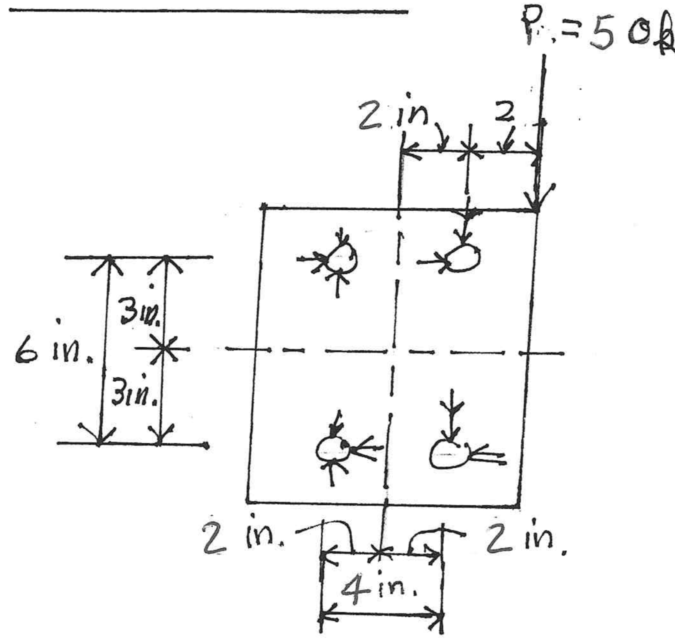
CHAPTER 13

PROB #13-1



$$M = Pe = (50)(4.0) = 200 \text{ in.-k}$$

$$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (4)(2.0)^2 + (4)(3)^2 = 52 \text{ in.}^2$$

Upper right and lower right bolts most stressed

$$\left.\begin{aligned} H &= \frac{Mv}{\Sigma d^2} = \frac{(200)(3)}{52} = 11.54 \text{ k} \rightarrow \\ V &= \frac{Mh}{\Sigma d^2} = \frac{(200)(2)}{52} = 7.69 \text{ k} \downarrow \end{aligned}\right\} \text{For upper right bolt}$$

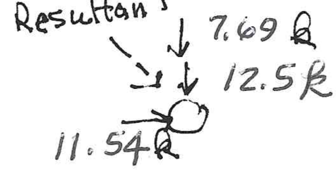
$$\frac{P}{4} = \frac{50}{4} = 12.5 \text{ k} \downarrow$$

$$\text{Resultant force} = \sqrt{(11.54)^2 + (7.69 + 12.5)^2}$$

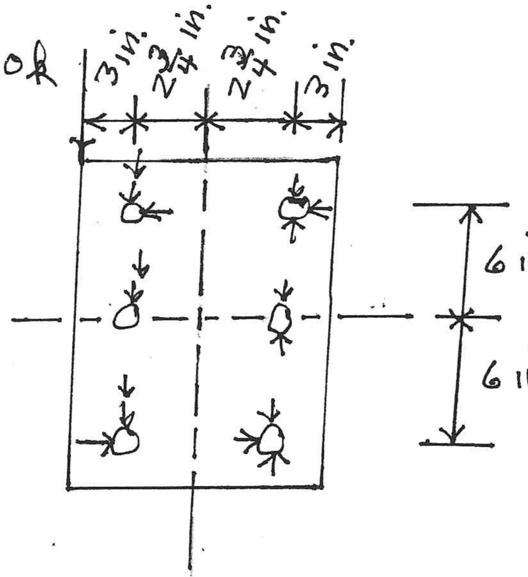
$$= \boxed{23.26 \text{ k}}$$

√ JCMc

√ SFC



PROB # 13-2



$$M = Pe = (60)(3 + 2.75) = 345 \text{ in.-k}$$

$$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (6)(2.75)^2 + (4)(6)^2 = 189.375 \text{ in.}^2$$

Upper left and lower left bolts most stressed

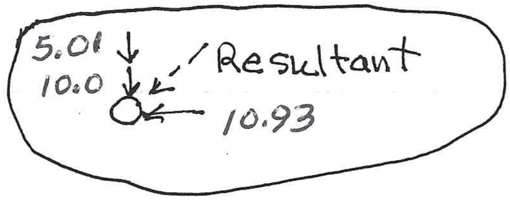
For upper left bolt:

$$H = \frac{Mv}{\Sigma d^2} = \frac{(345)(6)}{189.375} = 10.93 \text{ k} \leftarrow$$

$$V = \frac{Mh}{\Sigma d^2} = \frac{(345)(2.75)}{189.375} = 5.01 \text{ k} \downarrow$$

$$\frac{P}{6} = \frac{60}{6} = 10.0 \text{ k} \downarrow$$

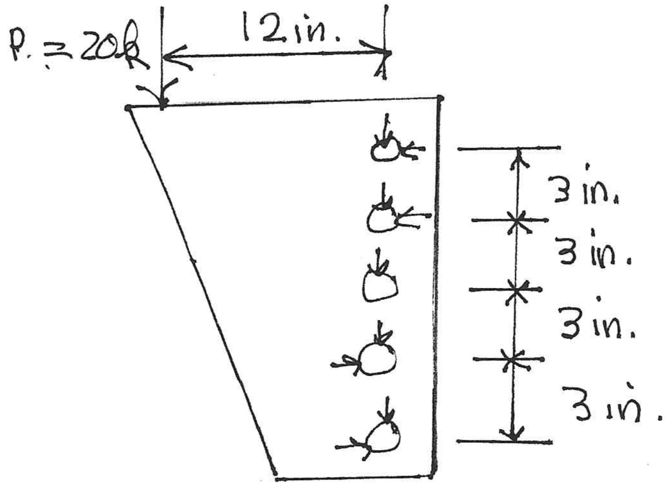
$$\text{Resultant force} = \sqrt{(10.93)^2 + (10 + 5.01)^2} = \boxed{18.57 \text{ k}}$$



