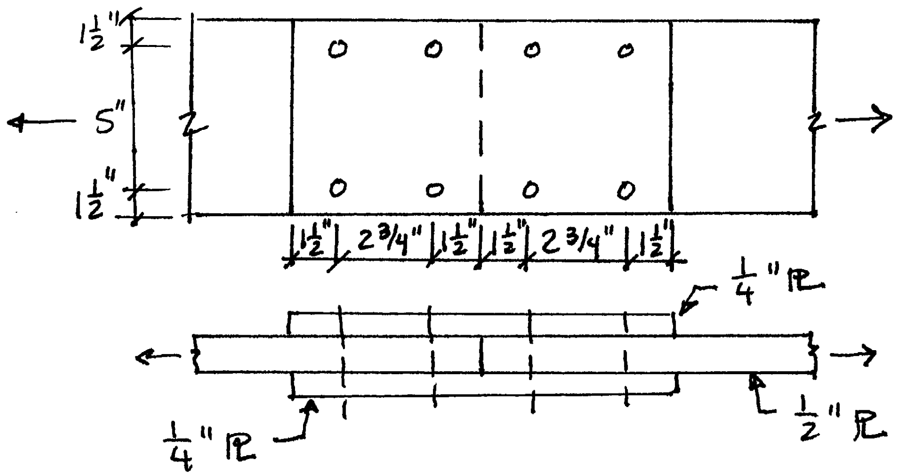
CE470 HW 3 DUE 2/12/09

Segui 7.4-2 (a, b), 7.4-3(a), 7.4-4 (a)
7.4-5 (a), 7.4-6(a), 7.6-1 (a)

Problem 7.4-2 (a, b)

A $\frac{1}{2}$" thick tension member is spliced with two 1/4" thick plates as shown. The bolts are 7/8" diameter, A325, and all steel is A36.



(a) Check all spacing and edge distance requirements.

AISC J3.3 $\quad s \geq 2\frac{2}{3}d = (2\frac{2}{3})(7/8") = 2.33"$

given $s = 2\,3/4" > 2.33"$ ✓ok

AISC Table J3.4 assume sheared edge

min $L_e = 1\frac{1}{2}" = L_e$ provided ✓ok.

(b) Compute the nominal strength based on shear and bearing

$A_b = \dfrac{\pi (7/8")^2}{4} = 0.6013 \text{ in}^2$ Assume A325N – Double shear

per bolt → $R_n = m\,0.4 F_u^b A_b = (2)(0.4)(120\text{ ksi})(0.6013\text{in}^2) = 57.7^k/\text{bolt}$

OR $R_n = 48\text{ ksi}\,(0.6013\text{ in}^2)(2) = 57.7^k/\text{bolt}$

(48 ksi ← Table J3.2)

$R_n = (4 \text{ bolts})(57.7^k/\text{bolt}) = 230.8 = \underline{231 \text{ Kips}}$

→

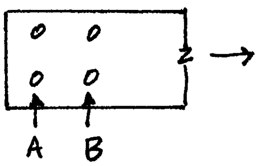
Problem 7.4-2 (a,b) cont'd.

b) cont'd.

bearing capacity. on $\frac{1}{2}$" plate
or $2 \times \frac{1}{4}$" plates $= \frac{1}{2}$"
$\therefore$ same whether on splice plates or tension member.

