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Section	A
Subject	Steel structure
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Problem No #1

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 Method

Solution :-

Required capacity = (1.2x 60)+(1.6x110)

= 248 K

Enter design strength table of manual with KL = 18 ft

and P = 248 k

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

$$\frac{k_x L_x}{k_y l_y} = \frac{36}{18} = 2$$

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

$$r_x / r_y > \frac{k_x l_x}{k_y l_y}$$

$r_x = 5.23$ $\quad r_y = 2.48$ $\quad A = 15.6 \text{ in}^2$

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

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

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

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

$$= 0.97 < 1.5$$

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

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

$$F_{cr} = 24.28$$

$$P_n = A_g F_{cr}$$

$$= 15.6 \times 24.28$$

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

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

$$= 321.96 > 248 \text{ k}$$

ok

$$\boxed{\text{So use } W_{12} \times 53}$$

Question No # 2)

Given that :-

Lightest W = section

⇒ D.L = 1.5 K L.L = 4.5 K

(At each quater point)

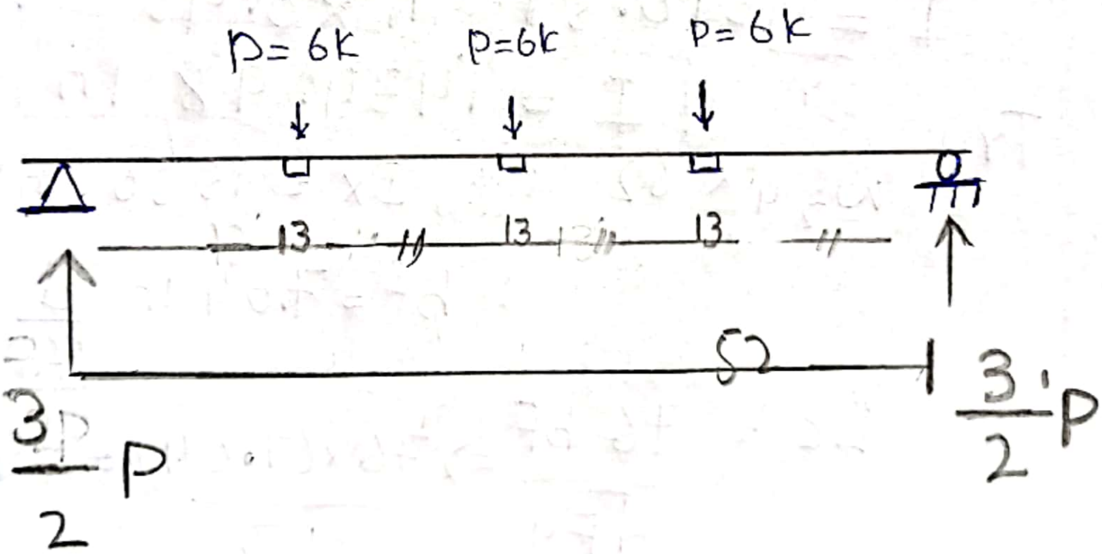
→ Total length = 52

→ Live load deflection = $\frac{1}{360}$ of span

ΔLim

→ F_y = 36 ksi

AISC | ASD Method



Solution :-

Design load = 4.5 + 1.5 = 6 K

P = 6 K

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

(5)

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

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

$$= 156 \text{ k.ft}$$

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

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

$$I = 1510.51 \text{ In}^4 \times 0.95$$

$$\boxed{I = 1434.98 \text{ In}^4}$$

Try $W_{24} \times 62$, $I_x = 1550 \text{ In}^4$

$b_f = 7.04$ In $\frac{d}{A_F} = 5.72$

$$L_c = \frac{76\, b_f}{\sqrt{F_y}} \Rightarrow \frac{76 \times (7.04)}{\sqrt{36}} = 89'' = 7.14'$$

$$L_c = \frac{20000}{F_y \frac{d}{A_F}} \Rightarrow \frac{20{,}000}{36 \times 5.72} = 97.12'' = 8.09'$$

