Final Term Exam Summer Semester 2020

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Q1:- Select the Lightest W shape of A-36 Steel ....

-- Use AISC / LRFD Method.

Lightest W-shape column

A36 steel

DL = 60k LL = 110k

Pin supported at top and bottom

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

AISC / LRFD Method.

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

$= 248 k$

Enter design strength table of manual with

KL = 18 ft and P = 248 k.

Some possible sections are

$W_{14} \times 61$ -	$P = 364 k$	$r_x/r_y = 2.44$.
$W_{12} \times 53$	$P = 320 k$	$r_x/r_y = 2.11$
$W_{10} \times 49$	$P = 301 k$	$r_x/r_y = 1.71$.
$W 8 \times 58$	$P = 300 k$	$r_x/r_y = 1.74$

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

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

$$\frac{r_x}{r_y} > \frac{k_x l_x}{k_y l_y}$$

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

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

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

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

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

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

$$= 0.97 < 1.5$$

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

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

$$F_{cr} = 24.28$$

$$P_n = A_g F_{cr}.$$

$$= 15.6 \times 24.28$$

$$P_n = 378.78K.$$

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

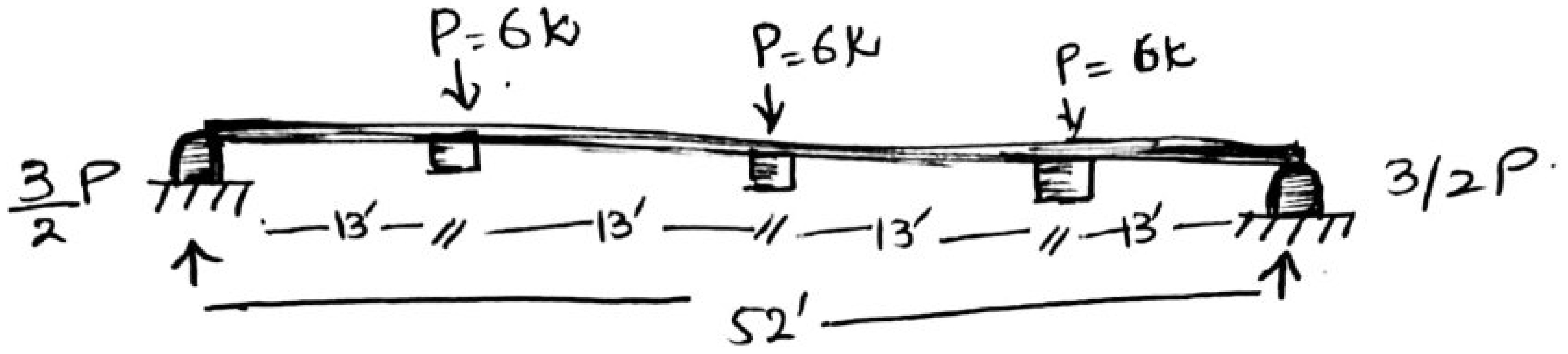
$$= 321.96 > 248K.$$

Ok.

So, use

<u>**W12 x 53**</u>

Q2: Determine the Lightest W section to support concentrated loads ..... Use AISC / ASD Method.



→ Lightest W-section.

→ D.L = 1.5 k   L.L = 4.5 k.

(At each quarter point)

→ Total length = 52'

→ Live load deflection = 1/360 of span.

→ $F_y = 36$ ksi

AISC / ASD Method.

Solution:

Design load = 4.5 + 1.5 = 6 k.

P = 6 k.

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

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

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

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

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

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

Try $W24\times62$: $I_x = 1550 in^4$

$b_f = 7.04\ in,\ d/A_f = 5.72$

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

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

$L > L_c$ from table 5.2.

$C_b = 1.13$

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

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

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

<u>Condition</u>: $\sqrt{\frac{102{,}000 C_b}{F_y}} \leq \frac{L}{r_T} < \sqrt{\frac{510{,}000 C_b}{F_y}}.$

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 $= \frac{62\ lb}{ft} = 0.062\ ^k/ft$.

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

$M = 20.95\ k.ft$.

Total $M = 156 + 20.95$

$M = 176.95$

$Sx = 131$

$$f_b = \frac{M}{Sx} \Rightarrow \frac{176.95 \times 12}{131} = 16.2\ Ksi$$

$f_b < F_b$

OK

Use $\underline{W24 \times 62}$

Q3: Determine an A-36 double-angle tension ....

.... Use ASD Method.

Sol: Given D.L = 50k.

L.L = 150k.

Bolts Dia = 3/4"

Length = 18 ft

Connection Type = Bearing

ASD Method.

Required : Design A36 steel double angle tension member

Solution:

Total load = D.L + L.L
= 50 + 150
= 200k or 100k/Angle.

→ For yielding at the gross area allowable stresses are

$0.6\,F_y = 0.6 \times 36$
$= 22\,ksi$

→ For Fracture at the net area allowable stresses are $0.5\,F_u = 0.5 \times 58$
$= 29\,Ksi$

Since, the Connection in bolted so,

$A_g \neq A_n$.

Now, $A_e = 0.85\,A_n$.

For yielding $A_g \times 22 = 100$.

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

$A_g = 4.54\ in^2$

For Fracture. $29 \times A_e = 100$

$A_e = 3.44\ in^2$.

$A_n = A_e/0.85 \Rightarrow 3.44/0.85 \Rightarrow A_n = \boxed{4.04\ in^2}$

Assume 15% deduction in gross area for holes

So, $A_g = \frac{A_n}{0.85} \Rightarrow A_g = \frac{4.04}{0.85}$

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

For $L\,4 \times 4 \times 5/8$ $A_g = 4.61 \propto 4.76$ OK.

