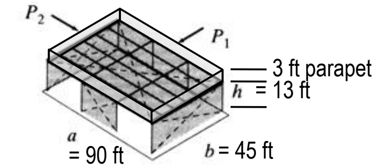
# ARCH 631. Assignment #8

**Date:** 3/6/18, *due 4/5/18* *Worth 25 pts.*

**Problems:**



(a) Basic structure with fully rigid roof plane (diaphragm) and three shear walls

**1.** A 45 ft x 90 ft structure has the openings and shear walls shown in Figure 14.7 on page 534 (with no rear shear walls). The roof diaphragm is 13 ft from the base, but this structure has a parapet wall extending 3 ft *past* the roof level where the loads are transmitted. Determine the shear forces in the shear walls, $R_1$, $R_2$ and $R_3$, when the design wind load is 23 lb/ft$^2$.

Answer: $R_1 = R_2 = 9{,}832.5$ lb, $R_3 = 9{,}832.5$ lb

**2.** For the shear wall on the long side ($R_3$) of the building in Problem 1, determine the overturning moment.

Answer: $M_0 = 127{,}822$ lb-ft

**3.** If the shear wall on the long side ($R_3$) of the building in Problem 1 is removed, the diaphragm can be considered to behave like a deep truss with a distributed load on it. Determine the maximum force in the top and bottom "chords" from the maximum moment.

Answer: $T = C = 4{,}916$ lb

**4.** You are designing a building in seismic zone 3 which is a large auditorium (>300 occupancy) (I = 1.25). Z = 0.30, C = 1.25S/T$^{2/3}$, S =1.2, T = 0.5, $R_W$ = 6, and the total dead load = 85,000 lbs. What is the base shear?

Answer: $V = 12.6$ kips

**5.** Complete text problem 16.2 on page 514.

**16.2** With respect to shear stresses alone, what is the required diameter for a bolt in single shear that transfers a shear force of 6000 lb between two plates? Assume that $F_v = 14{,}000$ lb/in.$^2$

Answer: $^3/_4$-in. diameter.

**6.** Complete text problem 16.3 on page 514.

**16.3** How many inches of $^1/_8$-in. weld are necessary to transfer a shear force of 6000 lb from one plate to another? Assume that $F_v = 13{,}600$ lb/in.$^2$

Answer: 5 in.

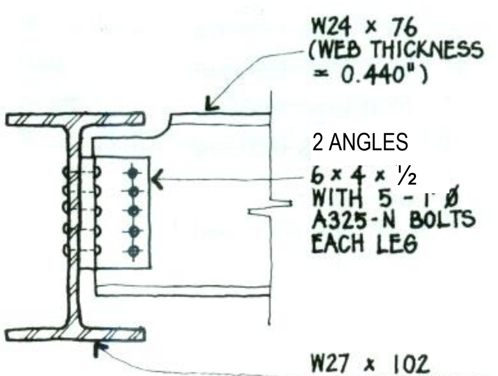
**7.** Complete text problem 16.4 on page 588. *Note: Assume $F_v = 14{,}000$ psi.*

