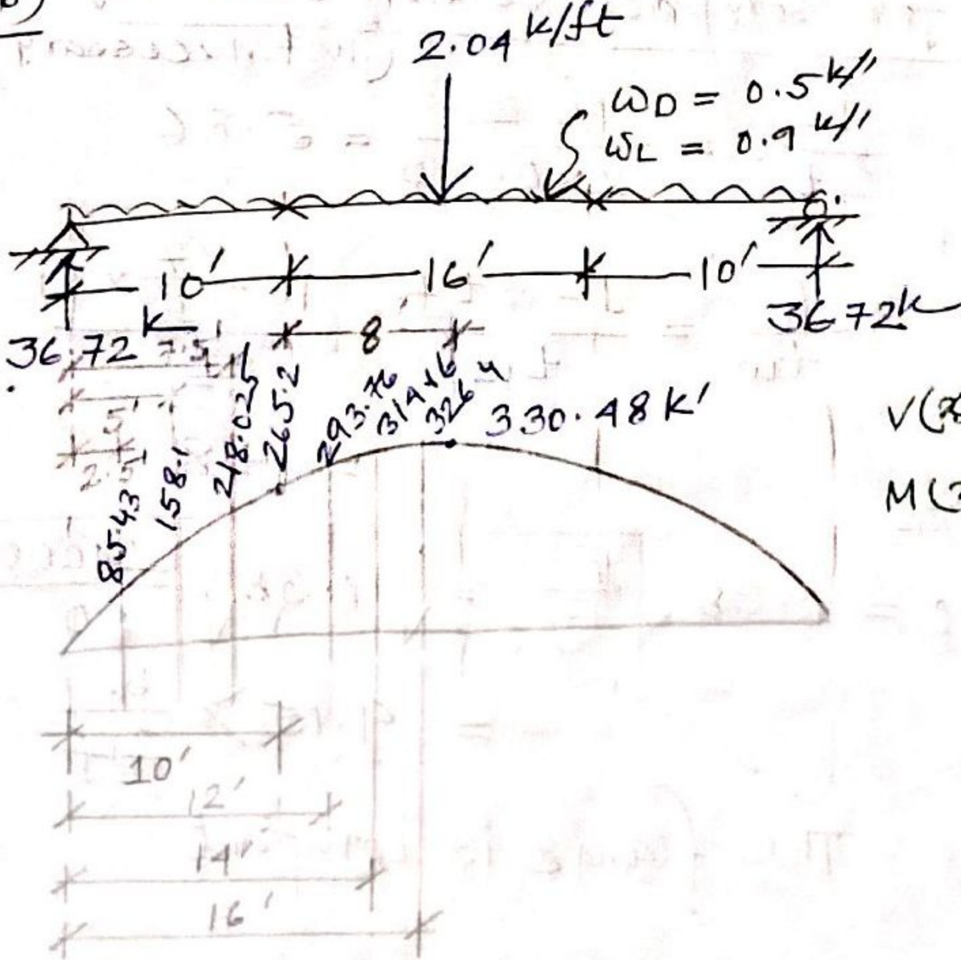
2012-2013

1(b):



$$V(x) = \frac{wL}{2} - wx$$

$$M(x) = \frac{wLx}{2} - \frac{wx^2}{2}$$

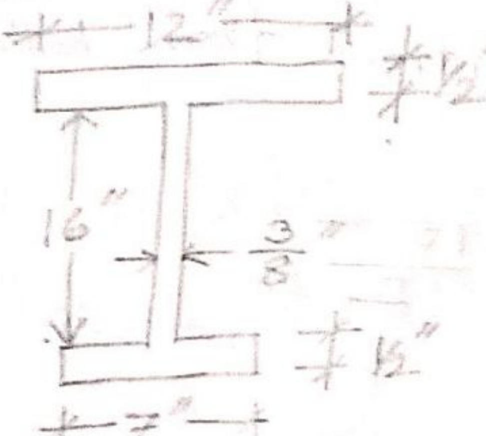
$$C_b = \frac{12.5\, M_{max}}{2.5 M_{max} + 3M_A + 4M_B + 3M_C} R_m$$

$$= \frac{12.5 \times 330.48}{2.5 \times 330.48 + 3 \times 293.76 + 4 \times 314.16 + 3 \times 326.4} \times 1$$

$$= 1.0476$$

2012-2013

1(c)



$A_g = (12\times\frac{1}{2}) + (16\times\frac{3}{8}) + (7\times\frac{1}{2}) = 15.5\,in^2$

$A_{f1} = 12\times\frac{1}{2} = 6\,in^2$

$A_w = 16\times\frac{3}{8} = 6\,in^2$

$A_{f2} = 7\times\frac{1}{2} = 3.5\,in^2$

Distance of elastic centroid from bottom,

$$\bar{y} = \frac{6\times(16+\frac{1}{2}+\frac{1}{2}\times\frac{1}{2}) + 6\times(\frac{1}{2}+\frac{16}{2}) + 3.5\times(\frac{1}{2}\times\frac{1}{2})}{6+6+3.5}$$

$= 9.83$

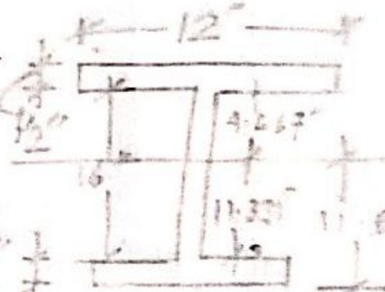
$$I_x = \frac{12\times0.5^3}{12} + (12\times0.5)(16.75-9.83)^2 + \frac{7\times0.5^3}{12} + (7\times0.5)(9.83-0.25)^2 + \frac{\frac{3}{8}\times16^3}{12} + (\frac{3}{8}\times16)(9.83-8.5)^2$$

$= 747.35\,in^4$

$$S_x = \frac{I_x}{c} = \frac{747.35}{9.83} = 76.03 \text{ in}^3$$

Distance of plastic centroid from bottom $= \bar{y}_p$

$$7 \times \frac{1}{2} + \frac{3}{8}\left(\bar{y}_p - \frac{1}{2}\right) = \frac{15.5}{2}$$



$$\Rightarrow \quad \bar{y}_p = 11.833$$

centroid of top half-area about plastic centroid $= y_1$

$$y_1 = \frac{\left(12 \times \frac{1}{2}\right) \times \left(4.667 + \frac{1}{2} \times \frac{1}{2}\right) + \left(4.667 \times \frac{3}{8}\right) \times \frac{4.667}{2}}{\left(12 \times \frac{1}{2}\right) + \left(4.667 \times \frac{3}{8}\right)}$$

$$= 4.334''$$

centroid of bottom half-area about plastic centroid $= y_2$

$$y_2 = \frac{\left(7 \times \frac{1}{2}\right) \times \left(11.333 + \frac{1}{2} \times \frac{1}{2}\right) + \left(11.133 \times \frac{3}{8}\right) \times \frac{11.133}{2}}{\left(7 \times \frac{1}{2}\right) + \left(11.133 \times \frac{3}{8}\right)}$$

$$= 8.310''$$

$$Z = A_g \times \frac{y_1 + y_2}{2} = 15.5 \times \frac{4.334 + 8.310}{2}$$

$$= 97.991$$

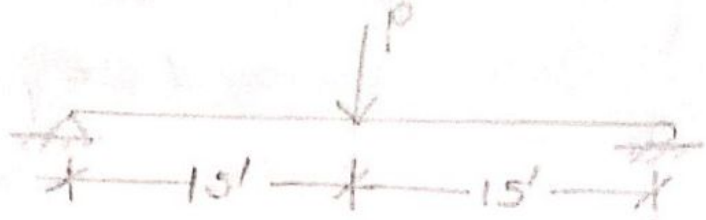
Shape Factor, $\xi = \frac{Z}{S_x} = \frac{97.991}{76.03}$

$= 1.289$

2012-2013

2 (b)

W10 × 77



Check for compact section criteria: (not necessary)

$$\frac{b_f}{2t_f} = \frac{10.2}{2\times0.870} = 5.86$$

$$\frac{h}{t_w} = \frac{d-3t_f}{t_w} = \frac{10-\left(\frac{7}{8}\times3\right)}{\frac{1}{2}}$$

$$= 14.8$$

Flange:

$$\lambda_{pf} = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000}{50}}$$

$$= 9.15 > \frac{b_f}{2t_f}$$

∴ The flange is compact.

Web:

$$\lambda_{pw} = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{29000}{50}}$$

$$= 90.55 > \frac{h}{t_w}$$

∴ The web is compact.

