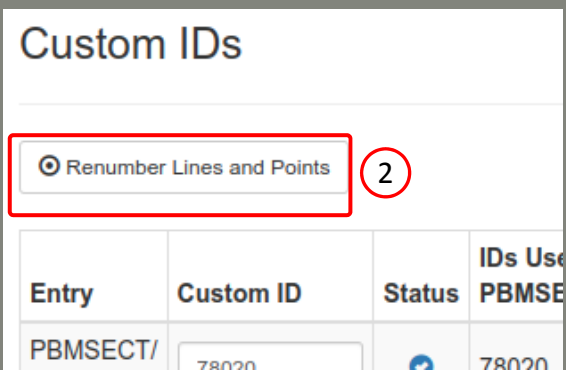
Correct: Point 8 is moved to avoid being too close to line 15



# UFM 7201 Cause 2

This UFM sometimes occurs if the POINT IDs are not numbered sequentially.

1. Click Renumber Lines and Points to automatically renumber the POINT IDs

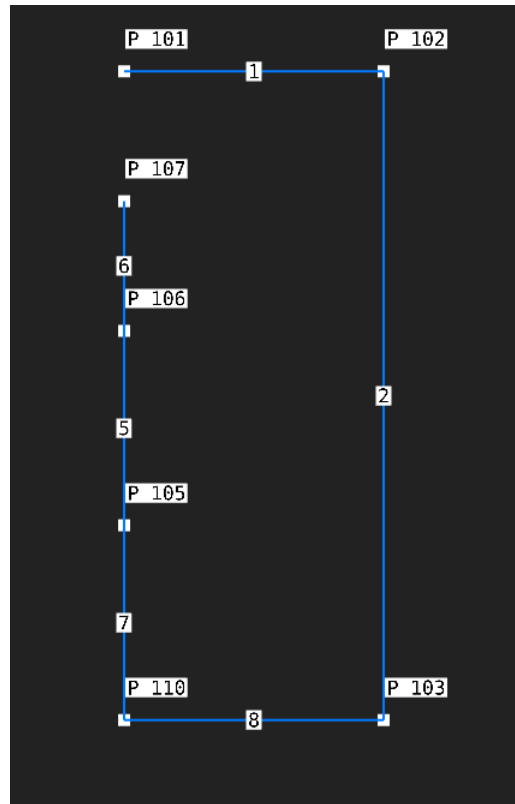


```

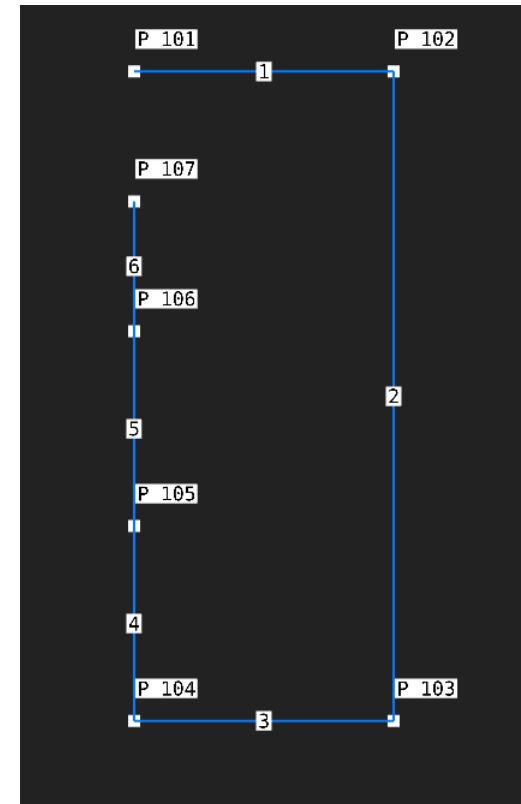
*** USER FATAL MESSAGE 7201 (ARNFCK)
PBRSECT/PBMSECT ENTRY ID=32, INTERSECTION OF SEGMENTS WITHIN A LOOP OR BETWEEN LOOPS FOUND.
USER ACTION : IF FORM=CP OR OP, USE LESSER NUMBER OF POINTS TO DESCRIBE THE PROFILE. ESPECIALLY IN MERGING AREA OF TWO LINES.
                IF FORM=GS, CHECK FOR OVERLAPPING POINTS AND/OR POINTS WITH SAME COORDINATES.

INTERSECTION
X-COOR      Y-COOR      PROXIMITY POINT ID
5.0000E+00  5.0395-322
USER ACTION: MAKE SURE POINTS IN CLOSE PROXIMITY OF ABOVE COORDINATES ARE SEPARATED BY
A DISTANCE LARGER THAN THE THICKNESS OF THE SEGMENT.
PLEASE NOTE THAT LIST OF PROXIMITY POINTS IS NOT EXHAUSTIVE. REVIEW OF ALL POINTS INVOLVED IS RECOMMENDED.
POST-SCRIPT OUTPUT FILE MAY BE UTILIZED AS A TOOL TO LOCATE THE PROBLEM SPOT.

*** USER FATAL MESSAGE 6624 (IFP9)
SEE INFORMATION MESSAGES ABOVE
    
```



