

# Manual of Steel Construction

---

AISC Steel Construction Manual, 15<sup>th</sup> Edition

Part 1

Dimensions and Properties

C. C. Fu, Ph.D., P.E.

University of Maryland at College Park

# *Wide-flange (W) Shapes*

---

- Most widely used section
- Two flanges held apart by a web
- Essentially parallel inner and outer flange surfaces

Section designation

W24x55 ← Weight per foot

Nominal depth

Major (strong) axis

Flange

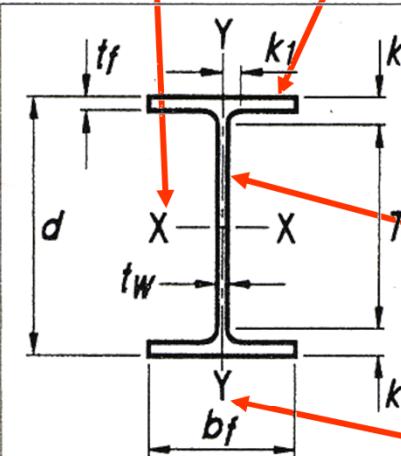
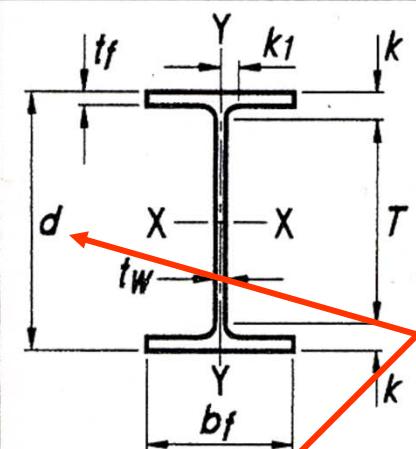


Table 1-1.  
W-Shapes  
Dimensions

Minor (weak) axis

| Shape    | Area,<br>A | Depth,<br>d | Web                 |                 | Flange          |                     | Distance |       |        | Work-<br>able<br>Gage <sup>†</sup> |        |        |        |       |
|----------|------------|-------------|---------------------|-----------------|-----------------|---------------------|----------|-------|--------|------------------------------------|--------|--------|--------|-------|
|          |            |             | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Width,<br>$b_f$ | Thickness,<br>$t_f$ | $k$      | $k_1$ | T      |                                    |        |        |        |       |
|          |            |             | in. <sup>2</sup>    | in.             | in.             | in.                 | in.      | in.   | in.    | in.                                |        |        |        |       |
| W44×335* | 98.3       | 44.0        | 44                  | 1.02            | 1               | 16.0                | 16       | 1.77  | 1 3/4  | 2.56                               | 2 5/8  | 1 5/16 | 38 3/4 | 5 1/2 |
| x290     | 85.8       | 43.6        | 43 5/8              | 0.870           | 7/8             | 15.8                | 15 7/8   | 1.58  | 1 9/16 | 2.37                               | 2 7/16 | 1 1/4  |        |       |
| x262     | 77.2       | 43.3        | 43 1/4              | 0.790           | 13/16           | 15.8                | 15 3/4   | 1.42  | 1 7/16 | 2.21                               | 2 1/4  | 1 3/16 |        |       |
| x230     | 67.7       | 42.9        | 42 7/8              | 0.710           | 11/16           | 15.8                | 15 3/4   | 1.22  | 1 1/4  | 2.01                               | 2 1/16 | 1 3/16 |        |       |

Designation

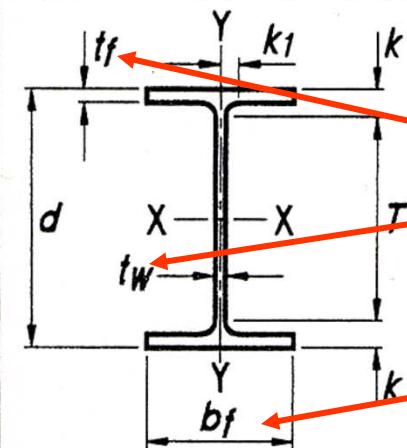


**Table 1-1.**  
**W-Shapes**  
**Dimensions**

Cross-sectional area  
Actual depth

| Shape    | Area,<br>A       | Depth,<br>d | Web                 |                 | Flange          |                     | Distance |        |      | Work-<br>able<br>Gage† |      |        |        |        |       |
|----------|------------------|-------------|---------------------|-----------------|-----------------|---------------------|----------|--------|------|------------------------|------|--------|--------|--------|-------|
|          | in. <sup>2</sup> | in.         | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Width,<br>$b_f$ | Thickness,<br>$t_f$ | k        | $k_1$  | T    |                        |      |        |        |        |       |
| W44×335* | 98.3             | 44.0        | 44                  | 1.02            | 1               | 1/2                 | 16.0     | 16     | 1.77 | 1 3/4                  | 2.56 | 2 5/8  | 1 5/16 | 38 3/4 | 5 1/2 |
| x290     | 85.8             | 43.6        | 43 5/8              | 0.870           | 7/8             | 7/16                | 15.8     | 15 7/8 | 1.58 | 1 9/16                 | 2.37 | 2 7/16 | 1 1/4  |        |       |
| x262     | 77.2             | 43.3        | 43 1/4              | 0.790           | 13/16           | 7/16                | 15.8     | 15 3/4 | 1.42 | 1 7/16                 | 2.21 | 2 1/4  | 1 3/16 |        |       |
| x230     | 67.7             | 42.9        | 42 7/8              | 0.710           | 11/16           | 3/8                 | 15.8     | 15 3/4 | 1.22 | 1 1/4                  | 2.01 | 2 1/16 | 1 3/16 |        |       |

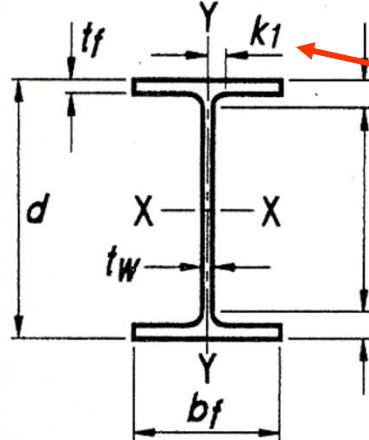
**Table 1-1.**  
**W-Shapes**  
**Dimensions**



