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Subject : steel structure

Submitted to :

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Problem No 1

Given data :

Lightest W-shape column

A-36 steel

DL = 60 k

L.L = 110 K

Pin supported at top and bottom

$K_x L_x$ = 36 ft

$K_y L_y$ = 18 ft

AISC / LRFD

Sol :

Required Capacity =

$$(1.2 \times 60) + (1.6 \times 10) = 248\,k$$

design strength table of manual with KL = 18 ft and p = 248K

⟹ some section are

$W_{14} \times 61$ $P = 364$ $r_x/r_y = 2.44$

$W_{12} \times 53$ $P = 320$ $r_x/r_y = 2.11$

$W_{10} \times 49$ $P = 301$ $r_x/r_y = 1.71$

$W_8 \times 58$ $P = 300k$ $r_x/r_y = 1.74$

Now

$$\frac{K_x L_x}{K_y L_y} = \frac{36}{18} = 2$$

$W_{12} \times 53$ $r_x/r_y = 2.11$

$$r_x/r_y > \frac{K_x l_x}{K_y l_y}$$

$r_x = 5.23$ $r_y = 2.48$ $A = 15.6\ in^2$

$$\frac{K_x l_x}{r_y} = \frac{18 \times 12}{2.48} = 87.09$$

$$\frac{KL}{r} = 87.09$$

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$$\lambda_c = \frac{KL}{r_x} \sqrt{\frac{F_y}{E}}$$

$$= \frac{87.09}{\pi} \sqrt{\frac{36}{29,000}}$$

$$= 0.97 < 1.5$$

$$F_{cr} = 0.658^{\lambda_c^2} \times F_y$$

$$= 0.658^{(0.97)^2} \times 36$$

$$F_{cr} = 24.28$$

$$P_n = A_g F_{cr}$$

$$= 15.6 \times 24.28$$

$$P_n = 378.78 \text{ K}$$

$$\phi P_n = 0.85 \times 378.78$$

$$= \boxed{321.96 > 248 \text{ K}}$$

OK

So use $W_{12} \times 53$

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Problem No 2

Given data :-

Lightest W = section

$DL = 1.5\,K$

$L.L = 4.5\,K$

(At each quater point)

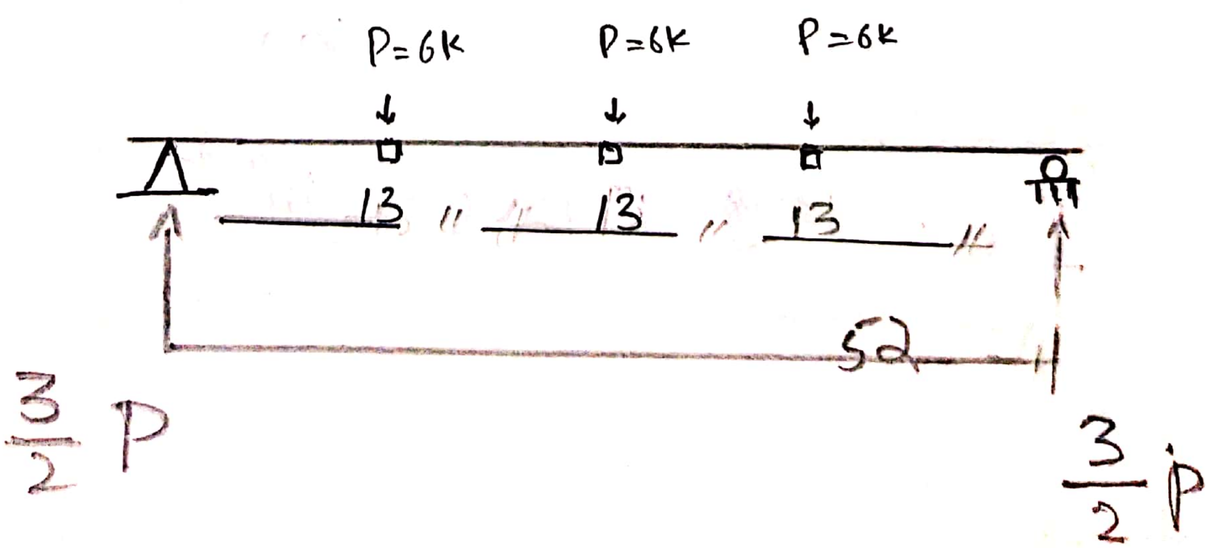
→ Total length = 52

→ Live load deflection Δ_{Lim} = $\frac{1}{360}$ of Spam

$F_y = 36\,ksi$

AISC / ASD.

