steelwise

A new standard for HSS.

# HOLLOW PRODUCT, SOLID BENEFIT

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**THIS PAST APRIL,** ASTM International published a new material standard for the production of hollow structural sections (HSS).

The specification, ASTM A1085-13, is the culmination of six-plus years of work by the AISC HSS Marketing Committee, and the impetus for its creation was a list of desired improvements to the requirements in ASTM A500—e.g., designers have long asked for an elimination of the wall thickness reduction factor required for ASTM A500 to allow for simpler design calculations, as well as suitability for use in fatigue applications and better control of $F_y$ and $F_u$ for seismic overstrength. ASTM A1085 delivers on these wishes and more and contains several differences from ASTM A500.

## Tighter Material Tolerances

For starters, ASTM A500 permits wall thickness to be as much as 10% less than the specified nominal thickness compared to a 2.5% variation permitted in wide-flange shapes. To account for this larger variation, AISC *Specification* Section B4.2 requires that the design wall thickness must be taken as 93% of the nominal wall thickness. This affects both member and connection design; the latter can have a significant reduction when the thickness term is squared or cubed.

ASTM A1085 provides two controls on cross section that do not exist or are more lenient in ASTM A500: The wall thickness must be no more than 5% under nominal and the mass must be no more than 3.5% under nominal. In most situations, the latter requirement will ultimately dictate the wall thickness. Regardless, the permitted variation of ASTM 1085 HSS is similar to that for wide-flange shapes. Accordingly, the AISC Committee on Specifications is in the process of developing provisions that we expect will allow the unreduced wall thickness to be used for design of ASTM 1085 HSS. Citing a 2011 report on HSS wall thickness variations ("Characterizing Dimensional Variability in HSS Members," prepared for AISC by C.M. Foley and A. Marquez of Marquette University), the task committee responsible for Chapter B has agreed to draft language permitting the use of the nominal wall thickness as the design wall thickness when using A1085.

Additionally:

- For the first time in an HSS specification, a minimum corner radius for square and rectangular HSS is specified. There are two ranges for acceptable corner radii, depending on the thickness of the shape. The ranges specified will serve to reduce variances outside of normal practice. Radii that are too tight can be susceptible to corner cracking, particularly during the hot-dip galvanizing process. Conversely, when radii are too large, the HSS begins to take on a rounder appearance and may not produce the desired aesthetic effect.
- ASTM A1085 is applicable for HSS up to an 88-in. periphery and wall thicknesses ranging between 0.148 in. and ⅞ in. Savvy designers will notice that this precludes the production of material with ⅛-in. wall thickness. This limitation is a result of the CVN testing process, which cannot be performed on material thinner than the lower limit.

## Yield and Tensile Strengths

For simplicity, ASTM A1085, round, square and rectangular HSS are all made in a single grade and all have the same minimum specified yield strength: 50 ksi. The minimum specified tensile strength is 65 ksi. This will simplify calculations because engineers no longer need to select from (or remember!) different yield strengths for varying grades and shapes of HSS.

ASTM A1085 is the only HSS material specification in

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North America or Europe to place an upper limit on yield strength. All shapes are made with an upper yield strength limit of 70 ksi, which is of benefit in seismic design when the HSS is used as the ductile member.

The coefficients $R_y$ and $R_t$ are used in the AISC *Seismic Provisions* to determine the expected yield and tensile strengths. The available coefficients for other materials are derived from historic production data, which is in the process of being established for ASTM A1085. Data collection is taking place now as this product is now being produced, and the coefficients will be determined.

### Standard Charpy V-Notch (CVN) Requirement

ASTM 1085 provides a defined level of material toughness: 25 ft-lbs at 40°F. This corresponds to the AASHTO fracture critical requirements in Zone 2, which encompasses most of the U.S. When a more stringent toughness is required in other zones, the specifier has the option to request a custom CVN value through supplementary requirement.

### Material Chemistry

ASTM A1085's material chemistry is slightly different:

- Copper provisions of A500 were not used in ASTM A1085 to reflect current steel production practices
- Aluminum content is specified to ensure the steel is killed (oxygen is chemically bound with aluminum to improve steel soundness and facilitate production)
- Silicon content is limited to improve uniformity of coating when HSS are galvanized
- A maximum carbon equivalent limit is specified to improve weldability

### Using ASTM A1085

With approval of the authority having jurisdiction, ASTM A1085 is being produced and can now be specified. Domestic producers have stated their commitment to producing HSS in ASTM A1085 and making it available; see the producer survey and other online resources available at **www.aisc.org/A1085**. Steel service centers also are coordinating with producers. Engineers should discuss with their steel fabricators the use of ASTM A1085.

