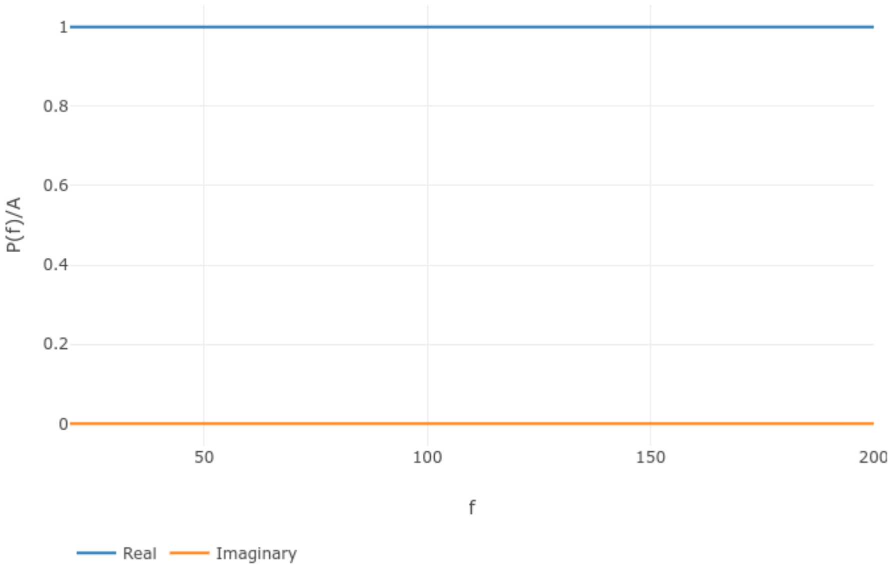
Workshop – Creation of Dynamic Loads via RLOAD1 or RLOAD2 Entries

AN MSC NASTRAN SOL 200 TUTORIAL

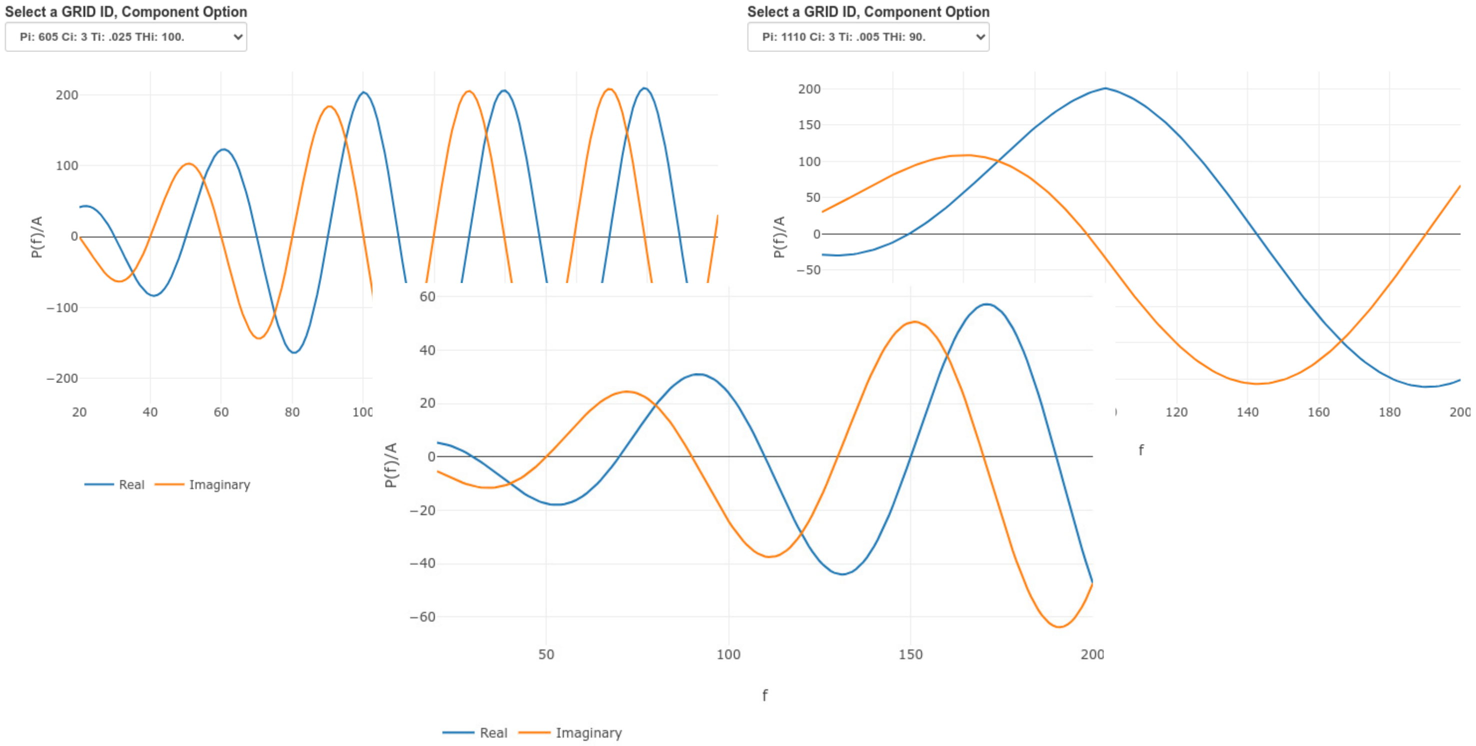
Goal: Update the Temporal Distribution of Dynamic Load

Goal: Create bulk data entries RLOAD1, TABLED1, TABLED4, DELAY, DPHASE

Before



After



Details of the structural model

Dynamic Response Optimization

This example demonstrates structural optimization when the structural loads are frequency dependent. The system considered is a flat rectangular plate clamped on three edges and free along the fourth, as shown in Figure 8-21. The problem investigates minimization of the mean square response of the transverse displacement at the midpoint of the free edge, while constraining the volume of the structure (and hence, weight) to be equal to that of the initial design. A pressure loading with an amplitude of $1.0\ \mathrm{lb_f/in^2}$ is applied across a frequency range of 20.0 to 200.0 Hz. A small amount of frequency-dependent modal damping has also been included.

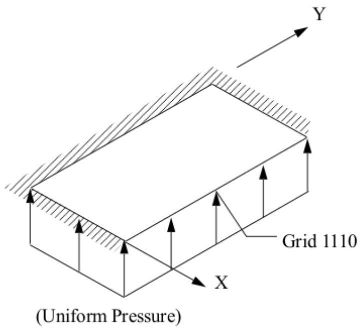
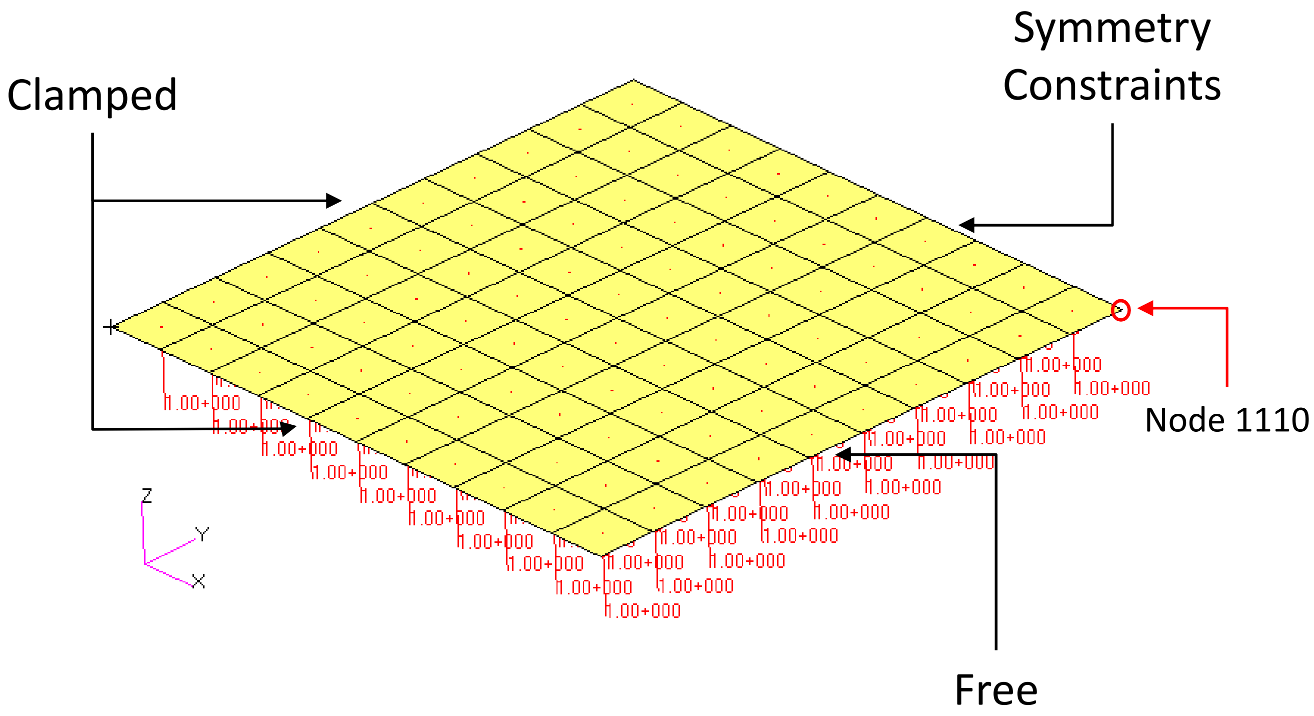


Figure 8-21 Pressure-Loaded Flat Plate

MSC Nastran Design Sensitivity and Optimization User's Guide Chapter 8 - Example Problems - Dynamic Response Optimization



Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

Tutorial

Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
   - Generate RLOAD1, RLOAD2, TABLED1, TABLED2, TABLED3, TABLED4, DELAY or DPHASE entries
3. Run MSC Nastran to confirm the dynamic load is correct

Special Topics Covered

Dynamic Loads - For frequency response analysis, the dynamic load is defined via RLOAD1, RLOAD2, TABLED1, TABLED2, TABLED3, TABLED4, DELAY or DPHASE entries. This exercise details the creation of these entries to define a desired dynamic load. A dynamic load is the product of a spatial distribution and a temporal distribution. The spatial distribution is the location of the load. The temporal distribution defines the variation of load based on the frequency. This exercise focuses exclusively on configuring the temporal distribution of dynamic loading.

GRID Dependent Delay and Phase – The dynamic applied may either be configured with constant delay or phase angle for all selected GRIDs OR a unique delay or phase angle may be specified for each GRID. This exercise details how to create DELAY and DPHASE entries, which define GRID dependent delay and phase angle values.

