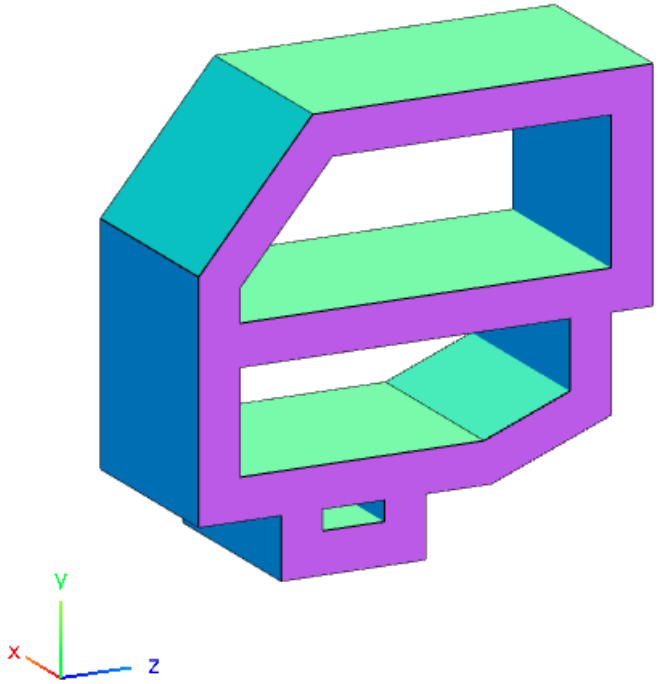
# Workshop - Arbitrary Beam Cross Section Optimization

A PBMSECT/PBRSECT AND SOL 200 WEB APP TUTORIAL

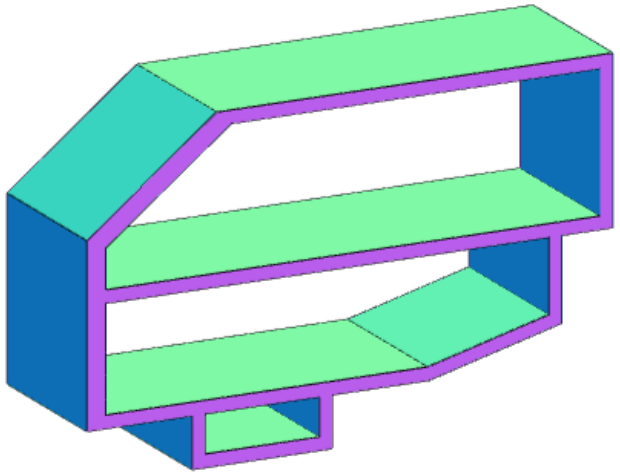
Questions? Email: christian@ the-engineering-lab.com

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

Before



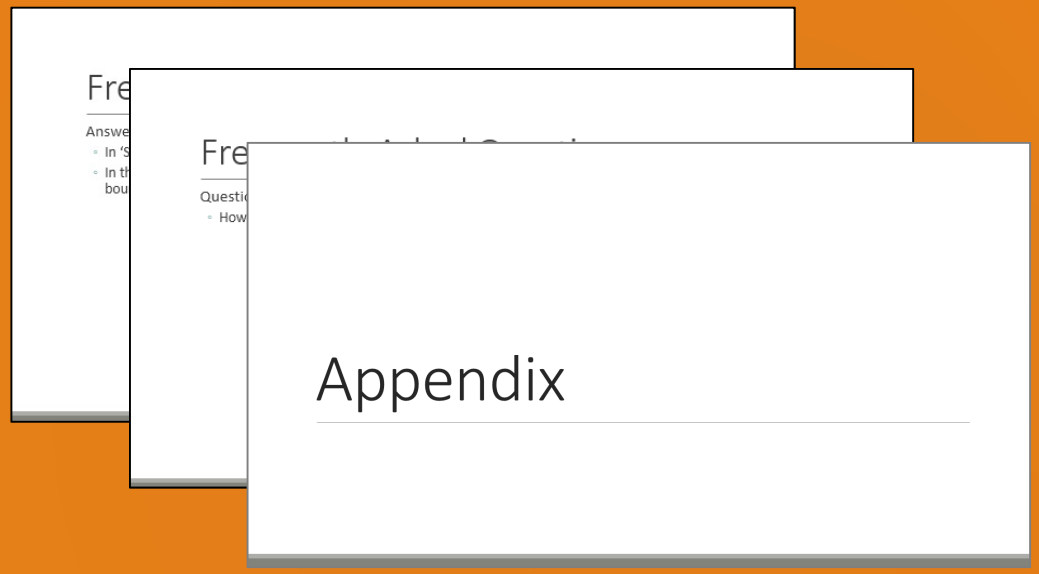

After



# 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

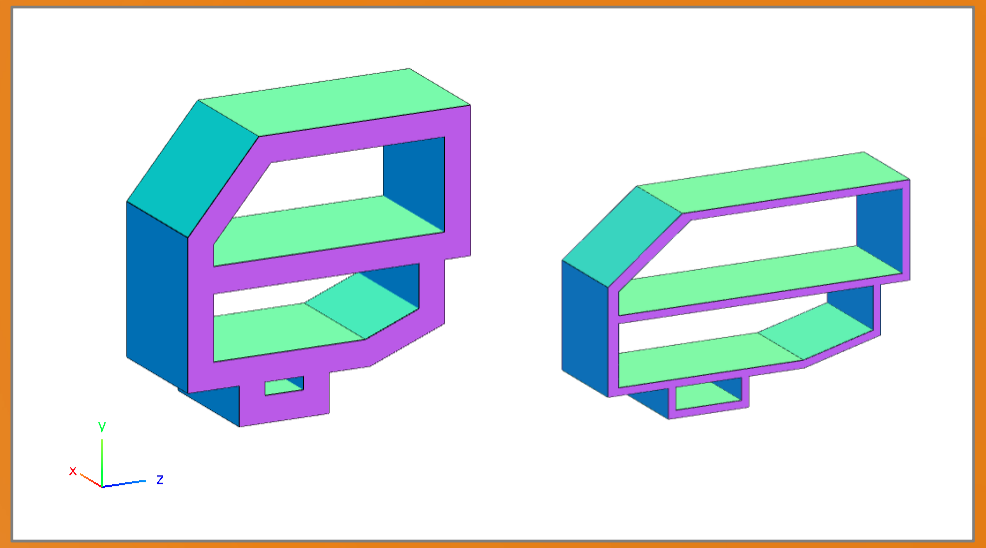
# Tutorial

# 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.

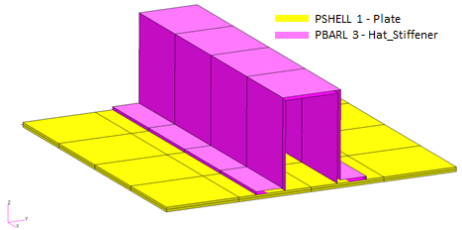
## Compatibility

- 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.

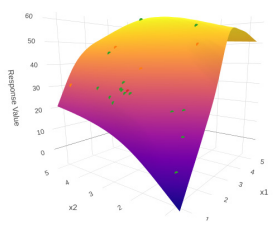
## Benefits

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

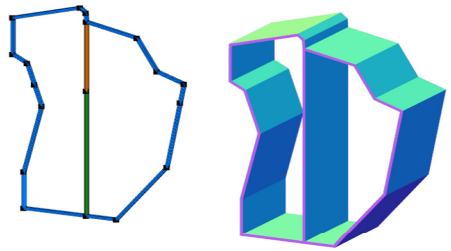
## Web Apps



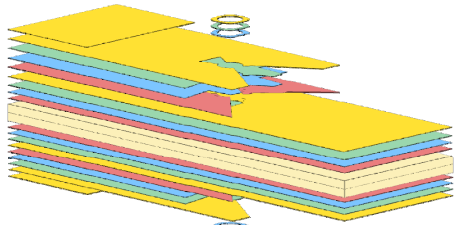

**Web Apps for MSC Nastran SOL 200**
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



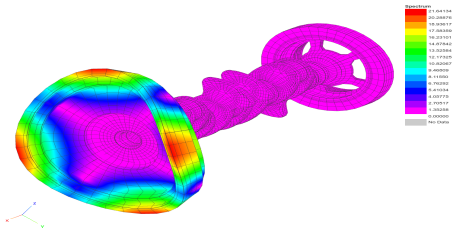
**Machine Learning Web App**
Bayesian Optimization for nonlinear response optimization (SOL 400)



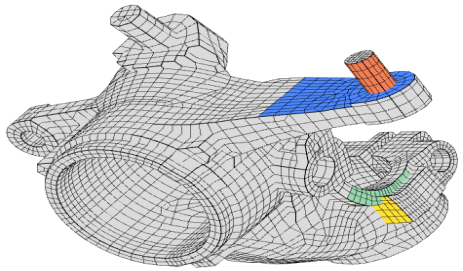
**PBMSECT Web App**
Generate PBMSECT and PBRSECT entries graphically



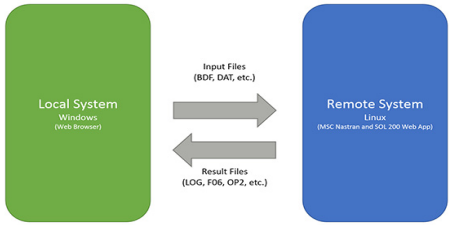
**Ply Shape Optimization Web App**
Optimize composite ply drop-off locations, and generate new PCOMPG entries



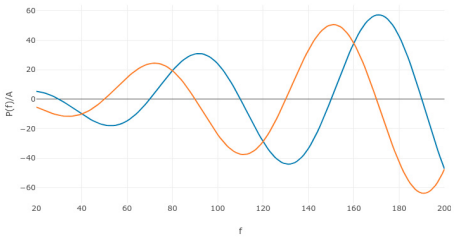
**Post-processor Web App**
View MSC Nastran results in a web browser on Windows and Linux



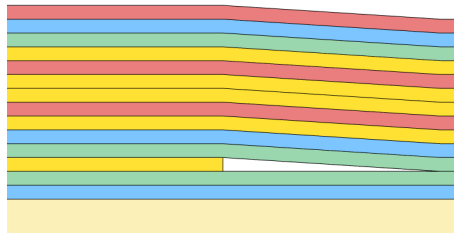
**Shape Optimization Web App**
Use a web application to configure and perform shape optimization.



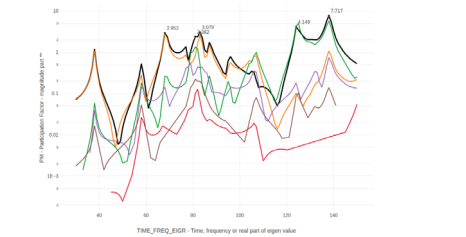

**Remote Execution Web App**
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



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



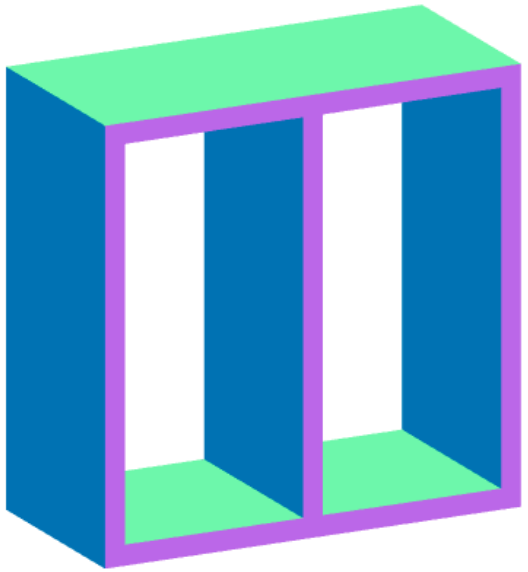
**HDF5 Explorer Web App**
Create graphs (XY plots) using data from the H5 file

# 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

# Locating the Web Apps

Throughout this tutorial the following web apps will be used

- Size web app
- Viewer
- PBMSECT web app

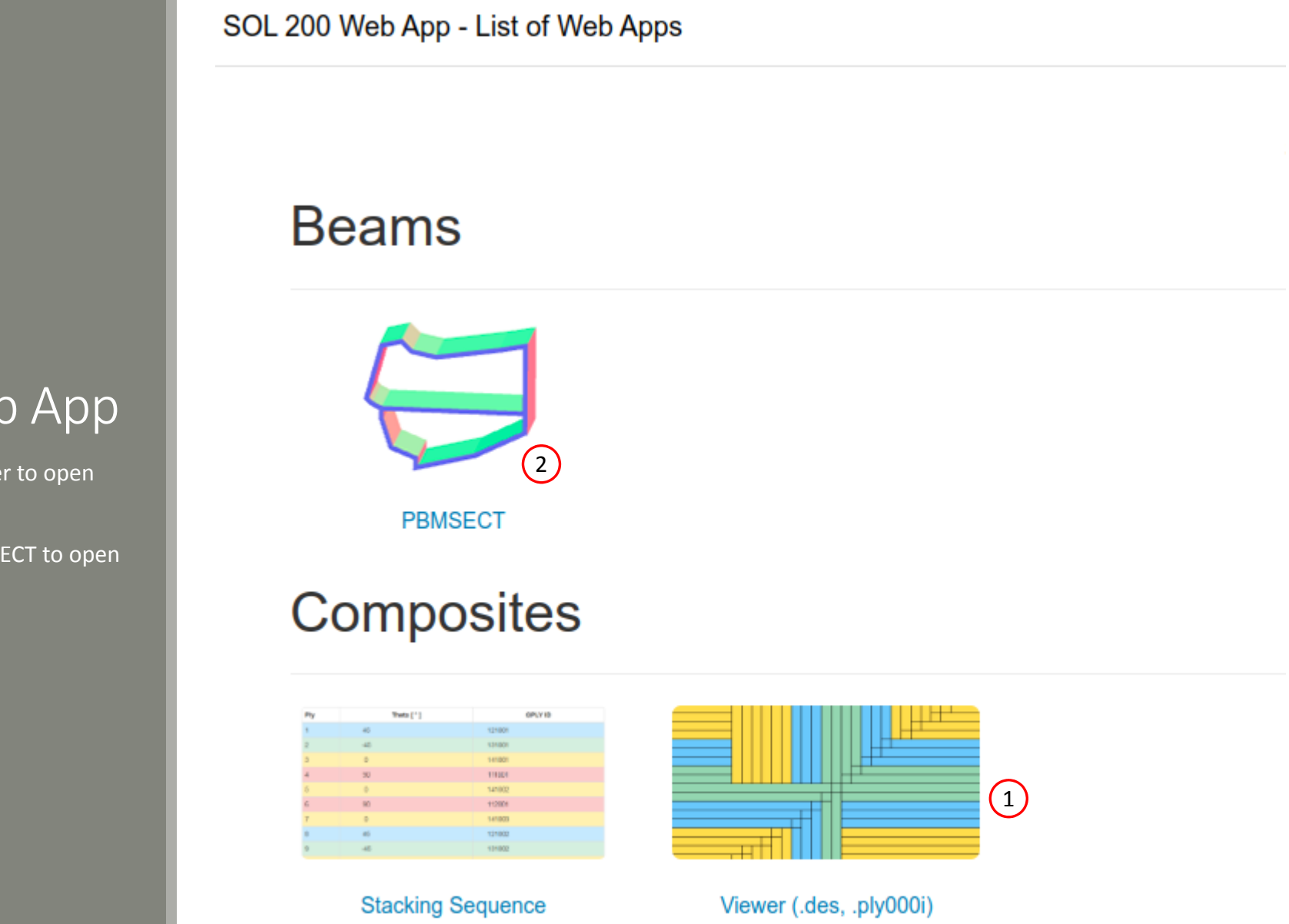
The following slides detail where to locate these web apps

# Viewer and PBMSECT Web App

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

# Viewer and PBMSECT Web App

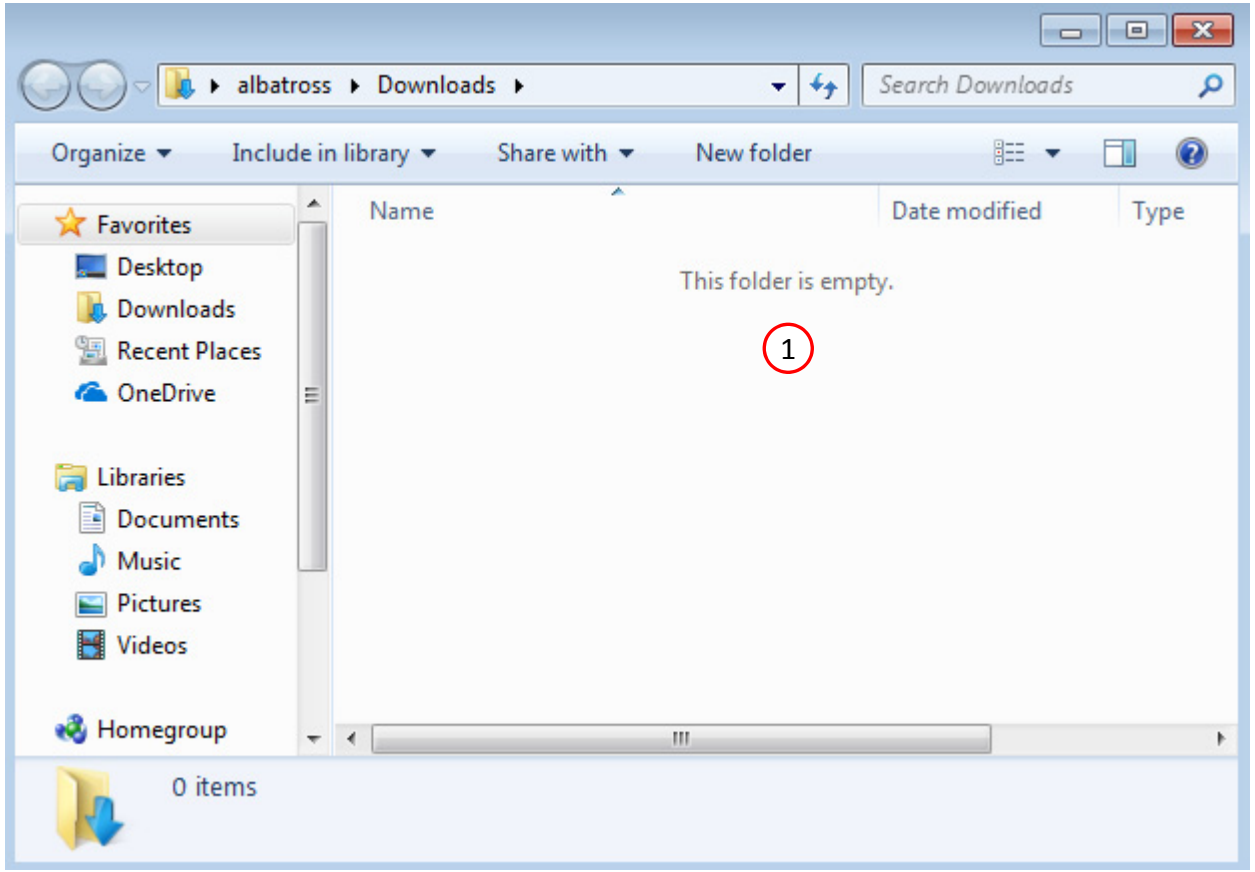
1. Click the icon titled Viewer to open the Viewer
2. Click the icon titled PBMSECT to open the PBMSECT web app



# 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

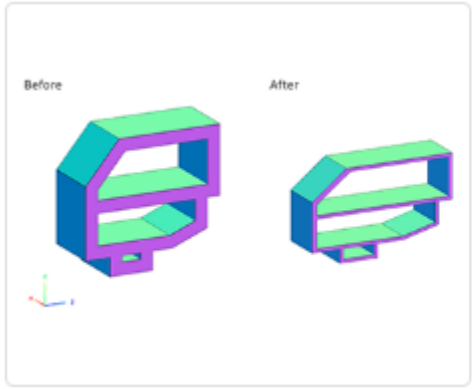
1. Click on the indicated link

- 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.

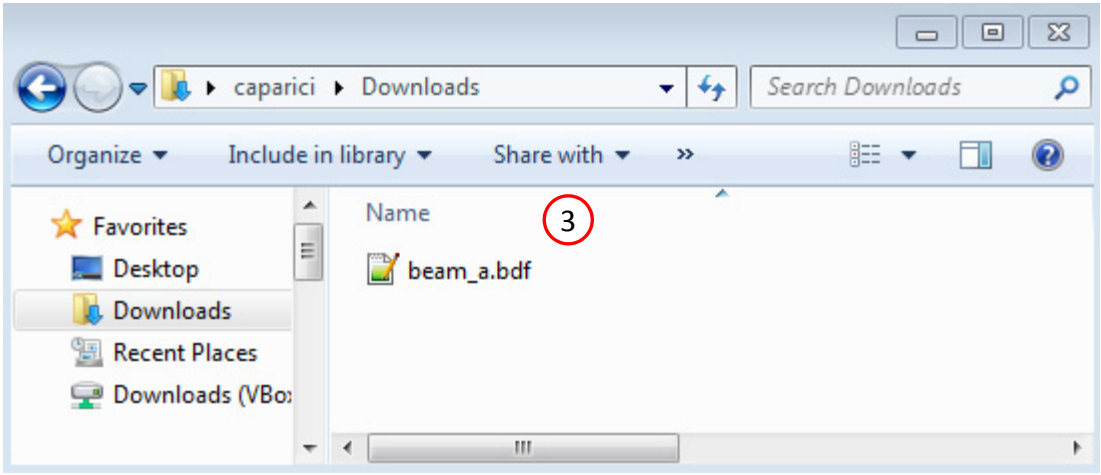



1

**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



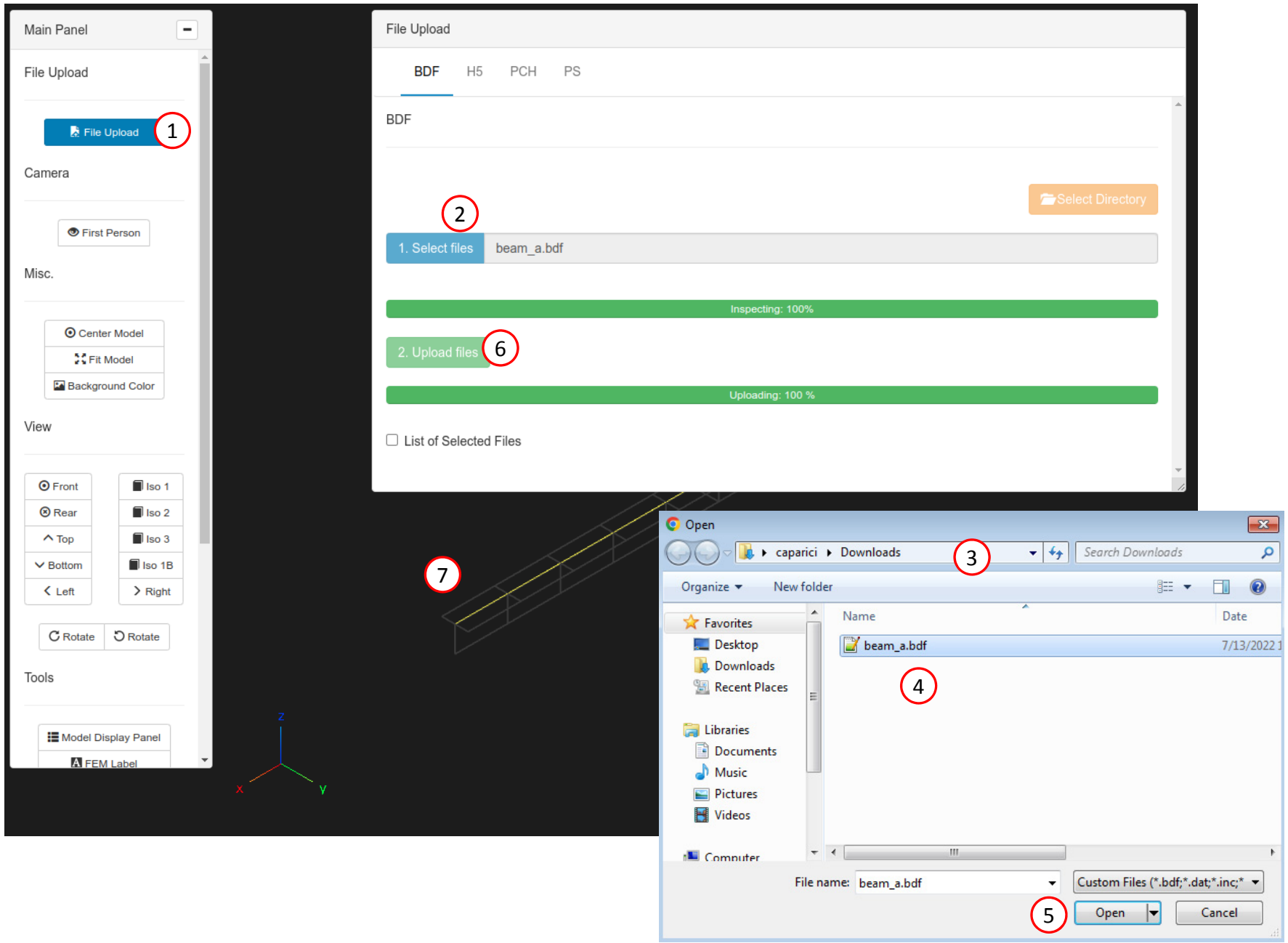
# Part B – Creating an Arbitrary Beam Cross Section (ABCS) with the PBMSECT Web App

# Viewer

Open the Viewer

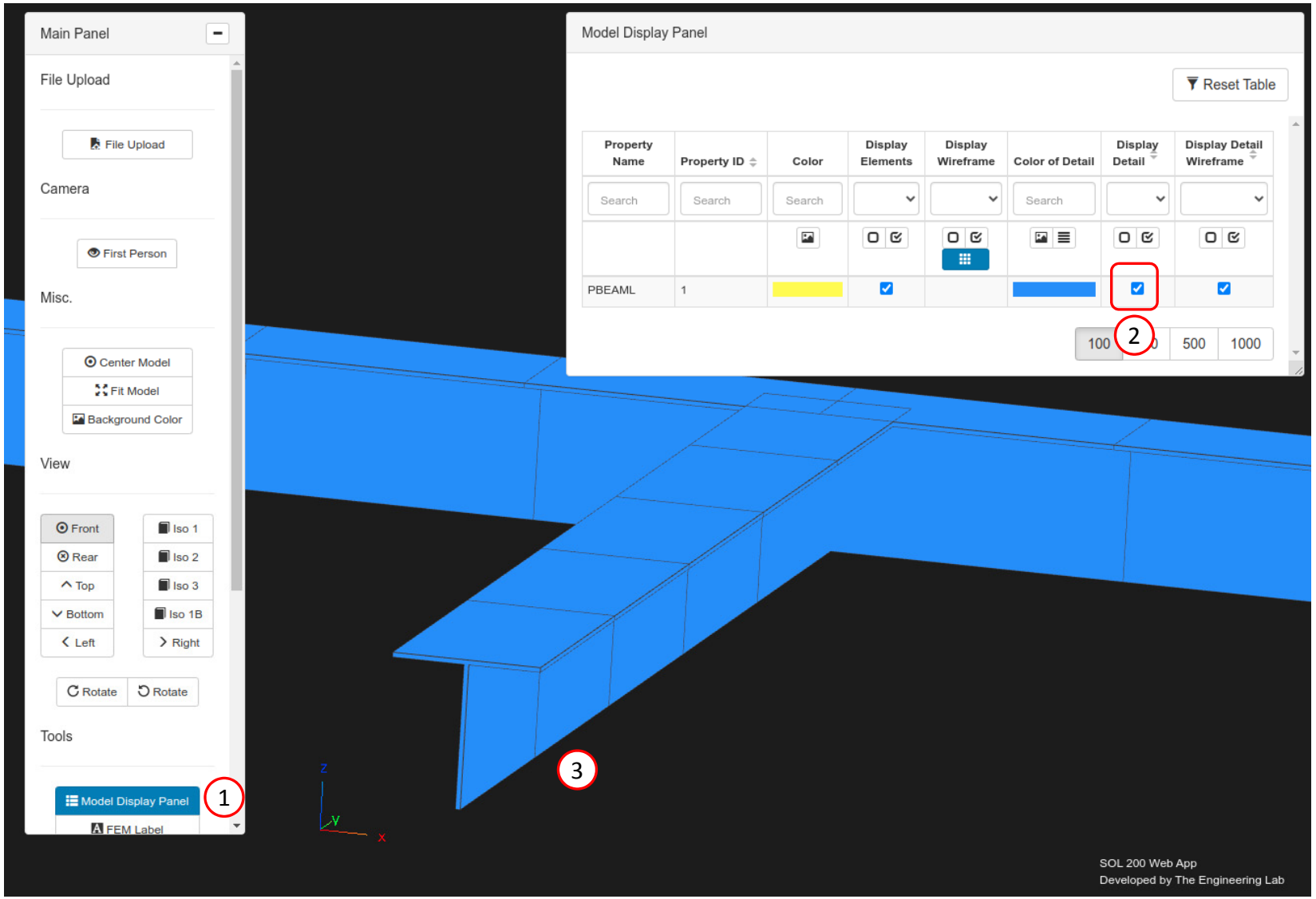
1. Click File Upload
2. Click Select files
3. Navigate to the directory Downloads
4. Select beam_a.bdf
5. Click Open
6. Click Upload files
7. The MSC Nastran model has been uploaded to the Viewer