- Section properties based upon the nominal wall thickness are available. Tables 1-3 show excerpts for square, rectangular and round ASTM A1085 HSS. These tables are modeled after Tables 1-11 through 1-13 in the AISC *Steel Construction Manual*. You will notice that the design wall thickness is equal to the nominal

Table 1: Typical Dimensions and Section Properties for A1085 Square HSS

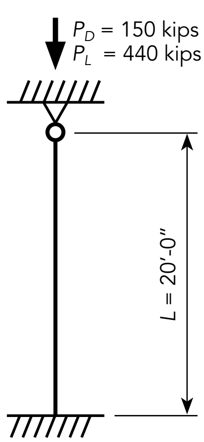
| Shape | Design Wall Thickness, *t* | Nominal *Wt* | Area, A | *b/t* | *h/t* | *I* | *S* | *r* | *Z* | Torsion *J* | Torsion *C* | Surface Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in. | lb/ft | in.$^2$ | | | in.$^4$ | in.$^3$ | in. | in.$^3$ | in.$^4$ | in.$^3$ | ft$^2$/ft |
| HSS10×10×¾ | 0.750 | 89.50 | 26.3 | 9.73 | 9.7 | 364 | 72.8 | 3.72 | 89.4 | 610 | 127 | 3.12 |
| ×⅝ | 0.625 | 76.33 | 22.4 | 12.4 | 12.4 | 321 | 64.2 | 3.79 | 77.6 | 529 | 109 | 3.15 |
| ×½ | 0.500 | 62.46 | 18.4 | 16.4 | 16.4 | 271 | 54.2 | 3.84 | 64.6 | 439 | 89.8 | 3.19 |
| ×⅜ | 0.375 | 47.90 | 14.1 | 23.5 | 23.5 | 214 | 42.8 | 3.90 | 50.4 | 341 | 69.3 | 3.23 |
| ×5/16 | 0.313 | 40.35 | 11.9 | 28.7 | 28.7 | 184 | 36.8 | 3.93 | 42.8 | 289 | 58.6 | 3.24 |
| ×¼ | 0.250 | 32.63 | 9.59 | 36.8 | 36.8 | 151 | 30.2 | 3.97 | 34.9 | 235 | 47.5 | 3.26 |
| ×3/16 | 0.188 | 24.73 | 7.29 | 50.0 | 50.0 | 116 | 23.2 | 3.99 | 26.7 | 180 | 36.2 | 3.28 |
| HSS9×9×⅝ | 0.625 | 67.82 | 19.9 | 10.8 | 10.8 | 227 | 50.4 | 3.38 | 61.5 | 377 | 86.7 | 2.82 |
| ×½ | 0.500 | 55.66 | 16.4 | 14.4 | 14.4 | 193 | 42.9 | 3.43 | 51.4 | 315 | 71.8 | 2.86 |
| ×⅜ | 0.375 | 42.79 | 12.6 | 20.8 | 20.8 | 154 | 34.2 | 3.50 | 40.3 | 246 | 55.6 | 2.89 |
| ×5/16 | 0.313 | 36.10 | 10.6 | 25.6 | 25.6 | 132 | 29.3 | 3.53 | 34.3 | 209 | 47.1 | 2.91 |
| ×¼ | 0.250 | 29.23 | 8.59 | 32.8 | 32.8 | 109 | 24.2 | 3.56 | 28.0 | 170 | 38.2 | 2.93 |
| ×3/16 | 0.188 | 22.18 | 6.54 | 44.7 | 44.7 | 84.0 | 18.7 | 3.58 | 21.5 | 130 | 29.2 | 2.95 |
| HSS8×8×⅝ | 0.625 | 59.32 | 17.4 | 9.20 | 9.20 | 153 | 38.2 | 2.97 | 47.2 | 258 | 67.0 | 2.49 |
| ×½ | 0.500 | 48.85 | 14.4 | 12.4 | 12.4 | 131 | 32.8 | 3.02 | 39.7 | 217 | 55.8 | 2.52 |
| ×⅜ | 0.375 | 37.69 | 11.1 | 18.1 | 18.1 | 106 | 26.5 | 3.09 | 31.3 | 170 | 43.4 | 2.56 |
| ×5/16 | 0.313 | 31.84 | 9.37 | 22.4 | 22.4 | 91.0 | 22.8 | 3.12 | 26.8 | 145 | 36.9 | 2.58 |
| ×¼ | 0.250 | 25.82 | 7.59 | 28.8 | 28.8 | 75.2 | 18.8 | 3.15 | 21.9 | 118 | 30.0 | 2.60 |
| ×3/16 | 0.188 | 19.63 | 5.78 | 39.4 | 39.4 | 58.4 | 14.6 | 3.18 | 16.9 | 90.8 | 22.9 | 2.61 |
| HSS7×7×⅝ | 0.625 | 50.81 | 14.9 | 7.60 | 7.60 | 97.6 | 27.9 | 2.56 | 34.8 | 166 | 49.9 | 2.15 |
| ×½ | 0.500 | 42.05 | 12.4 | 10.4 | 10.4 | 84.7 | 24.2 | 2.61 | 29.6 | 141 | 41.8 | 2.19 |
| ×⅜ | 0.375 | 32.58 | 9.58 | 15.5 | 15.5 | 68.7 | 19.6 | 2.68 | 23.5 | 112 | 32.7 | 2.23 |
| ×5/16 | 0.313 | 27.59 | 8.12 | 19.2 | 19.2 | 59.6 | 17.0 | 2.71 | 20.1 | 95.7 | 27.9 | 2.24 |
| ×¼ | 0.250 | 22.42 | 6.59 | 24.8 | 24.8 | 49.4 | 14.1 | 2.74 | 16.5 | 78.3 | 22.7 | 2.26 |
| ×3/16 | 0.188 | 17.08 | 5.03 | 34.0 | 34.0 | 38.6 | 11.0 | 2.77 | 12.8 | 60.3 | 17.4 | 2.28 |

