3.   **Block Shear Strength**

The available strength for the limit state of block shear rupture along a shear failure path or paths and a perpendicular tension failure path shall be determined as follows:

$$R_n = 0.60F_u A_{nv} + U_{bs}F_u A_{nt} \le 0.60F_y A_{gv} + U_{bs}F_u A_{nt} \qquad \text{(J4-5)}$$

$$\phi = 0.75 \text{ (LRFD)} \qquad \Omega = 2.00 \text{ (ASD)}$$

where

A_{nt} = net area subject to tension, in.² (mm²)

Where the tension stress is uniform, $U_{bs} = 1$; where the tension stress is nonuniform, $U_{bs} = 0.5$.

User Note: Typical cases where U_{bs} should be taken equal to 0.5 are illustrated in the Commentary.

Prepared by Eng.Maged Kamel.

The bolted Connection of a Tension Member

member to a gusset plate is shown in Fig. 5.5a and three possible modes of block shear failure are indicated in Figs. 5.5b, c, and d. Each mode involves shear failure along a plane parallel to the applied force and tension failure along a plane perpendicular to the applied force. Failure may occur in either the tension member, as in modes (b) and (c), or the gusset plate, as in mode (d). The failure path is defined by the centerlines of the bolt holes and shear of the bolts does not occur.
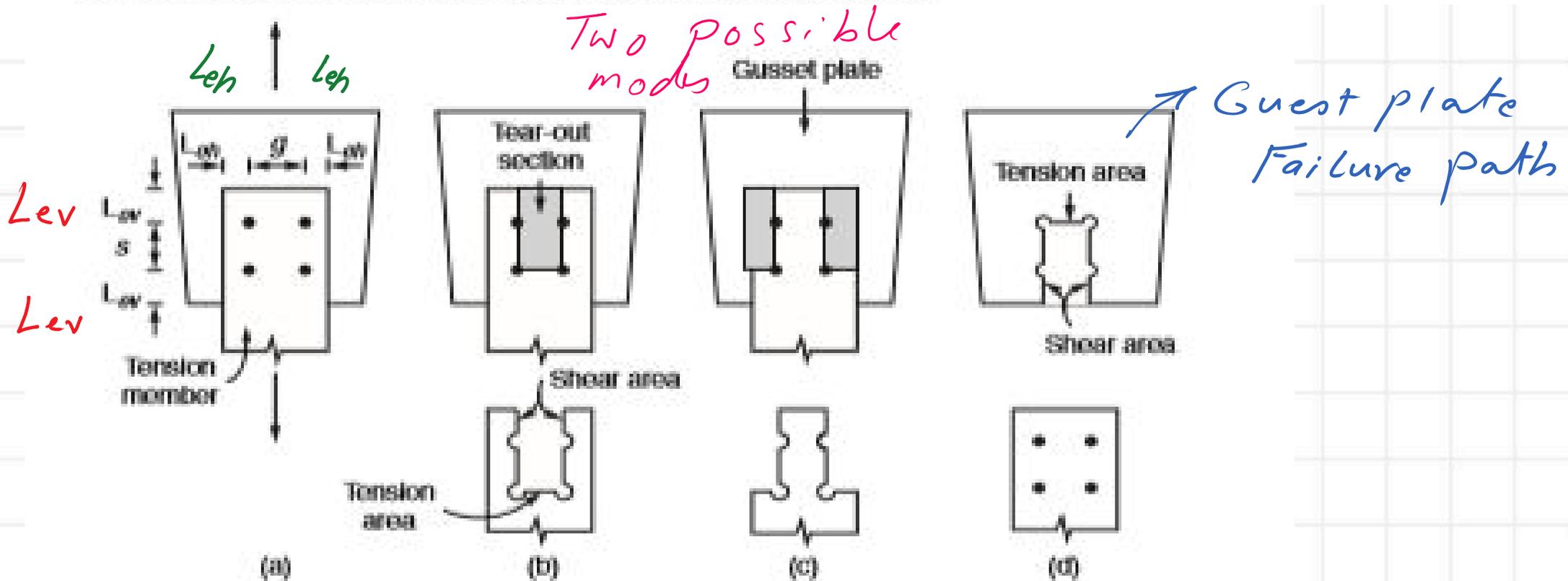
Two possible modes

Guset plate Failure path

Leh   Leh

Lev

Lev

(a)   (b)   (c)   (d)

FIGURE 5.5   Block shear failure.

