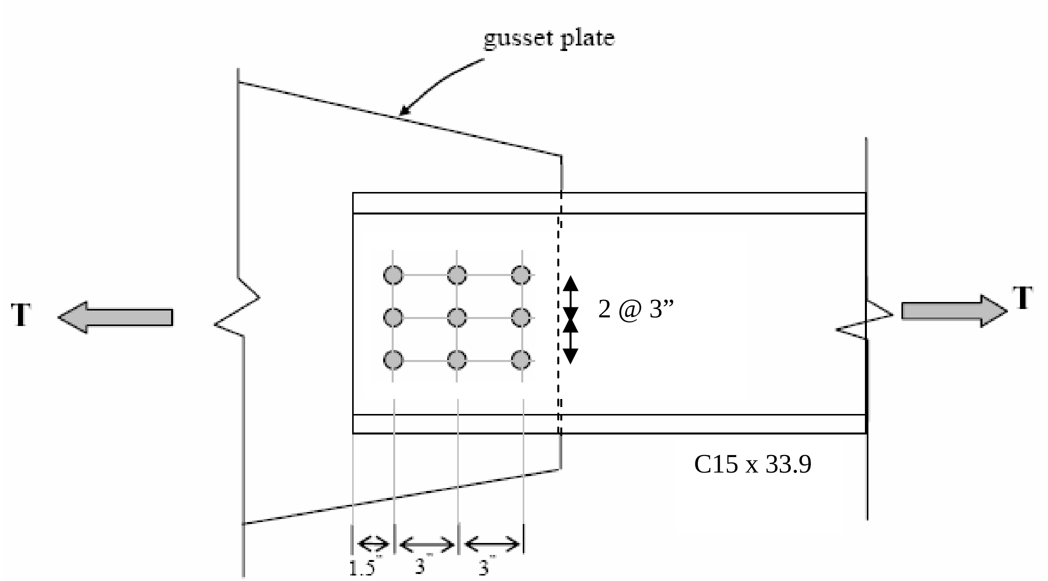
Solution to Homework 4:

In Class Problem:

<u>Given:</u>

Channel section: C15x33.9
A36 Steel: F_y = 36 ksi, F_u = 65 ksi



<u>Required:</u> Determine the design tensile strength.

Step 1: Limit state of yielding due to tension

$\phi T_n = 0.9 A_g F_y = 0.9*9.96*36 = 322.7$ kips

Step 2: Limit state of fracture due to tension

$A_n = A_g - n d_e t = 9.96 – 3(7/8)(0.4) = 8.91$ in^2
$U = 1 – (x / L) = 1 – 0.787 /6 = 0.87 > 0.9$ (ok)
$A_e = U A_n = 0.87*8.91 = 7.75$ in^2
$\phi T_n = 0.75 A_e F_u = 0.75*7.75*58 = 337.1$ kips

Step 3: Limit state of block shear rupture

A_{gv} = 2*(7.5*0.4) = 6.0 in^2
A_{nv} = 2*(7.5-2.5*7/8)0.4 = 4.25 in^2
A_{gt} = (6*0.4) = 2.4 in^2
A_{nt} =2.4 – 2*0.4*(7/8) = 1.7 in^2

F_uA_{nt} = 58*1.7 = 98.6 kips
$0.6F_uA_{nv}$ = 0.6*58*4.25 = 147.9 kips
$0.6F_uA_{nv} > F_uA_{nt}$

$\Rightarrow \phi R_n = 0.75(0.6F_uA_{nv} + F_yA_{gt})$ = 0.75(0.6*58*4.25 + 36*2.4) = 175.7 kips
Check: $0.75(0.6F_uA_{nv} + F_uA_{nt})$ = 0.75(0.6*58*4.25 + 58*1.7) = 184.9 kips (ok)

Therefore, the design tensile strength = 175.7 kips

Solution Hwk #4, Prob #1, Text Prob # 3.4 - 4

Member W 16 x 40 (Table 1 - 1, pg. 1 - 18 to 1 -19)

$A_g := 11.8$ in^2 $\quad$ $t_w := 0.305$ in $\quad$ $t_f := 0.505$ in $\quad$ $d := 16$ in

$\phi P_{ny} := 531$ Kips $\quad$ $\phi P_{nu} := 431$ Kips

$b_f := 7$ in $\quad$ $A_e := 8.85$ in^2 (Table 3.1, pp 3 - 18)

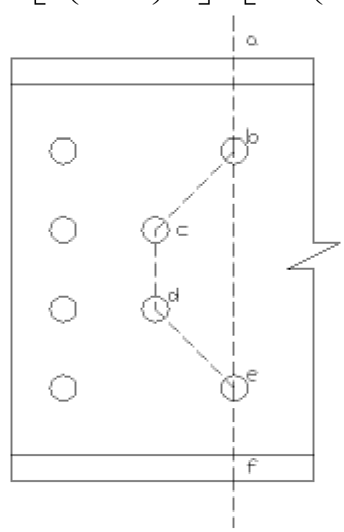
A992 Grade Steel $\quad$ $F_y := 50$ Ksi $\quad$ $F_u := 65$ Ksi

Yield Strength = $\phi_t P_n$ = $\quad$ $P_{ny} := 0.9 \cdot A_g \cdot F_y$ $\quad$ $P_{ny} = 531$ Kip

