

# Torsional and Constrained-Axis Flexural-Torsional Buckling Tables for Steel W-Shapes in Compression

DI LIU, BRAD DAVIS, LEIGH ARBER and RAFAEL SABELLI

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## ABSTRACT

Torsional buckling (TB), an applicable limit state for W-shape members subject to axial compression, often controls when the torsional effective unbraced length exceeds the minor-axis flexural buckling effective unbraced length. Constrained-axis flexural-torsional buckling (CAFTB) is a potential limit state for W-shape members that are constrained to buckle with the center of twist at a location other than the centroidal axis, as is the case for a typical beam with one flange braced by a diaphragm and the other unbraced. Manual calculation of the TB or CAFTB available compressive strength is a somewhat lengthy process, especially when the section is slender for axial compression, and no design aid currently exists in the AISC *Manual*. This paper provides tables that facilitate the determination of TB and CAFTB available compressive strengths. Several example calculations are also provided.

**Keywords:** members, columns, stability, buckling, torsion.

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## INTRODUCTION

Hot-rolled W-shape members are subjected to compressive axial forces when used as columns, braces, struts or collectors. The available compressive strength—LRFD design strength or ASD allowable strength—per the AISC *Specification* (AISC, 2010) Chapter E is the minimum based on the limit states of flexural buckling (FB) and torsional buckling (TB; see Figure 1a). W-shape FB available strength calculations are facilitated by design aids in Part 4 of the AISC *Steel Construction Manual* (AISC, 2011), especially Tables 4-1 and 4-22. TB is not included in these design aids because when the weak-axis FB effective unbraced length,  $(KL)_y$ , equals the TB effective unbraced length,  $K_zL$ , TB only controls for very few cases, and in those cases only by a margin of less than 0.5%.

However, there are some common situations for which the TB strength is likely to control by a significant margin, the most common being a column or collector with  $K_zL$  exceeding  $(KL)_y$ . For example, a column might have a mid-height weak-axis brace that restrains lateral translation but not twist; in that case,  $K_zL$  is twice as large as  $(KL)_y$ , and

torsional buckling is likely to control. When faced with one of these situations, the engineer must manually calculate the available compressive strength using the AISC *Specification* (2010) Sections E3, E4 and often E7.

There are also common situations in which the member has a potential buckling mode with combined lateral translation and twist, similar to flexural-torsional buckling except that the boundary conditions force the center of twist to be at a specific location. This mode is referred to as constrained-axis flexural-torsional buckling (CAFTB). The most common example is a floor or roof beam connected to a deck diaphragm, in which the top flange is continuously braced in the lateral direction and the bottom flange is unbraced between the supports as shown in Figure 1b, thus constraining the section to twist about the axis defined by the intersection of web centerline and outside face of the top flange. The AISC *Specification* (2010) does not provide an equation for determining the CAFTB available compressive strength, nor does the AISC *Manual* (2011) include a design aid with CAFTB available strengths. Thus, when designing a member with a potential CAFTB mode, designers usually resort to a conservative approach such as evaluating the aforementioned beam for weak-axis FB (a mode that does not apply in this example) with  $(KL)_y$  equal to the member length in lieu of computing the CAFTB strength.

Many ASTM A992 W-shapes that are commonly used as beams have webs that are slender for axial compression per the AISC *Specification* (AISC, 2010) Table B4.1a (e.g., W14×22 through W14×43, W18×35 through W18×60 and W21×44 through W21×83), indicating that they cannot be axially loaded to the yield stress without local buckling. The relatively lengthy calculations in Section E7 must be used to determine the available compressive strength for these slender sections.

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Di Liu, Ph.D. Candidate, Civil Engineering Department, University of Kentucky, Lexington, KY. E-mail: liu.di@uky.edu

Brad Davis, Assistant Professor, Civil Engineering Department, University of Kentucky, Lexington, KY (corresponding). E-mail: bdavis@engr.uky.edu

Leigh Arber, Staff Engineer, American Institute of Steel Construction, Chicago, IL. E-mail: arber@aisc.org

Rafael Sabelli, Principal and Director of Seismic Design, Walter P Moore, San Francisco, CA. E-mail: rsabelli@walterpmoore.com

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Therefore, the main objective of this paper is to provide a design aid that will facilitate the determination of W-shape TB and CAFTB available strengths over a common range of effective unbraced lengths for the most common yield stress in use today,  $F_y = 50$  ksi. The CAFTB available strength depends on the distance from the centroid and shear center to the constraining axis. However, a common constraining axis location is at the intersection of the web centerline and the outside face of one flange, so CAFTB available strengths are included for that case. Due to space considerations, only the LRFD design strength,  $\phi P_n$ , is shown. However, the ASD allowable strength is quickly determined by dividing the tabulated strength by the resistance factor,  $\phi_c = 0.9$ , and then dividing that value by the safety factor,  $\Omega_c = 1.67$ . A secondary objective is to provide guidance for computing the CAFTB strength for members with discrete bracing.

### TORSIONAL BUCKLING AVAILABLE STRENGTH

The TB design strength is computed using the AISC *Specification* (2010), as follows. First, the elastic TB stress is computed using the AISC *Specification* Equation E4-4, shown here. The derivation is included in Timoshenko and Gere (1961), Allen and Bulson (1980), and Salmon et al. (2009). The member ends are restrained against transverse displacement and twist, but not warping.

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

where

- $C_w$  = warping constant
- $K_z L$  = effective length between points that are braced against twist of the cross section
- $J$  = torsional constant
- $I_x$  = major principal axis moment-of-inertia
- $I_y$  = minor principal axis moment-of-inertia

The critical stress,  $F_{cr}$ , and nominal compressive strength,  $P_n$ , are then computed using the equations in the AISC *Specification* (2010) Section E3 or E7, depending on the local buckling classification. Finally, the tabulated design strength,  $\phi P_n$ , is computed by applying the resistance factor  $\phi_c = 0.9$ .

### CONSTRAINED-AXIS FLEXURAL-TORSIONAL BUCKLING AVAILABLE STRENGTHS FOR CONTINUOUSLY BRACED MEMBERS

The AISC *Specification* (2010) does not include an equation for the elastic buckling stress for CAFTB. However, Timoshenko and Gere (1961) provided an equation—their Equation 5-56—for the elastic buckling strength of a doubly symmetric member constrained to buckle about a continuous fixed axis that is offset from each principal axis. The member ends are restrained against transverse displacement and twist, but not warping. Timoshenko and Gere’s Equation 5-56 becomes the following equation when the constraining axis is in the plane of the web.

$$P_e = \left[ \frac{\pi^2 E (C_w + I_y a^2)}{(K_z L)^2} + GJ \right] \frac{1}{r_x^2 + r_y^2 + a^2} \quad (2)$$

where

- $a$  = distance from the constraining axis to the centroid
- $K_z L$  = effective unbraced length for CAFTB (e.g., the member length if one flange is continuously laterally braced and the other flange unbraced)
- $r_x$  = major principal axis radius of gyration
- $r_y$  = minor principal axis radius of gyration

Equation 2 is valid only if the object(s) providing the bracing force and stiffness do not deform. Helwig and Yura (1999) recommended reducing the elastic strength by 0.90 “to account for the finite stiffness provided by typical lateral

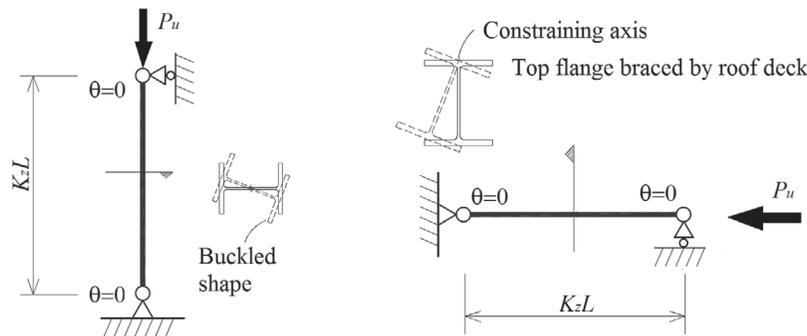


Fig. 1. Buckling mode illustrations: (a) torsional buckling; (b) constrained-axis flexural-torsional buckling.

bracing systems,” a recommendation adopted for this paper. The elastic CAFTB stress,  $F_e$ , is the elastic buckling strength,  $0.9P_e$ , divided by the gross area,  $A_g$ ;  $F_{cr}$  is computed using the AISC *Specification* (2010) Section E3 or E7, depending on the local buckling classification (non-slender or slender for axial compression). In summary, each tabulated CAFTB strength was computed in the following sequence:

1.  $P_e$  using Equation 2 with  $a = d/2$
2.  $F_e = 0.9P_e/A$
3.  $F_{cr}$  using Section E3 or E7
4.  $P_n = F_{cr}A$
5.  $\phi P_n$  where  $\phi = 0.9$

Table 1, included at the end of this paper, was generated for the case of  $a = 0.5d$ , which the authors consider to be a common case. It is also possible, however, to have  $a > 0.5d$ . Helwig and Yura (1999) indicated that the elastic CAFTB strength decreases with increasing  $a/d$  ratio when the constrained axis is in the plane of the web. Therefore, if  $a > 0.5d$ , the CAFTB available strength is less than the tabulated strength, and the available strength must be computed rather than pulled from the tables.

### CONSTRAINED-AXIS FLEXURAL-TORSIONAL BUCKLING OF DISCRETELY BRACED MEMBERS

CAFTB is also a potential limit state for discretely braced members—such as moment frame columns that are braced against transverse displacement at the outside flange by each girt while the inside flanges are only braced at selected girts, thus creating a potential CAFTB mode between the inside flange brace locations. Equation 2 does not directly apply to such situations, so the elastic buckling strength must be evaluated using some other method, such as eigenvalue buckling analysis within a finite element analysis (FEA) program. The following describes the development of a simplified procedure—based on Equation 2—that applies within specific limitations.

An ANSYS FEA model was created of each W-shape (W10 through W44) at each unbraced length ranging from 10 ft to 40 ft. Each W-shape member was modeled by two-node, seven-degree-of-freedom BEAM188 elements, which include torsional warping. Member ends were restrained against transverse displacement and twist, but not against warping. Discrete braces, each modeled by a rigid bar connecting the centroid of the W-shape and the constraint axis at  $a = d/2$ , were placed at one-third points along the member length. A linear spring element (COMBIN14) was used to model the finite support stiffness as shown in Figure 2.

Linear eigenvalue analysis was used to compute the elastic buckling load, which was divided by the value from Equation 2. This buckling load ratio varied from member to member and by span length. The lowest ratio for each member size is a reduction factor that can be applied to Equation 2 instead of the 0.90 factor discussed in the paragraph following Equation 2, thus providing a conservative and simple method for computing the CAFTB strength of discretely braced members subject to specific limitations.

For one-third point (or closer) spacing of discrete braces with  $k \geq 10$  kip/in., and  $a = d/2$ , a 0.75 reduction factor (instead of 0.9) can be used for the following sections: W10 under 60 lb/ft; W12 under 100 lb/ft; W14, W16, W18 under 120 lb/ft; W21, W24 under 150 lb/ft; W27 under 200 lb/ft; and W30 through W44 under 250 lb/ft. For one-third point (or closer) spacing of discrete braces with  $k \geq 30$  kip/in., and  $a = d/2$ , a 0.75 reduction factor (instead of 0.9) can be used for the following sections: W10 and W12 under 100 lb/ft; W14, W16, W18 under 150 lb/ft; W21 through W27 under 250 lb/ft; W30 through W44 under 350 lb/ft. In summary, the CAFTB strength is computed in the following sequence:

1.  $P_e$  using Eq. (2) with  $a = d/2$
2.  $F_e = 0.75P_e/A$
3.  $F_{cr}$  using Section E3 or E7
4.  $P_n = F_{cr}A$
5.  $\phi P_n$  where  $\phi = 0.9$

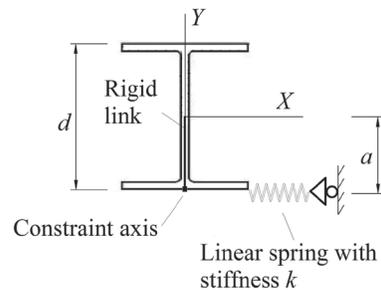


Fig. 2. Constraining axis condition for FEA modeling.

## EXAMPLE 1

### Torsional Buckling Available Strength of W-Shape

#### Given:

Determine the torsional buckling available strength of a W14×48 in axial compression.

$$K_z L = 32.0 \text{ ft} \quad F_y = 50 \text{ ksi} \quad E = 29000 \text{ ksi} \quad G = 11200 \text{ ksi} \quad A_g = 14.1 \text{ in.}^2 \quad I_x = 484 \text{ in.}^4 \\ I_y = 51.4 \text{ in.}^4 \quad J = 1.45 \text{ in.}^6 \quad C_w = 2240 \text{ in.}^6$$

#### Solution:

##### Local Buckling Classification

From AISC *Manual* Table 1-1, the W14×48 is nonslender for compression. AISC *Specification* Sections E3 and E4 apply.

