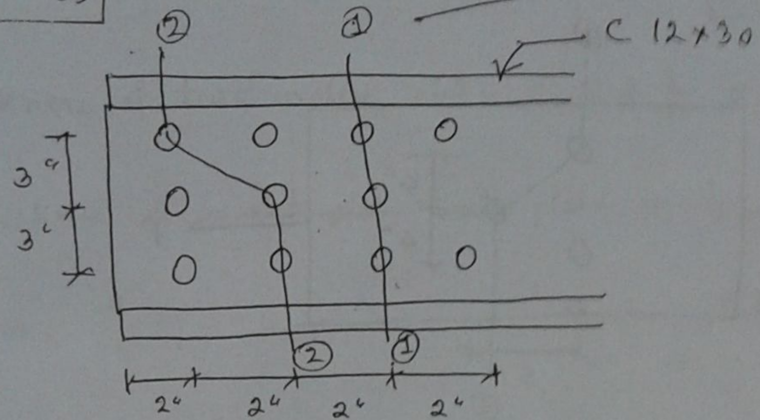
Ipshit.
0904116

2012 5-06. 7(a)



From table, $A_g = 8.82\ in^2$, thickness $= 0.51''$

~~① For yielding failure:~~ hole dia $= \frac{3}{4} + \frac{1}{8} = 0.875$

For path 1-1:

$$A_n = A_g - \Sigma dt + \Sigma \frac{s^2}{4g}$$

$$= 8.82 - 3 \times 0.51 \times 0.875$$

$$= 7.48\ in^2.$$

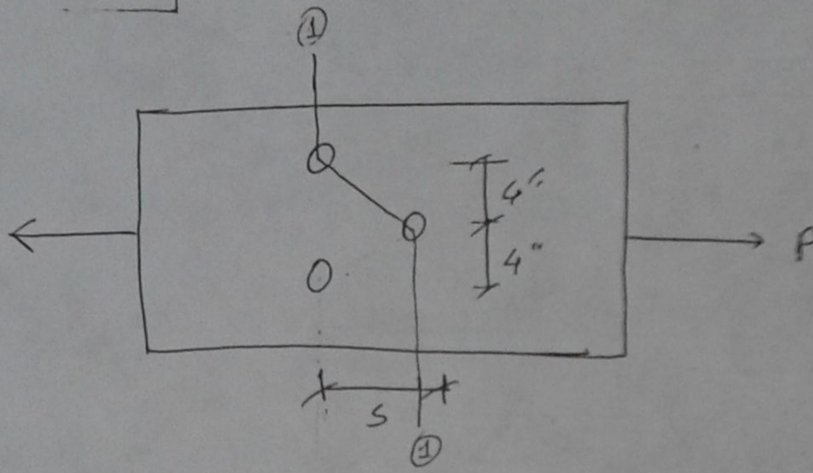
For path 2-2:

$$A_n = 8.82 - 3 \times 0.51 \times 0.875 + \frac{2^2}{4 \times 3} \times 0.51$$

$$= 7.65\ in^2.$$

$\therefore$ net section, $A_{net} = \boxed{7.48\ in^2}$

2005-06. 7(b)



Failure when only two bolts need to be subtracted = Failure path 1-1

$$\Rightarrow A_g - 2\times(dt) = A_g - 2(dt) + \frac{s^2}{4g}t$$

$$\Rightarrow s = 0.$$

Again, Failure when only two bolts need to be subtracted = Failure path 2-2

$$\Rightarrow A_g - 2(dt) = A_g - 3\times(dt) + 2\times\frac{s^2}{4g}t$$

$$\Rightarrow 2\times\frac{s^2}{4g}t = dt$$

$$\Rightarrow 2\times\frac{s^2}{4\times4} = (7/8 + \tfrac{1}{8})\times t$$

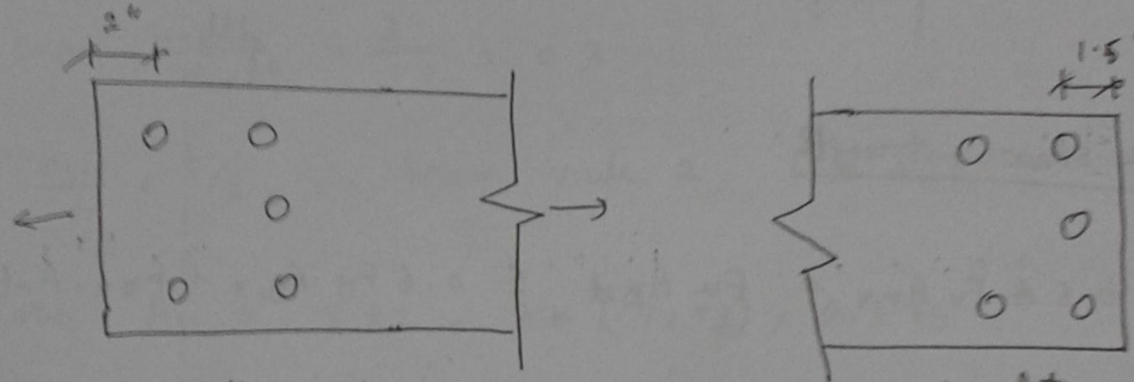
$$\therefore \boxed{s = 2.83 \text{ in}}$$

2005-06 · 8(c)

thickness of two splice plate $= 2 \times \frac{5}{16} = \frac{10}{16}$

thickness of ~~gusset plate~~ main plate $= \frac{1}{2}$"

Since, $\frac{10}{16} > \frac{1}{2}$ ⇒ so, Main plate will fail.



splice plate

main plate

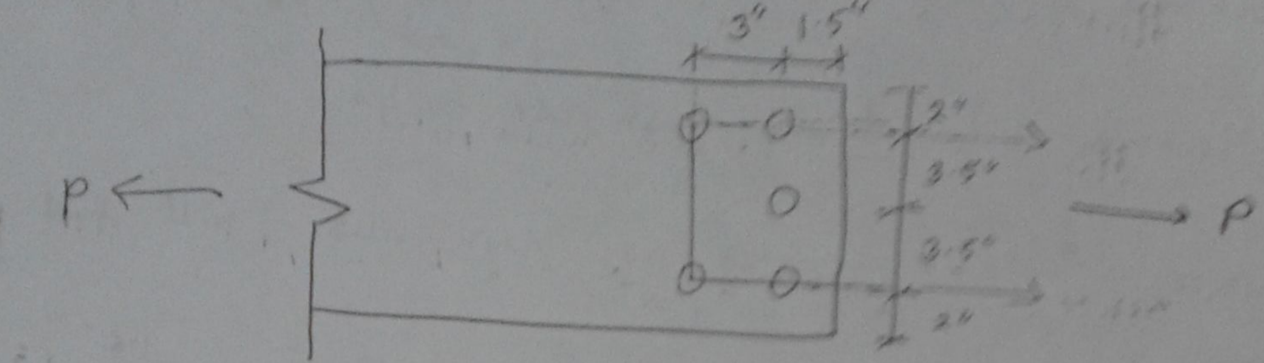
Again, distance from edge to bolt is 2" for splice plate.

for main plate, this distance is 1.5". So, shear area for main plate is larger than splice plate.

Hence, there is no need to check splice plate.

hole dia $= \frac{7}{8} + \frac{1}{8} = 1$"

Main plate:



Block shear strength:

$$0.6\,\cancel{A}\,F_u A_{n,v} + F_u A_{n,t} \le 0.6 F_y A_{g,v} + F_{bu} A_{nt}.$$

Now, $A_{n,v} = (3 + 1.5 - 1.5) \times \frac{1}{2} \times 2$

$= 3\ in^2.$

$A_{g,v} = (3 + 1.5) \times \frac{1}{2} \times 2 = 4.5\ in^2.$

$A_{n,t} = (3.5 + 3.5 - 1) \times \frac{1}{2} = 3\ in^2.$

$\therefore$ capacity $= \dfrac{0.6 \times 58 \times 3 + 58 \times 3}{2} \le \dfrac{0.6 \times 36 \times 4.5 + 58 \times 3}{2}$

$= 139.2 \le 135.6$

$\boxed{= 135.6\ k}$

$\boxed{\text{Confirm}}$

with Fordous

$\boxed{2006-07.\ 5(c)}$

Based on yielding;

$$\text{capacity} = \frac{F_y A_g}{\Omega} = \frac{36 \times 8.82}{1.67} = \boxed{190.13^k}$$

Based on fracture;

$$\text{Capo} \quad \frac{\text{width}}{\text{depth}} = \frac{3}{10} = 0.3$$

$\therefore \frac{b_w}{d} < 2/3 \quad \therefore$ from rule 2, $U = 0.85$.

$$\text{Now,} \quad A_n = 8.82 - 3 \times \left(7/8 + \tfrac{1}{8}\right) \times 0.673$$

$$= 6.8$$

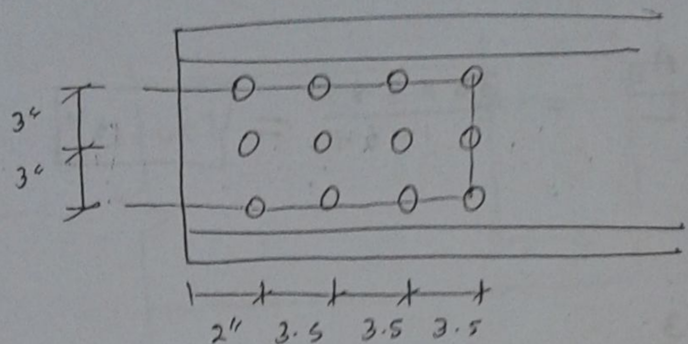
$$\therefore A_e = U A_n = 5.78 \ in^2.$$

$$\therefore \text{capacity} = \frac{F_u A_e}{\Omega} = \frac{5.78 \times 58}{\cancel{1.67}\,2} = \boxed{167.6\ K}$$

Based on block shear failure!

Since, channel web thickness $\leq$ gusset plate thickness,

so, channel is critical.