✓ gcm ✓

SFC ✓

PROB # 13-3



$$M = Pe = (20)(12) = 240 \text{ in.k}$$

$$\Sigma d^2 = \Sigma v^2 = (2)(3)^2 + (2)(6)^2 = 90 \text{ in.}^2$$

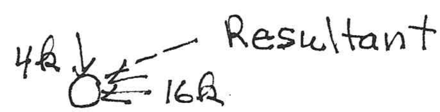
Top and bottom bolts most stressed

$$H = \frac{Mv}{\Sigma d^2} = \frac{(240)(6)}{90} = 16 k \rightarrow$$

$$V = \frac{Mh}{\Sigma d^2} \quad \frac{(240)(0)}{90} = 0$$

For top bolt

$$\frac{P}{5} = \frac{20}{5} = 4k \downarrow$$

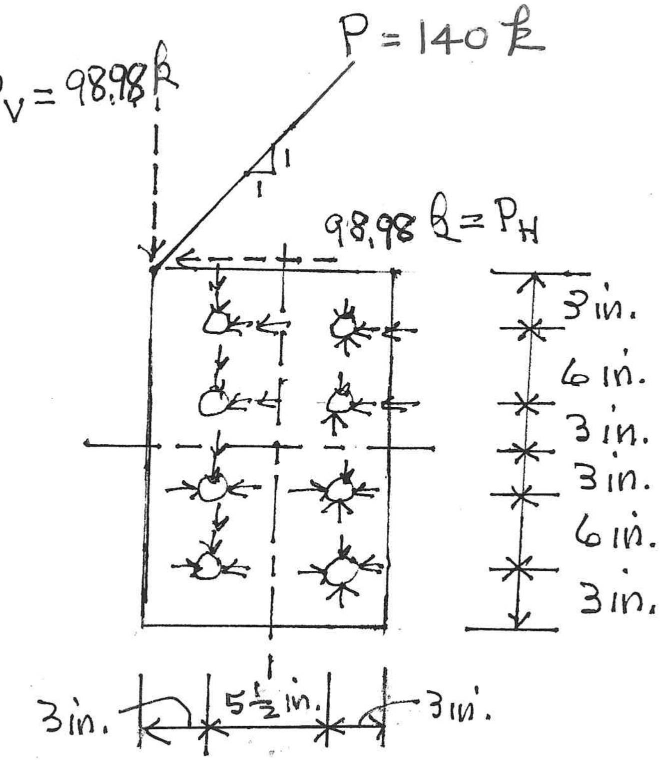


$$\text{Resultant} = \sqrt{(16)^2 + (4)^2} = \boxed{16.49 k}$$

✓ gcmc

SFC ✓

PROB # 13-4



$$M = (98.98)(3+2.75) + (98.98)(3+6+3) = 1756.89 \text{ in.k}$$

$$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (8)(2.75)^2 + (4)(3)^2 + (4)(9)^2$$

$$= 420.5 \text{ in.}^2$$

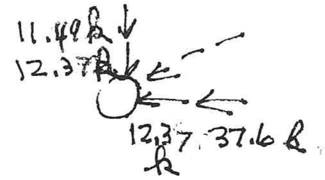
Upper left bolt most stressed

$$H = \frac{Mv}{\Sigma d^2} = \frac{(1756.89)(9)}{420.5} = 37.60 \text{ k} \leftarrow$$

$$V = \frac{Mh}{\Sigma d^2} = \frac{(1756.89)(2.75)}{420.5} = 11.49 \text{ k} \downarrow$$

$$\frac{P_H}{8} = \frac{98.98}{8} = 12.37 \text{ k} \leftarrow$$

$$\frac{P_V}{8} = \frac{98.98}{8} = 12.37 \text{ k} \downarrow$$



$$\text{Resultant} = \sqrt{(37.60+12.37)^2 + (11.49+12.37)^2}$$

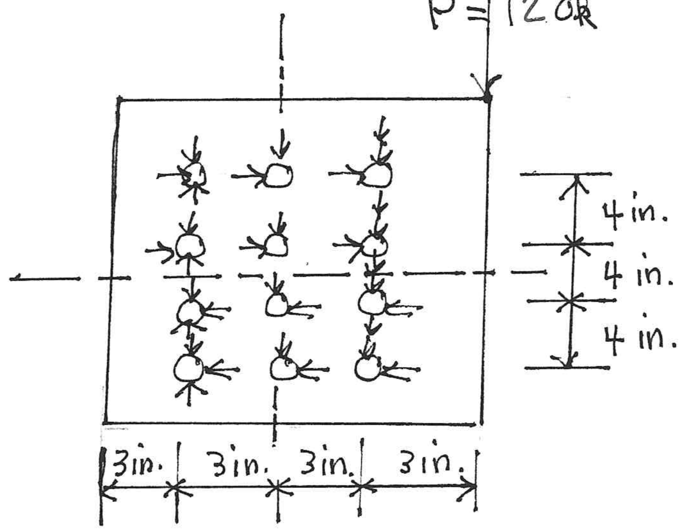
$$= \boxed{55.37 \text{ k}}$$

✓ JCMc

✓SFC

13-4

PROB # 13-5



$M = (120)(3+3) = 720 \text{ in.k}$

$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (8)(3)^2 + (6)(2)^2 + (6)(6)^2 = 312 \text{ in.}^2$

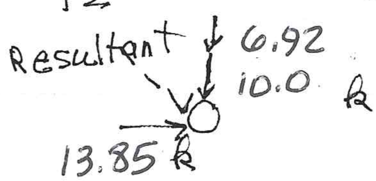
Upper right and lower right bolts most stressed

$H = \frac{Mv}{\Sigma d^2} = \frac{(720)(6)}{312} = 13.85 k \rightarrow$

$V = \frac{Mh}{\Sigma d^2} = \frac{(720)(3)}{312} = 6.92 k \downarrow$

For upper right bolt

$\frac{P}{12} = \frac{120}{12} = 10.0 k \downarrow$



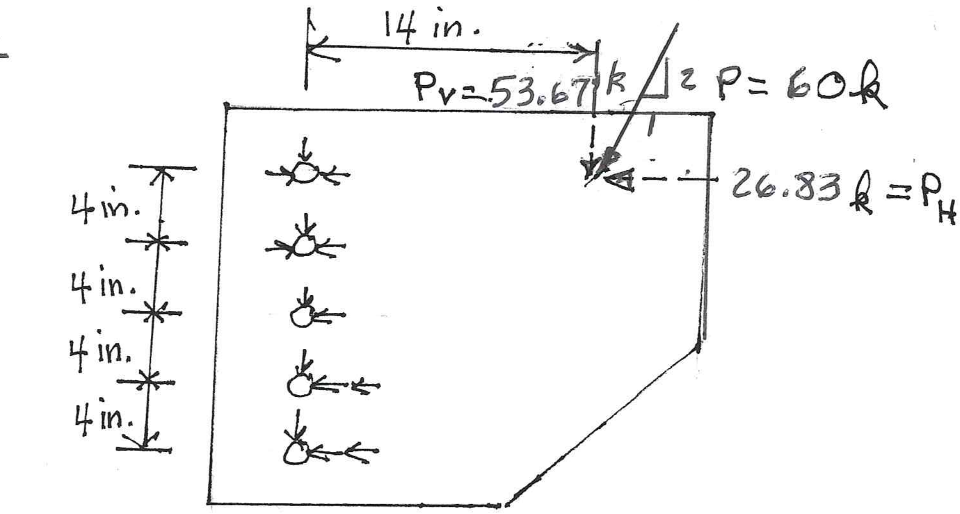
$\text{Resultant} = \sqrt{(13.85)^2 + (6.92 + 10.0)^2}$

$= \boxed{21.87 k}$

rjcmc

SFC ✓

PROB # 13-6



$$M = (53.67)(14) - (26.83)(8) = 536.74 \text{ in.-k}$$

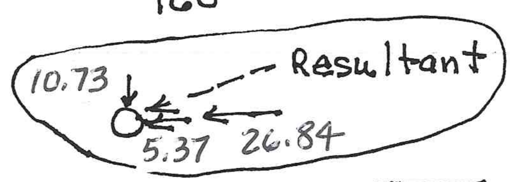
$$\Sigma d^2 = (2)(4)^2 + (2)(8)^2 = 160 \text{ in.}^2$$

Bottom bolt most stressed

$$\frac{P_V}{5} = \frac{53.67}{5} = 10.73 \text{ k} \downarrow$$

$$\frac{P_H}{5} = \frac{26.83}{5} = 5.37 \text{ k} \leftarrow$$

$$H = \frac{Mv}{\Sigma d^2} = \frac{(536.74)(8)}{160} = 26.84 \text{ k} \leftarrow$$