- 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



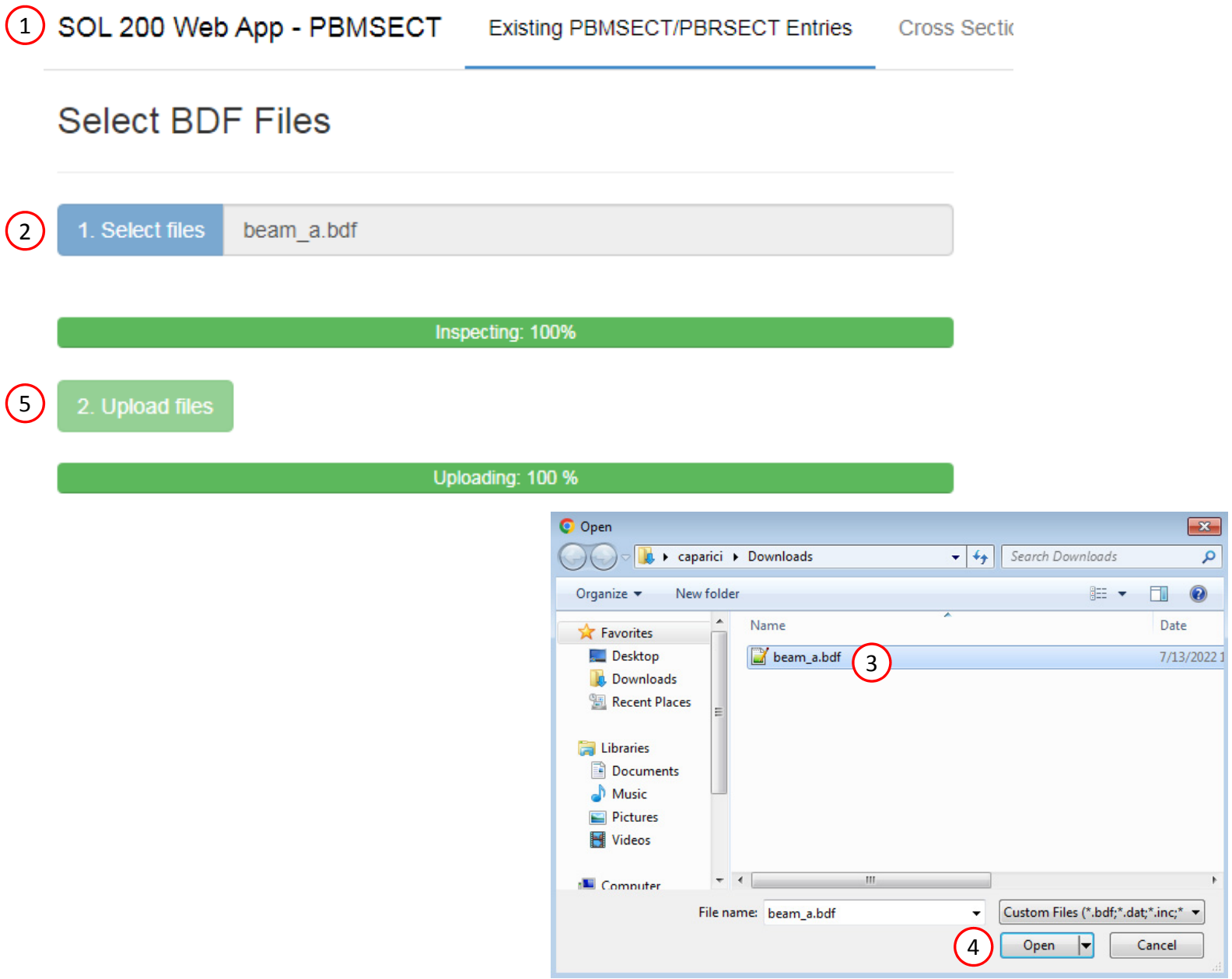

5

# 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

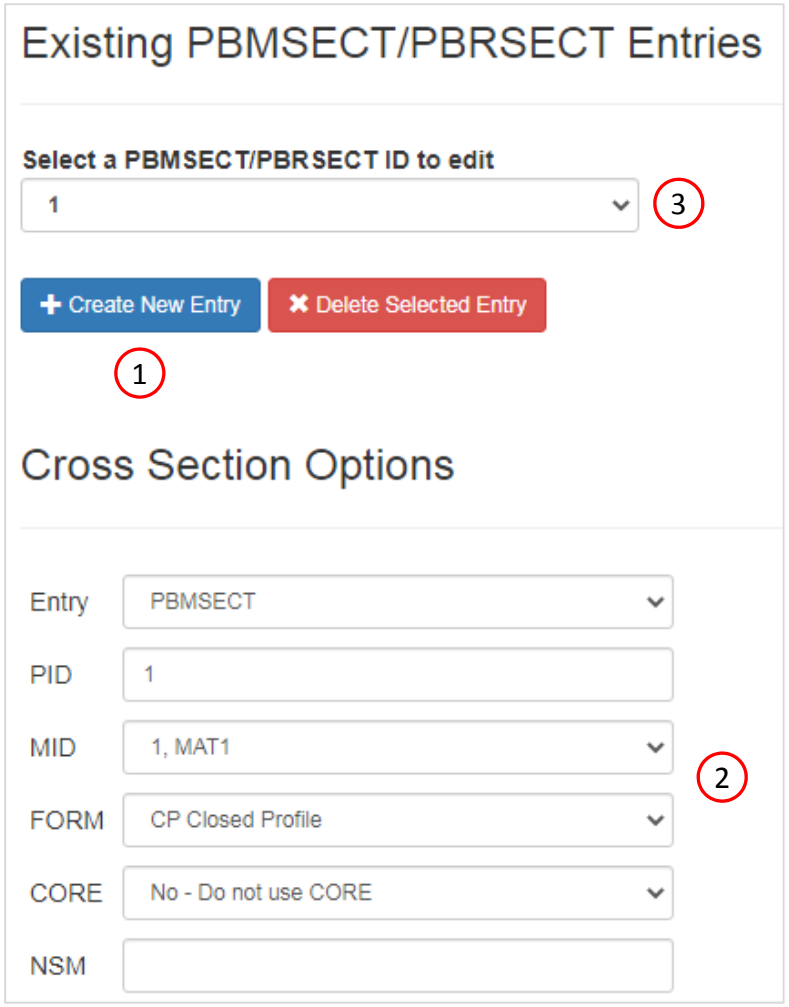
1. Open the PBMSECT web app
2. Click Select files
3. Select beam_a.bdf
4. Click Open
5. Click Upload files

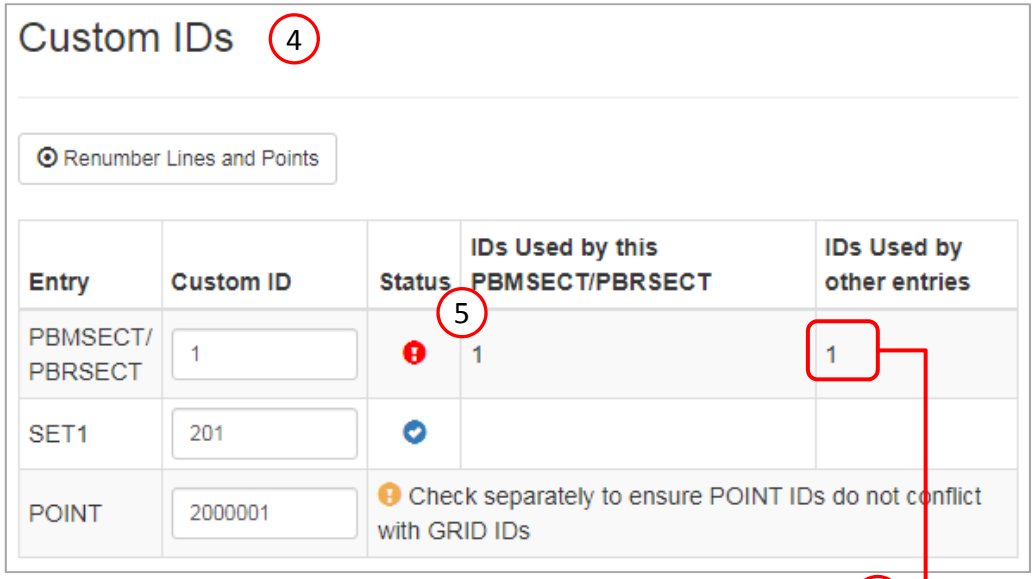
- The selected BDF file was created by a separate pre processor. The PBMSECT Web App only generates the following entries: PBMSECT, PBRSECT, POINT and SET1.

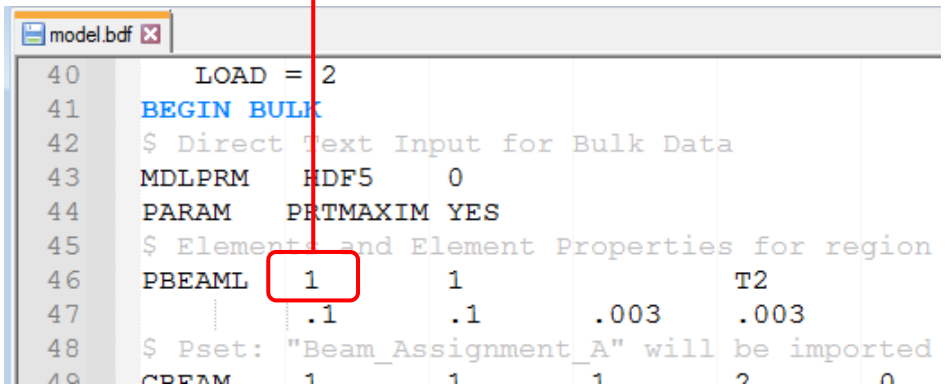


# Create a New PBMSECT Entry

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.

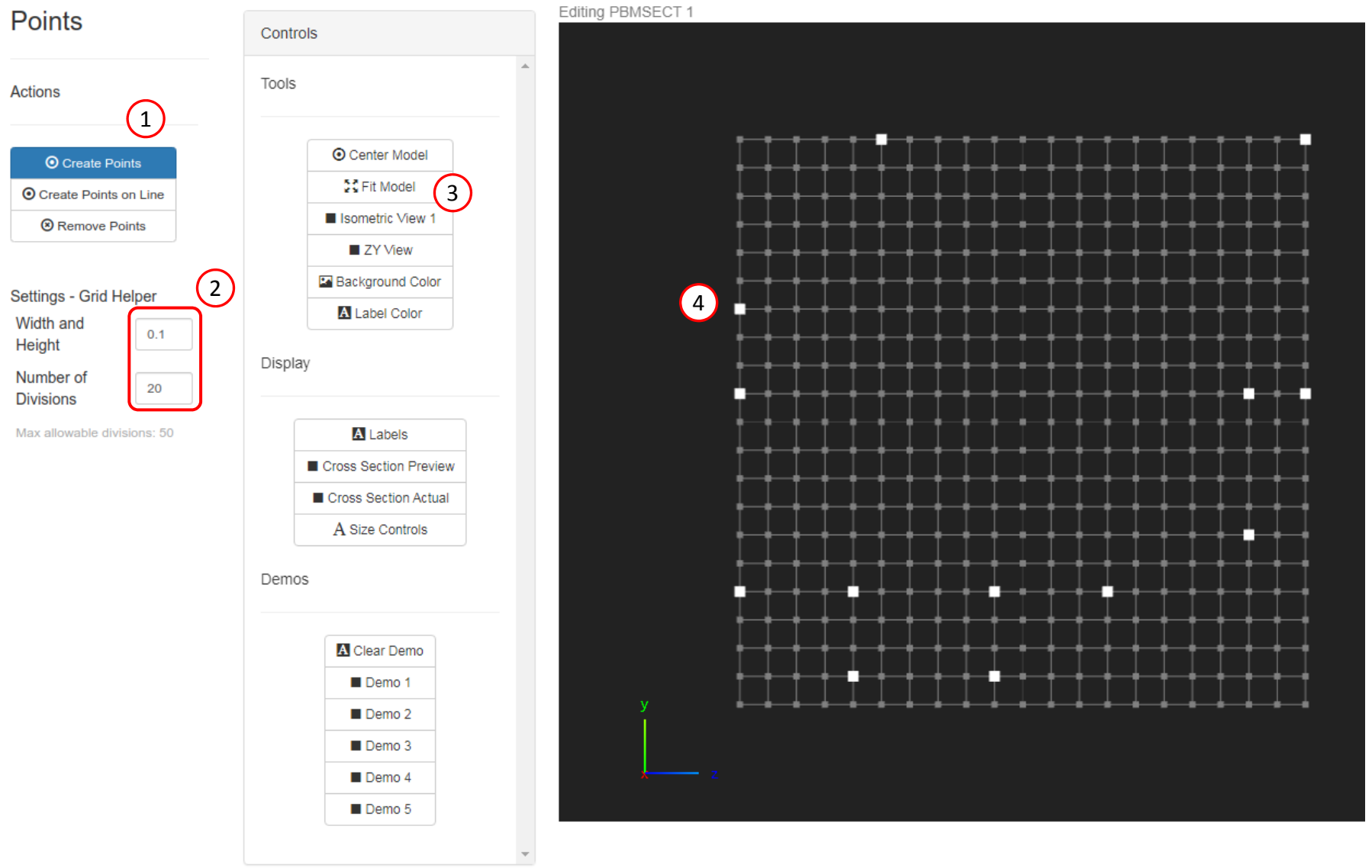


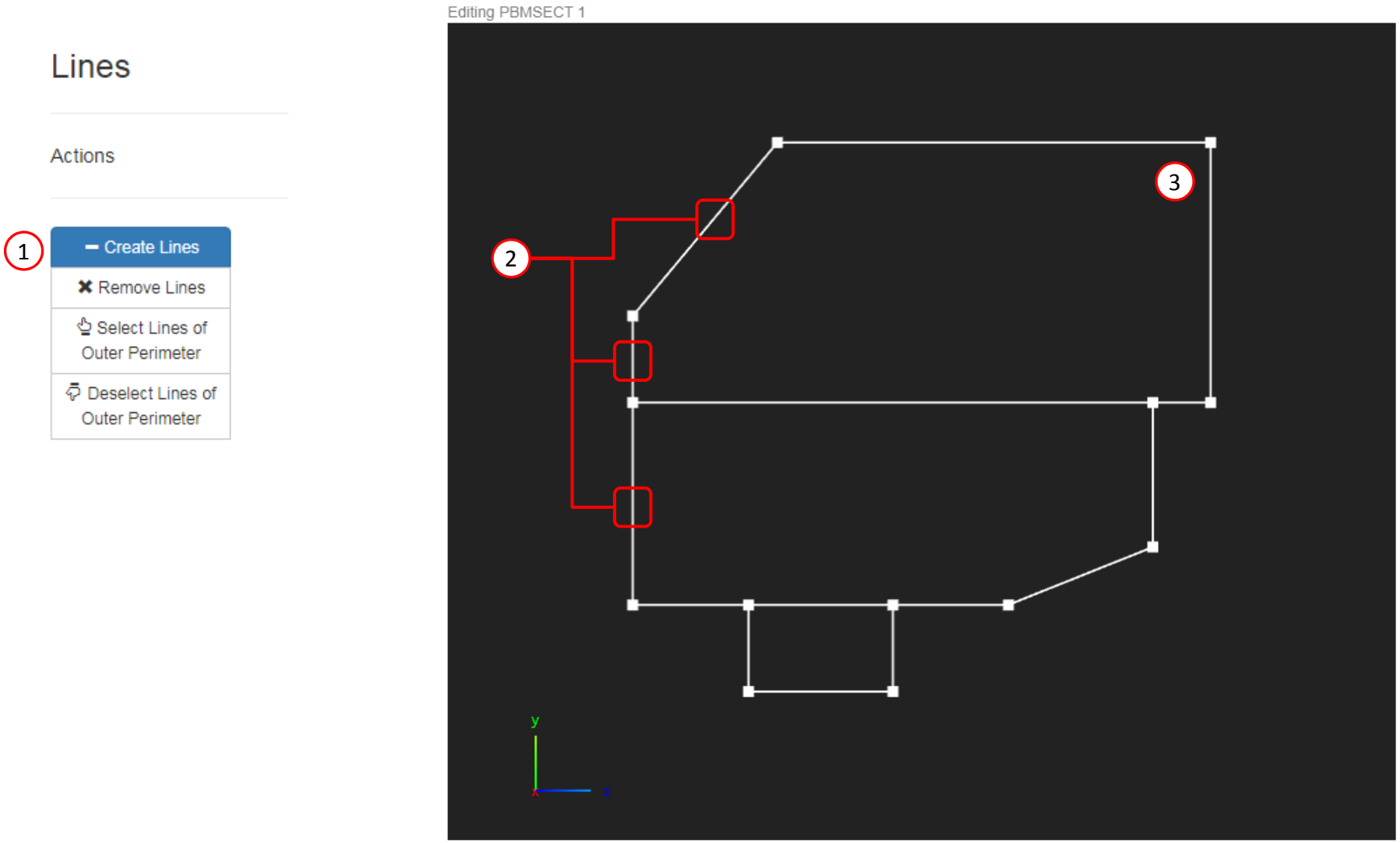
# Points

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.



# 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



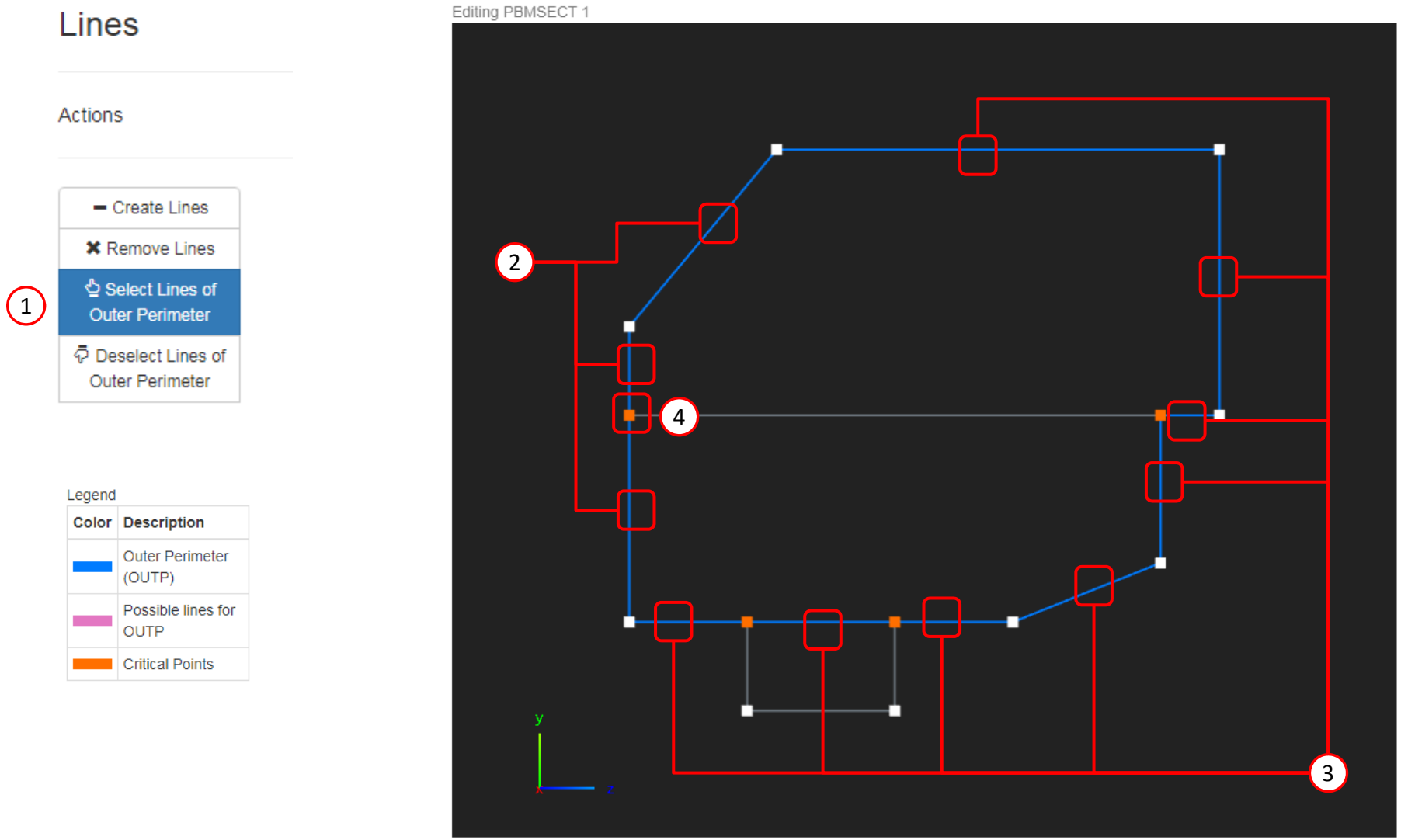
# Outer Perimeter

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)

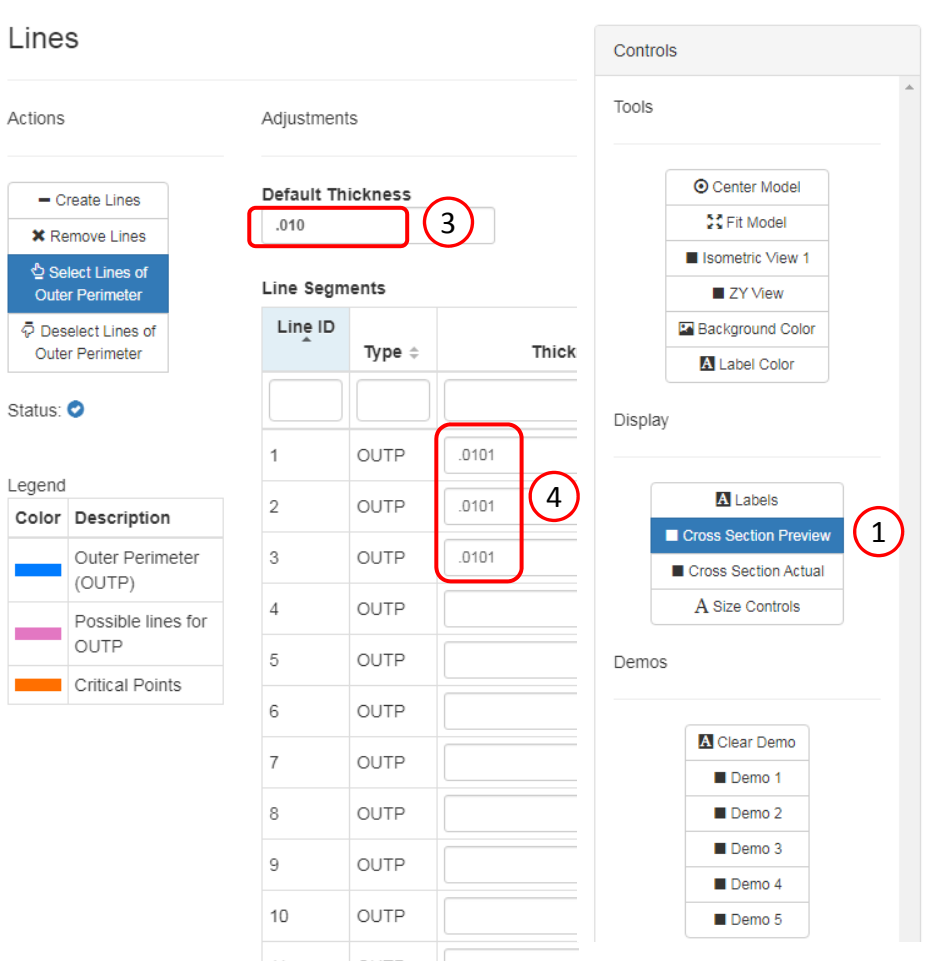
**IMPORTANT!**

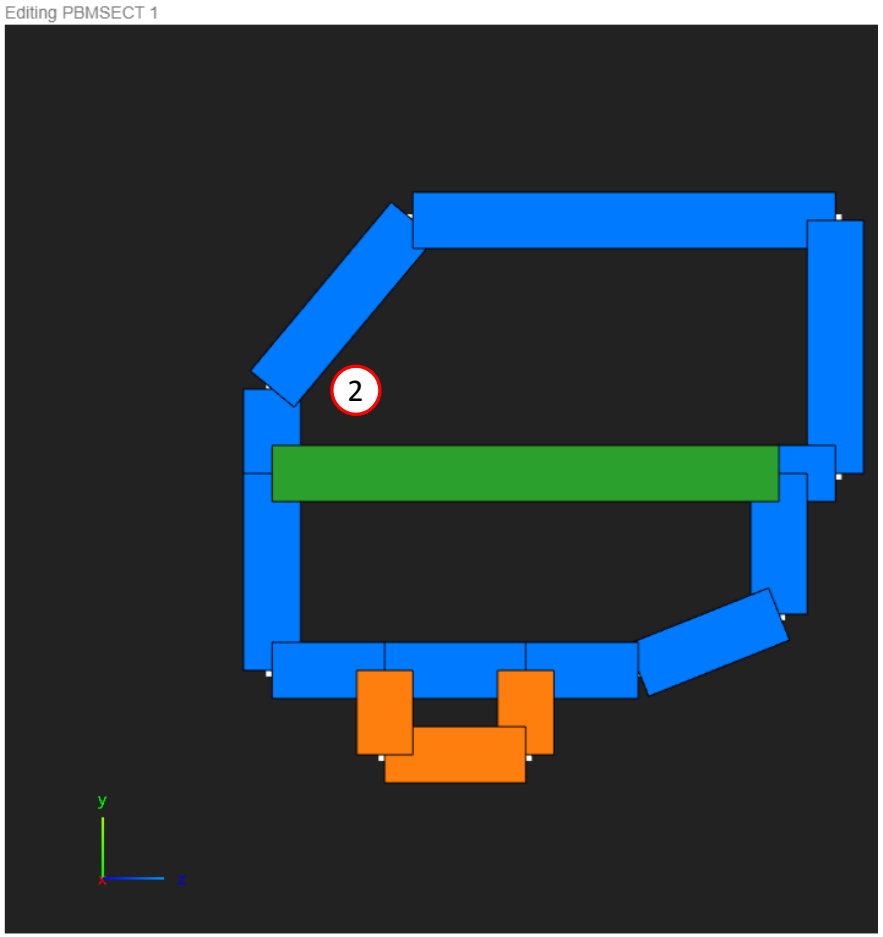
Defining the outer perimeter is the most critical step in defining the PBMSECT/PBRSECT entry. Constantly inspect the outer perimeter. Only one continuous outer perimeters is valid.



# 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.




Corresponding Bulk Data Entries 5

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

PBMSECT 1       1       CP                                                6
        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

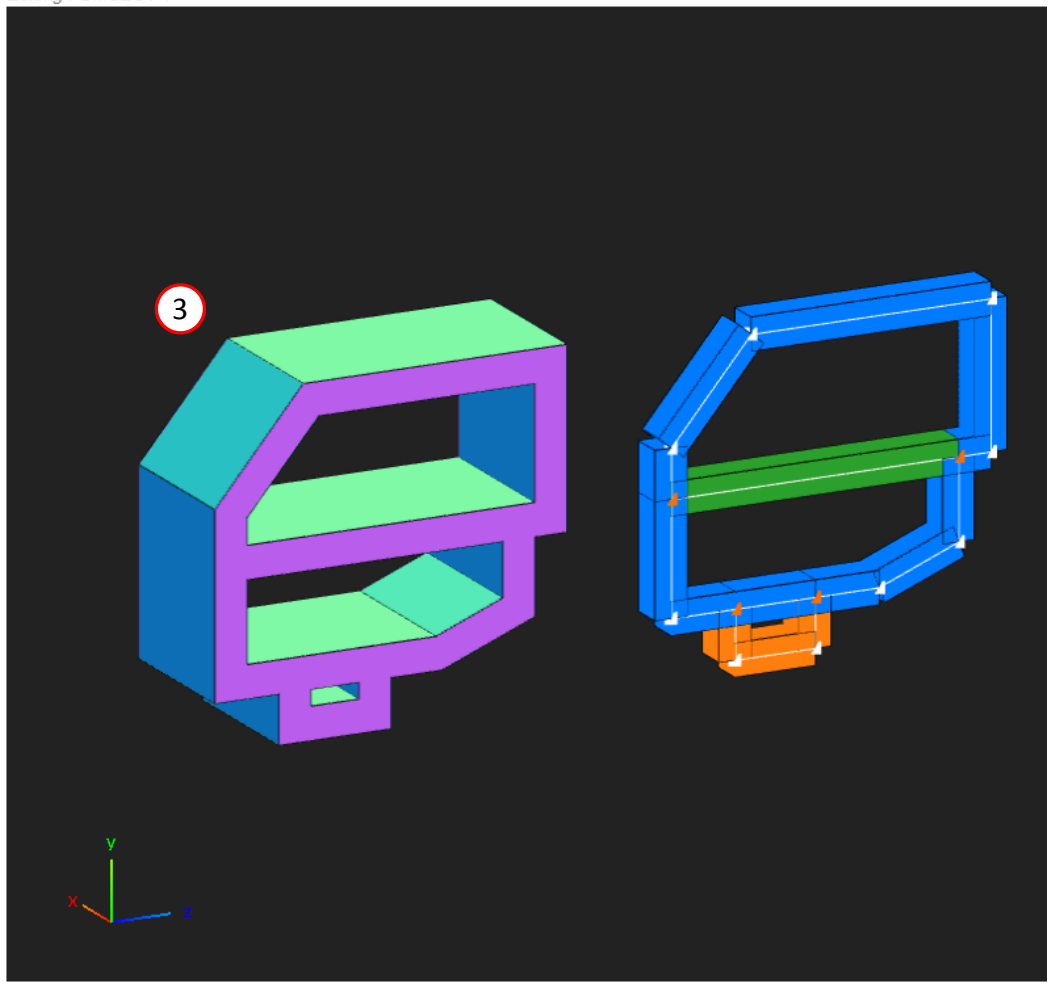
```
$   1  ||   2  ||   3  ||   4  ||   5  ||   6  ||   7  ||   8  ||   9  ||  10  |

PBMSECT 1       1       CP
        OUTP=201,BRP=202,BRP=203,T=.010,T(1)=[.0101,PT=(2000012,2000007)
        ]
POINT   2000007         -0.025000.050000
POINT   2000008         0.0500000.050000
POINT   2000012         -0.05000-0.02999
POINT   2000013         -0.02999-0.02999
POINT   2000014         -0.00499-0.02999
POINT   2000015         0.014999-0.02999
POINT   2000016         -0.02999-0.04500
POINT   2000017         -0.00499-0.04500
POINT   2000018         -0.050000.019999
POINT   2000019         -0.050000.004999
POINT   2000020         0.0399990.004999
POINT   2000021         0.0500000.004999
POINT   2000022         0.039999-0.01999
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/854e82ee40045805a441ff1e2

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


                                                * * * * * * * * * * * * * * * * * * * *
                                                * * * * * * * * * * * * * * * * * * * *
                                                * *                               * *
                                                * *          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
```

1

**PBEAM** Beam Property

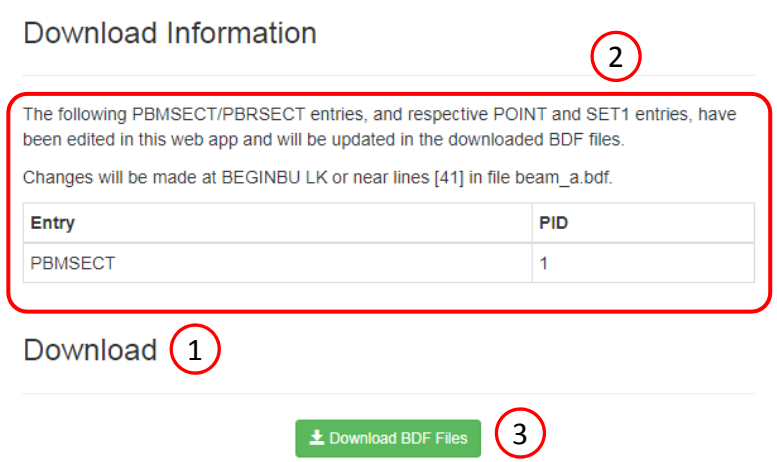
Defines the properties of a beam element (CBEAM entry). This element may be used to model tapered beams.