use $d_{hole} = 7/8" + 1/16" = 15/16"$

assume deformation IS a design consideration



for A bolts $L_c = 1\frac{1}{2}" - \frac{15}{16}"(\frac{1}{2}) = 1.0313"$

for B bolts $L_c = 2\frac{3}{4}" - 2(\frac{1}{2})(\frac{15}{16}") = 1.813"$

$R_n = 1.2 L_c t F_u \leq 2.4 d t F_u.$

$2.4(\frac{7}{8}")(\frac{1}{2}")(58\,ksi) = 60.9^k$

A. $1.2(1.0313")(\frac{1}{2}")(58\,ksi) = 35.9^k$ ← use this.

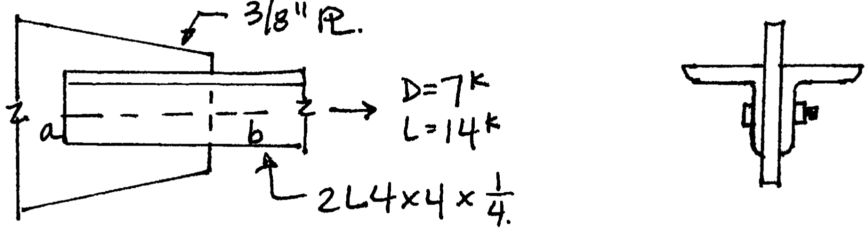
B $1.2(1.813")(1/2")(58\,ksi) = 63.1^k \leq \underline{60.9^k}$ ← use this

total $R_n = 2(35.9^k) + 2(60.9^k)$
$= 193.6$ kips
$R_n = \underline{194^k}$

$\therefore$ bearing controls $\boxed{R_n = 194^k}$

Problem 7.4-3(a)

Determine the number of 3/4" dia. A325 bolts required, based on shear and bearing, along line a-b. The given loads are service loads. A36 steel is used. Assume the bearing strength is controlled by the upper limit of 2.4dtFu. Use LRFD.



$P_u = 1.2D + 1.6L = 1.2(7^k) + 1.6(14^k) = 30.8^k$

Shear. Assume A325N $\qquad A_b = \dfrac{\pi(3/4")^2}{4} = 0.4418 \text{ in}^2$

$R_n/\text{bolt} = m\, 0.4 F_u^b A_b = (2)(0.4)(120\text{ksi})(0.4418 \text{ in}^2) = \underline{42.4^k/\text{bolt}}$

OR $\quad R_n/\text{bolt} = \underset{\text{Table J3.2}}{(48\text{ ksi})}(0.4418 \text{ in}^2)(2) = 42.4\ ^k/\text{bolt}$

bearing $\qquad R_n/\text{bolt} = 2.4(3/4")(3/8")(58\text{ksi})$

$\uparrow 3/8" < 2 \times \frac{1}{4}" = \frac{1}{2}" \qquad = \underline{39.15}\ ^k/\text{bolt}$

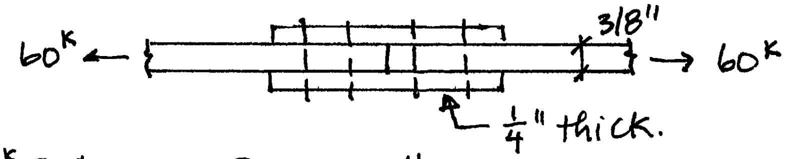
$\therefore$ bearing controls.

$\# \text{ bolts} = \dfrac{P_u}{\phi R_n/\text{bolt}} = \dfrac{30.8^k}{0.75(39.15\ ^k/\text{bolt})} = 1.05 \text{ bolts}$

$\boxed{\text{USE 2 bolts.}}$

Problem 7.4-4(a)

The splice plates shown are $\frac{1}{4}$" thick. How many 7/8" dia. A325 bolts are required? The given load is a service load consisting of 25% dead load and 75% live load. A36 steel is used. Use LRFD.



$P = 60^k = D + L = D + 3D = 4D$

$D = 15^k \quad , \quad L = 3D = 45^k$

$P_u = 1.2D + 1.6L = 1.2(15^k) + 1.6(45^k) = 90^k$

Shear on bolts, assume A325N $\qquad A_b = \frac{\pi(7/8")^2}{4} = 0.6013 \text{ in}^2$

$\phi R_n/\text{bolt} = \phi m \, 0.4 F_u^b A_b$
$= 0.75(2)(0.4)(120 \text{ ksi})(0.6013 \text{ in}^2) = \underline{43.3^k/\text{bolt}}$

Bearing? Assume deformation IS a design consideration. Since no spacing or edge distance dimensions given, assume $\phi 2.4 d t F_u$ controls. $\quad \underset{\text{splice plates}}{2 \times \frac{1}{4}"} = 1/2" > 3/8"$ controls

