

Summary for the content of post 7

- ① Quick review of the different modes of Failure for bearing connections
- ② Solved problem 12-1 From Prof. McCormack
Determine design strength for a given Bearing connection
 - ① Tensile rupture
 - ② Tensile yielding
 - ③ Bearing and shear strength by calculations

1. From plate 1, the load passes to the side surfaces of the bolts.
2. The bolts bear on the holes, tending to crush the plate material [Figure 13–4(a)].
3. The load passes through the bolts and into plate 2, producing bearing stress on the holes.
4. The opposing forces acting on plates 1 and 2 tend to cut (shear) the bolts at the interface between the two plates [Figure 13–4(b)].
5. The tensile forces on plates 1 and 2 tend to tear the material across the section with minimum area to resist the tensile force. That occurs through the section where the bolt holes are located [Figure 13–4(c)].
6. As the bolts bear on the side surfaces of the holes in the plates, there is a tendency to tear out the material from the bolt to the edge of the material in either plate [Figure 13–4(d)].

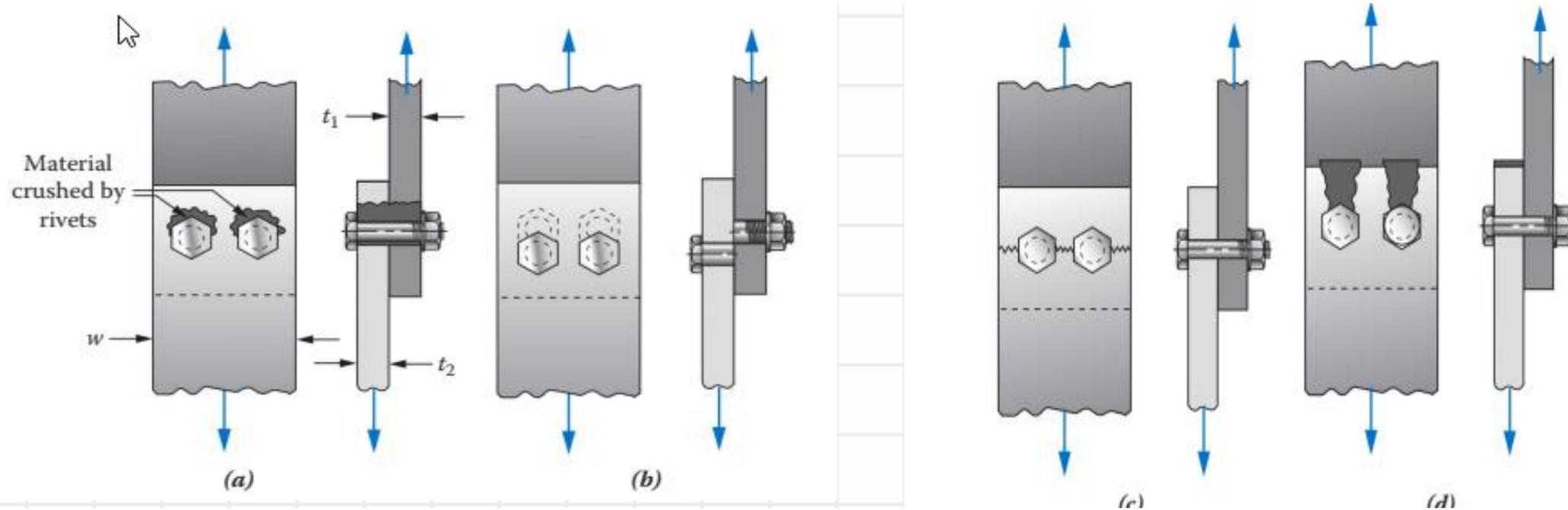
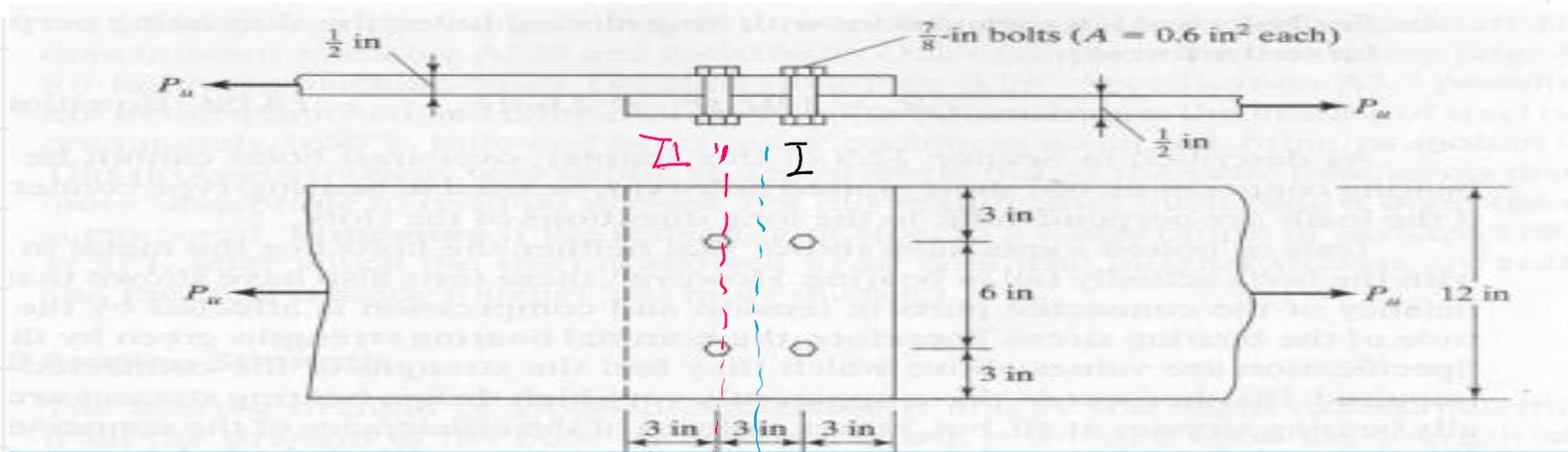


FIGURE 13–4 Types of failure of bolted connections: (a) bearing failure, (b) shear of rivets, (c) tensile failure, and (d) end tearout.

