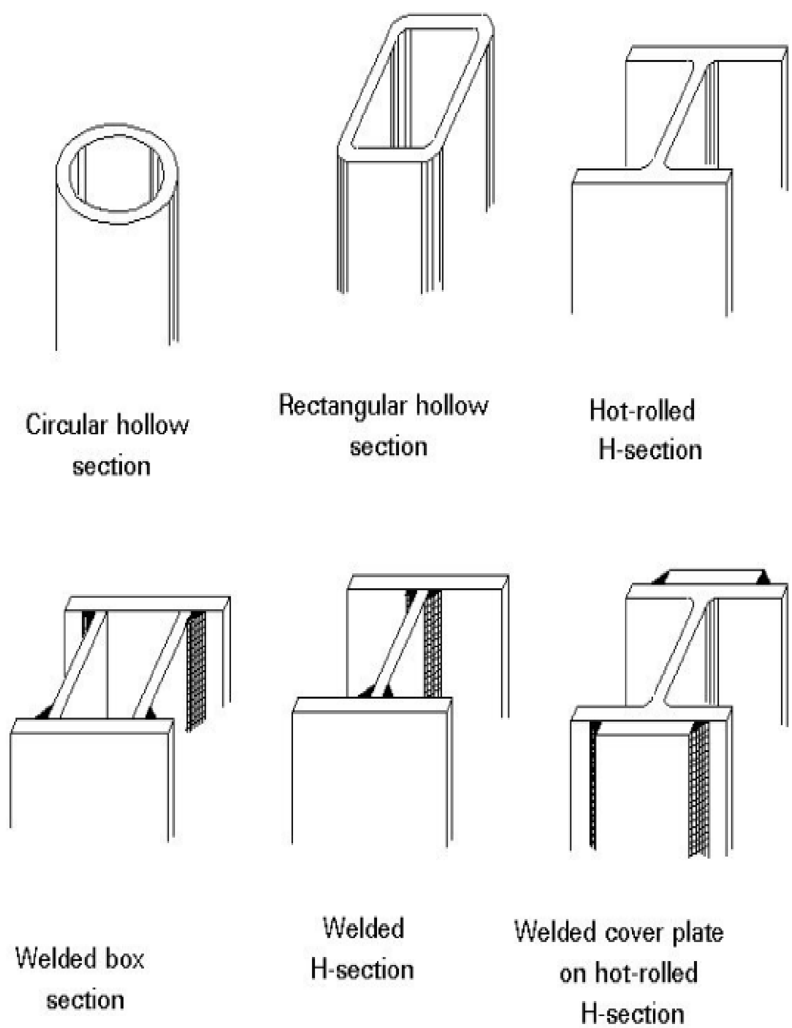
COMPRESSION MEMBERS

Types of compression members – Theory of columns – Column curves – Effective length of compression members – Slenderness ratio – Design of simple and compound section compression members – Design of lacing and battened types of columns – Design of column bases and column splicing

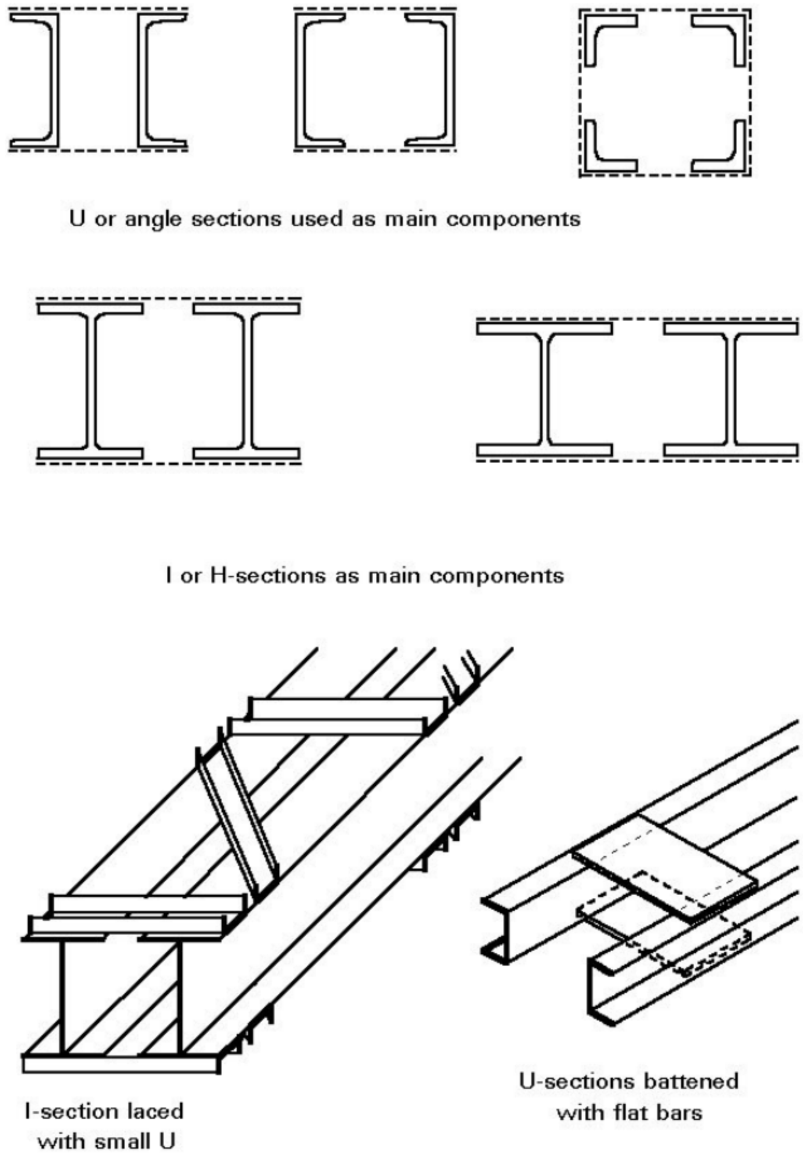
Introduction

Steel Compression members

- Building columns
- Frame Bracing
- Truss members (chords and bracing)



