105

Homework #13

very good except amplitudes

more than required

Problem Description: Use SolidWorks, or any other commercial FEA software, to create a square plate 10m x 10m x 0.01m made of steel. Use a shell mesh and support one edge to form a square deep cantilever. Compute the first seven mode shapes (including the out of plane ones). Provide an image of each of those mode shapes.

Mech 517: In addition to the above calculations you have an extra problem. After the above calculations are complete, add the additional restraint of zero displacements perpendicular to the square face. Compute the first seven modes for that in-plane vibration. Provide an image of each of those planar shapes.

SolidWorks

A square deep cantilever was constructed using the dimensions above. The extrusion was then assigned a shell mesh by selecting the front face and creating a shell mesh with depth 0.01m. The material properties are listed in Table 1. For the first part of the assignment the front face edge was given a fixed geometry to prevent displacement or rotation about the left side. This constraint is shown below in figure 1.

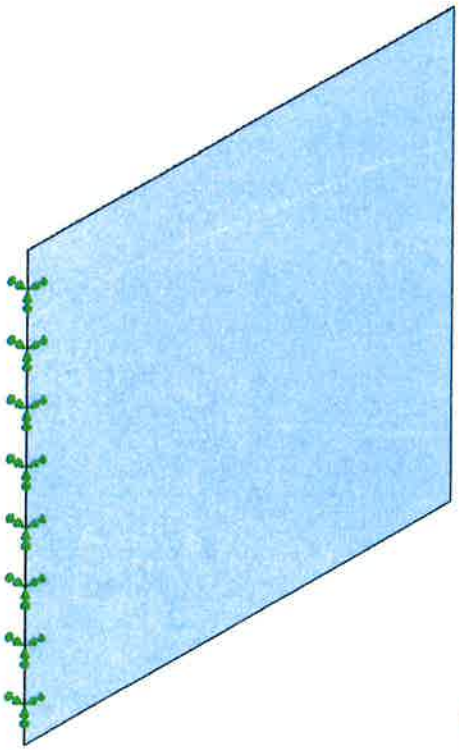

Figure 1. 10m x 10m x 0.01m steel shell deep cantilever with fixed geometry applied to the left side edge.

Table 1. Material Properties used in SolidWorks Simulation

Material Type	Alloy Steel
Density	7700 kg/m^3
Young's Modulus	2e+11 Pa
Tensile Yield Strength	6.2e+8 Pa
Tensile Ultimate Strength	7.23e+8 Pa

The simulation was performed and the first seven modes are given below in figures 2-7.

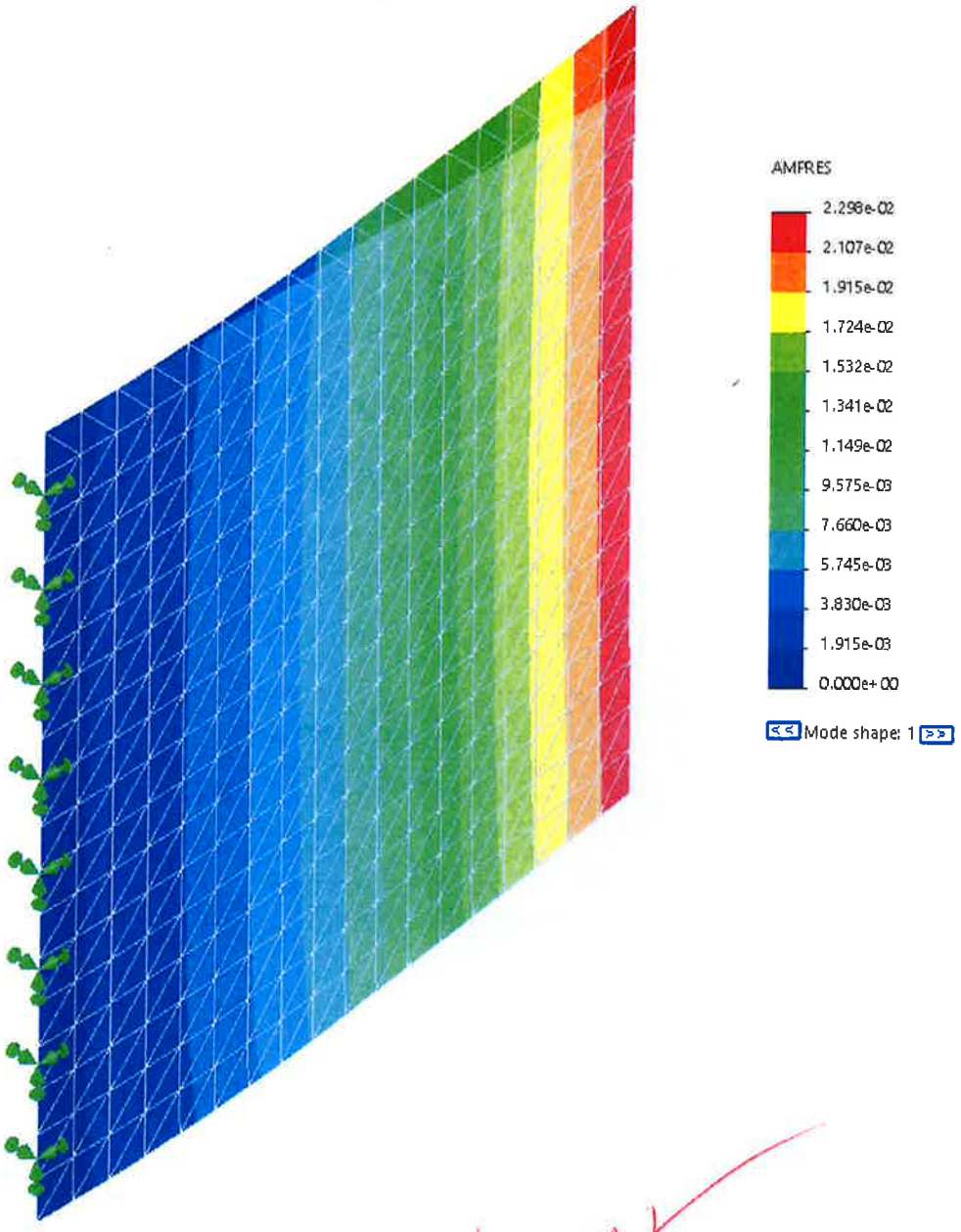

Figure 2: Mode shape 1 at resonant frequency 0.0868 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.298e-02 m.

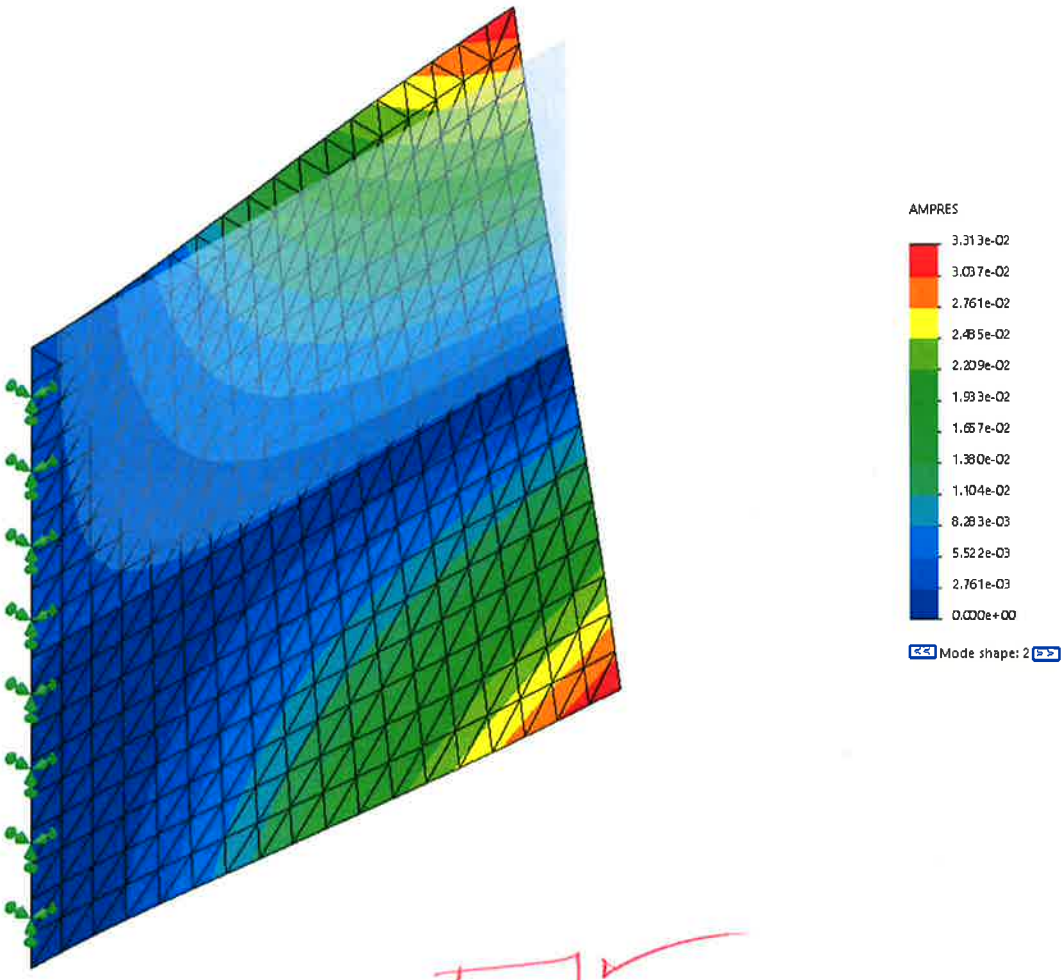

Figure 3: Mode shape 2 at resonant frequency 0.215 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.313-02 m.

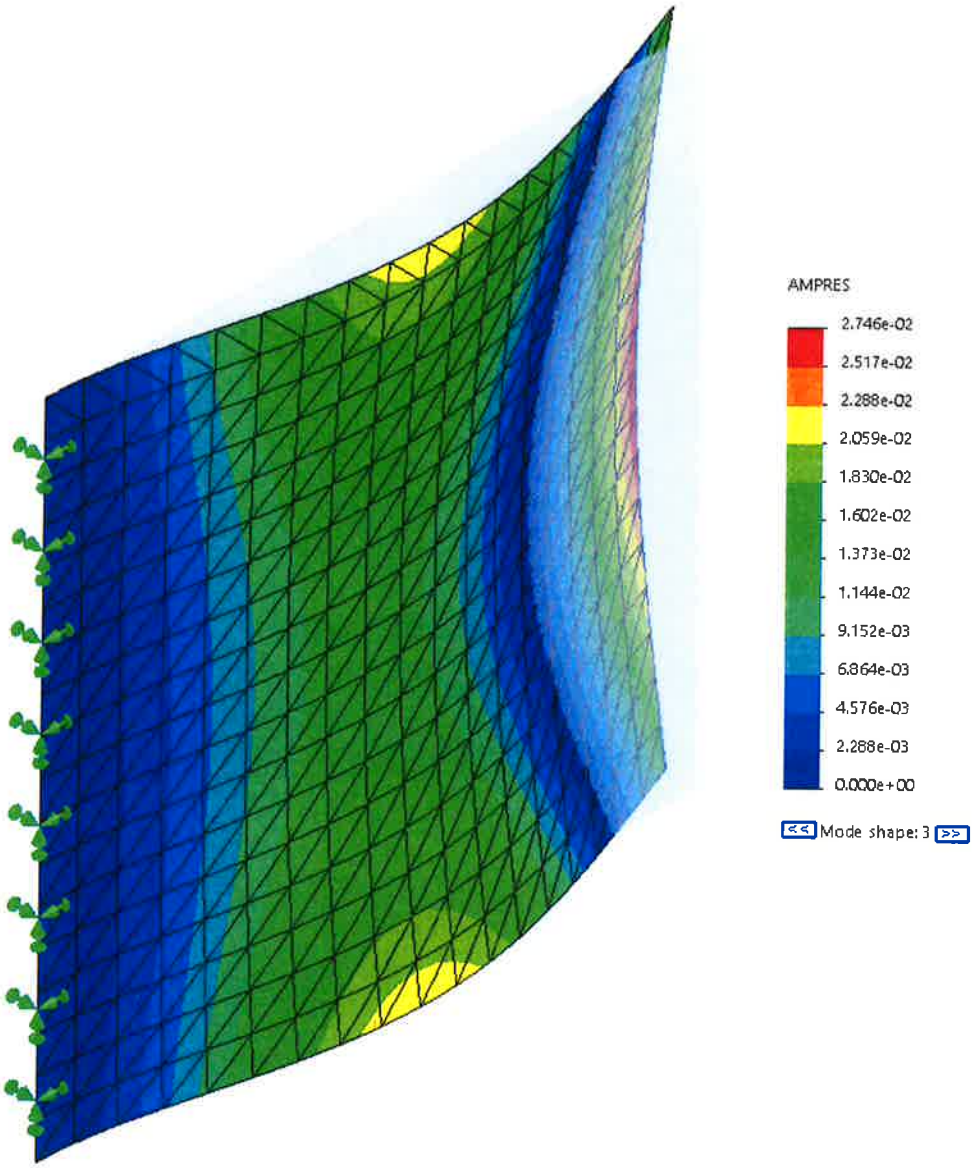

Figure 4: Mode shape 3 at resonant frequency 0.534 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.746-02 m.

