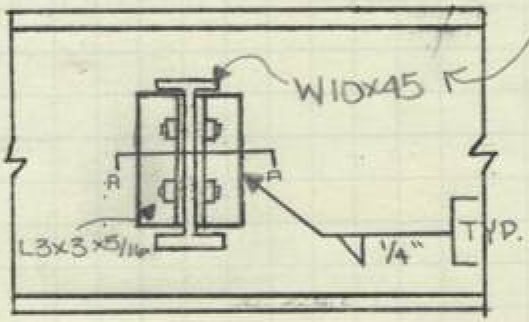
W14×82
W10×45
$F_y = 50$ ksi
$F_u = 65$ ksi

L3×3×5/16
$F_y = 36$ ksi
$F_u = 58$ ksi

Electrode
$F_{E80} = 80$ ksi

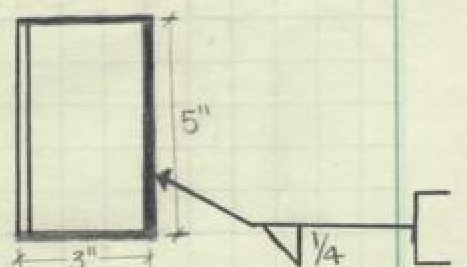


NOT TO SCALE

$$\phi R_n = \min \begin{cases} \phi F_w A_w \\ \phi F_{BM} A_{BM} \end{cases} \quad \text{(AISC J2.4)}$$

$$\phi F_{BM} A_{BM} = \min \begin{cases} .75 A_{nv} (.6 F_u) & \text{(Eq. J4-4)} \\ 1.0 A_g (.6 F_y) & \text{(Eq. J4-3)} \end{cases}$$

ONE SIDE
L3×3×5/16



Strength of Weld

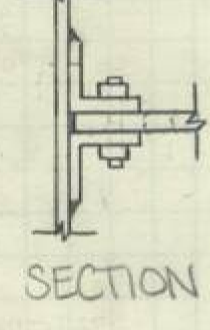
$$\phi R_n = .75 F_w A_w$$
$$= .75(.6 F_{E80})(2 L_w)(t_w)$$
$$= .75(.6(80))(2(5+2(3)))(.707(.25))$$
$$= \underline{139.9\text{ k}}$$

$A_{L3x3} = 1.78 \text{ in}^2$
$L_w = [5 + 2(3)]$ in
$t_w = .707(D_w)$ in
$D_w = .25$ in

Shear Rupture Strength of Base Material

The controlling thickness is the thickness of the W14×82.

Top View of Connection



SECTION AA

$$\phi R_n = .75 F_{BM} A_{BM} \quad \text{(Eq. J4-4)}$$

$$= .75(.6 F_u)(t_w)$$
$$= .75(.6)(65\text{ ksi})(1/2\text{ in})$$
$$= 14.62\text{ k/in of weld}$$

$$= 14.62\text{ k/in}\,(L_w)$$
$$= 14.62\text{ k/in}\,(5 + 2(3))$$
$$= \underline{160.82\text{ k}}$$

Shear Yielding of Base Material

$\phi R_n = \phi F_{BM} A_{BM}$ (Eq J4-3)

$= 1.0(.6F_y)A_g$
$= 1.0(.6)(2)(36)(1.78in^2)$

$= 76.9k$

The angles will control since the strength and cross-sectional area are less than the W-section.

$\therefore \phi R_n = \min(139.9k, 160.8k, 76.9k)$

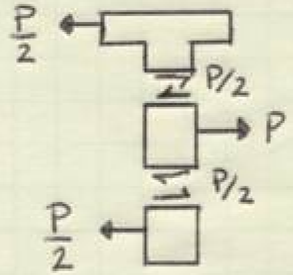
$\phi R_n = 76.9k$

The maximum applied forceo that the weld will be able to hold is 76.9 k.

- Bolt shear Rupture:

- Bolt Type:

$3/4''\ \phi$, A325 N



$$\phi R_n = 0.75\, F_n\, A_b\, \#\text{bolts}$$

→ J3-1 pg 16.1-108

$F_n = F_{nv}$ → Table J3.2 pg 16.1-104

$F_{nv} = 48\ \text{ksi}$

$A_b = \frac{\pi}{4}\left(3/4''\right)^2 = 0.442\ \text{in}^2$

$\#\text{bolts} = 2$

$$\phi R_n = 0.75\,(48\ \text{ksi})(.442\ \text{in}^2)(2) = 31.8\text{K}$$

$P_u < \phi R_n$

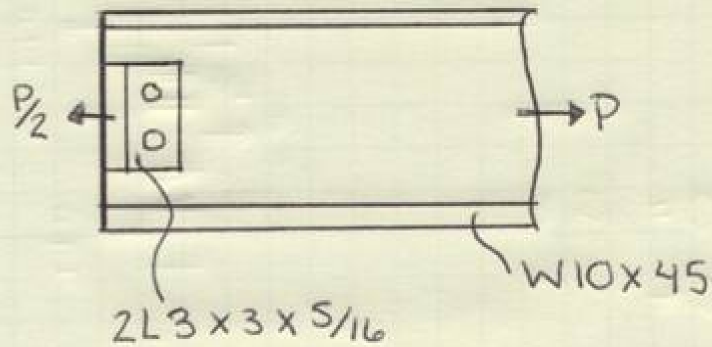
$\simeq \frac{1}{2}P < \phi R_n \simeq P \leq 2\phi R_n$

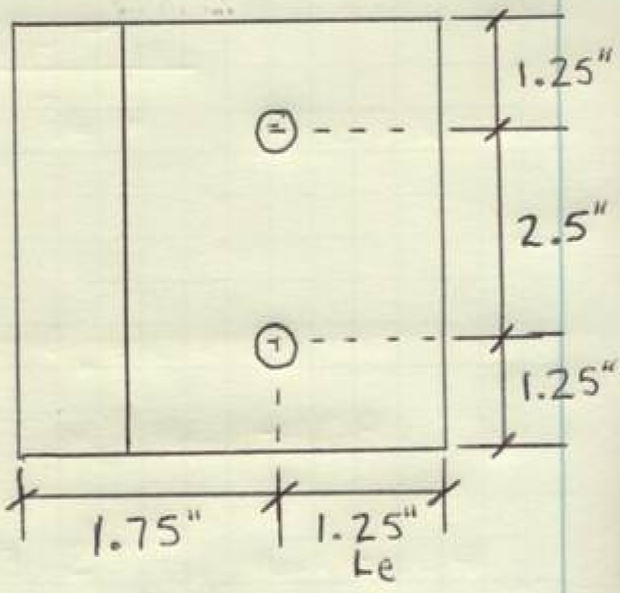
$$P < 2(31.8\text{K}) = 63.6\text{K}$$

Note: $\frac{1}{2}P$ is from the maximum shear force on the bolt

$$\underline{\underline{P_u < \phi R_n = 63.6\text{ K}}}$$

- Bolt Bearing:





2L3 x 3 x 5/16
$F_u = 58$ ksi

- Double Angle:

  - Deformation considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.2 L_c t F_u \\ 2.4 d t F_u \end{cases}$$

per bolt

J3-6a
Pg 16.1 - 111

$$L_c = L_e - \tfrac{1}{2} d_h = 1.25" - \tfrac{1}{2}\left(\tfrac{3}{4}" + \tfrac{1}{8}\right) = 0.8125"$$

$$1.2 L_c t F_u = 1.2(0.8125")(5/16")(58 \text{ ksi}) = 17.7 \text{ k}$$

$$2.4 d t F_u = 2.4(3/4")(5/16")(58 \text{ ksi}) = 32.6 \text{ k}$$

$$\phi R_n = 0.75(17.7 \text{ k}) \cdot 2_{bolts} \cdot 2_{angles}$$

$$\underline{\underline{P_u < \phi R_n = 53.1 \text{ k}}}$$

- Double Angle

- Deformation is not considered

$$\phi R_n = 0.75 \min \begin{cases} 1.5 L_c t F_u \\ 3.0 d t F_u \end{cases} \quad \text{J3-6b}$$

Pg 16.1-111

per bolt

$$L_c = L_e - \tfrac{1}{2} d_h = 1.25'' - \tfrac{1}{2}(\tfrac{3}{4}'' + \tfrac{1}{8}'') = 0.8125''$$

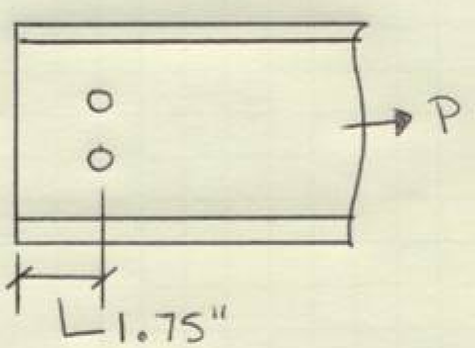
$$1.5 L_c t F_u = 1.5(0.8125'')(\tfrac{5}{16}'')(58\ \text{ksi}) = 22.1\ \text{k}$$

$$3.0 d t F_u = 3.0(\tfrac{3}{4}'')(\tfrac{5}{16}'')(58\ \text{ksi}) = 40.8\ \text{k}$$

$$\phi R_n = 0.75(22.1\ \text{k})(2\ \text{angles})(2\ \text{bolts}) = 66.3\ \text{K}$$

$$\underline{\underline{P_u < \phi R_n = 66.3\ \text{k}}}$$

- W-section:



W10 x 45

$t_{web} = 3/8$ inch

$F_u = 65$ ksi

W-section

- Deformation is considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.2 L_c t F_u \\ 2.4 d t F_u \end{cases} \qquad \text{J3-6a}$$

Pg 16.1-111

per bolt

$$L_c = L_e - \tfrac{1}{2} d_h = 1.75 - \tfrac{1}{2}(3/4 + 1/8) = 1.31''$$

$$1.2 L_c t F_u = 1.2(1.31'')(3/8'')(65\ ksi) = 38.3\ k$$

$$2.4 d t F_u = 2.4(3/4'')(3/8'')(65\ ksi) = 43.9\ k$$

$$\phi R_n = .75(38.3\ k)\, 2_{bolts} = 57.5\ k$$

$$\underline{\underline{P_u < \phi R_n = 57.5\ k}}$$

- Deformation is not considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.5 L_c t F_u \\ 3.0 d t F_u \end{cases} \qquad \text{J3-6b}$$

Pg 16.1-111

per bolt

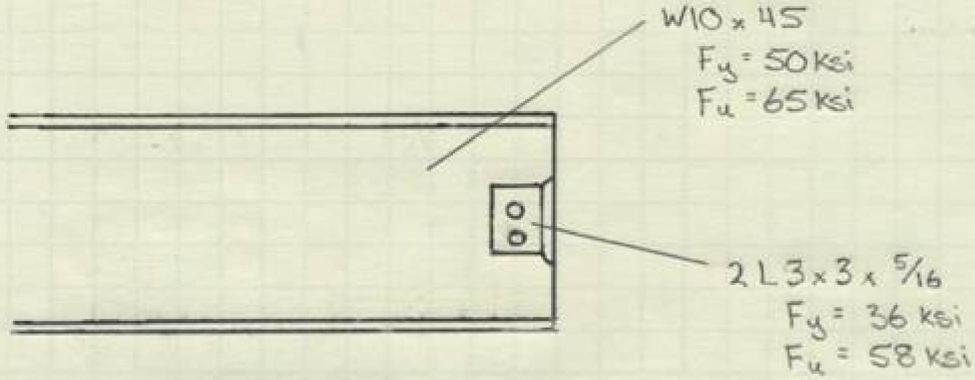
$$L_c = L_e - \tfrac{1}{2} d_h = 1.75 - \tfrac{1}{2}(3/4 + 1/8) = 1.31 \text{ inches}$$

$$1.5 L_c t F_u = 1.5(1.31'')(3/8'')(65\ ksi) = 49.7\ k$$

$$3.0 d t F_u = 3.0(3/4'')(3/8'')(65\ ksi) = 54.8\ k$$

$$\phi R_n = 0.75(49.7\ k)(2_{bolts}) = 71.8\ k$$

$$\underline{\underline{P_u < \phi R_n = 71.8\ k}}$$



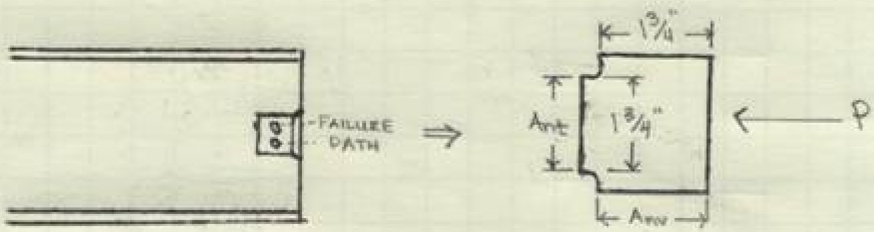
EQUATIONS

$$P_n = \min \begin{cases} 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \\ 0.6 F_y A_{gv} + U_{bs} F_u A_{nt} \end{cases} \quad \text{(AISC J4-5)}$$

where A_{gv} = GROSS AREA SUBJECTED TO SHEAR, in^2
A_{nv} = NET AREA SUBJECTED TO SHEAR, in^2
A_{gt} = GROSS AREA SUBJECTED TO TENSION, in^2
A_{nt} = NET AREA SUBJECTED TO TENSION, in^2
U_{bs} = 1.0 IF TENSION STRESS IS UNIFORM;
0.5 IF TENSION STRESS IS NOT UNIFORM

