3rd edition

EXAMPLE 4-6

Tension Member with Block Shear

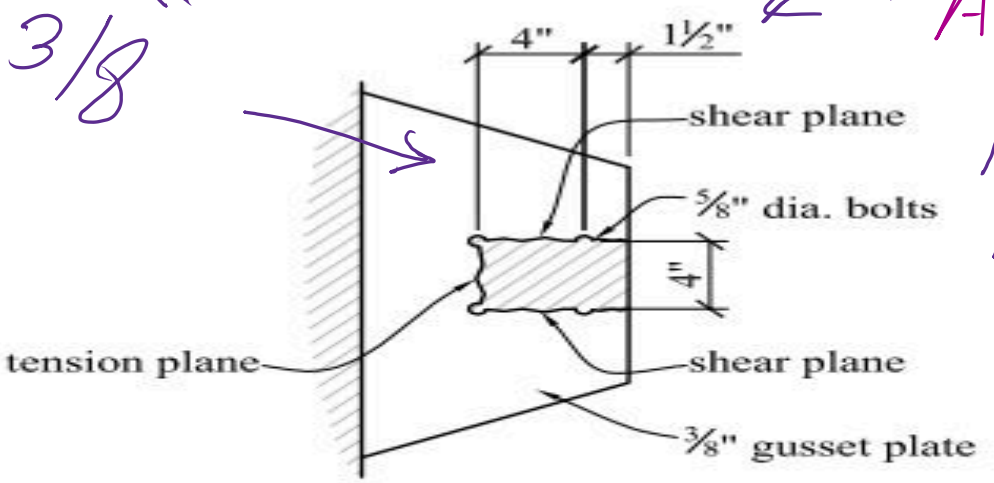
Consider Block - Shear

For the connection shown in Example 4-4, determine if the channel and gusset plate are adequate for the applied tension load considering block shear. Assume that the width of the plate is such that block shear along the failure plane shown in Figure 4-12 controls the design of the plate.

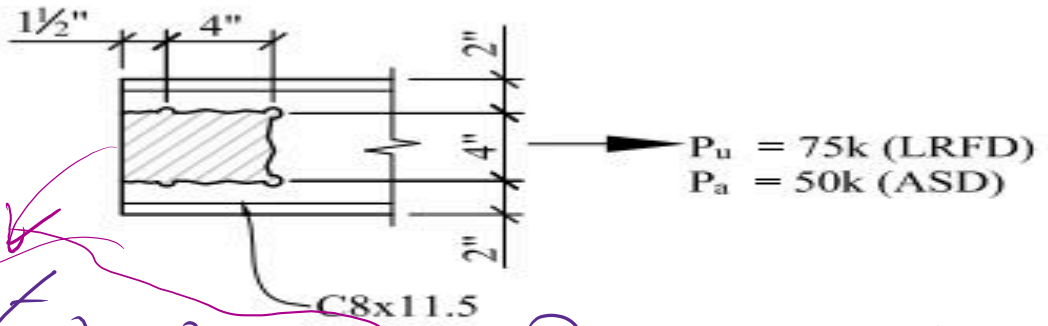
3/8"

