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Subject: Steel Structure

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Prob # 01

Lightest W-shape Column
A36 steel
DL = 60k L.L = 110k
Pin supported at top and bottom
$K_xL_x = 36ft$, $K_yl_y = 18ft$
AISC / LRFD Method

Sol:

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

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

Some possible Sections are :-

W14x61	P = 364	$r_x/r_y = 2.44$
W12x53	P = 320	$r_x/r_y = 2.11$
W10x49	P = 301	$r_x/r_y = 1.71$
W8x58	P = 300 K	$r_x/r_y = 1.74$

Now

$$\frac{K_xL_x}{K_yl_y} = \frac{36}{18} = 2$$

Try W12x53 $r_x/r_y = 2.11$

$$r_x/r_y > \frac{K_xl_x}{K_yl_y}$$

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

$\frac{k_x l_x}{r_x} = \frac{36 \times 12}{5.23} = 82.6$

$\frac{k_y l_y}{r_y} = \frac{18 \times 12}{2.48} = 87.09$

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

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

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

$= 0.97 < 1.5$

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

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

$F_{cr} = 24.28$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78 k$

$\phi P_n = 0.85 \times 378.78$

$= 321.96 > 248$

OK

So, Use $W_{12 \times 53}$

Prob :- 2

→ 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
Δ lim

→ Fy = 36ksi

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 ~~multip~~ multiplied by the factor from table 5.4

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

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

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

$I = 1510.51\ in^4$

Try W24 x 62

$I_x = 1550\ in^4$

$b_f = 7.09\ in \quad d/A_f = 5.72$

$$L_c = \frac{76\, b_f}{\sqrt{F_y}} \Rightarrow \frac{76 \times (7.09)}{\sqrt{36}} = 89'' = 7.41'$$

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

$L > L_c$ 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

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

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

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

$M = 20.95 \, k \cdot ft$

Total $M = 156 + 20.95$

$M = 176.95$

$fb = \frac{M}{Sx} \Rightarrow \frac{176.95 \times 12}{131} = 16.2 \, ksi$ $\quad Sx = 131$

$fb < Fb$

OK

Use W24X62

Question no 3

(6)

Given Data

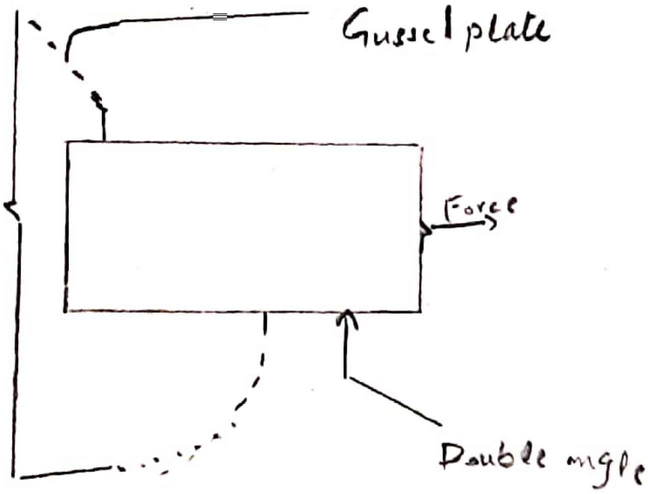
D.L = 50k

L.L = 150

B. dia = 3/4"

Length = 18 ft

Connection type Bearing type



Solution => Total load = DL + live load

=> 50+150

=> 200kips or

100 kip/Angle

For yielding at the gross area allowable

stresses are $0.6 Fu = 0.6 \times 36$

$= 22 ksi$

For Fracture at the net are allowable stresses are

$0.5 F_u = 0.5 \times 58$

$\Rightarrow 29$ ksi

Since the Connection is bolted So $A_g \neq A_n$

Now $A_e = 0.85 A_N$

For yeilding

$A_g \times 22 = 75$

$A_g = 75/22$

$= 3.4 \text{ in}^2$

For Fracture

$29 \times A_e = 75$

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

Assume 15% reduction in gross area for holes

So $A_g = A_n / 0.85 = 3.58 \text{ in}^2$

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

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

$r_x = 1.59$ in & with 3/8in G.P

$r_y = 1.47$ in

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

Design of Bolts:

- Using A325 bolts with threads including in shear plane

$A = 0.44 in^2$ (dia = 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 x 21 x 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 Gussed plates

Bearing stress = 1.2 Fu = 69.6 Ksi

So

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

$$\boxed{t = 0.38\text{ in}}$$

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 $= 0.5 \times F_u \times A_e$

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

=> 157 kips > 150 k

Check for tearing failure

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

$$\boxed{P = 16.53\text{ kips}}$$

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

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

$$2 = \frac{2P}{22.04} + 3/4/2$$

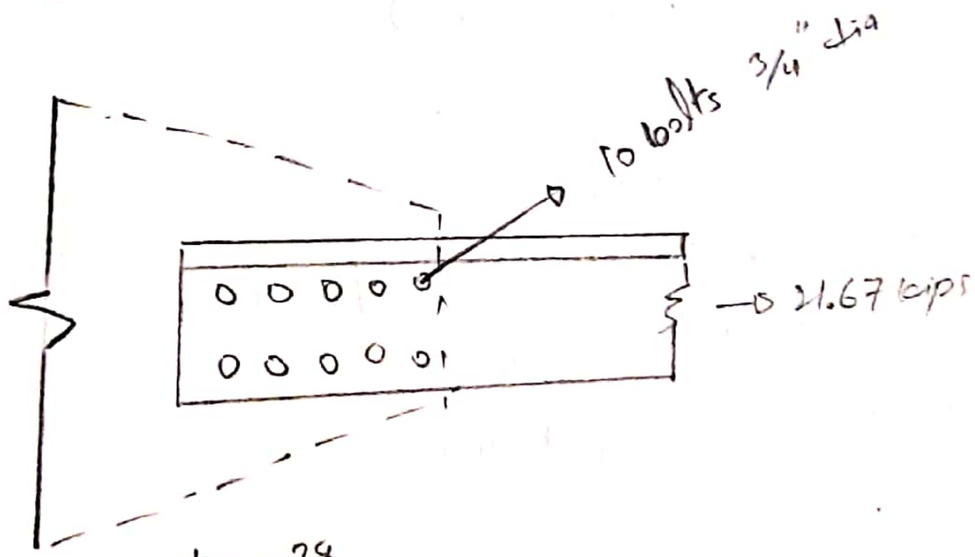
$$2 = \frac{2P}{220.4} + 0.37$$

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

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

$$22.04 = P + 0.37$$

$$\boxed{P = 21.67 \text{ kips}}$$



t = 0.38

use two 3/4"