Sol :-



design load $= 4.5 + 1.5 = 6K$

$P = 6K$

$$\Delta = \frac{5}{48} \frac{ML^2}{EI} \quad \text{— } (1)$$

Δ by this equation is multiplied by the factor from table 5.4

$$M = \left(\frac{3}{2} \times 6 \times 26\right) - (6 \times 13)$$

$$= 156 \text{ k·ft}$$

$$\text{eq } (1) \Rightarrow I = \frac{5}{48} \times \frac{ML^2}{E\Delta} \times 0.95$$

$$I = \frac{5}{48} \frac{(56 \times 12)(52 \times 12)^2}{29,000 \left(\frac{52}{360} \times 12\right)}$$

$$\boxed{I = \cancel{1871}\ 1510.51 \text{ in}^4 \times 0.95}$$

$$I = 1434.98 \text{ in}^4$$

Try $W_{24} \times 62$ ②

$I_x = 1550 \ in^4$

$b_f = 7.04 \ in$

$\frac{d}{A_f} = 5.72$

$$L_c = \frac{76 b_f}{\sqrt{F_y}}$$

$$\frac{76 \times (7.04}{\sqrt{36}} = 89'' = 7.14'$$

$$L_c = \frac{20000}{F_y \frac{d}{A_F}} \Rightarrow \frac{20,000}{36 \times 5.72}$$

$$= 97.12'' \doteq 8.09'$$

$L > L_c$ from table 5.2

$C_b = 1.13$

$$\sqrt{\frac{102,000 \ C_b}{F_y}} = \sqrt{\frac{102,000 \times 1.13}{36}}$$

$$= 127$$

$$\frac{L}{\gamma T} = \frac{13 \times 12}{1.71} = 91.22$$

Condition

$$\sqrt{\frac{102{,}000\ cb}{Fy}} \le \frac{L}{\gamma T} \le \sqrt{\frac{102{,}000\ cb}{Fy}}$$

So

$$Fb = \left[\frac{2}{3} - \frac{Fy\left(\frac{L}{\gamma T}\right)^2}{1530 \times 10^3 \times cb}\right] Fy$$

$$= \left[\frac{2}{3} - \frac{36\,(91.22)^2}{1530 \times 10^3 \times 1.13}\right] Fy$$

$Fb = 17.76$ ksi allowable

The beam self wt

$$= 62\ \frac{lb}{ft} = 0.062\ \frac{k}{ft}$$

$$M = \frac{WL^2}{8} = \frac{1}{8}(0.062)(52)^2$$

$$M = 20.95 \text{ Kft}$$

Total $M = 156 + 20.95$

$M = 176.95$

$$F_b = \frac{M}{S_x} \Rightarrow \frac{176.95 \times 12}{131} = 16.2 \text{ ksi}$$

