Question 3.2-3

The yield strength for A572 steel is 50 ksi and the ultimate tensile strength is 65 ksi. For C8 x 11.5, the area is 3.37 in^2, and the web thickness is 0.22 inches. First, the yield strength is determined. The equation is as follows:

$$P_n = 0.9 \times F_y \times A_g = 0.9 \times 50 \text{ ksi} \times 3.37 \text{ in}^2 = 151.65 \text{ kips}$$

Next, the rupture strength is determined. The net area of the holes is found by adding 1/8 to the 7/8 inch diameter and getting a net effective area of the following:

$$A_e = 0.85 \times \big(3.37 \text{ in}^2 - (2 \times 0.22 \text{ in} \times 1 \text{ in}) = 2.93 \text{ in}^2\big) = 0.85 \times 2.93 \text{ in}^2 = 2.49 \text{ in}^2$$

This area is used to determine rupture strength:

$$P_n = 0.75 \times F_u \times A_e = 0.75 \times 65 \text{ ksi} \times 2.49 \text{ in}^2 = 121.39 \text{ kips}$$

Using a load combination and the fact that $L = 3D$, the following equation is obtained:

$$1.2D + 1.6L = 1.2D + 4.8D = 6D = 121.39 \text{ kips}$$

$$D = 20.23 \text{ kips}$$

Now that the dead load is obtained, sum the dead load and live load to get service load capacity:

$$D + L = D + 3D = 20.23 \text{ kips} + 60.69 \text{ kips} = \boxed{80.92 \text{ kips}}$$

Question 3.2-6

The yield strength for A36 steel is 36 ksi and the ultimate tensile strength is 58 ksi. For L3 x 2 x 1/4, the area is 1.2 in^2, and the web thickness is 0.25 inches, however there are two angles, which will be accounted for by doubling the yield strength, which is:

$$P_n = 2 \times 0.9 \times F_y \times A_g = 2 \times 0.9 \times 36 \text{ ksi} \times 1.2 \text{ in}^2 = 77.76 \text{ kips}$$

Next, the rupture strength is determined. The net area of the holes is found by adding 1/8 to the 3/4 inch diameter and getting a net effective area of the following:

$$A_e = 0.85 \times \left(1.2 \text{ in}^2 - (0.25 \text{ in} \times \frac{7}{8} \text{ in}) = 2.93 \text{ in}^2\right) = 0.85 \times 0.98 \text{ in}^2 = 0.83 \text{ in}^2$$

This area is used to determine rupture strength:

$$P_n = 2 \times 0.75 \times F_u \times A_e = 2 \times 0.75 \times 58 \text{ ksi} \times 0.83 \text{ in}^2 = 72.57 \text{ kips}$$

It is given that the dead load is 12 kips and the live load is 36 kips, checking both load combinations yield the following:

$$1.4D = 1.4 \times 12 \text{ kips} = 16.8 \text{ kips}$$

$$1.2D + 1.6L = 1.2 \times 12 \text{ kips} + 1.6 \times 36 \text{ kips} = 72 \text{ kips}$$

Since both combinations are less than both the yield and rupture strengths, $\boxed{\text{the member has enough strength}}$.

Question 3.3-1

For part (a), the gross area is 5.9 in^2. The reduction factor and net effective area are calculated as follows:

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.47 \text{ in}}{5 \text{ in}} = 0.706$$

$$A_e = U \times A_g = 5.9 \text{ in}^2 \times 0.706 = \boxed{4.17 \text{ in}^2}$$

For part (b), table D3.1 is used. According to section 4, plates where the tension load is transmitted by longitudinal welds when $1.5w \geq l \geq w$ (which is the determined case), $U = 0.75$. Since it's a plate, the net effective area is found as follows:

$$A_e = 0.75 \times \frac{3}{8} \text{ in} \times 4 \text{ in} = \boxed{1.13 \text{ in}^2}$$

For part (c), transverse welds have a U of 1, which makes the net effective area as follows:

$$A_e = \frac{5}{8} \text{ in} \times 5 \text{ in} = \boxed{3.13 \text{ in}^2}$$

For part (d), the diameter of the bolts is adjusted by 1/8 inch since the diameter is less than 1 inch. Additionally, since the plate is bolted, $U = 1$. The thickness is 1/2 inch and the net effective area is found as follows:

$$A_e = 1 \times 0.5 \text{ in} \times 5.5 \text{ in} - \left(0.5 \text{ in} \times \left(\frac{3}{4} \text{ in} + \frac{1}{8} \text{ in}\right)\right) = \boxed{2.31 \text{ in}^2}$$

