

24-650 Applied Finite Element Analysis

Homework No 4

Steel Building Beam model

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The objective of this assignment was to compare the results of a static structural simulation for a Steel Building using a Beam model and a Solid model. The Solid model is shown in **Error! Reference source not found.**

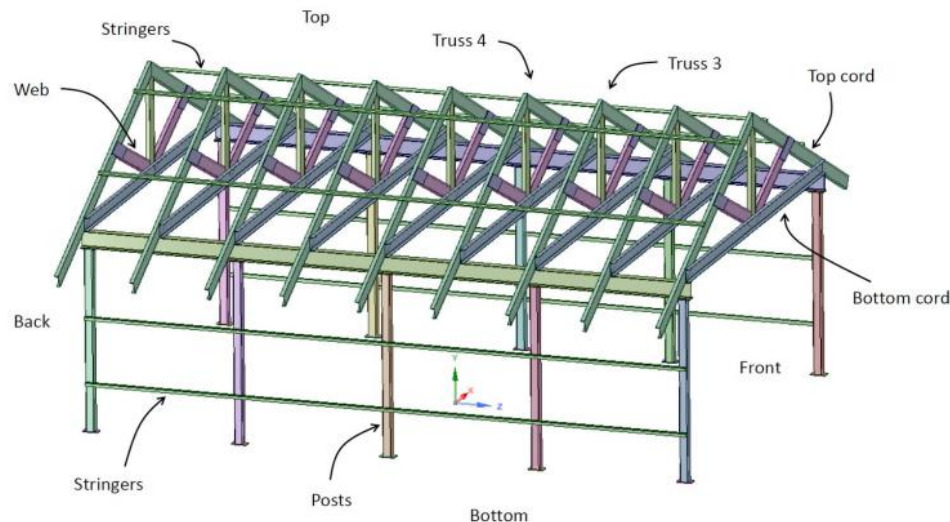


Figure 1: Solid model

1. Setup

The first step was to create the Beam model using SpaceClaim. To do this, I took the Solid Model for the Steel Building and I extracted the beams from the solid elements. Then I proceeded to move, extend and trim some lines to create the connection nodes. The final result is shown in Figure A.1.

Once the Beam model was ready, I imported the lines to Ansys Mechanical and I created the default mesh. This is shown in Figure A.2. The **default mesh** consisted of **1,002 nodes** and **547 elements**.

With the mesh ready, I attached a **point mass** of **2,000 [kg]** and Moments of Inertia of **8×10^8 [kg mm²]**. The location of this mass is shown in Figure A.4. Then, I applied a **fixed support** to the ten bottom vertexes. This is shown in Figure A.3. After that, I proceeded to do the modal analysis for **structural steel** and **3 max modes to find**. The values obtained for frequencies are shown in

Table 1 and the Modes are shown in Figure A.5 through Figure A.7

2. Results and Analysis

2.1 Beam model:

Mode 1	2.5416 [Hz]
Mode 2	3.7668 [Hz]
Mode 3	5.3567 [Hz]

Table 1: Modes Frequency for Beam model with point mass (default mesh)

The results of the Static Structural analysis of the Beam model are shown in Table 2.

Item	Value	Figure
Total mass (without point mass)	6,061.4 [kg]	
Modal frequency 1 without point mass	4.6394 [Hz]	Figure A.8
Deformation max (location)	0.5282 [mm] (located at the center of the bottom cord 4)	Figure A.09 Figure A.10
Axial force max (location)	10,451 [N] (traction) (located at the intersection of bottom cord 4 and the top cord 4)	Figure A.11 Figure A.12
Total bending moment max (location)	2.5897E+06 [N mm] (located at the intersection of bottom cord 4 and the top cord 4)	Figure A.13 Figure A.14
Total shear force max (location)	4,074.3 [N] (located at the connection between the lateral horizontal beam and the top cord 5)	Figure A.15 Figure A.16
Direct stress max (location)	4.7985 [MPa] (traction) (located at the bottom cord 4)	Figure A.17 Figure A.18
Direct stress min (location)	5.7126 [MPa] (compression) (located at the top cord 4)	Figure A.17 Figure A.18
Reaction force max (location)	14,556 [N] (located at bottom of post 2 on both sides)	Figure A.19 Figure A.20
Reaction force min (location)	4,186.3 [N] (located at bottom of post 1 on both sides)	Figure A.21 Figure A.22

Table 2: Beam model results

2.2 Solid Model:

For the Solid model I had to add Mesh Method set as tetrahedrons. The mesh size was set to 200 mm. The **mesh** consisted of **229,800 nodes** and **112,068 elements**.

The results of the Static Structural analysis of the Solid model are shown in Table 3.

Item	Value	Figure
Total mass (without point mass)	6,115.4 [kg]	
Deformation max (location)	0.5038 [mm]	Figure A.25 Figure A.26
Reaction force max (location)	14,465 [N]	Figure A.27 Figure A.28
Reaction force min (location)	4,372 [N]	Figure A.29 Figure A.30

Table 3: Solid model results

As can be seen in the results, there is a mass difference of **0.88%** between the Solid model and the Beam model. This small difference occurs for the following reasons:

- The Solid model includes the small plates that connect the main beams, which adds mass.
- The Beam model has an extra beam line that support the point mass. This extra beam adds mass.
- The Beam model has extensions of some lines, which adds mass.

Regarding the total deformation, there is a difference of **4.84%** between the Solid model and the Beam model. The reason for this difference is that the geometry is not exactly similar for both models (some lines were extended and moved from their position) and also because the way the solver works for both models is different.

Finally, there is a difference of **0.65%** for the Max Reaction Force and **4.24%** for the Min Reaction Force. The difference for these values is closely related to the difference in weight for both models.

Even if there is a difference of around 5% for some values, the computational effort for the Solid model is really high compared to the Beam model. For the Solid model, it took **20 s** to solve the simulation, whereas for the Beam model, it only took **3 s** to solve.