Web thickness

Flange properties

| Shape    | Area,<br>A<br>in. <sup>2</sup> | Depth,<br>d<br>in. | Web                 |                 | Flange          |                     | Distance |        |       | Work-<br>able<br>Gage†<br>in. |       |        |        |       |
|----------|--------------------------------|--------------------|---------------------|-----------------|-----------------|---------------------|----------|--------|-------|-------------------------------|-------|--------|--------|-------|
|          |                                |                    | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Width,<br>$b_f$ | Thickness,<br>$t_f$ | $k$      | $k_1$  | T     |                               |       |        |        |       |
|          |                                |                    | in.                 | in.             | in.             | in.                 | in.      | in.    | in.   |                               |       |        |        |       |
| W44×335* | 98.3                           | 44.0               | 44                  | 1.02            | 1               | 1/2                 | 16.0     | 16     | 1 3/4 | 2.56                          | 2 5/8 | 1 5/16 | 38 3/4 | 5 1/2 |
| x290     | 85.8                           | 43.6               | 43 5/8              | 0.870           | 7/8             | 7/16                | 15.8     | 15 7/8 | 1.58  | 1 9/16                        | 2.37  | 2 7/16 | 1 1/4  |       |
| x262     | 77.2                           | 43.3               | 43 1/4              | 0.790           | 13/16           | 7/16                | 15.8     | 15 3/4 | 1.42  | 1 7/16                        | 2.21  | 2 1/4  | 1 3/16 |       |
| x230     | 67.7                           | 42.9               | 42 7/8              | 0.710           | 11/16           | 3/8                 | 15.8     | 15 3/4 | 1.22  | 1 1/4                         | 2.01  | 2 1/16 | 1 3/16 |       |



**Table 1-1.**  
**W-Shapes**  
**Dimensions**

| Shape    | Area,<br>A<br>in. <sup>2</sup> | Depth,<br>d<br>in. | Web                        |                        | Flange                 |                            | Distance   |              |          | Work-<br>able<br>Gage†<br>in. |        |        |        |       |
|----------|--------------------------------|--------------------|----------------------------|------------------------|------------------------|----------------------------|------------|--------------|----------|-------------------------------|--------|--------|--------|-------|
|          |                                |                    | Thickness,<br>$t_w$<br>in. | $\frac{t_w}{2}$<br>in. | Width,<br>$b_f$<br>in. | Thickness,<br>$t_f$<br>in. | $k$<br>in. | $k_1$<br>in. | T<br>in. |                               |        |        |        |       |
|          | in.                            | in.                | in.                        | in.                    | in.                    | in.                        | in.        | in.          | in.      | in.                           |        |        |        |       |
| W44×335* | 98.3                           | 44.0               | 44                         | 1.02                   | 1                      | 16.0                       | 16         | 1.77         | 1 3/4    | 2.56                          | 2 5/8  | 1 5/16 | 38 3/4 | 5 1/2 |
| ×290     | 85.8                           | 43.6               | 43 5/8                     | 0.870                  | 7/8                    | 15.8                       | 15 7/8     | 1.58         | 1 9/16   | 2.37                          | 2 7/16 | 1 1/4  |        |       |
| ×262     | 77.2                           | 43.3               | 43 1/4                     | 0.790                  | 13/16                  | 15.8                       | 15 3/4     | 1.42         | 1 7/16   | 2.21                          | 2 1/4  | 1 3/16 |        |       |
| ×230     | 67.7                           | 42.9               | 42 7/8                     | 0.710                  | 11/16                  | 15.8                       | 15 3/4     | 1.22         | 1 1/4    | 2.01                          | 2 1/16 | 1 3/16 |        |       |

Spacing between rows  
of bolts in flange

Second moment,  
elastic section modulus,  
radius of gyration,  
plastic section modulus  
for strong and weak axes

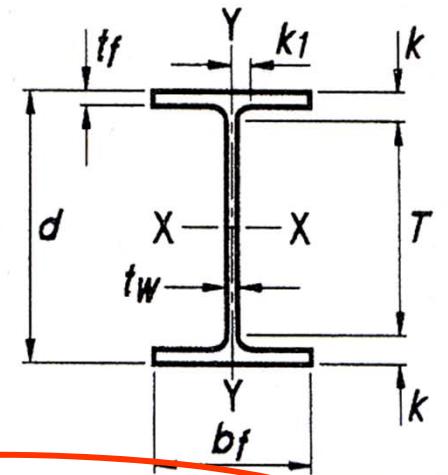
Table 1-1 (cont.).  
W-Shapes  
Properties

Weight per foot

Flange and web stability  
parameters

| Nominal Wt. | Compact Section Criteria |       |          | $X_1$ | $X_2 \times 10^6$    | Axis X-X         |                  |      |                  | Axis Y-Y         |                  |      |                  |
|-------------|--------------------------|-------|----------|-------|----------------------|------------------|------------------|------|------------------|------------------|------------------|------|------------------|
|             | $b_f$                    | $h$   | $F_y'''$ |       |                      | $I$              | $S$              | $r$  | $Z$              | $I$              | $S$              | $r$  | $Z$              |
| lb/ft       | $2t_f$                   | $t_w$ | ksi      | ksi   | (1/ksi) <sup>2</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in. <sup>3</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in. <sup>3</sup> |
| 335         | 4.51                     | 38.1  | 44.3     | 2430  | 5110                 | 31100            | 1410             | 17.8 | 1620             | 1200             | 151              | 3.50 | 236              |
| 290         | 5.01                     | 44.7  | 32.2     | 2150  | 8170                 | 27100            | 1240             | 17.8 | 1420             | 1050             | 132              | 3.49 | 206              |
| 262         | 5.55                     | 49.2  | 26.6     | 1930  | 12300                | 24200            | 1120             | 17.7 | 1270             | 927              | 118              | 3.46 | 183              |
| 230         | 6.45                     | 54.8  | 21.5     | 1690  | 21100                | 20800            | 971              | 17.5 | 1100             | 796              | 101              | 3.43 | 157              |

Used for beam strength calculations



## M-Shapes

- Not classified in ASTM 6 as W-, S- or HP- shapes
- Same properties ( $A$ ,  $d$ ,  $t_w$ ,  $b_f$ , etc) as W- shapes

## HP-Shapes

- Also known as bearing piles
- Similar to W-shapes, except their webs and flanges are of equal thickness and the depth and flange width are nominally equal for a given designation

