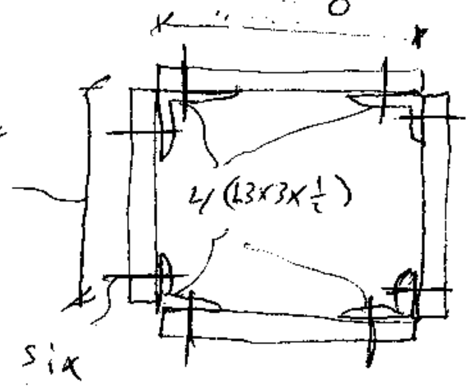
1/ Determine the allowable tension force ~~allowable~~ of the member shown in the fig which Consist of four equal Leg $L\ 3\times3\times\frac{1}{2}$}. The member with necessary tie plate is assumed to be (~~4~~ 6 ft) Long and is to have one Line of six A325 threads included $\frac{5}{8}$ inch diam. in each Leg ?

Note.
* All structural steel with $F_y = 50$ ksi & $F_u = 65$ ksi
* All Bolts are in standard holes.
* Neglect block shear effect.

$L3\times3\times\frac{1}{2}$

area = 2.75 in²

$r_x = r_y = 0.898$ in



$$T_1 = 0.6\ F_y\ A_g$$
$$= 0.6\,(50)\ 4\times 2.75 = 330^k$$

$$T_2 = 0.5\ F_u\ A_{eff}$$
$$= 0.5\,(65)\ A_{eff}$$

$$A_{eff} = 4\,(A_{net})_{angle} \times C_t$$
$$= 4\left[A_g - 2\left(\frac{5}{8}+\frac{1}{8}\right)t\right] C_t$$
$$= 4\left[2.75 - 2\left(\frac{6}{8}\right)\frac{1}{2}\right] 1$$
$$= 8 \text{ in}^2$$

$$\therefore T_2 = 0.5\,(65)\ 8 = 260^k$$

check for

① Bolts Capacity

A325 $F_v = 21$ ksi thread included.

∴ shear capacity/one bolts $= \frac{\pi d^2}{4} \times F_v$

$= \frac{\pi (5/8)^2}{4} \times 21 = 6.44^k$

Bearing Capacity/one bolts $= 1.2\, F_u \times t_{min} \times$ dia. of bolts

$= 1.2\,(65) \times 3/8 \times \frac{5}{8}$

$= 18.28^k$

∴ shear capacity control $= 6.44^k$

Total capacity of bolts $= 6.44 \times 48 = 309.12^k$

∴ max. tension force $= 260^k$

② length of member

$\left(\frac{L}{r}\right)_{max} \leq 240$ for tension member.

$\frac{16 \times 12}{0.898} = 213.8 < 240$ o.k

③ Tie plate capacity.

$T_1 = 0.6\, A_g\, F_y = 0.6(50)\left(8 \times \frac{3}{8}\right) 4 = 360^k$

$T_2 = 0.5\, F_u\, A_{eff} =$

$C_t = 1$

$A_{eff} = 4\left[\left(8 \times \frac{3}{8}\right) - 2\left(\frac{5}{8} + \frac{1}{8}\right)\frac{3}{8}\right] \times 1$

$= 9.75$ in²

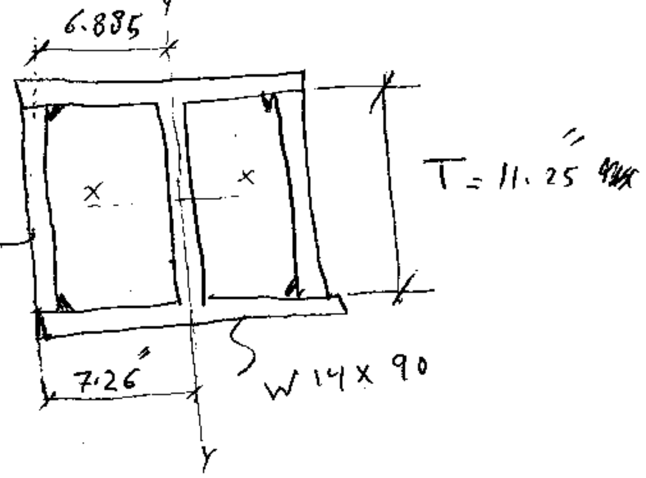
∴ $T_2 = 9.75 \times 0.5 \times 65 = 316.8^k$

260^k angles area.

