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Section:- B

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SubJect:- Steel Structures

Question#1

→ Lightest W- shaple column
A36 steel

D.L = 60K , L.L = 110K

Pin supported at top and bottom

$K_x l_n = 36 ft$, $K_y l_y = 18ft$

AISC/LRFD method

★ Solution:

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

$\boxed{= 248K}$

Entre 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 = 300K	$r_x/r_y = 1.74$

Now $\frac{K_x l_x}{K_y l_x} = \frac{36}{18} = 2$

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

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

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

$$\frac{K_x l_x}{r_y} = \frac{36 \times 12}{5.23} = 82.6$$

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

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

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

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

Scanned by CamScanner

$$\boxed{\lambda_c = 0.97 < 1.5}$$

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

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

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

$$P_n = A_g F_{cr}$$

$$= 15.6 \times 24.28$$

$$P_n = 378.78K$$

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

$$= 321.96 > 248K$$

OK

So use $W_{12} \times 53$

Given data:- Question #2

lightest w- shape

D.L = 1.5K , L.L = 4.5K

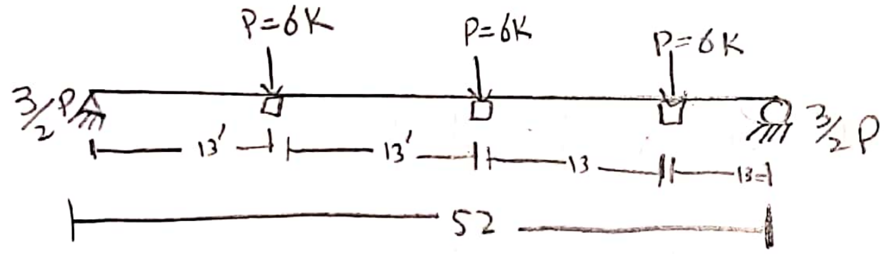
(at each quater point Total length = 52')

live load deflection = 1/360 of span

Δ_{lim}

f_y = 36 Ksi

AISC/ASD method



Solution:-

Design load = 4.5+1.5

= 6K

P = 6K

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

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

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

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

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

$\boxed{I = 1510.51 \text{ in}^4 \times 0.95}$ $\boxed{I = 1434.98 \text{ in}^4}$

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

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

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

$$L = \frac{76 \, b_f y}{\sqrt{f_y}} \Rightarrow \frac{76 \times (7.04)}{\sqrt{36}} = 89'' = 7.41'$$

$L > L_c$ 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

$$\sqrt{\frac{102,000\, cb}{fy}} \leq \frac{L}{r_T} \leq \sqrt{\frac{510,000\, cb}{fy}}$$

So

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

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

$Fb = 17.76$ Ksi allowable

The beam self weight $= 62\, lb/ft = 0.062\, K/ft$

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

$$\boxed{M = 20.95\ K/ft}$$

Total $M = 156 + 20.95$

$$\boxed{M = 176.95}$$

$f_b = \frac{M}{S_x}$ $S_x = 131$

$= \frac{176.95 \times 12}{131}$

$\boxed{= 16.2 \text{ Ksi}}$

$f_b < F_b$ OK

Use $W_{24} \times 62$

Q#3

Q NO#3

Given data:-

$D.L = 50K$

$L.L = 150K$

Bolt dia = $3/4''$

length = 18ft

Connection type = bearing ASD method

Required data:-

Design A_{36} steel double angle tension membre

Solution:-

Total load

$= DL + L.L$

$= 50 + 150$

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

→ for yielding at gross area allowable stress are

$0.6\,f_y$

$= 0.6 \times 36$

$\boxed{= 22\ Ksi}$

→ for fracture at the net area

allowable stresses

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

$$\boxed{= 29\,ksi}$$

⇒ Since the connection in bolted so

$$A_g \neq A_n$$

Now $A_e = 0.85\,A_n$

for yielding

$$A_g \times 22 = 100$$

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

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

for fracture,

$$29 \times A_e = 100$$

$$A_e = 3.44\,in^2$$

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

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

Scanned by CamScanner

Assume 15% deduction in gross area for holes

So,

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

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

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

for $L\ 4 \times 4 \times \frac{5}{8}$ $A_g = 4.61 \cong 4.76$ OK

$r_x = 1.20$, $r_y = 1.20$ with $\frac{3}{8}$ in gusset plate

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

∴ OK

Bolt design:-

Using A325 bolts with threads included in shear plane

$d_s = \frac{3}{4}$"

$$\text{Area} = \frac{\pi}{4}(d)^2 \Rightarrow \frac{\pi}{4}(0.75)^2 = \boxed{0.441 \text{ in}^2}$$

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 = $1.2 f_u$

$= 1.2 \times 5.8$

$\boxed{= 69.6 \text{ ksi}}$

allowable bearing on two $5/8''$ thick angle

long legs = $69.6 \times 2 \times 5/8 \times 0.75$

$= 62.25 > 18.5$

So shear govern's

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

use 10 bolts

Design of gusset plate

Bearing stress = $1.2 f_u$

$= 1.2 \times 58$

$\boxed{= 69.6 \text{ ksi}}$

allowable bearing = $69.6 \times 10 \times 0.75 \times t$

$= 200$

$t = 0.38 \text{ in}$

use $\frac{3}{4}''$ G-p

Cheaking various limit states.

$$\text{yielding} = 0.6 f_y A_g$$
$$= 0.6 \times 36 \times (8 \times 0.95)$$
$$= 129.6 < 200K$$
$$= \text{Not OK.}$$

Try $L_7 \times 4 \times \frac{1}{2}$ $A_g = 5.25$

$\gamma_x = 2.25$ $\gamma_y = 1.11$ with $\frac{3}{8}''$ G.p

$$\frac{l}{\gamma_{min}} = \frac{18 \times 12}{1.11} \quad 194.59 \leq 300K$$
OK

allowable bearing on two $\frac{1}{2}''$ thick angle long legs $= 69.6 \times 2 \times \frac{1}{2} \times 0.75$

$$52.2 > 18.5$$

So shear govans.

Cheaking various limit state.

yielding

$= 0.6\ f_y A_g$

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

$= 226.8 > 200K$ ok

Fracture =

$= 0.5\ f_u \times A_e$

$= 0.5 \times 58 \times 0.85\ (14 - (3/4) \cdot \times 2) \times 3/4$

$= 231K > 200\ K$

OK.

Check for ~~tearing~~ bearing failure

$$l_e = \frac{2p}{f_{ut}}$$

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

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

$$p = 18.125K$$

$$L = \frac{2p}{f_{ut}} + \frac{d_n}{2}$$

$$2 \quad \frac{2p}{58 \times 0.5}$$

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

$$116.1 - 0.375 = 2p$$

$$115.72 = 2p$$

$$\boxed{p = 57.86K}$$

Capacity

Since 10 bolts & five bolt per row

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

499.13 K > 200 K
OK