A36 steel For both

$P_{bolt} = 75k$



block shear in plate



$t_w = 0.22"$

$P_a = 50k$

block shear in channel

FIGURE 4-12 Detail for Example 4-6

block shear in plate block shear in channel

FIGURE 4-12 Detail for Example 4-6

Channel

A36

$F_y = 36$ ksi

$F_u = 58$ ksi

Solution ① We need to know the web thickness

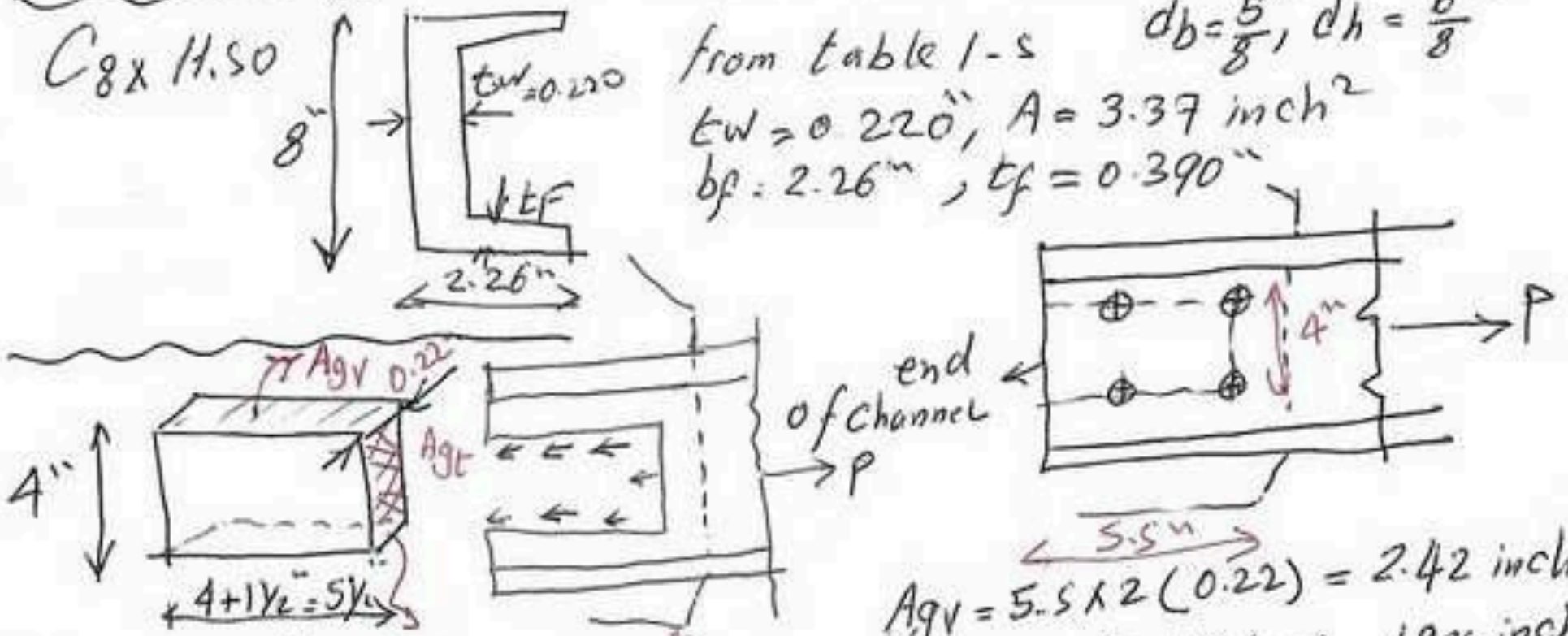
$C_{8} \times 11.50$

$d_b = \frac{5}{8}$", $d_h = \frac{6}{8}$"

from table 1-5

$t_w = 0.220$", $A = 3.37$ inch^2

$b_f = 2.26$", $t_f = 0.390$"