∴ max tension force control by net

Q2/

Find the Compressive axial Load for a built-up Column that has a Cross section as shown in the fig. The steel is A36, the Length is (20 ft) and the ends are assumed to be fixed-pinned (the recommended design K value is 0.8)



W 14 x 90

$A_g = 26.5$ in²

$d = 14.02$ in

$b_f = 14.52$ in

$t_w = 0.44$ in

$t_f = 0.71$ in

$I_x = 999$ in⁴

$I_y = 362$ in⁴

Sol. Determine the built-up cross section moment of inertia.

$$I_x = (I_x)_{W14\times90} + \left(\frac{bh^3}{12}\right)_{plate}$$

$$= 999 + 2\,\frac{(0.75)(11.25)^3}{12} = 1176.978 \text{ in}^4$$

$$I_y = (I_y)_{W14\times90} + \left(\frac{bh^3}{12}\right)_{plate} + \sum Ad^2$$

$$= 362 + 2\left(\frac{11.25\,(0.75)^3}{12}\right) + 2\,(0.75)(11.25)(6.885)^2 = 1162.72 \text{ in}^4$$

$$(Area)_{total} = 26.5 + 2\,(11.25)(0.75) = 43.375 \text{ in}^2$$

$$\therefore r_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{1162.72}{43.375}} = 5.177 \text{ in}$$

$$\& \quad r_x = \sqrt{\frac{1176.978}{43.375}} = 5.20912''$$

$\therefore r_y$ Control the capacity.

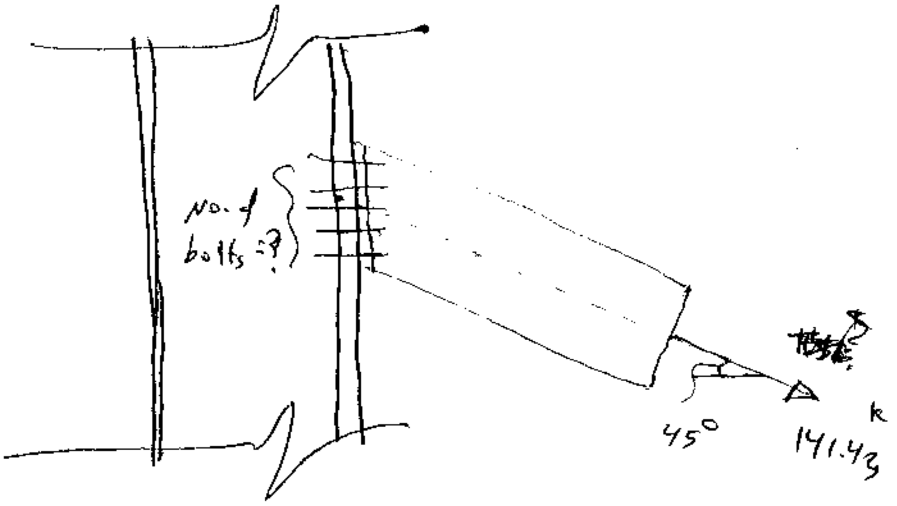
$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

$$\frac{KL}{r_y} = \frac{0.8 * 20 * 12}{5.20912} = 36.858 < C_c = 126.1$$

$$\therefore F_a = \frac{\left[1 - \frac{(KL/r)^2}{2C_c^2}\right] F_y}{\frac{5}{3} + \frac{3}{8}\frac{(KL/r)}{C_c} - \frac{1}{8}\frac{(KL/r)^3}{C_c^3}} = 19.435^k$$

$$\therefore P_{cap.} = F_a \times A_{total} = 19.435 \times 43.375 = 843 \text{ k}$$

Q.3/ Determine the No. of 7/8 inch diam. A325 bolts (thread included) required to Connecte the structural Tee section to the Column shown in the fig. with slip-critical Connection type? All structural steel is A36 & adequate to support tension force act through the Centered of the connection. 141.42^k



$$f_t = \frac{\text{Tensile force}}{\text{No. of bolts} * \text{area of bolts}}$$

$$= \frac{100}{\text{No. of bolts} * \frac{\pi (7/8)^2}{4}}$$

$$f_t = \frac{166.3}{\text{No. of bolts}}$$

$$(F_s)_{new} = F_s\left[1 - \frac{f_t * A_{bolt}}{T_b}\right]$$

$F_s = 17^k$ for A325 & $T_b = 39^k$ for A325, 7/8 diam.