Prepared by Eng.Maged Kamel.

Example 5.7. Block Shear, Bolted Connection

Determine the block shear strength of the connection shown in Fig. 5.5a. Both members have a yield stress of 36 ksi and a tensile strength of 58 ksi. The tension member thickness is $t = 1/2$ in, the gusset plate thickness is $t_g = 1.0$ in, and the bolts are 7/8-in diameter. The relevant dimensions are $s = 3$ in, $g = 2$ in, $L_{eh} = 2$ in, and $L_{ev} = 2$ in.

G. plate $t_g = 1.0$
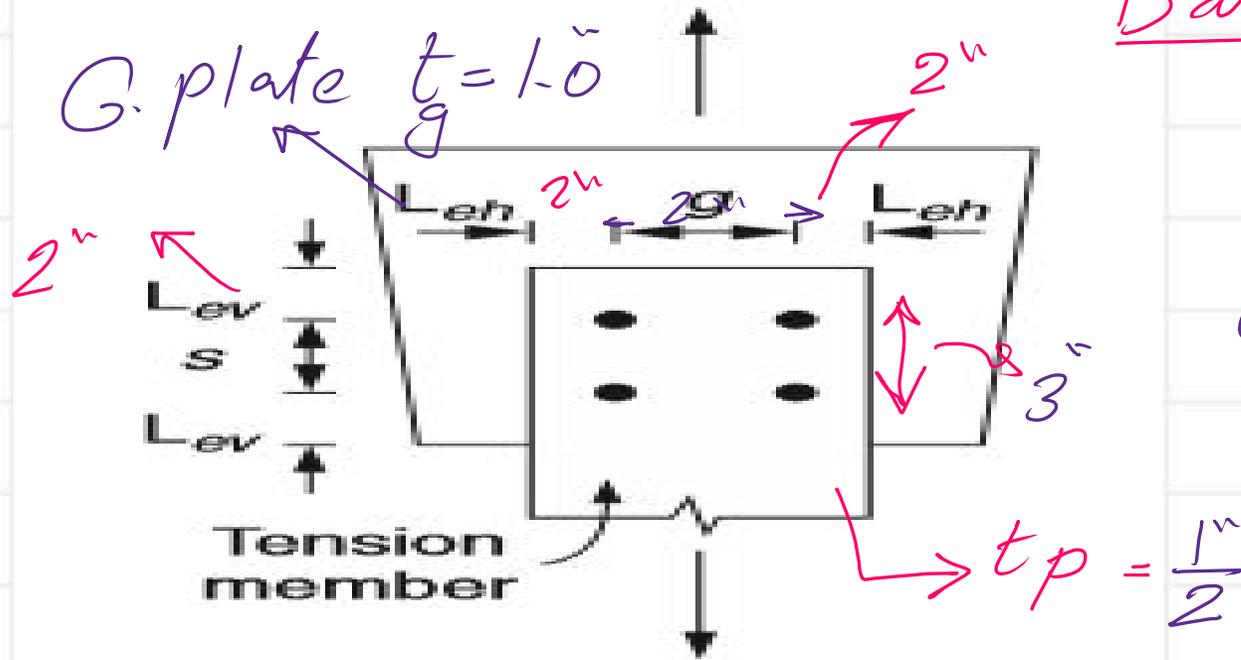
Tension member

Data : $F_y = 36$ ksi
$F_U = 58$ ksi

$d_b = \frac{7}{8} \Rightarrow d_h = \frac{7}{8} + \frac{1}{8} = 1''$

$\rightarrow t_p = \frac{1''}{2}$

Prepared by Eng.Maged Kamel.