$L > L_C$ from table 5.2

$cb = 1.13$

$$\sqrt{\frac{102,000\ cb}{Fy}} = \sqrt{\frac{102,000 \times 1.13}{36}} = 57$$

$$\sqrt{\frac{510,000\ cb}{Fy}} = \sqrt{\frac{510,000 \times 1.13}{36}} = 127$$

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

Condition

$$\sqrt{\frac{102,000\ cb}{Fy}} < \frac{L}{r_T} < \sqrt{\frac{510,000\ cb}{Fy}}$$

So

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

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

$Fb = 17.76$ ksi allowable

The beam self weight

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

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

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

Total $M = 156 + 20.95$

$$M = 176.95$$

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

$$F_b < F_b \quad ok$$

$$\boxed{\text{Use } W_{24} \times W_{62}}$$

Question # 3

Given data

D.L = 50 K

L.L = 150 K

Bolt Dia = 3/4"

Length = 18 ft

Connection Type = Bearing

ASD Method

Required :-

Design A36 Steel double angle Tension Member

Solution :-

Total load = D.L + L.L

= 50 + 150

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

⇒ For yielding at the grass area allowable stress are

$$0.6\,F_y = 0.6 \times 36$$

$$= 22 \text{ ksi}$$

→ For Fracture at the net area allowable stress are

$$0.5\,F_u = 0.5 \times 58$$

$$= 29 \text{ Ksi}$$

→ Since the connection in bolted so

$$A_g \neq A_n$$

Now $A_e = 0.85\,A_n$

For yielding

$$A_g \times 22 = 100$$

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

$$A_g = 4.54 \text{ in}^2$$

For Fracture

$$29 \times A_e = 100$$

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

$$A_n = \frac{A_e}{0.85} \Rightarrow \frac{3.44}{0.85} \Rightarrow \boxed{A_n = 4.04 \text{ in}^2}$$

⇒ Assume 15% deduction 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 $L\,4 \times 4 \times \frac{5}{8}$ $\quad Ag = 4.61 \propto 4.76$ ok

$r_x = 1.20 \quad r_y = 1.20$ with $\frac{3}{8}$ in Gusset plate

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

ok

Bolt Design

using A325 bolt with thread included in shear plane as

$$\text{dia} = \frac{3}{4}''$$

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

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

Allowable bolt shear = 21 ksi

Since bolt are in double shear

So allowable shear per bolt

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

Allowable bolt bearing stress = $1.2\ F_u$

$= 1.2 \times 58 = 69.6$ ksi

Allowable bearing on two $\frac{5}{8}''$ thick angle

long legs $= 69.6 \times \frac{2}{3} \times 0.75 = 65.25 > 18.5$

So shear govans

Number of bolt $= \frac{200}{18.5} = 10.81$

use 10 bolts

Design of gusset plate:

Bearing stress = $\underline{1.2\ F_u}$

$= 1.2 \times 58 = 69.6$ ksi

So

Allowable bearing

$= 69.6 \times 10 \times 0.75 \times t = 200$

$t = 0.38$ in

Use $\frac{3}{4}''$ G.P

Checking various limit States

Yielding $= 0.6\, F_y\, A_g$

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

$= 129.6K < 200\ K$

note ok

Try $L\, 7 \times 4 \times \frac{1}{2}$ $A_g = 5.25$

$r_x = 2.25$ $r_y = 1.11$ with $\frac{3}{8}''$ G.P

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

ok

Allowable bearing on two $\frac{1}{2}''$ thich angle long leg $= 69.6 \times 2 \times \frac{1}{2} \times 0.75$

$52.2 > 18.5$

So shear governs

So

Cheacking various Limit state

Yielding = $0.6\ F_y A_g$

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

$= 226.8 > 200\ k$ ok

Fracture = $0.5 \times F_u \times A_e$

$= 0.5 \times 58 \times 0.85 \left[14 - \left(\frac{3}{4}\right) \times 2\right] \times \frac{3}{4}$

