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Sample Calculations - Connection 9

W12X35

1" DIA. A325N BOLTS

HSS6X6X1/4

3/8" PLT

CIV 445 - CONNECTION PROJECT
CONNECTION 9 ILLUSTRATION
→ Limit State: Shear Rupture

\[ R_n = 0.6 F_u A_{ny} \]

Path 1:
\[ A_{ny} = 2(1.5\text{"})(0.375\text{"}) = 1.125 \text{ in}^2 \]
\[ A_{ny} = 1.125 - 2\left(\frac{1}{2}(1.125\text{"})(0.375)\right) = 0.703 \text{ in}^2 \]
\[ R_n = 0.6(58 \text{ ksi})(0.703 \text{ in}^2) = 24.5 \text{ k} \]

→ Limit State: Shear Yielding

\[ R_n = 0.60 F_y A_g \]
\[ = 0.60(36 \text{ ksi})(7\text{"})(0.375\text{"}) = 56.7 \text{ k} \]

→ Limit State: Weld Strength

\[ \phi R_n = \min \left\{ \phi F_{bm} A_{bm}, \frac{\phi F_{w} A_w}{0.15 L_w t_n (0.6 F_{Ex})} \right\} \geq F_u \]

\[ \phi F_{bm} A_{bm} = \min \left\{ 0.75 A_{w} (0.6 F_u), 0.75 F_{bm} L_w (0.6 F_u), 0.15 F_u A_e, 0.75 F_u (0.6 A_g) \right\} \]
\[ = 0.75(2\text{"})(0.25\text{"})(0.6)(70 \text{ ksi}) = 94.5 \text{ k} \]

\[ \phi F_{w} A_w = \min \left\{ 0.75(0.25\text{"})(0.6)(25 \text{ in})^2 (0.6)(58 \text{ ksi}) = 78.3 \text{ k} \right\} \]
\[ = 0.75 \text{ k} \]

\[ \phi R_n = \min(94.5, 78.3, 30.6, 56.7 \text{ k}) = 30.6 \text{ k} \]
Limit State: Bolt bearing strength

\[ R_n \text{ per bolt hole} = \min \left\{ \frac{1.2 L_e + F_u}{2.4 d_t + F_u} \right\} \]

* assumes deformation at the bolt hole at service load is not a design consideration

\[ d_h = 1'' + \frac{1}{8}'' = 1\frac{1}{8}'' \]

\[ L_e = 1.5'' \]

\[ R_n \text{ per bolt} = \min \left\{ 1.2(1.5 - \frac{1}{2}(1.125''))(\frac{3}{8}'') (58 \text{ ksi}) = 24.5 \text{ k} \right\} \]

\[ 2.4(1'')(\frac{3}{8}'') (58 \text{ ksi}) = 52.2 \text{ k} \]

\[ R_n = 0.75(24.5)(4 \text{ bolts}) = 74 \text{ k} \]

Limit state: Bolt shear

\[ R_n \text{ per bolt} = \frac{F_{sw} A_b}{(48 \text{ ksi})(1'')^2 \pi}{4} = 37.7 \text{ k} \]

\[ R_n = 0.75(37.7 \text{ k})(4 \text{ bolts}) = 113 \text{ k} \]

Limit state: Bolt tension

* refer to Table J3.2; assumed A325 bolts

\[ F_n = 52.0 \text{ k} \]

\[ P_t = 52.0 \text{ k} (4 \text{ bolts}) = 212 \text{ k} \]
Limit state: Paying action

\[
\tau_{\min} = \sqrt{\frac{4.44}{P F_u}} \frac{T \cdot b'}{P F_u}
\]

\[
T \leq \frac{F_u t^2 \rho}{2.22 b}
\]

*Where \( \rho \geq g \)

**NOTE:** The thickness of the flange, \( t_f \), is 0.52", while the plate thickness is 0.375". Also, the steel grade for the plate is lower (A36 vs A992), therefore, the base plate thickness controls.

**NOTE:** The tributary length per pair of bolts is 4.0" perpendicular to the plane shown in the figure above. Since \( g = 5.0" > 4.3" \), the value for \( g \) controls.

\[
\frac{F_u t^2 \rho}{2.22 b} = \frac{(58 \text{ ksi})(\frac{3}{8}")^2(5.0")}{2.22 (2.35")} = 7.82 \text{ k}
\]

\[
\Rightarrow 2T = 2(7.82) = 15.64 \text{ k}
\]