For part (e), the diameter of the bolts is adjusted by 1/8 inch since the diameter is less than 1 inch. Additionally, since the plate is bolted, $U = 1$. The thickness is 5/8 inch and the net effective area is found as follows:

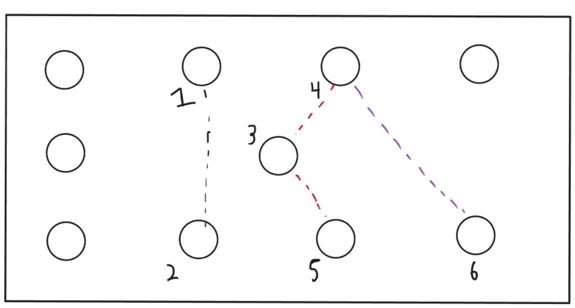
$$A_e = 1 \times \frac{5}{8} \text{ in} \times 6 \text{ in} - \left(\frac{5}{8} \text{ in} \times \left(\frac{7}{8} \text{ in} + \frac{1}{8} \text{ in}\right)\right) = \boxed{3.13 \text{ in}^2}$$

Question 3.4-2

The yield strength for A36 steel is 36 ksi and the ultimate tensile strength is 58 ksi. The diameter of the bolts is adjusted by 1/8 inch since the diameter is less than 1 inch. Additionally, since the plate is bolted, $U = 1$. The yielding strength is found as follows:

$$P_n = 0.9 \times F_y \times A_g = 0.9 \times 36 \text{ ksi} \times 10 \text{ in}^2 = 324 \text{ kips}$$

After looking at the diagram, the critical section for failure was found from 4 to 3 to 5 (see below):



With three holes, a pitch of 2 inches, and a gage of 3 inches, the net effective area can be found using the following equation, with d being the adjusted diameter, n being the number of holes, s being the pitch, t being the thickness, and g being the gage:

$$A_n = A_g - t \times \left(n \times d - 2 \times \frac{s^2}{4 \times g}\right) = 10 \text{ in}^2 - 0.5 \text{ in} \times \left(3 \times \frac{7}{8} \text{ in} - 2 \times \frac{(2 \text{ in})^2}{4 \times 3 \text{ in}}\right) = 8.04 \text{ in}^2$$

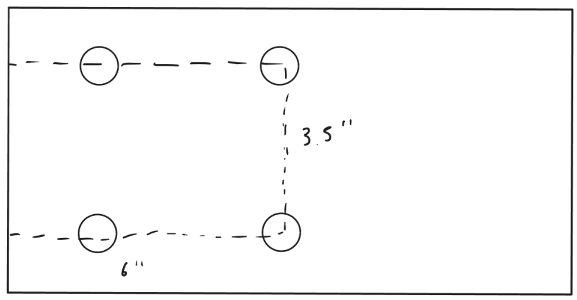
Using the equation for rupture, the following equation is used:

$$P_n = 0.75 \times F_u \times A_n = 0.75 \times 58 \text{ ksi} \times 8.04 \text{ in}^2 = 349.74 \text{ kips}$$

The nominal strength is the smaller value of the two, or $\boxed{324 \text{ kips}}$.

Question 3.5-2

The block shear section is shown below:



The yield strength for A36 steel is 36 ksi and the ultimate tensile strength is 58 ksi. The gross area of the section is calculated as follows, with t being the thickness and L being the shear length:

$$A_{gv} = t \times L \times 2 = 0.5 \text{ in} \times 6 \text{ in} \times 2 = 6 \text{ in}^2$$

Since there are 1.5 diameters in the shear area, the net shear effective area is found as follows, with t being the thickness, L being the shear length, d being the adjusted diameter, and n being the number of diameters:

$$A_{nv} = t \times (L - n \times d) \times 2 = 0.5 \text{ in} \times \left(6 \text{ in} - \frac{9}{8} \text{ in} \times 1.5\right) \times 2 = 4.31 \text{ in}^2$$