Not Correct: The POINT IDs are not numbered in sequential order.

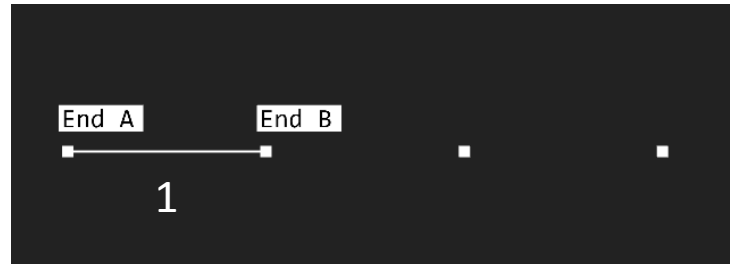


Correct: The POINT IDs are now numbered in sequential order.

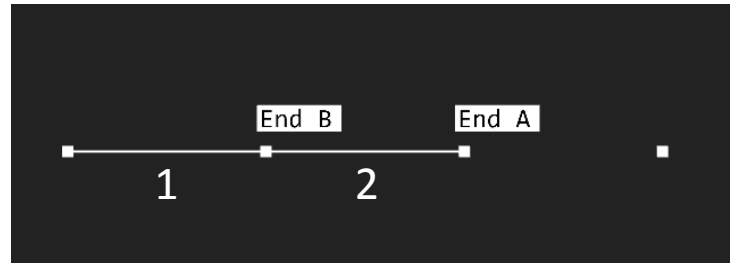
# UFM 7201

If this error persists, recreate the lines and ensure the next line created starts the end of the last line created.

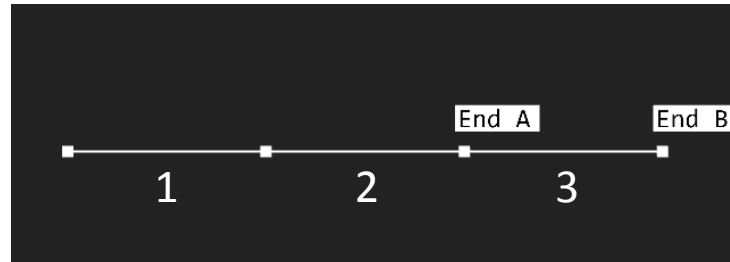
Step 1



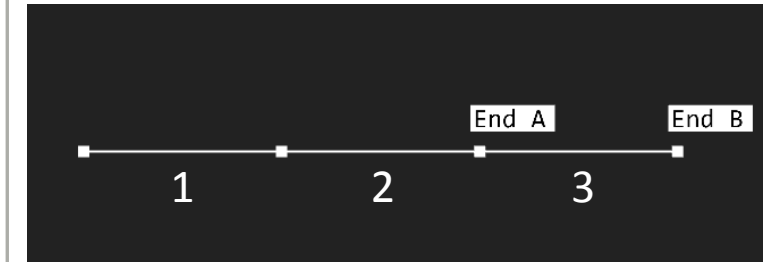
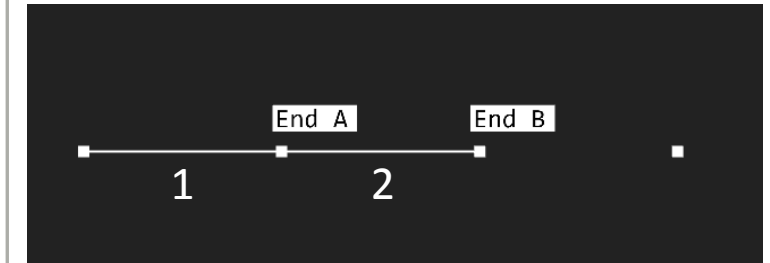
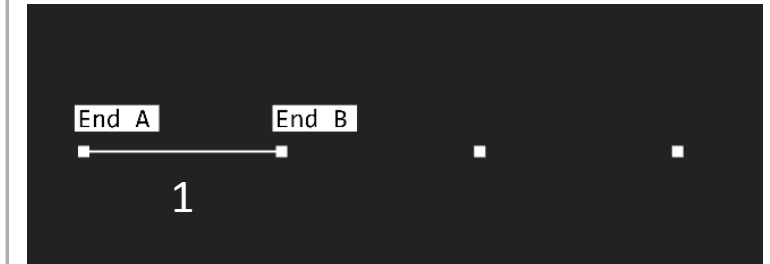
Step 2