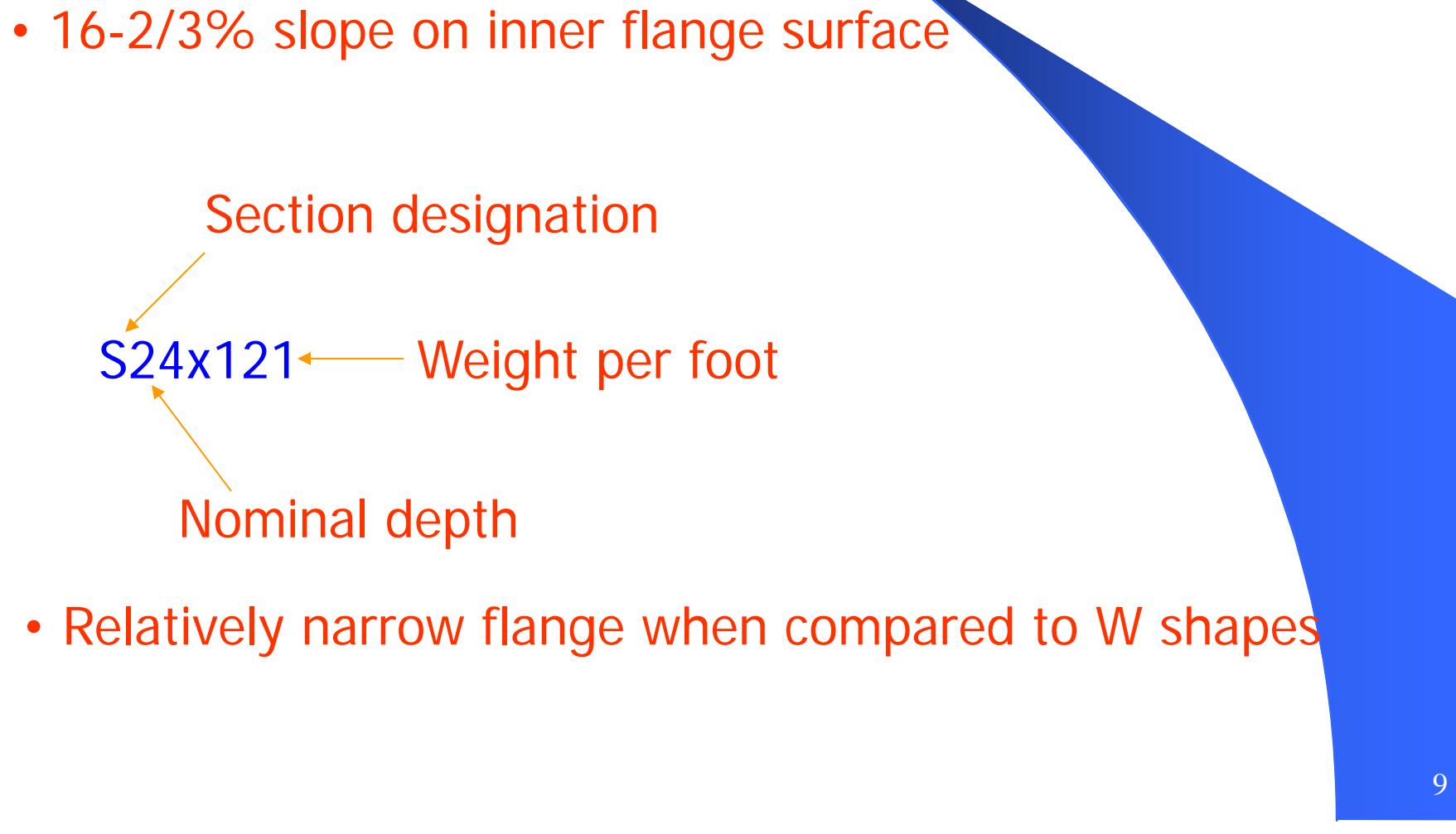
# *American Standard (S) Shapes*

---

- 16-2/3% slope on inner flange surface

Section designation  
S24x121  
Nominal depth

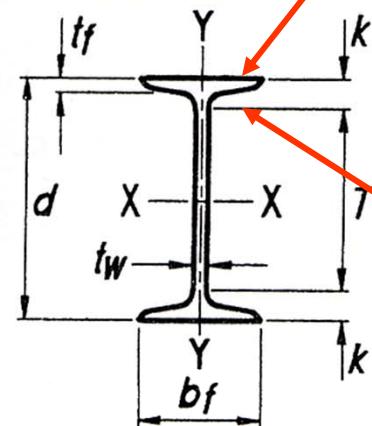
Weight per foot



- Relatively narrow flange when compared to W shapes

Narrow flange

Table 1-3.  
S-Shapes  
(American Standard Beams)  
Dimensions

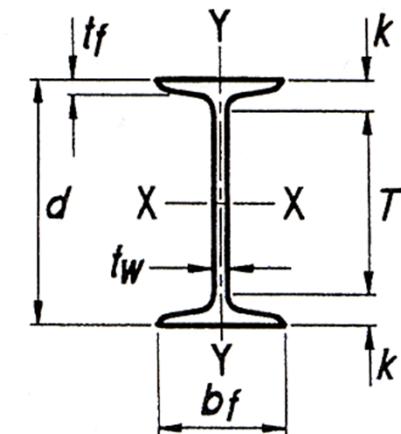


Note slope on inside of flange

| Shape           | Area,<br>$A$     | Depth,<br>$d$ | Web                 |                 | Flange          |                     |              | Distance   |                                    |                  |
|-----------------|------------------|---------------|---------------------|-----------------|-----------------|---------------------|--------------|------------|------------------------------------|------------------|
|                 |                  |               | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Width,<br>$b_f$ | Thickness,<br>$t_f$ | $k$          | $T$        | Work-<br>able<br>Gage <sup>†</sup> |                  |
|                 | in. <sup>2</sup> | in.           | in.                 | in.             | in.             | in.                 | in.          | in.        | in.                                |                  |
| S24×121<br>x106 | 35.5<br>31.1     | 24.5<br>24.5  | 24 1/2<br>24 1/2    | 0.800<br>0.620  | 13/16<br>5/8    | 7/16<br>5/16        | 8.05<br>7.87 | 8<br>7 7/8 | 1.09<br>1.09                       | 1 1/16<br>1 1/16 |
|                 |                  |               |                     |                 |                 |                     |              |            | 2                                  | 20 1/2<br>20 1/2 |
|                 |                  |               |                     |                 |                 |                     |              |            | 4                                  | 4                |

Same properties as for W shapes

**Table 1-3 (cont.).  
S-Shapes  
(American Standard Beams)  
Properties**



| Nominal Wt. | Compact Section Criteria |                 |          | $X_1$ | $X_2 \times 10^6$ | Axis X-X           |                  |                  |     | Axis Y-Y         |                  |                  |      |
|-------------|--------------------------|-----------------|----------|-------|-------------------|--------------------|------------------|------------------|-----|------------------|------------------|------------------|------|
|             | $b_f$                    | $\frac{h}{t_w}$ | $F_y'''$ |       |                   | $I$                | $S$              | $r$              | $Z$ | $I$              | $S$              | $r$              | $Z$  |
|             | lb/ft                    | $2t_f$          | $t_w$    | ksi   | ksi               | $(1/\text{ksi})^2$ | in. <sup>4</sup> | in. <sup>3</sup> | in. | in. <sup>3</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  |
| 121         | 3.69                     | 25.9            | –        | 3310  | 1770              | 3160               | 258              | 9.43             | 306 | 83.0             | 20.6             | 1.53             | 36.3 |
| 106         | 3.61                     | 33.4            | 57.8     | 2960  | 2470              | 2940               | 240              | 9.71             | 279 | 76.8             | 19.5             | 1.57             | 33.4 |

