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Sample Calculations - Connection 8

W14x82

2-L3x3x5/16

TYP.

1/4

A325N 3/4" ϕ

W10x45

NOT TO SCALE

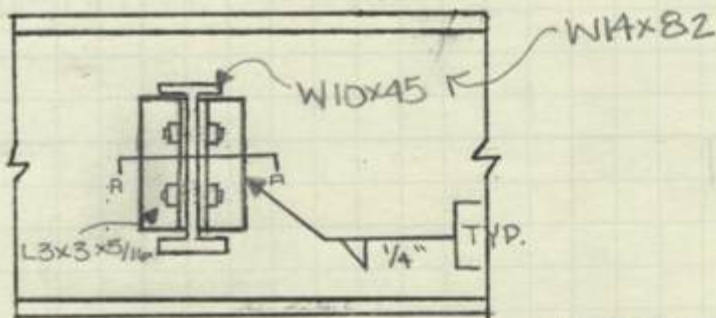
Material Properties Used

W14x82
 $F_y = 50 \text{ ksi}$
 $F_u = 65 \text{ ksi}$

W10x45
 $F_y = 50 \text{ ksi}$
 $F_u = 65 \text{ ksi}$

L3x3x5/16
 $F_y = 36 \text{ ksi}$
 $F_u = 58 \text{ ksi}$

Electrode
 $F_{ES0} = 80 \text{ ksi}$



W14x82
W10x45
 $F_y = 50 \text{ ksi}$
 $F_u = 65 \text{ ksi}$

L3x3x5/16
 $F_y = 36 \text{ ksi}$
 $F_u = 58 \text{ ksi}$

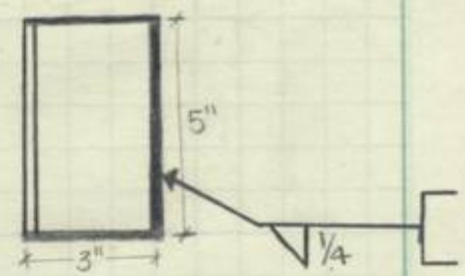
Electrode
 $F_{E80} = 80 \text{ ksi}$

NOT TO SCALE

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

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

ONE SIDE
L3x3x5/16



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

Strength of weld

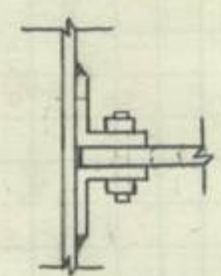
$$\begin{aligned} \phi R_n &= .75 F_w A_w \\ &= .75 (.6 F_{E80}) (2 L_w) (t_w) \\ &= .75 (.6 (80)) (2 (5 + 2(3))) (.707 (.25)) \\ &= \underline{139.9 \text{ k}} \end{aligned}$$

Shear Rupture Strength of Base Material

The controlling thickness is the thickness of the W14x82.

$$\begin{aligned} \phi R_n &= .75 F_{BM} A_{BM} \quad (\text{Eq. J4-4}) \\ &= .75 (.6 F_u) (t_w) \\ &= .75 (.6) (65 \text{ ksi}) (.5 \text{ in}) \\ &= 14.62 \text{ k/in of weld} \\ &= 14.62 \text{ k/in} (L_w) \\ &= 14.62 \text{ k/in} (5 + 2(3)) \\ &= \underline{160.82 \text{ k}} \end{aligned}$$

Top View of Connection



SECTION AA

Shear Yielding of Base Material

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

$$\begin{aligned} &= 1.0 (.6 F_y) A_g \\ &= 1.0 (.6) (2) (36) (1.78 \text{ in}^2) \\ &= 76.9 \text{ k} \end{aligned}$$

