Tension Joints

P tension load per bolt

$$P = \frac{P_{total}}{N}$$

Stiffness constant

$$\frac{P_b}{k_b} = \Delta\delta_b = \Delta\delta_m = \frac{P_m}{k_m}$$

$$P_m = \frac{k_m}{k_b} P_b$$

$$P_b = \frac{k_b P}{k_b + k_m} = CP$$

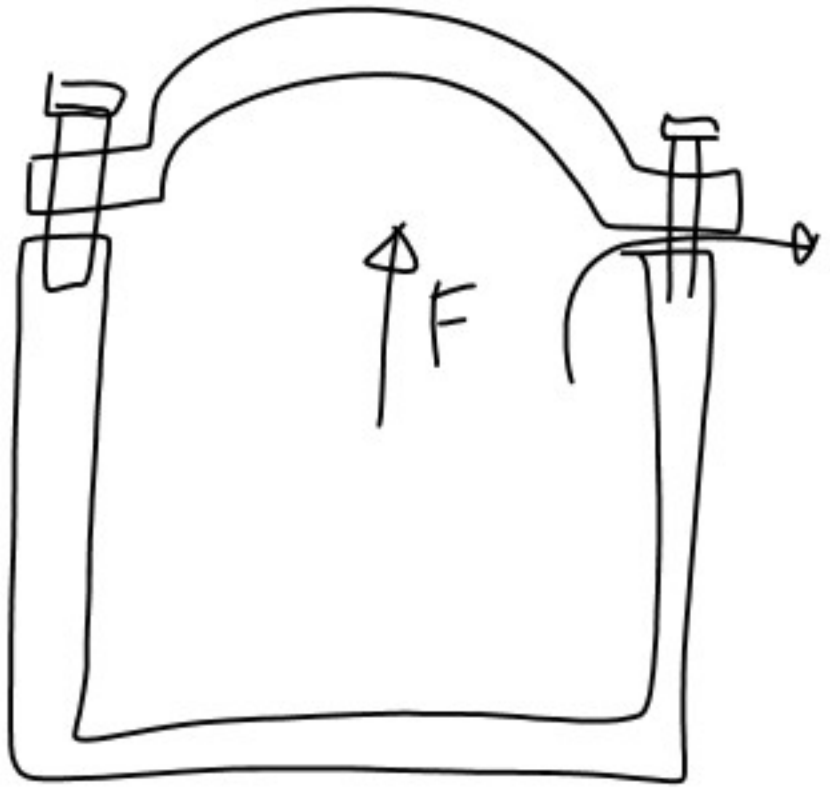
$$C = \frac{k_b}{k_b + k_m}$$

$$P_m = P - P_b = (1 - C)P$$

F_i preload

$$F_b = P_b + F_i = CP + F_i$$

$$F_m = P_m - F_i = (1-C)P - F_i$$



Torque to preload

$$T = \frac{F_i d_m}{2}\left(\frac{l + \pi f d_m \sec\alpha}{\pi d_m - f l \sec\alpha}\right) + \frac{F_i f_c d_c}{2}$$

$$T = K F_i d$$

$$K = \left(\frac{d_m}{2d}\right)\left(\frac{\tan\lambda + f\sec\alpha}{1 - f\tan\lambda\sec\alpha}\right) + 0.625 f_c$$

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Static Loading

$$\sigma_b = \frac{F_b}{A_t} = \frac{CP - F_i}{A_t}$$

$$n_p = \frac{S_p}{\sigma_b} = \frac{S_p A_t}{CP + F_i}$$

Load Factor

$$S_p = \frac{C n_L P + F_i}{A_t}$$

$$n_L = \frac{S_p A_t - F_i}{CP}$$

Factor of safety on Seperation

$$n_0 = \frac{F_i}{P(1-C)}$$

$$F_i = \begin{cases} 0.75 F_p & \text{reused fasteners} \\ 0.95 F_p & \text{permanent bolts} \end{cases}$$

