Torque Wrench FEM Summary

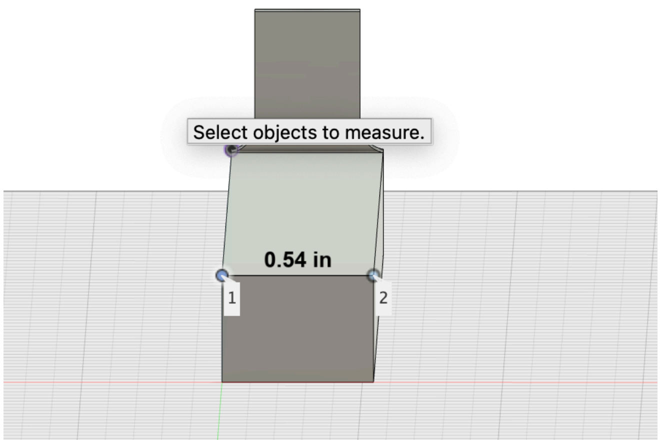
Reginald Harris
RDH252

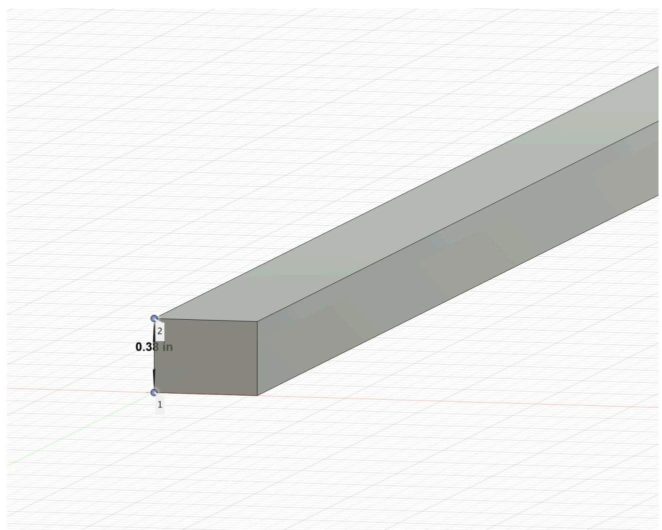
1. CAD Model Overview

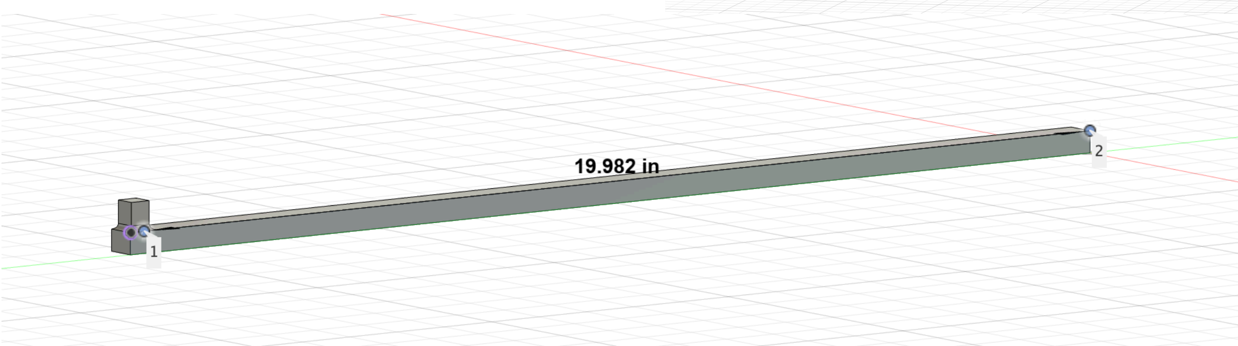
This is the final CAD model I made using the optimized geometry suggested by my MATLAB script.