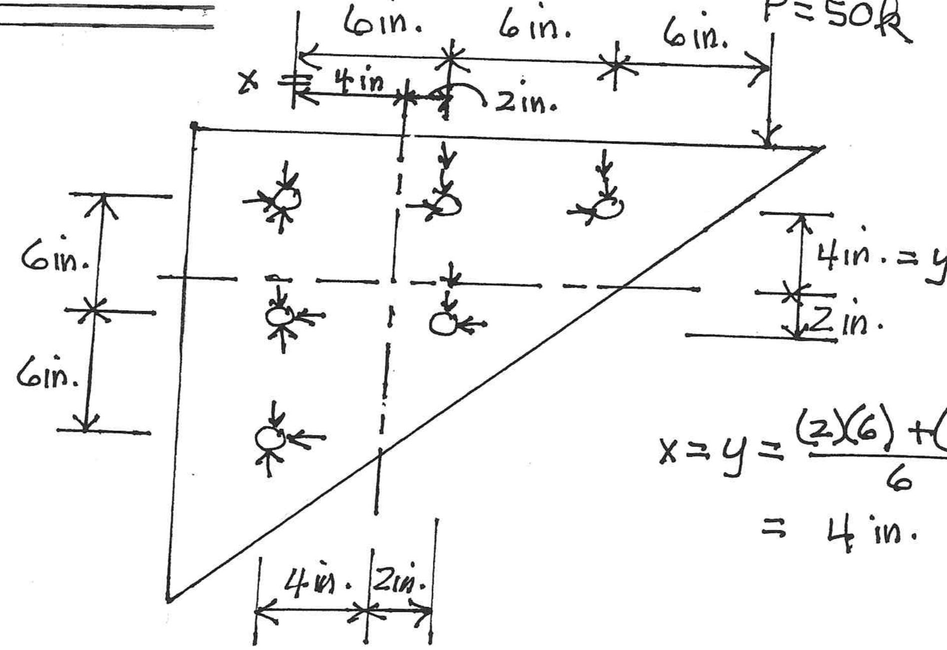
$$\text{Resultant} = \sqrt{(10.73)^2 + (5.37 + 26.84)^2}$$

$$= \boxed{33.95 \text{ k}}$$

✓ JCMc

SFC ✓

PROB # 13-7



$$x = y = \frac{(2)(6) + (1)(12)}{6} = 4 \text{ in.}$$

$$M = Pe = (50)(14) = 700 \text{ in. k}$$

$$\Sigma d^2 = [\Sigma h^2 = (3)(4)^2 + (2)(2)^2 + (1)(8)^2]\,2 = 240 \text{ in.}^2$$

Upper far right bolt most stressed

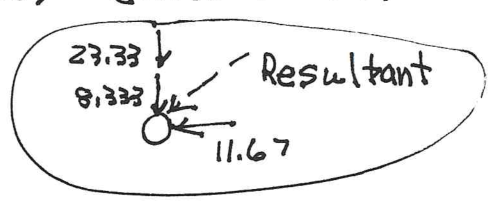
$$\frac{P}{6} = \frac{50}{6} = 8.333 \text{ k} \downarrow$$

$$H = \frac{Mv}{\Sigma d^2} = \frac{(700)(4)}{240} = 11.67 \text{ k} \rightarrow$$

$$V = \frac{Mh}{\Sigma d^2} = \frac{(700)(8)}{240} = 23.33 \text{ k} \downarrow$$

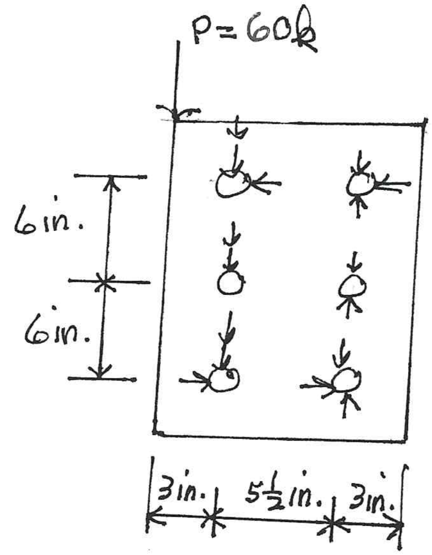
$$\text{Resultant force} = \sqrt{(11.67)^2 + (8.333 + 23.33)^2}$$

$$= \boxed{33.75 \text{ k}}$$



SFC ✓

PROB #13-8



$$e\ \text{effective} = e_{actual} - \frac{1+m}{3}$$

$$= 5.75 - \frac{1+3}{2} = 3.75 \text{ in.}$$

$$M = (60)(3.75) = 225 \text{ in.-k}$$

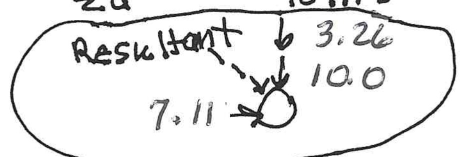
$$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (4)(6)^2 + (6)(2.75)^2 = 189.375 \text{ in.}^2$$

Lower left bolt most stressed

$$\frac{P}{6} = \frac{60}{6} = 10.0 \text{ k} \downarrow$$

$$H = \frac{Mv}{\Sigma d^2} = \frac{(225)(6)}{189.75} = 7.11 \text{ k} \rightarrow$$

$$V = \frac{Mh}{\Sigma d^2} = \frac{(225)(2.75)}{189.75} = 3.26 \text{ k} \downarrow$$

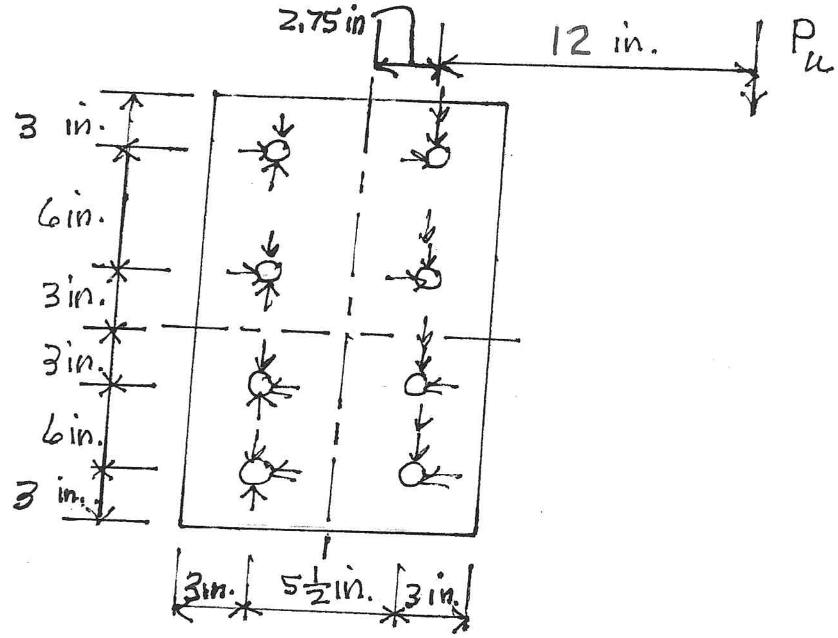


$$\text{Resultant} = \sqrt{(7.11)^2 + (10.0+3.26)^2}$$

$$= \boxed{15.05 \text{ k}}$$

SFC ✓

PROB # 13-9



$M = (P_u)(14.75) = 14.75\,P_u$

$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (8)(2.75)^2 + (4)(3)^2 + (4)(9)^2 = 420.5\ \text{in.}^2$

Upper right and lower right bolts most stressed

$H = \dfrac{Mv}{\Sigma d^2} = \dfrac{(14.75\,P_u)(9)}{420.5} = 0.316\,P_u \rightarrow$

$V = \dfrac{Mh}{\Sigma d^2} = \dfrac{(14.75\,P_u)(2.75)}{420.5} = 0.096\,P_u \downarrow$

$\dfrac{P}{8} = 0.125\,P \downarrow$

Resultant $\downarrow 0.125\,P_u$ $\downarrow 0.096\,P_u$ $0.316\,P_u$

$\text{Resultant} = \sqrt{(0.316\,P_u)^2 + (0.096\,P_u + 0.125\,P_u)^2}$

$= 0.386\,P_u$

Bolts in SS and bearing on $\frac{5}{8}$ in.

