25-650: Applied FEA

Assignment 8

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Due: 5/2/2024

Overall Objective

Use the structural optimization feature within Ansys Workbench to assist with designing a bracket with minimized mass, fatigue damage under 1.0 and deformation under 1mm under a fully reversible load of 26,000N and 25,000 cycles.

Assumptions

For all situations below, it is assumed that the bottom face of the bracket is fixed. The center of mass of the bottom 25mm thick base plate must also be kept constant if L and W are changed (see geometry below for further information). It is assumed that the force acts upon the cylindrical face represented by the surface in the diagram.

Results

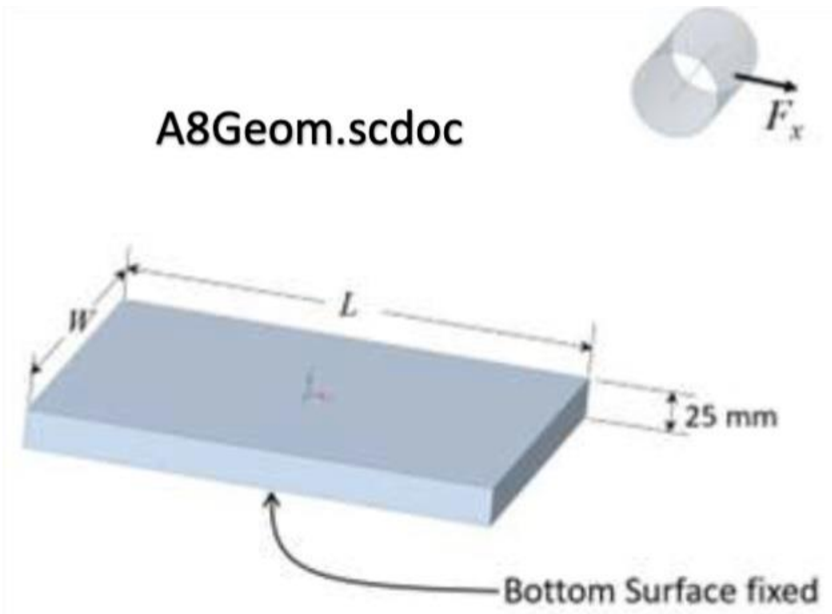
L (mm)	330
W (mm)	90
Mass (kg)	8.78
Max Stress (Mpa)	32.92
Max Deformation (mm)	0.229
Fatigue Damage	0.554

Material Data

For this analysis, the bracket was made of A6 aluminum alloy. The properties are as follows: E = 71 GPa, ν = 0.31, ρ = 2700 kg/m3 and the following S-N fatigue strength versus life cycles data with semi-log interpolation:

Stress (MPa)	Cycles
105	1,000
68.2	1,600
42.2	6,500
21.4	500,000
17.2	1,800,000
14.1	10,700,000

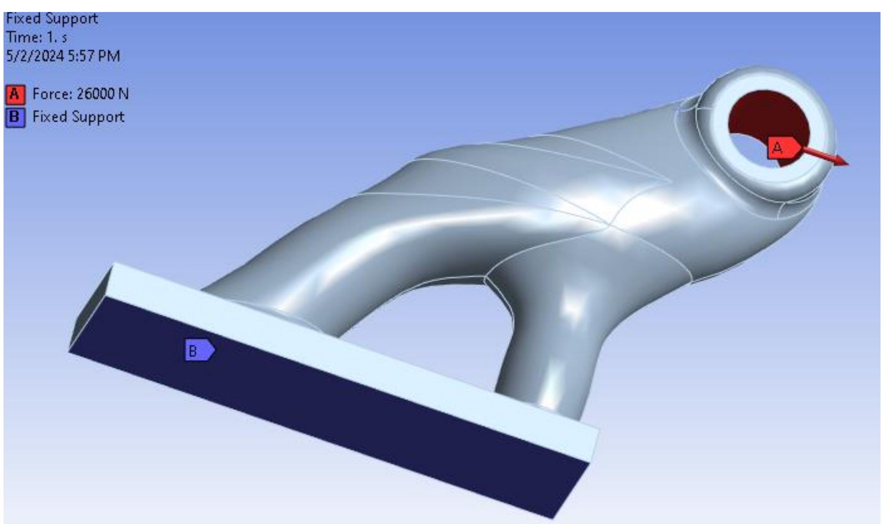
Geometry



Boundary Conditions

For this analysis, the following conditions were used:

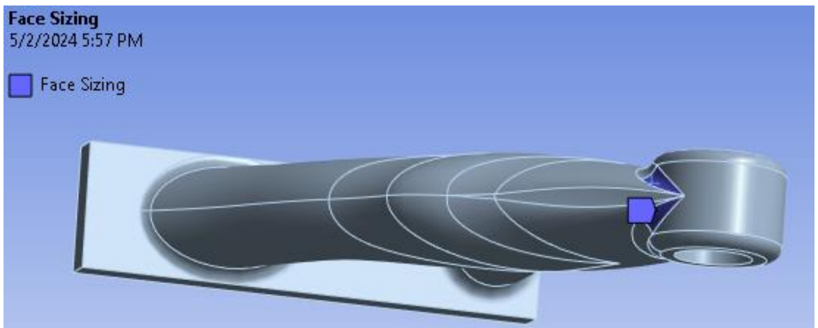
- Fixed support along the bottom face
- Fully reversible load of 26,000N at 25,000 cycles

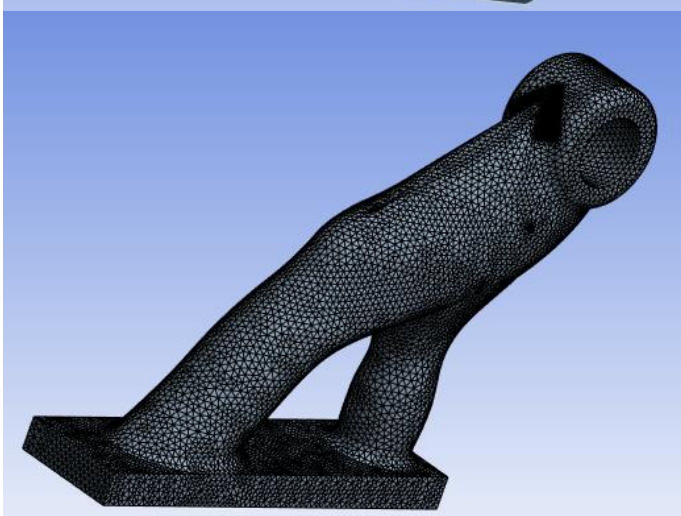


Mesh Settings

Three meshes were used to demonstrate convergence of the peak equivalent stress (used for calculation of damage). First, a 5mm overall element sizing was used to narrow in on peak stress areas. Next a face sizing feature was added at 2mm for the second mesh and then further refined to 1mm to prove convergence of the result. Mesh results and settings are shown below.

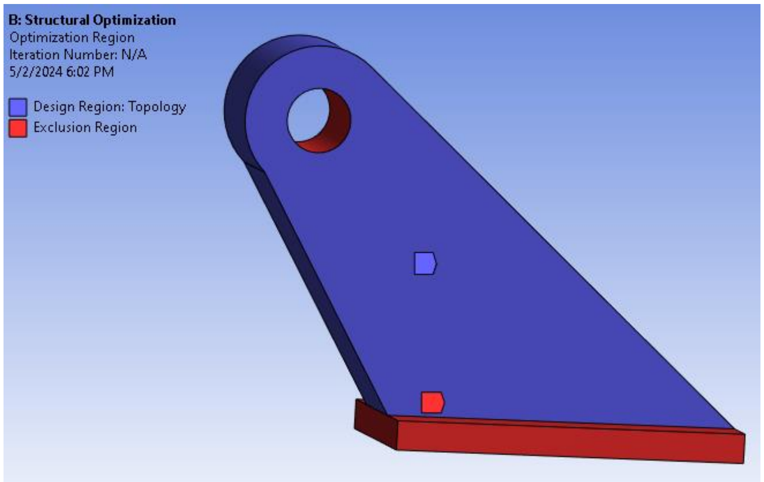
	Nodes	Elements	Equivalent Stress (MPa)		Total Deformation (mm)	
			Minimum	Maximum	Minimum	Maximum
Solution 1: 05/02/2024 05:38 PM	181,736	121,684	8.0173e-003	32.034	0.	0.22856
Solution 2: 05/02/2024 05:48 PM	186,740	125,033	8.4047e-003	32.798	0.	0.22848
Solution 3: 05/02/2024 05:49 PM	200,247	134,001	8.0564e-003	32.916	0.	0.22856