Mode B

Tension member   Shear   shear

Tear-out section

$d_b = 1$

2"

3"

Shear area

tion

(b)

5"

Tension
2"

6"

N

P

$t_p = \frac{1}{2}"$

A_{gv}

$\frac{y}{2}"$

5"

5"

2"

A_{gt}
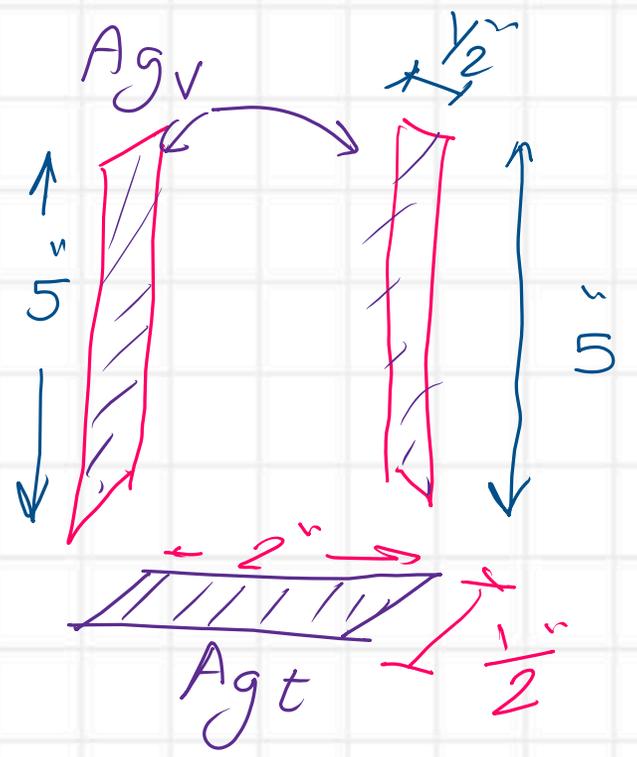
$\frac{1}{2}"$
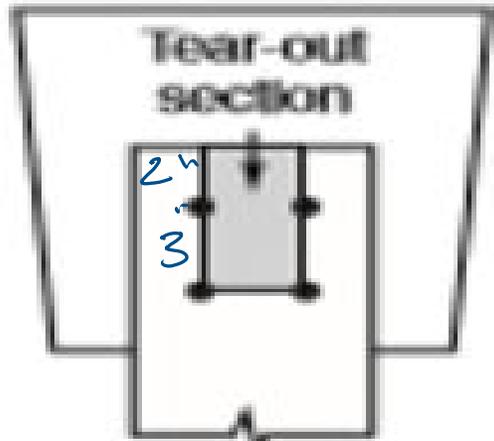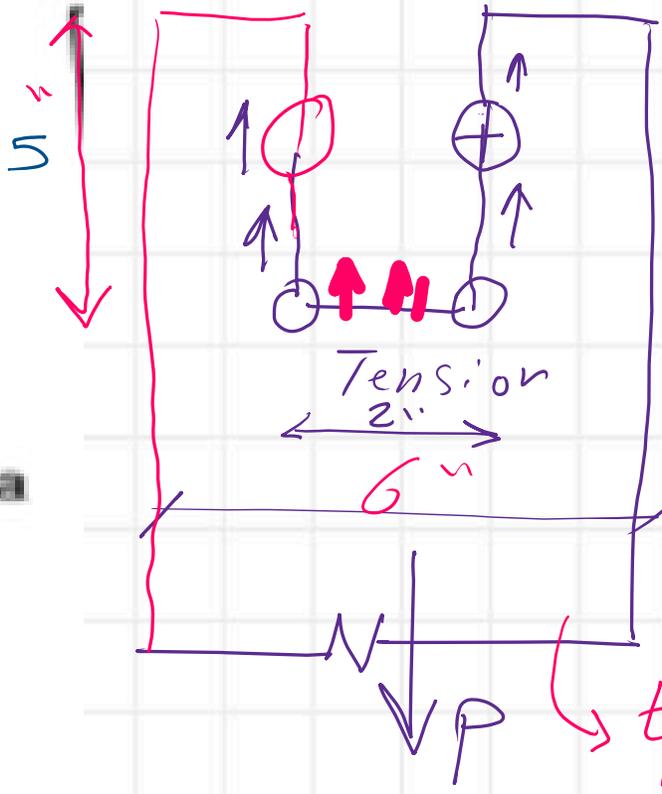
$A_{gt} = 2\left(\frac{1}{2}\right) = 1.0 \text{ inch}^2$

