Name :- Ahmad Ali

ID :- 7746.

Subject :- Steel Structures.

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Prob:- 1

Lightest W-Shape colum
A-36 steel
D.L = 60 k , L.L = 110 k
Pin Support at top and bottom
$K_x L_x = 36 ft$, $K_y l_y = 18 ft$
AISC / LRFD Method.

Solution:-

Required capacity = $(1.2 \times 60) + (1.6 \times 110)$
= 248 k

Enter design strength table of manul with KL = 18 ft and P = 248 k.

Some Possible Section are:-

W14 x 61	P = 364	$r_x / r_y = 2.44$
W12 x 53	P = 320	$r_x / r_y = 2.11$
W10 x 49	P = 301	$r_x / r_y = 1.71$
W8 x 58	P = 300 k	$r_x / r_y = 1.74$

Now,

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

Try W12x53 $\quad r_x/r_y = 2.11$

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

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

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

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

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

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

$$= \frac{87.09}{\pi}\sqrt{\frac{36}{29.000}}$$

$$= 0.97 < 1.5$$

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

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

$F_{cr} = 24.28$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78\,k$

$\phi P_n = 0.85 \times 378.78$

$= 321.96 > 248\,k$ OK

So, use W12x53

Prob:-2

→ 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
Δ_{lim}

→ F_y = 36 ksi

AISC / ASD method

* Solution:- *

Design Load = 4.5 + 1.5

$P = 6K$

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

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

$$M = \left(\frac{3}{2} \times 6 \times 26\right) - (6 \times 13) = 156\,K\cdot ft$$

$$\text{equ (1)} \Rightarrow I = \frac{5}{48} \times \frac{ML^2}{EI} \times 0.95$$

$$I = \frac{5}{48}\frac{(156 \times 12)(52 \times 12)^2}{29{,}000\left(\frac{52}{360} \times 12\right)}$$

$$I = 1510.51\ in^4$$

Try W24 X 62 $\quad I_x = 15501\ in^4$

$b_f = 7.04\ in$, $d/A_f = 5.72$

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

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

$L > L_c$

from table 5.2
$C_b = 1.13$

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

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

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

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

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

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

Total $M = 156 + 20.95$

$M = 176.95$ $\qquad S_x = 131$

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

$$f_b < F_b$$

Use W24 x 62

Q3:

Given Data:

D.L = 50 Kips
L.L = 150 kips
Bolt dia = 3/4
Length = 18 ft

Solution:

Total Load = D.L + L.L
= 50 + 150
= 200 kips or 100 kip/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 $A_g \times A_n$

Now $A_e = 0.85\ A_n$

For yielding

$A_g \times 22 = 75$

$A_g = \frac{75}{22}$

$A_g = 3.41\ in^2$

For Fracture

$$29 \times A_e = 75$$

$$A_e = 2.59 \text{ in}^2$$

$$A_n = \frac{A_e}{0.85} = 3.04 \text{ in}^2$$

Assume 15% reduction in gross area for holes

so $A_g = \frac{A_n}{0.85} = 3.58 \text{ in}^2$

For $5'' \times 3\frac{1}{2}'' \times \frac{7}{16}''$

$A = 3.53 \text{ in}^2 \simeq 3.58 \text{ in}^2$ ok

$r_x = 1.59 \text{ in}^2$ and with 3/8 in GP

$r_y = 1.47$ in

$$\frac{L}{r_{min}} = \frac{18 \times 12}{1.47} = 146.93 \leq 300 \quad \text{ok}$$

Design of Bolts: Using A325 bolts with threads included in shear plane

$A = 0.44 \text{ in}^2$ (dia $= \frac{3}{4}''$)

Allowable bolts are shear $= 21$ ksi

(Table 2.11 Gray Load)