3. Appendix

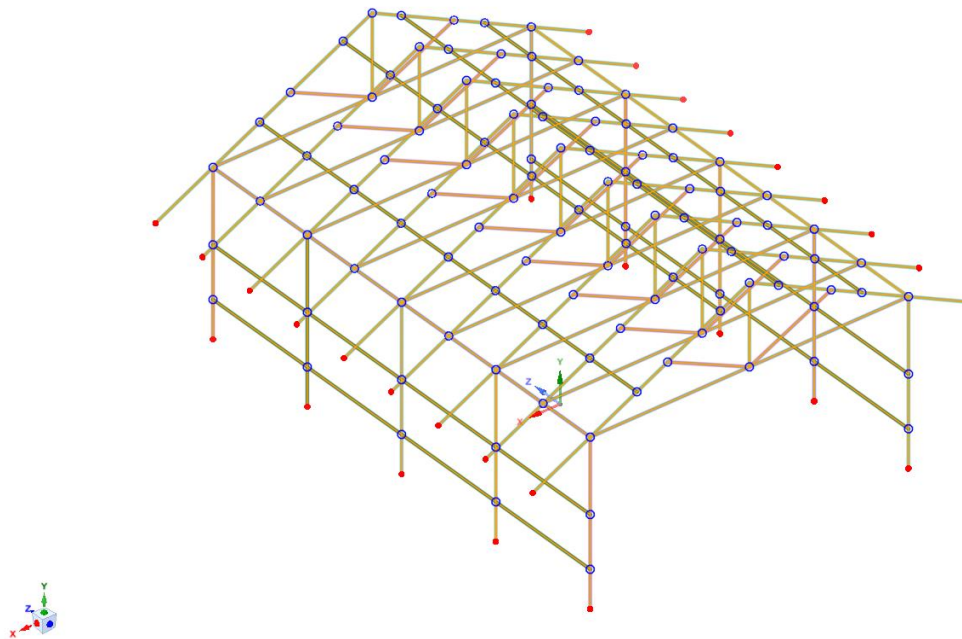


Figure A.1: Beam model in SpaceClaim

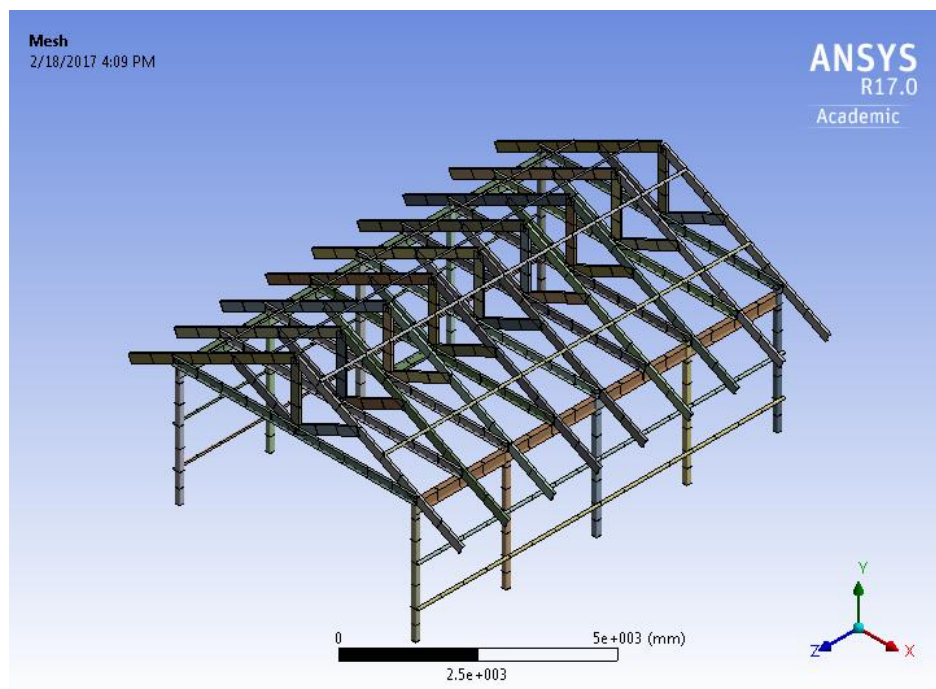


Figure A.2: Beam model default mesh

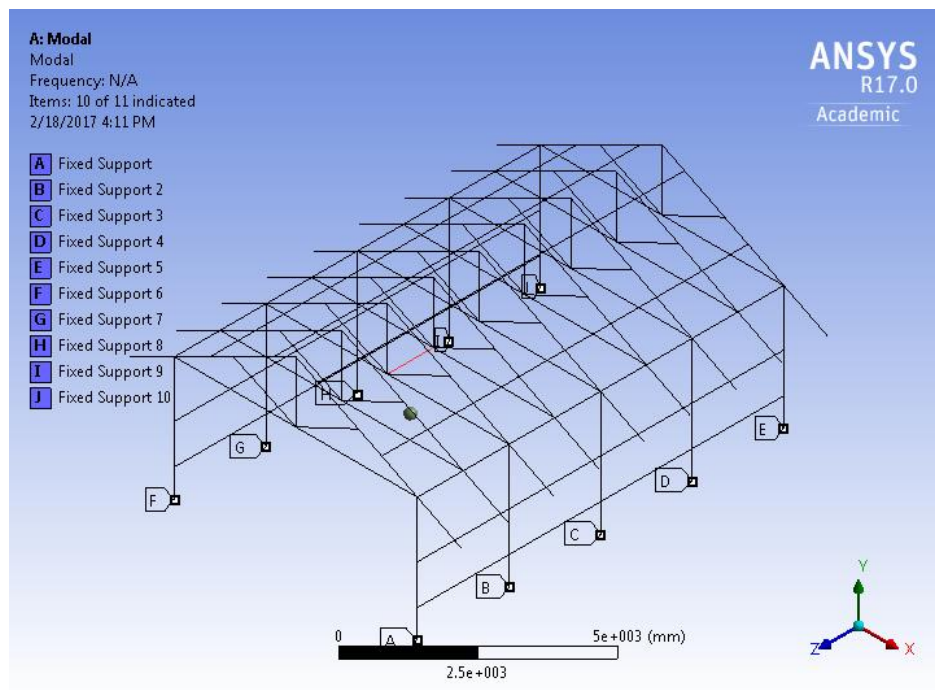


Figure A.3: Beam model Boundary Conditions

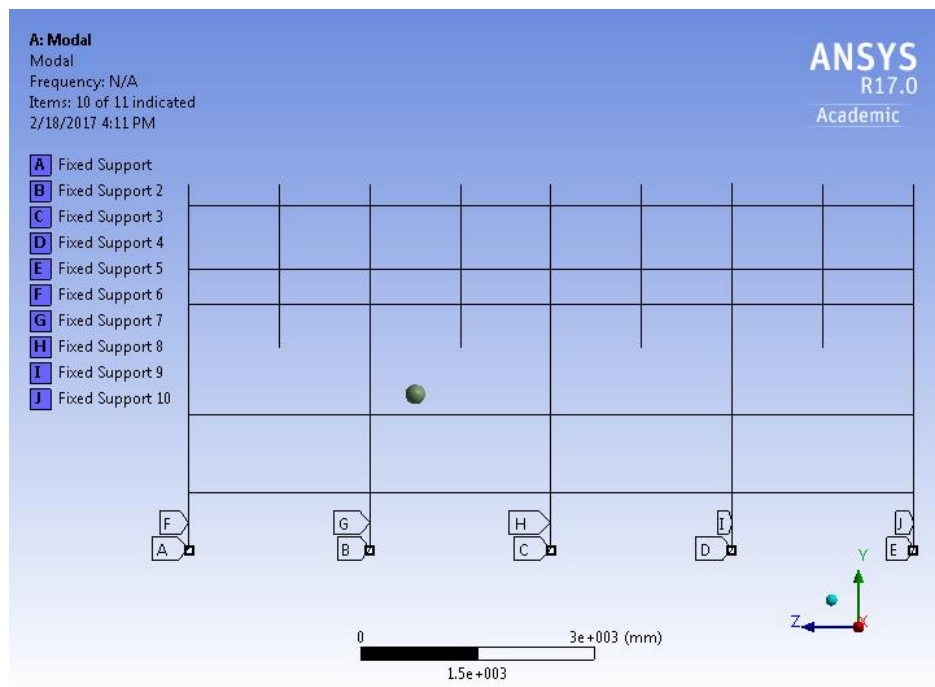


Figure A.4: Beam model Point mass location.

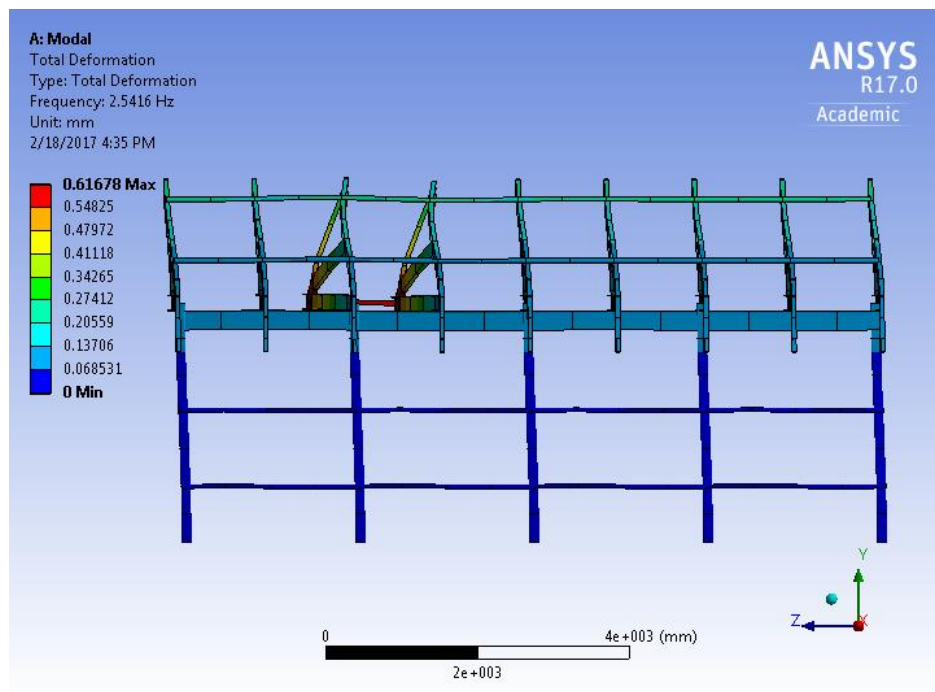


Figure A.5: Beam model with point mass (Mode 1)

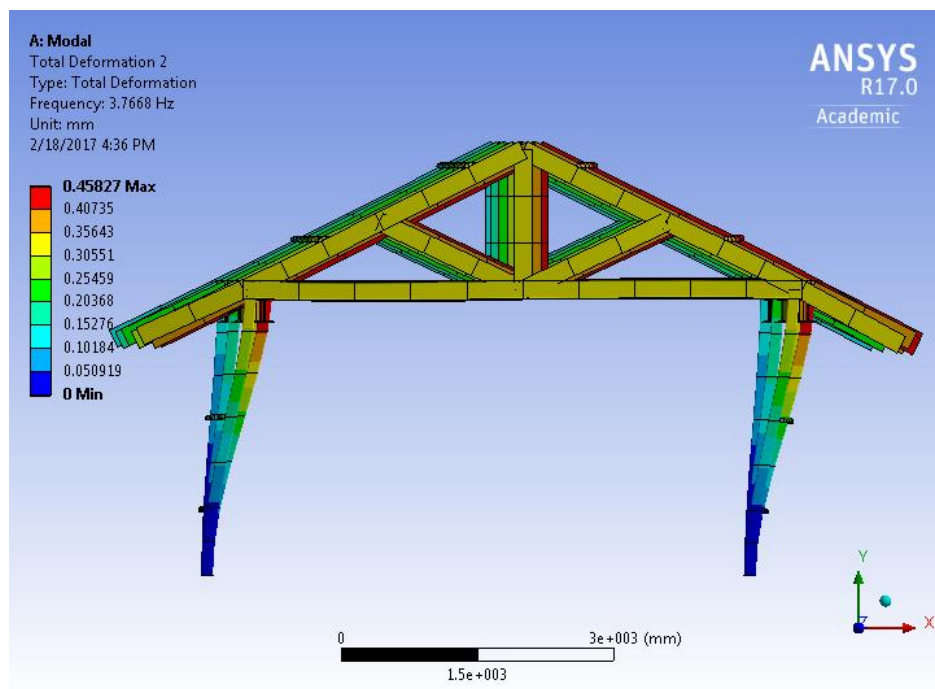


Figure A.6: Beam model with point mass (Mode 2)