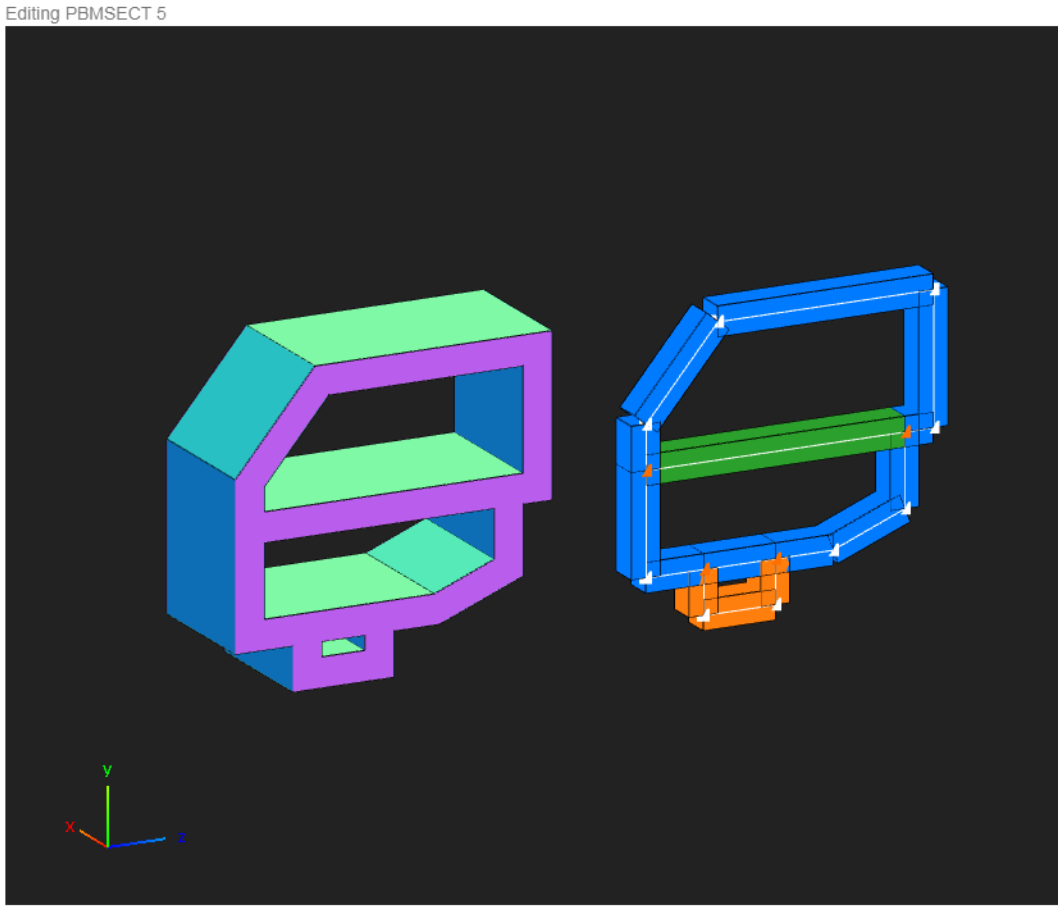
**Format:**

| 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

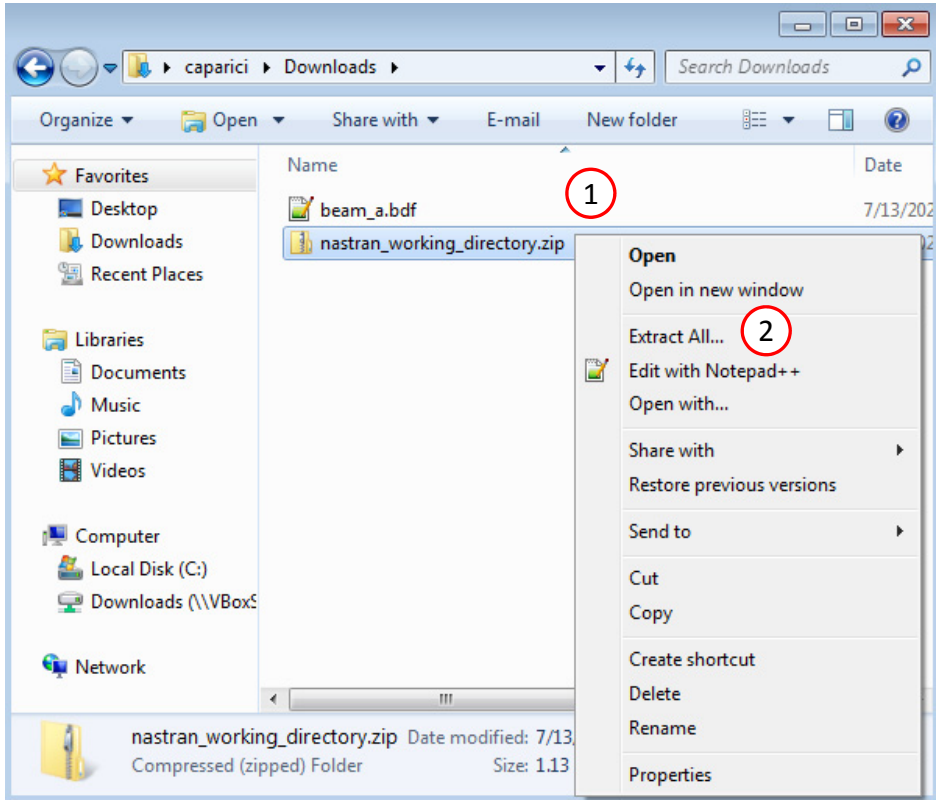
1. Navigate to the Download section
2. The Download Information section provides details regarding how the original BDF files will be edited and downloaded
3. Click Download BDF Files

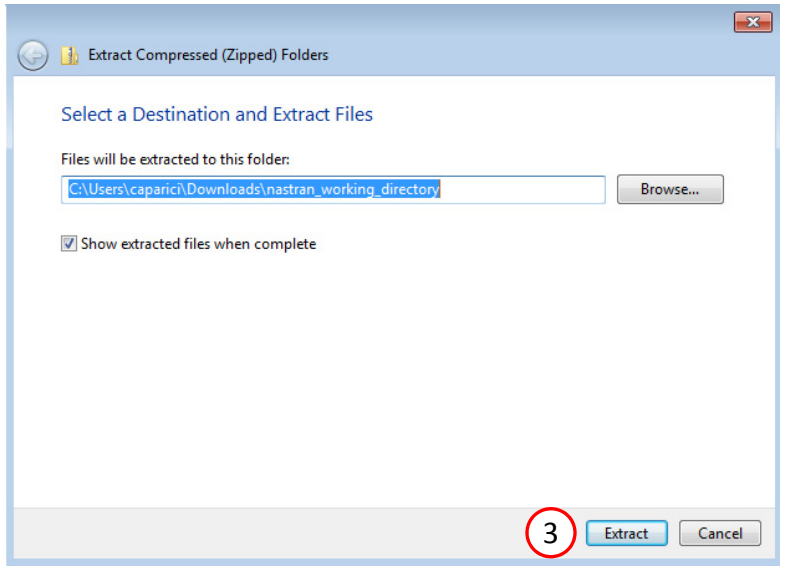


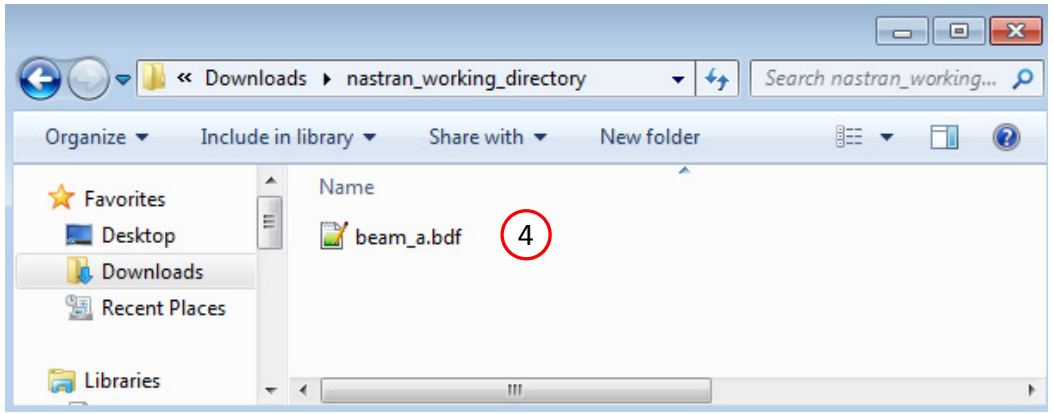



# Extract the ZIP File

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

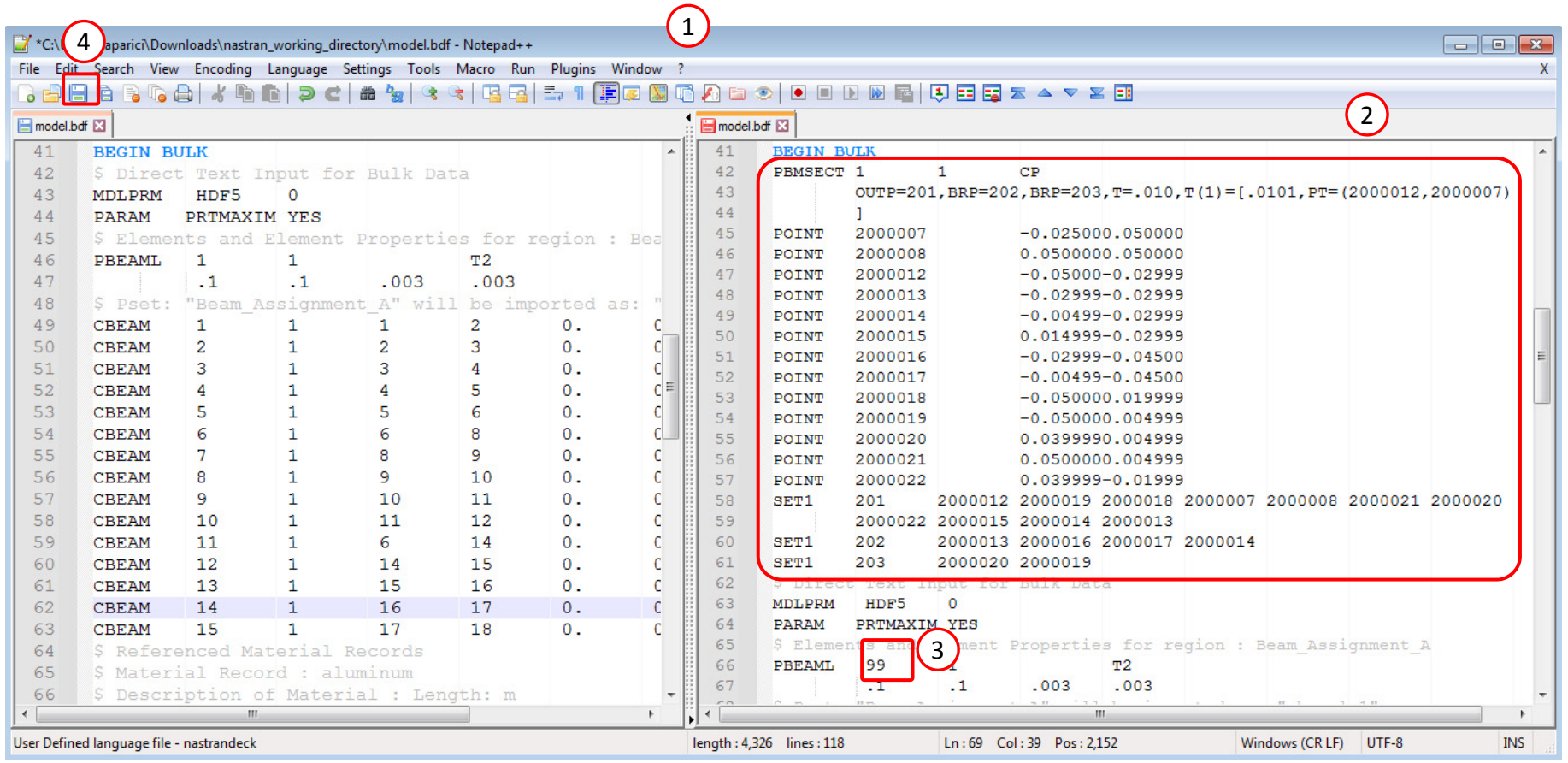


# Compare the Original and New BDF Files

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



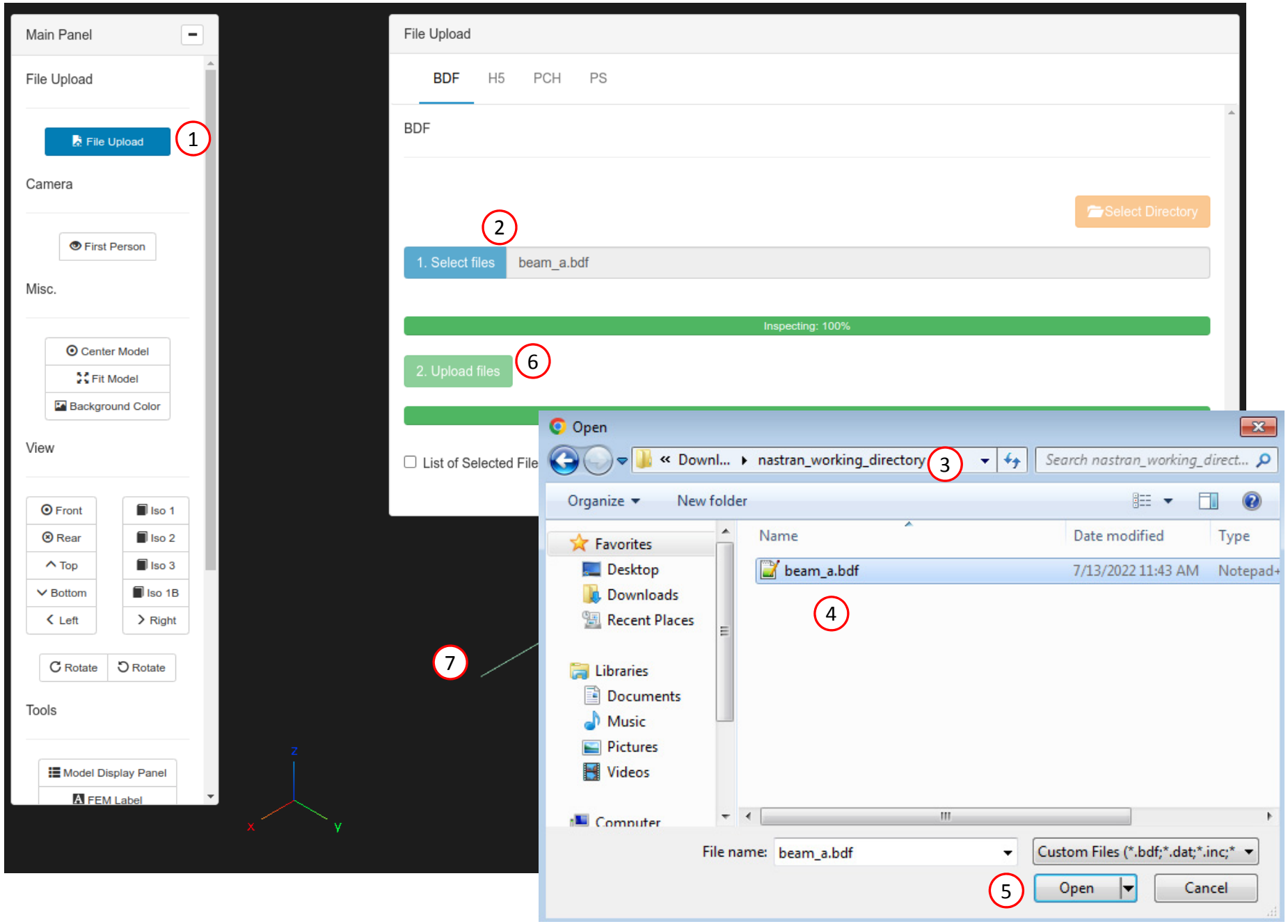

Downloads/beam_a.bdf

nastran_working_directory/beam_a.bdf

# View the Model in the Viewer

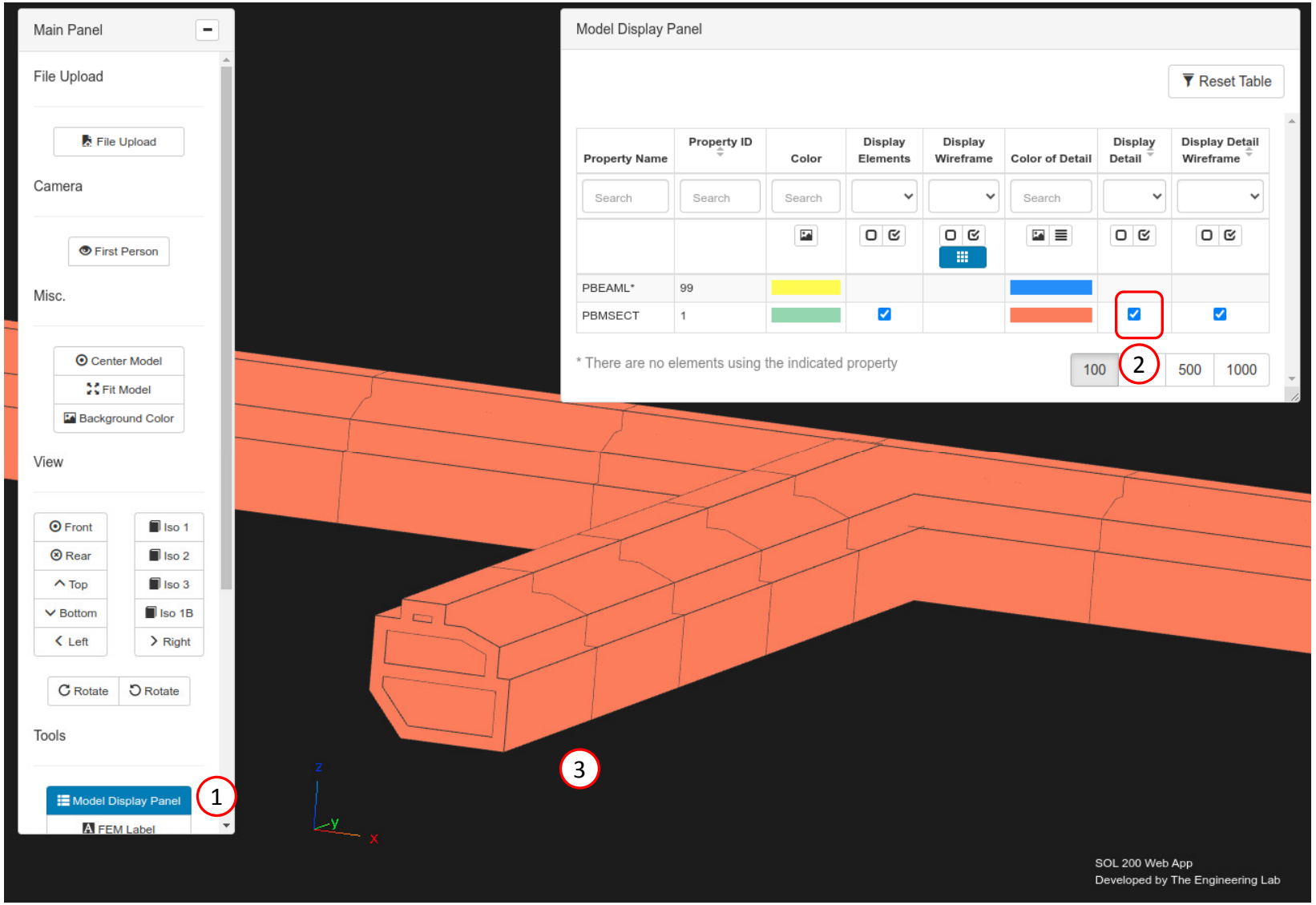
Open the Viewer in a new web browser tab or window (Not shown)

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



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

# Optimization Problem Statement

## Design Variables

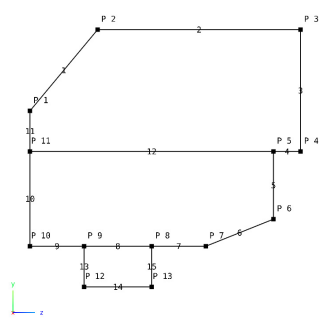
x1: Width of arbitrary cross section (ABCS)

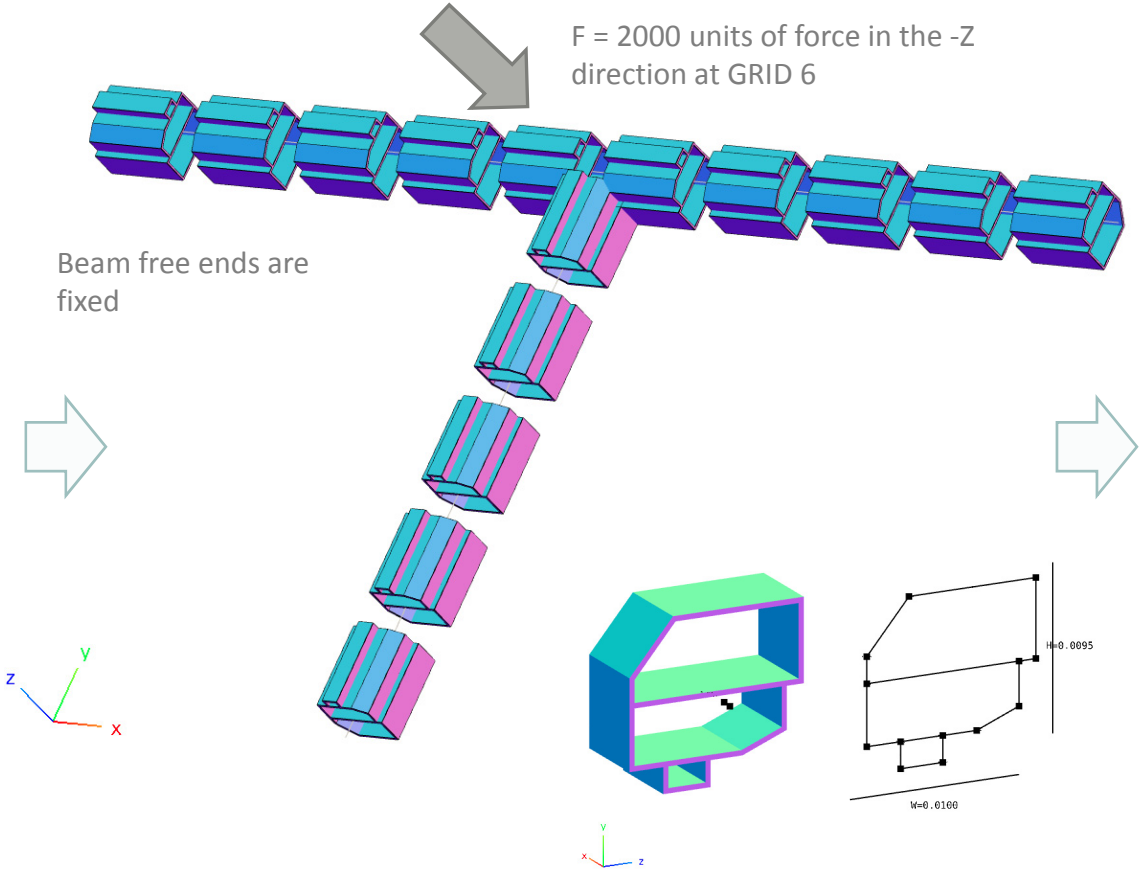
x2: Height of ABCS

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

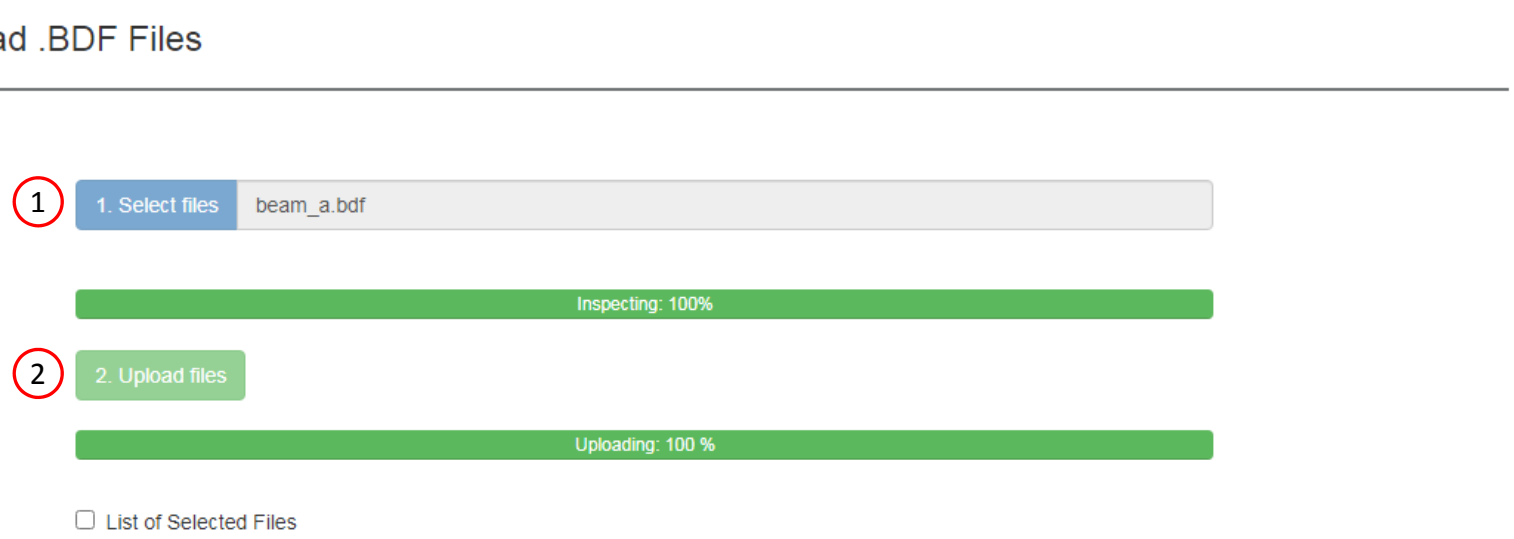
1. Navigate to the homepage
2. Click on the indicated link

- 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.