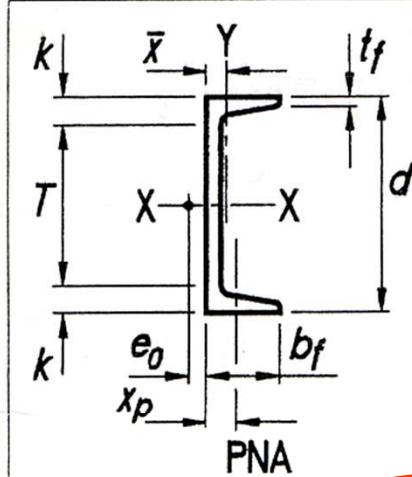
# *Channels*

---

- 16-2/3% slope on inner flange surface

Section designation  
C15x50  
Actual depth  
Weight per foot

**MC** – Miscellaneous channel – 2 on 12 slope on  
inner flange



**Table 1-5.**  
**C-Shapes**  
**(American Standard Channels)**  
**Dimensions**

Property for design

Actual depth

Property for  
detailing

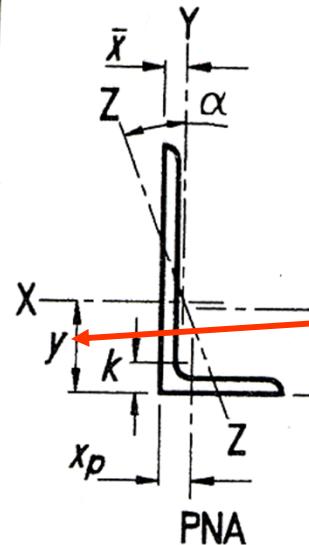
| Shape  | Area,<br>A | Depth,<br>d      |     | Web                 |                 | Flange          |                     | Distance |       |     | Work-<br>able<br>Gage <sup>†</sup> |
|--------|------------|------------------|-----|---------------------|-----------------|-----------------|---------------------|----------|-------|-----|------------------------------------|
|        |            | in. <sup>2</sup> | in. | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Width,<br>$b_f$ | Thickness,<br>$t_f$ | in.      | in.   | in. |                                    |
|        |            | in.              | in. | in.                 | in.             | in.             | in.                 | in.      | in.   | in. |                                    |
| C15×50 | 14.7       | 15.0             | 15  | 0.716               | 11/16           | 3/8             | 3.72                | 3 3/4    | 0.650 | 5/8 | 1 7/16                             |
| ×40    | 11.8       |                  |     | 0.520               | 1/2             | 1/4             | 3.52                | 3 1/2    |       |     | 12 1/8                             |
| ×33.9  | 9.95       |                  |     | 0.400               | 3/8             | 3/16            | 3.40                | 3 3/8    |       |     | 2 1/4                              |
|        |            |                  |     |                     |                 |                 |                     |          |       |     | 2                                  |
|        |            |                  |     |                     |                 |                 |                     |          |       |     | 2                                  |

# Angles

Section designation  
Short leg length  
 $L6x4x3/4$   
Thickness  
Long leg length

- Major axes do not correspond to X and Y axes

**Table 1-7.**  
**Angles**  
**(L-Shapes)**  
**Properties**



Location of plastic centroid  
 Location of elastic centroid  
 X axis properties

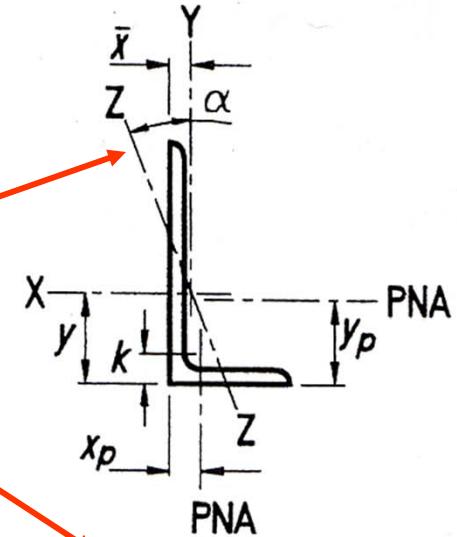
| Shape      | $k$    | Wt.   | Area,<br>$A$     | Axis X-X         |                  |      |           |                  |       |
|------------|--------|-------|------------------|------------------|------------------|------|-----------|------------------|-------|
|            |        |       |                  | $i$              | $s$              | $r$  | $\bar{y}$ | $Z$              | $y_p$ |
|            | in.    | lb/ft | in. <sup>2</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in.       | in. <sup>3</sup> | in.   |
| L8×8×1 1/8 | 1 3/4  | 57.2  | 16.8             | 98.1             | 17.5             | 2.41 | 2.40      | 31.6             | 1.05  |
| ×1         | 1 5/8  | 51.3  | 15.1             | 89.1             | 15.8             | 2.43 | 2.36      | 28.5             | 0.943 |
| ×7/8       | 1 1/2  | 45.3  | 13.3             | 79.7             | 14.0             | 2.45 | 2.31      | 25.3             | 0.832 |
| ×3/4       | 1 3/8  | 39.2  | 11.5             | 69.9             | 12.2             | 2.46 | 2.26      | 22.0             | 0.720 |
| ×5/8       | 1 1/4  | 33.0  | 9.69             | 59.6             | 10.3             | 2.48 | 2.21      | 18.6             | 0.606 |
| ×9/16      | 1 3/16 | 29.8  | 8.77             | 54.2             | 9.33             | 2.49 | 2.19      | 16.8             | 0.548 |
| ×1/2       | 1 1/8  | 26.7  | 7.84             | 48.8             | 8.36             | 2.49 | 2.17      | 15.1             | 0.490 |