Example 12-1

Determine the design strength $\phi_c P_n$ and the allowable strength $\frac{P_n}{\Omega}$ for the bearing-type connection shown in Fig. 12.5. The steel is A36 ($F_y = 36$ ksi and $F_u = 58$ ksi), the bolts



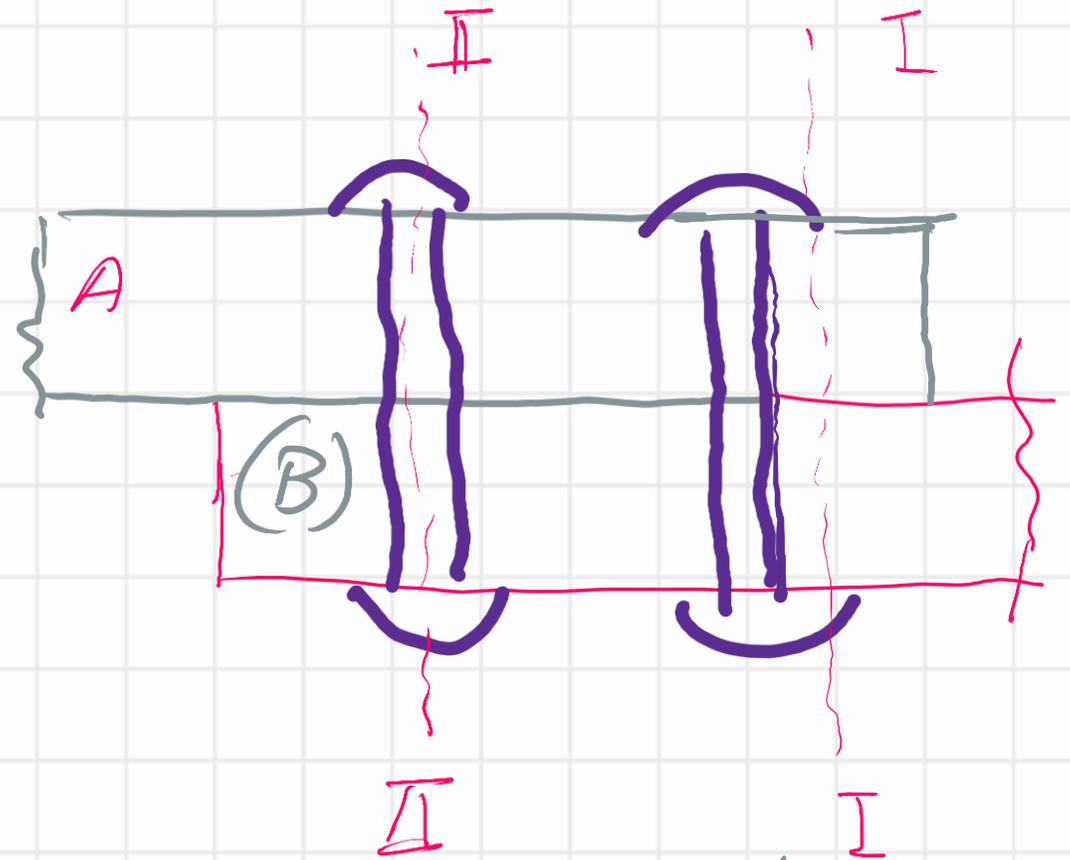
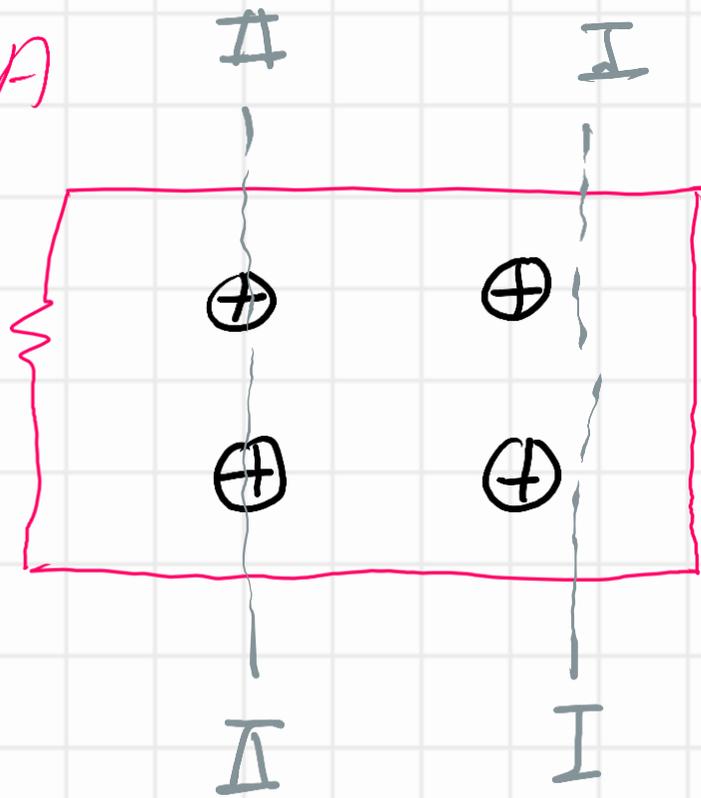
are 7/8-in A325, the holes are standard sizes, and the threads are excluded from the shear plane. Assume that deformations at bolt holes are a design consideration.

Section I-I For yielding

Section II-II
For Tensile rupture

Prepared by Eng. Maged Kamel.

Plate A



Plates A, B are similar, we will estimate
for Plate A (upper plate) all forces

Bolts A325 $\phi_b = 7/8"$ A325-X
Group A

Plates $t_{PL} = 1/2"$, width $12"$

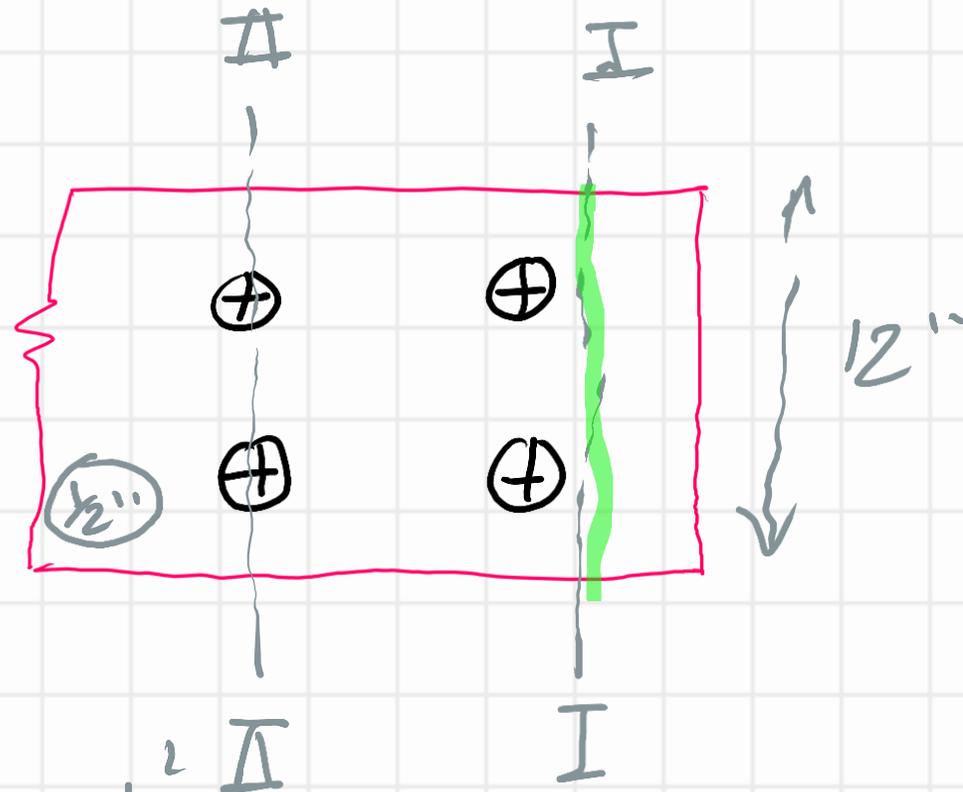
$F_y = 36 \text{ ksi}$
 $F_u = 58 \text{ ksi}$ } A36
steel