Key Measurments:

- **Beam Height:** 0.54 inches
- **Beam Width:** 0.38 inches
- **Beam Length:** 20 inches
- **Strain Gauge Location:** 0.25 inches from drive head







2. Material Selection and Properties

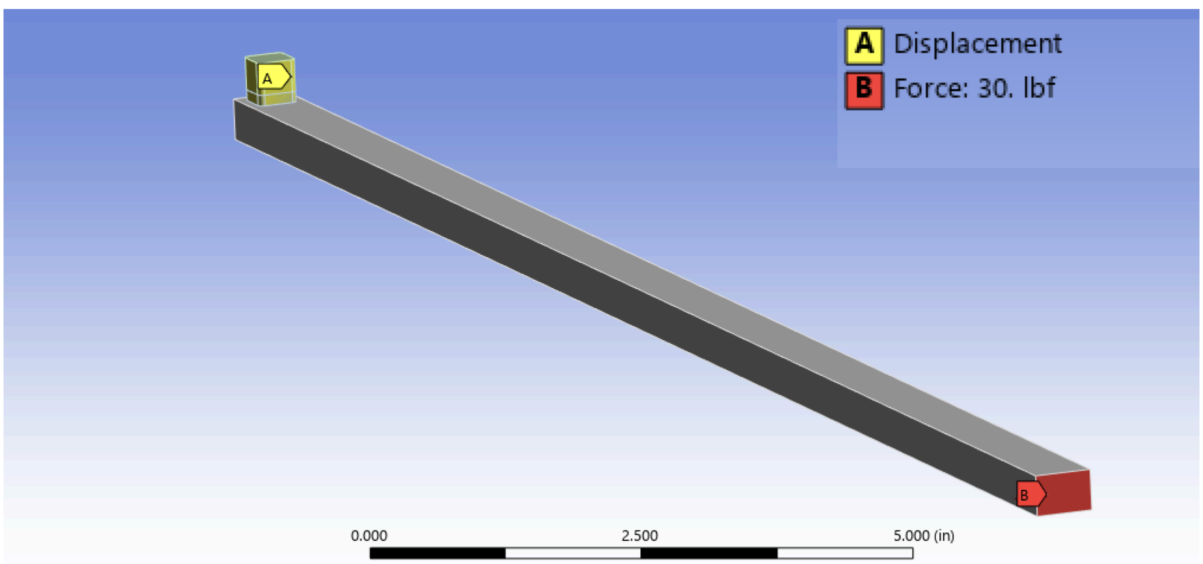
Titanium alloy was selected because it provides a combination of strength, fracture toughness, and fatigue resistance, all of which are essential for a torque-measuring component. Being a ductile material Titanium maintains elastic behavior under high stresses, resists crack initiation and crack growth, and performs reliably under cyclic loading. Compared to aluminum or steel, titanium offers a better balance of stiffness, durability, and toughness, making it the best material choice for this torque wrench beam.

Material Properties:

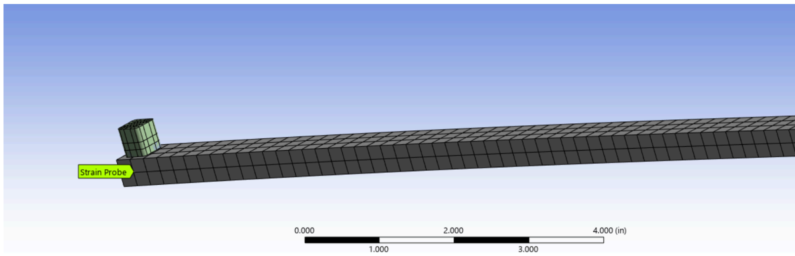
- **Elastic modulus:** 16×10^6 psi
- **Ultimate strength:** 130 ksi
- **Fatigue strength:** 70 ksi
- **Fracture toughness:** 55 ksi√in
- **Poisson's ratio:** 0.29

3. FEM Boundary Conditions

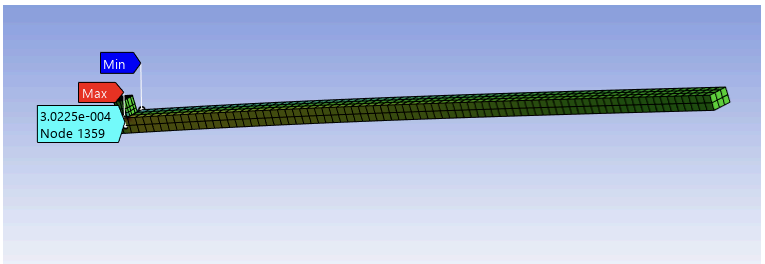
In the FEM model, I fully constrained the drive end in all three axial directions of the beam to simulate engagement with a fastener. A 30 lbf load in the x direction is applied at the free end, which produces an equivalent torque of 600 in-lb.



