1/19/22 ME 314

Late HW = 20% Penalty

After solutions posted : no Credit

Q: For the last Problem

Find the load factor guarding against joint seperation $F_m = 0$ (or $F_c = 0$)

$$F_m = F_i - (1-C)\, F_e$$

Set $F_m = 0$ (or any other stated value)

$$0 = 34.77 - (1-0.44)\, F_e^{**}$$

$$\Rightarrow F_e^{**} = 62 \text{ Kips}$$

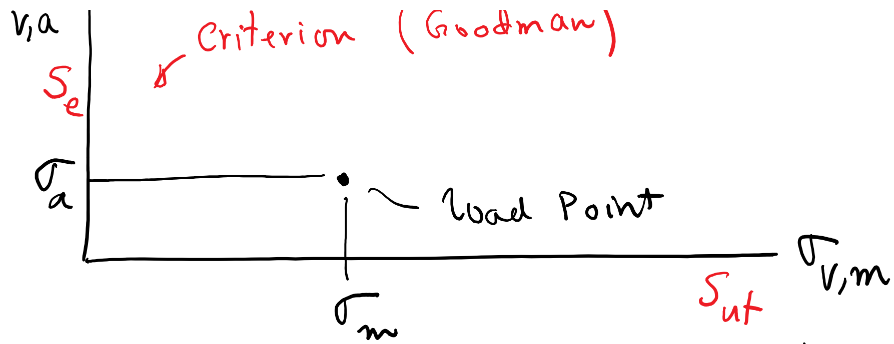
$$n_L = \frac{F_e^{**}}{F_e} = \frac{62}{20} = 3.1 \leftarrow$$

Fatigue Analysis of bolts or screws

Review (quick) of fatigue analysis

① Determine the $\sigma_{v,alt}$, $\sigma_{v,mean}$

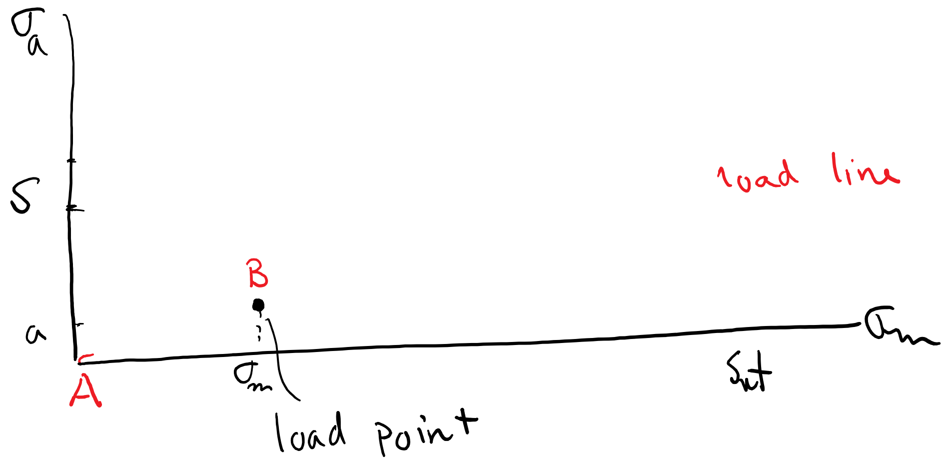
② Go into $\sigma_m - \sigma_a$ graph and locate the load Point



③ Draw the failure curve (Goodman is most common)

There is only one unknown in this graph : $\underbrace{S_e}_{\text{endurance limit}}$

④ Draw the load line (A line showing how the σ_m and σ_a increase as the ext. loads increase



margin of safety $n = \dfrac{AC}{AB}$

$$\frac{1}{n} = \frac{\sigma_m}{S_{ut}} + \frac{\sigma_a}{S_e}$$

How to estimate $S_e \equiv$ endurance limit

1. Direct testing (Very expensive, Very time

Best: From direct testing (Very expensive, Very time Consuming)

