

Practice problem - 5 - From the Unified Steel Design
of steel structures
's Boon

Part - 2

Chapter - 10 → Connections elements.
3rd edition.

4th edition

Second part in Post 8 is For Bolts

Design shear strength For

For Bolt sizes $A490-N$ & $A-490-X$
 $\frac{5}{8}$ " , $\frac{3}{4}$ " , $\frac{7}{8}$ " and 1"

Problems 3 - is For Nominal shear strength $A490-N$
4 - is For Nominal shear strength $A490-X$

5. Develop a table showing the design shear strength for A325-N, A325-X, A490-N, and A490-X bolts for the following sizes: 5/8, 3/4, 7/8, and 1 in.

Solution

A 490-N

2016

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) ^a	27 (186) ^{b(1)}
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)

F_{nv} from Table J3.2

→ 68 (469) N

$F_{nv} = 68 \text{ ksi}$

$\phi = 0.75$

Group B - A490

$$\begin{aligned} \text{A-490 bolt} \} & F_u = 150 \text{ ksi} \Rightarrow (1035 \text{ MPA}) \\ & F_{ut} = 0.75 F_u = 0.75 (150) = 112.5 \text{ ksi} \\ & F_{ut} \approx 113 \text{ ksi} \Rightarrow (780 \text{ MPA}) \end{aligned}$$

A490

$$F_{nv} = 0.625 (F_u) C_a C_b$$

$$\text{A490-N} = 0.625 (150) (0.9) (0.80)$$

$$= 67.5 \text{ ksi} \Rightarrow (68 \text{ ksi}) \text{ or}$$

$$C_a = 0.90$$

$$C_b = 0.80 \Rightarrow \text{N-Ty}$$

$$C_b = 1 \Rightarrow \text{X-}$$

$$\Rightarrow (469 \text{ MPA})$$

A490-X

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

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

For Dia $\frac{5''}{8}$ $\rightarrow F_{nv} \rightarrow N\text{-bolts} = 68 \text{ ksi}$

A - 490-N bolts
 $F_{nv} = 68 \text{ ksi}$

$$\phi F_{nv} = 0.75(68) = 51 \text{ ksi}$$

$$A = \frac{\pi}{4} \left(\frac{5}{8}\right)^2 = 0.307 \text{ inch}^2$$

$$\phi F_{nv}(A) = (51)(0.307) = 15.66 \text{ kips}$$

$\approx 15.70 \text{ kips} \rightarrow$ Design shear stress

$$\phi F_{nv} = 0.75(68) = 51 \text{ ksi}$$

$$\text{For dia } \frac{3}{4}'' \rightarrow A = \frac{\pi}{4} \left(\frac{3}{4}\right)^2 = 0.442 \text{ inch}^2$$

$$\phi F_{nv} \cdot A = 51(0.442) = 22.54 = 22.50 \text{ kips}$$

$$\phi F_{nv} = 0.75(68) = 51.0 \text{ ksi}$$

$$\text{For dia } \left(\frac{7}{8}\right)'' \Rightarrow A = \frac{\pi}{4} \left(\frac{7}{8}\right)^2 = 0.601 \text{ inch}^2$$

$$\phi F_{nv} A = 51(0.601) = 30.65 \text{ kips}$$

Prepared by Eng. Maged Kamel.

For Dia 1" $\rightarrow F_{nv} \rightarrow N\text{-bolts} = 68 \text{ ksi}$

A - 490-N-bolts
 $F_{nv} = 68 \text{ ksi}$

$$\phi F_{nv} = 0.75(68) = 51.0 \text{ kips}$$

$$A = \frac{\pi}{4}(1)^2 = 0.785 \text{ inch}^2$$

$$\phi F_n(A) = 51.0(0.785) = 40.03 \text{ kips} \\ = 40 \text{ kips}$$

We have $\phi F_{nv} = 51.0 \text{ ksi} \rightarrow \text{Group A 490} \rightarrow N$

Matches with part A \rightarrow Table 7-1

For Nominal shear Use $F_{nv} = 68 \text{ ksi}$

$$R_{nv} \Rightarrow \frac{5}{8} \text{''} \rightarrow \uparrow (0.307) = 20.88 \text{ kips}$$

$$\frac{3}{4} \text{''} \rightarrow 68 (0.442) = 30.06 \text{ kips}$$

$$\frac{7}{8} \text{''} \rightarrow 68 (0.601) = 40.87 \text{ kips}$$

$$1 \text{''} \rightarrow \downarrow (0.785) = 53.38 \text{ kips}$$

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A-490-N-bolt \Rightarrow Group B

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				
Designation	Thread Cond.	F_{nv}/Ω	ϕF_{nv}	Loading	r_n/Ω	ϕr_n						
		ASD	LRFD		ASD	LRFD	ASD	LRFD	ASD	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
	X	34.0	51.0	D	16.6	24.9	23.9	35.8	32.5	48.7	42.4	63.6
Group B	N	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
	X	42.0	63.0	D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
Group C	N	45.0	67.5	S	-	-	-	-	-	-	35.3	53.0
	X	56.5	84.8	D	-	-	-	-	-	-	70.7	106
A307	Not applicable	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 1" bolt

S-shear

$$\phi R_n = 40 \text{ kips}$$

Group B

For $\frac{5}{8}$ " bolt \rightarrow S-S

$$\phi R_n = 15.7 \text{ kips}$$

For $\frac{3}{4}$ " bolt \rightarrow S-S

$$\phi R_n = 22.5 \text{ kips}$$

For $\frac{7}{8}$ " bolt \rightarrow S-S

$$\phi R_n = 30.7 \text{ kips}$$

5. Develop a table showing the design shear strength for A325-N, A325-X, A490-N, and A490-X bolts for the following sizes: 5/8, 3/4, 7/8, and 1 in.

