Solved problem - 10.1 - Shear part

Prof. ALAN williams

Steel Structures Design

Double shear

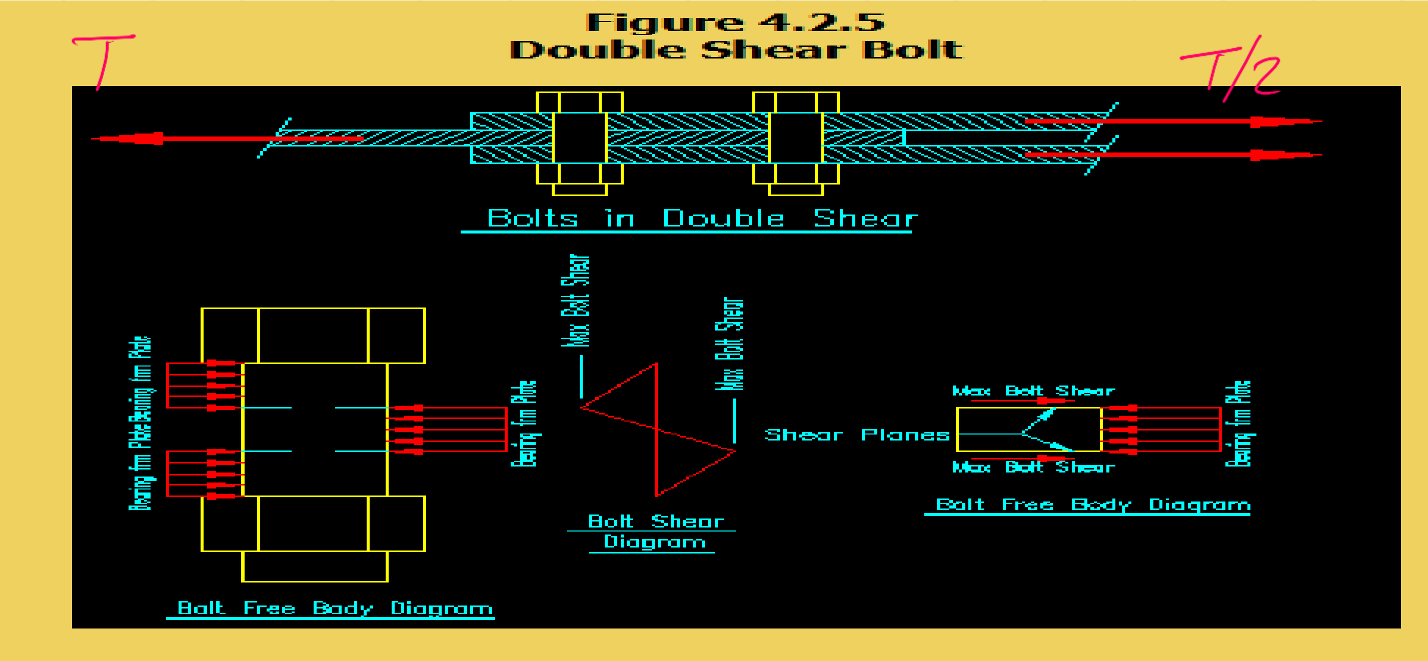
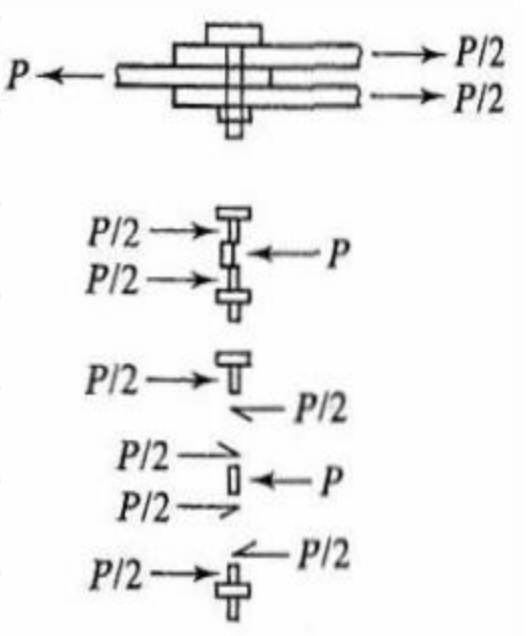


Figure 4.2.5
Double Shear Bolt

T/2



(b) Double Shear

ⓐ Use J3.2 Table.

ⓑ Use Table 7-1 .

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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.

