#7.6-1 Determine the DESIGN STRENGTH

bolts: $3\frac{3}{4}''$ diameter, A325
Steel: A572, Grade 50

Bolt shear strength:

$$A_b = \pi d_b^2 \frac{4}{4} = \pi (3\frac{3}{4})^2 \frac{4}{4} = 0.4418 \text{ in}^2$$

From Table 7.1 (text), when threads are in the plane of shear:

$$Q R_n = \Phi F_v A_b = 0.75 \times 48 \times 0.4418$$

$$= 15.9 \text{ kips}$$

for 4 bolts: $$15.9 \times 4 = (Q R_n)_4 = 63.62 \text{ kips}$$

Bearing strength:

$$d_h = d_b + \frac{1}{4}b = \frac{3}{4} + \frac{1}{16} = 0.8125''$$

I) Bearing on TENSION Member:

for the holes nearest to the edge of member:

$$L_c = L_c - \frac{d_h}{2} = 2\frac{1}{2} - \frac{0.8125}{2} = 2.09 \text{ In}$$

$$2d_b = 2 \times \frac{3}{4} = 1.5 \text{ in} \Rightarrow 2.09 > 1.5 \Rightarrow$$

$$Q R_n = 0.75 (2.4d + F_u) = 0.75 (2.4 \times \frac{3}{4} \times \frac{1}{4} \times 65)$$

$$Q R_n = 21.94 \text{ kips}$$

for other holes:

$$L_c = s - d_h = 2.5 - 0.8125 = 1.6875 > 2d_b \Rightarrow$$

$$Q R_n = 0.75 (2.4 \times \frac{3}{4} \times \frac{1}{4} \times 65) = 21.94 \text{ kips}$$

⇒ Bearing strength of the Tension member:

$$Q R_n = 2 [Q R_n \text{ (holes nearest to edge)}] + 2 [Q R_n \text{ (other holes)}]$$

$$= 2 \times 21.94 + 2 \times 21.94 = 87.75 \text{ kips}$$

II) Bearing Strength of the Gusset plate:

$$t = \frac{3}{4}''$$

I) holes nearest to edge:

$$L_c = 1.5 - \frac{0.8125}{2} = 1.09 < 2d_b$$

$$Q R_n = \Phi (1.2L_c + F_u) = 0.75 \times 1.2 \times 1.09 \times 0.8125 \times 65$$
\[\varphi R_n = 23.944 \approx 24 \text{ kips}\]

II) for others: \(L_e = 2.5 - 0.8125 = 1.6875 > 2d_b (1.5)\)

\[\varphi R_n = \varphi (2.4d + F_u) = 0.75 \times 2.4 \times \frac{3}{4} \times \frac{3}{8} \times 65\]

\[\varphi R_n = 32.9 \text{ kips}\]

⇒ Bearing strength of the Gusset plate:

\[\varphi R_n = 2 \left[ \varphi R_n \text{ (holes nearest to edge)} \right] + 2 \left[ \varphi R_n \text{ (other holes)} \right]\]

\[= 2 \times 24 + 2 \times 32.9 = 113.8 \text{ kips}\]

Comparing the three different strengths, the lowest controls ⇒ Bolt shear strength = 63.62 kips

is the design strength for the connection.

\[\#7.9 - 1 \quad d_b = \frac{3}{4}'' \quad (A325 - \text{Bearing Type})\]

for bearing type, with threads in the plane of shear:

\[\text{Total shear} = \frac{\sqrt{2}}{2} P_u = \frac{\sqrt{2}}{2} \times 115 = 81.32 \text{ kips}\]

\[V_u = \text{each bolt shear} = \frac{81.32}{6} = 13.55 \text{ kips}\]

\[A_b = \frac{\pi d_b^2}{4} = \frac{\pi \times (0.75)^2}{4} = 0.4418 \text{ in}^2\]

from Table 7.1 ⇒ \(F_y = 48 \text{ ksi}\)

\[(\varphi R_n)_V = 0.75 \times 48 \times 0.4418 = 15.9 \text{ kips}\]

\[(\varphi R_n)_V = 15.9 > V_u = 13.55 \text{ kips} / \text{bolt is ok}\]

for tension:

\[P_u = \text{tension per bolt} = \frac{\sqrt{2} \times 115}{6} = 13.55 \text{ kips}\]

from AISC Table J3.2 ⇒ \(F_t = 90 \text{ ksi}\)

\[(\varphi R_n)_t = \varphi F_t A_b = 0.75 \times 90 \times 0.4418\]