$F_b < f_b$ OK

$\boxed{\text{Use } W24 \times W62}$

Problem NO 3

Given data :-

$D.L = 50K$

$L.L = 150K$

Bolt Dia = $3/4''$

Length = 18 ft

Connecting type = Bearing

ASD Method

Required data :-

Design A36 Steel double angle tension member

Solution :-

Total load = $D.L + L.L$

$= 50 + 150$

$= 200K$ or $\frac{100K}{Angle}$

For yielding at the grass area allowable stress are

$0.6\ F_y = 0.6 \times 36$

$= 22$ ksi

→ For Fracture at the net area allowable stress are

$0.5\ F_u = 0.5 \times 58$

$= 29$ ksi

→ Since the connection in bolted so angle

$A_g \neq A_n$

Now = $A_e = 0.85 A_n$

→ For yielding

$A_g \times 22 = 100$

$A_g = \frac{100}{22}$

$A_g = 4.54\ in^2$

For fracture

$$29 \times A = 100$$

$$Ae = 3.44 \text{ in}^2$$

$$An = Ae/0.85$$

$$= 3.44/0.85 = \boxed{4.04 \text{ in}^2}$$

→ Assume 15 % duction in gross area for holes

So, $Ag = \frac{An}{0.85} \Rightarrow Ag = \frac{4.04}{0.85}$

$$\boxed{Ag = 4.76 \text{ in}^2}$$

For $L\,4 \times 4 \times \frac{5}{8}$ $Ag = 4.61$ ~~ok~~ ≈ 4.76 ok

$r_x = 1.20$ $r_y = 1.20$ with $3/8$ in gusset plate

$$\frac{l}{r_{min}} = \frac{18 \times 12}{1.20} = 180 \leq 300\text{k}$$

OK

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Bolt design::

Using A325 ~~bolts~~ with threads included in shear plate as

dia = 3/4"

$$Area = \frac{\pi}{4}(d)^2 \Rightarrow \pi/4\,(0.75)^2$$

$$\boxed{A = 0.441\ in^2}$$

Allowable bolts shear = 21 ksi

Since bolts are in double shear

So allowable shear per bolt =

$$2 \times 21 \times 0.44 = 18.5\ k$$

Allowable bolt ~~sh~~ bearing stress =

$$1.2\ Fu = 1.2 \times 58 = 69.6\ k$$

Allowable bearing on two 5/8" thick angle

$$\text{long legs} = 69.6 \times 2 \times \frac{5}{8} \times 0.75 = 65.25$$

$$> 18.5$$

So shear governs

No of bolts $= \frac{200}{18.5} = 10.81$

use of bolts

design of gusset plate

⇒ Bearing stress $= 1.2\,F_u$

$= 1.2 \times 58 = 69.6$ ksi

So

⇒ Allowable bearing $= 69.6 \times 10 \times 0.75 \times t = 200$

$t = 0.38$ in

Use $3/4''$ G.P

Checking various limit states

⇒ yielding $= 0.6\,F_y\,A_g$

$= 0.6 \times 36 \times (8 \times 0.75)$

$129.6\,k < 200\,k$

Not ok

Try $L7 \times 4 \times 1/2$ $A_g = 5.25$

$r_x = 2.25$ $r_y = 1.11$ with $3/8$" G.P

$$\frac{L}{r_{min}} = \frac{18 \times 12}{1.11} \quad 194.59 \leq 300k$$

OK

Allowable bearing on two $1/2$" thick angle long legs $= 69.6 \times 2 \times 1/2 \times 0.75$

52.2 ~~7~~ 18.5

so shear govern

→ checking various Limit State

→ Yielding $= 0.6 F_y A_g$

$= 0.6 \times 36 \times (14 \times 0.75)$

$= 226.8 > 200k$ OK

→ Fracture $=$

$0.5 \times F_u \times A_e$

$0.5 \times 58 \times 0.85 \left[14 - (3/4) \times 2\right] \times 3/4$

$= 231k > 200k$ OK

Check for tearing failure

$$L_e = \frac{2P}{F_u t}$$

$$1.25 = \frac{2P}{58 \times 0.5}$$

$$(1.25)(58 \times 0.5) = 2P$$

$$P = 18.125\ K$$

$$L = \frac{2P}{F_u t} + \frac{d_b}{2}$$

$$2 = \frac{2P}{58 \times 0.5} + \frac{3/4}{2}$$

$$2 \times (58 \times 0.5) = 2P + 0.375$$

$$116.1 - 0.375 = 2P$$

$$115.72 = 2P$$

$$P = 57.86\ K$$

= Capacity since 10 bolts and five bolts per row $2 \times 18.125 \times 8 \times$

