Example 10.1. Bolts in Shear and Bearing with Deformation a Design Consideration

The connection shown in Fig. 10.7 consists of four, grade A490, ¾-in-diameter bolts. The bolts are snug-tight and threads are excluded from the shear planes. Deformation around the bolt holes is a design consideration and the bolt spacing is as indicated. The angles and gusset plate are fabricated from A36 steel. Assuming that the angles and gusset plate are satisfactory, determine the shear force that may be applied to the bolts in the connection.

Bearing part

3/4"

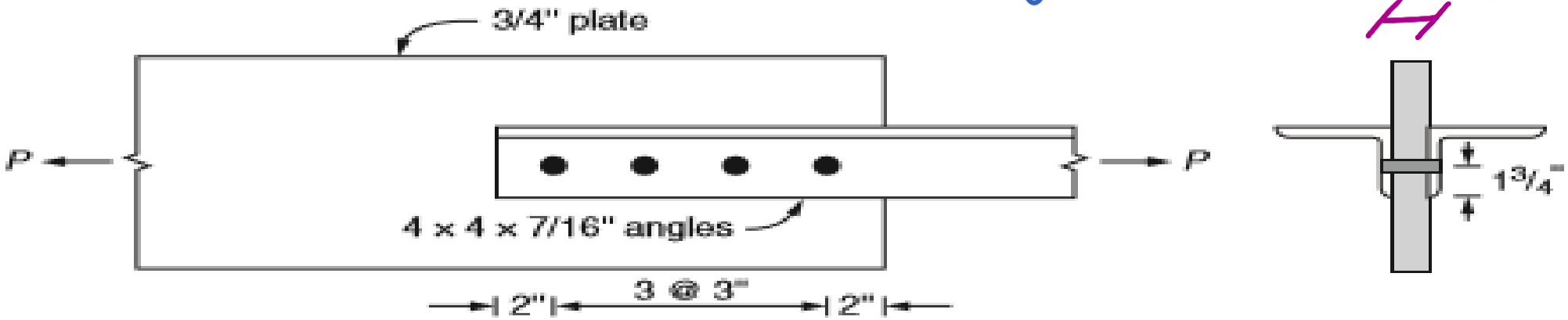


FIGURE 10.7 Details for Example 10.1.

$d_b = \frac{3}{4}$" X- Type No = 4

S = 3"

Plate A36

Fu = 58 ksi

Prepared by Eng.Maged Kamel.

Example 10.1. Bolts in Shear and Bearing with Deformation a Design Consideration

The connection shown in Fig. 10.7 consists of four, grade A490, ¾-in-diameter bolts. The bolts are snug-tight and threads are excluded from the shear planes. Deformation around the bolt holes is a design consideration and the bolt spacing is as indicated. The angles and gusset plate are fabricated from A36 steel. Assuming that the angles and gusset plate are satisfactory, determine the shear force that may be applied to the bolts in the connection.

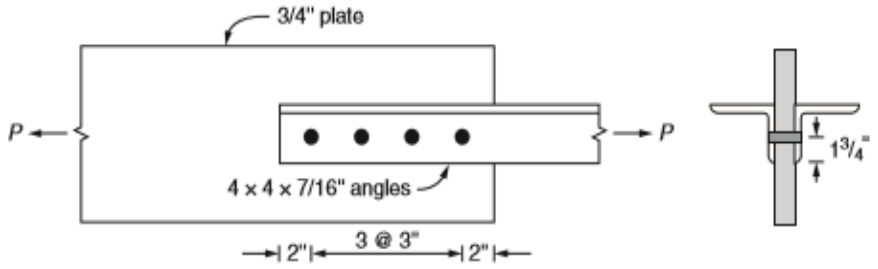
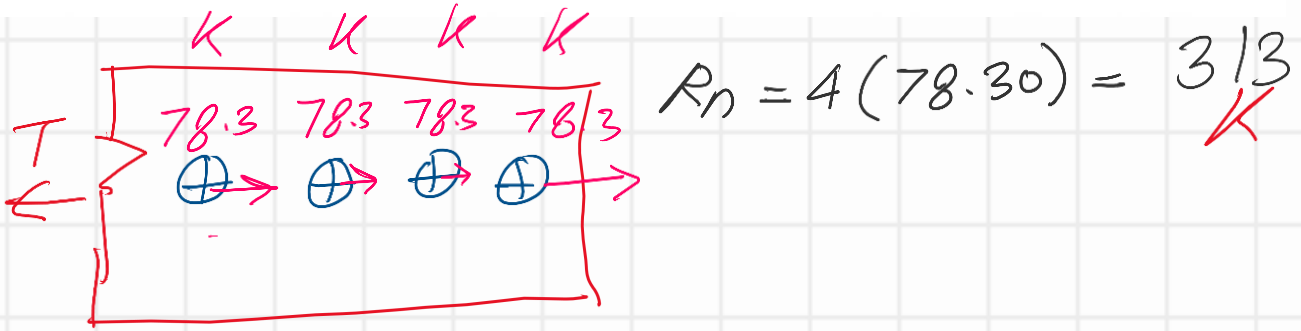
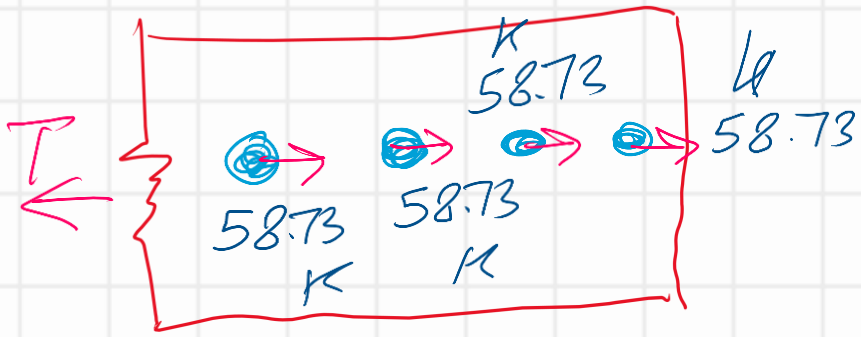


