

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
19     (psi)
20     KIC = matl_property{i}{4}; % fracture toughness (psi sqrt(in))
21     sfatigue = matl_property{i}{5}; % fatigue strength from Granta for 10^6 cycles
22     name = matl_property{i}{6}; % material name
23
24     % Extract beam dimensions
25     L = dimensions{i}{1}; % length from drive to where load applied (inches)
26     h = dimensions{i}{2}; % width
27     b = dimensions{i}{3}; % thickness
28     c = dimensions{i}{4}; % distance from center of drive to center of strain gauge
29
30     % Yield/brittle failure
31     I = (b*h^3)/12;
32     sigmax = M*(h/2)/I; % max normal (psi)
33     Xo = sigu/sigmax; % safety factor against brittle failure
34     P = M/L; % equivalent load
35     umax = (P*L^3)/(3*E*I); % max deflection
36
37     % Fracture failure w crack depth=0.04in
38     a = 0.04; % crack depth (in)
39     Sg = 6*M/(b*h^2);
40     KI = 1.12*Sg*sqrt(pi*a);
41     Xk = KIC/KI; % safety factor against fracture
42
43     % Fatigue failure
44     Xs = sfatigue/sigmax; % safety factor against fatigue
45
46     % Strain gauge
47     Mb = M*(1-c/L);
48     sigmaxeps = Mb*(h/2)/I;
49     eps = sigmaxeps/E;
50     k = 2;
51     output = k*eps/2;
52
53     fprintf("TEST of %s \n", name)
54     fprintf('    output=%2e, Xo=%2f, Xk=%2f, Xs=%2f \n', output, Xo, Xk, Xs)
55     fprintf('    max normal stress = %3e, strain at gauge = %3e, deflection = %3f \n',
56             sigmax, eps, umax)
57 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
...
```