Since, there are no supports except for one at the ends, $L_b = 30' = 360''$

$$L_p = 1.76\, r_y \sqrt{\frac{E}{F_y}} = 1.76 \times 2.60 \sqrt{\frac{29000}{50}}$$

$$= 110.20''$$

$$L_r = 1.95\, r_{ts} \frac{E}{0.7\, F_y} \sqrt{\frac{Jc}{S_x h_o}} \sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7 F_y}{E} \frac{S_x h_o}{Jc}\right)^2}}$$

$$= 1.95 \times 2.95 \times \frac{29000}{0.7 \times 50} \sqrt{\frac{5.11 \times 1}{85.9 \times 9.73}}$$

$$\sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7 \times 50}{29000} \times \frac{85.9 \times 9.73}{5.11 \times 1}\right)^2}}$$

$$= 542.15''$$

Since, $L_p < L_b < L_r$,

$$M_n = C_b \left[M_p - (M_p - 0.7\, F_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le M_p$$

Here, $M_p = F_y Z_x$

$$= 50 \times 97.6$$

$$= 4880\, k''$$

$$M_n = 1.32\left[4880 - (4880 - 0.7 \times 50 \times 97.6)\left(\frac{360 - 110.20}{542.15 - 110.20}\right)\right]$$

$$= 5324.03$$

since, $M_n \leq M_p$,

Nominal Moment capacity = 4880 k-"

$$\text{ASD moment capacity} = \frac{4880}{1.67}$$

$$= 2922.16 \text{ k-"}$$

since, moment due to self-weight can be ignored,

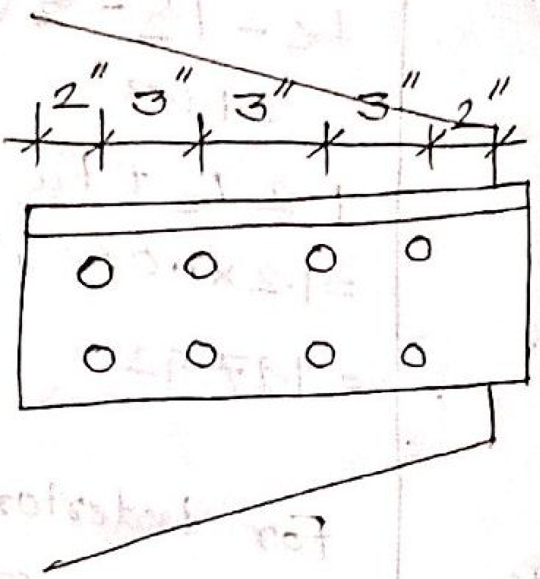
$$M_u = \frac{P \times 15 \times 15}{30 \times 12}$$

$$\Rightarrow 2922.16 = \frac{15}{2} P \quad 0.625\,P$$

$$\therefore P = 389.62^k \quad .4675.456 \text{ Kip}$$

2012-2013

2(c)



Bolt shear

Bolts are in double shear

$R_{ns} = m\, F_{nv}\, A_b$

$= 2 \times (0.4 \times 120) \left\{ \frac{\pi}{4} \times \left(\frac{7}{8}\right)^2 \right\}$

$= 57.73^k$

Bearing strength

Tension Member

$(2.4\, d\, t\, F_u) \times 2$

$= (2.4 \times \frac{7}{8} \times \frac{5}{8} \times 70) \times 2$

$= 91.88 \times 2$

$= 183.76^k$

Gusset

$2.4\, d\, t\, F_u$

$= 2.4 \times \frac{7}{8} \times \frac{5}{8} \times 58$

$= 76.13^k$

Ext. bolts

$L_c = 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{16}\right)$

$= 1.53''$

$(1.2 L_c t F_u) \times 2$

$= (1.2 \times 1.53 \times \frac{5}{8} \times 70) \times 2$

$= 80.33 \times 2$

$= 160.66^k$

Int. bolts

$L_c = 3 - \left(\frac{7}{8} + \frac{1}{16}\right)$

$= 2.06''$

$(1.2 L_c t F_u) \times 2$

$= (1.2 \times 2.06 \times \frac{5}{8} \times 70) \times 2$

$= 108.15 \times 2$

$= 216.30^k > 2.4 d t F_u$

therefore, 183.76^k

Ext. bolts

$L_c = 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{16}\right)$

$= 1.53''$

$1.2 L_c t F_u$

$= 1.2 \times 1.53 \times \frac{5}{8} \times 50$

$= 57.36^k$

Int. bolts

$L_c = 3 - \left(\frac{7}{8} + \frac{1}{16}\right)$

$= 2.06''$

$1.2 L_c t F_u$

$= 1.2 \times 2.06 \times \frac{5}{8} \times 50$

$= 77.25^k > 2.4 d t F_u$

therefore, 76.13^k

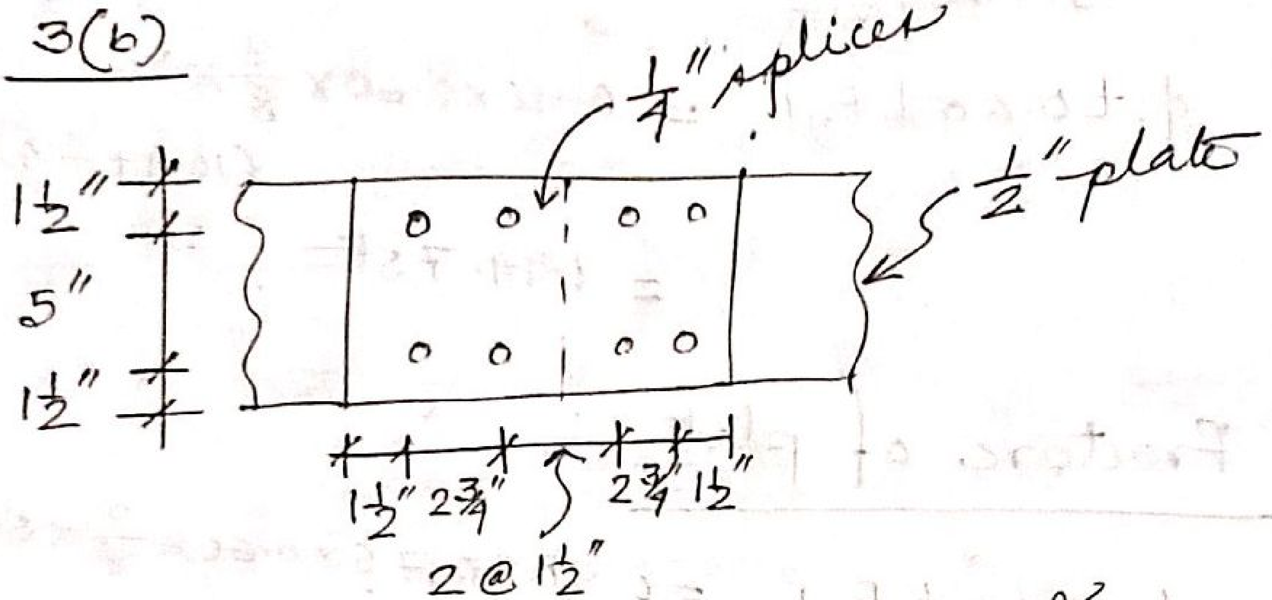
Bolt shear governs for all cases except for exterior bolts.

Total capacity $= 2(57.36) + 6(57.73)$
$= 461.1^k$

ASD capacity $= \frac{461.1^k}{2.00} = 230.55^k$

2012-2013

3(b)