$A_{gv} = 5.5 \times 2(0.22) = 2.42$ inch^2

$A_{gt} = 0.22(4) = 0.88$ inch^2

$A_{nv} = 2.42 - \left[3\left(\frac{6}{8}\right)(0.22)\right] = 1.925$ inch^2

$A_{nt} = 0.88 - (1)\left(\frac{6}{8}\right)(0.22)$

$A_{nt} = 0.715$ inch^2

Shear Yielding + Tension rupture : C channel

upper limit

$\phi(0.6 F_y A_{gv} + U A_{nt} F_u)$

$0.75\left[(0.6)(36)(2.42) + 1(0.715)(58)\right]$

$= 0.75\left[52.272 + 41.47\right] = 70.31$ kips

LRFD $\phi = 0.75$

$A_{gv} = 2.42$ inch^2

$A_{nv} = 1.925$ inch^2

$A_{nt} = 0.715$ inch^2

$U_{BS} = 1.0$

$F_y = 36$ ksi

$F_u = 58$ ksi

Shear rupture + Tension rupture

$\phi(0.60 F_u A_{nv} + U A_{nt} F_u)$

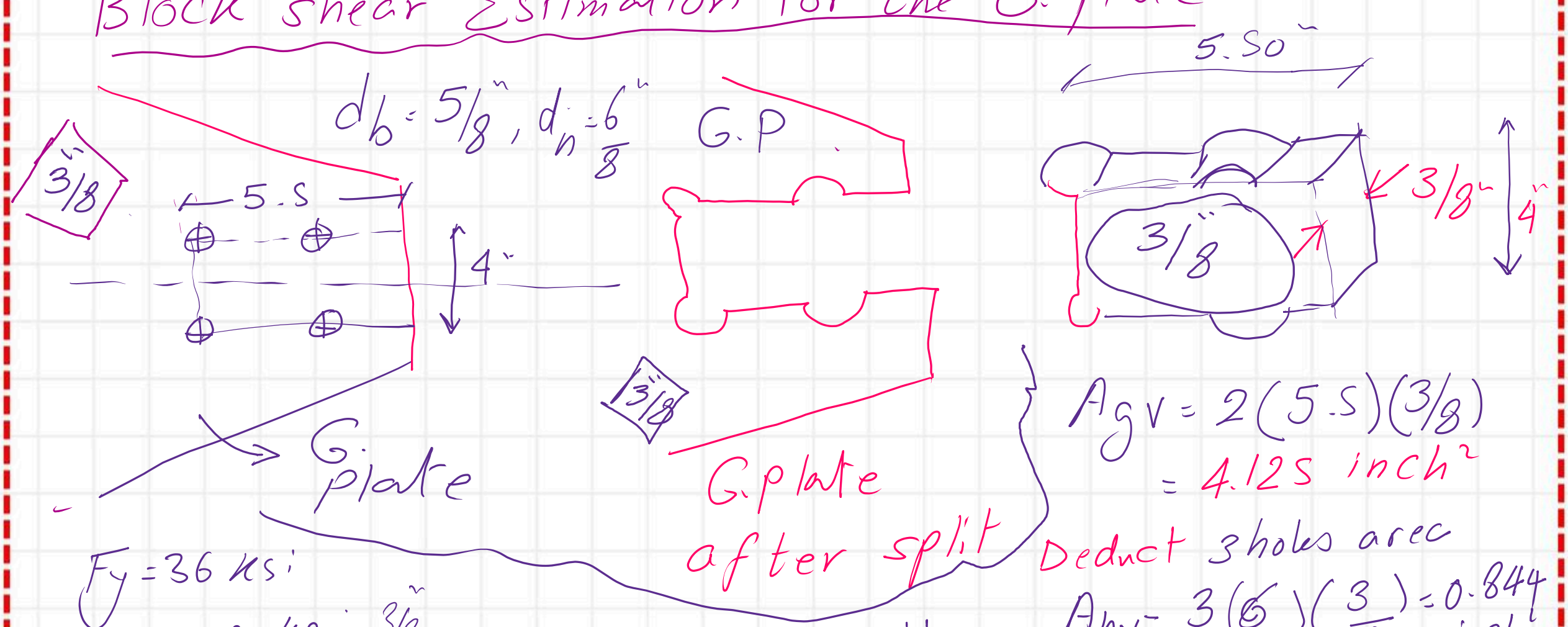
$0.75\left[0.6(58)(1.925) + 1(0.715)(58)\right]$

