Ansys Mechanical Linear and Nonlinear Dynamics

WS 08.1: Girder Assembly

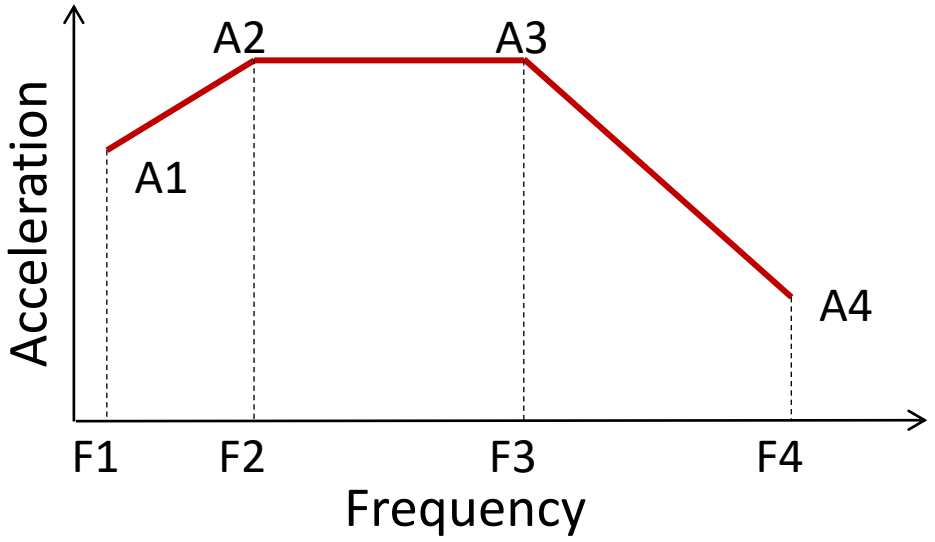
Release 2022 R2

Please note:

- These training materials were developed and tested in Ansys Release 2022 R2. Although they are expected to behave similarly in later releases, this has not been tested and is not guaranteed.
- The screen images included with these training materials may vary from the visual appearance of a local software session.
- Although some workshop files may open successfully in previous releases, backward compatibility is somewhat unlikely and is not guaranteed.

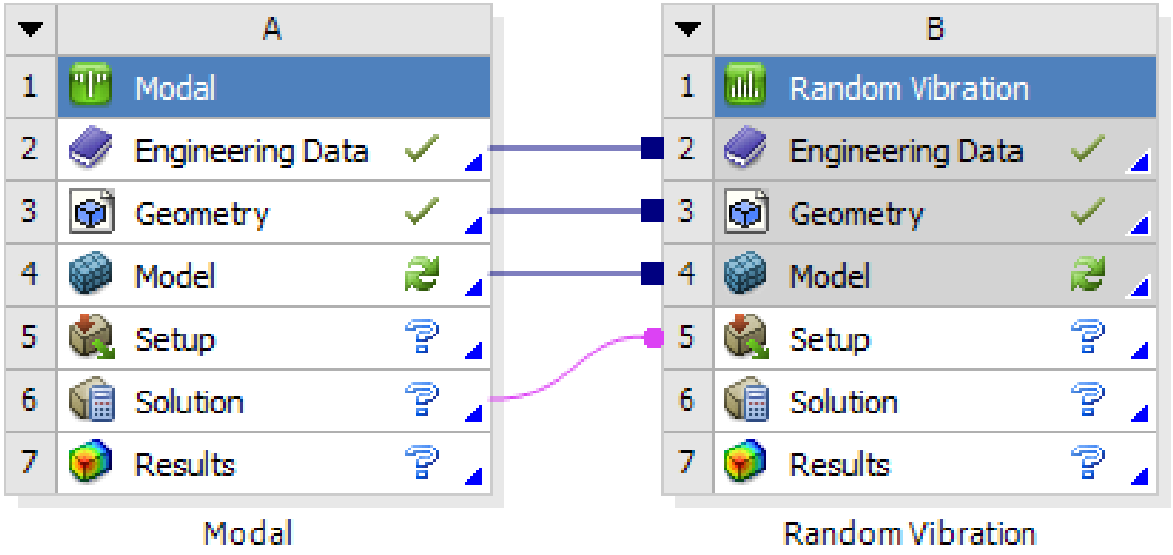
Workshop - Goals

- Our goal is to investigate the vibration characteristics of a Girder Assembly.
- In this workshop, we will examine the displacements and stresses in a steel assembly due to an acceleration spectrum.
- A PSD spectrum can be specified via Acceleration, Velocity, or Displacement.
  - The spectrum will typically be measured during physical tests or documented in a written specification relating to the system or component.
  - The data points can be entered for each frequency and amplitude.



Workshop - Project Schematic

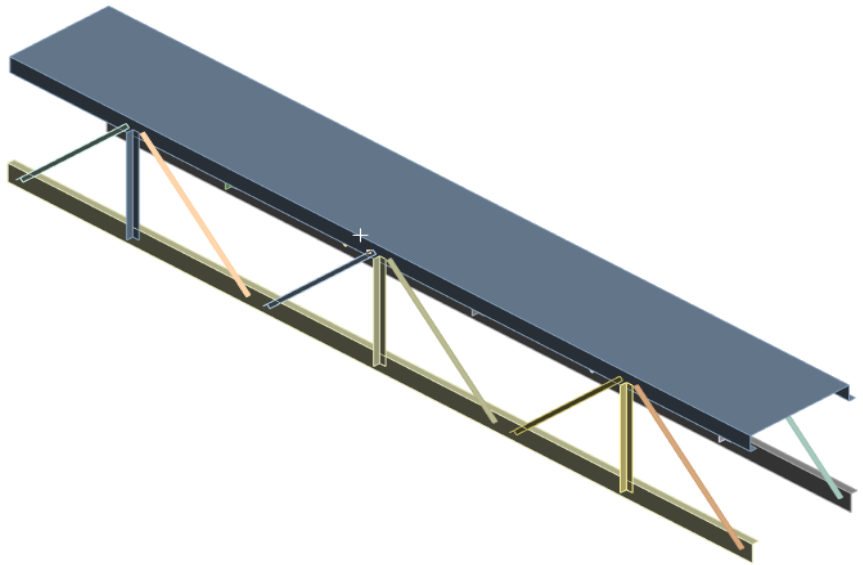
- Start a new Workbench session and insert a new Modal analysis system.
- Drop a Random Vibration system onto the Solution cell of the Modal system.



- Import Geometry file "Girder.stp"
  - Disable line body imports while importing the .stp file (it can be done in properties of cell A3).

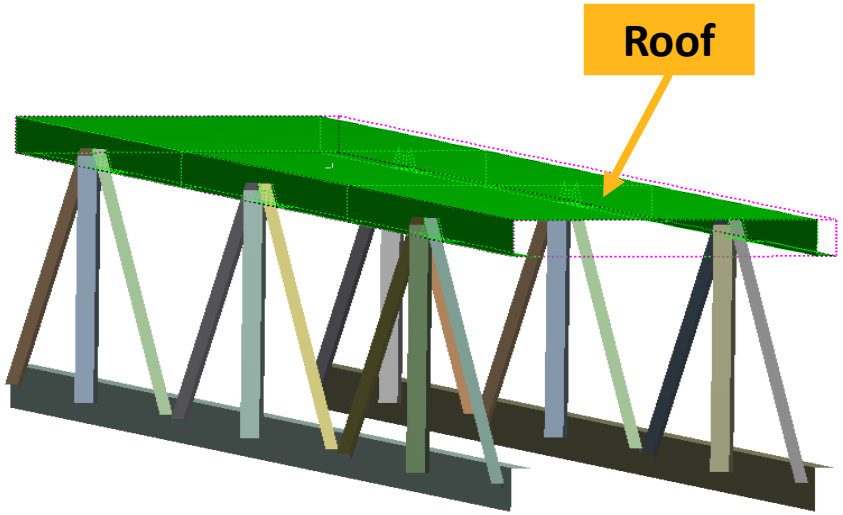
Workshop - Preprocessing

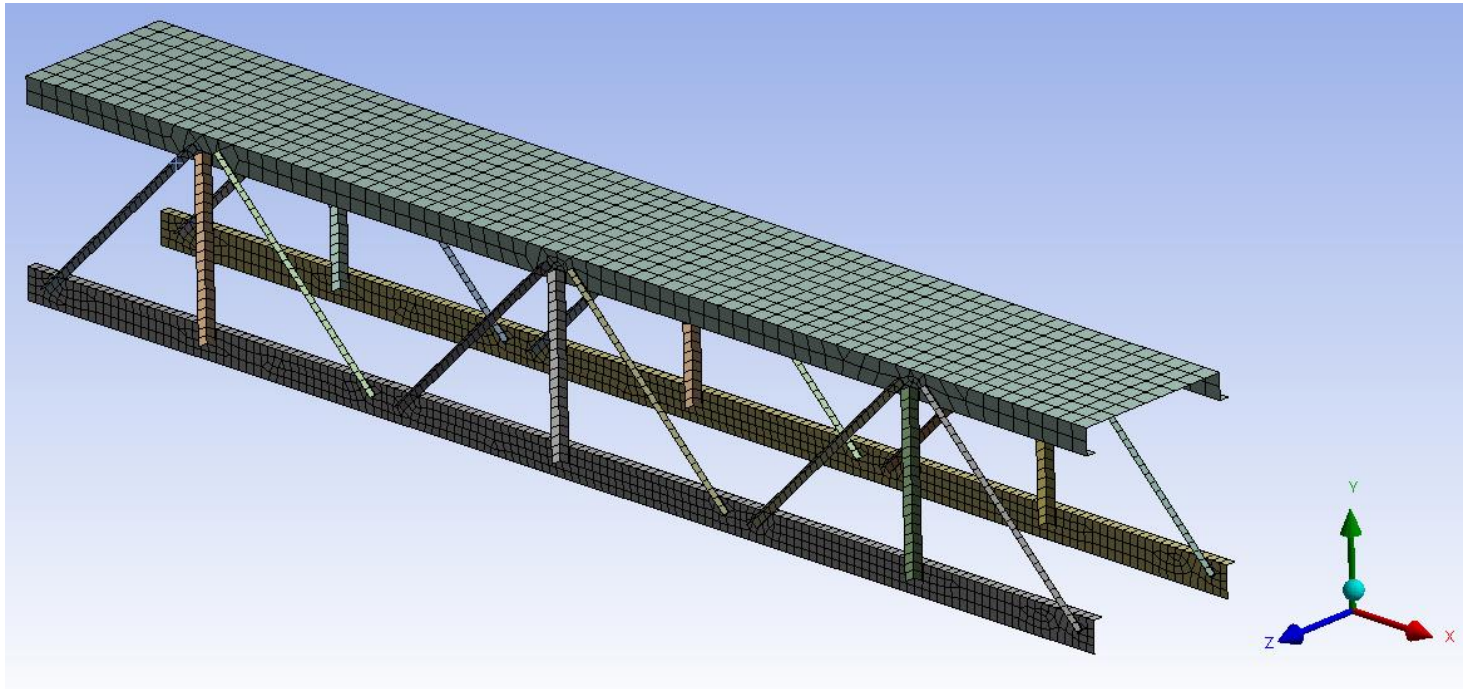
- Edit the Model cell of the Modal analysis to open the Mechanical application.
- In Mechanical, set the units system as follows:
  - US Customary (in, lbm, lbf, F, s, V, A)
  - Degrees
  - RPM
- Select all the bodies to assign a uniform thickness of 0.5 in.



Workshop - Preprocessing Mesh Size

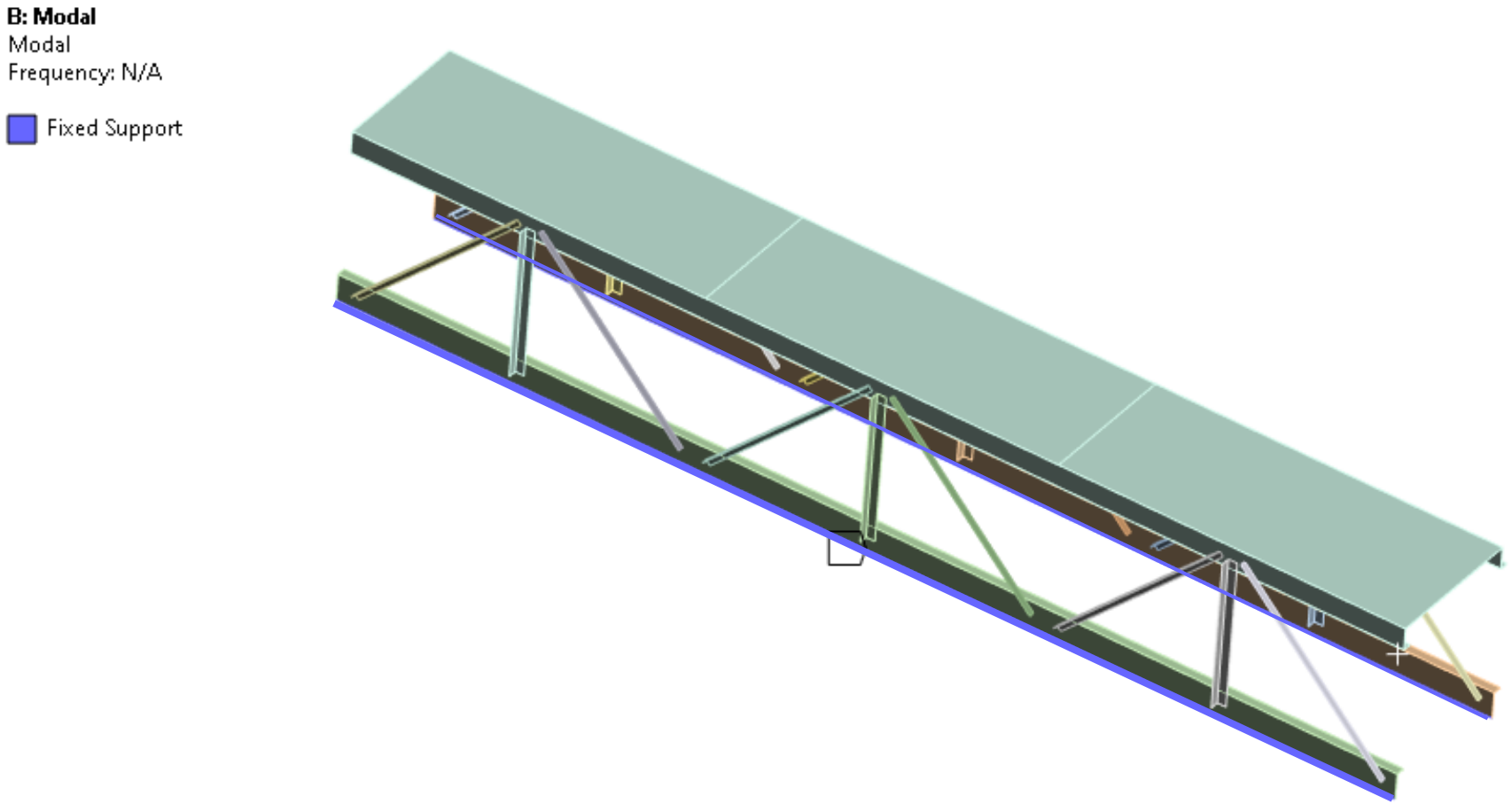
- The assembly consists of multiple slender bodies plus a large flat Roof plate.
- Define a relatively fine mesh size on the slender members but a larger element on roof.
  - Set Adaptive Sizing → On in the details of the Mesh branch
  - Define an Element Size of 4” on the Roof body
  - Define an Element Size of 2” on all other bodies (20 total)
- Generate Mesh