Main plate, $A_g = 8 \times \frac{1}{2} = 4\ in^2$

splice plates, $A_g = 2\left(8 \times \frac{1}{4}\right) = 4\ in^2$

Bolt shear

$R_{ns} = m\, F_{nv}\, A_b$

4 connectors in double shear for 8 shear areas

$= 8 \times (0.4 \times 120) \times \left\{\frac{\pi}{4} \times (7/8)^2\right\}$

$= 230.91^k$

Bolt Bearing

Tension Member

$(2.4\, d\, t\, F_u) \times 4$

$= \left(2.4 \times \frac{7}{8} \times \frac{1}{2} \times 58\right) \times 4$

$= (60.9^k) \times 4$ — 4 Bearing surfaces in the main plate

$= 243.6^k$

splice plates

$2.4\, d\, t\, F_u$

$= \left(2.4 \times \frac{7}{8} \times \frac{1}{4} \times 58\right) \times 8$

$= (60.9^k) \times 8$ — 10 Bearing surfaces in the splice plate

$= 487.2^k$

For exterior bolts,

$L_c = 1\frac{1}{2} - \frac{1}{2}\left(\frac{7}{8}+\frac{1}{16}\right)$

$= 1.03$

$1.2 L_c t F_u$

$= 1.2 \times 1.03 \times \frac{1}{2} \times 58$

$= 35.84$

For interior bolts,

$L_c = 2\frac{3}{4} - (7/8 + 1/16)$

$= 1.8125$

$1.2 L_c t F_u$

$= 1.2 \times 1.8125 \times \frac{1}{2} \times 58$

$= 63.075^k > 60.9^k$

$= 60.9^k$

Bearing capacity

$= 2 \times 35.84 + 2 \times 60.9$

$= 193.48^k$

For exterior bolts,

$L_c = 1\frac{1}{2} - \frac{1}{2}\left(\frac{7}{8}+\frac{1}{16}\right)$

$= 1.03$

$1.2 L_c t F_u$

$= 1.2 \times 1.03 \times \frac{1}{4} \times 58$

$= 1.\ 7.92$

For interior bolts,

$L_c = 2\frac{3}{4} - (7/8 + 1/16)$

$= 1.8125$

$1.2 L_c t F_u$

$= 1.2 \times 1.8125 \times \frac{1}{4} \times 58$

$= 31.54^k$

Bearing capacity

$= 4 \times 17.92 + 4 \times 31.54$

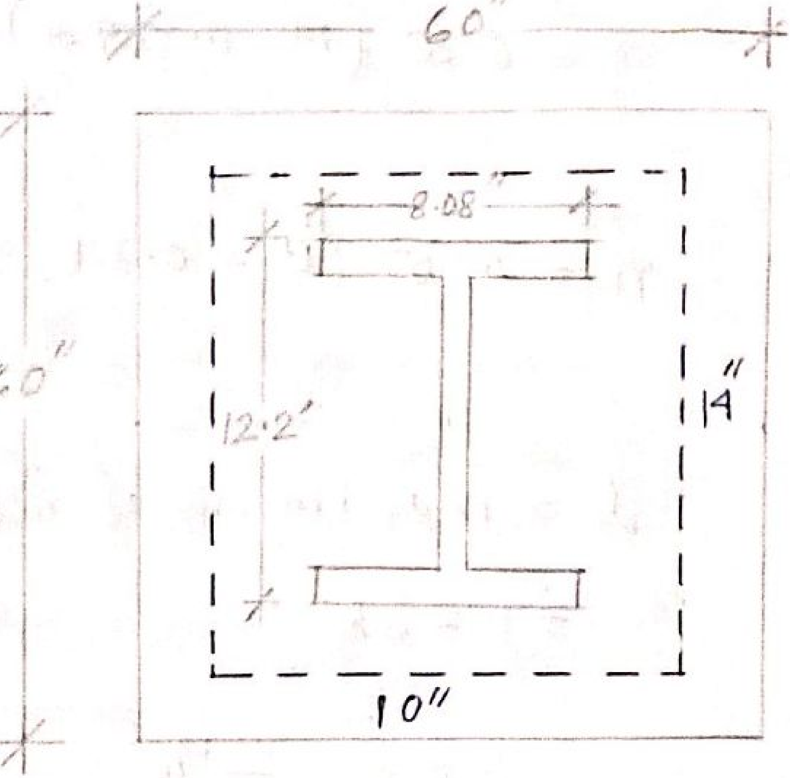
$= 197.84^k$

Limiting state is the bearing capacity of tension plate. Therefore, design capacity $= 0.75 \times 193.48^k$

$= 145.11^k$

2012-2013

3(c)



W12×50

$b_f = 8.08''$

$d = 12.2''$

Assume

$\sqrt{A_2/A_1} = 1.5$

$f_{p(max)} = 0.85 f_c' (1.5)$

$= 0.85 \times 3.5 \times 1.5$

$= 4.46$ ksi

Factored axial load, $P = 370^k$.

$$B \times N = \frac{P}{\phi f_{p\,max}} = \frac{370}{0.60 \times 4.46}$$

$= 138.27\ in^2$

Base plate dimensions are taken in proportion with the column dimensions.

Let, $B = 10''$

$N = 14''$

$m = 0.5\,(N - 0.95d) = 0.5(14 - 0.95 \times 12.2)$

$= 1.205$

$n = 0.5\,(B - 0.8\,b_f) = 0.5(10 - 0.8 \times 8.08)$

$= 1.768$

l = maximum of m & n

$= 1.768$

$$t = l\sqrt{\frac{2P_u}{\phi F_y BN}}$$

$$= 1.768\sqrt{\frac{2 \times 370}{0.90 \times 36 \times 10 \times 14}}$$

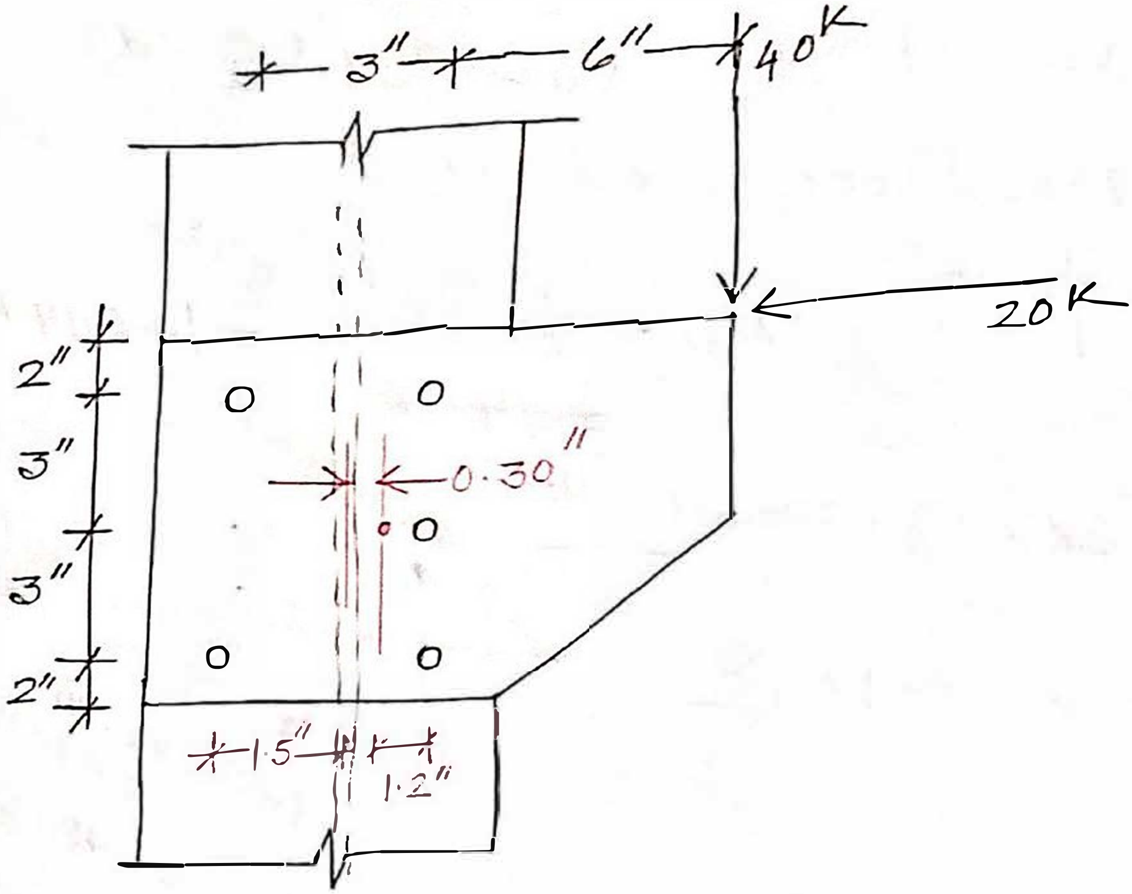
$= 0.714''$

$\approx 1''$

Base plate size $= 10'' \times 14''$

thickness $= 1''$

2012 - 2013
4(b)



$$\bar{x} = \frac{2(-3) + 1(0) + 2(3)}{2 + 1 + 2} = 0$$

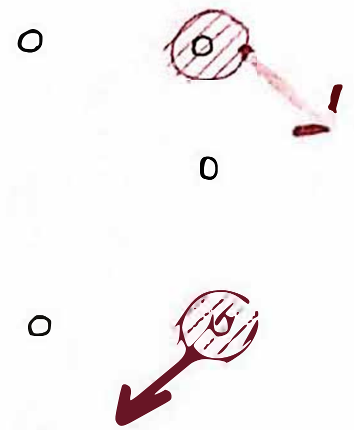
$$\bar{y} = \frac{2(-1.5) + 3(1.5)}{2 + 3} = 0.30$$