##### Torsional Buckling about z-z Axis

$$F_e = \left[ \frac{\pi^2 E C_w}{(K_z L)^2} + GJ \right] \frac{1}{I_x + I_y} = \left[ \frac{\pi^2 (29000)(2240)}{[32(12)]^2} + 11200(1.45) \right] \frac{1}{484 + 51.4} = 38.4 \text{ ksi}$$

$$\frac{F_y}{F_e} = \frac{50 \text{ ksi}}{38.4 \text{ ksi}} = 1.30 < 2.25$$

$$F_{cr} = \left[ 0.658^{\frac{F_y}{F_e}} \right] F_y = \left[ 0.658^{1.30} \right] 50 = 29.0 \text{ ksi}$$

$$P_n = F_{cr} A_g = 29.0 \text{ ksi}(14.1 \text{ in.}^2) = 409 \text{ kips}$$

##### LRFD Design Strength

$$\phi_c P_n = 0.9(409 \text{ kips}) = 368 \text{ kips (matches table)}$$

##### ASD Allowable Strength

$$P_n / \Omega_c = 409 \text{ kips} / 1.67 = 245 \text{ kips}$$

## EXAMPLE 2

### Torsional Buckling Available Strength of W-Shape

#### Given:

Determine torsional buckling available strength (LRFD) of a W16×26 in axial compression.

$$K_z L = 8 \text{ ft} \quad F_y = 50 \text{ ksi} \quad E = 29000 \text{ ksi} \quad G = 11200 \text{ ksi} \quad A_g = 7.68 \text{ in.}^2 \quad d = 15.7 \text{ in.} \quad t_w = 0.250 \text{ in.} \\ b_f = 5.50 \text{ in.} \quad t_f = 0.345 \text{ in.} \quad k = 0.747 \text{ in.} \quad I_x = 301 \text{ in.}^4 \quad I_y = 9.59 \text{ in.}^4 \quad J = 0.262 \text{ in.}^6 \quad C_w = 565 \text{ in.}^6$$

**Solution:**

*Local Buckling Classification*

From AISC *Specification* Table B 4.1a, Case 1, the limiting width-to-thickness ratio for the flange is

$$\lambda_r = 0.56 \sqrt{\frac{29000}{50}} = 13.5$$

For the W16×26,

$$\frac{b_f}{2t_f} = \frac{5.50}{2(0.345)} = 7.97$$

$$\frac{b_f}{2t_f} = 7.97 < 13.5, \text{ the flange is nonslender}$$

From AISC *Specification* Table B 4.1a, Case 5, the limiting width-to-thickness ratio for the web is

$$\lambda_r = 1.49 \sqrt{\frac{29000}{50}} = 35.9$$

For the W16×26,

$$\frac{h}{t_w} = \frac{d - 2(k)}{t_w} = \frac{15.7 - 2(0.747)}{0.250} = 56.8$$

$$\frac{h}{t_w} = 56.8 > 35.9, \text{ the web is slender for axial compression. AISC Specification Section E7 applies.}$$

*Reduction Factor ( $Q_a$ ) for Slender Web*

$$F_e = \left[ \frac{\pi^2 E C_w}{(K_z L)^2} + GJ \right] \frac{1}{I_x + I_y} = \left[ \frac{\pi^2 (29000)(565)}{[8(12)]^2} + 11200(0.262) \right] \frac{1}{301 + 9.59} = 65.9 \text{ ksi}$$

$$\frac{F_y}{F_e} = \frac{50 \text{ ksi}}{65.9 \text{ ksi}} = 0.759 < 2.25$$

$$f = F_{cr} = \left[ 0.658 \frac{F_y}{F_e} \right] F_y = \left[ 0.658^{0.759} \right] 50 = 36.4 \text{ ksi}$$

$$b_e = 1.92t \sqrt{\frac{E}{f}} \left[ 1 - \frac{0.34}{(b/t)} \sqrt{\frac{E}{f}} \right] = 1.92(0.250) \sqrt{\frac{29000}{36.4}} \left[ 1 - \frac{0.34}{56.8} \sqrt{\frac{29000}{36.4}} \right] = 11.3 \text{ in.}$$

$$A_e = 7.68 - (14.2 - 11.3)(0.250) = 6.96 \text{ in.}^2$$

$$Q = Q_a = A_e / A_g = 6.96 / 7.68 = 0.906$$

*Torsional Buckling about z-z Axis*

$$QF_y / F_e = 0.906(50) / 65.9 = 0.687 < 2.25$$

$$F_{cr} = Q \left[ 0.658 \frac{QF_y}{F_e} \right] F_y = 0.906 \left( 0.658^{0.687} \right) 50 = 34.0 \text{ ksi}$$

$$P_n = F_{cr} A_g = 34.0 \text{ ksi} (7.68 \text{ in.}^2) = 261 \text{ kips}$$

*LRFD Available Strength*

$$\phi_c P_n = 0.9(261 \text{ kips}) = 235 \text{ kips (matches table)}$$

### EXAMPLE 3

#### W-Shape Available Strength Calculation

**Given:**

The following W14×90 column supports the axial load shown in Figure 3. The column is simply supported and torsionally pinned at its top and bottom. It is restrained against weak-axis translation at mid-height.  $(KL)_y = 15 \text{ ft}$ ,  $(KL)_x = K_z L = 30 \text{ ft}$ . Determine the column's available strength (LRFD) in axial compression considering all applicable limit states, and determine whether it is adequate to support the given loads.

**Solution:**

From AISC Manual Table 1-1, for W14×90,  $A_g = 26.5 \text{ in.}^2$ ,  $r_x = 6.14 \text{ in.}$ ,  $r_y = 3.70 \text{ in.}$

*Local Buckling Classification*

From Table 1-1, the W14×90 is nonslender for compression; therefore AISC Specification Sections E3 and E4 apply.

*Flexural Buckling about Weak (y-y) Axis*

The effective unbraced length in the y-y axis,  $(KL)_y$ , is 15 ft.

From AISC Manual Table 4-1,  $\phi_c P_n = 1000 \text{ kips}$

*Flexural Buckling about Strong (x-x) Axis*

The effective unbraced length in the x-x axis,  $(KL)_x$ , is 30 ft.

$$(KL)_x / r_x = 30(12) / 6.14 = 58.6$$

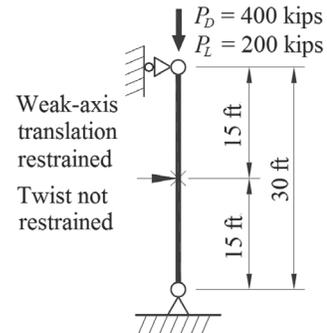


Fig. 3. Example 3.

From AISC *Manual* Table 4-22,

$$\phi_c F_{cr} = 35.0 \text{ ksi}$$

$$\phi_c P_n = \phi_c F_{cr} A_g = (35.0)(26.5) = 928 \text{ kips}$$

#### *Torsional Buckling*

The effective length for torsional buckling,  $K_z L$ , is 30 ft.

From the table in this paper,  $\phi_c P_n = 838$  kips.

Torsional buckling controls:  $\phi_c P_n = 838 \text{ kips} > P_u = (1.2)400 + 1.6(200) = 800 \text{ kips}$ ; therefore the column is adequate.

### EXAMPLE 4

#### Constrained Axis Flexural Torsional Buckling Available Strength of W-Shape

##### **Given:**

Determine the constrained axis flexural torsional buckling available strength of a W18×35 in axial compression. The constrained axis is located at the intersection of the web centerline and the outside face of flange.

$$K_z L = 8.00 \text{ ft} \quad F_y = 50 \text{ ksi} \quad E = 29000 \text{ ksi} \quad G = 11200 \text{ ksi} \quad A_g = 10.3 \text{ in.}^2 \quad d = 17.7 \text{ in.}$$

$$t_w = 0.300 \text{ in.} \quad b_f = 6.00 \text{ in.} \quad t_f = 0.425 \text{ in.} \quad k = 0.827 \text{ in.} \quad I_x = 510 \text{ in.}^4 \quad r_x = 7.04 \text{ in.}$$

$$I_y = 15.3 \text{ in.}^4 \quad r_y = 1.22 \text{ in.} \quad J = 0.506 \text{ in.}^4 \quad C_w = 1140 \text{ in.}^6$$

##### **Solution:**

##### *Local Buckling Classification*

From AISC *Specification* Table B 4.1a, Case 1, the limiting width-to-thickness ratio for the flange is

$$\lambda_r = 0.56 \sqrt{\frac{29000}{50}} = 13.5$$

For the W18×35,

$$\frac{b_f}{2t_f} = \frac{6.00}{2(0.425)} = 7.06$$

Because  $\frac{b_f}{2t_f} = 7.06 < 13.5$ , the flange is nonslender.

From Table B 4.1a, Case 5, the limiting width-to-thickness ratio for the web is

$$\lambda_r = 1.49 \sqrt{\frac{29000}{50}} = 35.9$$

For the W18×35,

$$\frac{h}{t_w} = \frac{d-2(k)}{t_w} = \frac{17.7-2(0.827)}{0.300} = 53.5$$

Because  $\frac{h}{t_w} = 53.5 > 35.9$ , the web is slender, and AISC Specification Section E7 applies.

$$F_e = 0.9 \left[ \frac{\pi^2 E (C_w + I_y a^2)}{(K_z L)^2} + GJ \right] \frac{1}{(r_x^2 + r_y^2 + a^2) A_g}$$

$$= 0.9 \left[ \frac{\pi^2 (29000) \left( 1140 + 15.3 \left( \frac{17.7}{2} \right)^2 \right)}{[8(12)]^2} + 11200(0.506) \right] \frac{1}{[7.04^2 + 1.22^2 + (0.5(17.7))^2](10.3)} = 52.9 \text{ ksi}$$

$$F_y/F_e = 50/52.9 = 0.945 < 2.25$$

$$f = F_{cr} = \left[ 0.658 \frac{F_y}{F_e} \right] F_y = (0.658^{0.945}) 50 = 33.7 \text{ ksi}$$

$$b_e = 1.92t \sqrt{\frac{E}{f}} \left[ 1 - \frac{0.34}{(b/t)} \sqrt{\frac{E}{f}} \right] = 1.92(0.300) \sqrt{\frac{29000}{33.7}} \left[ 1 - \frac{0.34}{53.5} \sqrt{\frac{29000}{33.7}} \right] = 13.7 \text{ in.}$$

$$A_e = 10.3 - (16.0 - 13.7)(0.300) = 9.61 \text{ in.}^2$$

$$Q = Q_a = A_e/A_g = 9.61/10.3 = 0.933$$

$$QF_y/F_e = 0.933 (50) / 52.9 = 0.882 < 2.25$$

$$F_{cr} = Q \left[ 0.658 \frac{QF_y}{F_e} \right] F_y = 0.933 (0.658^{0.882}) 50 = 32.2 \text{ ksi}$$

$$P_n = F_{cr} A_g = 32.2(10.3) = 332 \text{ kips}$$

*LRFD Available Strength*

$$\phi_c P_n = 0.9(331 \text{ kips}) = 299 \text{ kips (matches table)}$$

## EXAMPLE 5

### Available Strength of W-Shape in Axial Compression

#### Given:

Determine the available strength (LRFD) of a W14×132 in axial compression (see Figure 4).

$$(KL)_x = 40.0 \text{ ft} \quad K_z L = 40.0 \text{ ft} \quad F_y = 50 \text{ ksi} \quad E = 29000 \text{ ksi}$$

$$A_g = 38.8 \text{ in.}^2 \quad r_x = 6.28 \text{ in.}$$

#### Solution:

##### Local Buckling Classification

From Table 1-1, the W14×132 is nonslender for compression; therefore AISC Specification Sections E3 and E4 apply.

##### Flexural Buckling about Strong (x-x) Axis

The effective unbraced length about the x-x axis,  $(KL)_x$ , is 40 ft.

$$(KL)_x/r_x = 40(12)/6.28 = 76.4$$

From AISC Manual Table 4-22,

$$\phi_c F_{cr} = 29.4 \text{ ksi}$$

$$\phi_c P_n = \phi_c F_{cr} A_g = 29.4(38.8) = 1140 \text{ kips}$$

##### Constrained Axis Flexural Torsional Buckling

The effective length for CAFTB,  $K_z L$ , is 40 ft.

From the table in this paper,  $\phi_c P_n = 1090$  kips.

##### LRFD Design Strength

$$\phi_c P_n = 1090 \text{ kips}$$

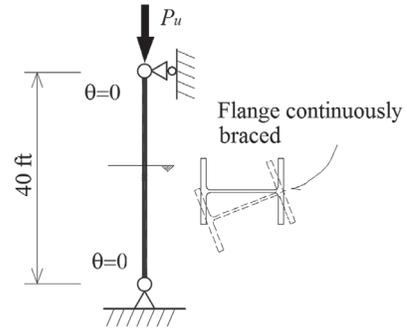
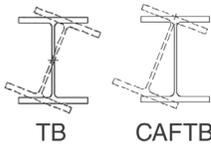


Fig. 4. Example 5.

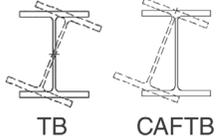
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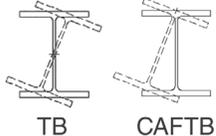
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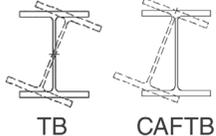
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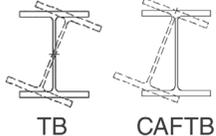
$F_y = 50$ ksi		<b>Table 1.</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W36x														
lb / ft	800		652		529		487		441		395		361		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	10600	10600	8640	8640	7020	7020	6430	6430	5850	5850	5220	5220	4770	4770
	6	10500	10400	8500	8460	6900	6860	6320	6290	5740	5710	5120	5090	4680	4650
	7	10400	10300	8460	8390	6860	6810	6280	6230	5710	5660	5090	5050	4650	4610
	8	10400	10300	8410	8320	6820	6750	6240	6180	5670	5610	5050	5000	4610	4560
	9	10300	10200	8360	8250	6770	6680	6200	6120	5630	5550	5010	4950	4580	4510
	10	10300	10100	8310	8170	6720	6610	6150	6050	5580	5490	4970	4890	4540	4460
	11	10200	10000	8260	8090	6680	6540	6110	5980	5540	5420	4930	4820	4490	4400
	12	10200	9910	8210	8010	6630	6460	6060	5910	5490	5350	4880	4760	4450	4340
	13	10100	9820	8170	7920	6580	6380	6010	5830	5450	5280	4840	4690	4410	4270
	14	10100	9730	8120	7830	6530	6300	5960	5750	5400	5210	4790	4620	4360	4210
	15	10000	9640	8070	7750	6490	6220	5920	5670	5350	5130	4750	4550	4320	4140
	16	10000	9550	8030	7660	6440	6130	5870	5590	5310	5050	4700	4470	4270	4070
	17	9960	9460	7990	7580	6400	6050	5830	5510	5260	4970	4660	4400	4230	4000
	18	9930	9380	7950	7490	6360	5970	5780	5430	5220	4900	4610	4330	4180	3920
	19	9890	9300	7920	7410	6310	5890	5740	5360	5170	4820	4570	4250	4140	3850
	20	9860	9220	7880	7330	6280	5810	5700	5280	5130	4740	4530	4180	4100	3780
	22	9810	9070	7820	7180	6200	5660	5630	5130	5060	4590	4450	4030	4010	3640
	24	9770	8940	7760	7040	6140	5510	5560	4980	4980	4450	4370	3890	3940	3500
	26	9730	8820	7720	6910	6080	5370	5500	4850	4920	4310	4300	3760	3870	3370
	28	9690	8700	7670	6790	6030	5250	5450	4720	4860	4180	4240	3630	3800	3240
30	9660	8610	7640	6680	5990	5130	5400	4600	4810	4060	4180	3510	3740	3120	
32	9640	8520	7610	6580	5950	5020	5350	4490	4760	3950	4130	3390	3680	3010	
34	9620	8440	7580	6490	5910	4920	5310	4390	4720	3850	4080	3290	3630	2900	
36	9600	8360	7550	6410	5880	4830	5280	4300	4680	3750	4040	3190	3590	2800	
38	9580	8300	7530	6330	5850	4750	5250	4210	4640	3660	4000	3100	3540	2710	
40	9570	8240	7510	6270	5820	4670	5220	4140	4610	3580	3970	3020	3510	2630	