FIGURE 10.7 Details for Example 10.1.



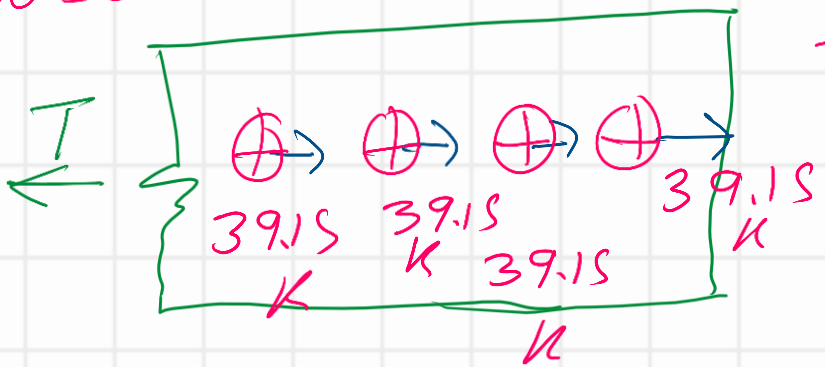
$R_n = 4(78.30) = 313$ K

LRFD $\phi = 0.75 \times 78.30 = 58.73$ K



ASD $\Omega = 2$ K

$\frac{1}{2}(78.30) = 39.15$



Prepared by Eng.Maged Kamel.

Check ASD value For Bearing For inner bolts

$d_b = 3/4"$

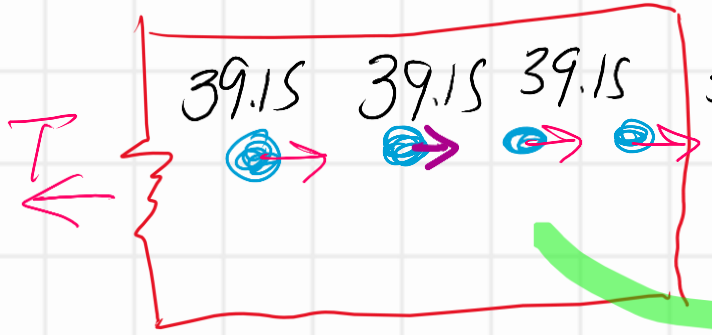
inner bolts

$F_u = 58$ ksi

3"

Table 7-4
Available Bearing Strength at Bolt Holes Based on Bolt Spacing
kips/in. thickness

Hole Type	Bolt Spacing, s, in.	F_u, ksi	Nominal Bolt Diameter, d, in.							
			5/8		3/4		7/8		1	
			r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD
STD SSLT	$2\frac{2}{3}d_b$	58	34.1	51.1	41.3	62.0	48.6	72.9	55.8	83.7
		65	38.2	57.3	46.3	69.5	54.4	81.7	62.6	93.8
	3 in.	(58	43.5	65.3	52.2	78.3	60.9	91.4	67.4	101
		65)	48.8	73.1	58.5	87.8	68.3	102	75.6	113
SSLP	$2\frac{2}{3}d_b$	58	27.6	41.3	34.8	52.2	42.1	63.1	47.1	70.7
		65	30.9	46.3	39.0	58.5	47.1	70.7	52.8	79.2
	3 in.	58	43.5	65.3	52.2	78.3	60.9	91.4	58.7	88.1
		65	48.8	73.1	58.5	87.8	68.3	102	65.8	98.7
OVS	$2\frac{2}{3}d_b$	58	29.7	44.6	37.0	55.5	44.2	66.3	49.3	74.0
		65	33.3	50.0	41.4	62.2	49.6	74.3	55.3	82.9
	3 in.	58	43.5	65.3	52.2	78.3	60.9	91.4	60.9	91.4
		65	48.8	73.1	58.5	87.8	68.3	102	68.3	102
LSLP	$2\frac{2}{3}d_b$	58	3.62	5.44	4.35	6.53	5.08	7.61	5.80	8.70
		65	4.06	6.09	4.88	7.31	5.69	8.53	6.50	9.75
	3 in.	58	43.5	65.3	39.2	58.7	28.3	42.4	17.4	26.1
		65	48.8	73.1	43.9	65.8	31.7	47.5	19.5	29.3



