SNS COLLEGE OF TECHNOLOGY

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET304-DESIGN OF STEEL STRUCTURES

III YEAR / VI SEMESTER

Unit 3 :DESIGN OF COMPRESSION MEMBERS
Topic 1- INTRODUCTION TO COMPRESSION MEMBERS

COMPRESSION MEMBERS

Members which are subjected to compression are called compression members and load in all such members may be axial or non axial depending upon the position of the member.

INTRODUCTION

When a load tends to squeeze or shorten a member, the stresses produced are said to be compressive in nature and the member is called a compression member.

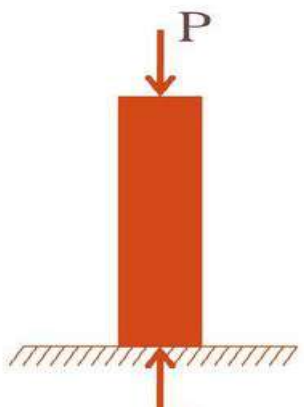


Figure 3.1. A Simple Compression Member

DEFINITION

Members which are subjected to compression are called compression member and load in all such members may be axial or non axial depending upon the position of the member. Columns are vertical compression member which are subjected to compressive force in a direction parallel to its longitudinal axis. When load is centric, columns are known as centric or axially loaded columns and when load is eccentric such columns are known as eccentric or non axially loaded columns.

CLASSIFICATION OF COLUMNS

Columns are of folowing types

1.Short columns

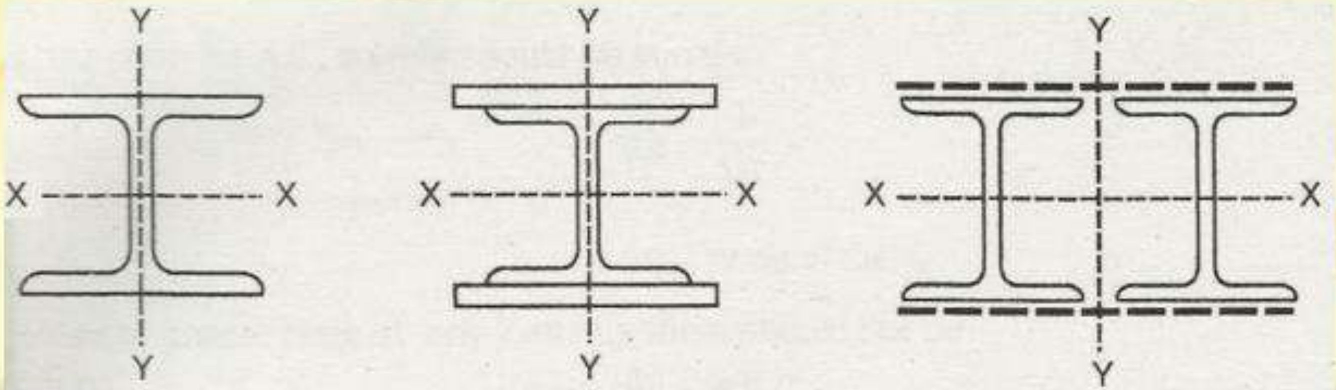
2. Long columns

1) **Short columns:**-When the ratio of effective length of column to the least lateral dimension is less than equal to 12 is known as short column. The failure of such type of columns purely due to direct crushing. The load capacity of the column is equal to the safe compressive stress and x-sectional area of column.

2) Long Columns: *- When the ratio of effective length of column to the least lateral dimension is greater than 12 is known as long column. The failure of such type of columns is mainly due to buckling or bending. The column fails in bending before the compressive stress reaches the crushing value. Direct stress has little importance in its failure.*

Common Sections For Columns

1. **I-section.** I-section can be used as columns. But ISHB section are more suitable as these provide minimum difference in two radii of gyrations. To get stronger section, additional plates can be attached on both flanges. For heavy column section, I-sections can be spaced to achieve the most economical sections.