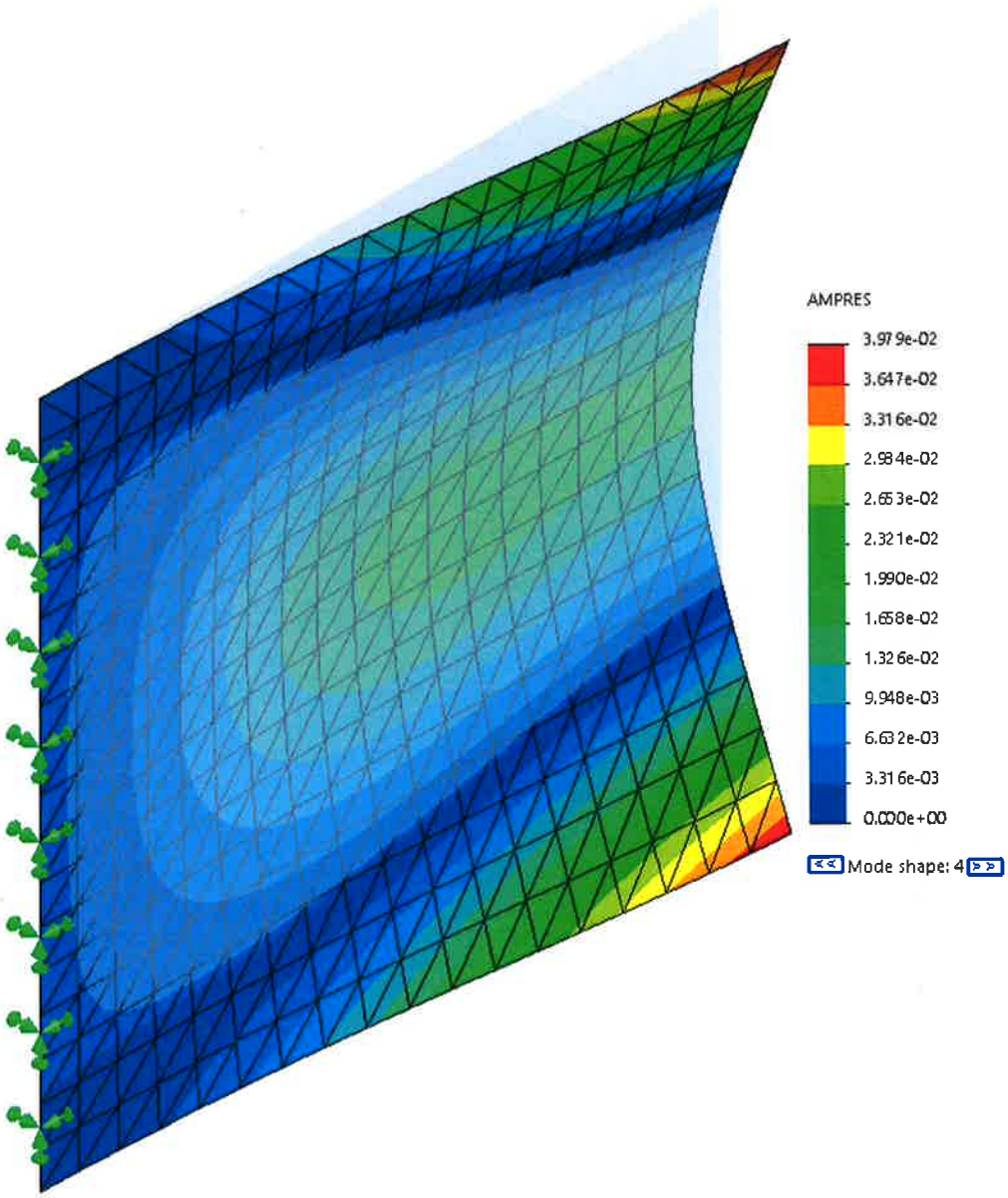

Figure 5: Mode shape 4 at resonant frequency 0.680 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.980-02 m.

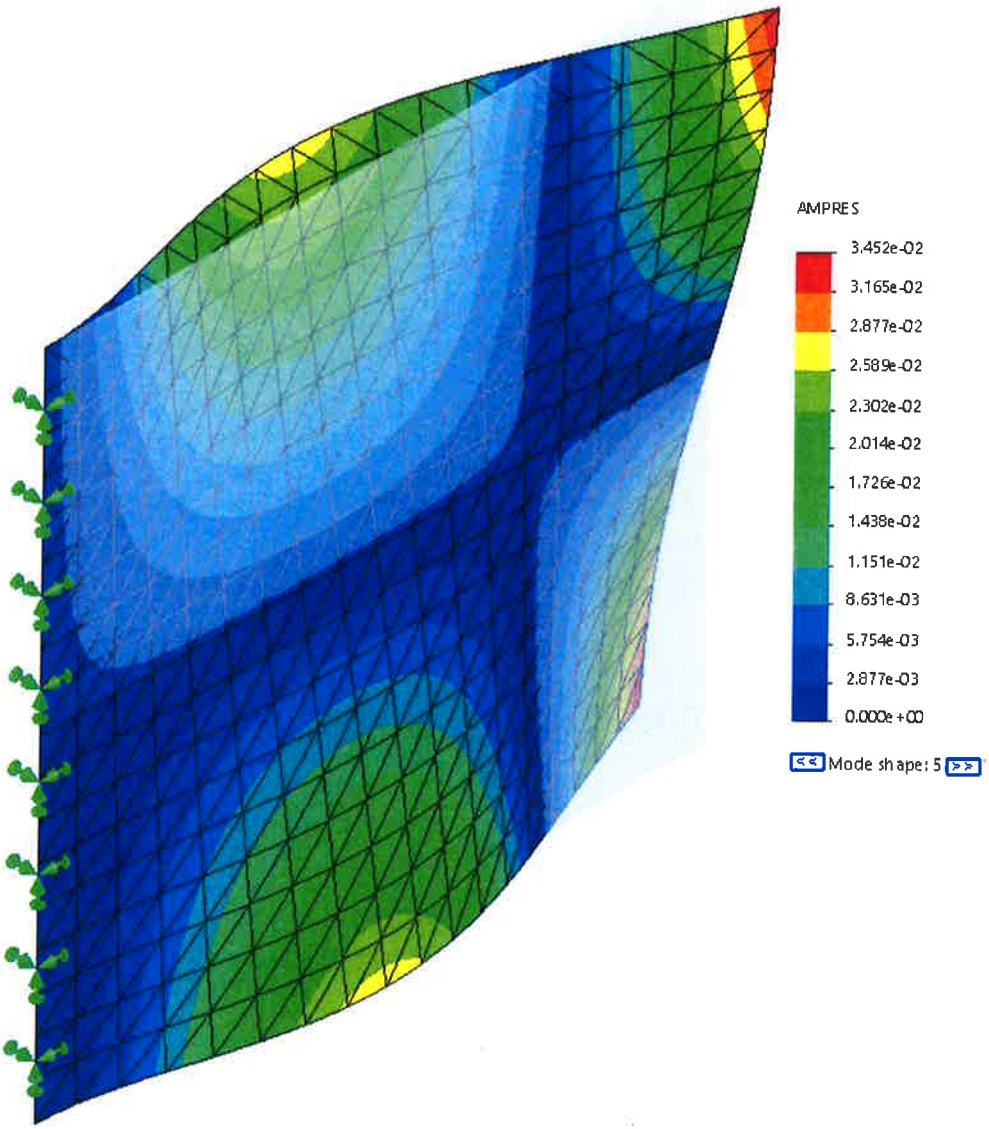

Figure 6: Mode shape 5 at resonant frequency 0.778 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.452-02 m.

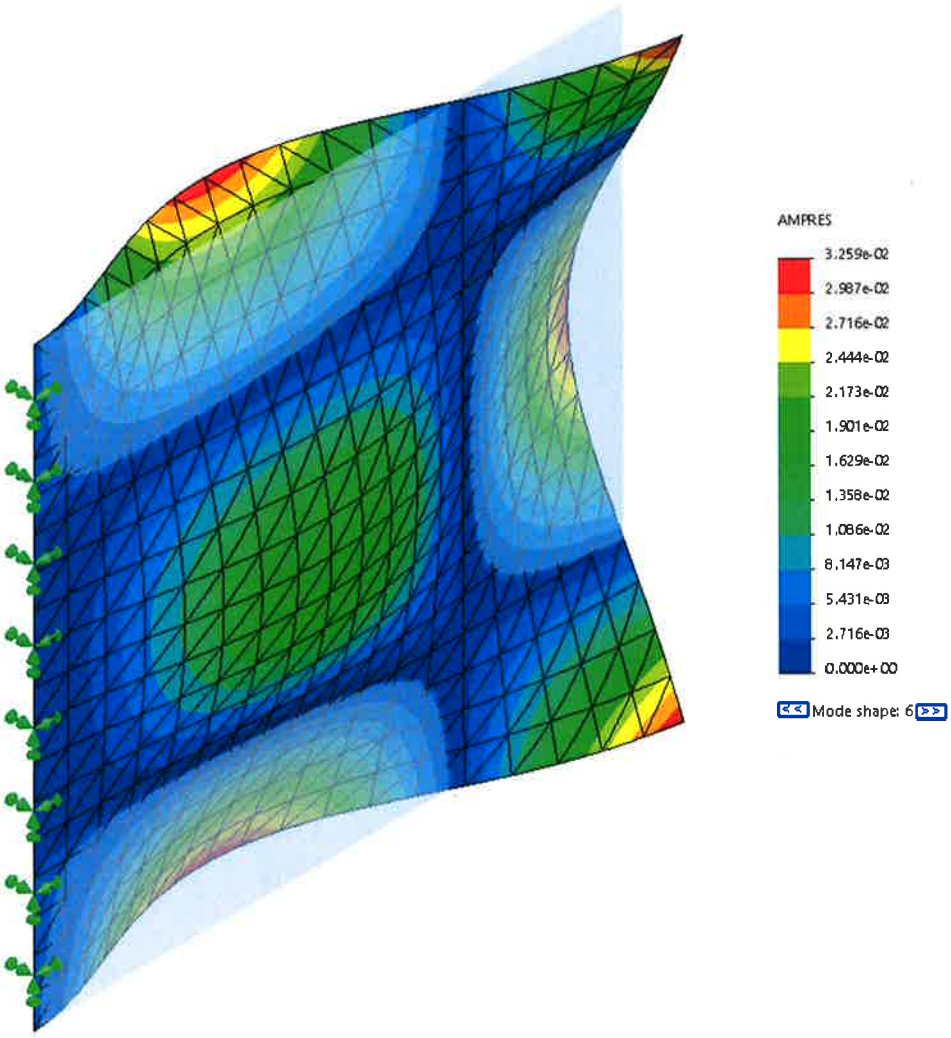

Figure 7: Mode shape 6 at resonant frequency 1.361 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.259-02 m.

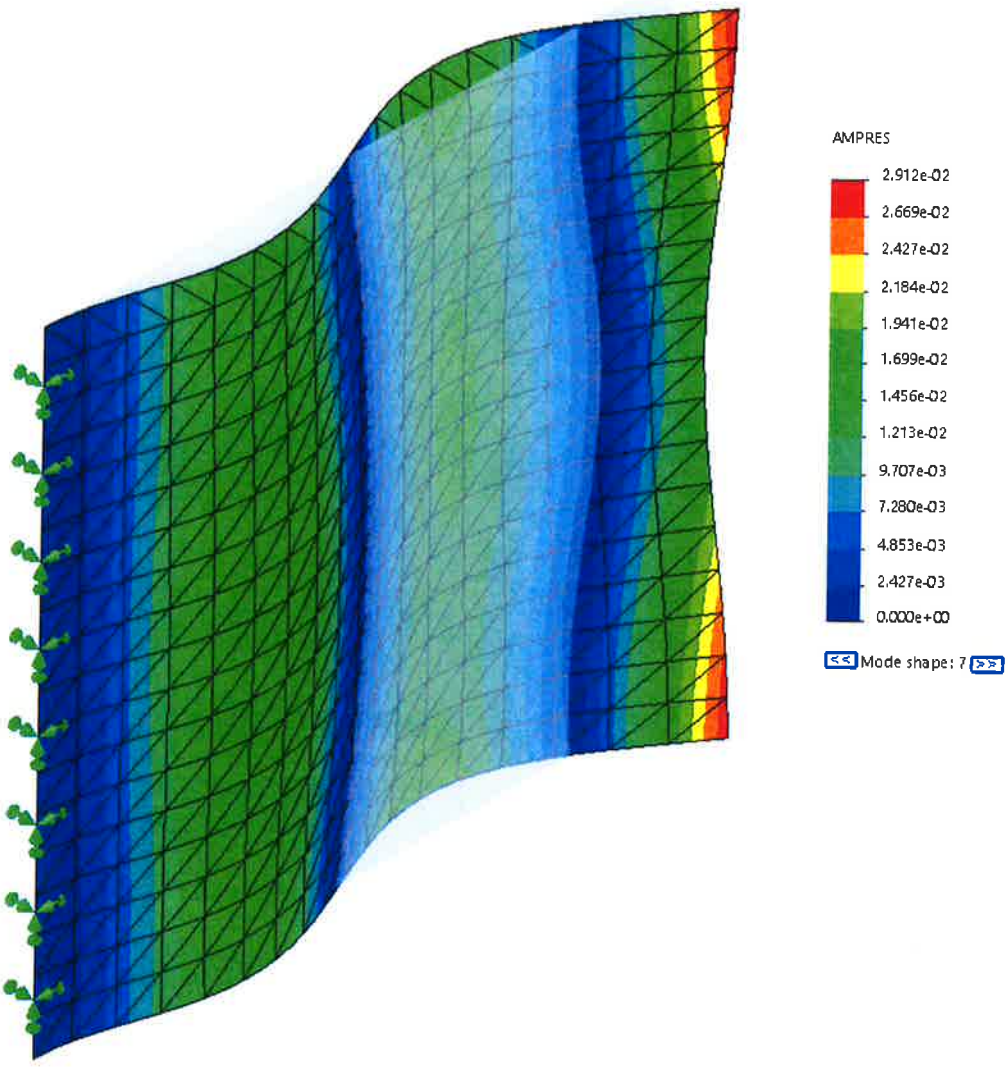

Figure 8: Mode shape 7 at resonant frequency 1.530 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.912-02 m.