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

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

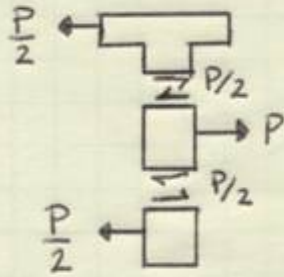
$$\phi R_n = 76.9 \text{ k}$$

The maximum applied force 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

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

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

$$\# \text{bolts} = 2$$

$$\phi R_n = 0.75 (48 \text{ ksi}) (0.442 \text{ in}^2) (2) = 31.8 \text{ k}$$

$$P_u < \phi R_n$$

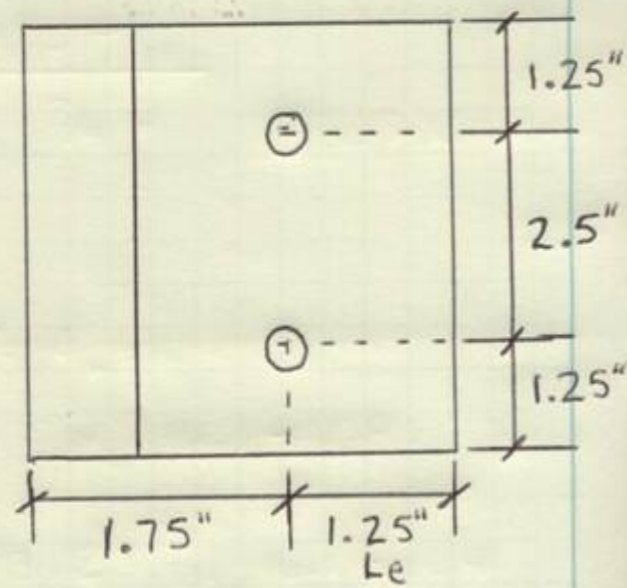
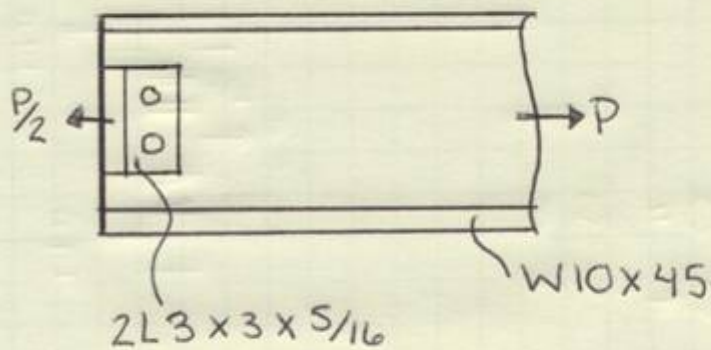
$$\approx \frac{1}{2} P < \phi R_n \approx P \leq 2 \phi R_n$$

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

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:



- Double Angle:

- Deformation considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.2 L_e t F_u \\ 2.4 d t F_u \\ \text{per bolt} \end{cases} \quad \text{J3-6a} \\ \text{Pg 16.1 - III}$$

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

$$1.2 L_e t F_u = 1.2 (0.8125'') \left(\frac{5}{16}'' \right) (58 \text{ ksi}) = 17.7 \text{ k}$$

$$2.4 d t F_u = 2.4 \left(\frac{3}{4}'' \right) \left(\frac{5}{16}'' \right) (58 \text{ ksi}) = 32.6 \text{ k}$$

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

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

- Double Angle

- Deformation is not considered

$$\phi R_n = 0.75 \min \begin{cases} 1.5 L_c t F_u \\ 3.0 d t F_u \end{cases}$$

per bolt

J3-6b

Pg 16.1-111

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

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

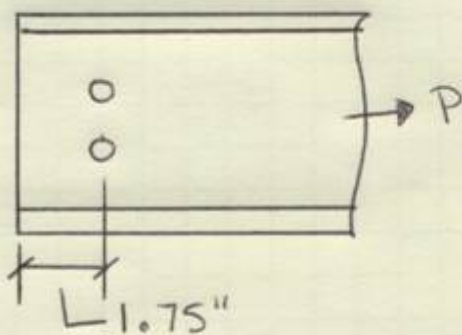
~~error~~

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

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

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

- W-section:



W10x45

$t_{web} = \frac{3}{8}$ inch

$F_u = 65 \text{ ksi}$

W-section

- Deformation is considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.2 L_e t F_u \\ 2.4 d t F_u \end{cases} \quad \begin{array}{l} \text{J3-6a} \\ \text{Pg 16.1-111} \end{array}$$

per bolt

$$L_e = L_e - \frac{1}{2} d_n = 1.75 - \frac{1}{2} \left(\frac{3}{4} + \frac{1}{8} \right) = 1.31''$$

$$1.2 L_e t F_u = 1.2 (1.31'') \left(\frac{3}{8}'' \right) (65 \text{ ksi}) = 38.3 \text{ k}$$

$$2.4 d t F_u = 2.4 \left(\frac{3}{4}'' \right) \left(\frac{3}{8}'' \right) (65 \text{ ksi}) = 43.9 \text{ k}$$

$$\phi R_n = 0.75 (38.3 \text{ k}) (2 \text{ bolts}) = 57.5 \text{ k}$$

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

- Deformation is not considered in design:

$$\phi R_n = 0.75 \min \begin{cases} 1.5 L_e t F_u \\ 3.0 d t F_u \end{cases} \quad \begin{array}{l} \text{J3-6b} \\ \text{Pg 16.1-111} \end{array}$$

per bolt

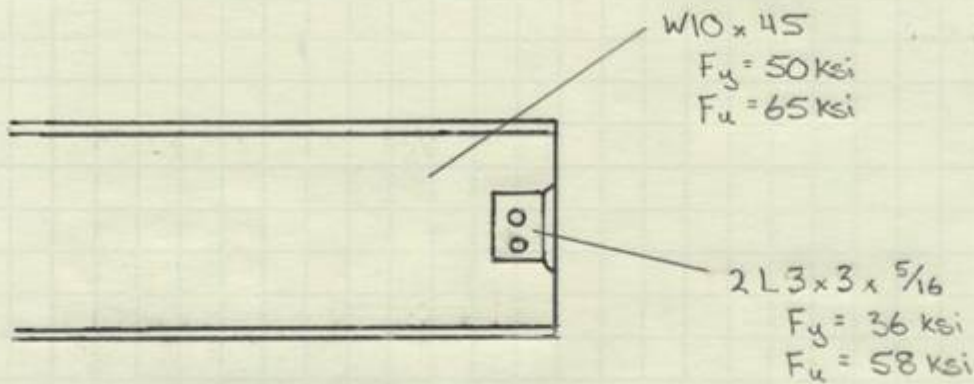
$$L_e = L_e - \frac{1}{2} d_n = 1.75 - \frac{1}{2} \left(\frac{3}{4} + \frac{1}{8} \right) = 1.31 \text{ inches}$$

