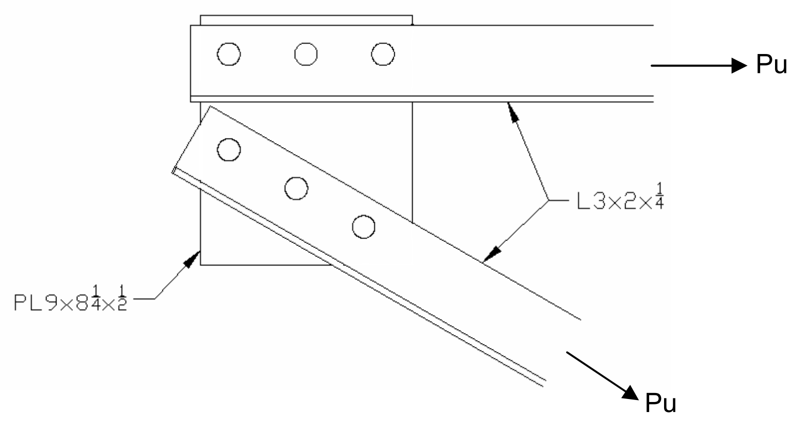
Sample Calculations – Connection 46



A36 steel properties from AISC Table 2-3:

$F_y = 36\ ksi$

$F_u = 58\ ksi$

A325N bolt properties from AISC Table J3.2:

$F_{nv} = 48\ ksi$

L3x2x1/4 properties from AISC Table 1-7:

$A_g = 1.19\ in^2$

$\bar{x} = 0.487\ in$

7/8 inch diameter bolt properties from AISC Table J3.4:

$L_e = 1\frac{1}{2} in$

$L_e^{'} = 1\frac{1}{8} in$

Tension Yielding

$\phi P_n = 0.9 A_g F_y$

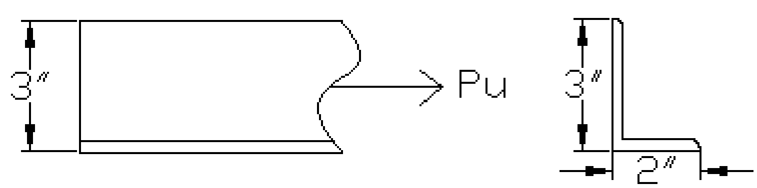


Figure 9. *Tension yielding L3x2x1/4*

L3x2x1/4: $\phi P_n = 0.9(1.19\ in^2)36\ ksi = 38.6\ ksi$

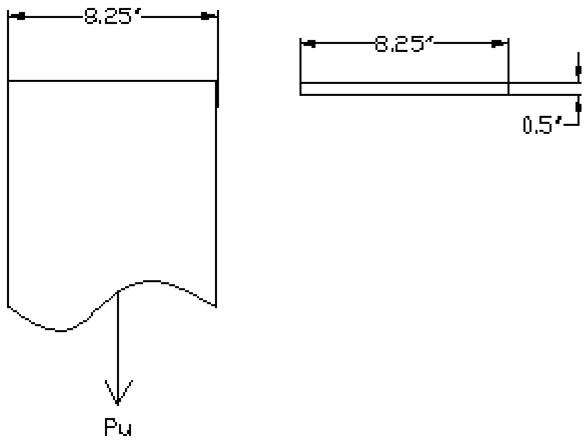


Figure 10. *Tension yielding PL9x8 1/4x1/2*

PL9x8-1/4x1/2: $\phi P_{n,\min} = 0.9\ (8.25\ in)\frac{1}{2} in(36\ ksi) = 133.7\ kip$

Fracture of Net Effective Area

$$\phi P_n = 0.75 F_u A_e = 0.75 F_u U A_n$$

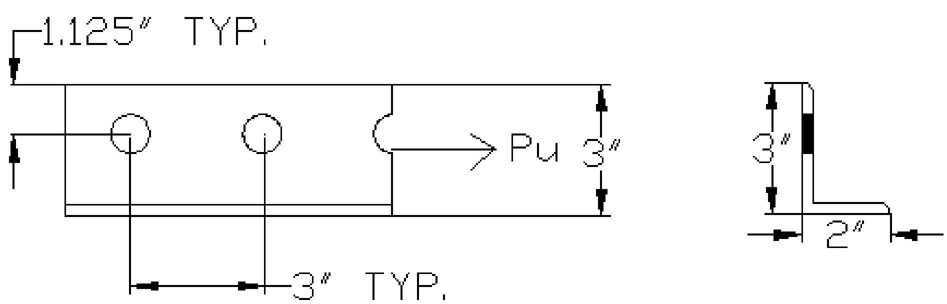


Figure 11. *Fracture of net effective area L3x2x1/4*

L3x2x1/4

$$A_n = 1.19\ in^2 - \frac{1}{4} in\left(\frac{7}{8} in + \frac{1}{16} in_{tolerance} + \frac{1}{16} in_{damage}\right) = 0.94\ in^2$$