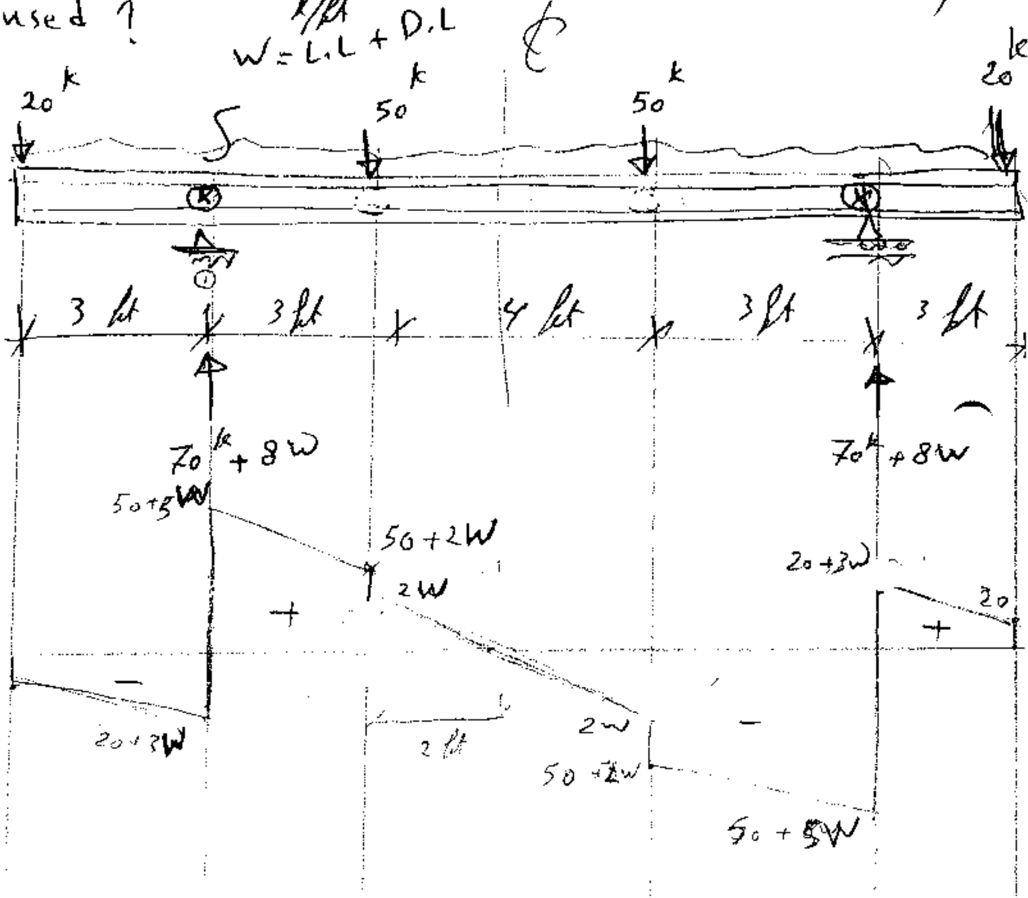
$$\therefore (F_s)_{new} = 17\left[1 - \frac{\frac{166.3}{\text{No. of bolt}} * \frac{\pi (7/8)^2}{4}}{39}\right]$$

$$= 17\left[1 - \frac{2.5641}{\text{No. of bolts}}\right]$$

but $P_s = (F_s)_{new} * A_{bolts} * \text{No. of bolts} * N_s$ for Compine shear & Tension

$P_s = 141.49 \cos 45 = 100^k = 17\left[1 - \frac{2.5641}{\text{No. of bolts}}\right] * \frac{\pi (7/8)^2}{4} * \text{No. of bolts} * 1$

Q4 / Determine the max allowable superimposed uniform distributed Load (P k/ft) for the beam shown in the fig if A-36 steel is used & (K) indicate point of lateral support for the Compression flange. & the major axis of the beam is used?