$2 \times 18.125 + 8 \times \cancel{87}_{57}.86$

$499.13\,K > 200\,K$

$\underline{\underline{OK}}$

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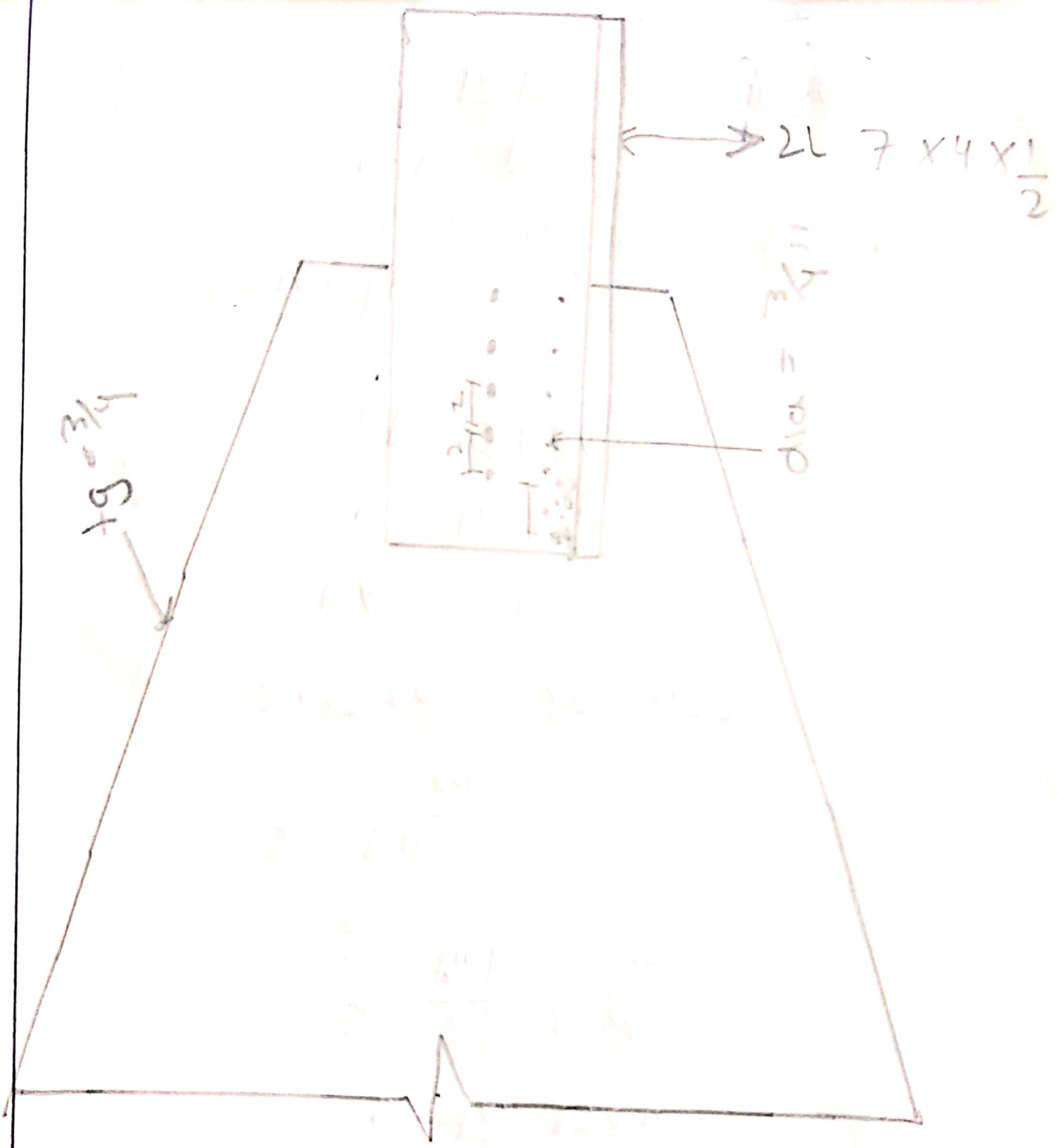
2L 7 x 4 x 1/2
dia = 3/4"
tg = 3/4