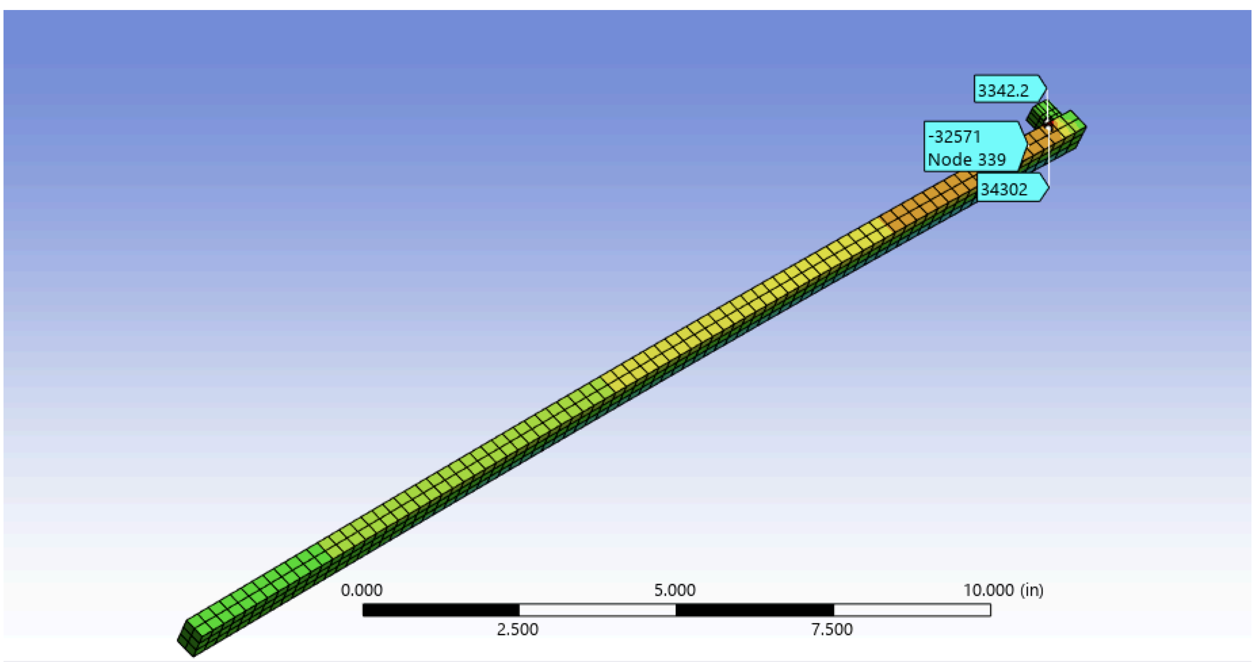
4. Normal Strain Contour + Strain Probe at Strain Gauge