Designation

Table 1-7 (cont.).  
 Angles  
 (L-Shapes)  
 Properties

Minor (weak) axis

Y axis properties



| Shape      | Axis Y-Y                |                         |            |                  |                         |              | Axis Z-Z   |                 | $Q_s^*$<br>$F_y = 36$<br>ksi |
|------------|-------------------------|-------------------------|------------|------------------|-------------------------|--------------|------------|-----------------|------------------------------|
|            | $I$<br>in. <sup>4</sup> | $S$<br>in. <sup>3</sup> | $r$<br>in. | $\bar{x}$<br>in. | $Z$<br>in. <sup>3</sup> | $x_p$<br>in. | $r$<br>in. | Tan<br>$\alpha$ |                              |
| L8×8×1 1/8 | 98.1                    | 17.5                    | 2.41       | 2.40             | 31.6                    | 1.05         | 1.56       | 1.00            | -                            |
| x 1        | 89.1                    | 15.8                    | 2.43       | 2.36             | 28.5                    | 0.943        | 1.56       | 1.00            | -                            |
| x 7/8      | 79.7                    | 14.0                    | 2.45       | 2.31             | 25.3                    | 0.832        | 1.57       | 1.00            | -                            |
| x 3/4      | 69.9                    | 12.2                    | 2.46       | 2.26             | 22.0                    | 0.720        | 1.57       | 1.00            | -                            |
| x 5/8      | 59.6                    | 10.3                    | 2.48       | 2.21             | 18.6                    | 0.606        | 1.58       | 1.00            | 0.997                        |
| x 9/16     | 54.2                    | 9.33                    | 2.49       | 2.19             | 16.8                    | 0.548        | 1.58       | 1.00            | 0.959                        |
| x 1/2      | 48.8                    | 8.36                    | 2.49       | 2.17             | 15.1                    | 0.490        | 1.59       | 1.00            | 0.912                        |

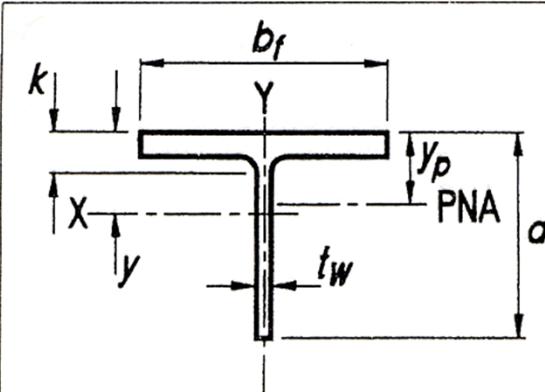
# Tees

---

- WT – cut from W shape

WT22x131 is cut from W44x262

- ST – cut from S shape
- MT – cut from M shape

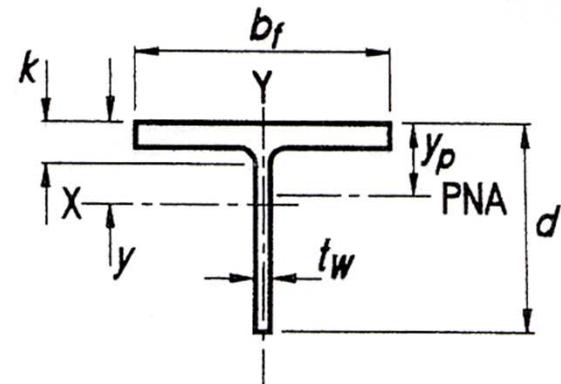


**Table 1-8.**  
**WT-Shapes**  
**(Structural Tees Split  
from W-Shapes)**  
**Dimensions**

Stem, not web

| Shape       | Area,<br>A | Depth of<br>Tee,<br>d | Stem                |                 |       | Flange          |                     |      |        | Distance |                                    |      |
|-------------|------------|-----------------------|---------------------|-----------------|-------|-----------------|---------------------|------|--------|----------|------------------------------------|------|
|             |            |                       | Thickness,<br>$t_w$ | $\frac{t_w}{2}$ | Area  | Width,<br>$b_f$ | Thickness,<br>$t_f$ |      |        | k        | Work-<br>able<br>Gage <sup>†</sup> |      |
|             |            |                       | in. <sup>2</sup>    | in.             | in.   | in.             | in.                 | in.  | in.    | in.      | in.                                |      |
| WT22×167.5* | 49.1       | 22.0                  | 22                  | 1.02            | 1     | 1/2             | 22.5                | 16.0 | 16     | 1.77     | 1 3/4                              | 2.56 |
| ×145        | 42.9       | 21.8                  | 21 3/4              | 0.870           | 7/8   | 7/16            | 19.0                | 15.8 | 15 7/8 | 1.58     | 1 9/16                             | 2.37 |
| ×131        | 38.6       | 21.7                  | 21 5/8              | 0.790           | 13/16 | 7/16            | 17.1                | 15.8 | 15 3/4 | 1.42     | 1 7/16                             | 2.21 |
| ×115        | 33.8       | 21.5                  | 21 1/2              | 0.710           | 11/16 | 3/8             | 15.2                | 15.8 | 15 3/4 | 1.22     | 1 1/4                              | 2.01 |

**Table 1-8 (cont.).**  
**WT-Shapes**  
**(Structural Tees Split**  
**from W-Shapes)**  
**Properties**



| Nominal Wt. | $\frac{h}{t_w}$ | Axis X-X         |                  |      |           |                  |       | Axis Y-Y         |                  |      |                  | $Q_s^{**}$             |
|-------------|-----------------|------------------|------------------|------|-----------|------------------|-------|------------------|------------------|------|------------------|------------------------|
|             |                 | $I$              | $S$              | $r$  | $\bar{y}$ | $Z$              | $y_p$ | $I$              | $S$              | $r$  | $Z$              |                        |
| lb/ft       |                 | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in.       | in. <sup>3</sup> | in.   | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in. <sup>3</sup> | $F_y = 50 \text{ ksi}$ |
| 167.5       | 19.1            | 2160             | 131              | 6.63 | 5.51      | 233              | 1.54  | 600              | 75.3             | 3.50 | 118              | 0.817                  |
| 145         | 22.3            | 1840             | 111              | 6.55 | 5.27      | 197              | 1.35  | 523              | 66.1             | 3.49 | 103              | 0.636                  |
| 131         | 24.6            | 1650             | 100              | 6.53 | 5.20      | 177              | 1.23  | 463              | 58.8             | 3.46 | 91.3             | 0.532                  |
| 115         | 27.4            | 1440             | 88.6             | 6.53 | 5.17      | 157              | 1.07  | 398              | 50.5             | 3.43 | 78.3             | 0.438                  |

Reduction factor for  
slender stiffened  
compression elements

# ***Hollow Structural Shapes (HSS)***

---

- Rectangular (or square)
- Round

## **Steel Pipe**

Pipe diameter (Std., X-Strong, XX-Strong)

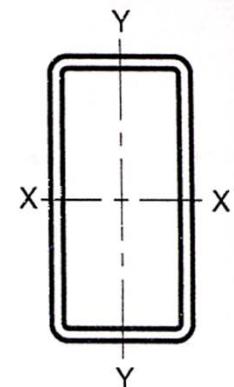
For example, Pipe 5 Std.