\[(\varphi R_n)_t = 29.82 \text{ kips} > P_u = 13.55 \text{ kips}\]
Check interaction:
\[
\left( \frac{P_u}{(\varphi R_n)_t} \right)^2 + \left( \frac{V_u}{(\varphi R_n)_v} \right)^2 \leq 1.0
\]
\[
\left( \frac{13.55}{29.82} \right)^2 + \left( \frac{13.55}{13.9} \right)^2 = 0.93 < 1.0 \quad \text{O.K.}
\]
Now check the bearing in the connection:
for W10 x 68, \( t = 0.77 \) in
\[
\varphi R_n = \varphi (2.4 \times d_b \times t \times F_u) = 0.75 (2.4 \times \frac{3}{4} \times 0.77 \times 65)
\]
\[
\varphi R_n = 67.57 \quad V_u = 13.55 \quad \text{O.K.}
\]
\[
\Rightarrow \text{So the bolts ARE ADEQUATE.}
\]

#7.9-5
\[
P_u = 1.2 P_{d} + 1.6 P_c = 1.2 \left[ \frac{165}{2} \right] + 1.6 \left[ \frac{165}{2} \right]
\]
\[
= 231 \text{ kips}
\]
\[
\Rightarrow V_u = P_{dy} = \sqrt{2} P_u = \sqrt{2} \times 231 = 163.34 \text{ k}
\]
\[
T_u = P_{u} = \frac{\sqrt{2}}{2} P_u = \frac{\sqrt{2}}{2} \times 231 = 163.34 \text{ k}
\]

For the connection of the Gusset to the tension member:
\[
A_b = \pi \left( \frac{d_b}{4} \right)^2 = \pi \left( \frac{3}{4} \right)^2 = 0.4418 \text{ in}^2
\]
\[
\varphi R_{st} = \varphi (1.13 \times T_m N_b N_s)
\]
\[
\Rightarrow \varphi = 1 \quad \text{for standard holes}, \quad \varphi = 0.33 \quad T_m = 35
\]
\[
R_{st} = 1.13 \times 0.33 \times 35 \times N_b \times 2 \Rightarrow
\]
\[
R_{st} = 261 \quad N_b = 231 \Rightarrow N_b = 8.8
\]
\[
\Rightarrow \text{USE } N_b = 9 \text{ bolts (for connecting The tension member to the Gusset plate), based on proper spacing}
\]
we arrange bolts as shown on next page (Note that we assume that NO ECCENTRICITY is present, by probable stress redistribution if needed.)
for connection of Gusset to Column Flange:

\[ \Phi R_{s1} = \Phi (1.138 T_m N_b N_s) \left(1 - \frac{T_u}{1.13 T_m N_b}\right) \]

from AISC Eqn. A-J3-2)

from Table J3.1 for \( d_b = \frac{3}{4}'' \) & A490 \( T_m = 35 \) kips,

\( \Phi = 1 , \epsilon' = 0.33 , N_s = 1 \) (one slip plane)

\[ \Phi R_{s1} = 1 \times 1.138 \times 0.33 \times 35 \times 1 \times N_b \left[1 - \frac{163.34}{1.13 \times 35 N_b}\right] \]

\[ \Phi R_{s1} = 13.05 \left[ N_b - 4.13 \right] = V_u \]

\[ 163.34 = 13.05 \left[ N_b - 4.13 \right] \Rightarrow N_b = 16.645 \Rightarrow N_b = 18 \text{ bolts, (9 in each row)} \]

for spacing from Table J3.4, for \( \frac{3}{4}'' \) bolts,

\( S \geq 3d = 2.25'' \) & \( 4e \geq 1 \frac{1}{4}'' \) so, based on these criteria

we arrange the bolts as shown:

check bearing: \( W 18 \times 60 \quad t_f = 0.675 < t \) of \( 21.5 \times 3 \times \frac{3}{8} = 2 \times \frac{3}{8} \)

\[ \Phi R_n = \Phi (2.4 \times d_b \times t_f \times F_u) = 0.75 \times 2.4 \times \frac{3}{4} \times 0.645 \times 65 \]

\[ = 60.98 \text{ kips} > V_u = 9.07 \text{ O.K.} \]

(Note: We assume proper arrangement of bolts)

bolt shear: \( P_u = 231 \text{ kips} \quad P_{ux} = \sqrt{2} \times 231 = 163.34 \)

\[ V_u = \frac{P_{ux}}{N_b} = \frac{163.34}{18} = 9.07 \quad A_b = 0.442 \]

\[ (\Phi R_n)_v = \Phi F_v A_b = 0.75 \times 60 \times 0.442 = 19.88 > 9.07 \text{ O.K.} \]

So, we use 18 bolts to connect the 21.5 \times 3 \times \frac{3}{8} to the column flange.