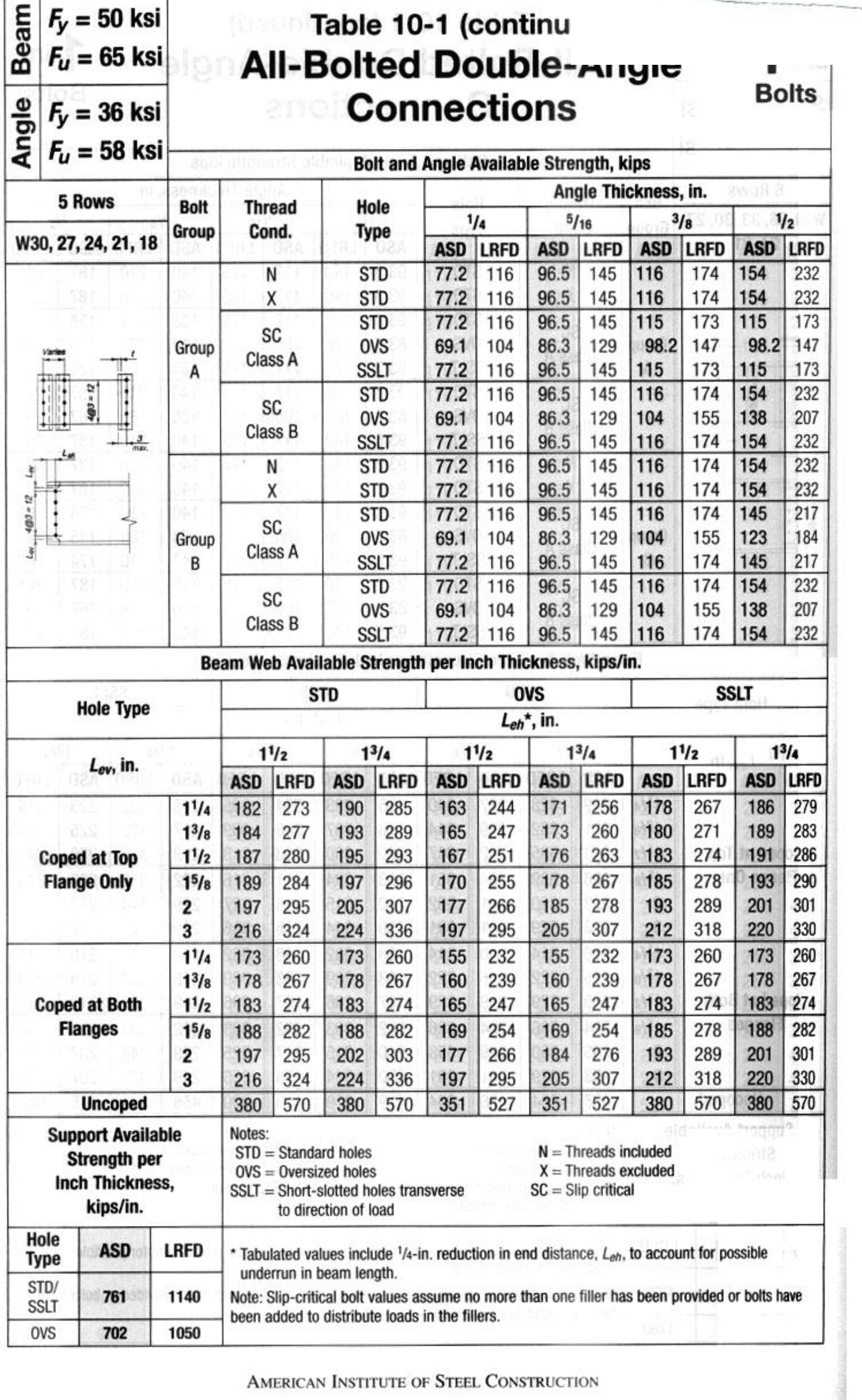
**16.4.** Will a bolt $^1/_2$ in. in diameter used in double shear carry a force of 2000 lb? What shear stress is present?

Answer: Yes. $f_v = 5093$ lb/in.$^2$

**8.** What is the capacity of the connection shown? All connection material is ASTM A36 ($F_y$ = 36 ksi, $F_u$ = 58 ksi), while the beams are A992 ($F_y$ = 50 ksi, $F_u$ = 65 ksi). Assume that the connection angles are adequate with standard holes and 3 in. spacing, and that the coping distances ($L_{ev}$ & $L_{eh}$) are sufficiently large. Use LRFD design.