yielding of plate (A or B)

sec I-I

$$d_b = d_b + \frac{1}{8}" = \frac{7}{8} + \frac{1}{8} = 1"$$

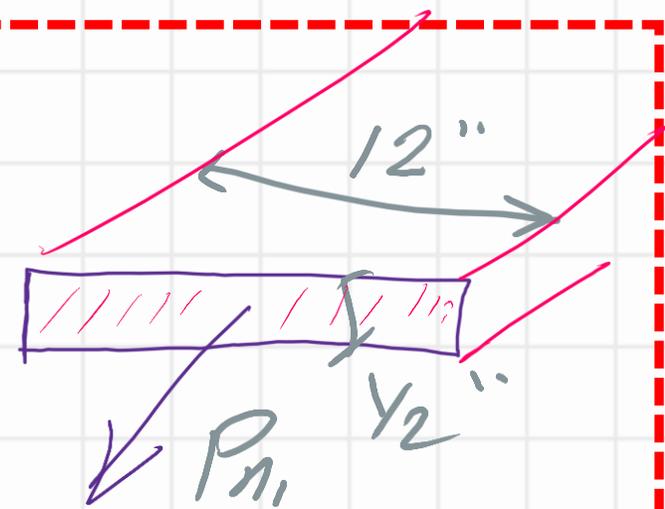
$$A_g = t_{PL}(w) = \frac{1}{2}(12) = 6.0 \text{ inch}^2$$



Yielding of plate (A) or (B)

Continued

$$F_u = 58 \text{ Ks}; \quad F_y = 36 \text{ Ks}; \quad A_g$$



$$P_{n1} = R_{n1} = A_g F_y = 6 \text{ inch}^2 (36 \text{ Kips/inch}^2) = 216 \text{ Kips}$$

$$\text{LRFD: } \phi_t = 0.90 \Rightarrow \phi_t P_n = 0.9(216) = 194.40 \text{ Kips}$$

$$\text{ASD: } \frac{1}{\Omega_t} = \frac{1}{1.67} \Rightarrow \frac{1}{\Omega_t} P_n = \frac{1}{1.67} (216) = 129.34 \text{ Kips}$$

$$\text{or } 0.6(216) \Rightarrow 129.60 \text{ Kips}$$

Bolts A325 $\phi_b = 7/8"$ A325-X
Group A

Plates $t_{PL} = 1/2"$, width $12"$

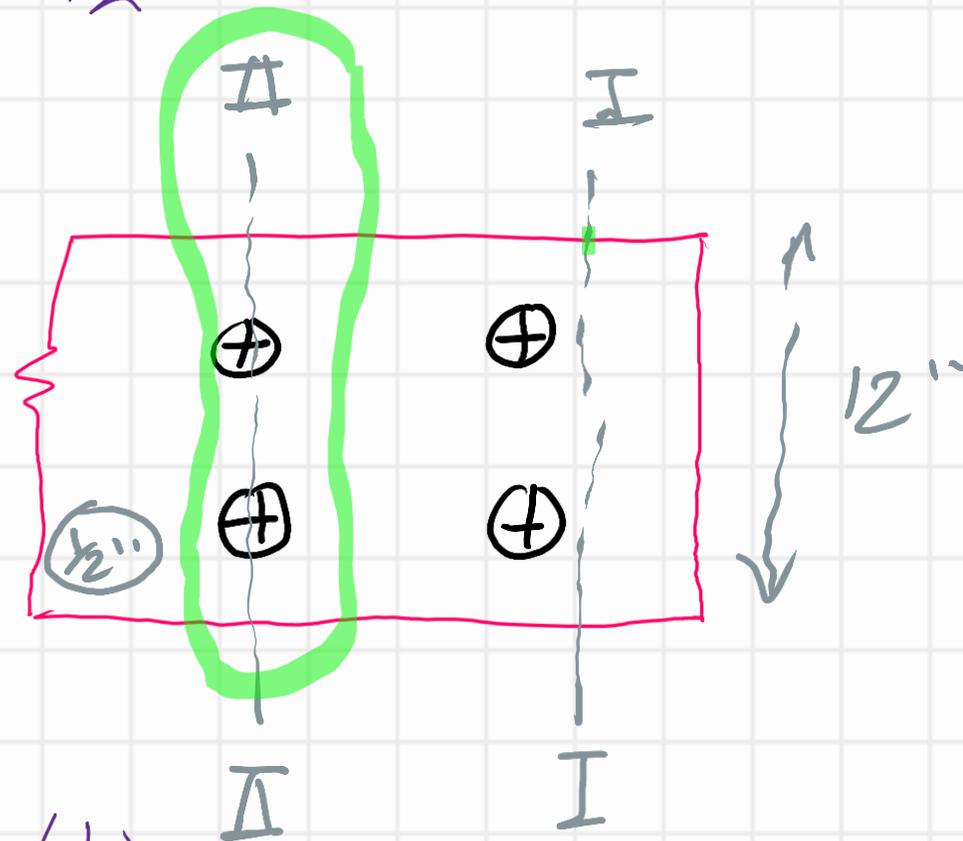
$F_y = 36$ ksi
 $F_u = 58$ ksi } A36
steel

Tensile rupture (A or B)

sec

$$d_h = d_b + \frac{1}{8}" = 1 + \frac{1}{8} = 1\frac{1}{8}"$$

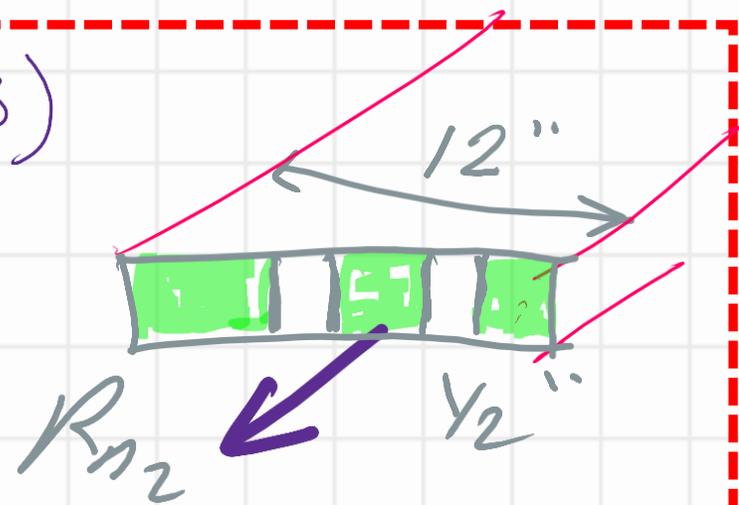
$$A_n = A_g - A_h \cdot t_p = 6 - 2(1)(\frac{1}{2}) = 5 \text{ inch}^2$$



