Name Jamal Alif

ID 7480

Subject Steel Structures

Teacher Engr. Amjad Islam

Summer Final term Exam

Problem # 1

Select the lightest W shape of A - 36 steel column - - -

Data:-

Lightest W- Shape Column

A36 steel

Dead Load, DL = 60k

Live load, L.L = 110k

Pin supported at top and bottom

$K_x L_x = 36ft$, $K_y L_y = 18ft$

AISC | LRFD method.

Solution:-

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

$= 248K$

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

Some possible Sections 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

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

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

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

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

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

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

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

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

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

$= 0.97 < 1.5$

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

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

$F_{cr} = 24.28$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78k$

$\phi P_n = 0.85 \times 378.78$

$= 321.96 > 248k$

OK

So

Use $W_{12 \times 53}$.

Q2)

Give:-

Lightest W section

$D.L = 1.5k$ $L.L = 4.5k$

(At each quarter point)

Total length $= 52'$

Live load deflection $\Delta_{lim} = \frac{1}{360}$ of span

$F_y = 36\,ksi$

AISC | ASD method

Solution:-

Design load $= 4.5 + 1.5 = 6k$

$P = 6k$

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

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

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

$$eq① \Rightarrow I = \frac{5}{48} \times \frac{ML^2}{E\Delta} \times 0.95$$

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

$$I = 1510.5 \text{ in}^4$$

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

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

$$L_c = \frac{76 b_f}{\sqrt{f_y}}$$

$$= \frac{76(7.04)}{\sqrt{36}} = 89'' = 7.41'$$

$$L_c = \frac{20{,}000}{f_y \frac{d}{A_f}} = \frac{20{,}000}{36 \times 5.72} = 97.2'' = 8.09'$$

$L > L_c$

from table 5.2
$c_b = 1.13$

$$\sqrt{\frac{102{,}000\, c_b}{f_y}} = \sqrt{\frac{102{,}000 \times 1.13}{36}} = 57$$

$$\sqrt{\frac{510{,}000\,C_b}{f_y}} = \sqrt{\frac{510{,}000\,(1.13)}{36}}$$

$$= 127$$

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

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

Scanned with CamScanner

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

$M = 20.95$ kft

Total

$M = 156 + 20.95$

$M = 176.95$

$S_x = 131$

$$f_b = \frac{M}{S_x} \Rightarrow \frac{176.95 \times 12}{131} = 16.21 \text{ ksi}$$

$f_b < F_b$

OK

Use $W_{24 \times 62}$

Q3)

Given:-

Length = 18ft

Dead load = 50k

Live load = 150k

bolts = A325, $\frac{3}{4}$" dia

Connection type = Bearing

Steel = A36

Threads not Excluded.

Required:-

A_{36} Doubl Angle Tension

Solution:-

Total load = DL + L.L

= 50 + 150

= 200 kips

or

100 kips / Angle

For yielding at gross area allowable stress are -> $0.6 f_y$ => 0.6×36

= 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 yielding

$A_g \times 22 = 100$

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

$A_g = 45 in^2$

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 choles

So

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

$\Rightarrow \quad A_g = \dfrac{4.05}{0.85}$

$\Rightarrow \quad A_g = 4.76\,in^2$

For

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

$r_x = 1.91$

$r_y = 1.15$

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

$= 187.82$

$= 187.82 \leq 300$ OK.

Design for bolts:-

Using A325 bolt threads not exclude.

$A = 0.44\,in^2$

dia $= 3/4''$

Allowable bolt shear $= 21$ Ksi $\rightarrow$ [Table 2.11]

Since

The bolts are in double shear

so

=> Allowable bolts bearing stress = 1.2 Fu

= 1.2x 58

= 69.6ksi

=> Allowable shear per bolt =

=> 2x21x0.44

=> 18.5kips

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

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

=> 45.68kips > 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 = 1.2Fu

=> 1.2 x58

=> 69.6ksi