$A_{g,v} = (2+3.5+3.5+3.5) \times 0.673 \times 2$

$= 16.825 \text{ in}^2$

$A_{n,v} = (2+3.5+3.5+3.5 - 3.5\times 1) \times 0.673 \times 2$

$= 12.116 \text{ in}^2$

$A_{n,t} = (3+3-2\times 1) \times 0.673 \times 1 = 2.69 \text{ in}^2$

$\therefore$ Block shear capacity $=$

$$= \frac{0.6 \times \cancel{58} \times F_u \times A_{n,v} + F_u \, A_{nt}}{2} \le \frac{0.6 \times F_y \times A_{g,v} + F_u \times A_{nt}}{2}$$

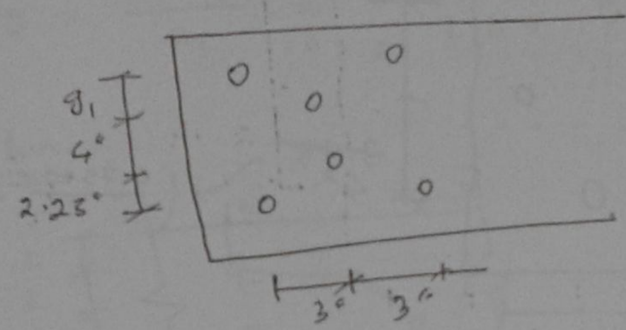
$= 288.8^k \le 259.7^k$

$= \boxed{259.7^k}$

$\therefore$ $\boxed{\text{Capacity} = 167.6^k}$

$\boxed{2006\text{-}07.\ 7(b)}$ (previous math).

$\boxed{2006\text{-}07.\ 8(b)}$



~~Failur by fracture (without zigzag),~~

$\cancel{= \frac{F_u A_e}{\Omega}} =$

Area without zigzag = Area with zig-zag

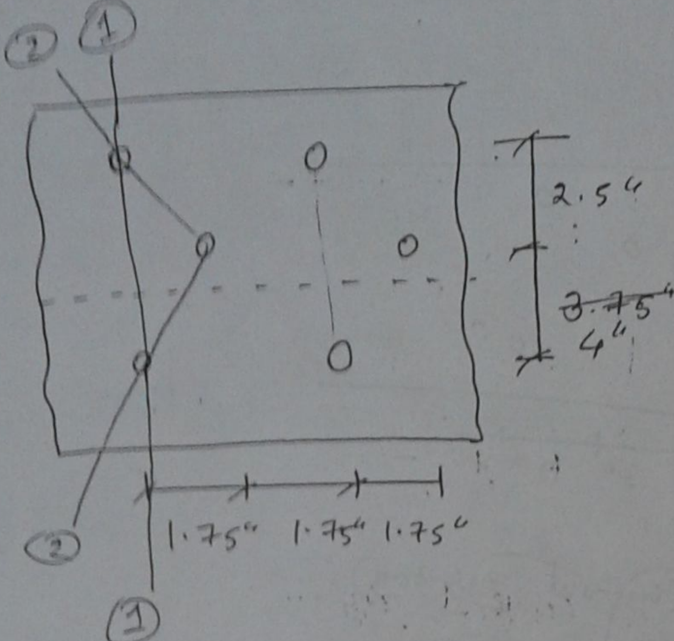
$$\Rightarrow \left[20 - 2\times\left(\frac{3}{4}+\frac{1}{8}\right)\right]\times t = \left[20 - 4\times\left(\frac{3}{4}+\frac{1}{8}\right) + \cancel{2\times}\frac{3^2}{4\times g_1} + \frac{3^2}{4\times 2.25}\right]\times t$$

$$\Rightarrow 2\times\left(\frac{3}{4}+\frac{1}{8}\right) = \frac{3^2}{4\times g_1} + \frac{3^2}{4\times 2.25}$$

$$\therefore \boxed{g_1 = 3''}$$

confirm

2007-08: 5(c)



$$\left(\frac{4.75-0.5}{2} + 2.125 - \frac{1}{4}\times 2\right)$$

For Failure path 1-1:

$$A_n = A_g - 2\times dt$$

$$= \left(6+4-\frac{1}{4}\right)\times\frac{1}{4} - 2\times\left(7/8+\frac{1}{8}\right)\times\frac{1}{4}$$

$$= 2.4375 - 2\times\frac{1}{4} = 1.9375\ in^2$$

For Failure path 2-2:

$$A_n = 2.4375 - 3\times 1\times\frac{1}{4} + \left(\frac{1.75^2}{4\times 2.5} + \frac{1.75^2}{4\times 4}\right)\times\frac{1}{4}$$

$$= 1.812\ in^2.$$

$\therefore$ Net section effective in tension (for each angle).

$$A_e = U A_n = \underbrace{1}_{\text{all connected member}}\times 1.812 = \boxed{1.812\ in^2}$$

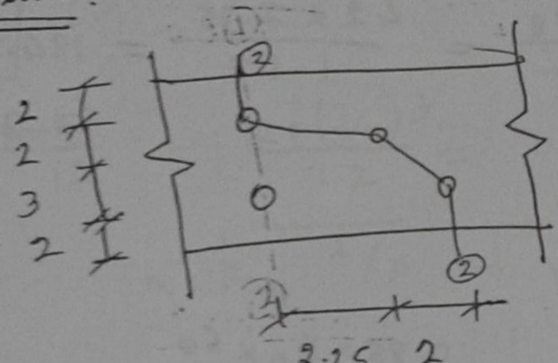
confirm

2007-08 . 8	8(b)

Yielding Failure:

$$\text{capacity} = \frac{F_y A_g}{\Omega} = \frac{36 \times 9 \times 0.5}{1.67} = 97^K$$

Fracture failure:



Failure path 1-1:

$$A_n = 9 \times 0.5 - 2 \times (7/8 + 1/8) \times 0.5 = 3.5 \, in^2.$$

Failure path 2-2:

$$A_n = 9 \times 0.5 - 3 \times 0.5 \times 1 + \left(\frac{2.25^2}{4 \times 2} + \frac{2^2}{4 \times 3}\right) \times 0.5$$

$$= 3.483 \, in^2.$$

$$\therefore \text{capacity} = \frac{A_e F_u}{\Omega} = \frac{1 \times 3.483 \times 58}{2} = 101^K.$$

$$\therefore \text{Capacity} = \boxed{97^K}$$

2008-09. #8 → done before.

2009-10. 8 → done before.

2010-11. 5(b) → (should be done in bolt concept)

Yielding Failure:

$$\text{capacity} = \frac{F_y A_g}{\Omega} = \frac{42 \times 7.35}{1.67} = 184.85^k \times 2$$

$$= 369.7K.$$

~~Frac~~

Fracture Failure:

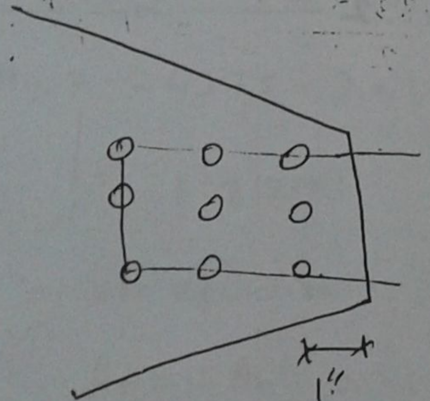
$$\text{Capacity} = \frac{A_e F_u}{\Omega} = \frac{0.85 \times A_n \times 60}{2}$$

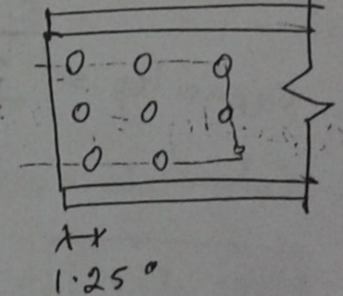
$$= \frac{0.85 \times (7.35 - 3 \times 1 \times 3/8) \times 60}{2}$$

$$= 158.74 \times 2$$

$$= 317.5^k.$$

Block Shear Failure:





So, gusset plate will fail before channel.

Since the ~~s~~ vertical dimensions (gages) are not given,

block shear strength should not be checked.

কাটিছুছু ne

~~$\therefore$ capacity = 317.5k.~~

$$\cancel{\therefore DL = 317.5 - \overset{240}{\cancel{225}}(LL) = \cancel{92}}\ \boxed{\cancel{77.5^k}}$$

$\boxed{2010\text{-}11.\ 7(b)}$

$$I_{min} = \frac{bh^3}{12} = \frac{10 \times (3/4)^3}{12} = 0.35\ \cancel{m}\ in^4$$

$$I = Ar^2 \quad \therefore r_{min} = \sqrt{I/A} = \sqrt{\frac{0.35}{10 \times 3/4}} = 0.2165$$

$$\therefore \frac{L}{r} = \frac{5 \times 12}{0.2165} = 277 < 300 \longrightarrow \text{O.K.}$$

<u>Based on yielding:</u>

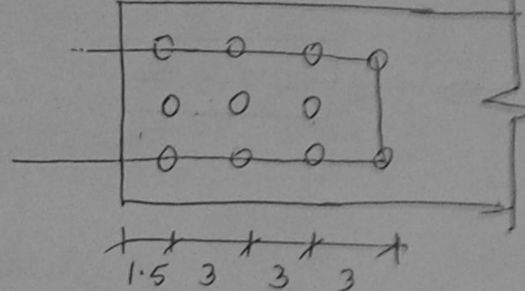
$$\text{capacity} = \frac{36 \times 10 \times 3/4}{1.67} = 161.7^k.$$

<u>Based on Fracture:</u>

$3 \times (\frac{2}{4} + \frac{1}{8}) \times 3/4$

$$\text{Capacity} = \frac{\overset{0.85}{1} \times (10 \times 3/4 - \overset{\times 3/4}{3 \times 1}) \times 58}{2} = 152.25^k.$$

Block shear strength:



$\cancel{A_{g,v} =}$

$\cancel{A_{g,v} = (1.5 + 3\times 3) \times \tfrac{3}{4} = 10.5} =$

$A_{g,v} = (1.5 + 3\times 3) \times 3/4 = 7.875 \text{ in}^2 \times 2 = 15.75 \text{ in}^2$

$A_{n,v} = \left[1.5 + 3\times 3 - 3.5\times\left(\frac{3}{4} + \frac{1}{2}\right)\right] \times \frac{3}{4} \times 2$

$\cancel{= 8.2\times 2} = 11.156 \text{ in}^2$

$A_{n,t} = \left[3 + 3 - \left(\frac{3}{4} + 1/2\right)\right] \times 3/4 = 3.84 \text{ in}^2.$

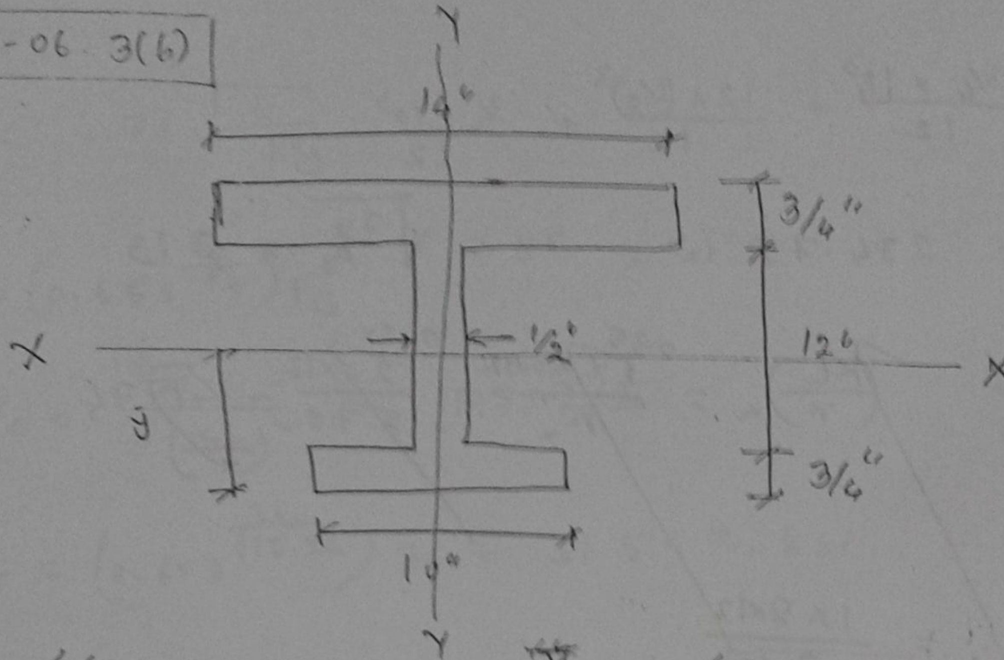
Now, capacity $= \dfrac{0.6\, F_u A_{n,v} + F_u A_{nt}}{2} \le \dfrac{0.6\, F_y A_{g,v} + F_u A_{nt}}{2}$

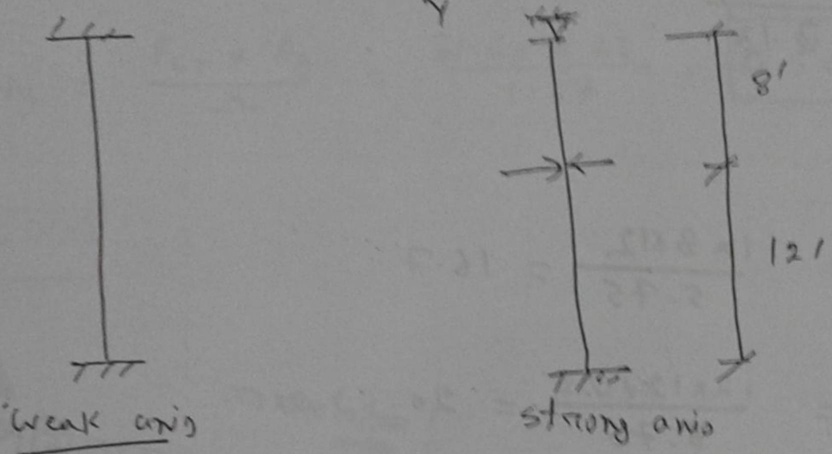
$= \dfrac{0.6\times 58\times 11.156 + 58\times 3.84}{2} \le \dfrac{0.6\times 36\times 15.75 + 58\times 3.84}{2}$

$= \boxed{281.46\text{ k}}$

$\therefore$ $\boxed{\text{Capacity} = 152.25\text{ k}}$

2005-06 3(b)





$$A_g = 14 \times 3/4 + 10 \times 3/4 + 12 \times 1/2 = 24 \text{ in}^2.$$

$$\bar{y} = \frac{10 \times 3/4 \times 3/8 + 12 \times 1/2 \times (6 + 3/4) + 14 \times 3/4 \times (12 + 3/4 + 3/8)}{24}$$

$$= 7.55''$$

$$I_{x-x} = \frac{10 \times (3/4)^3}{12} + 10 \times 3/4 \times (7.55 - 3/8)^2 + \frac{1/2 \times 12^3}{12}$$

$$+ \frac{1}{2} \times 12 \times (3/4 + 6 - 7.55)^2 + \frac{14 \times (3/4)^3}{12} + 14 \times 3/4 \times (5.95 - 3/8)^2$$

$$= 793 \text{ in}^4.$$

$$r_x = \sqrt{\frac{I_x}{A_g}} = 5.75 \text{ in.}$$

$$I_{y-y} = \frac{3/4 \times 12^3}{12} + \frac{12 \times (1/2)^3}{12} + \frac{3/4 \times 10^3}{12}$$

$$= 234.75 \text{ in}^4. \quad r_y = \sqrt{\frac{I_y}{A_g}} = 3.13$$

~~Strong axis:~~

$$\cancel{\left(\frac{KL}{r}\right)_x = \frac{0.35 \times 20 \times 12}{r_x} = \frac{0.35 \times 12}{5.75} = 41.74}$$

~~Weak axis:~~

$$\cancel{\left(\frac{KL}{r}\right)_{y_1} = \frac{1 \times 8 \times 12}{3.13}}$$

Strong axis:

$$\left(\frac{KL}{r}\right)_{x1} = \frac{1 \times 8 \times 12}{5.75} = 16.7$$

$$\left(\frac{KL}{r}\right)_{x2} = \frac{12 \times 12 \times 0.8}{5.75} = 20.03$$

Weak axis:

$$\left(\frac{KL}{r}\right)_y = \frac{20 \times 12 \times 0.65}{3.13} = 49.84 \text{ (governs)}.$$

$$\therefore \frac{KL}{r} = 49.84.$$

Now, $4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29 \times 10^3}{36}} = 133.7.$

$$\therefore \frac{KL}{r} < 4.71\sqrt{\frac{E}{F_y}}.$$

$$\therefore F_{cr} = \left(0.658^{\frac{F_y}{F_e}}\right)F_y$$

Now, $F_e = \dfrac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = 115.22$

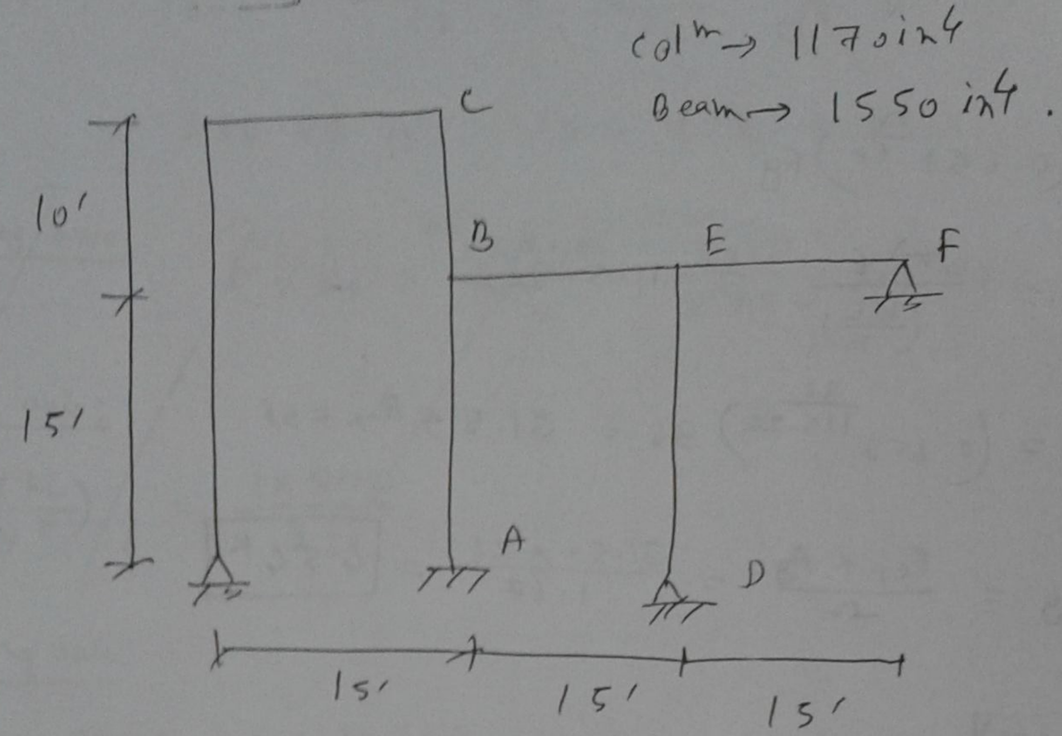
$$\therefore F_{cr} = \left(0.658^{\frac{36}{115.22}}\right)36 = 31.59 \text{ ksi}.$$

$$\therefore \text{capacity} = \frac{F_{cr} \times A_g}{\Omega} = \frac{31.59 \times 24}{1.67} = \boxed{454^k}$$

~~2009~~

$\boxed{2015\text{-}06.4(a)}$

2006-07, 1(a)



column AB: (sidesway inhibited - braced)

$$G_A = 1.0,$$

$$G_B = \frac{\Sigma\left(\frac{EI}{L}\right)_{columns}}{\Sigma\left(\frac{EI}{L}\right)_{Beams}}$$

$$= \frac{\frac{1170}{15} + \frac{1170}{10}}{\frac{1550}{15}}$$

$$= 1.89$$

$\therefore \boxed{K = 0.81}$

column BC: (unbraced)

$G_B = 1.89,$

$$G_C = \frac{1170/10}{\frac{1550}{15}} = 1.13$$

$\therefore \boxed{K = 1.45}$

column DE:

$G_D = 10,$

$$G_E = \frac{1170/15}{\frac{1550}{15} + \frac{1550}{15} \times 1/2}$$

$= 0.5$

$\therefore K = 0.81$

2006-07. 1(b)

hinged at top & fixed at bottom either principal axis.

