AISC Specification Section E7.1 gives the procedure for calculating Q_s for slender unstiffened elements. The procedure is straightforward, and involves comparing the width-to-thickness ratio with a limiting value and then computing Q_s from an expression that is a function of the width-to-thickness ratio, F_y, and E.

The computation of Q_a for slender stiffened elements is given in AISC E7.2 and is slightly more complicated than the procedure for unstiffened elements. The general procedure is as follows.

- Compute an effective area of the cross section. This requires a knowledge of the stress in the effective area, so iteration is required. The Specification allows a simplifying assumption, however, so iteration can be avoided.
- Compute $Q_a = A_e/A_g$, where A_e is the effective area, and A_g is the gross or unreduced area.

The details of the computation of Q_s and Q_a will not be given here but will be shown in the following example, which illustrates the procedure for an HSS.

EXAMPLE 4.4

Determine the axial compressive strength of an HSS 8 × 4 × ⅛ with an effective length of 15 feet with respect to each principal axis. Use $F_y = 46$ ksi.

SOLUTION Compute the overall, or flexural, buckling strength.

$$\text{Maximum } \frac{KL}{r} = \frac{KL}{r_y} = \frac{15 \times 12}{1.71} = 105.3 < 200 \qquad \text{(OK)}$$

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29{,}000}{46}} = 118$$

Since 105.3 < 118, use AISC Equation E3-2.

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2(29{,}000)}{(105.3)^2} = 25.81 \text{ ksi}$$

$$F_{cr} = 0.658^{(F_y/F_e)} F_y = 0.658^{(46/25.81)}(46) = 21.82 \text{ ksi}$$

The nominal strength is

$$P_n = F_{cr}A_g = 21.82(2.70) = 58.91 \text{ kips}$$

Check width-to-thickness ratios:

From the dimensions and properties table in the *Manual,* the width-to-thickness ratio for the larger overall dimension is

$$\frac{h}{t} = 66.0$$

The ratio for the smaller dimension is

$$\frac{b}{t} = 31.5$$

From AISC Table B4.1a, Case 6 (and Figure 4.9 in this book), the upper limit for nonslender elements is

$$1.40\sqrt{\frac{E}{F_y}} = 1.40\sqrt{\frac{29,000}{46}} = 35.15$$

Since $h/t > 1.40\sqrt{E/F_y}$, the larger dimension element is slender and the local buckling strength must be computed. (Although the limiting width-to-thickness ratio is labeled *b/t* in the table, that is a generic notation, and it applies to h/t as well.)

Because this cross-sectional element is a stiffened element, $Q_s = 1.0$, and Q_a must be computed from AISC Section E7.2. The shape is a rectangular section of uniform thickness, with

$$\frac{b}{t} \geq 1.40\sqrt{\frac{E}{f}},$$

So AISC E7.2 (b) applies, where

$$f = \frac{P_n}{A_e}$$

and A_e is the reduced effective area. The Specification user note for square and rectangular sections permits a value of $f = F_y$ to be used in lieu of determining f by iteration. From AISC Equation E7-18, the effective width of the slender element is

$$b_e = 1.92t\sqrt{\frac{E}{f}}\left[1 - \frac{0.38}{b/t}\sqrt{\frac{E}{f}}\right] \leq b \qquad \text{(AISC Equation E7-18)}$$

For the 8-inch side, using $f = F_y$ and the *design* thickness* from the dimensions and properties table,

$$b_e = 1.92(0.116)\sqrt{\frac{29,000}{46}}\left[1 - \frac{0.38}{(66.0)}\sqrt{\frac{29,000}{46}}\right] = 4.784 \text{ in.}$$

*The *design* thickness of an HSS is 0.93 times the *nominal* thickness (AISC B4.2). Using the design thickness in strength computations is a conservative way to account for tolerances in the manufacturing process.