SNS COLLEGE OF TECHNOLOGY

AN AUTONOMOUS INSTITUTION

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET302-DESIGN OF RC STRUCTURAL ELEMENTS

III YEAR / V SEMESTER

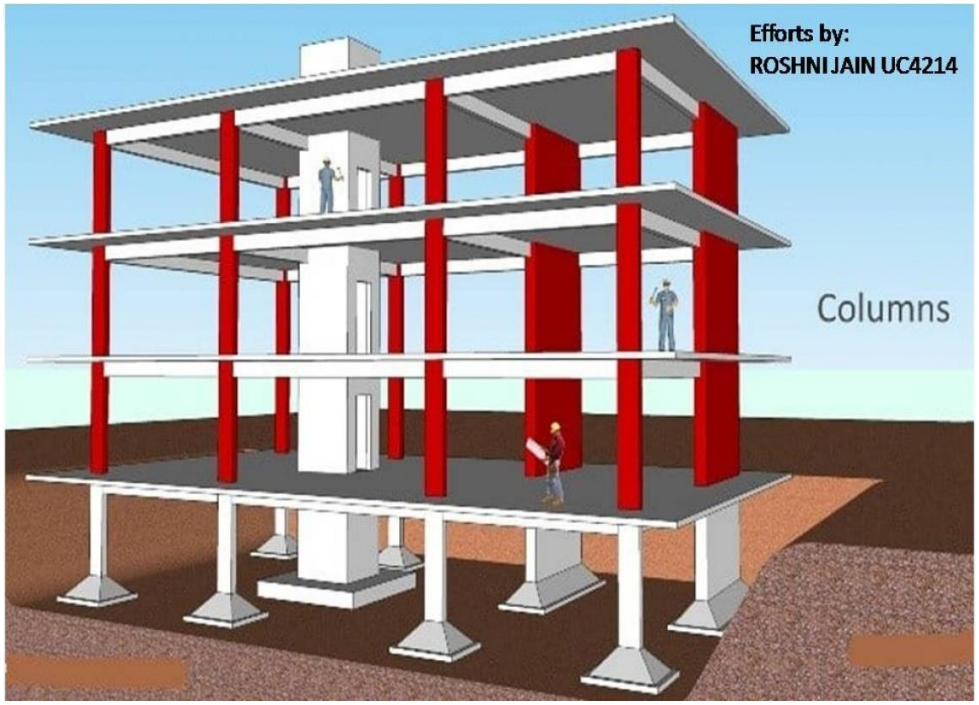
UNIT III - LIMIT STATE DESIGN OF COLUMNS

Introduction to Columns

Topics

Types of columns -Design of rectangular and circular columns for axial load – Design of short columns subjected to axial load and uniaxial / biaxial bending - Interaction charts. Design of slender columns subjected to biaxial bending

- Column is a vertical member which takes complete load of the beam, slabs and the entire structure and the floor and other area of the building is adjusted as per the requirement of the client or owner.
- The size of the columns, quantity of cement sand and aggregate to be mixed, the number of steel bars to be placed, spacing between the stirrups is all mentioned in the structural drawing which is designed by structural designer as per the actual load on the column and considering the factor of safety.



- A column is a vertical member which effectively takes load by compression. Basically column is a compression member as load acts along its longitudinal axis.
- Bending moment may occur due to wind earthquake or accidental loads. Column transfers the load of the structure of slabs beams above to below, and finally load is transferred to the soil.
- Position of the columns should be so that there are no tensile stresses developed at the cross section of the columns.

Types Of Columns

There are different column types used in structures. The types of Columns can be classified depending upon several conditions, which are

I. Based on the shape.
II. Based on the type of reinforcement.
III. Based on the types of loading.
IV. Based on the slenderness ratio.
V. Based on materials.

Types Of Columns Based On Shape

I. Square Column & Rectangular Column

Square or rectangular columns are mostly used in building construction. These types of columns are economically good and easy to construct because of their easy shuttering and reinforcement placement.

Circular Column:

Circular columns are mostly used in piling and elevation of buildings for aesthetic purposes. In circular columns, more than 4 steel bars are used as reinforcement.

Its bending resistance is usually higher than square or rectangular columns.

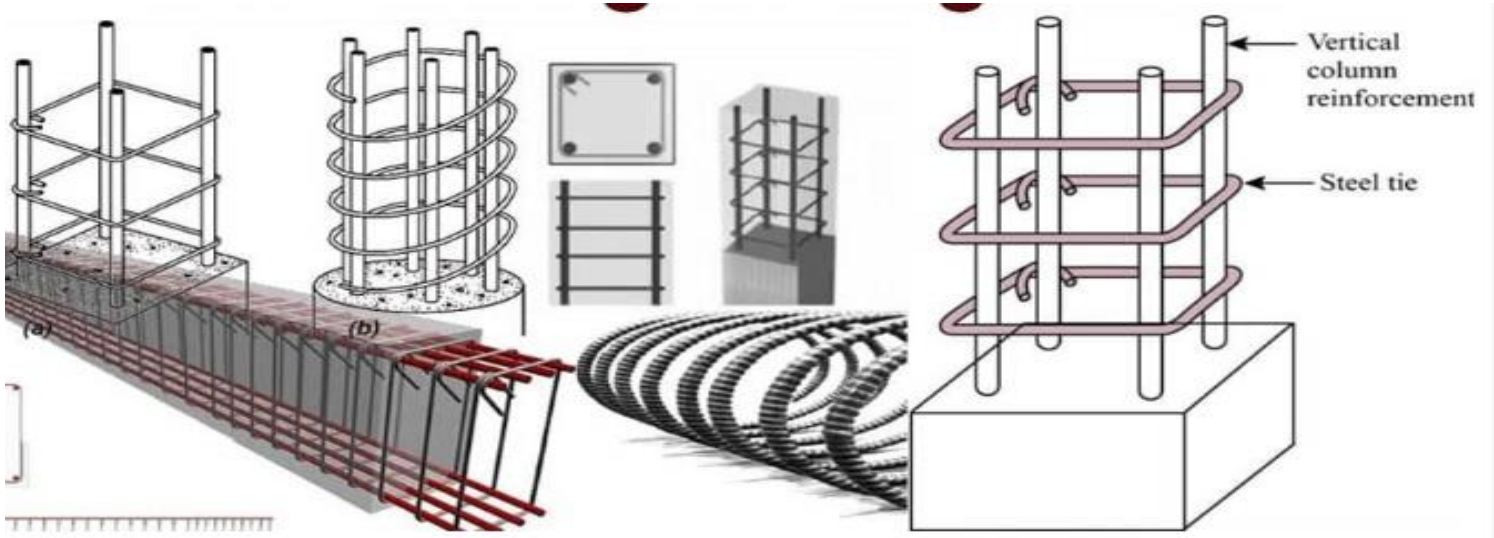
Other than buildings, circular columns are also used as bridge pillars due to good deflection resistance.