$\therefore K_x = K_y = 0.8$, $L_x = L_y = 20'$ (not given in question, correction came)

Now, $KL = 0.8 \times 20 = 16$ and Load $= 400k$,

Section $\longrightarrow$ W 12×87.

$A_g = 25.6 \text{ in}^2,$

$r_y = 3.07, \quad r_x / r_y = 1.75 \quad \therefore r_x = 5.37$

$$\frac{KL}{r} = \frac{16}{3.07} = 5.2 \times 12 = 62.54$$

$$4.71\sqrt{\frac{E}{F_y}} = 133.7$$

$$\therefore \frac{KL}{r} < 4.71\sqrt{E/F_y} \rightarrow \quad F_{cr} = \left(0.658^{F_y/F_e}\right) F_y.$$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = 73.18$$

$\therefore F_{cr} = 29.3$ ksi.

$$\therefore \text{Allowable load} = \frac{29.3 \times 25.6}{1.67}$$

$$= 449.2^K > 400^K \longrightarrow \text{o.K.}$$

$\boxed{2016\text{-}07.\ 2(a)}$

Flange width, $b_f = 20''$

$\therefore b = \frac{b_f}{2} = 10''$

$t_f = 1/2''$, $t_w = 3/4''$, $d = 24''$

$\therefore h = d - 3t_f = 24 - 3 \times 1/2 = 22.5$.

$\frac{b}{t_f} = \frac{10}{1/2} = \cancel{22}\ 20$

$0.56\sqrt{\frac{E}{F_y}} = 13.49$

$\because \frac{b}{t_f} > 0.56\sqrt{\frac{E}{F_y}} \rightarrow$ Local buckling of flange would occur

$\frac{h}{t_w} = 30$, $1.49\sqrt{\frac{E}{F_y}} = 35.88$

$\because \frac{h}{t_w} < 1.49\sqrt{\frac{E}{F_y}} \longrightarrow$ local buckling of web would not occur.

$\boxed{2006-07.\ 2(i)}$

$K_y = 0.65, \quad K_x = 0.8,$

$L_y = 20', \quad L_x = 20',$

$A_g = 16.7, \quad r_x = 8.36, \quad r_y = 1.35,$

$$\left(\frac{KL}{r}\right)_x = \frac{0.8 \times 20}{8.36} = 22.97,$$

$$\left(\frac{KL}{r}\right)_y = \frac{0.65 \times 20 \times 12}{1.35} = 115.56$$

$$4.71\sqrt{\frac{E}{F_y}} = 103.55$$

$$\left(\frac{KL}{r}\right)_y > 4.71\sqrt{\frac{E}{F_y}}$$

$$\therefore F_{cr} = 0.877\ F_e$$

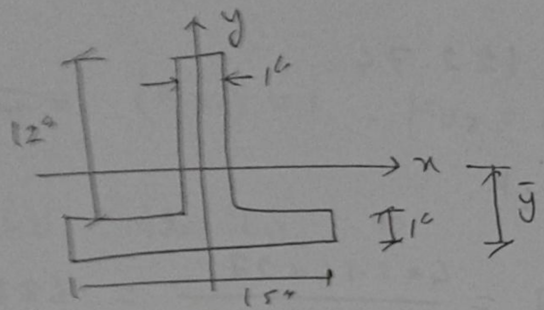
Now, $F_e = \dfrac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = 21.43$

$$\therefore F_{cr} = 18.8\ \text{ksi}$$

$\therefore$ capacity, $P_{allowable} = \dfrac{18.8 \times 16.7}{1.67}$

$$= \boxed{188^k}$$

2007-08 1(c)



$A_g = 12 + 15 = 27 \text{ in}^2$.

$\bar{y} = \dfrac{15 \times 1 \times 0.5 + 12 \times (6+1)}{27} = 3.39"$

$I_{x-x} = \dfrac{15 \times 1^3}{12} + 15 \times (3.39 - 0.5)^2 + \dfrac{1 \times 12^3}{12} + 12 \times (9.61 - 6)^2$

$= \cancel{4296} \; 426.02$

$I_{y-y} = \cancel{\dfrac{1 \times 12^3}{12} + \dfrac{1 \times 15^3}{}} \; \dfrac{12 \times 1^3}{12} + \dfrac{1 \times 15^3}{12} = 282.25.$

$r_x = \sqrt{\dfrac{I_x}{A}} = 3.976 \quad , r_y = 3.233$

$\left(\dfrac{KL}{r}\right)_x = \dfrac{0.8 \times 20 \times 12}{3.976} = 48.29$

$\left(\dfrac{KL}{r}\right)_y = \dfrac{0.65 \times 20 \times 12}{3.233} = 48.25$

$\therefore \left(\dfrac{KL}{r}\right) = 48.29$

$4.71\sqrt{\dfrac{E}{F_y}} = 113.43$

$\dfrac{KL}{r} < 4.71\sqrt{\dfrac{E}{F_y}} \longrightarrow \therefore F_{cr} = \left(0.658^{F_y/F_e}\right) F_y$

$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = 122.74$

$\therefore F_{cr} = 42.16^k.$

$\therefore$ allowable load $= \frac{42.16 \times 27}{1.67} = 681.61$

$\approx \boxed{682^k}$

2007 - 02 . 2

$\boxed{2007\text{-}08.\ 6(a)}$

$K_x = 1.0$, ~~K_{y2}~~ $(K_{y1}) = 1$, $K_{y2} = 1.0$

$L_x = 26$, $L_{y1} = 13$, $L_{y2} = 13'$

$r_x = 6.05''$, $r_y = 2.48''$

$\left(\frac{KL}{r}\right)_x = 51.57$

$\left(\frac{KL}{r}\right)_{y1} = \left(\frac{KL}{r}\right)_{y2} = 62.9$

$\therefore \frac{KL}{r} = 62.9$, $4.71\sqrt{\frac{E}{F_y}} = 133.7$

$F_e = 72.34$

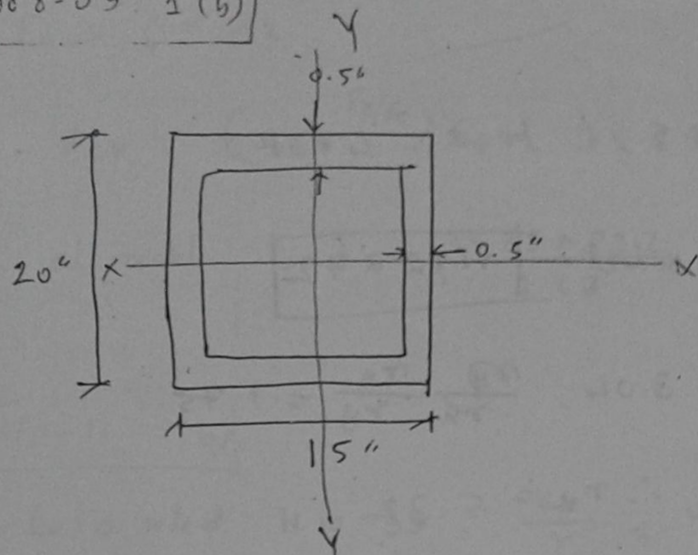
$F_{cr} = \left(0.658^{F_y/F_e}\right) F_y = 29.23^k\ ksi$

$\therefore$ Allowable load $= \frac{29.23 \times 24.1}{1.67} = 421.8^k$,

$> 300^k$.

So, adequate.

2008-09 1 (b)



$$I_{x-x} = \frac{15\times20^3}{12} - \frac{14\times19^3}{12} = 1997.8 \ in^4$$

$$I_{y-y} = \frac{20\times15^3}{12} - \frac{19\times14^3}{12} = 1280.33 \ in^4.$$

$$A_g = 20\times15 - 19\times14 = 34.$$

$$r_x = 7.665, \quad r_y = 6.14$$

$$\left(\frac{KL}{r}\right)_x = \frac{0.65\times24\times12}{7.665} = 24.42$$

$$\left(\frac{KL}{r}\right)_y = \frac{0.8\times12\times12}{6.14} = 18.76$$

$$4.71\sqrt{\frac{E}{F_y}} = 133.68$$

Now, $F_e = \dfrac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = 479.96$ ksi.

$$\therefore F_{cr} = \left(0.658^{F_y/F_e}\right)F_y = 34.89 \text{ ksi}.$$

$\therefore$ Allowable load $= \dfrac{34.89\times34}{1.67} = \boxed{710.3^K}$ Ans

$\boxed{2008-09,\ 2(a)}$

$K_yL_y = 1 \times 15 = 15$, load $= 470k$.

from column table, select. $\boxed{W12 \times 72}$

$A = 21.1\ in^2$, $r_y = 3.04$, $\cancel{\frac{r_y}{r_x}}\ \frac{r_x}{r_y} = 1.75$.