Rupture of plate (A) or (B)

Continued

$$F_u = 58 \text{ Ksi}; \quad F_y = 36 \text{ Ksi}; \quad U = 1 \quad \rightarrow \quad A_g$$



$$P_{n2} = R_{n2} = U A_n F_u = (1)(5)(58) = 290 \text{ Kips}$$

inch² Kips
inch²

$$\text{LRFD: } \phi_t = 0.75 \Rightarrow \phi_t P_{n2} = 0.75(290) = 217.5 \text{ Kips}$$

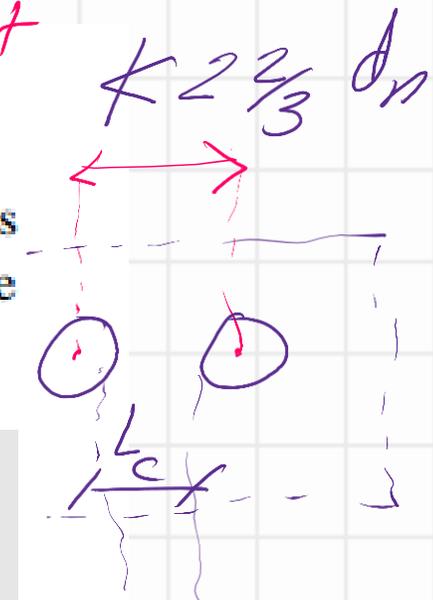
$$\text{ASD: } \frac{1}{\Omega_t} = \frac{1}{2} \Rightarrow \frac{1}{\Omega_t} P_{n2} = \frac{290}{2} = 145 \text{ Kips}$$

Prior to check bearing \rightarrow these are the important items

3. Minimum Spacing

The distance between centers of standard, oversized or slotted holes shall not be less than $2\frac{2}{3}$ times the nominal diameter, d , of the fastener. However, the clear distance between bolt holes or slots shall not be less than d .

User Note: A distance between centers of standard, oversize or slotted holes of $3d$ is preferred.



For $\phi = \frac{7}{8}$

TABLE J3.3
Nominal Hole Dimensions, in.

Bolt Diameter, in.	Hole Dimensions			
	Standard (Dia.)	Oversize (Dia.)	Short-Slot (Width \times Length)	Long-Slot (Width \times Length)
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{9}{16} \times \frac{11}{16}$	$\frac{9}{16} \times 1\frac{1}{4}$
$\frac{5}{8}$	$\frac{11}{16}$	$\frac{13}{16}$	$\frac{11}{16} \times \frac{7}{8}$	$\frac{11}{16} \times 1\frac{9}{16}$
$\frac{3}{4}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16} \times 1$	$\frac{13}{16} \times 1\frac{7}{8}$
$\frac{7}{8}$	$\frac{15}{16}$	$1\frac{1}{16}$	$\frac{15}{16} \times 1\frac{1}{8}$	$\frac{15}{16} \times 2\frac{3}{16}$
1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{8} \times 1\frac{5}{16}$	$1\frac{1}{8} \times 2\frac{1}{2}$
$\geq 1\frac{1}{8}$	$d + \frac{1}{8}$	$d + \frac{5}{16}$	$(d + \frac{1}{8}) \times (d + \frac{3}{8})$	$(d + \frac{1}{8}) \times 2.5d$

$$d_n = d_h = \frac{7}{8} + \frac{1}{16}$$

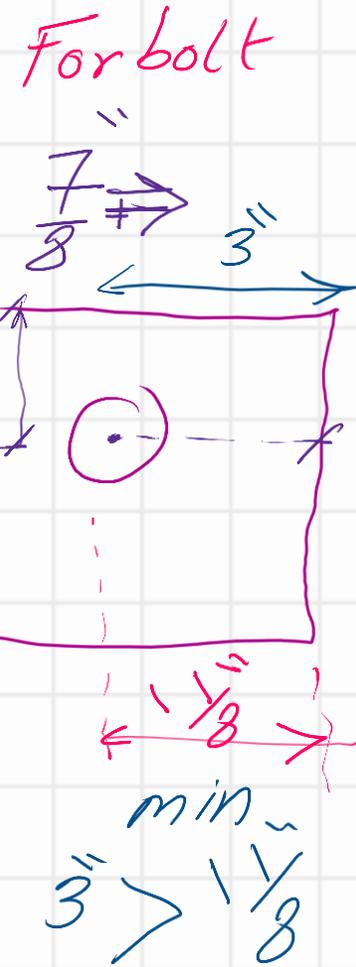
$$= \frac{14 + 1}{16}$$

$$d_h = \frac{15}{16}$$

Check edge distance

TABLE J3.4
Minimum Edge Distance^[a] from
Center of Standard Hole^[b] to Edge of
Connected Part, in.

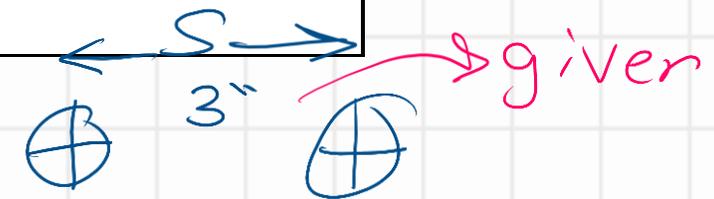
Bolt Diameter, in.	Minimum Edge Distance
1/2	3/4
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2
1 1/4	1 5/8
Over 1 1/4	1 1/4 d