II.On The Basis Of Types Of Reinforcement

a.Tied Column

It employs reinforced cement concrete and comprises closely spaced tie bars as the main longitudinal reinforcement. Most of the columns in the structure are tied columns, and thus belong to the category of RCC Column.

The ties can only be spaced so far apart that they do not interfere with the setting of concrete while yet being near enough to prevent barrelling failure between them. The column will face shear failure and barrelling in between ties if ties are too wide apart.

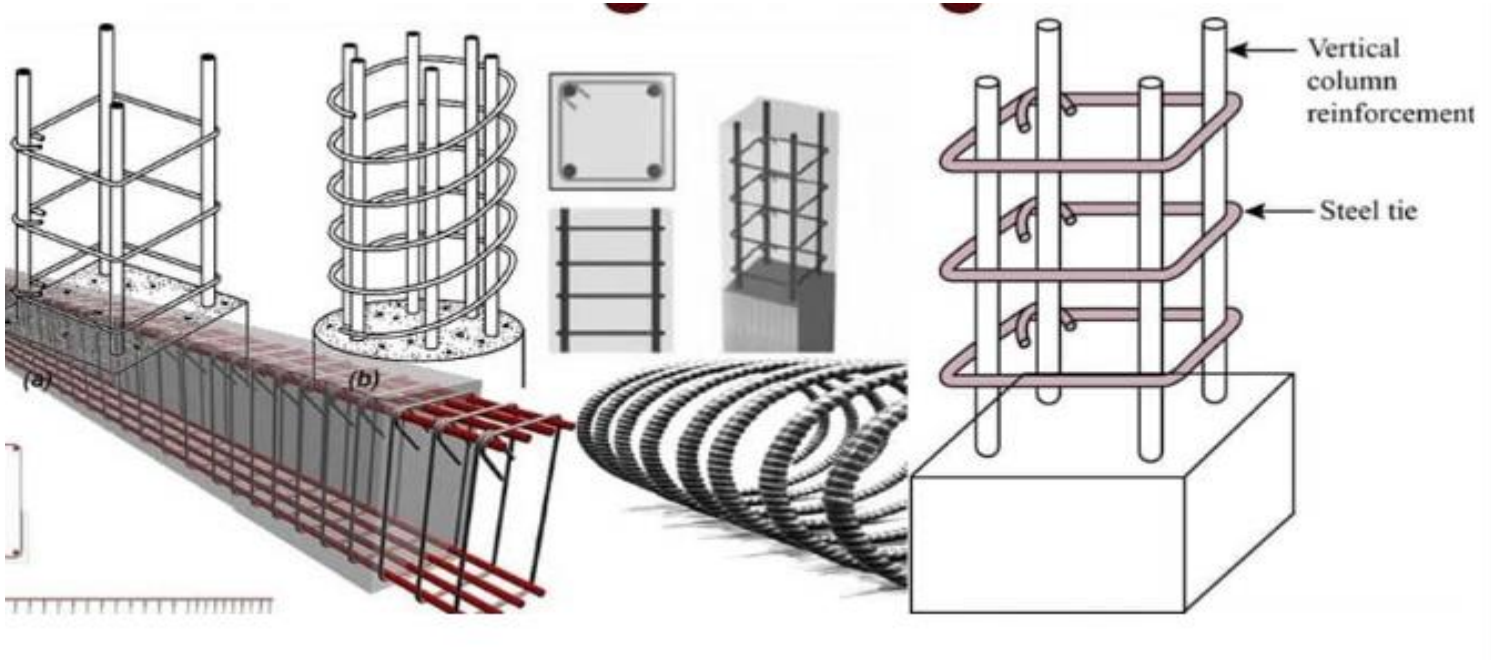


b.Spiral Column

This is a special form of RCC column. The longitudinal bars of this column is contained within closely spaced, constantly coiled spiral column reinforcement.

