

PROBLEM 1A36 STEEL $\rightarrow F_y = 36 \text{ KSI}$, $F_u = 58 \text{ KSI}$

$$P_u = 1.2D + 1.6L = 1.2(50 \text{ K}) + 1.6(100 \text{ K}) = 220 \text{ K}$$

1" DIA BOLTS, CLASS A

CHECK YIELDING

$$\phi P_n > P_u$$

$$(0.9)(A_g)(36 \text{ KSI}) > 220 \text{ K}$$

$$A_g \geq 6.79 \text{ in}^2 \rightarrow \text{CHOOSE } L6 \times 4 \times \frac{3}{4}'' \quad A_g = 6.94 \text{ in}^2$$

$$\phi P_n = 225 \text{ K} > P_u$$

CHECK BEARING

$$\phi R_n / \text{BOLT} = \phi 2.4 d t F_u = (0.75)(2.4)(1'')(3/4'')(58 \text{ KSI}) = 78.3 \text{ K / BOLT}$$

CHECK SHEAR

$$A_b = \frac{\pi (1'')^2}{4} = 0.785 \text{ in}^2$$

 $F_{uv} = 54 \text{ KSI}$ FOR CLASS A AND THREADS IN PLANE

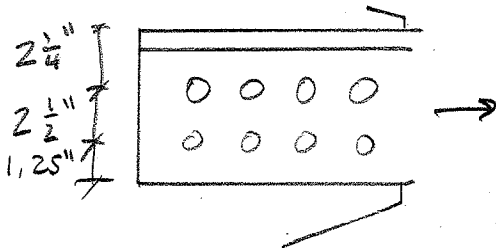
$$\phi R_n = (0.75) A_b F_{uv} = 31.8 \text{ K / BOLT} \rightarrow \text{CONTROLS OVER BEARING}$$

$$\# \text{ OF BOLTS REQ'D} \rightarrow P_u = 220 \text{ K} < (\# \text{ BOLTS})(31.8 \text{ K / BOLT})$$

$$\# \text{ BOLTS} > 6.91 \rightarrow \text{USE 2 ROWS OF 4}$$

$$\phi R_n = (8 \text{ BOLTS})(31.8 \text{ K / BOLT}) = 254 \text{ K} > P_u$$

FOR A 6" LEG (TABLE 1-7A)



NET SECTION FRACTURE CHECK

$$d_{\text{hole}} = 1" + \frac{1}{8}" = 1.125"$$

$$A_g = 6.94 \text{ in}^2$$

$$A_n = A_g - 2(d_{\text{hole}})t = (6.94 \text{ in}^2) - 2(1.125")(\frac{3}{4}") = 5.25 \text{ in}^2$$

$$u = 1 - \frac{\bar{x}}{L} \rightarrow \bar{x} = 1.07 \text{ in}, \text{ FIND } L \text{ REQ'D}$$

$$u = 1 - \frac{1.07}{L}$$

$$A_e = u A_n = (1 - \frac{1.07}{L})(5.25 \text{ in}^2)$$

$$\phi P_n = (0.75) A_e F_u > P_u = 220 \text{ K}$$

$$(0.75)(1 - \frac{1.07}{L})(5.25 \text{ in}^2)(58 \text{ KSI}) > 220 \text{ K}$$

$$1 - \frac{1.07}{L} > 0.96$$

$$L > 30"$$

TRY A LARGER ANGLE

$$L \ 6 \times 4 \times \frac{7}{8}"$$

$$A_g = 8.00 \text{ in}^2 \rightarrow \text{YIELD} \rightarrow \phi P_n = 259.2 \text{ K} > P_u \checkmark$$

$$A_n = A_g - 2(1.125")(\frac{7}{8}") = 6.03 \text{ in}^2$$

$$A_e = (1 - \frac{1.12}{L})(6.03 \text{ in}^2)$$

$$\phi P_n = (0.75)(1 - \frac{1.12}{L})(6.03 \text{ in}^2)(58 \text{ KSI}) > 220 \text{ K}$$

$$1 - \frac{1.12}{L} > 0.839$$

$$L > 6.94 \text{ in} \text{ REASONABLE}$$

$$\phi P_n = 228 \text{ K}$$

$$\text{FOR } L = 10"$$

BLOCK SHEAR



$$3d = 3"$$

$$t = \frac{7}{8}"$$

$$A_{gv} = t(L_{\text{TOTAL}}) = 0.875 L_{\text{TOTAL}}$$

$$A_{nv} = t(L_{\text{TOTAL}} - 3.5 d_{\text{hole}}) = 0.875 L_{\text{TOTAL}} - 3.45 \text{ in}^2$$

$$A_{nt} = t(2.5" + 1.25" - 1.5 d_{\text{hole}}) = 1.80 \text{ in}^2$$

$$\phi P_n = 0.75(0.6 F_u A_{nv} + F_u A_{nt}) \quad \text{OR} \quad \phi P_n = 0.75(0.6 F_y A_{gv} + F_u A_{nt})$$

