

## Compression Members

### Chapter 4 (AISC Manual)

Compression members are structural elements that subjected to compression forces. These forces applied along longitudinal axis through centroid of the cross section.

#### Analysis of Compression Members

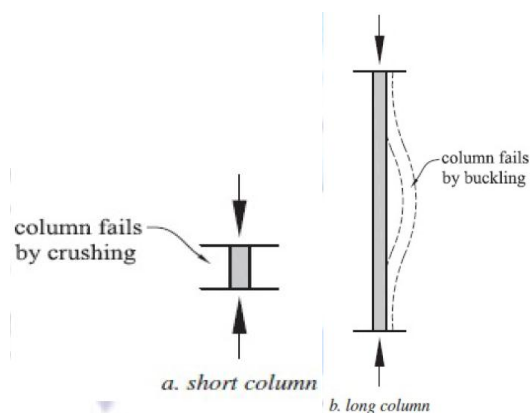
There are three general modes by which axially loaded columns can fail. These are:-

- 1) **Flexural Buckling** ( also called **Euler Buckling**): is the primary type of buckling. Members are subject to flexure, or bending, when they become unstable.
- 2) **Local Buckling**: occurs when some part or parts of the cross section of a column are so thin that they buckle locally in compression before the other modes of buckling can occur. The susceptibility of a column to local buckling is measured by the width – thickness ratios of the parts of its cross section.
- 3) **Flexural Torsional Buckling**: may occur in columns that have certain cross – sectional configurations. These columns fail by twisting ( torsion) or by a combination of torsional and flexural buckling.

#### Column Critical Buckling Load:

There are two types of columns:

- 1) **Short Column**: the failure mode is crushing compression as shown in Figure (a).
- 2) **Long Column**: the failure mode is buckling at the mid-span of the member as shown in Figure (b).



This is called a slender, or long, column, intermediate column fail by a combination of buckling and compression.

### ► Euler Formula

For a pure compression member, the axial load at which the column begins to bow outward is called the Euler Critical Buckling Load. The Euler critical buckling load for a column with pinned ends is:

$$P_e = \frac{\pi^2 EI}{L^2} \quad (4-1)$$

Where

$P_e$  = Elastic critical buckling load, lb.,

$E$  = Modulus of elasticity, 29000 ksi.

$I$  = Moment of inertia(in<sup>4</sup>).

$L$  = Length of the column brace points(in).

Knowing that  $I = Ar^2$  and that the compression stress on any member is  $f_c = P/A$ , we can express the Euler critical buckling load in terms of stress as:





$$F_e = \frac{\pi^2 E}{(L/r)^2} \quad (4-2)$$

Where,  $F_e$  = Euler elastic critical buckling stress(ksi),  $A$  = Cross-sectional area(in<sup>2</sup>),  
 $r$  = Radius of gyration,

The Euler equations above assumed that the ends of the column are pinned. For other end conditions, an adjustment or effective length factor ( $K$ ), is applied to the column length.

\*The effective length of a column is defined as  $KL$ , where  $K$  is usually determined by one of two methods:

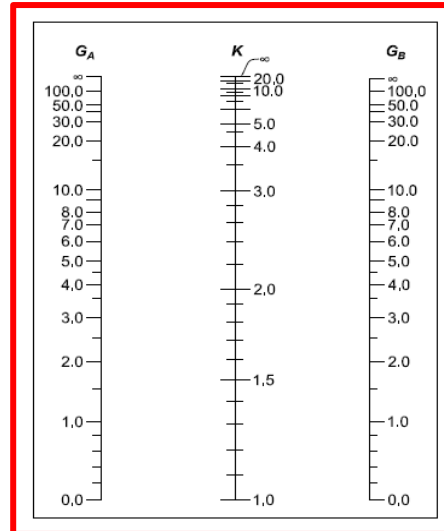
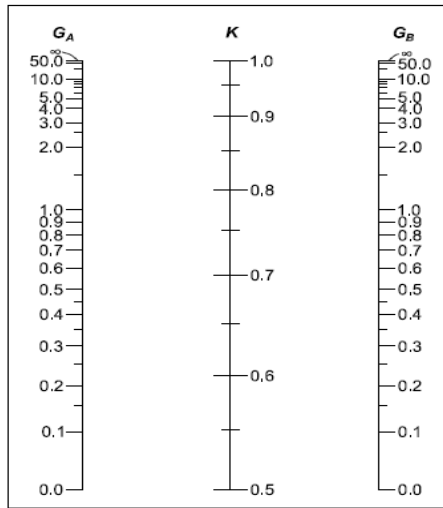
- 1) AISC Table C–C2.2, this table is especially useful for preliminary design when the size of the beams, girders, and columns are still unknown.