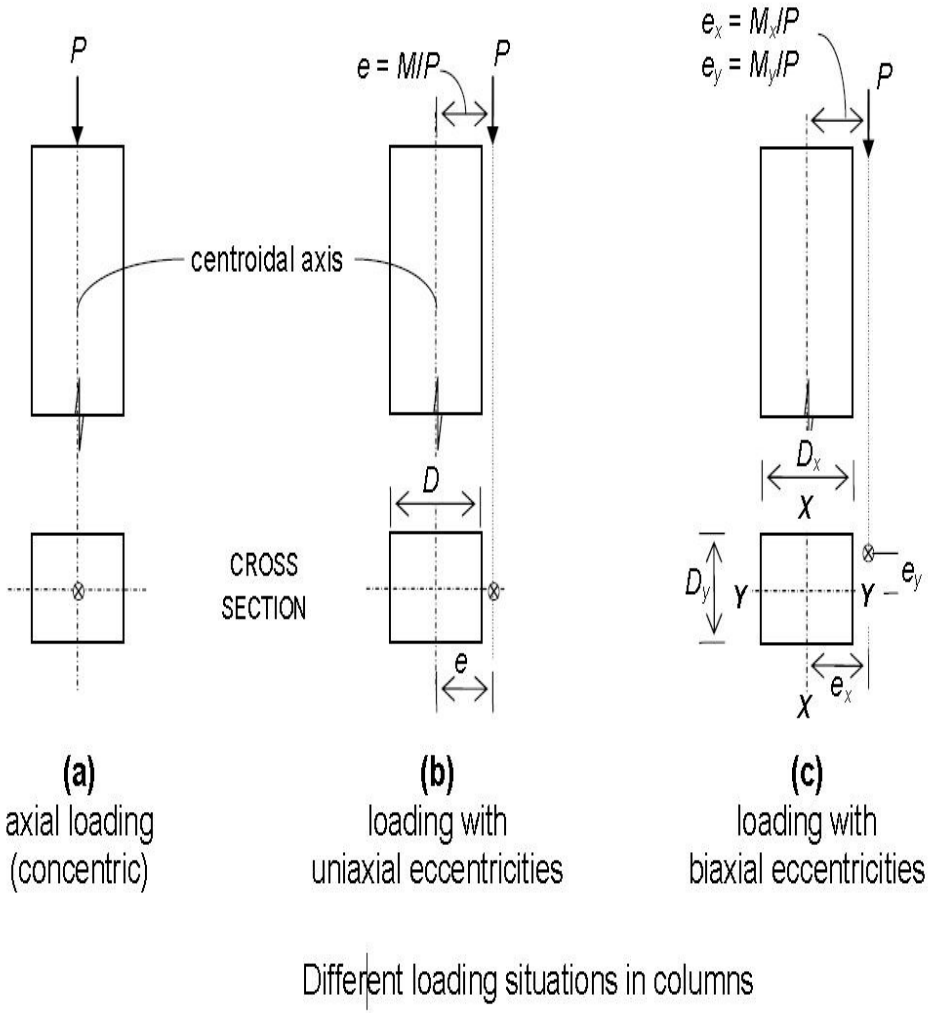
The role of Spiral reinforcement is that it defers axial load failure while offering lateral restraints, thereby increasing the strength of the column.

Notably, in these types of columns, there are Six longitudinal main bars in a spirally reinforced column as column reinforcement.



III. Column Types Based On The Type Of Loading

1. Axially loaded column or centrally or concentrically loaded column (Pu)
2. A column subjected to axial load and unaxial bending (Pu + Mux) or (P + Muy)
3. A column subjected to axial load and biaxial bending (Pu + Mux + Muy)

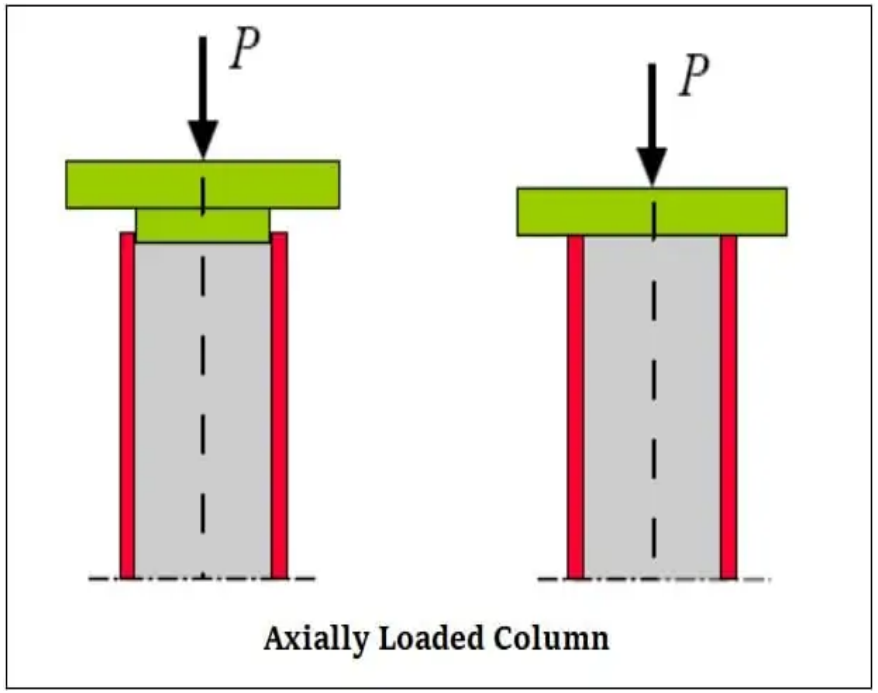


Different loading situations in columns

III. Column Types Based On The Type Of Loading

Axially Loaded Column

When the resultant of the load coincides with the centroid of the cross-section of a column, it is called axially loaded or concentrically loaded column. These types of columns rarely used in construction.



