Question 7.4-6

Calculate the nominal shear capacity of a bolt.

$$A = \frac{\pi}{4} \times d^2 = \frac{\pi}{4} \times (7/8)^2 = 0.6013 \text{ in}^2$$

$$R_{nv} = 54 \text{ ksi} \times 0.6013 \text{ in}^2 = 64.94 \text{ kips}$$

Calculate the adjusted diameter:

$$h = 7/8 + 1/16 = 15/16 \text{ in}$$

Calculate l_c:

$$l_c = l_e - \frac{h}{2} = 2 - 15/32 = 1.53 \text{ in}$$

Now calculate the nominal tensile strength:

$$R_{nl} = 1.2 \times l_c \times t \times F_u = 1.2 \times 1.53 \times \frac{3}{8} \times 58 = 39.96 \text{ kips}$$

Now compute the upper limit:

$$2.4 \times d \times t \times F_u = 2.4 \times \frac{7}{8} \times \frac{3}{8} \times 58 = 45.68 \text{ kips}$$

Now do the same for an edge bolt:

$$l_c = s - h = 3 - 15/16 = 2.06 \text{ in}$$

$$R_{nl} = 1.2 \times l_c \times t \times F_u = 1.2 \times 2.06 \times \frac{3}{8} \times 58 = 53.84 \text{ kips}$$

The smaller value will control for the edge bolt, since the upper limit remains unchanged. The total strength is as follows:

$$39.93 + 4 \times 45.68 = 222.7 \text{ kips}$$

Now we just use LRFD:

$$\phi R_n = 0.75 \times 222.7 = 167 \text{ kips}$$

$$P = 1.2D + 1.6L = 1.2 \times 40 + 1.6 \times 100 = 208 \text{ kips}$$

The load is too large. Therefore, there is $\boxed{\text{not enough capacity for bearing}}$.

Question 7.7-2

We gotta do two load combos to see which one controls:

$$P = 1.2D + 1.6L = 1.2 \times 50 + 1.6 \times 100 = 220 \text{ kips}$$

$$P = 1.2D + 1W + 0.5L = 1.2 \times 50 + 1 \times 45 + 0.5 \times 100 = 155 \text{ kips}$$

Now use the following equation:

$$R_n = \mu D_u h_f T_b n_s = 0.3 \times 1.13 \times 1 \times T_b \times 1$$

Now, T_b will vary based on the size of the bolt, but I think the best deal will be using $1\frac{1}{4}$ bolts. The required number of bolts is found using the design strength and the value of T_b from Table J3-1.

$$R_n = \mu D_u h_f T_b n_s = 0.3 \times 1.13 \times 1 \times 71 \times 1 = 24.07 \text{ kips}$$

$$\frac{220}{24.07} = 10 \text{ bolts}$$

Now we need a new design strength.

$$\phi R_n = 10 \times 24.07 = 240.7 \text{ kips}$$

Now we need gross area and the corresponding effective area:

$$A_g = \frac{P}{0.9F_y} = \frac{220}{0.6 \times 36} = 6.79 \text{ in}^2$$

$$A_e = \frac{P}{0.75F_u} = \frac{220}{0.75 \times 58} = 5.06 \text{ in}^2$$

Now, let's pick a good angle, first, by coming up with a goal radius of gyration:

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

From the manual, it looks like the most effective section that meets all the area and radius of gyration requirements is $\boxed{\text{LX8X6X5/8}}$. Now we calculate the net area.

$$A_n = A_g - A_h = 8.41 - 2 \times (1.25 + 0.125) \times \frac{5}{8} = 6.69 \text{ in}^2$$

Since there are 4 bolts, multiply this by a factor of 0.8.

$$A_n = 0.8 \times 6.69 = 5.35 \text{ in}^2$$

Now determine the minimum spacing:

$$2 \times \frac{2}{3} \times \frac{5}{4} = 3.33 \text{ in}$$

I'll round this up and use a spacing of 4 inches. Now we check the bearing, using an edge distance of 2.5 inches (from Table J3-4) and a corresponding load of 70.1 kips/in from Table 7-6:

$$\phi r_n = 0.375 \times 70.1 = 26.3 \text{ kips}$$

Now check the case for the inner bolts, for a load of 104 kips/in (from Table 7-5).