Buckled shape of column is shown by dashed line.	(a)	(b)	(c)	(d)	(e)	(f)
Theoretical $K$ value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.10	2.0
End condition code	 Rotation fixed and translation fixed  Rotation free and translation fixed  Rotation fixed and translation free  Rotation free and translation free					



2) Alignment charts ( AISC **Table C–C2.3** and **C–C2.4** ), they provide more accurate values for the effective length factor than AISC **Table C–C2.2**, but the process of obtaining these values is more tedious than the first method, and the alignment charts can only be used if the **initial sizes of the columns and girders are known.**

$$G_{top.} = G_{bot.} = \frac{\sum I/L)column}{\sum I/L)beam}$$



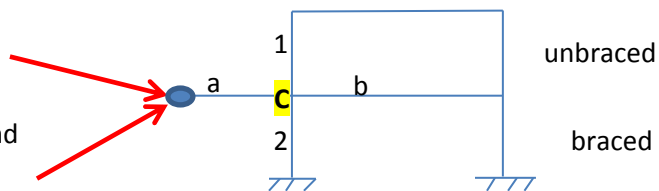
**Fig. C-C2.3.** Alignment chart- sidesway inhibited (**braced frame**).

**Fig. C-C2.4.** Alignment chart- sidesway uninhibited (moment frame).  $\rightarrow$  **un-braced**

**Case 1** Pin in the far end



**Case 2** Fixed in the far end



$$G_C = \frac{\frac{1+2}{L+\frac{a}{L}}}{\frac{b+\frac{a}{L}}{L+\frac{a}{L}}} \times \alpha \quad \text{Case 1 } \alpha=1.5 \text{ (from table below)}$$

$$G_C = \frac{\frac{1+2}{L+\frac{a}{L}}}{\frac{b+\frac{a}{L}}{L+\frac{a}{L}}} \times \alpha \quad \text{Case 2 } \alpha = 2 \text{ (from table below)}$$

**Factors consider far end condition of beam ( $\alpha$ )**

Case	Hinged far end of beam	Fixed far end of beam
Sidesway is prevented	1.5	2
Sidesway is not prevented	0.5	0.67

**Note:**  $G=10$  if the support pinned (Hinged) end column.  
 $G=1$  if the support fixed and rigid end column.

**Note:** 1. if the sentence (the frame braced)  $\rightarrow K=1$

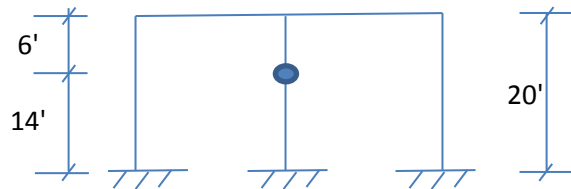
**2. Truss  $K_x = K_y = 1$**

When the column end conditions are other than pinned, equations (4-1) and (4-2) are modified as follows:

$$P_e = \frac{\pi^2 EI}{(KL)^2} \quad (4-3)$$

$$F_e = \frac{\pi^2 E}{(KL/r)^2} \quad (4-4)$$

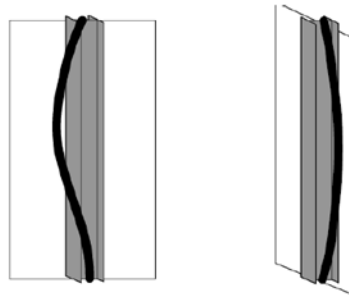
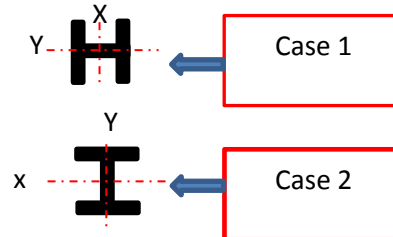
The term  $KL/r$  is called the slenderness ratio, and the AISC Specification recommends limiting the column slenderness ratio such that:  $KL/r \leq 200$ .



**Case 1/**  $l_x = 20'$ ,  $l_y = 14'$

**Case 2/**  $l_x = 14'$ ,  $l_y = 20'$

**Note:** use the larger length (Worst case).

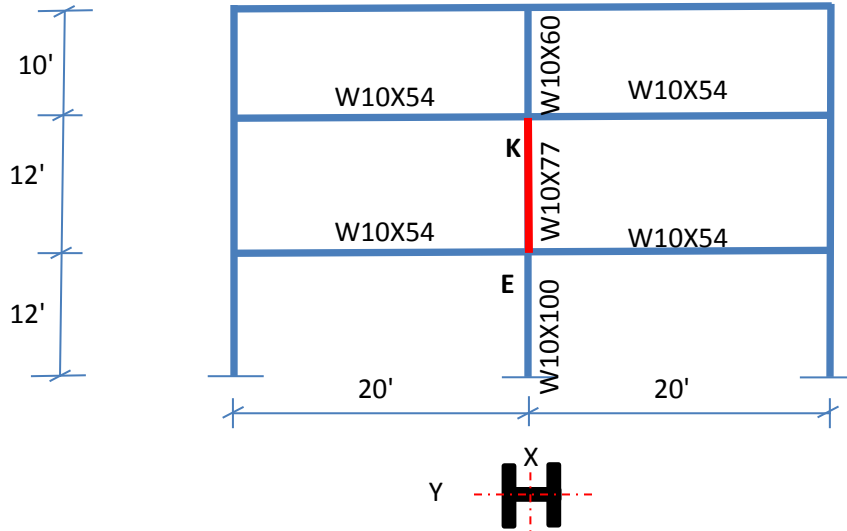


(a)

(b)

**Case 1: (a) major-axis buckling; (b) minor-axis buckling**

**Example 1/** Find the effective length factor for the member KE for the frame shown below assuming that the frame is braced only in plane perpendicular to the frame direction.