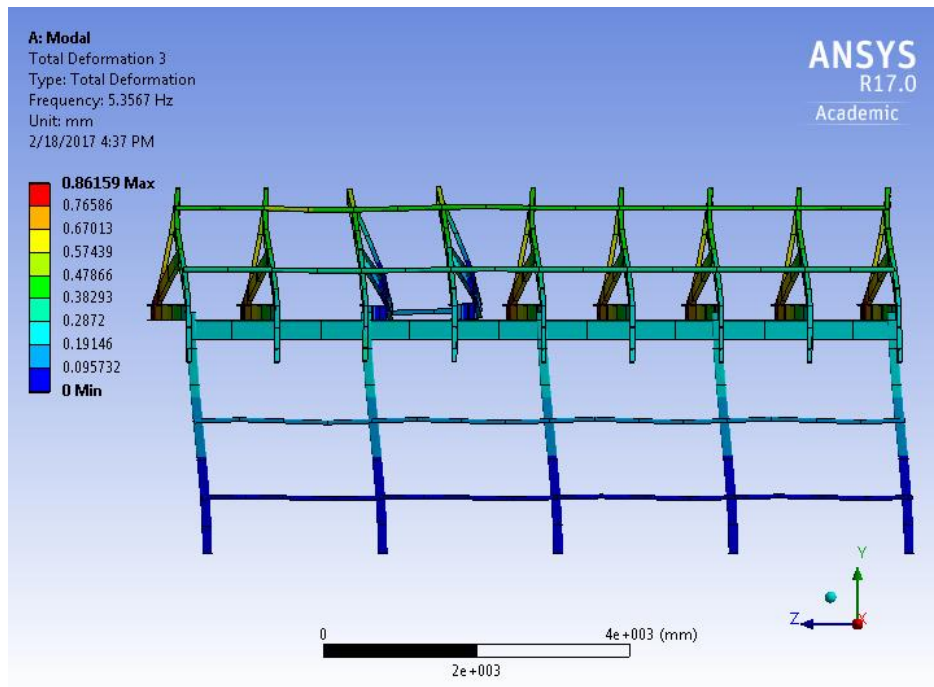


Figure A.7: Beam model with point mass (Mode 3)

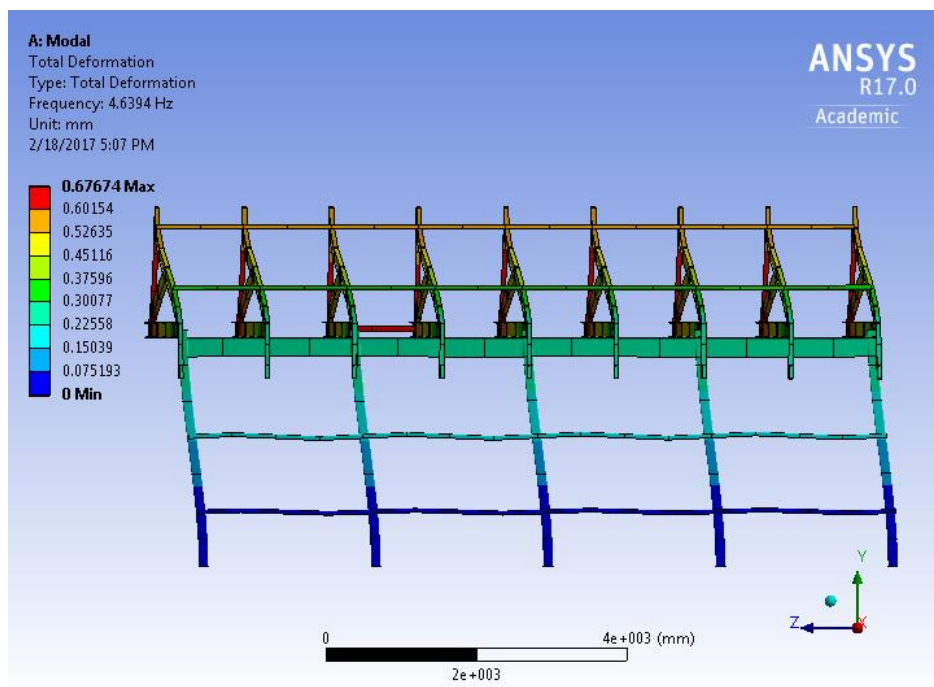


Figure A.8: Beam model without point mass (Mode 1)

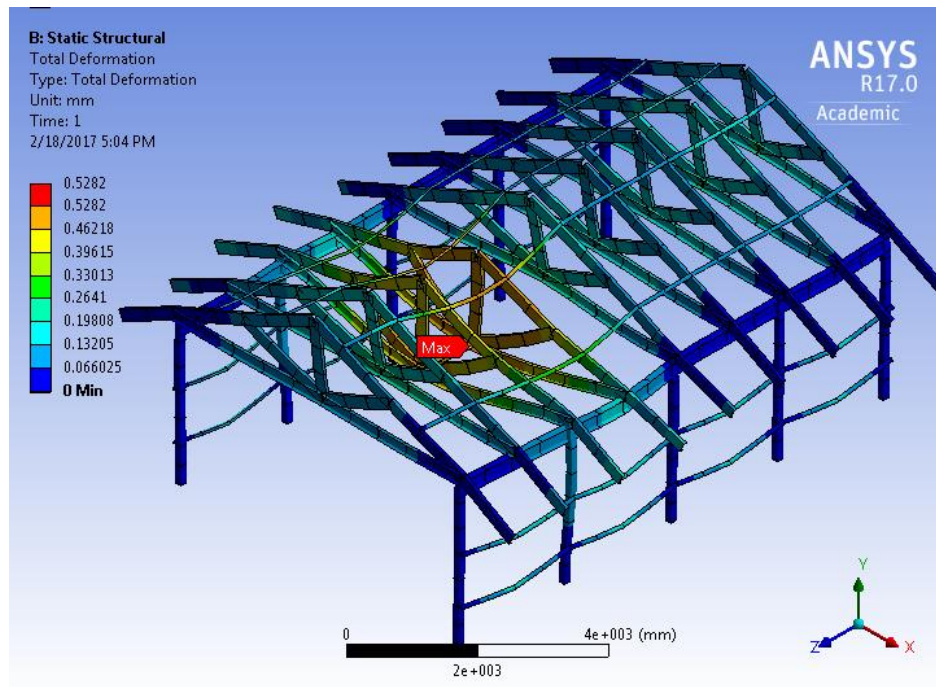


Figure A.9: Total Deformation, Beam model with point mass

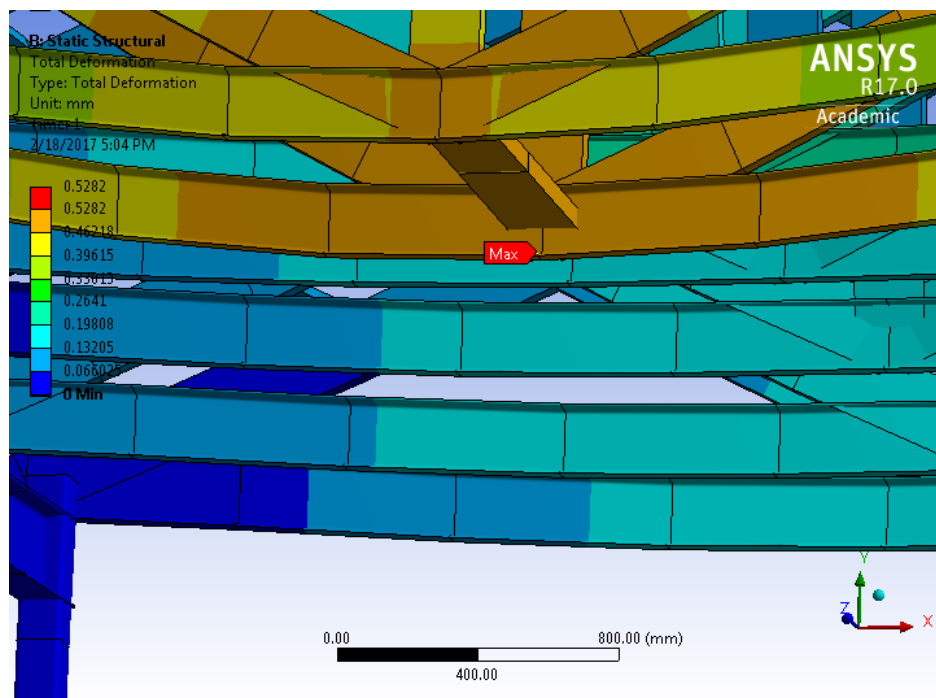


Figure A.10: Total Deformation, Beam model with point mass (Zoom)