The in-plane frequencies were treated in a similar manner; however, a roller fixture was applied to the front face of the shell to cease movement in the out of plane direction. This is shown below in figure 9.

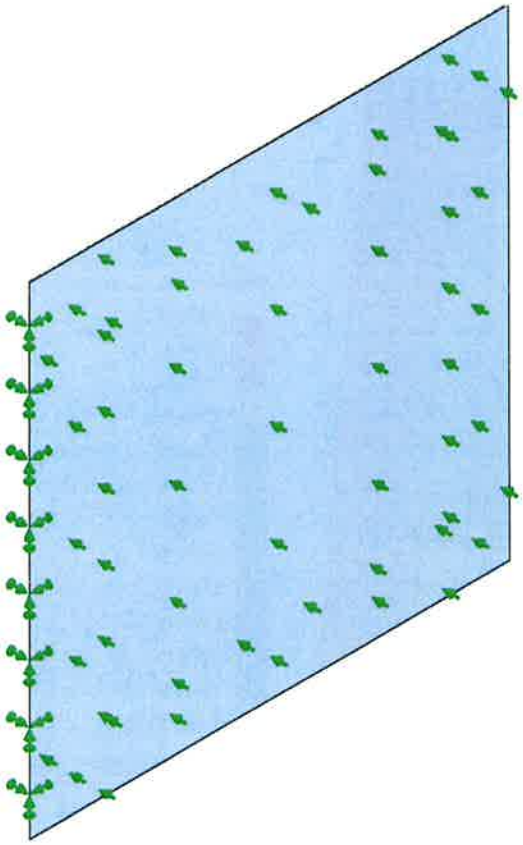

Figure 9. Constraints for the in-plane frequency analysis. The left edge still has the fixed geometry and the face now has rollers to constrain the movement in the out of plane direction.

The seven natural modes with their resonant frequencies are shown below.

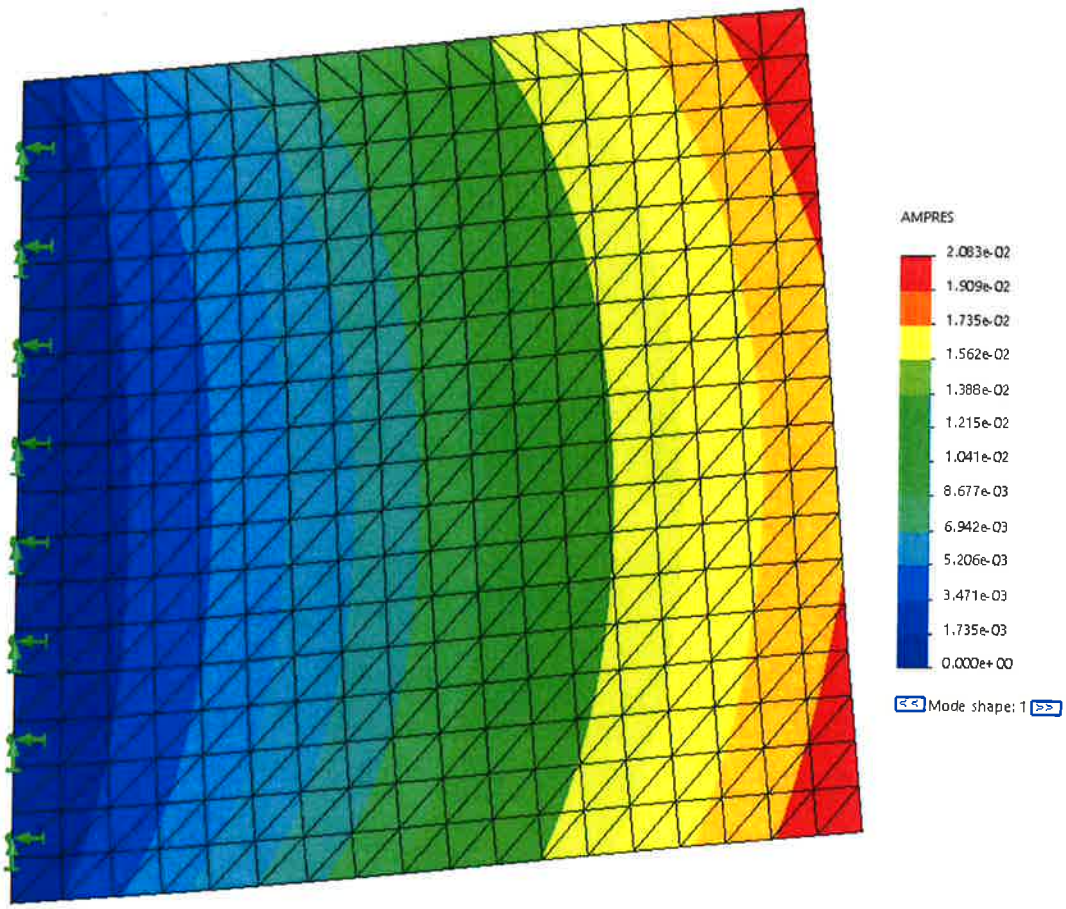

Figure 10: Mode shape 1 at resonant frequency 54.89 Hz. The max displacement was 2.083e-02 m.

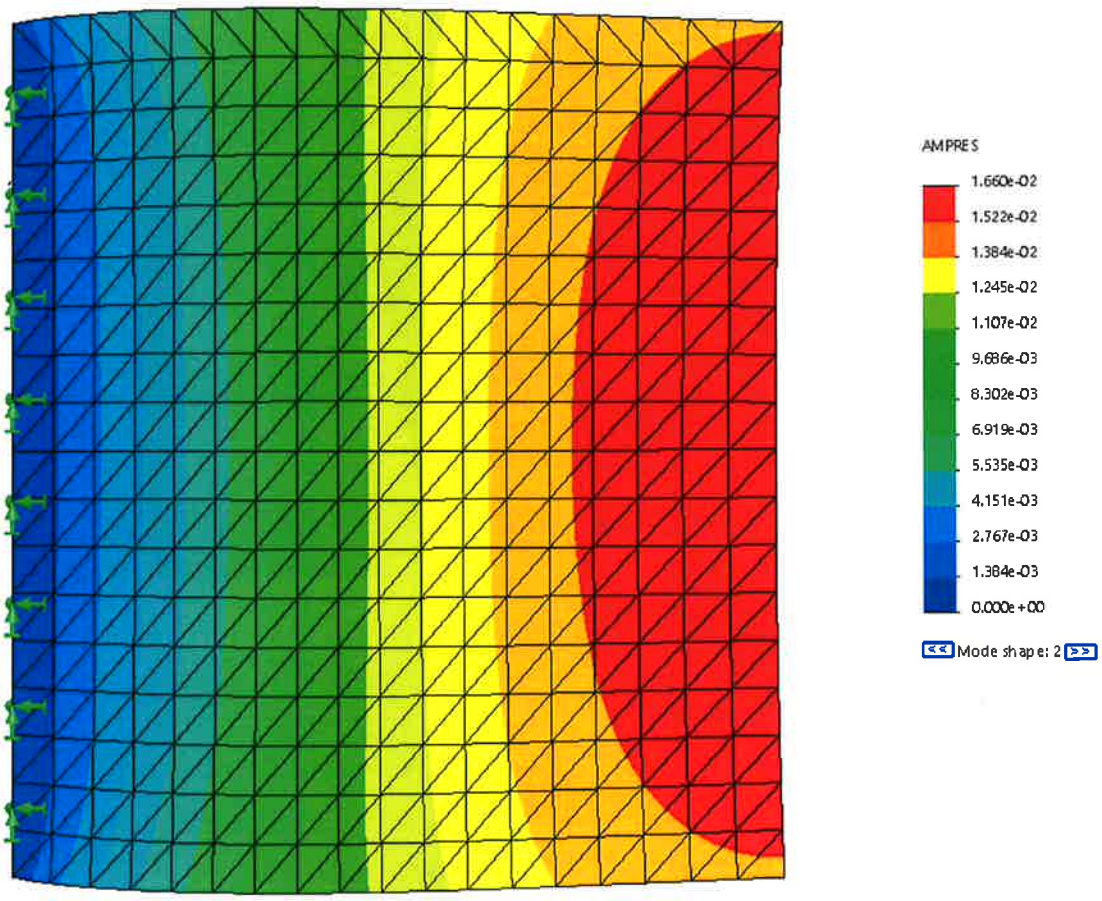

Figure 11: Mode shape 2 at resonant frequency 131.22 Hz. The max displacement was 1.660e-02 m.

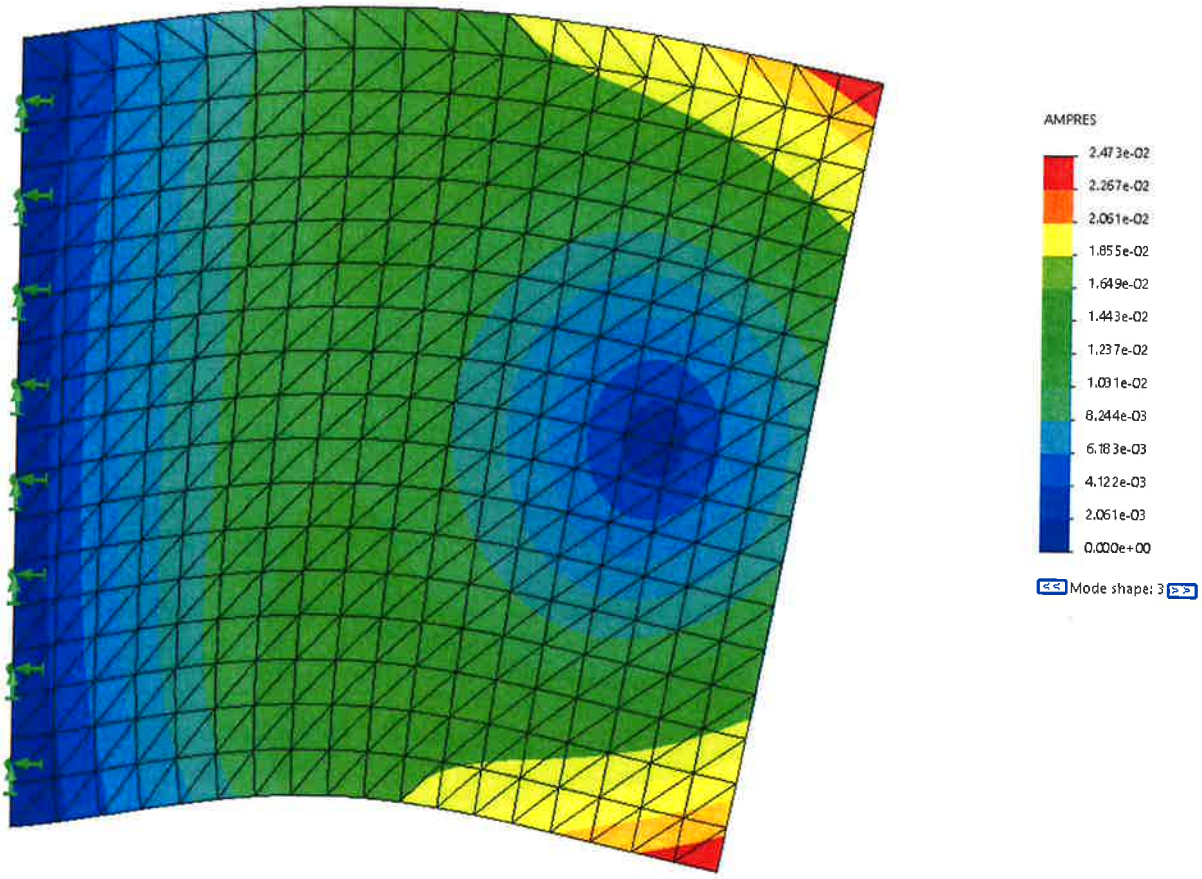

Figure 12: Mode shape 3 at resonant frequency 147.78 Hz. The max displacement was 2.473-02 m.