# 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 |
|---|---|---|---|---|---|
| | Search | Search | Search | Search | Search |
| + | W | Overall width | PBMSECT | 1 | .1 |
| + | H | Overall height | PBMSECT | 1 | .095 |
| + | T | Overall thickness | PBMSECT | 1 | .010 |
| + | T(1) | Thickness of segment | PBMSECT | 1 | .0101 |
| + | DIM1(A) | T2 - Width of flange | PBEAML | 99 | .1 |

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

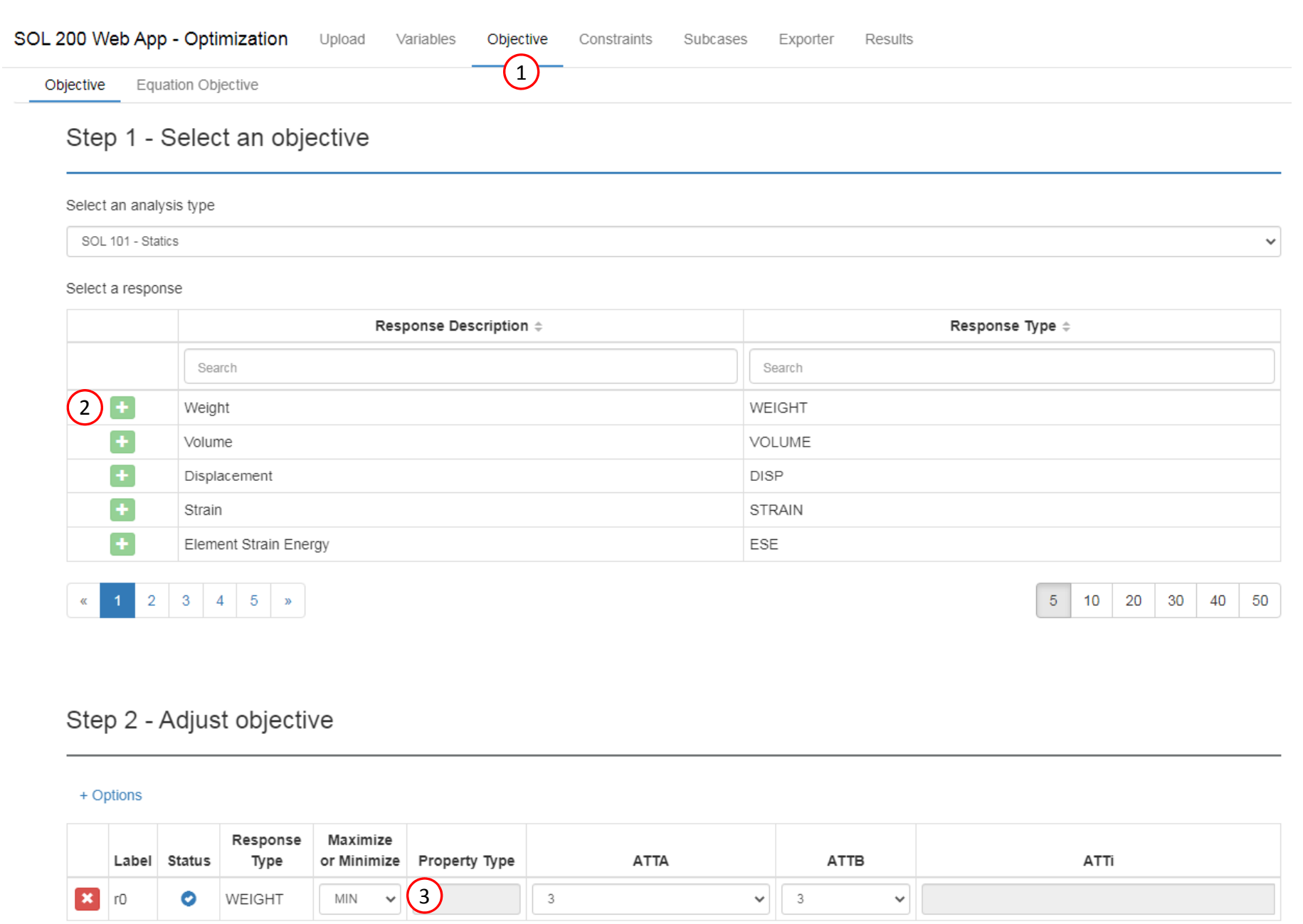
| | Label | Status | Property | Property Description | Entry | Entry ID | Initial Value | Lower Bound | Upper Bound | Allowed Discrete Values |
|---|---|---|---|---|---|---|---|---|---|---|
| | Search | Search | Search | Search | Search | Search | Search | Search | Search | Search |
| ✖ | x1 | ✔ | W | Overall width | PBMSECT | 1 | 1.000E-1 | .08 | .2 | Examples: -2.0, 1.0, THRU, 10.0, |
| ✖ | x2 | ✔ | H | Overall height | PBMSECT | 1 | 9.500E-2 | .05 | .2 | Examples: -2.0, 1.0, THRU, 10.0, |
| ✖ | x3 | ✔ | T | Overall thickness | PBMSECT | 1 | .010 | .002 | .02 | Examples: -2.0, 1.0, THRU, 10.0, |
| ✖ | x4 | ✔ | T(1) | Thickness of segment | PBMSECT | 1 | .0101 | .003 | .02 | Examples: -2.0, 1.0, THRU, 10.0, |

2

# Create Design Objective

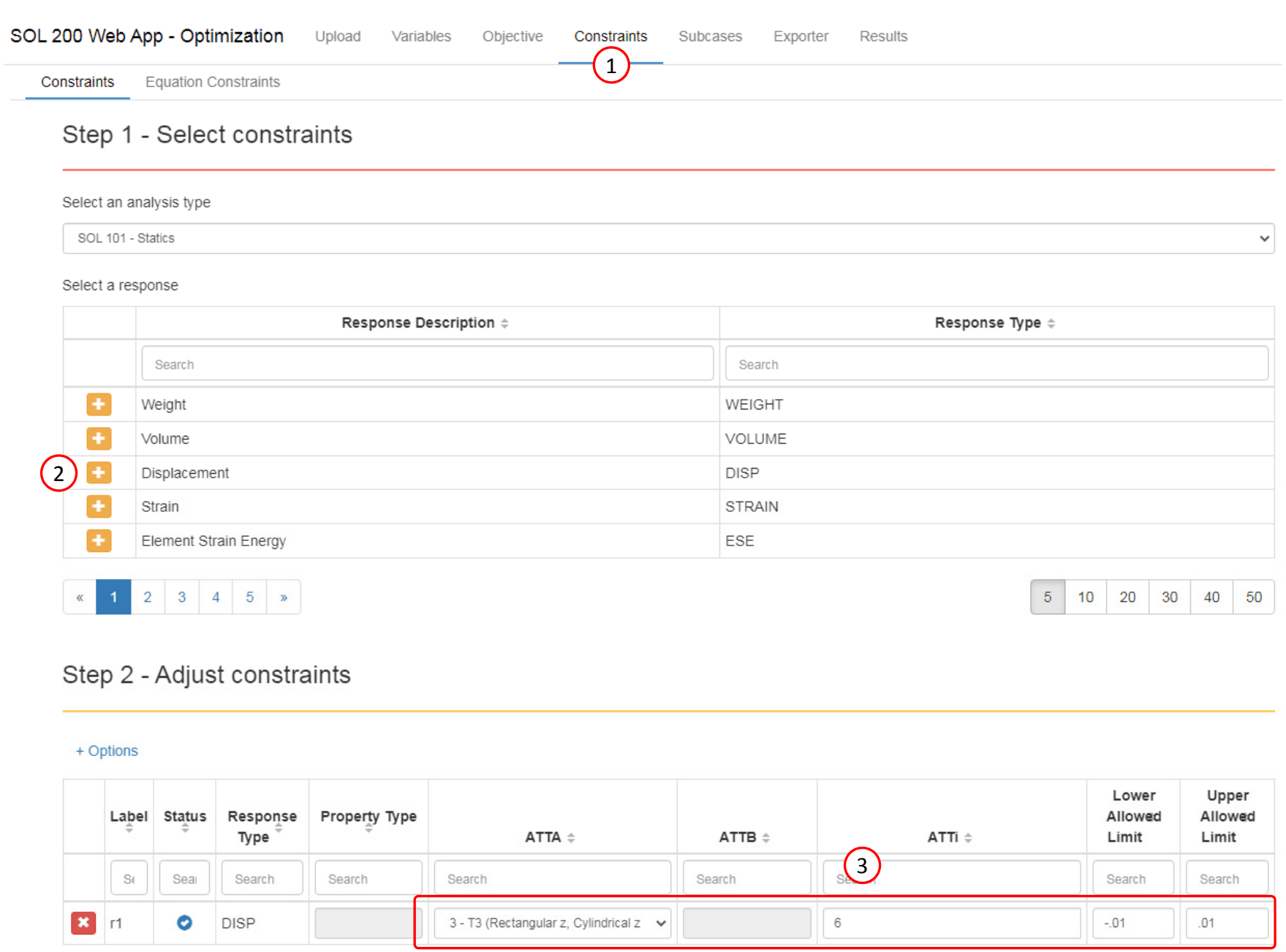
1. Click Objective
2. Select the plus (+) icon for weight
3. The objective has been set to minimize the weight, no further modification is necessary

- 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.



# 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



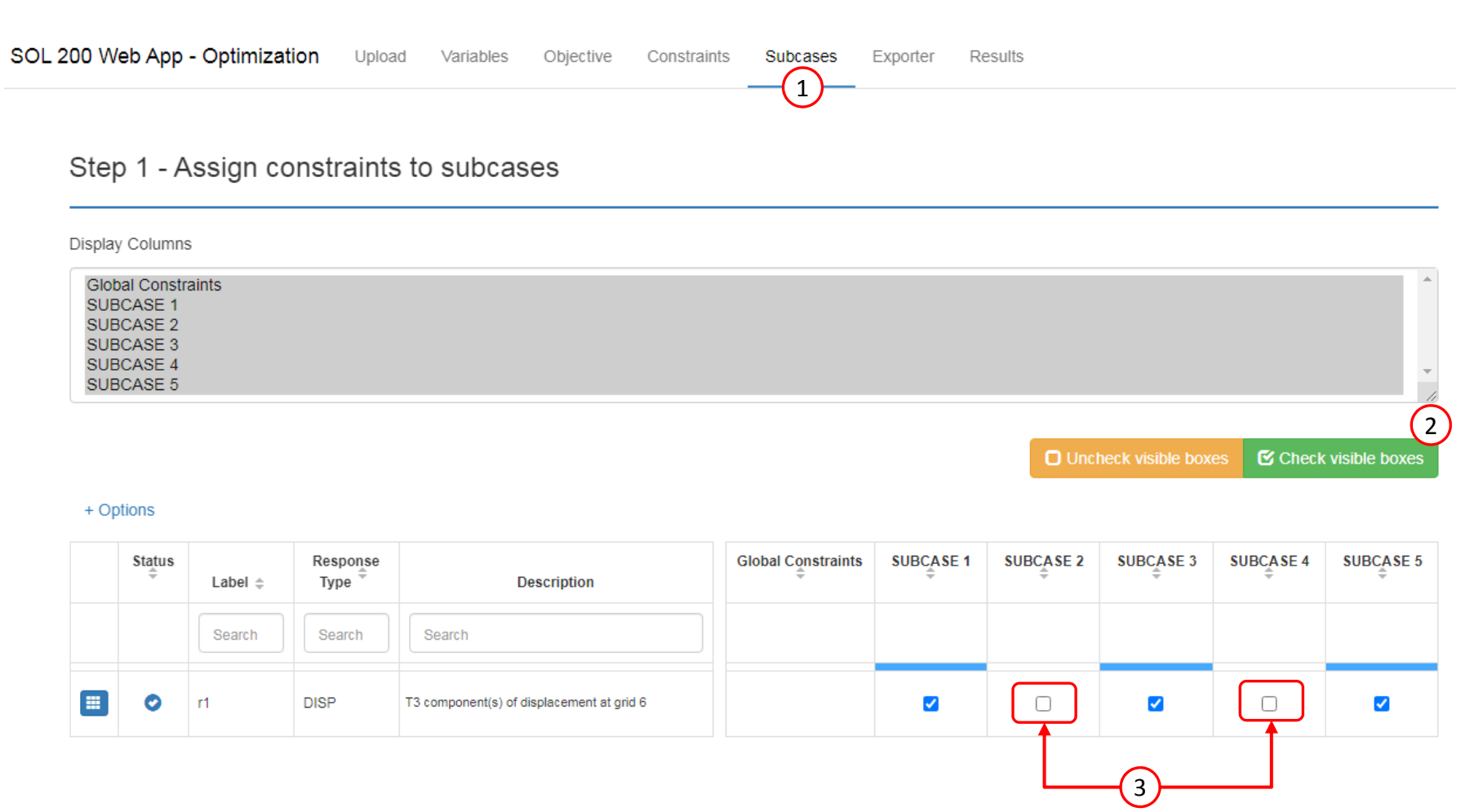
# Assign Constraints to Load Cases (SUBCASES)

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

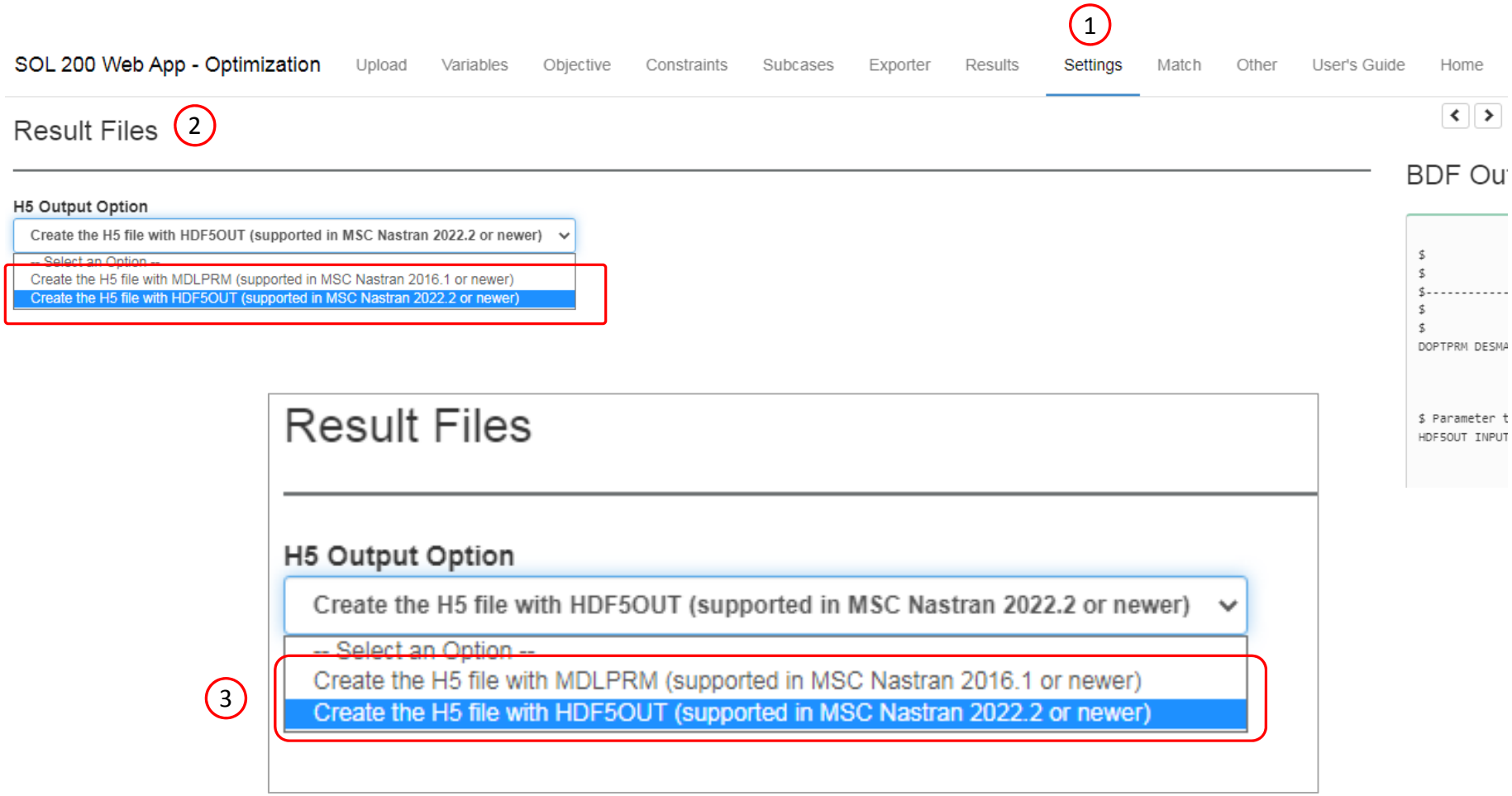
Check visible boxes



# 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

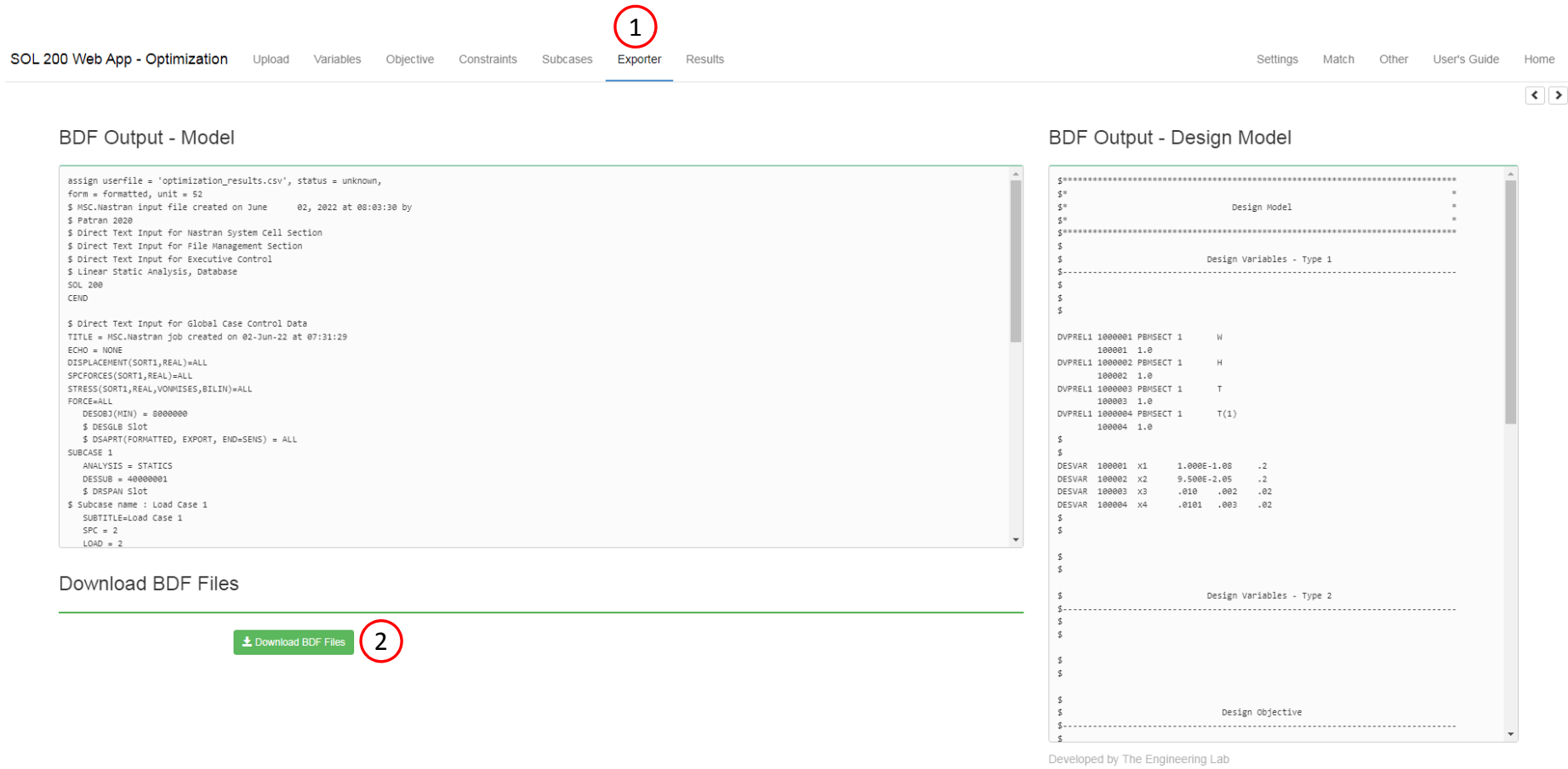
- The H5 file is used by the Post-processor web app to display MSC Nastran results.
- The H5 file is used by the HDF5 Explorer to create graphs (XY Plots) of MSC Nastran results.



# Export New BDF Files

1. Click on Exporter
2. Click on Download BDF Files

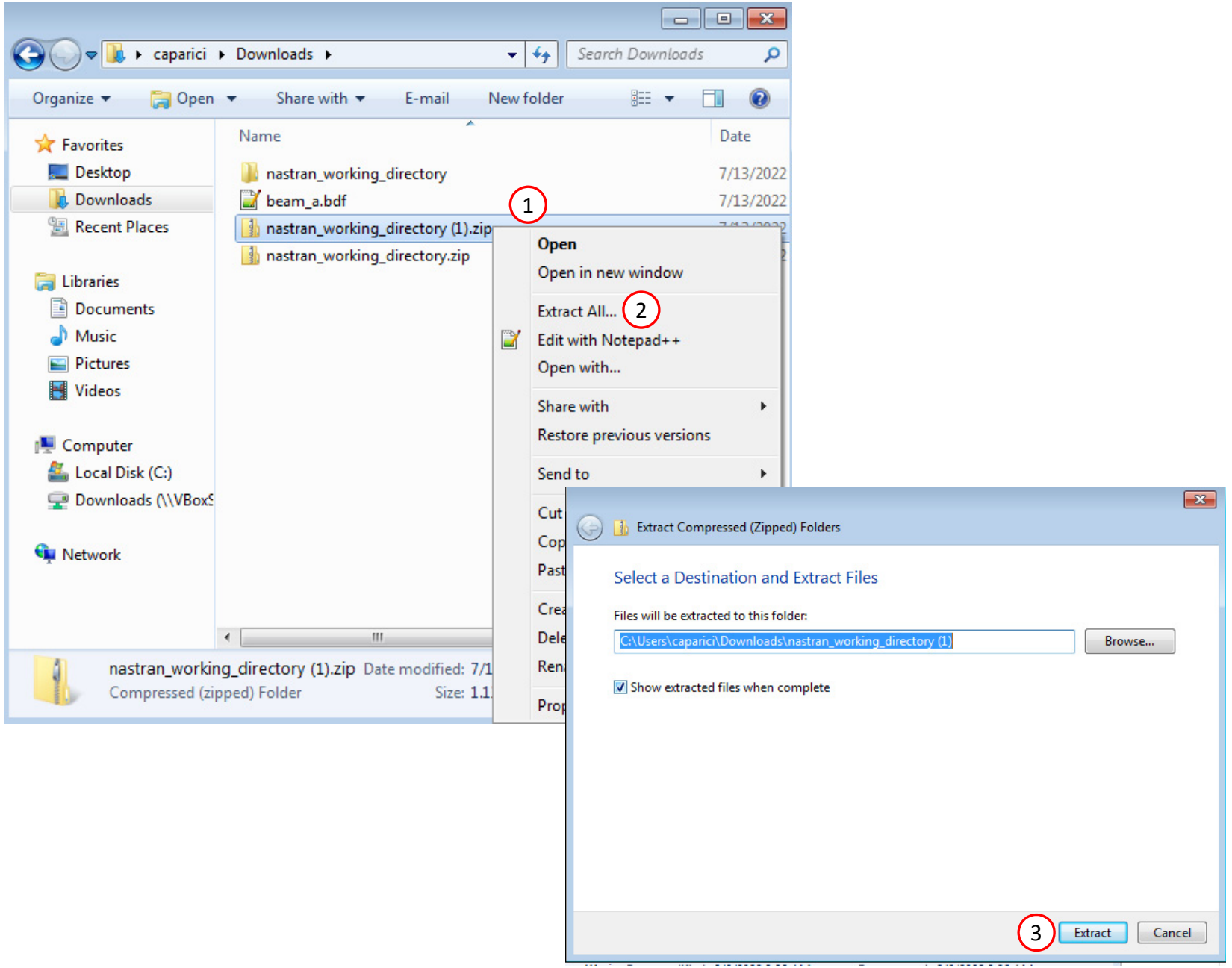
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



# 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

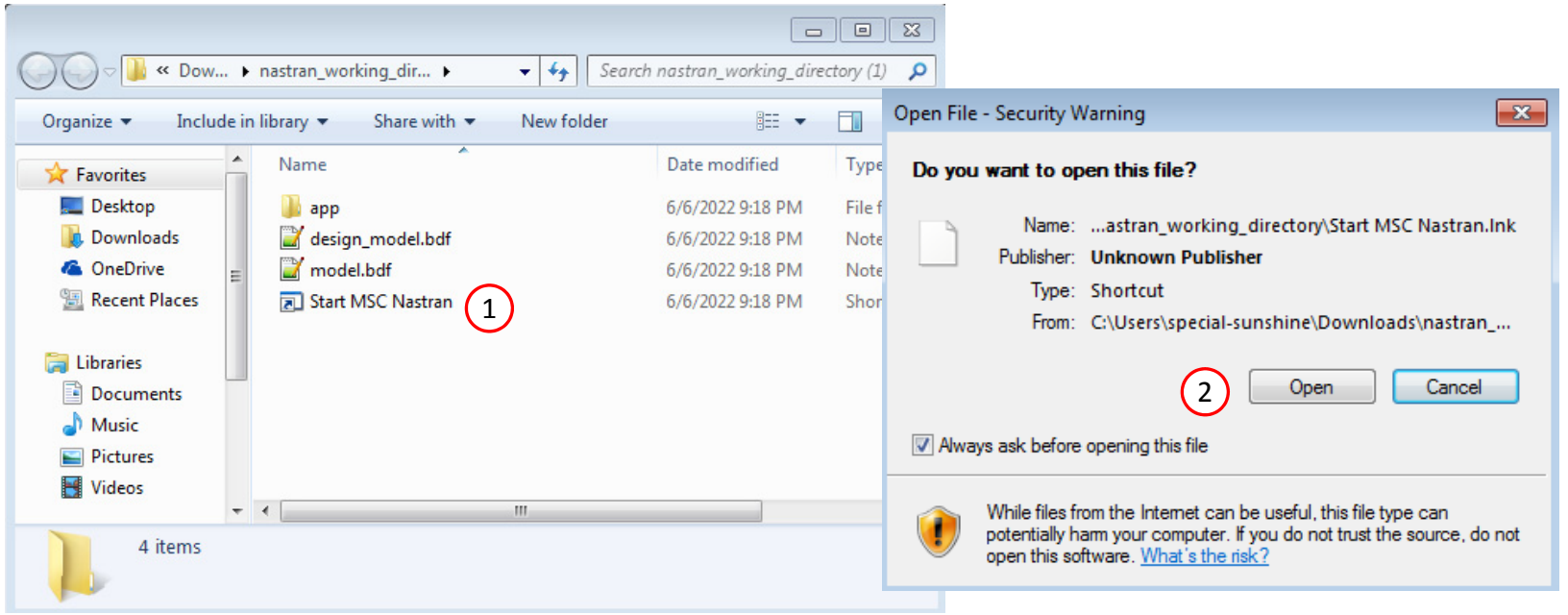
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the 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.