$\phi R_n/\text{bolt} = 0.75(2.4)(7/8")(3/8")(58 \text{ ksi})$
$= \underline{34.26}^k/\text{bolt}$

∴ bearing controls.

$$\# \text{ bolts} = \frac{P_u}{\phi R_n/\text{bolt}} = \frac{90^k}{34.26^k/\text{bolt}} = 2.63 \text{ bolts}$$

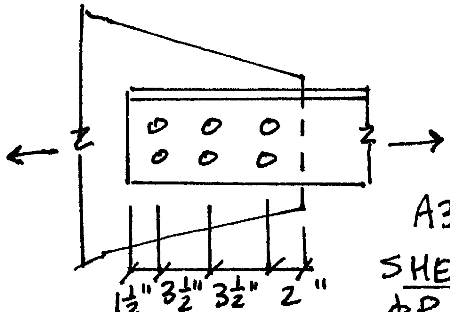
depends on widths of plates →

$\boxed{\text{USE 3 bolts in 1 line or 4 bolts (2 rows) each side of splice}}$

(6 or 8 bolts total)

Problem 7.4-5(a)

The tension member is an L6 x 3½ x 5/16, connected to a 5/16" thick gusset plate with 3/4" dia. bolts. Both the tension member and the gusset plate are A36 steel. What is the total service load that can be supported (based on bolt shear and bearing) if the ratio of live load to dead load is 2.0? The bolt threads are in the plane of shear. Use LRFD.



$P_u = 1.4D$

or $1.2D + 1.6L = 1.2D + 1.6(2D)$
$= 4.4D.$

A325N $A_b = \frac{\pi(3/4")^2}{4} = 0.4418 \text{ in}^2$

SHEAR

$\phi R_n/\text{bolt} = \phi m\, 0.4 F_u^b A_b = 0.75(1)(0.4)(120\text{ksi})(0.4418\text{in}^2)$
$= 15.9^k/\text{bolt}$

total $\phi R_n = (6 \text{ bolts})(15.9^k/\text{bolt}) = \underline{95.4^k}$

bearing use $d_{hole} = 3/4" + 1/16" = 13/16"$

- holes near edge $L_c = 1\frac{1}{2}" - \frac{1}{2}(\frac{13}{16}") = 1.0938"$
  (more critical for angle with $L_e = 1\frac{1}{2}" < 2"$ for gusset)
- other holes $L_c = 3\frac{1}{2}" - 2(\frac{1}{2})(\frac{13}{16}") = 2.688"$

Assume deformation IS a design consideration.

$\phi R_n = \phi 1.2 L_c t F_u \le \phi 2.4 d t F_u$
$= 0.75(2.4)(3/4")(5/16")(58 \text{ ksi})$
$= 24.47^k$

edge $\phi 1.2 L_c t F_u = 0.75(1.2)(1.0938")(5/16")(58\text{ksi}) = 17.84^k$

others $\phi 1.2 L_c t F_u = 0.75(1.2)(2.688")(5/16")(58\text{ksi}) = \underline{43.85^k}$

use 24.47^k

total $\phi R_n = 2(17.84^k) + 4(24.47^k)$
$= \underline{133.6^k}$

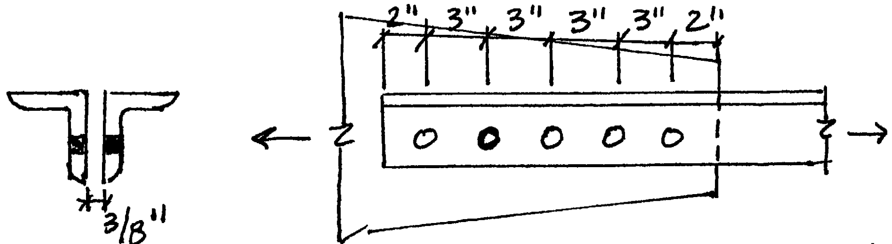
∴ shear controls $\phi R_n = 95.4^k \ge P_u = 4.4D$
$D \le 21.68^k$

$P = D + L = D + 2D = 3(21.68^k) = 65.0^k$

$\boxed{P = 65.0^k}$

Problem 7.4-6(a)

A double-angle tension member, 2L4x3x½ LLBB, is connected to a 3/8" thick gusset plate w/ 7/8" dia. A325 bolts. Tension member and gusset plate are A36 steel. Does the connection have enough capacity based on shear and bearing? It is not known whether the bolt threads will be in shear. Use LRFD.