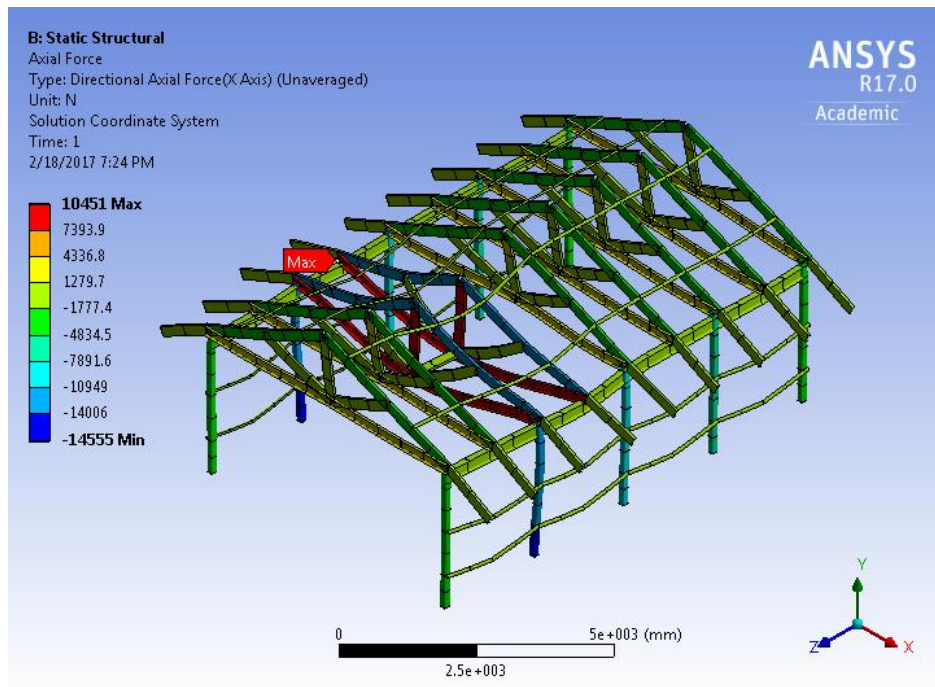


Figure A.11: Axial Force, Beam model with point mass

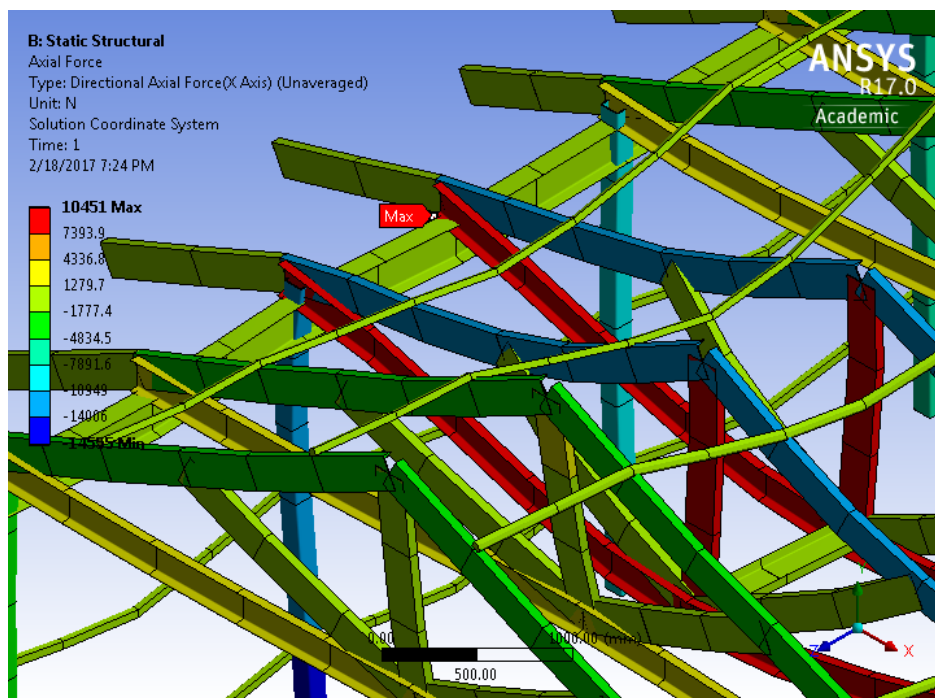


Figure A.12: Axial Force, Beam model with point mass (Zoom)

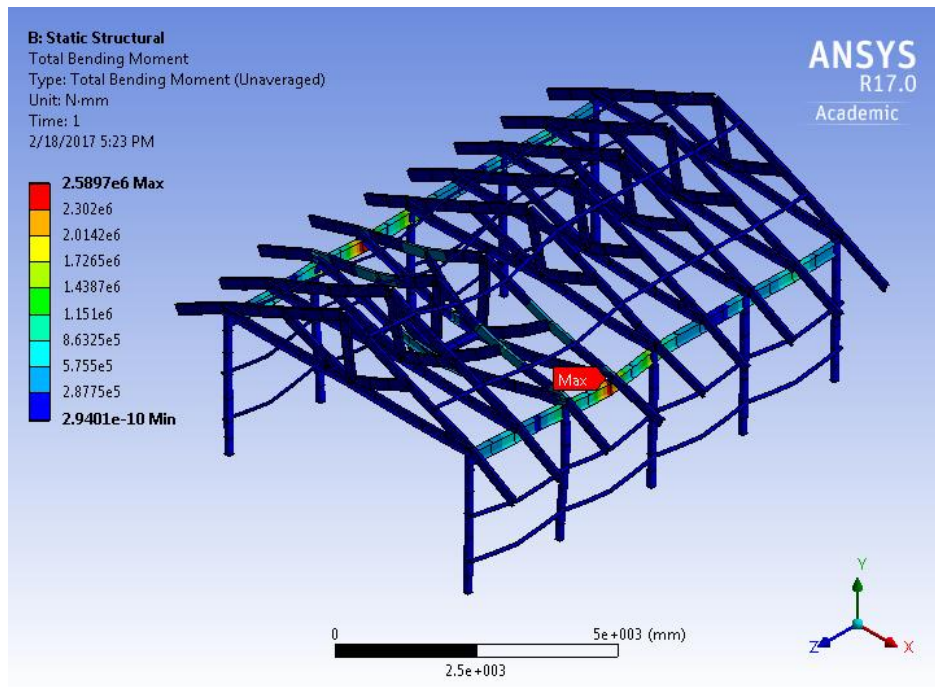


Figure A.13: Total Bending Moment, Beam model with point mass

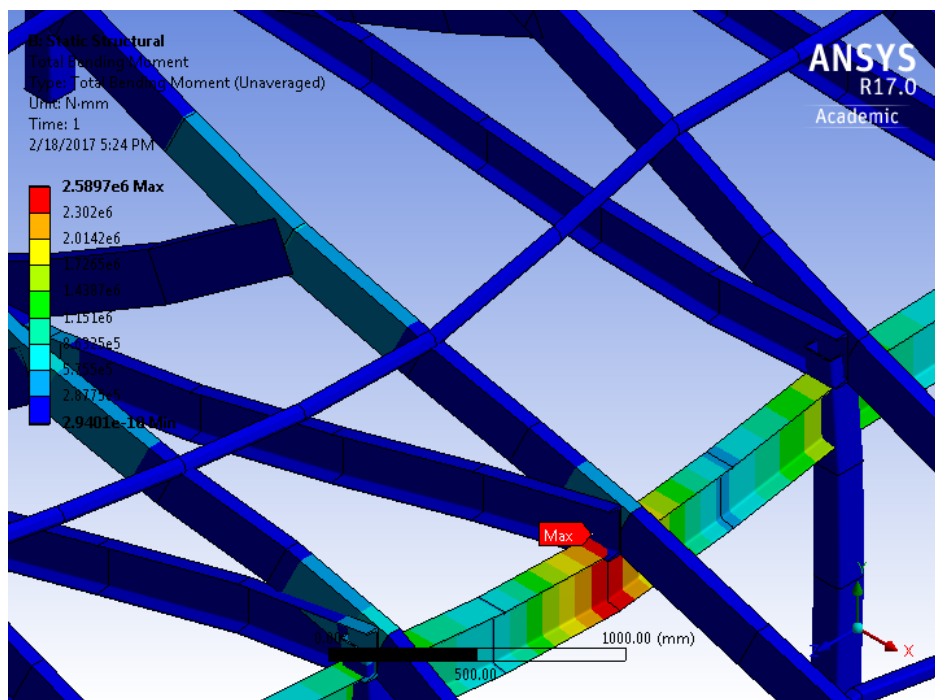


Figure A.14: Total Bending Moment, Beam model with point mass (Zoom)