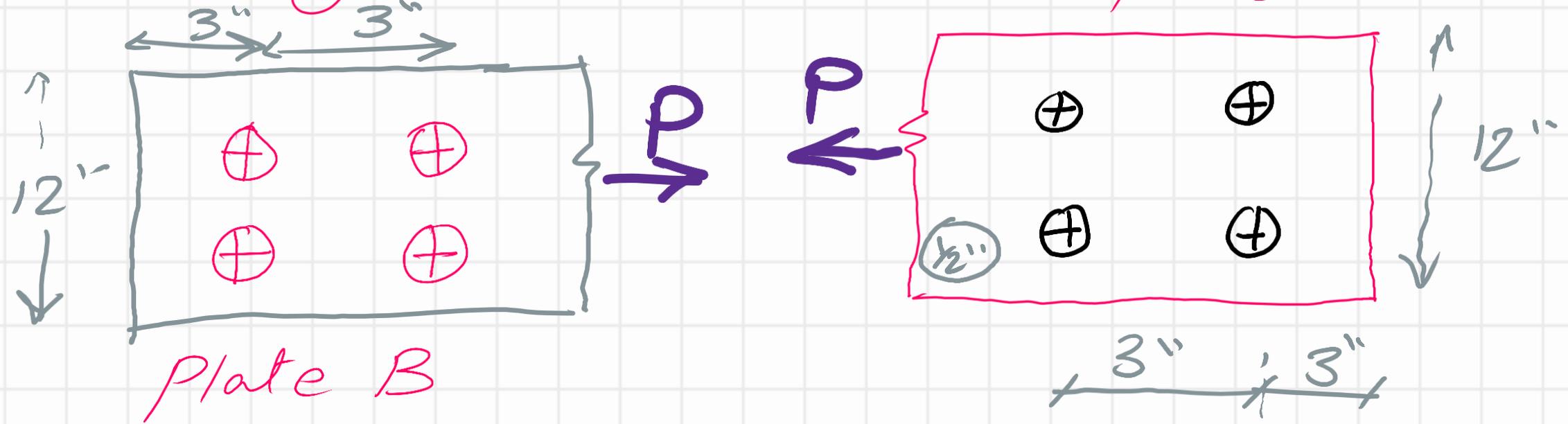
^[a] If necessary, lesser edge distances are permitted provided the applicable provisions from [Sections J3.10](#) and [J4](#) are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record.
^[b] For oversized or slotted holes, see [Table J3.5](#).

$$\min S = 2 \frac{2}{3} d = 2.66 (7/8) = 2.32$$

Prepared by Eng. Maged Kamel.



© Bearing strength of bolt



① Check edge requirements

$$l_{e, \text{act}} = 3'' \Rightarrow l_{e, \text{req}} = 1 \frac{1}{8}'' = 7/8''$$