***Partial** answer:* **possible** limits are 232, 318, 248.6 or 582 kips, *so* ...





Beam $F_y$ = 50 ksi $F_u$ = 65 ksi

Angle $F_y$ = 36 ksi $F_u$ = 58 ksi

Table 10-1 (continu

All-Bolted Double-Angle Connections

Bolts

Bolt and Angle Available Strength, kips

| 5 Rows | Bolt Group | Thread Cond. | Hole Type | Angle Thickness, in. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1/4 | | 5/16 | | 3/8 | | 1/2 | |
| W30, 27, 24, 21, 18 | | | | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD |
| | Group A | N | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | X | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | SC Class A | STD | 77.2 | 116 | 96.5 | 145 | 115 | 173 | 115 | 173 |
| | | | OVS | 69.1 | 104 | 86.3 | 129 | 98.2 | 147 | 98.2 | 147 |
| | | | SSLT | 77.2 | 116 | 96.5 | 145 | 115 | 173 | 115 | 173 |
| | | SC Class B | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | | OVS | 69.1 | 104 | 86.3 | 129 | 104 | 155 | 138 | 207 |
| | | | SSLT | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | Group B | N | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | X | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | SC Class A | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 145 | 217 |
| | | | OVS | 69.1 | 104 | 86.3 | 129 | 104 | 155 | 123 | 184 |
| | | | SSLT | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 145 | 217 |
| | | SC Class B | STD | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |
| | | | OVS | 69.1 | 104 | 86.3 | 129 | 104 | 155 | 138 | 207 |
| | | | SSLT | 77.2 | 116 | 96.5 | 145 | 116 | 174 | 154 | 232 |

Beam Web Available Strength per Inch Thickness, kips/in.

| Hole Type | | STD | | | | OVS | | | | SSLT | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $L_{eh}$*, in. | | | | | | | | | | | |
| $L_{ev}$, in. | | 1½ | | 1¾ | | 1½ | | 1¾ | | 1½ | | 1¾ | |
| | | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD |
| Coped at Top Flange Only | 1¼ | 182 | 273 | 190 | 285 | 163 | 244 | 171 | 256 | 178 | 267 | 186 | 279 |
| | 1⅜ | 184 | 277 | 193 | 289 | 165 | 247 | 173 | 260 | 180 | 271 | 189 | 283 |
| | 1½ | 187 | 280 | 195 | 293 | 167 | 251 | 176 | 263 | 183 | 274 | 191 | 286 |
| | 1⅝ | 189 | 284 | 197 | 296 | 170 | 255 | 178 | 267 | 185 | 278 | 193 | 290 |
| | 2 | 197 | 295 | 205 | 307 | 177 | 266 | 185 | 278 | 193 | 289 | 201 | 301 |
| | 3 | 216 | 324 | 224 | 336 | 197 | 295 | 205 | 307 | 212 | 318 | 220 | 330 |
| Coped at Both Flanges | 1¼ | 173 | 260 | 173 | 260 | 155 | 232 | 155 | 232 | 173 | 260 | 173 | 260 |
| | 1⅜ | 178 | 267 | 178 | 267 | 160 | 239 | 160 | 239 | 178 | 267 | 178 | 267 |
| | 1½ | 183 | 274 | 183 | 274 | 165 | 247 | 165 | 247 | 183 | 274 | 183 | 274 |
| | 1⅝ | 188 | 282 | 188 | 282 | 169 | 254 | 169 | 254 | 185 | 278 | 188 | 282 |
| | 2 | 197 | 295 | 202 | 303 | 177 | 266 | 184 | 276 | 193 | 289 | 201 | 301 |
| | 3 | 216 | 324 | 224 | 336 | 197 | 295 | 205 | 307 | 212 | 318 | 220 | 330 |
| Uncoped | | 380 | 570 | 380 | 570 | 351 | 527 | 351 | 527 | 380 | 570 | 380 | 570 |

Support Available Strength per Inch Thickness, kips/in.

| Hole Type | ASD | LRFD |
|---|---|---|
| STD/ SSLT | 761 | 1140 |
| OVS | 702 | 1050 |

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance, $L_{eh}$, to account for possible underrun in beam length.