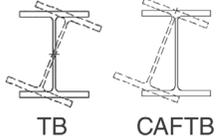
Shape		W36x													
		330		302		282		262		247		231		256	
Design	TB	CAFTB													
Unbraced Length $K_z L$ (ft)	0	4360	4360	4000	4000	3720	3720	3410	3410	3170	3170	2940	2940	3390	3390
	6	4270	4250	3930	3900	3650	3630	3350	3340	3110	3100	2890	2870	3270	3220
	7	4250	4210	3900	3870	3630	3600	3330	3310	3090	3070	2870	2850	3230	3170
	8	4210	4170	3870	3830	3600	3560	3310	3280	3070	3040	2850	2830	3180	3100
	9	4180	4120	3840	3780	3570	3520	3280	3240	3050	3010	2830	2800	3140	3040
	10	4140	4070	3800	3740	3540	3480	3260	3210	3020	2980	2800	2760	3090	2970
	11	4100	4020	3760	3690	3500	3430	3230	3170	2990	2940	2780	2730	3040	2890
	12	4060	3960	3720	3630	3460	3380	3190	3120	2960	2900	2750	2690	2990	2820
	13	4020	3900	3680	3570	3420	3320	3160	3080	2930	2850	2720	2650	2940	2740
	14	3970	3830	3640	3510	3380	3260	3130	3030	2900	2810	2690	2610	2890	2660
	15	3930	3770	3600	3450	3340	3210	3090	2970	2860	2760	2660	2560	2850	2580
	16	3890	3700	3550	3390	3300	3140	3050	2910	2830	2710	2630	2520	2800	2500
	17	3840	3640	3510	3320	3250	3080	3020	2850	2790	2660	2590	2470	2750	2420
	18	3800	3570	3470	3260	3210	3020	2980	2790	2760	2610	2560	2420	2710	2350
	19	3750	3500	3420	3190	3170	2960	2930	2730	2720	2560	2520	2370	2670	2270
	20	3710	3430	3380	3130	3130	2890	2890	2670	2690	2500	2490	2320	2630	2200
	22	3630	3290	3300	2990	3040	2760	2810	2550	2610	2380	2420	2210	2550	2060
	24	3550	3160	3220	2860	2960	2640	2730	2420	2540	2260	2350	2100	2490	1940
	26	3480	3030	3140	2740	2890	2510	2650	2300	2460	2140	2280	1990	2430	1820
	28	3410	2900	3070	2610	2820	2400	2580	2180	2390	2030	2210	1880	2370	1710
30	3340	2790	3000	2500	2750	2280	2510	2070	2320	1920	2150	1770	2330	1620	
32	3290	2670	2940	2390	2690	2170	2440	1960	2250	1810	2080	1670	2280	1530	
34	3230	2570	2880	2280	2630	2070	2380	1860	2190	1710	2020	1570	2250	1460	
36	3180	2470	2830	2180	2570	1970	2330	1770	2130	1620	1960	1480	2210	1390	
38	3140	2380	2780	2090	2520	1880	2270	1680	2080	1530	1900	1390	2180	1320	
40	3100	2290	2740	2000	2470	1800	2220	1590	2030	1450	1850	1310	2150	1270	

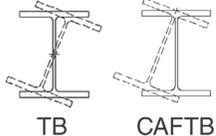
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W36x														
lb / ft	232		210		194		182		170		160		150		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	3020	3020	2710	2710	2430	2430	2250	2250	2050	2050	1900	1900	1760	1760
	6	2920	2890	2620	2590	2350	2330	2180	2150	1990	1970	1840	1820	1710	1690
	7	2890	2840	2590	2550	2330	2290	2150	2120	1970	1940	1820	1790	1690	1660
	8	2860	2800	2560	2500	2300	2250	2130	2080	1950	1900	1800	1760	1670	1640
	9	2820	2730	2530	2450	2270	2210	2100	2040	1920	1870	1780	1730	1650	1600
	10	2780	2670	2490	2400	2240	2160	2070	2000	1890	1830	1750	1690	1620	1570
	11	2730	2600	2450	2340	2200	2110	2040	1950	1860	1780	1720	1650	1600	1530
	12	2690	2530	2410	2280	2170	2050	2000	1900	1830	1740	1690	1610	1570	1490
	13	2640	2450	2370	2210	2130	1990	1970	1850	1800	1690	1660	1560	1540	1450
	14	2590	2380	2330	2140	2090	1940	1930	1790	1760	1640	1630	1510	1510	1400
	15	2540	2300	2290	2060	2050	1870	1890	1740	1730	1580	1600	1460	1480	1360
	16	2500	2230	2240	1990	2010	1810	1860	1680	1690	1530	1560	1410	1450	1310
	17	2450	2150	2190	1920	1980	1740	1820	1620	1660	1480	1530	1360	1420	1260
	18	2410	2080	2150	1850	1940	1680	1780	1560	1620	1420	1500	1310	1380	1210
	19	2370	2010	2110	1780	1900	1610	1750	1500	1590	1370	1460	1260	1350	1160
	20	2330	1940	2060	1710	1860	1540	1710	1440	1560	1310	1430	1200	1320	1110
	22	2250	1810	1980	1580	1790	1420	1640	1310	1490	1200	1360	1100	1250	1010
	24	2180	1680	1910	1460	1720	1300	1580	1200	1420	1090	1300	993	1190	909
	26	2120	1570	1840	1340	1650	1190	1510	1090	1360	986	1240	895	1130	813
	28	2060	1470	1780	1240	1590	1090	1450	997	1310	893	1180	803	1080	724
30	2010	1370	1730	1150	1530	1000	1390	908	1250	807	1130	723	1020	650	
32	1960	1290	1680	1060	1480	919	1340	831	1200	736	1080	658	974	590	
34	1920	1210	1630	987	1430	851	1290	767	1150	677	1030	604	927	540	
36	1890	1140	1590	924	1390	793	1250	713	1110	628	990	558	883	498	
38	1860	1080	1560	870	1350	745	1210	667	1070	586	950	520	843	462	
40	1830	1030	1520	824	1320	703	1180	629	1030	551	914	487	806	432	

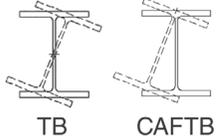
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W36x		W33x												
lb / ft	135		387		354		318		291		263		241		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1550	1550	5130	5130	4680	4680	4220	4220	3850	3850	3480	3480	3190	3190
	6	1510	1490	5030	5000	4580	4560	4130	4100	3770	3750	3410	3390	3130	3110
	7	1490	1460	4990	4950	4550	4520	4100	4060	3740	3710	3380	3350	3110	3080
	8	1470	1440	4960	4900	4520	4470	4070	4020	3710	3670	3350	3320	3080	3040
	9	1450	1410	4920	4850	4480	4420	4030	3970	3680	3620	3320	3270	3050	3000
	10	1430	1380	4880	4790	4440	4360	3990	3920	3640	3580	3290	3230	3020	2960
	11	1400	1340	4840	4730	4400	4300	3960	3870	3610	3520	3250	3180	2980	2920
	12	1380	1300	4790	4660	4360	4240	3920	3810	3570	3470	3210	3130	2950	2870
	13	1350	1270	4750	4590	4320	4180	3870	3750	3530	3410	3180	3080	2910	2820
	14	1330	1220	4710	4530	4280	4110	3830	3680	3490	3350	3140	3020	2870	2760
	15	1300	1180	4670	4460	4230	4040	3790	3620	3450	3290	3100	2960	2840	2710
	16	1270	1140	4620	4380	4190	3980	3750	3560	3410	3230	3060	2910	2800	2650
	17	1240	1090	4580	4310	4150	3910	3710	3490	3370	3170	3020	2850	2760	2600
	18	1210	1040	4540	4240	4110	3840	3670	3420	3330	3100	2980	2790	2720	2540
	19	1180	998	4510	4170	4070	3770	3630	3360	3290	3040	2940	2730	2680	2480
	20	1150	951	4470	4100	4040	3710	3590	3290	3250	2980	2900	2670	2640	2420
	22	1080	856	4400	3970	3970	3570	3520	3170	3170	2850	2830	2550	2570	2310
	24	1020	763	4340	3840	3900	3450	3450	3040	3100	2730	2760	2430	2490	2190
	26	966	672	4280	3720	3840	3330	3390	2920	3040	2620	2690	2320	2430	2080
	28	910	594	4230	3610	3790	3220	3330	2810	2980	2510	2630	2210	2360	1980
30	857	531	4190	3500	3740	3110	3280	2700	2920	2400	2570	2110	2300	1880	
32	808	480	4150	3410	3700	3010	3230	2610	2870	2300	2520	2010	2240	1780	
34	760	437	4110	3320	3660	2920	3190	2510	2830	2210	2470	1920	2190	1690	
36	717	402	4080	3230	3620	2840	3150	2430	2790	2130	2420	1840	2140	1600	
38	676	372	4050	3160	3590	2760	3110	2350	2750	2050	2380	1760	2100	1530	
40	640	346	4020	3090	3560	2690	3080	2280	2710	1970	2340	1690	2060	1450	

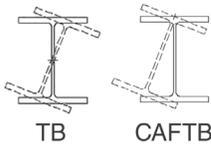
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W33x														
lb / ft	221		201		169		152		141		130		118		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2880	2880	2550	2550	2090	2090	1860	1860	1690	1690	1530	1530	1350	1350
	6	2830	2810	2510	2490	2020	1990	1800	1770	1630	1610	1480	1460	1310	1290
	7	2810	2790	2490	2470	1990	1960	1780	1750	1610	1590	1460	1440	1290	1270
	8	2790	2760	2470	2450	1970	1920	1750	1710	1590	1560	1440	1410	1280	1250
	9	2760	2730	2450	2420	1940	1880	1730	1680	1570	1520	1420	1380	1260	1220
	10	2740	2690	2430	2390	1910	1840	1700	1640	1540	1490	1400	1350	1240	1190
	11	2710	2650	2400	2350	1880	1790	1670	1600	1520	1450	1370	1310	1210	1160
	12	2680	2610	2370	2320	1850	1750	1640	1550	1490	1410	1350	1280	1190	1120
	13	2650	2570	2350	2280	1810	1700	1610	1510	1460	1360	1320	1240	1170	1090
	14	2620	2530	2320	2240	1780	1640	1580	1460	1430	1320	1290	1190	1140	1050
	15	2580	2480	2290	2200	1750	1590	1550	1410	1400	1270	1260	1150	1110	1010
	16	2550	2420	2260	2160	1710	1540	1510	1360	1370	1230	1240	1110	1090	971
	17	2520	2370	2220	2110	1680	1480	1480	1310	1340	1180	1210	1060	1060	930
	18	2480	2310	2190	2070	1650	1430	1450	1260	1310	1130	1180	1020	1030	888
	19	2440	2260	2160	2020	1610	1370	1420	1210	1280	1080	1150	974	1010	846
	20	2400	2200	2130	1970	1580	1310	1390	1160	1250	1040	1120	929	978	803
	22	2330	2090	2060	1870	1520	1200	1330	1050	1190	940	1060	839	923	719
	24	2250	1980	2000	1770	1460	1100	1270	954	1130	846	1010	750	869	637
	26	2180	1870	1940	1660	1410	1010	1210	865	1080	760	952	667	818	559
	28	2120	1770	1870	1560	1360	928	1160	782	1030	681	902	593	769	495
30	2060	1670	1810	1470	1310	851	1120	709	982	614	855	533	722	443	
32	2000	1580	1750	1380	1270	784	1070	648	937	560	811	484	679	401	
34	1940	1490	1690	1290	1230	728	1030	598	896	515	770	444	638	366	
36	1890	1400	1640	1210	1200	681	994	556	859	478	732	410	600	337	
38	1850	1330	1600	1140	1170	641	961	521	825	446	698	381	566	312	
40	1800	1250	1550	1070	1140	607	932	491	795	419	667	356	537	291	

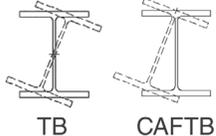
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W30x														
lb/ft	391		357		326		292		261		235		211		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	5170	5170	4720	4720	4320	4320	3870	3870	3460	3460	3120	3120	2800	2800
	6	5070	5040	4620	4590	4220	4190	3780	3760	3380	3360	3040	3020	2740	2720
	7	5030	4990	4590	4550	4190	4150	3750	3720	3360	3330	3020	2990	2710	2690
	8	5000	4940	4560	4500	4160	4110	3720	3680	3330	3290	2990	2960	2690	2650
	9	4960	4880	4520	4450	4120	4060	3690	3630	3300	3240	2960	2920	2660	2620
	10	4920	4820	4480	4390	4080	4000	3650	3580	3260	3200	2930	2870	2630	2580
	11	4880	4760	4440	4330	4050	3950	3620	3530	3230	3150	2900	2830	2600	2540
	12	4840	4700	4400	4270	4010	3890	3580	3470	3190	3100	2860	2780	2570	2490
	13	4800	4630	4370	4210	3970	3830	3540	3420	3150	3040	2830	2730	2530	2440
	14	4770	4560	4330	4150	3930	3770	3500	3360	3120	2990	2790	2680	2500	2390
	15	4730	4500	4290	4080	3900	3700	3470	3300	3080	2930	2760	2620	2460	2340
	16	4690	4430	4260	4020	3860	3640	3430	3240	3040	2870	2720	2570	2430	2290
	17	4660	4370	4220	3960	3820	3580	3400	3180	3010	2810	2690	2510	2390	2240
	18	4630	4300	4190	3890	3790	3520	3360	3120	2970	2760	2650	2460	2360	2190
	19	4600	4240	4160	3830	3760	3460	3330	3060	2940	2700	2620	2410	2320	2140
	20	4570	4180	4130	3770	3730	3400	3300	3000	2910	2640	2580	2350	2290	2090
	22	4520	4070	4070	3660	3670	3280	3240	2890	2840	2530	2520	2240	2220	1980
	24	4470	3960	4020	3550	3620	3170	3180	2780	2790	2420	2460	2140	2160	1880
	26	4430	3860	3980	3450	3570	3070	3130	2680	2730	2320	2400	2040	2100	1780
	28	4400	3770	3940	3350	3530	2980	3080	2580	2680	2230	2350	1950	2050	1690
30	4370	3680	3910	3270	3490	2890	3040	2500	2640	2140	2310	1860	2000	1610	
32	4340	3610	3880	3190	3460	2810	3010	2410	2600	2060	2260	1780	1950	1520	
34	4320	3540	3850	3120	3430	2740	2970	2340	2560	1980	2220	1700	1910	1450	
36	4300	3480	3830	3060	3410	2670	2940	2270	2530	1910	2190	1630	1870	1380	
38	4280	3420	3810	3000	3380	2610	2920	2210	2500	1840	2160	1570	1840	1310	
40	4260	3370	3790	2940	3360	2560	2890	2150	2470	1790	2130	1510	1800	1250	