$\therefore r_x = 5.32$

$\left(\frac{KL}{r}\right)_x = \frac{30 \times 1 \times 12}{5.32} = 67.7$

$\left(\frac{KL}{r}\right)_y = \frac{\cancel{30}12 \times 15}{3.04} = 59.2$

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

$F_e = 62.45 \qquad \therefore F_{cr} = 35.76$

$\therefore$ allowable load $= \frac{35.76 \times 21.1}{1.67} = 451.85^k \cancel{< 470k}$

$< 470 \rightarrow$ not o.k ~~→ o.k.~~

So, let's choose $W12 \times 79$,

$A_g = 23.2$, $r_y = 3.05$, $r_x = 5.3375$.

$\left(\frac{KL}{r}\right)_x = \frac{30 \times 12}{5.3375} = 67.45$

$\left(\frac{KL}{r}\right)_y = \frac{12 \times 15}{3.05} = 59.02$

$F_e = 62.92$

$\therefore F_{cr} = (0.658^{F_y/F_e}) F_y = 35.25$

$\therefore$ allowable load $= \dfrac{35.85 \times 23.2}{1.67} = 498^k \; (> 470^k)$

$\longrightarrow$ o.k.

$\boxed{2010\text{-}11 \;\; 2(b)}$

Let's select W 10×39, $\dfrac{KL}{r} = \dfrac{0.8 \times 20}{1.98} = 96.97$

$F_e = 30.44$

$F_{cr} = (0.658^{F_y/F_e}) F_y = 21.94$ ksi.

$\therefore$ allowable load $= \dfrac{21.94 \times 11.5}{1.67} = 151.1^k \; (< 180^k)$

$\longrightarrow$ not o.k.

Again, let's select W 12×40, $\dfrac{KL}{r} = \cancel{83}\ 99.68$

$F_e = 28.92$

$F_{cr} = 21.38^k$. $\therefore P_{allow} = \dfrac{21.38 \times 11.8}{1.67} = 151^k \; (< 180^k)$

$\longrightarrow$ not ok.

Select W 10×45 $\quad \dfrac{KL}{r} = \cancel{7.96}\ 95.52$

$F_e = 31.37 \quad \therefore F_{cr} = 22.27$

$\therefore P_{allow} = 177.34^k \; (< 180^k)$. [1.47% variation].

So, ~~B~~ W 10×45 section can be used.

[2005-06. 1(b)]

Shear strength of bolt:

$F_{nv} = 60$ ksi.

$m = 1$, $A_b = \frac{\pi}{4} \times (7/8)^2 \cancel{\times 0.673} = 0.6$ in^2.

$\therefore$ Shear strength of bolt, $\frac{R_n}{\Omega} = \frac{F_{nv}\, m\, A_{nv}}{2}$

$= \frac{60 \times 1 \times 0.6}{2} = 18^k$/bolt.

$\therefore$ Total shear strength $= 4 \times 18 = \boxed{72.16^k}$

Bearing strength:

For edge hole:

$L_c = 2'' - (7/8 + \frac{1}{16}) \times 1/2 = 1.53''$

bearing strength of a hole $= \frac{1.2 L_c t F_u}{\Omega} \le \frac{2.4 d t F_u}{\Omega}$

$= \frac{1.2 \times 1.53 \times 0.673 \times 58}{2} \le \frac{2.4 \times (7/8 \cancel{+ \frac{1}{16}}) \times 0.673 \times 58}{2}$

$= 35.73 \le 40.98$

$= 35.83$

For other hole:

$$L_c = 3'' - 2\left(\frac{7}{8} + \frac{1}{16}\right) = 2.0625''$$

$$\text{bearing strength} = \frac{1.2 L_c t F_u}{\Omega} \le \frac{2.4\, d t F_u}{\Omega}$$

$$= \frac{1.2 \times 2.0625 \times 0.673 \times 58}{2} \le \frac{2.4 \times 7/8 \times 0.673 \times 58}{2}$$

$$= 40.986\ K$$

$\therefore$ Total bearing strength $= 40.986 \times 2 + 35.83 \times 2$

$$= \boxed{153.6^k}$$

Tension member capacity:

By yielding:

$$\text{Capacity} = \frac{F_y A_g}{\Omega} = \frac{36 \times 8.82}{1.67} = 190.13$$

By Fracture:

$$\frac{b}{d} = \frac{3}{10} = 0.3 < 2/3 \qquad \therefore U = 0.85$$

$$A_e = U A_n = 0.85 \times \left(8.82 - 2 \times \left(7/8 + \frac{1}{8}\right) \times 0.673\right)$$

$$= 6.35$$

$$\therefore \text{Capacity} = \frac{6.35 \times 58}{2} = \boxed{184^k}$$

$\therefore$ Allowable load carrying capacity $= \boxed{72.16^k}$

2006-07. 6(a)

$DL + LL = 320^k$.

shear strength of a bolt $= \dfrac{F_{nv}\, m A_b}{\Omega}$

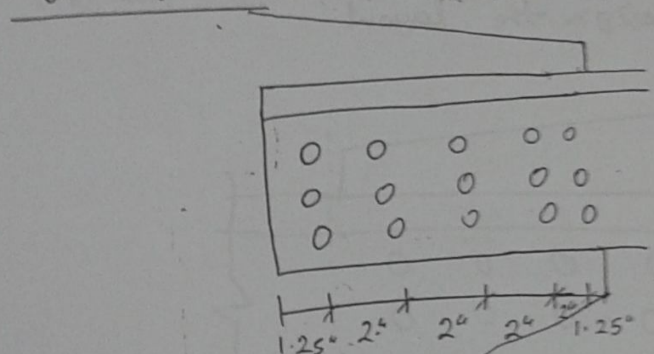
$= \dfrac{60 \times 2 \times \pi/4 \times (3/4)^2}{2}$

$= 26.5$ K/bolt.

Total bolts required $= \dfrac{320}{26.5} =$ ~~12 bolts~~ 12.07 bolts

≈ 15 bolts.

Layout of design:



Check for bearing capacity:

For edge hole:

$L_c = 1.25 - \left(\frac{3}{4} + 1/16\right) \times 0.5 = 0.844''$

bearing strength $= \dfrac{1.2 L_c t F_u}{\Omega} \leq \dfrac{2.4\, d t F_u}{\Omega}$

$= 14.68 \leq 26.1$

$= 14.68^k$

For other hole:

$L_c = 2'' - (3/4 + 1/16) = 1.1875.$

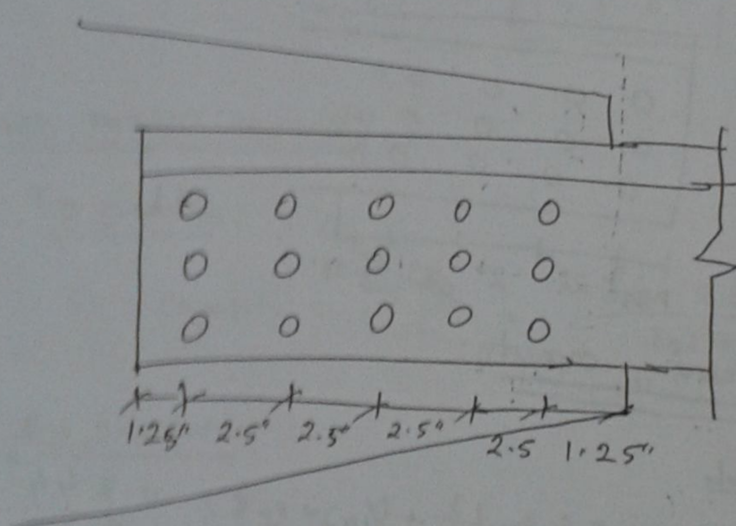
$\therefore$ bearing strength $= 20.666 \leq 26.1$

$= 20.66^k.$

$\therefore$ Total bearing capacity $= 20.66 \times 12 + 14.68 \times 3$

$= 291.96^k \ (< 320^k) \rightarrow$ not ok

So, we have to redesign the layout.



For edge hole:

Capacity $= 14.68$ k.

For other hole :

$$L_c = 2.5'' - (3/4 + 1/16) = 1.6275''$$

$\therefore$ bearing strength $= 29.36^k \leq 26.1 = 26.1$

$\therefore$ Total bearing capacity $= \overset{26.1}{\cancel{29.36}} \times 12 + 14.63 \times 3$

$\cancel{= 396^k\ (> 320^k)}$

$= 357^k\ (> 320^k) \rightarrow$ o.k.

$\boxed{2007\text{-}08.\ 7(b)} \rightarrow$ same as this math.

2008-09. 6(a) $\longrightarrow$ same.

$\boxed{2010-11 \cdot 5(b)}$

Here, it only said tearing through free edges.

$\therefore$ need to check ~~n~~ only [bearing strength.]

for the double channel, $t = 0.387 \times 2 = 0.774''$

gusset plate, $t = 3/4'' = 0.75''$

$\therefore$ ~~channel~~ gusset plate will fail.

edge hole:

$L_c = \cancel{1.25} \; 1 - (7/8 + \frac{1}{16}) \times \frac{1}{2} = \cancel{0.0625}'' \; 0.53$

bearing strength $= \frac{1.2 L_c t F_u}{\Omega} \le \frac{2.4 d t F_u}{\Omega}$

$= \cancel{1.6875} \; 14.34 \le 47.25$

$= 14.34^k$ /hole.

other hole:

$L_e = 2.5 - (7/8 + 1/16) = 1.5625$

bearing strength $= \frac{1.2 \times 1.5625 \times 0.75 \times 60}{2} \le \frac{2.4 \times 7/8 \times 3/4 \times 60}{2}$

$= 42.1875 \le 47.25$

$= 42.1875^k$ /hole.

