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7386

STEEL STRUCTURE

SUMMER FINAL TERM

Q#1

Select the lightest W Shape of A-36 Steel Coloumn of 36 ft long to Carry a dead Compression load of 60k ~~ft~~ and a live Compression load of 110k. Assume that the Coloumn is Pin-Supported at the top and bottom in both directions and the additional Support Provided at 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.

Data:-

Lightest W Shape Coloumn

A36 Steel

$D.L = 60k$

$L.L = 110k$

Pin supported at top and bottom

$k_xL_x = 36ft$

$k_yL_y = 18ft$

AISC/LRFD METHOD

Solution:-

Required Capacity = (1.2×60) + (1.6×110)
= 248k

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

Some Possible Sections are

W14×61	P = 364	$r_x/r_y = 2.44$
W12×53	P = 320	$r_x/r_y = 2.11$
W10×48	P = 301	$r_x/r_y = 1.71$
W8×58	P = 300k	$r_x/r_y = 1.74$

Now $\frac{k_x L_x}{k_y L_y} = \frac{36}{18} = 2$

Try W12×53 $r_x/r_y = 2.11$

$r_x/r_y > \frac{k_x L_x}{k_y L_y}$

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

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

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

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

$$\lambda_c = \frac{kL}{r\pi}\sqrt{\frac{F_y}{E}}$$

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

$$= 0.97 < 1.5$$

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

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

$$F_{cr} = 24.28$$

$$P_n = A_g F_{cr}$$

$$= 15.6 \times 24.28$$

$$P_n = 378.78\,k$$

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

$$= 321.96 > 248k$$

ok

Use $W_{12} \times 53$

Q2.

Determine the lightest W Section to Support Concentrated Loads of 1.5 kips dead Load and 4.5 kips live load at Each Quarter Point of a 52-ft Simple Span. The beam is laterally supported 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.

Data given:-

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}

→ 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 Equation is Multiplied by the factor from table 5.4

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

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

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

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

Try W24x62 , $I_x = 1550 \text{ in}^4$

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

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

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

$L > L_c$ 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

$$F_b = \left[\frac{2}{3} - \frac{F_y (L/r_T)^2}{1530 \times 10^3 \times C_b}\right] F_y$$

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

$F_b = 17.76$ ksi Allowable

The beam self weight $= 62 \frac{lb}{ft} = 0.062 K/ft$

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

$M = 20.95 k \cdot ft$

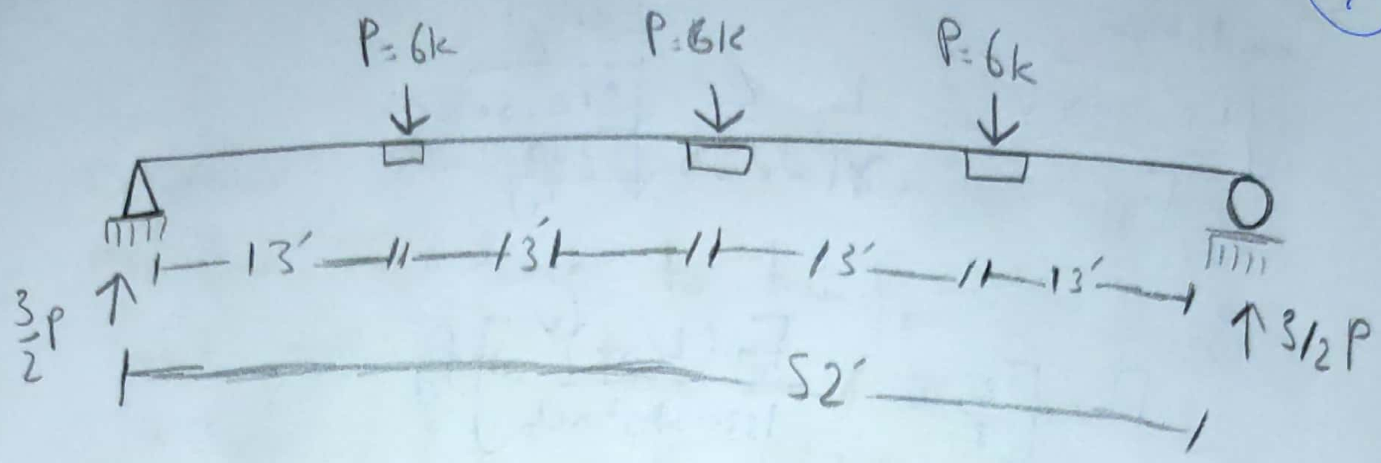
Total $M = 156 + 20.95$

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

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

$$f_b < F_b$$

Use $W24 \times 62$


P=6k
P=6k
P=6k
13′
13′
13′
13′
3/2 P
3/2 P
52′

Q#3

Determine an A-36 double Angle tension member 18ft long to transfer 50k Dead Load and 150k live Load. The Connection is bearing type with A325 bolts with 3/4 in diameter (standard ~~bolts~~ holes) with threads not ~~Excited~~ Excluded from the Shear Plane. Use two lines of bolts. Use ASD Method.

Given Data:-

Length = L = 18 ft

Dead Load = D.L = 50k

Live Load = L.L = 150k

bolts = A325, 3/4" dia

Connection type = Bearing

Steel = A36

Threads not Excluded.

Required Data:-

A36 Double Angle tension

Solution:-

Total Load = D.L + L.L

= 50 + 150

= 200 kips

or

200 kips/Angle

For yielding at gross area Available stresses are

$0.6F_y \Rightarrow 0.6 \times 36$

$\Rightarrow 22$ ksi

For Fracture at net area 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 yielding

$A_g \times 22 = 100$

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

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

For Fracture

$29 \times A_e = 100$

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

$A_e = 3.45\ in^2$

$$A_n = \frac{A_e}{0.85} = 4.05\ in^2$$

Assume 15% Reduction in gross Area for holes

So

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

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

$\Rightarrow A_g = 4.76\ in$

for $6 \times 4 \times \frac{1}{2}$: $A = 4.75\ in^2 \approx 4.76\ in^2$

$r_x = 1.91$

$r_y = 1.15$

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

$= 187.82$

$= 187.82 \leq 300$ ok

Design for Bolts:-

Using A325 bolt threads not Exclude

$A = 0.44 in^2$

$dia = 3/4"$

Allowable bolt shear = 21 ksi → [Table 2.11]

Since

Thea bolt are in double shear

So

⇒ Allowable bolts bearing stress = 1.2 Fu

⇒ 1.2×58

⇒ 69.6 ksi

⇒ Allowable shear Per bolt

⇒ 2×21×0.44

⇒ 18.5 kips

⇒ Allowable bearing on Two 7/8" Thick Angle long legs.

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

= 45.68 kips > 18.5kips

So
Shear governs

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

=> 10.81

So we will use 12 bolts

Design of Gusset Plate

Bearing Stress = $1.2 f_u$

=> 1.2×58

=> 69.6 ksi