UNIT IV DESIGN OF COLUMNS

Types of columns –Axially Loaded columns – Design of short Rectangular Square and circular columns –Design of Slender columns- Design for Uniaxial and Biaxial bending using Column Curves

Compression members are structural elements primarily subjected to axial compressive forces and hence, their design is guided by considerations of strength and buckling. Examples of compression member pedestal, column, wall and strut.

Effective length: The vertical distance between the points of inflection of the compression member in the buckled configuration in a plane is termed as effective length *le* of that compression member in that plane. The effective length is different from the unsupported length *l* of the member, though it depends on the unsupported length and the type of end restraints. The relation between the effective and unsupported lengths of any compression member is

$$le = k\, l$$

Where *k* is the ratio of effective to the unsupported lengths.

Pedestal: Pedestal is a vertical compression member whose effective length *le* does not exceed three times of its least horizontal dimension *b*. The other horizontal dimension *D* shall not exceed four times of *b*.

Column: Column is a vertical compression member whose unsupported length *l* shall not exceed sixty times of *b* (least lateral dimension), if restrained at the two ends. Further, its unsupported length of a cantilever column shall not exceed $100b^2/D$, where *D* is the larger lateral dimension which is also restricted up to four times of *b*

Wall: Wall is a vertical compression member whose effective height H_{we} to thickness *t* (least lateral dimension) shall not exceed 30. The larger horizontal dimension i.e., the length of the wall *L* is more than 4t.

Types of columns

A column may be classified based on different criteria such as:

1. **Based on shape**
   - Rectangle
   - Square
   - Circular

2. **Based on slenderness ratio or height**

   Short column and Long column or Short and Slender Compression Members

   A compression member may be considered as short when both the slenderness ratios namely l_{ex}/D and l_{ey}/b are less than 12:
   Where
   l_{ex}= effective length in respect of the major axis, D= depth in respect of the major axis, l_{ey}= effective length in respect of the minor axis, and b = width of the member.

   It shall otherwise be considered as a slender or long compression member.

   The great majority of concrete columns are sufficiently stocky (short) that slenderness can be ignored. Such columns are referred to as short columns. Short column generally fails by crushing of concrete due to axial force. If the moments induced by slenderness effects weaken a column appreciably, it is referred to as a slender column or a long column. Long columns generally fail by bending effect than due to axial effect. Long column carry less load compared to long column.

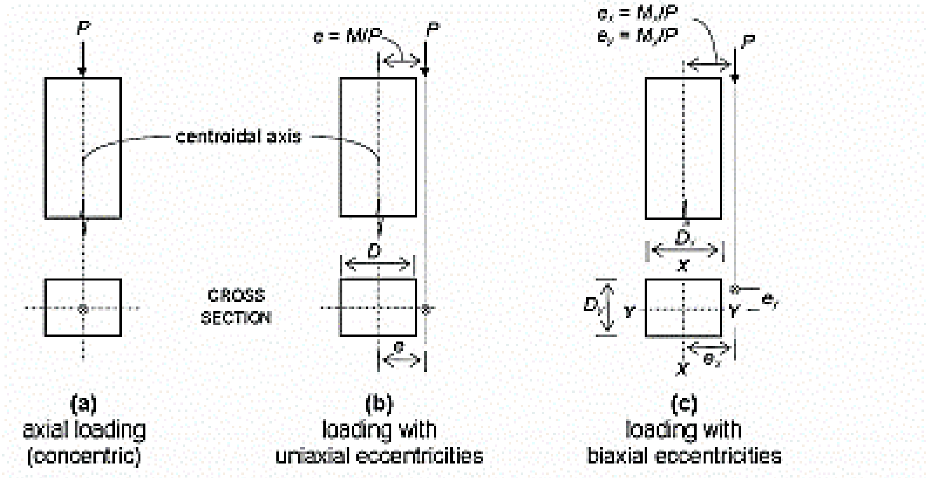
3. **Based on pattern of lateral reinforcement**

   - Tied columns with ties as laterals
   - Columns with Spiral steel as laterals or spiral columns

   Majority of columns in any buildings are tied columns. In a tied column the longitudinal bars are tied together with smaller bars at intervals up the column. Tied columns may be square, rectangular, L-shaped, circular, or any other required shape. Occasionally, when high strength and/or high ductility are required, the bars are placed in a circle, and the ties are replaced by a bar bent into a helix or spiral. Such a column, called a spiral column. Spiral columns are generally circular, although square or polygonal shapes are sometimes used. The spiral acts to restrain the lateral expansion of the column core under high axial loads and, in doing so, delays the failure of the core, making the column more ductile. Spiral columns are used more extensively in seismic regions. If properly designed, spiral column carries 5% extra load at failure compared to similar tied column.

4. Based on type of loading

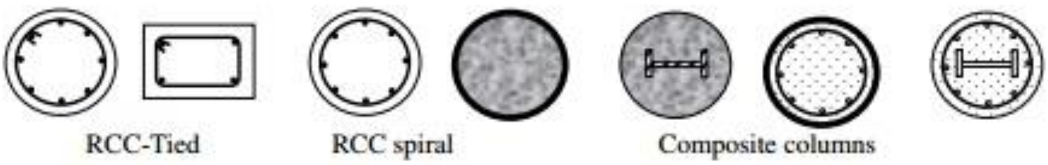
- Axially loaded column or centrally or concentrically loaded column (P_u)
- A column subjected to axial load and uniaxial bending (P_u + $M_{ux)}$ or (P + M_{uy})
- A column subjected to axial load and biaxial bending (P_u + M_{ux} + M_{uy})



Different loading situations in columns

5. Based on materials

- Timber
- Stone
- Masonry
- RCC
- PSC
- Steel
- Aluminium ,
- Composite column



Minimum Eccentricity

In practical construction, columns are rarely truly concentric. Even a theoretical column loaded axially will have accidental eccentricity due to inaccuracy in construction or variation of materials etc. Accordingly, all axially loaded columns should be designed considering the minimum eccentricity

$e_{x\ min} \geq$ greater of (l/500 + D/30) or 20 mm

$e_{y\ min} \geq$ greater of (l/500 + b/30) or 20 mm

where l, D and b are the unsupported length, larger lateral dimension and least lateral dimension, respectively.

Longitudinal Reinforcement

The longitudinal reinforcing bars carry the compressive loads along with the concrete. stipulates the guidelines regarding the minimum and maximum amount, number of bars, minimum diameter of bars, spacing of bars etc. The following are the salient points:

- The minimum amount of steel should be at least 0.8 per cent of the gross cross-sectional area of the column required if for any reason the provided area is more than the required area.
- The maximum amount of steel should be 4 per cent of the gross cross-sectional area of the column so that it does not exceed 6 per cent when bars from column below have to be lapped with those in the column under consideration.
- Four and six are the minimum number of longitudinal bars in rectangular and circular columns, respectively.
- The diameter of the longitudinal bars should be at least 12 mm.
- Columns having helical reinforcement shall have at least six longitudinal bars within and in contact with the helical reinforcement. The bars shall be placed equidistant around its inner circumference.
- The bars shall be spaced not exceeding 300 mm along the periphery of the column.
- The amount of reinforcement for pedestal shall be at least 0.15 per cent of the cross-sectional area provided.

Pitch and Diameter of Lateral Ties

Pitch: The maximum pitch of transverse reinforcement shall be the least of the following:

(i) the least lateral dimension of the compression members;

(ii) sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied; and

(iii) 300 mm.

(b) Diameter: The diameter of the polygonal links or lateral ties shall be not less than one-fourth of the diameter of the largest longitudinal bar, and in no case less than 6 mm.