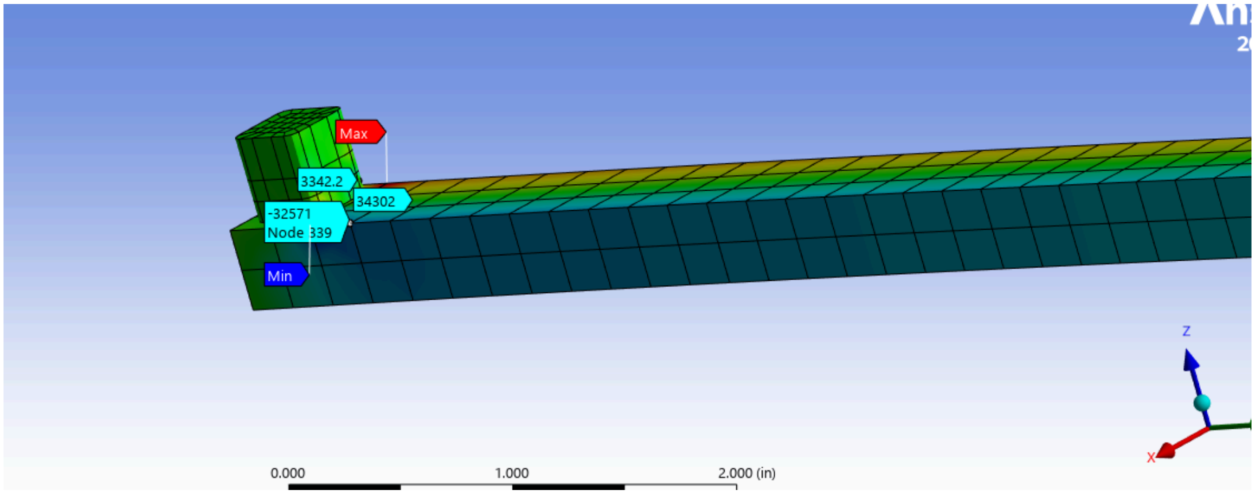


Maximum Value Over Time	
Normal - X Axis	2.2941e-004 in..
Normal - Y Axis	-8.3626e-004 i...
Normal - Z Axis	3.1213e-004 in..
XY Shear	2.8051e-004 in..
YZ Shear	9.4154e-004 in..
XZ Shear	-5.7463e-005 i...
Equivalent (von-Mises)	1.1196e-003 in..
Maximum Principal	4.8214e-004 in..
Middle Principal	2.4379e-004 in..
Minimum Principal	-1.0207e-003 i...
Intensity	1.5028e-003 in..
Minimum Value Over Time	

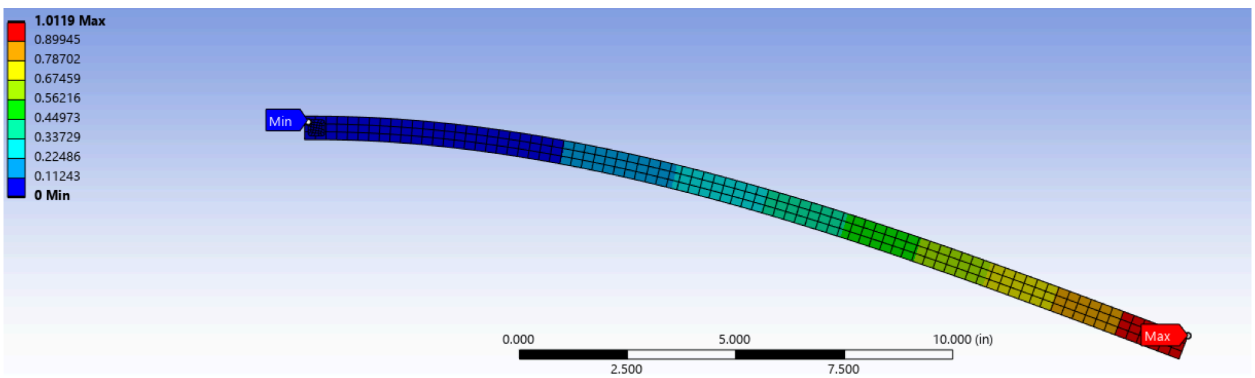


5. Maximum Principal Stress Contour





6. Beam Deflection Map



7. FEM Results

- **Load Point Deflection:** 1.0119 inches
- **Maximum Normal Stres:**
  - **Along Wrench Body:** ~3.34 ksi
  - **Drive Head:** ~34 ksi
- **Strain at Strain Gauge:** 3121 microstrains

8. Torque Wrench Sensitivity

Given that we measured strain at the strain gauge to be around 3121 microstrains the output/torque wrench sensitivity can be calculated:

Output = (strain gauge strain)/(1000 microstrains per mV/V)
= 3121 micrstrains/1000
= **3.121 mV/V**

9. Strain Gauge Selction + Location

Type:

- Foil Strain Gauge
- Linear Strain Gauge (Applied Axiallly)

A foil strain gauge was selected because its metallic grid bonds securely to the titanium surface and provides accurate, stable strain measurements under repeated bending loads. The gauge is applied as a linear axial strain gauge since the torque wrench beam experiences primarily uniaxial bending, making a single-axis gauge ideal for capturing the main strain direction.

Dimensions:

Grid Length: 0.12 inches
Grid Width: 0.06 inches
Backing Length: 0.28 inches
Backing Width: 0.12 - 0.16 inches
Gauge Thickness: 0.001 inches
Gauge Location (Relative to Drive Head): 0.25 inches