Since the bolts are in double Shear so

Allowable Shear per bolts

$= 2 \times 21 * 0.44 = 18.5$ kips

Allowable bearing on Two 7/16" thick angle

Long = 69.6 x 2 x 7/16 x 0.75

= 45.68 kips > 18.5 kips

Allowable bolts bearing Stress

= 1.2 Fu = 1.2 x 58

= 69.6 ksi

Now No of bolts =

$\frac{200}{18.5} = 10.81$

or 10 Bolts

Design of Gusset plates

Bearing Stress = 1.2 Fu = 69.6 ksi

So Allowable bearing = 69.6 x 10 x 0.75 x t

= 200

t = 0.38 in

use $3/4$" G.P

Checking various limit states

Yielding $= 0.6\, f_y\, A_g$

$= 0.6 \times 36 \times (10 \times 0.75)$

$= 162$ kip $>$ 150 kips

Fracture $= 0.5 \times F_u \times A_e$

$\Rightarrow 0.5 \times 58 \times 0.85\, [10 - (3/4) \times 2] \times 3/4$

$\Rightarrow 157$ kips $>$ 150 k

Check for tearing failure

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

$1.25 = \frac{2P}{58 \times 0.38}$

$P = 16.53$ kips

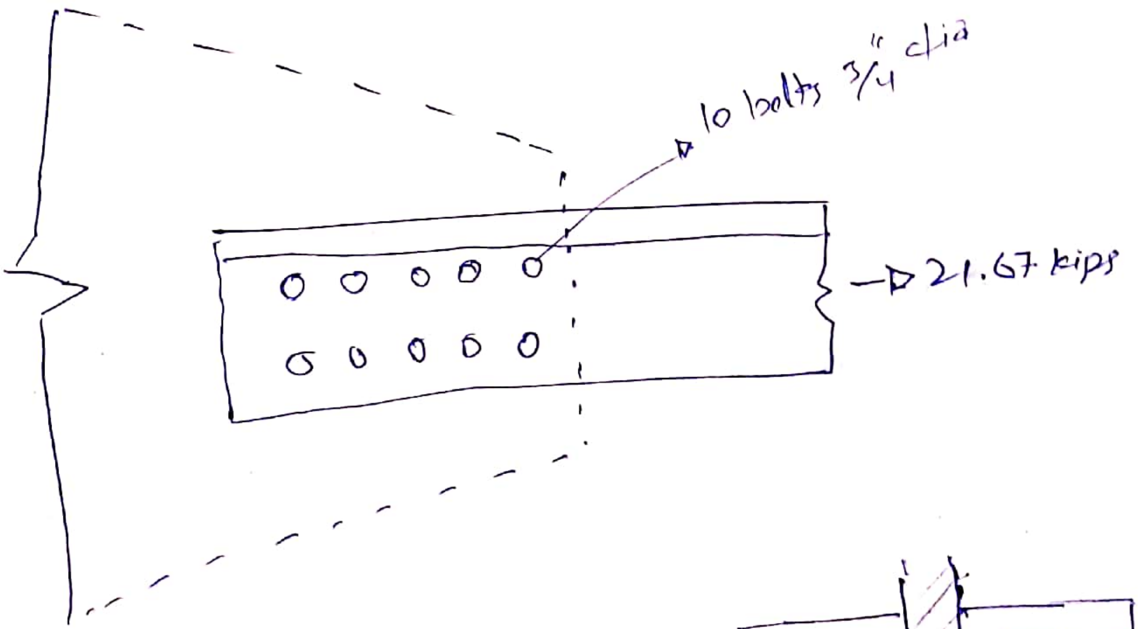
$$L = \frac{2P}{F_u t} + \frac{d_n}{2}$$

$$2 = \frac{2P}{58 \times 0.38} + \frac{3/4}{2} \Rightarrow 2 = \frac{2P}{22.04} + 0.37$$

$$2 \times 22.04 = 2P + 0.37$$

$$\frac{44.08}{2} = \frac{2P + 0.37}{2}$$

$$P = 21.67 \text{ kip}$$



t = 0.38

use two 3/4"