

MatLab Code: (Hand Calculations)

```
1 M = 600; % max torque (in-lbf)
2
3 %%% Material Properties %%%
4 matl_property = {{32.E6, 0.29, 370.E3, 15.E3, 115.E3, 'M42 Steel'};
5           {16.1E6, 0.35, 148E3, 74.6E3, 90E3, "Ti-6Al-4V, aged"}}
6   };
7 dimensions = {{16, 0.75, 0.5, 1, 'M42 Steel'};
8           {16, 0.5, 0.5, 1, "Ti-6Al-4V, aged"}};
9   };
10 disp(" ")
11 disp("REQUIREMENTS: ")
12 disp("    output>1e-3,      Xo>4,      Xk>2,      Xs>1.5")
13
14 for i = 1:2
15   % Extract material properties
16   E = matl_property{i}{1}; % Young's modulus (psi)
17   nu = matl_property{i}{2}; % Poisson's ratio
18   sigu = matl_property{i}{3}; % tensile strength use yield or ultimate depending on mate
(psi)
19   KIC = matl_property{i}{4}; % fracture toughness (psi sqrt(in))
20   sfatigue = matl_property{i}{5}; % fatigue strength from Granta for 10^6 cycles
21   name = matl_property{i}{6}; % material name
22
23   % Extract beam dimensions
24   L = dimensions{i}{1}; % length from drive to where load applied (inches)
25   h = dimensions{i}{2}; % width
26   b = dimensions{i}{3}; % thickness
27   c = dimensions{i}{4}; % distance from center of drive to center of strain gauge
28
29   % Yield/brittle failure
30   I = (b*h^3)/12;
31   sigmax = M*(h/2)/I; % max normal (psi)
32   Xo = sigu/sigmax; % safety factor against brittle failure
33   P = M/L; % equivalent load
34   umax = (P*L^3)/(3*E*I); % max deflection
35
36   % Fracture failure w crack depth=0.04in
37   a = 0.04; % crack depth (in)
38   Sg = 6*M/(b*h^2);
39   KI = 1.12*Sg*sqrt(pi*a);
40   Xk = KIC/KI; % safety factor against fracture
41
42   % Fatigue failure
43   Xs = sfatigue/sigmax; % safety factor against fatigue
44
45   % Strain gauge
46   Mb = M*(1-c/L);
47   sigmaxeps = Mb*(h/2)/I;
48   eps = sigmaxeps/E;
49   k = 2;
50   output = k*eps/2;
51
52   fprintf("TEST of %s \n", name)
53   fprintf('    output=%.2e, Xo=%.2f, Xk=%.2f, Xs=%.2f \n', output, Xo, Xk, Xs)
54   fprintf('    max normal stress = %.3e, strain at gauge = %.3e, deflection = %.3f \n',
sigmax, eps, umax)
55 end
```

Output:

```
Command Window

REQUIREMENTS:
    output>1e-3,      Xo>4,      Xk>2,      Xs>1.5
TEST of M42 Steel
    output=3.75e-04, Xo=28.91, Xk=2.95, Xs=8.98
    max normal stress = 1.280e+04, strain at gauge = 3.750e-04, deflection = 0.091
TEST of Ti-6Al-4V, aged
    output=1.68e-03, Xo=5.14, Xk=6.52, Xs=3.12
    max normal stress = 2.880e+04, strain at gauge = 1.677e-03, deflection = 0.611
...
```