<table>
<tr><th colspan="9">Table 2-9. Room Temperature Physical Properties, Annealed Condition</th></tr>
<tr><th rowspan="2">Type</th><th colspan="2">Initial Modulus of Elasticity</th><th colspan="2">Density</th><th colspan="2">Thermal Conductivity at 68 F (20 C)</th><th colspan="2">Specific Thermal Capacity at 68 F (20 C)</th></tr>
<tr><th>ksi</th><th>MPa</th><th>lb/ft^3</th><th>kg/m^3</th><th>BTU/ (hr-ft- F)</th><th>W/(m-K)</th><th>BTU/ (lb- F)</th><th>J/(kg-K)</th></tr>
<tr><td>S30400
S30403</td><td>28,000</td><td>193,000</td><td>490</td><td>7900</td><td rowspan="3">8.7</td><td rowspan="3">15</td><td rowspan="4">0.12</td><td rowspan="4">500</td></tr>
<tr><td>S31600
S31603</td><td>28,000</td><td>193,000</td><td>500</td><td>8000</td></tr>
<tr><td>S32101
S32304
S32205</td><td>29,000</td><td>200,000</td><td>485</td><td>7800</td></tr>
<tr><td>S17400</td><td>28,500</td><td>197,000</td><td>485</td><td>7800</td><td>9.2</td><td>16</td></tr>
</table>

Note:
The data are taken from EN 10088, *Stainless Steels—Part 1: List of Stainless Steels* (CEN, 2005d) apart from the values for the initial modulus of elasticity which are taken from *Boiler and Pressure Vessel Code, Section II: Materials—Part D: Properties (Customary)* (ASME, 2010), with the value for the austenitic stainless steels rounded down to 28,000 ksi (193,000 MPa).
Poisson's ratio can be taken as 0.3 and the shear modulus of elasticity, *G*, as 0.385*E*.

LRFD	ASD
$\phi_c = 0.90$ $\phi_c P_n = 0.90(130\text{ kips})$ $= 117\text{ kips}$	$\Omega c = 1.67$ $\frac{P_n}{\Omega_c} = \frac{130\text{ kips}}{1.67}$ $= 77.8\text{ kips}$

Example 3—W-Shape Subject to Compression and Bi-Axial Bending

Given:

Determine if a 9-ft-long W6×16, laser fused, Type S31600 stainless steel section in a symmetric braced frame has sufficient strength to support the following required strengths:

LRFD	ASD
$P_u = 7.00\text{ kips}$ $M_{ux} = 3.00\text{ kip-ft}$ $M_{uy} = 3.00\text{ kip-ft}$	$P_a = 4.70\text{ kips}$ $M_{ax} = 2.00\text{ kip-ft}$ $M_{ay} = 2.00\text{ kip-ft}$

Assume the column has adequate restraint to prevent lateral-torsional buckling.

Solution:

From Table 2-2 and Table 2-9, the material properties are as follows:

Type S31600 stainless steel
$F_y = 30\text{ ksi}$
$E = 28{,}000\text{ ksi}$

From AISC *Manual* Table 1-1 (AISC, 2010d), the geometric properties are as follows (assume these values are conservative for a laser-fused section):

W6×16
$A = 4.74\text{ in.}^2$
$I_x = 32.1\text{ in.}^4$
$I_y = 4.43\text{ in.}^4$
$Z_x = 11.7\text{ in.}^3$
$Z_y = 3.39\text{ in.}^3$
$S_y = 2.20\text{ in.}^3$
$r_x = 2.60\text{ in.}$
$r_y = 0.967\text{ in.}$
$b_f = 4.03\text{ in.}$
$t_f = 0.405\text{ in.}$
$t_w = 0.260\text{ in.}$
$d = 6.28\text{ in.}$
$h_o = 5.88\text{ in.}$
$\frac{h}{t_w} = 19.1$
$\frac{b_f}{2t_f} = 4.98$