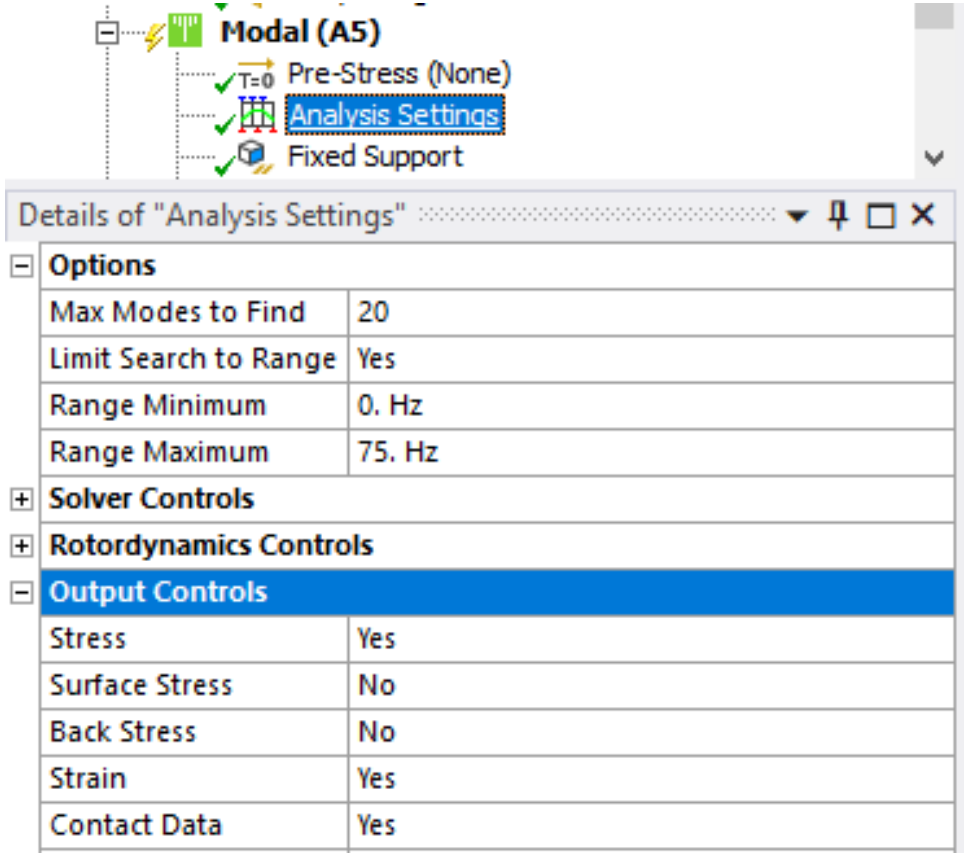
Workshop – Modal Environment

- Insert a Fixed Support on the two lower edges of the truss (2 edges in total).



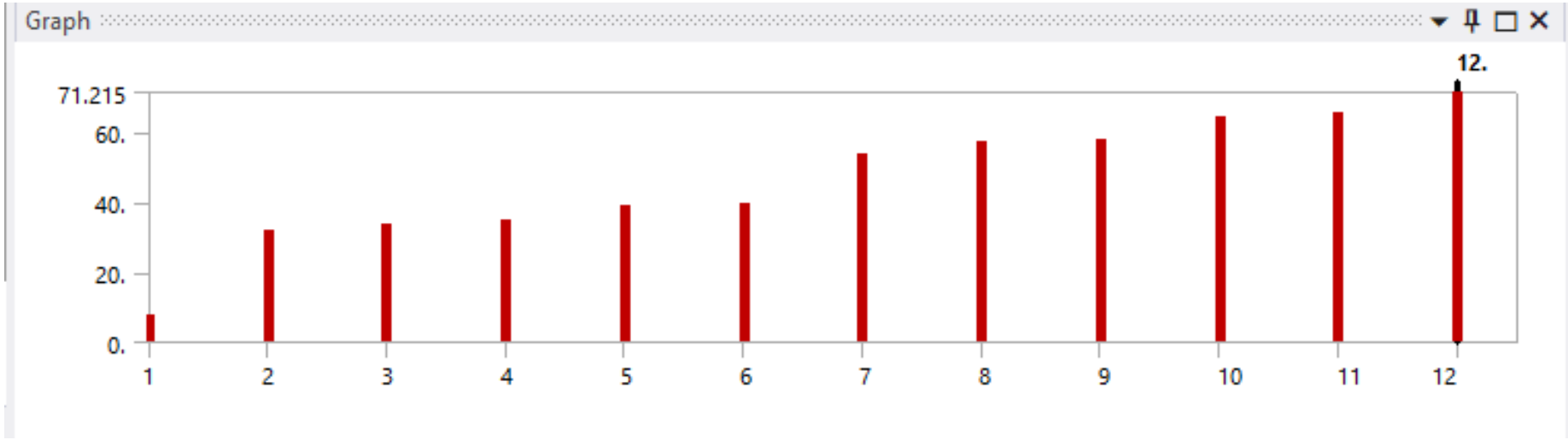
Workshop – Modal Analysis Settings

- The PSD excitation curve contains accelerations applied over a frequency range of 5-45 Hz. We'll extract enough modes to obtain frequencies up through 1.5 X 45 = 67.5 Hz
- From Analysis Settings in the Modal Environment branch:
  - Set Max Modes to Find = 20
  - Set Limit Search Range = Yes
  - Set Range Maximum = 75 Hz
  - Under Output Controls, ensure that Stress and Strain are set to "Yes" (these outputs are requested by default when a downstream random analysis is requested)



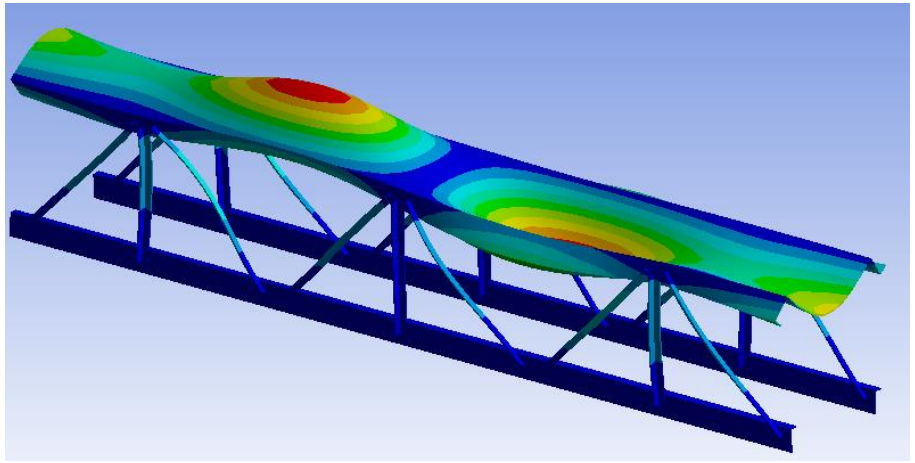
Workshop - Modal Results

- Solve the modal analysis and review the mode shapes for each frequency.