$$M = 40 \times \left(6 + \frac{3}{2} - 0.30\right) - 20 \times 5$$

$$= 188^{k''} \quad (2)$$

$$\Sigma d^2 = 2(1.2^2 + 3^2) + 1(1.2^2 + 0^2) + 2(1.8^2 + 3^2)$$

$$= 46.8$$

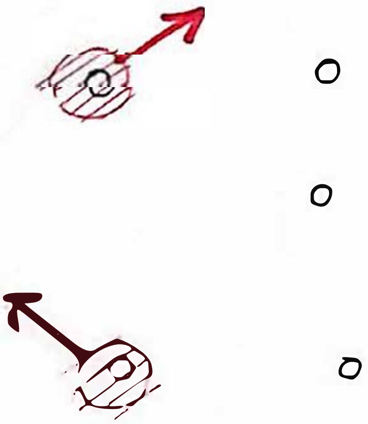


$$R_x = \frac{M_y}{\Sigma d^2} = \frac{188 \times 3}{46.8}$$

$$= 12.05^k$$

$$R_y = \frac{M_x}{\Sigma d^2} = \frac{188 \times 1.2}{46.8}$$

$$= 4.82^k$$

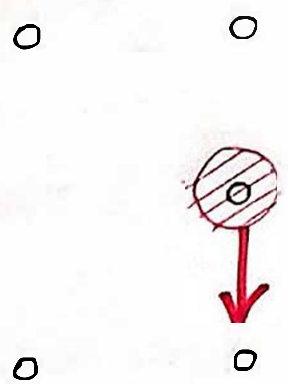


$$R_x = \frac{M_y}{\Sigma d^2} = \frac{188 \times 3}{46.8}$$

$$= 12.05^k$$

$$R_y = \frac{M_x}{\Sigma d^2} = \frac{188 \times 1.8}{46.8}$$

$$= 7.23^k$$



$$R_x = \frac{M_y}{\Sigma d^2} = \frac{188 \times 0}{46.8}$$

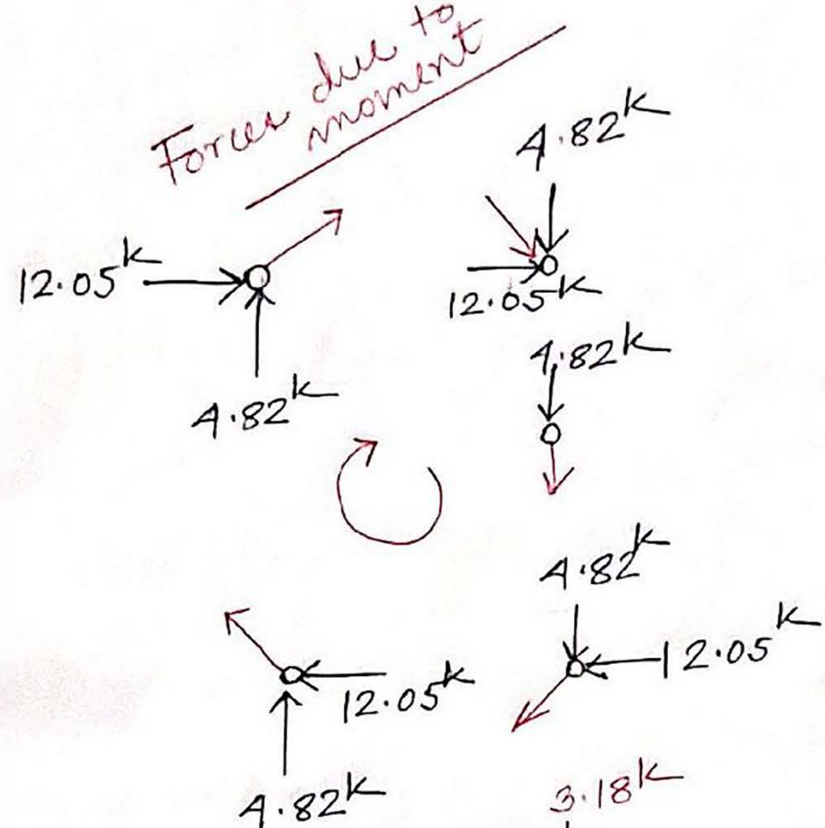
$$= 0^k$$

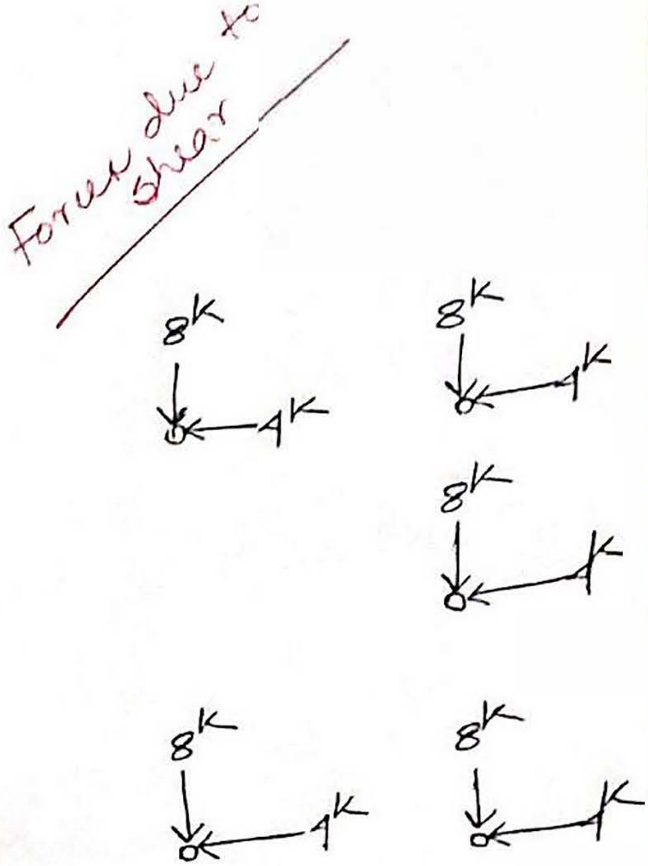
$$R_y = \frac{M_x}{\Sigma d^2} = \frac{188 \times 1.2}{46.8}$$

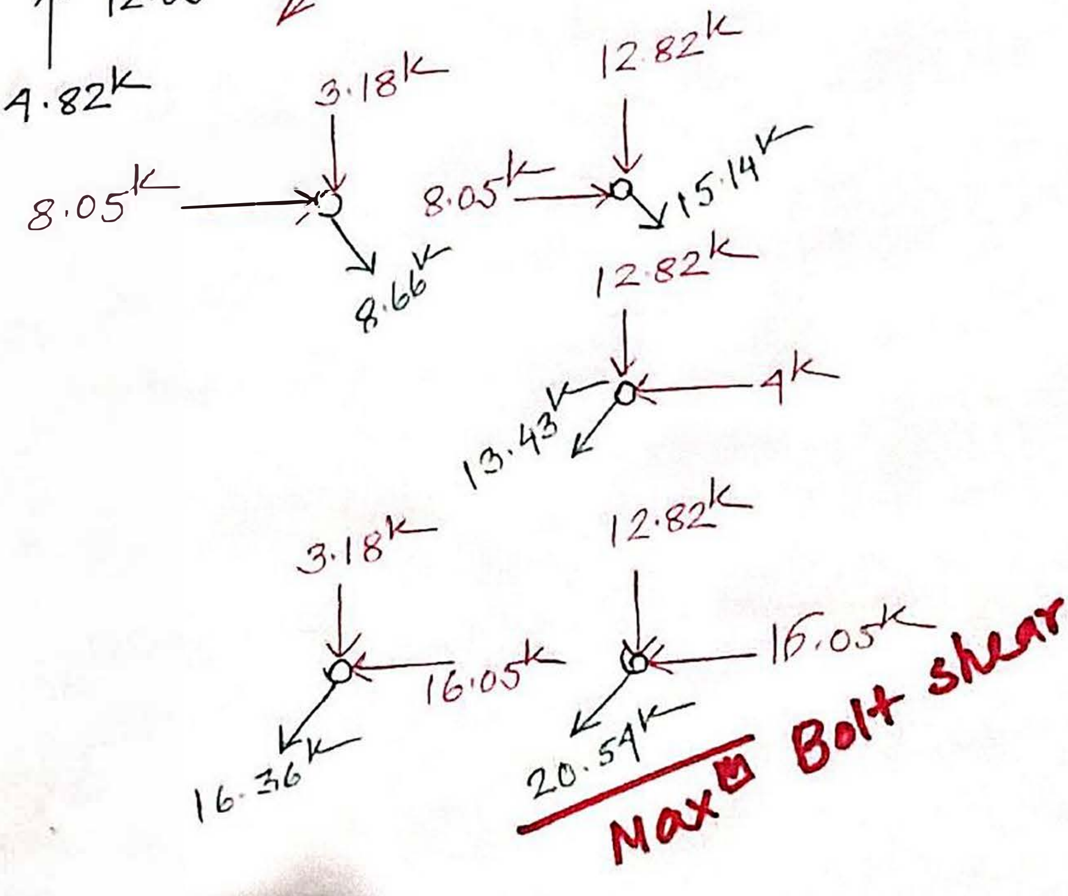
$$= 4.82^k$$

$$\frac{R_{vx}}{N} = \frac{20}{5} = 4^k \ (\leftarrow)$$

$$\frac{R_{vy}}{N} = \frac{40}{5} = 8^k \ (\downarrow)$$

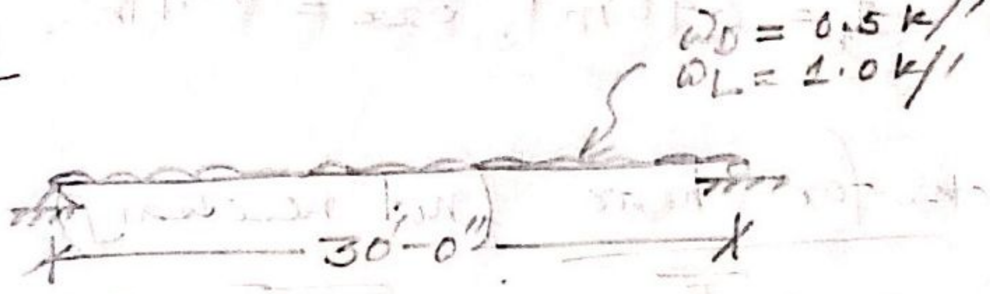






2012- 2013

4 (c)



Strength requirement

$$M_n = \frac{\omega L^2}{8} = \frac{(1+0.5)\times 30^2}{8}$$

$$= 168.75 \text{ k}' = 2025 \text{ k-}''$$

$$Z_x = \frac{1.67 \times 2025}{50} = 67.635 \text{ in}^3$$

select section with $Z_x > 67.635 \text{ in}^3$

serviceability requirement

$$\Delta = \frac{L}{360} = \frac{30\times 12}{360} = 1''$$

Now, $\Delta = \frac{5}{384} \times \frac{\omega L^4}{EI}$

$$\Rightarrow I = \frac{5}{384} \times \frac{\omega L^4}{E\Delta} = \frac{5}{384} \times \frac{\left(\frac{1}{12}\right)\times (30\times 12)^4}{29000\times 1}$$

$$= 628.45 \text{ in}^4$$

select section with, $I > 628.45 \text{ in}^4$

we select W14×61 from AISC manual

with, $I_x = 640 \text{ in}^4$, $S_{xx} = 92.1 \text{ in}^3$.