Since there is 1 diameter in the tension area, the net tension effective area is found as follows, with t being the thickness, L being the tension length, d being the adjusted diameter, and n being the number of diameters:

$$A_{nt} = t \times (L - n \times d) = 0.5 \text{ in} \times \left(3.5 \text{ in} - \frac{9}{8} \text{ in}\right) = 1.19 \text{ in}^2$$

The following equations are then used for block shear, with U_{bs} being 1:

$$R_n = 0.6 \times F_u \times A_{nv} + U_b s \times F_u \times A_{nt} = 0.6 \times 58 \text{ ksi} \times 4.31 \text{ in}^2 + 58 \text{ ksi} \times 1.19 \text{ in}^2 = 219.01 \text{ kips}$$

$$R_n = 0.6 \times F_y \times A_{gv} + U_b s \times F_u \times A_{nt} = 0.6 \times 36 \text{ ksi} \times 6 \text{ in}^2 + 58 \text{ ksi} \times 1.19 \text{ in}^2 = 198.62 \text{ kips}$$

The smaller value is used, which is $\boxed{198.62 \text{ kips}}$.

Question 3.6-6

The first step is to calculate the design load as per LRFD using the following equation:

$$P_n = 1.2 \times D + 1.6 \times L = 1.2 \times 100 \text{ kips} + 1.6 \times 50 \text{ kips} = 200 \text{ kips}$$

The yield strength for A36 steel is 36 ksi and the ultimate tensile strength is 58 ksi. The required gross area can now be calculated by rearranging the yielding equation:

$$P_n = 0.9 \times F_y \times A_g$$

$$A_g = \frac{P_n}{0.9 \times F_y} = \frac{200 \text{ kips}}{0.9 \times 36 \text{ ksi}} = 6.17 \text{ in}^2$$

The required net effective area can now be calculated by rearranging the failure equation:

$$P_n = 0.75 \times F_u \times A_e$$

$$A_e = \frac{P_n}{0.75 \times F_u} = \frac{200 \text{ kips}}{0.75 \times 58 \text{ ksi}} = 4.6 \text{ in}^2$$

The required radius of gyration is calculated as follows, with L being the length of the member in inches:

$$r = \frac{L}{300} = \frac{20 \text{ ft} \times 12}{300} = 0.8 \text{ in}$$

Using Table 1-5, the lightest section that satisfies both the required gross area and the required radius of gyration (r on the Y-Y axis) is C15 X 33.9, however, the net effective area must be checked to confirm.

$$A_n = 10 \text{ in}^2 - 0.4 \text{ in} \times \left(\frac{9}{8} \text{ in} \times 2\right) = 9.1 \text{ in}^2$$

Lastly, use the reduction factor to finish calculating the net effective area, with $\bar{x}$ being the centroid from Table 1-5 and L being the length of the connection:

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.788 \text{ in}}{6 \text{ in}} = 0.87$$

$$A_e = U \times A_n = 0.87 \times 9.1 \text{ in}^2 = 7.9 \text{ in}^2$$

Since this value meets the requirement for net effective area, the lightest channel for this case is $\boxed{\text{C15 X 33.9}}$.

Question 3.7-4

First, the angle between AC and BC is calculated:

$$\theta = \tan^{-1}\left(\frac{20 \text{ ft}}{40 \text{ ft}}\right) = 26.57°$$

The design case used is $1.0W$ for LRFD, which means the loading is 10 kips. The force in the member AC (using joint C) is found as follows:

$$\sum F_x = 10 \text{ kips} - P_u \times \cos(26.57°) = 0$$

$$P_u = 11.18 \text{ kips}$$

The yield strength for A36 steel is 36 ksi and the ultimate tensile strength is 58 ksi. The required area can be calculated using the following equation:

$$A_b = \frac{P_u}{0.75 \times (0.75 \times F_u)} = \frac{11.18 \text{ kips}}{0.75 \times (0.75 \times 58 \text{ ksi})} = 0.343 \text{ in}^2$$

The required diameter is calculated as follows:

$$A_b = \frac{\pi}{4} D^2 \qquad D = \sqrt{\frac{4}{\pi} \times A_b} = \sqrt{\frac{4}{\pi} \times 0.343 \text{ in}^2} = 0.66 \text{ in}$$

In accordance with Table J3.3, the diameter of the rod should be $\boxed{\frac{11}{16} \text{ in}}$.