- Same part
- Same loading

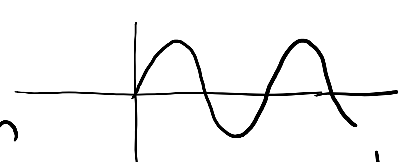
Direct testing is justified for:

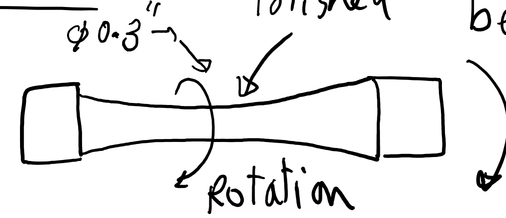
- High volume parts
- When weight is very important (Aircraft - rockets - shuttle)
- Standard Parts (fasteners)

$\sigma = \sigma_{nom}$ Do not apply stress conc. factor to the stresses

Good Method

From material Testing





Rotating bending Test

$S_e' \equiv$ endurance limit of specimen in a rotating bending experiment

$$S_e = K_a K_b K_c K_d K_e K_f$$

K_a — Surface
K_b — Size
K_d — Temp
K_e — reliability
K_f — misc. (stress Concentration)

Surface | Size | Loading Type

For Steels, if S_e' is not available from the Test, we can use

$$S_e' = \frac{1}{2} S_{ut} \quad \text{when } S_{ut} \le 200 \text{ ksi}$$

$$S_e' = 100 \text{ ksi} \quad \text{when } S_{ut} > 200 \text{ ksi}$$

Example Comparing the resut of direct testing compared to rotating bending testing

For fasteners

Example 1 in UNC grade-5 bolt

From Direct testing $S_e = 18.6$ Ksi (Table 8-17)

From S_e' estimate

$$S_e' = \frac{1}{2} S_{ut} = \frac{1}{2}(120) = 60 \text{ ksi}$$

60 ksi

$$S_e = K_a K_b K_c K_d K_e K_f S_e'$$

$K_a = 0.76$

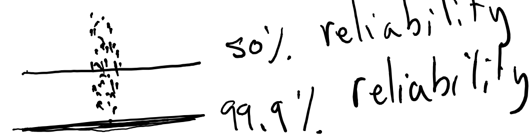
K_b = size = 1 (axial loading)

K_c = loading type = 0.85 (axial loading)

K_d = Temp. = 1

$K_e \equiv$ reliability

$\equiv 0.8$



$K_f \equiv$ stress concentration = 1/3

ksi

$S_e = 10.3$

From direct testing

ksi

$S_e = 18.6$

Design of fasteners subject to cyclic loading

Example

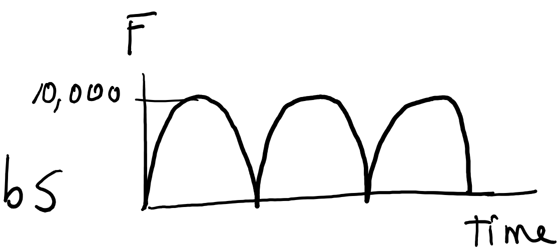
Given: 1 in UNC Grade-5

Rolled threads

F_e = 0 to 10 000 lbs

$F_i = 0.75\,F_p$

$K_m = 5\,K_b$



Find: Factor of safety guarding against eventual Fatigue failure

a) $F_i = 0.75\,F_p = 38.6$ kips

b) $F_{b,min} = F_i = 38.6$ kips

10.000 lbs (max Ext load)

c) $F_{b,max} = F_i + C\, F_{emax}$

where $C = \frac{K_b}{K_b + K_m} = \frac{1}{6} = 0.167$

$F_{b,max} = 40.27$ kips

d) $\sigma_{min} = \frac{F_{b,min}}{A_t} = \frac{38.6}{0.606} = 63.7$ ksi

minimum nominal stress

e) $\sigma_{max} = \frac{F_{b,max}}{A_t} = 66.4$ ksi

f) We Do not apply stress conc. factor to these stresses

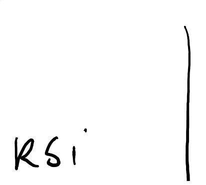
g) $\sigma_{mean} = \frac{\sigma_{min} + \sigma_{max}}{2} \cong 65$ ksi

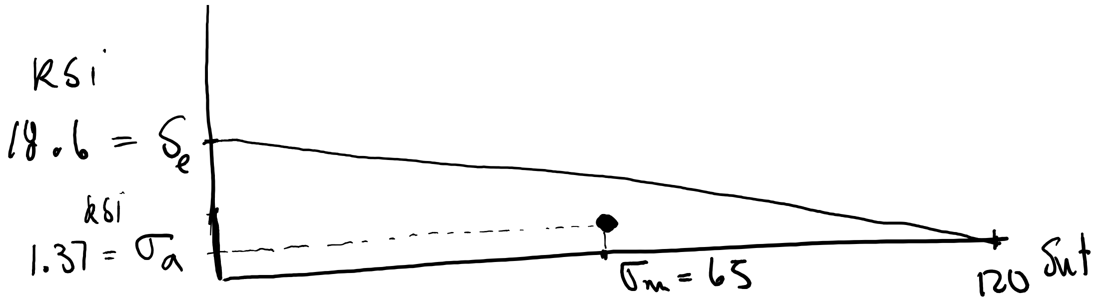
h) $\sigma_{alt} = \frac{\sigma_{max} - \sigma_{min}}{2} \cong 1.37$ ksi

i) end. limit $S_e = 18.6$ ksi (Table 8-17)

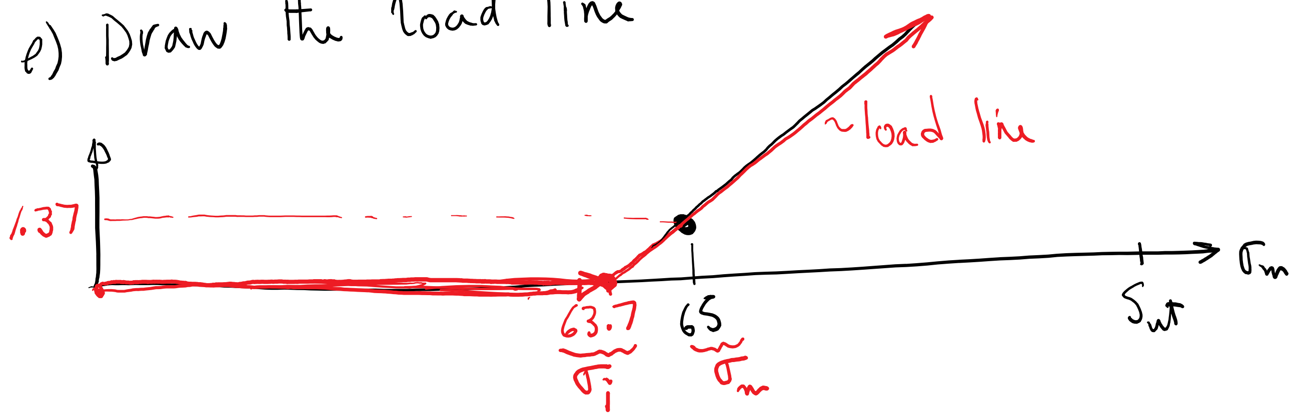
j) $S_{ut} = 120$ ksi (Table 8-9)

