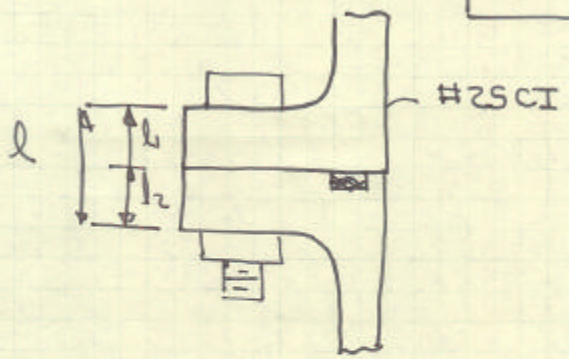
Shigley x 1.4
P. 317
P. 1014




5/8-11 UNC bolt, grade 3

$l_1 = l_2 = 3/4"$

$0 \le P \le 12{,}000$ lbs, $\eta_s = ?$

Max preload

$F_i = .9 S_p A_t$

Grade 3 – $S_p = 80$ ksi

5/8-11 ~ $A_t = 0.226\ in^2$

$F_i = 16{,}270$ lb

$$k_m = \frac{2\pi d^2 E}{l}$$

$$k_b = \frac{\pi d^2 E}{4l}$$

* Because mat'ls different, $k_m \neq (k_b)(8)$ *

$$k_m = \frac{(2\pi)(5/8)^2 (12\times10^6)\ in^2 \cdot lb/in^2}{1.5\ in}$$

$$k_m = 19.6 \times 10^6\ lb/in$$

$$k_b = \frac{(\pi)(5/8)^2(30\times10^6)}{(1.5)(4)}$$

$$\boxed{k_b = 6.1\times10^6 \text{ lb/in}}$$

$$F_b = \left(\frac{k_b}{k_b+k_m}\right)P_e + F_i$$

$$F_m = \left(\frac{k_m}{k_m+k_b}\right)P_e - F_i$$

$F_{b,min} = F_i$ $\quad P_{e,min} = 0$

$$\boxed{F_{b,min} = 16{,}270 \text{ lb}}$$

$$F_{b,max} = \left(\frac{K_b}{K_b+k_m}\right)P_{e,max} + F_i$$

$$F_{b,max} = \left(\frac{6.1}{19.6+6.1}\right)12{,}000 + F_i$$

$$\boxed{F_{b,max} = 19{,}120 \text{ lb}}$$

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

$$\boxed{\sigma_{b,max} = 84.6 \text{ ksi}}$$

$\sigma_{ult} = 100$ ksi

$$\boxed{\sigma_{ult} > \sigma_{b,max}} \sim \text{OK}$$

$$F_{min} = \left(\frac{k_m}{k_b+k_m}\right)P_e - F_i$$

$$\boxed{F_{min} = -7120 \text{ lb}}$$

$F_b > 0$ ~all times
$F_m < 0$ ~all times
} criteria ✓

For Fatigue:

$$n_f = \frac{\sigma_{ult} - \sigma_\nu}{C_k\left[K_f \sigma_a \left(\frac{\sigma_{ult}}{S_e}\right) + \sigma_m\right]}$$

$$K_f = \begin{cases} 2.2 & \text{rolled threads} \\ 2.8 & \text{cut threads} \end{cases}$$

$$C_k = \frac{k_b}{k_b + k_m} = 0.24$$

$\sigma_{max} = 84.6$ ksi

$$\sigma_{min} = \frac{F_\nu}{A_t}$$

$\sigma_{min} = 72.0$ ksi

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = 6.3 \text{ ksi} = \sigma_a$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = 78.3 \text{ ksi} = \sigma_m$$

$$S_e = k_a k_b k_c k_d k_e S_e'$$
$$= (0.73)(0.85)(50)$$

$S_e = 31.0$ ksi

$$n_f = \frac{100 - 72}{(0.24)\left[(2.8)(6.3)\left(\frac{100}{31}\right) + 78.3\right]}$$

$n_f = 0.87 < 1.00$

Fatigue failure predicted

Design – what changes to make?

- More bolts / less load per bolt
- Change component mat'l to steel
- Stronger bolt ~ logical choice?

- Use grade 8

  $S_p = 120$ ksi

  $\sigma_{yp} = 130$ ksi

  $\sigma_{ult} = 150$ ksi

  $\eta_s = ?$ – you calculate it

- Steel flanges

  $\eta_s = ?$ "

- Double number of bolts so

  $0 \le P \le 60000$ lb

  $\eta_s = ?$