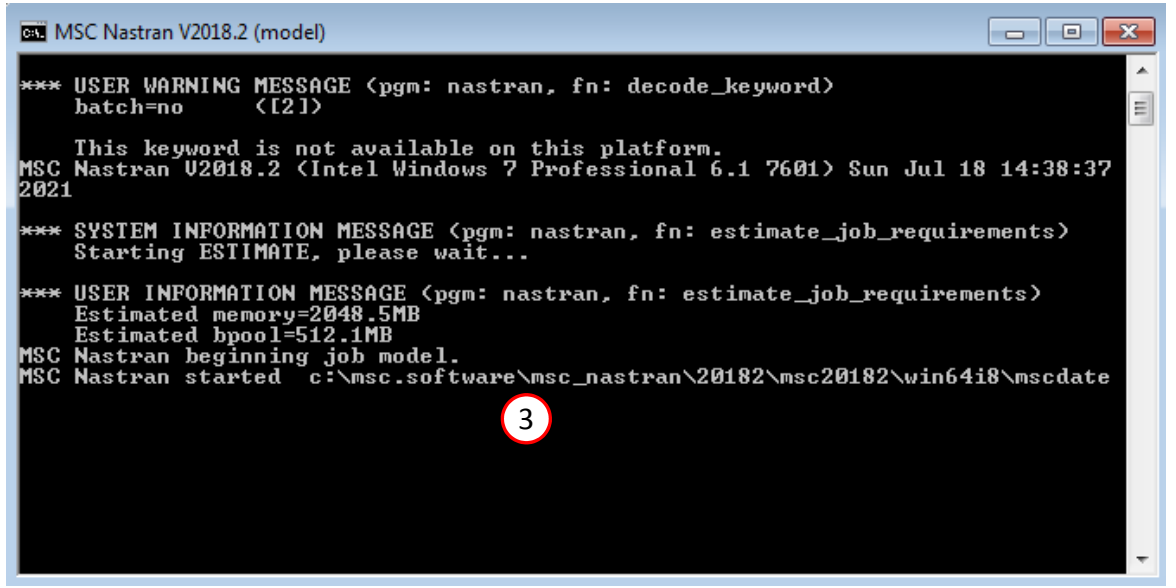
**Using Linux?**

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

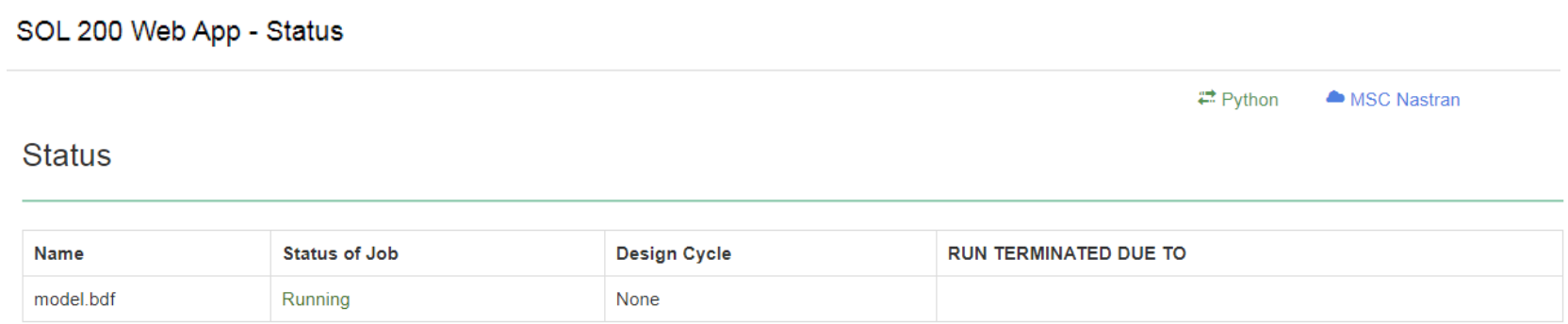


# Status

1. While MSC Nastran is running, a status page will show the current state of MSC Nastran

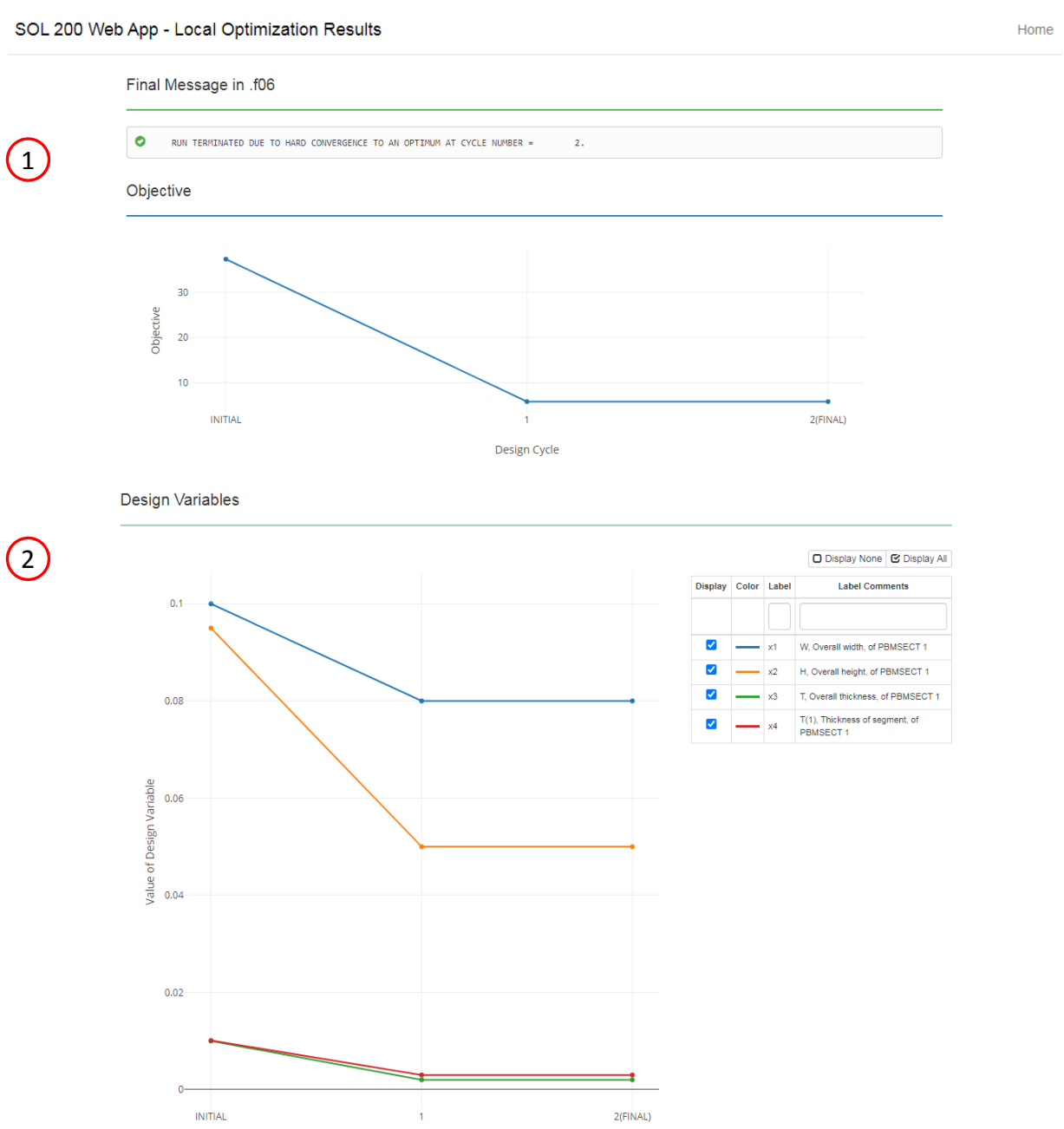
- The status of the MSC Nastran job is reported on the Status page. Note that Windows 7 users will experience a delay in the status updates. All other users of Windows 10 and Red Hat Linux will see immediate status updates.



# 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.

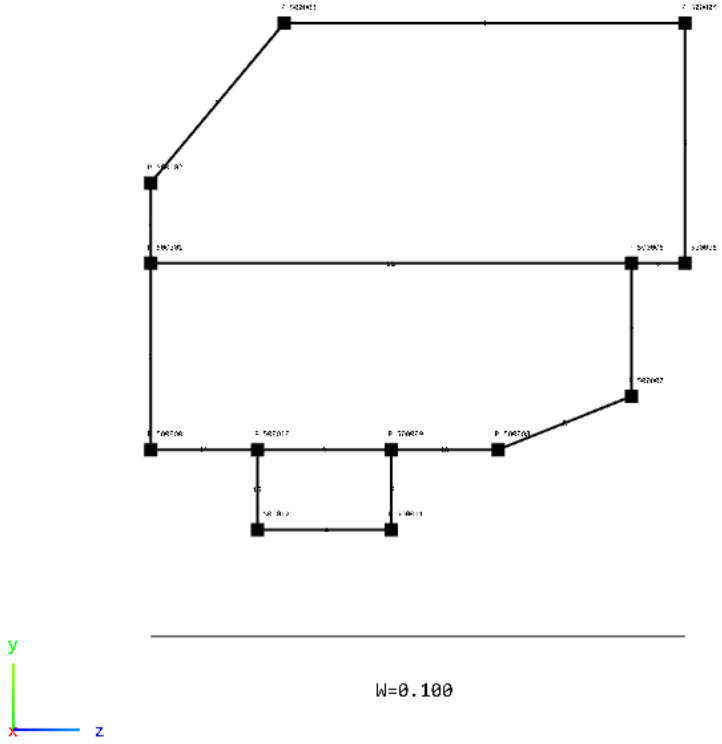
- After an optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- For this optimization, each variable has been reduced. On close inspection, each variable has been reduced to its lower bound.



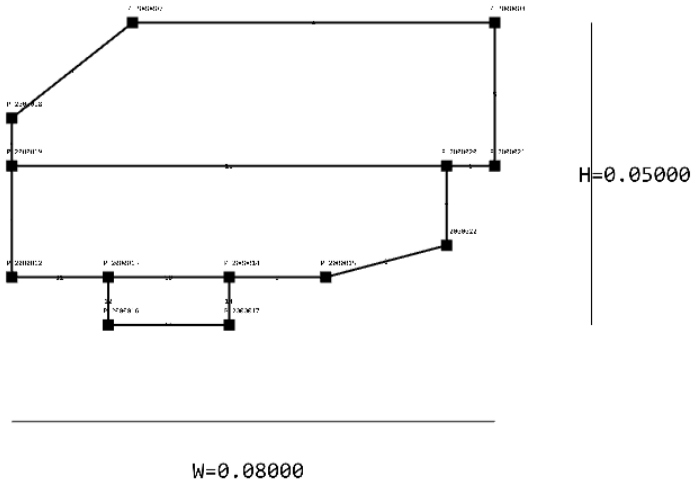
# Comparison of Original and New Arbitrary Beam Cross Section

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

## Before Optimization

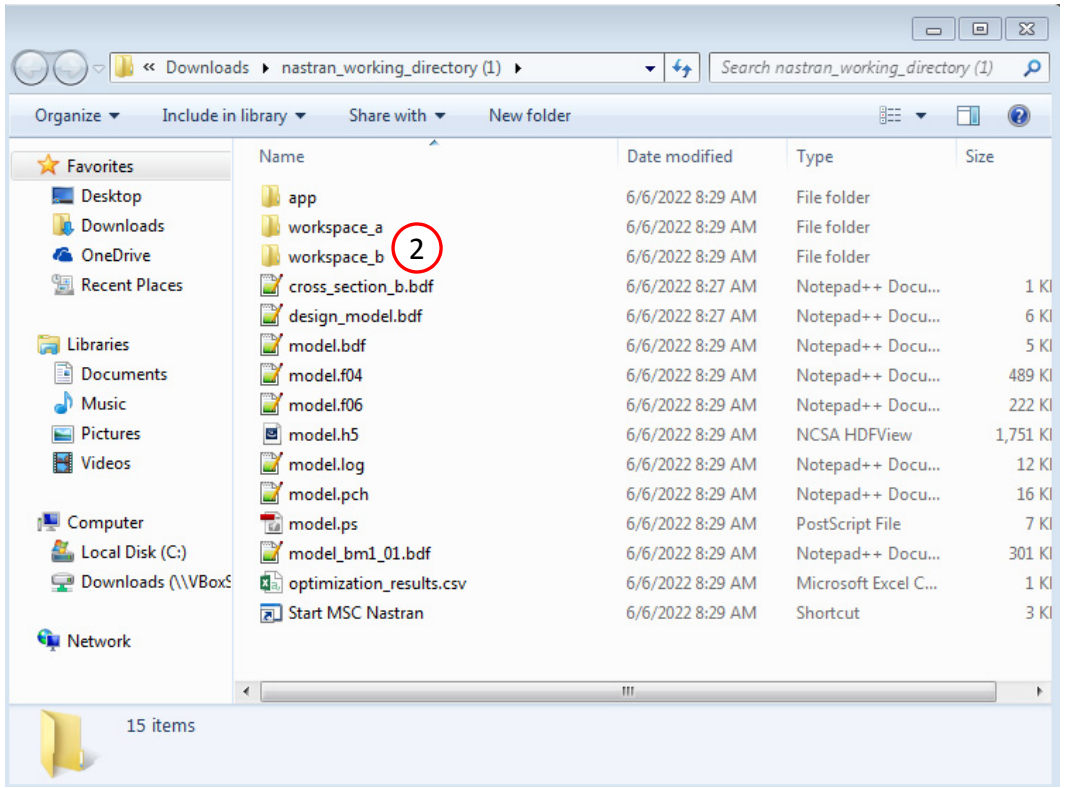


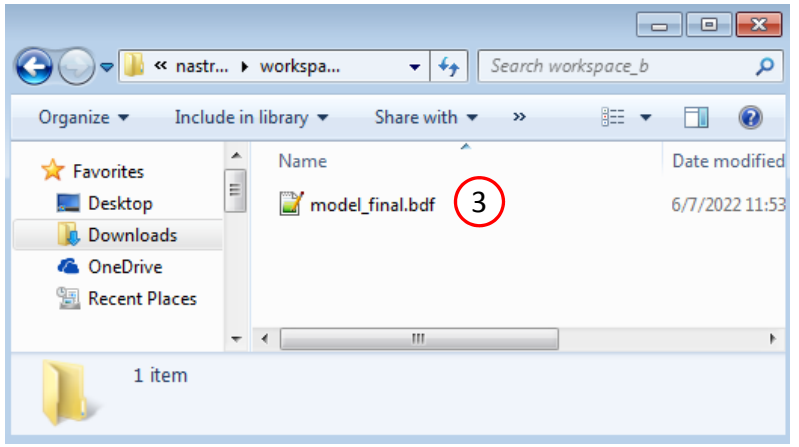

## After Optimization

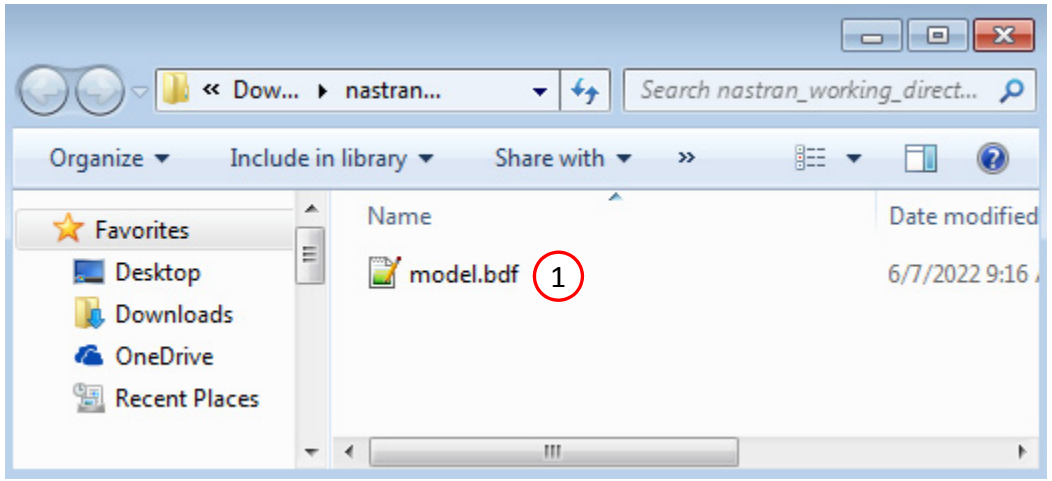


# Comparison of the Original and New PBMSECT Entries

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

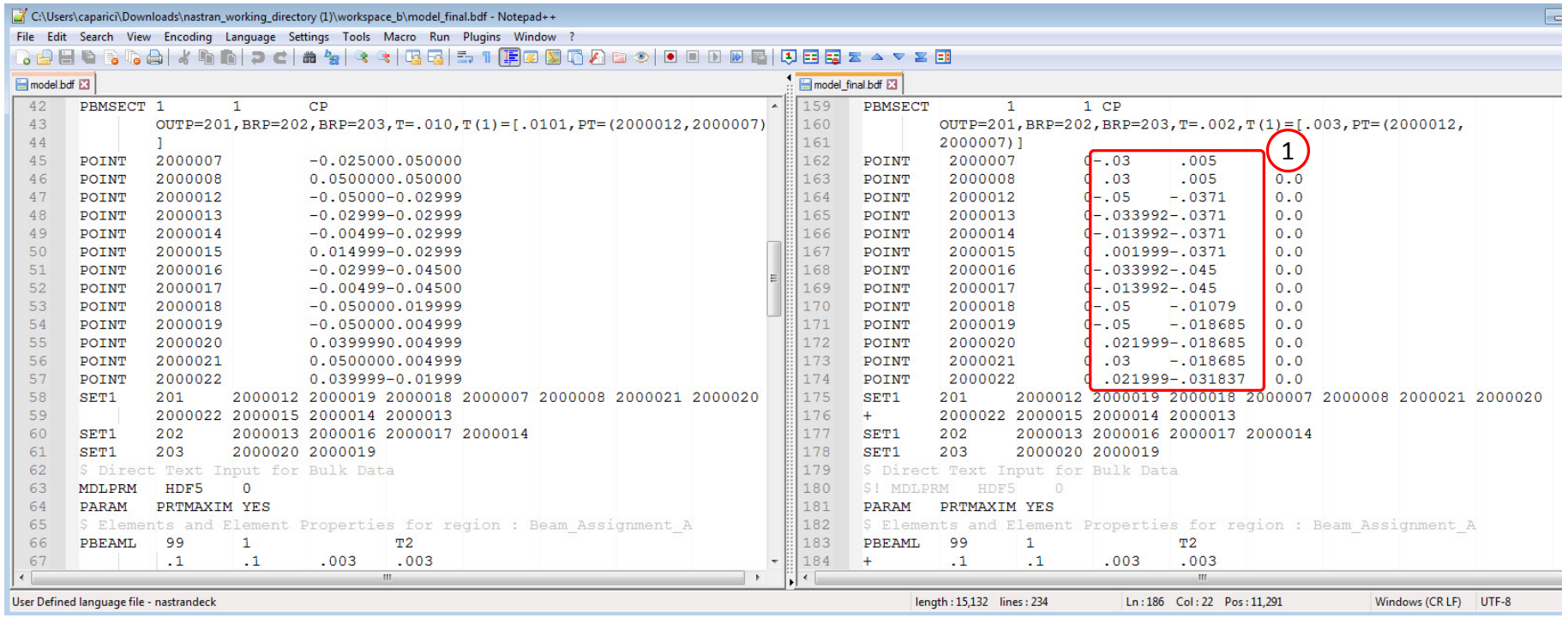


# Comparison of the Original and New PBMSECT Entries

1. model_final.bdf contains updated POINT entries that describe the new ABCS



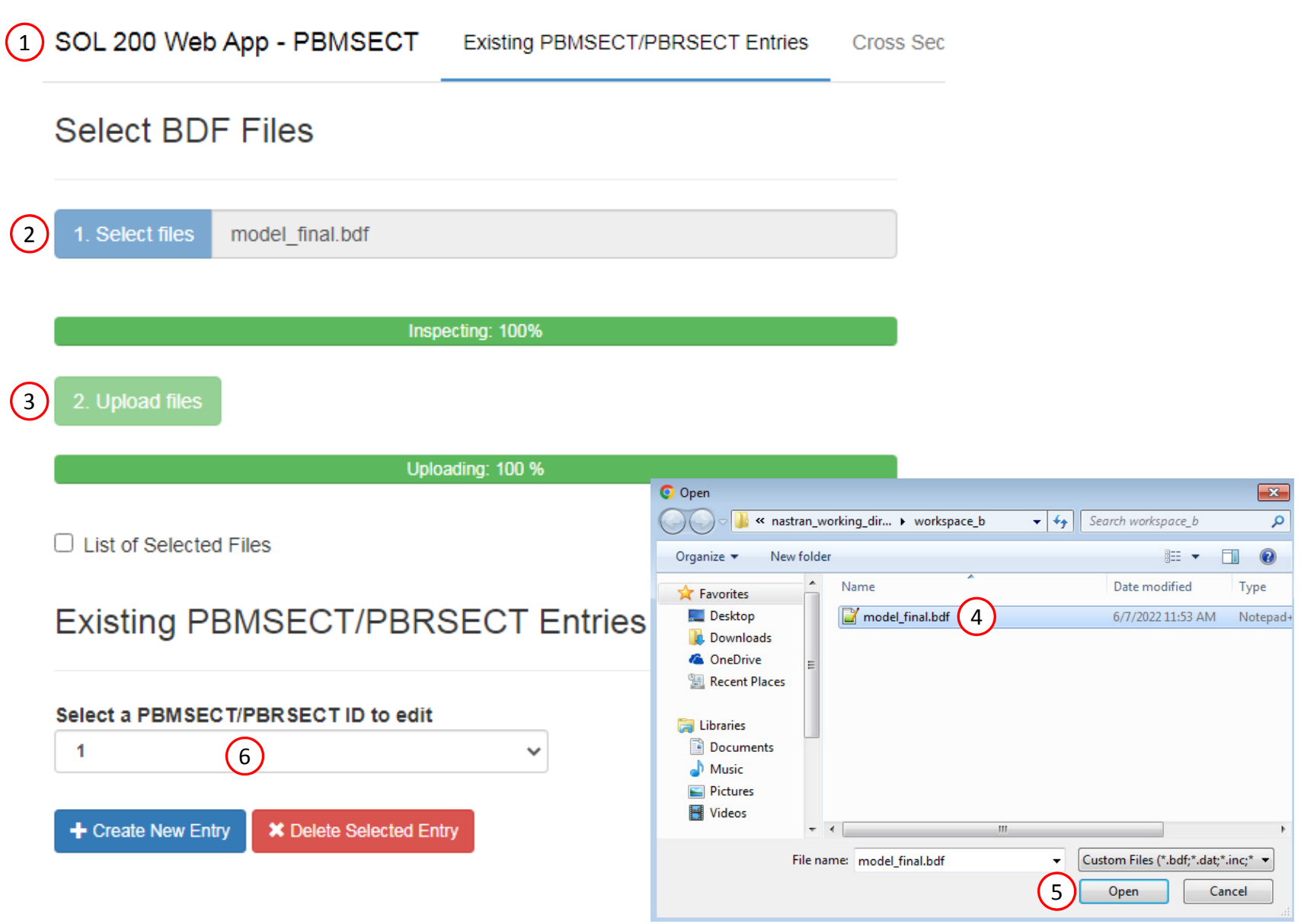

Original BDF/DAT File

Updated BDF/DAT File

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

# PBMSECT Web App

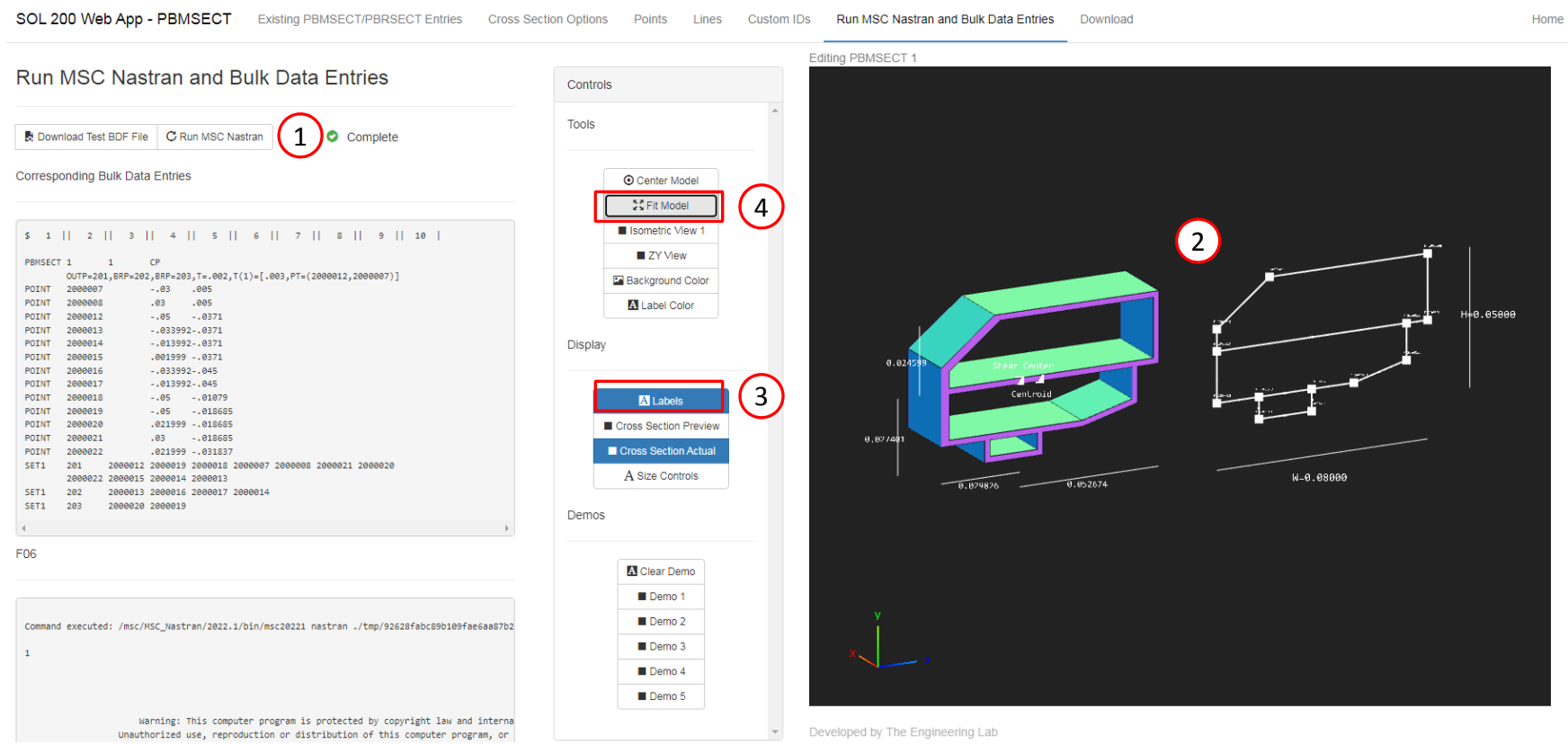
1. Open the PBMSECT web app
2. Click Select files
3. Select nastran_working_driectory (1)/workspace_b/model_final.bdf
4. Click Open
5. Click Upload files
6. Select PBMSECT 1 from the list of available entries