Check for shear (not necessary)

$$2.24\sqrt{\frac{E}{F_y}} = 2.24\sqrt{\frac{29000}{50}} = 53.9 \text{ ksi}$$

For the section (W14×61) chosen

$$\frac{d}{t_w} = \frac{13.9}{0.375} = 37.07 < 53.9 \text{ (ok)}$$

$$\phi V_n = 1 \times 0.6 F_y d t_w = 1 \times 0.6 \times 50 \times 13.9 \times 0.375$$
$$= 156.38^k$$

$$V = \frac{wL}{2} = \frac{1.5 \times 30}{2} = 22.5^k$$

So, the section is ok for shear.

Check for compact section criteria (not necessary)

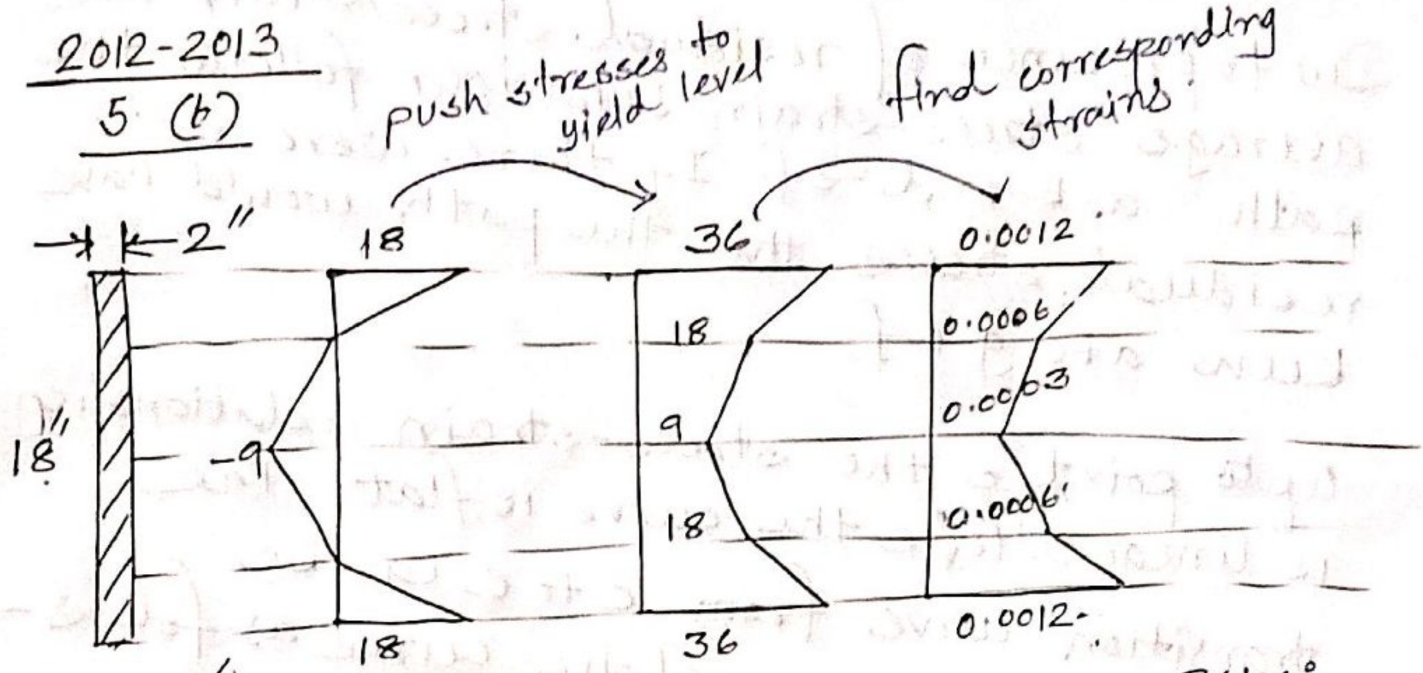
$$\lambda_{pf} = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000}{50}} = 9.15 > \frac{b_f}{2t_f}$$
$$= \frac{10}{2 \times 0.645} = 7.75$$

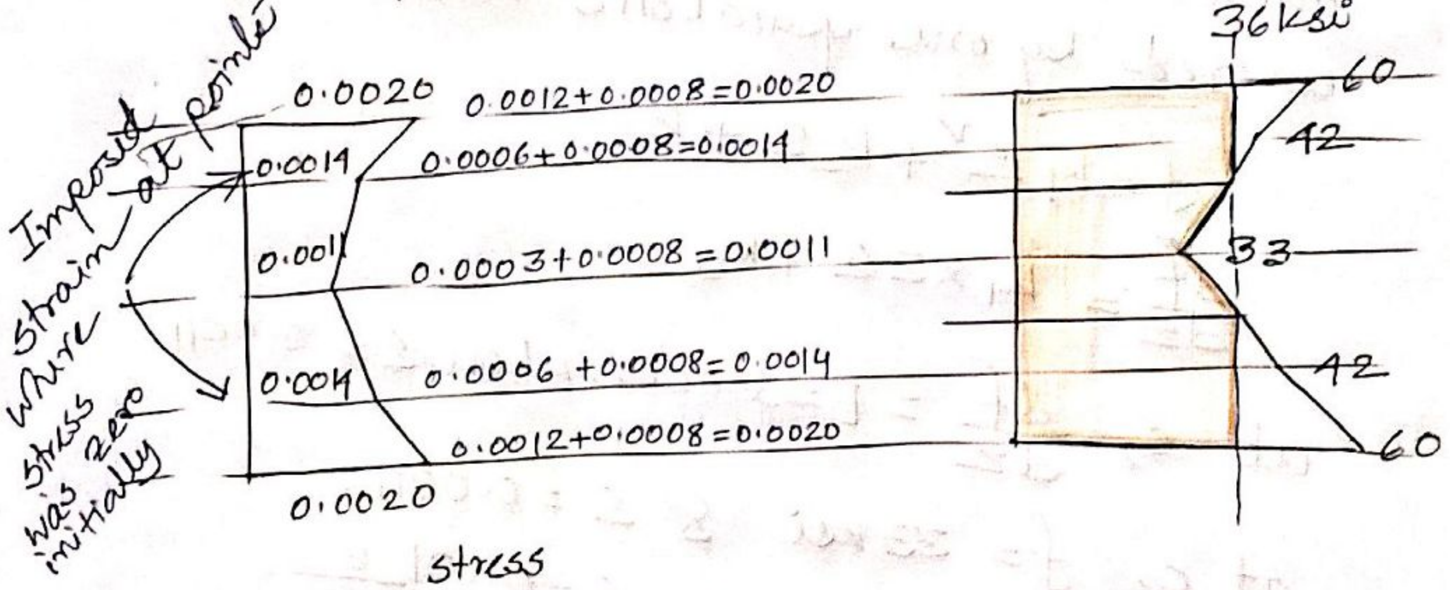
$$\lambda_{pw} = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{29000}{50}} = 90.55 > \frac{h}{t_w}$$
$$= \frac{d - 3t_f}{t_w}$$
$$= \frac{13.9 - 3 \times 0.645}{0.375} = 31.91$$