Check element slenderness

From Table 3-2, for a rolled I-shaped section subject to major or minor axis bending, an unstiffened compression element, such as the flanges, may be considered compact if:

$$\frac{b}{t} \le 0.33\sqrt{\frac{E}{F_y}}$$
$$\le 0.33\sqrt{\frac{28{,}000 \text{ ksi}}{30 \text{ ksi}}}$$
$$\le 10.1$$

$$\frac{b}{t} = \frac{b_f}{2t_f} = 4.98 \le 10.1, \text{ therefore the flange is compact.}$$

The web of a I-shaped section is considered compact if:

$$\frac{h}{t_w} \le 2.54\sqrt{\frac{E}{F_y}}$$
$$\le 2.54\sqrt{\frac{28{,}000 \text{ ksi}}{30 \text{ ksi}}}$$
$$\le 77.6$$

$$\frac{h}{t_w} = 19.1 \le 77.6, \text{ therefore, the web is compact.}$$

For a stiffened element, the more stringent limit of a stiffened element subject to a compression load (Table 3-1) governs over the limit of a stiffened element subject to flexure (Table 3-2):

$$\frac{h}{t_w} \le 1.24\sqrt{\frac{E}{F_y}}$$
$$\le 1.24\sqrt{\frac{28{,}000 \text{ ksi}}{30 \text{ ksi}}}$$
$$\le 37.9$$

$$\frac{h}{t_w} \le 37.9 \text{ therefore the section is nonslender under axial compression}$$

Determine the available compressive strength

From AISC *Specification* Commentary Table C-A-7.1, for a pinned-pinned condition, $K = 1.0$; therefore, the slenderness ratio is:

$$\frac{KL}{r} = \frac{(1.0)(9.00 \text{ ft})(12 \text{ in./ft})}{0.967 \text{ in.}}$$
$$= 112$$

Determine the applicable equation for critical stress, F_{cr}, from Section 5.3 as follows:

$$3.77\sqrt{\frac{E}{F_y}} = 3.77\sqrt{\frac{28{,}000 \text{ ksi}}{30 \text{ ksi}}}$$

$= 115 > 112$, therefore modified AISC *Specification* Equation E3-2 from Section 5.3 applies

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} \qquad \text{(Spec. Eq. E3-4)}$$

$$= \frac{\pi^2 (28{,}000 \text{ ksi})}{(112)^2}$$

$$= 22.0 \text{ ksi}$$

$$F_{cr} = \left(0.50^{\frac{F_y}{F_e}}\right) F_y \quad \text{(modified } \textit{Spec.} \text{ Eq. E3-2)}$$

$$= \left(0.50^{\frac{30 \text{ ksi}}{22.0 \text{ ksi}}}\right)(30 \text{ ksi})$$

$$= 11.7 \text{ ksi}$$

The nominal compressive strength is:

$$P_n = F_{cr} A_g \quad \text{(}\textit{Spec.} \text{ Eq. E3-1)}$$

$$= 11.7 \text{ ksi } (4.74 \text{ in.}^2)$$

$$= 55.5 \text{ kips}$$

From Section 5.1, the available compressive strength is:

LRFD	ASD
$\phi_c P_n = 0.90(55.5 \text{ kips})$ $= 50.0 \text{ kips}$	$\frac{P_n}{\Omega_c} = \frac{55.5 \text{ kips}}{1.67}$ $= 33.2 \text{ kips}$

Determine the available flexural strength

For a compact section bent about the major axis, the limit states of yielding and lateral-torsional buckling apply. This member was said to have adequate restraint to prevent lateral-torsional buckling; therefore the limit state of yielding will control. As discussed in Section 6.2, the AISC *Specification* Section F2 applies to stainless steel, where the nominal flexural strength for yielding is defined as follows:

$$M_{nx} = M_p \quad \text{(}\textit{Spec.} \text{ Eq. F2-1)}$$

$$= F_y Z_x$$

$$= (30 \text{ ksi})(11.7 \text{ in.}^3)/(12 \text{ in./ft})$$

$$= 29.3 \text{ kip-ft}$$

From Section 6.1, the available flexural strength about the major axis is:

LRFD	ASD
$\phi_b M_{nx} = 0.90(29.3 \text{ kip-ft})$ $= 26.4 \text{ kip-ft}$	$\frac{M_{nx}}{\Omega_b} = \frac{29.3 \text{ kip-ft}}{1.67}$ $= 17.5 \text{ kip-ft}$

As discussed in Section 6.2, the AISC *Specification* Section F6 applies to stainless steel I-shaped members bent about their minor axis and the limit states of yielding and flange local buckling apply; however, for sections with compact flanges the limit state of flange local buckling does not apply. The limit state of yielding will control:

$$M_{ny} = F_y Z_y \le 1.6 F_y S_y \quad \text{(Spec. Eq. F6-1)}$$

$$= (30\text{ ksi})(3.39\text{ in.}^3)/(12\text{ in./ft})$$

$$= 8.48\text{ kip-ft}$$

$$1.6F_y S_y = 1.6(30\text{ ksi})(2.20\text{ in.}^3)/(12\text{ in./ft})$$

$$= 8.80\text{ kip-ft}$$

Therefore, $M_{ny} = 8.48$ kip-ft.

From Section 6.1, the available flexural strength about the minor axis is:

LRFD	ASD
$\phi_b M_{ny} = 0.90(8.48\text{ kip-ft})$ $= 7.63\text{ kip-ft}$	$\dfrac{M_{ny}}{\Omega_b} = \dfrac{8.48\text{ kip-ft}}{1.67}$ $= 5.08\text{ kip-ft}$

As discussed in Section 8.1.1, for doubly symmetric members subject to flexure and compression, the guidance in AISC *Specification* Section H1.1 applies. Determine whether AISC *Specification* Equation H1-1a or Equation H1-1b is applicable in this example:

LRFD	ASD
$\dfrac{P_r}{P_c} = \dfrac{P_u}{\phi_c P_n}$ $= \dfrac{7.00\text{ kips}}{50.0\text{ kips}}$ $= 0.140 < 0.2$	$\dfrac{P_r}{P_c} = \dfrac{P_r}{P_n/\Omega_c}$ $= \dfrac{4.70\text{ kips}}{33.2\text{ kips}}$ $= 0.142 < 0.2$

From AISC *Specification* Section H1, check the applicable interaction Equation H1-1b, as follows:

LRFD	ASD
$\dfrac{P_u}{2(\phi_c P_n)} + \left(\dfrac{M_{ux}}{\phi_b M_{nx}} + \dfrac{M_{uy}}{\phi_b M_{ny}}\right) \le 1.0$ $\dfrac{7.00\text{ kips}}{2(50.0\text{ kips})} + \left(\dfrac{3.00\text{ kip-ft}}{26.4\text{ kip-ft}} + \dfrac{3.00\text{ kip-ft}}{7.63\text{ kip-ft}}\right) \le 1.0$ $0.577 < 1.0$ **o.k.**	$\dfrac{P_a}{2(P_n/\Omega_b)} + \left(\dfrac{M_{ax}}{M_{nx}/\Omega_b} + \dfrac{M_{ay}}{M_{ny}/\Omega_b}\right) \le 1.0$ $\dfrac{4.70\text{ kips}}{2(33.2\text{ kips})} + \left(\dfrac{2.00\text{ kip-ft}}{17.5\text{ kip-ft}} + \dfrac{2.00\text{ kip-ft}}{5.08\text{ kip-ft}}\right) \le 1.0$ $0.579 < 1.0$ **o.k.**

Therefore, the W6×16 is adequate.

Example 4—Channel Subject to Strong-Axis Bending

Given:

Determine the available flexural and shear strength of a C12×30 Type S30400 stainless steel beam with a simple span of 30 ft. Also, determine the deflection at midspan due to an unfactored dead load of 5 kips applied at the midpoint. The beam is laterally restrained at its midpoint. The self-weight of the beam will be ignored for the purposes of this calculation.

Solution:

From Table 2-2 and Table 2-9, the material properties are as follows:

Type S31600 stainless steel