$\therefore$ Bearing strength $= 3 \times 14.34 + 6 \times 42.1275$

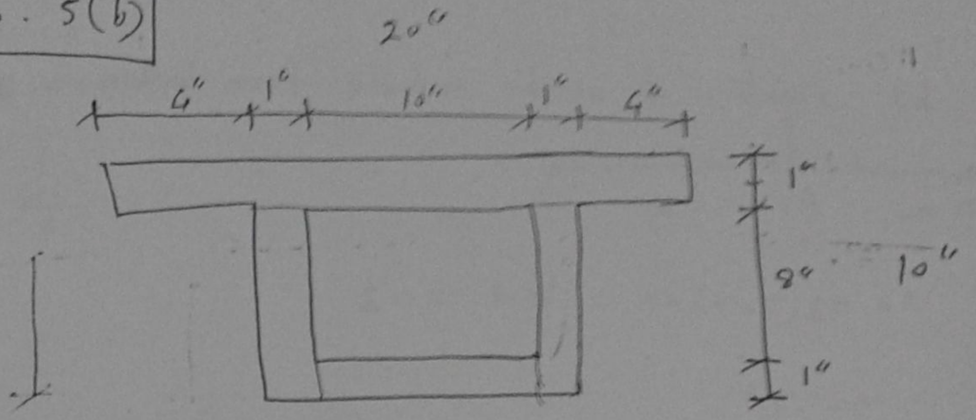
$= 296.15^{k}$.

$DL + LL = 296.15^{k}$

$\therefore \boxed{DL = 56.15\,K}$

confirm

$\boxed{2015\text{-}06.\ 5(b)}$



$$\text{Shape Factor} = \frac{\text{Plastic moment}}{\text{yield moment}} = \frac{M_p}{M_y} = \frac{f_y Z_x}{f_y S_x} = \frac{Z_x}{S_x}$$

$$Z_x = \int y \, dA \,, \qquad S_x = \frac{I_x}{c}$$

Now, $\cancel{\bar{y} = \frac{20\times1+9\times1\times2+10\times1}{\times2}}$

$$\bar{y} = \frac{20\times9.5+9\times4.5+10\times0.5}{20+9\times2+10\times1} = 5.75'' \text{ (from bottom)}$$

$$I_x = \frac{20\times1^3}{12} + 20\times(4.25-0.5)^2 + \frac{1\times9^3}{12}\times2 + 2\times9\times(4.5-5.75)^2$$

$$+ \frac{10\times1^3}{12} + 10\times(5.75-0.5)^2$$

$$= 709 \text{ in}^4.$$

$$\therefore S_x = \frac{I_x}{c} = \frac{709}{5.75} = 123.3 \text{ in}^3.$$

$\cancel{\text{Now, } Z_x = 20\times(4.25-0.5) + 2\times9\times(4.5-5.75-4.5)}$

$\cancel{+ 10\times(5.75-0.5)}$

Now, let location of plastic centroid from bottom $= x$.

Now, $A_1 = A_2$

$$\Rightarrow 20 + 2(7-x)\times 1 = 10 + x \times 2$$

$$\therefore x = 7^{\circ}$$

$$\therefore Z = 20\times(3-0.5) + \cancel{2\times(7-6.5)}\ 7\times + 10\times(7-0.5)$$

$$+ 2\times 2\times(2-\cancel{0.5}\,1) + 2\times 7\times(7-\cancel{4.5}\,3.5)$$

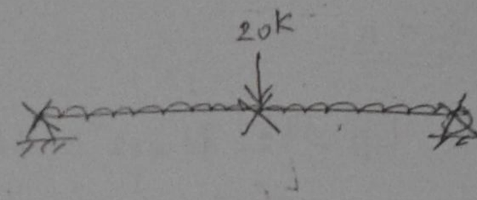
$$\cancel{2\times 7\times 1\times 3.5 + 10\times 2\times 1\times 1}$$

$$= 168$$

$$\therefore \text{Shape factor} = \frac{168}{123.3} = \boxed{1.3625}$$

$\boxed{2015-16 \quad 6(b)}$

W 18 × 106



$M = \frac{PL}{4} + \frac{wL^2}{8}$

FLB:

$\lambda = \frac{b_f}{2t} = \frac{11.2}{2 \times 0.94} = 5.96$

$\lambda_p = 0.38\sqrt{\frac{E}{F_y}} = 10.78.$

$\therefore \lambda < \lambda_p \rightarrow$ compact section.

$\therefore M_x = M_p = F_y Z_x \leq 1.5 M_y$

$= 36 \times 230 \leq 1.5 \times 36 \times 204$

$= 8280$ k-in

WLB:

$\frac{h}{t_w} = \frac{18.73 - 3 \times 0.94}{0.59} = 26.97.$

$\lambda_p = 3.76\sqrt{\frac{E}{F_y}} = 106.7$

$\therefore \frac{h}{t_w} < \lambda_p \rightarrow$ compact section.

$\therefore M_x = 8280$ k-in.

LTB:

$$L_b = 20\ ft \times 12 = 240$$

$$L_p = 1.76\ r_y \sqrt{\frac{E}{F_y}}$$

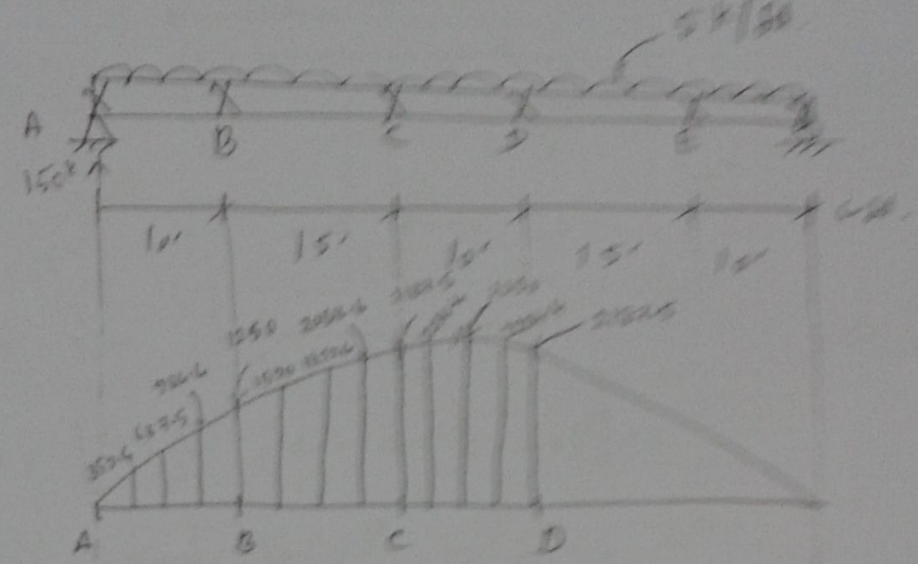
$$= 1.76 \times 2.66 \sqrt{\frac{29 \times 10^3}{36}} = 132.87$$

$\cancel{\therefore L_b < L_p \rightarrow com}$

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

$$= 1.95 \times 7.84$$

$\boxed{2005\text{-}06.\ 8(a)}$



Segment AB:

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

$$= \boxed{1.58}$$

Segment BC:

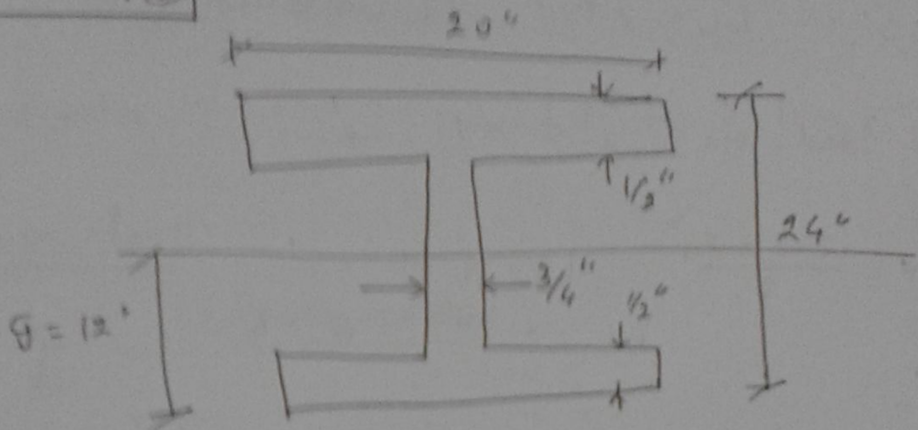
$$\boxed{C_b = 1.146}$$

Segment CD:

$$\boxed{C_b = 1.003}$$

2006-07. 3(b) → proper data not given.

2006-07. 4(b)



$$I_{xx} = \left[\frac{20\times0.5^3}{12} + 20\times0.5\times(12-0.5)^2\right]\times2 + \frac{3/4\times23^3}{12} = 3406\ in^4.$$

$$S_x = \frac{I_x}{c} = \cancel{0.96}\ 283.8$$

$$Z_x = 20\times0.5\times(\cancel{12-0.5}\ 12-0.25)\times2 + \tfrac{3}{4}\times11.5\times\left(\frac{11.5}{2}\right)\times2$$

$$= 336.2$$

$$\therefore \text{Shape factor} = \frac{Z_x}{S_x} = \boxed{1.18}$$

$\boxed{2006-07.\ 4(c)}$

W21×44. $LL = 2\ k/l$, $DL = 0.5\ k/ft$.

$\therefore$ Total load, $w_u = 2.5\ k/l$

$$\text{moment} = \frac{2.5 \times 24^2}{2} = 180\ k\text{-}ft.$$

FLB:

$$\lambda = \frac{b_{f}}{2t_f} = 7.2$$

$$\lambda_p = \cancel{0.23}\ 0.38\sqrt{\frac{E}{F_y}} = 9.15$$

$\therefore \lambda < \lambda_p \rightarrow$ section is compact.

$$\therefore M_n = M_p \le 1.5 M_y$$
$$= F_y Z_x \le 1.5\ F_y S_x$$
$$= 50 \times 95.4 \le 1.5 \times 50 \times 81.6$$
$$= 4770\ k\text{-}in$$

WLB:

$$\lambda = \frac{h}{t_w} = \frac{d - 3t_f}{t_w} = \frac{20.66 - 0.45 \times 3}{0.35} = 55.17.$$

$$\lambda_p = 3.76\sqrt{E/F_y} = \cancel{12.3}\ 90.55$$

$\cancel{\lambda_r =}$

$\therefore M_n = 4770\ k\text{-}in. = 397.5$

Since, continuous lateral supports, LTB doesn't control

~~Moment < M_n~~

$$M_{allowable} = \frac{M_n}{1.67} = 238 \text{ k-ft} > M_u \rightarrow \text{o.k.}$$

Shear check:

$$\frac{h}{t_w} = \frac{\cancel{20.66 - 2 \times 3 \times 0.645}}{} \; 55.17$$

$$2.24\sqrt{\frac{E}{F_y}} = 53.94$$

Deflection check:

$$\Delta_{max} = \frac{5wL^4}{384EI} = \cancel{\frac{5 \times 2.5 \times (24 \times 12)^4}{384 \times 29 \times 10^3 \times 843}} =$$

$$= \frac{5 \times 2.5 \times 24^4}{384 \times 29 \times 10^3 \times 144 \times 843 \times \frac{1}{144^2}}$$

$$= 0.0636'$$

$$\Delta_L = \frac{L}{240} = 0.1$$

$\therefore \Delta_{max} < \Delta_L \rightarrow$ o.k. for deflection.