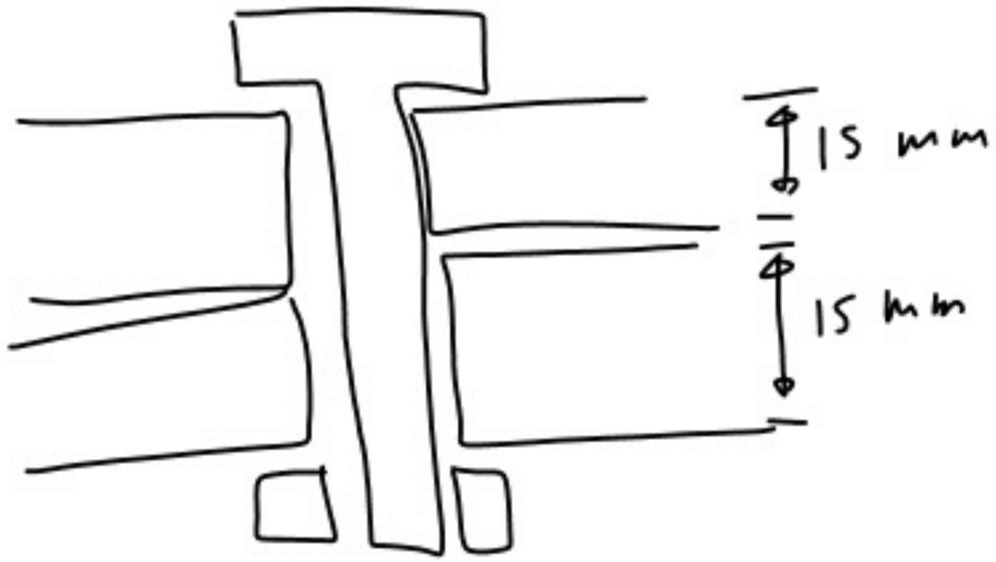
$F_p = A_t S_p$ proof force

8–11 An M14 × 2 hex-head bolt with a nut is used to clamp together two 15-mm steel plates.

(*a*) Determine a suitable length for the bolt, rounded up to the nearest 5 mm.

(*b*) Determine the bolt stiffness.

(*c*) Determine the stiffness of the members.



$L > l + H$

$l = 15\text{ mm} \cdot 2 = 30\text{ mm}$

$H = 12.8\text{ mm}$ A-31

$L > 30 + 12.8$

$L > 42.8$

$L = 45\text{ mm}$

$$K_b = \frac{A_d A_t E}{A_d l_t + A_t l_d} = \frac{154\ mm^2\ 115\ mm^2\ 207\ GPa}{154\ mm^2\ 19\ mm + 115\ mm^2\ 11\ mm} = \frac{3665970\ \ mm^4\ GPa}{4191\ \ mm^3}$$

$$= 875\ \ mm\ GPa \left(\frac{1\ m}{1000\ mm}\right)\left(\frac{1\times10^9\ Pa}{1\ GPa}\right)\left(\frac{1\ N/m^2}{1\ Pa}\right)$$

$$\boxed{k_b = 875\times10^6\ N/m}$$

$$A_d = \pi d^2/4 = \pi\ 14^2/4 = 154\ mm^2$$

$A_t = 115\ mm^2$ Table 8-1

$$l_t = l - l_d = 30 - 11 = 19\ mm$$

$$l_d = L - L_T = 45 - (2d+6) = 45 - (2\cdot14+6) = 11\ mm$$

$E = 207\ GPA$

$A = 0.78715 \qquad B = 0.62873$

$$\frac{k_m}{Ed} = Ae^{Bd/l}$$

$$k_m = EdAe^{Bd/l}$$

$$= 207\ \text{GPa}\ 14\,\text{mm}\ 0.78715e^{\frac{0.62873 \cdot 14\,\text{m}}{30\,\text{mm}}} = 3059\ \text{GPa mm}\left(\frac{1\times10^{6}\ \text{N/m}}{1\ \text{GPa mm}}\right) = \boxed{3.059\times10^{9}\ \text{N/m}}$$

8–29 For a bolted assembly with six bolts, the stiffness of each bolt is $k_b = 3$ Mlbf/in and the stiffness of the members is $k_m = 12$ Mlbf/in per bolt. An external load of 80 kips is applied to the entire joint. Assume the load is equally distributed to all the bolts. It has been determined to use $\frac{1}{2}$ in-13 UNC grade 8 bolts with rolled threads. Assume the bolts are preloaded to 75 percent of the proof load.

(*a*) Determine the yielding factor of safety.

(*b*) Determine the overload factor of safety.

(*c*) Determine the factor of safety based on joint separation.

$P_{total} = 80$ Kips

$$P = \frac{P_{total}}{N} = \frac{80}{6} = 13.33 \text{ Kips}$$

$S_p = 120$ Kpsi $\quad F_p = S_p A_t = 120 \cdot 0.1419 = 17.03$ Kips

$A_t = 0.1419 \text{ in}^2$

$F_i = 0.75 F_p$

$= 0.75 \cdot 17.03 = 12.77$ Kips

$S_y = 130$ Kpsi

$$n = \frac{S_y A_t}{(CP + F_i)} = \frac{130 \text{ Kpsi } 0.1419 \text{ in}^2}{0.2 \cdot 13.33 \text{ Kips} + 12.77 \text{ Kips}} = \boxed{1.2}$$

$$C = \frac{k_b}{k_b + k_m} = \frac{3}{3+12} = 0.2$$