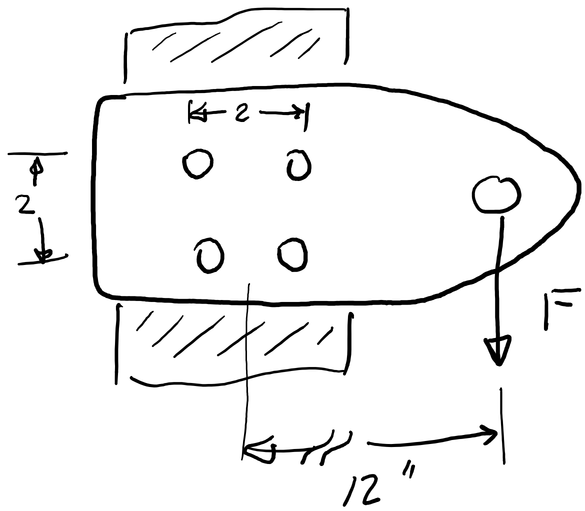
1-24-22

Design of fasteners holding a bracket under Shear loading



Given: $F = 1000$ lbs

$\frac{1}{2}$ in UNC-13 Screws

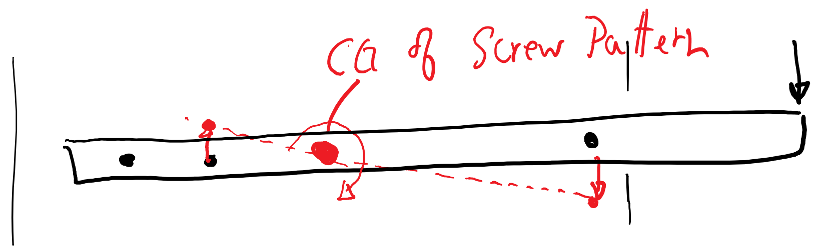
Grade-2

Find: Factor of Safety guarding against screw shanks yielding

Assumptions

- Bracket is rigid
- Friction with wall is lost
- Shear loads are taken by srcrew shanks
- The shear force taken by each

Screw is Proportional to the distance between the Screw and the Centroid of the Screw Pattern

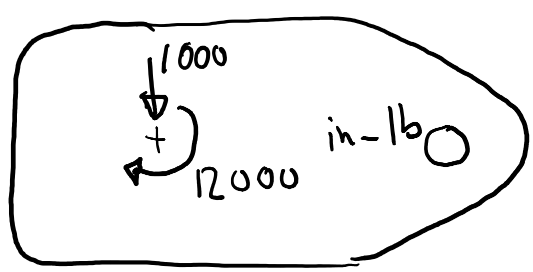


(Page 447)

- Screws are all in tight fit to the holes in the bracket

Solution

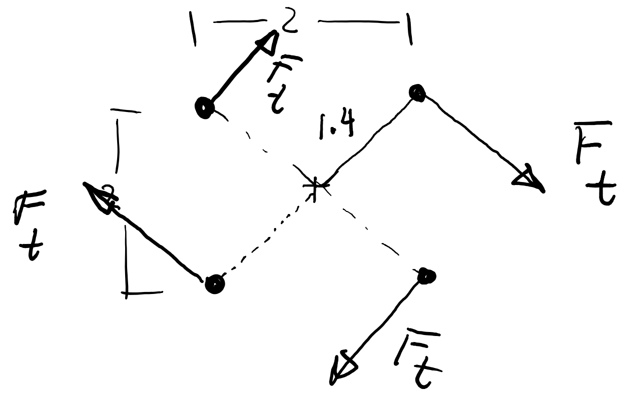
1) Move the load to the CG of the Screw Pattern



2) Find reaction shear forces due to the load

$$F_d = \frac{F}{4} = \frac{1000}{4} = 250 \text{ lbs} \downarrow$$

3) Find reaction shear forces due to the Torsional moment

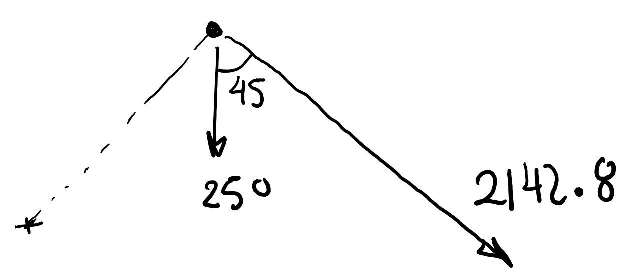


$$T = 4\,(F_t * 1.4)$$

lbs

$$12000 = 4\,(F_t * 1.4) \Rightarrow F_t = 2142.8$$

4) Combine direct shear with torsional shear force to find the total shear force



5) $F_x = 2142.8 \cos(45)$
$= 1515.2$ lbs

$F_y = 250 + 2142.8 \cos 45$
$= 1765.2$ lbs

lbs

$$F_{res.} = \sqrt{F_x^2 + F_y^2} \Rightarrow F_{res.} = 2326.3$$

6) Calculate Shear Stress τ and Compare it to S_{sy} (shear strength)

