Note Title 2/22/2007

Tension Member Design

- Select area based on yielding and fracture limit states

(1) $A_g \geq \dfrac{P_u}{0.9 F_y}$ (yielding)

(2) $A_g \geq \dfrac{P_u}{0.75 F_u U} + A_{bh}$

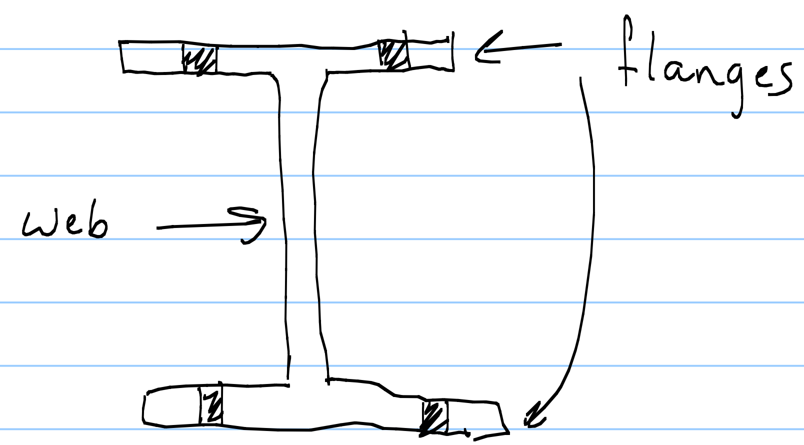
may need to estimate for preliminary design

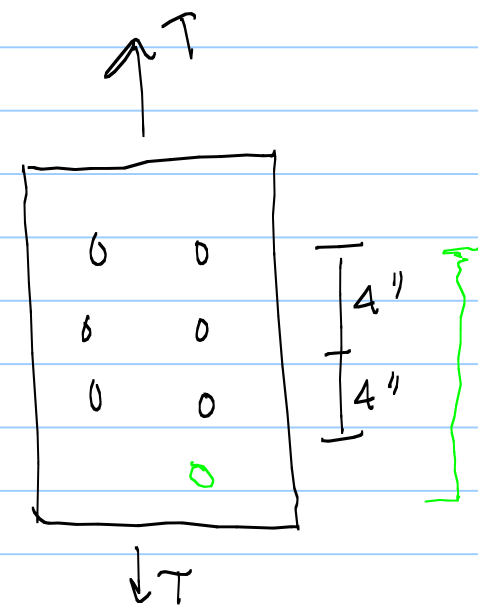
- Slenderness Requirement : $L / r_{min} \leq 300$

r = radius of gyration

Example 1. (4-1).

Select the lightest W14 section available to support tensile loads of $P_D = 220$ k and $P_L = 250$ k.
The member is 30' long.
The member has 2 lines of holes in each flange for 1" bolts.
There will be at least 3 bolts in each line, 4" on center.
Use Grade 50 steel.
Use $U = 1 - \bar{x}/\ell$





$P_u = 1.2D + 1.6L = 1.2(220) + 1.6(250) = \underline{\underline{664 \text{ kips}}}$

$P_u = 1.4D = 1.4(220) = 308 \text{ kips}$

Area Requirement for Yielding:

$$A_g \geq \frac{P_u}{0.9F_y} = \frac{664}{0.9(50)} = 14.76 \text{ in}^2$$

Area Requirement for Fracture:

$$A_g \geq \frac{P_u}{0.75UF_u} + A_{bh}$$

$\rightarrow$ Estimate $U \approx 0.8 - 0.9 \Rightarrow$ Assume $U = 0.85$

→ Estimate $A_{bh} = 4(1 + 1/8)(0.65) = 2.9 \text{ in}^2$

(0.65 → estimate)

$$A_g \geq \frac{664}{0.75(0.85)(65)} + 2.9 = 18.9 \text{ in}^2$$

(65 → F_u)