Tabular Data

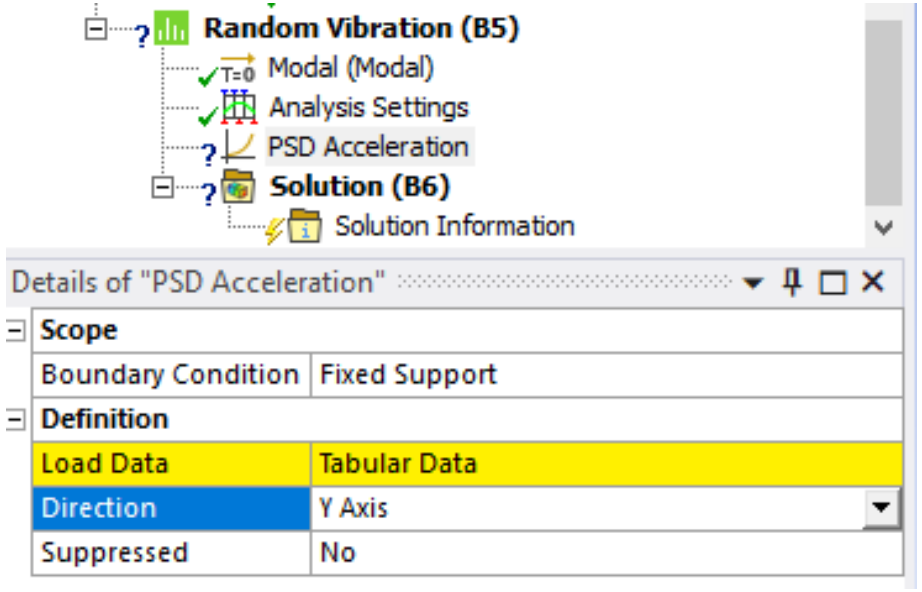
	Mode	Frequency [Hz]
1	1.	7.5842
2	2.	31.573
3	3.	33.385
4	4.	34.672
5	5.	38.949
6	6.	39.487
7	7.	53.293
8	8.	57.147
9	9.	57.827
10	10.	64.214
11	11.	65.25

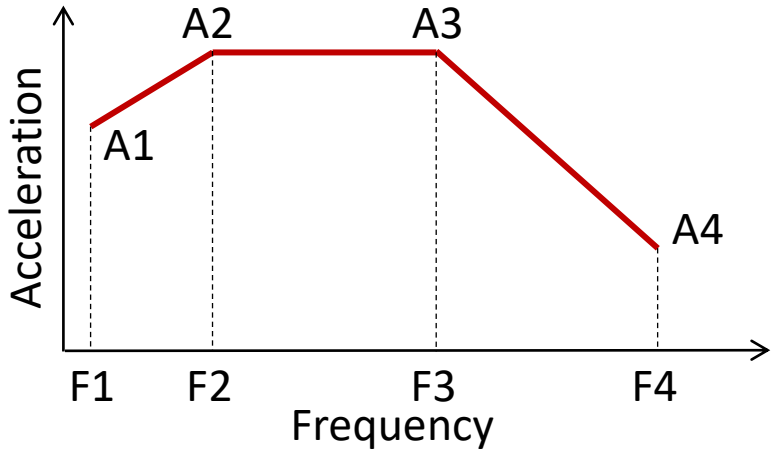


Note: your result magnitudes may vary slightly throughout this workshop due to mesh and software release differences

Workshop – Random Vibration Environment

- For the PSD Base Excitation loads, select the Random Vibration branch, then choose PSD Base Acceleration > PSD Acceleration from the context toolbar
  - Set Boundary Condition to Fixed Support or All Fixed Supports, depending on whether you used a single or multiple fixed supports in the Modal branch.
  - Set Direction to Y Axis



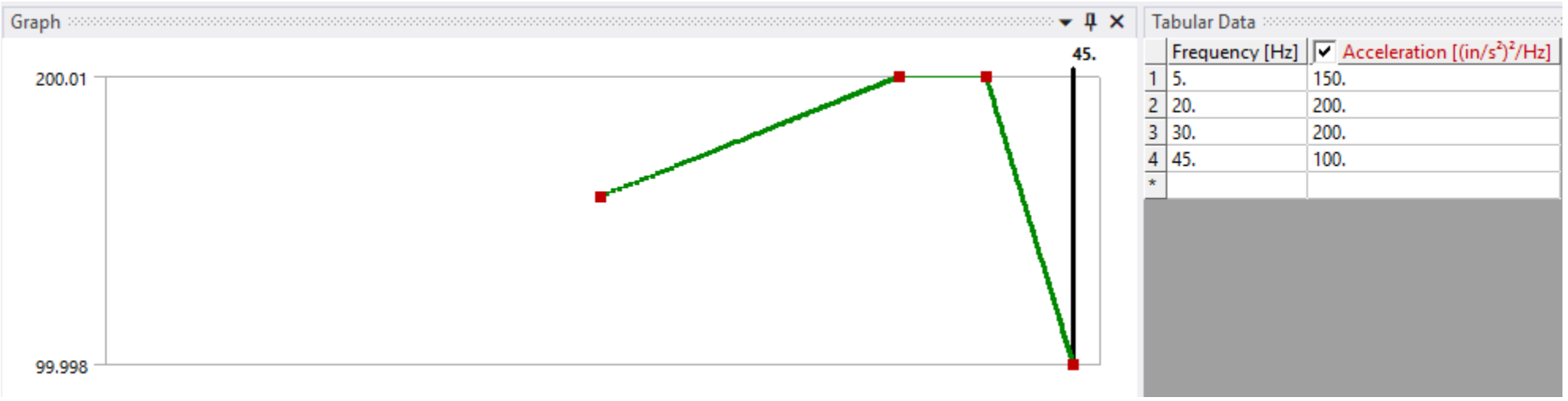


Workshop - PSD Loads

- Enter the following tabular data for the PSD Acceleration load:

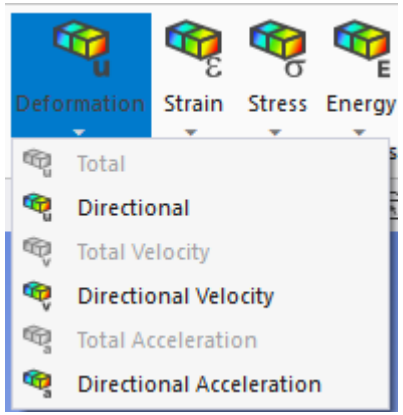
Frequency [Hz]	Acceleration [(in/s²)²/Hz]
5	150
20	200
30	200
45	100

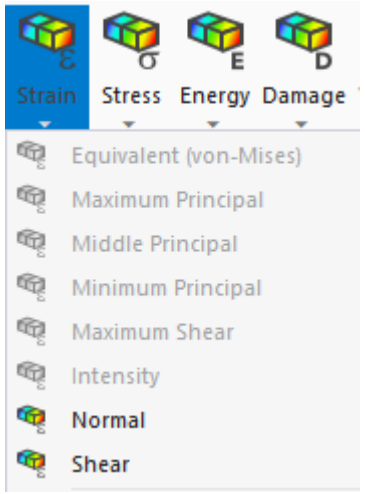
- Solve.

