Name : M. Asif

ID # : 7734

Sbject : Steel structure

Instructor : Engr. Amjad Islam

Department : Civil Engineering.

Date : 29 sept 2020.

QNO. 1.

Lightest W-shape column
A36 steel.

D. L = 60K

L. L = ~~100~~ 110K.

Pin supported at top and bottom $K_x l_x = 36ft$ $K_y l_y = 18ft$

AISC/LRFD method:

Sol:

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

$\Rightarrow 248K.$

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

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

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

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

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

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

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

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

$$= 0.97 < 1.5$$

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

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

$F_{cr} = 24.28$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78\,K$

$\phi P_n = 0.85 \times 378.78$

$= 321.96 > 248\,K$ OK.

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

QNO. 2.

→ Lightest W-section

→ D.L = 1.5 K L.L = 4.5 K
(At each quater point)

→ Total length = 52'

→ Live load deflection Δlim
= $\frac{1}{360}$ of span

→ F_y = 36 ksi

AISC/ASD Method.

Sol:-

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.

(b)

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

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

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

$I = 1510.51\ in^4$

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

Try $W_{24} \times 62$, $I_x = 1540\ in^4$

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

$\cancel{L = \frac{20{,}000}{f_y \frac{d}{A_f}}}$

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

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

$L > L_c$ from table

5.2 $C_b = 1.13$

$$\sqrt{\frac{102{,}000 C_b}{F_y}} = \sqrt{\frac{510{,}000 \times 1.13}{36}} \Rightarrow 127$$

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

Condition:

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

So.

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

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

$F_b = 17.76$ Ksi allowable

The beam self weight

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

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

$M = 20.95$ K ft.

Scanned with CamScanner

Total $M = 156 + 20.95$

$M = 176.95$

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

$f_b < F_b$

OK

Use $W_{24} \times 62$.

Q No. 3. Given:

D.L = 50K
L.L = 150K

Length = 18 ft

Bolts Dia = 3/4"

ASD Method.

Required:-
Design A36 steel ~~Total load~~ double angle tension member.

Sol:-
Total load = D.L + L.L
= 50 + 150
= 200K or 100K/Angle

→ For yielding at the grass area allowable stresses are:

$0.6F_y = 0.6 \times 36$

$= \cancel{50}.22$ Ksi

→ For Fracture at the net area allowable stresses are:

$0.5F_u = 0.5 \times 58$

$\Rightarrow 29$ Ksi

→ Since the connection is bolted so $A_g \neq A_n$

Now $A_e = 0.85 A_n$

For yielding:

$A_g \times 22 = 100$

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

$A_g = 4.54 \text{ in}^2$

For Fracture :

$$29 \times Ae = 100$$

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

$$Ae = 3.44 in^2$$

$$An = Ae/0.85 \Rightarrow 3.44/0.85$$

$$\boxed{An = 4.04 in^2}$$

⇒ Assume 15% deduction in gross area for holes

So,

$$Ag = \frac{An}{0.85} \Rightarrow Ag = \frac{4.04}{0.85}$$

$$\boxed{Ag = 4.76 in^2}$$

Scanned with CamScanner

For $L\,4 \times 4 \times \frac{5}{8}$ $A_g = 4.61 \leq 4.76$ ok

$r_x = 1.20$ $r_y = 1.20$ with

$\frac{3}{8}$ in Gusset plate

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

OK

Bolts Design :-

Using A325 bolts with threads included in shear plane as dia $= 3/4''$

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

$$\boxed{A = 0.441 \text{ in}^2}$$

Allowable bolts shear $= 21$ ksi

since bolts are in double shear so allowable shear per bolt $= 2 \times 21 \times 0.44 = 18.5$ K

Allowable bolt bearing

stress = $1.2F_u = 1.2 \times 58 = 69.6\,ksi$

Allowable bearing on two

5/8" thick angle long

legs = $69.6 \times 2 \times 5/8 \times 0.75 = 65.25$
> 18.5

so shear govers

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

use 10 bolts.

Design of gusset plate.

Bearing stress = $1.2\,F_u$
$= 1.2 \times 58 = 69.6\,ksi$

So

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

$t = 0.38\,in$

use $\frac{3}{4}''$ G.P

checking various limit states

yielding = 0.6 Fu Ag

= (0.6) Fu Ag

= 0.6 × 36 × (8 × 0.75)

⇒ 129.6 K < 200K
Not OK

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

r_x = 2.25 r_y = 1.110
with 3/8" G.P

$\frac{l}{r_{min}} = \frac{18 \times 12}{1.11}$ 194.59 < 300K
OK

Allowable bearing on two 1/2" thick angle long legs = 69.6 × 2 × $\frac{1}{2}$ × 0.75

= 52.2 > 18.5

so shear governs.