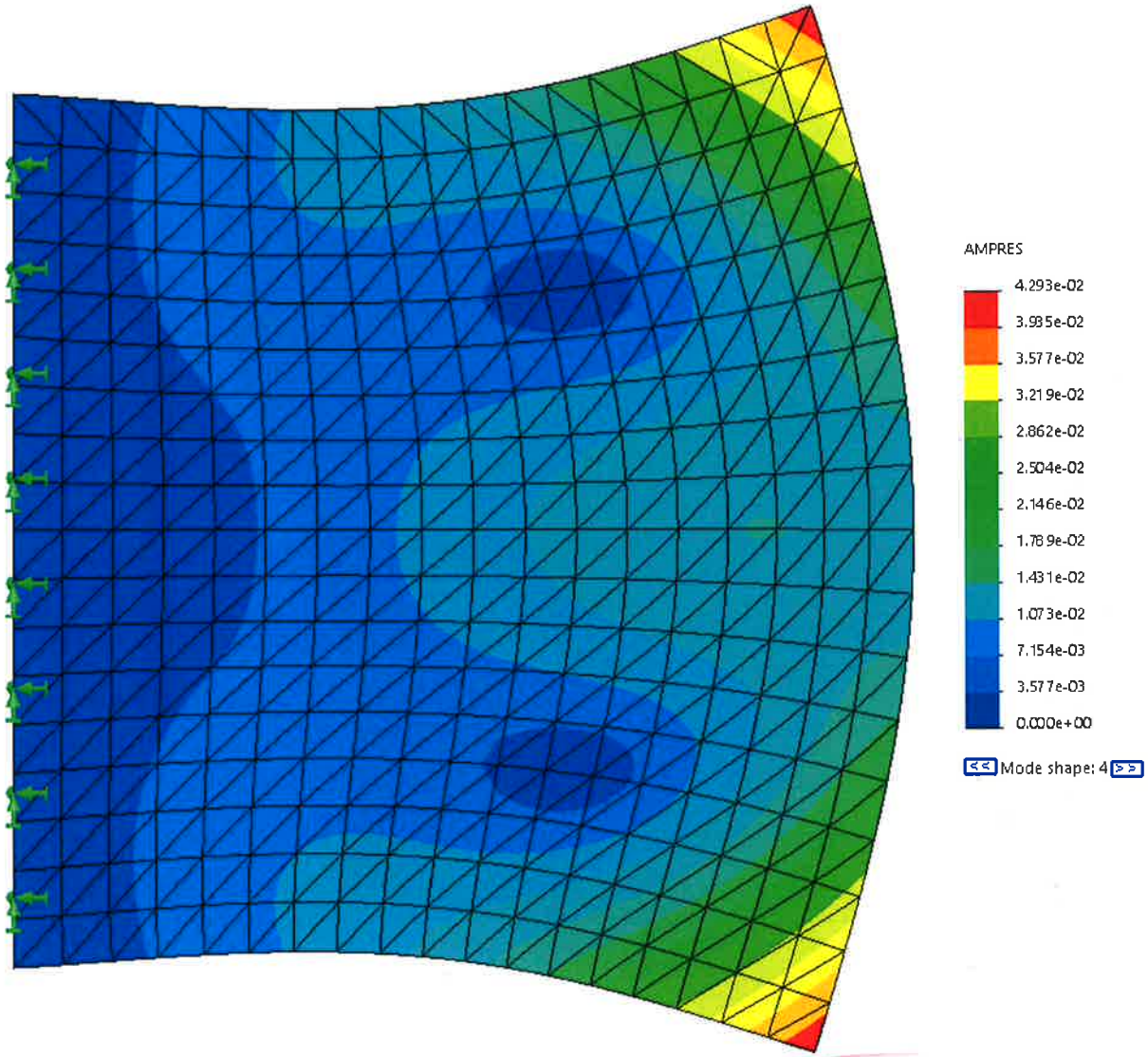

Figure 13: Mode shape 4 at resonant frequency 234.00 Hz. The max displacement was 4.293-02 m.

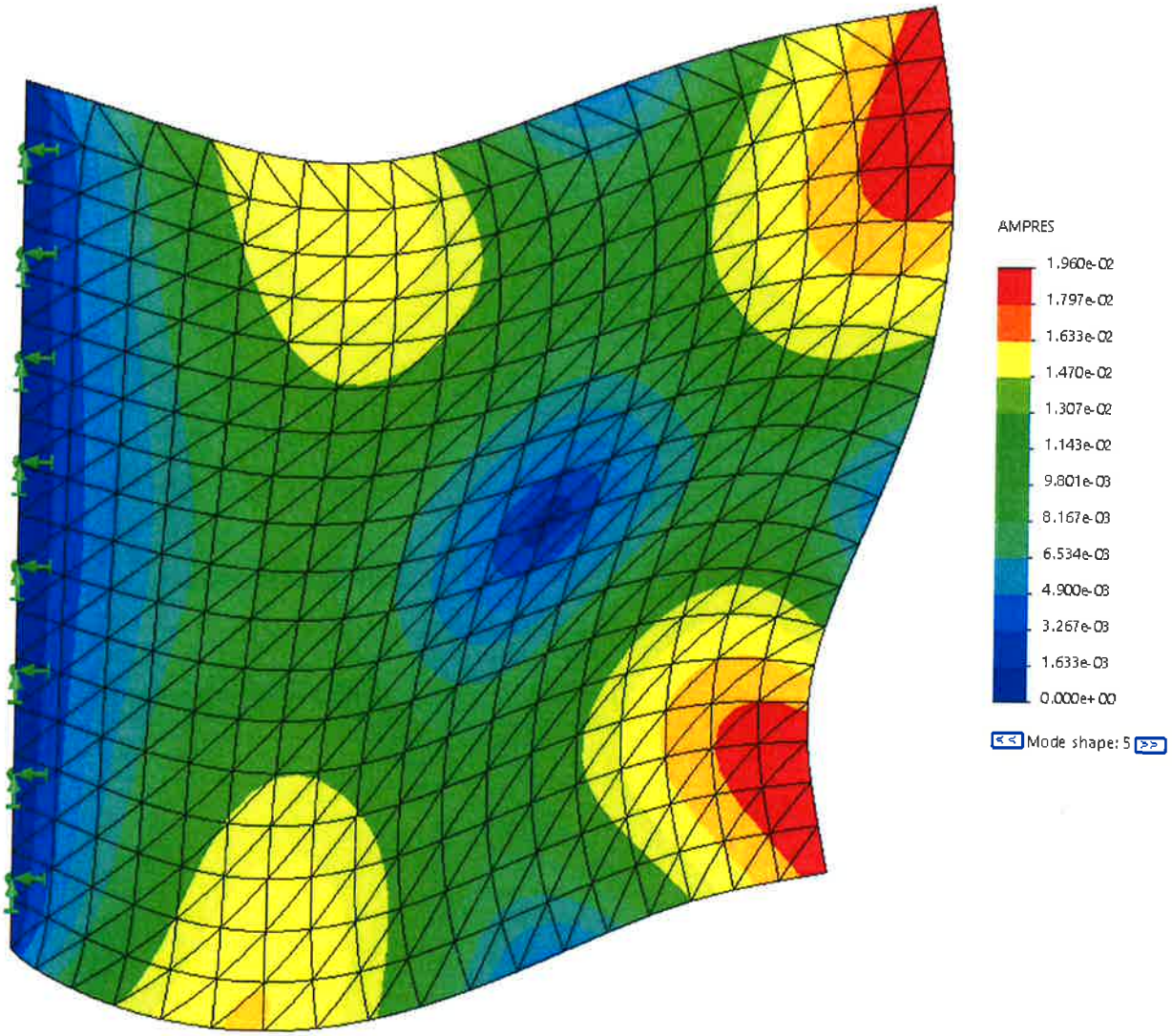

Figure 14: Mode shape 5 at resonant frequency 254.09 Hz. The max displacement was 1.960-02 m.

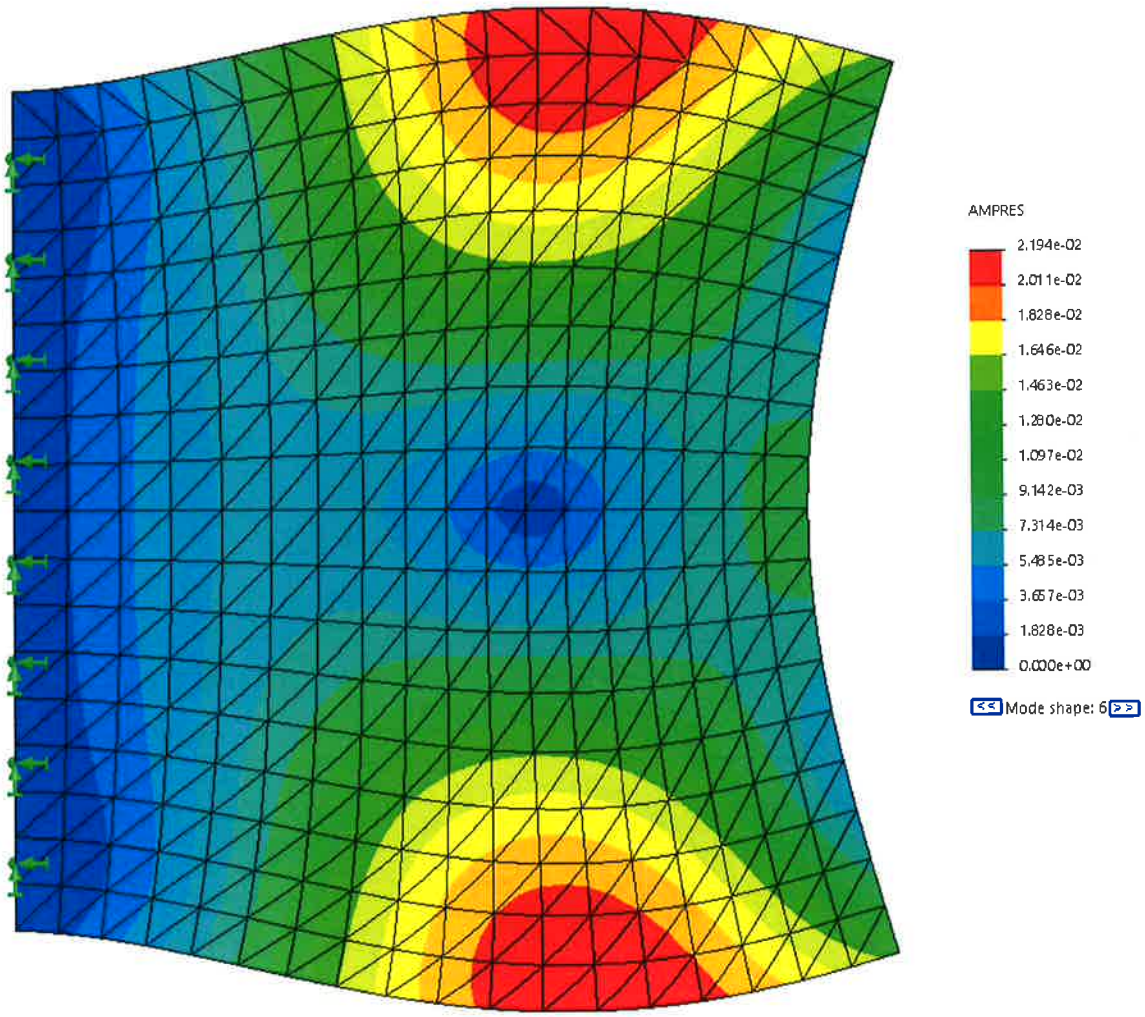

Figure 15: Mode shape 6 at resonant frequency 267.94 Hz. The max displacement was 2.194-02 m.