A36 steel

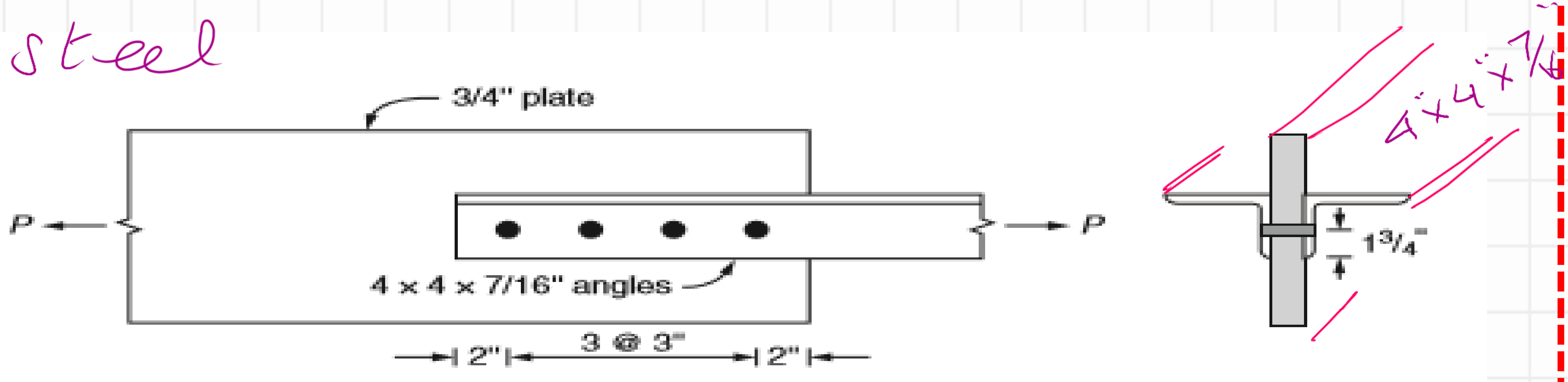

FIGURE 10.7 Details for Example 10.1.

$d_b = \frac{3"}{4}$ X-Type Grade A490 → Group-B

$A_b = \frac{\pi}{4}\left(\frac{3}{4}\right)^2 = 0.442$ inch²

Prepared by Eng.Maged Kamel.

Specification reference Equation For Nominal Shear

AISC-360-16

16.1-131

6. **Tensile and Shear Strength of Bolts and Threaded Parts**

The design tensile or shear strength, ϕR_n, and the allowable tensile or shear strength, R_n/Ω, of a snug-tightened or pretensioned high-strength bolt or threaded part shall be determined according to the limit states of tension rupture and shear rupture as:

$$R_n = F_n A_b \tag{J3-1}$$

$\phi = 0.75$ (LRFD) $\quad \Omega = 2.00$ (ASD)

→ $F_{nv} A_b$ For shear

where

A_b = nominal unthreaded body area of bolt or threaded part, in.^{2} (mm^2)

F_n = nominal tensile stress, F_{nt}, or shear stress, F_{nv}, from Table J3.2, ksi (MPa)

F_{nv} Table J3.2

We Could Estimate Both LRFD & ASD

For shear J3.2

A490 bolt } $F_U = 150$ ksi $\Rightarrow$ (1035 MPA)

$F_{Ut} = 0.75 F_U = 0.75(150) = 112.5$ ksi

$F_{Ut} \simeq 113$ ksi $\Rightarrow$ (780 MPA)

[A490 - X] =

$F_{nv} \Rightarrow 0.625(150)(0.90)(1) = 84.4$ ksi

$F_{nv} \simeq 84$ ksi $\Rightarrow$ (579 MPA)

$\phi_b = \frac{3}{4}''$

$\boxed{\phi_b = 0.75}$ LRFD

Fnv For one bolt

X - Type = 84 ksi

$A_b = \frac{\pi}{4}\left(\frac{3}{4}\right)^2 = \frac{\pi}{64}(9) = 0.4417 \simeq 0.442 \text{ inch}^2$

$n = 4$ $\qquad n' = 2$

There is a Double Shear. For one bolt

$nn'(F_{nv})(A_b) = (1)(2)(84)(0.442) = 74.256 \text{ kips}$

$\phi_b R_{nv} = 0.75(74.256) = 55.692 \text{ kips}$

$\phi_b R_{nv} = 4(55.692) = 222.768 \text{ kips}$

4 bolts

$\simeq 222.80 \text{ kips}$

$\phi_b = \frac{3}{4}''$

Fnv For one bolt

ASD

X-Type = 84 ksi $\quad \Omega_b = 2.0$

$A_b = \frac{\pi}{4}\left(\frac{3}{4}\right)^2 = \frac{\pi}{64}(9) = 0.4417 \simeq 0.442 \text{ inch}^2$

$n = 4 \qquad n' = 2$

There is a Double Shear. For one bolt

$n n' (F_{nv})(A_b) = (1)(2)(84)(0.442) = 74.256$ kips

$\frac{1}{\Omega_b} R_{nv} = \frac{1}{2}(74.256) = 37.128$ kips

$b R_{nv} = 4(37.128) = 148.512$ Kips

4 bolts

Case of Double Shear

Fu1t = 120 ksi ASTM A325

Fu = 150 ksi ASTM A490

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)[b]
A307 bolts	45 (310)[c]	27 (186)[c] [d]
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)
X 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.

$F_{nv} = 84$ ksi

Prepared by Eng.Maged Kamel.