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.487\,in}{6\,in} = 0.9188$$

$$\phi P_n = 0.75(58\ ksi)0.9188(0.94\ in^2) = 37.6\ kip$$

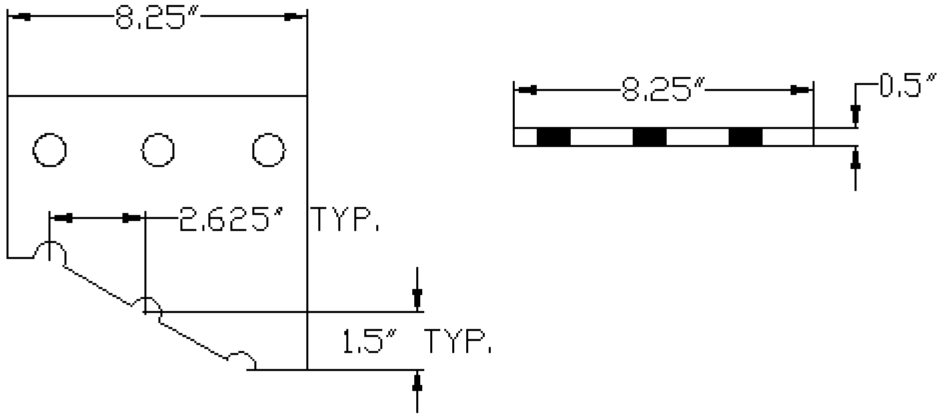


Figure 12. *Fracture of net effective area PL9x8-1/4x1/2*

PL9x8-1/4x1/2

$$\sum \frac{s^2}{4g} = 2\left(\frac{(1.5\ in)^2}{4(2.625\ in)}\right) = 0.4286$$

$$A_n = \left(8.25\ in - 3\left(\frac{7}{8} in + \frac{1}{16} in_{tolerance} + \frac{1}{16} in_{damage}\right) + 0.4286\ in\right) 0.5\ in = 2.84\ in^2$$

$$U = 1.0\ Table\ D3.1\ Case 1$$

$$\phi P_{n,\min} = 0.75(58\ ksi)1.0(2.84\ in^2) = 123.5\ kip$$

Block Shear

$$\phi P_n = 0.75 \min\begin{cases} 0.6 F_u A_{nv} \\ 0.6 F_y A_{gv} \end{cases} + U_{bs} F_u A_{nt}$$

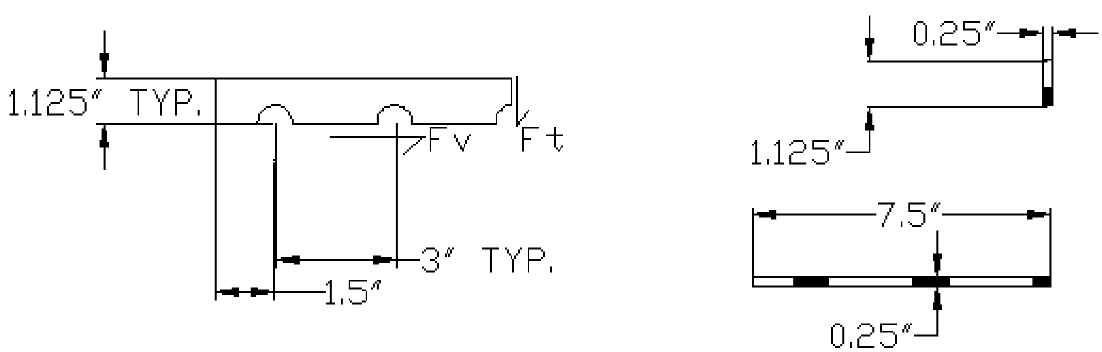


Figure 13. *Block shear L3x2x1/4*

L3x2x1/4

$$A_{gv} = 0.25\ in(7.5\ in) = 1.875\ in^2$$

$$A_{nv} = 1.875\ in^2 - 0.25 in(2.5)\left(\frac{7}{8}in + \frac{1}{16}in_{tolerance} + \frac{1}{16}in_{damage}\right) = 1.25\ in^2$$

$$A_{nt} = 0.25\ in\left(1.125\ in - 0.5\left(\frac{7}{8}in - \frac{1}{16}in_{tolerance} - \frac{1}{16}in_{damage}\right)\right) = 0.156\ in^2$$

$$\phi P_n = 0.75\min\begin{cases}0.6(58\ ksi)1.25\ in^2\\0.6(36\ ksi)1.875\ in^2\end{cases} + 1.0(58\ ksi)0.156\ in^2 = 0.75(40.5\ kip + 9.06\ kip) = 49.6\ kip$$