**Table 1-11.**  
**Rectangular (and Square) HSS**  
**Dimensions and Properties**

| Shape    | Wall Thickness,<br><i>t</i> |        | Nom-<br>inal<br>Wt. | Area,<br><i>A</i> | $\frac{b}{t}$ | $\frac{h}{t}$ | Axis X-X         |                  |          |                  |
|----------|-----------------------------|--------|---------------------|-------------------|---------------|---------------|------------------|------------------|----------|------------------|
|          | nominal                     | design |                     |                   |               |               | <i>I</i>         | <i>S</i>         | <i>r</i> | <i>Z</i>         |
|          | in.                         | in.    |                     |                   |               |               | in. <sup>4</sup> | in. <sup>3</sup> | in.      | in. <sup>3</sup> |
| HSS20×12 | 5/8                         | 0.581  | 127                 | 35.0              | 17.7          | 31.4          | 1880             | 188              | 7.33     | 230              |
|          | 1/2                         | 0.465  | 103                 | 28.3              | 22.8          | 40.0          | 1550             | 155              | 7.39     | 188              |
|          | 3/8                         | 0.349  | 78.4                | 21.5              | 31.4          | 54.3          | 1200             | 120              | 7.45     | 144              |
|          | 5/16                        | 0.291  | 65.8                | 18.1              | 38.2          | 65.7          | 1010             | 101              | 7.48     | 122              |

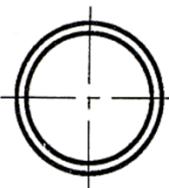
# Hollow Structural Shapes (HSS)

| Shape    | Wall Thickness,<br>$t$ |        | Axis Y-Y       |                |      |                | Torsion        |                | Surface<br>Area Per<br>Foot<br>$\text{ft}^2$ |
|----------|------------------------|--------|----------------|----------------|------|----------------|----------------|----------------|--|
|          | nominal                | design | $I$            | $S$            | $r$  | $Z$            | $J$            | $C$            |  |
|          | in.                    | in.    | $\text{in.}^4$ | $\text{in.}^3$ | in.  | $\text{in.}^3$ | $\text{in.}^4$ | $\text{in.}^3$ |  |
| HSS20x12 | $\frac{5}{8}$          | 0.581  | 851            | 142            | 4.93 | 162            | 1890           | 257            | 5.17   |
|          | $\frac{1}{2}$          | 0.465  | 705            | 117            | 4.99 | 132            | 1540           | 209            | 5.20   |
|          | $\frac{3}{8}$          | 0.349  | 547            | 91.1           | 5.04 | 102            | 1180           | 160            | 5.23   |
|          | $\frac{5}{16}$         | 0.291  | 464            | 77.3           | 5.07 | 85.8           | 997            | 134            | 5.25   |



Diameter over design thickness

Nominal versus  
design thickness



| Shape     | Table 1-12.<br>Round HSS<br>Dimensions and Properties |                |                     |                  |               |                  |                  |              |                  |                  | Surf.<br>Area<br>Per Ft |                 |
|-----------|---|----------------|---------------------|------------------|---------------|------------------|------------------|--------------|------------------|------------------|-------------------------|-----------------|
|           | Wall Thickness,<br>$t$                                |                | Nom-<br>inal<br>Wt. | Area,<br>$A$     | $\frac{D}{t}$ | $I$              | $S$              | $r$          | $Z$              | Torsion          |                         |                 |
|           | nominal   | design         |                     |                  |               |                  |                  |              |                  | $J$              | $C$                     |                 |
|           | in.   | in.            | lb/ft               | in. <sup>2</sup> |               | in. <sup>4</sup> | in. <sup>3</sup> | in.          | in. <sup>3</sup> | in. <sup>4</sup> | in. <sup>3</sup>        | ft <sup>2</sup> |
| HSS20.000 | 0.500<br>0.375  | 0.465<br>0.349 | 104<br>78.7         | 28.5<br>21.5     | 43.0<br>57.3  | 1360<br>1040     | 136<br>104       | 6.91<br>6.95 | 177<br>135       | 2720<br>2080     | 272<br>208              | 5.24<br>5.24    |

# ***Double Angles***

---

2L6x4x3/4

- Major axes are now x and y
- X axis properties may be obtained from x axis properties of single angle
- Y axis properties depend on separation between backs angles and whether LLBB or SLBB

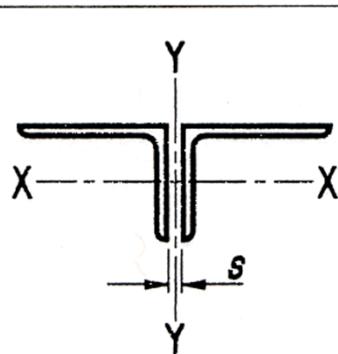
## Equal leg angles

Long legs back-to-back

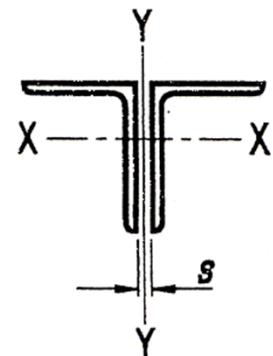
Short legs back-to-back

| Shape       | Axis Y-Y<br>Radii of Gyration |       |       |                      |       |       | $Q_s^*$           |                  |                   |                  |
|-------------|-------------------------------|-------|-------|----------------------|-------|-------|-------------------|------------------|-------------------|------------------|
|             | LLBB                          |       |       | SLBB                 |       |       | LLBB              |                  | SLBB              |                  |
|             | Separation $s$ , in.          |       |       | Separation $s$ , in. |       |       | Angles in Contact | Angles Separated | Angles in Contact | Angles Separated |
|             | 0                             | $3/8$ | $3/4$ | 0                    | $3/8$ | $3/4$ |                   |                  |                   |                  |
| 2L8×8×1 1/8 | 3.41                          | 3.54  | 3.68  | 3.41                 | 3.54  | 3.68  | —                 | —                | —                 | —                |
| x1          | 3.39                          | 3.52  | 3.66  | 3.39                 | 3.52  | 3.66  | —                 | —                | —                 | —                |
| x7/8        | 3.36                          | 3.50  | 3.63  | 3.36                 | 3.50  | 3.63  | —                 | —                | —                 | —                |
| x3/4        | 3.34                          | 3.47  | 3.61  | 3.34                 | 3.47  | 3.61  | —                 | —                | —                 | —                |
| x5/8        | 3.32                          | 3.45  | 3.58  | 3.32                 | 3.45  | 3.58  | —                 | 0.997            | —                 | 0.997            |
| x9/16       | 3.31                          | 3.44  | 3.57  | 3.31                 | 3.44  | 3.57  | —                 | 0.959            | —                 | 0.959            |
| x1/2        | 3.30                          | 3.43  | 3.56  | 3.30                 | 3.43  | 3.56  | 0.998             | 0.912            | 0.998             | 0.912            |