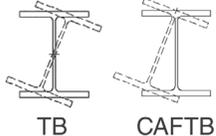
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W30x														
lb / ft	191		173		148		132		124		116		108		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2490	2490	2220	2220	1880	1880	1640	1640	1520	1520	1400	1400	1280	1280
	6	2440	2420	2170	2160	1800	1770	1570	1550	1460	1430	1350	1330	1230	1210
	7	2420	2400	2150	2140	1780	1740	1550	1520	1440	1410	1330	1300	1210	1190
	8	2400	2370	2130	2110	1750	1700	1530	1480	1410	1370	1310	1270	1190	1160
	9	2380	2340	2110	2090	1720	1660	1500	1450	1390	1340	1280	1240	1170	1130
	10	2350	2310	2090	2060	1690	1610	1470	1410	1360	1300	1260	1200	1150	1090
	11	2320	2280	2070	2020	1660	1560	1440	1360	1340	1260	1230	1160	1120	1060
	12	2300	2240	2040	1990	1630	1510	1410	1320	1310	1220	1210	1120	1100	1020
	13	2270	2190	2020	1960	1590	1460	1380	1270	1280	1180	1180	1080	1070	982
	14	2240	2150	1990	1920	1560	1410	1350	1220	1250	1130	1150	1040	1050	941
	15	2200	2100	1960	1880	1530	1350	1320	1180	1220	1090	1120	995	1020	900
	16	2170	2050	1940	1840	1500	1290	1290	1120	1190	1040	1090	950	991	858
	17	2140	2000	1910	1800	1470	1240	1260	1070	1160	993	1070	906	964	815
	18	2100	1960	1880	1760	1440	1180	1230	1020	1130	944	1040	861	937	773
	19	2070	1910	1850	1710	1410	1130	1200	971	1100	896	1010	814	910	730
	20	2040	1860	1820	1660	1380	1080	1180	923	1080	849	983	769	884	686
	22	1970	1760	1760	1570	1320	990	1120	833	1020	762	931	684	832	605
	24	1910	1660	1700	1480	1270	905	1070	751	976	682	882	607	784	530
	26	1850	1570	1640	1390	1230	829	1020	677	928	609	836	538	739	468
	28	1790	1480	1580	1300	1190	761	978	611	885	549	792	483	695	418
30	1740	1400	1530	1220	1150	701	941	559	846	499	753	438	655	378	
32	1690	1320	1480	1150	1120	652	907	515	811	459	718	402	620	345	
34	1650	1240	1440	1070	1090	611	877	480	781	426	686	371	588	318	
36	1610	1180	1390	1010	1070	576	850	450	753	398	658	346	560	295	
38	1570	1110	1360	945	1050	547	826	424	728	374	633	325	533	276	
40	1540	1050	1320	887	1030	522	805	402	706	354	611	306	511	260	

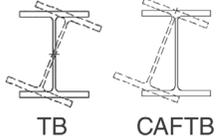
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W30x				W27x										
lb / ft	99		90		539		368		336		307		281		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1150	1150	1010	1010	7150	7150	4900	4900	4460	4460	4060	4060	3740	3740
	6	1100	1080	968	952	7020	6970	4790	4760	4360	4330	3960	3930	3650	3620
	7	1080	1060	954	933	6980	6910	4760	4710	4330	4280	3930	3890	3620	3580
	8	1070	1040	939	911	6940	6850	4730	4660	4290	4230	3900	3840	3590	3540
	9	1050	1010	922	887	6910	6780	4690	4600	4260	4180	3860	3790	3550	3490
	10	1030	978	903	861	6870	6710	4650	4550	4220	4130	3830	3740	3520	3440
	11	1000	945	884	833	6840	6650	4620	4490	4190	4070	3790	3690	3480	3390
	12	982	911	863	803	6810	6580	4580	4430	4150	4010	3760	3630	3450	3330
	13	958	876	842	772	6780	6520	4550	4360	4120	3950	3730	3570	3420	3280
	14	933	838	820	739	6750	6450	4520	4300	4090	3890	3690	3520	3380	3220
	15	907	800	797	705	6730	6390	4490	4240	4060	3830	3660	3460	3350	3160
	16	882	761	774	671	6710	6340	4460	4190	4030	3780	3630	3400	3320	3110
	17	856	722	751	636	6690	6280	4440	4130	4000	3720	3610	3350	3290	3050
	18	830	682	727	601	6670	6230	4410	4070	3980	3670	3580	3290	3270	3000
	19	805	643	704	565	6650	6180	4390	4020	3950	3610	3550	3240	3240	2950
	20	780	603	680	530	6640	6130	4370	3970	3930	3560	3530	3190	3210	2900
	22	730	526	634	461	6610	6050	4330	3870	3890	3460	3490	3090	3170	2800
	24	683	457	590	397	6590	5980	4300	3790	3850	3380	3450	3000	3130	2710
	26	639	401	548	348	6570	5910	4270	3710	3820	3300	3420	2920	3090	2620
	28	597	357	509	309	6560	5860	4250	3640	3800	3220	3390	2850	3060	2550
30	558	322	472	277	6550	5810	4230	3580	3770	3160	3360	2780	3030	2480	
32	523	293	437	251	6540	5760	4210	3520	3750	3100	3340	2720	3010	2410	
34	491	269	407	230	6530	5730	4190	3470	3740	3050	3320	2660	2990	2360	
36	463	249	382	212	6520	5690	4180	3420	3720	3000	3300	2620	2970	2310	
38	440	232	361	196	6510	5660	4170	3380	3710	2960	3290	2570	2950	2260	
40	420	217	343	183	6510	5640	4160	3350	3700	2920	3270	2530	2940	2220	

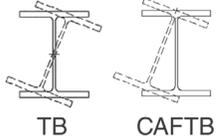
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W27x														
lb / ft	258		235		217		194		178		161		146		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	3420	3420	3120	3120	2880	2880	2570	2570	2360	2360	2130	2130	1900	1900
	6	3340	3310	3040	3020	2800	2780	2500	2480	2300	2280	2080	2070	1850	1840
	7	3310	3280	3020	2980	2770	2750	2480	2450	2280	2250	2060	2040	1830	1820
	8	3280	3230	2990	2950	2750	2710	2450	2420	2250	2220	2040	2010	1820	1790
	9	3250	3190	2960	2900	2720	2670	2420	2380	2220	2180	2010	1980	1800	1770
	10	3210	3140	2920	2860	2690	2630	2390	2340	2200	2150	1990	1940	1780	1740
	11	3180	3090	2890	2810	2660	2580	2360	2300	2170	2110	1960	1910	1750	1710
	12	3150	3040	2860	2760	2620	2530	2330	2260	2140	2060	1930	1870	1730	1680
	13	3110	2990	2830	2710	2590	2490	2300	2210	2110	2020	1900	1830	1700	1640
	14	3080	2930	2790	2660	2560	2440	2270	2160	2080	1980	1870	1780	1680	1610
	15	3050	2880	2760	2610	2530	2390	2240	2120	2040	1930	1840	1740	1650	1570
	16	3020	2820	2730	2550	2490	2340	2210	2070	2010	1880	1810	1700	1630	1530
	17	2990	2770	2700	2500	2460	2280	2180	2020	1980	1840	1780	1650	1600	1480
	18	2960	2720	2670	2450	2430	2230	2150	1970	1950	1790	1750	1610	1570	1440
	19	2930	2660	2640	2400	2400	2190	2120	1920	1920	1740	1720	1560	1540	1400
	20	2900	2610	2610	2350	2380	2140	2090	1880	1890	1700	1690	1520	1510	1360
	22	2860	2520	2560	2250	2320	2040	2030	1790	1840	1600	1640	1430	1460	1270
	24	2810	2430	2520	2160	2280	1950	1980	1700	1780	1520	1580	1350	1400	1190
	26	2770	2340	2470	2080	2230	1870	1940	1620	1740	1440	1530	1270	1350	1120
	28	2740	2260	2440	2000	2200	1790	1900	1540	1690	1360	1490	1190	1310	1040
30	2710	2190	2400	1930	2160	1720	1860	1470	1650	1290	1450	1120	1260	975	
32	2680	2130	2370	1860	2130	1650	1830	1400	1610	1220	1410	1060	1220	911	
34	2660	2070	2350	1800	2100	1590	1790	1340	1580	1160	1370	997	1190	852	
36	2640	2010	2330	1740	2080	1540	1770	1280	1550	1100	1340	941	1150	798	
38	2620	1970	2300	1690	2050	1490	1740	1230	1520	1050	1310	889	1120	747	
40	2600	1920	2290	1650	2030	1440	1720	1190	1500	1000	1280	842	1090	701	

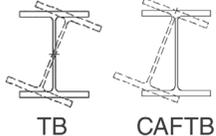
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W27x										W24x				
lb / ft	129		114		102		94		84		370		335		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1650	1650	1440	1440	1240	1240	1120	1120	982	982	4900	4900	4420	4420
	6	1580	1550	1370	1350	1190	1170	1080	1060	939	924	4790	4740	4310	4270
	7	1550	1520	1350	1320	1170	1150	1060	1040	924	904	4750	4690	4280	4230
	8	1530	1480	1330	1290	1150	1120	1040	1010	908	881	4720	4640	4250	4180
	9	1500	1440	1300	1250	1130	1090	1020	981	890	856	4690	4590	4220	4120
	10	1470	1400	1280	1220	1110	1050	1000	951	871	829	4660	4530	4190	4070
	11	1440	1350	1250	1180	1080	1020	977	919	851	800	4630	4470	4160	4010
	12	1410	1300	1220	1140	1060	981	954	885	830	770	4600	4420	4130	3960
	13	1380	1250	1200	1090	1030	943	931	849	808	738	4580	4360	4100	3900
	14	1350	1200	1170	1050	1010	904	907	813	786	705	4560	4310	4080	3850
	15	1320	1150	1140	1000	982	865	882	776	763	672	4540	4260	4060	3800
	16	1290	1100	1110	953	957	825	858	739	740	638	4520	4210	4040	3750
	17	1260	1050	1090	908	932	785	834	701	718	603	4500	4160	4020	3710
	18	1240	1010	1060	863	907	744	810	664	695	569	4480	4120	4000	3660
	19	1210	964	1040	820	883	704	787	627	673	535	4470	4080	3980	3620
	20	1180	922	1010	779	860	665	764	590	651	502	4460	4040	3970	3580
	22	1140	843	960	703	816	593	721	520	609	437	4430	3970	3940	3510
	24	1100	773	917	634	775	528	680	457	569	379	4410	3910	3920	3440
	26	1060	711	878	572	736	469	643	405	532	334	4400	3850	3910	3390
	28	1030	655	844	519	701	423	607	364	497	299	4390	3810	3890	3340
30	1000	606	813	476	669	386	575	331	465	270	4370	3770	3880	3290	
32	979	566	786	441	641	356	546	303	437	246	4360	3730	3870	3260	
34	958	533	762	412	617	331	521	281	411	227	4360	3700	3860	3220	
36	939	505	741	388	595	310	498	262	389	210	4350	3670	3850	3190	
38	922	481	722	367	575	292	478	246	370	197	4340	3650	3840	3170	
40	908	461	706	350	558	277	460	232	354	185	4340	3630	3840	3140	

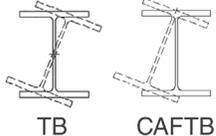
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W24x														
lb / ft	306		279		250		229		207		192		176		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	4040	4040	3690	3690	3310	3310	3020	3020	2730	2730	2540	2540	2330	2330
	6	3930	3900	3590	3550	3210	3190	2940	2910	2650	2630	2460	2440	2250	2230
	7	3900	3850	3560	3510	3190	3150	2910	2870	2620	2590	2440	2410	2230	2200
	8	3870	3800	3520	3470	3160	3100	2880	2830	2600	2550	2410	2370	2200	2170
	9	3840	3750	3490	3420	3120	3060	2850	2790	2570	2510	2380	2340	2180	2130
	10	3810	3700	3460	3370	3090	3010	2820	2740	2540	2470	2360	2290	2150	2090
	11	3780	3650	3430	3310	3060	2960	2790	2690	2510	2420	2330	2250	2120	2050
	12	3750	3590	3400	3260	3030	2910	2760	2640	2480	2380	2300	2200	2090	2010
	13	3720	3540	3380	3210	3010	2860	2730	2590	2450	2330	2270	2160	2060	1960
	14	3690	3490	3350	3160	2980	2810	2700	2550	2420	2280	2240	2110	2030	1920
	15	3670	3440	3320	3110	2950	2760	2680	2500	2390	2230	2210	2070	2010	1870
	16	3650	3390	3300	3060	2930	2710	2650	2450	2370	2190	2180	2020	1980	1830
	17	3630	3340	3280	3010	2910	2660	2630	2400	2340	2140	2160	1980	1950	1780
	18	3610	3290	3260	2970	2880	2620	2600	2360	2320	2090	2130	1930	1930	1740
	19	3590	3250	3240	2920	2860	2580	2580	2310	2300	2050	2110	1890	1900	1700
	20	3580	3210	3230	2880	2850	2530	2560	2270	2280	2010	2090	1850	1880	1660
	22	3550	3140	3190	2810	2810	2450	2530	2190	2240	1930	2050	1770	1840	1580
	24	3530	3070	3170	2740	2780	2380	2500	2120	2200	1850	2010	1690	1800	1500
	26	3510	3010	3150	2670	2760	2320	2470	2050	2170	1790	1980	1620	1770	1430
	28	3490	2960	3130	2620	2740	2260	2450	1990	2150	1730	1950	1560	1740	1370
30	3480	2910	3110	2570	2720	2210	2420	1940	2120	1670	1930	1500	1710	1310	
32	3460	2870	3100	2530	2700	2160	2410	1890	2100	1620	1910	1450	1690	1260	
34	3450	2830	3090	2490	2690	2120	2390	1850	2090	1580	1890	1410	1670	1220	
36	3440	2800	3080	2460	2680	2090	2380	1810	2070	1540	1870	1360	1650	1170	
38	3430	2770	3070	2420	2670	2050	2370	1770	2060	1500	1850	1330	1630	1130	
40	3430	2750	3060	2400	2660	2030	2350	1740	2040	1470	1840	1290	1610	1100	

