Compound Loading

axial + bending + torsion (all at one point)

fluctuating stress

Von Mises

$$\sigma_a' = \left\{ \left[(K_f)_{bend} (\sigma_{ao})_{bend} + (K_f)_{axia} \frac{(\sigma_{ao})_{axial}}{0.85} \right]^2 + 3\left[(K_{fs})_{tor} (\tau_{ao})_{tor} \right]^2 \right\}^{1/2}$$

$$\sigma_m' = \left\{ \left[(K_f)_{bend} (\sigma_{mo})_{bend} + (K_f)_{ax} (\sigma_{mo})_{ax} + 3\left[(K_{fs})_{tor} (\tau_{mo})_{tor} \right]^2 \right\}^{1/2}$$

Load factor k_c

Don't use it!

yield $\Rightarrow$ $\sigma_a' + \sigma_m' = \frac{S_y}{n}$

$$S_e = k_a k_b k_d k_e k_f S_e'$$

$\sigma_{max} = K_f \sigma_o$

Don't include K_f in k_f (misc factor)

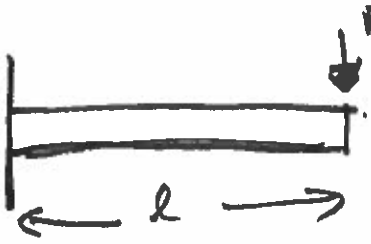
tension

$$n = \frac{S_{yt}}{\sigma_a' + \sigma_m'} \qquad (\sigma_m + \sigma_a) \qquad \tau_a + \tau_m$$

von mises — shear

$$n = \frac{-S_{yt}}{\sigma_m' - \sigma_a'}$$ compression

HW 7 Problem 4



factor of safety $n = 2$

fully reversed

$$\sigma_a = \frac{6Fl}{h^2 w} \qquad \sigma_m = 0$$

Hot rolled

$$S_e = K_a K_b \frac{S_{ut}}{0.5}$$ (S_e')

K_a: surface — K_b: size factor

K_b: $< 51\text{mm}$

$-0.157 > 51\text{mm}$

$1.51 d_e$

$$d_e = 0.808\sqrt{hw}$$

$$n = \frac{(S_f)_{10^4}}{\sigma_a}$$

$$(S_f) = a N^b$$

$$a = (f S_{ut})^2 / S_{ec}$$

$f = 0.9$

$$b = -\frac{1}{3}\log\left(\frac{f S_{ut}}{S_e}\right)$$

$$(S_f) = 2.62E+6 N^{\frac{-0.145\log(S_{ut}^{0.718}(hw)^{0.0785})}{+1.65}} \cdot S_{ut}^{1.72}(hw)^{0.0785}.$$

$$n = \frac{S_y}{\sigma_a}$$

$$\Omega = n = 512 h^{1.9738}$$

$$h = \left(\frac{2}{512}\right)^{\frac{1}{1.9738}} = 0.06 \text{ m}$$

1. guess at h
2. implicit function => solve iteratively: fsolve( ) (matlab)
3. analytical solution

if $d_e < 51!$ => change the equation for K_b and recalc

Cumlative Loading

Element that loaded: $n < N$

σ_1' for n_1 cycles for which N_1 cycles would produce failure.

σ_2' for n_2 cycles ... N_2 cycles

σ_3' n_3 N_3 cycles

$$\sum \frac{n_i}{N_i} = C$$

if $C < 1$ failure will not occur

if $C \geq 1$ failure will occur

Miner's Rule

What I want to know remaining # of cycles after various various cumlative loads?

If $C < 1$, remaining life:

$$n_r = \left[C - \sum_{i=1}^{m} \frac{n_i}{N_i}\right] N_r$$

$C = 1$ unless empirically derived

N_r: number of finite cycles to failure for the last stress A applied

n_r: remaing number of cycles for cumalitive load

Example A machined part is cycled $(\sigma_a)_1 = \pm 350$ MPa for $n_1 = 5 \times 10^3$ cycles, then $(\sigma_a)_2 = \pm 260$ MPa applied for $n_2 = 5 \times 10^4$ cycles, finally $(\sigma_a)_3 = \pm 225$ MPa is applied. How many cycles remain before failure?

$S_{ut} = 530$ MPa, $f = 0.9$, $S_e = 210$ MPa

$a = 1083.47$ $b = -.11876$

$$N_3 = \left[\frac{(\sigma_a)_3}{a}\right]^{1/b} = 559,400$$

$$N_2 = \left[\frac{(\sigma_a)_2}{a}\right]^{1/b} = 13,550$$

$N_1 = 165,600$

$$n_3 = \left[C - \sum_{i=1}^{2} \frac{n_i}{N_i} \right] N_3$$

$C = 1$

$$n_3 = \left[1 - \frac{5000}{13550} - \frac{50\,000}{165606} \right] 559400$$

$n_3 = 184{,}000$ cycles @ $(\sigma_a)_3$

$$n = \frac{\sigma_m}{S_e} + \frac{\sigma_a}{S_{ut}}$$

S_e → σ_{rev} equivalent