Psi

$$\tau = \frac{F}{A_d} = \frac{2326.3}{0.1963} = 11847.7$$

where $A_d = \frac{\pi d^2}{4} = \frac{\pi}{4}(0.5)^2$

$$A_d = 0.1963$$

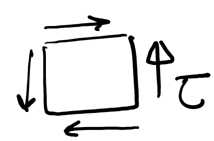
7) Calculate S_{ys}

$$S_{ys} = 0.58\, S_y$$

For grade-2 Psi

$$S_y = 57000$$

$$n = \frac{0.58\,(57000)}{11847.8} \cong 2.8$$



$$\sigma_v = \sqrt{\cancel{\sigma}^2 + 3\tau^2}$$

0

$$\sigma_v = \sqrt{3}\,\tau$$

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

$$n = \frac{S_y}{\sqrt{3}\,\tau}$$

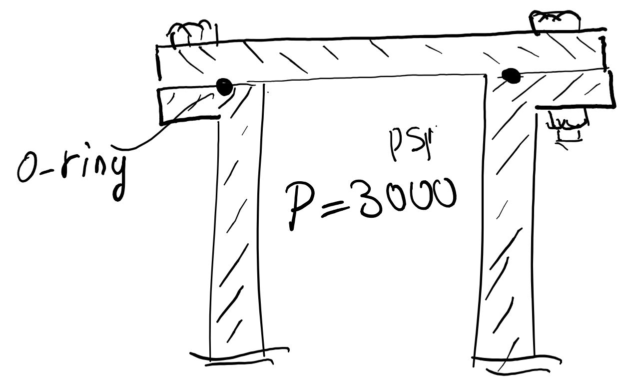
$$S_{ys} = \frac{S_y}{\sqrt{3}} = 0.58\, S_y$$

$$S_{ys} = \frac{S_y}{\sqrt{3}} = 0.58\, S_y$$

$$n = \frac{0.58\, S_y}{\tau}$$

Let's make up a problem

Given: Pressure cylinder



Pressure (Psi) $\equiv P_{max} = 3000$ psi

Material $\equiv$ steel

Sealing diameter $\equiv D_{Sealing} = 10$ inches

Number of fasteners $\equiv 8$

Bolt+Nut or Screw $\equiv$ Bolt & Nut

washer under head $\equiv$ yes

washer under Nut $\equiv$ yes

Fastener Size $\equiv \frac{1}{2}$ in UNC-13

strength grade $\equiv 5$

Thicknes of the plates $\equiv 1/2^{in}$

Initial tension $\equiv$ 75% of Proof load

Acceptable value of load factor in static loading $\equiv 2.5$ n_{L1}

Minimum acceptable compression force needed for proper sealing $\equiv 250^{lbs}$ (Per bolt) $F_{m,min} \equiv 250^{lbs}$ Per bolt

Acceptable value of load factor guarding against compression falling below 250^{lbs} $n_{L2} = 1.5$

Acceptable value of factor of safety in cyclic loading when the Pressure fluctuates between 0 and P_{max}

$n_f = 4$

Find: Is this an acceptable design

Solution Procedure

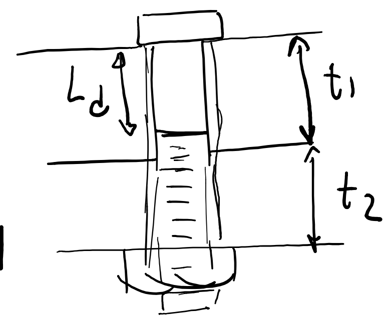
i) Select a suitable length for the fastener based on minimum acceptable length

$$L_{min} = t_1 + t_2 + t_{nut} + 2\,t_w + 2(1/p)$$

$$L_{Selected} = L =$$

2) check to make sure the length is not too long

$$L_d < t_1 + t_2 + t_w$$



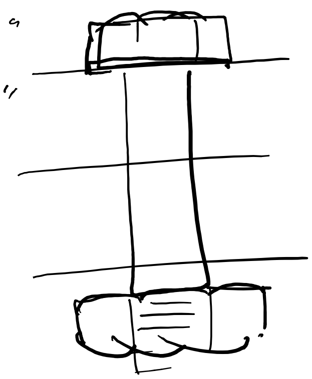
3) Calculate L_T and L_d

$$L_T = 2d + 1/4$$

$$L_d = L - L_T$$

$t_W = 0.095"$

$t_{Nut} = 7/16"$



4) calculate ℓ
total grip

$$\ell = t_1 + t_2 + 2t_w$$

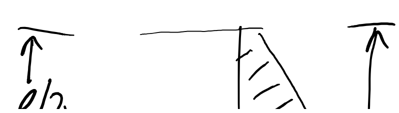
[if screw, then $\ell = t + d/2$]

5) Calculate $\ell_d = L_d$ and ℓ_t

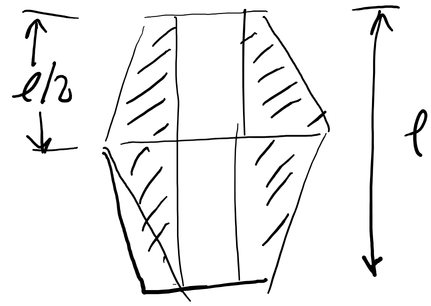
6) Calculate K_d and K_t $\left(K = \frac{AE}{L}\right)$