Table 2: Typical Dimensions and Section Properties for A1085 Rectangular HSS

| Shape | Design Wall Thickness, *t* | Nominal *Wt* | Area, *A* | *b/t* | *h/t* | Axis X-X | | | | Axis Y-Y | | | | Torsion | | Surface Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *I* | *S* | *r* | *Z* | *I* | *S* | *r* | *Z* | *J* | *C* | |
| | in. | lb/ft | $in.^2$ | | | $in.^4$ | $in.^3$ | in. | $in.^3$ | $in.^4$ | $in.^3$ | in. | $in.^3$ | $in.^4$ | $in.^3$ | $ft^2/ft$ |
| HSS14×10×5/8 | 0.625 | 93.34 | 27.4 | 12.4 | 18.8 | 728 | 104 | 5.15 | 127 | 431 | 86.2 | 3.97 | 101 | 885 | 156 | 3.82 |
| ×1/2 | 0.500 | 76.07 | 22.4 | 16.4 | 24.4 | 608 | 86.9 | 5.21 | 105 | 361 | 72.2 | 4.01 | 83.6 | 730 | 128 | 3.86 |
| ×3/8 | 0.375 | 58.10 | 17.1 | 23.5 | 34.1 | 476 | 68.0 | 5.28 | 81.5 | 284 | 56.8 | 4.08 | 64.8 | 564 | 98.2 | 3.89 |
| ×5/16 | 0.313 | 48.86 | 14.4 | 28.7 | 41.5 | 406 | 58.0 | 5.31 | 69.1 | 242 | 48.4 | 4.10 | 55.0 | 478 | 82.9 | 3.91 |
| ×1/4 | 0.250 | 39.43 | 11.6 | 36.8 | 52.8 | 331 | 47.3 | 5.34 | 56.0 | 198 | 39.6 | 4.13 | 44.6 | 387 | 67.0 | 3.93 |
| HSS14×6×5/8 | 0.625 | 76.33 | 22.4 | 6.00 | 18.8 | 504 | 72.0 | 4.74 | 94.0 | 130 | 43.3 | 2.41 | 51.2 | 352 | 88.9 | 3.15 |
| ×1/2 | 0.500 | 62.46 | 18.4 | 8.40 | 24.4 | 426 | 60.9 | 4.81 | 78.3 | 111 | 37.0 | 2.46 | 42.9 | 296 | 73.8 | 3.19 |
| ×3/8 | 0.375 | 47.90 | 14.1 | 12.8 | 34.1 | 337 | 48.1 | 4.89 | 61.1 | 89.1 | 29.7 | 2.51 | 33.6 | 233 | 57.3 | 3.23 |
| ×5/16 | 0.313 | 40.35 | 11.9 | 16.0 | 41.5 | 289 | 41.3 | 4.93 | 51.9 | 76.9 | 25.6 | 2.54 | 28.7 | 199 | 48.6 | 3.24 |
| ×1/4 | 0.250 | 32.63 | 9.59 | 20.8 | 52.8 | 237 | 33.9 | 4.97 | 42.3 | 63.4 | 21.1 | 2.57 | 23.4 | 162 | 39.5 | 3.26 |
| ×3/16 | 0.188 | 24.73 | 7.29 | 28.7 | 71.3 | 182 | 26.0 | 5.00 | 32.4 | 49.2 | 16.4 | 2.60 | 18.0 | 125 | 30.2 | 3.28 |
| HSS14×4×5/8 | 0.625 | 67.82 | 19.9 | 2.80 | 18.8 | 392 | 56.0 | 4.44 | 77.3 | 49.2 | 24.6 | 1.57 | 30.0 | 154 | 55.5 | 2.82 |