$= 0.75\left[66.99 + 41.47\right] = 81.35$ kips

Select $\phi P_n = 70.31$ kips $<$ 75 kips

C channel is not adequate

Block shear Estimation For the G. plate



$F_y = 36$ ksi

$F_U = 58$ ksi

$A_{gt} = \frac{3}{8}(4) = 1.50$ inch^2

$A_{nt} = 1.5 - (1)\left(\frac{6}{8}\right)\left(\frac{3}{8}\right)$

$= 1.219$ inch^2

$A_{gv} = 2(5.5)\left(\frac{3}{8}\right)$

$= 4.125$ inch^2

Deduct 3 holes area

$A_{hv} = 3\left(\frac{6}{8}\right)\left(\frac{3}{8}\right) = 0.844$ inch^2

$A_{nv} = 4.125 - 0.844$

$= 3.281$ inch^2

Shear yielding + Tension rupture

$$\phi(0.6 F_y A_{gv} + U A_{nt} F_u)$$

$$0.75\left[(0.6)(36)(4.125) + 1(1.219)(58)\right]$$

$$= 0.75\left[89.10 + 70.702\right] = 119.85 \text{ kips}$$

Gusset plate

LRFD $\phi = 0.75$

$A_{gv} = 4.125 \text{ inch}^2$

$A_{nv} = 3.218 \text{ inch}^2$

$A_{nt} = 1.219 \text{ inch}^2$

$U_{BS} = 1.0$

$F_y = 36 \text{ ksi}$

$F_u = 58 \text{ ksi}$

Shear rupture + Tension rupture

$$\phi(0.60 F_u A_{nv} + U A_{nt} F_u)$$

$$0.75\left[0.6(58)(3.218) + 1(1.219)(58)\right]$$

$$= 0.75\left[111.986 + 70.702\right] = 182.688 \text{ kips}$$

Select $\phi P_n = 119.85 \text{ kips} > 75 \text{ kips}$ G. Plate is adequate

Shear yielding + Tension rupture

$\frac{1}{\Omega}(0.6 F_y A_{gv} + U_{BS} A_{nt} F_u)$ upper limit

$= \frac{1}{2}[(0.6)(36)(4.125) + 1(1.219)(58)]$

$= 1/2\ [\ 89.10 + 70.702] = 79.90$ kips

Shear rupture + Tension rupture

$\frac{1}{\Omega}(0.60 F_u A_{nv} + U_{BS} A_{nt} F_u)$

$= \frac{1}{2}(0.6(58)(3.218) + 1(1.219)(58)]$

$= 1/2\ [\ 111.986 + 70.702] = 91.344$ kips

Select $\frac{P_n}{\Omega} = 79.90$ kips > 54 kips G. Plate is adequate

Gusset plate

ASD $\Omega = 2.00$

$A_{gv} = 4.125$ inch^2

$A_{nv} = 3.218$ inch^2

$A_{nt} = 1.219$ inch^2

$U_{BS} = 1.0$

$F_y = 36$ ksi

$F_u = 58$ ksi

$P_T = 54$ kips

Shear yielding + Tension rupture channel

ASD

$\Omega = 2.00$

$\frac{1}{\Omega}(0.6 F_y A_{gv} + U A_{nt} F_u)$ upper Limit

$= \frac{1}{2}[(0.6)(36)(2.42) + 1(0.715)(58)]$

$= \frac{1}{2}[52.272 + 41.47] = 46.871$ kips

$A_{gv} = 2.42$ inch^2

$A_{nv} = 1.925$ inch^2

$A_{nt} = 0.715$ inch^2

$U_{BS} = 1.0$

$F_y = 36$ ksi

$F_u = 58$ ksi

Shear rupture + Tension rupture

$\frac{1}{\Omega}(0.60 F_u A_{nv} + U A_{nt} F_u)$

$= \frac{1}{2}(0.6(58)(1.925) + 1(0.715)(58)$

$= \frac{1}{2}[66.99 + 41.47] = 54.23$ kips

Select $\frac{P_n}{\Omega} = 46.871$ kips < 54 kips

$P_T = 54$ kips

C Channel is not adequate

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