Step 3



Not Ideal: End B of line 1 is connected to End B of line 2



Ideal: End B of line 1 is connected to End A of line 2

# What if the arbitrary cross section is not visible in the Viewer?

---

# Viewer

1. Click Model Display Panel
2. Mark the indicated checkboxes
3. If the arbitrary cross section (ABCS) is not displayed, then an error has occurred

The Viewer needs information about the ABCS in order to display the cross section. This ABCS information is obtained from the PostScript and BDF files.

When the BDF files are uploaded to the Viewer, in the background MSC Nastran is executed to generate the PS and BDF files.

If the MSC Nastran run is unsuccessful, the PS and BDF files will be unavailable, and the ABCS will not be displayed.

The following slides discuss how to manually upload the PS and BDF files to the Viewer so the ABCS is displayed.

**Main Panel**

File Upload

File Upload

Camera

First Person

Misc.

Center Model

Fit Model

Background Color

View

Front

Rear

Top

Bottom

Left

Right

Iso 1

Iso 2

Iso 3

Iso 1B

Rotate

Rotate

Tools

Model Display Panel

FEM Label

**Model Display Panel**

Reset Table

Property Name	Property ID	Color	Display Elements	Display Wireframe	Color of Detail	Display Detail	Display Detail Wireframe
Search	Search	Search			Search		
			<input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/>		<input type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/>
PBEAML*	99						
PBMSECT	1		<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

\* There are no elements using the indicated property

100 200 500 1000

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# Verify the Status

1. Click File Upload
2. Click Upload PS
3. If an error occurred during the MSC Nastran run, this is indicated in the status column of the first row of the table.

Main Panel

File Upload

File Upload

Camera

First Person

Misc.

Center Model

Fit Model

Background Color

View

Front

Rear

Top

Bottom

Left

Right

Iso 1

Iso 2

Iso 3

Iso 1B

Rotate

Rotate

Tools

Model Display Panel

FEM Label

File Upload

BDF H5 PCH PS

Method	Status	Display	Comments
Auto ABCS Display		<input type="checkbox"/>	After the BDF files are uploaded and in the background, MSC Nastran will automatically be executed and the necessary PS and BDF files will be acquired. The cross section will then be displayed. This requires MSC Nastran to be installed and configured on the same machine as the SOL 200 Web App, i.e. the machine that is running <code>node app.min.js</code> .
Manual ABCS Display		<input checked="" type="checkbox"/>	MSC Nastran must be manually executed separately to produce the PS and BDF files. Then, the PS and BDF files are manually uploaded to this section. Remember to click Parse to display the cross sections.