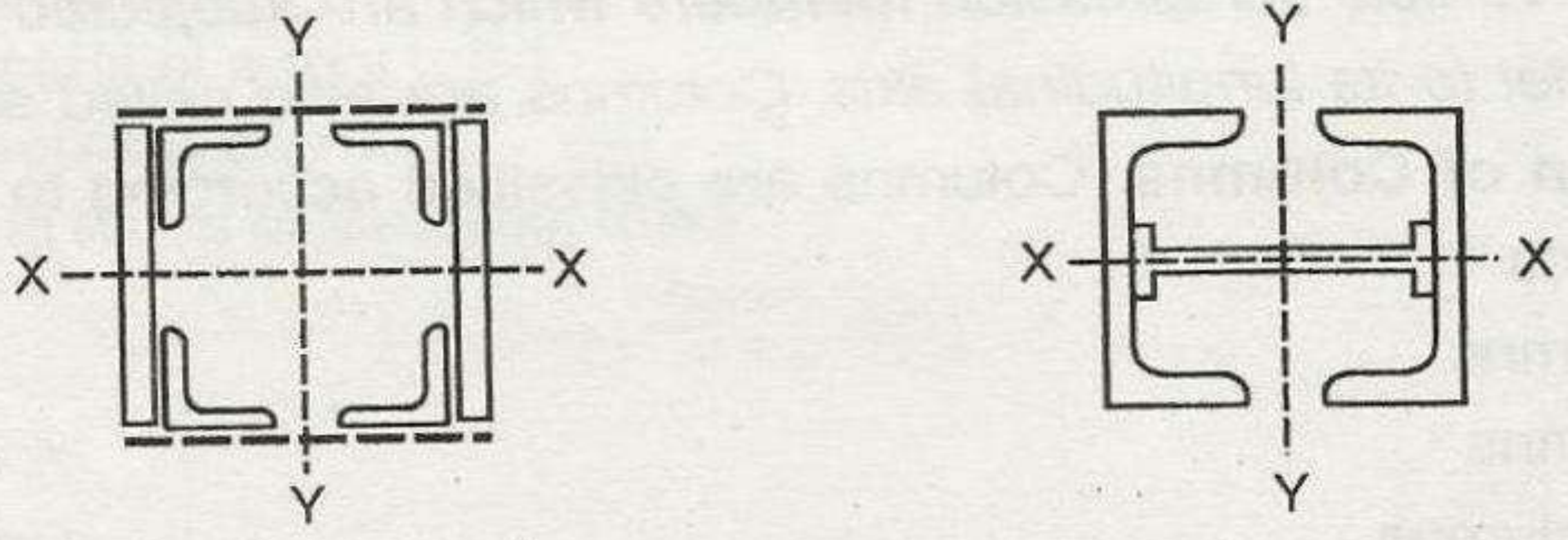


I-sections

2. Channel section. Single ISMC and ISLC are suitable as columns for light loads. Double ISJC, ISLC and ISMC can serve as good column sections when laced or battened and these can support moderate load. These can be spaced back to back for better strength and economy. Double channels with flanges butting and welded to toe to toe are also used as columns.

Channel Sections

3. Miscellaneous section. In addition to the above given sections, the combination of other sections can be used as column.