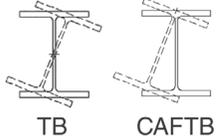
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W24x														
lb / ft	162		146		131		117		104		103		94		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2150	2150	1930	1930	1740	1740	1510	1510	1320	1320	1330	1330	1190	1190
	6	2080	2070	1870	1860	1680	1660	1470	1460	1280	1270	1260	1230	1130	1110
	7	2060	2040	1850	1830	1660	1640	1450	1440	1270	1250	1230	1200	1110	1080
	8	2040	2000	1830	1800	1640	1610	1440	1420	1250	1230	1210	1160	1090	1040
	9	2010	1970	1800	1770	1620	1580	1420	1390	1230	1210	1180	1120	1060	1010
	10	1980	1930	1780	1730	1590	1550	1400	1370	1220	1190	1160	1080	1040	974
	11	1960	1890	1750	1690	1570	1510	1380	1340	1200	1160	1130	1030	1010	936
	12	1930	1850	1720	1660	1540	1480	1350	1310	1180	1140	1100	989	988	896
	13	1900	1810	1700	1620	1510	1440	1330	1280	1160	1110	1070	944	964	853
	14	1870	1770	1670	1580	1490	1400	1310	1240	1140	1080	1050	899	939	811
	15	1840	1720	1640	1530	1460	1360	1290	1200	1120	1050	1020	856	916	769
	16	1820	1680	1610	1490	1430	1320	1260	1170	1100	1020	996	815	891	729
	17	1790	1640	1590	1450	1410	1280	1240	1130	1070	990	973	775	867	691
	18	1760	1600	1560	1410	1380	1250	1210	1090	1050	959	951	738	844	654
	19	1740	1550	1540	1370	1350	1210	1180	1060	1030	926	930	702	823	619
	20	1710	1510	1510	1330	1330	1170	1160	1020	1010	891	911	669	802	586
	22	1670	1430	1470	1250	1280	1090	1110	950	965	824	876	607	765	526
	24	1630	1360	1420	1180	1240	1020	1070	883	923	760	845	554	733	473
	26	1590	1290	1380	1110	1200	956	1030	819	881	699	819	506	704	428
	28	1560	1230	1350	1050	1160	894	988	760	842	642	796	467	680	392
30	1530	1170	1320	993	1130	837	953	705	806	590	776	435	658	363	
32	1500	1120	1290	940	1100	785	920	654	773	542	759	409	639	339	
34	1480	1070	1260	892	1070	737	891	608	743	496	744	388	623	320	
36	1460	1020	1240	848	1040	694	865	565	716	459	731	370	608	303	
38	1440	985	1220	808	1020	653	840	528	690	427	719	355	595	290	
40	1420	949	1200	772	999	617	818	497	667	399	709	342	584	278	

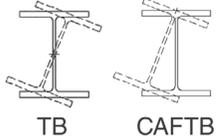
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W24x										W21x				
lb / ft	84		76		68		62		55		201		182		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1030	1030	917	917	804	804	724	724	621	621	2670	2670	2410	2410
	6	978	959	868	851	761	746	664	636	569	545	2590	2560	2330	2310
	7	960	933	852	828	747	725	644	607	552	520	2560	2530	2310	2280
	8	940	906	834	803	731	703	623	575	534	492	2530	2490	2290	2250
	9	919	875	815	776	714	678	601	540	514	461	2510	2450	2260	2210
	10	897	843	794	747	696	652	578	504	494	429	2480	2410	2230	2170
	11	875	809	773	716	676	624	555	468	473	396	2460	2370	2210	2130
	12	852	774	752	684	657	595	532	430	451	363	2430	2320	2180	2090
	13	828	739	730	651	636	564	510	392	430	329	2410	2280	2160	2050
	14	805	703	708	618	616	534	488	356	410	296	2380	2240	2140	2000
	15	783	666	687	584	595	503	466	322	389	264	2360	2200	2110	1960
	16	761	628	665	551	575	472	446	290	370	237	2340	2160	2090	1920
	17	739	592	644	517	555	441	426	264	351	215	2320	2120	2070	1890
	18	719	557	624	484	535	410	407	242	333	196	2310	2080	2050	1850
	19	699	524	604	452	516	381	389	223	316	180	2290	2040	2040	1810
	20	679	492	586	422	498	352	373	207	300	167	2270	2010	2020	1780
	22	642	435	550	367	462	302	343	182	270	145	2250	1940	1990	1710
	24	609	385	517	322	430	264	318	162	246	129	2220	1890	1960	1650
	26	579	346	486	288	400	234	297	147	228	116	2200	1830	1940	1600
	28	553	315	460	260	373	211	280	135	214	106	2190	1790	1920	1550
30	530	289	436	238	349	192	266	125	202	97.4	2170	1750	1910	1510	
32	511	269	416	220	328	176	255	117	192	90.7	2160	1710	1890	1470	
34	493	252	398	205	310	163	246	111	184	85.1	2150	1680	1880	1440	
36	478	238	381	193	296	153	238	105	178	80.5	2140	1650	1870	1410	
38	464	226	367	182	283	143	231	101	172	76.5	2130	1620	1860	1380	
40	452	215	355	173	273	136	226	96.6	167	73.1	2120	1600	1850	1350	

$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W21x														
lb / ft	166		147		132		122		111		101		93		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2200	2200	1940	1940	1750	1750	1620	1620	1470	1470	1320	1320	1230	1230
	6	2120	2110	1880	1860	1690	1670	1560	1540	1410	1400	1280	1270	1140	1110
	7	2100	2080	1860	1830	1670	1640	1540	1520	1400	1380	1270	1250	1120	1070
	8	2080	2040	1830	1800	1640	1620	1520	1490	1380	1360	1250	1230	1090	1030
	9	2050	2010	1810	1770	1620	1590	1500	1470	1360	1330	1230	1210	1060	990
	10	2030	1970	1790	1740	1600	1550	1470	1430	1340	1300	1220	1190	1040	947
	11	2000	1930	1760	1700	1570	1520	1450	1400	1310	1270	1200	1160	1010	905
	12	1980	1890	1740	1660	1550	1480	1430	1370	1290	1240	1170	1130	985	864
	13	1950	1850	1710	1620	1530	1450	1400	1330	1270	1200	1150	1100	961	823
	14	1930	1810	1690	1580	1500	1410	1380	1300	1240	1170	1130	1070	939	784
	15	1900	1770	1660	1550	1480	1370	1360	1260	1220	1140	1110	1030	918	747
	16	1880	1730	1640	1510	1450	1340	1330	1230	1200	1100	1080	1000	899	712
	17	1860	1700	1620	1470	1430	1300	1310	1190	1170	1070	1060	969	880	679
	18	1840	1660	1600	1430	1410	1260	1290	1160	1150	1040	1040	937	864	648
	19	1820	1620	1580	1400	1390	1230	1270	1120	1130	1000	1020	906	848	619
	20	1810	1590	1560	1360	1370	1200	1250	1090	1110	972	997	875	834	592
	22	1770	1520	1520	1290	1330	1130	1210	1030	1070	909	958	815	809	544
	24	1750	1460	1490	1230	1300	1070	1170	965	1040	851	921	758	788	502
	26	1720	1410	1460	1170	1270	1010	1140	909	1000	796	888	704	770	466
	28	1700	1360	1440	1120	1240	960	1110	858	974	746	857	655	754	435
30	1680	1320	1410	1080	1220	913	1090	811	948	700	829	610	741	411	
32	1670	1280	1390	1030	1200	871	1070	768	924	658	804	569	729	391	
34	1650	1240	1380	995	1180	832	1040	729	902	620	781	531	720	374	
36	1640	1210	1360	960	1160	797	1030	694	883	585	761	496	711	360	
38	1630	1180	1350	929	1140	766	1010	662	865	553	742	466	704	348	
40	1620	1150	1340	901	1130	737	996	633	849	525	726	440	697	338	

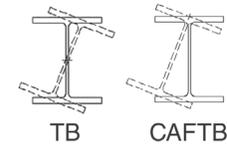
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W21x														
lb / ft	83		73		68		62		55		48		57		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1090	1090	929	929	850	850	761	761	657	657	555	555	690	690
	6	1020	988	870	849	796	777	712	695	615	600	519	506	625	596
	7	993	954	852	822	779	753	697	673	602	581	507	489	605	566
	8	968	917	832	793	760	726	679	649	586	560	494	470	584	534
	9	942	878	811	762	741	698	661	623	570	536	480	450	563	501
	10	916	839	789	729	720	667	642	595	553	512	464	428	541	466
	11	890	799	767	693	700	636	623	566	536	486	449	405	521	431
	12	865	759	746	656	679	604	604	536	518	459	432	381	500	395
	13	841	721	725	620	659	570	584	506	500	432	416	356	481	361
	14	818	684	702	585	639	536	565	477	482	405	399	332	462	330
	15	797	648	680	551	619	503	546	445	464	378	383	307	445	302
	16	777	614	660	518	601	472	528	415	447	350	366	283	428	275
	17	758	582	641	488	581	443	510	387	430	323	350	258	412	252
	18	741	551	622	459	563	415	494	360	413	298	335	235	397	233
	19	724	523	606	432	546	388	477	335	397	274	319	215	384	217
	20	709	497	590	407	530	364	461	311	382	253	305	197	372	204
	22	682	449	561	361	501	320	432	270	353	219	277	169	350	182
	24	659	407	537	323	476	285	406	240	327	192	252	148	333	165
	26	639	374	516	294	454	258	384	216	305	172	230	132	318	152
	28	623	347	498	271	436	237	364	197	285	156	212	118	305	142
30	608	325	482	252	420	220	348	182	268	143	198	108	295	133	
32	595	307	468	237	406	206	333	169	253	132	186	99.1	286	126	
34	585	293	457	224	393	194	320	159	242	123	176	91.9	278	121	
36	575	280	446	214	383	184	309	150	232	116	168	85.9	271	116	
38	567	270	437	205	373	176	299	143	223	109	161	80.8	266	112	
40	559	261	429	197	365	169	290	136	216	104	155	76.5	261	109	

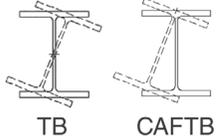
$F_y = 50$ ksi		Table 1. (continued) Torsional Buckling Design Strength in Axial Compression $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W21x				W18x										
lb / ft	50		44		311		283		258		234		211		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	592	592	505	505	4120	4120	3750	3750	3420	3420	3090	3090	2800	2800
	6	535	509	456	434	4010	3970	3650	3600	3320	3280	2990	2960	2710	2680
	7	517	482	440	410	3990	3920	3620	3560	3300	3240	2970	2920	2690	2640
	8	498	453	423	384	3970	3880	3600	3520	3270	3200	2950	2880	2670	2610
	9	478	422	406	357	3950	3840	3580	3480	3250	3160	2920	2840	2640	2570
	10	458	390	387	329	3930	3800	3560	3440	3230	3120	2900	2800	2620	2530
	11	438	358	369	300	3920	3760	3550	3400	3220	3080	2890	2760	2600	2490
	12	418	325	351	271	3910	3720	3530	3360	3200	3040	2870	2720	2590	2450
	13	399	294	333	242	3890	3690	3520	3330	3190	3010	2860	2690	2570	2420
	14	381	264	315	215	3880	3660	3510	3290	3180	2970	2840	2660	2560	2380
	15	363	237	299	192	3880	3630	3500	3260	3170	2940	2830	2620	2540	2350
	16	347	215	283	173	3870	3610	3490	3240	3160	2910	2820	2600	2530	2320
	17	331	196	267	157	3860	3580	3480	3210	3150	2890	2810	2570	2520	2290
	18	316	180	253	144	3860	3560	3480	3190	3140	2860	2800	2540	2510	2260
	19	302	167	240	133	3850	3540	3470	3170	3130	2840	2800	2520	2500	2240
	20	289	156	227	123	3850	3520	3460	3150	3130	2820	2790	2500	2500	2220
	22	268	138	205	108	3840	3490	3460	3120	3120	2780	2780	2460	2480	2170
	24	249	124	189	96.3	3830	3470	3450	3090	3110	2750	2770	2430	2470	2140
	26	234	113	176	87.3	3830	3450	3440	3060	3100	2730	2760	2400	2460	2110
	28	222	105	166	80.1	3820	3430	3440	3040	3100	2710	2760	2380	2460	2080
30	212	97.8	158	74.4	3820	3410	3430	3030	3090	2690	2750	2360	2450	2060	
32	204	92.2	151	69.6	3820	3400	3430	3010	3090	2670	2750	2340	2450	2040	
34	198	87.5	146	65.7	3820	3390	3430	3000	3090	2660	2740	2330	2440	2020	
36	192	83.6	141	62.4	3810	3380	3430	2990	3080	2650	2740	2310	2440	2010	
38	188	80.3	137	59.6	3810	3370	3420	2980	3080	2640	2740	2300	2430	2000	
40	184	77.5	134	57.3	3810	3360	3420	2970	3080	2630	2740	2290	2430	1990	

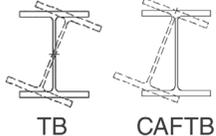
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W18x														
lb / ft	192		175		158		143		130		119		106		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2530	2530	2310	2310	2080	2080	1890	1890	1720	1720	1580	1580	1400	1400
	6	2440	2420	2230	2210	2010	1980	1820	1800	1660	1640	1520	1500	1340	1330
	7	2420	2380	2210	2170	1980	1950	1800	1770	1630	1610	1500	1470	1320	1300
	8	2400	2340	2190	2140	1960	1920	1770	1740	1610	1580	1480	1440	1300	1280
	9	2370	2310	2160	2100	1940	1880	1750	1700	1590	1550	1450	1410	1280	1250
	10	2350	2270	2140	2060	1920	1850	1730	1670	1570	1510	1430	1380	1260	1220
	11	2330	2230	2120	2020	1900	1810	1710	1630	1550	1480	1410	1350	1240	1190
	12	2320	2190	2100	1990	1880	1780	1690	1600	1530	1450	1390	1320	1220	1160
	13	2300	2160	2080	1950	1860	1740	1670	1560	1510	1410	1370	1280	1200	1120
	14	2280	2120	2070	1920	1840	1710	1650	1530	1490	1380	1350	1250	1180	1090
	15	2270	2090	2050	1880	1830	1670	1640	1500	1470	1350	1330	1220	1160	1060
	16	2260	2060	2040	1850	1810	1640	1620	1460	1460	1310	1310	1190	1140	1030
	17	2250	2030	2030	1820	1800	1610	1600	1430	1440	1280	1300	1150	1120	1000
	18	2240	2000	2020	1790	1780	1580	1590	1410	1430	1250	1280	1130	1110	971
	19	2230	1980	2000	1770	1770	1560	1580	1380	1410	1230	1270	1100	1090	942
	20	2220	1960	2000	1740	1760	1530	1570	1350	1400	1200	1250	1070	1080	915
	22	2200	1910	1980	1700	1740	1480	1550	1300	1380	1150	1230	1020	1050	864
	24	2190	1880	1970	1660	1730	1440	1530	1260	1360	1110	1200	971	1030	818
	26	2180	1840	1950	1620	1720	1410	1520	1220	1340	1070	1190	930	1010	776
	28	2170	1820	1940	1590	1710	1370	1500	1190	1330	1030	1170	893	988	739
30	2170	1790	1940	1570	1700	1350	1490	1160	1320	1000	1160	860	972	705	
32	2160	1770	1930	1550	1690	1320	1480	1140	1310	974	1140	830	958	675	
34	2160	1750	1920	1530	1680	1300	1480	1110	1300	950	1130	804	946	649	
36	2150	1740	1920	1510	1680	1280	1470	1090	1290	928	1120	781	935	625	
38	2150	1720	1910	1490	1670	1270	1460	1080	1280	909	1110	760	925	604	
40	2150	1710	1910	1480	1670	1250	1460	1060	1280	892	1110	742	917	585	