$$1.5 L_e t F_u = 1.5 (1.31'') \left(\frac{3}{8}'' \right) (65 \text{ ksi}) = 49.7 \text{ k}$$

$$3.0 d t F_u = 3.0 \left(\frac{3}{4}'' \right) \left(\frac{3}{8}'' \right) (65 \text{ ksi}) = 54.8 \text{ k}$$

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

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



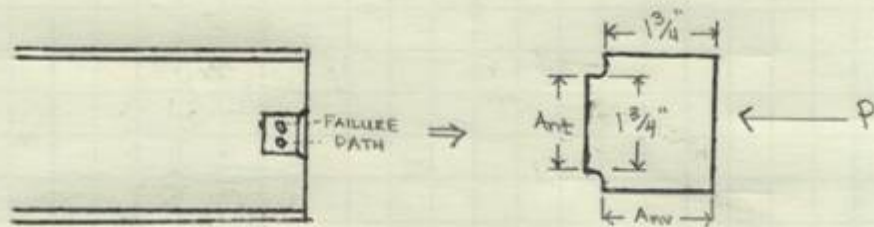
EQUATIONS

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

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:



$$A_{gv} = (1 A_{gv})(t) = 2(1 \frac{3}{4} \text{ in})(\frac{3}{8} \text{ in}) = 1.3125 \text{ in}^2$$

$$A_{nv} = A_{gv} - (\# \text{ of holes})(d_h + \frac{1}{16} \text{ in} + \frac{1}{16} \text{ in})(t)$$

$$= 1.3125 \text{ in}^2 - (1)(\frac{3}{4} \text{ in} + \frac{1}{16} \text{ in} + \frac{1}{16} \text{ in})(\frac{3}{8} \text{ in}) = 0.9844 \text{ in}^2$$

$$A_{gt} = (1 A_{gt})(t) = (2.5 \text{ in})(\frac{3}{8} \text{ in}) = 0.9375 \text{ in}^2$$

$$A_{nt} = A_{gt} - (\# \text{ of holes})(d_h + \frac{1}{16} \text{ in} + \frac{1}{16} \text{ in})(t)$$

$$= 0.9375 \text{ in}^2 - (1)(\frac{3}{4} \text{ in} + \frac{1}{16} \text{ in} + \frac{1}{16} \text{ in})(\frac{3}{8} \text{ in}) = 0.6094 \text{ in}^2$$

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

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

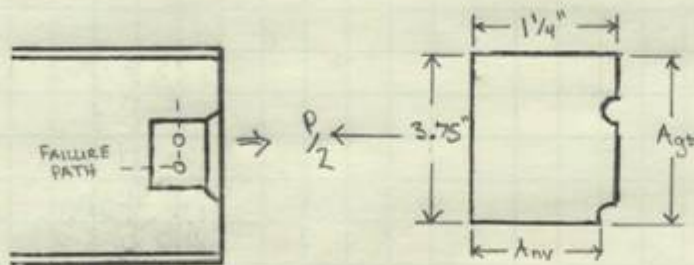
$$P_{nb} = \min \begin{cases} 78.0^k \\ 79.0^k \end{cases}$$

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

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

BLOCK SHEAR RUPTURE ON L3x3x 5/16 SECTION

FBD:



NOTE: $\frac{P}{2}$ BECAUSE ONE ANGLE SECTION TAKES HALF OF THE TOTAL LOAD

$$A_{gv} = (l_{Agv})(t) = (1\frac{1}{4}")(5/16") = 0.3906 \text{ in}^2$$

$$A_{nv} = A_{gv} - (\# \text{ of holes})(d_h + 1/16" + 1/16")(t) \\ = 0.3906 \text{ in}^2 - (1/2)(3/4" + 1/16" + 1/16")(5/16") = 0.2539 \text{ in}^2$$

$$A_{gt} = (l_{Ag_t})(t) = (3.75")(5/16") = 1.17 \text{ in}^2$$

$$A_{nt} = A_{gt} - (\# \text{ of holes})(d_h + 1/16" + 1/16")(t) \\ = 1.17 \text{ in}^2 - (1.5)(3/4" + 1/16" + 1/16")(5/16") = 0.7617 \text{ in}^2$$

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

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

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

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

$$P_{nb} = 105.23^k$$

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