11.1 Determine the service load tension capacity $T$ of the connection shown. The load $T$ is 20% Dead load and 80% live load. 7/8-inch A325 bolts are used in the shown pattern. The plates are A572 Grade 60 steel. Deformation of bolt holes is not tolerated under service loads. Case (a): Assume threads are excluded from the shear plates (Type X) and Case (b): assume the threads are included in the shear planes (Type N). Specify the minimum dimensions $A$ and $B$ for each case. Use LRFD. Check the connection with regard to: (i) Gross and net area strengths of the connected plates, (ii) fastener shear failure, (iii) bearing failure of connected plates, and (iv) block shear failure.

11.2 Determine the total number of 7/8-inch A325X bolts required for the tension splice shown in the figure. The total factored load is $P_u = 180k$ in tension as shown. Check only bolt shear and bearing strengths.
Problem 11.16) DL = 20%; LL = 20%; A572 Gr 60 steel; \( d_b = 0.875 \text{ in.}; \ A325-X \)

\[ T/2 \quad \text{and} \quad T/2 \]

\[ P = \frac{3}{8} \times 10 \quad \text{and} \quad P = \frac{1}{2} \times 10 \]

\[ F_y = 60 \text{ ksi} \]

\[ A_{325-X} \]

\[ \frac{7}{8} \text{"diam bolts} \]

\[ A_g = 10(0.50) = 5.00 \text{ sq in.} \]

Section with 3 holes:
\[ A_n = A_g - 3 \text{holes} = 5.00 - 3(0.875 + 0.125)0.50 = 3.50 \text{ sq in.} \]

Design strengths based on member strength:
\[ \phi T_n = \phi F_y A_g = 0.90(60)5.00 = 270 \text{ kips (yielding)} \]
\[ \phi T_n = \phi F_u A_e = \phi F_u U A_n = 0.75(75)(1.0)3.50 = 197 \text{ kips (fracture)} \]

**BEARING-TYPE CONNECTION (A325-X)**

\[ \phi R_n = \phi(0.50F_u^b)ma_b = 0.75(60)(2)0.6013 = 54.1 \text{ kips / bolt (shear)} \]

Minimum edge distance for \( \frac{7}{8} \)-inch bolts is \( 1\frac{1}{2} \) in. (see Table J3.4). Bearing strength per bolt is computed from \[ R_n = 1.2L_c T F_u \quad (J3-6a) \]
\[ \phi R_n = 0.75(1.2)(1.5 - 0.5)(\frac{1}{2})75 = 33.75 \text{ kips/bolt (bearing)} \]

Design strength based on bolts (bearing) is:
\[ \phi T_n = (\# \text{of bolts})(\phi R_n) = 6(33.75) = 202.5 \text{ kips} \]

Minimum center-to-center spacing is \( 2\frac{1}{3}d \) (J3.3)
\[ B_{\text{minimum}} = 2.6\left(\frac{7}{8}\right) = 2.3 \text{ in} \]
11.1(a) continued

Check block shear rupture strength Eq (54.5)

\[
\begin{align*}
A_{uv} &= 2(2.3 + 1.5) \frac{1}{2} = 3.83 \text{ in}^2 \\
A_{nu} &= 2(2.3 + 1.5 - 1.5(1)) \frac{1}{2} = 2.3 \text{ in}^2 \\
A_{nt} &= (6 - 2(1)) \frac{1}{2} = 2 \text{ in}^2 \\
0.6 F_{u} A_{nu} &= 0.6(75)2.3 = 105 \text{ k} \quad \text{controls} \\
0.6 F_{y} A_{uv} &= 0.6(60)3.83 = 138 \text{ k} \\
\phi R_{n} &= 0.75 \left[ 105 + 75(2) \right] = 191.25 \text{ k} \quad \text{controls}
\end{align*}
\]

To increase block shear strength to member strength of 197 k increase the dimension B

\[
\begin{align*}
A_{uv} &= 2 \left[ B + 1.5 - 1.5 \right] \frac{1}{2} = B \text{ in}^2 \\
\phi R_{n} &= 0.75 \left[ 0.6(75)B + 75(2) \right] \geq 197 \text{ k} \\
33.75 B + 112.5 &\geq 197 \text{ k} \\
B &\geq 2.504''
\end{align*}
\]

\[
197 k \geq T_{u} = 1.2(0.20T) + 1.6(0.80T) = 1.52 T
\]

\[
T = \frac{197}{1.52} = 129.6 k \quad \text{maximum service load}
\]

\[
\begin{align*}
A_{\min} &= 1.5 \text{ in} \\
B_{\min} &= 2.504 \text{ in}
\end{align*}
\]
11.1 (6)

The only change is in the bolt shear strength

\[ \phi R_n = \phi (0.40 F_u^b) m A_b = 0.75(48)(2)0.6013 = 43.29 \text{ k/lbolt} \]

6 (43.29) = 259.8 k > 197k member strength

Therefore the tension load capacity of this connection is not reduced when threads of bolts are included in shear planes.

11.2 Solution for plate width of 13 inches (modified)

Shear strength per bolt is:

\[ \phi R_n = \phi (0.50 F_u^b) m A_b = 0.75(60)(2)0.6013 = 54.12 \text{ k/lbolt} \]

Bearing strength per bolt is:

\[ \phi R_n = 0.75(1.2)(1.5-0.5)\frac{1}{2} (58) = 26.1 \text{ k/lbolt} \]

To carry \( P_u = 180 \text{ k} \), we need \( \frac{180 \text{ k}}{26.1 \text{ k/lbolt}} = 6.897 \) bolts

we need to use at least 7 bolts.

![Possible layout of bolt holes](Image)
Problem 11.2 - An interpretative solution of the original problem with 7'' width.

11.2 Determine the total number of 7/8-inch A325X bolts required for the tension splice shown in the figure. The total factored load is $P_u=180k$ in tension as shown.

Shear strength per bolt is:

$$\phi R_n = \phi (0.50 F_{uc}) m A_b = 0.75(60)(2)0.6013 = 54.12 \text{ k/lb bolt}$$

Bearing strength per bolt is:

$$\phi R_n = 0.75(1.2)(1.5-0.5)\frac{1}{2}(58) = 26.1 \text{ k/lb bolt}$$

To carry $P_u=180k$, we need $\frac{180k}{26.1k/bolt} = 6.897$ bolts, we need to use at least 7 bolts.

7 bolts will not fit on two lines unless the width of the plate is increased to 10''. Alternately, we need to increase the end distance to increase bearing strength of each bolt.
11.2 Continued

Maximum bearing strength is:
\[ R_n = 2.4d_t F_u = 2.4 \left( \frac{7}{3} \right) \frac{1}{2} (58) = 60.9 \text{kN} \]
\[ \phi R_n = 0.75 (60.9) = 45.675 \text{ kN/bolt} \]

Required No. of bolts = \[ \frac{180}{45.675} = 3.941 \text{ bolts} \]

So, use 4 bolts. Increase the end distance so that it does not control.

\[ \frac{180}{45} = 45^k = 0.5(1.2)(L_e - 0.5) \frac{1}{2} (58) \]
\[ 45 = 17.4 \ Le - 8.7 \]
\[ L_e = \frac{53.7}{17.4} = 3.086" \]

Minimum dimensions for connection to work with 4 bolts.