# 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 will 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

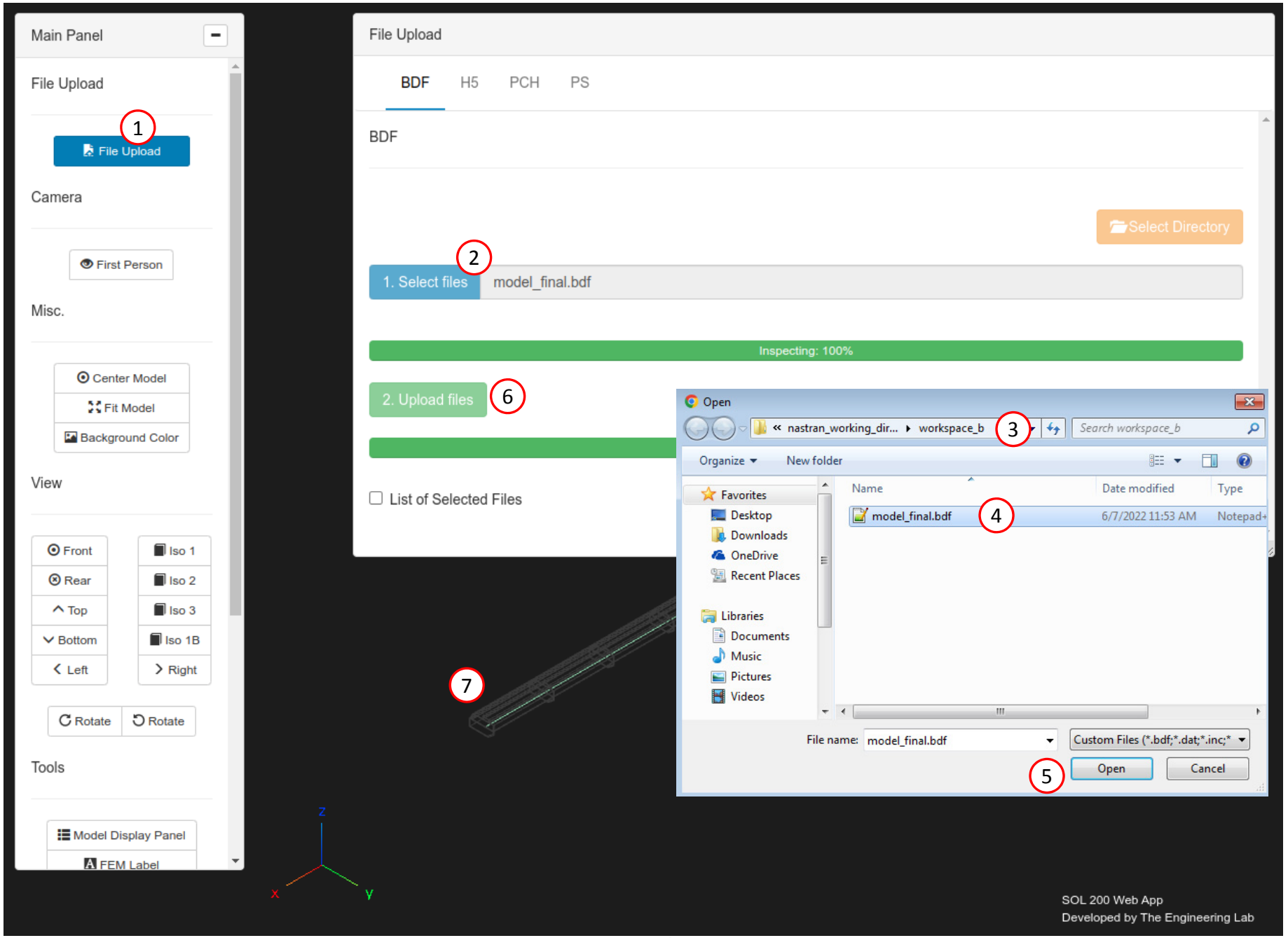


# Part E – Inspecting the new ABCS in the Viewer

# Viewer

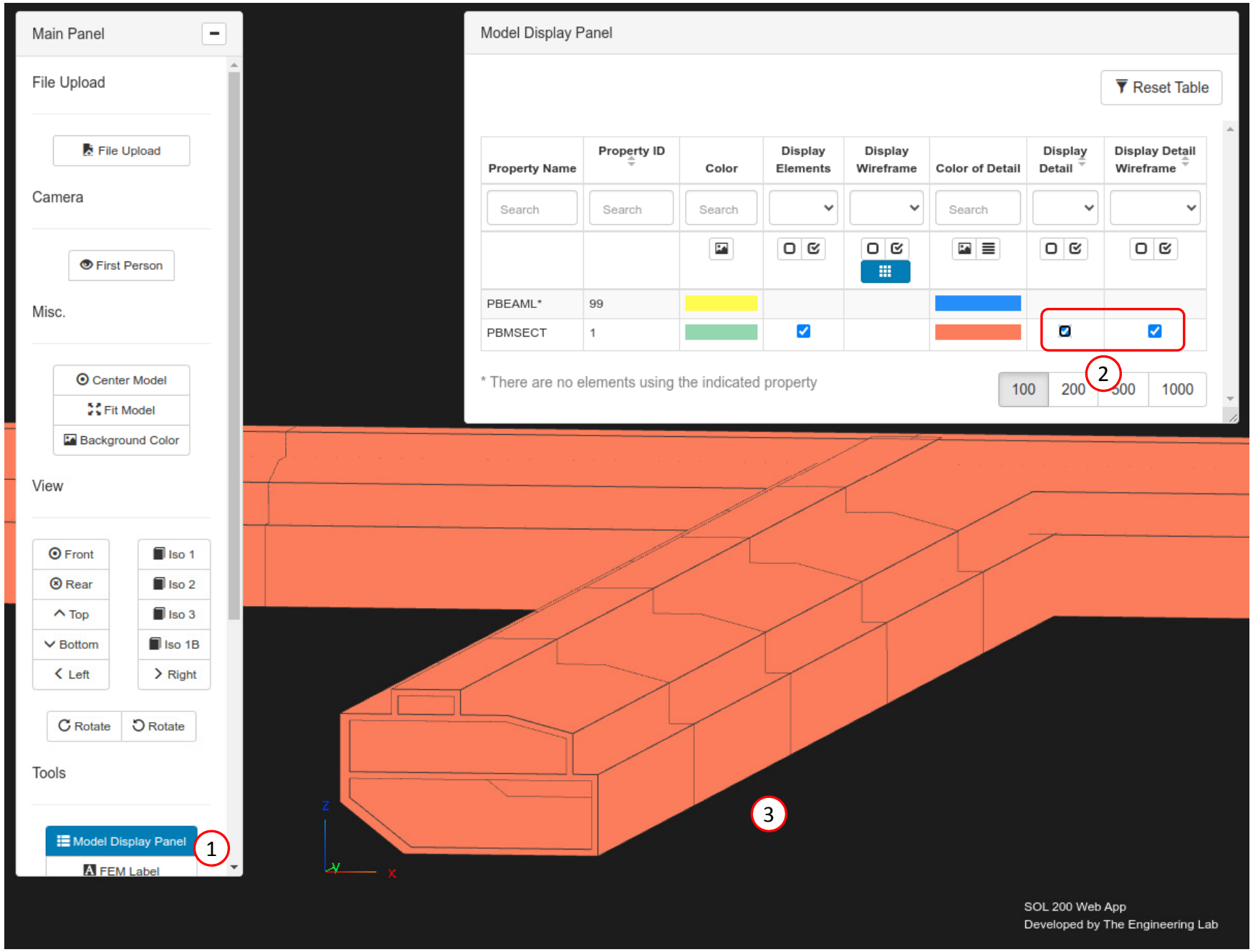
Open the Viewer

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



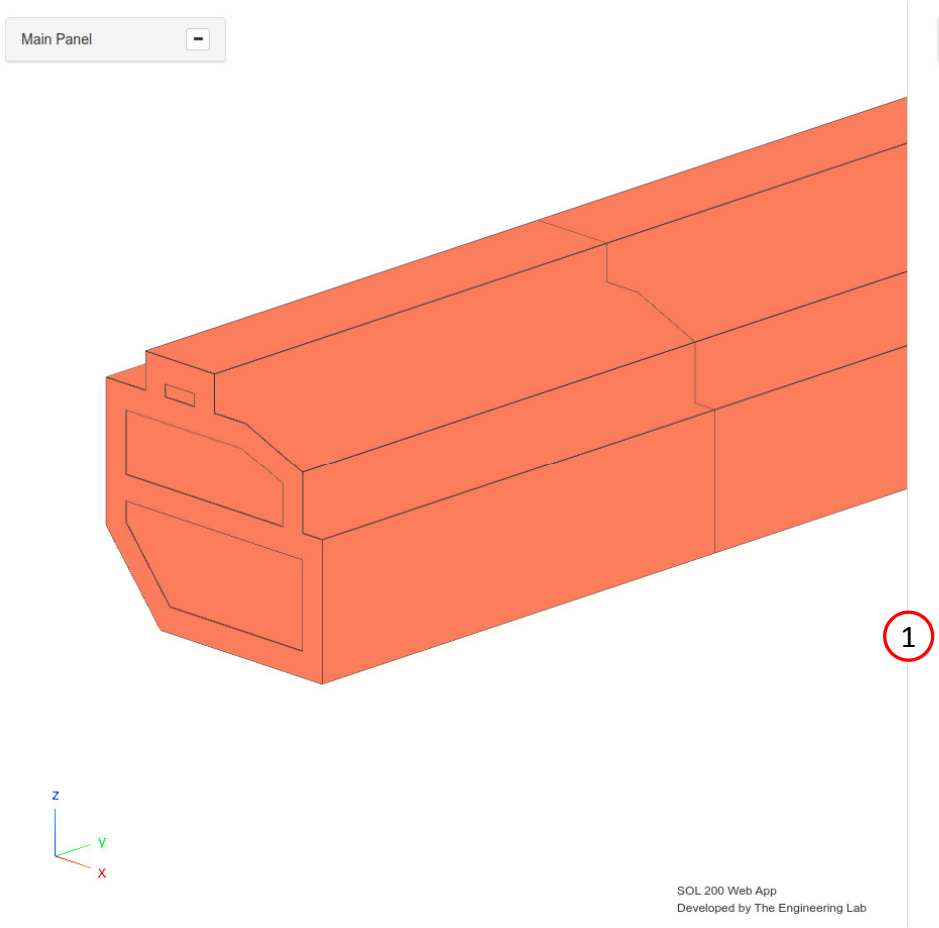
# Viewer

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

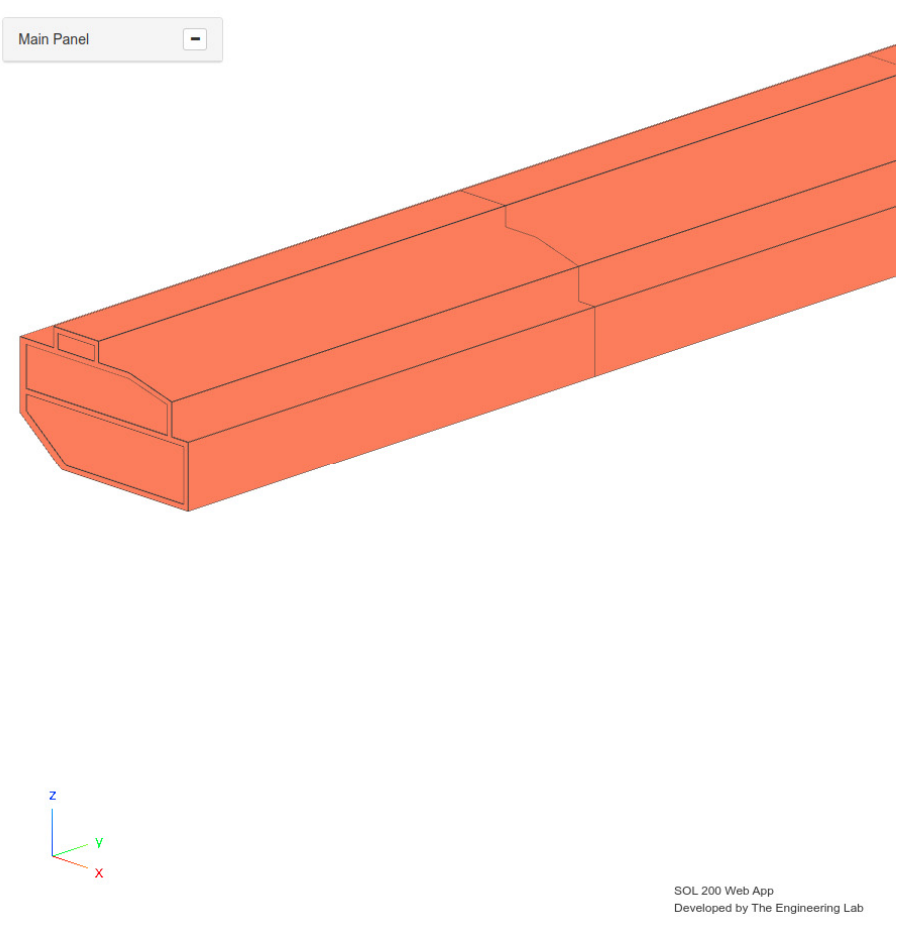


# Viewer

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.




1



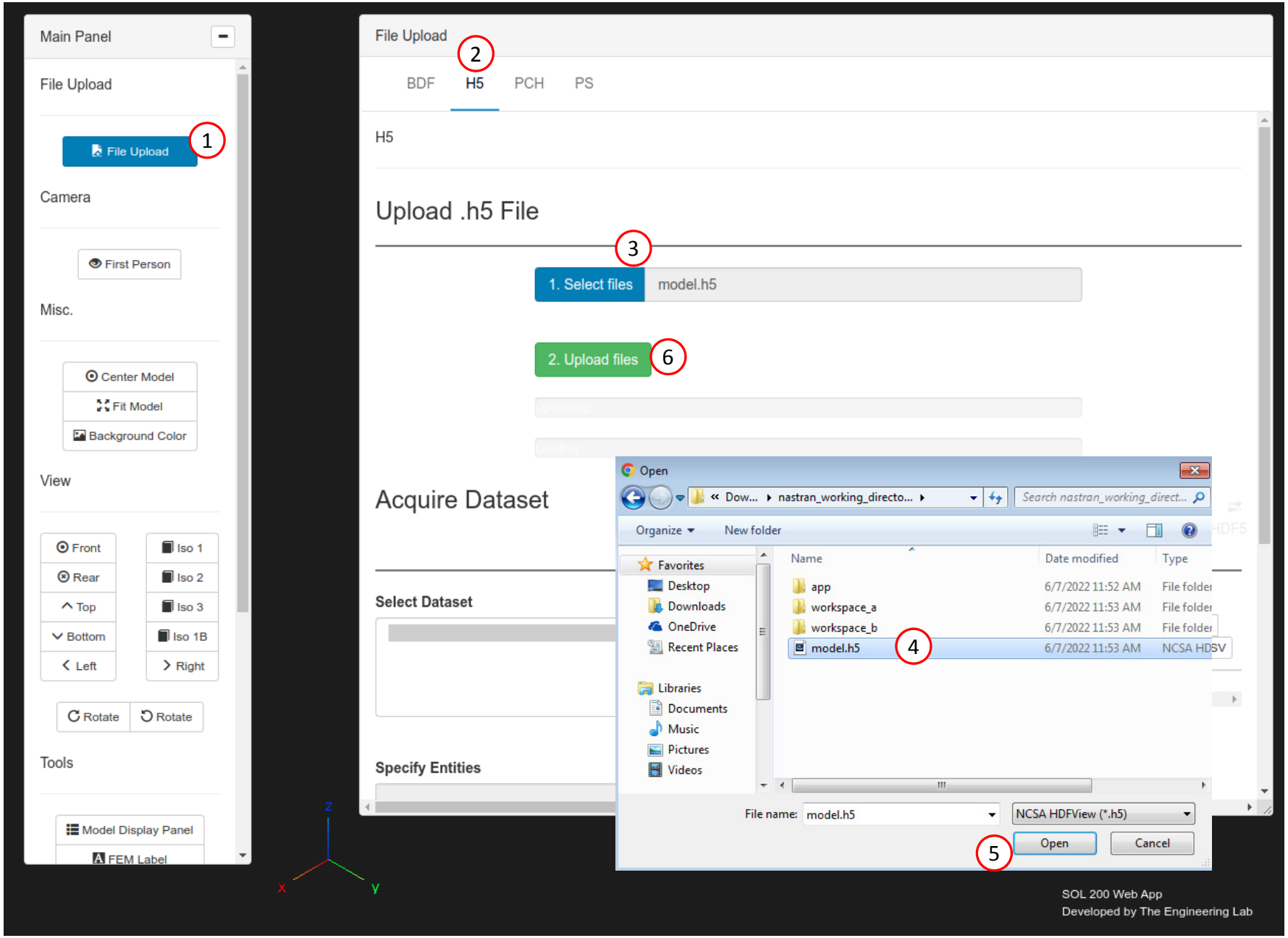

Initial Design
model.bdf

Final Design
model_final.bdf

# Part F – Inspecting the PBMSECT and CBEAM Results

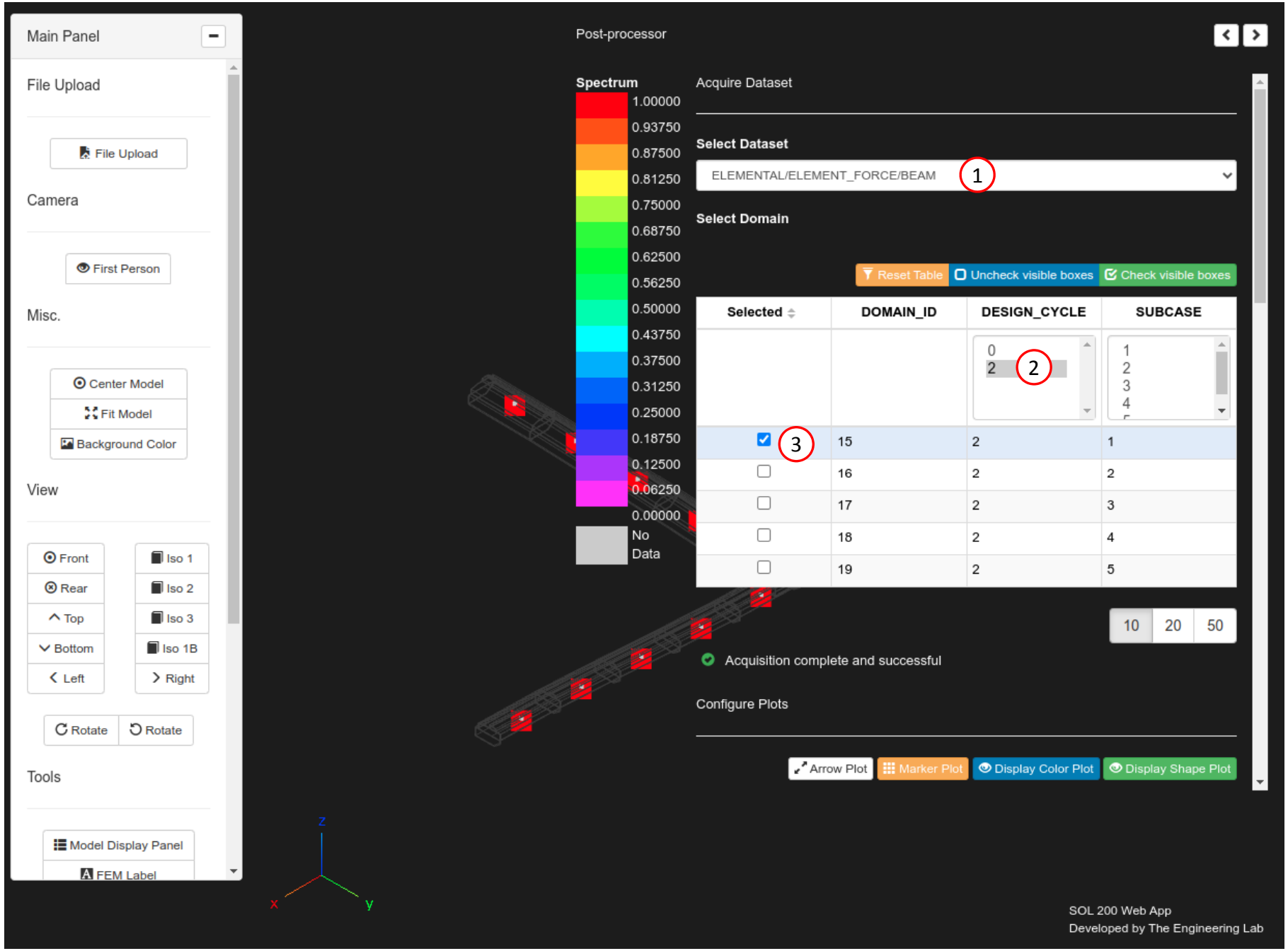
# Upload the H5 File

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



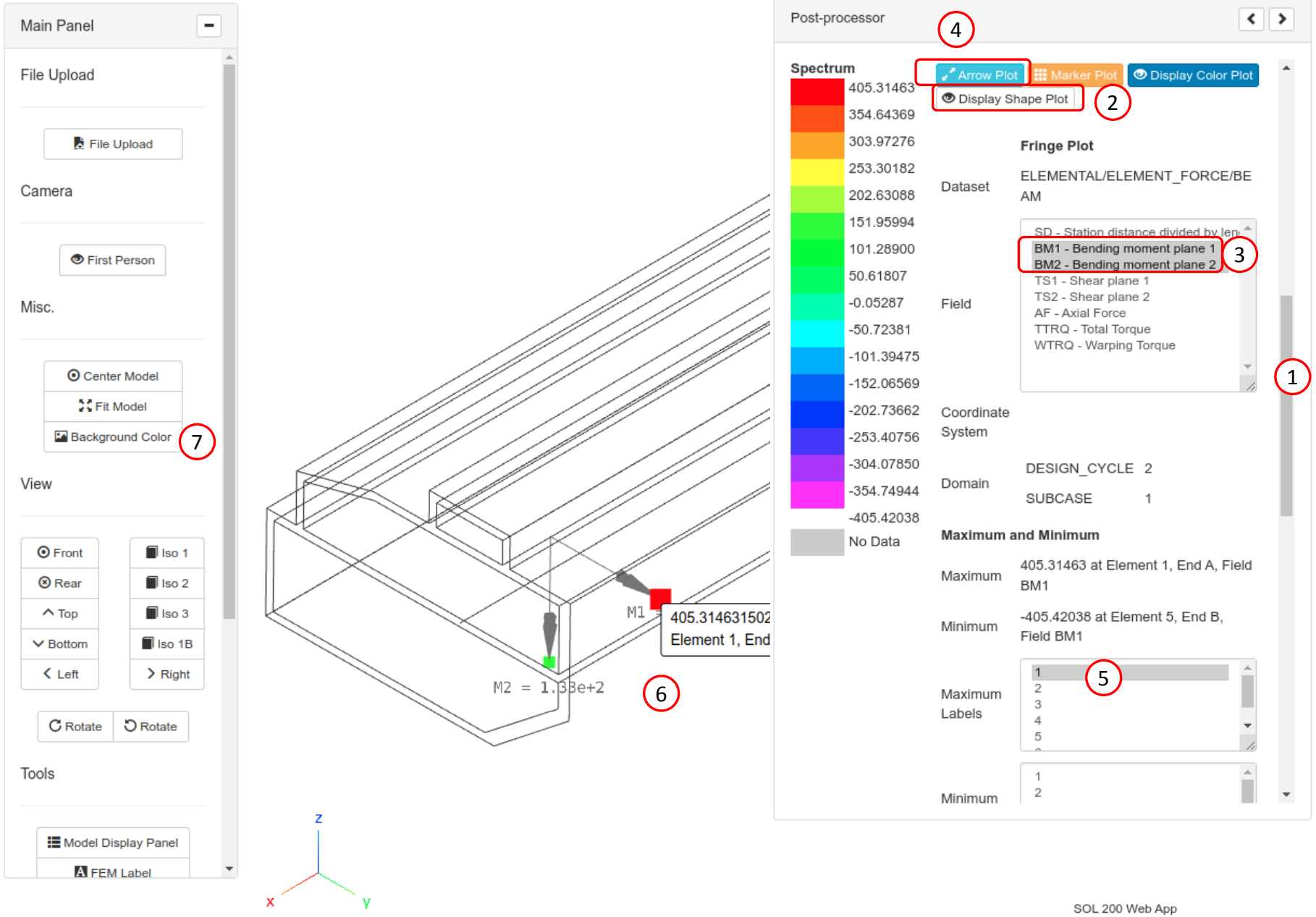
# Display Internal Element Moments

1. Select dataset: ELEMENTAL/ELEMENT_FORCE/BEAM
2. Select DESIGN_CYCLE 2
3. Select the indicated checkbox



# Display Internal Element Moments

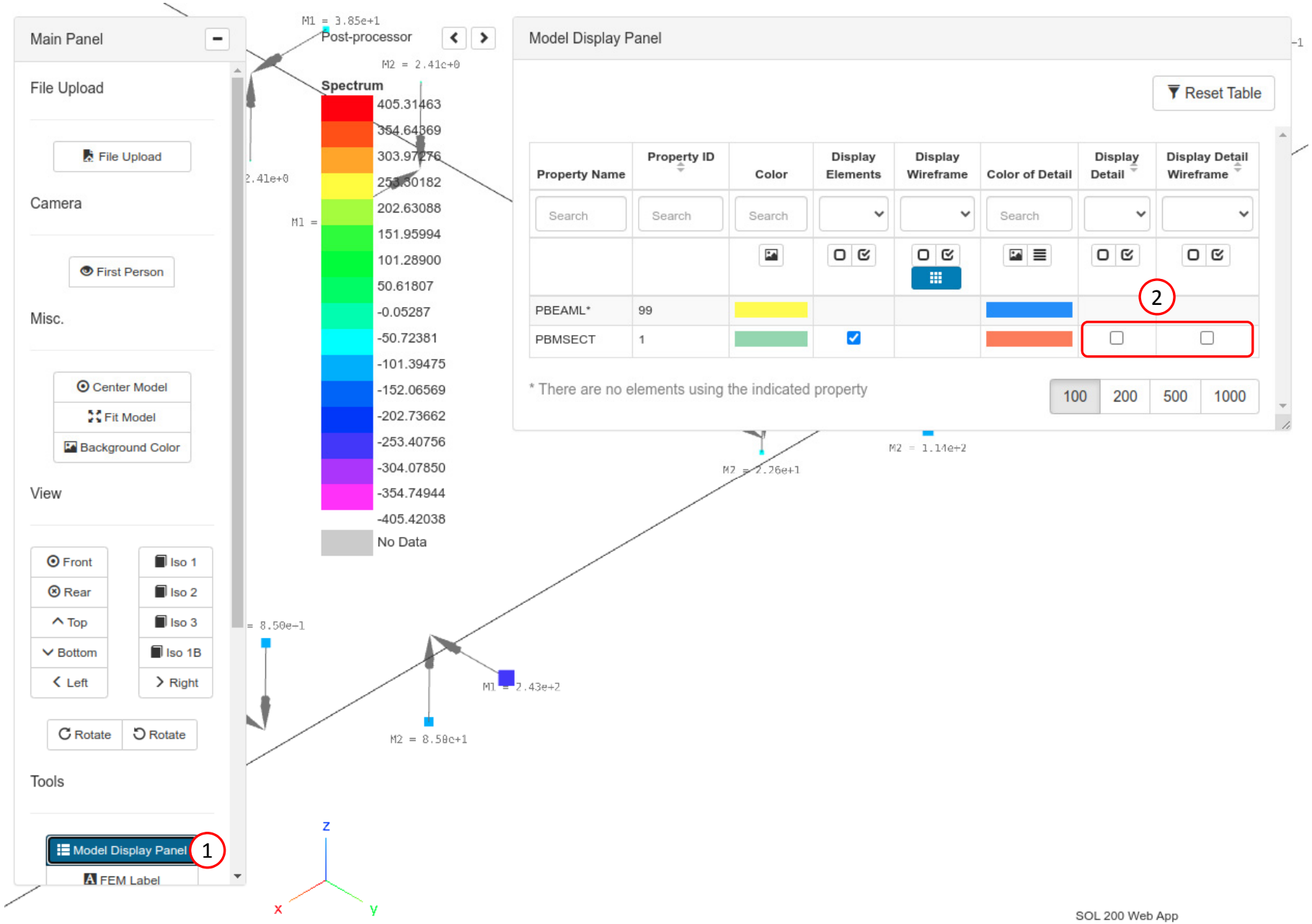
1. Use scroll bar to move to the Fringe Plot section
2. Click Display Shape Plot
3. Select the indicated fields for moments M1 and M2
4. Click Arrow Plot
5. Display the first maximum label
6. Rotate and zoom in to the location of the first maximum label
7. Click Background Color




SOL 200 Web App
Developed by The Engineering Lab

# Display Internal Element Moments

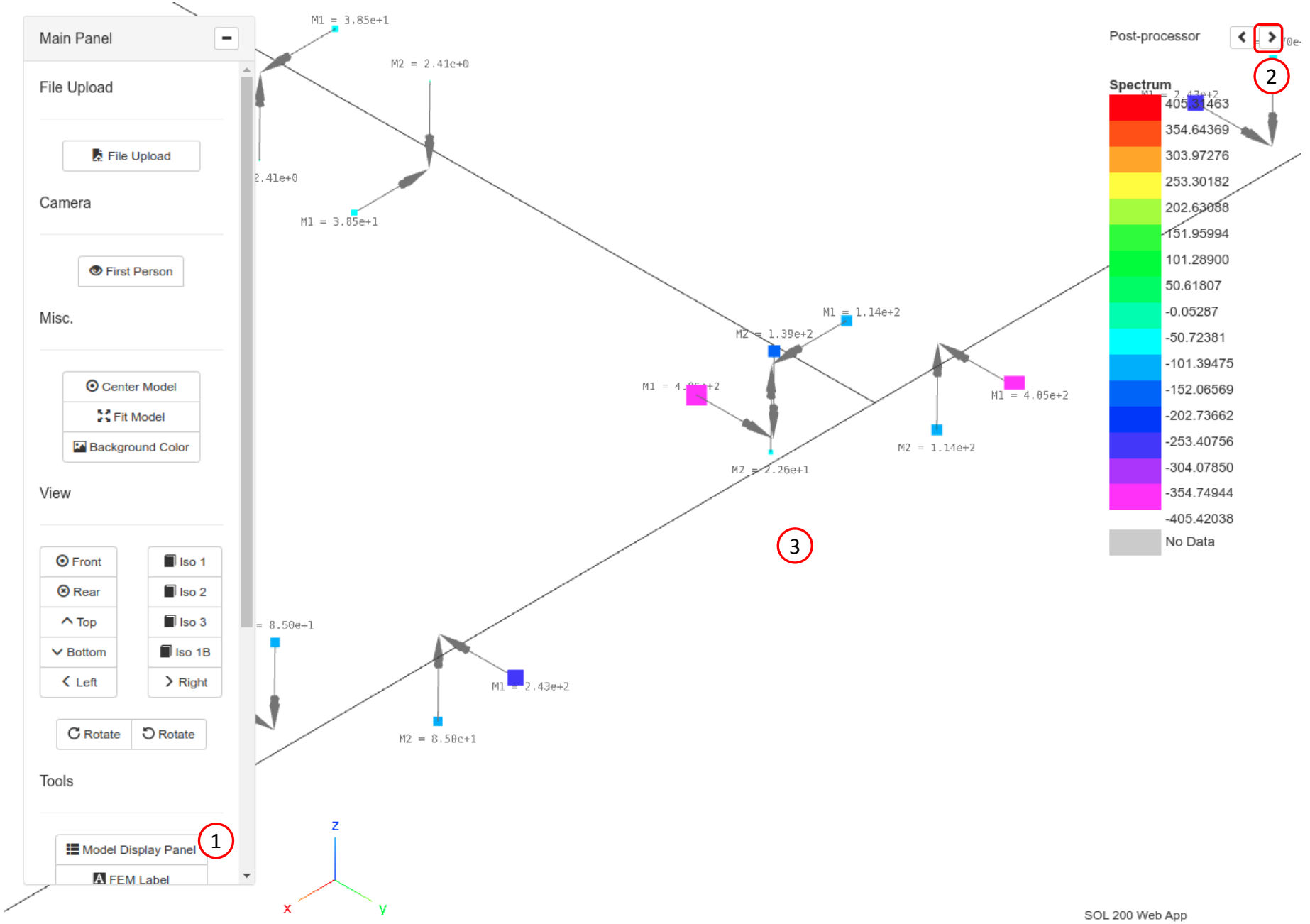
1. Click Model Display Panel
2. Deselect the indicated checkboxes




SOL 200 Web App
Developed by The Engineering Lab

# 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



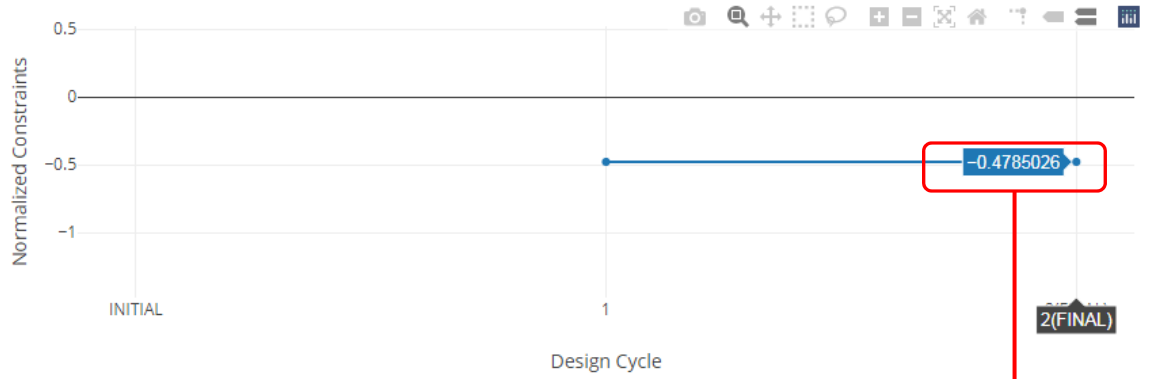

SOL 200 Web App
Developed by The Engineering Lab

# 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 -.4785026 and corresponds to a displacement of -.0052150 (z component of displacement at grid 6 and subcase 5).