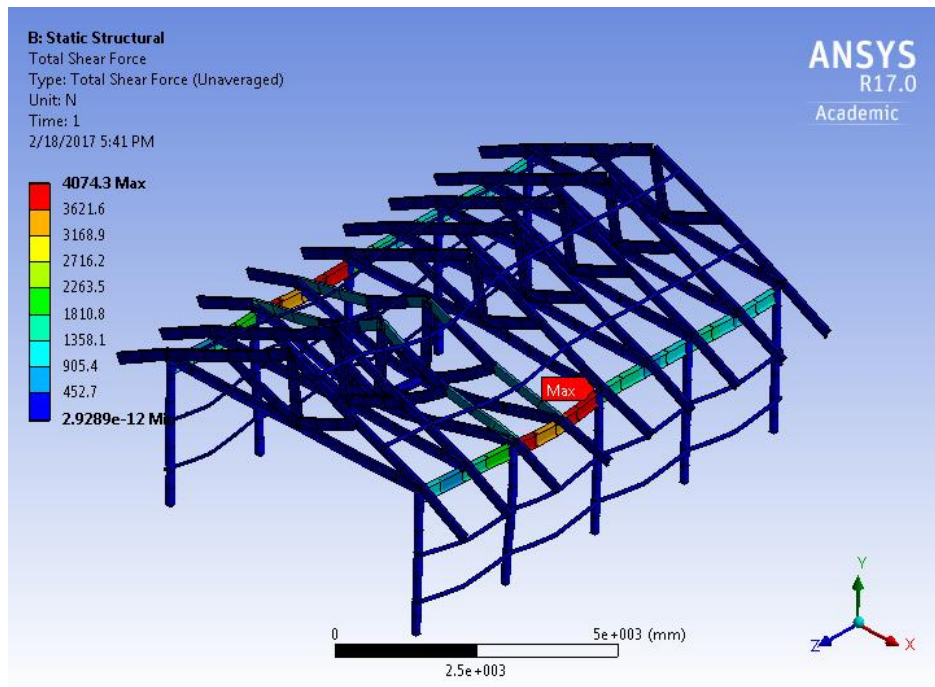


Figure A.15: Total Shear Force, Beam model with point mass

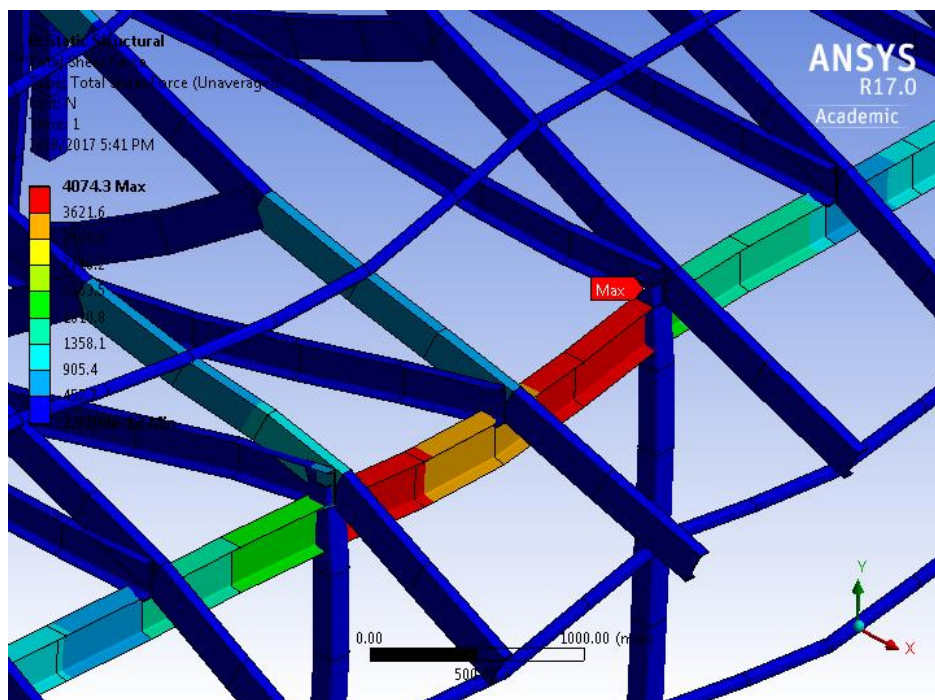


Figure A.16: Total Shear Force, Beam model with point mass (Zoom)

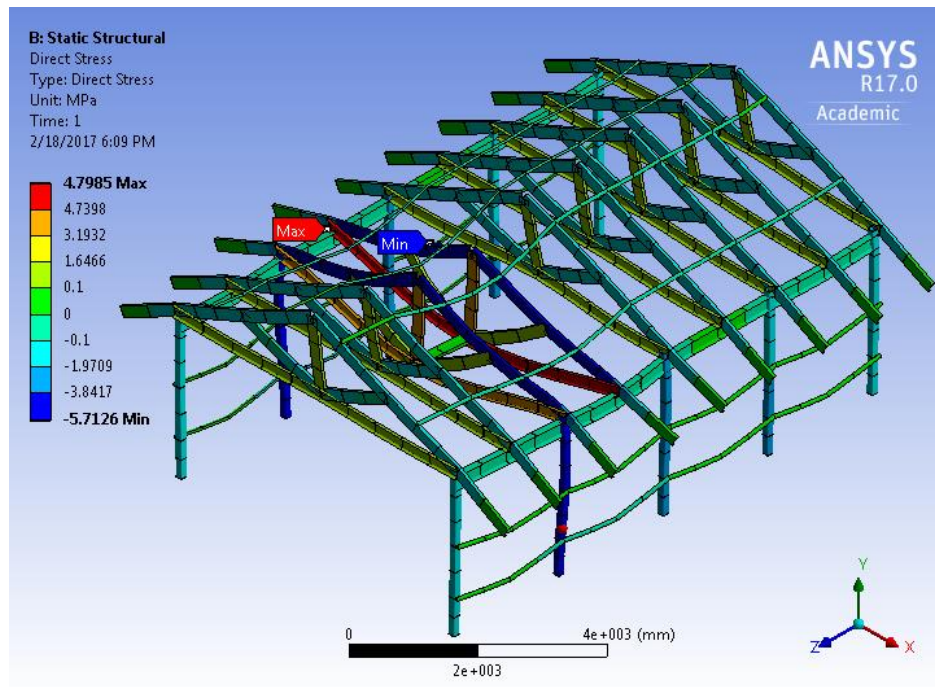


Figure A.17: Direct Stress, Beam model with point mass

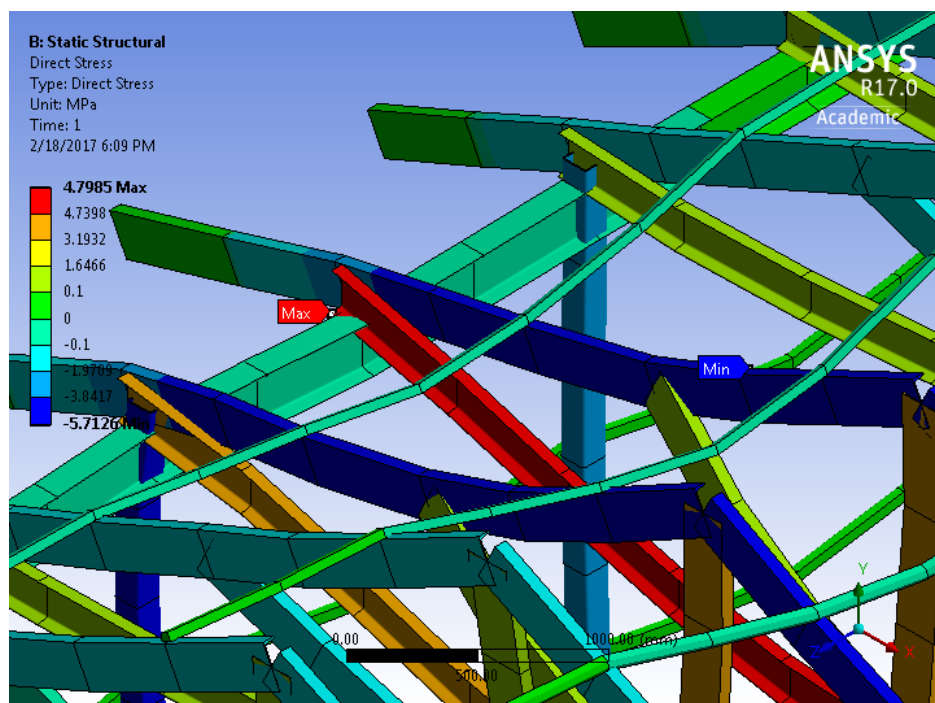


Figure A.18: Direct Stress, Beam model with point mass (Zoom)