BLOCK SHEAR RUPTURE ON W10x45 SECTION

FBD:



$$A_{gv} = (l_{A_{gv}})(t) = 2(1\tfrac{3}{4}")(\tfrac{3}{8}") = 1.3125\ in^2$$

$$A_{nv} = A_{gv} - (\#\text{ of holes})(d_b + \tfrac{1}{16}" + \tfrac{1}{16}")(t)$$
$$= 1.3125\ in^2 - (1)(\tfrac{3}{4}" + \tfrac{1}{16}" + \tfrac{1}{16}")(\tfrac{3}{8}") = 0.9844\ in^2$$

$$A_{gt} = (l_{A_{gt}})(t) = (2.5")(\tfrac{3}{8}") = 0.9375\ in^2$$

$$A_{nt} = A_{gt} - (\#\text{ of holes})(d_b + \tfrac{1}{16}" + \tfrac{1}{16}")(t)$$
$$= 0.9375\ in^2 - (1)(\tfrac{3}{4}" + \tfrac{1}{16}" + \tfrac{1}{16}")(\tfrac{3}{8}") = 0.6094\ in^2$$

$$P_{nb} = \min \begin{cases} 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \\ 0.6 F_y A_{gv} + U_{bs} F_u A_{nt} \end{cases}$$

$$P_{nb} = \min \begin{cases} 0.6(65\ ksi)(0.9844\ in^2) + (1.0)(65\ ksi)(0.6094\ in^2) \\ 0.6(50\ ksi)(1.3125\ in^2) + (1.0)(65\ ksi)(0.6094\ in^2) \end{cases}$$

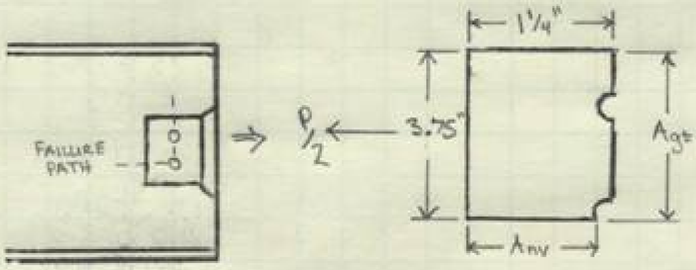
$$P_{nb} = \min \begin{cases} 78.0^k \\ 79.0^k \end{cases}$$

$$P_{nb} = 78.0^k$$

$$\phi P_{nb} = 0.75(P_{nb}) = 0.75(78.0^k) = 58.5^k$$

BLOCK SHEAR RUPTURE ON L3x3x5/16 SECTION

FBD:



NOTE: P/2 BECAUSE ONE ANGLE SECTION TAKES HALF OF THE TOTAL LOAD

$$A_{gv} = (l_{Agv})(t) = (1\tfrac{1}{4}")(\tfrac{5}{16}") = 0.3906 \text{ in}^2$$
$$A_{nv} = A_{gv} - (\#\text{ of holes})(d_b + \tfrac{1}{16}" + \tfrac{1}{16}")(t)$$
$$= 0.3906\text{in}^2 - (\tfrac{1}{2})(\tfrac{3}{4}" + \tfrac{1}{16}" + \tfrac{1}{16}")(\tfrac{5}{16}") = 0.2539 \text{ in}^2$$
$$A_{gt} = (l_{Agt})(t) = (3.75")(\tfrac{5}{16}") = 1.17 \text{ in}^2$$
$$A_{nt} = A_{gt} - (\#\text{ of holes})(d_b + \tfrac{1}{16}" + \tfrac{1}{16}")(t)$$
$$= 1.17 \text{ in}^2 - (1.5)(\tfrac{3}{4}" + \tfrac{1}{16}" + \tfrac{1}{16}")(\tfrac{5}{16}") = 0.7617 \text{ in}^2$$

$$\tfrac{1}{2}P_{nb} = \min \begin{cases} 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \\ 0.6 F_y A_{gv} + U_{bs} F_u A_{nt} \end{cases}$$

$$\tfrac{1}{2}P_{nb} = \min \begin{cases} 0.6(58\text{ksi})(0.2539\text{in}^2) + (1.0)(58\text{ksi})(0.7617 \text{ in}^2) \\ 0.6(36\text{ksi})(0.3906\text{in}^2) + 1.0(58\text{ksi})(0.7617 \text{ in}^2) \end{cases}$$

$$\tfrac{1}{2}P_{nb} = \min \begin{cases} 53.0^k \\ 52.6^k \end{cases}$$

$$\tfrac{1}{2}P_{nb} = 52.6^k$$
$$P_{nb} = 105.23^k$$

$$\phi P_{nb} = 0.75(P_{nb}) = 0.75(105.23^k) = 78.9^k$$