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

Chapter - 10 → Connections elements.

3rd edition.

4rth edition

First part in Post 8 is For Bolts

Design shear strength For

A325-N & A-325-X

For Bolt sizes $\frac{5}{8}$", $\frac{3}{4}$", $\frac{7}{8}$" and 1".

Problems 1- is For Nominal shear strength A325-N

2- is For Nominal shear strength A325-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.

For Group A → $F_u = 120$ ksi (A325-N)

TABLE J3.2
Nominal Strength of Fasteners and Threaded Parts, ksi (MPa)

N.S

Description of Fasteners	Nominal Tensile Strength, F_{nt}, ksi (MPa)[3]	Nominal Shear Strength in Bearing-Type Connections, F_{nv}, ksi (MPa)[3]
A307 bolts	45 (310)[4]	27 (186)[4][5]
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)

0.75 F_u

Solution

N- not excluded

X- Excluded
(0.625) F_u

limit state of shear
$\phi = 0.75$

Group A325

A325 bolts:

$F_U = 120$ ksi $\Rightarrow$ (830 MPa)

$F_{ut} = 0.75 F_U = 0.75(120) = 90$ ksi (620 MPA)

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

$C_a = 0.90$

$C_b = 0.80 \rightarrow$ N-Type

or $C_b = 1 \rightarrow$ X-Type

A325-N $= 0.625(120)(0.9)(0.80)$

$= 54$ ksi $\Rightarrow$ (372 MPa)

A325-X

$F_{nv} = 0.625(120)(0.90)(1) = 67.50$ ksi

$F_{nv} \simeq 68$ ksi $\Rightarrow$ (469 MPA)

$\rightarrow C_a = 0.9 \leq 38$

C_a: Length Factor, C_b: threaded Factor.

$C_b = 0.80$ - N

$C_b = 1.0$ - X

A-325 N-bolts

F_{nv} = 54 ksi

For Dia $\frac{5}{8}$" → F_{nv} → N bolts = 54 ksi

$\phi F_{nv} = 0.75(54) = 40.50$ ksi

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

$\phi F_{nv}(A) = 40.50(0.307) = 12.434$ kips

≈ 12.40 kips → Design shear stren

$\phi F_{nv} = 0.75(54) = 40.50$ ksi

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

$\phi F_{nv} \cdot A = 40.50(0.442) = 17.90$ kips

$\phi F_{nv} = 0.75(54) = 40.50$ ksi

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

$\phi F_{nv} A = 40.50(0.601) = 24.34$ kips

A-325 N-bolts
F_{nv} = 54 ksi

For Dia 1" → F_{nv} → N bolts = 54 ksi

$\phi F_{nv} = 0.75(54) = 40.50$ kips

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

$\phi F_{nv}(A) = 40.50(0.785) = 31.79$ kips

$= 31.80$ kips

We have $\phi F_{nv} = 40.50$ ksi → Group A 325 → N

Matches with part A → Table 7-1

For Nominal shear Use $F_{nv} = 54$ ksi

R_{nv} ⇒ 5/8" → 54(0.307) = 16.58 kips

3/4 → 54(0.442) = 23.87 kips

7/8 → 54(0.601) = 32.45 kips

1 → 54(0.785) = 42.39 kips

For 1" bolt

S.shear

$\phi R_n = 31.80$ kips

Group-A

For $\frac{5}{8}$" bolt ⇒ S.S

$\phi R_n = 12.4$ kips

For $\frac{3}{4}$" bolt ⇒ S.S

$\phi R_n = 17.9$ kips

For $\frac{7}{8}$" bolt ⇒ S.S

$\phi R_n = 24.3$ kips

A-325 bolt ⇒ Group A

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 (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
Group C	N	45.0	67.5	S	—	—	—	—	—	—	35.3	53.0
				D	—	—	—	—	—	—	70.7	106
	X	56.5	84.8	S	—	—	—	—	—	—	44.4	66.6
				D	—	—	—	—	—	—	88.7	133
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

S-S

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.

$F_U = 120$ ksi A325 – X

TABLE J3.2
Nominal Strength of Fasteners and Threaded Parts, ksi (MPa)

Description of Fasteners	Nominal Tensile Strength, F_{nt}, ksi (MPa)[3]	Nominal Shear Strength in Bearing-Type Connections, F_{nv}, ksi (MPa)[3]
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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)

N.S

0.7 F_U

X

Solution

$F_{nv} = 68$ ksi

limit state of shear

$\phi = 0.75$

A-325-X-bolts

F_{nv} = 68 ksi

For Dia $\frac{5}{8}$" → F_{nv} → X-bolts = 68 ksi

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

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

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

$\approx$ 15.70 kips → Design shear stren

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

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

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

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

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

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

A-325X-bolts

F_{nv} = 68 ksi

For Dia 1" → F_{nv} → X-bolts = 68 ksi

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

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

$\phi F_{nv}(A) = 51.0(0.785) = 40.03$ kips

$= 40$ kips

We have $\phi F_{nv} = 51$ ksi → Group A 325 → X

Matches with part A → Table 7-1

For Nominal shear Use F_{nv} = 68 ksi

R_{nv} ⇒ 5/8" → ↑ (0.307) = 20.88 kips ⇝ 20.90 kips

3/4 → (0.442) = 30.05 kips ⇝ 30.0

7/8 → 68 (0.601) = 40.87 kips ⇝ 40.90

1 → ↓ (0.785) = 53.38 kips

For 1" bolt

S-shear

ϕR_n = 40 kips

Group-A

For $\frac{5}{8}$" bolt ⇒ S-S

ϕR_n = 15.7 kips

For $\frac{3}{4}$" bolt ⇒ S-S

ϕR_n = 22.5 kips

For $\frac{7}{8}$" bolt ⇒ S-S

ϕR_n = 30.7 kips

A-325-X bolt ⇒ Group A

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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 (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
Group C	N	45.0	67.5	S	—	—	—	—	—	—	35.3	53.0
				D	—	—	—	—	—	—	70.7	106
	X	56.5	84.8	S	—	—	—	—	—	—	44.4	66.6
				D	—	—	—	—	—	—	88.7	133
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

S-S

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