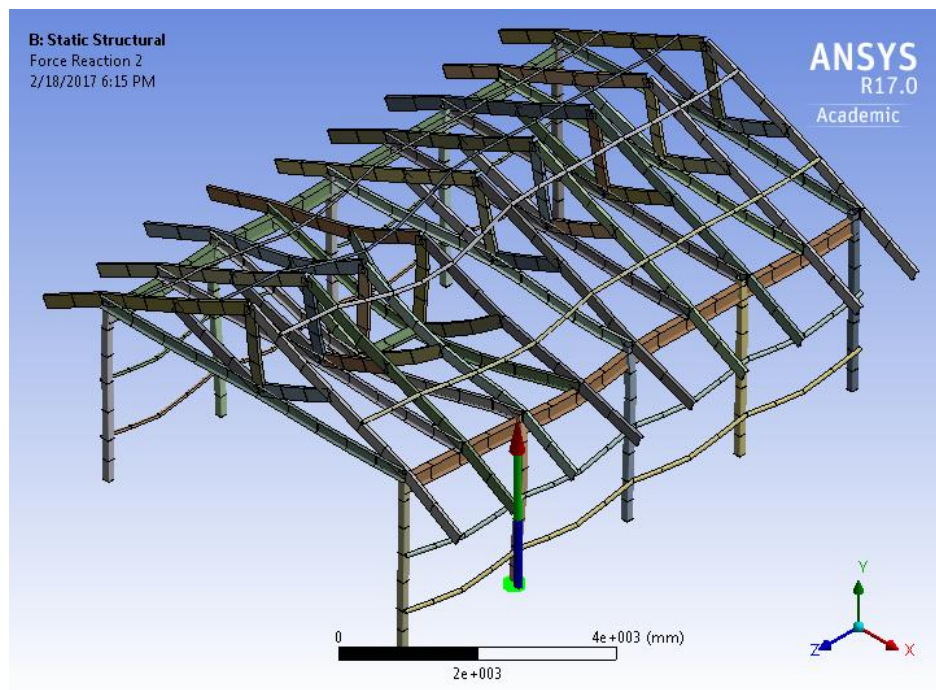


Figure A.19: Max Reaction Force, Beam model with point mass (location 1)

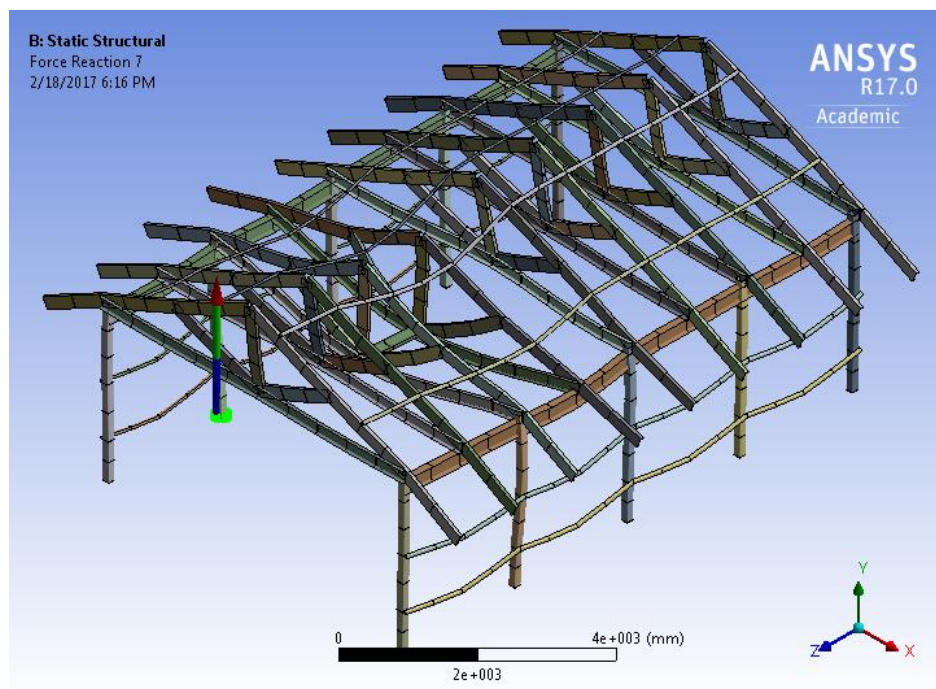


Figure A.20: Max Reaction Force, Beam model with point mass (location 2)

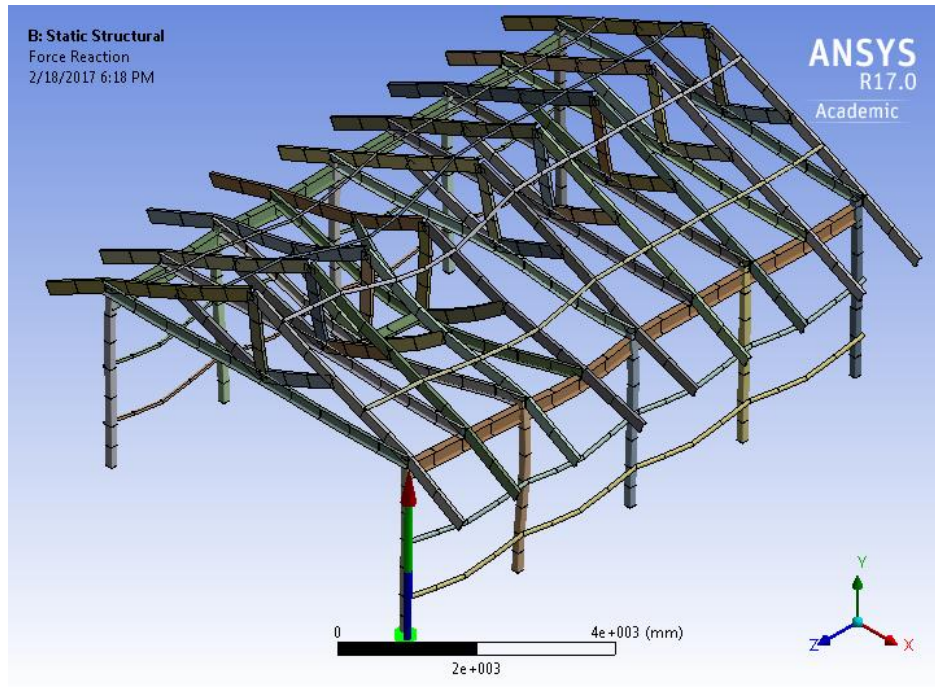


Figure A.21: Min Reaction Force, Beam model with point mass (location 1)

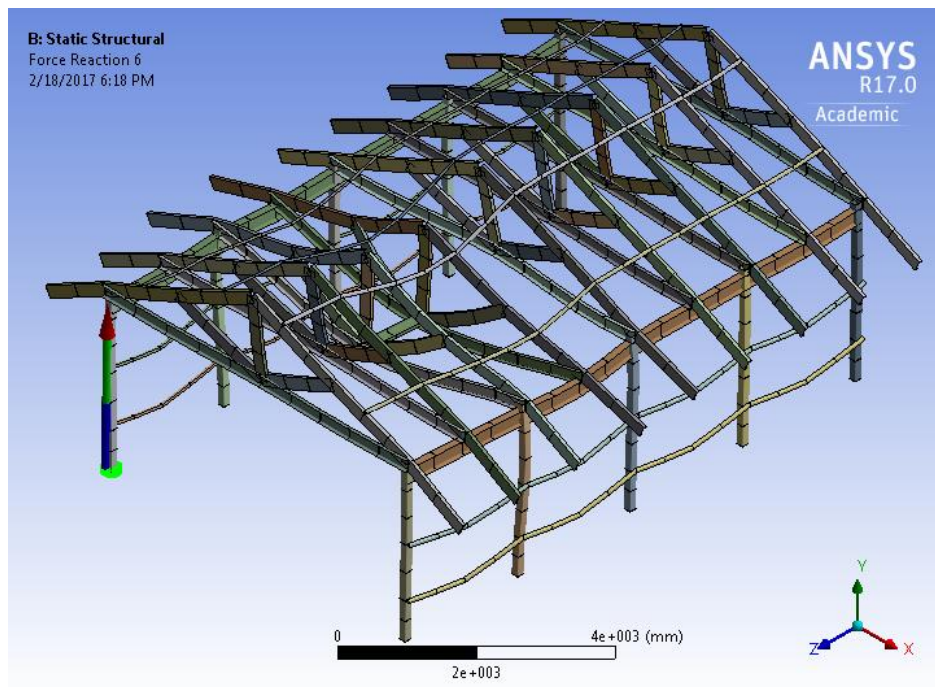


Figure A.22: Min Reaction Force, Beam model with point mass (location 2)