Bearing strength of 1 bolt

$L_c = 3 - \dfrac{\frac{3}{4} + \frac{1}{8}}{2} = 2.56$ in.

PROB # 13-9 CONT'D.

$$R_n = 1.2 L_c t F_u (\text{No of bolts}) \leq 2.4 d t F_u (\text{No of bolts})$$

$$= (1.2)(2.56)(\tfrac{5}{8})(58)(1) = 111.4\text{k} < (2.4)(\tfrac{3}{4})(\tfrac{5}{8})(58)(1) = \underline{\underline{65.2\text{k}}}$$

$$\phi R_n = (0.75)(65.2) = 48.9\text{k each}$$

Shearing strength of 1 bolt

$$R_n = (0.44)(68) = 29.9\text{ k}$$

LRFD $\left[\ \phi R_n = (0.75)(29.9) = \underline{\underline{22.4\text{k}}}\right.$

Equating

$$0.386\, P_u = 22.4$$

$$\boxed{P_u = 58.0\text{k}}$$

✓ JCMc

ASD

$$\frac{R_n}{\Omega} = \frac{29.9}{2.0} = 14.95\text{ k}$$

$$0.386\, P_a = 14.95$$

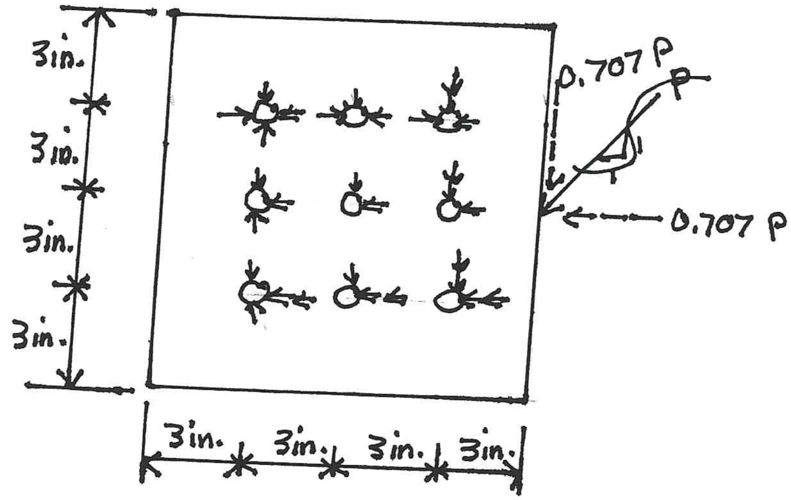
$$\boxed{P_a = 38.7\text{k}}$$

SFC ✓

13-10

PROB # 13-10

(a) Elastic Analysis



Lower right bolt most stressed

$M = (0.707P)(6) = 4.242P$

$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (6)(3)^2 + (6)(3)^2 = 108$

$H = \dfrac{Mv}{\Sigma d^2} = \dfrac{(4.242P)(3)}{108} = 0.118P \leftarrow$

$V = \dfrac{Mh}{\Sigma d^2} = \dfrac{(4.242)(3)}{108} = 0.118P \downarrow$

$\dfrac{0.707P}{9} = 0.0786P \downarrow$

$\dfrac{0.707P}{9} = 0.0786P \leftarrow$

Result. $R = \sqrt{(0.118P + 0.0786P)^2(2)} = 0.278P$

(b) Slip critical bolts (Standard size holes)

Nominal strength of 1 slip critical $\frac{7}{8}$ bolt in D.S.

$r_n = \mu D_u h_f T_b N_s$

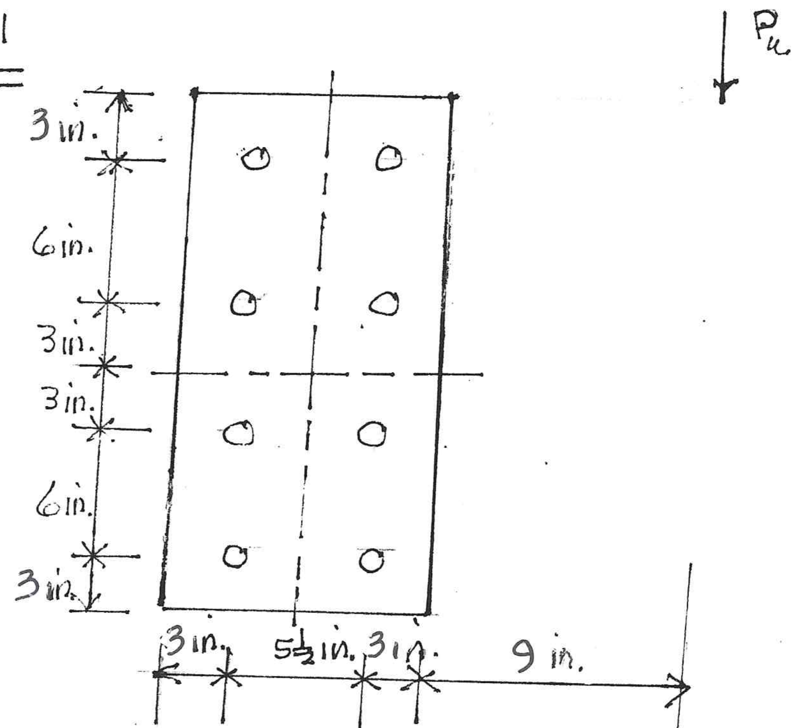
$= (0.30)(1.13)(1.00)(39)(2) = 26.44k$

√JCMc

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi r_n = (1.00)(26.44) = 26.44k$ each $0.278P_u = 26.44$ $\boxed{P_u = 95.1k}$	$\dfrac{r_n}{\Omega} = \dfrac{26.44}{1.50} = 17.63k$ each $0.278P_a = 17.63$ $\boxed{P_a = 63.4k}$

SFC ✓

PROB # 13-11



Bolts in SS & bearing on $\frac{5}{8}$ in.

r_n = nominal shear strength for 1

$= (0.44)(68) = 29.92$ k ← Controls

r_n = nominal bearing strength of 1 bolt

$L_c = 3 - \frac{3/4 + 1/8}{2} = 2.56$ in.