$$= 22.84 L_{\text{TOTAL}} - 11.75 \text{ K}$$

$$= 14.18 L_{\text{TOTAL}} + 78.3 \text{ K}$$

$$\text{SAY } L_{\text{TOTAL}} = 12"$$

$$\phi P_n = 262 \text{ K} \checkmark$$

$$\phi P_n = 252 \text{ K} \checkmark$$

PROBLEM 2

C9 x 20

A572 $\rightarrow F_y = 50 \text{ ksi}$ $F_u = 65 \text{ ksi}$

$t_w = 0.448 \text{ in}$

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

$t_{GP} = 1/2''$

$$P_u = 1.2D + 1.6L = 1.2(40K) + 1.6(80K) = 176K$$

SLIP CRITICAL

$$\phi R_n = (1.0) \mu D_u h_f T_b N_s$$

$$\mu = 0.3$$

$$D_u = 1.13$$

$$h_f = 1.0$$

$$T_b = T_b$$

$$N_s = 1.0$$

$$\phi R_n / \text{BOLT} = 0.339 T_b \rightarrow$$

REQ'D

$$\begin{aligned} 3/4'' &\rightarrow T_b = 28 \rightarrow \# \text{ BOLTS} = 19 \\ 7/8'' &\rightarrow T_b = 39 \rightarrow \# \text{ BOLTS} = 13 \\ 1'' &\rightarrow T_b = 51 \rightarrow \# \text{ BOLTS} = 11 \\ 1 1/8'' &\rightarrow T_b = 56 \rightarrow \# \text{ BOLTS} = 10 \end{aligned}$$

USE $1 1/8''$ BOLTS $\rightarrow 10$ BOLTS
 $\phi R_n = 190K > P_u$

(2 ROWS OF 5)

$$S = 3''$$

$$\text{EDGE} = 1.5''$$

ASSUMED FOR GUSSET AND PLATE

SHEAR STRENGTH

$$A_b = \frac{\pi (1.125'')^2}{4} = 0.99 \text{ in}^2$$

$$F_{nv} = 54 \text{ ksi (THREADS IN PLANE AISC TABLE J3.2)}$$

$$\phi R_n = (0.75)(0.99 \text{ in}^2)(54 \text{ ksi}) = 40.1 K / \text{BOLT}$$

BEARING STRENGTH

CHECK GUSSET PLATE (EDGE DISTANCES THE SAME SO ONLY CHECK GUSSET)

$$h = d + 1/16'' = 1.1875''$$

$$\begin{aligned} l_c &= 1.5'' - \frac{h}{2} = 0.90625'' \rightarrow \phi R_n = \phi 1.2 l_c t F_u \\ &= (0.75)(1.2)(0.91 \text{ in})(0.5'')(58 \text{ ksi}) \\ &= 23.7 K / \text{BOLT} \end{aligned}$$

$$\text{UPPER LIMIT} \rightarrow 2.4 d t F_u = 78.3 K / \text{BOLT}$$

OTHER BOLTS

$$l_c = 3'' - 1.1875'' = 1.81''$$

$$\phi R_n = 0.75(1.2)(1.81'') (0.5'') (58 \text{ KSI}) = 44.1 \text{ K/BOLT}$$

SHEAR GOVERNS FOR
THESE BOLTS

$$\phi R_n = 2 \text{ BOLTS } (23.7 \frac{\text{K}}{\text{BOLT}}) + 8 \text{ BOLTS } (44.1 \text{ K/BOLT}) = \underline{368.2 \text{ K}}$$

PROBLEM 3

$\frac{1}{2}" \times 6 \frac{1}{2}"$ A36 PLATE ($F_y = 36 \text{ KSI}$, $F_u = 58 \text{ KSI}$)
 $\frac{5}{8}"$ THICK GUSSET PLATE

BOLTS ARE $1 \frac{1}{8}"$ DIA. GROUP A

NO SLIP

$$P_u = 1.2 D + 1.6 L = 1.2 (P) + 1.6 (3P) = 6P$$

P = MAX SERVICE LOAD

MEMBER YIELDING

$$A_g = 0.5" \times 6.5" = 3.25 \text{ in}^2$$

$$\phi P_n = (0.9)(A_g)(F_y) = \underline{105.3 \text{ K}}$$

NSF

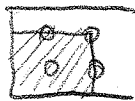
$$A_n = A_g - 2(d_{\text{hole}})t = 3.25 \text{ in}^2 - 2(1.125" + \frac{1}{8}")(0.5") = 2 \text{ in}^2$$