$A_{nt} = 1.0 - (1)(1)\left(\frac{1}{2}\right)$

$= 0.50 \text{ inch}^2$

$A_{gv} = 2\left(\frac{1}{2}\right)(5) = 5 \text{ inch}^2$

Deduct 3 bolts areas $\Rightarrow 3(1)\frac{1}{2} = 1.50 \text{ inch}^2$ (-)

$A_{nv} = 5 - 1.50 = 3.50 \text{ inch}^2$

For mode B   Block Shear Nominal strength

For Tension member

$Ag_V = 5.0$ inch^2 $F_y = 36$ ksi

$Anv = 3.50$ inch^2 $F_U = 58$ ksi

$Ant = 0.50$ inch^2 $UBS = 1$

Shear yielding + Tension rupture   Nominal (upper bound)

$$Ag_V(0.60 F_y) + UBS(Ant\, F_U) = (5)(0.6)(36) + 1(0.5)(58)$$

$$Pn = 108 + 29 = 137 \text{ kips}$$

Shear rupture + Tension rupture

$$Aov(0.60\, F_U) + UBS(Ant\, F_U) = 3.5(0.6)(58) + 1(0.5)(58)$$
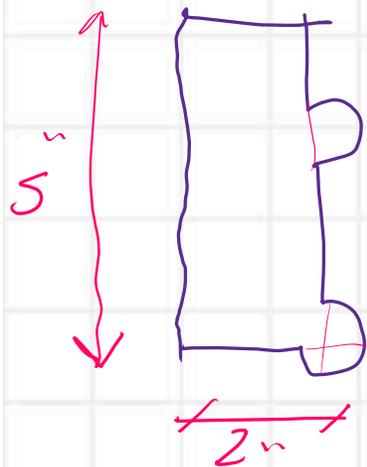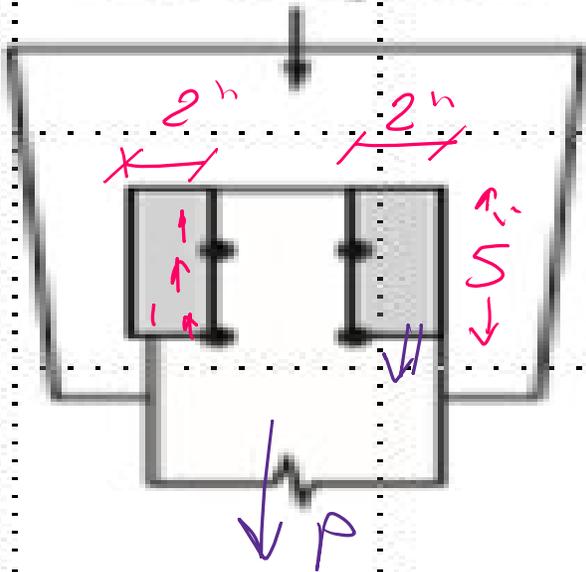
$$Pn = 121.80 + 29 = 150.80 \text{ kips}$$

$$Pn = \min(137, 150.80) = 137 \text{ kips}$$

Mode C Tension member $t_p = \frac{1}{2}''$, $d_h = 1''$

Gusset plate

$2''$ $2''$

5

$No = 2$

5

$2''$

$$Ag_v = 2(5)\left(\frac{1}{2}\right)$$

$$= 5.0 \text{ inch}^2$$

$$A_h = 2(1.5)\left(\frac{1}{2}''\right) = 1.5 \text{ inch}^2$$

$$A_{nv} = 5 - 1.5 = 3.50 \text{ inch}^2$$

$\downarrow P$

(c)

deduct 3 hole area

$$A_{gt} = 2(2)\left(\frac{1}{2}\right) = 2.00 \text{ inch}^2$$

Deduct 1 hole area

$$A_{nt} = 2 - (1)(1)\left(\frac{1}{2}\right) = 1.50 \text{ inch}^2$$
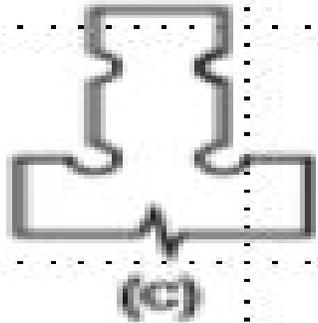
For mode C   Block Shear Nominal strength