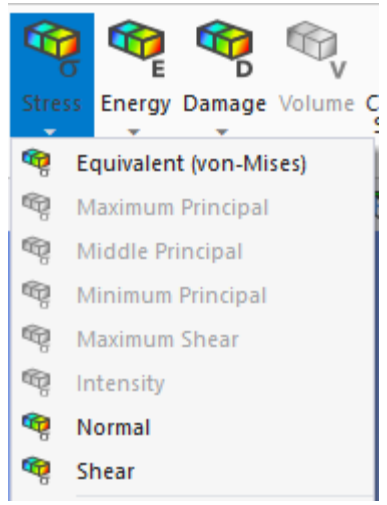


Workshop - Random Vibration Results

- Due to the applied spectrum, you can Insert
  - Directional Deformations
  - Normal and Shear Strains
  - Normal, Shear, Equivalent Stresses
    - Use 3 Sigma scale factors to encompass 99.7% probability of obtaining maximum values!

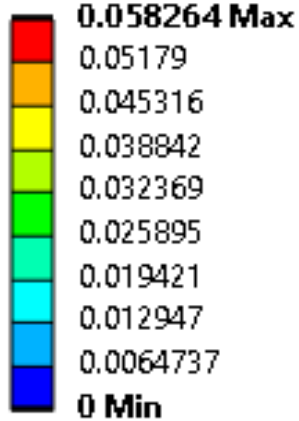


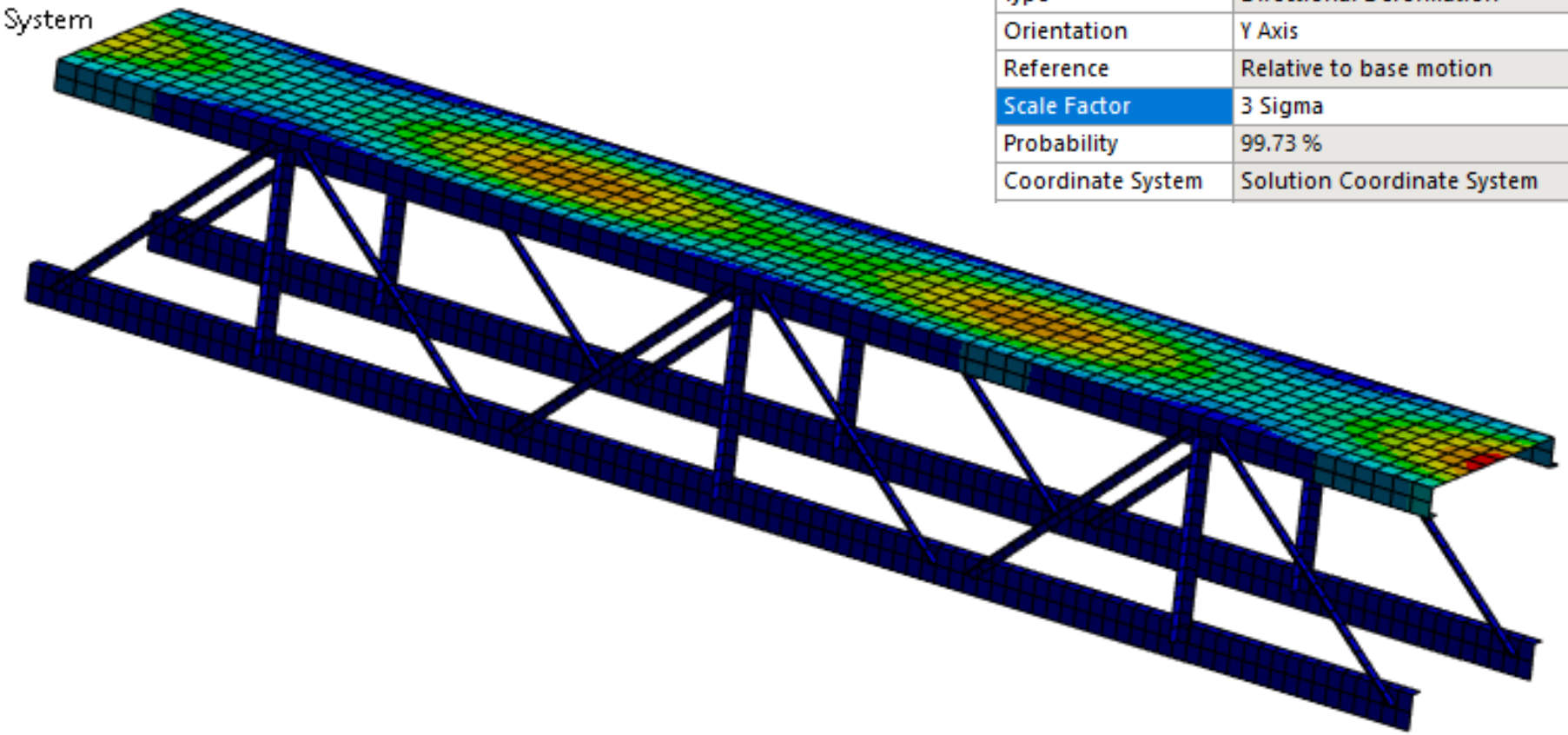




Workshop - Random Vibration Results

B: Random Vibration
Directional Deformation
Type: Directional Deformation(Y Axis)
Scale Factor Value: 3 Sigma
Probability: 99.73 %
Unit: in
Solution Coordinate System
Time: 0 s