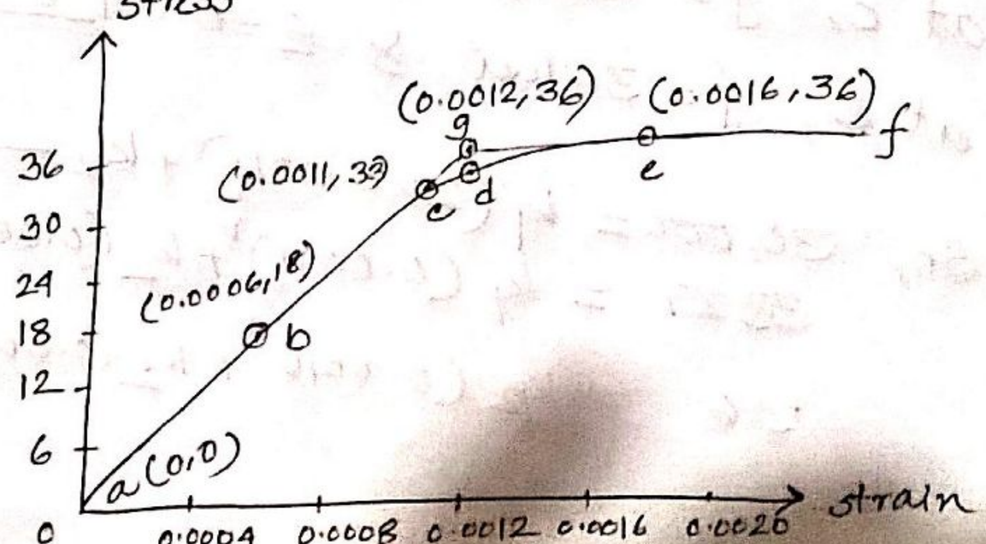
∴ section is compact

2012-2013

5 (b)


push stresses to yield level
find corresponding strains
2"
18"
18
-9
18
36
18
9
18
36
0.0012
0.0006
0.0003
0.0006
0.0012


Imposed strain at points where stress was zero initially
0.0020
0.0014
0.0011
0.0014
0.0020
0.0012+0.0008=0.0020
0.0006+0.0008=0.0014
0.0003+0.0008=0.0011
0.0006+0.0008=0.0014
0.0012+0.0008=0.0020
36ksi
60
42
33
42
60


stress
strain
36
30
24
18
12
6
0
0.0004
0.0008
0.0012
0.0016
0.0020
a (0,0)
(0.0006,18)
b
(0.0011,33)
c
d
(0.0012,36)
g
(0.0016,36)
e
f

Due to presence of residual stress/strain the average stress-strain behaviour follows the path a-b-c-d-e-f. If there were no residual stresses then the path would have been a-b-c-g-e-f.

Upto point c the stress-strain relationship is linear, after e the curve is flat. The transition curve from c to e can be covered by one parabolic curve as follows-

$$f = k_1 \varepsilon^2 + k_2 \varepsilon + k_3$$

$$\frac{df}{d\varepsilon} = k_1 \times 2\varepsilon + k_2$$

at c, $\frac{df}{d\varepsilon} = E = 30{,}000$, when $\varepsilon = 0.0011$.

at c, $f = 33$ ksi & $\varepsilon = 0.0011$

at e, $f = 36$ ksi & $\varepsilon = 0.0016$

So, $30{,}000 = k_1(2 \times 0.0011) + k_2$ — (1)

$33 = k_1 (0.0011)^2 + k_2 (0.0011) + k_3$ — (2)

$36 = k_1 (0.0016)^2 + k_2 (0.0016) + k_3$ — (3)

Solving, we get,

$k_1 = -4800\,0000$

$k_2 = 135600$

$k_3 = -58.08$

so, $f = -4800\,0000\,\varepsilon^2 + 135600\,\varepsilon - 58.08$

at, d, for $\varepsilon = 0.0012$,

$f = -4800\,0000\,(0.0012)^2 + 135600\,(0.0012) - 58.08$

$= 35.52$ ksi

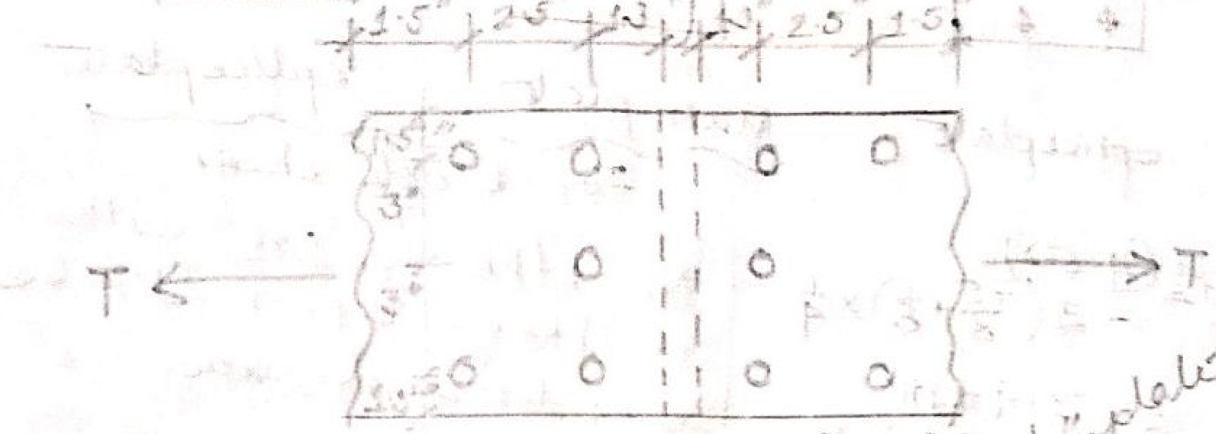
at, d, $\frac{df}{d\varepsilon} = k_1 \times 2\varepsilon + k_2$

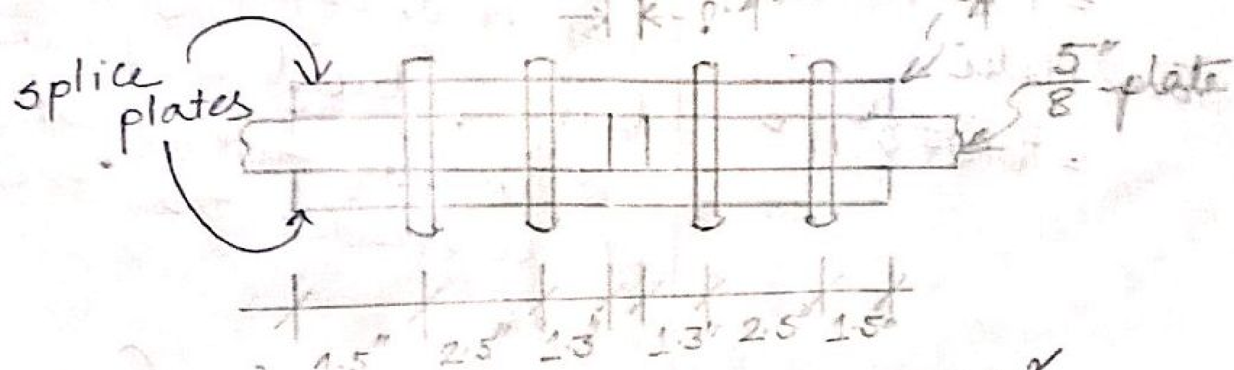
$= -4800\,0000 \times 2 \times (0.0012) + 135600$

$= 20400$ ksi

2012-2013

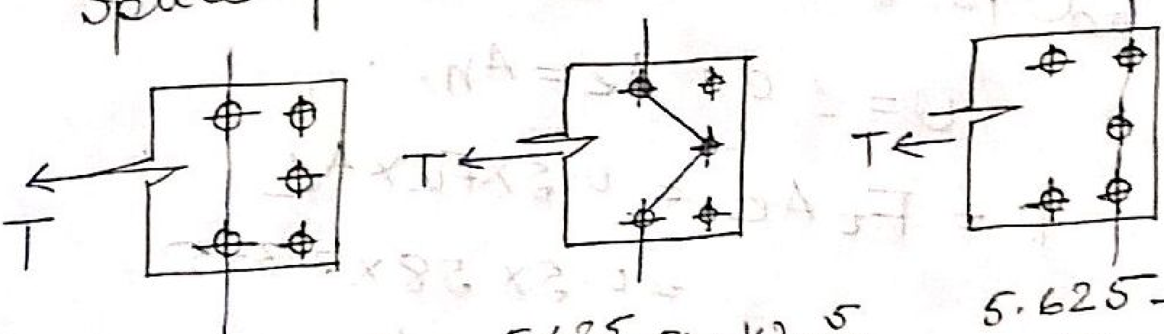
6(b)





Main plate $= 9 \times \frac{5}{8} = 5.625 \text{ in}^2$

Splice plates $= 2 \times \left(9 \times \frac{1}{4}\right) = 4.500 \text{ in}^2$