$$l_{e, \text{act}} > l_{e, \text{req}} \quad \text{OK}$$

© Bearing strength of bolt

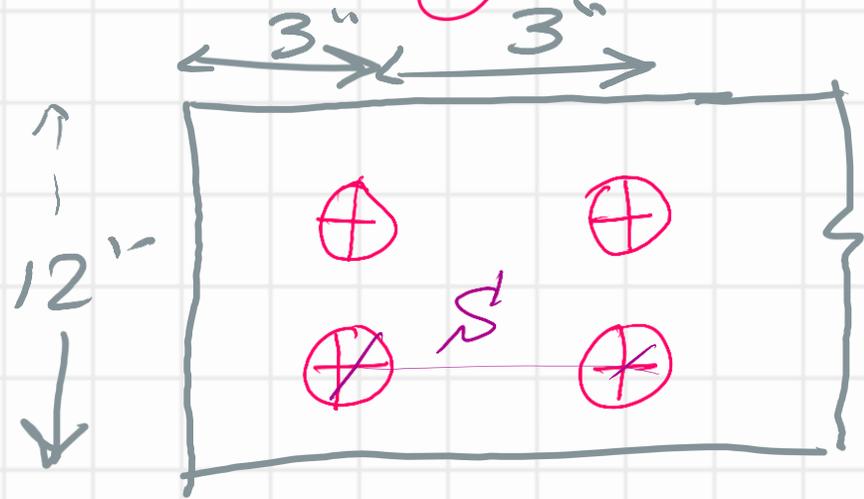


Plate B

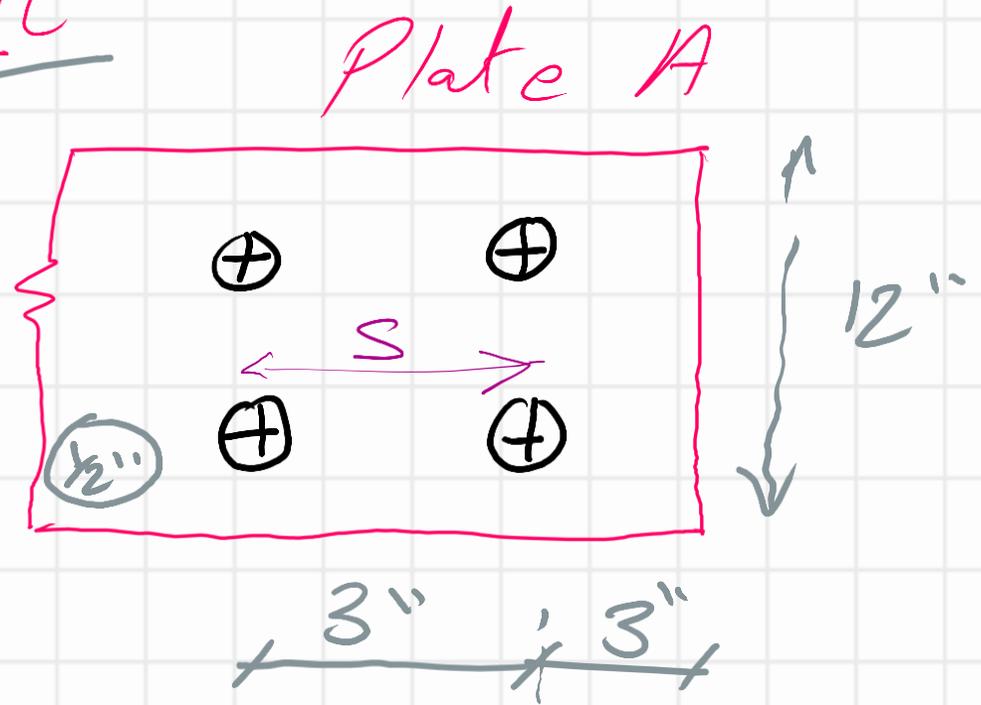


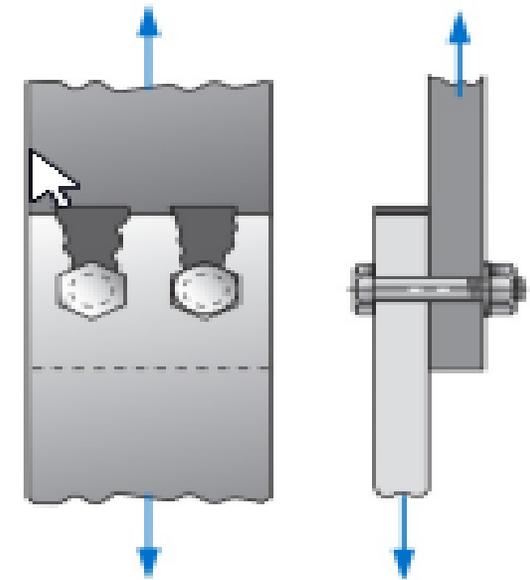
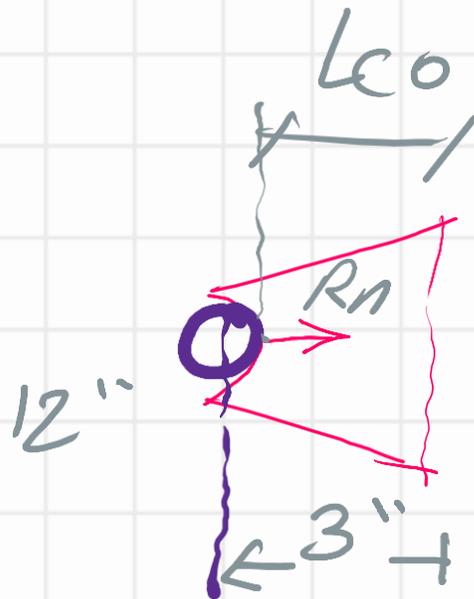
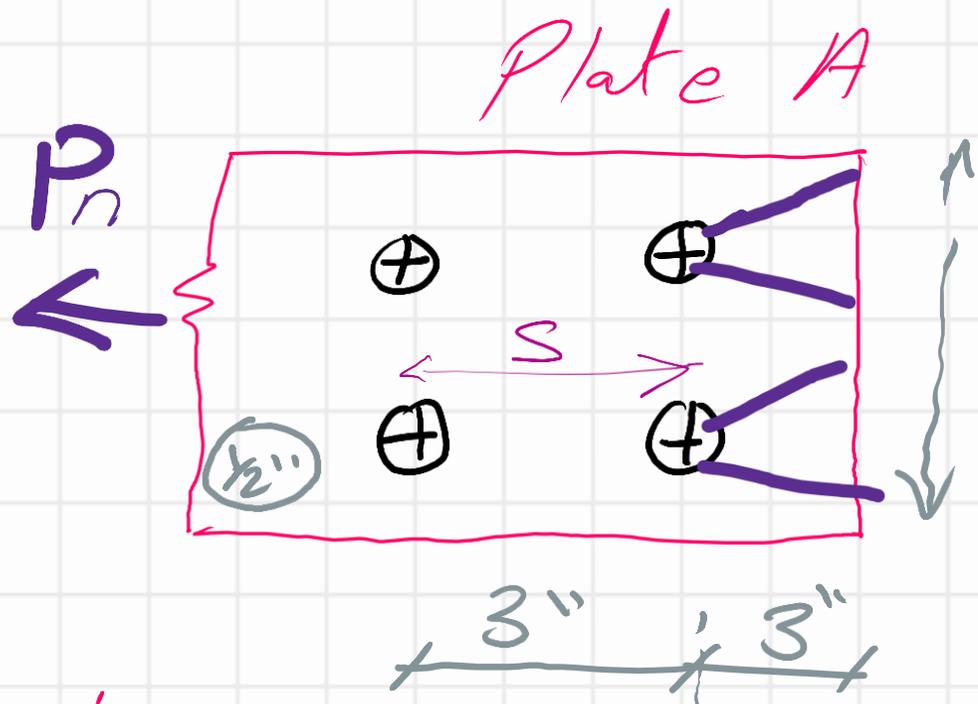
Plate A

© Check spacing between bolts

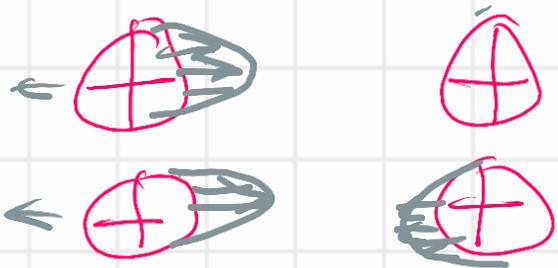
$$S_{act} = 3" \Rightarrow S_{Pref} = 2 \frac{2}{3} d_b = 2.67 \left(\frac{7}{8}\right) = 2.33" \quad S > S_{req} \text{ ok}$$

$$d_h = d_b + \frac{1}{16} = \frac{7}{8} + \frac{1}{16} \Rightarrow 15/16"$$

Tear out

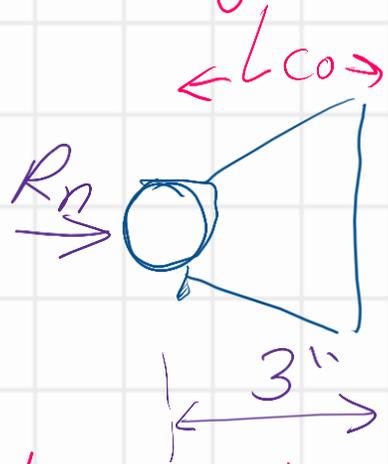


$$L_{c0 \text{ act}} = 3" - \frac{1}{2}(d_h) = 3" - \frac{1}{2}\left(\frac{15}{16}\right) = \frac{96-15}{32} = \frac{81}{32} = 2.531"$$