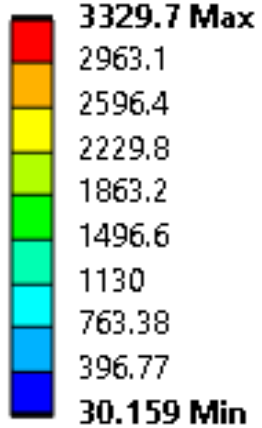


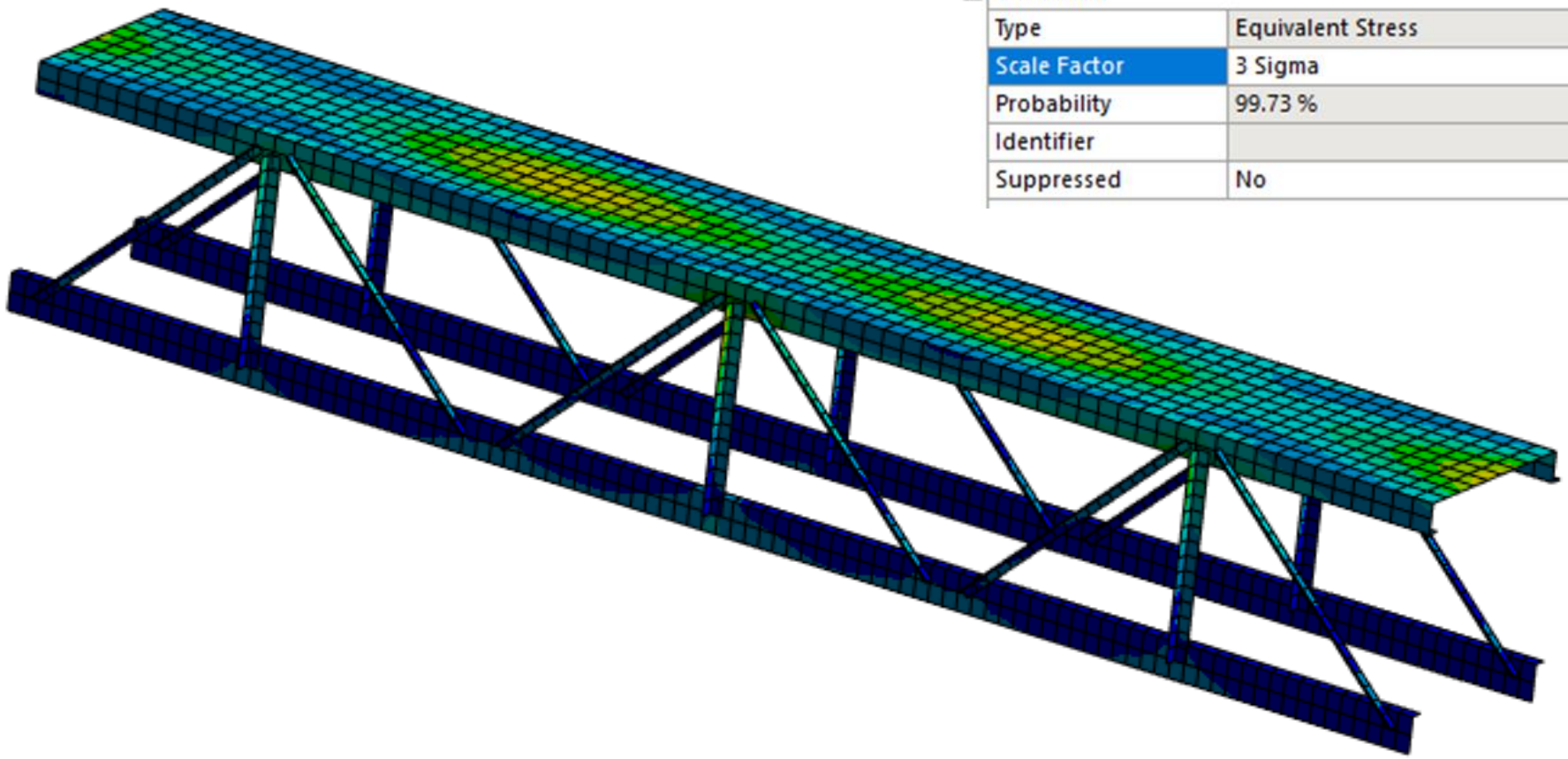
Details of "Directional Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Directional Deformation
Orientation	Y Axis
Reference	Relative to base motion
Scale Factor	3 Sigma
Probability	99.73 %
Coordinate System	Solution Coordinate System

Workshop - Random Vibration Results

B: Random Vibration
Equivalent Stress
Type: Equivalent Stress - Top/Bottom
Scale Factor Value: 3 Sigma
Probability: 99.73 %
Unit: psi
Time: 0 s





Details of "Equivalent Stress"

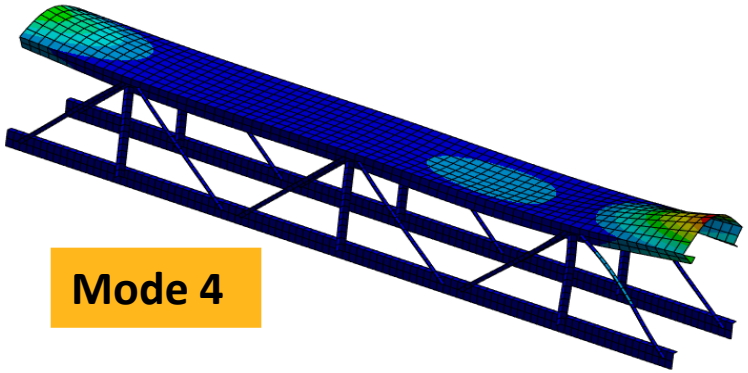
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Position	Top/Bottom
Definition	
Type	Equivalent Stress
Scale Factor	3 Sigma
Probability	99.73 %
Identifier	
Suppressed	No

Workshop - Random Vibration Results

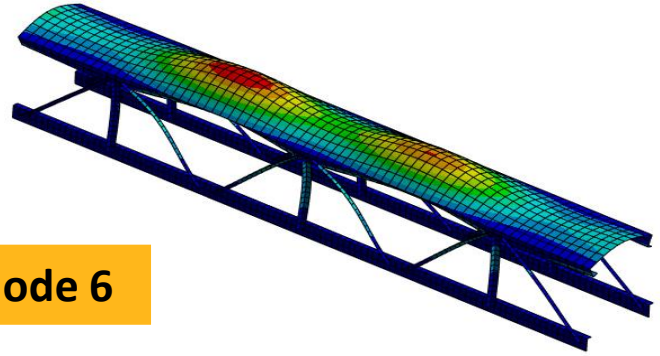
- The modal analysis showed modes 4 and 6 with significant participation factors in the Y direction (Solution Information). Corresponding mode shapes show peak amplitudes of the Roof structure. We would expect higher response PSDs at these frequencies.

Participation Factor

Mode	Frequency [Hz]	X Direction	Y Direction	Z Direction	Rotation X	Rotation Y	Rotation Z
1	7.5842	3.79e-003	-5.4954e-003	2.5473	-6.8771	-240.78	-0.21611
2	31.573	1.9371e-002	8.7325e-002	1.4879e-003	-1.791	-209.29	19.565
3	33.385	-4.5879e-002	0.21962	3.4486e-003	-4.2758	-21.161	-68.396
4	34.672	1.2634e-002	0.60072	1.6911e-004	-11.847	17.454	79.952
5	38.949	1.2104e-003	8.9086e-002	-2.6598e-004	-1.678	5.6524	119.49
6	39.487	8.3488e-004	1.5962	-1.0334e-003	-31.645	7.7799	146.86
7	53.293	-2.792e-003	-4.4204e-002	1.1054e-003	0.96836	-3.8403	-5.2881
8	57.147	-4.1831e-002	2.6832e-002	-1.1384e-003	1.2611	-9.8154	20.001
9	57.827	5.9503e-003	3.4075e-002	3.1163e-004	0.51823	-8.2218	-26.889
10	64.214	1.4396e-002	-3.3523e-002	1.4216e-002	6.2397	1.0183	-7.4536
11	65.25	4.8497e-003	-0.29059	2.0945e-002	2.3446	-4.347	-25.113
12	71.215	2.5748e-003	-7.8964e-003	-2.3849e-003	-0.1718	8.2665	1.2546