$r_n = 1.5 L_c t F_u \ngtr 2.4 d t F_u$

$(1.5)(2.56)(\frac{5}{8})(58) = 139.2$ k $> (2.4)(\frac{3}{4})(\frac{5}{8})(58) = 65.25$ k

From AISC Table 7-9

$\theta = 0$

$e_x = 12 + \frac{5.5}{2} = 14.75$

n, bolts = 4 → $s = 6$

$C = 3.11$ from Table

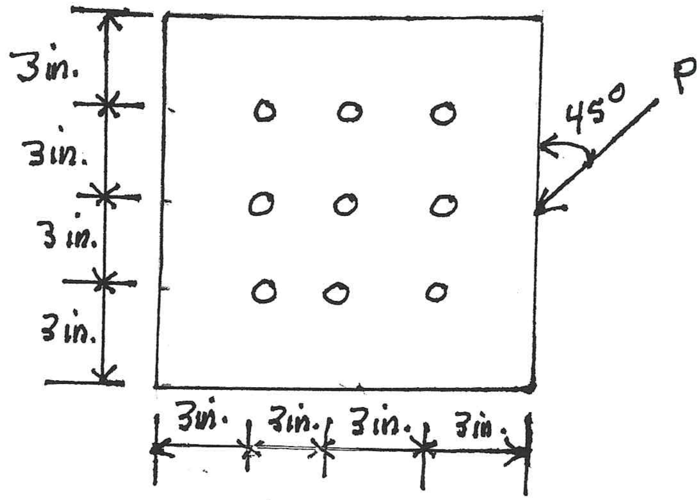
$P_u = C \phi r_n = (3.11)(0.75 \times 29.92) = \boxed{69.8 k}$

Note: If P_a is desired its value is 46.5k

JCMc

SFC

PROB# 13-12



For slip critical connection

$r_n = (0.30)(1.13)(1.00)(39)(2) = 26.44\ k$

using AISC table 7-12 (page 7-59)

$e_x = 6$ in.

$s = 3$ in.

n, bolts = 4

$C = 4.78$

$R_n = C \times r_n = (4.78)(26.44) = 126.38\ k$

ASD $\left[\dfrac{R_n}{\Omega} = \dfrac{126.38}{2.00} = \boxed{63.2\ k} \right.$ ASD

rgcmc

LRFD $\left[\phi R_n = 0.75(126.38) = \boxed{94.8\ k} \right.$ LRFD

SFC ✓

PROB # 13-13

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = 200\,k$	$P_a = 125\,k$
$V_u = \left(\frac{3}{5}\right)(200) = 120\,k$	$V_a = \left(\frac{3}{5}\right)(125) = 75\,k$
$H_u = \left(\frac{4}{5}\right)(200) = 160\,k$	$H_a = \left(\frac{4}{5}\right)(125) = 100\,k$
$\left.\begin{array}{l} F_{nt} = 90\,ksi \\ F_{nv} = 68\,ksi \end{array}\right\}$ AISC Table J3.2	$\left.\begin{array}{l} F_{nt} = 90\,ksi \\ F_{nv} = 68\,ksi \end{array}\right\}$ AISC Table J3.2
$f_v = \frac{120}{(8)(0.6)} = 25\,ksi$	$f_v = \frac{75}{(8)(0.6)} = 15.62\,ksi$
$f_t = \frac{160}{(8)(0.6)} = 33.33\,ksi$	$f_t = \frac{100}{(8)(0.6)} = 20.83\,ksi$
$F'_{nt} = 1.3F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_v \le F_{nt}$ (AISC Eq. J3-3a)	$F'_{nt} = 1.3F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} \le F_{nt}$ (AISC Eq. J3-3b)
$F'_{nt} = (1.3)(90) - \frac{90}{(0.75)(68)}(25)$	$F'_{nt} = (1.3)(90) - \frac{(2)(90)}{68}(15.62)$
$= 72.9\,ksi < 90\,ksi$ <u>ok</u>	$= 75.6\,ksi < 90\,ksi$ <u>ok</u>
$\phi F'_{nt} = (0.75)(72.9) = 54.7\,ksi > f_t = 33.33\,ksi$	$\frac{F'_{nt}}{\Omega} = \frac{75.6}{2.00} = 37.8\,ksi > f_t = 20.83\,ksi$
$\boxed{\text{Connection is ok}}$	$\boxed{\text{Connection is ok}}$

vg CMc

SFC ✓

PROB# 13-14

R_n for 1 A325 $\frac{7}{8}$ bolt in a slip critical connection

$$R_n = \mu D_u h_f T_b N_s = (0.30)(1.13)(1.00)(39)(1) = 13.22\text{ k}$$

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$V_u = \left(\frac{3}{5}\right)(200) = 120\text{ k}$ $T_u = \left(\frac{4}{5}\right)(200) = 160\text{ k}$ $\phi R_n = (1.00)(13.22) = 13.22\text{ k/bolt}$ Reduction factor due to tensile load $k_{sc} = 1 - \frac{T_u}{D_u T_b N_b}$ (AISC Eq J3-5a) $k_{sc} = 1 - \frac{160}{(1.13)(39)(8)} = 0.546$ Reduced ϕR_n/bolt $= (0.546)(13.22)$ $= 7.22\text{ k/bolt}$ Design slip resistance for 8 bolts $= (8)(7.22) = 57.7\text{ k}$ $< 120\text{ k}$ N.G. $\boxed{\text{Connection is unsatisfactory}}$	$V_a = \left(\frac{3}{5}\right)(125) = 75\text{ k}$ $T_a = \left(\frac{4}{5}\right)(125) = 100\text{ k}$ $\frac{R_n}{\Omega} = \frac{13.22}{1.50} = 8.81\text{ k/bolt}$ Reduction factor due to tensile load $k_s = 1 - \frac{1.5 T_a}{D_u T_b N_b}$ (AISC Eq. J3-5b) $k_s = 1 - \frac{(1.5)(100)}{(1.13)(39)(8)} = 0.575$ Reduced $\frac{R_n}{\Omega}$/bolt $= (0.575)(8.81)$ $= 5.07\text{ k/bolt}$ Allowable slip resistance for 8 bolts $= (8)(5.07) = 40.5\text{ k}$ $< 75\text{ k}$ N.G. $\boxed{\text{Connection is unsatisfactory}}$

✓ JCMc

SFC ✓

PROB# 13-15

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$V = \frac{1}{\sqrt{5}} P_u = 0.447 P_u$	$V = \frac{1}{\sqrt{5}} P_a = 0.447 P_a$
$H = \frac{2}{\sqrt{5}} P_u = 0.894 P_u$	$H = \frac{2}{\sqrt{5}} P_a = 0.894 P_a$
$F_{nt} = 113$ ksi, $F_{nv} = 84$ ksi AISC Table J3.2	$F_{nt} = 113$ ksi, $F_{nv} = 84$ ksi AISC Table J3.2
$f_v = \frac{0.447 P_u}{(8)(0.44)} = 0.127 P_u$	$f_v = \frac{0.447 P_a}{(8)(0.44)} = 0.127 P_a$
$f_t = \frac{0.894 P_u}{(8)(0.44)} = 0.254 P_u$	$f_t = \frac{0.894 P_a}{(8)(0.44)} = 0.254 P_a$
$F'_{nt} = 1.3 F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_v = F_{nt}$ (AISC Eq. J3-3a)	$F'_{nt} = 1.3 F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} f_v = F_{nt}$ (AISC Eq. J3-3b)
	$F'_{nt} = 1.3 F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} f_v = F_{nt}$
$(1.3)(113) - \frac{113}{(0.75)(84)}(0.127 P_u) = 113$	$(1.3)(113) - \frac{(2.00)(113)}{84}(0.127 P_a) = 113$
$146.9 - 0.228 P_u = 113$	$146.9 - 0.342 P_a = 113$
$\boxed{P_u = 148.7 \text{ k}}$	$\boxed{P_a = 99.2 \text{ k}}$