$Ag_V = 5.0$ inch^2 For Tension member

$Anv = 3.5$ inch^2 $F_y = 36$ ksi

$Ant = 1.50$ inch^2 $F_U = 58$ ksi

                                  $UBS = 1$

Shear yielding + Tension rupture Nominal (upper bound)

$Ag_V (0.60 F_y) + UBS (Ant F_U) = (5)(0.6)(36) + 1(1.5)(58)$

$P_n = 108 + 87 = 195$ kips

Shear rupture + Tension rupture

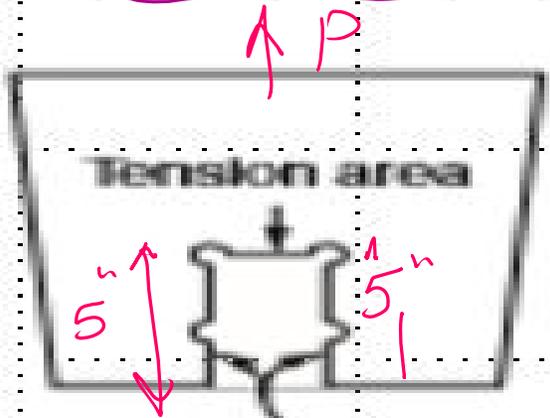$Anv (0.60 F_U) + UBS (Ant F_U) = 3.5(0.6)(58) + 1(1.5)(58)$

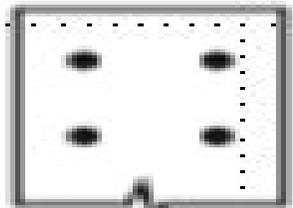$P_n = 121.80 + 87 = 208.80$ kips

$P_n = min(195, 208) = 195$ kips

Mode d For Plate

$t_g = 1''$
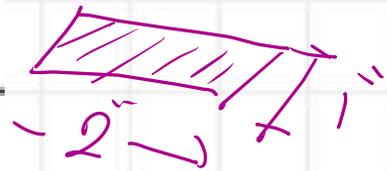
$d_h = 1''$

5
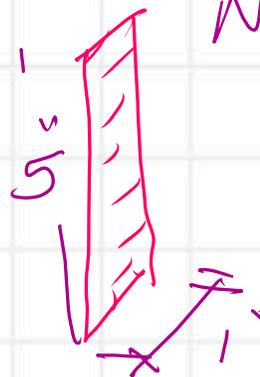
$No. = 2$

$Ag_v = 2(5)(1) = 10.0 \ inch^2$

Deduct 3 hole areas

$A_h = 3(1'')(1'') = 3.00 \ inch^2$ (−)

$A_{nv} = 10.0 - 3 = 7.00 \ inch^2$

$A_{gt} = \overset{No}{1}(2)(1'') = 2 \ inch^2$

Deduct 1 hole area

$A_{nt} = 2 - (1)(1)(1) = 1.0 \ inch^2$

↑P

Tension area

5"   5"

Shear area

$g = 2''$

(d)

For mode d   Block Shear Nominal strength

For G.plate

$Ag_v = 10.0$ inch^2 $Fy = 36$ ksi

$Anv = 7.0$ inch^2 $Fu = 58$ ksi

$Ant = 1.0$ inch^2 $UBS = 1$

Shear yielding + Tension rupture Nominal (upper bound)

$Ag_v (0.60 \, Fy) + UBS (Ant \, Fu) = (10)(0.6)(36) + 1(1)(58)$

$Pn = 216 + 58 = 274$ kips

Shear rupture + Tension rupture

$Anv (0.60 \, Fu) + UBS (Ant \, Fu) = 7(0.6)(58) + 1(1)(58)$

$Pn = 243.60 + 58 = 301.60$ k

$Pn = min (274, 301.6) = 274$ kips

Mode b : $P_n = 137.0$ kips
Mode c $P_n = 195.0$ kips
Mode d $P_n = 274$ kips

Mode b will govern since it has the lowest value

$\phi_{bs} = 0.75$ $\phi P_n = 0.75(137) = 102.75$ kips $\approx 103 k$ — <u>LRFD</u>

$\Omega = 2.0$ $\dfrac{P_n}{\Omega} = \dfrac{1}{2}(137) = 68.5$ kips $\approx 69 k$

$\boxed{ASD}$