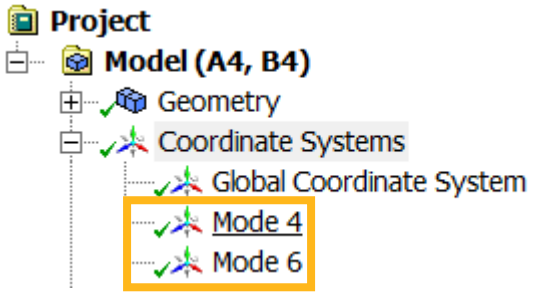
Mode 4

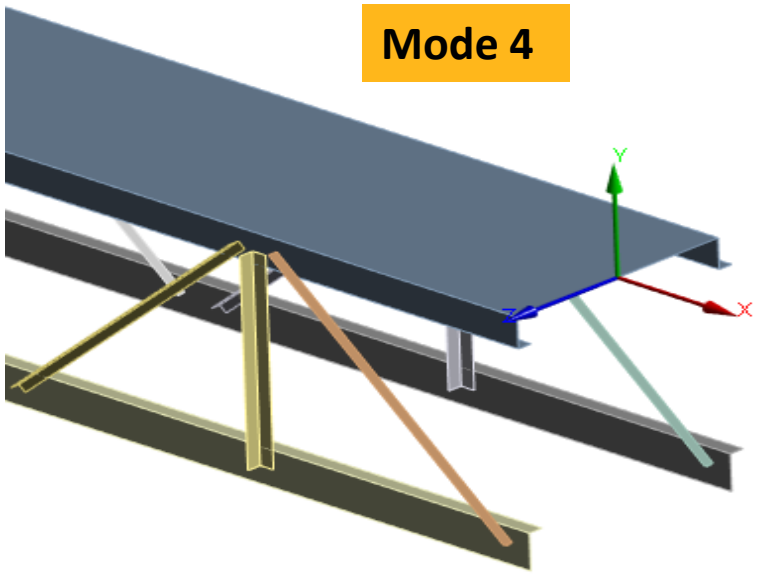


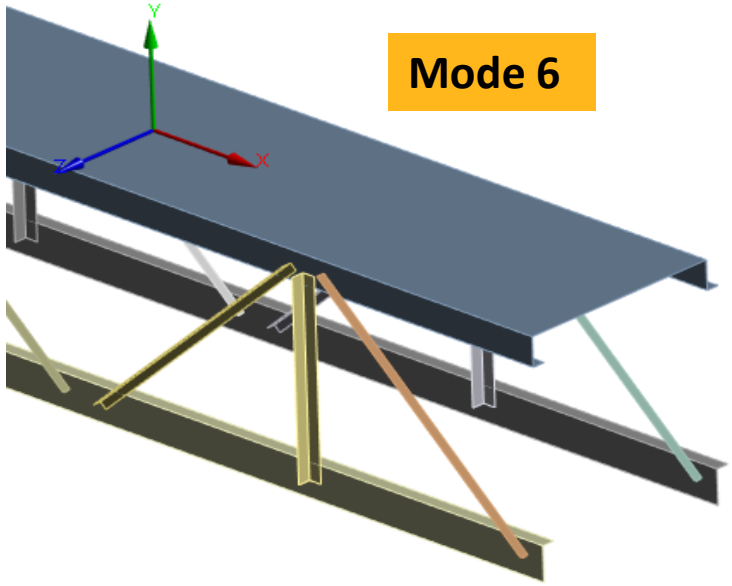
Mode 6

Workshop - Random Vibration Results

- Insert Response PSDs on the Roof, using Coordinate System scoping at the approximate peak locations indicated by Modes 4 and 6:
  - Create 2 Local Coordinate Systems, using Edge scoping as indicated in the figures below, rename each coordinate system to Mode 4 and Mode 6 respectively for clarity
  - For Mode 6 select the same edge used for Mode 4 then provide a translation X offset of –96 in.

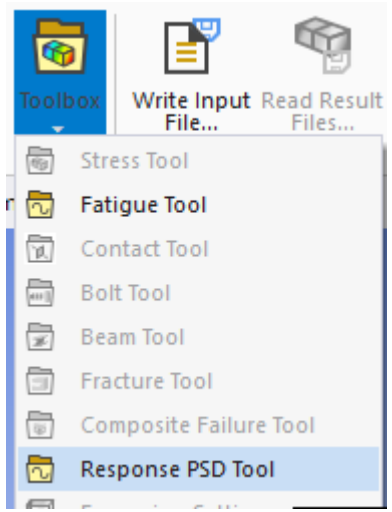


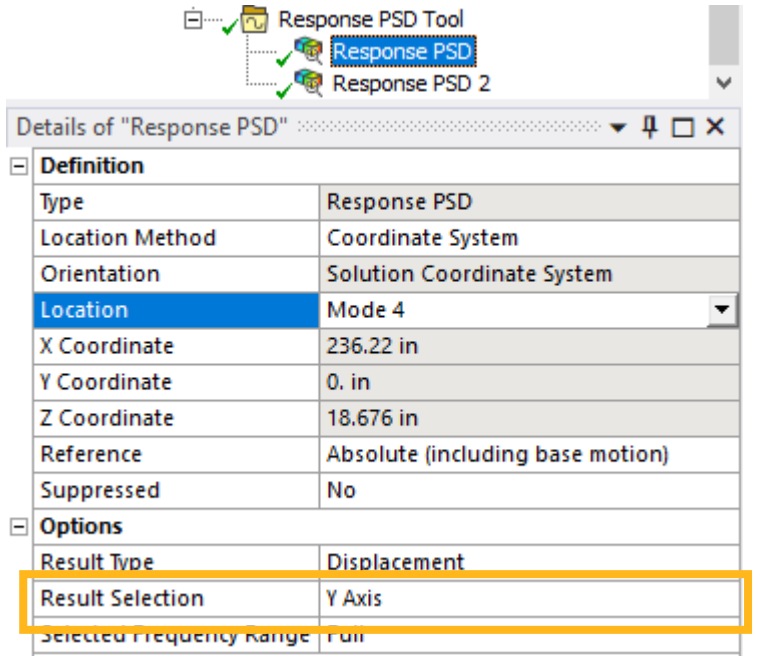


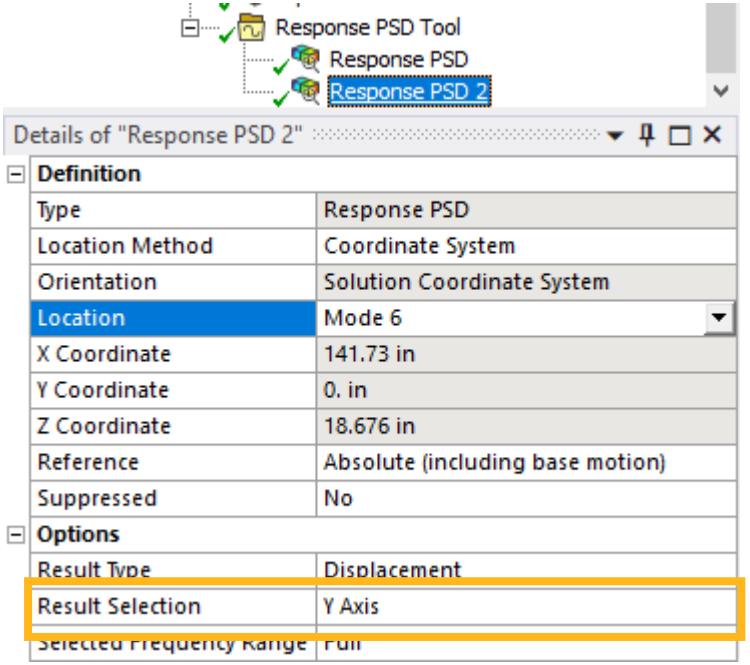


Workshop - Random Vibration Results

- Insert Response PSDs Probes on the Roof, using Coordinate scoping at the approximate peak locations indicated by Modes 4 and 6:
  - From the Solution branch of the Random Vibration environment, Insert a Response PSD Tool
  - Insert 2 response PSD displacement results in the Y direction, one at each coordinate system location defined previously