$= 231\ k > 200$
ok

Check bor tearing Failure

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

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

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

$p = 18.125\ k$

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

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

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

$$116.1 - 0375 = 2p$$

$$115.72 = 2P$$

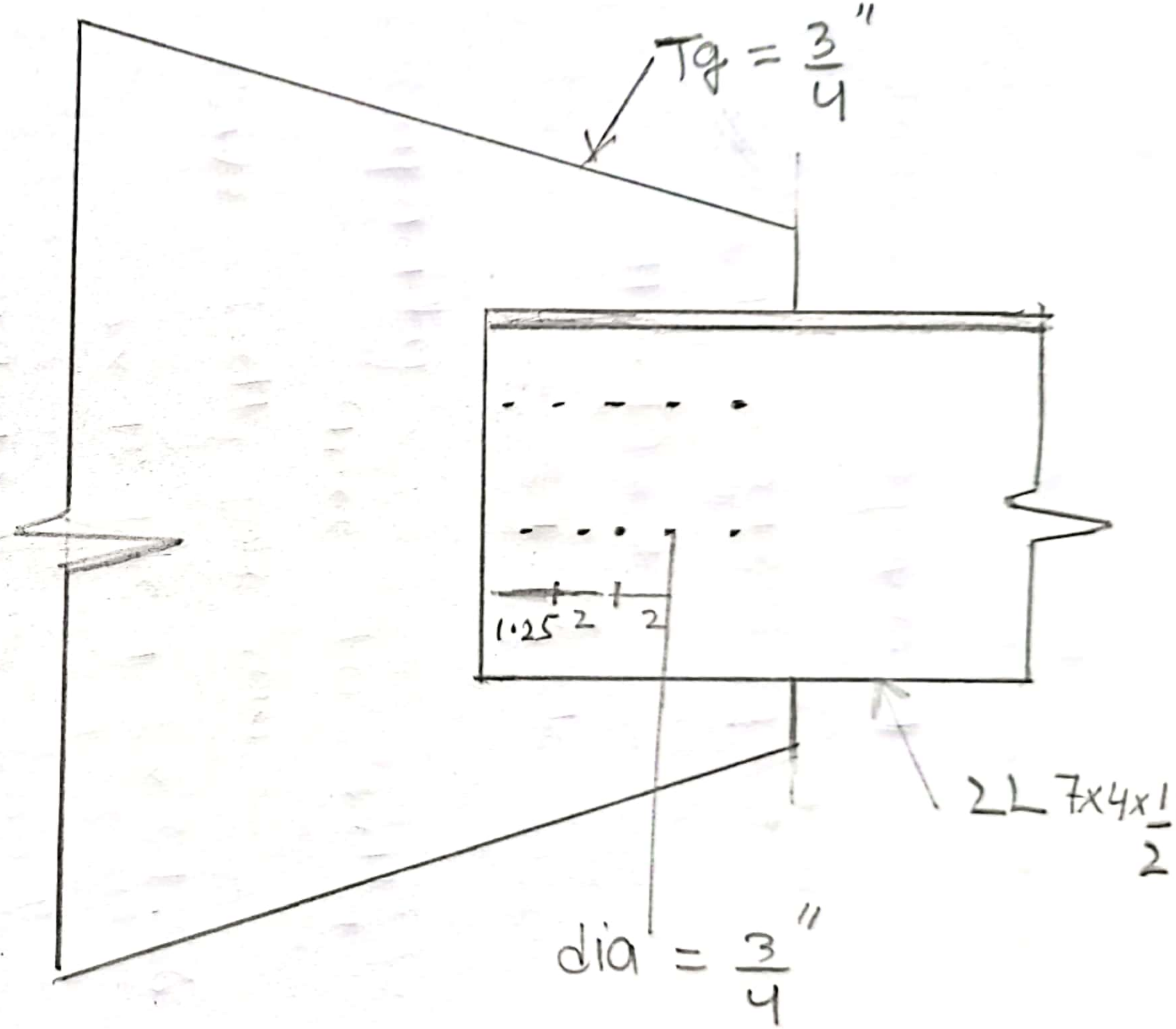
$$P = 57.86 \text{ k}$$

Capacity since 10 bolt & Five bolt per row

$$2 \times 18.125 + 8 \times 57.86$$

$$\boxed{499.13 \text{ k} > 200 \text{ k} \quad \text{ok}}$$

Scanned with CamScanner



Tg = 3/4"
1.25 2 2
2L 7x4x1/2
dia = 3/4"