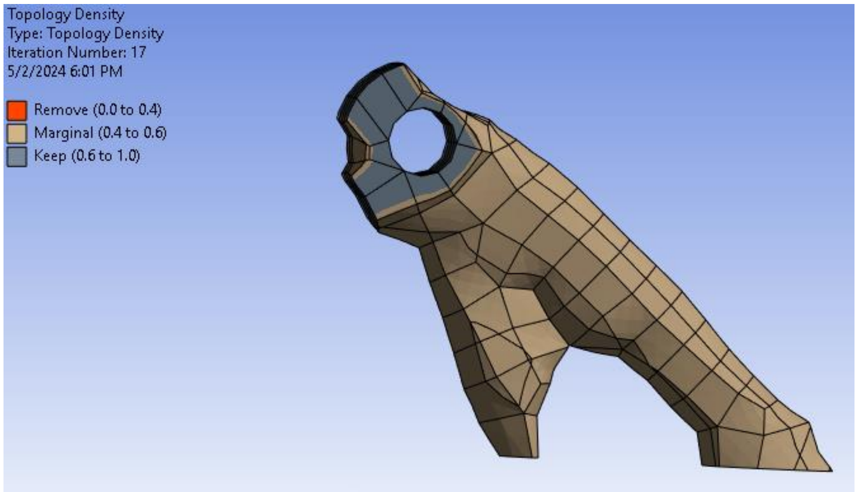




Topology Optimization

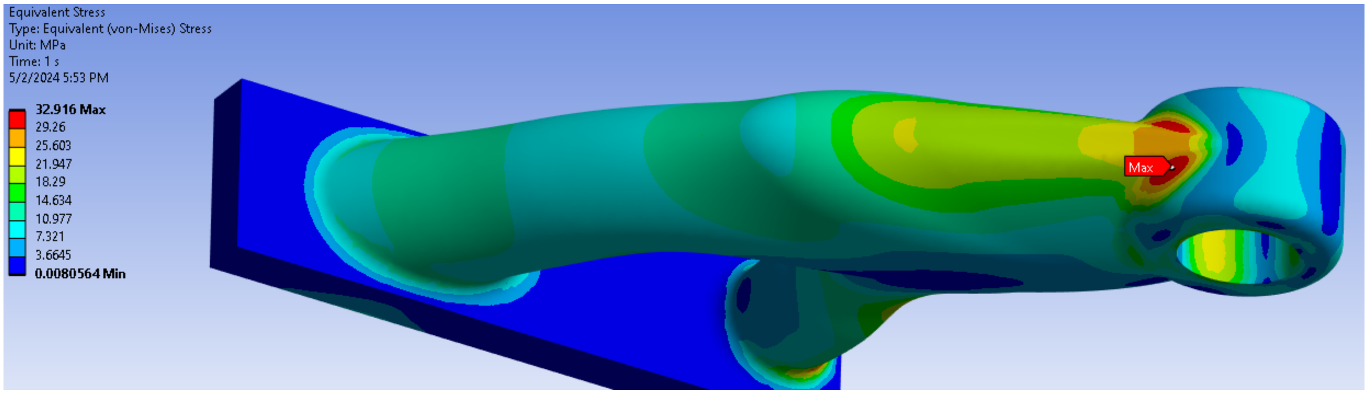
The topology optimization was started with a bulk material design (total weight of 20.1kg). The bottom plate and cylindrical face were excluded from the design region because they cannot be altered. A response constraint of 50% was used to find where mass should be removed. The topology optimization resulted in the topology density shown below.