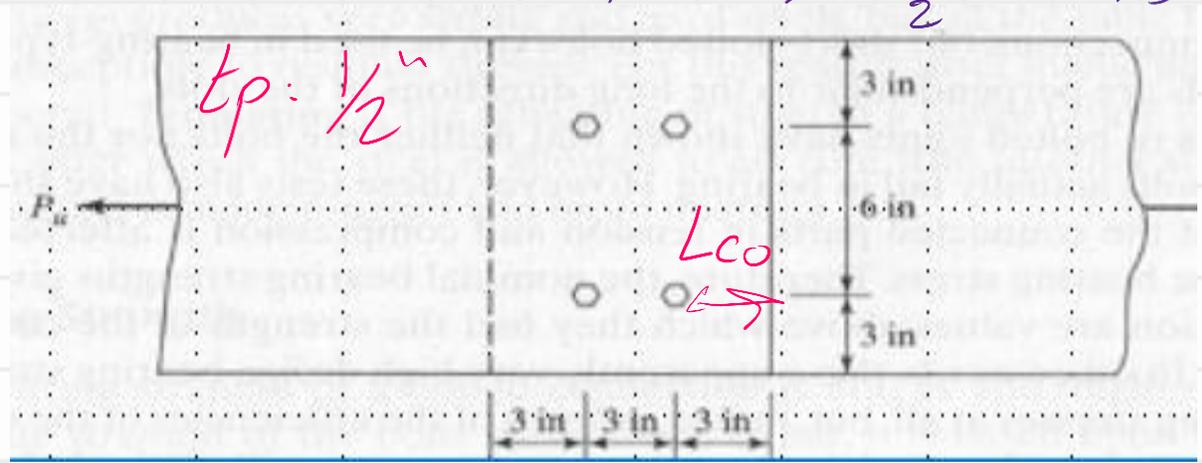


Bearing edge bolts

$$d_h = 15/16'' \rightarrow \frac{d_h}{2} = 15/32$$



A36
 $F_u = 58 \text{ ksi}$



$$L_{co} = 3'' - \frac{d_h}{2} = 3 - \frac{15}{32} = 2.531''$$

check against $2d_b$

$$L_{co} > 2d_b$$

$$d_b = 7/8''$$

$$2d_b = \frac{14}{8} = 1.75''$$

upper limit equation

Controls \Rightarrow

$$2.4 d_b (t) (F_u)$$

For information: $R_n = 1.2 l_{co} t F_u$

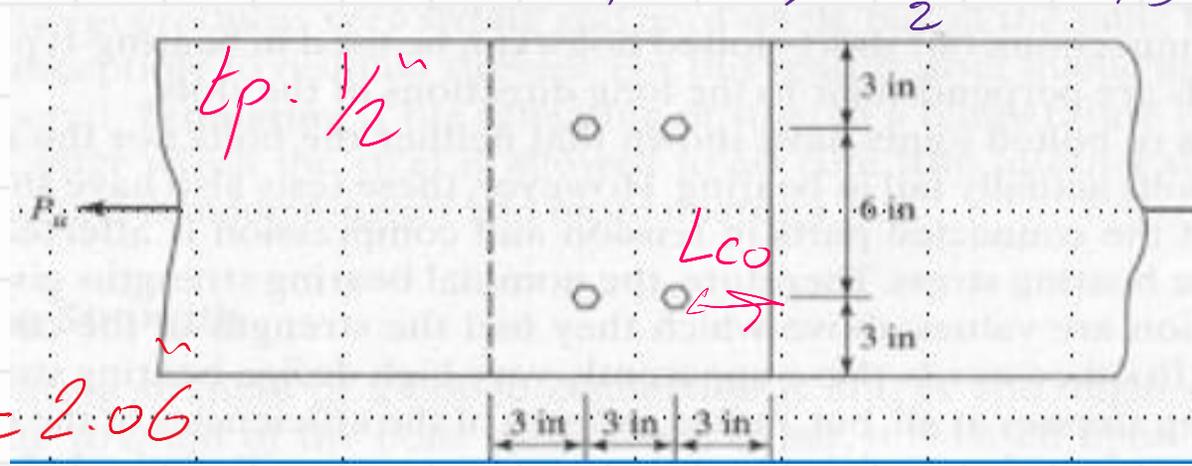
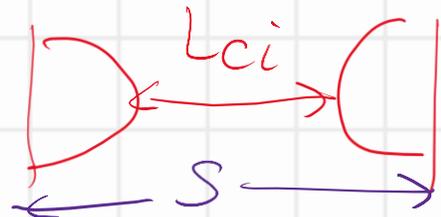
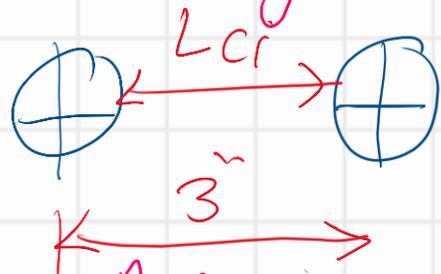
$$R_{nU} = 2.4 (7/8) (1/2) (58) = 60.9 \text{ k}$$

$$= 1.2 (2.531) (1/2) (58) = 88.07 \text{ k} > R_{nU}$$

Bearing

inner bolts

$$d_h = 15/16'' \rightarrow \frac{d_h}{2} = 15/32$$



A36

$F_u = 58 \text{ ksi}$

$$s - d_h = 3 - \frac{15}{16} = \frac{33}{16} = 2.06$$

check against $2d_b$

$$L_{ci} > 2d_b$$

$$d_b = 7/8''$$

$$2d_b = \frac{14}{8} = 1.75''$$

Upper Limits Controls

$$R_n = 60.96 \text{ K}$$

For information R_n for inner bolts:



$$= 1 - 2(2.06)(1/2)(58) = 71.688 > R_{nU}$$

For shear calculation

TABLE J3.2

Nominal Strength of Fasteners and Threaded Parts, ksi (MPa)

Description of Fasteners	Nominal Tensile Strength, F_{nt} , ksi (MPa) ^(a)	Nominal Shear Strength in Bearing-Type Connections, F_{nv} , ksi (MPa) ^(a)
A307 bolts	45 (310) ^(d)	27 (186) ^{(d)(i)}
Group A (e.g., A325) bolts, when threads are not excluded from shear planes	90 (620)	54 (372)
Group A (e.g., A325) bolts, when threads are excluded from shear planes	90 (620)	68 (469)
Group B (e.g., A490) bolts, when threads are not excluded from shear planes	113 (780)	68 (469)
Group B (e.g., A490) bolts, when threads are excluded from shear planes	113 (780)	84 (579)



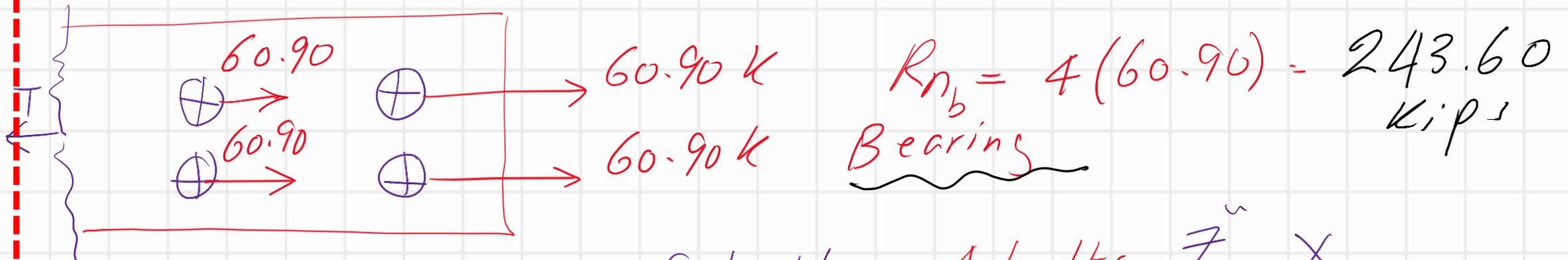
Group C (e.g., F3043) bolt assemblies, when threads and transition area of shank are not excluded from the shear plane	150 (1040)	90 (620)
Group C (e.g., F3043) bolt assemblies, when threads and transition area of shank are excluded from the shear plane	150 (1040)	113 (779)
Threaded parts meeting the requirements of Section A3.4, when threads are not excluded from shear planes	$0.75F_u$	$0.450F_u$
Threaded parts meeting the requirements of Section A3.4, when threads are excluded from shear planes	$0.75F_u$	$0.563F_u$

^(a) For high-strength bolts subject to tensile fatigue loading, see Appendix 3.
^(b) For end loaded connections with a fastener pattern length greater than 38 in. (950 mm), F_{nv} shall be reduced to 83.3% of the tabulated values. Fastener pattern length is the maximum distance parallel to the line of force between the centerline of the bolts connecting two parts with one faying surface.
^(c) For A307 bolts, the tabulated values shall be reduced by 1% for each 1/16 in. (2 mm) over five diameters of length in the grip.
^(d) Threads permitted in shear planes.