$\boxed{2007-08, 3(c)}$

$DL = 0.75\ K/'$, $LL = 1\ K/'$, Total load $= 1.75\ K/'$

Moment, $M_u = \dfrac{1.75 \times 25^2}{2} = 136.72\ K\text{-ft}.$

Assume, the section is fully compact.

$\therefore M_n = M_p = \phi F_y Z_x$

$M_{allowable} = \dfrac{M_n}{\Omega} = M_u$

$\Rightarrow \dfrac{F_y Z_x}{1.67} = 136.72 \times 12$

$\therefore Z_x \geq 76.1\ in^3.$

Select W 12×53 section ($Z_x = 77.9\ in^3$).

<u>FLB check:</u>

$\lambda = \dfrac{b_f}{2t_f} = 8.7.$

$\lambda_p = 0.38\sqrt{E/F_y} = 10.78$

$\because \lambda < \lambda_p \longrightarrow$ compact w.r.t FLB. $\Rightarrow$

So, assumtion is corrнадо.

WLB check:

$$\frac{h}{t_w} = \frac{d - 3t_f}{t_w} = \frac{12.06 - 3 \times 0.575}{0.345} = 29.96$$

$$3.76\sqrt{\frac{E}{F_y}} \approx 106.7$$

$$\therefore \frac{h}{t_w} < 3.76\sqrt{E/F_y} \rightarrow \text{section is compact} \longrightarrow \text{o.k.}$$

Shear check:

$$h/t_w = 29.96$$

$$2.24\sqrt{E/F_y} = 63.57$$

$$\therefore h/t_w < 2.24\sqrt{E/F_y} \longrightarrow \text{o.k.}$$

Now, $V_n = 0.6\, F_y A_w = 0.6 \times 36 \times d \times t_w = 0.6 \times 36 \times 12.06 \times 0.345$

$$= 89.87.$$

$\therefore$ Allowable shear, $* = \dfrac{V_n}{1.5} = 59.91^k$.

$$V_u = \frac{1.75 \times 25}{2} = 21.9^k. \quad < 59.91 \longrightarrow \text{o.k.}$$

Deflection check:

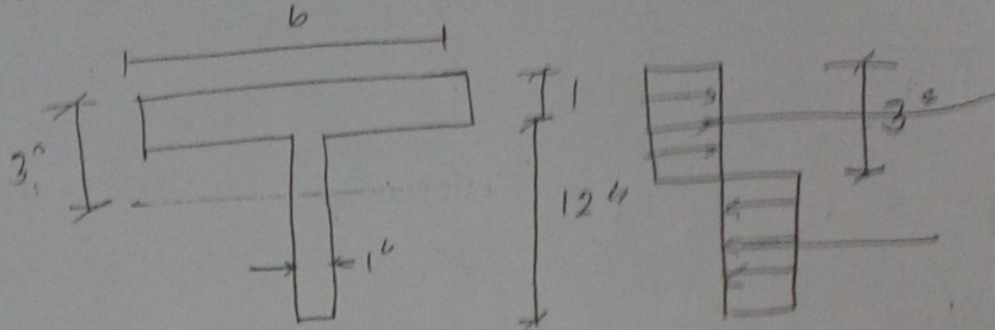
$$\Delta_{max} = \frac{5wL^4}{384\,EI} = \frac{5 \times 1.75 \times 25^4 \times 144^2}{384 \times 29 \times 10^3 \times 425} = 0.104$$

$$\Delta_L = \frac{L}{240} = \cancel{1.25}\ \cancel{0.20}\ 0.1042$$

$$\Delta_{max} < \Delta_L \longrightarrow \text{o.k.}$$

$\boxed{2007\text{-}08.\ 7(b)}$

$M_p = 2820\ k\text{-}in.$

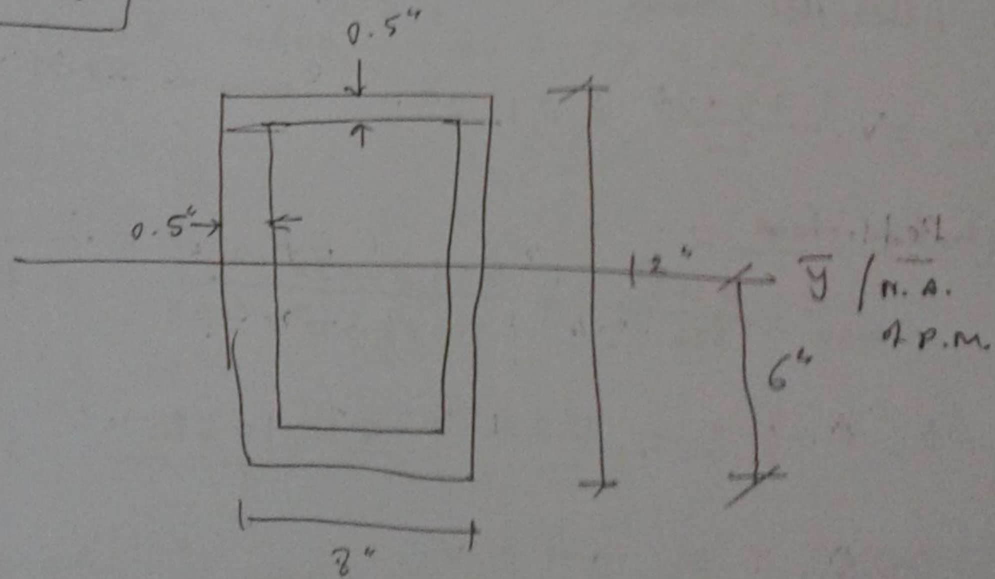


$Area = b \times 1 + 2 \times 1 = 2 + b.$

$$\therefore F_y \times (2+b) \times \cancel{1.25}\,(1.5+5) = 2820$$

$$\therefore \boxed{b = 9.02"}$$

$\boxed{2007\text{-}08.\ 7(c)}$



$I = \cancel{12^3} \; \frac{8\times12^3}{12} - \frac{7\times11^3}{12} = 375.6 \text{ in}^4.$

$S_x = \frac{I}{y} = \frac{375.6}{6''} = 62.6$

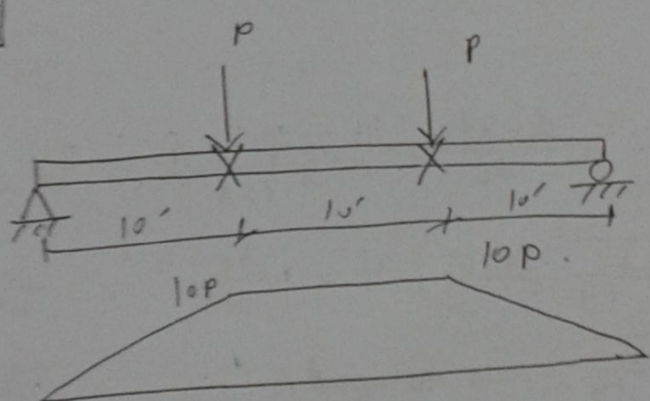
$Z_x = 2\times\left[8\times0.5\times(6-0.25) + 5.5\times0.5\times2\times(\cancel{6}\; 5.5/2)\right]$

$= 76.25.$

$\therefore$ shape factor $= \frac{Z_x}{S_x} = \boxed{1.218}$.

$\boxed{2008-09 \rightarrow 3(c)}$ → done before (simillar).

$\boxed{2008-09.\ 4(b)}$



W 10×112.

FLB:

$$\lambda = \frac{b_f}{2t_f} = 4.2$$

$$0.38\sqrt{\frac{E}{F_y}} = 10.785$$

$\because \lambda < 0.38\sqrt{E/F_y} \longrightarrow$ compact section.

$$M_n = M_p \leq 1.5 M_y$$

$$= 36 \times 147 \leq 1.5 \times 36 \times 126$$

$$= 5292 \text{ k-in}$$

WLB:

$$\lambda = \frac{h}{t_w} = \frac{d - 3t_f}{t_w} = \frac{11.36 - 3 \times 1.25}{0.755} = 10.08$$

$$3.76\sqrt{\frac{E}{F_y}} = 106.7$$

$\lambda < 3.76\sqrt{\frac{E}{F_y}} \longrightarrow$ compact.

LTB:

$$L_b = 10' = 10 \times 12 = 120''$$

$$L_p = 1.76\, r_y \sqrt{\frac{E}{F_y}} = 1.76 \times 2.68 \times \sqrt{\frac{29 \times 10^3}{36}}$$

$$= 133.87''$$

$L_b < L_p \longrightarrow$ compact.

$\therefore M_n = M_p = 5292$ k-in.

$$M_{allowable} = \frac{5292}{1.67} = 10 \times 12 \times P$$

$$\therefore \boxed{P = 26.4^k}$$

$\boxed{\text{2009-10.2(a)}}$

Flange, $\dfrac{b_f}{2t_f} = \dfrac{10}{2 \times 3/8} = 13.33$ (top-flange)

or, $\dfrac{b_f}{2t_f} = \dfrac{16}{2 \times 3/8} = 21.33$ (Bottom flange).

$$0.56\sqrt{\frac{E}{F_y}} = 15.89$$

$\therefore$ Bottom flange will have local buckling.