W 21 x 101

$A = 29.8\ in^2$
$d = 21.36\ in$
$t_w = 0.5\ in$
$b_f = 12.29\ in$
$t_f = 0.8\ in$
$r_T = 3.27\ in$
$d/A_f = 2.17\ in^{-1}$
$I_x = 2420\ in^4$
$S_x = 227\ in^3$
$r_x = 9.02\ in$
$I_y = 248\ in^4$
$S_y = 40.3\ in^3$
$r_y = 2.89\ in$
$E = 29000\ ksi$

S.F.D

$$M_{max} = \left(\frac{20+20+3W}{2}\right)(-3) + \left(\frac{50+5W+50+2W}{2}\right)3 + \left(\frac{2W \times 2}{2}\right)$$

$$= -60 - 4.5W + 150 + 10.5W + 2W$$

$$\boxed{M_{max} = 90 + 8W}\ k.ft$$

where $W = P + (Beam)_{D.L}$

$$\boxed{V_{max} = 50 + 5W}\ k$$

① check for moment

$$l_c = \frac{76\, b_f}{\sqrt{F_y}} = \frac{76\,(12.29)}{\sqrt{36}}\left(\frac{1}{12}\right) = 12.97'$$

or

$$L_c = \frac{20000}{36\ d/A_f} = \frac{20000}{(36)(2.17)}\left(\frac{1}{12}\right) = 21.33'$$

$\therefore l_c = 12.97'$ but $L_{beam} = 10'$

$L_{beam} < L_c$

$$\frac{b_f}{2t_f} = \frac{12.29}{2(0.8)} = \frac{65}{\sqrt{F_y}} = 10.833$$

$$\therefore \frac{b_f}{2t_f} < \frac{65}{\sqrt{F_y}}$$

So $F_b = 0.66 F_y = 23.76$ ksi

$$\therefore \frac{M_{max}}{S_x} = F_b$$

$$\frac{(90 + 8W)\,12}{227} = 23.76$$

$$\therefore 8W = \frac{(227)\,23.76}{12} - 90$$

$$W = 44.93 \text{ k/ft}$$

② check for shear.

$F_{v\,all.} = 0.4\,F_y = 0.4(36) = 14.4$ ksi

$$f_{act} = \frac{50 + 5W}{d * t_w} = \frac{50 + (44.93)}{(21.36)\,0.5} = 8.88 \text{ ksi} < 14.4 \text{ ksi}$$

(o.k)

$$\therefore W_{max} = 44.93 \text{ k/ft} = P + (\text{Beam})_{D.L}$$
$$= P + 0.101$$

$$\therefore P = W - 0.101 = 44.93 - 0.101$$
$$= 44.829 \text{ k/ft}$$

$\therefore 100 = 10.222448 \left[1 - \dfrac{2.5641}{\text{No. of bolts}} \right] \times \text{No. of bolts}$

$= 10.222448(\text{No. of bolts}) - 26.211379$

$\therefore \text{No. of bolts} = \dfrac{126.211379}{10.222448}$

$= 12.34$

use 14 bolts of A325 for slip-critical connection type.

seven bolts for each side of Tee section flange.

check for allowable shear stress of bolts

$\dfrac{100^k}{14\left(\frac{\pi (7/8)^2}{4}\right)} = 11.878^{ksi} < 21.0 \text{ ksi}$ o.k for shear

check for allowable tensile stress of bolts.

$F_t = 55 - 1.8 f_v \leq 44 \text{ ksi}$

but $f_v = \dfrac{100}{14\left(\frac{\pi (7/8)^2}{4}\right)} = 11.878^{ksi}$

$\therefore F_t = 55 - 1.8(11.878)$

$= 33.618^{ksi} \leq 44 \text{ ksi}$ o.k.

but $f_t = \dfrac{100}{14\left(\frac{\pi (7/8)^2}{4}\right)} = 11.878^{ksi} < 33.618^{ksi}$

o.k for tension.