Note: Slip-critical bolt values assume no more than one filler has been provided or bolts have been added to distribute loads in the fillers.

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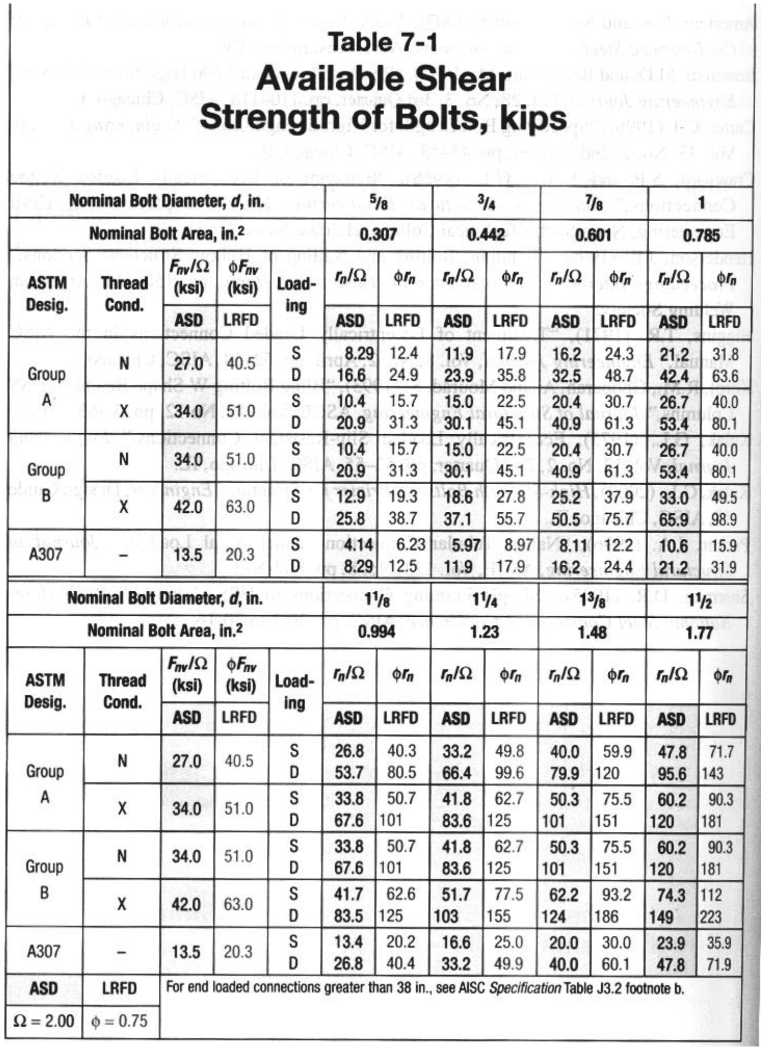
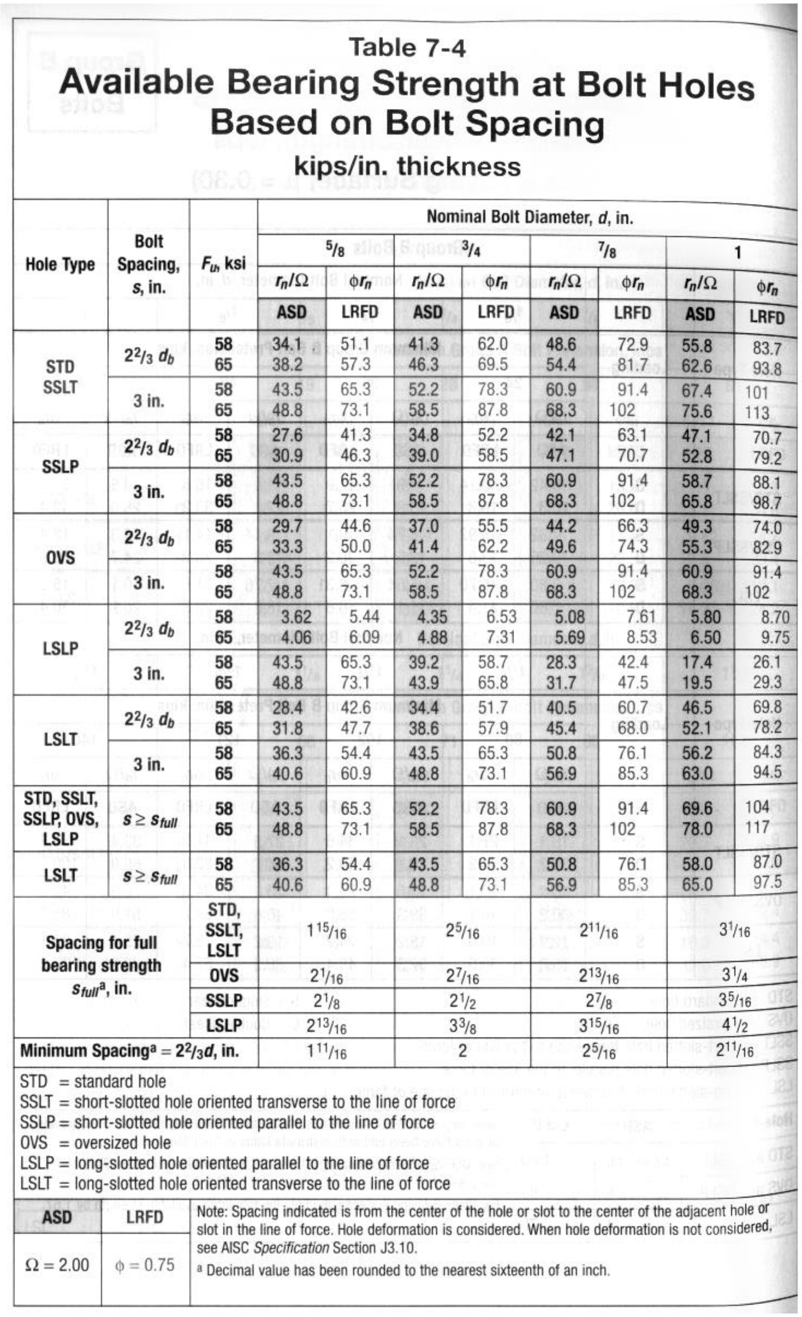