Manual ABCS Display

A) Upload PS File

1. Select files

2. Upload files

Uploading

C) Parse Files

5. Parse

B) Upload BDF Files

3. Select files

4. Upload files

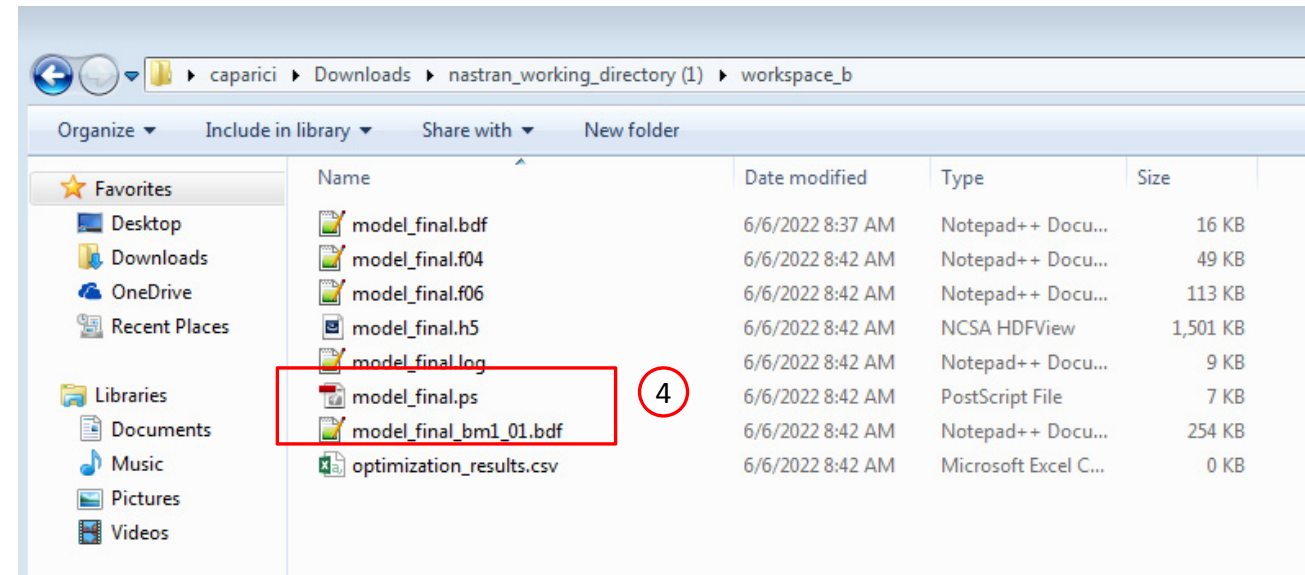
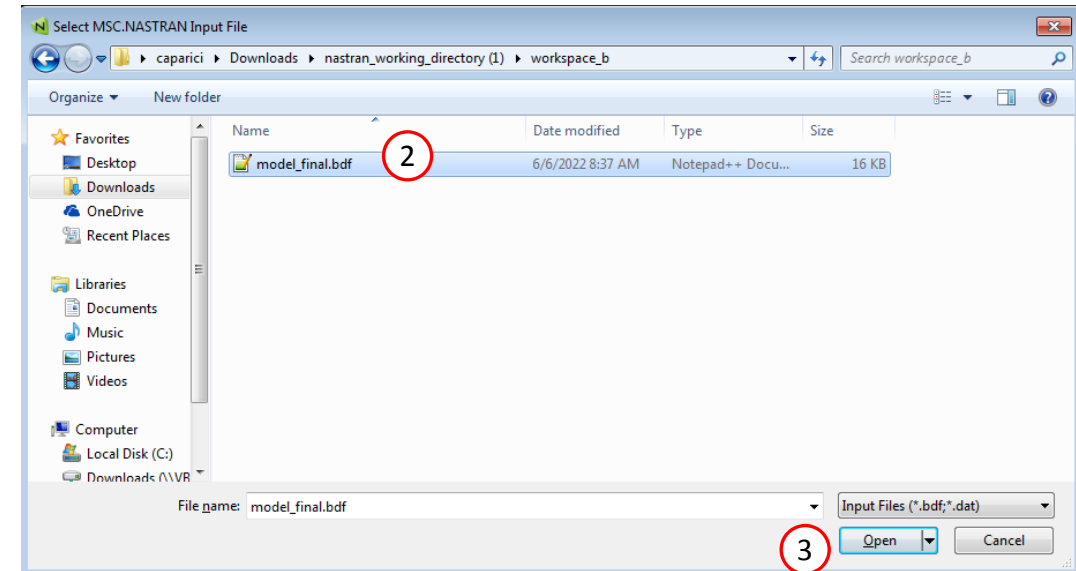
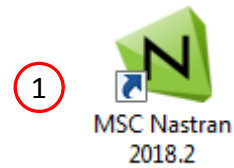
Uploading

Summary of detected PBMSECT and PBRSECT entries

Entry Name	ID	File Name PS	File Name BDF
------------	----	--------------	---------------