$$\phi r_n = 0.375 \times 104 = 39 \text{ kips}$$

Now we have to check block shear. First use the shear length multiplied by thickness to get the shear area.

$$A_{gv} = 0.375 \times (2.5 + 4 \times 4) \times 2 = 13.88 \text{ in}^2$$

$$A_{nv} = 0.375 \times (18.5 - 4.5 \times 1.375) \times 2 = 9.23 \text{ in}^2$$

Now we need net area in tension.

$$A_{nt} = 0.375 \times (3 - 1.375) = 0.61 \text{ in}^2$$

Now we just use the equations below:

$$R_n = 0.6F_u A_{nv} + U_{bs} F_u A_{nt} = 0.6 \times 58 \times 9.23 + 58 \times 0.61 = 356.7 \text{ kips}$$

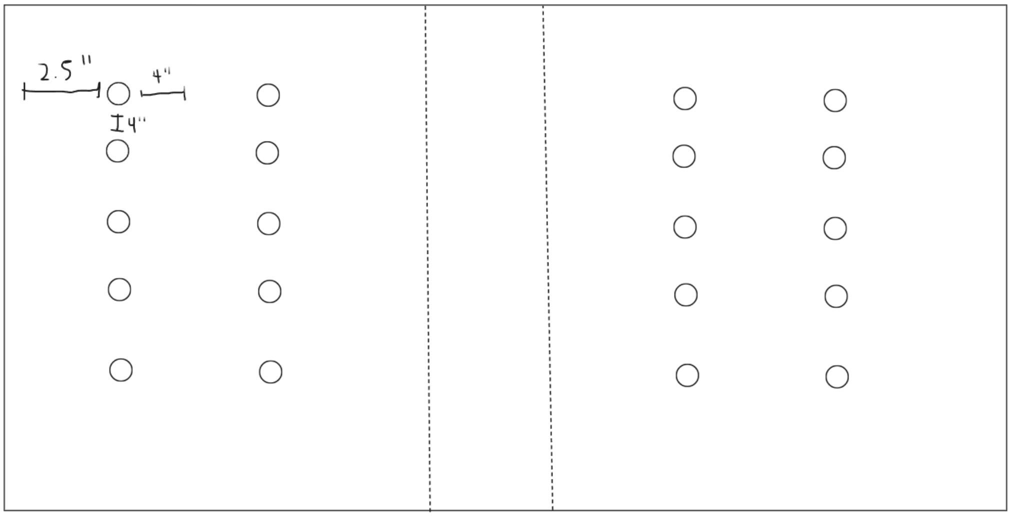
Now check upper limit:

$$0.6F_y A_{gv} + U_{bs} F_u A_{nt} = 0.6 \times 36 \times 13.88 + 58 \times 0.61 = 335.2 \text{ kips}$$

The upper limit controls. Multiply by 0.75 for design strength.

$$0.75 \times 335.2 = 251 \text{ kips}$$

This is greater than the factored load. Figure is below of $\boxed{\text{ten bolts of } 1\frac{1}{4} \text{ inch diameter}}$.



Question 7.8-2

Begin by calculating constants a and b.

$$a = \frac{b_f - 5.375}{2} = \frac{4 + 4 + \frac{3}{8} - 5.5}{2} = 1.5 \text{ in}$$

$$b = \frac{5.375 - t_w}{2} = \frac{5.375 - \frac{3}{8} - \frac{5}{8}}{2} = 2.188 \text{ in}$$

Calculate modified values:

$$a' = a + \frac{d}{2} = 1.5 + 0.25 = 1.75 \text{ in}$$

$$b' = b - \frac{d}{2} = 2.188 - 0.25 = 1.94 \text{ in}$$

$$d' = 0.5 + 0.125 = 0.625 \text{ in}$$

With an available length of 7 inches, but only two connections available, p will be taken as 3.5 inches. Let's check the upper limit:

$$2b = 2 \times 2.188 = 4.376$$

Which is greater than p, so p controls. Now calculate δ.