SOL 200 Web App Capabilities

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

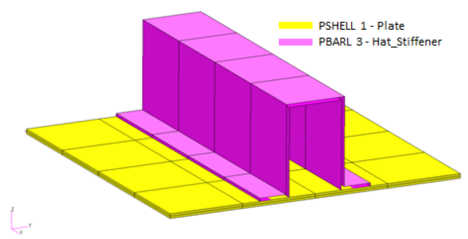
Compatibility

- 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.

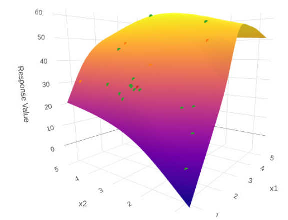
Benefits

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

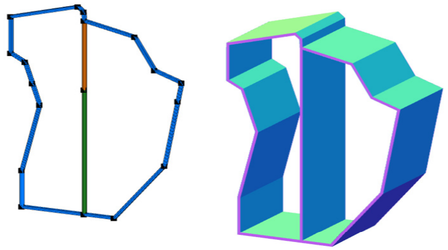
Web Apps



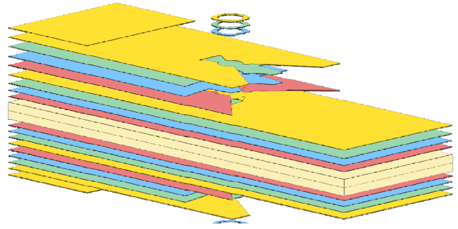
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



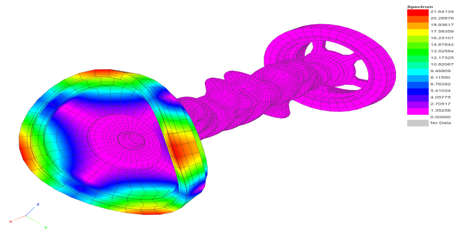
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



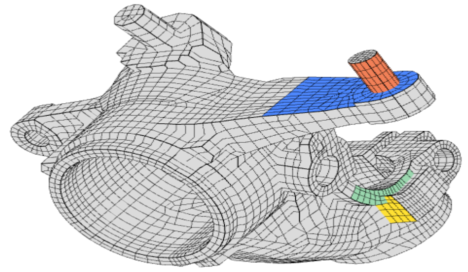
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



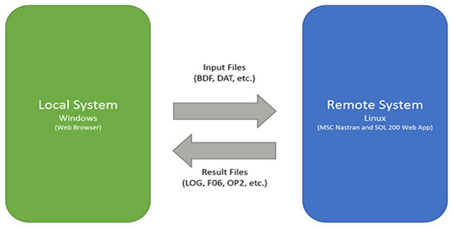
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



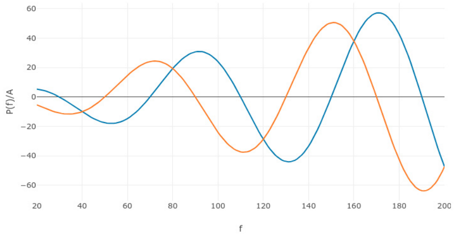
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



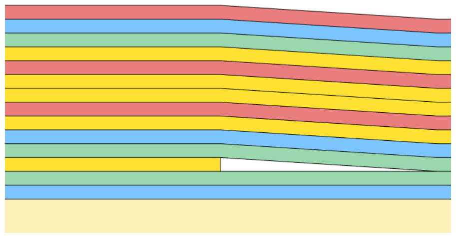
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



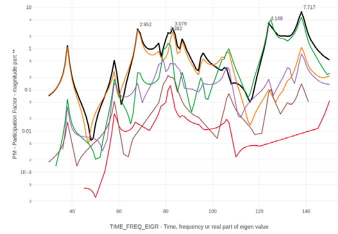
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



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

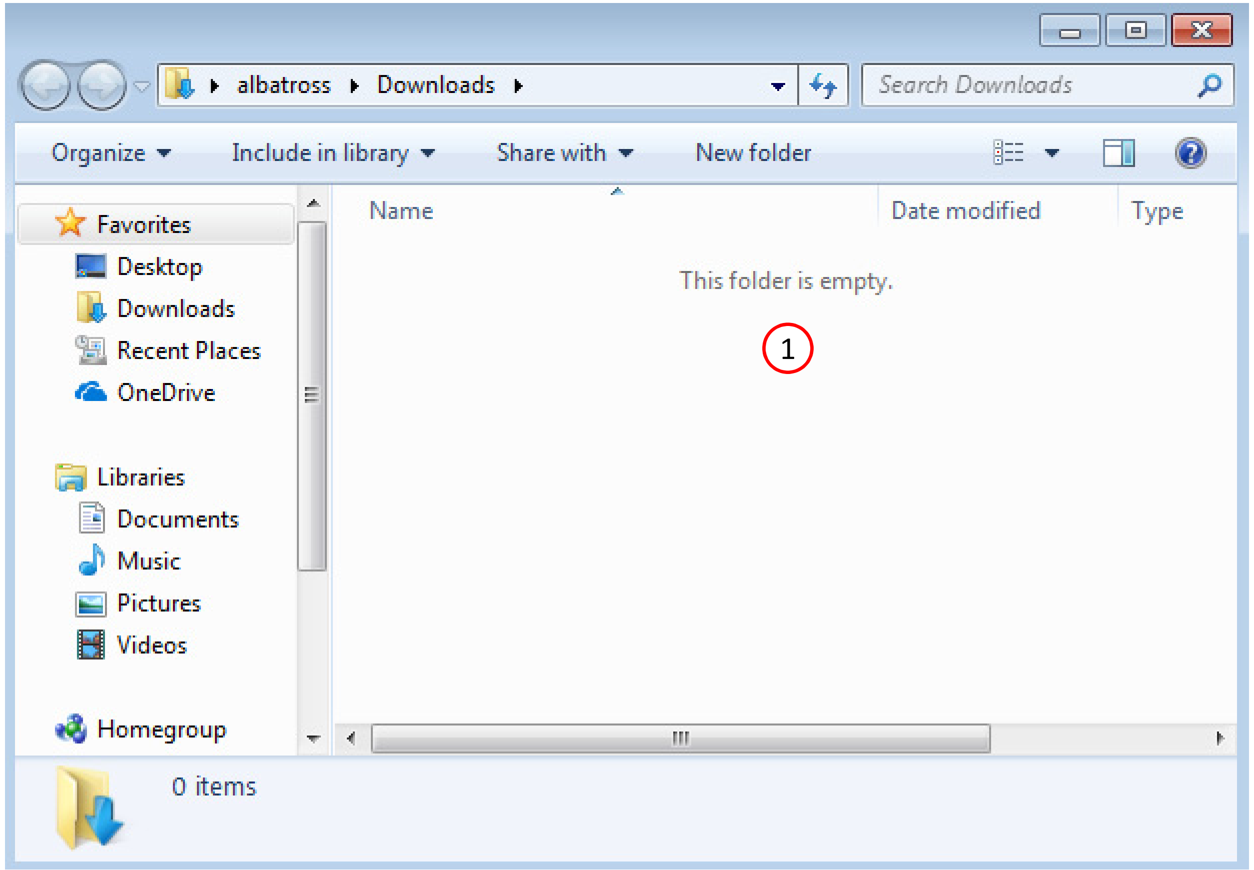


HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

Before Starting

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

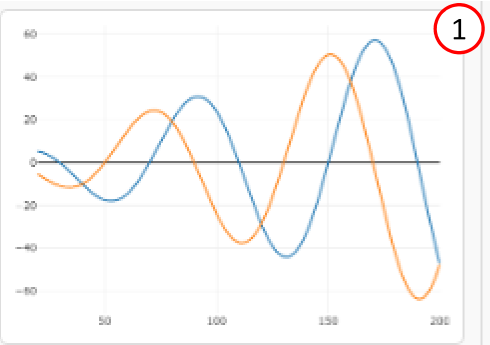
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

The Engineering Lab

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

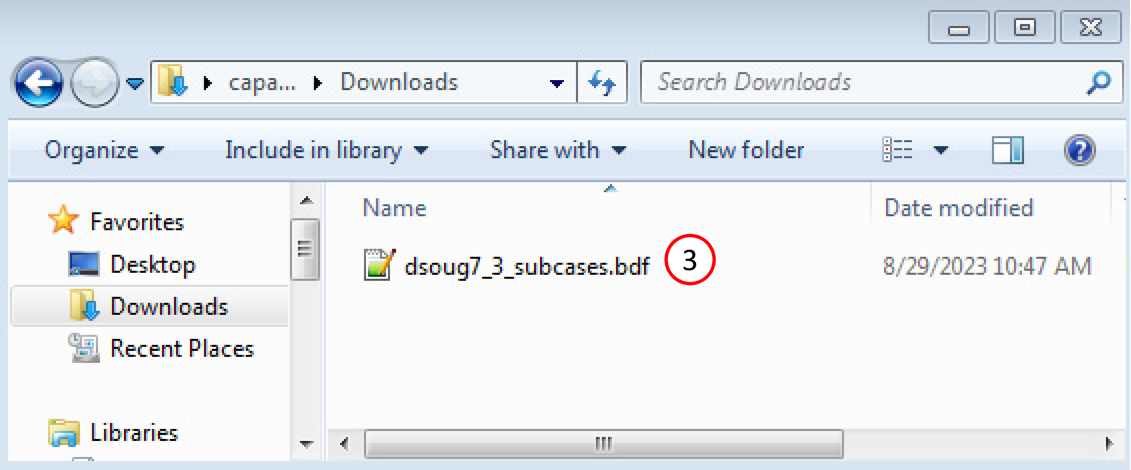
Creation of Dynamic Loads via RLOAD1 or RLOAD2 Entries

Link

A critical part of dynamic analysis is defining the dynamic load. For frequency response analysis, the dynamic load is defined via the RLOAD1 or RLOAD2 bulk data entries. For the simplest dynamic loads, only RLOAD1 or RLOAD2 entries are sufficient. For more complex dynamic loads, the following entries might be required: RLOAD1, RLOAD2, TABLED1, TABLED2, TABLED3, TABLED4, DELAY or DPHASE.

This exercise details the use of the Dynamic Loads web app to define dynamic loads and the following entries: RLOAD1, RLOAD2, TABLED1, TABLED2, TABLED3, TABLED4, DELAY or DPHASE.