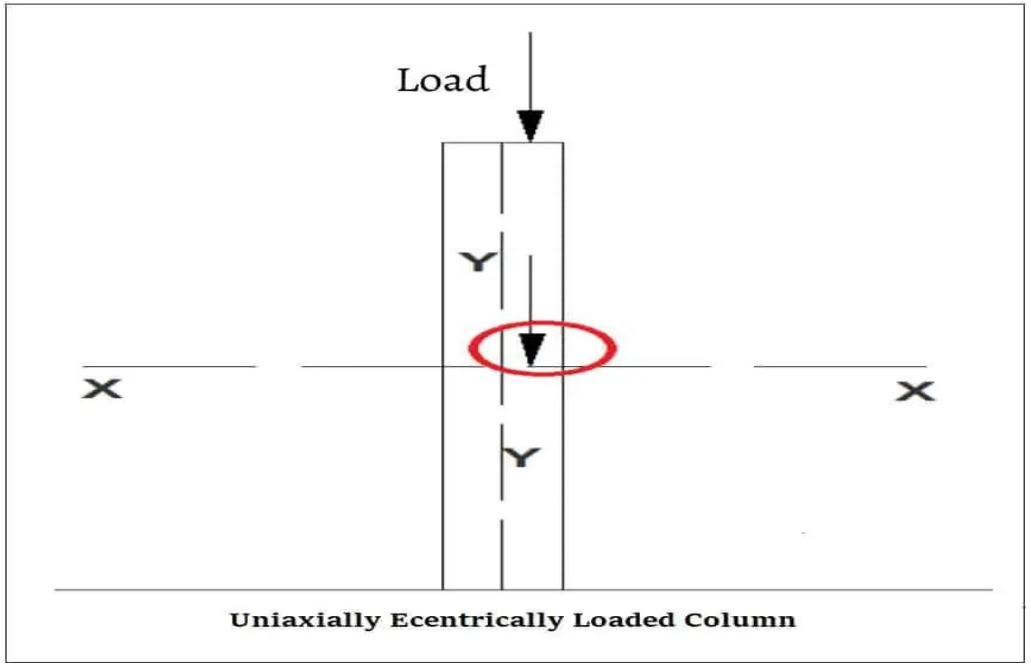
Axially Loaded Column

Eccentrically Loaded Column

When the resultant of the load does not coincide with the centroid of the cross-section of a column, it is called axially loaded or eccentrically loaded column.

1. Uniaxially Eccentrically Loaded Column

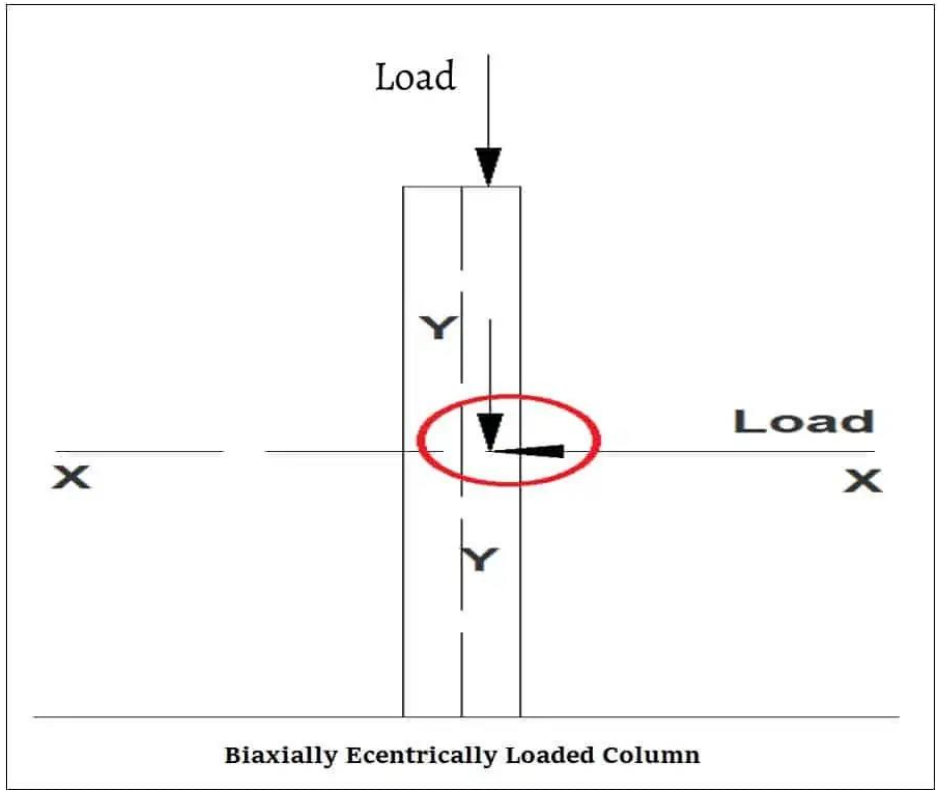
When the eccentric load acts on either X-axis or Y axis is called uniaxially eccentrically loaded column.



Uniaxially Ecentrically Loaded Column

2. Biaxially Eccentrically loaded column

When the eccentric load does not act on either X-axis or Y-axis it is called biaxially eccentrically loaded column.