$5.625 - 2\left(5/8 + 1/8\right) \times \frac{5}{8}$

$= 4.6875$

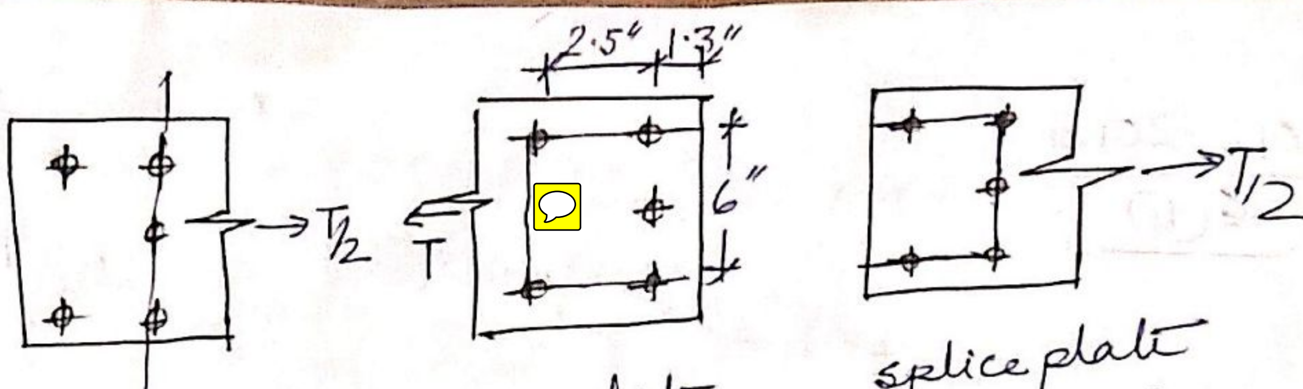
$5.625 - 3\left(5/8 + 1/8\right) \times \frac{5}{8} + 2\left(\frac{2.5^2}{4 \times 3}\right) \times \frac{5}{8}$

$= 4.8698$

$5.625 - 3\left(5/8 + 1/8\right) \times \frac{5}{8}$

$= 4.2188$, for 60 percent load is equivalent to $100 \times \frac{4.2188}{60}$ or, 7.03 in^2 for 100 percent load

Main Plate



spliceplate   Main plate   splice plate

For Block shear

$\frac{1}{2}(4.50) - 3\left(\frac{5}{8}+\frac{1}{8}\right)\times\frac{1}{4}$

$= 1.6875\ in^2$

For 2 Plates,

$= 3.375\ in^2$

No other failure paths in the splices need to be considered because the required capacity is being reduced and the net area of further paths will be greater than the above

The minimum net area for full load is $3.375\ in^2$

$U = 1.0,\ A_e = A_n.$

$T = F_t A_e = 0.5 \times F_u \times A_e$

$= 0.5 \times 58 \times 3.375$

$= 97.88^k$

2012-2013

7(a)

W14X90

$r_x = 6.14''$

$r_y = 3.70''$

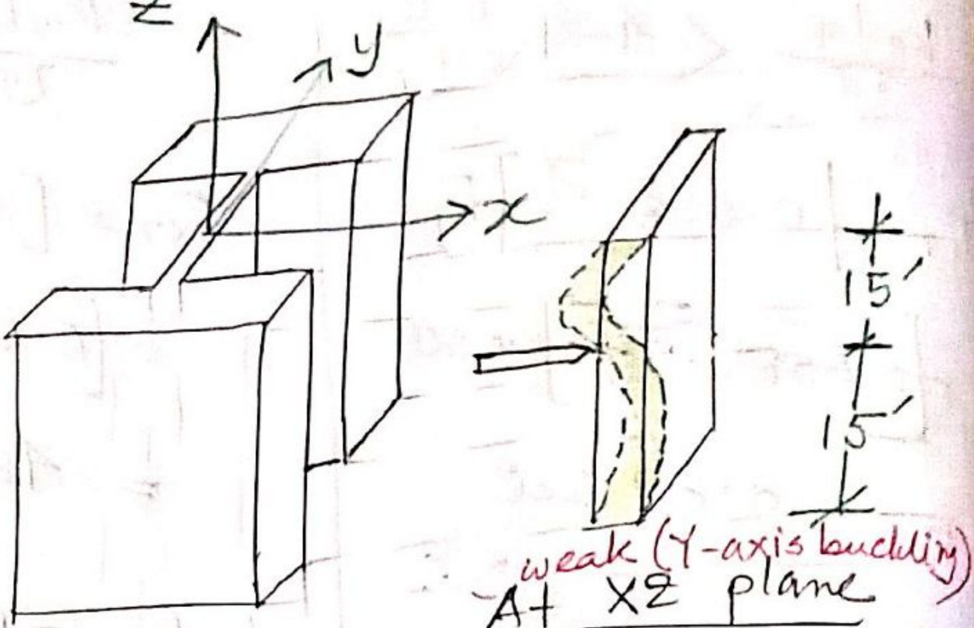
$A = 26.5\ in^2$

$L_y = 15'$

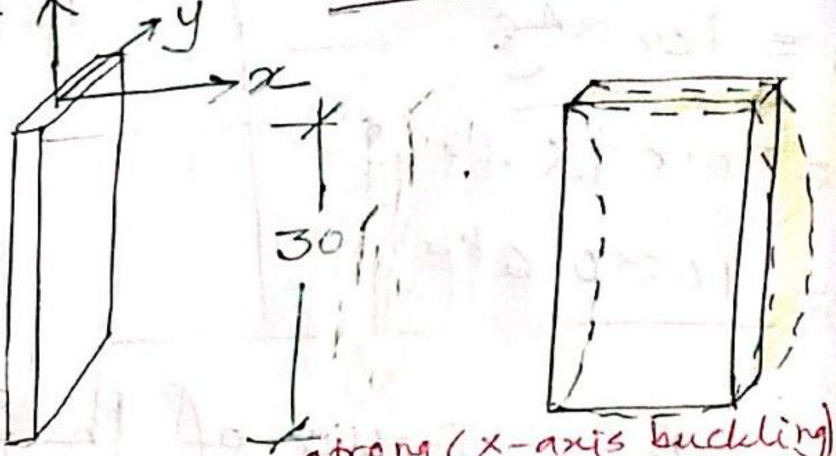
$L_x = 30'$

X → strong axis

Y → weak axis



At XZ plane



At YZ plane

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000}{50}} = 113.43$$

Buckling along x axis

$$\frac{K_x L_x}{r_x} = \frac{1 \times 30 \times 12}{6.14} = 58.63$$

$$F_e = \frac{\pi^2 E}{\left(\frac{K_x L_x}{r_x}\right)^2} = \frac{\pi^2 \times 29000}{(58.63)^2} = 83.26\ ksi$$

Buckling along y axis

$$\frac{k_y L_y}{r_y} = \frac{1 \times 15 \times 12}{3.70} = 48.65$$

$$F_e = \frac{\pi^2 E}{\left(\frac{k_y L_y}{r_y}\right)^2} = \frac{\pi^2 \times 29000}{(48.65)^2} = 120.93$$

$$\frac{K_x L_x}{r_x} < 4.71\sqrt{\frac{E}{F_y}}$$

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y$$

$$= \left[0.658^{\frac{50}{83.26}}\right] \times 50$$

$$= 38.89 \text{ ksi}$$

$$P_{nx} = F_{cr} \times A_g$$

$$= 38.89 \times 26.5$$

$$= 1030.6^k$$

$$\frac{K_y L_y}{r_y} < 4.71\sqrt{\frac{E}{F_y}}$$

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y$$

$$= \left[0.658^{\frac{50}{120.93}}\right] \times 50$$

$$= 42.05 \text{ ksi}$$

$$P_{nY} = F_{cr} \times A_g$$

$$= 42.05 \times 26.5$$

$$= 1114.3^k$$

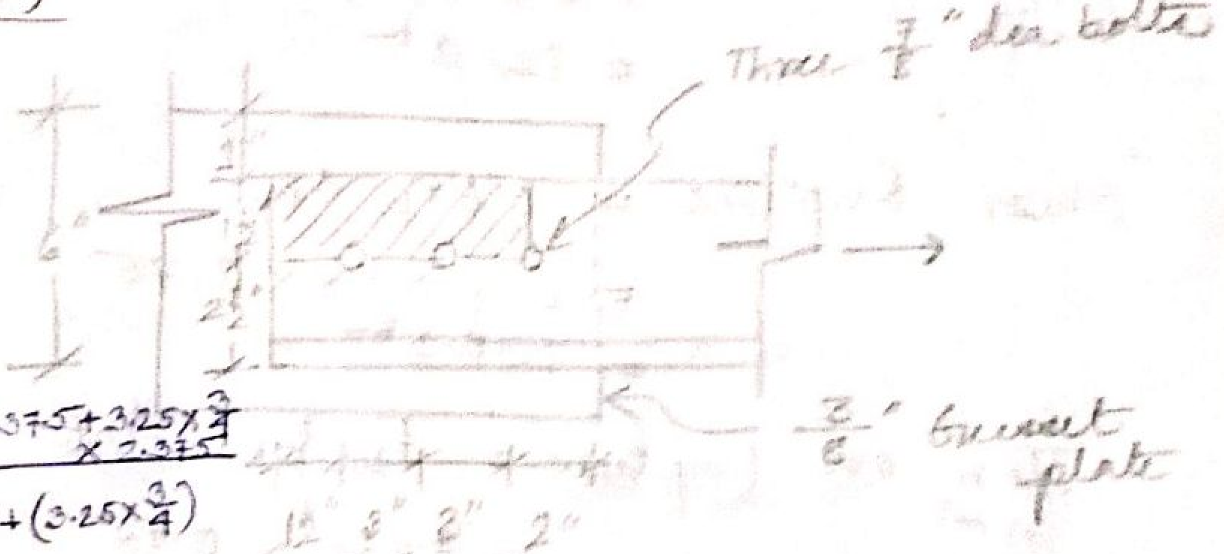
P_n = smaller of P_{nx} & P_{nY}

$$= 1030.6^k$$

Allowable strength $= \frac{1030.6}{1.67} = 617.13^k$

2012 - 2013

7 (b)