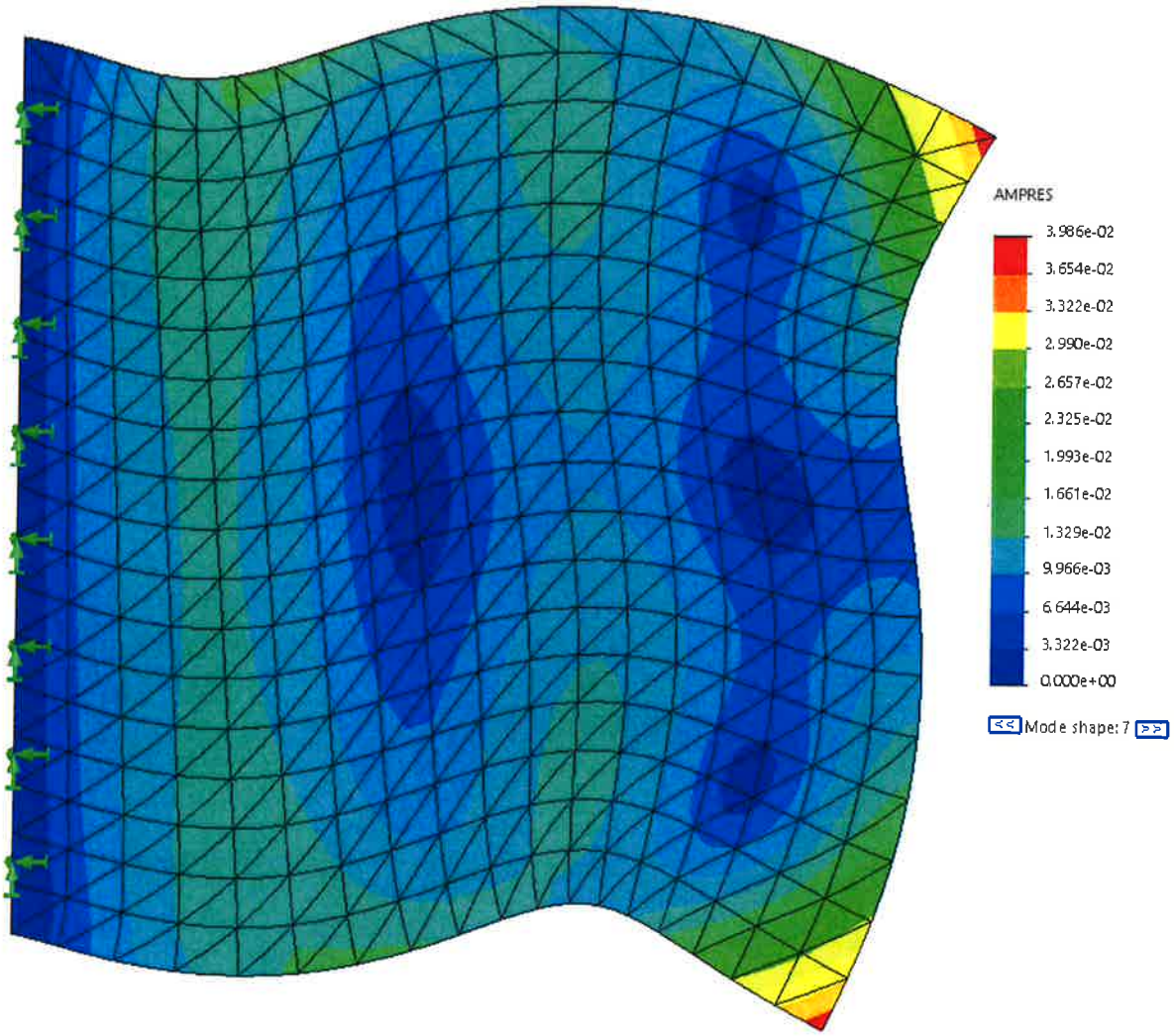

Figure 16: Mode shape 7 at resonant frequency 338.32 Hz. The max displacement was 3.896-02 m.

ANSYS

A square deep cantilever was constructed using the same dimensions as above. The extrusion was then assigned a shell mesh creating a mid-surface plane between the two square faces and applying a mesh of 0.01m-thick to that plane. For the first part of the assignment the front face edge was given a fixed geometry to prevent displacement or rotation about the left side. This constraint is shown below.

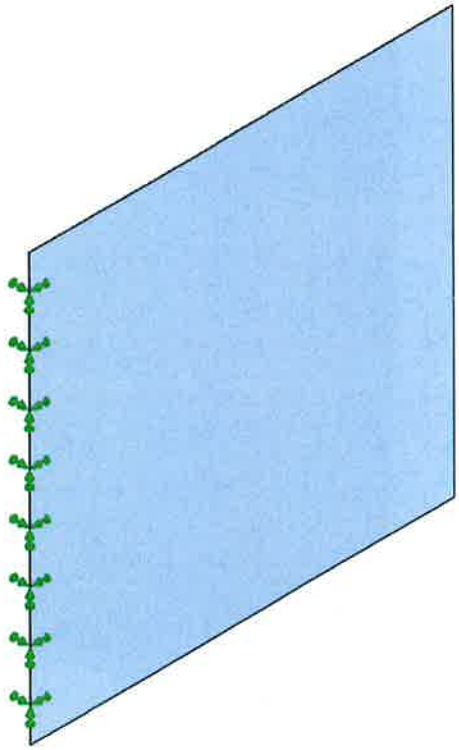

Figure 17. 10m x 10m x 0.01m steel shell deep cantilever with fixed geometry applied to the left side edge.

The material properties for this analysis are shown in Table 2 below.

Table 2. ANSYS Material Properties

Material Type	Structural Steel
Density	7850 kg/m^3
Young's Modulus	2e+11 Pa
Tensile Yield Strength	2.5e+8 Pa
Tensile Ultimate Strength	4.6e+8 Pa

y ?

The simulation was performed and the first seven modes are given below in figures 17-23.

not needed

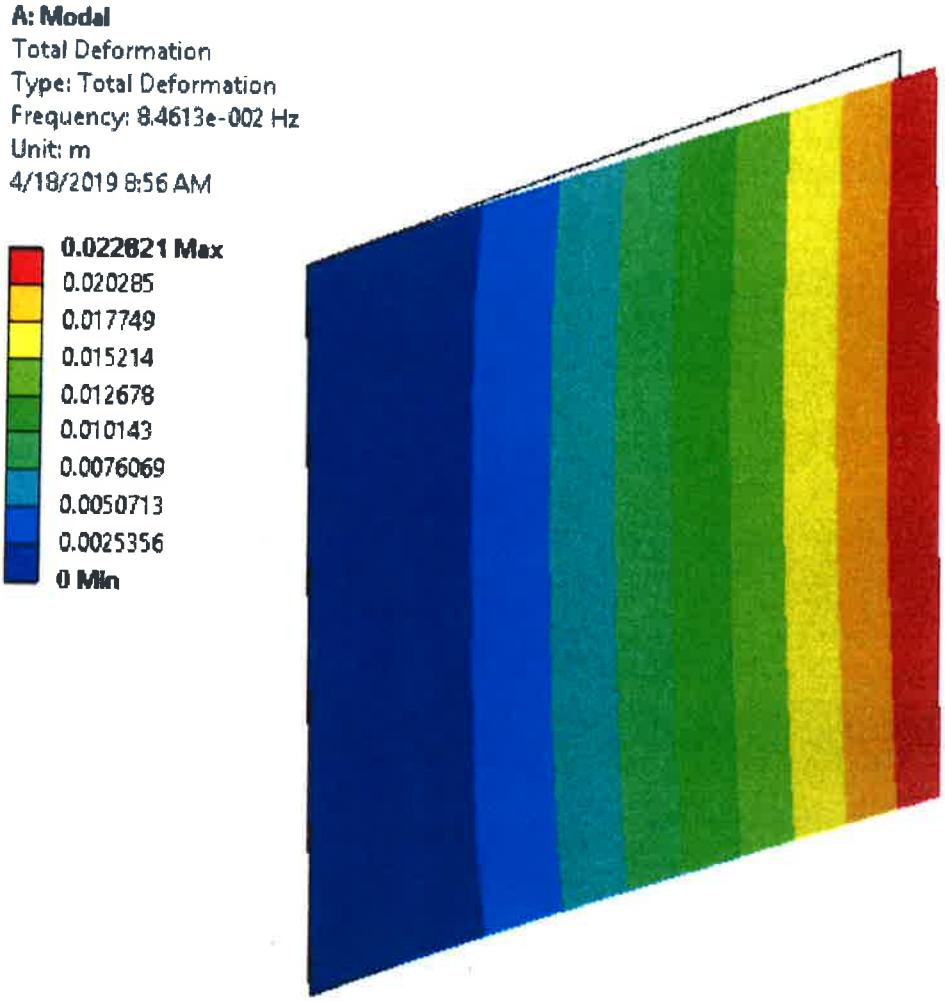

Figure 18: Mode shape 1 at resonant frequency 0.0846 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.28e-02 m.

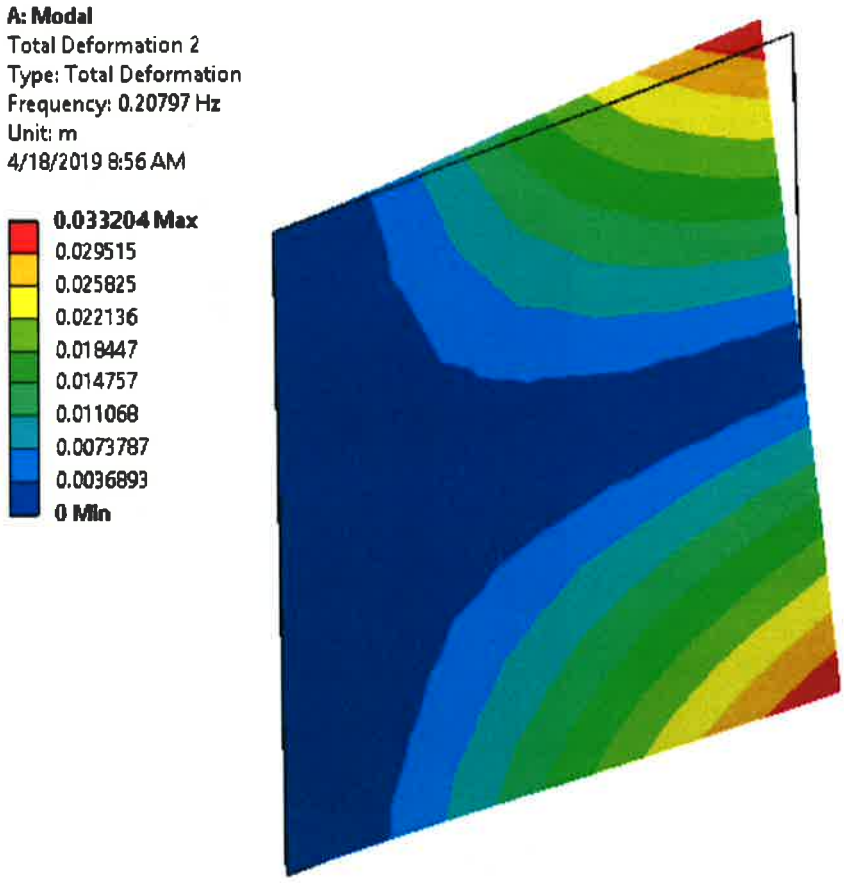

Figure 19: Mode shape 2 at resonant frequency 0.278 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.32-02 m.

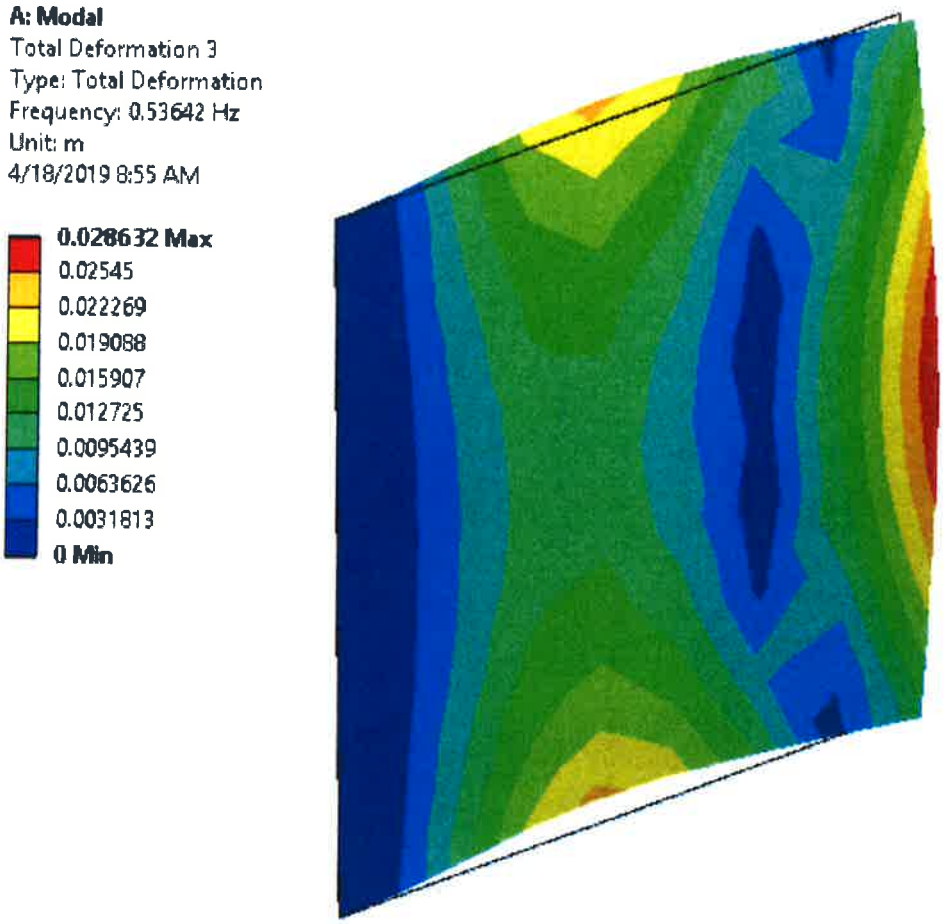

Figure 20: Mode shape 3 at resonant frequency 0.536 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.86-02 m.