# Unequal leg angles



**Table 1-14 (cont.).  
Double Angles  
(2L-Shapes)  
Properties**



| Shape         | Axis Y-Y             |      |       |       |                      |      | $Q_s^*$ |       |                   |                  |
|---------------|----------------------|------|-------|-------|----------------------|------|---------|-------|-------------------|------------------|
|               | Radii of Gyration    |      |       |       |                      |      |         |       |                   |                  |
|               | LLBB                 |      |       | SLBB  |                      |      | LLBB    |       | SLBB              |                  |
|               | Separation $s$ , in. | 0    | $3/8$ | $3/4$ | Separation $s$ , in. | 0    | $3/8$   | $3/4$ | Angles in Contact | Angles Separated |
| 2L5×3 1/2×3/4 | 1.39                 | 1.53 | 1.68  | 2.33  | 2.47                 | 2.62 | —       | —     | —                 | —                |
| $\times 5/8$  | 1.37                 | 1.50 | 1.65  | 2.30  | 2.45                 | 2.59 | —       | —     | —                 | —                |
| $\times 1/2$  | 1.35                 | 1.48 | 1.62  | 2.28  | 2.42                 | 2.57 | —       | —     | —                 | —                |
| $\times 3/8$  | 1.33                 | 1.46 | 1.59  | 2.26  | 2.39                 | 2.54 | —       | 0.983 | —                 | 0.983            |
| $\times 5/16$ | 1.32                 | 1.44 | 1.58  | 2.25  | 2.38                 | 2.52 | —       | 0.912 | 0.998             | 0.912            |
| $\times 1/4$  | 1.31                 | 1.43 | 1.57  | 2.23  | 2.37                 | 2.51 | —       | 0.804 | 0.894             | 0.804            |

## ***Double Channels***

---

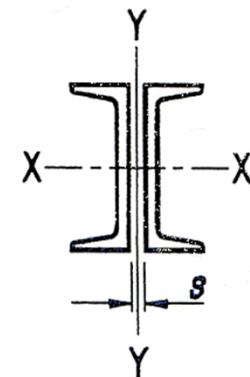
- Designated as 2C or 2MC

2C15x50

- Y axis properties depend on back-to-back separation
- X axis properties can be obtained from x axis properties of single channel

Y axis properties depend  
on back-to-back  
distance between  
individual channels

Table 1-15.  
2C-Shapes  
(Double Channels)  
Properties



| Shape   | Axis Y-Y          |                  |      |                  |                  |                  |      |                  |                  |                  |      |                  |
|---------|-------------------|------------------|------|------------------|------------------|------------------|------|------------------|------------------|------------------|------|------------------|
|         | Separation s, in. |                  |      |                  |                  |                  |      |                  |                  |                  |      |                  |
|         | 0                 |                  |      |                  | 3/8              |                  |      |                  | 3/4              |                  |      |                  |
|         | I                 | S                | r    | Z                | I                | S                | r    | Z                | I                | S                | r    | Z                |
|         | in. <sup>4</sup>  | in. <sup>3</sup> | in.  | in. <sup>3</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in. <sup>3</sup> | in. <sup>4</sup> | in. <sup>3</sup> | in.  | in. <sup>3</sup> |
| 2C15x50 | 40.7              | 11.0             | 1.18 | 30.7             | 50.5             | 12.9             | 1.31 | 36.2             | 62.4             | 15.3             | 1.46 | 41.7             |
| x40     | 32.6              | 9.25             | 1.18 | 22.9             | 40.2             | 10.9             | 1.31 | 27.3             | 49.6             | 12.7             | 1.45 | 31.7             |
| x33.9   | 28.5              | 8.38             | 1.20 | 19.0             | 35.1             | 9.78             | 1.33 | 22.7             | 43.1             | 11.4             | 1.47 | 26.4             |

$$\frac{VQ}{Ib}$$



**Table 1-25.**  
**W-Shapes**  
**Torsional Properties**

| Shape    | Torsional Constant, $J$<br>in. <sup>4</sup> | Warping Constant, $C_w$<br>in. <sup>6</sup> | $\sqrt{\frac{EC_w}{GJ}}$<br>in. | Normalized Warping Constant, $W_{ho}$<br>in. <sup>2</sup> | Warping Statical Moment, $S_w$<br>in. <sup>4</sup> | Statical Moment           |                           |
|----------|---|---|---------------------------------|---|--|---------------------------|---------------------------|
|          |   |   |                                 |   |  | $Q_f$<br>in. <sup>3</sup> | $Q_w$<br>in. <sup>3</sup> |
| W44×335* | 74.4  | 536000                                      | 137                             | 168   | 1190   | 279                       | 805                       |
| ×290     | 51.5  | 464000                                      | 153                             | 166   | 1040   | 248                       | 704                       |
| ×262     | 37.7  | 407000                                      | 167                             | 165   | 922  | 222                       | 630                       |
| ×230     | 24.9  | 346000                                      | 190                             | 164   | 789  | 191                       | 546                       |