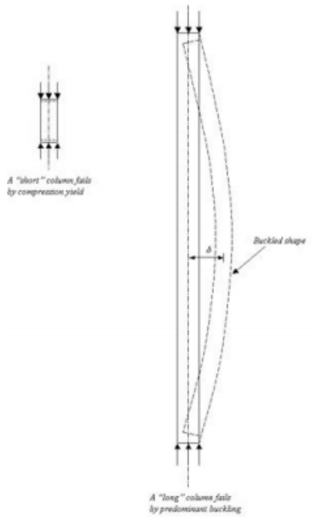
Different C/S of Columns



Built up Columns

Column, top chords of trusses, diagonals and bracing members are all examples of compression members. Columns are usually thought of as straight compression members whose lengths are considerably greater than their cross-sectional dimensions.

An initially straight strut or column, compressed by gradually increasing equal and opposite axial forces at the ends is considered first. Columns and struts are termed “long” or “short” depending on their proneness to buckling. If the strut is “short”, the applied forces will cause a compressive strain, which results in the shortening of the strut in the direction of the applied forces. Under incremental loading, this shortening continues until the column yields or "squashes". However, if the strut is “long”, similar axial shortening is observed only at the initial stages of incremental loading. Thereafter, as the applied forces are increased in magnitude, the strut becomes "unstable" and develops a deformation in a direction normal to the loading axis and its axis is no longer straight. (See Fig.1). The strut is said to have "buckled"



Short vs Long Columns

Buckling behaviour is thus characterized by large deformations developed in a direction (or plane) normal to that of the loading that produces it. When the applied loading is increased, the buckling deformation also increases. Buckling occurs mainly in members subjected to compressive forces. If the member has high bending stiffness, its buckling resistance is high. Also, when the member length is increased, the buckling resistance is decreased. Thus the buckling resistance is high when the member is short or "stocky" (i.e. the member has a high bending stiffness and is short) conversely, the buckling resistance is low when the member is long or "slender". Common hot rolled and built-up steel members used for carrying axial compression, usually fail by flexural buckling. The buckling strength of these members is affected by residual stresses, initial bow and accidental eccentricities of load.

Structural steel has high yield strength and ultimate strength compared with other construction materials. Hence compression members made of steel tend to be slender compared with reinforced concrete or prestressed concrete compression members.

Buckling is of particular interest while employing slender steel members. Members fabricated from steel plating or sheeting and subjected to compressive stresses also experience local buckling of the plate elements. This chapter introduces buckling in the context of axially

compressed struts and identifies the factors governing the buckling behaviour. Both global and local buckling is instability phenomena and should be avoided by an adequate margin of safety.
Traditionally, the design of compression members was based on Euler analysis of ideal columns which gives an upper band to the buckling load. However, practical columns are far from ideal and buckle at much lower loads. The first significant step in the design procedures for such columns was the use of Perry Robertsons curves.
Modern codes advocate the use of multiple-column curves for design. Although these design procedures are more accurate in predicting the buckling load of practical columns, Euler's theory helps in the understanding of the behaviour of slender columns and is reviewed in the following sections.

Buckling

Elastic (Euler) buckling

Inelastic buckling

Buckling modes

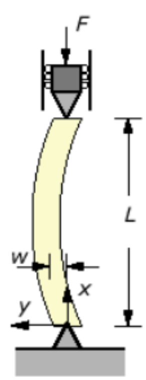
Overall buckling

Flexural buckling

Torsional buckling

Torsional-flexural buckling

Local buckling



Simply supported column subjected to axial load F

The design compressive strength Pd, of a member is given by

$$P < P_d$$

Where
$P_d = A_c f_{cd}$

Ac- Cross sectional area of the section as per code 7.3.2
Fcd-Design compressive stress obtained as per code 7.1.2.1.
The design compressive stress, fcd , of axially loaded compression members shall be calculated using the following equation:

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

where

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

λ = non-dimensional effective slenderness ratio

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

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.

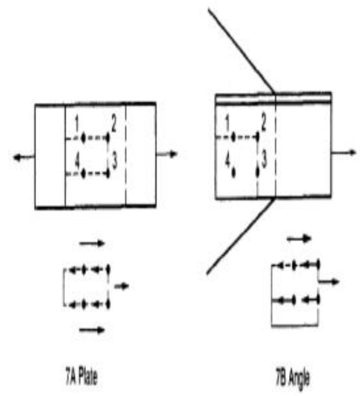


FIG. 7 BLOCK SHEAR FAILURE

Effective Length of Compression Members

The effective length KL, is calculated from the actual length L, of the member, considering the rotational and relative translational boundary conditions at the ends. The actual length shall be taken as the length from centre-to-centre of its intersections with the supporting members in the plane of the buckling deformation. In the case of a member with a free end, the free standing length from the center of the intersecting member at the supported end, shall be taken as the actual length.

Effective Length

Where the boundary conditions in the plane of buckling can be assessed, the effective length, KL can be calculated on the basis of Table 11. Where frame analysis does not consider the equilibrium of a framed structure in the deformed shape (second-order analysis or advanced analysis), the effective length of compression members in such cases can be calculated using the procedure given in D-1. The effective length of stepped column in single storey buildings can be calculated using the procedure given in D-2.