✓ JCMc

FC ✓

PROB # 13-16

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$V = \frac{1}{\sqrt{5}} P_u = 0.447 P_u$	$V = \frac{1}{\sqrt{5}} P_a = 0.447 P_a$
$H = \frac{2}{\sqrt{5}} P_u = 0.894 P_u$	$H = \frac{2}{\sqrt{5}} P_a = 0.894 P_a$
$F_{nt} = 90\text{ ksi}$, $F_{nv} = 68\text{ ksi}$ } AISC Table J3-2	$F_{nt} = 90\text{ ksi}$, $F_{nv} = 68\text{ ksi}$ } AISC Table J3-2
$f_v = \frac{0.447 P_u}{(8)(0.44)} = 0.127 P_u$	$f_v = \frac{0.447 P_a}{(8)(0.44)} = 0.127 P_a$
$f_t = \frac{0.894 P_u}{(8)(0.44)} = 0.254 P_u$	$f_t = \frac{0.894 P_a}{(8)(0.44)} = 0.254 P_a$
$F'_{nt} = 1.3 F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_v \leq F_{nt}$ (AISC Eq. J3-3a)	$F'_{nt} = 1.3 F_{nt} - \frac{\Omega F_{nt}}{\phi F_{nv}} f_v \leq F_{nt}$ (AISC Eq. J3-3b)
$F'_{nt} = (1.3)(90) - \frac{90}{(0.75)(68)}(0.127 P_u) \leq 90$	$F'_{nt} = (1.3)(90) - \frac{(2)(90)}{68}(0.127 P_a) = 90$
$117 - 0.224 P_u = 90$	$117 - 0.336 P_a \leq 90$
$P_u = 120.5\text{ k}$	$\boxed{P_a = 80.3\text{ k}}$

vjcm^c

SFC ✓

PROBLEM # 13-17

DESIGN OF BOLTS IN ANGLES

BOLTS in DS & Bearing on 7/8 in.

LRFD	ASD
$P_u = 165^K$	$P_a = 115^K$

Bearing strength of 1 bolt

$L_c = 1.0$

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

$= (1.2)(1.0)(7/8)(65) = \underline{\underline{68.25^K}} \le 2.4(3/4)(7/8)(65) = 102.38^K$

Double shearing strength of 1 bolt

$R_n = 2(0.44)(68) = 59.84^K \leftarrow$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(59.84) = 44.9K$	$\frac{R_n}{\Omega} = \frac{59.84}{2.00} = 29.9\ K$
No. of bolts req'd $= \frac{165}{44.9}$ $= 3.67$ bolts	No. of bolts req'd $= \frac{115}{29.9}$ $= 3.85$ bolts
USE 4 - 3/4 - in. A325 bearing type bolts (ANGLE)	USE 4 - 3/4 - in. A325 bearing type bolts (ANGLE)

PROB # 13-17 CONTD.

DESIGN OF BOLTS IN FLANGE OF W-SECTION

LRFD	ASD
$P_{u,H} = (0.8)(165) = 132\ k$	$P_{aH} = (0.8)(115) = 92\ k$
$P_{uv} = (0.6)(165) = 99\ k$	$P_{av} = (0.6)(115) = 69\ k$
Tension per bolt $= \frac{132}{N_b}$	Tension per bolt $= \frac{92}{N_b}$
Shear per bolt $= \frac{99}{N_b}$	Shear per volt $= \frac{69}{N_b}$
$f_v = \frac{99}{(N_b)(0.44)} = \frac{225}{N_b}$	$f_v = \frac{69}{N_b(0.44)} = \frac{156.8}{N_b}$
Checking combined tension and shear	Checking combined shear & tension
$F'_{nt} = (1.3)(90) - \frac{90}{(0.75)(68)}\left(\frac{225}{N_b}\right) \leq F_{nt}$	$F'_{nt} = (1.3)(90) - \frac{(2.00)(90)}{68}\left(\frac{156.8}{N_b}\right)$
$F'_{nt} = 117 - \frac{397}{N_b}$	$F'_{nt} = 117 - \frac{415.1}{N_b} \leq 90$
$r_m = F'_{nt} A_b = \left(117 - \frac{397}{N_b}\right)(0.44)$	$r_m = F'_{nt} A_b = \left(117 - \frac{415.1}{N_b}\right)(0.44)$
$= 51.48 - \frac{174.7}{N_b}$	$r_m = 51.48 - \frac{182.6}{N_b}$
$\phi r_m = (0.75)\left(51.48 - \frac{174.7}{N_b}\right)$	$\frac{r_m}{\Omega} = \frac{r_m}{2.00} = 25.74 - \frac{91.3}{N_b}$
$= 38.61 - \frac{131.0}{N_b}$	$25.74 - \frac{91.3}{N_b} = \frac{92}{N_b}$
$38.61 - \frac{131.0}{N_b} = \frac{132}{N_b}$	$25.74 N_b = 183.3$
$N_b = 6.81$ bolts Say 7 or 8	$N_b = 7.12$ bolts say 8

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PROB# 13-18

Rivets in SS & Bearing on $\frac{1}{2}$ in.

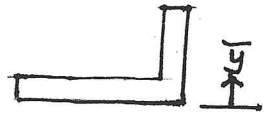
LRFD	ASD
Tensile yielding of PLs	**Tensile yielding of PLs**
$\phi_t P_n = \phi_t F_y A_g$	$\frac{P_n}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \frac{(36)(\frac{1}{2} \times 14)}{1.67}$
$= (0.9)(36)(\frac{1}{2} \times 14) = 226.8\text{k}$	$= 150.9\text{k}$
Tensile rupture	**Tensile rupture**
Noting $U = 1.0$	Noting $U = 1.0$
$A_n = 7.00 - (4)(\frac{3}{4} + \frac{1}{8})(\frac{1}{2}) = 5.25 \text{ in.}^2$	$A_n = 7.00 - (4)(\frac{3}{4} + \frac{1}{8})(\frac{1}{2}) = 5.25 \text{ in.}^2$
$A_e = (1.00)(5.25) = 5.25 \text{ in.}^2$	$A_e = (1.00)(5.25) = 5.25 \text{ in.}^2$
$P_n = (58)(5.25) = 304.5\text{k}$	$P_n = F_u A_e = (58)(5.25) = 304.5\text{k}$
$\phi_t P_n = (0.75)(304.5) = 228.4\text{k}$	$\frac{P_n}{\Omega_t} = \frac{304.5}{2.00} = 152.2\text{k} \leftarrow$
SS Strength of rivets	**SS Strength of rivets**
$R_n = (12)(0.44)(25) = 132\text{k}$	$R_n = (12)(0.44)(25) = 132\text{k}$
$\phi R_n = (0.75)(132) = 99\text{k}$	$\frac{R_n}{\Omega} = \frac{132}{2.00} = 66\text{k}$
Bearing strength of rivets	**Bearing strength of rivets**
L_c = lesser of $1.50 - \frac{1}{2}(\frac{3}{4} + \frac{1}{8}) = 1.06$ in	L_c = lesser of $1.50 - \frac{1}{2}(\frac{3}{4} + \frac{1}{8}) = 1.06$ in.
or $3.00 - (\frac{3}{4} + \frac{1}{8}) = 2.125$ in.	or $3.00 - (\frac{3}{4} + \frac{1}{8}) = 2.125$ in.
$R_n = 1.2 L_c t F_u$(No of rivets)	$R_n = (1.2)(L_c t F_u)$(No of rivets)
$\le 2.4 d t F_u$ (No of rivets)	$\le 2.4 d t F_u$ (No of rivets)
$(1.2)(1.06)(\frac{1}{2})(58)(12) = 442.7\text{k}$	$(1.2)(1.06)(\frac{1}{2})(58)(12) = 442.78$
$< (2.4)(\frac{3}{4})(\frac{1}{2})(58)(12) = 626.4\text{k}$	$< (2.4)(\frac{3}{4})(\frac{1}{2})(58)(12) = 626.4\text{k}$
$\phi R_n = (0.75)(442.7) = 332\text{k}$	$\frac{R_n}{\Omega} = \frac{442.7}{2.00} = 221.3\text{k}$