$$\delta = 1 - \frac{d'}{p} = 1 - \frac{0.625}{3.5} = 0.82 \text{ in}$$

Now, calculate the area of the bolts:

$$A_b = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 0.5^2 = 0.1963 \text{ in}^2$$

Now, calculate design strength:

$$B = 0.75 \times F_{nt} \times A_b = 0.75 \times 90 \times 0.1963 = 13.25 \text{ kips}$$

Obtain the factored load using LRFD:

$$1.2D + 1.6L = 1.2 \times 6 + 1.6 \times 15 = 31.2 \text{ kips}$$

Calculate the external factored load:

$$T_b = \frac{31.2}{4} = 7.8 \text{ kips/bolt}$$

Now we want to see if 1 will control for α. Let's calculate it below:

$$\alpha = \frac{\left(\frac{B}{T} - 1\right)\frac{a'}{b'}}{\delta\left(1 - \left(\frac{B}{T} - 1\right)\frac{a'}{b'}\right)} = \frac{\left(\frac{13.25}{7.8} - 1\right)\frac{1.75}{1.9638}}{0.8214\left(1 - \left(\frac{13.25}{7.8} - 1\right)\frac{1.75}{1.938}\right)} = 2.081$$

This is larger than 1, so 1 will control. Last thing we have to check is the required flange thickness.

$$t_f = \sqrt{\frac{4Tb'}{\phi_b p F_u(1+\delta\alpha)}} = \sqrt{\frac{4Tb'}{\phi_b p F_u(1+\delta\alpha)}} = \sqrt{\frac{4 \times 7.8 \times 1.938}{0.9 \times 3.5 \times 58(1+0.8214)}} = 0.426 \text{ in}$$

Since the actual flange thickness of 5/8 inch is greater, this section is $\boxed{\text{adequate}}$.

Question 7.9-4

Compute total factored load:

$$P = 1.2D + 1.6L = 1.2 \times 0.25 \times 120 + 1.6 \times 0.75 \times 120 = 180 \text{ kips}$$

Calculate design shear capacity:

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4} \times (0.875)^2 = 0.601 \text{ in}^2$$

$$\phi R_n = 0.75 \times F_{nv} \times A = 0.75 \times 60 \times 0.601 = 54.1 \text{ kips/bolt}$$

Now calculate the bearing strength:

$$0.75 \times 2.4 \times d \times t \times F_u = 0.75 \times 2.4 \times \frac{7}{8} \times \frac{7}{8} \times 58 = 79.9 \text{ kips/bolt}$$

Now we have to use the same equation we used a few questions ago:

$$R_n = \mu D_u h_f T_b n_s = 0.35 \times 1.13 \times 1 \times 49 \times 2 = 38.76 \text{ kips}$$

Now we use this to get the number of required bolts:

$$\frac{P}{R_n} = \frac{188}{38.76} = 4.64$$

So we are going to need five bolts. I will now calculate the tensile force based off of the diagram:

$$T_u = \frac{180}{\sqrt{2}} = 127.3 \text{ kips}$$

Now we can get the reduction factor:

$$k_s = 1 - \frac{T_u}{D_u \times T_b \times N_b} = 1 - \frac{127.3}{1.13 \times 49 \times N_b}$$

$$N_b = \frac{T_v}{R_n \times k_s} = \frac{127.3}{38.76 \times \left(1 - \frac{127.3}{1.13 \times 49}\right)}$$

$$N_b = \frac{127.3}{38.76} + \left(\frac{127.3}{1.13 \times 49 \times N_b}\right) = 5.58$$

Now calculate minimum spacing:

$$s = 2 \times \frac{2}{3} \times d = 2 \times \frac{2}{3} \times \frac{7}{8} = 2.33 \text{ in}$$