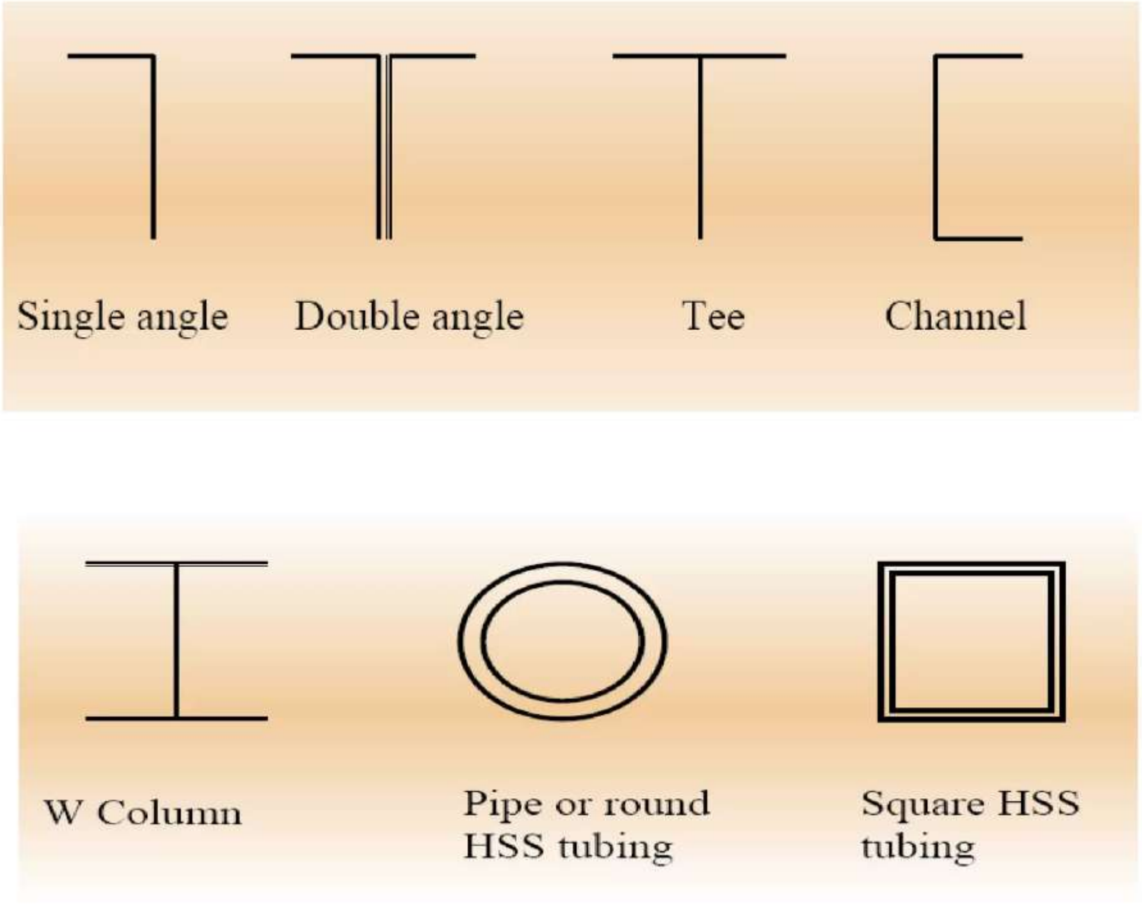


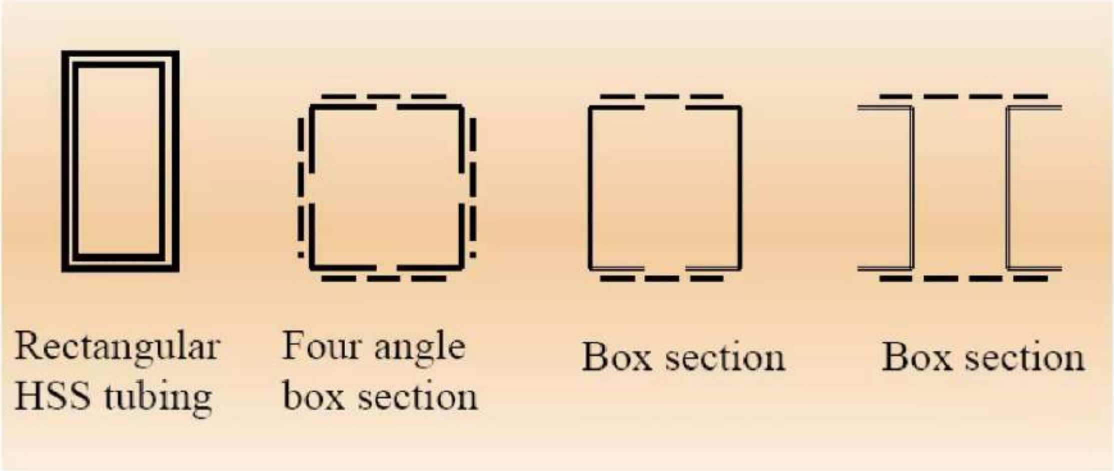
Miscellaneous Sections

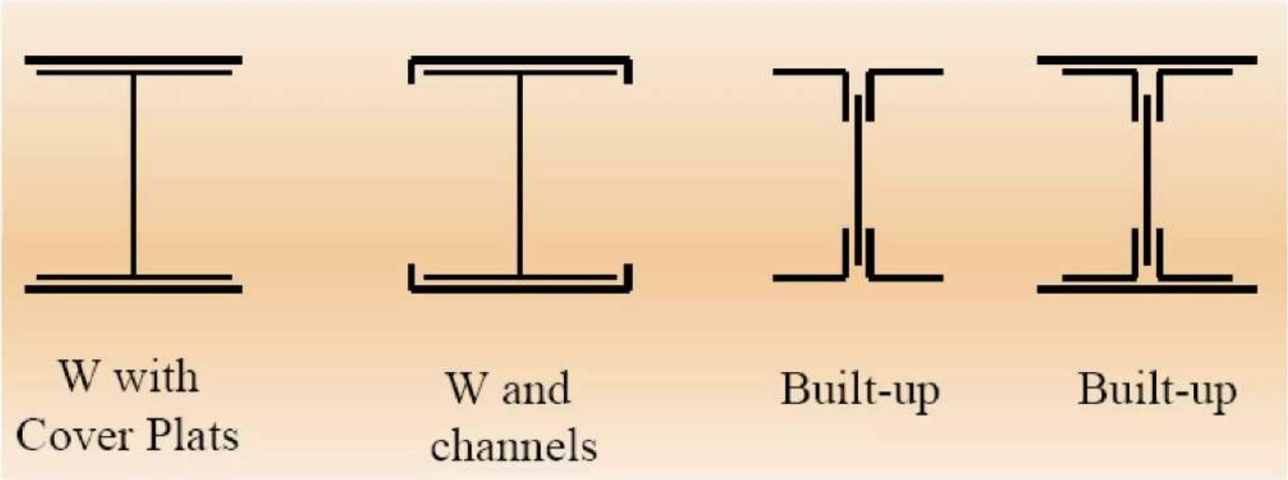
- Sections used for compression member

- In theory numerous shapes can be used for columns to resist given loads.
- However, from practical point of view, the number of possible solutions is severely limited by section availability, connection problems, and type of structure in which the section is to be used.