D = 40k
L = 100k

$P_u = 1.2D + 1.6L = 1.2(40^k) + 1.6(100^k)$
$= 208^k$

Shear

$A_b = \dfrac{\pi(7/8")^2}{4} = 0.6013 \text{ in}^2$ assume A325 <u>N</u>

$\phi R_n/\text{bolt} = \phi m\, 0.4 F_u^b A_b = 0.75(2)(0.4)(120\text{ksi})(0.6013 \text{ in}^2)$
$= 43.3^k/\text{bolt}$

$\phi R_n = (5 \text{ bolts})(43.3^k/\text{bolt}) = 216.5^k > 208^k$ ✓ok.

bearing $3/8" < (2 \times \tfrac{1}{2}") = 1"$ ∴ bearing on gusset plate controls

Assume deformation <u>is</u> design consideration

$\phi R_n = \phi 1.2 L_c t F_u \le \phi 2.4 d t F_u.$

$0.75(2.4)(7/8")(3/8")(58\text{ksi}) = 34.3^k$

edge bolt $L_c = 2" - \tfrac{1}{2}(15/16") = 1.5313"$
others $L_c = 3" - 2(\tfrac{1}{2})(15/16") = 2.0625"$

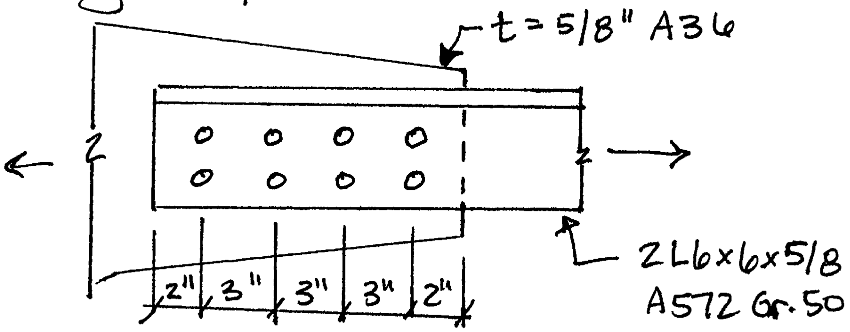
edge $\phi R_n = 0.75(1.2)(1.5313")(3/8")(58\text{ksi}) = \underline{29.98^k} < 34.3^k$
others $\phi R_n = 0.75(1.2)(2.0625")(3/8")(58\text{ksi}) = 40.37^k > \underline{34.3^k}$ ↑ use this

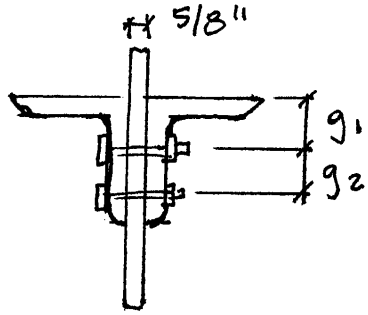
total $\phi R_n = 29.98^k + 4(34.3^k) = 167^k < 208^k$
N.G.

$\boxed{\text{Connection does NOT have adequate capacity.}}$

Problem 7.6-1 (a)

A 2L6x6x5/8 is connected to a 5/8" gusset plate. Determine the maximum service load that can be applied if the ratio of dead load to live load is 8.5. The bolts are 7/8" diameter, A325 bearing-type bolts. A572 Grade 50 steel is used for the angle, and A36 Steel is used for the gusset plate. Use LRFD.