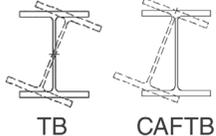
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W18x														
lb / ft	97		86		76		71		65		60		55		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1280	1280	1140	1140	991	991	940	940	859	859	775	775	701	701
	6	1230	1210	1090	1080	952	943	863	834	786	760	717	696	648	630
	7	1210	1190	1070	1060	939	926	841	802	765	730	699	670	631	607
	8	1190	1170	1050	1030	924	908	818	768	743	698	681	639	614	582
	9	1170	1140	1040	1010	909	887	796	733	722	665	660	608	596	555
	10	1150	1110	1020	983	892	863	774	698	700	631	639	576	578	526
	11	1130	1080	997	956	874	838	754	664	680	598	619	544	560	495
	12	1110	1050	977	928	855	812	734	630	660	566	599	514	542	466
	13	1090	1020	957	900	836	786	716	598	641	536	580	484	523	437
	14	1070	993	938	871	816	759	699	568	624	506	563	455	505	409
	15	1050	963	918	843	798	732	683	539	608	479	546	429	489	383
	16	1030	933	900	814	779	706	669	513	593	453	531	403	473	358
	17	1010	904	881	786	761	679	656	488	580	428	517	380	458	335
	18	998	875	864	759	744	653	644	465	567	406	504	358	445	314
	19	981	848	847	732	727	628	633	444	555	385	492	338	433	294
	20	966	821	831	706	711	603	623	424	545	366	481	319	421	275
	22	938	771	802	657	680	556	605	389	526	331	462	285	401	244
	24	913	725	775	612	653	513	590	359	511	303	445	259	383	220
	26	891	683	752	571	628	473	578	335	497	280	431	239	368	202
	28	872	646	730	534	605	437	568	315	486	262	420	223	356	187
30	854	612	712	500	585	404	559	299	477	248	409	210	345	175	
32	839	582	695	470	567	374	551	286	469	236	401	199	336	165	
34	826	555	680	443	552	349	545	275	462	227	393	190	328	157	
36	814	531	667	418	537	328	539	266	456	219	387	183	321	150	
38	804	510	656	398	524	309	534	259	450	212	381	177	315	145	
40	794	490	645	380	513	294	530	252	446	206	376	171	310	140	

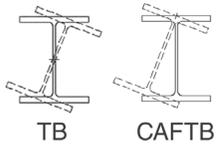
Shape		W18x								W16x					
		50		46		40		35		100		89		77	
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	620	620	567	567	477	477	405	405	1320	1320	1180	1180	1020	1020
	6	573	557	506	481	425	404	360	342	1260	1250	1120	1110	967	955
	7	558	536	489	454	410	381	346	321	1240	1220	1110	1090	951	935
	8	542	514	471	426	393	357	332	299	1230	1200	1090	1060	934	912
	9	526	490	452	397	377	331	316	276	1210	1170	1070	1040	916	889
	10	509	465	435	366	361	306	301	252	1190	1140	1050	1010	898	864
	11	492	439	418	336	345	280	286	229	1170	1110	1030	981	880	838
	12	475	413	401	308	329	255	271	205	1150	1080	1010	953	863	812
	13	459	386	386	281	315	230	256	182	1130	1050	996	925	845	786
	14	443	360	371	257	301	208	242	162	1120	1020	979	897	828	760
	15	428	335	357	235	288	187	229	145	1100	995	963	870	812	734
	16	414	311	344	216	276	170	217	131	1090	969	948	843	796	709
	17	399	289	332	199	264	156	205	120	1070	943	934	818	781	684
	18	385	269	322	185	254	145	195	110	1060	918	920	793	767	660
	19	373	249	313	174	244	135	185	102	1050	895	908	770	754	638
	20	361	232	304	164	235	126	175	95.1	1040	873	896	748	742	616
	22	340	204	289	148	220	113	160	84.0	1020	832	876	706	719	575
	24	322	183	277	135	207	102	149	75.5	1010	796	858	669	699	539
	26	306	166	267	126	196	94.5	140	69.0	991	765	842	637	681	506
	28	293	153	259	118	188	88.1	132	63.8	980	737	829	608	666	477
30	282	143	252	112	181	82.9	127	59.5	970	712	817	582	653	451	
32	272	134	246	107	175	78.7	122	56.1	961	691	807	559	641	428	
34	264	127	241	103	170	75.3	118	53.3	953	672	799	539	631	408	
36	256	121	236	99.8	166	72.3	115	50.9	947	655	791	521	622	389	
38	250	116	233	96.9	163	69.9	112	48.8	941	640	784	506	614	373	
40	244	112	229	94.4	160	67.7	110	47.1	936	627	778	492	607	359	



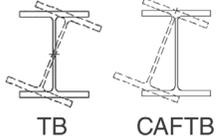
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W16x														
lb / ft	67		57		50		45		40		36		31		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	882	882	756	756	653	653	577	577	496	496	438	438	367	367
	6	837	827	686	660	597	576	527	510	453	440	400	387	321	302
	7	823	809	666	631	579	550	512	489	440	422	388	371	307	282
	8	807	789	647	602	560	522	497	466	426	402	375	353	293	261
	9	791	768	628	572	541	495	481	441	412	381	362	333	279	240
	10	774	745	609	542	523	467	465	415	397	360	348	313	265	218
	11	757	722	592	513	506	440	449	389	383	338	334	293	251	196
	12	740	698	576	485	489	413	433	363	369	317	321	272	239	176
	13	723	674	561	459	474	388	417	339	355	294	307	251	227	156
	14	706	650	547	434	460	365	402	316	342	273	294	231	215	139
	15	690	626	535	411	447	343	389	295	329	253	282	212	205	126
	16	674	602	523	390	434	322	376	275	318	234	270	194	195	115
	17	659	579	513	370	423	303	365	256	306	216	259	177	186	106
	18	644	556	503	352	413	285	354	239	295	200	247	162	178	98.1
	19	631	535	495	336	404	269	344	223	285	185	237	149	171	91.6
	20	618	514	487	321	395	254	335	209	276	173	228	139	164	86.1
	22	594	474	473	294	381	228	319	187	260	153	211	122	152	77.1
	24	573	439	462	272	368	209	306	169	246	137	196	109	143	70.4
	26	554	407	453	254	358	194	295	156	234	125	184	98.5	136	65.1
	28	537	378	445	240	349	182	285	145	224	116	174	90.5	131	60.9
30	523	353	438	229	342	172	277	137	216	108	165	84.0	126	57.5	
32	510	330	433	220	335	164	270	130	209	102	158	78.7	123	54.8	
34	498	310	428	212	330	158	264	124	202	97.1	153	74.3	120	52.5	
36	488	294	424	206	325	152	259	119	197	92.8	148	70.6	117	50.6	
38	479	280	420	201	321	147	255	115	192	89.2	144	67.5	115	48.9	
40	471	268	417	196	317	143	251	112	188	86.0	140	64.8	113	47.5	

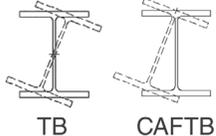
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W16x		W14x												
lb / ft	26		730		665		605		550		500		455		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	297	297	9670	9670	8820	8820	8010	8010	7290	7290	6610	6610	6030	6030
	6	259	243	9570	9530	8720	8680	7910	7870	7190	7160	6520	6490	5940	5910
	7	247	226	9550	9490	8700	8640	7890	7840	7170	7130	6500	6460	5920	5880
	8	235	208	9540	9450	8680	8600	7870	7800	7160	7090	6480	6430	5900	5850
	9	222	189	9520	9420	8670	8570	7860	7770	7140	7060	6470	6390	5880	5820
	10	209	169	9510	9390	8660	8540	7850	7740	7130	7030	6450	6360	5870	5780
	11	197	151	9500	9360	8650	8510	7840	7710	7120	7000	6440	6330	5860	5750
	12	184	132	9500	9330	8640	8480	7830	7680	7110	6970	6430	6300	5850	5730
	13	173	116	9490	9310	8630	8460	7820	7660	7100	6940	6420	6280	5840	5700
	14	162	102	9480	9280	8630	8430	7820	7630	7090	6920	6420	6250	5830	5680
	15	152	91.8	9480	9260	8620	8410	7810	7610	7090	6900	6410	6230	5820	5650
	16	142	83.2	9470	9250	8620	8400	7810	7600	7080	6880	6410	6210	5820	5630
	17	133	76.0	9470	9230	8610	8380	7800	7580	7080	6860	6400	6200	5810	5610
	18	125	70.0	9470	9220	8610	8370	7800	7560	7070	6850	6400	6180	5810	5600
	19	118	64.9	9470	9200	8610	8350	7800	7550	7070	6830	6390	6160	5800	5580
	20	112	60.6	9460	9190	8610	8340	7790	7540	7070	6820	6390	6150	5800	5570
	22	103	53.6	9460	9170	8600	8320	7790	7520	7060	6800	6380	6130	5790	5540
	24	95.3	48.3	9460	9160	8600	8310	7780	7500	7060	6780	6380	6110	5790	5520
	26	89.7	44.2	9450	9150	8600	8290	7780	7490	7060	6770	6380	6090	5780	5500
	28	85.2	40.9	9450	9140	8590	8280	7780	7470	7050	6750	6370	6080	5780	5490
30	81.6	38.3	9450	9130	8590	8270	7780	7460	7050	6740	6370	6070	5780	5480	
32	78.7	36.1	9450	9120	8590	8260	7780	7460	7050	6730	6370	6060	5780	5470	
34	76.2	34.3	9450	9110	8590	8260	7770	7450	7050	6730	6370	6050	5770	5460	
36	74.2	32.8	9450	9110	8590	8250	7770	7440	7050	6720	6370	6040	5770	5450	
38	72.4	31.6	9450	9100	8590	8250	7770	7440	7050	6710	6360	6040	5770	5440	
40	71.0	30.5	9450	9100	8590	8240	7770	7430	7050	6710	6360	6030	5770	5440	

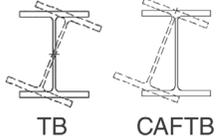
$F_y = 50$ ksi		Table 1. (continued) Torsional Buckling Design Strength in Axial Compression $\phi_c P_n$ , kip										 TB CAFTB			
Shape	W14x														
lb / ft	426		398		370		342		311		283		257		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	5620	5620	5260	5260	4900	4900	4540	4540	4110	4110	3750	3750	3400	3400
	6	5540	5510	5180	5160	4820	4800	4460	4450	4030	4020	3670	3660	3330	3320
	7	5520	5480	5160	5130	4800	4770	4440	4420	4010	3990	3650	3640	3310	3300
	8	5500	5450	5140	5100	4780	4740	4420	4390	4000	3960	3630	3610	3290	3270
	9	5480	5420	5120	5060	4760	4710	4410	4360	3980	3930	3620	3580	3270	3240
	10	5470	5390	5110	5030	4750	4680	4390	4330	3960	3900	3600	3550	3260	3210
	11	5450	5360	5090	5000	4730	4650	4380	4300	3950	3870	3580	3520	3240	3180
	12	5440	5330	5080	4970	4720	4620	4360	4270	3930	3850	3570	3490	3220	3160
	13	5430	5300	5070	4950	4710	4590	4350	4240	3920	3820	3550	3460	3210	3130
	14	5420	5280	5060	4920	4700	4570	4340	4210	3910	3790	3540	3440	3200	3100
	15	5420	5260	5050	4900	4690	4540	4330	4190	3900	3770	3530	3410	3180	3080
	16	5410	5230	5050	4880	4680	4520	4320	4170	3890	3740	3520	3390	3170	3050
	17	5400	5220	5040	4860	4680	4500	4310	4150	3880	3720	3510	3370	3160	3030
	18	5400	5200	5040	4840	4670	4480	4310	4130	3870	3700	3500	3340	3150	3010
	19	5400	5180	5030	4820	4670	4460	4300	4110	3870	3680	3500	3320	3150	2980
	20	5390	5170	5030	4810	4660	4450	4300	4090	3860	3670	3490	3310	3140	2970
	22	5380	5140	5020	4780	4650	4420	4290	4060	3850	3630	3480	3270	3130	2930
	24	5380	5120	5010	4760	4650	4400	4280	4040	3840	3610	3470	3240	3120	2900
	26	5380	5100	5010	4740	4640	4380	4280	4010	3840	3580	3460	3220	3110	2870
	28	5370	5090	5010	4720	4640	4360	4270	3990	3830	3560	3460	3200	3100	2850
30	5370	5070	5000	4710	4630	4340	4270	3980	3830	3550	3450	3180	3090	2830	
32	5370	5060	5000	4700	4630	4330	4260	3960	3820	3530	3450	3160	3090	2810	
34	5360	5050	5000	4690	4630	4320	4260	3950	3820	3520	3440	3150	3080	2790	
36	5360	5040	5000	4680	4630	4310	4260	3940	3820	3510	3440	3130	3080	2780	
38	5360	5040	4990	4670	4630	4300	4260	3930	3810	3500	3440	3120	3080	2770	
40	5360	5030	4990	4660	4620	4290	4250	3920	3810	3490	3430	3110	3070	2760	

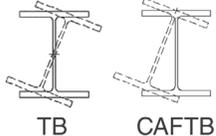
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W14x														
lb / ft	233		211		193		176		159		145		132		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	3080	3080	2790	2790	2560	2560	2330	2330	2100	2100	1920	1920	1750	1750
	6	3010	3010	2730	2720	2500	2490	2270	2270	2050	2050	1870	1870	1700	1690
	7	3000	2980	2710	2700	2480	2470	2260	2250	2030	2030	1860	1850	1680	1680
	8	2980	2960	2690	2670	2460	2450	2240	2230	2020	2010	1840	1830	1670	1660
	9	2960	2930	2670	2650	2440	2420	2220	2200	2000	1980	1820	1810	1650	1640
	10	2940	2900	2650	2620	2420	2400	2200	2180	1980	1960	1810	1790	1630	1610
	11	2920	2870	2630	2590	2400	2370	2180	2150	1960	1940	1790	1770	1610	1590
	12	2910	2850	2620	2570	2390	2340	2170	2130	1940	1910	1770	1740	1600	1570
	13	2890	2820	2600	2540	2370	2320	2150	2100	1930	1890	1750	1720	1580	1540
	14	2880	2790	2590	2510	2360	2290	2130	2080	1910	1860	1740	1690	1560	1520
	15	2860	2770	2570	2490	2340	2260	2120	2050	1890	1840	1720	1670	1550	1500
	16	2850	2740	2560	2460	2330	2240	2110	2020	1880	1810	1700	1640	1530	1470
	17	2840	2720	2550	2440	2320	2210	2090	2000	1870	1790	1690	1620	1520	1450
	18	2830	2690	2540	2410	2300	2190	2080	1980	1850	1760	1680	1600	1510	1420
	19	2820	2670	2530	2390	2290	2170	2070	1950	1840	1740	1660	1570	1490	1400
	20	2820	2650	2520	2370	2280	2150	2060	1930	1830	1720	1650	1550	1480	1380
	22	2800	2620	2500	2330	2270	2110	2040	1890	1810	1670	1630	1510	1460	1340
	24	2790	2580	2490	2300	2250	2070	2020	1850	1790	1630	1610	1470	1440	1300
	26	2780	2550	2480	2260	2240	2040	2010	1820	1770	1600	1590	1430	1420	1260
	28	2770	2530	2470	2240	2230	2010	1990	1790	1760	1570	1570	1400	1410	1230
30	2760	2510	2460	2210	2220	1980	1980	1760	1750	1540	1560	1370	1400	1200	
32	2760	2490	2450	2190	2210	1960	1970	1730	1740	1510	1550	1340	1380	1170	
34	2750	2470	2450	2170	2200	1940	1970	1710	1730	1490	1540	1310	1370	1150	
36	2750	2450	2440	2150	2200	1920	1960	1690	1720	1460	1530	1290	1370	1130	
38	2740	2440	2440	2140	2190	1900	1950	1670	1710	1450	1520	1270	1360	1110	
40	2740	2430	2430	2130	2190	1890	1950	1660	1700	1430	1510	1250	1350	1090	