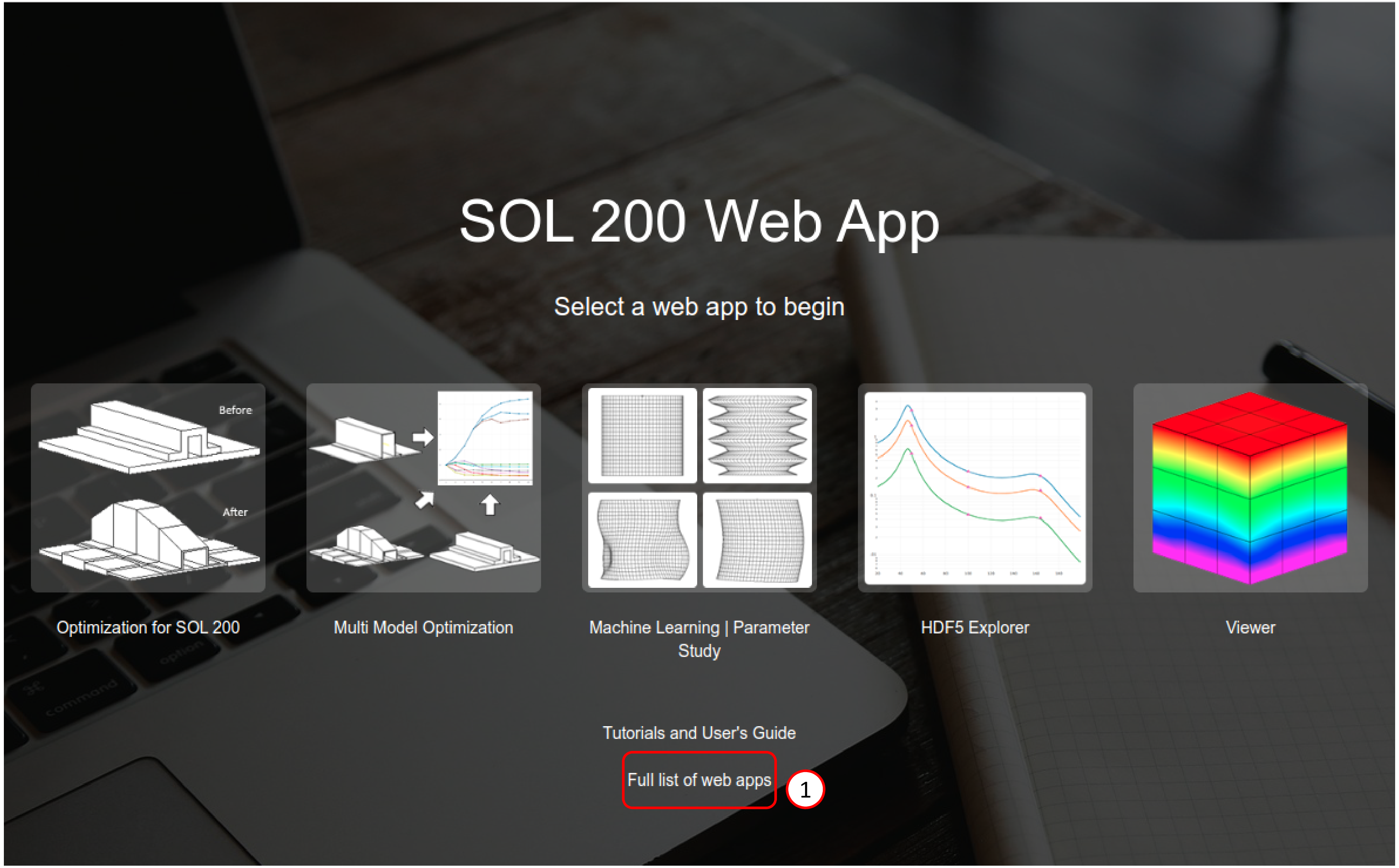
Starting Files: Link 2
Solution BDF Files: Link