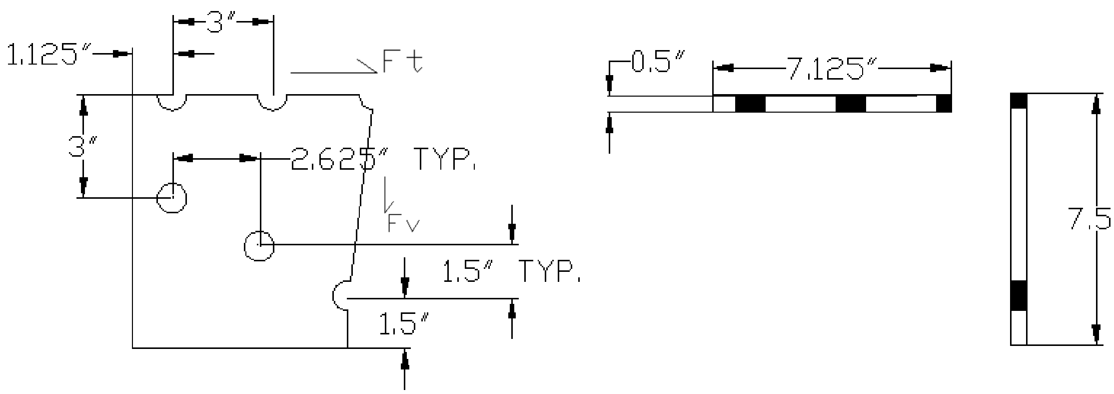


Figure 14. *Block shear PL9x8-1/4x1/2*

PL9x8-1/4x1/2

$$A_{gv} = \left(1.5\ in + \sqrt{(1.5\ in)^2 + (6\ in)^2}\right)0.5\ in = 3.84\ in^2$$

$$A_{nv} = 3.84\ in^2 - 1.5\left(\frac{7}{8}in + \frac{1}{16}in_{tolerance} + \frac{1}{16}in_{damage}\right)0.5\ in = 3.09\ in^2$$

$$A_{nt} = \left(7.125\ in - 2.5\left(\frac{7}{8}in + \frac{1}{16}in_{tolerance} + \frac{1}{16}in_{damage}\right)\right)0.5\ in = 2.3125\ in^2$$

$$\phi P_{n,\min} = 0.75\min\begin{cases}0.6(58\ ksi)3.09\ in^2\\0.6(36\ ksi)3.84\ in^2\end{cases} + 1.0(58\ ksi)2.3125\ in^2 = 0.75(82.9\ kip + 134.1\ kip) = 162.8\ kip$$

Bolt Shear Strength

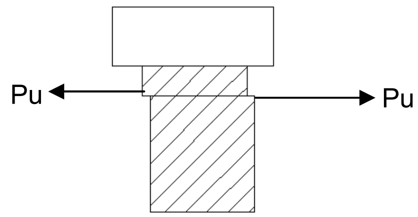


Figure 15. *Bolt shear strength failure (in single shear)*

7/8 inch A325N bolts

$$\phi R_n = \phi F_{nv} A_b N$$

$$\phi R_n = (0.75)48\ ksi \frac{\pi}{4}\left(\frac{7}{8} in\right)^2 3\ shear\ planes = 64.9\ kip$$

Bolt Hole Bearing

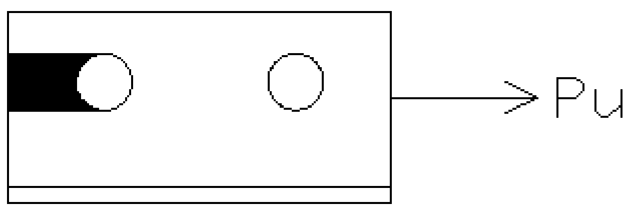


Figure 16. *Bolt hole bearing failure*

7/8 inch A325N bolts
Assuming bolt hole deformation at service load is a design consideration

$$\phi R_n = \phi N \min\begin{cases} 1.2 L_c t F_u \\ 2.4 d t F_u \end{cases}$$

$$\phi R_n = 0.75\ (3\ bolts)\min\begin{cases} 1.2\left(1.5\ in - \frac{7}{16} in\right)58\ ksi \\ 2.4\left(\frac{7}{8} in\right)\frac{1}{4} in\,(58\ ksi) \end{cases} = 2.25(30.45\ kip) = 68.5\ kip$$