# Manually Generating the PS and BDF Files

1. Double click the MSC Nastran desktop shortcut
2. Select this file  
nastran\_working\_directory  
(1)/workspace\_b/model\_final.bdf
3. Click Open
4. The PS and BDF files have been  
generated by MSC Nastran



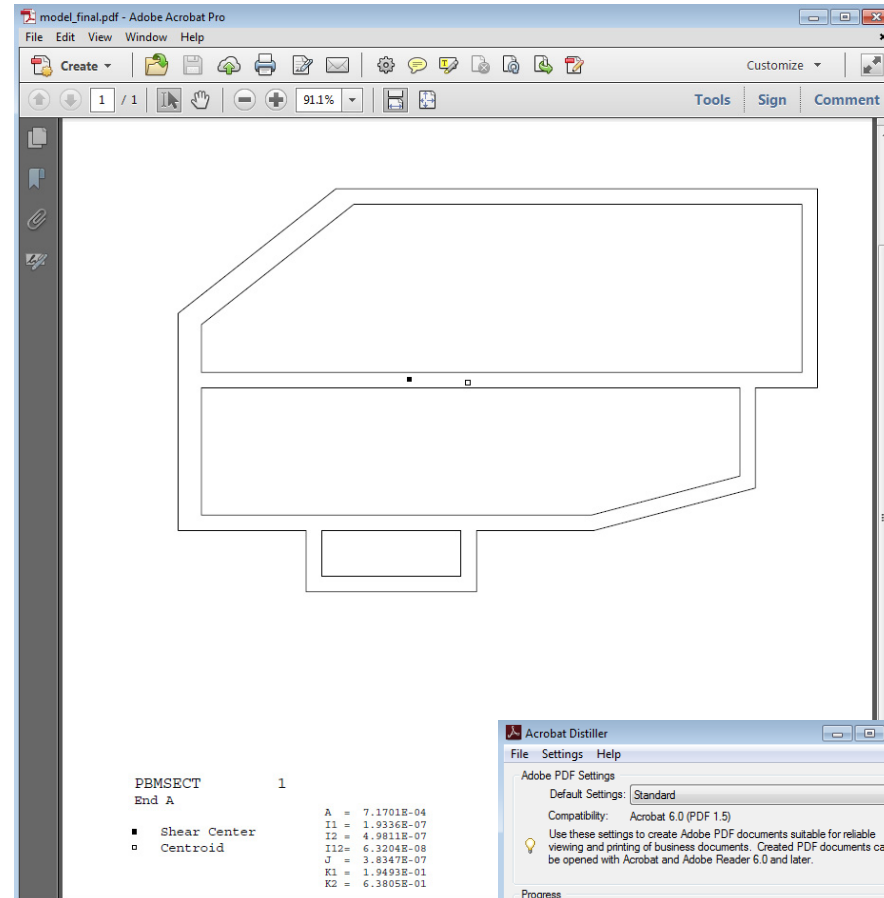


# Viewing the PS and BDF Files

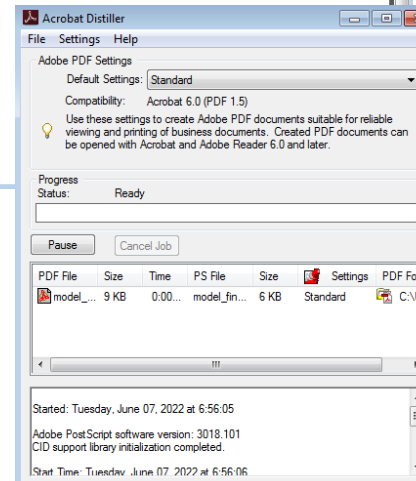
These steps are optional

1. An application is used to convert the PostScript (PS) file into a PDF file
2. A pre-processor, in this case Patran, is used to view the file model\_final\_bm1\_01.bdf