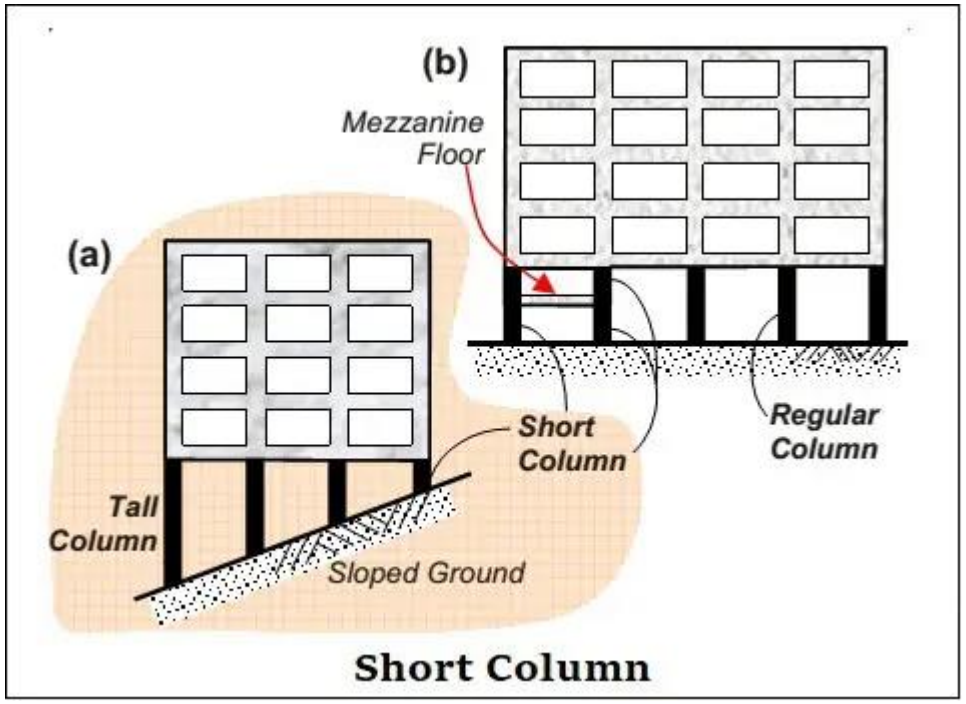
Biaxially Ecentrically Loaded Column

IV. Column Types Based On Slenderness Ratio or height

Short Column

If the ratio of the effective length of the column to its least lateral dimension (Slenderness Ratio) is less than 12, the column is referred to as a short.

Short column collapses due to crushing, resulting due to pure compression failure.



Short Column

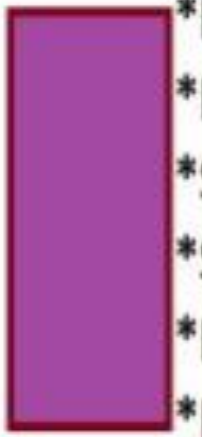
Long Column

•Slenderness ratio of column (effective length to least lateral dimension) categorized as long columns should be greater than 12.

•Notably, Long columns fail due to buckling or bending, while short columns fail by crushing

Difference between Short Column and Long Column

Short Column



*Length/Least Dimension < 12
*Fails by Crushing
*Slenderness Ratio < 45
*Subjected to Compressive stress
*Radius of Gyration is more
*More Load Capacity

Long Column

** Length/Least Dimension > 12
** Fails by Buckling
** Slenderness Ratio > 45
** Subjected to Buckling stress
** Radius of Gyration is less
** Less Load Capacity

