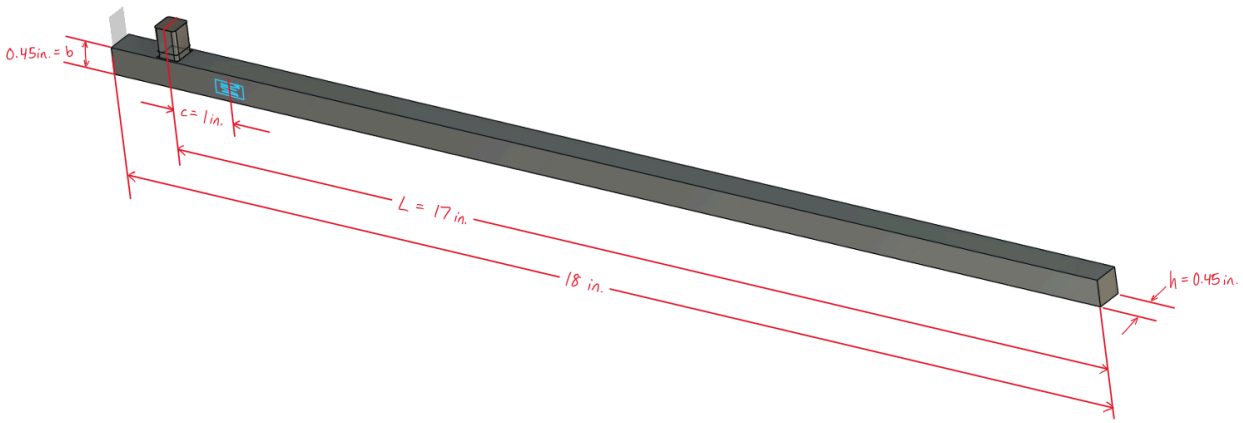
MAE 3270 - Torque Wrench Design

Nicole Kim
Alma Meili Ren

5.2 Your Design:

5.2.1 Results:

1. CAD Model



2. Material used and its relevant mechanical properties

   Chosen material: Intermediate alloy, Fe-5Cr-Mo-V aircraft steel, quenched & tempered

```
% dimensions to determine:
L = 17;                         % (inches)
h = 0.45;                          % (inches)
b = 0.45;                         % (inches)
c = 1.0;                         % (inches)
I = (b*h^3)/12;                  % moment of inertia (inches^4) - based on chosen geometry

% chosen material:
name = 'Fe-5Cr-Mo-V';
E = 31.E6;                       % Young's modulus (psi)
nu = .375;                       % Poisson's ration (dimensionless)
su = 240.E3;                     % tensile strength -- use yield or ultimate strength depending
on material (psi)
KIC = 120.E3;                    % fracture toughness (psi sqrt(in))
sfatigue = 125.E3;               % fatigue strength from Granta for 10^6 cycles
```

Mechanical properties of Fe-5Cr-Mo-V and our chosen dimensions

```
T = 600;                        % max torque (in-lbf) FIXED

% dimensions to determine:
L = 17;                        % (inches)
h = 0.45;                         % (inches)
b = 0.45;                       % (inches)
c = 1.0;                        % (inches)
I = (b*h^3)/12;                 % moment of inertia (inches^4) - based on chosen geometry

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on material (psi)
KIC = 120.E3;                   % fracture toughness (psi sqrt(in))
sfatigue = 125.E3;              % fatigue strength from Granta for 10^6 cycles

% Stress and deflection analysis
smax = T * (h/2) / I;           % max normal stress (psi)
Mg = T * (1 - c/L);             % Moment at gauge
sgauge = Mg * (h/2) / I;        % stress at gauge
X0 = su / smax;                 % safety factor for yield or brittle failure
delta = (T*L^2)/(3*E*I);        % load point deflection (inches)

% Crack analysis
a = .04;                        % crack depth (inches)
F = 1.12;                       % geometric factor
KI = F * sqrt(pi*a) * smax;     % stress intensity factor (psi*sqrt(in))
XK = KIC / KI;                  % safety factor for crack growth


% Fatigue analysis
Xs = sfatigue / smax;           % safety factor for fatigue

% Strain gauge
strain = sgauge / E;
output = 1000 * (2 * strain / 2);


% Print values
disp("Chosen material: " + name);

fprintf('\nStress and deflection analysis:\n');
fprintf('load point deflection = %.3f in\n', delta);
fprintf('max normal stress = %.2f ksi\n', (smax*10^-3));

fprintf('\nSafety factor results:\n');
fprintf('safety factor for strength = %.2f\n', X0);
fprintf('safety factor for crack growth = %.2f\n', XK);
fprintf('safety factor for fatigue = %.2f\n', Xs);

fprintf('\nStrain gauge results:\n');
fprintf('strain at gauge = %.f microstrain\n', (strain*10^6));
fprintf('output = %.2f mV/V at 600 in-lbf using half bridge\n', output);