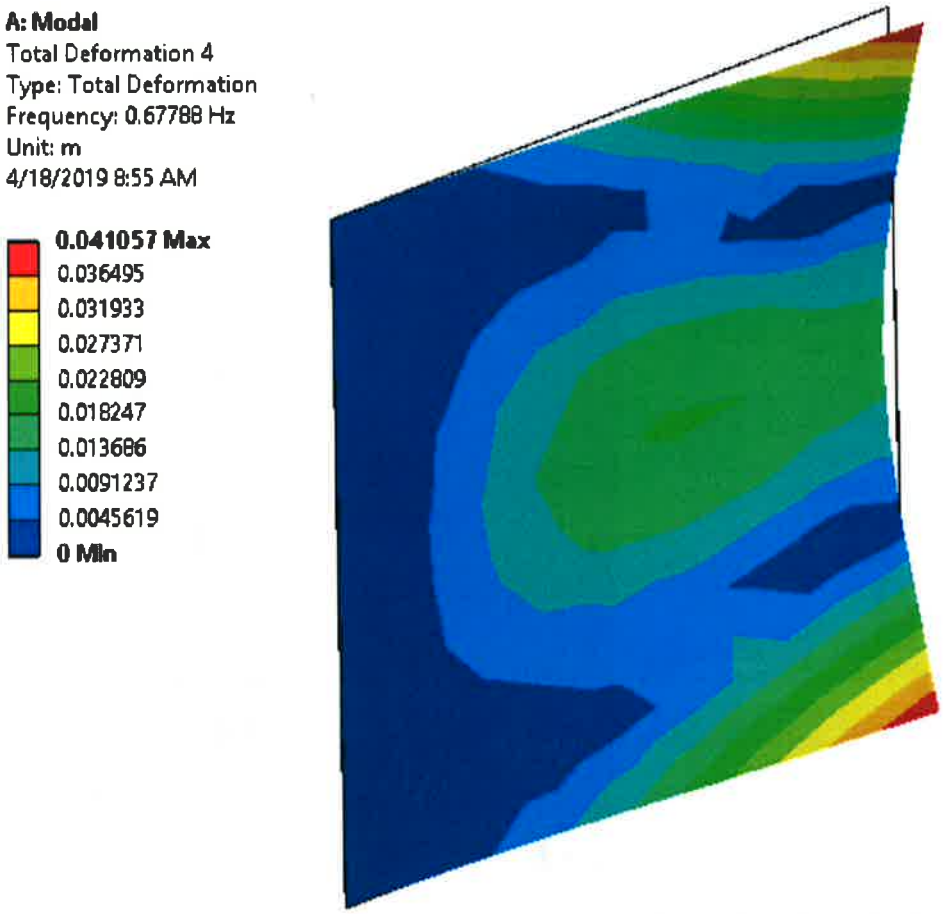

Figure 21: Mode shape 4 at resonant frequency 0.678 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.980-02 m.

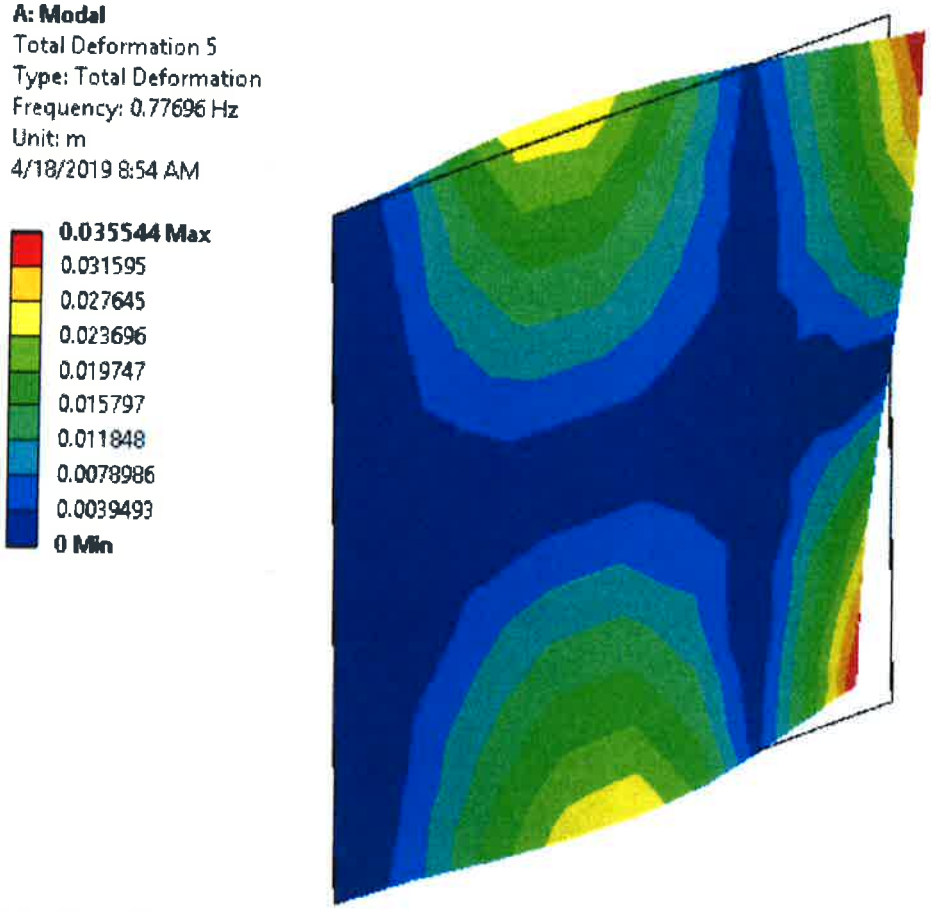

Figure 22: Mode shape 5 at resonant frequency 0.778 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.452-02 m.

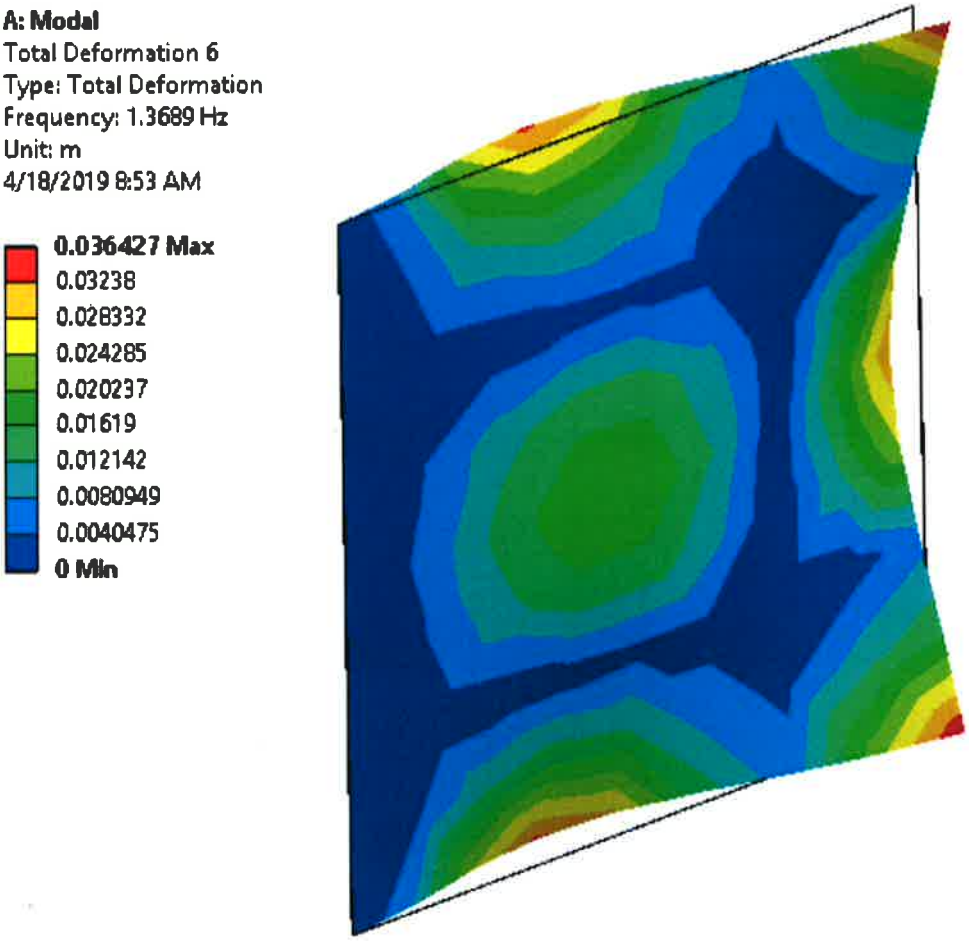

Figure 23: Mode shape 6 at resonant frequency 1.369 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 3.64-02 m.

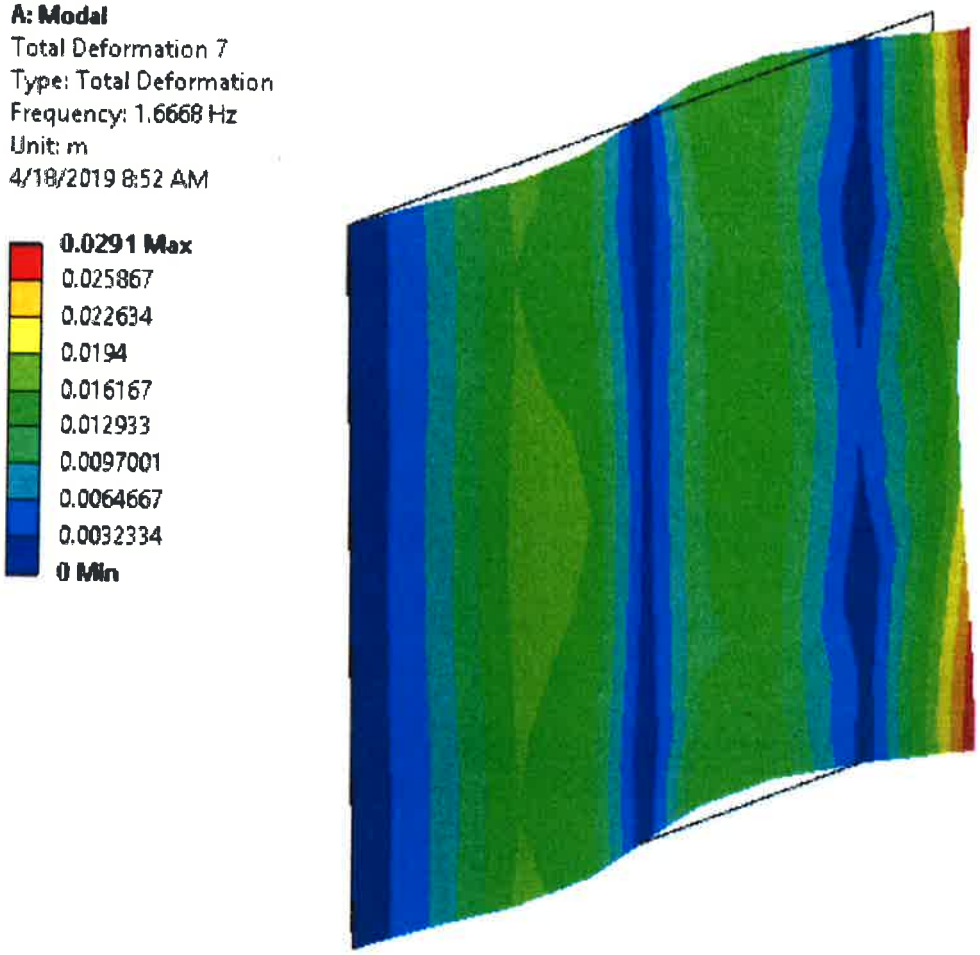

Figure 24: Mode shape 7 at resonant frequency 1.667 Hz. The undeformed cantilever is shown in light grey for reference. The max displacement was 2.91-02 m.

The in-plane frequencies were treated in a similar manner; however, a frictionless displacement constraint was applied to the front face of the shell to cease movement in the out of plane direction. This is shown below in figure 24.

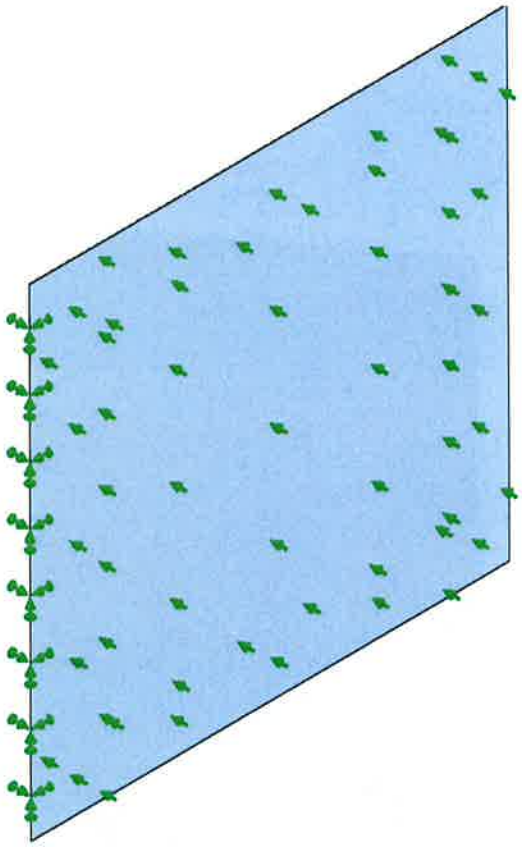

Figure 25. Constraints for the in-plane frequency analysis. The left edge still has the fixed geometry and the face now has a frictionless constraint to prevent movement in the out of plane direction.