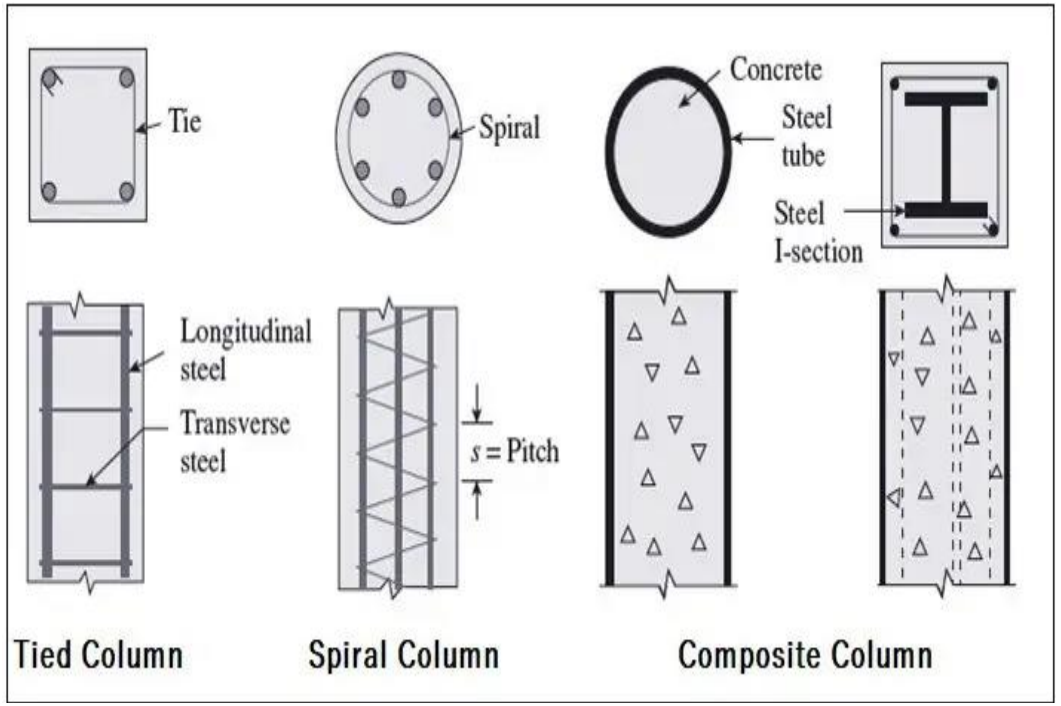
1,280 × 720

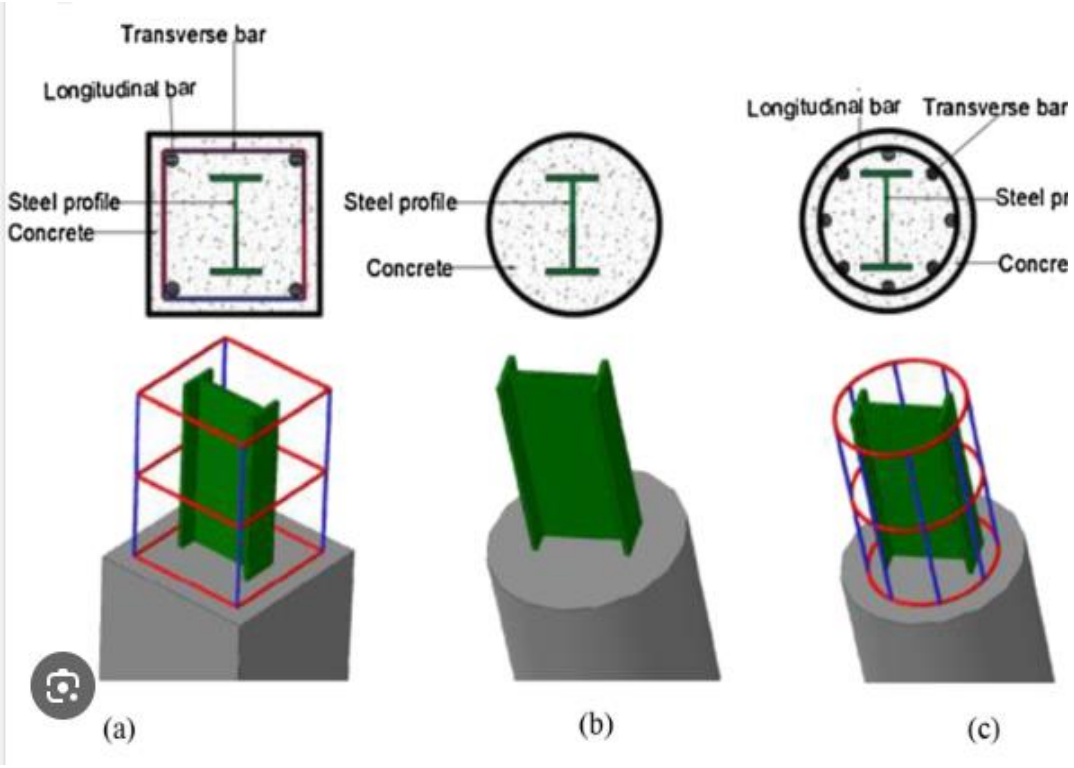
V . Based on materials.

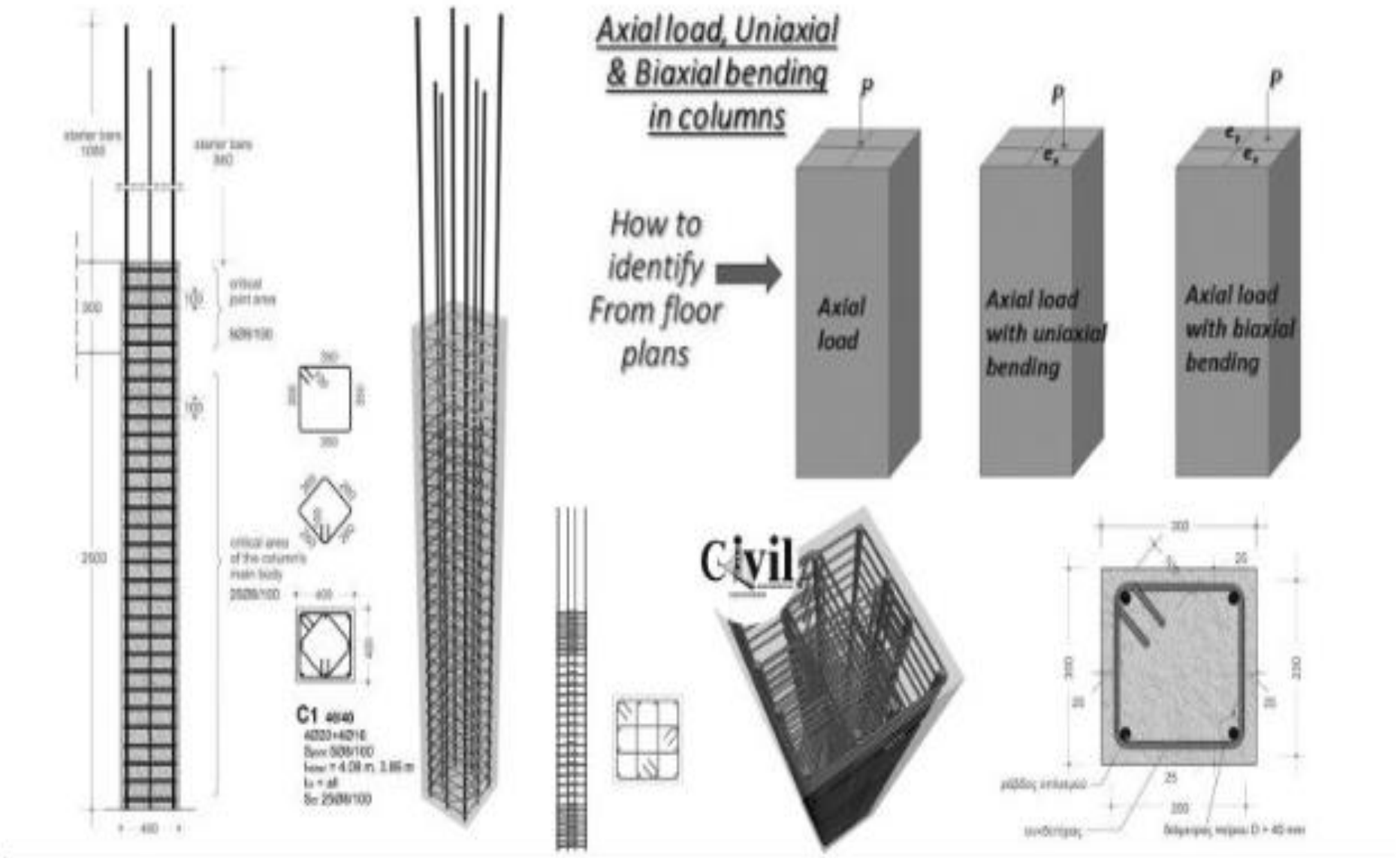
Based on the building materials used in construction, columns can be classified as being made of reinforced concrete, steel, wood, brick, block, or stone.