Figure 1. Types of Compression Members




Rectangular
HSS tubing
Four angle
box section
Box section
Box section


W with
Cover Plats
W and
channels
Built-up
Built-up

Effective length of compression member

- **Column End Condition And Effective Length**

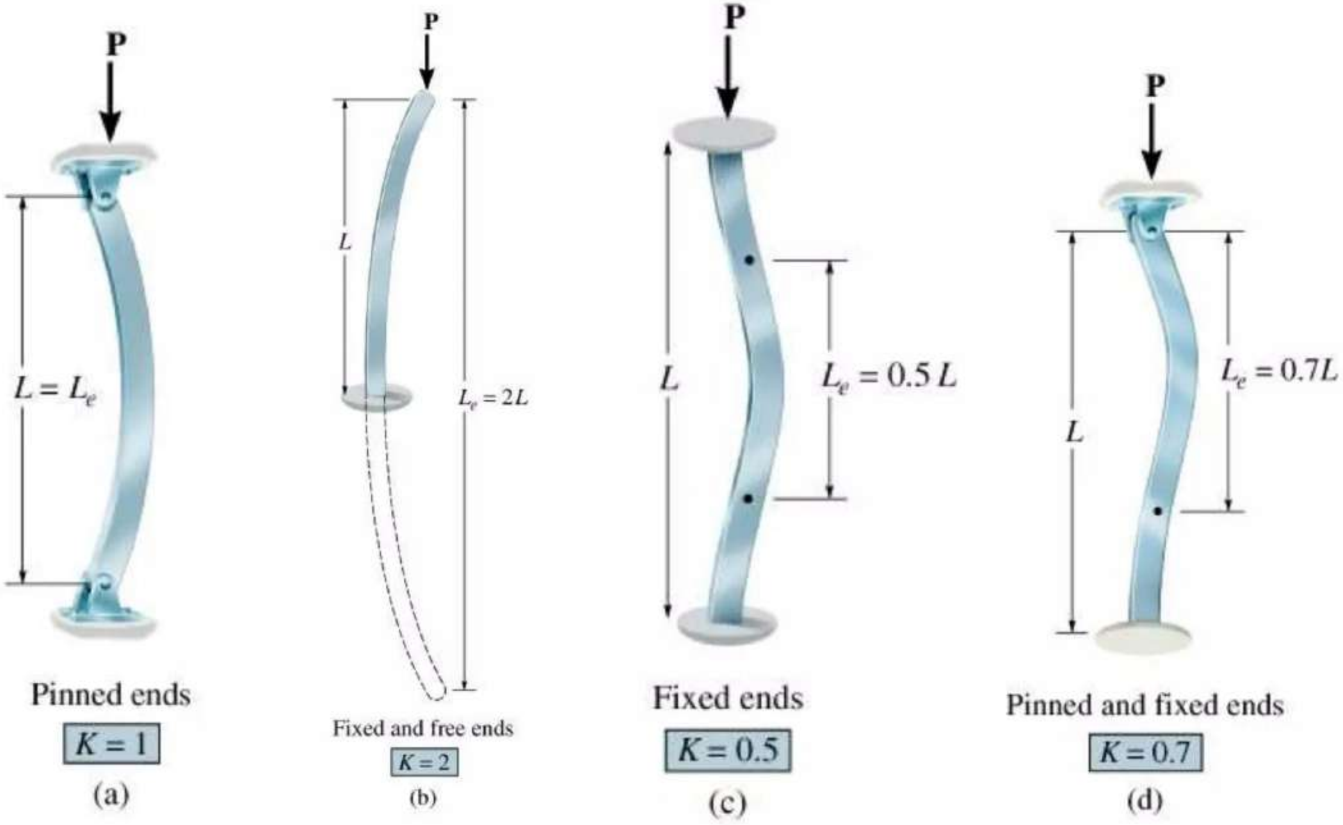
1.Both end hinged.

2.Both end fixed.

3.One end fixed and other hinged.

4.One end fixed and other free.

Effective length



- **Slenderness ratio (λ) :**

Slenderness Ratio =
effective length of column/Minimum radius of gyration

$$\lambda = le/r$$

If λ is more , its load carrying capacity will be less.

- Short compression member

1. $L/r \le 88.85$ for $F_y = 250$ Mpa
2. Failure stress equal to yield stress
3. No buckling

- Long compression member

1. They will buckle elastically
2. Axial buckling stress is below proportional limit.

Compression Member Failure

- There are three basic types of column failures.
- One, a compressive material failure(very short and fat).
- Two, a buckling failure,(very long and skinny).
- Three, a combination of both compressive and buckling failures.(length and width of a column is in between a short and fat and long and skinny column).