ANSWRS

$\boxed{99\text{k LRFD}}$ $\boxed{66\text{k ASD}}$

PROB # 13-19

Using an L $5 \times 3 \times \frac{5}{16}$ ($A = 2.41\ in.^2$, $\bar{y} = 0.673\ in.$)



LRFD

For tensile yielding

$P_n = F_y A_g = (36)(2.41) = 86.8\ k$

$\phi_t P_n = (0.9)(86.8) = 78.1\ k$

For tensile rupture

U given $= 0.9$

$A_e = U A_n = (0.9)\left[2.41 - \left(\frac{5}{16}\right)\left(\frac{7}{8} + \frac{1}{8}\right)\right]$

$= 1.888\ in.^2$

$P_n = F_u A_e = (58)(1.888) = 109.5\ k$

$\phi_t P_n = (0.75)(109.5) = 82.1\ k$

Bolts in SS & Bearing on $\frac{5}{16}$ in.

Shear

$R_n = (5)(0.6)(25) = 75\ k$

$\phi R_n = (0.75)(75) = 56.2\ k \leftarrow$

Bearing

$L_c = 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = \underline{1.50\ in.}$

or $3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00\ in.$

$R_n = (5)(1.2) L_c t F_u \leq (5)(2.4) d t F_u$

$= (5)(1.2)(1.5)\left(\frac{5}{16}\right)(58) = 163\ k$

$< (5)(2.4)\left(\frac{7}{8}\right)\left(\frac{5}{16}\right)(58) = 190.3\ k$

$\phi R_n = (0.75)(163.1) = 122.3\ k$

ASD

For tensile yielding

$P_n = F_y A_g = (36)(2.41) = 86.8\ k$

$\frac{P_n}{\Omega} = \frac{86.8}{1.67} = 52.0\ k$

For tensile rupture

U given $= 0.9$

$A_e = U A_n = (0.9)\left[2.41 - \left(\frac{5}{16}\right)\left(\frac{7}{8} + \frac{1}{8}\right)\right]$

$= 1.888\ in.^2$

$P_n = F_u A_e = (58)(1.888) = 109.5\ k$

$\frac{P_n}{\Omega} = \frac{109.5}{2.00} = 54.7\ k$

Bolts in SS & Bearing on $\frac{5}{16}$ in.

Shear

$R_n = (5)(0.6)(25) = 75\ k$

$\frac{R_n}{\Omega} = \frac{75}{2.00} = 37.5\ k \leftarrow$

Bearing

$L_c = 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50\ in. \leftarrow$

or $3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00\ in.$

$R_n = (5)(1.2) L_c t F_u \leq (5)(2.4)(d t F_u)$

$= (5)(1.2)(1.5)\left(\frac{5}{16}\right)(58) = 163\ k$

$(5)(2.4)\left(\frac{7}{8}\right)\left(\frac{5}{16}\right)(58) =$

$\frac{R_n}{\Omega} = \frac{163.1}{2.00} = 81.5\ k$

ANSWRS. $\boxed{56.2\ k\ \text{LRFD}}$ $\boxed{37.5\ k\ \text{ASD}}$

SFC✓ ✓ JCMc

PROB # 13-20

LRFD	ASD
$P_u = 185\ k$	$P_a = 125\ k$

Rivets in SS & Bearing on $\frac{1}{2}$ in.

Shear

$R_n = (0.60)(25) = 15\ k$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(15) = 11.25\ k$ each	$\frac{R_n}{\Omega} = \frac{15}{2.00} = 7.50\ k$ each ←

Bearing

$L_c =$ lesser of $2 - (\frac{1}{2})(0.75 + \frac{1}{8}) = \underline{1.56\ in.}$ or $4 - (0.75 + \frac{1}{8}) = 3.125\ in.$

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

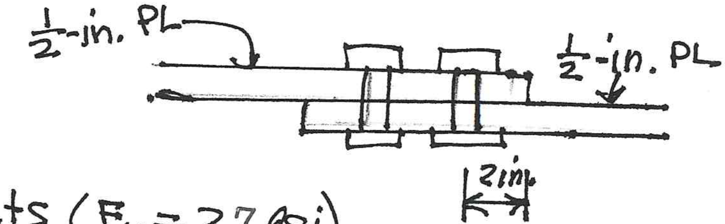
$R_n = (1.2)(1.56)(\frac{1}{2})(58) = 54.3\ k > (2.4)(\frac{3}{4})(\frac{1}{2})(58) = \underline{52.2\ k}$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(52.2) = 39.1\ k$ each	$\frac{R_n}{\Omega} = \frac{52.2}{2.00} = 26.1\ k$ each
No. of rivets reqd $= \frac{185}{11.25} = 16.44$ $\boxed{\text{Say 17 or 18}}$	No. of rivets reqd. $= \frac{125}{7.50} = 16.67$ $\boxed{\text{Say 17 or 18}}$

rjcm^c

SFC ✓

PROB #13-21



Using $\frac{7}{8}$-in. A307 bolts ($F_v = 27$ ksi)

Bolts in SS & Bearing on $\frac{1}{2}$ in.

LRFD $P_u = 185$ k	ASD $P_a = 125$ k
SS strength of 1 bolt	SS strength of 1 bolt
$r_n = (0.44)(27) = 11.88$ k ←	$r_n = (0.44)(27) = 11.88$ k ←
Bearing strength of 1 bolt	Bearing strength of 1 bolt
$L_c = 2 - \frac{3/4 + 1/8}{2} = 1.56$ in.	$L_c = 2 - \frac{3/4 + 1/8}{2} = 1.56$ in.
$r_n = 1.2 L_c t F_u \leq 2.4 d t F_u$	$r_n = 1.2 L_c t F_u \leq 2.4 d t F_u$
$= (1.2)(1.56)(\frac{1}{2})(58)$	$= (1.2)(1.56)(\frac{1}{2})(58)$
$= 54.29$ k	$= 54.29$ k
$> (2.4)(\frac{7}{8})(\frac{1}{2})(58) = 60.9$ k	$> (2.4)(\frac{7}{8})(\frac{1}{2})(58) = 60.9$ k
$\phi r_n = (0.75)(11.88) = 8.91$ k	$\frac{r_n}{\Omega} = \frac{11.88}{2.00} = 5.94$ k
No of bolts required	No of bolts reqd
$= \frac{185}{8.91} = 20.8$ bolts	$= \frac{125}{5.94} = 21.0$ bolts

Answers → USE 21 or 22 bolts → USE 21 or 22 bolts

✓ gcm^c

SFC ✓

PROB # 13-22

Rivet in DS and Bearing on $\frac{3}{4}$ in.