Checking various limit states :

yielding = $0.6 F_u A_g$

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

$= 226.8 > 200k$ OK!

Fracture = $0.5 \times F_u \times A_e$

$= 0.5 \times 58 \times 0.85 \left[14 - \left(\frac{3}{4}\right) \times 2\right] \times \frac{3}{4}$

$= 231k > 200k$
OK!

check for tearing failure

$L_e = \frac{2P}{F_u t}$

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

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

$p = 18.125\,K$

$L = \frac{2p}{F_u t} + \frac{d_h}{2}$

$2 = \frac{2p}{58 \times 0.5} + \frac{3/4}{2}$

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

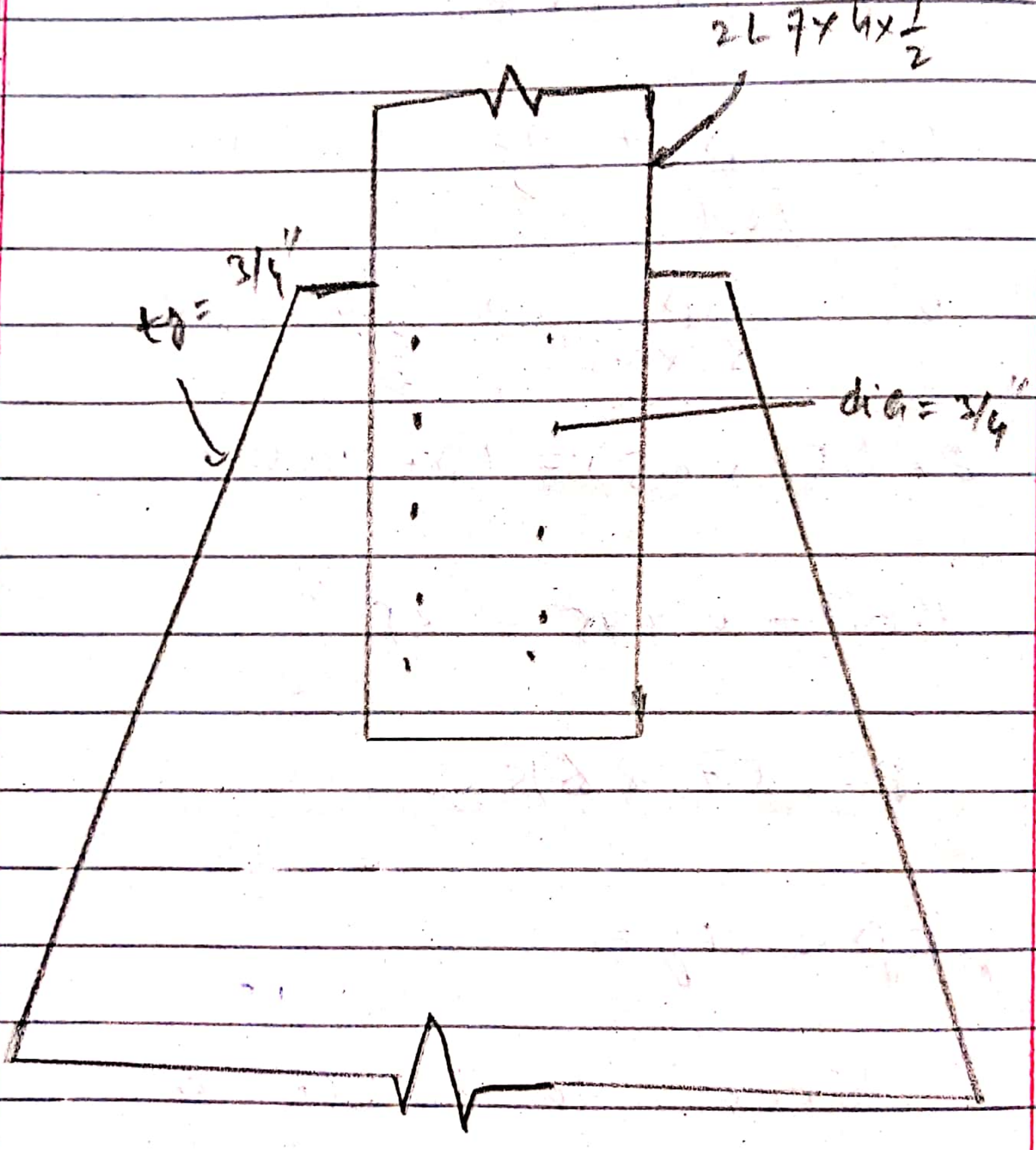
$116.1 - 0.375 = 2p$

$p = 57.88\,K.$

Capacity =

Since 10 bolts & five bolts per row

$2 \times 18.125 + 8 \times 57.86$



2L 7x4x$\frac{1}{2}$
tg = 3/4"
dia = 3/4"