Open the Dynamic Loads Web App

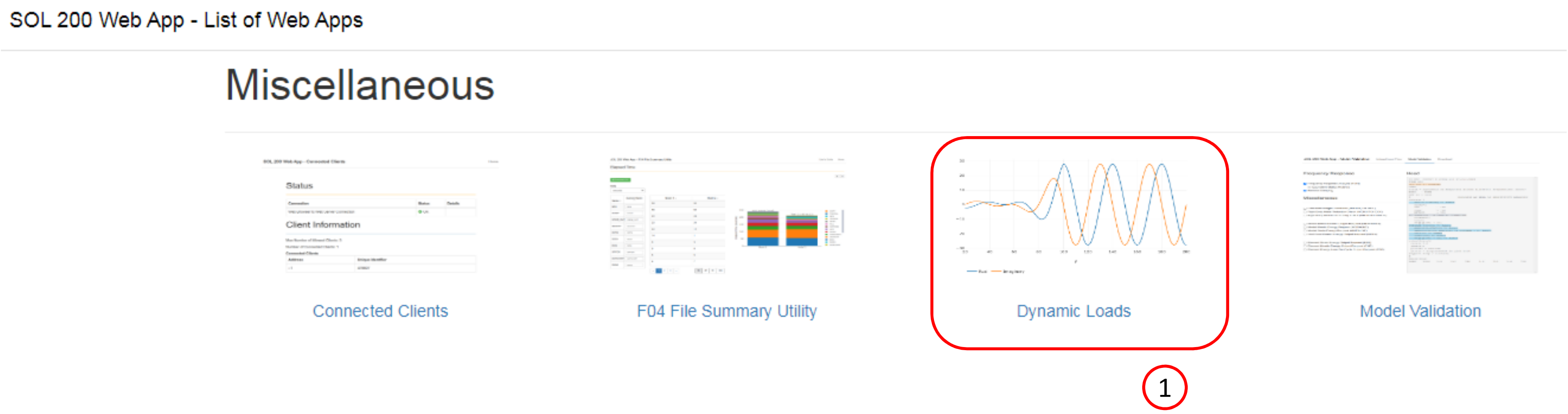
1. Click on the indicated link

The Engineering Lab



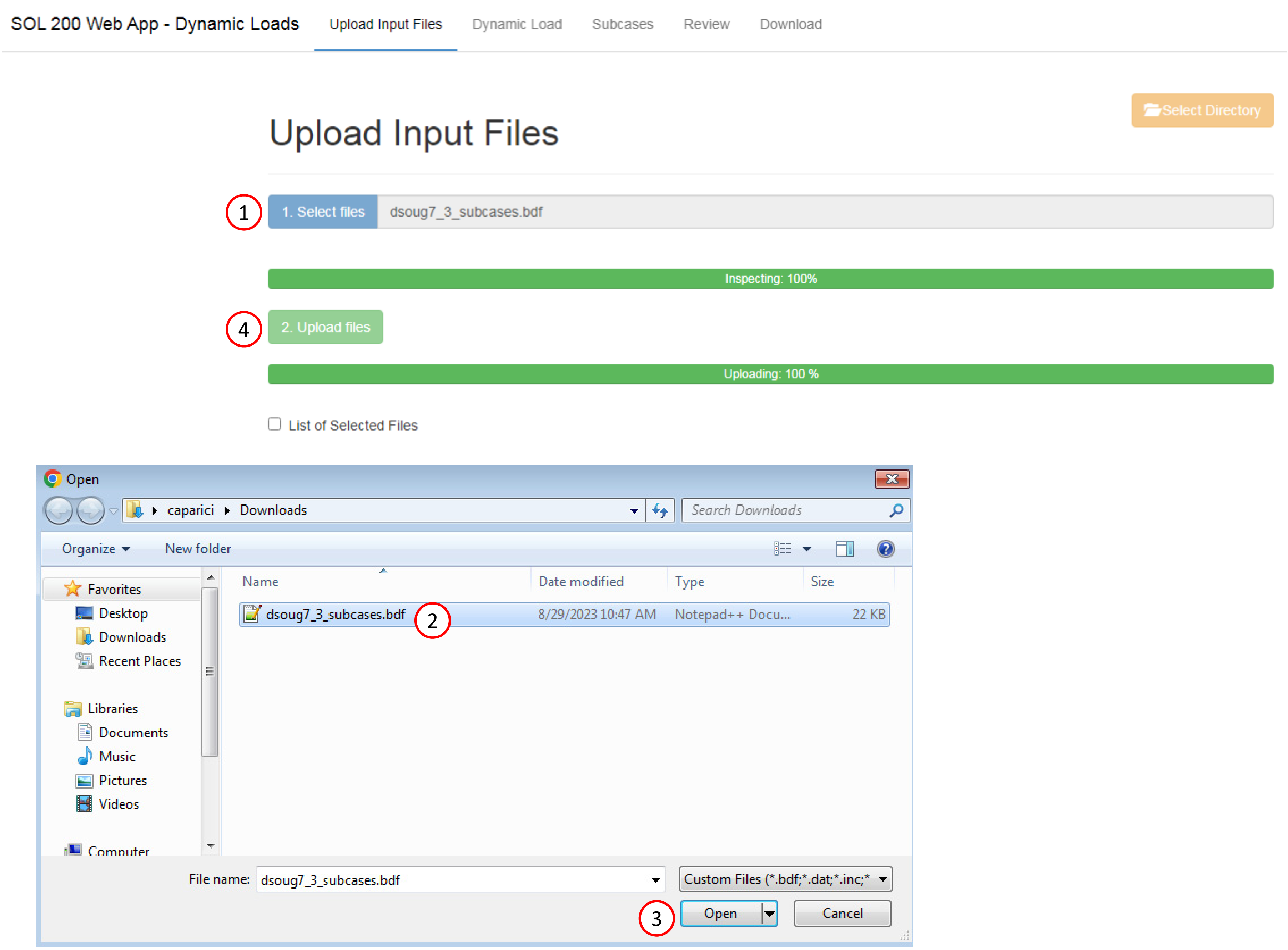
Open the Dynamic Loads Web App

1. Click on the Dynamic Loads link



Upload BDF File

1. Click Select files
2. Select the indicated file
3. Click Open
4. Click Upload files

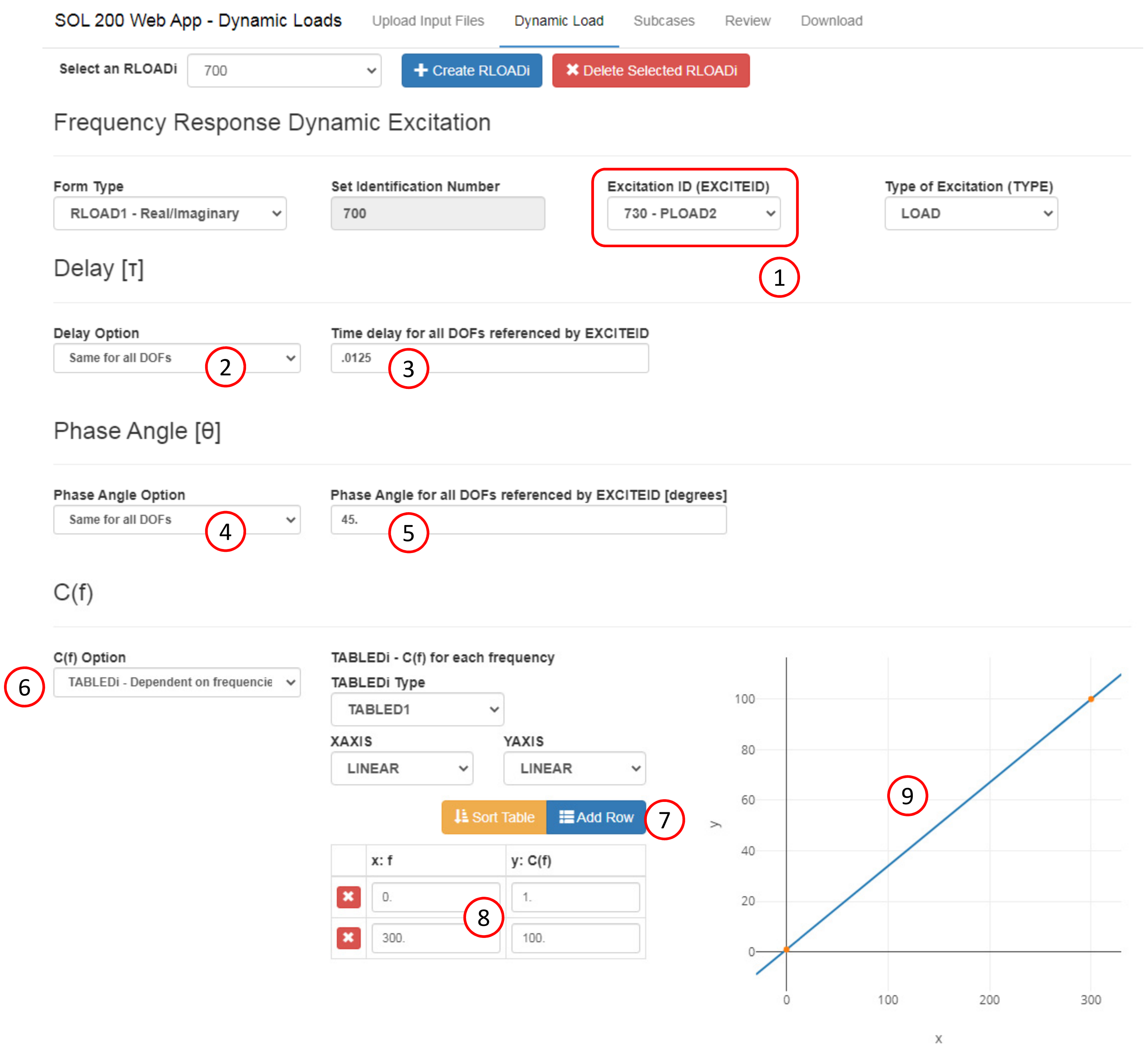


Modify Existing Dynamic Load RLOAD1

1. Ensure the Excitation ID is set to 730 – PLOAD2
2. Set Delay Option to Same for all DOFs
3. Set Time delay for all DOFs [..] to .0125
4. Set Phase Angle Option to Same for All DOFs
5. Set Phase Angle for all DOFs [...] to 45.
6. Set the C(F) Option to TABLEDi – Dependent on [...]
7. Click Add Row 2 times
8. Supply the following values into the table

x: f	y: C(f)
0.	1.
300.	100.

9. The interpolated plot of the TABLEDi entry is displayed



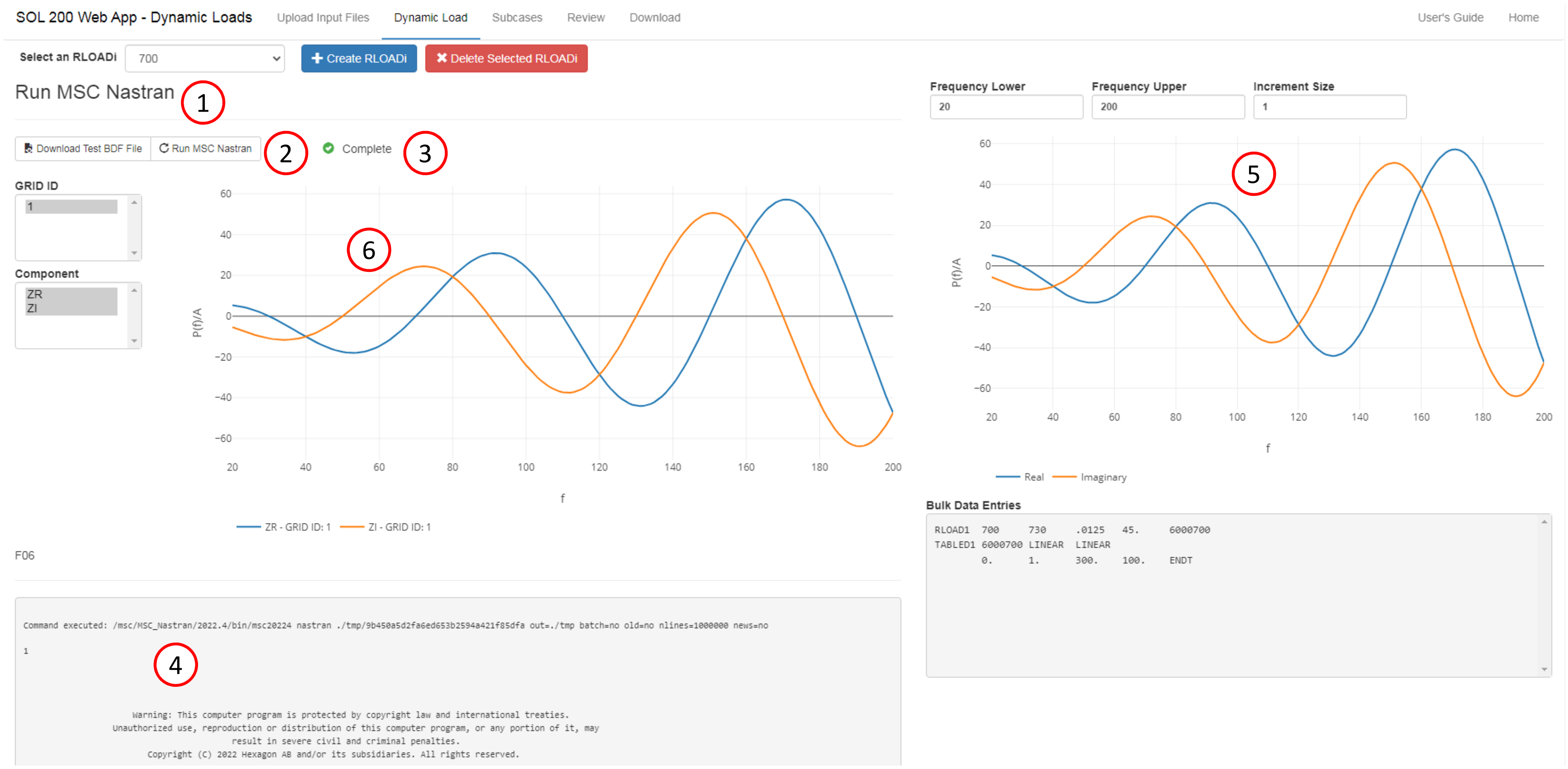
Modify Existing Dynamic Load RLOAD1

1. Set the following:
   - Frequency Lower: 20
   - Frequency Upper: 200
2. A plot of the temporal distribution of dynamic load is displayed
3. The corresponding bulk data entries are displayed

Modify Existing Dynamic Load RLOAD1

1. Scroll to section Run MSC Nastran
2. Click Run MSC Nastran
3. Ensure the status is Complete
4. If the status indicates an error, refer to the F06 file output to debug the issue
5. A preview is displayed of the temporal distribution of dynamic load
6. The actual temporal distribution of dynamic load generated by MSC Nastran is displayed

- To confirm the temporal distribution has been defined as intended, an MSC Nastran run is performed and the temporal distribution is inspected.