LRFD	ASD
$P_u = (1.2)(60) + (1.6)(80) = 200\,k$	$P_a = 60 + 80 = 140\,k$

r_m = DS strength of 1 rivet

$= (2)(0.785)(25.0) = 39.25\,k$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi r_m = (0.75)(39.25) = 29.44\,k$	$\frac{r_m}{\Omega} = \frac{39.25}{2.00} = 19.62\,k$

r_m = Bearing strength of 1 rivet

$L_c = 1.5 - (\frac{1}{2})(1 + \frac{1}{8}) = 0.9375$ in.

$r_m = 1.2 L_c t F_u \leq 2.4\, d t F_u$

$= (1.2)(0.9375)(\frac{3}{4})(58) = \underline{\underline{48.94\,k}} < (2.4)(1)(\frac{3}{4})(58) = 104.4\,k$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi r_m = (0.75)(48.94) = 36.70\,k$ No of rivets reqd. $= \frac{200}{29.44} = 6.79$	$\frac{r_m}{\Omega} = \frac{48.94}{2.00} = 24.47\,k$ No of rivets reqd. $= \frac{140}{19.62} = 7.14$

Answrs. $\boxed{\text{Use 7 rivets LRFD}}$ $\boxed{\text{Use 8 rivets ASD}}$

✓ gcm

SFC ✓

PROB # 13-23

LRFD	ASD
$P_u = 475^k$	$P_a = 320^k$
Assume rivets in DS (not multiple shear) & bear. on 2.5in.	Assume rivets in DS (not multiple shear) & bear. on 2.5in.
<u>Shear strength</u>	<u>Shear strength</u>
$R_n = (2)(0.6)(25) = 30^k$	$R_n = (2)(0.6)(25) = 30^k$
$\phi R_n = (0.75)(30) = 22.5^k$ each	$\frac{R_n}{\Omega} = \frac{30}{2.00} = 15^k$ each
<u>Bearing strength</u>	<u>Bearing strength</u>
$L_c = 1.5 - (\frac{1}{2})(\frac{7}{8}+\frac{1}{8}) = \underline{1.00\text{ in.}}$	$L_c = 1.5 - \frac{1}{2}(\frac{7}{8}+\frac{1}{8}) = \underline{1.00\text{ in.}}$
or $3 - (\frac{7}{8}+\frac{1}{8}) = 2.00$ in.	or $3 - (\frac{7}{8}+\frac{1}{8}) = 2.00$ in.
$R_n = 1.2 L_c t F_u \leq 2.4\, d t F_u$	$R_n = 1.2 L_c t F_u \leq 2.4\, d t F_u$
$= (1.2)(1.0)(2.5)(58) = \underline{174^k}$	$= (1.2)(1.0)(2.5)(58) = \underline{174^k}$
$< (2.4)(\frac{7}{8})(2.5)(58) = 304.5^k$	$< (2.4)(\frac{7}{8})(2.5)(58) = 304.5^k$
$\phi R_n = (0.75)(174) = 130.5^k$ each	$\frac{R_n}{\Omega} = \frac{174}{2.00} = 87^k$ each
No. of rivets reqd $= \frac{475}{22.5}$	No. of rivets reqd. $= \frac{320}{15}$
$= \boxed{21.11 \text{ Say } 22}$	$= \boxed{21.33 \text{ Say } 22}$

✓ JCMc

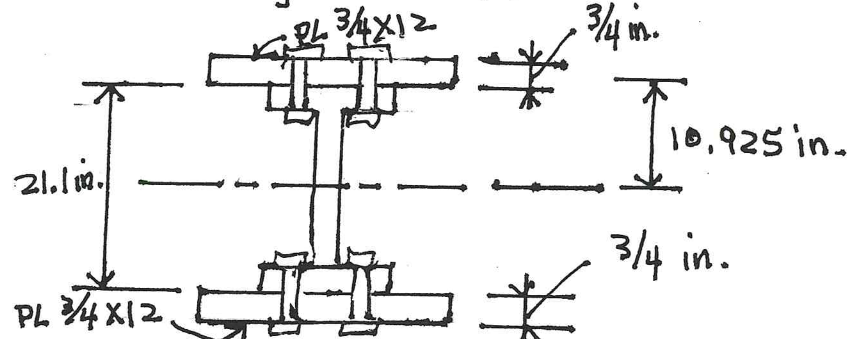
SFC ✓

13-25

PROB #13-24

Bolts in SS and Bearing on 0.685 in.

$V_u = 140\text{k}$
$V_a = 100\text{k}$



using a W21X68 ($d = 21.1$ in., $I_x = 1480$ in.^{4}, $t_f = 0.685$ in.)

$$I_x = 1480 + (2)\left(\tfrac{3}{4}\times 12\right)(10.925)^2 = 3628 \text{ in.}^4$$
$$Q = \left(\tfrac{3}{4}\right)(12)(10.925) = 98.32 \text{ in.}^3$$

LRFD	ASD
$f_v = \dfrac{V_u Q}{I} = \dfrac{(140)(98.32)}{3628} = 3.794 \text{ k/in.}$	$f_v = \dfrac{V_a Q}{I} = \dfrac{(100)(98.32)}{3628} = 2.71 \text{ k/in.}$

SS strength of 1 bolt

$$r_n = (0.6)(24) = 14.4\text{k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi r_n = (0.75)(14.4) = 10.8\text{ k}$	$\dfrac{r_n}{\Omega} = \dfrac{14.4}{2.00} = 7.2\text{ k}$ ←

Bearing strength of 1 bolt

Assume $L_c = 2 - \dfrac{\frac{7}{8}+\frac{1}{8}}{2} = 1.50$ in.

$$r_n = 1.2 L_c t F_u \le 2.4 d t F_u$$
$$= (1.2)(1.50)(0.685)(58) = \underline{\underline{71.51\text{k}}} < (2.4)\left(\tfrac{7}{8}\right)(0.685)(58) = 83.43\text{k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi r_n = (0.75)(71.51) = 53.6\text{k}$	$\dfrac{r_n}{\Omega} = \dfrac{71.51}{2.00} = 35.8\text{k}$

ANSWR

Spacing of bolts LRFD
$$= \frac{(2)(10.8)}{3.794} = 5.69 \text{ in.}$$
$\boxed{\text{Say } 5\tfrac{1}{2} \text{ in.}}$

Spacing of bolts ASD
$$= \frac{(2)(7.2)}{2.71} = 5.31$$
$\boxed{\text{Say } 5 \text{ in.}}$

rjcMc

SFC ✓

13-26