- Calculation of Net Area

line a-b-e-f $\quad$ $A_{n1} := A_g - \left[2 \cdot \left(\frac{3}{4} + \frac{1}{8}\right) \cdot t_w\right]$ $\quad$ $A_{n1} = 11.266$ in^2

line a-b-c-d-e-f $\quad$ $A_{n2} := A_g - \left[4 \cdot \left(\frac{3}{4} + \frac{1}{8}\right) \cdot t_w\right] + \left[t_w \cdot 2 \cdot \left(\frac{3^2}{4 \cdot 3}\right)\right]$ $\quad$ $A_{n2} = 11.19$ in^2



Net Area is lesser of above, $\quad$ $A_n := \mathrm{if}(A_{n1} < A_{n2}, A_{n1}, A_{n2})$ $\quad$ $A_n = 11.19$ in^2

$U := 0.75$ Assumed 2 bolts per line $\quad$ $U = 0.75$

Effective Area $\quad$ $A_e := U \cdot A_n$ $\quad$ $A_e = 8.393$ in^2

Fracture Strength = = $\phi_t P_n$ = $\quad$ $P_{nu} := 0.75 \cdot A_e \cdot F_u$ $\quad$ $P_{nu} = 409.134$ Kip

. Therefore design strength = 409 kips

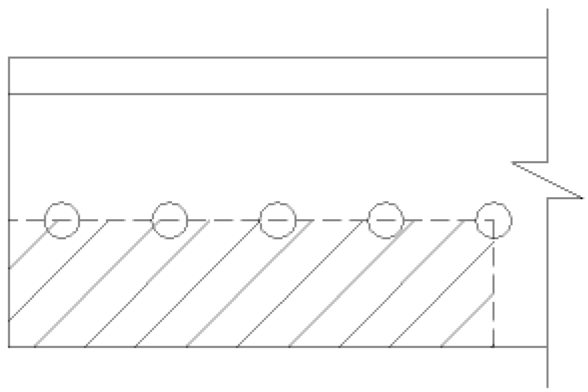
Solution Hwk #4, Prob # 2, Text Prob # 3.5 - 3

Member WT 8 x 13 Properties:

$A_g := 3.84$ in^2 $\quad t_w := 0.25$ in $\quad b_f := 0.345$ in

$d := 7.85$ in $\quad t_f := 5.5$ in $\quad x := 2.09$ in

A992 Steel $\quad F_u := 65$ Ksi $\quad F_y := 50$ Ksi



$7.845 - 4.5 = 3.345$

$A_{gv} := 13.5 \cdot t_w$ $\qquad A_{gv} = 3.375$ in^2

$$A_{nv} := A_{gv} - \left[4.5 \cdot \left(\frac{7}{8} + \frac{1}{8}\right) \cdot t_w\right] \qquad A_{nv} = 2.25 \ in^2$$

$A_{gt} := 3.345 \cdot t_w$ $\qquad A_{gt} = 0.836$ in^2

$$A_{nt} := A_{gt} - \left[0.5 \cdot \left(\frac{7}{8} + \frac{1}{8}\right) \cdot t_w\right] \qquad A_{nt} = 0.711 \ in^2$$

Now,

$F_u \cdot A_{nt} = 46.231$ Kips & $0.6 \cdot F_u \cdot A_{nv} = 87.75$ Kips

Since, FuAnt < 0.6FuAnv, Equation with fracture shear path governs....

$$\phi R_n := 0.75 \cdot \left(0.6 \cdot F_u \cdot A_{nv} + F_y \cdot A_{gt}\right) \qquad \phi R_n = 97.172 \ \text{Kips}$$

Problem 3

$L := 175$ kips

$D := 175$ kips

$P := 1.2 \cdot D + 1.6 \cdot L \rightarrow 490.0$ kips

$Fy := 50$ ksi $\quad Fu := 65$ ksi $\quad L := 8$ in

W10x49

$Ag := 14.4 \ in^2 \quad xbar := 0.807$ in $\quad tf := 0.56$ in $\quad bf := 10$ in

$\phi Pny := Ag \cdot Fy \cdot 0.9 \rightarrow 648.00$ kips Gross Yield

$$An := Ag - 4 \cdot \left(1.25 + \frac{1}{8}\right) \cdot tf \qquad An = 11.32 \ in^2$$

$$U := 1 - \frac{xbar}{L}$$

$Ae := U \cdot An \qquad Ae = 10.178 \quad in^2$

$\phi Pnf := Ae \cdot Fu \cdot 0.75 \rightarrow 496.18213125000000000$ kips Fracture Strength

For Block Shear

$A_{gv} := 10.5 \cdot tf \cdot 4 \qquad A_{gv} = 23.52 \ in^2$

$$A_{nv} := A_{gv} - 4 \cdot \left[2.5 \cdot \left(\frac{5}{4} + \frac{1}{8}\right) \cdot tf\right] \qquad A_{nv} = 15.82 \ in^2$$

$A_{gt} := 4 \cdot 2 \cdot tf \qquad A_{gt} = 4.48 \ in^2$

$$A_{nt} := A_{gt} - 4 \cdot \left[0.5 \cdot \left(\frac{5}{4} + \frac{1}{8}\right) \cdot tf\right] \qquad A_{nt} = 2.94 \ in^2$$

Now,

$Fu \cdot A_{nt} = 191.1$ Kips & $0.6 \cdot Fu \cdot A_{nv} = 616.98$ Kips

Since, FuAnt < 0.6FuAnv, Equation with fracture shear path governs....

$\phi R_n := 0.75 \cdot (0.6 \cdot Fu \cdot A_{nv} + Fy \cdot A_{gt}) \qquad \phi R_n = 630.735$ Kips

Design strength = 496 kips > 490 kips

Max Length=300r = 300*2.54/12 = 63.5 ft > 30 ft (ok)