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Subject :- Steel Structure

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Final Term Exam

Qno1:-

Select the lighest W shape of A-36 Steel column of 36ft long to carry a dead compression load of 60k and a live compression load of 110K. Assume that the column is pin-supported at the top and bottom in both directions and that an additional support provided at the mid-length to prevent buckling about Y-axis so that $K_xL_x = 36$ ft and $K_yL_y = 18$ft. Use AISC/LRFD method

Solution:-

Required Capacity = $(1.2\times60)+(1.6\times110)$
$= 248K$

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

Some possible section are

$W_{14}\times61$	$P = 364$	$r_x/r_y = 2.44$
$W_{12}\times53$	$P = 320$	$r_x/r_y = 2.11$
$W_{10}\times49$	$P = 301$	$r_x/r_y = 1.71$
$W_{8}\times58$	$P = 300k$	$r_x/r_y = 1.74$

Now

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

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

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

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

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

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

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

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

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

$$= 0.97 < 1.5$$

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

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

$$F_{cr} = 24.28$$

Scanned with CamScanner

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78k$

$\phi P_n = 0.85 \times 378.78$

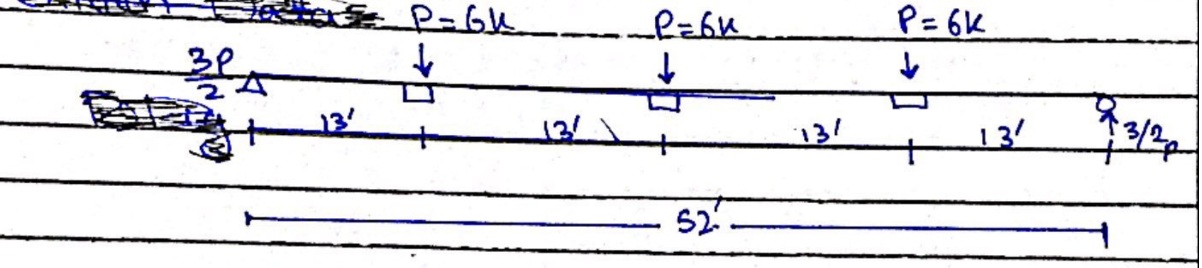
$= 321.96 > 248\ k$

OK

So we use $W_{12} \times 53$

Qno 2:-

Determine the lightest W section to support concentrated loads of 1.5 Kips dead load and 4.5 live load at Each quarter point of a 52.ft simple span. The beam is laterally supported at the ends and at the points of load application. Live load deflection is limited to 1/360 of the span fy = 36 ksi. Use AISC/ASD method.



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

Fy = 36 ksi

AISC/ASD method.

Solution:-

Design load $= 4.5 + 1.5 = 6k$

$P = 6k$

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

Δ by this Eq is multiplied by factor from table 5.4

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

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

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

$I = 1510.51\ in^4$

Try $W24 \times 62$, $I_x = 1550\ in^4$

$bf = 7.04$ $d/Af = 5.72$

$$L_c = \frac{76\,bf}{\sqrt{f_y}} \Rightarrow \frac{76(7.04)}{\sqrt{36}} = 89'' = 7.41'$$

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

L > Lc From table 5.2

$C_b = 1.13$

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

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

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

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 $= 62\ \frac{lb}{ft}$

$= 0.062\ k/ft$

7 7487

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

$M = 20.95$ k-ft

Total $M = 156 + 20.95$

$M = 176.95$

$S_x = 131$

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

$f_b < F_b$

OK

Use W24x62

Q no 3:-

Determine A-36 double angle tension member 18 ft long to transfer 50k Dead load and 150k Live load. The connection is bearing type with A325 bolts with 3/4-in diameter (standard holes) with threads not excluded from the shear plane. Use two line of bolts. Use ASD method

Given Data

DL = 50k
B.dia = 3/4"
L.L = 150k
Length = 18ft

Connection type ⇒ Bearing type
bolts = A 325, 3/4' dia
Steel = A36

Threads not Excluded

Solution:-

Total Load = DL + LL
= 50+150
= 200kips or 100 kip/Angle

For yielding at the gross area allowable stresses are 0.6 Fu = 0.6 × 36

= 22 ksi

For fracture at the net are allowable stresses are

$0.6 f_y \Rightarrow 0.6 \times 36$
$= 22$ ksi

For fracture at net allowable stresses are

$0.5 f_u = 0.5 \times 58$
$= 29$ ksi

As connection is not bolted so

$A_g \neq A_n$

Now:-

$A_e = 0.85 A_n$

For Yeilding

$A_g \times 22 = 100$

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

$\boxed{A_g = 4.5 in^2}$

For fracture

$29 \times A_e = 100$

$A_e = \frac{100}{29}$

$A_e = 3.45 \ in^2$

$A_n = A_e / .85 = 4.05 in^2$

Assume 15% reduction in gross area for holes

So

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

$$A_g = \frac{4.05}{0.85}$$

$$A_g = 4.76 in^2$$

For

$6 \times 4 \times \frac{1}{2}$ $A = 4.75 in^2 \approx 4.77 in^2$

$r_x = 1.91$

$r_y = 1.15$

$$\frac{L}{r_{min}} = \frac{18 \times 12}{1.15}$$

$$= 187.82$$

$187.82 \leq 300$ ok

Design for bolts

Using A325 bolt threads not exclude

$A = 0.44 in^2$

dia = 3/4"

Allowable bolts are in double shear

So

Allowable bolts bearing stress

$= 1.2 \times 58$

$= 869.6\,ksi$

=> Allowable Shear per bolt

$= 2 \times 21 \times 0.44$

$= 18.5\,kips$

=> Allowable bearing on two 7/8" Thick angle long

legs $= 69.6 \times 2 \times \frac{7}{16} \times 0.75$

$\Rightarrow 45.68\,kips > 18.5\,kips$

So

Shear governs

Now:- Number of bolts $= \frac{200}{18.5}$

So we will use 12 bolts

Design of Gusset plate:-

Bearing Stress $= 1.2F_u$

$= 1.2 \times 58$

$= 69.6\,ksi$