| ×1/2 | 0.500 | 55.66 | 16.4 | 4.40 | 24.4 | 335 | 47.9 | 4.52 | 64.8 | 43.1 | 21.6 | 1.62 | 25.5 | 134 | 46.8 | 2.86 |
| ×3/8 | 0.375 | 42.79 | 12.6 | 7.47 | 34.1 | 267 | 38.1 | 4.60 | 50.8 | 35.4 | 17.7 | 1.68 | 20.3 | 108 | 36.8 | 2.89 |
| ×5/16 | 0.313 | 36.10 | 10.6 | 9.58 | 41.5 | 230 | 32.9 | 4.66 | 43.4 | 30.9 | 15.4 | 1.71 | 17.4 | 93.2 | 31.5 | 2.91 |
| ×1/4 | 0.250 | 29.23 | 8.59 | 12.8 | 52.8 | 189 | 27.0 | 4.69 | 35.4 | 25.8 | 12.9 | 1.73 | 14.3 | 77.0 | 25.7 | 2.93 |
| ×3/16 | 0.188 | 22.18 | 6.54 | 18.1 | 71.3 | 147 | 21.0 | 4.74 | 27.2 | 20.3 | 10.2 | 1.76 | 11.1 | 59.8 | 19.8 | 2.95 |
| HSS12×10×1/2 | 0.500 | 69.27 | 20.4 | 16.4 | 20.4 | 419 | 69.8 | 4.53 | 83.9 | 316 | 63.2 | 3.94 | 74.1 | 581 | 109 | 3.52 |
| ×3/8 | 0.375 | 53.00 | 15.6 | 23.5 | 28.8 | 330 | 55.0 | 4.60 | 65.2 | 249 | 49.8 | 4.00 | 57.6 | 450 | 83.7 | 3.56 |
| ×5/16 | 0.313 | 44.60 | 13.1 | 28.7 | 35.1 | 282 | 47.0 | 4.64 | 55.3 | 213 | 42.6 | 4.03 | 48.9 | 381 | 70.8 | 3.58 |
| ×1/4 | 0.250 | 36.03 | 10.6 | 36.8 | 44.8 | 230 | 38.3 | 4.66 | 44.9 | 174 | 34.8 | 4.05 | 39.7 | 309 | 57.2 | 3.60 |
| HSS12×8×5/8 | 0.625 | 76.33 | 22.4 | 9.20 | 15.6 | 419 | 69.8 | 4.32 | 87.1 | 221 | 55.2 | 3.14 | 65.6 | 481 | 104 | 3.15 |
| ×1/2 | 0.500 | 62.46 | 18.4 | 12.4 | 20.4 | 353 | 58.8 | 4.38 | 72.4 | 188 | 47.0 | 3.20 | 54.7 | 401 | 85.8 | 3.19 |
| ×3/8 | 0.375 | 47.90 | 14.1 | 18.1 | 28.8 | 279 | 46.5 | 4.45 | 56.5 | 149 | 37.2 | 3.25 | 42.7 | 312 | 66.3 | 3.23 |
| ×5/16 | 0.313 | 40.35 | 11.9 | 22.4 | 35.1 | 239 | 39.8 | 4.48 | 48.0 | 128 | 32.0 | 3.28 | 36.4 | 265 | 56.1 | 3.24 |
| ×1/4 | 0.250 | 32.63 | 9.59 | 28.8 | 44.8 | 196 | 32.7 | 4.52 | 39.1 | 105 | 26.2 | 3.31 | 29.6 | 216 | 45.5 | 3.26 |
| ×3/16 | 0.188 | 24.73 | 7.29 | 39.4 | 60.6 | 151 | 25.2 | 4.55 | 29.9 | 81.3 | 20.3 | 3.34 | 22.7 | 165 | 34.7 | 3.28 |