## Table 7-1
## Available Shear Strength of Bolts, kips

| 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. | $F_{nv}/\Omega$ (ksi) | $\phi F_{nv}$ (ksi) | Load-ing | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ |
| | | 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 |
| | | | | 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 |

| Nominal Bolt Diameter, $d$, in. | | | | | 1 1/8 | | 1 1/4 | | 1 3/8 | | 1 1/2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Bolt Area, in.$^2$ | | | | | 0.994 | | 1.23 | | 1.48 | | 1.77 | |
| ASTM Desig. | Thread Cond. | $F_{nv}/\Omega$ (ksi) | $\phi F_{nv}$ (ksi) | Load-ing | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ |
| | | ASD | LRFD | | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD |
| Group A | N | 27.0 | 40.5 | S | 26.8 | 40.3 | 33.2 | 49.8 | 40.0 | 59.9 | 47.8 | 71.7 |
| | | | | D | 53.7 | 80.5 | 66.4 | 99.6 | 79.9 | 120 | 95.6 | 143 |
| | X | 34.0 | 51.0 | S | 33.8 | 50.7 | 41.8 | 62.7 | 50.3 | 75.5 | 60.2 | 90.3 |
| | | | | D | 67.6 | 101 | 83.6 | 125 | 101 | 151 | 120 | 181 |
| Group B | N | 34.0 | 51.0 | S | 33.8 | 50.7 | 41.8 | 62.7 | 50.3 | 75.5 | 60.2 | 90.3 |
| | | | | D | 67.6 | 101 | 83.6 | 125 | 101 | 151 | 120 | 181 |
| | X | 42.0 | 63.0 | S | 41.7 | 62.6 | 51.7 | 77.5 | 62.2 | 93.2 | 74.3 | 112 |
| | | | | D | 83.5 | 125 | 103 | 155 | 124 | 186 | 149 | 223 |
| A307 | – | 13.5 | 20.3 | S | 13.4 | 20.2 | 16.6 | 25.0 | 20.0 | 30.0 | 23.9 | 35.9 |
| | | | | D | 26.8 | 40.4 | 33.2 | 49.9 | 40.0 | 60.1 | 47.8 | 71.9 |