Normalized Constraints

+ Info




SOL 200 Web App - Responses

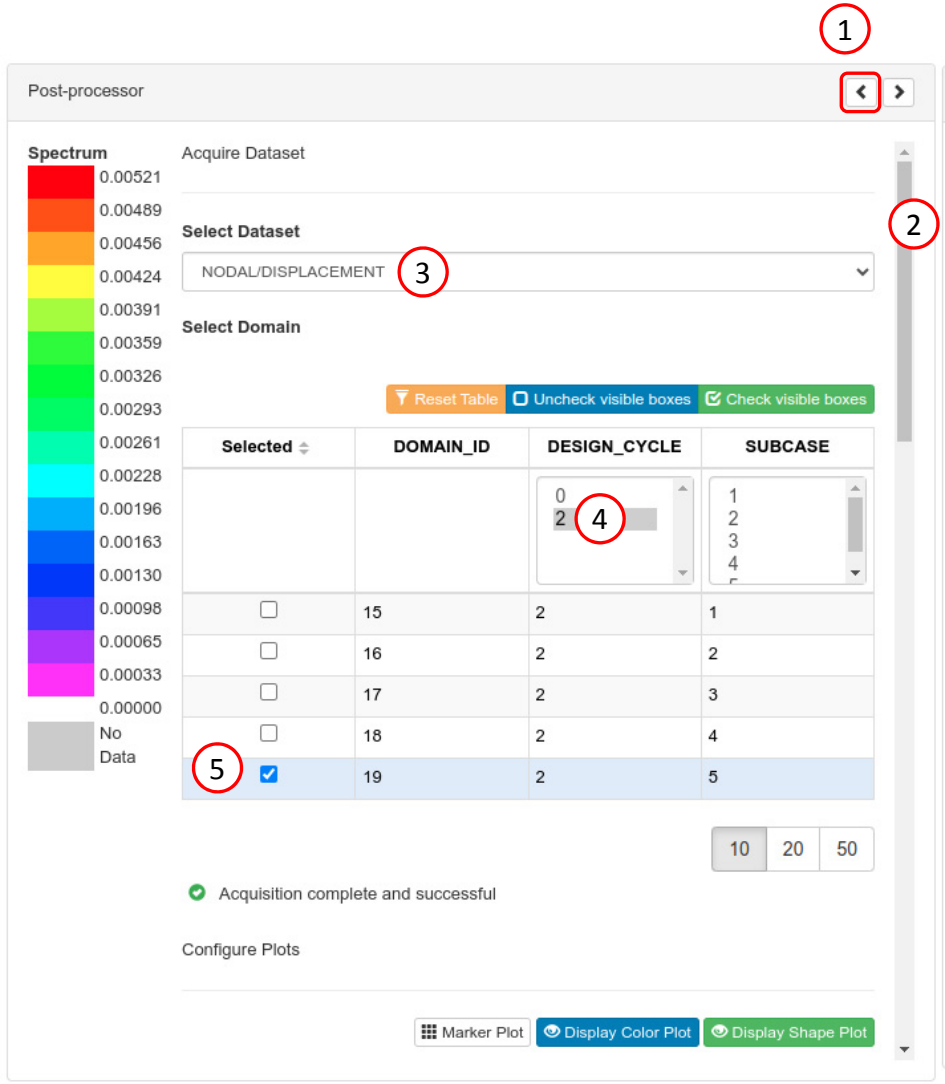
Responses

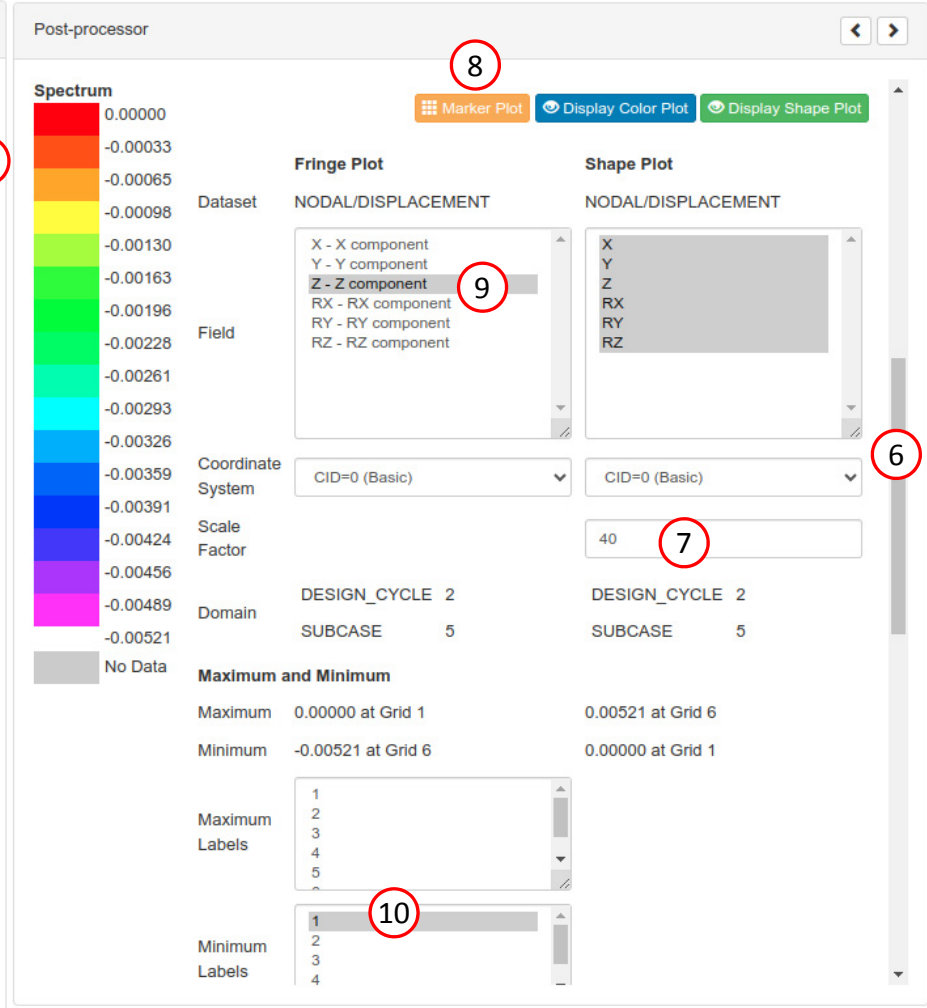
Reset view | Violated constraints | Active constraints | Maximum constraint for each design cycle

| Design Cycle | Subcase | Label | Response Type | Normalized Constraint | Lower Bound | Value | Upper Bound | Normalized Constraint | Show More Information | designCycleNumber | GRID ID | COMPONENT NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Search | Search | Sea | Search | Search | Search | Search | Sear | 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

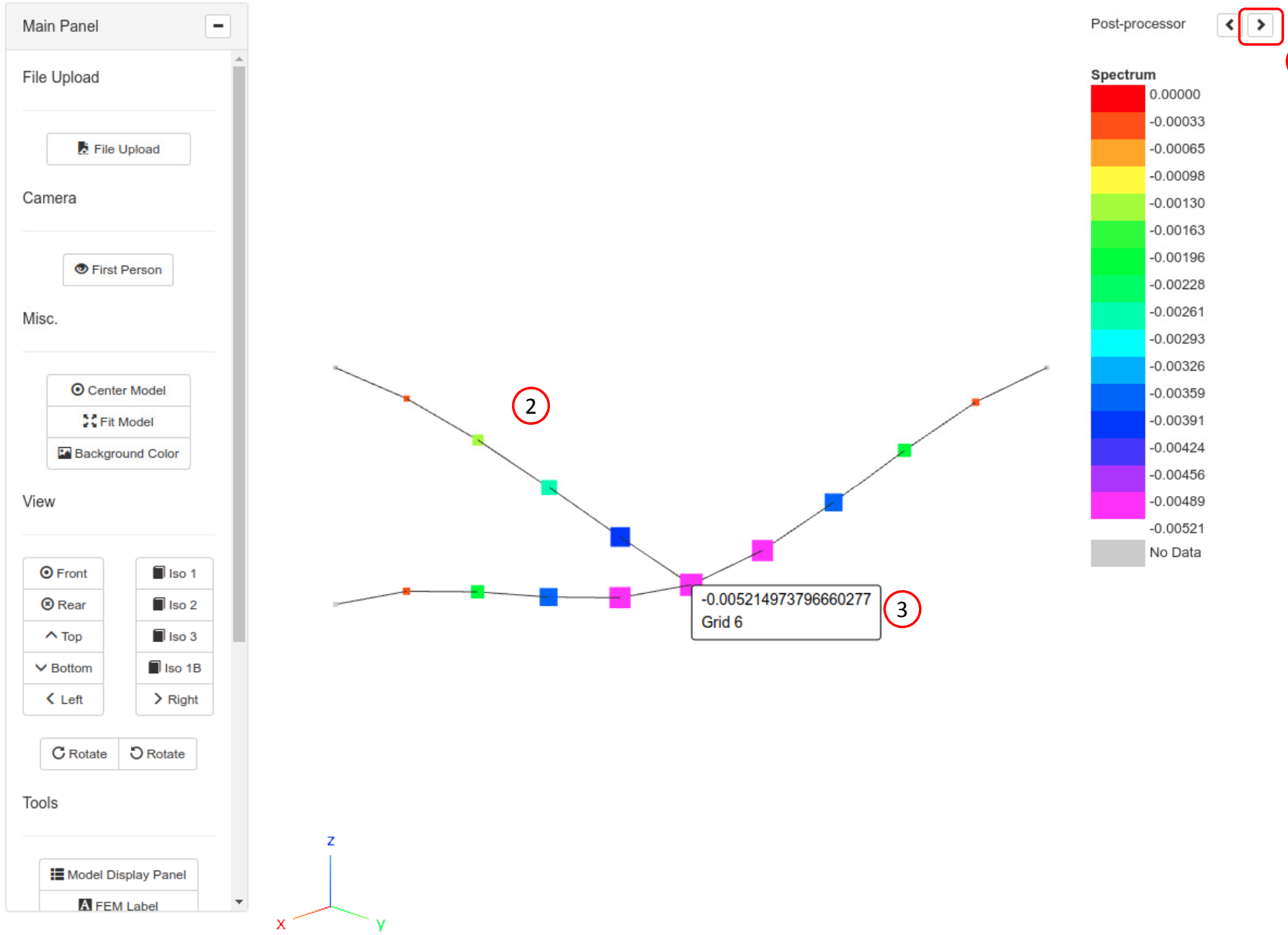
1. Click the indicated button to show the Post-processor panel
2. Move the scroll bar until the Acquire Dataset section is visible
3. Set Select Dataset to NODAL/DISPLACEMENT
4. Select DESIGN_CYCLE 2
5. Select the indicated checkbox
   - Note the checkbox corresponds to design cycle 2, subcase 5
6. Move 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



# 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

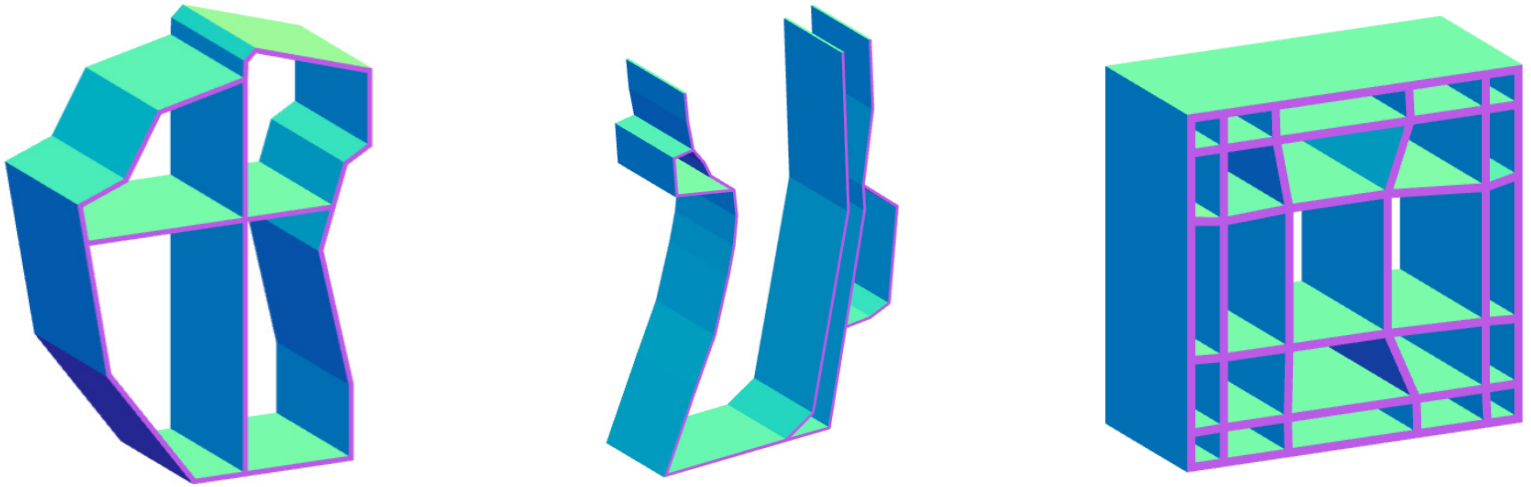
# Appendix Contents

- 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?

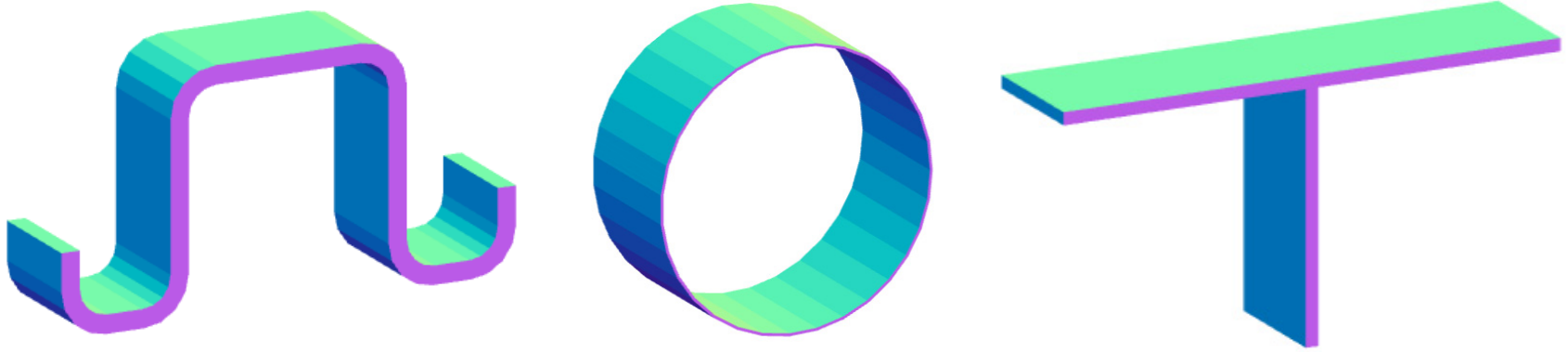
# Procedure to Create PBMSECT/PBRSECT Entries

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



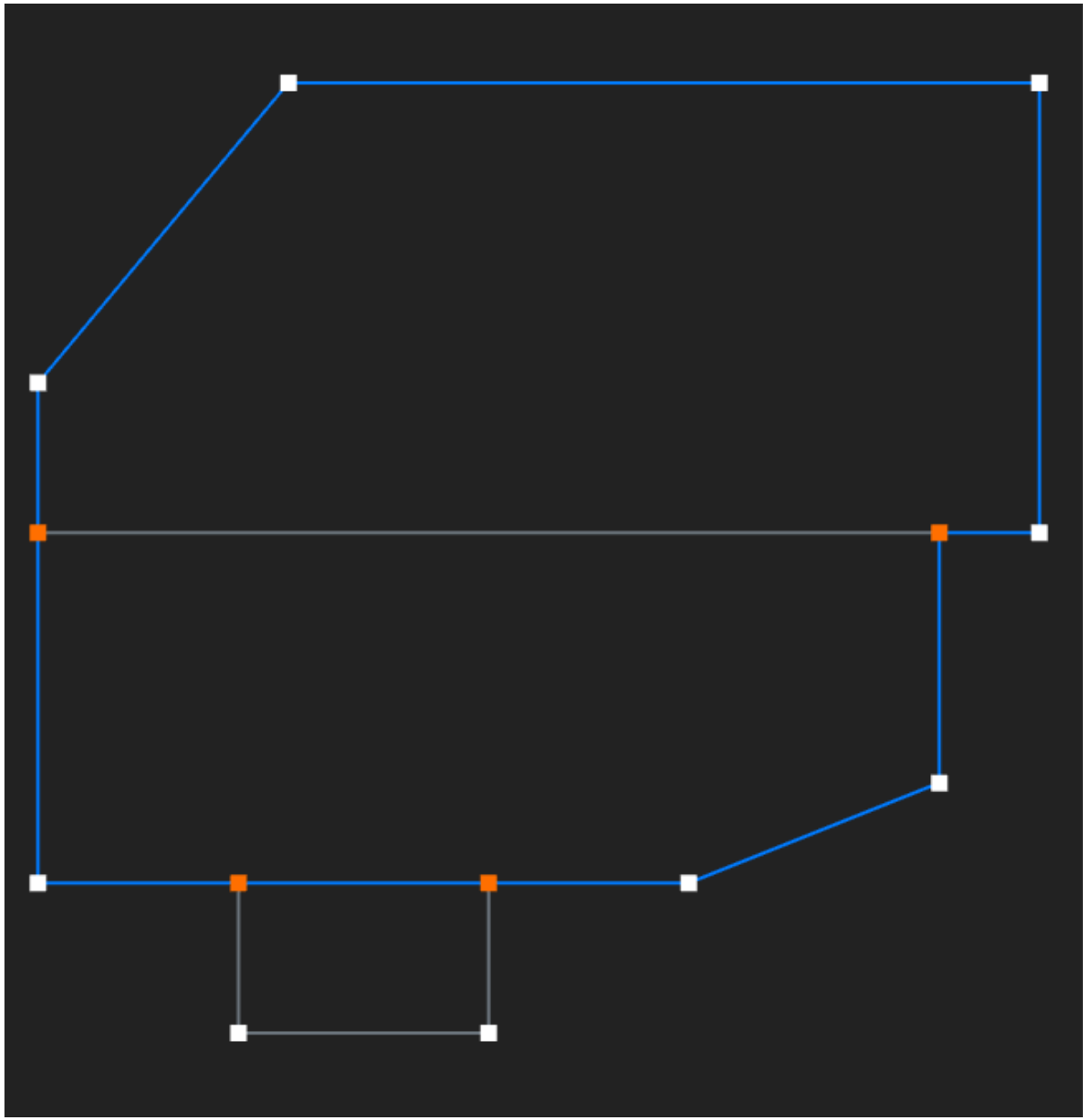
Composite Arbitrary Beam Cross Section Examples



# 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

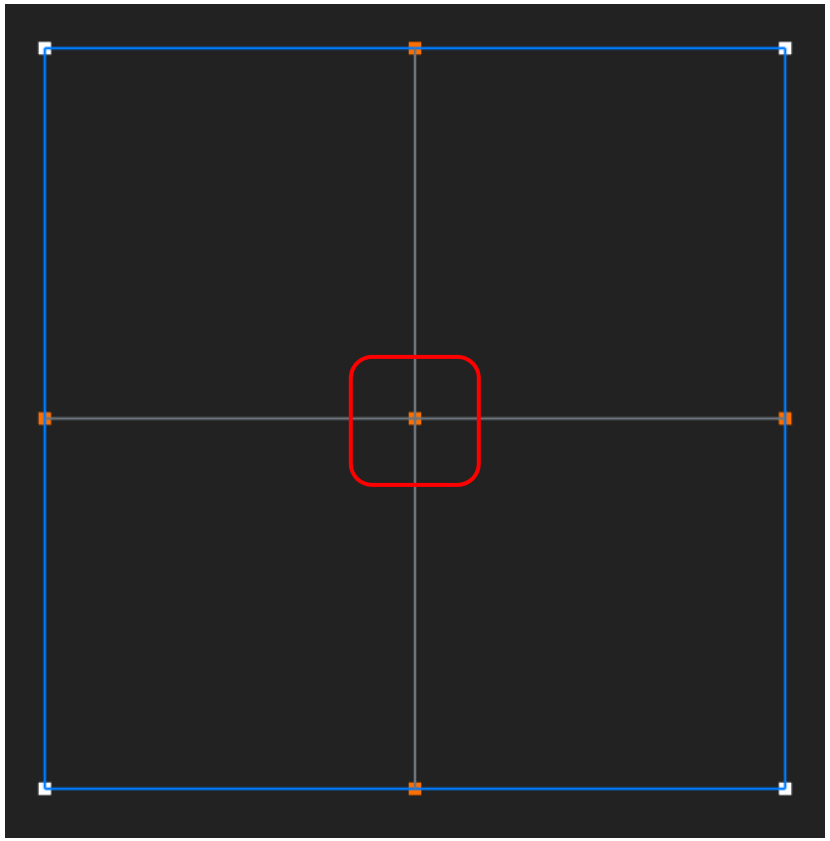
| Color | Description |
|---|---|
| | Outer Perimeter (OUTP) |
| | Possible lines for OUTP |
| | Critical Points |

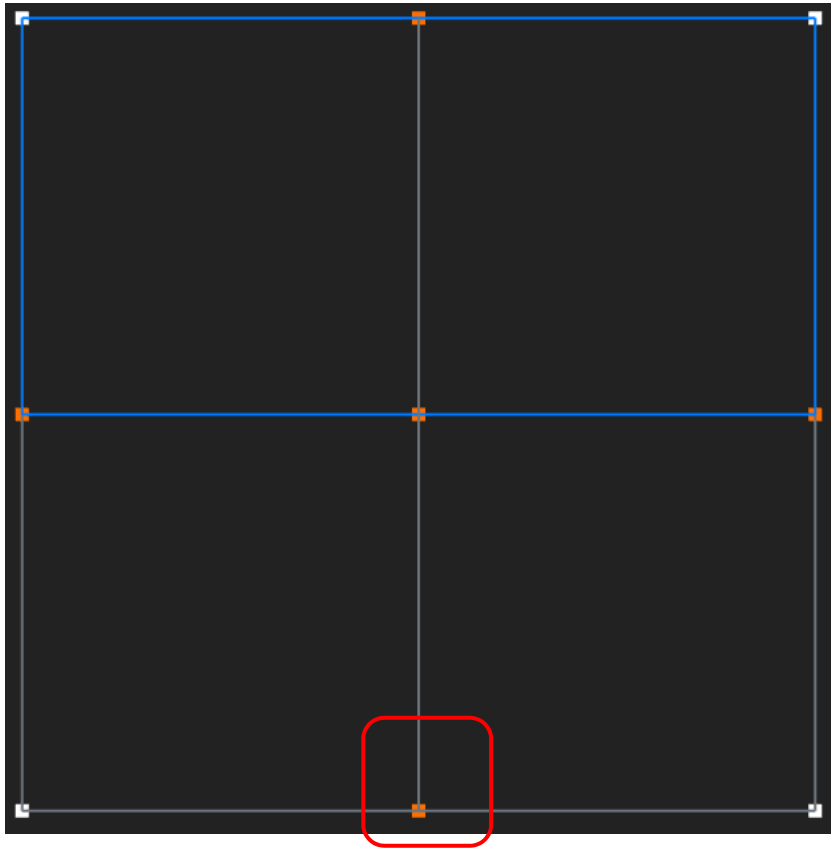
# Comment on Critical Points

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

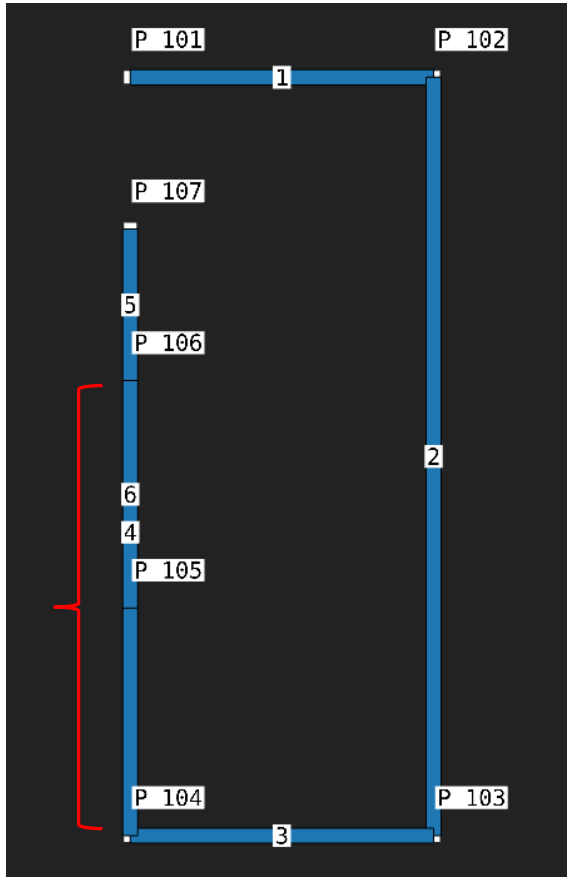
| Entry | Custom ID | Status | IDs Used by this PBMSECT/PBRSECT | IDs Used by other entries |
|---|---|---|---|---|
| PBMSECT/ PBRSECT | 78020 | ✔ | 78020 | |
| SET1 | 2000 | ✔ | | |
| POINT | 2001 | ! Check separately to ensure POINT IDs do not conflict with GRID IDs | | |

1

# UFM 7201 Cause 1

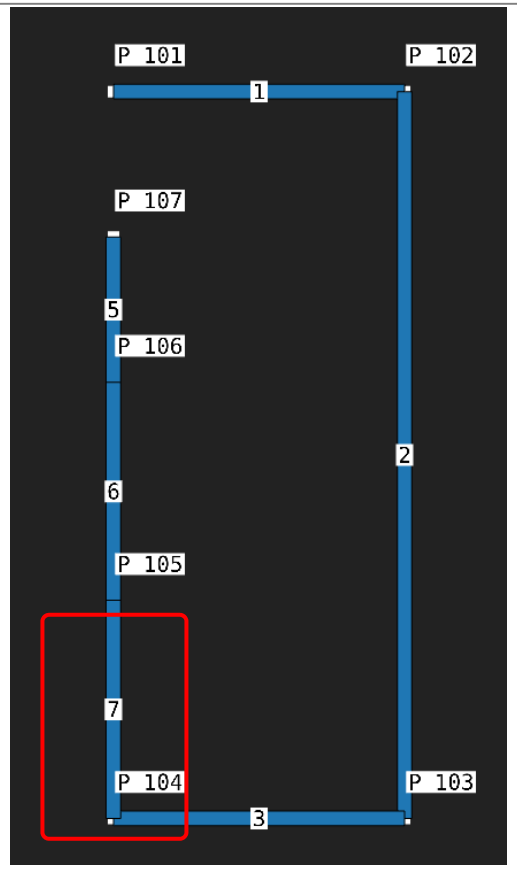
1. This UFM sometimes occurs if line segments overlap

```
*** 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



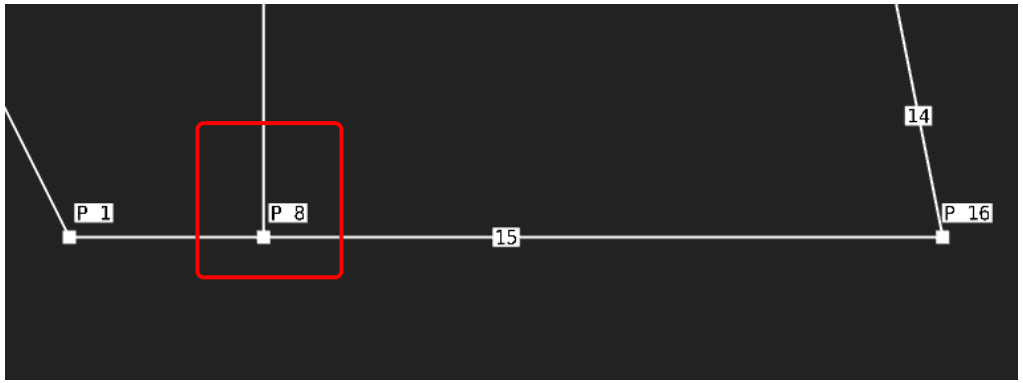

Correct: Line 4 is removed and line 7 is created.

# 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

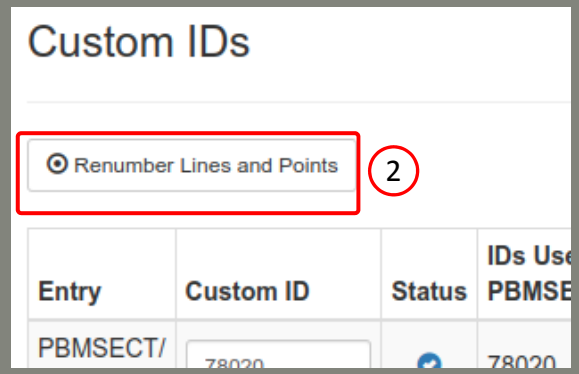



Correct: Point 8 is moved to avoid being too close to line 15

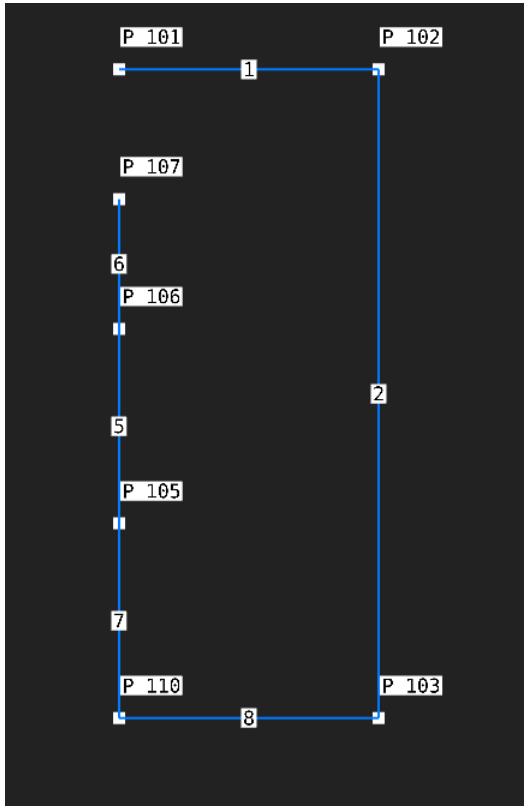
# UFM 7201 Cause 2

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

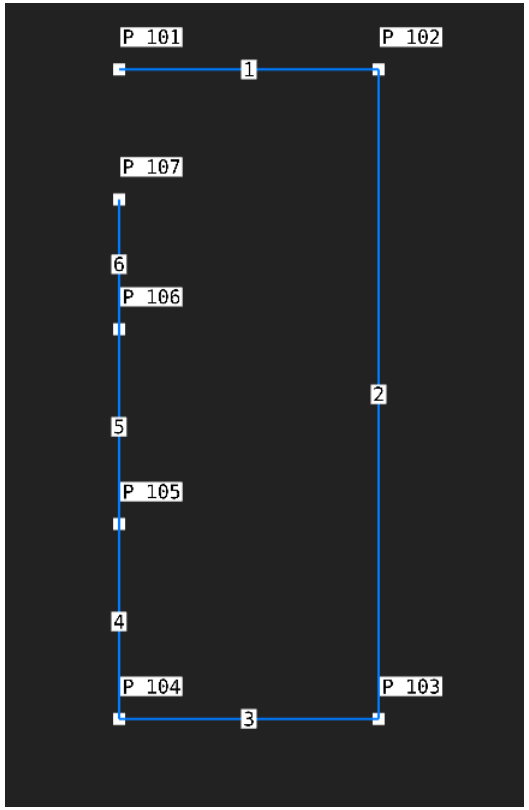
1. Click Renumber Lines and Points to automatically renumber the POINT IDs




```
*** 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.