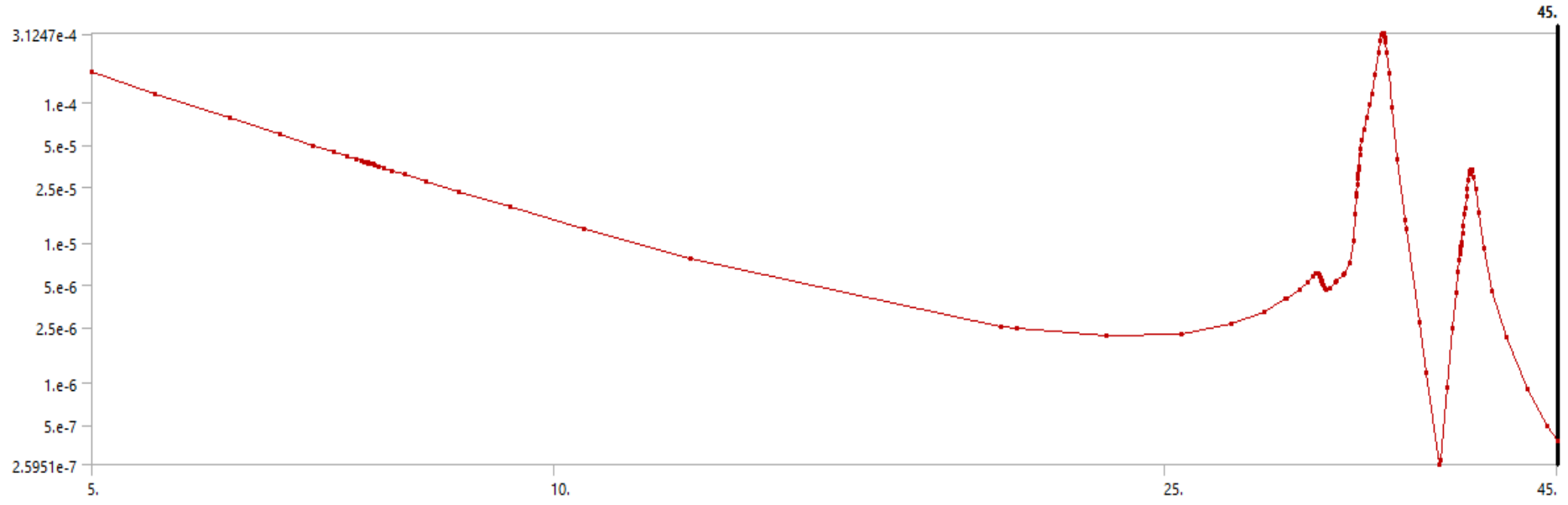
Workshop - Random Vibration Results

- Resulting Response PSDs at peak locations of Modes 4 , with RMS values:

Details of "Response PSD"

Definition	
Type	Response PSD
Location Method	Coordinate System
Orientation	Solution Coordinate System
Location	Mode 4
X Coordinate	236.22 in
Y Coordinate	0. in
Z Coordinate	18.676 in
Reference	Absolute (including base motion)
Suppressed	No
Options	
Result Type	Displacement
Result Selection	Y Axis
Selected Frequency Range	Full
Results	
Node ID	1636
RMS Value	2.686e-002 in
RMS Percentage	100. %
Expected Frequency	22.352 Hz

Graph



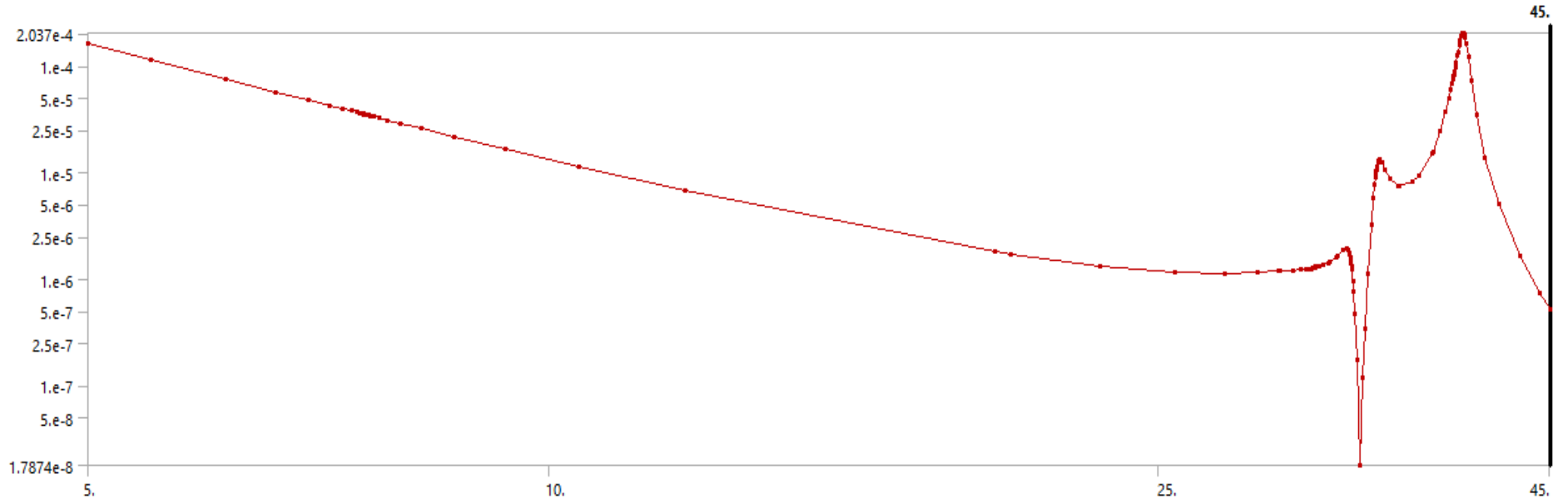
Workshop - Random Vibration Results

- Resulting Response PSDs at peak locations of Modes 6, with RMS values:

Details of "Response PSD 2"

Definition	
Type	Response PSD
Location Method	Coordinate System
Orientation	Solution Coordinate System
Location	Mode 6
X Coordinate	140.23 in
Y Coordinate	0. in
Z Coordinate	18.787 in
Reference	Absolute (including base motion)
Suppressed	No
Options	
Result Type	Displacement
Result Selection	Y Axis
Selected Frequency Range	Full
Results	
Node ID	2037
RMS Value	2.4529e-002 in
RMS Percentage	100. %
Expected Frequency	22.565 Hz

Graph



Workshop - Random Vibration Results

- Go Further
  - Repeat the Response PSD calculations, this time requesting RMS stress results

Details of "Response PSD 3"

Definition	
Type	Response PSD
Location Method	Coordinate System
Orientation	Solution Coordinate System
Location	Mode6
X Coordinate	141.73 in
Y Coordinate	0. in
Z Coordinate	18.676 in
Reference	Absolute (including base motion)
Suppressed	No
Options	
Result Type	Stress
Result Selection	Normal - X Axis
Selected Frequency Range	Full
Results	
RMS Value	31.564 psi
RMS Percentage	100. %
Expected Frequency	36.2 Hz

End of presentation