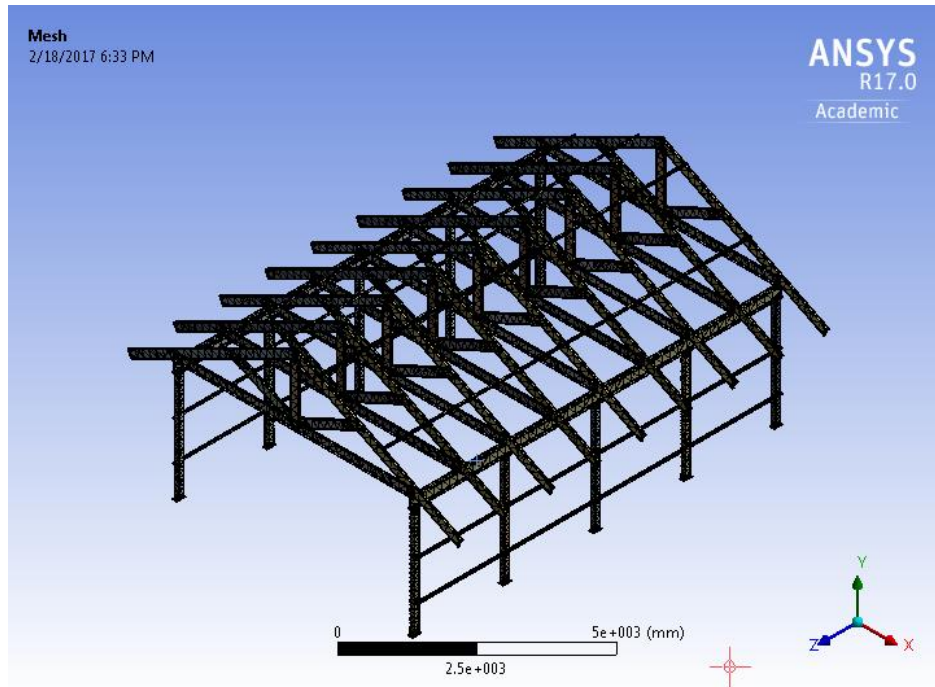


Figure A.23: Solid model mesh

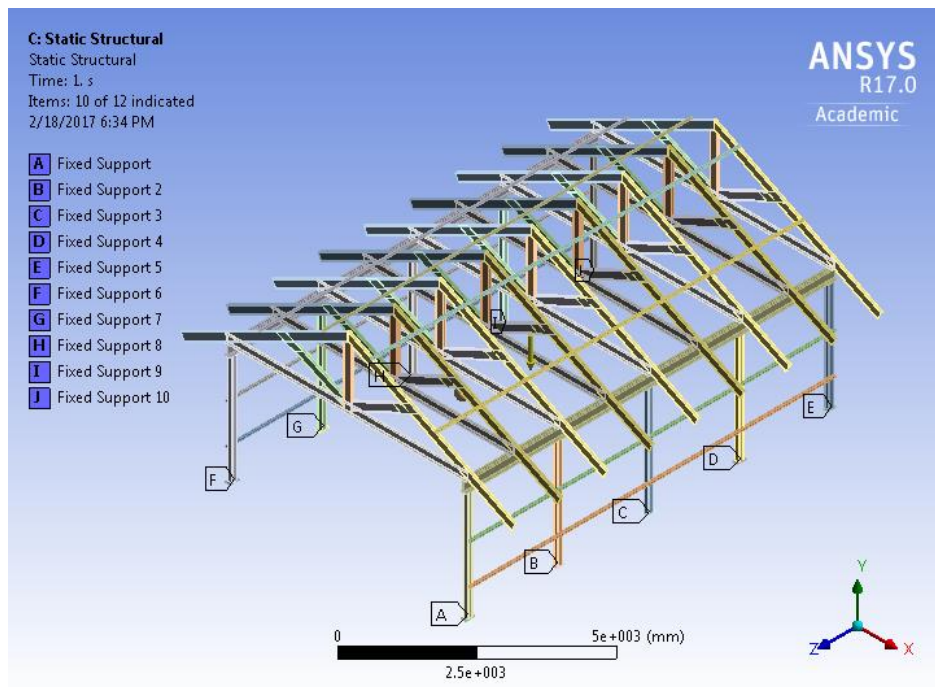


Figure A.24: Solid model Boundary Conditions

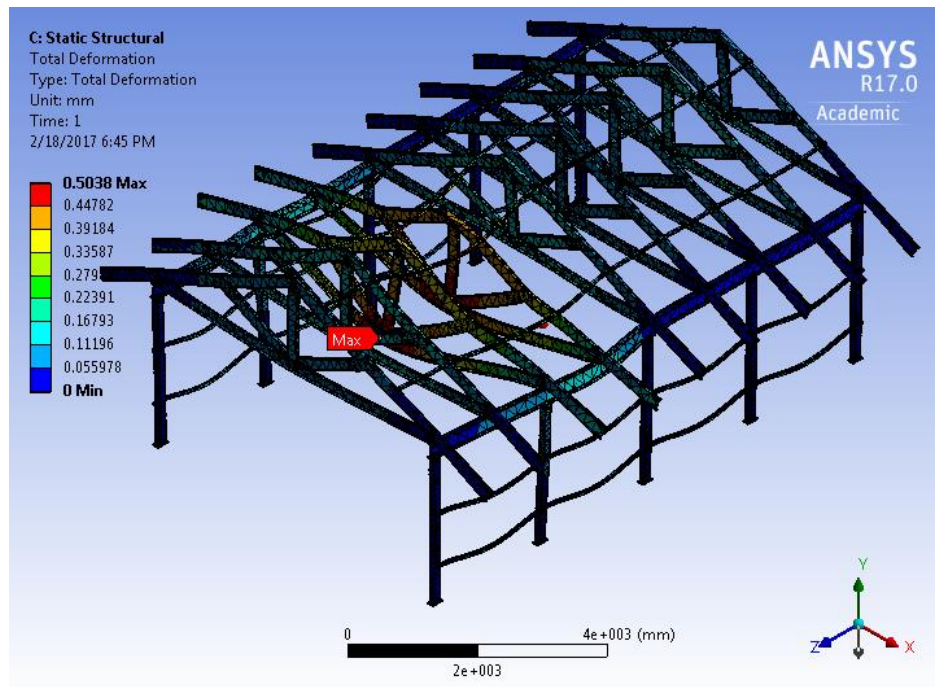


Figure A25: Total Deformation, Solid model with point mass

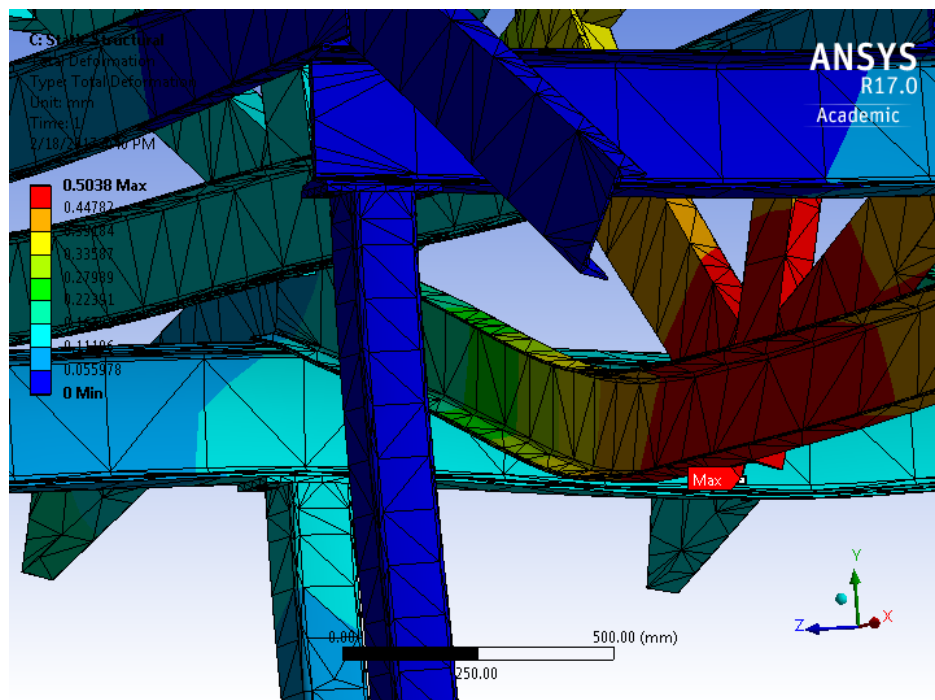


Figure A26: Total Deformation, Solid model with point mass (Zoom)