**Sol:**  $K_y = 1$  (the frame is braced only in plane perpendicular to the frame direction.)

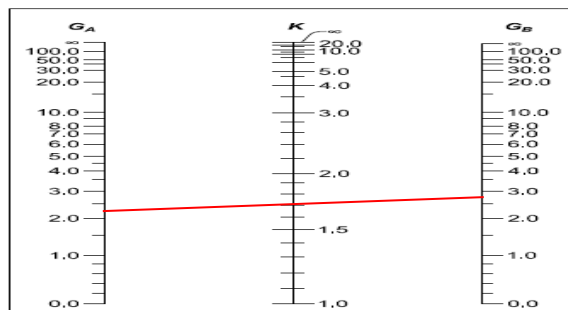
Sec.	Length	$I_x$
W10X60	10	341
W10X77	12	455
W10X100	12	623
W10X54	20	303

$$G_K = \frac{\frac{341}{10} + \frac{455}{12}}{2\left(\frac{303}{20}\right)} = 2.37$$

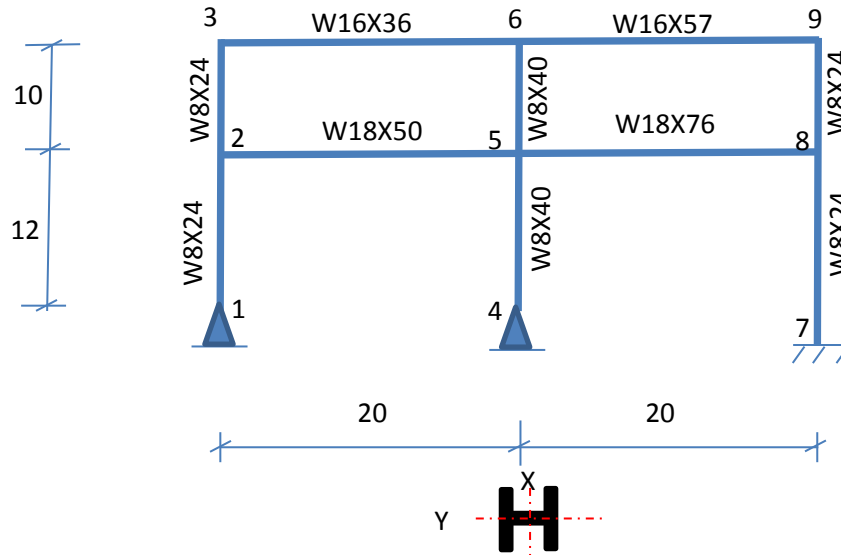
$$G_E = \frac{\frac{455}{12} + \frac{623}{12}}{2\left(\frac{303}{20}\right)} = 2.96$$

Fig. C-C2.4. Alignment chart-sidesway uninhibited (moment frame)

**$K_x = 1.71$**



**Example 2/** Find the effective length factor for the member **1-2** for the frame shown below assuming that the frame is braced only in weak direction which is perpendicular to the frame direction.



**Sol:**  $K_y = 1$  (the frame is braced only in weak direction which is perpendicular to the frame direction.)

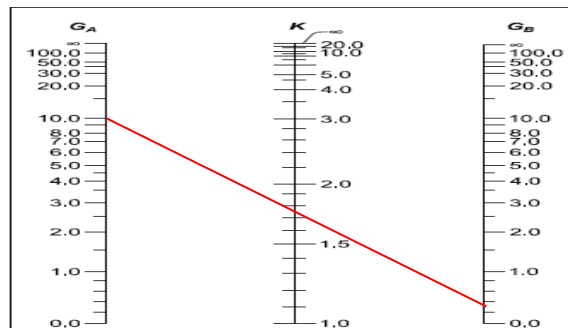
Sec.	Length	$I_x$
W8X24	10	82.7
W8X24	12	82.7
W18X50	20	800

$G_1 = 10$  (pinned or hinged).

$$G_2 = \frac{\frac{82.7}{10} + \frac{82.7}{12}}{\left(\frac{800}{20}\right)} = 0.38$$

Fig. C-C2.4. Alignment chart-sidesway uninhibited (moment frame)

**$K_x = 1.75$**



**H.W./** Find effective length factor for member 2-3, 4-5,5-6,6-7,7-8,8-9, respectively.

Note: if the member in example 1 and 2 was as figure below:

$$K_x = 1,$$

*and  $K_y$  Goto Fig. C-C2.4. Alignment chart-sidesway uninhibited (moment frame)*