Solution

A 490-X ↘

2016

F_{nv} from
Table J3.2

Description of Fasteners	Nominal Tensile Strength, F_{ut} , ksi (MPa) ^a	Nominal Shear Strength in Bearing-Type Connections, F_{nv} , ksi (MPa) ^a
A307 bolts	45 (310) ^b	27 (186) ^b
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)

↑

X

$\phi = 0.75$
 $F_{nv} = 84 \text{ ksi}$

A-490-X bolts

For dia $\frac{5}{8}$ $\rightarrow F_{nv} \rightarrow 84 \text{ ksi}$

$F_{nv} = 84 \text{ ksi}$

$$\phi F_{nv} = 0.75(84) = 63 \text{ ksi}$$

$$A = \frac{\pi}{4} \left(\frac{5}{8}\right)^2 = 0.307 \text{ inch}^2$$

$$\phi F_{nv}(A) = (63)(0.307) = 19.341 \text{ kips}$$

$\approx 19.34 \text{ kips} \rightarrow$ Design shear stress

$$\phi F_{nv} = 0.75(84) = 63 \text{ ksi}$$

$$\text{For dia } \frac{3}{4} \rightarrow A = \frac{\pi}{4} \left(\frac{3}{4}\right)^2 = 0.442 \text{ inch}^2$$

$$\phi F_{nv} \cdot A = 63(0.442) = 27.846 \text{ kips} = 27.80 \text{ kips}$$

$$\phi F_{nv} = 0.75(84) = 63 \text{ ksi}$$

$$\text{For dia } \left(\frac{7}{8}\right) \Rightarrow A = \frac{\pi}{4} \left(\frac{7}{8}\right)^2 = 0.601 \text{ inch}^2$$

$$\phi F_{nv} A = 63(0.601) = 37.87 \text{ kips}$$

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For Dia 1" $\rightarrow F_{nv} \rightarrow 84 \text{ ksi} - A 490 X$

A - 490 X - bolts
 $F_{nv} = 84 \text{ ksi}$

$$\phi F_{nv} = 0.75(84) = 63.0 \text{ kips}$$

$$A = \frac{\pi}{4}(1)^2 = 0.785 \text{ inch}^2$$

$$\phi F_n(A) = 63(0.785) = 49.455 \text{ kips}$$

$$= 49.50 \text{ kips}$$

We have $\phi F_{nv} = 63 \text{ ksi} \rightarrow \text{Group A-490} \rightarrow X$

|||

Matches with part A \rightarrow Table 7-1

For Nominal shear Use $F_{nv} = 84 \text{ ksi}$

$R_{nv} \Rightarrow 5/8$	\rightarrow	\uparrow	(0.307)	$=$	25.79	kips	\rightarrow
$3/4$	\rightarrow	84	(0.442)	$=$	37.13	kips	\rightarrow
$7/8$	\rightarrow		(0.601)	$=$	50.48	kips	\rightarrow
1	\rightarrow	\downarrow	(0.785)	$=$	65.94	kips	

A-490 x bolt \Rightarrow Group B

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				
Designation	Thread Cond.	F_{nv}/Ω	ϕF_{nv}	Loading	r_n/Ω	ϕr_n						
		ASD	LRFD		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	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
	X	34.0	51.0	D	16.6	24.9	23.9	35.8	32.5	48.7	42.4	63.6
Group B	N	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
	X	42.0	63.0	D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
Group C	N	45.0	67.5	S	-	-	-	-	-	-	35.3	53.0
	X	56.5	84.8	D	-	-	-	-	-	-	70.7	106
A307	Not applicable	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 1" bolt

S-Shear



$$\phi R_n = 49.5 \text{ kips}$$

Group B

For $5/8$ " bolt \rightarrow S-S

$$\phi R_n = 19.3 \text{ kips}$$

For $3/4$ " bolt \rightarrow S-S

$$\phi R_n = 27.80 \text{ kips}$$

For $7/8$ " bolt \rightarrow S-S

$$\phi R_n = 37.90 \text{ kips}$$

S-S

Prepared by Eng.Maged Kamel.

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) $0.75 F_u (120) = 90$	54 (372) $0.45 F_u$
Group A (e.g., A325) bolts, when threads are excluded from shear planes ✗	90 (620) ↓	68 (469) $0.563 F_u$
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) $0.563 (150)$

$F_{ult} = 120 \text{ ksi}$
 $F_u = 150 \text{ ksi}$

ASTM A325
 ASTM A490

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	$0.75 F_u$	$0.45 F_u$
Threaded parts meeting the requirements of Section A3.4, when threads are excluded from shear planes	$0.75 F_u$	$0.563 F_u$

^(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.

A325 - X
 ✓

$F_{nv} = 120 (0.625) (0.90) = 67.50 \approx 68 \text{ ksi} \rightarrow 0.563 F_u$
 $= 68 \times 0.80 = 54.40 = 54 \text{ ksi} \rightarrow 0.45 F_u$

Prepared by Eng. Maged Kamel.