**Comparing A1085 to A500**

The following is excerpted from a design example of a square HSS compression member without slender elements (see the full example at **www.aisc.org/A1085**).




**Given:**

Select an ASTM A1085 square HSS column, with a length of 20 ft, to support a dead load of 150 kips and live load of 440 kips in axial compression. The base is fixed and the top is pinned. Compare it to the size that would be required for an ASTM A500 Grade B square HSS.

**Solution:**

The required compressive strength is:

- LRFD: $P_u$ = 884 kips
- ASD: $P_a$ = 590 kips

Summary of results:

| HSS Standard | Selected Section | Area ($in.^2$) | Weight (lb/ft) | Design Strength, $\phi P_n$ (kips) | Allowable Strength, $P_n/\Omega$ (kips) |
|---|---|---|---|---|---|
| ASTM A1085 | HSS12×12×1/2 | 22.4 | 76.1 | 891 | 593 |
| ASTM A500 Gr. B | HSS12×12×5/8 | 25.7 | 93.3 | 946 | 629 |

The column size required for ASTM A1085 material is an HSS12×12×1/2, which has a design strength of 891 kips and an allowable strength of 593 kips. This same cross section in ASTM A500 Grade B material is not adequate (design strength is 773 kips and allowable strength is 514 kips). Using a 5/8-in. wall thickness, the HSS12×12×5/8 has a design strength of 946 kips and an allowable strength of 629 kips. However, it weighs 17 lbs more per ft.

In this case, using ASTM A1085 allows an 18% reduction in weight. Since fabrication, erection and other costs are likely unaffected, that's a direct savings that likely will more than offset the additional cost of the A1085 material.

wall thickness for ASTM A1085, and this has a direct effect on every property in the table with the exception of the nominal weight, which has always been based upon nominal dimensions.

- Axial compression strength tables also are available, as illustrated in Table 4, which shows an excerpt of an axial compression table for square A1085 HSS. These tables are modeled after Tables 4-3 through 4-5 in the AISC *Steel Construction Manual*.
- A design example is provided that compares a column designed with ASTM 1085 material to a column designed with A500 material. The calculations for the design example are omitted in this article, but a summary of the comparison results is shown.