$r_x = 1.20$ $r_y = 1.20$ with $3/8$ in Gusset plate

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

OK.

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

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

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

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 $= 1.2\,F_u = 1.2 \times 58$

$= 69.6$ 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 governs.

Number of bolts $= \dfrac{200}{18.5} = 10.81$.

use 10 bolts.

Design of gusset plate;

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

1.2×58

(iii) 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 service states

yielding $= 0.6 F_y A_g$.

$= (0.6) F_y A_g$.

$= 0.6 \times 36 \times (8 \times 0.75)$

$= 129.6$ k $<$ 200 k.

Not OK

Try $L\,7 \times 4 \times \frac{1}{2}$ $A_g = 5.25$

$r_x = 2.25$ $r_y = 1.11$ with $\frac{3}{8}$" G.P.

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

OK

Allowable bearing on two $\frac{1}{2}$" thick angle

long leg $= 69.6 \times \frac{1}{2} \times 2 \times 0.75$

$52.2 > 18.5$

So shear governs.

Checking various limit states.

yielding $= 0.6 F_y A_g$

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

$= 226.8 > 200$ k

OK

Fracture $= 0.5 \times F_u \times A_e$

$= 0.5 \times 58 \times 0.85 \left[14 - (3/4) \times 2\right] 3/4.$

$= 231$ k > 200 k

OK.

Check for tearing failure

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

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

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

$$P = 18.125\ K.$$

$$L = \frac{2P}{F_u t} \times \frac{d_b}{2}$$

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

$$2\,(58 \times 0.5) = 2P = 0.375$$

$$116.1 - 0.375 = 2P$$

$$115.72 = 2P$$

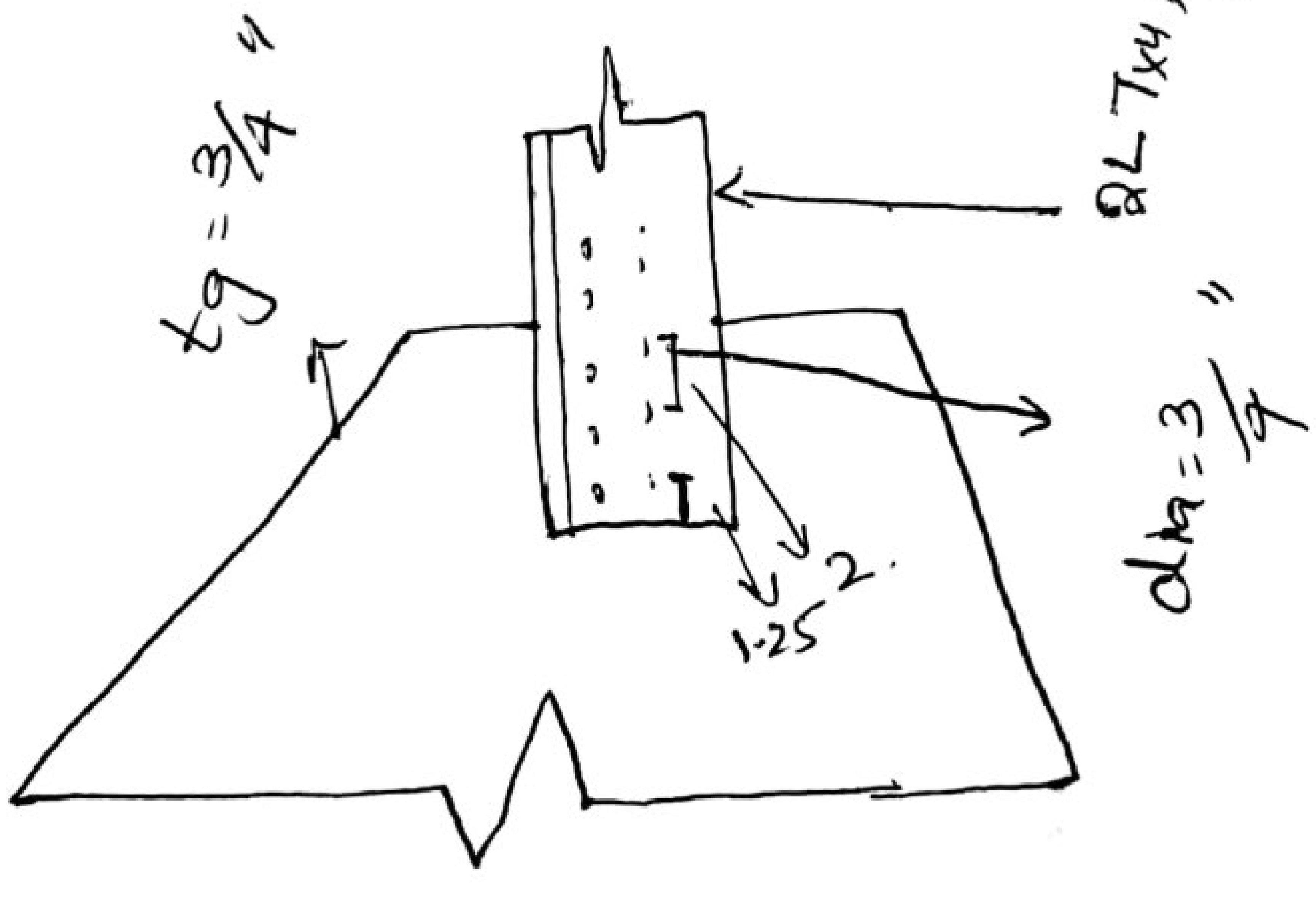
$$P = 57.86\ K.$$

Capacity since 10 bolts and five bolts per row

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

$$499.13K > 200$$

OK



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