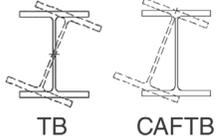
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB		 CAFTB	
Shape	W14x														
lb / ft	120		109		99		90		82		74		68		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1590	1590	1440	1440	1310	1310	1190	1190	1080	1080	981	981	900	900
	6	1540	1540	1400	1400	1270	1270	1160	1150	1030	1010	931	921	853	844
	7	1530	1520	1380	1380	1260	1250	1140	1140	1010	994	917	902	839	826
	8	1510	1510	1370	1360	1240	1240	1130	1130	996	972	901	881	824	806
	9	1500	1490	1350	1350	1230	1220	1120	1110	980	949	886	860	809	785
	10	1480	1470	1340	1330	1210	1200	1100	1090	964	926	870	837	794	763
	11	1460	1440	1320	1300	1200	1180	1090	1080	949	902	855	814	779	741
	12	1450	1420	1300	1280	1180	1160	1070	1060	935	878	841	792	764	719
	13	1430	1400	1290	1260	1170	1140	1060	1040	922	855	827	769	750	697
	14	1410	1370	1270	1240	1150	1120	1040	1020	909	832	814	747	737	676
	15	1400	1350	1260	1220	1130	1100	1020	996	897	810	802	726	724	655
	16	1380	1330	1240	1190	1120	1080	1010	975	886	789	790	705	712	634
	17	1370	1300	1230	1170	1100	1060	993	955	876	770	779	685	701	615
	18	1350	1280	1210	1150	1090	1040	978	934	867	751	770	666	691	596
	19	1340	1260	1200	1130	1070	1010	963	913	858	733	760	648	681	578
	20	1330	1240	1180	1110	1060	993	949	892	850	716	752	631	672	561
	22	1300	1200	1160	1060	1030	952	923	852	837	685	737	600	656	530
	24	1280	1160	1140	1030	1010	913	899	814	825	658	724	572	642	502
	26	1260	1120	1120	990	990	877	877	778	815	635	713	548	630	477
	28	1250	1090	1100	956	971	843	856	744	807	614	704	526	620	456
30	1230	1060	1080	925	954	811	838	712	799	596	696	508	611	436	
32	1220	1030	1070	897	939	782	822	683	793	580	689	491	604	420	
34	1210	1000	1060	871	925	756	807	656	788	567	683	477	597	405	
36	1200	981	1050	847	913	731	794	631	783	555	678	464	591	392	
38	1190	960	1040	826	902	709	782	609	779	544	673	452	586	380	
40	1180	941	1030	806	892	689	771	588	776	534	669	442	582	370	

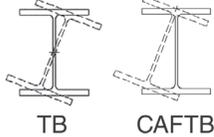
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W14x														
lb / ft	61		53		48		43		38		34		30		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	805	805	702	702	634	634	561	561	491	491	429	429	374	374
	6	762	754	650	635	586	573	521	511	446	431	389	377	338	327
	7	749	738	635	615	571	554	508	493	432	413	377	360	327	312
	8	735	720	620	593	557	534	494	474	419	391	364	342	315	295
	9	720	700	605	571	542	513	480	454	404	369	351	323	303	278
	10	706	680	590	548	528	491	466	434	389	347	338	304	291	260
	11	691	659	576	526	514	470	452	414	375	325	326	283	279	242
	12	676	638	563	504	500	449	439	394	361	304	313	263	267	223
	13	662	618	551	483	488	429	426	374	349	284	301	244	255	205
	14	649	597	539	463	476	409	414	356	337	265	289	226	244	188
	15	636	576	529	444	465	390	403	338	326	248	278	210	233	172
	16	624	557	519	426	455	373	392	320	316	231	268	194	222	158
	17	612	538	510	409	445	356	383	304	307	216	259	180	213	144
	18	601	519	502	393	437	340	373	289	299	203	250	166	204	132
	19	591	501	494	378	429	326	365	275	291	190	242	155	196	123
	20	581	485	487	365	421	312	357	262	284	179	235	145	188	114
	22	564	453	475	341	408	288	344	238	272	160	222	129	175	101
	24	549	425	465	320	398	267	332	217	262	146	211	117	164	90.5
	26	536	401	457	302	388	250	322	200	254	136	202	107	154	82.5
	28	525	379	450	287	381	234	313	186	247	127	195	99.9	146	76.2
30	515	359	444	274	374	221	306	175	241	120	188	93.9	140	71.1	
32	506	342	439	262	368	211	300	165	236	114	183	88.9	134	66.9	
34	499	327	434	253	363	202	294	158	231	110	178	84.8	130	63.5	
36	492	313	431	245	359	195	290	151	227	106	174	81.4	126	60.6	
38	487	301	427	238	355	189	286	146	224	102	170	78.5	123	58.1	
40	481	291	424	232	352	183	282	142	221	99.6	167	76.0	120	56.0	

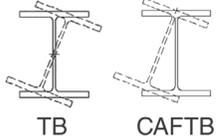
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W14x				W12x										
lb / ft	26		22		336		305		279		252		230		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	318	318	259	259	4450	4450	4030	4030	3690	3690	3330	3330	3050	3050
	6	270	251	219	203	4370	4330	3950	3910	3610	3580	3260	3230	2970	2950
	7	257	232	207	186	4350	4300	3930	3890	3590	3550	3240	3200	2960	2920
	8	244	212	195	168	4340	4280	3920	3860	3580	3520	3230	3180	2940	2900
	9	232	192	184	150	4330	4250	3910	3830	3570	3500	3220	3150	2930	2870
	10	220	171	173	133	4330	4230	3900	3810	3560	3470	3210	3130	2920	2850
	11	209	153	162	116	4320	4210	3890	3790	3550	3450	3200	3110	2910	2820
	12	198	136	152	101	4310	4190	3890	3770	3550	3430	3190	3090	2900	2800
	13	189	121	142	89.3	4310	4170	3880	3750	3540	3410	3190	3070	2900	2780
	14	180	109	134	79.9	4300	4160	3880	3740	3530	3400	3180	3050	2890	2770
	15	172	99.8	125	72.3	4300	4140	3880	3720	3530	3380	3180	3030	2880	2750
	16	165	92.0	118	66.1	4300	4130	3870	3710	3530	3370	3170	3020	2880	2730
	17	158	85.5	112	60.9	4300	4120	3870	3700	3520	3360	3170	3010	2880	2720
	18	153	80.0	106	56.6	4290	4110	3870	3690	3520	3350	3170	3000	2870	2710
	19	148	75.4	101	53.0	4290	4100	3870	3680	3520	3340	3160	2990	2870	2700
	20	143	71.5	96.7	49.9	4290	4100	3860	3670	3520	3330	3160	2980	2870	2690
	22	136	65.1	90.0	44.9	4290	4080	3860	3660	3510	3310	3160	2960	2860	2670
	24	129	60.3	84.9	41.1	4290	4070	3860	3650	3510	3300	3150	2950	2860	2660
	26	124	56.6	80.9	38.1	4280	4060	3860	3640	3510	3290	3150	2940	2860	2650
	28	120	53.6	77.7	35.7	4280	4060	3850	3630	3510	3280	3150	2930	2850	2640
30	117	51.2	75.2	33.8	4280	4050	3850	3630	3510	3280	3150	2920	2850	2630	
32	115	49.2	73.1	32.3	4280	4050	3850	3620	3500	3270	3150	2920	2850	2620	
34	112	47.6	71.4	31.0	4280	4040	3850	3620	3500	3270	3150	2910	2850	2610	
36	111	46.2	69.9	29.9	4280	4040	3850	3610	3500	3260	3140	2910	2850	2610	
38	109	45.1	68.7	29.0	4280	4040	3850	3610	3500	3260	3140	2900	2850	2600	
40	108	44.1	67.6	28.2	4280	4030	3850	3610	3500	3260	3140	2900	2850	2600	

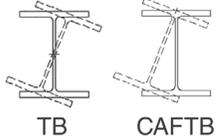
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W12x														
lb / ft	210		190		170		152		136		120		106		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	2780	2780	2520	2520	2250	2250	2010	2010	1800	1800	1580	1580	1400	1400
	6	2710	2690	2450	2430	2180	2170	1950	1940	1740	1730	1530	1520	1350	1350
	7	2690	2660	2430	2410	2170	2140	1930	1910	1720	1700	1510	1500	1340	1330
	8	2680	2640	2420	2380	2150	2120	1920	1890	1710	1680	1500	1480	1320	1310
	9	2670	2610	2410	2360	2140	2100	1900	1870	1690	1660	1480	1460	1310	1290
	10	2650	2590	2390	2330	2130	2070	1890	1840	1680	1640	1470	1430	1290	1260
	11	2650	2560	2380	2310	2110	2050	1880	1820	1660	1610	1450	1410	1280	1240
	12	2640	2540	2370	2290	2100	2030	1870	1800	1650	1590	1440	1390	1270	1220
	13	2630	2520	2370	2270	2090	2010	1860	1780	1640	1570	1430	1370	1250	1200
	14	2620	2500	2360	2250	2090	1990	1850	1760	1630	1550	1420	1350	1240	1180
	15	2620	2490	2350	2230	2080	1970	1840	1740	1620	1530	1410	1330	1230	1160
	16	2610	2470	2350	2210	2070	1950	1830	1720	1610	1510	1400	1310	1220	1140
	17	2610	2460	2340	2200	2070	1930	1830	1700	1610	1490	1390	1290	1210	1120
	18	2600	2450	2340	2190	2060	1920	1820	1690	1600	1480	1380	1270	1200	1100
	19	2600	2430	2330	2170	2060	1910	1820	1670	1590	1460	1380	1260	1200	1090
	20	2600	2420	2330	2160	2050	1890	1810	1660	1590	1450	1370	1240	1190	1070
	22	2590	2400	2320	2140	2050	1870	1800	1640	1580	1420	1360	1210	1180	1040
	24	2590	2390	2320	2120	2040	1850	1800	1610	1570	1400	1350	1190	1170	1020
	26	2590	2380	2320	2110	2040	1840	1790	1600	1570	1380	1340	1170	1160	994
	28	2580	2370	2310	2100	2030	1830	1790	1580	1560	1360	1340	1150	1150	974
30	2580	2360	2310	2090	2030	1810	1780	1570	1560	1350	1330	1140	1140	957	
32	2580	2350	2310	2080	2030	1800	1780	1560	1550	1340	1330	1120	1140	941	
34	2580	2340	2310	2070	2030	1800	1780	1550	1550	1330	1320	1110	1130	928	
36	2580	2340	2310	2070	2020	1790	1780	1540	1550	1320	1320	1100	1130	916	
38	2570	2330	2300	2060	2020	1780	1770	1530	1540	1310	1320	1090	1130	905	
40	2570	2330	2300	2050	2020	1780	1770	1530	1540	1300	1320	1080	1120	896	

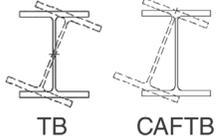
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W12x														
lb / ft	96		87		79		72		65		58		53		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	1270	1270	1150	1150	1040	1040	949	949	859	859	765	765	702	702
	6	1220	1210	1110	1100	1000	998	910	907	823	820	724	718	663	657
	7	1210	1200	1090	1090	989	982	898	893	812	807	712	702	651	643
	8	1190	1180	1080	1070	975	966	885	877	799	792	699	686	639	627
	9	1180	1160	1060	1050	961	948	871	861	786	777	686	668	626	610
	10	1160	1140	1050	1030	947	929	858	843	773	760	672	650	613	593
	11	1150	1120	1040	1010	933	910	844	825	759	743	660	632	600	575
	12	1130	1100	1020	988	919	891	830	806	746	725	647	614	588	557
	13	1120	1080	1010	968	906	871	816	787	732	707	635	595	576	539
	14	1110	1050	996	948	893	851	803	768	719	689	624	577	564	522
	15	1100	1030	984	928	880	832	791	750	706	670	613	560	553	504
	16	1090	1020	973	909	869	813	779	731	694	652	603	543	542	487
	17	1080	997	962	890	858	794	767	713	683	635	594	527	532	471
	18	1070	979	952	872	847	776	756	695	671	617	585	511	523	455
	19	1060	962	943	855	837	759	746	678	661	601	577	496	515	441
	20	1050	946	935	838	828	742	737	662	651	584	569	482	507	426
	22	1040	916	920	807	812	711	719	630	632	553	556	456	492	400
	24	1030	889	906	780	798	683	704	602	616	525	545	433	480	376
	26	1020	866	895	755	785	658	691	576	601	499	535	413	469	356
	28	1010	845	886	733	775	635	679	553	589	475	526	395	459	337
30	1000	826	877	713	765	614	669	532	577	454	519	379	451	321	
32	995	810	870	696	757	596	660	513	567	435	513	365	444	307	
34	990	795	864	680	750	580	652	496	559	418	507	353	438	294	
36	985	782	858	666	744	565	645	481	551	402	503	343	433	283	
38	981	771	854	654	739	552	639	467	544	388	498	333	428	273	
40	977	761	849	643	734	540	633	455	538	376	495	325	424	264	