```
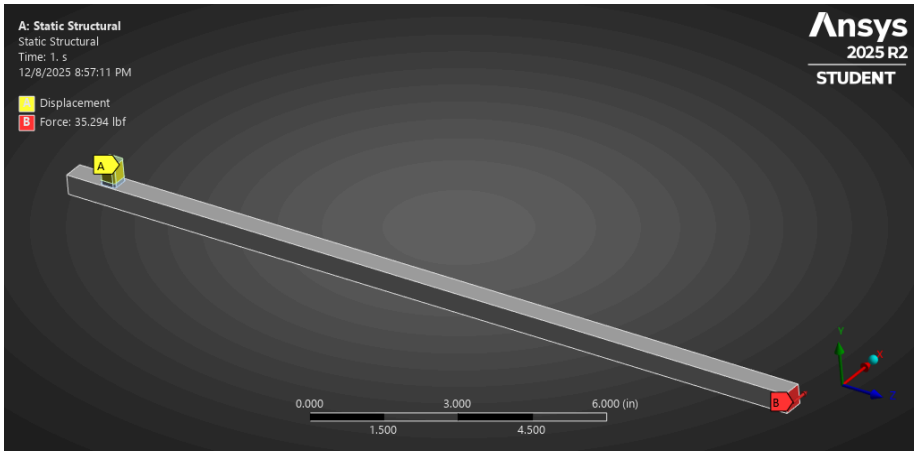

Full code used to compute hand calculations and confirm requirements

```
>> FinalHW
Chosen material: Fe-5Cr-Mo-V

Stress and deflection analysis:
load point deflection = 0.546 in
max normal stress = 39.51 ksi

Safety factor results:
safety factor for strength = 6.08
safety factor for crack growth = 7.65
safety factor for fatigue = 3.16

Strain gauge results:
strain at gauge = 1199 microstrain
output = 1.20 mV/V at 600 in-lbf using half bridge
```

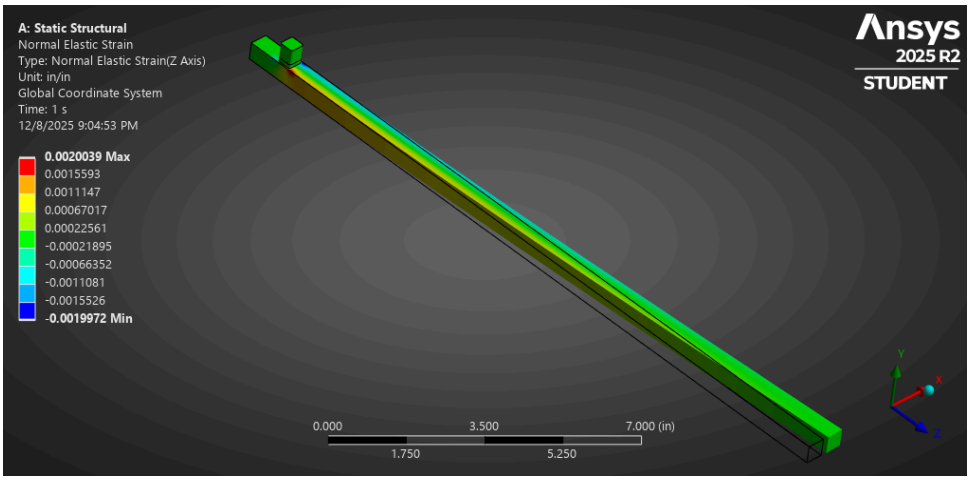
Results of hand calculations with our chosen dimensions and material