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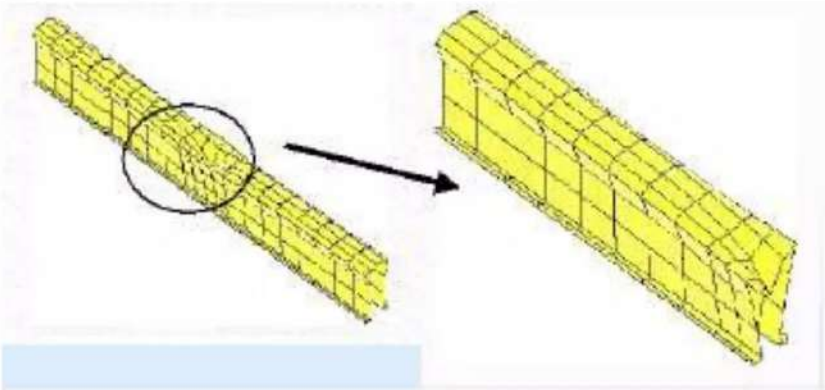
Compression Member Failure

- **Local Buckling** This occurs when some part or parts of x-section of a column are so thin that they buckle locally in compression before other modes of buckling can occur



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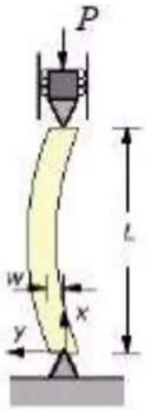
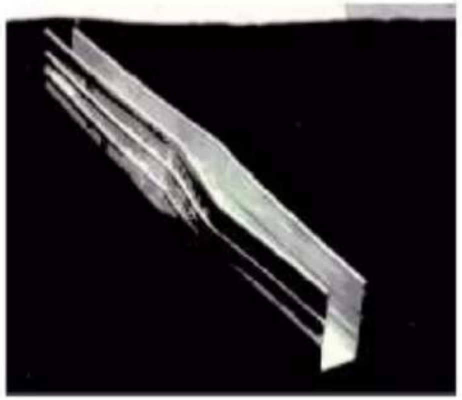
Compression Member Failure

- **Flexural Buckling** (also called Euler Buckling) is the primary type of buckling members are subjected to bending or flexure when they become unstable



Simply supported column
subjected to axial load P



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Compression Member Failure

- Squashing :

  When the length of column is relatively small and column is stocky and its component plates are prevented from local buckling, then column will be able to attain its full strength before failure.