From Calculations

$PL > t_{PL} = 3/4"$, $S = 3"$

$\frac{1}{\Omega_b} r_n = 52.2 \frac{k}{inch}(\frac{3}{4}) = 39.15$ kips

Same value For 3 bolts

$L_e = 2''$ $F_U = 58$ ksi $t_{PL} = 3/4''$ A36

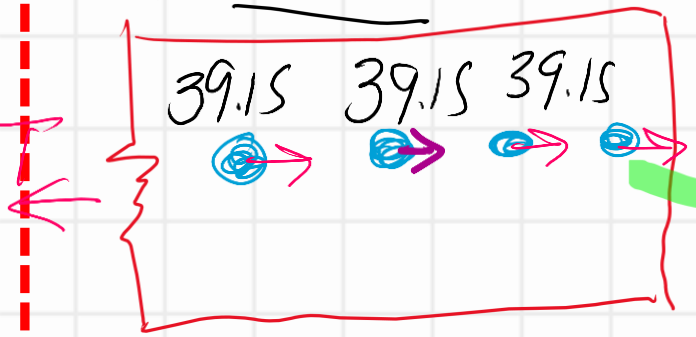
$d_b = 3/4''$

Table 7-5
Available Bearing Strength at Bolt Holes Based on Edge Distance
kips/in. thickness

Hole Type	Edge Distance L_e, in.	F_u, ksi	Nominal Bolt Diameter, d, in.							
			5/8		3/4		7/8		1	
			r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD	r_n/Ω ASD	ϕr_n LRFD
STD SSLT	1 1/4	58	31.5	47.3	29.4	44.0	27.2	40.8	25.0	37.5
		65	35.3	53.0	32.9	49.4	30.5	45.7	28.0	42.0
	2	58	43.5	65.3	52.2	78.3	53.3	79.9	51.1	76.7
		65	48.8	73.1	58.5	87.8	59.7	89.6	57.3	85.9
SSLP	1 1/4	58	28.3	42.4	26.1	39.2	23.9	35.9	20.7	31.0
		65	31.7	47.5	29.3	43.9	26.8	40.2	23.2	34.7
	2	58	43.5	65.3	52.2	78.3	50.0	75.0	46.8	70.1
		65	48.8	73.1	58.5	87.8	56.1	84.1	52.4	78.6
OVS	1 1/4	58	29.4	44.0	27.2	40.8	25.0	37.5	21.8	32.6
		65	32.9	49.4	30.5	45.7	28.0	42.0	24.4	36.6
	2	58	43.5	65.3	52.2	78.3	51.1	76.7	47.9	71.8
		65	48.8	73.1	58.5	87.8	57.3	85.9	53.6	80.4
LSLP	1 1/4	58	16.3	24.5	10.9	16.3	5.44	8.16	—	—
		65	18.3	27.4	12.2	18.3	6.09	9.14	—	—

ASD value

$\frac{r_n}{\Omega} = \frac{52.2 \text{ kips}}{\text{inch}}$ $t_0 = 3/4''$



39.15 k

$\frac{r_n}{\Omega} = 52.2 \left(\frac{3}{4}\right) = 39.15$ kips

Same For Exterior bolt

LRFD

55.75 k 55.75 k 55.75 k

Shear = 223 k ⇒ → → → →

55.75 k

ϕR_{nv}

Shear

→ → → → →

37.25 k 37.25 k 37.25 k 37.25 k

ASD

149 k

LRFD

Bearing = ϕR_n

235 k ⇒ → → → →

58.73 k 58.73 k 58.73 k 58.73 k

Bearing

→ → → → →

39.15 k 39.15 k 39.15 k 39.15 k

ASD

157 k

Select 223 kips LRFD

149 kips ASD

(Controlled by shear)

Min. ASD = 149 kips

Prepared by Eng.Maged Kamel.

Hence, tear out does not govern and a nominal bearing stress of $2.4F_u$ is applicable. The available bearing capacity of the four bolts on the 3/4-in plate material is

LRFD	ASD
The design bearing strength is $\varphi R_n = \varphi n \times 2.4dtF_u$ $= 0.75 \times 4 \times 2.4 \times 0.75 \times 0.75 \times 58$ $= 235$ kips	The allowable bearing strength is $R_n/\Omega = n \times 2.4dtF_u/\Omega$ $= 4 \times 2.4 \times 0.75 \times 0.75 \times 58/2$ $= 157$ kips

The author summary

The double shear capacity of the four, grade A490, 3/4-in-diameter bolts with threads excluded from the shear planes is

LRFD	ASD
The design shear strength is $\varphi_v R_{nv} = 2n\varphi_v F_{nv} A_b$ $= 2 \times 4 \times 0.75 \times 84 \times 0.442$ $= 223$ kips ... governs < 235 kips	The allowable shear strength is $R_{nv}/\Omega_v = 2nF_{nv}A_b/\Omega_v$ $= 2 \times 4 \times 84 \times 0.442/2$ $= 149$ kips ... governs < 157 kips

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