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Subject	*Steel Structure*
Assignment	*Final Term*
Semester	*8th*
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Q No 1

Lightest W-shape Column A36 steel.

DL = 60K

LL = 110K

Pin supported at top & bottom

$K_x L_x = 36$ ft $K_y L_y = 18$ ft.

AISC / LRFD Method.

Sol:-

Required Capacity = $(1.2 \times 60) + (1.6 \times 110) = 248K$.

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

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Some possible Sections are

$W14 \times 61 \quad P = 364 \quad r_x/r_y = 2.44$

$W12 \times 53 \quad P = 320 \quad r_x/r_y = 2.11$

$W10 \times 49 \quad P = 301 \quad r_x/r_y = 1.71$

$W8 \times 58 \quad P = 300k \quad r_x/r_y = 1.74$

Now

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

Try $W12 \times 53 \quad r_x/r_y = 2.11$

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

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

$$\frac{K_x L_x}{r_x} = \frac{36 \times 12}{5.23} = 82.6$$

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$$\frac{K_y L_y}{r_y} = \frac{18 \times 12}{2.48} = 87.09$$

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

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

$$= \frac{87.09}{\pi} \sqrt{\frac{36}{29000}}$$

$$= 0.97 < 1.5$$

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

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

$$\boxed{F_{cr} = 24.28}$$

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$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78\,K$

$\phi P_n = 0.85 \times 378.78$

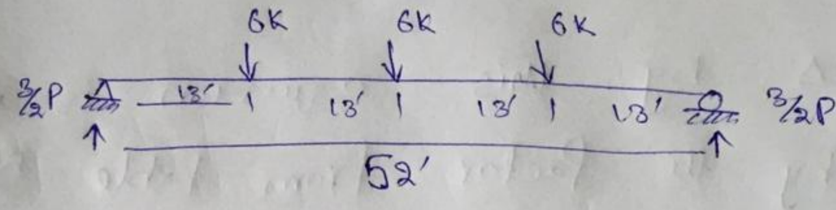
$= 321.96 > 248\,K$

OK

So

Use W12x53

Q 2



⇒ Lightest W– Section.

⇒ D.L = 1.5K   L.L = 4.5K

(At each quarter point).

⇒ Total Length = 52'

⇒ Live Load deflection $= \frac{1}{360}$ of span
Δ_{lim}

⇒ $F_y = 36ksi$ AISC /ASD Method.

Sol:

Design Load = 4.5 + 1.5 = 6K

P = 6K

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

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

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

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

Try W24 x 62

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

$$= \frac{76 \times (7.04)}{\sqrt{36}}$$

$$= 89''$$

$$\boxed{= 7.41'}$$

, $I_x = 1550 \text{ in}^4$

$b_f = 7.04$ in ,

$d/A_f = 5.72$

$$Lc = \frac{20000}{fy \frac{d}{Af}} \Rightarrow \frac{20000}{36 \times 5.72} = 97.12''$$

$$\boxed{Lc = 8.09'}$$

$L > LC$ from table 5.2

$Cb = 1.13$

$$\sqrt{\frac{102000\, cb}{Fy}} = \sqrt{\frac{102000 \times 1.13}{36}} = \underline{\underline{57}}$$

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

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

④.

Condition:

$$\sqrt{\frac{102000\,Cb}{Fy}} \le \frac{L}{r_T} \le \sqrt{\frac{510000\,Cb}{Fy}}$$

So

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

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

$Fb = 17.76$ ksi allowable

The beam self wt $= 62$ lb/ft $= 0.062$ k/ft

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

$$\boxed{M = 20.95\ k.ft}$$

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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

Use W24 x 62

Q3 ①

Given

$D \cdot L = 50K$

$L \cdot L = 150K$

Bolts Dia = $3/4"$

Length = 18 ft.

Connection type = Bearing

ASD Method.

Required:

Design A36 steel double angle tension member.

Sol: Total Load = $D \cdot L + L \cdot L$

$= 50 + 150$

$= 200\ K$ or $100\ K$/Angle.

=> For yielding at the gross area allowable stresses are:

$0.6 F_y = 0.6 \times 36$

$= 22\ ksi$

→ For Fracture at the net area allowable stresses are

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

$$= 29\ ksi$$

→ Since the Connection is bolted so

$$A_g \neq A_n$$

Now $A_e = 0.85\,A_n$

For yielding

$$A_g \times 22 = 100$$

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

$$\boxed{A_g = 4.54\,in^2}$$

For Fracture:

$$29 \times A_e = 100$$

$$A_e = 3.44\ in^2$$

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

⇒ Assume 15% deduction in gross area for holes.

So

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

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

⇒ For $L4 \times 4 \times 5/8$ $A_g = 4.61 \cong 4.76$ OK

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

$$\frac{L}{r_{min}} = \frac{18 \times 12}{1.20} = 180 \leq 300 \text{ k} \quad \text{OK}.$$

Bolts Design:

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

Area = $\pi/4 (d)^2 \Rightarrow \pi/4 (0.75)^2$

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

⇒ Allowable bolts shear - 21 ksi

⇒ Since bolts are in double shear

⇒ So allowable shear bolt = $2 \times 21 \times 0.44 = 18.5k$

⇒ Allowble bolt bearing stress = $1.2 F_u = 1.2 \times 58$

= 69.6 ksi

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

So shear governs

(4) (5)

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

use 10 bolts.

Design of gusset plate

Bearing stress = 1.2 Fu

= 1.2×58 = 69.6 ksi

So

Allowable bearing = 69.6 × 10 × 0.75 × t

= 200

t = 0.38 in

use 3/4" G.P

Checking various limit states

Yielding = 0.6 Fy Ag.

= 0.6 Fy Ag.

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

$= 129.6\ K < 200\ K$

Not OK

Try $L\ 7 \times 4 \times 1/2$ $Ag = 5.25$

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

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

OK

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

$52.2 > 18.5$

So shear governs.

Checking various limit states

yielding $= 0.6\ F_y\ A_g$

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

$= 266.87 > 200$

OK

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$$Fracture = 0.5 \times Fu \times Ae$$

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

$$= 231k > 200k$$

OK