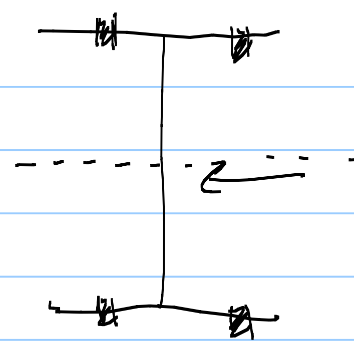
→ Try W14 x 68 ($A_g = 20.00 \text{ in}^2$)

$A_{bh} = 4(1\,1/8)(0.72) = 3.24 \text{ in}^2$

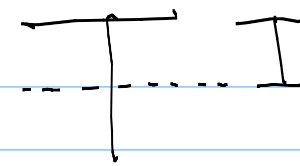
$U = 1 - \frac{\bar{x}}{L}$

$L = 8''$

$\bar{x}$



W14 x 68



WT 7 x 34

$$U = 1 - \frac{1.29}{8} = 0.84$$

Ag required for fracture : $A_g \geq \frac{664}{0.75(0.84)(65)} + 3.24$

$$A_g \geq 19.5 \text{ in}^2$$

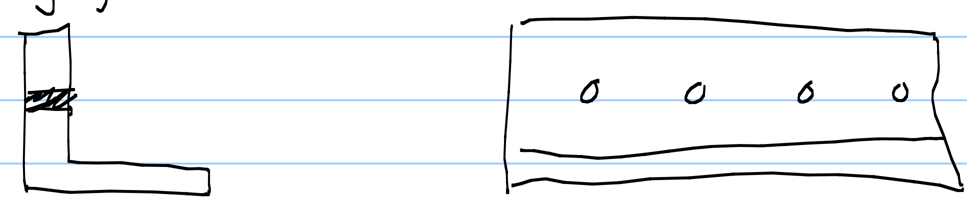
$A_g = 20.0 > 19.5$ ✓

Slenderness Check: $L/r \leq 300$

$$\frac{(30\,ft)(12\,in/ft)}{(2.46\,in)} = 146 < 300 \checkmark$$

→ Select W14x68 as <u>lightest</u> <u>acceptable</u> design.

Example 2. Select the lightest Grade 50 angle that can support tension loads 60 kips dead load and 6 kips live load. The member is 12' long. Assume 7/8" diameter bolts on a single gage line.



$$P_u = \max \begin{cases} 1.2D + 1.6L = 1.2(60) + 1.6(6) = 82 \text{ kips} \\ 1.4D = 1.4(60) = \underline{\underline{84 \text{ kips}}} \text{ (controls)} \end{cases}$$

Required Area for Yielding: $A_g \geq \dfrac{84}{(0.9)(50)} = 1.87 \text{ in}^2$

Required Area for Fracture :

$$A_g \geq \frac{P_u}{0.75\,U\,F_u} + A_{bh}$$

U (from Table D3.1) = 0.8

$$A_{bh} = (1)\left(\tfrac{7}{8} + \tfrac{1}{8}\right)t$$

$$A_g \geq \frac{84}{(0.75)(0.8)(65)} + (1)(1)t$$

t	Ag - fracture
3/16	2.34
1/4	2.40
5/16	2.47
3/8	2.53
7/16	2.59
1/2	2.65
5/8	2.78
3/4	2.90
7/8	3.02
1	3.15
1 1/8	3.28

	Possible Sections	Ag
	4 × 3 1/2 × 3/8	2.67
	5 × 3 × 7/16	3.31
✓	3 1/2 × 3 1/2 × 7/16	2.65
	3 1/2 × 3 × 1/2	3.00
	~~3 1/2 × 2 1/2 × 3/8~~	~~2.56~~
	~~3 1/2 × 3 1/2 × 3/8~~	~~2.48~~
	~~3 × 3 × 7/16~~	~~2.43~~
	~~4 × 4 × 5/16~~	~~2.40~~
(*)	L5 × 3 1/2 × 5/16	2.56

Ag = 2.56 > 2.47 ✓

Check Slenderness : $\frac{(12')(12)}{1.02} = 141 < 300$ ✓

Use L5 × 3 1/2 × 5/16