Composite Column

These columns consist of structural steel or cast iron columns enclosed with concrete, reinforced with longitudinal and spiral reinforcement. Composite columns are mostly used in truss structures to avoid the corrosion of steel.






Axial load, Uniaxial & Biaxial bending in columns
How to identify From floor plans
Axial load
Axial load with uniaxial bending
Axial load with biaxial bending
P
Civil

Specifications for covers and reinforcement in column

- For a longitudinal reinforcing bar in a column nominal cover shall in any case not be less than 40 mm, or less than the diameter of such bar.
- In the case of columns of minimum dimension of 200 mm or under, whose reinforcing bars do not exceed 12 mm, a nominal cover of 25 mm may be used. For footings minimum cover shall be 50 mm.

- Nominal Cover in mm to meet durability requirements based on exposure Mild 20, Moderate 30, Severe 45, Very severe 50, Extreme 75
- Nominal cover to meet specified period of fire resistance for all fire rating 0.5 to 4 hours is 40mm for columns only

Types of Reinforcements for columns and their requirements

Longitudinal Reinforcement

•Minimum area of cross-section of longitudinal bars must be atleast 0.8% of gross section area of the column.

•Maximum area of cross-section of longitudinal bars must not exceed 6% of the gross cross-section area of the column.

•The bars should not be less than 12mm in diameter.

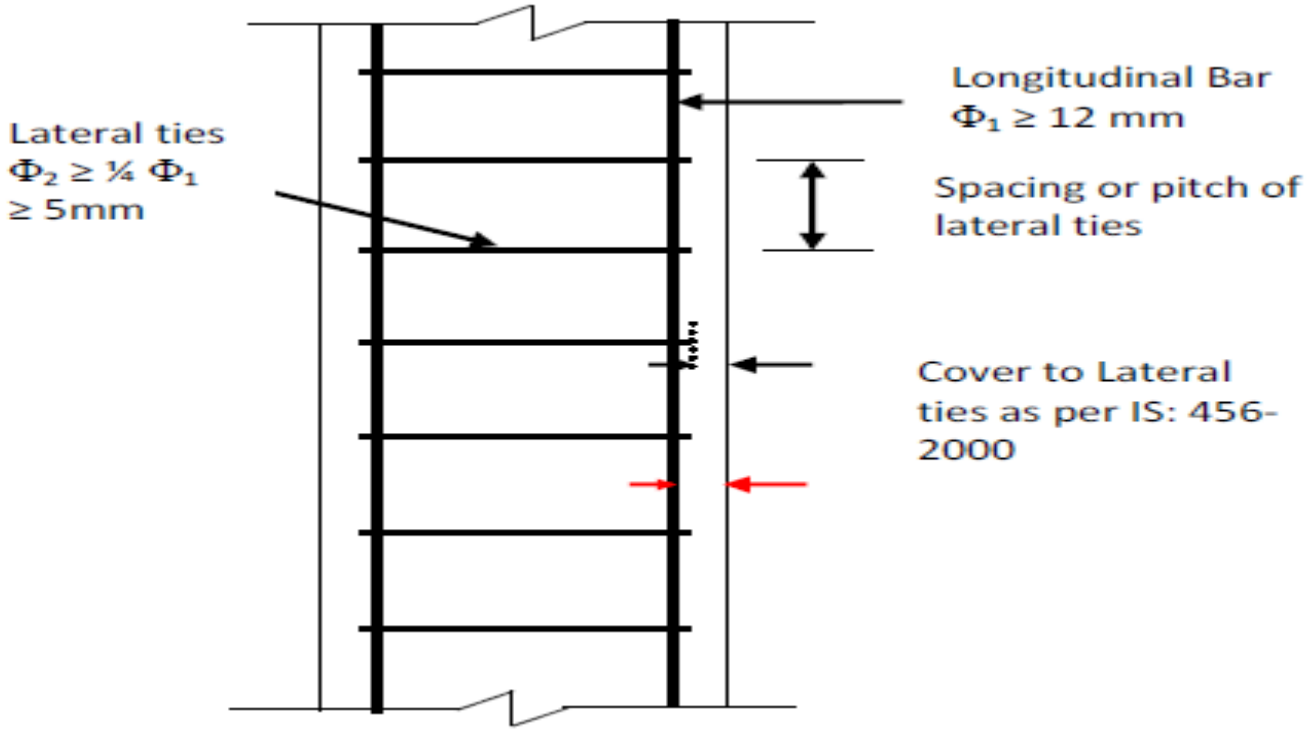
•Minimum number of longitudinal bars must be four in rectangular column and 6 in circular column.

•Spacing of longitudinal bars measures along the periphery of a column should not exceed 300mm.

