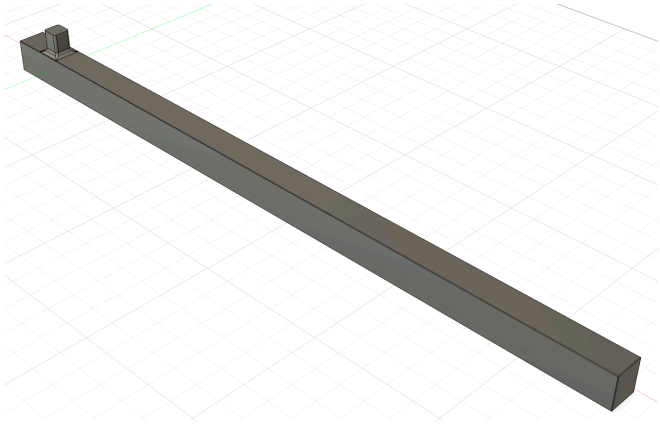
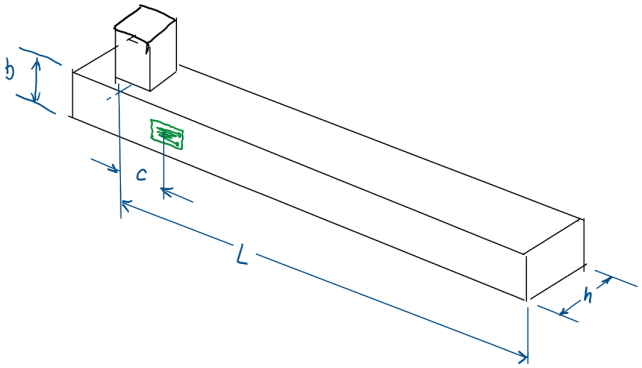
# Torque Wrench Design Project

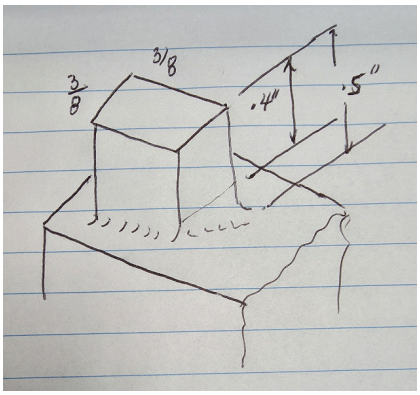
The project was to design a non-ratcheting, 3/8 inch drive instrumented torque wrench rated for 600 in-lbf. Torque will be transduced using strain gauges bonded to the outer surfaces of the wrench at high strain locations. The wrench design had to meet the following specifications:



- attain at least 1.0 mV/V output at the rated torque of 600 in-lbf.
- safety factor of $X_o$ = 4 for yield or brittle failure
- safety factor of $X_K$ = 2 for crack growth from an assumed crack of depth 0.04 inches (1 mm)
- fatigue stress safety factor of XS = 1.5.
- material must be a steel, aluminum or titanium alloy

We were to use hand calculations, CAD tools, and FEM tools to achieve this design.




b = 0.7in | h = 0.6in
c = 1in | L = 14in
Handle Filet of 0.5in
Full Length = 15in

The material we used for our project was a Titanium alpha alloy (Ti-24Al-11Nb). It's an alloy containing 64.7% titanium, 14% aluminum, and 21.5% niobium. Ti-24Al-11Nb is a strong choice for a torque wrench because it offers very high strength at a much lower weight than steel, along with high fatigue resistance, which helps the wrench stay accurate and durable over long-term repeated use. It has the following properties:

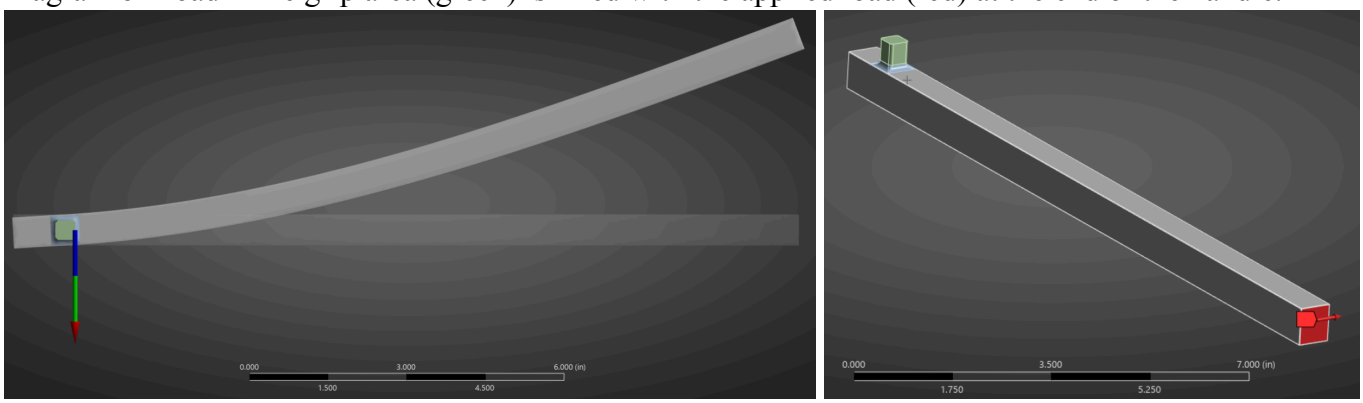
Elastic Modulus (E) = 13.1 Msi | Fracture Toughness ($K_{IC}$) = 12.7 ksi$\sqrt{in}$ | Tensile Strength ($\sigma_u$) = 104 ksi
Yield Strength ($\sigma_y$) = 84.3 ksi | Fatigue Strength ($\sigma_{allow}$) = 65 ksi | Poisson's ratio (v) = 0.35

Results of FEM Calculations:

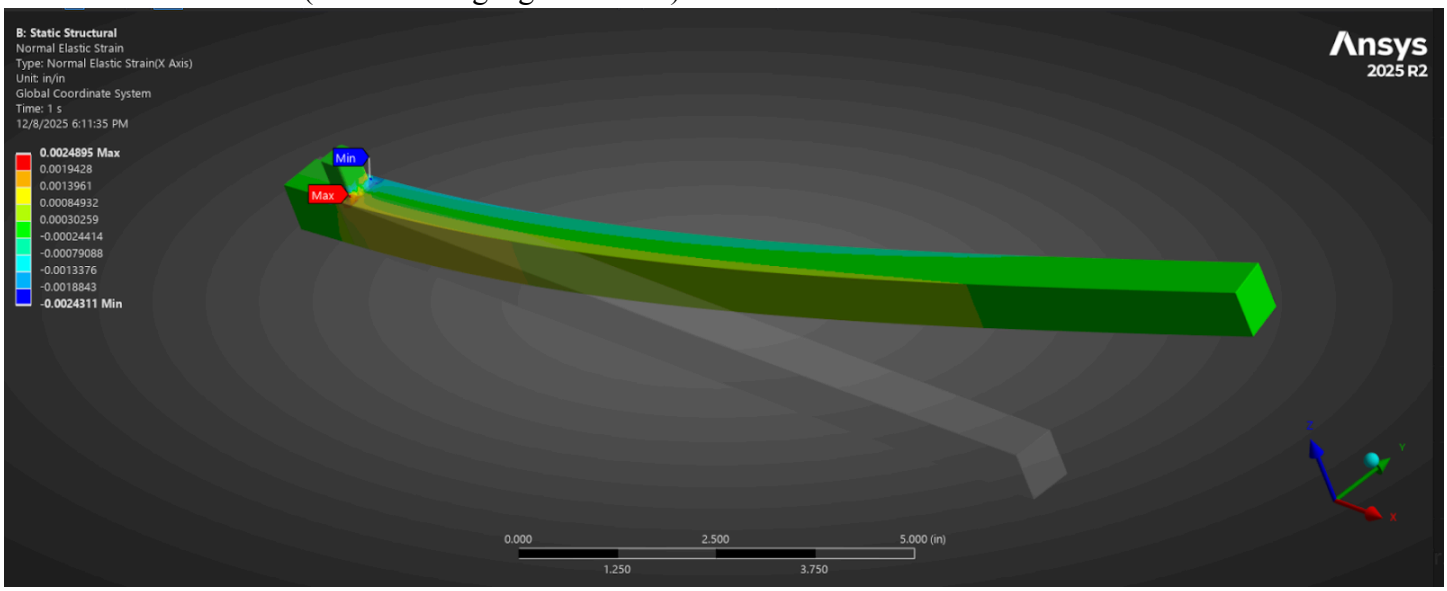
- Maximum normal stress = 49.649 ksi
- Strain at strain gauge = 1.0127 min/in.
- Deflection at load point = 0.30112 in.
- $Torque\ Wrench\ Sensitivity\ =\ \varepsilon_1 = 1.0127\ mV/V$

For my design, I would use a foil strain gauge which is a small, thin sensor that should fit in my model. It would have a grid length of 0.25in and would sit on the neutral axis of the side of the wrench as indicated in the above diagram.

Diagram of Load - The grip area (green) is fixed with the applied load (red) at the end of the handle.




Normal strain contours (in the strain gauge direction)




Contour plot of maximum principal stress