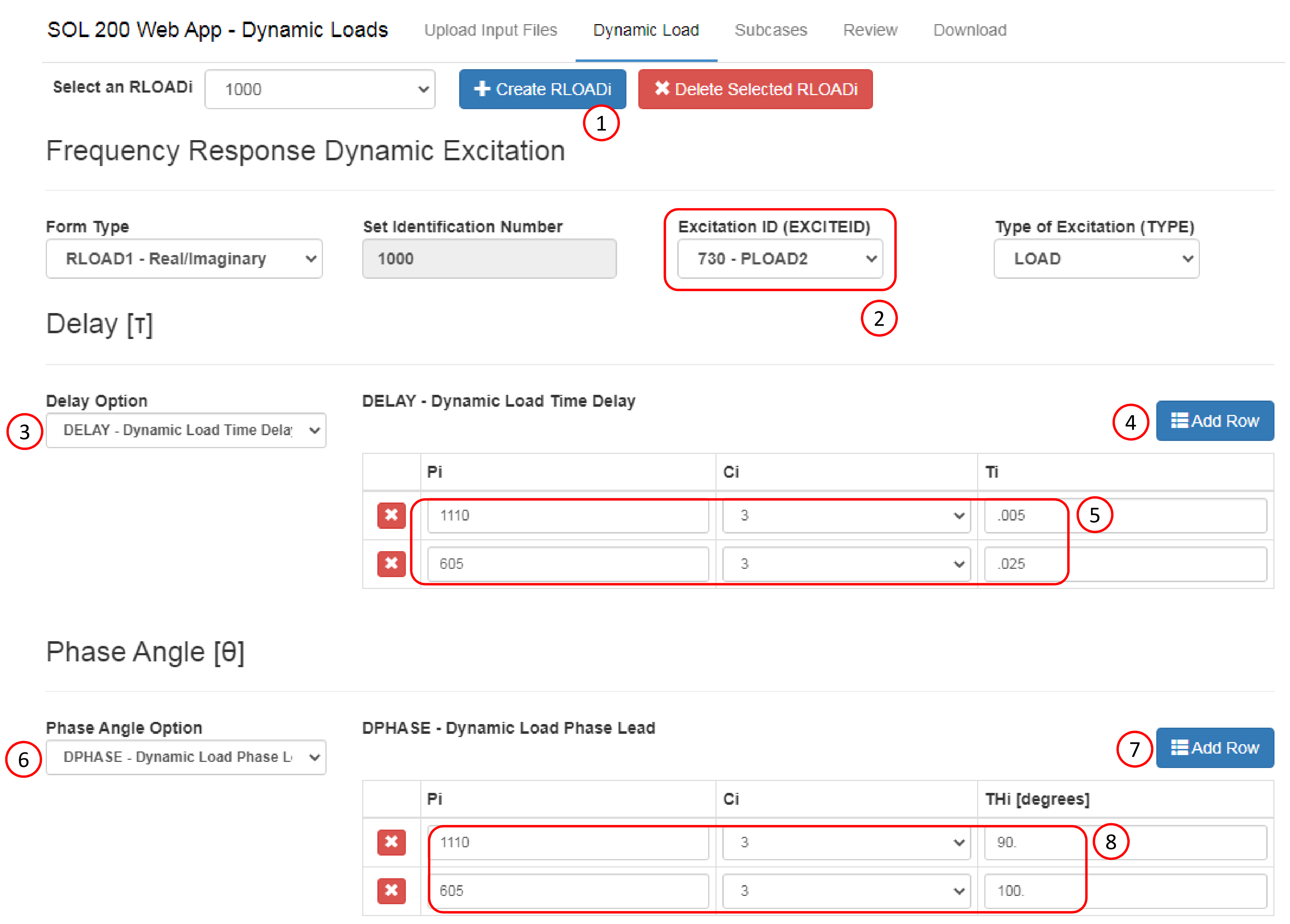
Create New Dynamic Load RLOAD1

1. Click Create RLOADi
2. Ensure the Excitation ID is set to 730 – PLOAD2
3. Set Delay Option to DELAY – Dynamic Load Time [...]
4. Click Add Row 2 times
5. Configure the indicated rows as follows

Pi	Ci	Ti
1110	3	.005
605	3	.025

6. Set Phase Angle Option to DPHASE – Dynamic Load Phase [...]
7. Click Add Row 2 times
8. Configure the indicated rows as follows

Pi	Ci	Ti
1110	3	90.
605	3	100.

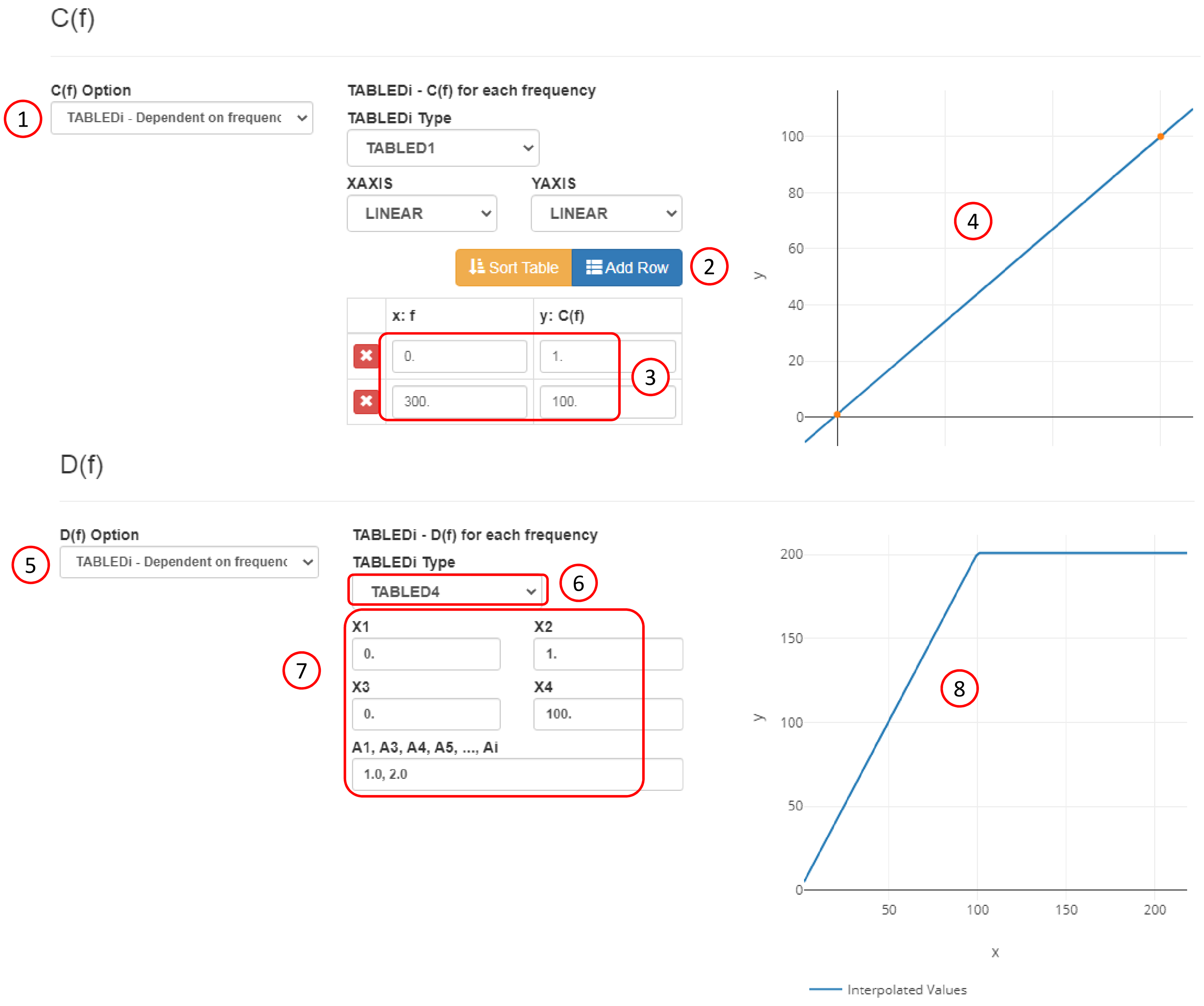


Create New Dynamic Load RLOAD1

1. Set C(f) Option to TABLEDi – Dependent on [...]
2. Click Add Row 2 times
3. Configure the indicated rows as follows

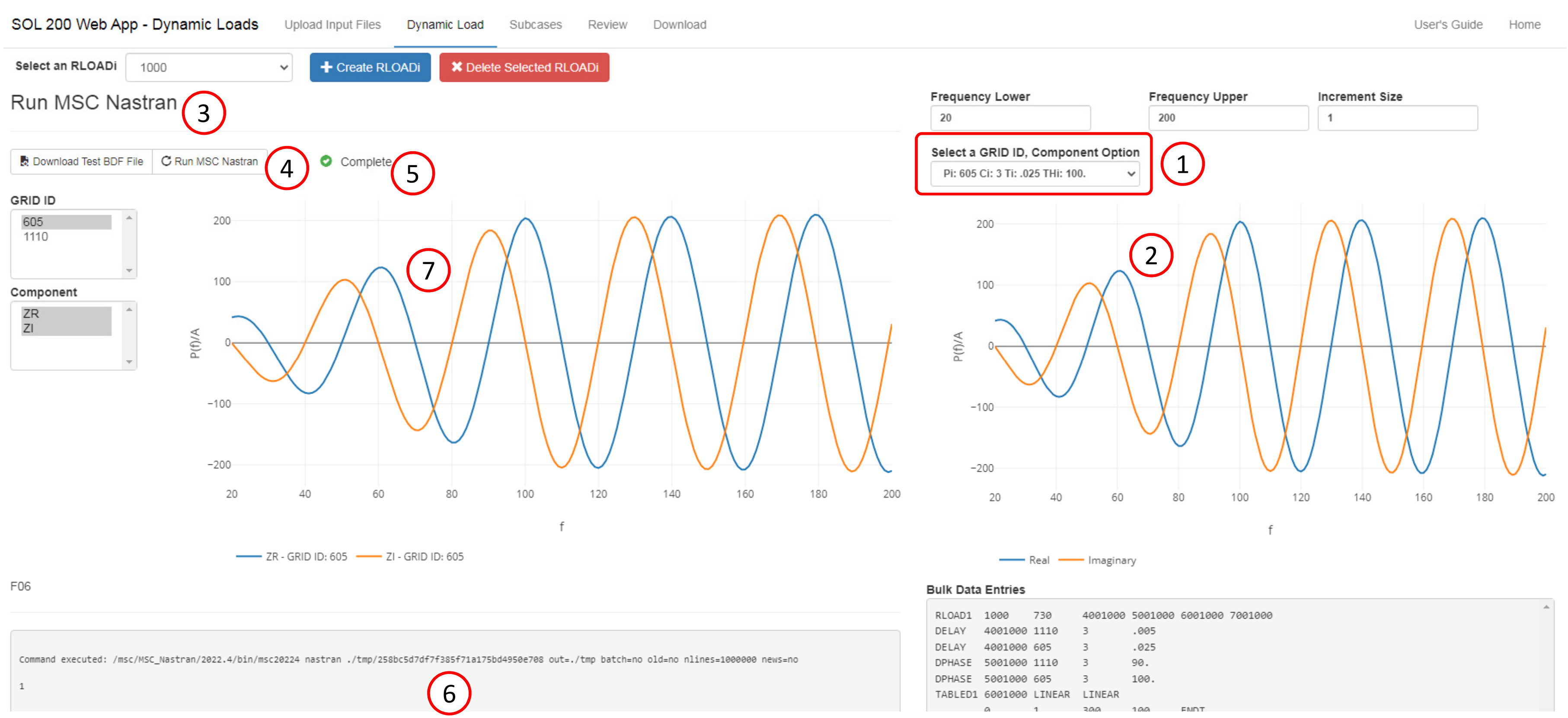
x: f	y: C(f)
0.	1.
300.	100.

