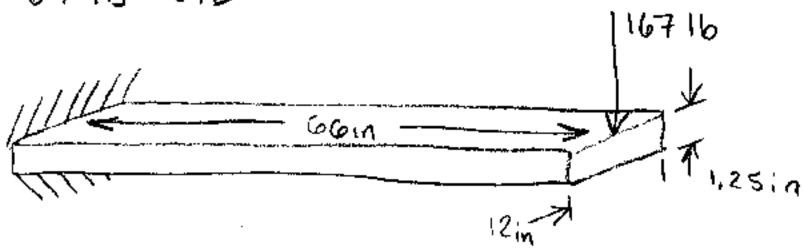
EXAM #3

① ALUMINUM CANTILEVER BEAM
167 lb LOAD



$$I = \frac{bh^3}{12} = \frac{12\,in\,(1.25\,in)^3}{12}$$
$$= 1.95\,in^4$$

FIND STIFFNESS AND DEFLECTION

$$y = -\frac{F\ell^3}{3EI} = \frac{167\,lb\,(66\,in)^3}{3(10.4\times10^6\,lb/in^2)\,1.95\,in^4} = -0.788\,in$$

$$K = \frac{167\,lb}{0.788\,in} = 212\,lb/in = \frac{F}{y}$$

(2) $F_{min} = 100 lb$, $F_{max} = 250 lb$ $\Big\}$ $F_m = 175 lb$, $F_{alt} = 75 lb$

A 230, PEENED & SET REMOVED

$N_a = 18 \rightarrow N_t = 20$ (SQUARED & GROUND)

$d = 0.112 in$

$D_o = 0.45 in \rightarrow D = 0.338$ $\Big\}$ $C = 3.0$

$L_f =$

(a) $$k = \frac{dG}{8 N_a C^3} = \frac{0.112 in\,(11.7 \times 10^6\ lb/in^2)}{8(18)(3)^3} = 337\ lb/in$$

(b) $N_t = N_a + 2 = 18 + 2 = 20$

(c) $$\delta_w = \frac{F_{max} - F_{min}}{K} = \frac{150 lb}{337 lb/in} = 0.445 in$$

(d) $S_{ut} = 225\ kpsi$; $\tau_y = 70\%\, S_{ut} = 157.5\ kpsi$

$$L_s = d N_t = 0.112 in (20) = 2.24 in$$

$$\delta_{max} = L_f - L_s = 3.5 in - 2.24 in = 1.26 in$$

$$F_{max} = K \delta_{max} = 1.26 in\,(337 lb/in) = 425 lb$$

$$\tau_s = \tau_{max} = \frac{8FD}{\pi d^3} K_s = \frac{8(425 lb)\,0.338 in}{\pi (.112 in)^3}\, 1.16 = 260 ksi$$

THIS EXCEEDS THE YIELD STRENGTH, THERE IS NO MARGIN OF SAFETY IN YIELD!

(e) $$S_{es} = 0.707 \frac{S_{ew} S_{us}}{S_{us} - 0.707 S_{ew}} = 0.707 \frac{67.5(150.75)}{150.75 - 0.707(67.5)} = 98.77 kpsi$$

$S_{ew} = 67.5 ksi$ (PEENED)

$S_{us} = 0.67 (S_{ut}) = 0.67 (225 kpsi) = 150.75 kpsi$

$$\tau_i = \frac{8F_iC}{\pi d^2}K_s = \frac{8(100\,lb)3}{\pi(.112in)^2}1.16 = 70.64\,kpsi$$

$$\tau_m = \frac{8F_mC}{\pi d^2}K_s = \frac{8(175\,lb)3}{\pi(.112in)^2}1.16 = 123.6\,kpsi$$

$$\tau_{alt} = \frac{8F_{alt}C}{\pi d^2}K_w = \frac{8(75\,lb)3}{\pi(.112in)^2}1.55 = 70.80\,kpsi$$

$$N_f = \frac{S_{es}(S_{us}-\tau_i)}{S_{es}(\tau_m-\tau_i)+S_{us}\tau_a} = \frac{99(151-71)}{99(124-71)+151(71)}$$

$$= 0.50$$

THIS SPRING WILL FAIL IN FATIGUE!

ⓕ SINCE IT IS SAFE TO ASSUME THAT THE SPRING CONSTANT AND APPLIED FORCES ARE REQUIRED DESIGN CRITERIA, WE NEED TO CHANGE THE MATERIAL, WIRE DIAMETER, AND OR THE COIL DIAMETER. IN CASE THE SPRING FITS INSIDE SOME PIECE OF EQUIPMENT, THE COIL DIAMETER IS THE LAST THING WE WOULD WANT TO CHANGE. WIRE DIAMETER WILL YIELD THE LARGEST GAINS. A 25% INCREASE IN WIRE DIAMETER WILL EASILY DRIVE BOTH FACTORS OF SAFETY LARGER THAN ONE.

NOTE: THE SPRING INDEX IS ALREADY LOW FOR THIS SPRING, AND A LARGER WIRE DIAMETER WOULD MAKE IT EVEN LOWER. THE BEST REDESIGN WOULD INCLUDE BOTH A LARGER COIL & WIRE DIAMETER.

EXAM #3 - <u>CONT'D</u>

ME 340
3/9/99

(3) 3600 rpm = 60 rev/sec !

BIG PROBLEMS; DRIVING A SPRING AT IT'S NATURAL FREQUENCY WILL CAUSE SURGING AND RAPID FAILURE.