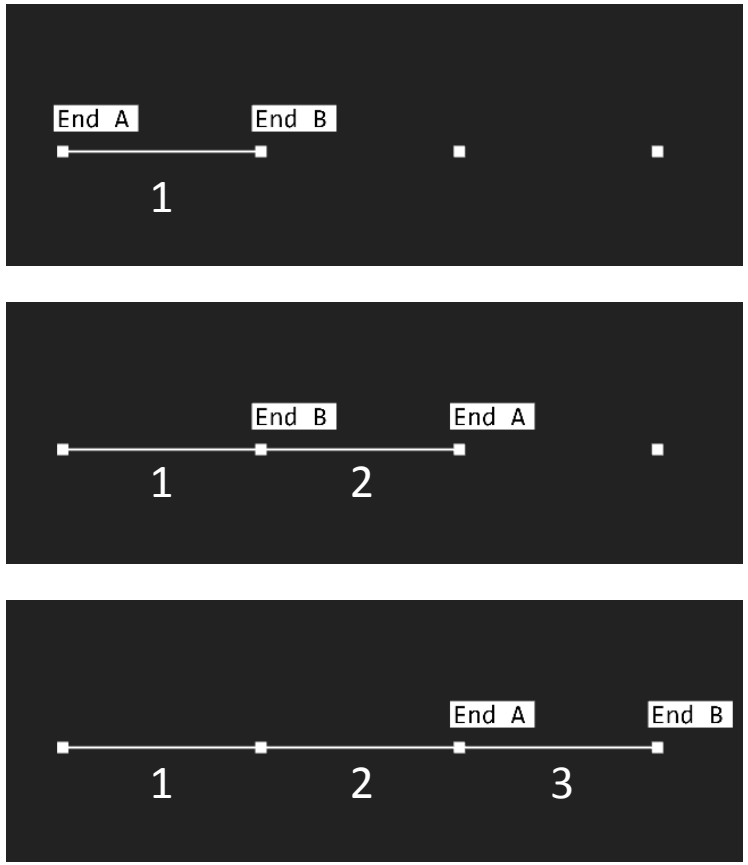
# UFM 7201

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

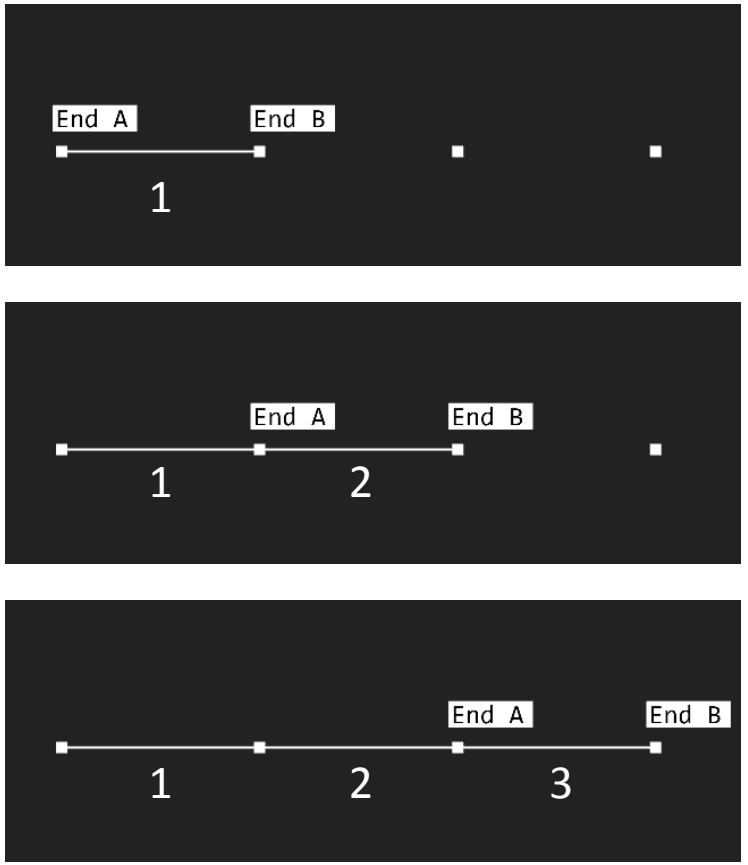
Step 1

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

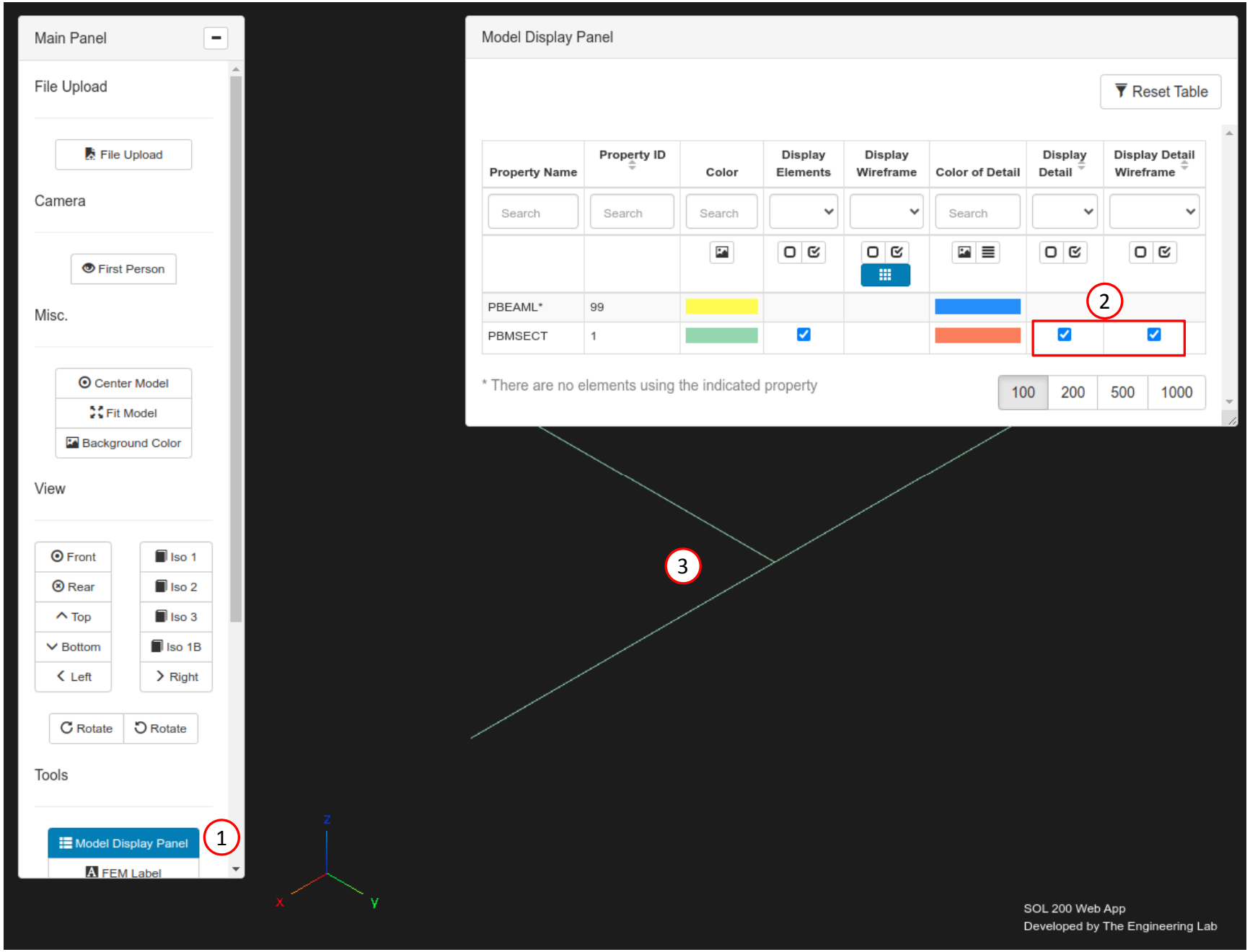
1. Click Model Display Panel
2. Mark the indicated checkboxes
3. If the arbitrary cross section (ABCS) is not displayed, then an error has occurred

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.

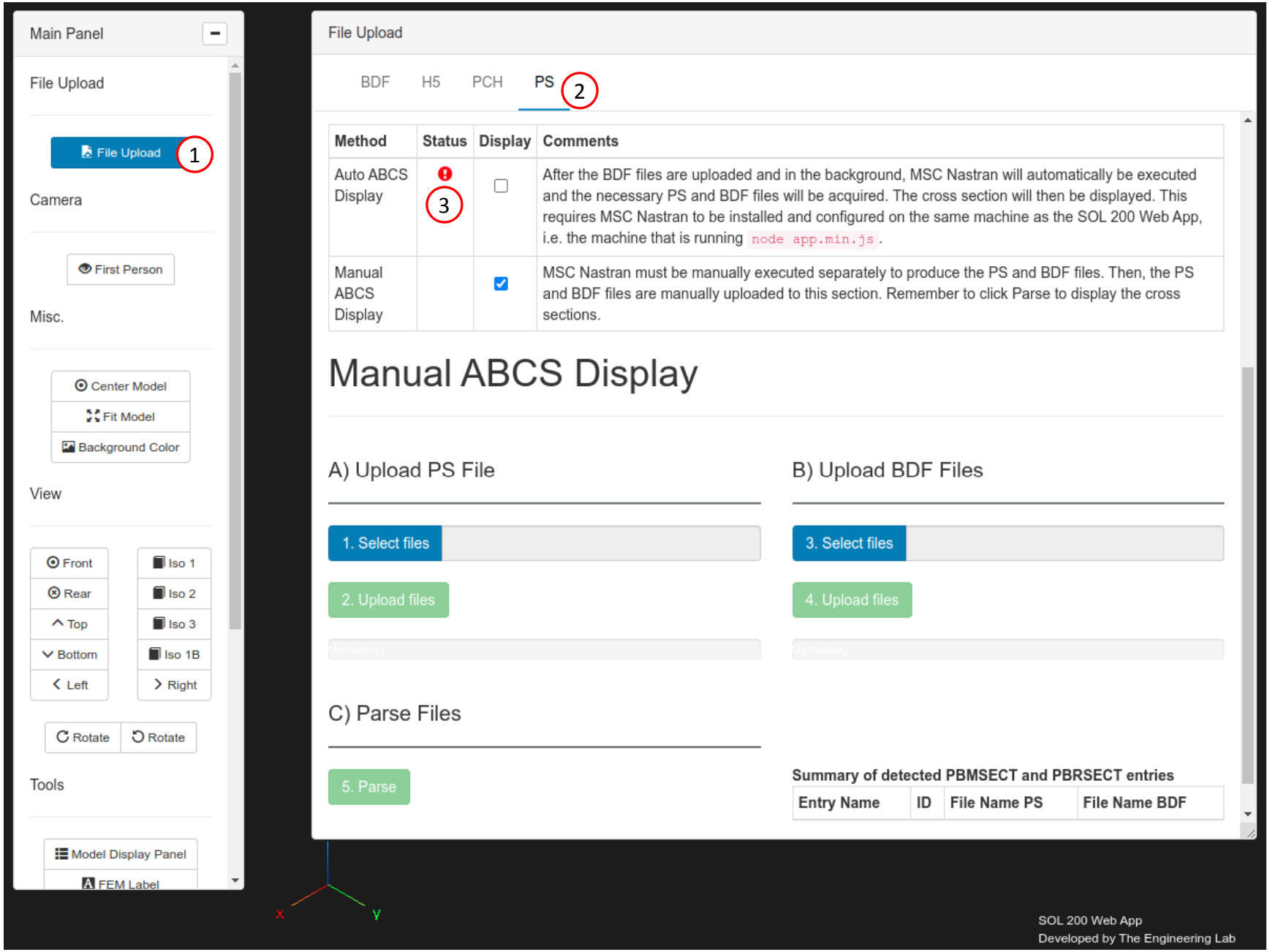
If the MSC Nastran run is unsuccessful, the PS and BDF files will be unavailable, and the ABCS will not be displayed.

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



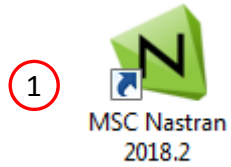
# Verify the Status

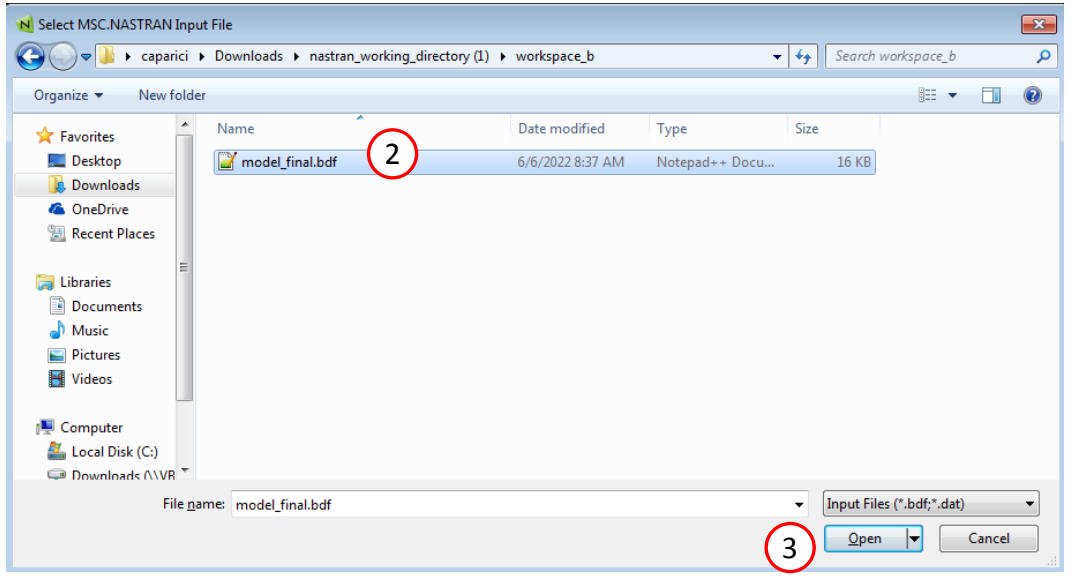
1. Click File Upload
2. Click Upload PS
3. If an error occurred during the MSC Nastran run, this is indicate in the status column of the first row of the table.

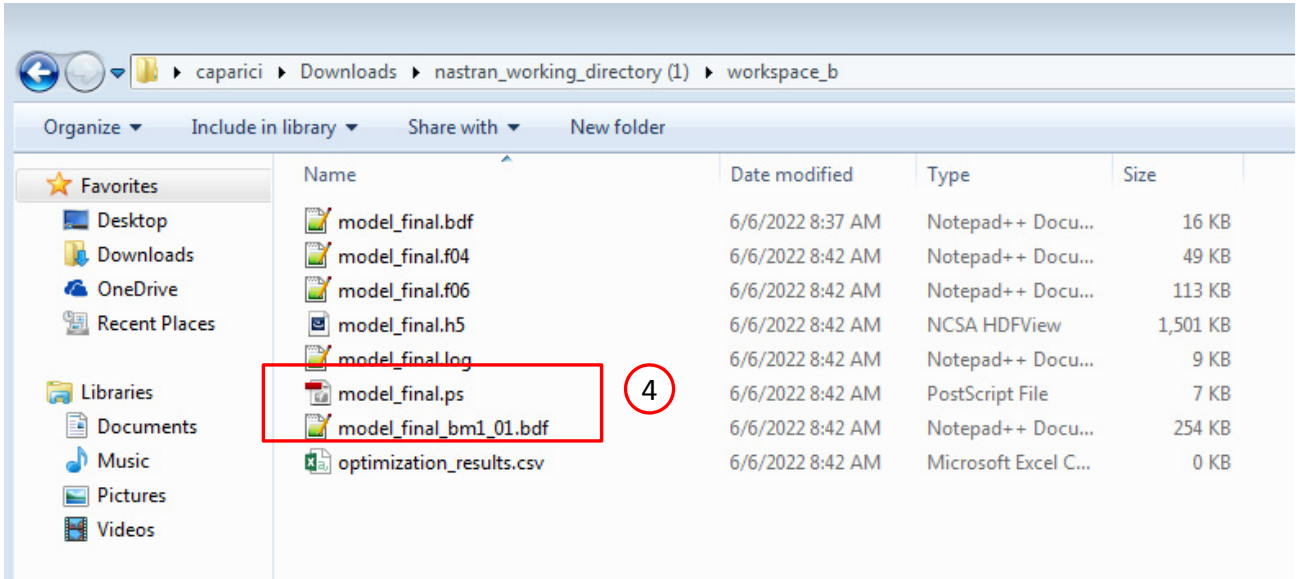


# Manually Generating the PS and BDF Files

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



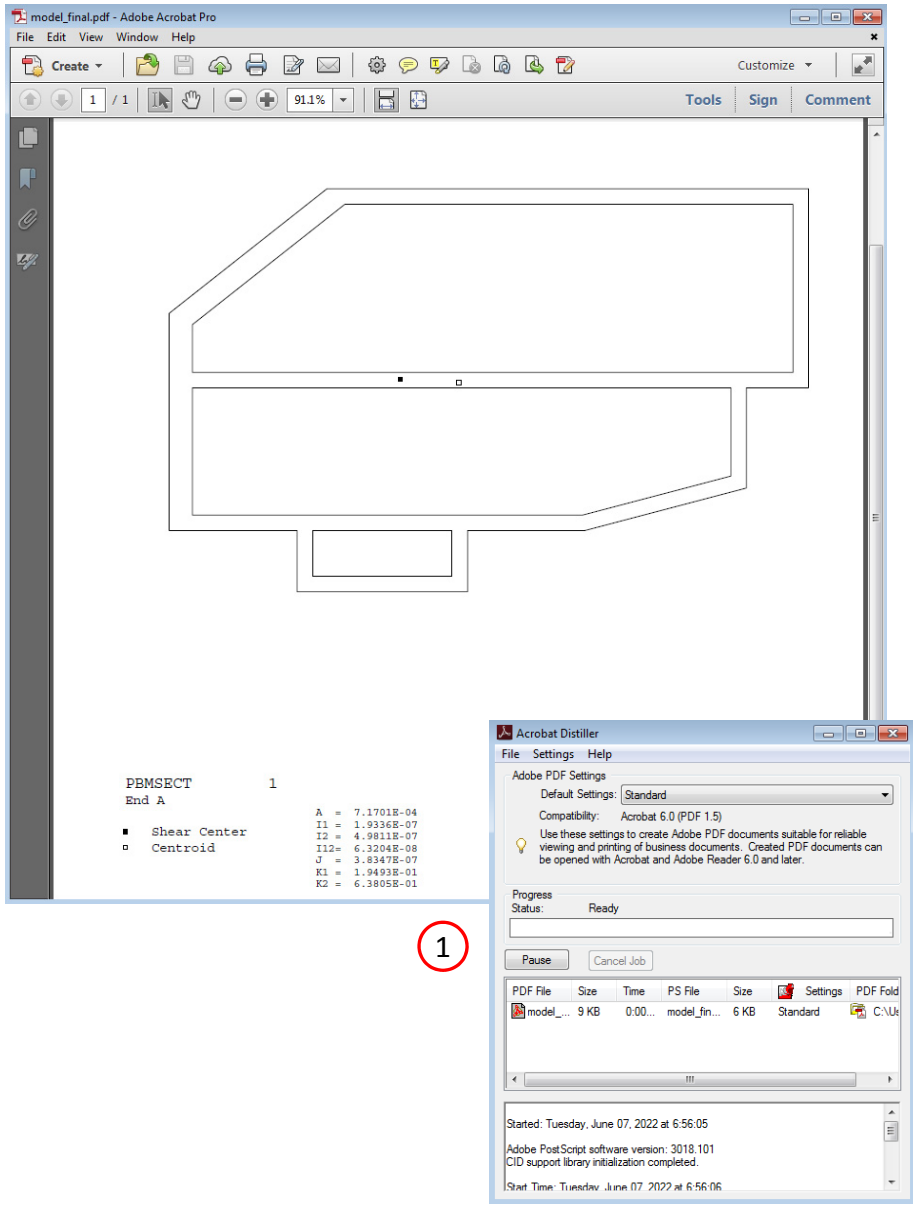



# Viewing the PS and BDF Files

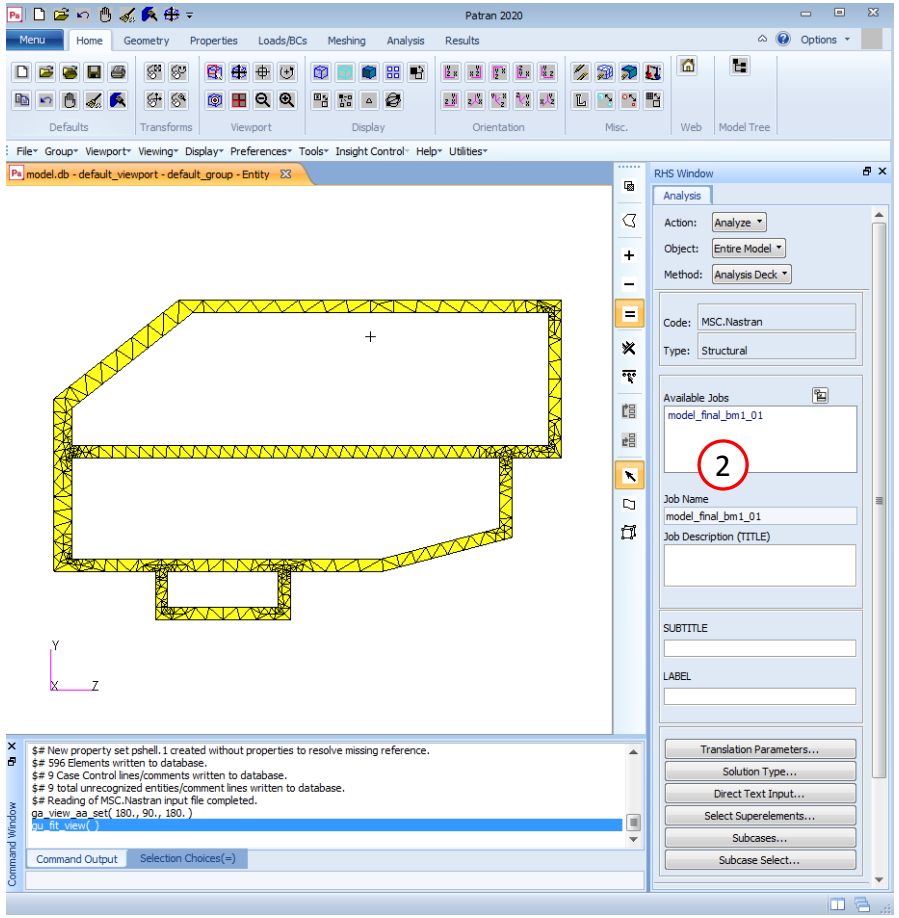
These steps are optional

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

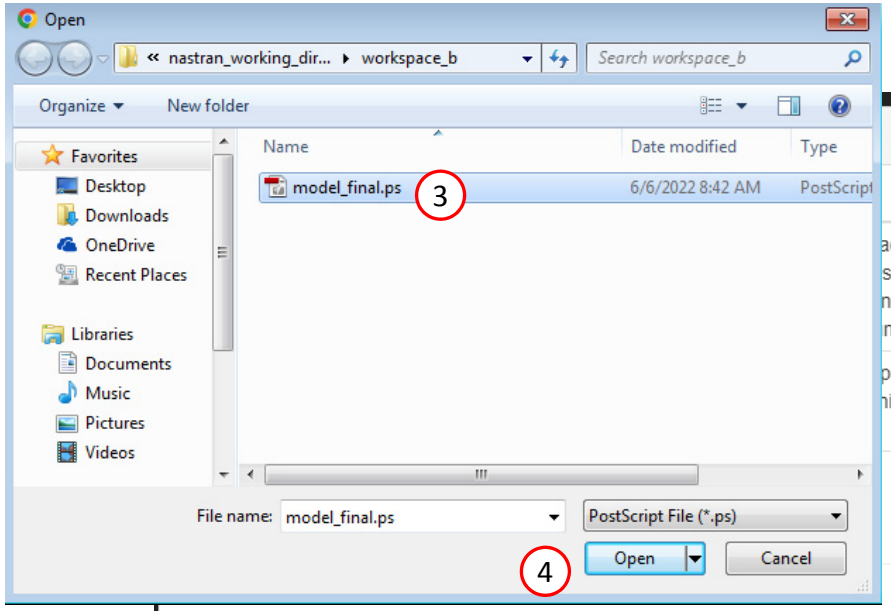


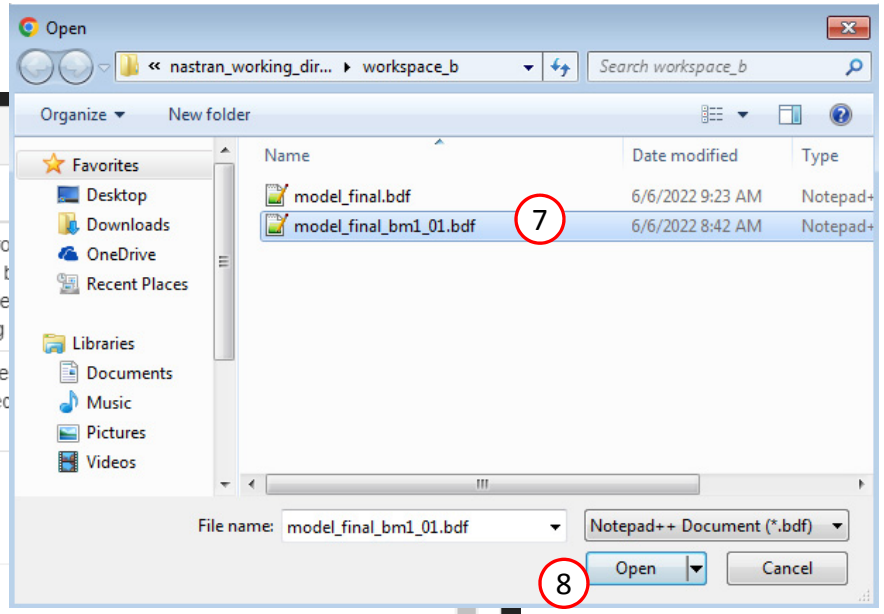

model_final_bm1_01.bdf

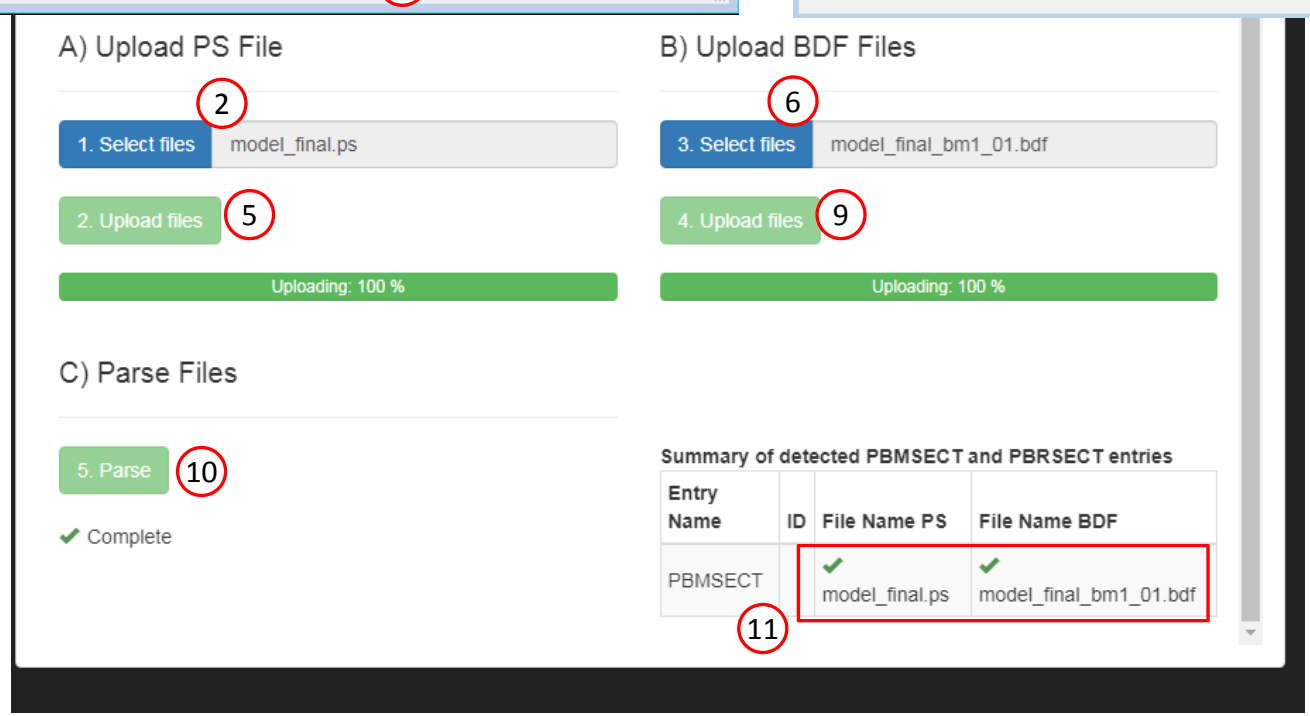


# Upload the PS and BDF Files to the Viewer

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. Slick 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.



# 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