The seven natural modes with their resonant frequencies are shown below with the undeformed wireframe plotted for reference.

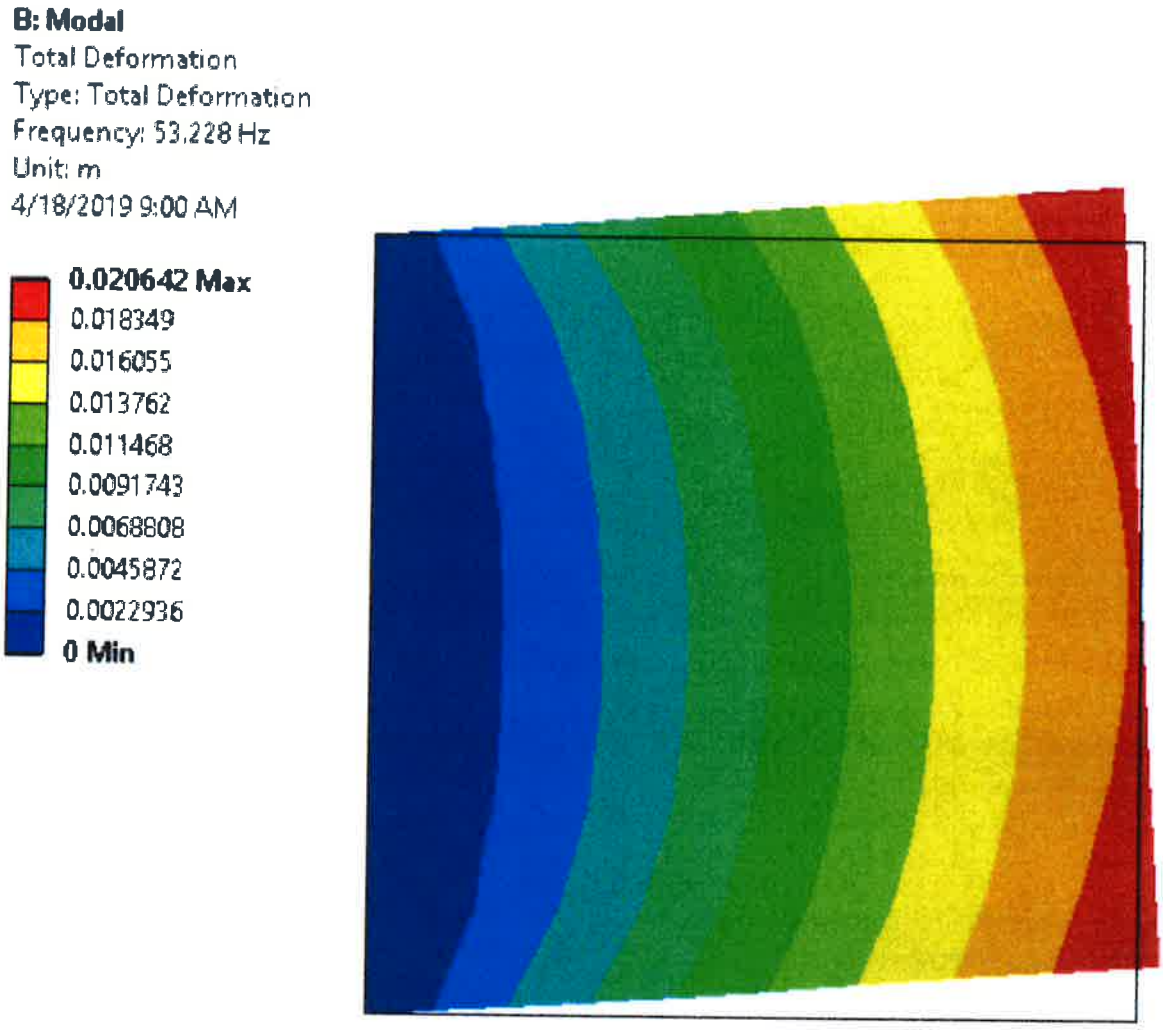

Figure 26: Mode shape 1 at resonant frequency 53.228 Hz. The max displacement was 2.06e-02 m.

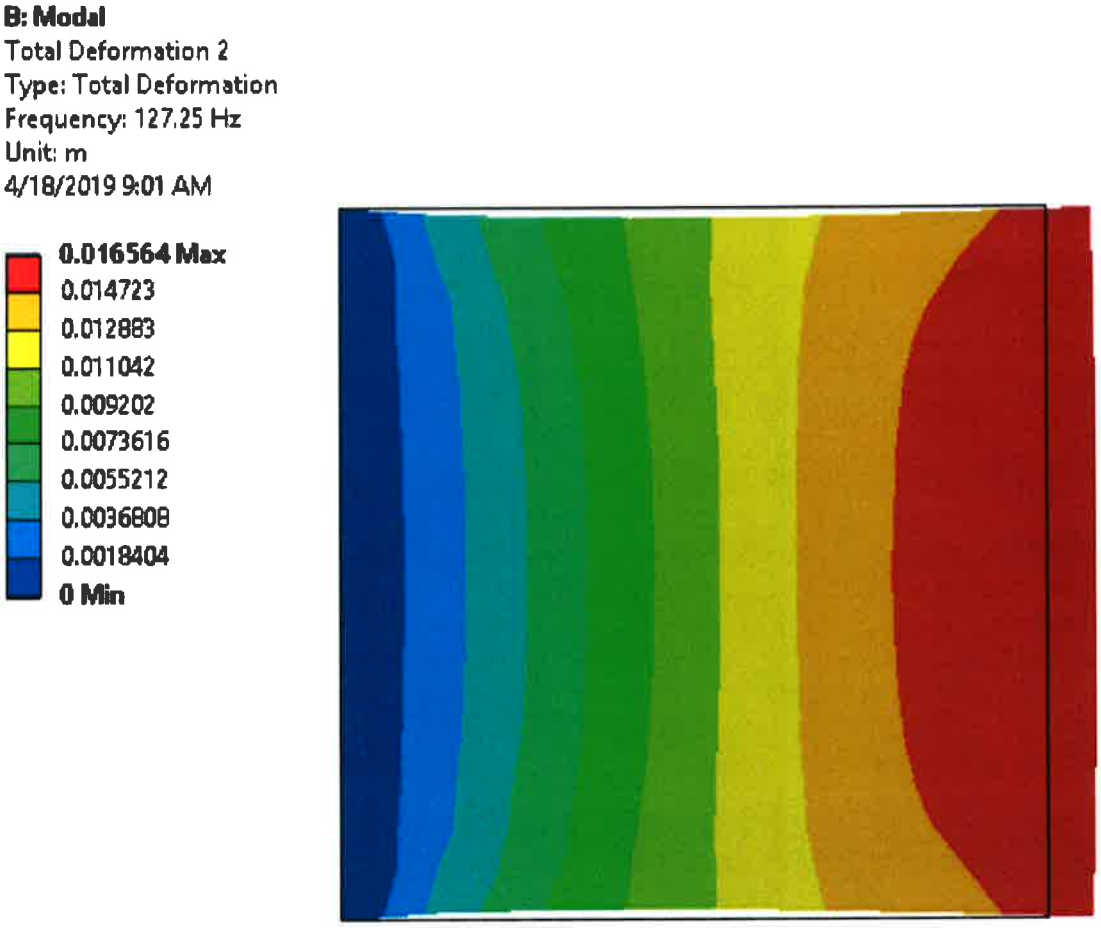

Figure 27: Mode shape 2 at resonant frequency 127.25 Hz. The max displacement was 1.66e-02 m.

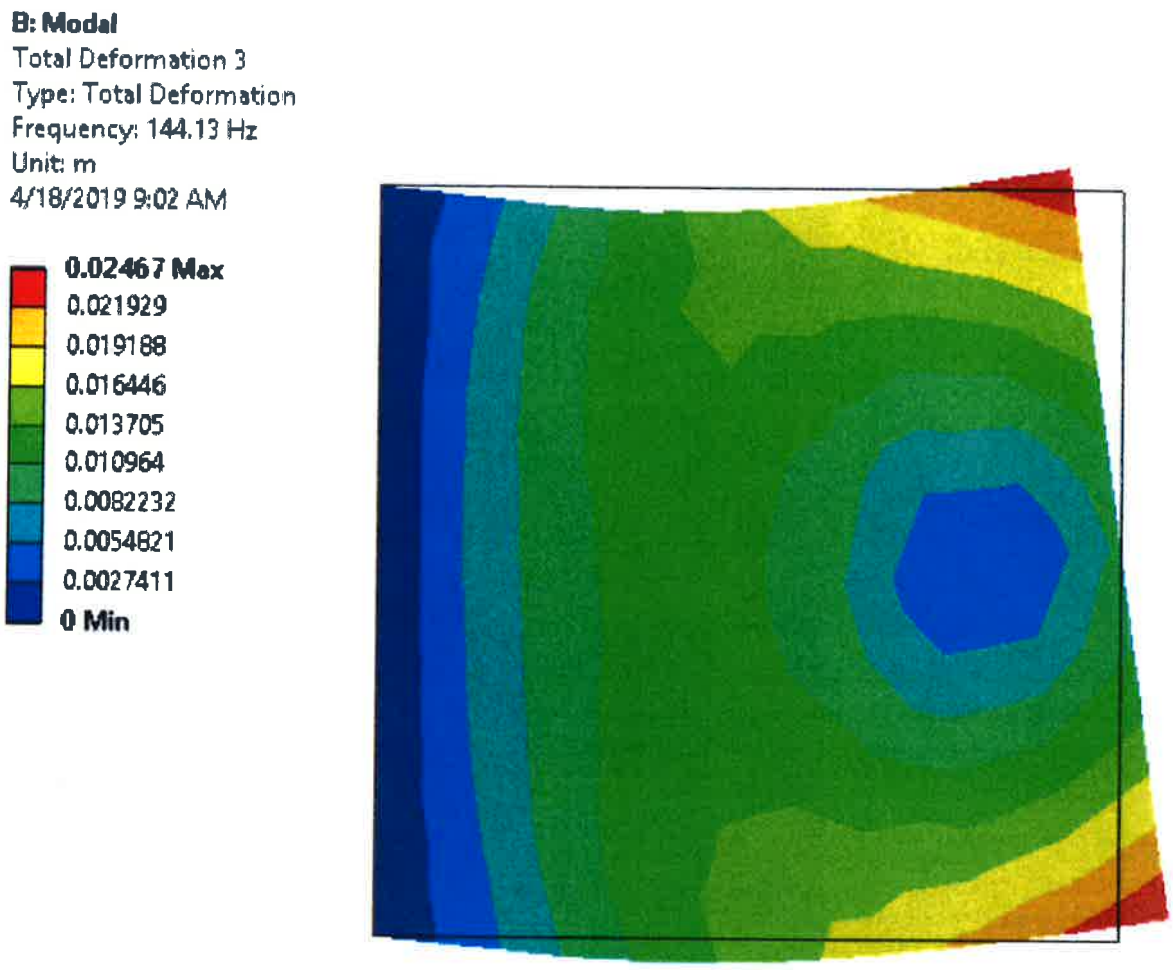

Figure 28: Mode shape 3 at resonant frequency 144.13 Hz. The max displacement was 2.46-02 m.