3. Diagram of how loads and boundary conditions were applied to the FEM model

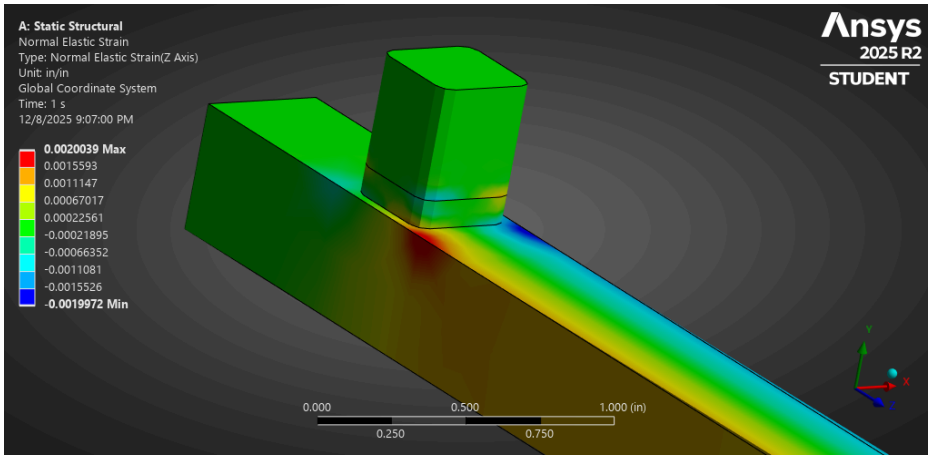


Note: “A” displacement is clamped boundary condition and “B” is applied force

4. Normal strain contours from FEM

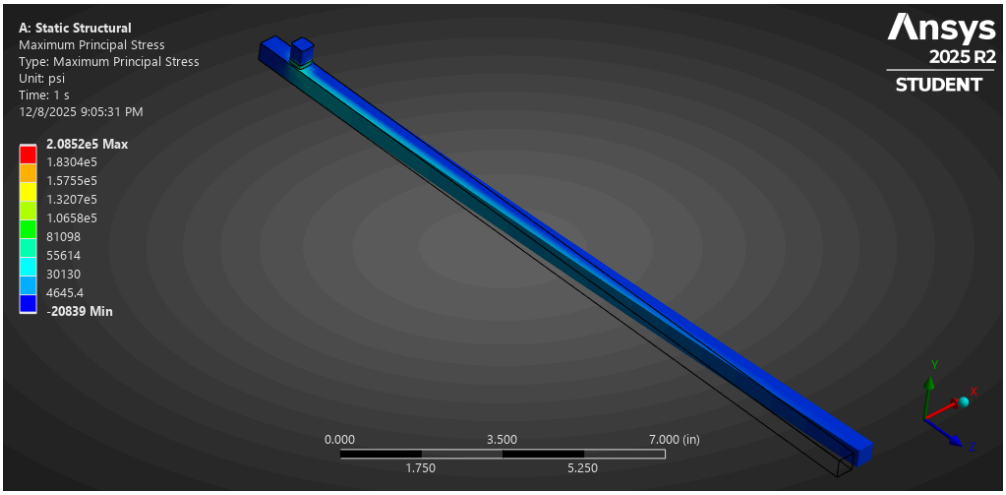


Zoomed out normal strain contour

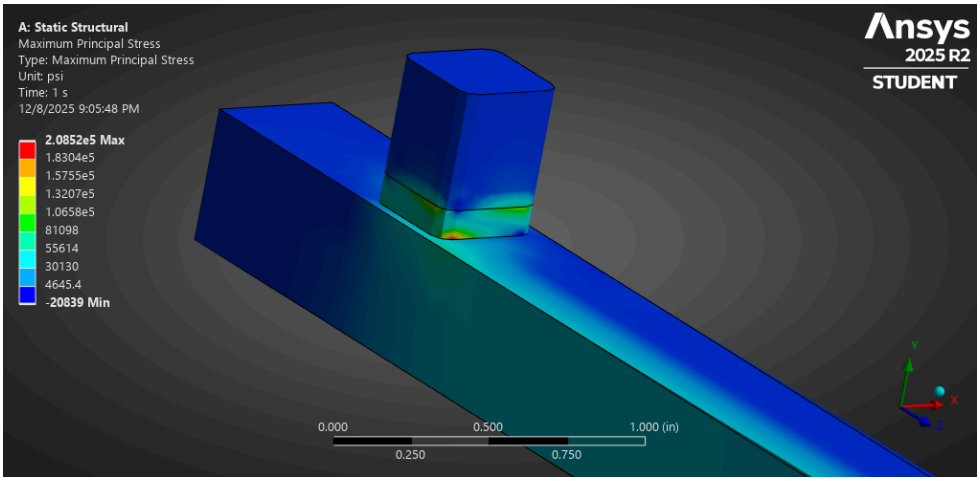


Zoomed in normal strain contour

5. Contour plot of maximum principal stress from FEM

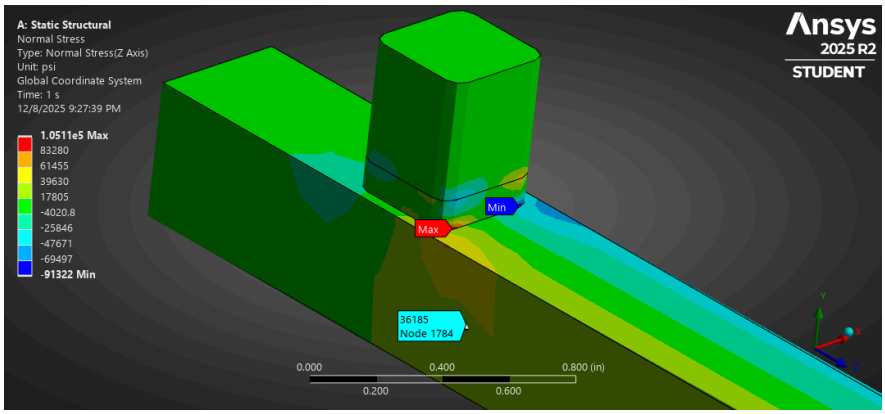


Zoomed out maximum principal stress contour

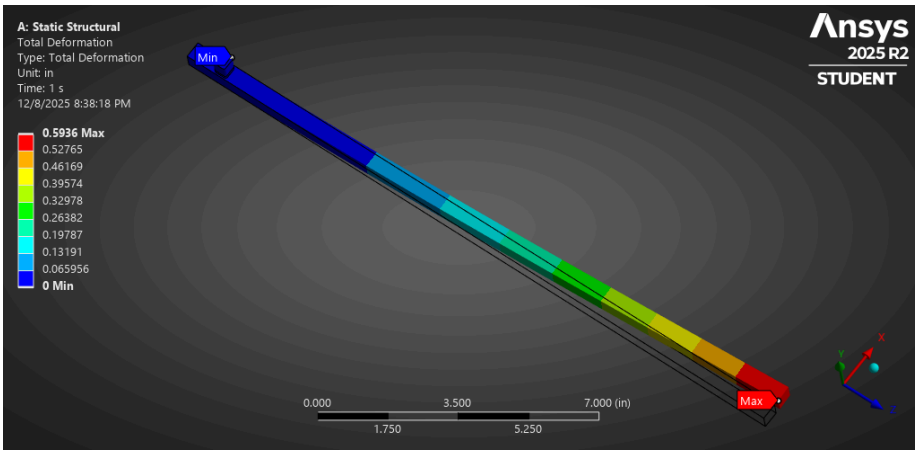


Zoomed in maximum principal stress contour

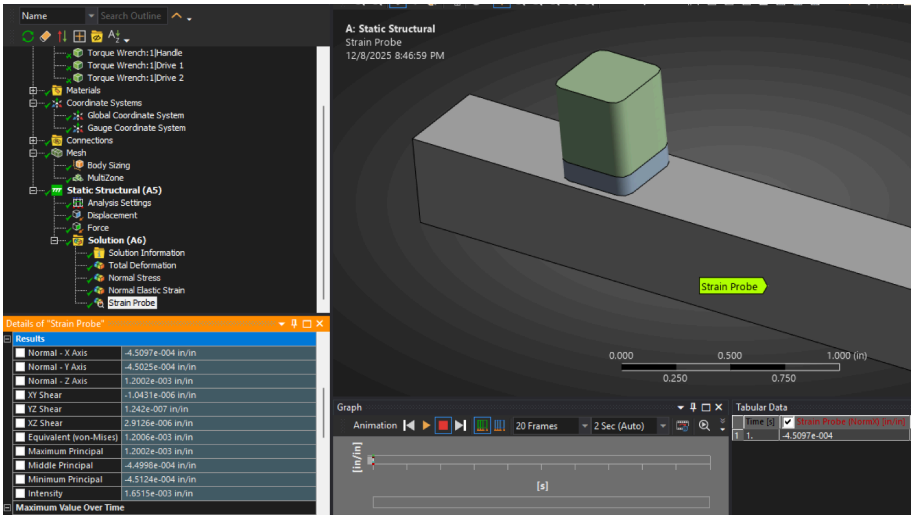
6. Results from FEM calculation



Maximum normal stress = 105.11 ksi



Load point deflection = 0.5936”



Strain at strain gauge = 1200.2 microstrain

7. Torque wrench sensitivity in mV/V using strain from FEM analysis

```
% Strain gauge
strain = 1.2002e-3;
output = 1000 * (2 * strain / 2);
```

```
Strain gauge results:
strain at gauge = 1200 microstrain
output = 1.20 mV/V at 600 in-lbf using half bridge
```

Torque wrench sensitivity = 1.20 mV/V at 600 in-lbf

8. Strain gauge selected (type and dimensions)

Selected strain gauge: SGD-2/350-LY11 Linear Strain Gage on DwyerOmega, 350 Î© Resistance

Gauge Type:

Miniature linear pattern, measurement of stress concentration

Dimensions:

Grid length = 6 mm

Grid width = 6.3 mm = 0.248 in.

(Note: The grid width is less than the width of the torque wrench, b)