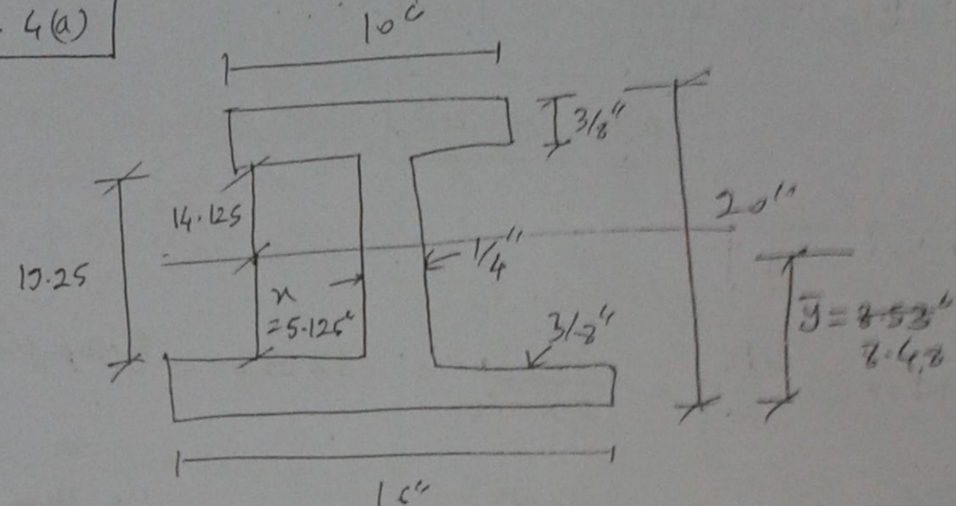
web, $\dfrac{h_w}{t_w} = \dfrac{d - 3t_f}{t_w} = \dfrac{20 - 3/8 \times 32}{1/4} = \cancel{75.5}\ 77$

$$1.49\sqrt{E/F_y} = 42.29$$

$\therefore \dfrac{h_w}{t_w} > 1.49\sqrt{E/F_y} \longrightarrow$ so, web will have local buckling.

$\boxed{2009 - 10.\ 3(b)}$ → you have to manually calculate I_x & S_x.

$\boxed{2009-10.\ 4(a)}$



$\bar{y} = \cancel{12 \times 3/8 + 16 \times 3}$

$$\bar{y} = \frac{10 \times 3/8 \times (\cancel{12.25}\ 20 - 3/16) + 12.25 \times 1/4 \times (\frac{12.25}{2} + 3/8) + 16 \times 3/8 \times (3/16)}{10 \times 3/8 + 16 \times 3/8 + 12.25 \times 1/4}$$

$\cancel{= 8.53"}$

$= 8.48"$

$$I_y = \frac{16 \times 0.375^3}{12} + 16 \times 0.375 \times (\overset{8.48}{\cancel{8.53}} - 0.375/2)^2$$

$$+ \frac{1/4 \times 12.25^3}{12} + (\overset{8.48}{\cancel{8.53}} - 3/8 - \frac{12.25}{2})^2 \times 0.25 \times 12.25$$

$$+ \frac{10 \times 0.375^3}{12} + 10 \times 0.375 \times (11.52 - 3/16)^2$$

$= 1049.8\ in^4.$

$$S_x = \frac{1048.8}{11.52} = \boxed{91.04}$$

$$10 \times 3/8 + (19.25 - x) \times 1/4 = x \times 1/4 + 16 \times 3/8 \quad \ldots (i)$$

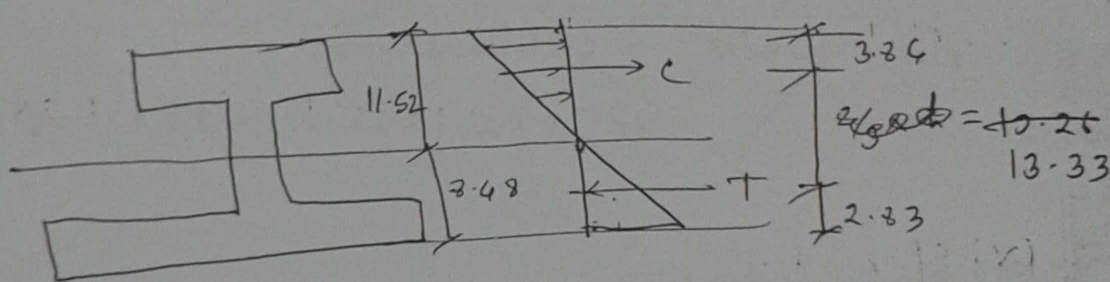
$$x = 5.125''$$

$$\therefore Z_x = \int y\,dA = 16 \times \frac{3}{8} \times (5.125 + 0.1875) + 5.125 \times 1/4 \times \frac{5.125}{2}$$

$$+ 14.125 \times 1/4 \times \frac{14.125}{2} + 10 \times \frac{3}{8} \times (14.125 + 0.1875)$$

$$= 113.77 \text{ in}^3$$

~~Step~~ (iii) Yield moment:



$$C = \left(10 \times \frac{3}{8} + (11.52 - \frac{3}{8}) \times 1/4\right) \times \frac{36}{2}$$

$$= 117.65.$$

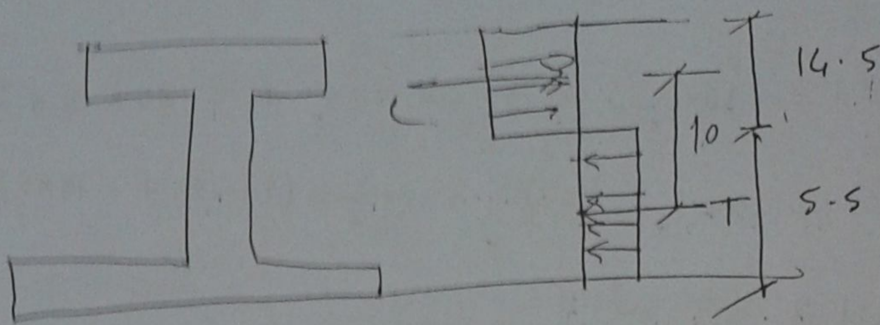
$\therefore$ ~~Plastic m~~

Yield moment = C × moment arm

$$= 117.65 \times 13.33$$

$$= \boxed{1568 \text{ k-in}}$$

(iv) plastic moment:



$C = (10 \times 3/8 + 14.125 \times 1/4) \times 36 = 262.125$.

$\therefore$ plastic moment $= C \times$ moment arm

$= 262.125 \times 10 = \boxed{2621.25 \text{ kin}}$

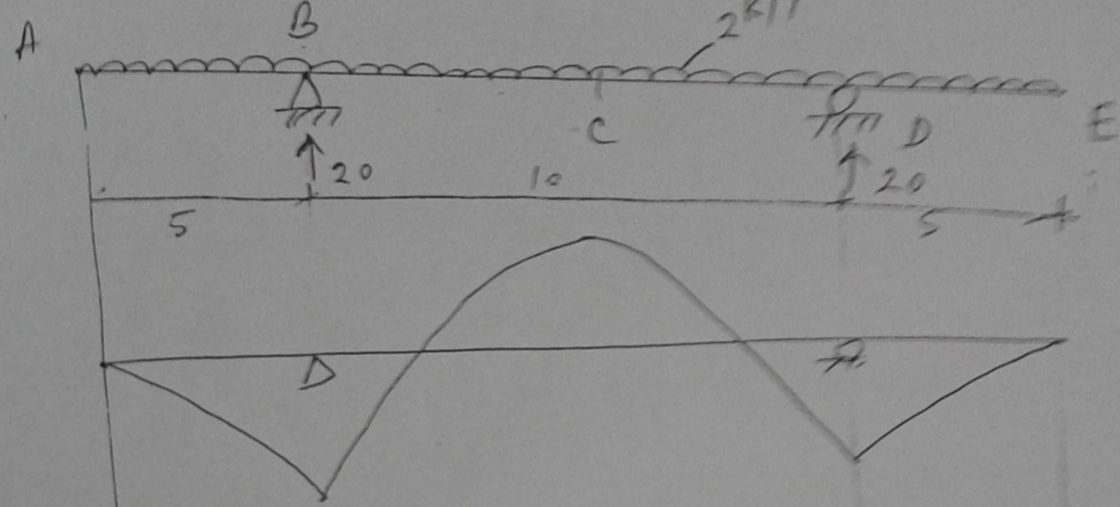
(v) shape factor:

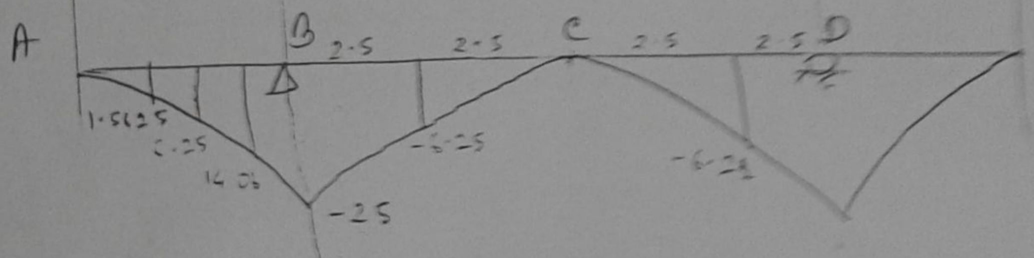
$= \frac{M_p}{M_y} = 1.67$

2009-10. 4(b) → simillar.

$\boxed{\text{2010-11. 3 (b) \& (d)}}$ → simillar.

2010-11. 4(b)





For segment AB / DE

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

$$= \boxed{2.326}$$

For segment BD:

$$C_b = \frac{12.5 \times 25}{2.5 \times 25 + 3(6.25 + 6.25) + 0} \le 3$$

$$= 3.125 \le 3$$

$$= \boxed{3}$$