AISC Table 1-15 2L6x6x5/8 $A = 14.3 \text{ in}^2$

Table 1-7 $\bar{x} = 1.72 \text{ in}$

[1-46] workable gages. $g_1 = 2\frac{1}{4}"$

$g_2 = 2\frac{1}{2}"$

Shear (bolts) Assume A325 N $A_b = \frac{\pi(7/8")^2}{4} = 0.6013 \text{ in}^2$

$$\phi R_n/\text{bolt} = \phi m 0.4 F_u^b A_b = 0.75(2)(0.4)(120\text{ksi})(0.6013\text{in}^2) = 43.3^k/\text{bolt}$$

8 bolts $\times$ 43.3^k/bolt = $\underline{346^k}$

bearing Assume deformation is a design consideration.

gusset = 5/8" and F_u = 58 ksi ← controls.

Angle ⇒ 2 × 5/8" and F_u = 65 ksi

edge bolts $L_c = 2" - \frac{1}{2}\left(\frac{15}{16}"\right) = 1.531"$

others $L_c = 3" - 2\left(\frac{1}{2}\right)\left(\frac{15}{16}"\right) = 2.0625"$

$$\phi R_n = \phi 1.2 L_c t F_u \le \phi 2.4 d t F_u = 0.75(2.4)\left(\tfrac{7}{8}"\right)\left(\tfrac{5}{8}"\right)(58\text{ ksi}) = 57.1^k$$

edge $0.75(1.2)(1.531")(5/8")(58\text{ ksi}) = \underline{49.95^k} \le 57.1^k$

others $0.75(1.2)(2.0625")(5/8")(58\text{ksi}) = 67.29 \le \underline{\underline{57.1^k}}$ →

↑ use

Problem 7.6-1 (a), cont'd.

bearing, cont'd. total $\phi R_n = 2(49.95^k) + 6(57.1^k)$
$= \underline{443^k}$. ∴ bearing does not control

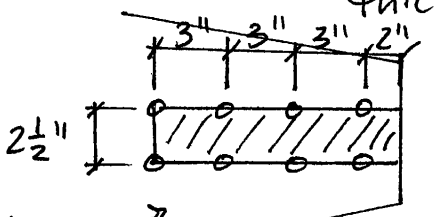
Yield of angles. $\phi P_n = 0.9(50\text{ ksi})(14.3\text{ in}^2) = \underline{643.5}^k$.

Net fracture $U = 1 - \frac{\bar{x}}{l} = 1 - \frac{1.72\text{ in}}{9\text{ in}} = 0.809$

$A_n = 14.3\text{ in}^2 - 4\text{ holes}\left(\frac{7}{8}'' + \frac{1}{8}''\right)(5/8'')$
$= 11.8\text{ in}^2$

$\phi P_n = 0.75(65\text{ksi})(0.809)(11.8\text{in}^2) = \underline{465.4}^k$

Block Shear (again, gusset plate will control because of thickness $(5/8'' < 2 \times 5/8'')$ and lower F_u)



side dimensions unknown. can only check this path.

$A_{nt} = (2.5'' - 2(\tfrac{1}{2})(1''))(5/8'') = 0.9375\text{in}^2$
$A_{gv} = 2(11'')(5/8'') = 13.75\text{ in}^2$
$A_{nv} = 2(11'' - 3.5(1''))(5/8'') = 9.375\text{in}^2$

$\phi R_n = \phi(0.6 F_u A_{nv} + U_{bs} F_u A_{nt})$
$\leq \phi(0.6 F_y A_{gv} + U_{bs} F_u A_{nt})$
$\phi R_n = 0.75(0.6(58\text{ksi})(9.375\text{in}^2) + (1.0)(58\text{ ksi})(0.9375\text{in}^2))$
$\leq 0.75(0.6(36\text{ksi})(13.75\text{in}^2) + (1.0)(58\text{ ksi})(0.9375\text{in}^2))$
$\phi R_n = 285.5^k \leq \underline{263.5}^k$
controls overall.

$D = 8.5L$
$P_u = 1.4D = 1.4(8.5L) = \underline{11.9L}$ ← controls
OR $= 1.2D + 1.6L = 1.2(8.5L) + 1.6L = 11.8L$

$\phi R_n \geq P_u$
$263.5^k \geq 11.9L$
$L \leq 22.1$

$P = D + L = 9.5L = 9.5(22.1^k)$

$\boxed{P = 210\text{ kips.}}$

block shear controls.