4. The interpolated plot of the TABLEDi entry is displayed
5. Set D(f) Option to TABLEDi – Dependent on [...]
6. Set TABLEDi Type to TABLED4
7. Set the following values:
   - X1: 0.
   - X2: 1.
   - X3: 0.
   - X4: 100.
   - A1, A2, A3: 1.0, 2.0
8. The interpolated plot of the TABLEDi entry is displayed



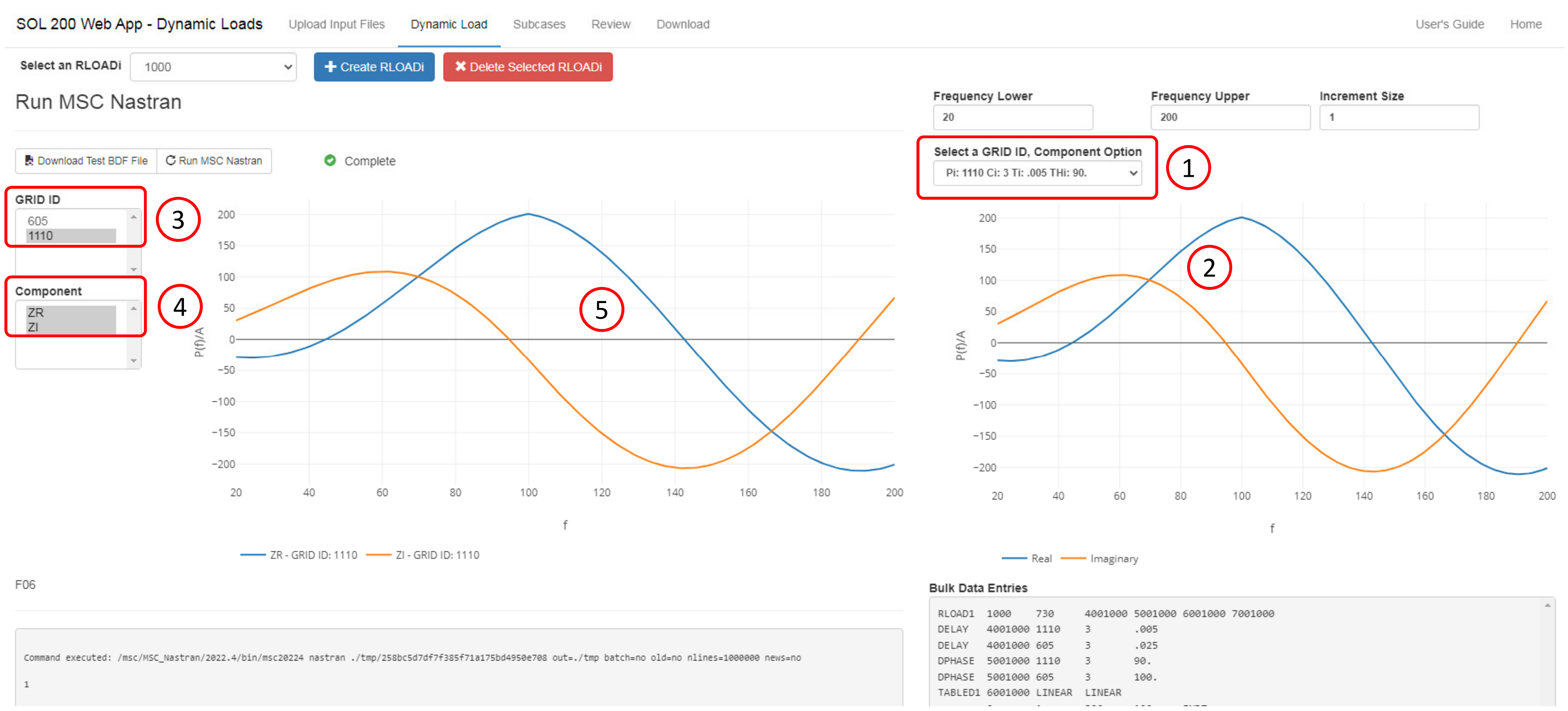
Create New Dynamic Load RLOAD1

1. Set Select a GRID ID, Component Option to Pi: 605, Ci: 3, […]
2. The Dynamic Loads web app has generated the temporal distribution of dynamic load for GRID 605, component 3
3. Scroll to section Run MSC Nastran
4. Click Run MSC Nastran
5. Ensure the status is Complete
6. If the status indicates an error, refer to the F06 file output to debug the issue
7. The MSC Nastran generated temporal distribution of dynamic load is generated



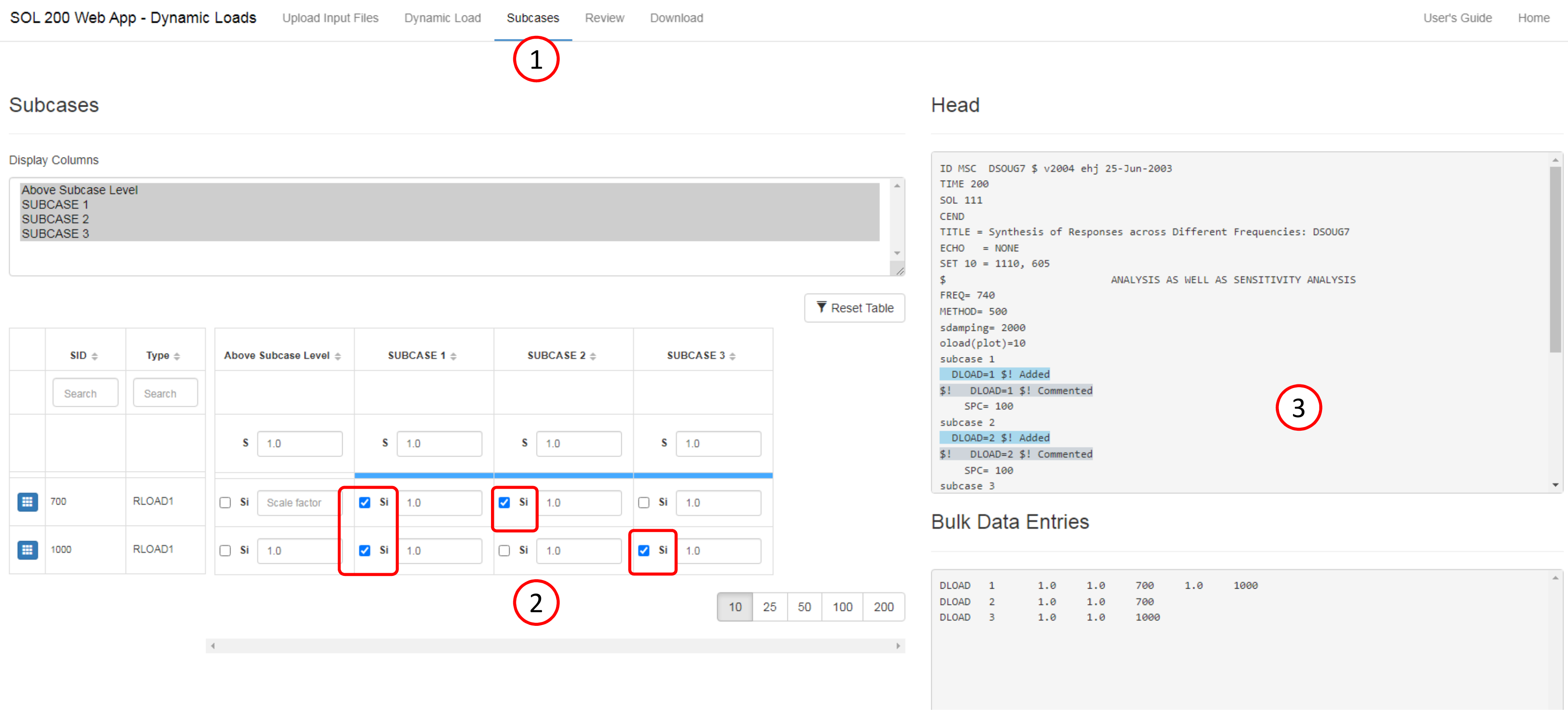
Create New Dynamic Load RLOAD1

1. Set Select a GRID ID, Component Option to Pi: 1110, Ci: 3, [...]
2. The Dynamic Loads web app has generated the temporal distribution of dynamic load for GRID 1110, component 3
3. Set GRID ID to 1110
4. Set Component to ZR and ZI
5. The MSC Nastran generated temporal distribution of dynamic load is displayed



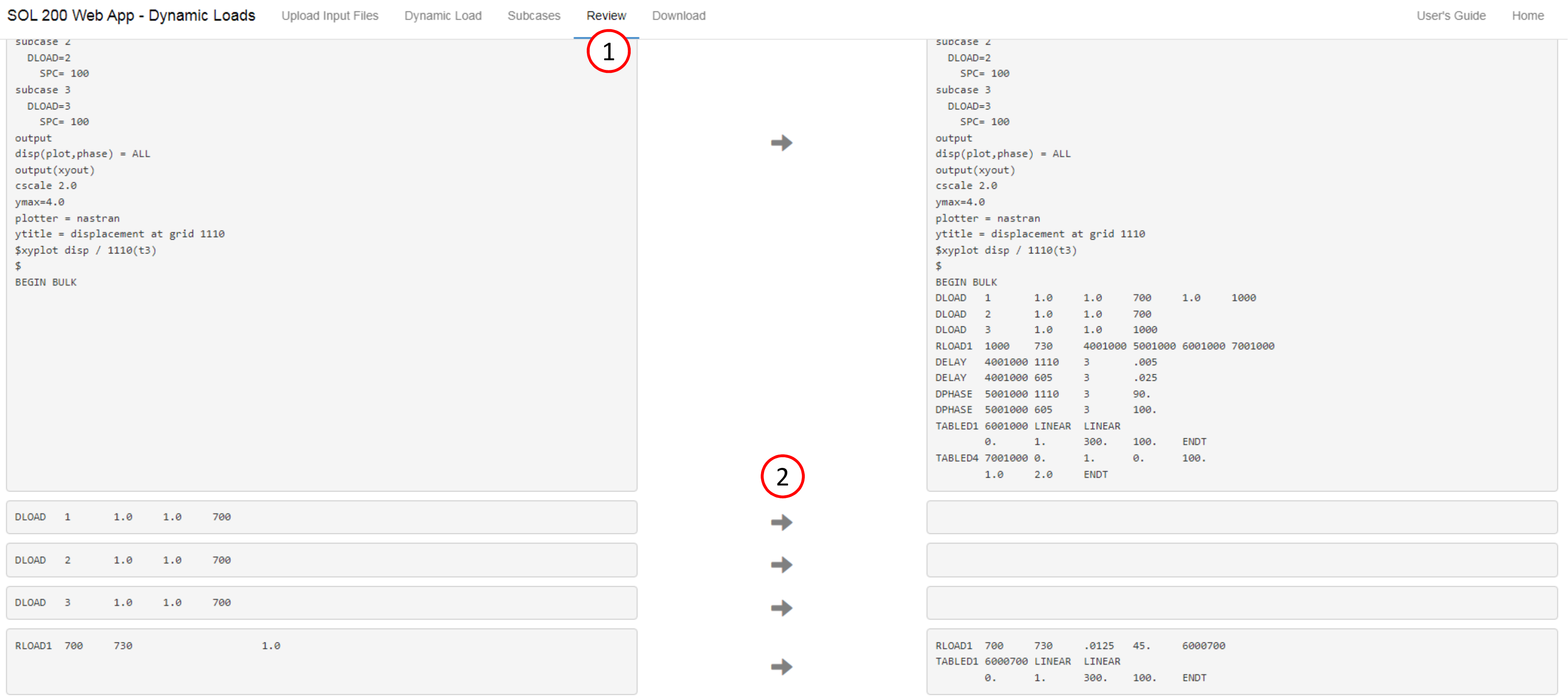
Assign Dynamic Loads to Subcases

1. Click Subcases
2. Mark the indicated checkboxes for SUBCASE 1, 2 and 3
3. The changes to the case control section are displayed