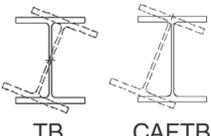
$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W12x														
lb / ft	50		45		40		35		30		26		22		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	657	657	589	589	526	526	462	462	382	382	323	323	278	278
	6	609	596	545	534	485	476	414	399	344	333	291	282	221	190
	7	596	578	532	517	473	460	400	379	333	318	281	269	208	168
	8	582	559	519	499	461	443	386	360	322	301	271	255	195	148
	9	569	539	506	480	448	425	373	340	310	284	260	240	184	130
	10	557	519	494	461	436	407	360	320	299	266	250	225	174	114
	11	545	500	482	443	424	390	349	301	288	248	239	210	166	101
	12	534	481	470	425	412	372	338	283	276	231	229	195	159	90.5
	13	524	463	460	407	401	355	327	266	266	215	220	180	153	82.6
	14	514	445	450	390	391	339	318	251	256	200	211	166	148	76.4
	15	506	429	441	374	382	323	310	236	247	186	202	153	143	71.3
	16	498	414	433	359	373	309	302	222	239	173	194	140	139	67.2
	17	491	400	425	345	365	295	295	210	231	161	186	129	136	63.8
	18	484	387	418	332	358	282	289	199	224	150	179	119	133	60.9
	19	478	374	412	319	351	269	283	189	218	140	172	110	131	58.5
	20	473	363	406	308	344	258	278	179	212	132	167	103	128	56.4
	22	464	343	396	288	333	238	269	163	203	118	156	91.5	125	53.1
	24	456	326	387	270	324	220	262	150	194	108	147	82.6	122	50.5
	26	450	311	380	255	316	205	256	141	187	100	140	75.7	119	48.6
	28	444	298	374	242	309	192	251	133	182	93.7	134	70.3	117	47.0
30	440	288	369	231	303	182	246	127	177	88.6	128	65.9	116	45.7	
32	436	278	364	221	298	173	243	122	173	84.4	124	62.2	115	44.7	
34	432	270	361	213	294	166	240	118	169	81.0	120	59.3	113	43.8	
36	430	264	357	206	290	160	237	114	166	78.0	117	56.7	112	43.1	
38	427	257	355	201	287	155	235	111	163	75.6	114	54.6	112	42.5	
40	425	252	352	196	284	150	233	109	161	73.5	112	52.8	111	42.0	

$F_y = 50$ ksi		Table 1. (continued) Torsional Buckling Design Strength in Axial Compression $\phi_c P_n$ , kip										 TB CAFTB			
Shape	W12x						W10x								
lb / ft	19		16		14		112		100		88		77		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	230	230	188	188	160	160	1480	1480	1320	1320	1170	1170	1020	1020
	6	180	157	145	124	123	104	1420	1410	1260	1250	1120	1110	972	963
	7	169	137	134	106	113	88.4	1410	1390	1250	1230	1100	1090	960	946
	8	157	118	123	88.3	103	72.9	1400	1370	1240	1210	1090	1070	948	928
	9	147	101	113	73.2	93.1	59.6	1390	1350	1230	1190	1080	1050	936	910
	10	137	86.3	103	61.9	84.2	50.1	1380	1330	1220	1180	1070	1030	926	893
	11	128	75.4	94.6	53.6	75.9	43.1	1370	1310	1210	1160	1060	1020	916	875
	12	121	67.1	87.1	47.3	68.5	37.8	1370	1300	1210	1140	1050	999	907	858
	13	114	60.6	80.6	42.4	62.6	33.7	1360	1280	1200	1130	1050	983	899	842
	14	109	55.5	75.0	38.5	57.9	30.4	1360	1270	1190	1110	1040	969	892	827
	15	104	51.4	70.6	35.3	54.1	27.7	1350	1260	1190	1100	1040	955	886	813
	16	99.6	48.0	67.0	32.7	51.0	25.5	1350	1250	1180	1090	1030	943	880	800
	17	95.9	45.2	63.9	30.6	48.4	23.7	1350	1240	1180	1080	1030	931	875	788
	18	92.7	42.8	61.4	28.8	46.3	22.2	1340	1230	1180	1070	1020	921	870	777
	19	90.0	40.8	59.3	27.3	44.4	21.0	1340	1220	1170	1060	1020	911	866	766
	20	87.7	39.2	57.4	26.0	42.9	19.9	1340	1210	1170	1050	1020	902	862	757
	22	83.9	36.4	54.5	23.9	40.4	18.1	1340	1200	1170	1040	1010	887	856	739
	24	81.1	34.3	52.3	22.3	38.5	16.8	1330	1190	1160	1030	1010	874	851	725
	26	78.9	32.7	50.5	21.1	37.0	15.7	1330	1180	1160	1020	1000	863	847	712
	28	77.2	31.5	49.2	20.1	35.8	14.9	1330	1180	1160	1010	1000	853	843	702
30	75.8	30.4	48.0	19.4	34.9	14.3	1330	1170	1160	1000	998	845	840	693	
32	74.6	29.6	47.1	18.7	34.1	13.7	1330	1160	1160	998	996	839	838	685	
34	73.7	28.9	46.4	18.2	33.5	13.3	1320	1160	1150	993	994	833	836	678	
36	72.9	28.3	45.7	17.7	32.9	12.9	1320	1160	1150	989	993	828	834	672	
38	72.2	27.8	45.2	17.3	32.5	12.6	1320	1150	1150	985	992	823	832	667	
40	71.6	27.4	44.8	17.0	32.1	12.3	1320	1150	1150	982	991	819	831	663	

$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W10x														
lb / ft	68		60		54		49		45		39		33		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	895	895	796	796	711	711	648	648	598	598	517	517	437	437
	6	850	843	754	748	671	667	611	607	555	545	477	469	401	394
	7	838	827	742	733	660	653	600	594	544	529	466	454	390	381
	8	826	811	730	718	649	638	589	580	533	513	456	439	380	367
	9	814	793	718	701	637	623	577	565	522	497	445	424	370	352
	10	803	776	707	684	626	607	566	550	513	481	435	408	359	338
	11	793	759	696	668	615	591	555	535	504	465	426	393	350	323
	12	783	743	686	652	605	576	545	519	496	451	417	378	341	309
	13	775	727	677	636	595	560	535	504	488	436	409	364	332	296
	14	767	712	668	620	586	545	526	489	482	423	402	351	324	283
	15	760	698	661	606	578	531	517	475	476	411	395	339	317	270
	16	753	684	653	592	570	517	509	461	471	400	389	327	310	259
	17	748	672	647	579	563	504	501	448	466	389	384	316	304	248
	18	742	660	641	567	556	491	494	436	462	380	379	306	298	238
	19	738	649	635	555	550	480	488	424	458	371	374	297	293	228
	20	733	639	630	544	545	469	482	413	454	362	370	288	288	219
	22	726	620	622	525	535	449	472	392	448	348	363	273	280	204
	24	720	605	615	508	527	431	463	374	444	336	357	260	273	191
	26	715	591	609	493	520	416	455	358	440	326	353	249	268	179
	28	710	580	604	480	514	402	449	345	436	317	349	240	263	169
30	707	570	599	469	510	390	443	332	434	309	345	232	258	161	
32	704	561	596	459	505	380	439	322	431	303	342	225	255	154	
34	701	553	592	451	502	371	434	312	429	298	340	219	252	148	
36	699	547	590	444	499	363	431	304	428	293	338	214	249	143	
38	697	541	587	437	496	357	428	297	426	289	336	209	247	139	
40	696	536	585	432	493	350	425	291	425	285	334	206	245	136	

$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W10x														
lb / ft	30		26		22		19		17		15		12		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	398	398	342	342	289	289	253	253	222	222	194	194	146	146
	6	349	332	298	283	251	239	197	170	170	146	146	124	111	94.5
	7	337	314	286	267	240	224	186	152	159	129	135	107	102	80.3
	8	327	297	276	250	229	208	176	136	149	113	126	92.4	93.4	67.4
	9	317	280	265	234	219	193	168	122	141	99.3	117	79.4	84.9	56.0
	10	308	264	256	219	209	179	161	110	133	87.4	109	68.2	77.4	47.4
	11	300	249	247	205	200	165	155	99.3	127	77.3	103	59.9	71.0	41.0
	12	292	235	240	191	192	152	150	90.2	122	69.6	97.3	53.5	65.4	36.2
	13	286	223	233	179	185	140	146	83.1	117	63.6	92.5	48.6	60.5	32.5
	14	280	211	226	168	178	129	142	77.5	113	58.9	88.4	44.6	56.3	29.5
	15	275	201	221	158	172	119	139	72.9	110	55.0	84.8	41.5	53.0	27.1
	16	271	192	216	149	166	110	137	69.2	107	51.9	81.8	38.9	50.3	25.1
	17	267	184	212	141	161	103	134	66.1	104	49.3	79.2	36.7	48.1	23.5
	18	264	177	208	134	157	95.9	132	63.5	102	47.1	76.8	34.9	46.2	22.1
	19	261	170	204	127	153	90.3	131	61.3	100	45.3	74.7	33.4	44.6	21.0
	20	258	164	201	121	149	85.6	129	59.5	98.5	43.7	72.9	32.1	43.2	20.0
	22	253	154	196	112	143	77.9	126	56.5	95.7	41.2	70.1	30.0	41.0	18.4
	24	250	146	192	105	138	72.0	124	54.2	93.5	39.2	67.9	28.4	39.3	17.2
	26	247	139	188	99.2	134	67.5	123	52.4	91.7	37.7	66.2	27.2	38.0	16.2
	28	244	134	185	94.9	131	63.9	122	51.0	90.3	36.6	64.9	26.2	37.0	15.5
30	242	130	183	91.4	128	61.0	120	49.9	89.1	35.6	63.8	25.4	36.2	14.9	
32	241	126	181	88.5	126	58.6	120	49.0	88.1	34.8	62.9	24.8	35.5	14.4	
34	239	124	179	86.1	124	56.6	119	48.2	87.3	34.2	62.2	24.2	34.9	14.0	
36	238	121	177	84.1	122	55.0	118	47.5	86.5	33.6	61.6	23.8	34.5	13.7	
38	237	119	176	82.4	120	53.6	118	47.0	85.9	33.2	61.0	23.4	34.1	13.4	
40	236	118	175	81.0	119	52.4	117	46.5	85.4	32.8	60.6	23.1	33.7	13.1	

$F_y = 50$ ksi		<b>Table 1. (continued)</b> <b>Torsional Buckling Design Strength in Axial Compression</b> $\phi_c P_n$ , kip										 TB      CAFTB			
Shape	W8x														
lb / ft	67		58		48		40		35		31		28		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	886	886	769	769	634	634	526	526	463	463	411	411	371	371
	6	839	822	723	710	592	582	487	480	427	421	377	372	333	323
	7	830	807	714	695	582	568	478	466	417	408	367	360	325	310
	8	823	792	706	680	574	554	469	453	408	395	358	348	317	297
	9	817	778	699	666	566	540	460	439	399	382	349	336	309	285
	10	811	766	693	653	559	527	453	426	391	369	341	323	302	273
	11	807	755	688	641	553	514	446	414	384	357	333	311	296	262
	12	803	744	684	631	548	503	439	402	377	345	326	300	291	252
	13	800	735	680	621	543	493	434	391	371	334	319	288	287	242
	14	797	727	677	612	539	483	429	381	365	324	313	278	283	234
	15	795	720	674	604	535	474	424	371	360	314	308	268	279	226
	16	793	714	671	597	532	466	421	363	356	305	303	259	276	219
	17	791	708	669	591	530	459	417	355	352	297	299	250	273	213
	18	790	703	667	585	527	453	414	348	348	289	295	242	271	207
	19	789	699	666	580	525	447	411	341	345	282	291	235	269	202
	20	787	695	664	575	523	442	409	335	342	275	288	228	267	197
	22	786	688	662	567	520	433	405	324	337	264	282	216	263	189
	24	784	683	660	561	518	425	401	316	333	255	277	206	261	182
	26	783	678	659	556	516	419	399	308	330	246	273	198	259	177
	28	782	675	657	551	514	413	396	302	327	240	270	190	257	172
30	781	672	656	548	513	409	395	297	325	234	267	184	255	169	
32	781	669	656	545	511	405	393	292	323	229	265	179	254	165	
34	780	667	655	542	510	402	392	288	321	224	263	174	253	163	
36	780	665	654	540	510	399	390	285	320	221	262	170	252	160	
38	779	664	654	538	509	397	389	282	319	218	260	167	252	158	
40	779	662	653	536	508	395	389	280	318	215	259	164	251	157	

$F_y = 50$ ksi		Table 1. (continued) Torsional Buckling Design Strength in Axial Compression $\phi_c P_n$ , kip										 TB      CAFTB	
		W8x											
Shape													
lb / ft	24		21		18		15		13		10		
Design	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	TB	CAFTB	
Unbraced Length $K_z L$ (ft)	0	319	319	277	277	237	237	200	200	173	173	129	129
	6	284	276	238	224	200	188	156	136	131	113	97.2	84.1
	7	275	264	229	211	191	175	149	122	123	99.9	89.5	73.1
	8	267	252	221	198	183	163	142	110	116	88.4	82.5	63.0
	9	259	240	214	185	176	151	136	100	110	78.4	76.3	54.1
	10	252	228	208	174	169	140	131	90.9	105	69.7	70.9	46.4
	11	246	217	202	164	163	130	127	83.2	101	62.2	66.2	40.5
	12	240	207	198	154	158	121	124	76.6	97.2	56.4	62.2	36.1
	13	235	197	193	146	153	112	121	71.0	94.0	51.8	58.7	32.6
	14	230	189	190	139	149	105	119	66.6	91.3	48.2	55.8	29.9
	15	226	181	187	132	145	98.5	116	63.0	89.0	45.3	53.2	27.7
	16	222	174	184	126	142	92.7	115	60.1	87.1	42.9	50.9	25.9
	17	219	167	181	121	139	87.3	113	57.7	85.4	41.0	49.0	24.4
	18	216	161	179	117	137	82.8	112	55.6	83.9	39.3	47.4	23.1
	19	214	156	178	113	135	79.0	111	53.9	82.6	37.9	46.0	22.0
	20	212	151	176	109	133	75.8	110	52.5	81.5	36.7	44.8	21.1
	22	208	142	173	103	130	70.6	108	50.1	79.6	34.8	42.9	19.7
	24	205	135	171	97.9	127	66.7	107	48.3	78.1	33.4	41.5	18.6
	26	202	130	169	94.2	125	63.6	106	46.9	77.0	32.2	40.3	17.7
	28	200	125	168	91.2	123	61.1	105	45.8	76.0	31.3	39.5	17.0
30	198	120	167	88.8	122	59.2	104	44.9	75.3	30.6	38.7	16.5	
32	197	117	166	86.8	120	57.6	103	44.2	74.6	30.0	38.2	16.0	
34	195	114	165	85.2	119	56.2	103	43.6	74.1	29.5	37.7	15.6	
36	194	112	164	83.9	119	55.1	103	43.1	73.6	29.1	37.3	15.3	
38	193	110	163	82.7	118	54.2	102	42.6	73.2	28.7	36.9	15.1	
40	193	108	163	81.7	117	53.3	102	42.3	72.9	28.5	36.6	14.8	