7) Calculate K_b $\left(\frac{1}{K_b} = \frac{1}{K_t} + \frac{1}{K_d}\right)$

8) Calculate K_m



8) Calculate K_m



$$K_m' = f(D, d, E, t)$$

t ≡ Frustum height

$E = 30 \times 10^6$

$d = 1/2'' = 0.5$

$D = 1.5d$

9) calculate K_m

$$K_m = \frac{1}{2} K_m'$$

10) Calculate Joint index $C = \frac{K_b}{K_b + K_m}$

11) Calculate total external load

$$F_e^{tot} = A_{Seal} P$$

$$F_e^{tot} = \frac{\pi D_{Seal}^2}{4} P$$

12) Calculate external force per bolt

$$F_e = \frac{F_e^{tot}}{\text{Number of bolts}} \equiv F_{emax}$$

13) Calculate initial tension in each bolt

$$F_i = 0.75\,(A_t S_p)$$

14) write expression for fastener force

$$F_b = F_i + C F_e$$

15) Set $F_b = F_p$ and find F_e^*

F_p = proof load

$$\underbrace{F_p}_{A_t S_p} = F_i + C F_e^*$$

16) Calculate load factor

$$n_{L1} = \frac{F_e^*}{F_e}$$

17) write an expression for the compression force

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

18) Set F_m equal to $F_{m,min}$ (per bolt) and solve for F_e^{**}

$**$

$$F_{m,min} = F_i - (1-c)\,F_e$$

19) Calculate load factor guarding against compression loss

$$n_{L2} = \frac{F_e^{**}}{F_e}$$

Q: is this acceptable $n_{L2} > 1.5$

20) Determine the minimum force in the bolt as the pressure fluctuates between 0 and P_{max}

$$F_{b,min} = F_i$$

21) calculate maximum force

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

22) Calculate minimum and maximum stresses in the bolt (nominal stresses)

$$\sigma_{min} = \frac{F_i}{A_t}$$

$$\sigma = \frac{F_{b,max}}{}$$

$$\sigma_{max} = \frac{F_{b,max}}{A_t}$$

23) Calculate the mean and alternating bolt forces

$$\sigma_m = \frac{\sigma_{min} + \sigma_{max}}{2}$$

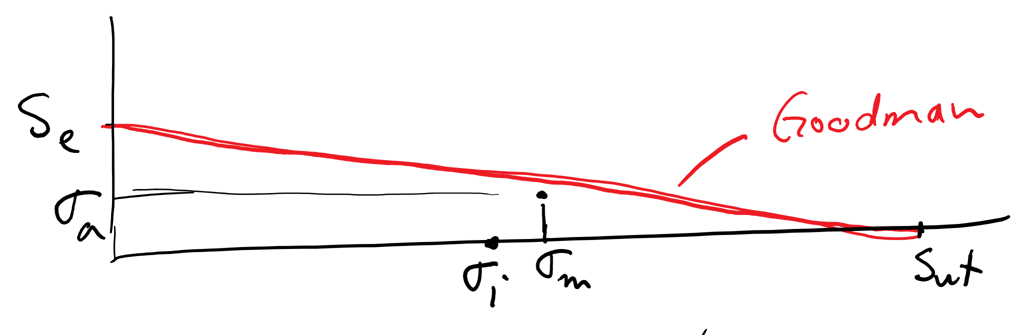
$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

24) Look up S_{ut} and S_e

$S_{ut} =$

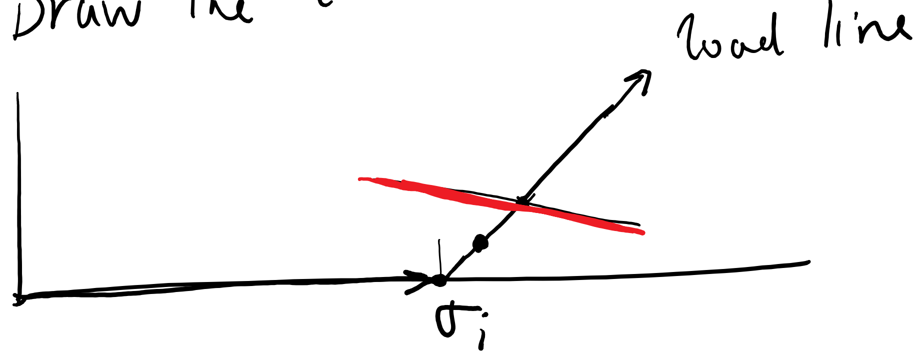
$S_e =$

25) Draw the $\sigma_m - \sigma_a$ graph indicating S_e, S_{ut}, σ_a, σ_m, σ_i



26) Draw the failure line (Goodman criterion)

27) Draw the load line



28) Calculate n_f

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

Q : is the factor of safety acceptable

is $n_f > 4$?