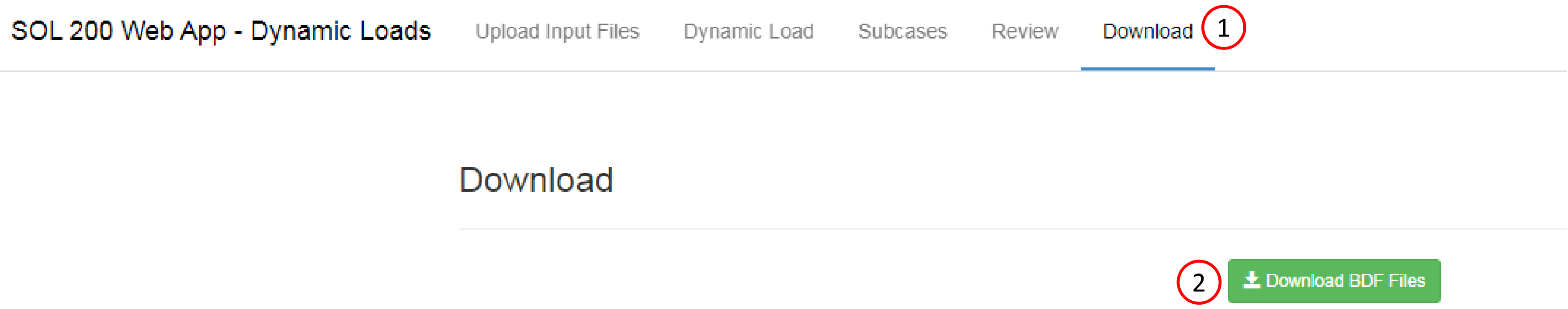
Inspect Changes to Bulk Data Entries

1. Click Review
2. A summary of changes to the BDF file are displayed



Download

1. Click Download
2. Click Download BDF Files



Ensure Applied Load Output (OLOAD)

1. Open the new BDF file and inspect the case control section. The OLOAD command is set to output the applied load for GRID ID 605 and 1110.

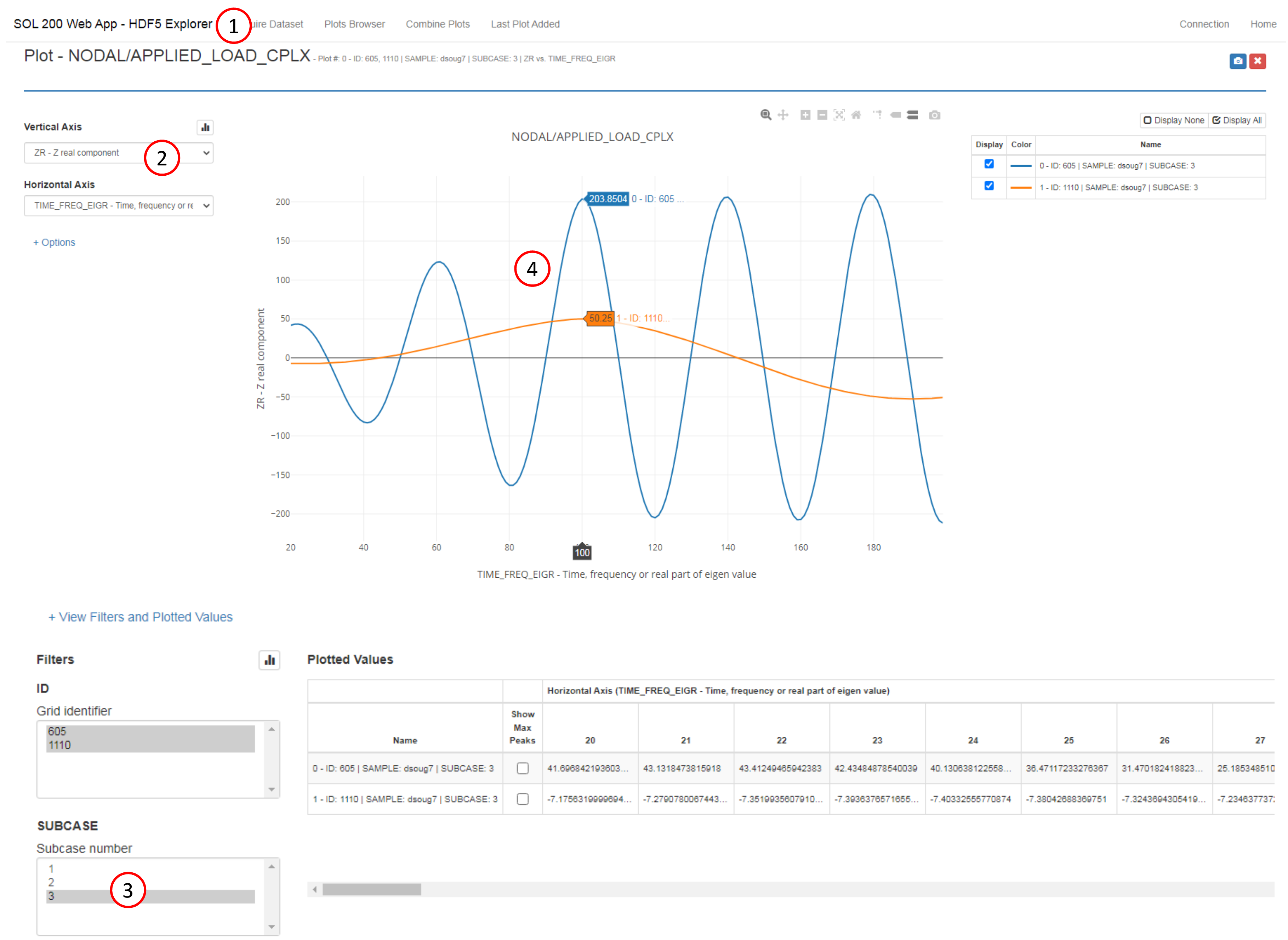
2. Run MSC Nastran for this BDF file (not shown) and a new H5 file should be generated.

3. The HDF5OUT entry is supported in MSC Nastran 2022.1 or newer. Remove this entry if you are using an older version of MSC Nastran.

```
ID MSC  DSOUG7 $ v2004 ehj 25-Jun-2003
TIME 200
SOL 111
CEND
TITLE = Synthesis of Responses across Different Frequencies: DSOUG7
ECHO    = NONE
SET 10 = 1110, 605
$                           ANALYSIS AS WELL AS SENSITIVITY ANALYSIS
FREQ= 740
METHOD= 500
sdamping= 2000
oload(plot)=10                  1
subcase 1
  DLOAD=1
    SPC= 100
subcase 2
  DLOAD=2
    SPC= 100
subcase 3
  DLOAD=3
    SPC= 100
[…]
BEGIN BULK
[…]
hdf5out              3
```

Inspect XY Plots of Applied Loads

1. Use the HDF5 Explorer to create XY plots of the applied load for GRID IDs 605 and 1110 for subcase 3 (Not shown)
2. Set Vertical Axis to ZR
3. Select only SUBCASE 3
4. At 100 Hz, note the follow applied load values
   - GRID 605: 203.8504
   - GRID 1110: 50.25



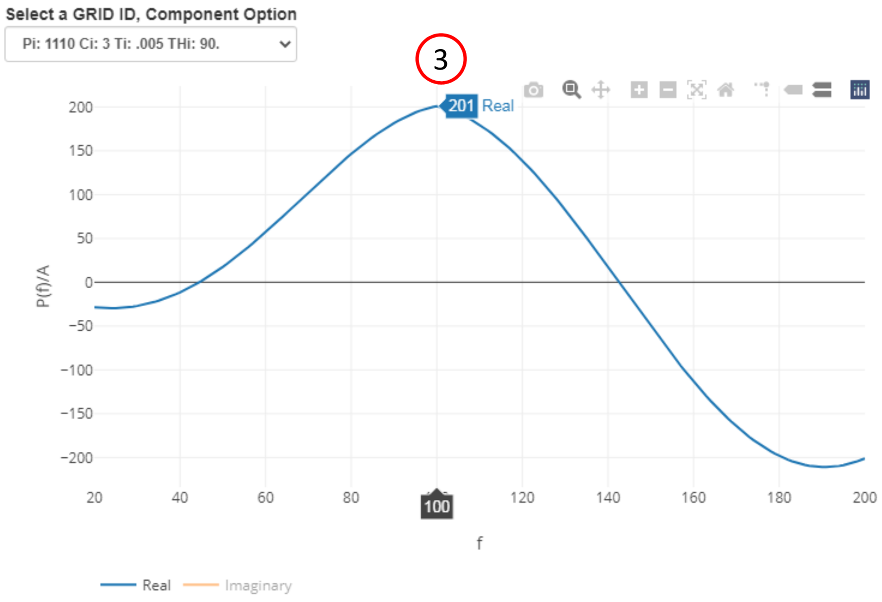
Inspect XY Plots of Applied Loads

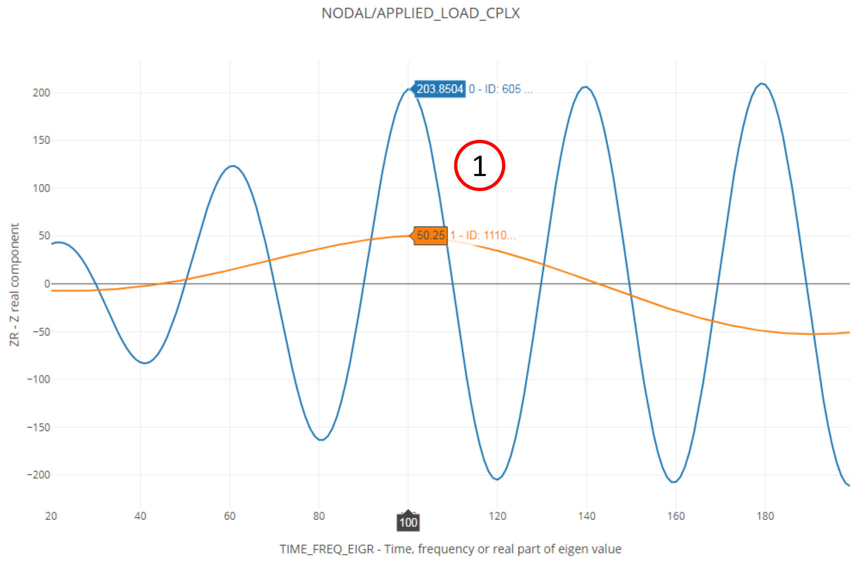
1. At 100 Hz, note the follow applied load values
    - GRID 605: 203.8504
    - GRID 1110: 50.25

The spatial distribution ranges between values of .25 and 1.0.