Cross section classification

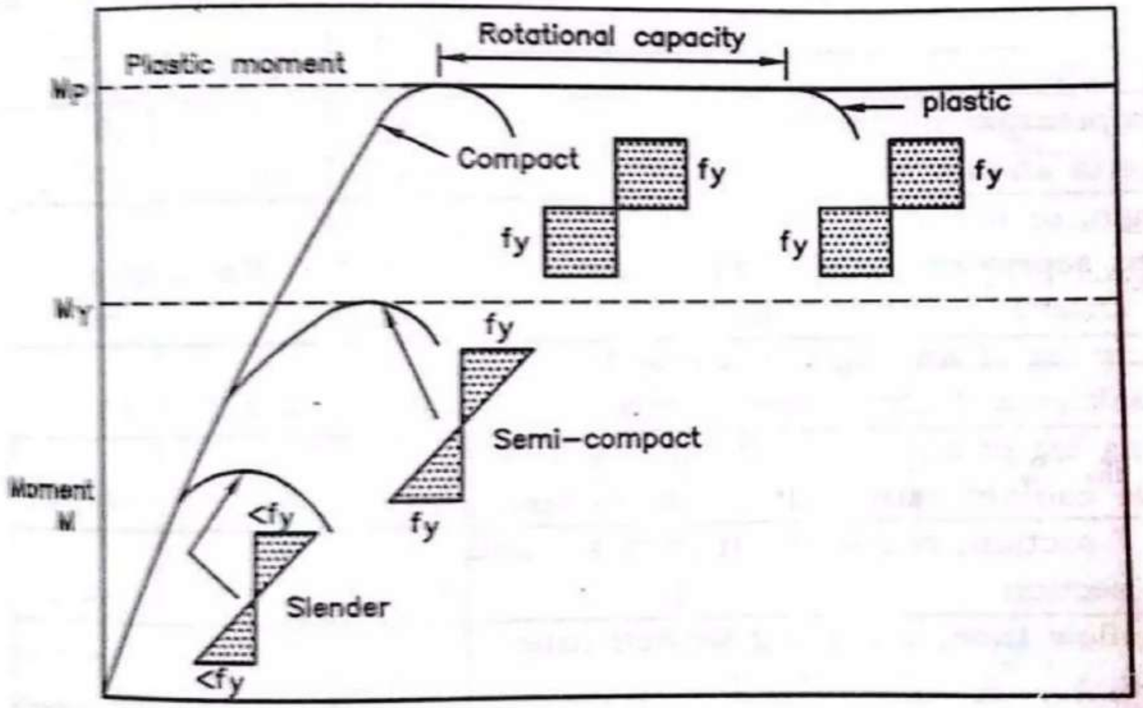


FIG. 5.4 MOMENT ROTATION BEHAVIOUR OF FOR CLASSES OF CROSS SECTIONS

Design compressive strength

7.1.2 The design compressive strength P_d, of a member is given by:

$$P < P_d$$

where

$$P_d = A_e f_{cd}$$

where

A_e = effective sectional area as defined in **7.3.2**, and

f_{cd} = design compressive stress, obtained as per **7.1.2.1**.

Clause 7.3.2

7.3.2 *Effective Sectional Area, A_e*

Except as modified in **3.7.2** (Class 4), the gross sectional area shall be taken as the effective sectional area for all compression members fabricated by welding, bolting and riveting so long as the section is semi-compact or better. Holes not fitted with rivets, bolts or pins shall be deducted from gross area to calculate effective sectional area.

IS 800: 2007 Clause 7.1.2.1

7.1.2.1 The design compressive stress, f_{cd}, of axially loaded compression members shall be calculated using the following equation:

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\phi + \left[\phi^2 - \lambda^2\right]^{0.5}} = \chi f_y / \gamma_{m0} \le f_y / \gamma_{m0}$$

where

ϕ = $0.5\,[1 + \alpha(\lambda - 0.2) + \lambda^2]$

λ = non-dimensional effective slenderness ratio

$$= \sqrt{f_y / f_{cc}} = \sqrt{f_y \left(\frac{KL}{r}\right)^2 \Big/ \pi^2 E}$$

f_{cc} = Euler buckling stress = $\dfrac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$

where

KL/r = effective slenderness ratio or ratio of effective length, KL to appropriate radius of gyration, r;

α = imperfection factor given in Table 7;

χ = stress reduction factor (*see* Table 8) for different buckling class, slenderness ratio and yield stress

$$= \frac{1}{\left[\phi + \left(\phi^2 - \lambda^2\right)^{0.5}\right]}$$

λ_{m0} = partial safety factor for material strength.

Table 7 Imperfection Factor, α

(*Clauses* 7.1.1 *and* 7.1.2.1)

Buckling Class	a	b	c	d
α	0.21	0.34	0.49	0.76

Column buckling curves

- Classification of different sections under different buckling class a, b,c and d are given in Table 10 of IS 800: 2007 (page 44).
- The stress reduction factor χ , and the design compressive stress fcd, for different buckling class, yield stress and effective slenderness ratio is given in table 8 (page 37)
- Table 9(page 40) shows the design compressive stress, fcd for different buckling class a to d.