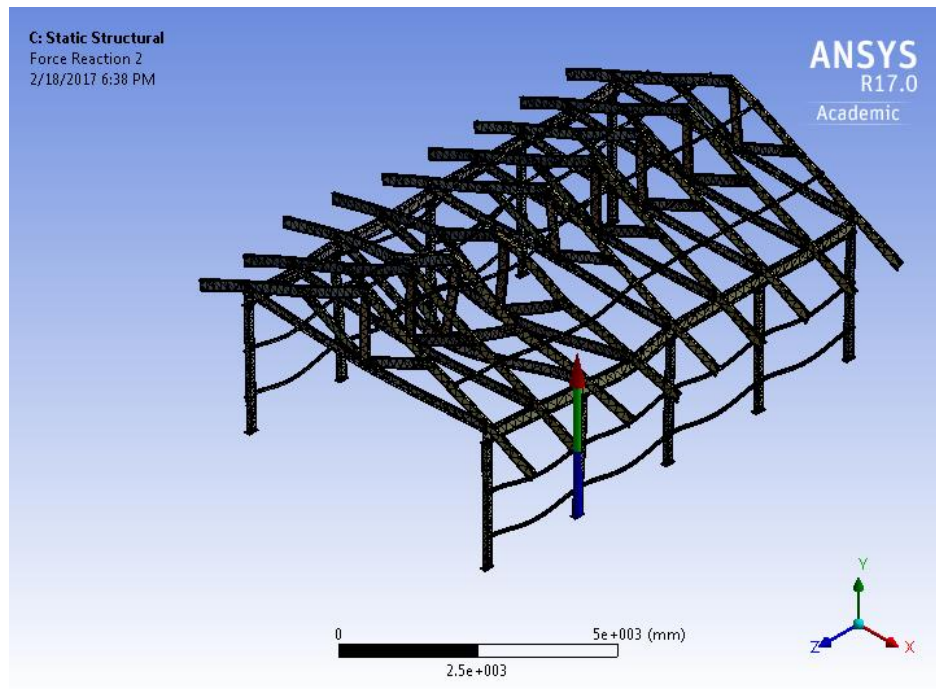


Figure A.27: Max Reaction Force, Solid model with point mass (location 1)

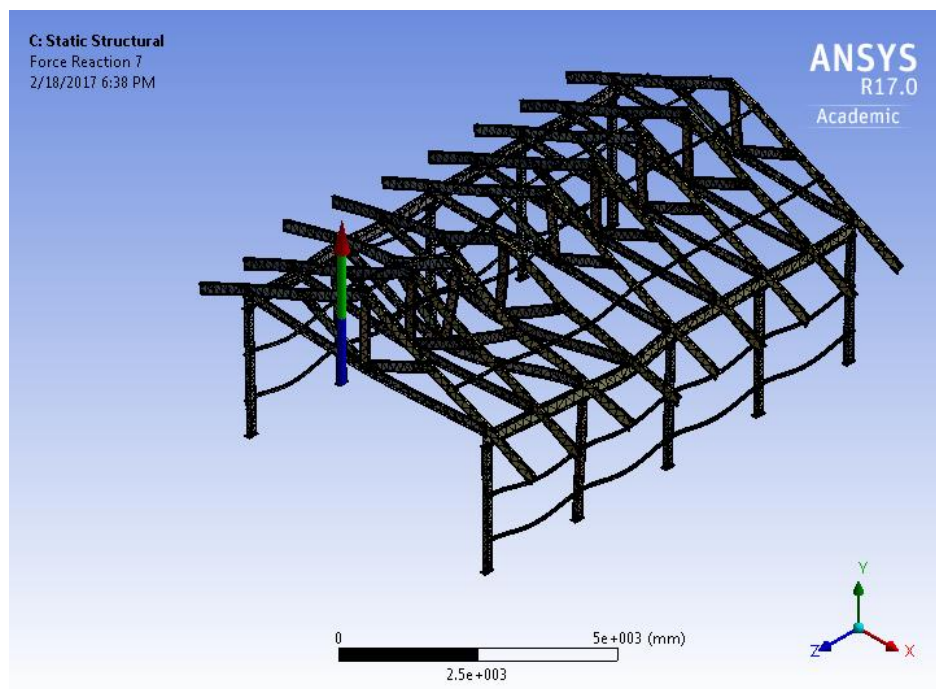


Figure A.28: Max Reaction Force, Solid model with point mass (location 2)

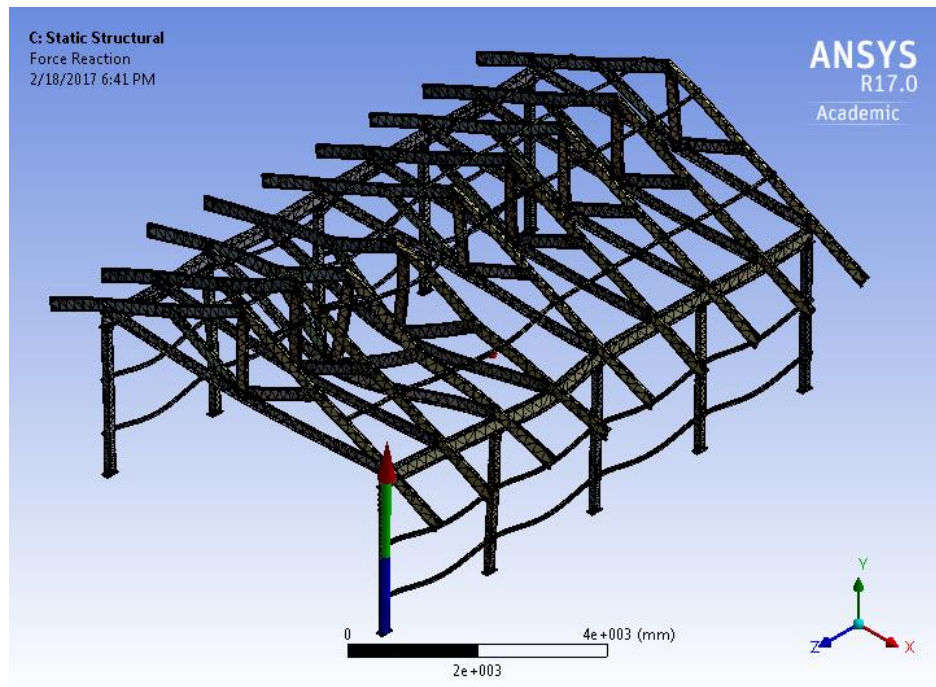


Figure A.29: Min Reaction Force, Solid model with point mass (location 1)

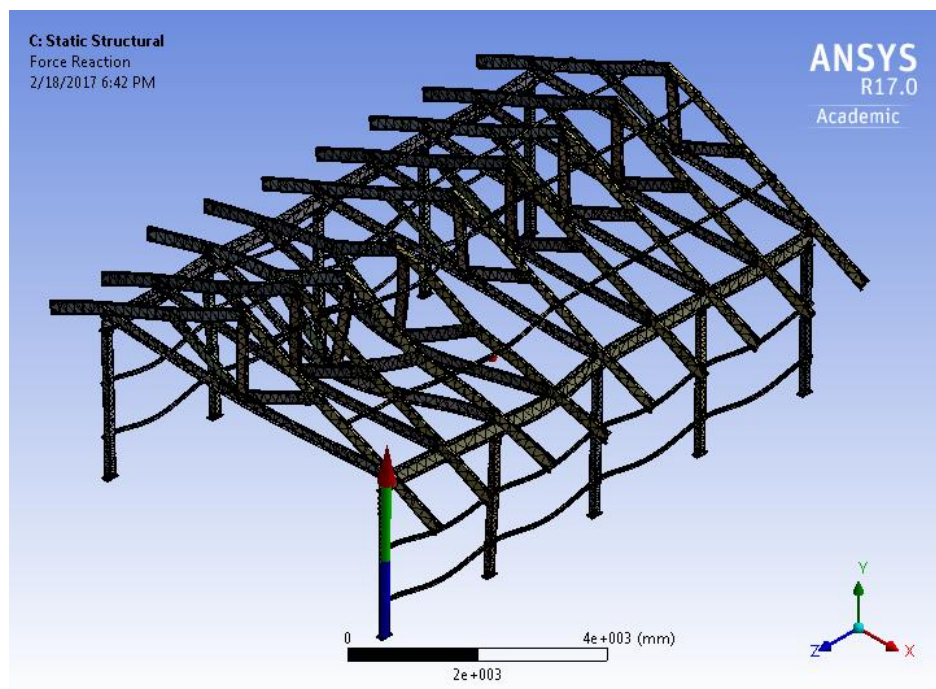


Figure A.30: Min Reaction Force, Solid model with point mass (location 2)