2. The temporal distribution at 100 Hz for GRID 605 is 203.8504 and correlates to the applied value. The spatial distribution at GRID 605 is 1.0. The product of spatial and temporal distribution is 203.85.04, which is the applied load at GRID 605 for 100 Hz.

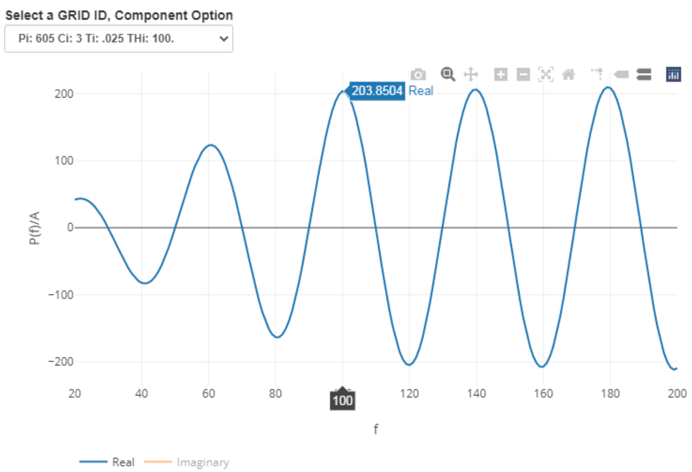
3. The temporal distribution at 100 Hz for GRID 1110 is 201. The spatial distribution at GRID 1110 is 0.25. The product of spatial and temporal distribution is 50.25, which is the applied load at GRID 1110 for 100 Hz.



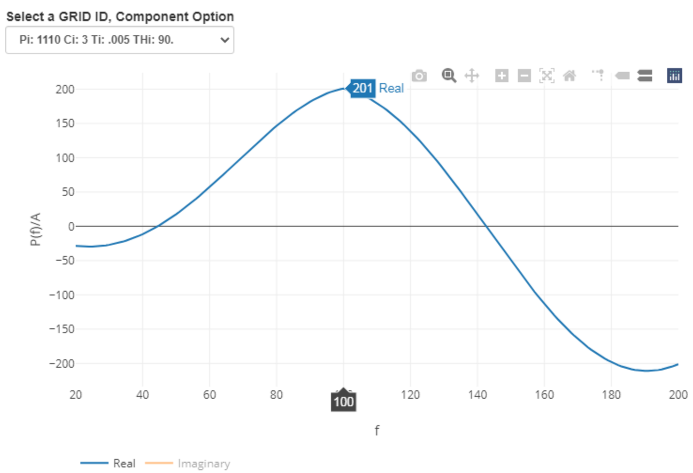


Temporal and Spatial Load Distribution

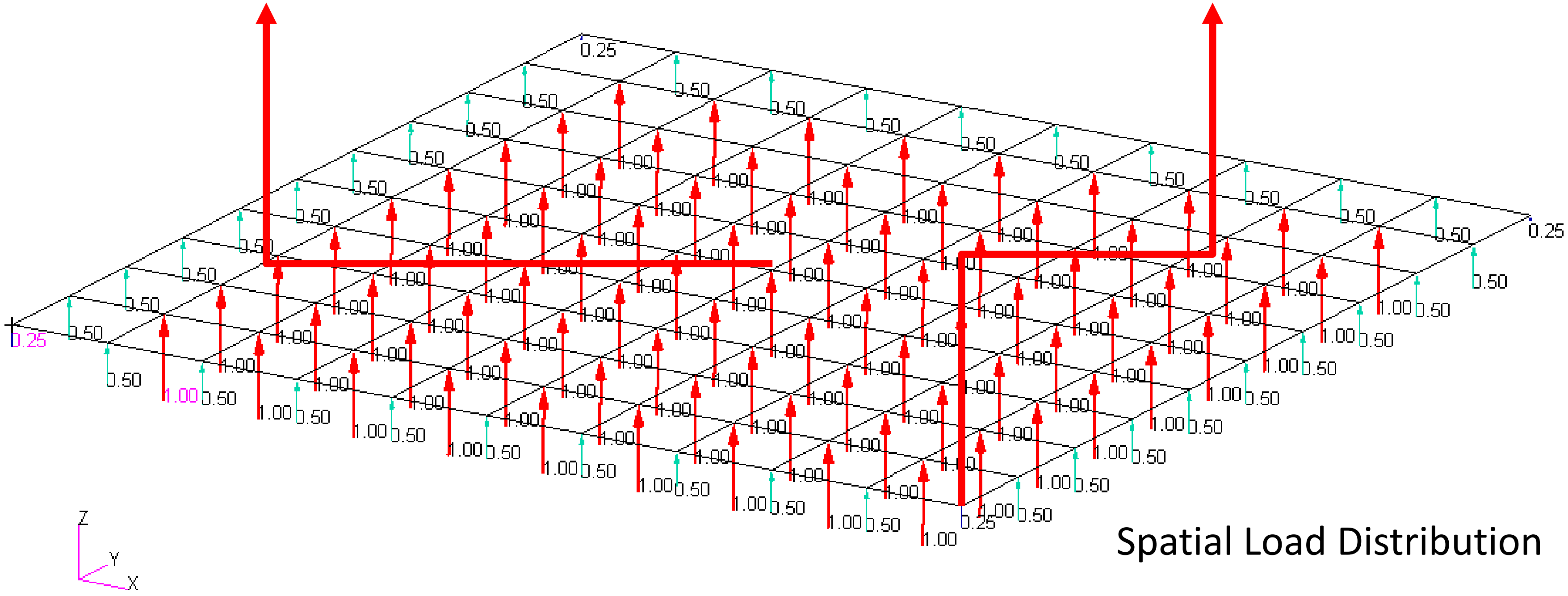
1. A uniform static pressure load is applied to each element in the Z direction. Each element is 1x1, so each element has a load of 1 applied. For each element, the load is distributed to each of the 4 GRIDs. For an interior GRID, such as GRID 605, the spatial load is 1.0. For a corner GRID, such as GRID 1110, the spatial load is 0.25. This is why the applied load was 50.25 at 100Hz or 0.25 of the temporal distribution at 100Hz which was 201.



Temporal Distribution for GRID 605



Temporal Distribution for GRID 1110



Spatial Load Distribution

End of Tutorial

Appendix

Appendix Contents

- Derivation of RLOAD1 real and imaginary values
- Derivation of RLOAD2 magnitude and phase values

RLOAD1

For frequency response analysis, the dynamic load is often defined via the RLOAD1 or RLOAD2 entry.

Recall Euler's Formula.

$$e^{ix} = \cos(x) + isin(x)$$

RLOAD1

Consider the dynamic load expressed via an RLOAD1 entry.

$$\{P(f)\} = \{A\}[C(f) + iD(f)]e^{i\{\theta - 2\pi f\tau\}}$$

The spatial distribution of dynamic loading is defined by {A}. The rest of the expression defines the temporal distribution of dynamic loading and is expressed as

$$\frac{\{P(f)\}}{\{A\}} = [C(f) + iD(f)]e^{i\{\theta - 2\pi f\tau\}}$$

Let

$$x = \theta - 2\pi f\tau$$

The temporal distribution of dynamic loading is rewritten as follows.

$$\frac{\{P(f)\}}{\{A\}} = [C(f) + iD(f)](\cos(x) + isin(x))$$

$$= C(f)\cos(x) + C(f)isin(x) + iD(f)\cos(x) + iD(f)isin(x)$$

$$= C(f)\cos(x) + i^2 D(f)sin(x) + i\,C(f)sin(x) + iD(f)\cos(x)$$

$$= (C(f)\cos(x) - D(f)sin(x)) + i\,(C(f)sin(x) + D(f)\cos(x))$$

The real term is defined as

$$C(f)\cos(x) - D(f)sin(x)$$

The imaginary term is defined as

$$C(f)sin(x) + D(f)\cos(x)$$

Note that θ is supplied in degrees. MSC Nastran internally converts θ to radians for use in sine and cosine.

RLOAD2

RLOAD2

Consider the dynamic load expressed via an RLOAD2 entry.

$$\{P(f)\} = \{A\}\, B(f) e^{i\{\phi(f) + \theta - 2\pi f \tau\}}$$

The temporal distribution of dynamic loading is defined as

$$\frac{\{P(f)\}}{\{A\}} = B(f) e^{i\{\phi(f) + \theta - 2\pi f \tau\}}$$

The magnitude term is defined as

$$|B(f)|$$

The phase term is more complicated.

If $\tau = 0$, the phase is

$$Phase(f) = \phi(f) + \theta$$

Otherwise, the phase term becomes more complicated and is expressed as

$$Phase(f) = m\left((f + c)\ \%\ \left(\frac{1}{\tau} - 1E{-}12\right)\right) + b$$

where

$$m = -360\tau$$

$$c = \frac{\phi(f) + \theta - 360}{-360\,\tau}$$

$$b = 360$$

Some readers may realize the phase term is a linear function, i.e. $y(x) = mx + b$. m defines the slope and c defines a horizontal shift of the function. The modulo operand (%) gives the phase term its cyclical characteristic. The offset term $-1E{-}12$ is used due to the following observation.

At certain values of f, the phase will be 0 and 360 simultaneously. MSC Nastran's function generator allows for only one value at each f and prefers 0 over 360. The offset of $-1E{-}12$ ensures 0 is obtained instead of 360.

RLOAD2, Continued

Below is an example of the phase values generated by MSC Nastran for $f \in [0, 17]$, with $\phi(f) = 0$, $\theta = 45$, $\tau = .125$. Note that θ is supplied in degrees. The phase term is in degrees.

$$Phase(0) = 45$$

$$Phase(1) = 0$$

$$Phase(1.01) = 359.55$$

$$Phase(8) = 45$$

$$Phase(9) = 0$$

$$Phase(9.01) = 359.55$$