Now for spacing stuff:

$$h = d + \frac{1}{16} = 0.9375 \text{ in}$$

$$\text{Edge: } l_c = l_e - \frac{h}{2} = 1.5 - \frac{15}{32} = 1.03 \text{ in}$$

$$\text{Other: } l_c = s - h = 2.5 - 0.9375 = 1.56 \text{ in}$$

Now let's work with the edge length first:

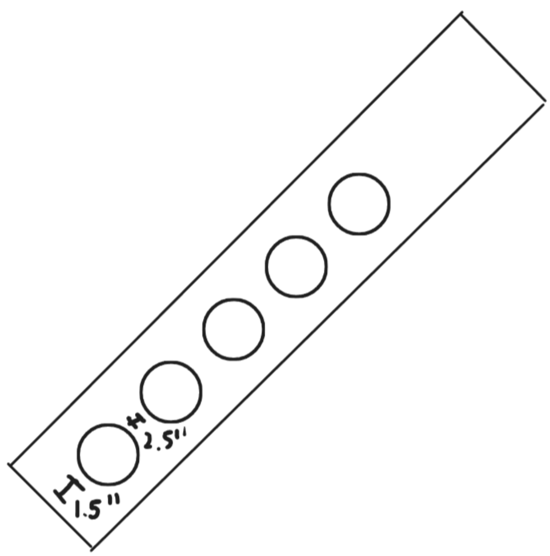
$$0.75 \times 1.2 \times l_c \times t \times F_u \leq 0.75 \times 2.4 \times d \times t \times F_u$$

$$0.75 \times 1.2 \times 1.03 \times \frac{3}{8} \times 58 \leq 0.75 \times 2.4 \times \frac{7}{8} \times \frac{3}{8} \times 58$$

This checks out. Now we work with other bolts.

$$0.75 \times 1.2 \times l_c \times t \times F_u = 0.75 \times 1.2 \times 1.56 \times \frac{7}{8} \times 58 = 71.4 \text{ kips}$$

Shear force per bolt is 180/5 which is 36 kips, all these values are greater than 36 so it'll all check out. Hence $\boxed{5}$ bolts are required. Below is an approximate drawing, according to manual specifications of edge distances and spacings.



Question 7.11-8

Let's determine yield strength first:

$$\phi_t P_n = 0.9 \times A_g \times F_y = 0.9 \times 1.94 \times 36 = 62.86 \text{ kips}$$

Shear lag is 0.8, calculate the net-cross sectional area using this:

$$A_e = 0.8 \times A_g = 0.8 \times 1.94 = 1.55 \text{ in}^2$$

Now calculate rupture:

$$\phi_t P_n = 0.75 \times A_g \times F_u = 0.75 \times 1.94 \times 58 = 67.5 \text{ kips}$$

Yield strength controls. Determine weld thickness. The minimum size from table J2-4 is 1/8 for thicknesses of 1/4. The maximum thickness is:

$$w_{max} = \frac{1}{4} - \frac{1}{16} = \frac{3}{16} \text{ in}$$

Now divide this value by 1/16 to get an N value of 3. Now calculate the weld strength per unit member:

$$\phi R_n = 1.392 \times N = 4.176 \text{kips/in}$$

Compute shear yield and rupture strength:

$$V_y = 0.6 \times F_y \times t = 0.6 \times 36 \times 0.25 = 5.4 \text{ kips/in}$$

$$V_r = 0.45 \times F_u \times t = 0.45 \times 58 \times 0.25 = 6.56 \text{ kips/in}$$

Weld strength per unit member controls. Calculate required length:

$$L = \frac{P_u}{\phi R_n} = \frac{62.86}{4.176} = 15.05 \text{ in}$$

Now calculate shear lag factor ($\bar{x}$ found as the centroid on the X-X axis):

$$U = 1 - \frac{\bar{x}}{l} = 1 - \frac{1.08}{8} = 0.87$$

This checks out, therefore, use $\boxed{\text{3/16 inch fillet weld}}$.