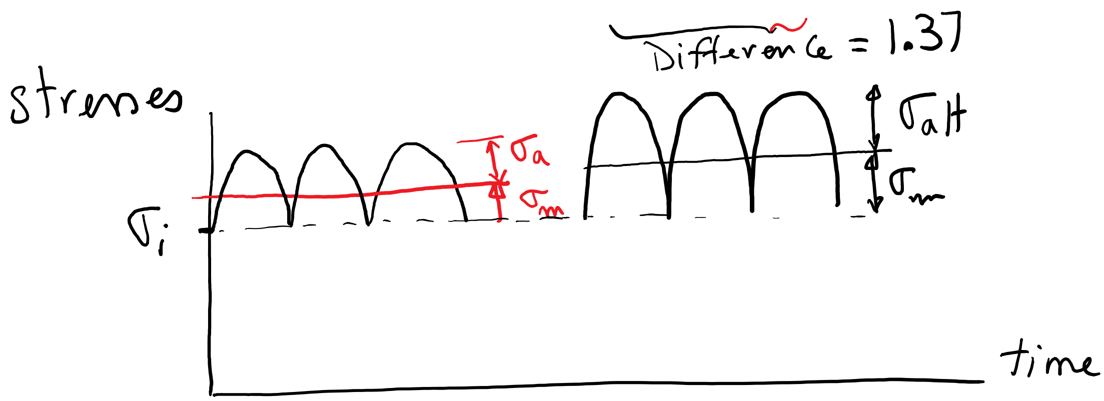
K) Goodman Criterion

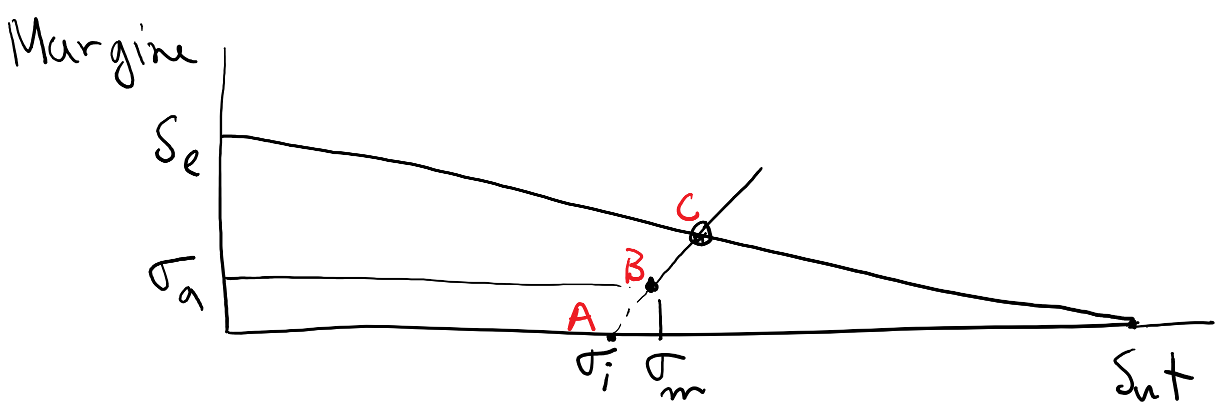




e) Draw the load line







$$n = \frac{AC}{BC} = f(S_{ut}, S_e, \sigma_i, \sigma_m, \sigma_a)$$

EQ 8-38

$$n_f = \frac{S_e (S_{ut} - \sigma_i)}{S_{ut}\sigma_a + S_e(\sigma_m - \sigma_i)}$$

$$n_f = 5.5 \leftarrow$$

Or EQ (8-48)

$$n_f = \frac{2 S_e (S_{ut} A_t - F_i)}{C P (S_{ut} + S_e)}$$

C: joint index

P: F_{emax}

$$n_f = \frac{2(18.6)(120 \cdot 0.606 - 38.6)}{0.167(10)(120 + 18.6)}$$

$$n_f = 5.5 \leftarrow$$

Metric Conversion

UNITS

Force	length	time	g_c		Mass
lb	in	s	386	in/sec^2	slugs
lb	ft	sec	32.2	ft/s^2	No name

lb	ft	sec	32.2	ft/s	name
N	m	sec	9.8	m/s^2	Kg

calculations involving force, stress, length

$$\text{stress} = \frac{F}{A} = \frac{N}{m^2} = Pa$$

$$\sigma = \frac{F}{A} = \frac{N}{mm^2} = MPa$$