$F_{nv} = 68$ ksi For excluded.

or from table 7.1

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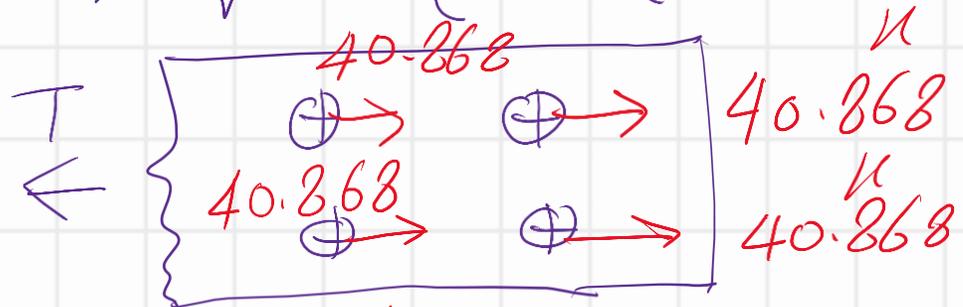


shear strength of bolts 4 bolts $\frac{7}{8}$ X

$F_{nv} = 68$ ksi S.S For one bolt

$A_b = \frac{\pi}{4} \left(\frac{7}{8}\right)^2 = 0.601$ inch², No. of bolts = 4

$R_{nv} = 1(68)(0.601) = 40.868$ kips



shear controls

$(R_{nv})_{4 \text{ bolts}} = 163.472$ k

SIXTH EDITION

Applied Strength of Materials

Robert L. Mott

Joseph A. Untener

13

Connections

4. Minimum Edge Distance

The distance from the center of a standard hole to an edge of a connected part in any direction shall not be less than either the applicable value from Table J3.4 or Table J3.4M, or as required in Section J3.10. The distance from the center of an oversized or slotted hole to an edge of a connected part shall be not less than that required for a standard hole to an edge of a connected part plus the applicable increment, C_2 , from Table J3.5 or Table J3.5M.

User Note: The edge distances in Tables J3.4 and J3.4M are minimum edge distances based on standard fabrication practices and workmanship tolerances. The appropriate provisions of Sections J3.10 and J4 must be satisfied.

When computing the distance ℓ_c , use the actual hole diameter (which is $\frac{1}{16}$ -inch larger than the bolt diameter), and do not add the $\frac{1}{16}$ inch as required in AISC B4.3b for computing the net area for tension and shear. In other words, use a hole diameter of

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

not $d + \frac{1}{8}$ inch (although if $d + \frac{1}{8}$ were used, the slight error would be on the conservative side).

SEGUI

Summary of Bearing Strength, Spacing, and Edge-Distance Requirements (Standard Holes)

a. Bearing strength:

$$R_n = 1.2\ell_{ct}F_u \leq 2.4dtF_u \quad (\text{AISC Equation J3-6a})$$

b. Minimum spacing and edge distance: In any direction, both in the line of force and transverse to the line of force,

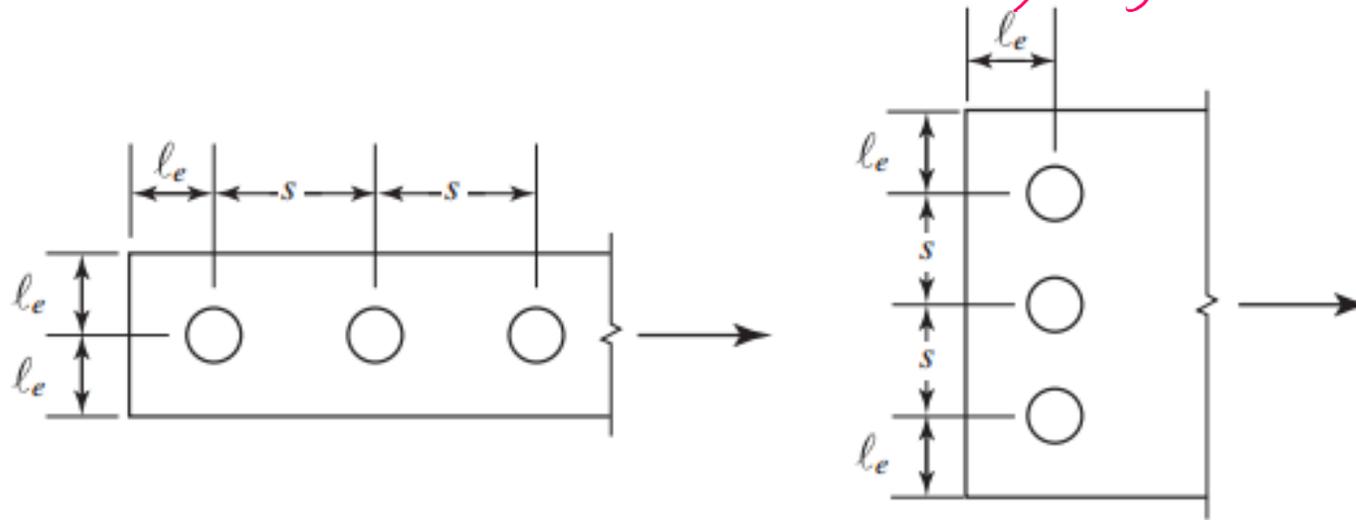
$$s \geq 2\frac{2}{3}d \quad (\text{preferably } 3d)$$

$$\ell_e \geq \text{value from AISC Table J3.4}$$

For single- and double-angle shapes, the usual gage distances given in Table 1-7A in Part 1 of the *Manual* (see Section 3.6) may be used in lieu of these minimums.

SEGUI

FIGURE 7.9



Spacing and Edge-Distance Requirements

To maintain clearances between bolt nuts and to provide room for wrench sockets, AISC J3.3 requires that center-to-center spacing of fasteners (in any direction) be no less than $2\frac{2}{3}d$ and preferably no less than $3d$, where d is the fastener diameter. Minimum edge distances (in any direction), measured from the center of the hole, are given in AISC Table J3.4 as a function of bolt size. The spacing and edge distance to be considered, denoted s and l_e , are illustrated in Figure 7.9.