CHAPTER E

DESIGN OF MEMBERS FOR COMPRESSION

This chapter addresses members subject to axial compression through the centroidal axis.

The chapter is organized as follows:

E1. General Provisions
E2. Effective Length
E3. Flexural Buckling of Members without Slender Elements
E4. Torsional and Flexural-Torsional Buckling of Members without Slender Elements
E5. Single Angle Compression Members
E6. Built-Up Members
E7. Members with Slender Elements

User Note: For cases not included in this chapter the following sections apply:

- H1 – H2 Members subject to combined axial compression and flexure
- H3 Members subject to axial compression and torsion
- I2 Composite axially loaded members
- J4.4 Compressive strength of connecting elements

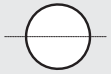
E1. GENERAL PROVISIONS

The *design compressive strength*, $\phi_c P_n$, and the *allowable compressive strength*, P_n/Ω_c, are determined as follows.

The *nominal compressive strength*, P_n, shall be the lowest value obtained based on the applicable *limit states* of *flexural buckling*, *torsional buckling*, and *flexural-torsional buckling*.

$\phi_c = 0.90$ (LRFD) $\Omega_c = 1.67$ (ASD)

TABLE USER NOTE E1.1
Selection Table for the Application of Chapter E Sections

Cross Section	Without Slender Elements		With Slender Elements	
	Sections in Chapter E	Limit States	Sections in Chapter E	Limit States
	E3 E4	FB TB	E7	LB FB TB
	E3 E4	FB FTB	E7	LB FB FTB
	E3	FB	E7	LB FB
	E3	FB	E7	LB FB
	E3 E4	FB FTB	E7	LB FB FTB
	E6 E3 E4	FB FTB	E6 E7	LB FB FTB
	E5		E5	
	E3	FB	N/A	N/A
Unsymmetrical shapes other than single angles	E4	FTB	E7	LB FTB

FB = flexural buckling, TB = torsional buckling, FTB = flexural-torsional buckling, LB = local buckling

E2. EFFECTIVE LENGTH

The *effective length factor*, *K,* for calculation of member slenderness, *KL/r,* shall be determined in accordance with Chapter C or Appendix 7,

where

L = laterally *unbraced length* of the member, in. (mm)
r = radius of gyration, in. (mm)

User Note: For members designed on the basis of compression, the effective slenderness ratio *KL/r* preferably should not exceed 200.

E3. FLEXURAL BUCKLING OF MEMBERS WITHOUT SLENDER ELEMENTS

This section applies to nonslender element compression members as defined in Section B4.1 for elements in uniform compression.

User Note: When the torsional *unbraced length* is larger than the lateral unbraced length, Section E4 may control the design of wide flange and similarly shaped *columns*.

The *nominal compressive strength*, P_n, shall be determined based on the *limit state* of *flexural buckling*.

$$P_n = F_{cr} A_g \tag{E3-1}$$

The *critical stress*, F_{cr}, is determined as follows:

(a) When $\frac{KL}{r} \le 4.71\sqrt{\frac{E}{F_y}}$ $\left(\text{or } \frac{F_y}{F_e} \le 2.25\right)$

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y \tag{E3-2}$$

(b) When $\frac{KL}{r} > 4.71\sqrt{\frac{E}{F_y}}$ $\left(\text{or } \frac{F_y}{F_e} > 2.25\right)$

$$F_{cr} = 0.877 F_e \tag{E3-3}$$

where

F_e = elastic *buckling* stress determined according to Equation E3-4, as specified in Appendix 7, Section 7.2.3(b), or through an elastic buckling analysis, as applicable, ksi (MPa)

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} \tag{E3-4}$$

User Note: The two inequalities for calculating the limits and applicability of Sections E3(a) and E3(b), one based on *KL/r* and one based on F_y/F_e, provide the same result.

E4. TORSIONAL AND FLEXURAL-TORSIONAL BUCKLING OF MEMBERS WITHOUT SLENDER ELEMENTS

This section applies to singly symmetric and unsymmetric members and certain doubly symmetric members, such as cruciform or built-up *columns* without slender elements, as defined in Section B4.1 for elements in uniform compression. In addition, this section applies to all doubly symmetric members without slender elements when the torsional *unbraced length* exceeds the lateral unbraced length. These provisions are required for single angles with $b/t > 20$.

The *nominal compressive strength*, P_n, shall be determined based on the *limit states* of *torsional* and *flexural-torsional buckling*, as follows:

$$P_n = F_{cr} A_g \tag{E4-1}$$

The *critical stress*, F_{cr}, is determined as follows:

(a) For double angle and tee-shaped compression members:

$$F_{cr} = \left(\frac{F_{cry} + F_{crz}}{2H}\right)\left[1 - \sqrt{1 - \frac{4 F_{cry} F_{crz} H}{\left(F_{cry} + F_{crz}\right)^2}}\right] \tag{E4-2}$$

where F_{cry} is taken as F_{cr} from Equation E3-2 or E3-3 for *flexural buckling* about the *y*-axis of symmetry, and $\frac{KL}{r} = \frac{K_y L}{r_y}$ for tee-shaped compression members, and $\frac{KL}{r} = \left(\frac{KL}{r}\right)_m$ from Section E6 for double angle compression members, and

$$F_{crz} = \frac{GJ}{A_g \bar{r}_o^2} \tag{E4-3}$$

(b) For all other cases, F_{cr} shall be determined according to Equation E3-2 or E3-3, using the torsional or flexural-torsional elastic *buckling* stress, F_e, determined as follows:

(i) For doubly symmetric members:

$$F_e = \left[\frac{\pi^2 E C_w}{\left(K_z L\right)^2} + GJ\right]\frac{1}{I_x + I_y} \tag{E4-4}$$

(ii) For singly symmetric members where *y* is the axis of symmetry: