LECTURE # 1

1. COLUMN:

It is a vertical member which is primarily subjected to axial compression in which major deformation is shortening.

2. TYPES OF COLUMNS:

i. Classification on the Basis of Shape:

- Square section.
- Rectangular section.
- Circular section.
- L-section.
- T-section.

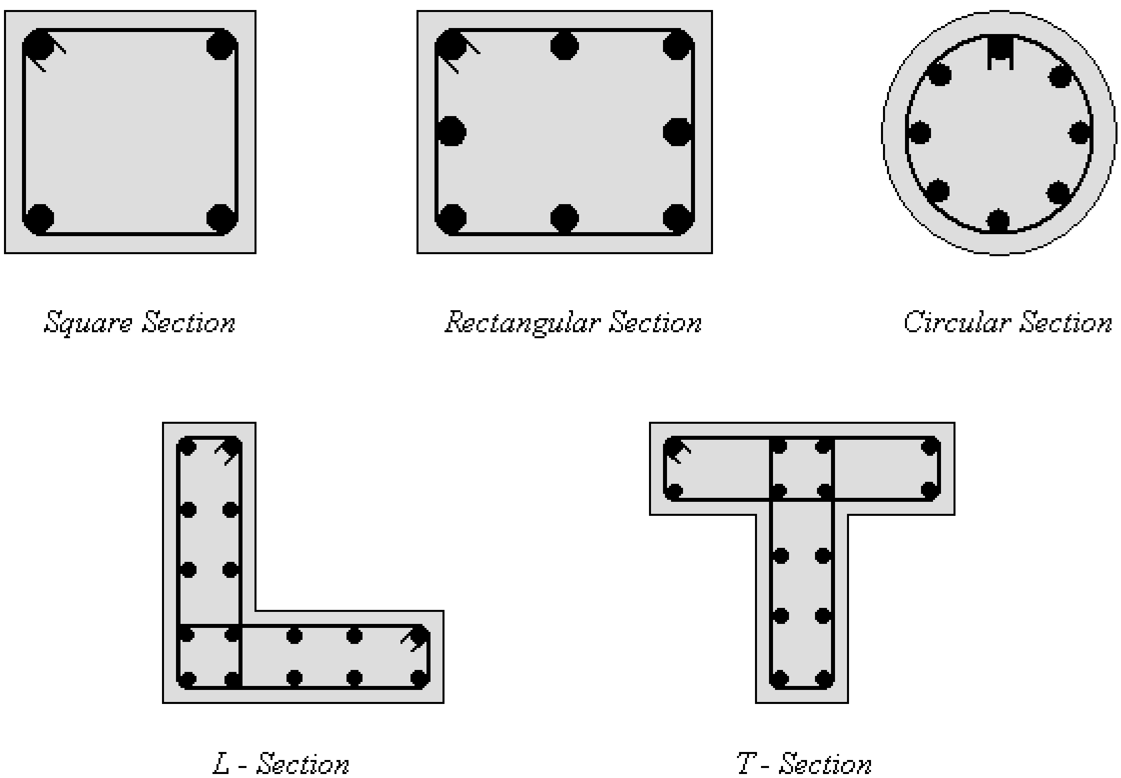


Fig.1 Classification on the Basis of Shape

ii. Classification on the Basis of Reinforcement:

- **Tied Columns:**

  These columns have the bars braced or tied at close intervals by close loops called ties.

- **Spiral Columns:**

  These columns have the bars and the core concrete wrapped with a closely spaced helix.

- **Composite Columns:**

  These columns consists of a structural steel or cast iron column encased in concrete reinforced with both longitudinal and transverse reinforcements.

- **Pipe Columns or Concrete Filled Steel Tubes:**

  These columns are circular, rectangular or square hollow sections filled with concrete without any additional reinforcement.

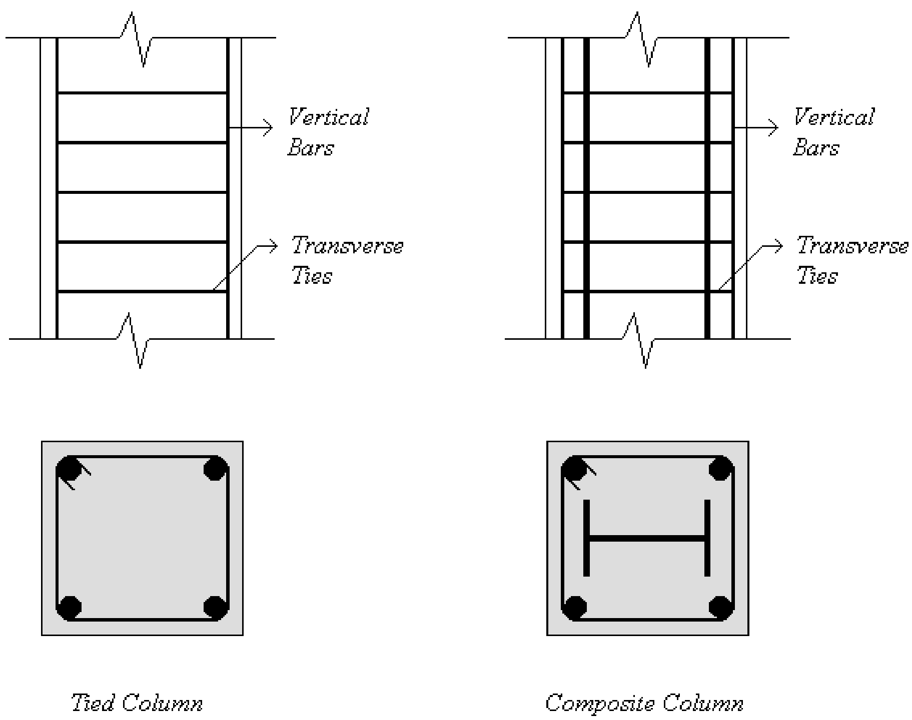


Fig.2(a) Classification on the Basis of Reinforcement

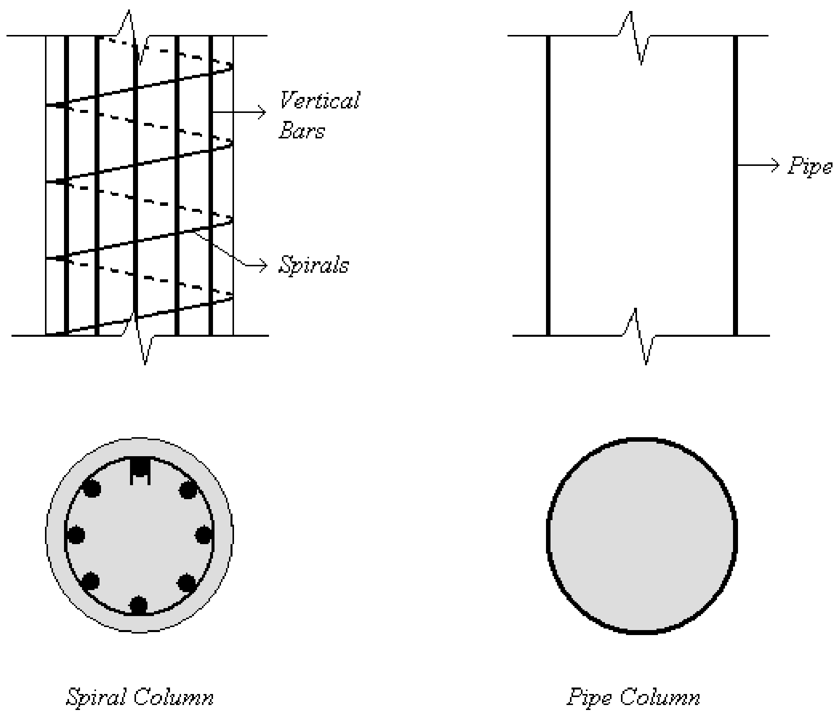


Fig.2(b) Classification on the Basis of Reinforcement

iii. Classification on the Basis of Type of Loading:

- **Concentrically Loaded Columns:**

  When the resultant of the load coincides with the centroid of the cross-section, the column is said to be concentrically loaded column. Fig. 3 shows a concentrically loaded column.

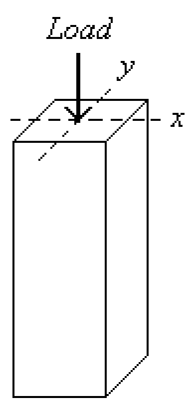


Fig.3 Concentrically Loaded Column

- **Eccentrically Loaded Columns:**

  When the resultant of the load does not coincide with the centroid of the cross-section, the column is said to be eccentrically loaded column. There are two types of eccentrically loaded columns;

  1. Uni-axially eccentrically loaded columns. (Fig. 4(a))
  2. Bi-axially eccentrically loaded columns. (Fig. 4(b))

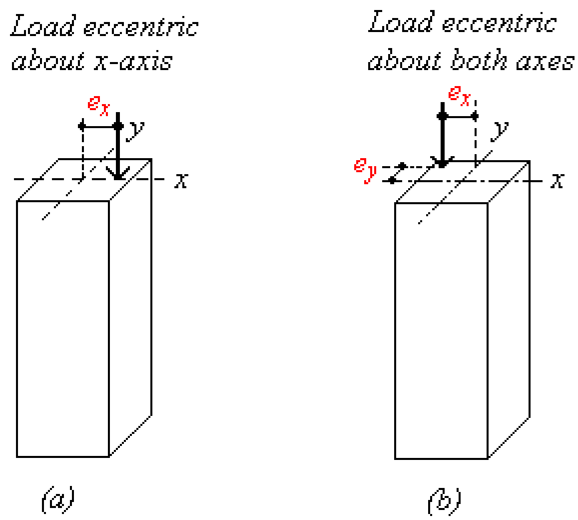


Fig.4 Eccentrically Loaded Columns

- **Sources of Eccentricity in Columns:**

Eccentricity is due to following three reasons;

1. Eccentric loading. (Fig. 5(a))
2. Initial crookedness. (Fig. 5(b))
3. Out-of-plumbness. (Fig. 5(c))

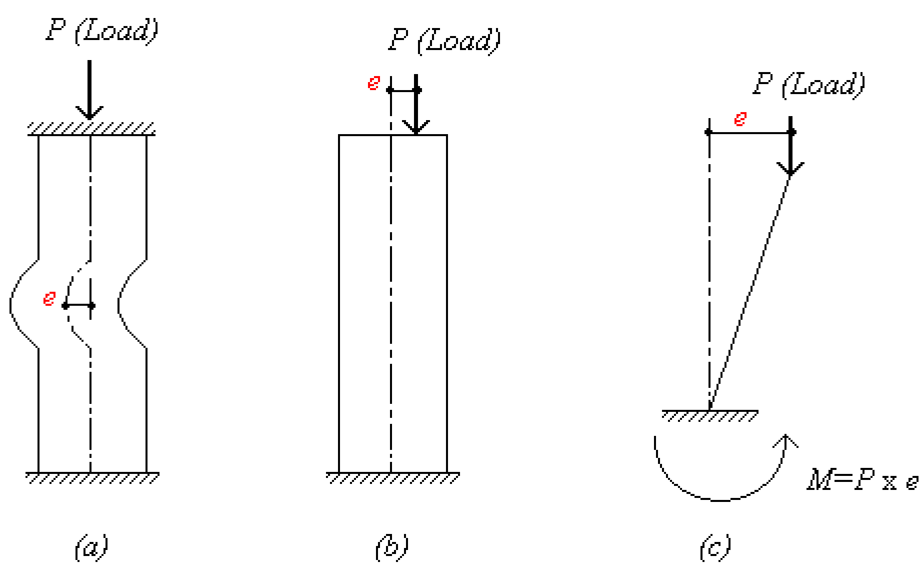


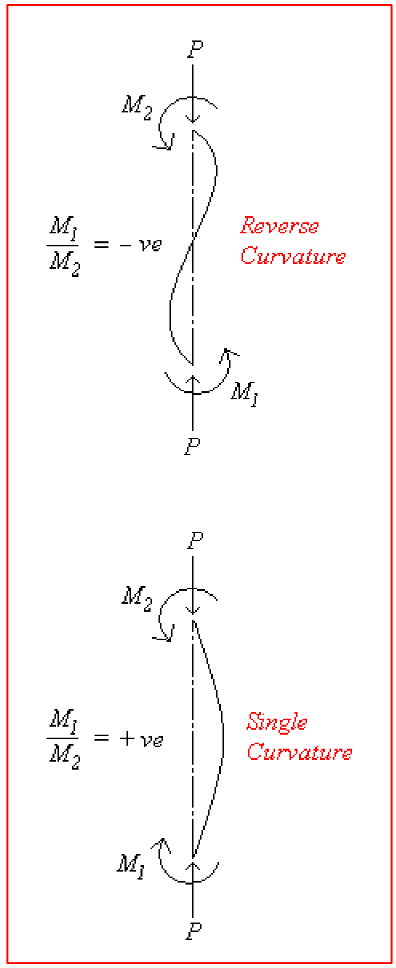
Fig.5 Sources of Eccentricity in Columns

3. CLASSIFICATION OF COLUMNS ACCORDING TO ACI CODE:

- **Short Column:**

In short columns there are no 2nd order effects and the failure is due to crushing of concrete without any instability. Moment magnification chances are very less in such columns because radius of gyration is more and length is small.

$$\frac{K\, l_u}{r} \leq 34 - 12\,\frac{M_1}{M_2}$$



Where,

K = Effective length factor taken from alignment charts.

M_1 = Magnitude of smaller end moment with sign.

M_2 = Magnitude of larger end moment with sign.

$\frac{M_1}{M_2}$ = 0, for concentrically loaded columns.

$\frac{M_1}{M_2}$ = +ve, when member is bent in single curvature.

$\frac{M_1}{M_2}$ = −ve, when member is bent in reverse curvature.

- **Slender Columns:**

These columns fail due to buckling, instability or 2nd order effect. The failure load is less than that of a short column. As length of column increases, the probability of failure due to buckling increases.

4. TYPES OF REINFORCEMENT IN COLUMNS:

- **Longitudinal Steel:**

It is that steel which is present along the length of the column. Following are the various purposes of longitudinal reinforcement;

1. The main function of longitudinal reinforcement is to prevent creep and shrinkage in concrete.

2. It provides resistance against lateral bending, cracking and reduction of moment of inertia value.
3. It reduces the size of the column.

- **Transverse Steel:**

1. It provides confinement to the inner concrete or core concrete i.e. the concrete which is present inside the longitudinal reinforcement. Confinement provides ductility and it also increases the strength of the concrete.
2. Transverse steel reduces the chances of buckling of longitudinal steel.
3. It holds the longitudinal steel in position during casting
4. Transverse steel provides resistance against shear.

5. TYPES OF TRANSVERSE REINFORCEMENT:

- **Ties or Transverse Ties:**

Lateral ties are used in the columns because of lesser construction cost and ease of placement.

- **Spiral Reinforcement:**

Spiral columns are used where we need more ductility i.e., in earthquake zones. Spirals are mostly provided in circular columns. Spiral columns sustain maximum load at excessive deformation and thus prevent the complete collapse of the structure before the total redistribution of moments and stresses is complete. The disadvantage of spiral reinforcement is that it is very difficult to place in the field, so, due to this reason its use is practically limited.

6. CAPACITY OF CONCENTRICALLY LOADED SHORT COLUMNS:

Steel always yields first because it is lesser in amount and due to pure compression it is yielded.

$\varepsilon_{cu} = 0.003$ (Strain at which concrete crushes)

$\varepsilon_y = 0.0015$ or 0.0021 (Strain at which steel yields)

After yielding of steel, load is taken by concrete alone and the resistance is provided by the concrete only. A stage comes when concrete crushes while steel is already yielded (final stage).

If the bond between concrete and steel is perfect then they equally shorten.

$$\varepsilon_c = \frac{f_c}{E_c} \quad \textit{and} \quad \varepsilon_s = \frac{f_s}{E_s}$$

$$\varepsilon_c = \varepsilon_s$$

$$\frac{f_c}{E_c} = \frac{f_s}{E_s}$$

$$\textit{Modular Ratio, } n = \frac{E_s}{E_c}$$

$$f_s = n f_c$$

Now,

$$A_g = A_{st} + A_c$$

$$P_n = P_c + P_s$$

$$P_n = A_c f_c + A_{st} f_s$$

$$P_n = f_c\,(A_g - A_{st}) + A_{st}\,(n f_c)$$

$$P_n = f_c\,[A_g + (n - 1)A_{st}]$$ (within elastic range, service loads)

7. PROBLEM:

A R.C. concentrically loaded short column has a cross-sectional area 450 x 450 mm^2 and is reinforced by Grade 420, 8 # 19 bars. If at any stage, concrete stress f_c = 10 MPa (f_c' = 20 MPa), what will be corresponding load carrying capacity of the column.

Solution:

$$f_c << f_c'$$

Therefore, material is within elastic range.

$$E_c = 4700\sqrt{f_c'} = 4700\sqrt{20} = 21019 \text{ MPa}$$

$$n = \frac{E_s}{E_c} = \frac{200000}{21019} \approx 10$$

Now using,

$P_n = f_c\,[A_g + (n - 1)A_{st}]$

$P_n = 10\,[\,(450 \text{ x } 450) + (10 - 1)2268\,]$

$P_n = 2229.12$ kN

$A_{st} = 8 \# 19 = 8 \text{ x } \dfrac{\pi (19)^2}{4}$

$A_{st} = 2268 \text{ mm}^2$

8. RESISTANCE FACTOR AT ULTIMATE STAGE:

When we go to the ultimate stage then the first thing which we have to decide is the value of 'ϕ' and to do that we must know whether the section of column is tension controlled or compression controlled.

Section of concentrically loaded column is always compression controlled.

For tied columns, $\phi = 0.65$

For spiral columns, $\phi = 0.75$

As there is always some eccentricity in a column, some additional safety factor is applied to ϕ factor,

Additional F.O.S. for tied columns = 0.80

Additional F.O.S. for spiral columns = 0.85

Therefore, total resistance factor for tied and spiral columns are;

For tied columns = 0.80 x 0.65

For spiral columns =0.85X0.75