Use Table 7_1 $n = 4$

A490

X – Type

$d_b = \frac{3}{4}''$

D.S

Table 7-1
Available Shear Strength of Bolts, kips

Nominal Bolt Diameter, d, in.					5/8		3/4		7/8		1	
Nominal Bolt Area, in.^{2}					0.307		0.442		0.601		0.785	
ASTM Desig.	Thread Cond.	F_{nv}/Ω (ksi) ASD	ϕF_{nv} (ksi) LRFD	Loading	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
Group A	N	27.0	40.5	S	8.29	12.4	11.9	17.9	16.2	24.3	21.2	31.8
				D	16.6	24.9	23.9	35.8	32.5	48.7	42.4	63.6
	X	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
				D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
Group B	N	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
				D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
	X	42.0	63.0	S	12.9	19.3	18.6	27.8	25.2	37.9	33.0	49.5
				D	25.8	38.7	37.1	55.7	50.5	75.7	65.9	98.9
A307	–	13.5	20.3	S	4.14	6.23	5.97	8.97	8.11	12.2	10.6	15.9
				D	8.29	12.5	11.9	17.9	16.2	24.4	21.2	31.9

For Group B LRFD

For $\frac{3}{4}''$ $\phi R_{nv} = 55.70$ Kips per bolt

$\phi R_{nv} = 4(55.70) = 222.80$ Kips

ASD For $\frac{3}{4}''$ $\frac{R_{nv}}{\Omega} = 37.10$ Kips per bolt

$\frac{R_{nv}}{\Omega} = 4(37.10)$

$= 148.40$ Kips

D.S ϕr_n

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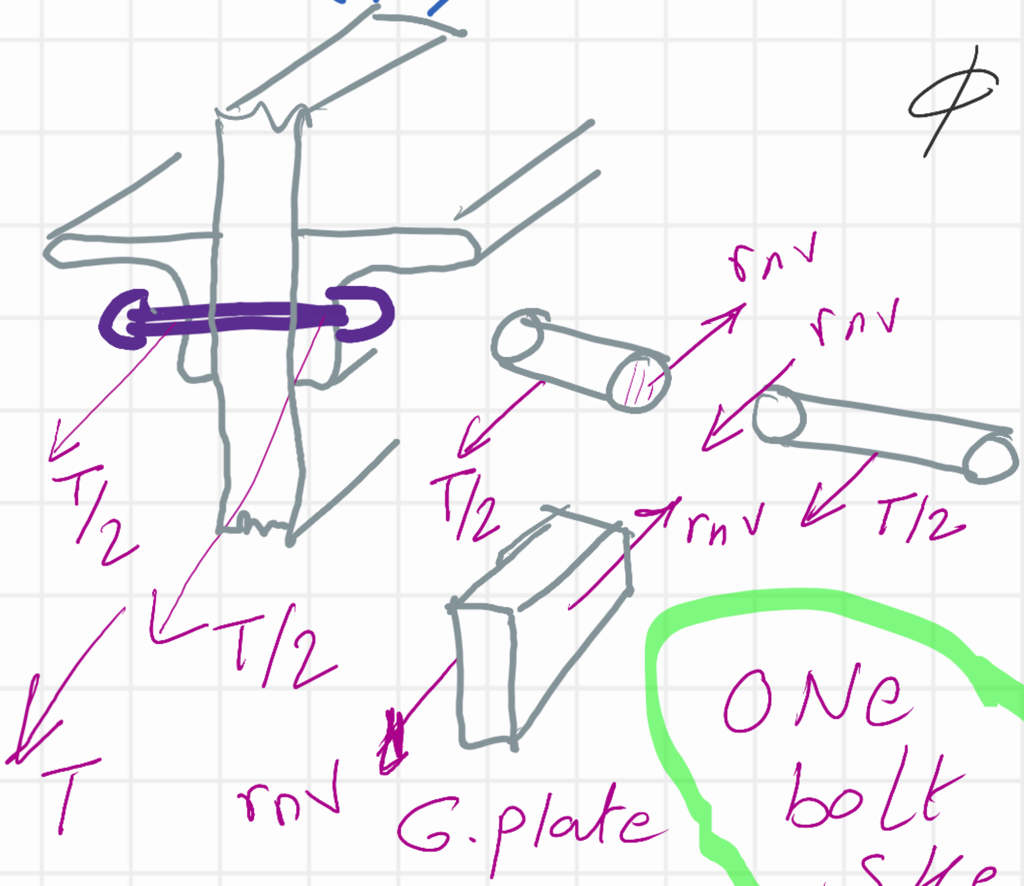
Shear value For 4 bolts From Table 7-1

$T = F_{nv} (\phi) = 222.80$ Kips $\simeq 223$ Kips

$\phi T = 223$ kips } LRFD Design



ONe bolt sketch

ASD Design

$\frac{1}{\Omega} T = 148.4$ kips

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This is a part of Author's Solution

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

Bearing Part in the next post

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