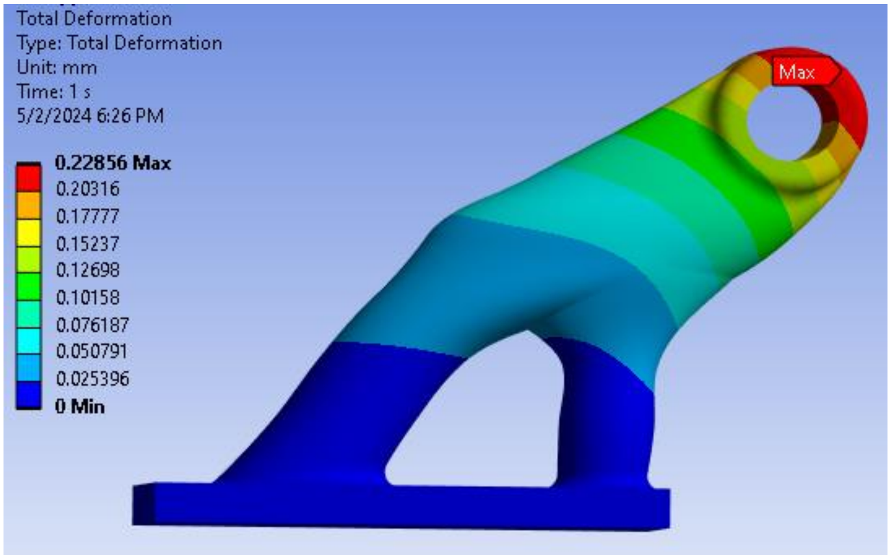


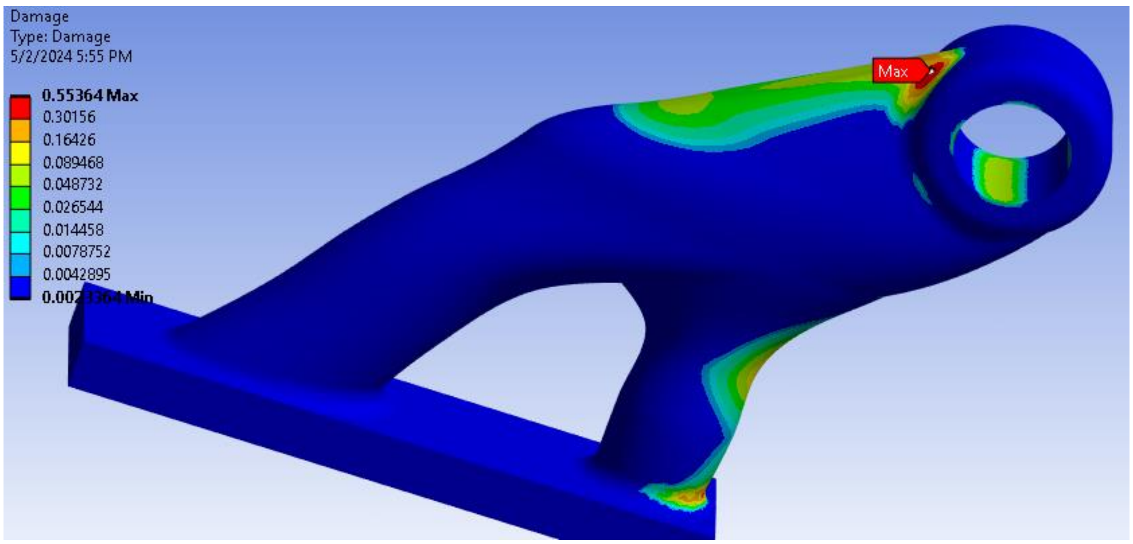


From this optimization, Fusion360 was used to create a shape similar in topology using multiple elliptical cross-sections and the loft feature. From there, the cylindrical connection point was extruded using the dimensions from the A8geom file. Overall, it took 6 iterations of modifying the shape to achieve a desirable result. Full converged results are below.

Full Results







Conclusion

Overall, the results of the simulations make sense given the conditions used. It makes sense that the topology density would suggest an arch-like structure given that the load is fully reversible, so legs in each direction would result in superior resistance to horizontal loading while minimizing mass.