$U = 1.0$ FOR PLATES (AISC TABLE D3.1)

$$A_e = U A_n = 2 \text{ in}^2$$

$$\phi P_n = (0.75)(2 \text{ in}^2)(58 \text{ KSI}) = \underline{87 \text{ K}}$$

BLOCK SHEAR MEMBER



$$A_{gv} = t(5") = 2.5 \text{ in}^2$$

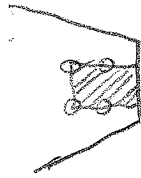
$$A_{nv} = t(5" - 1.5(d_{\text{hole}})) = 1.56 \text{ in}^2$$

$$A_{nt} = t(3" + 1.75" - 1.5(d_{\text{hole}})) = 1.44 \text{ in}^2$$

$$\begin{aligned} \phi P_n &= (0.75)[0.6 F_u A_{nv} + F_u A_{nt}] \\ &= 103 \text{ K} \end{aligned}$$

$$\begin{aligned} \text{OR } \phi P_n &= (0.75)[0.6 F_y A_{gv} + F_u A_{nt}] \\ &= \underline{103 \text{ K}} \end{aligned}$$

BLOCK SHEAR GUSSET PL



$$A_{gv} = 2 t_{GP} (5") = 6.25 \text{ in}^2$$

$$A_{nv} = 2 t_{GP} (5" - 1.5(d_{hole})) = 3.91 \text{ in}^2$$

$$A_{nt} = t_{GP} (3" - d_{hole}) = 1.09 \text{ in}^2$$

$$\phi R_n = 0.75 [0.6 F_u A_{nv} + F_u A_{nt}] \quad \text{OR} \quad \phi R_n = 0.75 [0.6 F_y A_{gv} + F_u A_{nt}]$$
$$= 149 \text{ K} \qquad \qquad \qquad = \underline{149 \text{ K}}$$

SLIP CRITICAL STRENGTH

$$\text{BOLT DIA} = 1\frac{1}{8}" \rightarrow T_b = 56 \text{ K (TABLE J3.1 AISC)}$$

$$\mu = 0.3$$

$$D_u = 1.13$$

$$h_F = 1.0$$

$$N_s = 1.0$$

$$\phi R_n = (1.0) \mu D_u h_F T_b N_s = (1.0)(0.3)(1.13)(1.0)(56 \text{ K})(1.0)$$
$$= 19.0 \text{ K / BOLT}$$

$$4 \text{ BOLTS } (19.0 \frac{\text{K}}{\text{BOLT}}) = \underline{75.9 \text{ K}}$$

SHEAR STRENGTH

$$A_b = \frac{\pi (1.125")^2}{4} = 0.99 \text{ in}^2$$

$$F_{uv} = 54 \text{ KSI}$$

CLASS A
THREADS
IN
PLANE

$$\phi R_n = (0.75) A_b F_{uv} = (0.75)(0.99 \text{ in}^2)(54 \text{ KSI}) = 40.1 \text{ K / BOLT}$$

$$4 \text{ BOLTS } (40.1 \text{ K / BOLT}) = \underline{160.4 \text{ K}}$$

BEARING STRENGTH

$$\text{UPPER LIMIT} = 2.4 d t F_u = 78.3 \text{ K / BOLT}$$

FOR PLATE

$$\text{EDGE} \rightarrow h = d + \frac{1}{16} = 1.125" + \frac{1}{16} = 1.1875" \rightarrow l_c = 2" - \frac{h}{2} = 1.41 \text{ in}$$

$$\phi R_n = 0.75 (1.2) (l_c) (\frac{t}{2}) (F_u) = 36.8 \text{ K / BOLT AT EDGE}$$

$$\text{OTHER} \rightarrow l_c = S - h = 3" - 1.1875" = 1.81 \text{ in}$$

$$\phi R_n = 0.75 (1.2) (1.81 \text{ in}) (\frac{t}{2}) (58 \text{ KSI}) = 47.2 \text{ K / BOLT}$$

GUSSET PLATE BEARING

EDGE $\rightarrow h = 1.1875"$ $l_c = 2" - \frac{h}{2} = 1.4111"$

$$\phi R_n = 0.75(1.2)(1.4111)(0.625)(58 \text{ ksi}) = 46 \text{ K/BOLT}$$

OTHER $\rightarrow l_c = 3" - 1.1875" = 1.8111"$

$$\phi R_n = 0.75(1.2)(1.8111)(0.625)(58 \text{ ksi}) = 59 \text{ K/BOLT}$$

LEFT 2 BOLTS $\rightarrow 36.8 \text{ K/BOLT}$ GOVERNS (BEARING MEMBER)

RIGHT 2 BOLTS $\rightarrow 40.1 \text{ K/BOLT}$ GOVERNS (SHEAR)

$$\phi R_n = (2 \text{ BOLTS})(36.8 \text{ K/BOLT}) + (2 \text{ BOLTS})(40.1 \text{ K/BOLT}) = \underline{153.8 \text{ K}}$$

SLIP CRITICAL CONTROLS $\rightarrow \phi P_n = 75.9 \text{ K}$

$$6P < \phi P_n$$

$$6P < 75.9 \text{ K}$$

$$P < 12.7 \text{ K}$$

12.7 K	DL
37.9 K	LL