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Subject Steel structure

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Problem # 1.

Lightest W-shape column. A-36 steel
DL = 60k   L.L = 110k
Pin supported at top and bottom
$K_x L_x = 36ft$ $K_y L_y = 18ft$
AISC/LRFD Method

Solution:-

Required Capacity = $(1.2 \times 60) + (1.6 \times 110)$

= 248K

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

Some possible 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 = 300	$r_x/r_y = 1.74$

Now

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

Try $W_{12\times53}$ $r_x/r_y = 2.11$

$$r_x/r_y > \frac{K_x L_x}{K_y L_y}$$

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

$$\frac{K_x L_x}{r_x} = \frac{36\times12}{5.23} = 82.6$$

$$\frac{K_y L_x}{r_y} = \frac{18\times12}{2.48} = 87.09$$

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

$$\lambda_c = \frac{KL}{r\pi}\sqrt{\frac{F_y}{E}}$$

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

$$= 0.97 < 1.5$$

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

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

$F_{cr} = 24.28$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78K$

$\phi P_n = 0.85 \times 378.78$

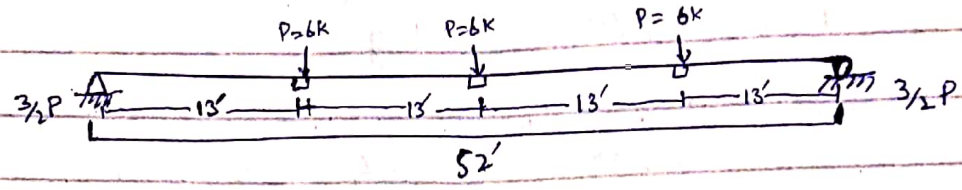
$= 321.96 > 248K$

OK

So

Use $W_{12} \times 53$

Q2:- Given data:-



→ Lightest W- section

D.L = 1.5K L.L = 4.5K
(At each quater point)

→ Total length = 52'
→ Live Load deflection = $\frac{1}{360}$ of span

→ F_y = 36Ksi
AISC/ASD method

Solution:-

Design Load = 4.5 + 1.5 = 6K
P = 6K

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

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

$$M = \left(\frac{3}{2} \times 6 \times 26\right) - (6 \times 13) = 156 \text{ k.ft}$$

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

$$I = \frac{5}{48} \frac{(156 \times 12)(52 \times 12)^2}{29000\left(\frac{52}{360} \times 12\right)}$$

$$\boxed{I = 1510.51 \text{ in}^4}$$

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

$b_f = 7.04 \text{ in}$, $d/A_f = 5.72$

$$L_c = \frac{76 b_f}{\sqrt{F_y}} = \frac{76 \times (7.04)}{\sqrt{36}} = 89'' = 7.41'$$

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

$L > L_c$ from table 5.2

$C_b = 1.13$

$$\Rightarrow \sqrt{\frac{102{,}000 C_b}{F_y}} = \sqrt{\frac{102{,}000 \times 1.13}{36}} = 57$$

$$\Rightarrow \sqrt{\frac{510{,}000 C_b}{F_y}} = \sqrt{\frac{510{,}000 \times 1.13}{36}} = 127$$

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

Condition.

$$\sqrt{\frac{102{,}000\,C_b}{F_y}} \leq \frac{L}{r_T} \leq \sqrt{\frac{510{,}000\,C_b}{F_y}}$$

So

$$F_b = \left[\frac{2}{3} - \frac{F_y (L/r_T)^2}{1530 \times 10^3 \times C_b}\right] F_y$$

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

$F_b = 17.76$ ksi allowable

The beam self weight $= 62 \frac{lb}{ft} = 0.062 \, k/ft$

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

$M = 20.95$ k.ft

Total $M = 156 + 20.95$

$M = 176.95$

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

$f_b < F_b$

OK

Use $W_{24 \times 62}$

—x——x——x——x——x——x——x—

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Q3. Given:-

D.L = 50k

L.L = 150k

Bolts Dia = 3/4"

Length = 18 ft

Connection Type = Bearing

ASD method.

Revuired:-

Design A36 steel double anle tension member.

Solution:-

Total load = D.L + L.L

= 50 + 150

= 200 k or 100k/angle

→ For yielding at the gross area allowable stresses are

$0.6F_y = 0.6 \times 36$

$= 22$ ksi

→ For Fracture at the net area allowable stress are

$0.5F_u = 0.5 \times 58$

$= 29$ ksi

→ Since the connection is 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

$$29 \times A_e = 100$$

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

$$A_n = A_e/0.85 \Rightarrow 3.44/0.85$$

$$\boxed{A_n = 4.04 \text{ in}^2}$$

→ Assume 15% deduction in gross area for holes

So, $A_g = \frac{A_n}{0.85} \Rightarrow A_g = \frac{4.04}{0.85}$

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

For $L_{4\times4\times5/8}$ $A_g = 4.61 \leq 4.76$ ok

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

$$\frac{L}{r_{min}} = \frac{18\times12}{1.20} = 180 \leq 300k \text{ ok}$$

Bolts Design:-

Using A325 bolts with threads included in shear plane as dia = 3/4"

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

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

Allowable bolts shear = 21 ksi

Since bolts are in double shear so,

Allowable shear per bolt = $2 \times 21 \times 0.44 = 18.5k$

Allowable bolt bearing stress = $1.2F_u = 1.2 \times 58 =$ 69.6k

Allowable bearing on two $\frac{5}{8}''$ thick angle long legs = $69.6 \times 2 \times \frac{5}{8} \times 0.75 = 65.25 > 18.5$

So sheer govars

— x — x — x — x — x —

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