Table 3: Typical Dimensions and Section Properties for A1085 Round HSS

| Shape | Design Wall Thickness, *t* | Nominal *Wt* | Area, A | *D/t* | *I* | *S* | *r* | *Z* | Torsion | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | *J* | *C* |
| | in. | lb/ft | in.$^2$ | | in.$^4$ | in.$^3$ | in. | in.$^3$ | in.$^4$ | in.$^3$ |
| HSS10×0.625 | 0.625 | 62.64 | 18.4 | 16.0 | 203 | 40.6 | 3.32 | 55.0 | 406 | 80.6 |
| ×0.500 | 0.500 | 50.78 | 14.9 | 20.0 | 169 | 33.8 | 3.36 | 45.2 | 338 | 67.2 |
| ×0.375 | 0.375 | 38.58 | 11.3 | 26.7 | 132 | 26.3 | 3.41 | 34.8 | 263 | 52.5 |
| ×0.312 | 0.312 | 32.31 | 9.50 | 32.1 | 112 | 22.3 | 3.43 | 29.3 | 223 | 44.5 |
| ×0.250 | 0.250 | 26.06 | 7.66 | 40.0 | 91.1 | 18.2 | 3.45 | 23.8 | 182 | 36.4 |
| ×0.188 | 0.188 | 19.72 | 5.80 | 53.2 | 69.8 | 14.0 | 3.47 | 18.1 | 140 | 27.9 |
| HSS9.625×0.500 | 0.500 | 48.77 | 14.3 | 19.2 | 150 | 31.1 | 3.23 | 41.7 | 299 | 61.9 |
| ×0.375 | 0.375 | 37.08 | 10.9 | 25.7 | 117 | 24.3 | 3.27 | 32.1 | 233 | 48.4 |
| ×0.312 | 0.312 | 31.06 | 9.13 | 30.8 | 99.1 | 20.6 | 3.29 | 27.1 | 198 | 41.1 |
| ×0.250 | 0.250 | 25.06 | 7.36 | 38.5 | 81.0 | 16.8 | 3.32 | 22.0 | 162 | 33.6 |
| ×0.188 | 0.188 | 18.97 | 5.57 | 51.2 | 62.1 | 12.9 | 3.34 | 16.7 | 124 | 25.8 |
| HSS8.625×0.625 | 0.625 | 53.45 | 15.7 | 13.8 | 126 | 29.3 | 2.84 | 40.1 | 253 | 58.0 |
| ×0.500 | 0.500 | 43.43 | 12.8 | 17.2 | 106 | 24.5 | 2.88 | 33.0 | 211 | 48.7 |
| ×0.375 | 0.375 | 33.07 | 9.72 | 23.0 | 82.9 | 19.2 | 2.92 | 25.5 | 166 | 38.3 |
| ×0.322 | 0.322 | 28.58 | 8.40 | 26.8 | 72.5 | 16.8 | 2.94 | 22.2 | 145 | 33.5 |
| ×0.250 | 0.250 | 22.38 | 6.58 | 34.5 | 57.7 | 13.4 | 2.96 | 17.5 | 115 | 26.7 |
| ×0.188 | 0.188 | 16.96 | 4.98 | 45.9 | 44.4 | 10.3 | 2.98 | 13.4 | 88.7 | 20.6 |
| HSS7.625×0.375 | 0.375 | 29.06 | 8.54 | 20.3 | 56.3 | 14.8 | 2.57 | 19.7 | 113 | 29.4 |
| ×0.328 | 0.328 | 25.59 | 7.52 | 23.2 | 50.1 | 13.2 | 2.58 | 17.5 | 100 | 26.2 |

### Cost

Any discussion of a new product in the marketplace is not complete without addressing potential cost implications. We expect that ASTM A1085 material will cost more than ASTM A500—but also that the weight savings due to the enhanced material properties will offset some or even all of the added material cost. And, as always, one should remember that material costs are only about 30% of a typical steel frame, with the rest made up by fabrication, erection and other costs. The largest savings and efficiencies can be achieved from constructability review and early involvement of your steel fabricator. MSC

Table 4: Available Strength in Axial Compression for A1085 Square HSS — $F_y$ = 50 ksi