# Table 2-4

## Applicable ASTM Specifications /Shapes

▼ Table 1

| Steel Type                                  | ASTM Designation  | $F_y$ Min. Yield Stress (ksi) | $F_u$ Tensile Stress <sup>a</sup> (ksi) | Applicable Shape Series |   |   |    |   |    |   |  | HSS<br>Rect. | HSS<br>Round | Pipe |
|---|-------------------|-------------------------------|---|-------------------------|---|---|----|---|----|---|--|--------------|--------------|------|
|   |                   |                               |   | W                       | M | S | HP | C | MC | L |  |              |              |      |
|   |                   |                               |   |                         |   |   |    |   |    |   |  |              |              |      |
| Carbon                                      | A36               | 36                            | 58–80 <sup>b</sup>                      |                         |   |   |    |   |    |   |  |              |              |      |
|   | A53 Gr. B         | 35                            | 60                                      |                         |   |   |    |   |    |   |  |              |              |      |
|   | A500              | Gr. B                         | 42                                      | 58                      |   |   |    |   |    |   |  |              |              |      |
|   |                   |                               | 46                                      | 58                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. C                         | 46                                      | 62                      |   |   |    |   |    |   |  |              |              |      |
|   |                   |                               | 50                                      | 62                      |   |   |    |   |    |   |  |              |              |      |
|   | A501              | Gr. A                         | 36                                      | 58                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. B                         | 50                                      | 70                      |   |   |    |   |    |   |  |              |              |      |
|   | A529 <sup>c</sup> | Gr. 50                        | 50                                      | 65–100                  |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. 55                        | 55                                      | 70–100                  |   |   |    |   |    |   |  |              |              |      |
| High-Strength Low-Alloy                     | A572              | Gr. 42                        | 42                                      | 60                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. 50                        | 50                                      | 65 <sup>d</sup>         |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. 55                        | 55                                      | 70                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. 60 <sup>e</sup>           | 60                                      | 75                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. 65 <sup>e</sup>           | 65                                      | 80                      |   |   |    |   |    |   |  |              |              |      |
|   | A618 <sup>f</sup> | Gr. I & II                    | 50 <sup>g</sup>                         | 70 <sup>g</sup>         |   |   |    |   |    |   |  |              |              |      |
|   |                   | Gr. III                       | 50                                      | 65                      |   |   |    |   |    |   |  |              |              |      |
|   | A913              | 50                            | 50 <sup>h</sup>                         | 60 <sup>h</sup>         |   |   |    |   |    |   |  |              |              |      |
|   |                   | 60                            | 60                                      | 75                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | 65                            | 65                                      | 80                      |   |   |    |   |    |   |  |              |              |      |
|   |                   | 70                            | 70                                      | 90                      |   |   |    |   |    |   |  |              |              |      |
|   | A992              | 50–65 <sup>i</sup>            | 65 <sup>i</sup>                         |                         |   |   |    |   |    |   |  |              |              |      |
| Corrosion Resistant High-Strength Low-Alloy | A242              | 42 <sup>j</sup>               | 63 <sup>j</sup>                         |                         |   |   |    |   |    |   |  |              |              |      |
|   |                   | 46 <sup>k</sup>               | 67 <sup>k</sup>                         |                         |   |   |    |   |    |   |  |              |              |      |
|   |                   | 50 <sup>l</sup>               | 70 <sup>l</sup>                         |                         |   |   |    |   |    |   |  |              |              |      |
|   | A588              | 50                            | 70                                      |                         |   |   |    |   |    |   |  |              |              |      |
|   | A847              | 50                            | 70                                      |                         |   |   |    |   |    |   |  |              |              |      |

■ Preferred material specification.

■ Other applicable material specification, the availability of which should be confirmed prior to specification.

# Table 2-6

## Applicable ASTM Specifications /Fasteners

Table 3

| Applicable ASTM Specifications for Various Types of Structural Fasteners |                                     |                                    |                         |                     |                         |               |              |                 |               |
|--|-------------------------------------|------------------------------------|-------------------------|---------------------|-------------------------|---------------|--------------|-----------------|---------------|
| ASTM Designation   | $F_y$<br>Min. Yield Stress<br>(ksi) | $F_u$<br>Tensile Strength<br>(ksi) | Diameter Range<br>(in.) | High-Strength Bolts | Shear-Shear Connections |               | Anchor Bolts | Threaded & Nuts | Headed Hooked |
|  |                                     |                                    |                         |                     | Common Bolts            | Machine Bolts |              |                 |               |
| A108   | —                                   | 50                                 | 0.375 to 0.75 incl.     |                     |                         |               |              |                 |               |
| A325 <sup>a</sup>  | —                                   | 105                                | over 1 to 1.5 incl.     |                     |                         |               |              |                 |               |
|  | —                                   | 120                                | 0.5 to 1 incl.          |                     |                         |               |              |                 |               |
| A490 <sup>a</sup>  | —                                   | 150                                | 0.5 to 1.5              |                     |                         |               |              |                 |               |
| F1852 <sup>a,b</sup>   | —                                   | 105                                | 1.125                   |                     |                         |               |              |                 |               |
|  | —                                   | 120                                | 0.5 to 1 incl.          |                     |                         |               |              |                 |               |
| F2280 <sup>a</sup>   | —                                   | 150                                | 0.5 to 1.125 incl.      |                     |                         |               |              |                 |               |
| A194 Gr. 2H  | —                                   | —                                  | 0.25 to 4               |                     |                         |               |              |                 |               |
| A543   | —                                   | —                                  | 0.25 to 4               |                     |                         |               |              |                 |               |
| F436 <sup>b</sup>  | —                                   | —                                  | 0.25 to 4               |                     |                         |               |              |                 |               |
| F959   | —                                   | —                                  | 0.5 to 1.5              |                     |                         |               |              |                 |               |
| A36  | 36                                  | 58-80                              | to 10                   |                     |                         |               |              |                 |               |
| A193 Gr. B7 <sup>c</sup>   | —                                   | 100                                | over 4 to 7             |                     |                         |               |              |                 |               |
|  | —                                   | 115                                | over 2.5 to 4           |                     |                         |               |              |                 |               |
|  | —                                   | 125                                | 2.5 and under           |                     |                         |               |              |                 |               |
| A307 Gr. A   | —                                   | 60                                 | 0.25 to 4               |                     |                         |               |              |                 |               |
| A354 Gr. BD  | —                                   | 140                                | 2.5 to 4 incl.          |                     |                         |               |              |                 |               |
|  | —                                   | 150                                | 0.25 to 2.5 incl.       |                     |                         |               |              |                 |               |
| A449   | —                                   | 90                                 | 1.75 to 3 incl.         |                     |                         |               |              |                 |               |
|  | —                                   | 105                                | 1.125 to 1.5 incl.      |                     |                         |               |              |                 |               |
|  | —                                   | 120                                | 0.25 to 1 incl.         |                     |                         |               |              |                 |               |
| A572   | Gr. 42                              | 42                                 | 60                      |                     |                         |               |              |                 |               |
|  | Gr. 50                              | 50                                 | 65                      |                     |                         |               |              |                 |               |
|  | Gr. 55                              | 55                                 | 70                      |                     |                         |               |              |                 |               |
|  | Gr. 60                              | 60                                 | 75                      |                     |                         |               |              |                 |               |
|  | Gr. 65                              | 65                                 | 80                      |                     |                         |               |              |                 |               |
| A588   | —                                   | 42                                 | 63                      |                     |                         |               |              |                 |               |
|  | —                                   | 46                                 | 67                      |                     |                         |               |              |                 |               |
|  | —                                   | 50                                 | 70                      |                     |                         |               |              |                 |               |
| A687   | 105                                 | 150 max.                           | 0.625 to 3              |                     |                         |               |              |                 |               |
| F1554  | Gr. 36                              | 36                                 | 58-80                   |                     |                         |               |              |                 |               |
|  | Gr. 55                              | 55                                 | 75-95                   |                     |                         |               |              |                 |               |
|  | Gr. 105                             | 105                                | 125-150                 |                     |                         |               |              |                 |               |