- The curve corresponding to different buckling class are presented in non-dimensional form as shown in the figure below. Using this curve one can find the value of fcd (design compressive stress) corresponding to non- dimensional effective slenderness ratio λ (page 35)

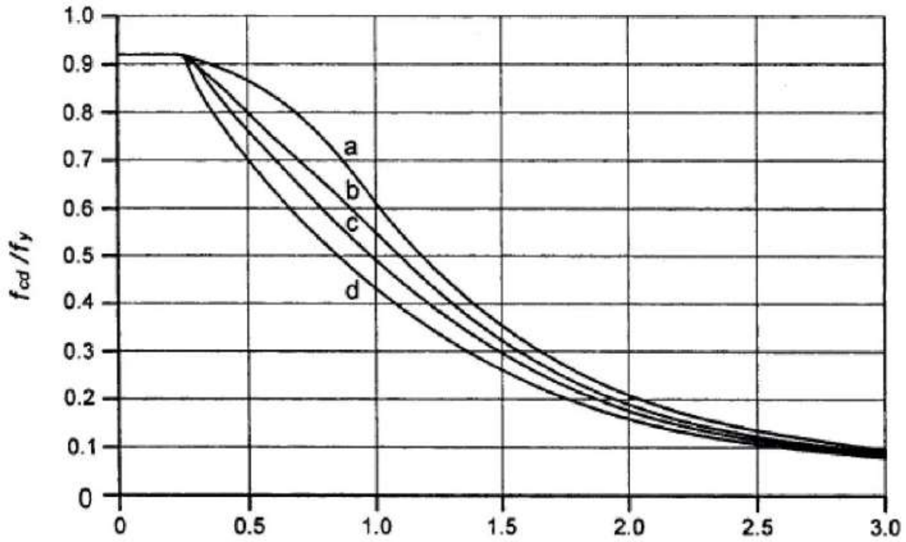
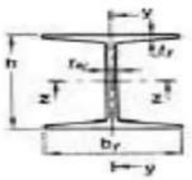
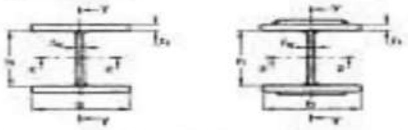
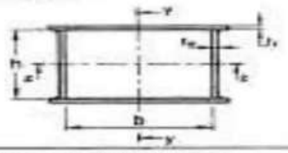


FIG. 8 COLUMN BUCKLING CURVES

Table 10 Buckling Class of Cross-Sections

(Clause 7.1.2.2)

Cross-Section (1)	Limits (2)	Buckling About Axis (3)	Buckling Class (4)
Rolled I-Sections 	$h/b_f > 1.2$: $t_f \le 40$ mm	z-z y-y	a b
	$40 \le$ mm $< t_f \le 100$ mm	z-z y-y	b c
	$h/b_f \le 1.2$: $t_f \le 100$ mm	z-z y-y	b c
	$t_f > 100$ mm	z-z y-y	d d
Welded I-Section 	$t_f \le 40$ mm	z-z y-y	b c
	$t_f > 40$ mm	z-z y-y	c d
Hollow Section 	Hot rolled	Any	a
	Cold formed	Any	b
Welded Box Section 	Generally (except as below)	Any	b
	Thick welds and $b/t_f < 30$ $h/t_w < 30$	z-z y-y	c c
Channel, Angle, T and Solid Sections 		Any	c
Built-up Member 		Any	c

Angle struts

- Single angle strut: (IS : 800 cl. 7.5.1)

  The compression in single angle struts may be transfered either concentrically to its centroid through end gusset or eccentrically by connecting one of its legs to a gusset or adjacent member.

1. Concentric loading
2. Loaded through one leg $\sqrt{k_1 + k_2 + \Lambda^2_{vv} + k_3 \ \Lambda^2_{\phi}}$

- Double angle struts

1. Connected back to back on opposite sides of G.P.

   The effective length kL in plane of end gusset shall be taken as between 0.7 and 0.85 times the distance between intersections.

2. Connected back to back to one side of G.P.(cl.7.5.2.2)

   The outstanding legs shall be connected by tack bolting or tack welding spaced at a distance not exceeding 600 mm. (cl. 10.2.5.5)

THANK YOU