$\bar{x} = \frac{4 \times \frac{3}{4} \times 0.375 + 3.25 \times \frac{3}{4} \times 2.375}{(4 \times \frac{3}{4}) + (3.25 \times \frac{3}{4})}$

$= 1.27$

$A_g = 4 \times \frac{3}{4} = 3 \text{ in}^2$

$A_n = 3 - (\frac{7}{8} + \frac{1}{8}) \times \frac{3}{4} = 2.25 \text{ in}^2$

Yielding: $T_n = F_y A_g = 36 \times 3 = 108^k$ → ASD capacity $= 64.67^k$

Fracture: $T_n = F_u A_e = F_u U A_n = f_u \times (1 - \frac{\bar{x}}{L}) \times A_n$

$= 58 \times (1 - \frac{1.27}{6}) \times 2.25$

$= 102.88^k$ → ASD capacity $= 51.44^k$

Block Shear:

$A_{nt} = \{1\frac{1}{2} - \frac{1}{2}(\frac{7}{8} + \frac{1}{8})\} \times \frac{3}{4} = 0.75 \text{ in}^2$

$A_{gv} = (7\frac{1}{2} \times \frac{3}{4}) = 5.625 \text{ in}^2$

$A_{nv} = 5.625 - 2.5 (\frac{7}{8} + \frac{1}{8}) \times \frac{3}{4} = 3.75 \text{ in}^2$

Shear Yielding $= 0.6 F_y A_{gv}$

$= 0.6 \times 36 \times 5.625$

$= 121.5^k$

Shear Rupture $= 0.6 F_u A_{nv}$

$= 0.6 \times 58 \times 3.75$

$= 130.5^k$

Tension Rupture $= F_u U_{bs} A_{nt}$

$= 58 \times 1 \times 0.75$

$= 43.5^k$

$T_n =$ Shear Yielding + Tension Rupture

$= (121.5 + 43.5)^k$

$= \underline{165^k}$ → ASD capacity $= 82.5^k$

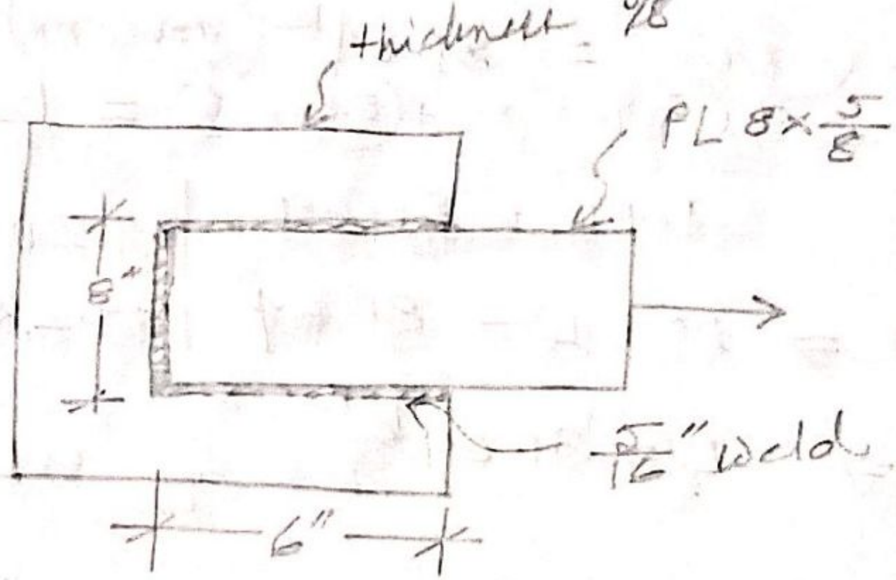
Considering all three limit states,

$T_n =$ [illegible]

ASD capacity $= 51.44^k$

2012-2013

8(a)



Yielding on gross area: $\frac{T_n}{\Omega} = \frac{F_y A_g}{\Omega}$

$= \frac{50 \times (8 \times \frac{5}{8})}{1.67}$

$= 149.7^k$

LRFD

$T_n = 0.90 \times 50 \times (8 \times \frac{5}{8})$

$= 225^k$

Rupture on effective area: $\frac{T_n}{\Omega} = \frac{F_u A_e}{\Omega}$

~~$U = 1 - \frac{\bar{x}}{L} = 1$ for~~

$= \frac{65 \times 1 \times (8 \times \frac{5}{8})}{2}$

$= 162.5^k$

LRFD

$T_n = 0.75 \times 65 \times 1 \times (8 \times \frac{5}{8})$

$= 243.75^k$

$\frac{R_{nw}}{\Omega}$ (transverse weld) $= \frac{0.6 \times \frac{1}{4} \cos 45° \times 70}{2} = 3.71^{k}/''$

LRFD $= 0.75 \times 0.6 \times \frac{1}{4} \cos 45° \times 70 = 5.57^{k}/''$

$\frac{R_{nw}}{\Omega}$ (longitudinal weld) $= \frac{0.6 \times \frac{5}{16} \cos 45° \times 70}{2} = 4.64^{k}/''$

LRFD $= 0.75 \times 0.6 \times \frac{5}{16} \cos 45° \times 70 = 6.96^{k}/''$

Weld capacity $= (3.71\times6) + (4.64\times8) + (3.71\times6)$

$= 81.64^k$ (governs)

LRFD $= (5.57\times6) + (6.96\times8) + (5.57\times6) = 122.52$ (governs)

$D + L = 81.64$

$\Rightarrow 50 + L = 81.64$

$\Rightarrow L = 31.64^k$

$1.2D + 1.6L = 122.52$

$\Rightarrow 1.2\times50 + 1.6\times L = 122.52$

$\therefore L = 39.075^k$

Check (Base material strength)

Yielding: $\frac{T_n}{\Omega} = \frac{0.6 t F_y L}{\Omega}$

$= \frac{0.6 \times 5/8 \times 50 \times (6+8+6)}{1.67}$

$= 224.5^k >$ connection strength (ok)

LRFD

$= 0.90 \times \frac{5}{8} \times 50 \times (6+8+6) \times 0.6$

$= 337.5^k >$ connection strength (ok)

Fracture: $\frac{T_n}{\Omega} = \frac{0.6 t F_u L}{\Omega}$

$= \frac{0.6 \times 5/8 \times 65 \times (6+8+6)}{2}$

$= 243.75^k >$ connection strength (ok)

LRFD

$= 0.75 \times 0.60 \times \frac{5}{8} \times 65 (6+8+6)$

$= 365.6^k$

2012-2013

8(b)

Due to fixed support the Beam ACF shall be unable to move horizontally. Thus columns of lower level shall be considered braced column and those on the upper level shall be considered unbraced columns.

Column BC

At B, $G_A = 1$ (practical value at fixed base instead of zero)

At C, $G_B = \dfrac{(I/L)_{CD} + (I/L)_{BC}}{(I/L)_{AC} \times 2 + (I/L)_{CF}}$

$= \dfrac{\frac{150}{12} + \frac{150}{15}}{\frac{600}{30} \times 2 + \frac{600}{20}}$

$= 0.32$

From alignment chart (Braced),

$K_{BC} = 0.70$

Column EF

At, E, $G_A = 10$ (practical value at hinge instead of infinity)

$$\text{At, F, } G_B = \frac{(I/L)_{FG} + (I/L)_{EF}}{(I/L)_{CF}}$$

$$= \frac{\frac{150}{12} + \frac{150}{15}}{\frac{600}{20}}$$

$$= 0.75$$

From alignment chart (Braced),

$K_{EF} = 0.84$

Column CD

$$\text{At, C, } G_A = \frac{(I/L)_{BC} + (I/L)_{CD}}{(I/L)_{AC} \times \frac{2}{3} + (I/L)_{CF}}$$

$$= \frac{\frac{150}{15} + \frac{150}{12}}{\frac{600}{30} \times \frac{2}{3} + \frac{600}{20}}$$

$$= 0.52$$

At, D, $G_{B} = \dfrac{(I/L)_{CD}}{(I/L)_{DG}}$

$$= \frac{\frac{150}{12}}{\frac{400}{20}}$$

$$= 0.625$$

From alignment chart (unbraced),

$K_{CD} = 1.18$

Column FG

At, F, $G_{A} = \dfrac{(I/L)_{EF} + (I/L)_{FG}}{(I/L)_{GF}}$

$$= \frac{\frac{150}{15} + \frac{150}{12}}{\frac{600}{20}}$$

$$= 0.75$$

At G, $G_{B} = \dfrac{(I/L)_{F/G}}{(I/L)_{GP}}$

$$= \frac{\frac{150}{12}}{\frac{400}{20}}$$

$$= 0.625$$

From alignment chart (unbraced),

$K_{FG} = 1.22$