| | | |
|---|---|---|
| ASD | LRFD | For end loaded connections greater than 38 in., see AISC *Specification* Table J3.2 footnote b. |
| $\Omega = 2.00$ | $\phi = 0.75$ | |



## 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 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ | $r_n/\Omega$ | $\phi r_n$ |
| | | | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | 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 |
| LSLT | $2\frac{2}{3}d_b$ | 58 | 28.4 | 42.6 | 34.4 | 51.7 | 40.5 | 60.7 | 46.5 | 69.8 |
| | | 65 | 31.8 | 47.7 | 38.6 | 57.9 | 45.4 | 68.0 | 52.1 | 78.2 |
| | 3 in. | 58 | 36.3 | 54.4 | 43.5 | 65.3 | 50.8 | 76.1 | 56.2 | 84.3 |
| | | 65 | 40.6 | 60.9 | 48.8 | 73.1 | 56.9 | 85.3 | 63.0 | 94.5 |
| STD, SSLT, SSLP, OVS, LSLP | $s \ge s_{full}$ | 58 | 43.5 | 65.3 | 52.2 | 78.3 | 60.9 | 91.4 | 69.6 | 104 |
| | | 65 | 48.8 | 73.1 | 58.5 | 87.8 | 68.3 | 102 | 78.0 | 117 |
| LSLT | $s \ge s_{full}$ | 58 | 36.3 | 54.4 | 43.5 | 65.3 | 50.8 | 76.1 | 58.0 | 87.0 |
| | | 65 | 40.6 | 60.9 | 48.8 | 73.1 | 56.9 | 85.3 | 65.0 | 97.5 |
| Spacing for full bearing strength $s_{full}$[a], in. | | STD, SSLT, LSLT | $1\frac{15}{16}$ | | $2\frac{5}{16}$ | | $2\frac{11}{16}$ | | $3\frac{1}{16}$ | |
| | | OVS | $2\frac{1}{16}$ | | $2\frac{7}{16}$ | | $2\frac{13}{16}$ | | $3\frac{1}{4}$ | |
| | | SSLP | $2\frac{1}{8}$ | | $2\frac{1}{2}$ | | $2\frac{7}{8}$ | | $3\frac{5}{16}$ | |
| | | LSLP | $2\frac{13}{16}$ | | $3\frac{3}{8}$ | | $3\frac{15}{16}$ | | $4\frac{1}{2}$ | |
| Minimum Spacing[a] = $2\frac{2}{3}d$, in. | | | $1\frac{11}{16}$ | | 2 | | $2\frac{5}{16}$ | | $2\frac{11}{16}$ | |

STD = standard hole
SSLT = short-slotted hole oriented transverse to the line of force
SSLP = short-slotted hole oriented parallel to the line of force
OVS = oversized hole
LSLP = long-slotted hole oriented parallel to the line of force
LSLT = long-slotted hole oriented transverse to the line of force

| | | |
|---|---|---|
| ASD | LRFD | Note: Spacing indicated is from the center of the hole or slot to the center of the adjacent hole or slot in the line of force. Hole deformation is considered. When hole deformation is not considered, see AISC *Specification* Section J3.10. |
| $\Omega = 2.00$ | $\phi = 0.75$ | [a] Decimal value has been rounded to the nearest sixteenth of an inch. |