| Shape | HSS22×22× | | | | HSS20×20× | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7/8 | | 3/4 | | 7/8 | | 3/4 | | 5/8 | |
| $t_{design}$, in | 0.875 | | 0.750 | | 0.875 | | 0.750 | | 0.625 | |
| Wt/ft | 244.88 | | 212.00 | | 221.06 | | 191.58 | | 161.40 | |
| Design | $P_n/\Omega_c$ | $\phi_c P_n$ | $P_n/\Omega_c$ | $\phi_c P_n$ | $P_n/\Omega_c$ | $\phi_c P_n$ | $P_n/\Omega_c$ | $\phi_c P_n$ | $P_n/\Omega_c$ | $\phi_c P_n$ |
| | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD | ASD | LRFD |
| Effective length KL (ft) with respect to least radius of gyration, $r_y$: 0 | 2160 | 3240 | 1870 | 2800 | 1950 | 2930 | 1690 | 2530 | 1420 | 2130 |
| 6 | 2140 | 3220 | 1860 | 2790 | 1930 | 2910 | 1680 | 2520 | 1410 | 2120 |
| 7 | 2140 | 3220 | 1850 | 2780 | 1930 | 2900 | 1670 | 2510 | 1410 | 2120 |
| 8 | 2140 | 3210 | 1850 | 2780 | 1920 | 2890 | 1670 | 2510 | 1400 | 2110 |
| 9 | 2130 | 3200 | 1840 | 2770 | 1920 | 2880 | 1660 | 2500 | 1400 | 2100 |
| 10 | 2120 | 3190 | 1840 | 2760 | 1910 | 2870 | 1660 | 2490 | 1400 | 2100 |
| 11 | 2120 | 3180 | 1830 | 2760 | 1910 | 2860 | 1650 | 2480 | 1390 | 2090 |
| 12 | 2110 | 3170 | 1830 | 2750 | 1900 | 2850 | 1640 | 2470 | 1380 | 2080 |
| 13 | 2100 | 3160 | 1820 | 2740 | 1890 | 2840 | 1640 | 2460 | 1380 | 2070 |
| 14 | 2100 | 3150 | 1810 | 2730 | 1880 | 2830 | 1630 | 2450 | 1370 | 2060 |
| 15 | 2090 | 3140 | 1810 | 2720 | 1870 | 2810 | 1620 | 2440 | 1370 | 2050 |
| 16 | 2080 | 3120 | 1800 | 2700 | 1860 | 2800 | 1610 | 2420 | 1360 | 2040 |
| 17 | 2070 | 3110 | 1790 | 2690 | 1850 | 2780 | 1600 | 2410 | 1350 | 2030 |
| 18 | 2060 | 3090 | 1780 | 2680 | 1840 | 2760 | 1590 | 2400 | 1340 | 2020 |
| 19 | 2050 | 3080 | 1770 | 2660 | 1830 | 2750 | 1580 | 2380 | 1330 | 2010 |
| 20 | 2040 | 3060 | 1760 | 2650 | 1810 | 2730 | 1570 | 2360 | 1330 | 1990 |
| 21 | 2020 | 3040 | 1750 | 2630 | 1800 | 2710 | 1560 | 2350 | 1320 | 1980 |
| 22 | 2010 | 3020 | 1740 | 2620 | 1790 | 2690 | 1550 | 2330 | 1310 | 1960 |
| 23 | 2000 | 3000 | 1730 | 2600 | 1770 | 2670 | 1540 | 2310 | 1300 | 1950 |
| 24 | 1980 | 2980 | 1720 | 2580 | 1760 | 2640 | 1530 | 2290 | 1290 | 1930 |
| 25 | 1970 | 2960 | 1710 | 2570 | 1740 | 2620 | 1510 | 2270 | 1280 | 1920 |
| 26 | 1960 | 2940 | 1690 | 2550 | 1730 | 2600 | 1500 | 2250 | 1270 | 1900 |
| 27 | 1940 | 2920 | 1680 | 2530 | 1710 | 2570 | 1490 | 2230 | 1250 | 1880 |
| 28 | 1930 | 2890 | 1670 | 2510 | 1700 | 2550 | 1470 | 2210 | 1240 | 1870 |
| 29 | 1910 | 2870 | 1660 | 2490 | 1680 | 2520 | 1460 | 2190 | 1230 | 1850 |
| 30 | 1890 | 2850 | 1640 | 2470 | 1660 | 2500 | 1440 | 2170 | 1220 | 1830 |
| 32 | 1860 | 2800 | 1610 | 2420 | 1630 | 2440 | 1410 | 2120 | 1190 | 1790 |
| 34 | 1830 | 2740 | 1580 | 2380 | 1590 | 2390 | 1380 | 2080 | 1170 | 1750 |
| 36 | 1790 | 2690 | 1550 | 2330 | 1550 | 2330 | 1350 | 2030 | 1140 | 1710 |
| 38 | 1750 | 2630 | 1520 | 2280 | 1510 | 2270 | 1310 | 1970 | 1110 | 1670 |
| 40 | 1710 | 2570 | 1490 | 2230 | 1470 | 2210 | 1280 | 1920 | 1080 | 1630 |
| Properties | | | | | | | | | | |
| $A_g$, in.$^2$ | 72.0 | | 62.3 | | 65.0 | | 56.3 | | 47.4 | |
| $I_x = I_y$, in.$^4$ | 5280 | | 4630 | | 3900 | | 3430 | | 2940 | |
| $r_x = r_y$, in. | 8.56 | | 8.62 | | 7.75 | | 7.81 | | 7.88 | |
| ASD | LRFD | | | | | | | | | |
| $\Omega_c$ = 1.67 | $\phi_c$ = 0.90 | | | | | | | | | |