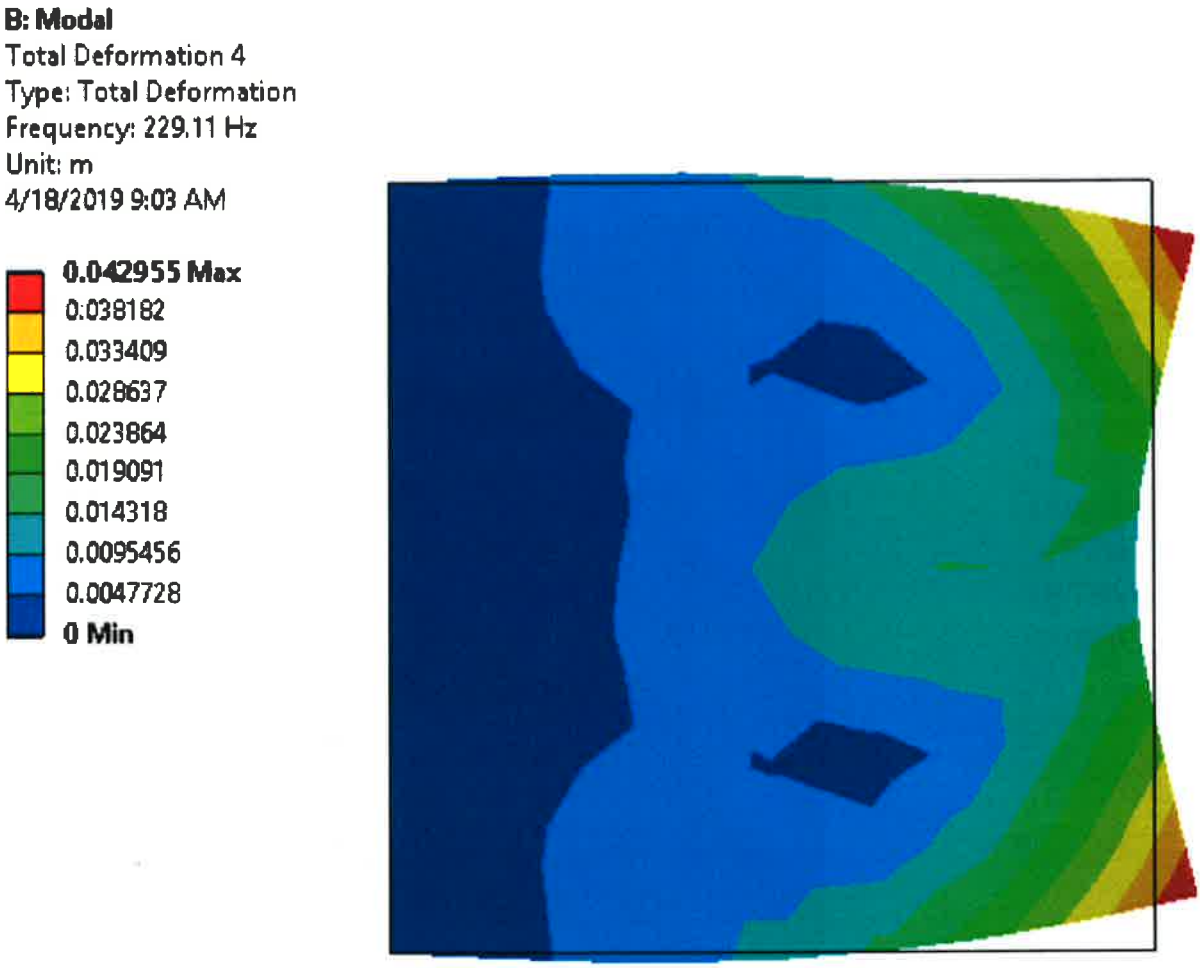

Figure 29: Mode shape 4 at resonant frequency 229.11 Hz. The max displacement was 4.296-02 m.

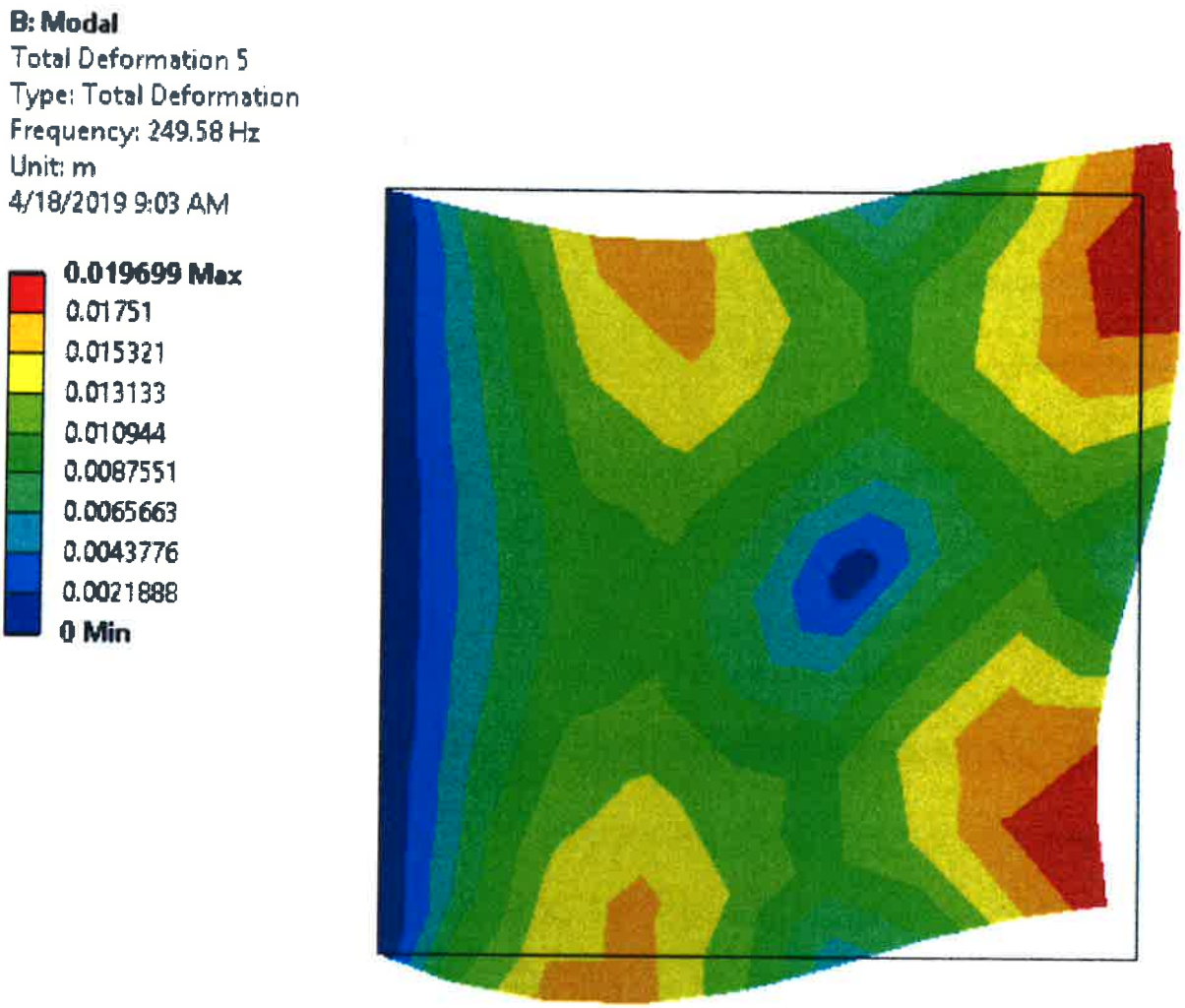

Figure 30: Mode shape 5 at resonant frequency 249.58 Hz. The max displacement was 1.97-02 m.

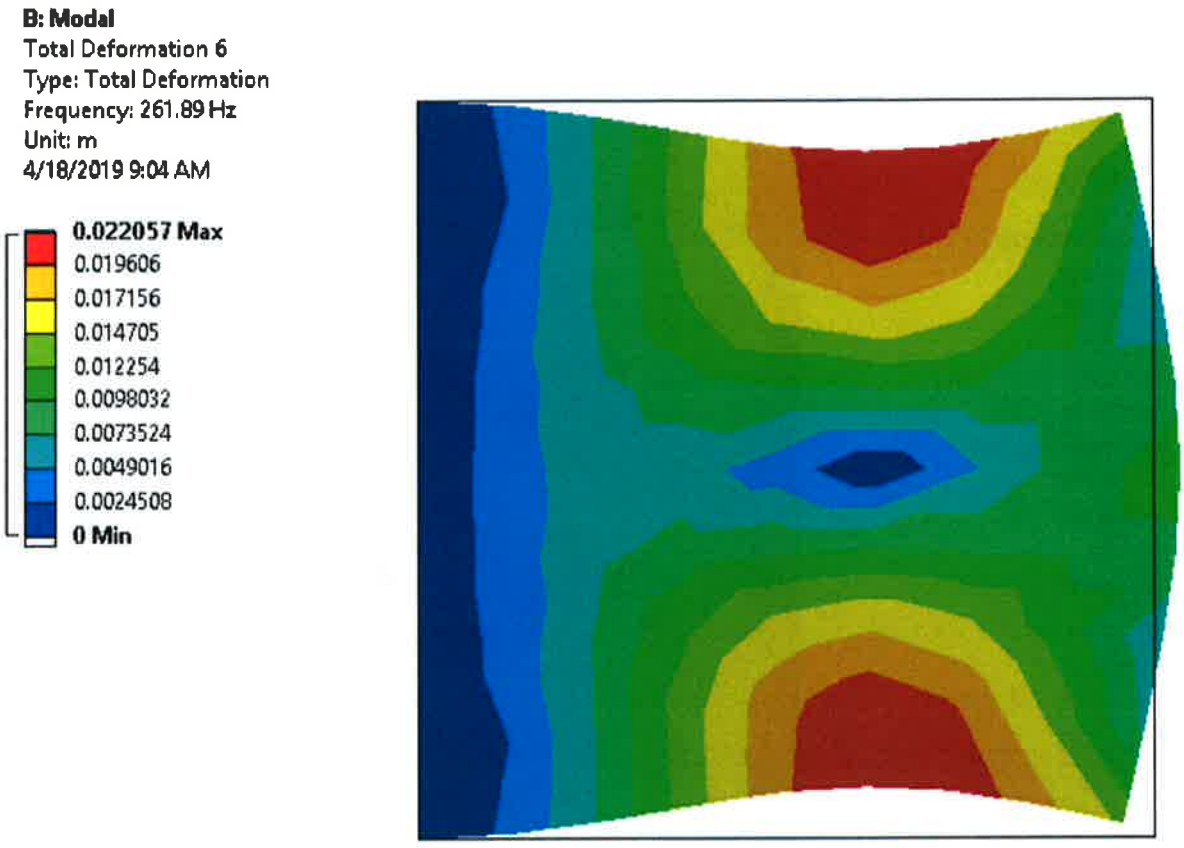

Figure 31: Mode shape 6 at resonant frequency 261.89 Hz. The max displacement was 2.21-02 m.

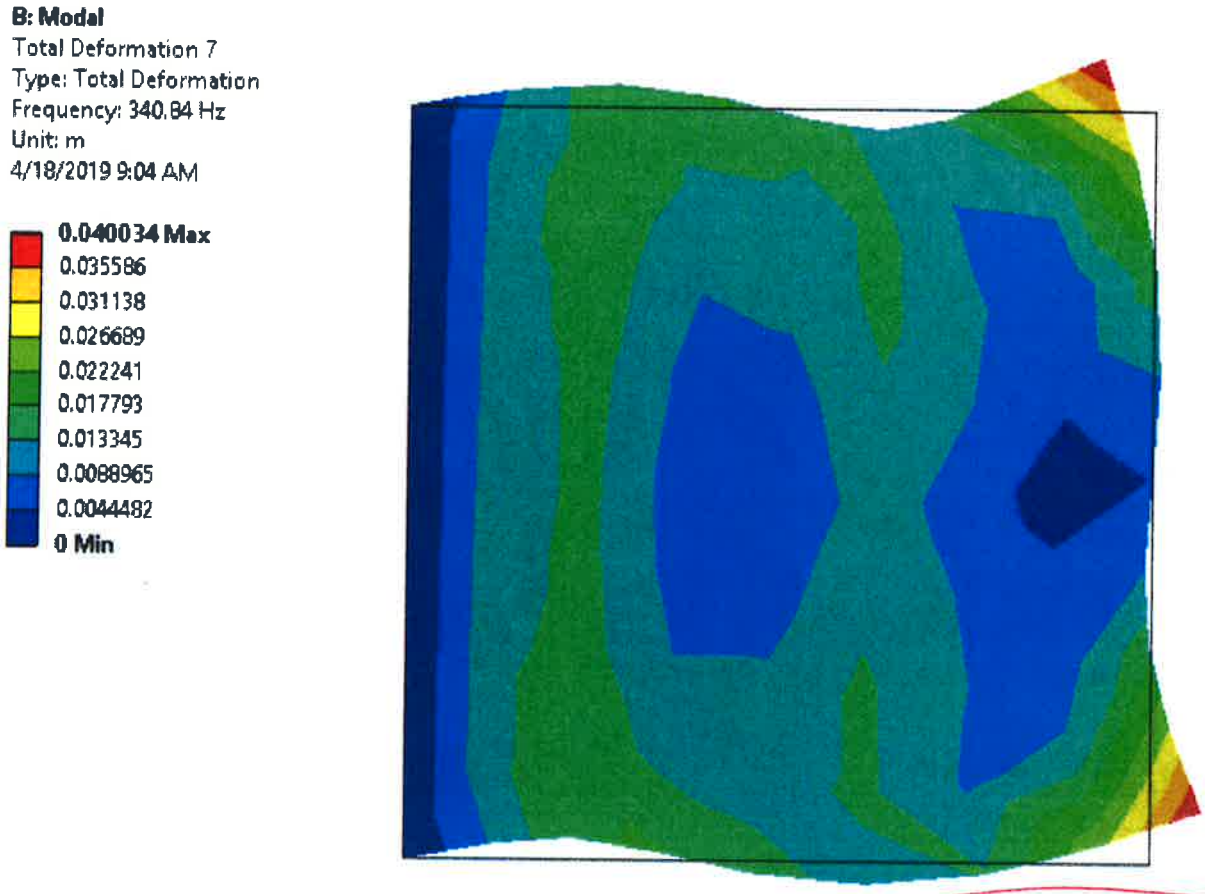

Figure 32: Mode shape 7 at resonant frequency 340.84 Hz. The max displacement was 4.003-02 m.