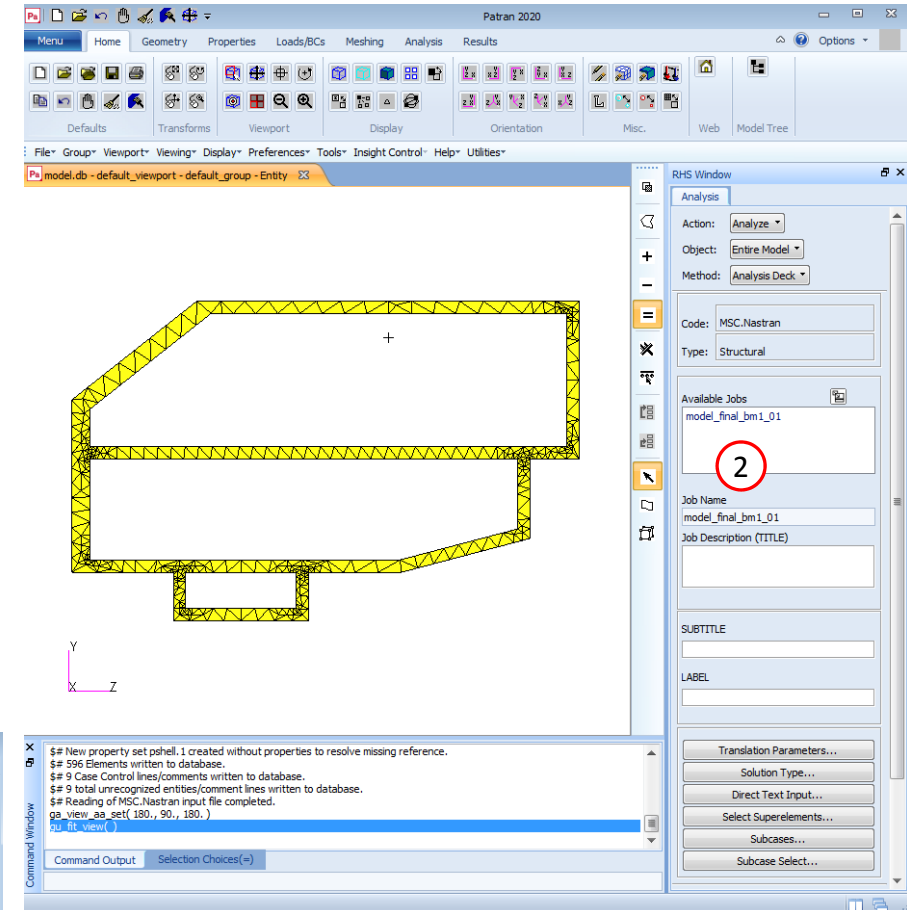
model\_final.ps



1



model\_final\_bm1\_01.bdf



# Upload the PS and BDF Files to the Viewer

1. Return to the Viewer
2. Click Select files
3. Select model\_final.ps
4. Click Open
5. Click Upload files
6. Click Select files
7. Select model\_final\_bm1\_01.bdf
8. Click Open
9. Click Upload files
10. Click Parse
11. The information in the PS and BDF files are used to construct the ABCS. If successful, the table should display green checkboxes.

The screenshot illustrates the file upload process in two main sections: A) Upload PS File and B) Upload BDF Files. Each section shows a file selection window, an upload button, and a progress bar.

**A) Upload PS File**

- 1. Select files (2)
- 2. Upload files (5)
- Uploading: 100 %

**B) Upload BDF Files**

- 3. Select files (6)
- 4. Upload files (9)
- Uploading: 100 %

**C) Parse Files**

- 5. Parse (10)
- Complete

**Summary of detected PBMSECT and PBRSECT entries**

Entry Name	ID	File Name PS	File Name BDF
PBMSECT		✓ model_final.ps	✓ model_final_bm1_01.bdf

# Inspect the ABCSs

1. Click Model Display Panel
  - In the future, click this button again to close the Model Display Panel
2. Mark the indicate checkbox to display the beam cross section
3. The ABCS is now displayed for the elements

The screenshot displays the SOL 200 Web App interface. On the left is the 'Main Panel' with sections for File Upload, Camera, Misc., View, and Tools. The 'Model Display Panel' is open on the right, featuring a table with properties and a 3D model of a beam structure in the background.

**Main Panel**

- File Upload**: File Upload button
- Camera**: First Person button
- Misc.**: Center Model, Fit Model, Background Color buttons
- View**: Front, Rear, Top, Bottom, Left, Right, Rotate buttons
- Tools**: Model Display Panel (circled 1), FEM Label button

**Model Display Panel**

Reset Table

Property Name	Property ID	Color	Display Elements	Display Wireframe	Color of Detail	Display Detail	Display Detail Wireframe
Search	Search	Search			Search		
PBEAML*	99						
PBMSECT	1		<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

\* There are no elements using the indicated property

100 200 500 1000

3

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