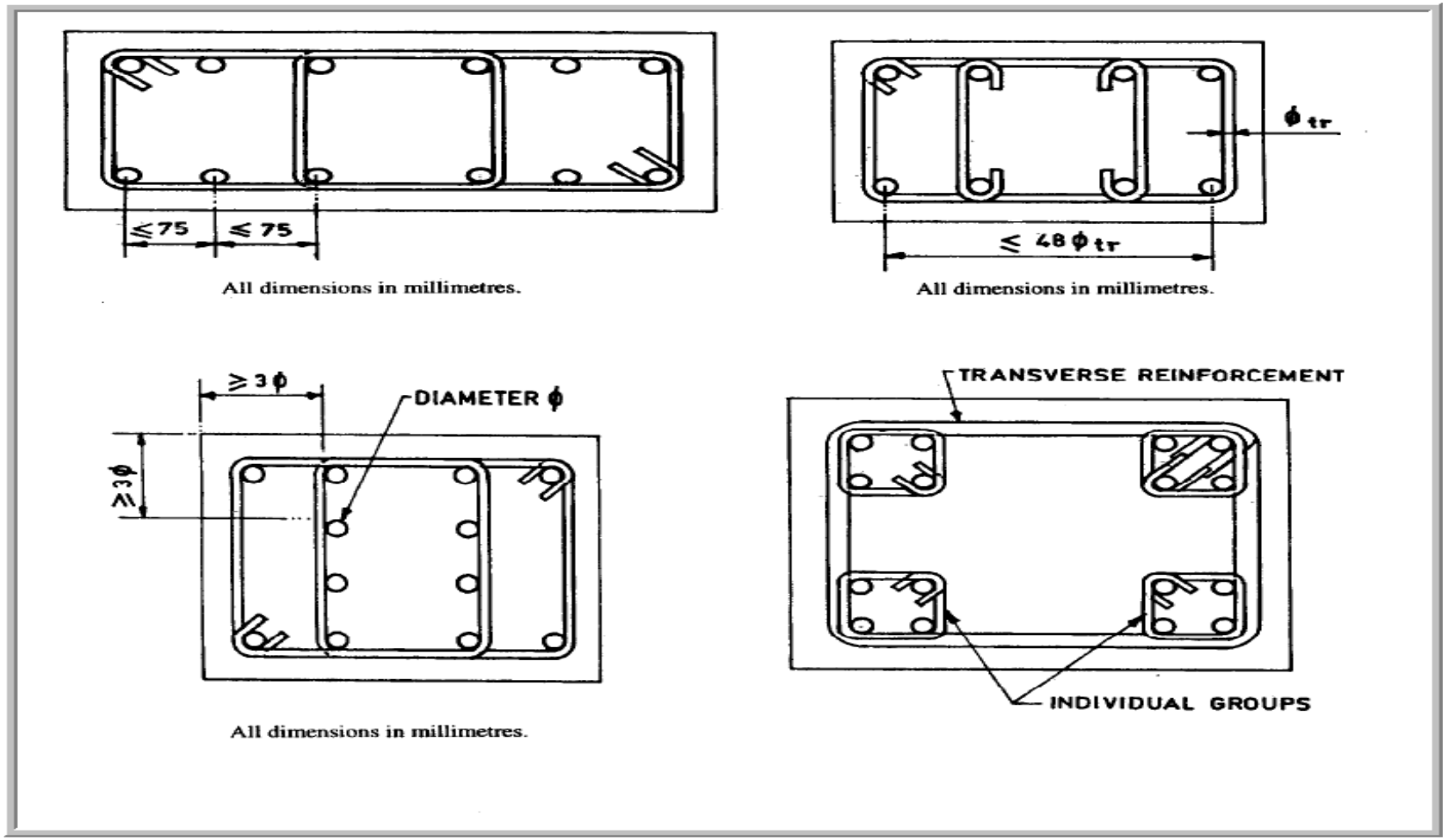
Transverse reinforcement

•It maybe in the form of lateral ties or spirals.

•The diameter of the lateral ties should not be less than $1/4^{th}$ of the diameter of the largest longitudinal bar and in no case less than 6mm.



Longitudinal Reinforcement



Transverse Reinforcement

The pitch of lateral ties should not exceed

•Least lateral dimension

•16 x diameter of longitudinal bars (small)

•300mm

Helical Reinforcement

The diameter of helical bars should not be less than $1/4^{th}$ the diameter of largest longitudinal and not less than 6mm.

The pitch should not exceed (if helical reinforcement is allowed);

•75mm

•$1/6^{th}$ of the core diameter of the column

Pitch should not be less than,

•25mm

•3 x diameter of helical bar

Pitch should not exceed (if helical reinforcement is not allowed)

Least lateral dimension

•16 x diameter of longitudinal bar (smaller)

•300mm

25 COMPRESSION MEMBERS

25.1 Definitions

25.1.1 Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.

25.1.2 *Short and Slender Compression Members*

A compression member may be considered as short when both the slenderness ratios $\frac{l_{ex}}{D}$ and $\frac{l_{ey}}{b}$ are less than 12:

Effective length of compression member

Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension. For normal usage assuming idealized conditions, the effective length of in a given plane may be assessed on the basis of Table 28 of IS: 456-2000.

Following terms are required.

Following are the end restraints:

1. Effectively held in position and restrained against rotation in both ends
2. Effectively held in position at both ends, restrained against rotation at one end
3. Effectively held in position at both ends, but not restrained against rotation
4. Effectively held in position and restrained against rotation at one end, and at the other restrained against rotation but not held in position

5.• Effectively held in position and restrained against rotation in one end, and at the other partially restrained against rotation but not held in position

6 Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position

7. Effectively held in position and restrained against rotation at one end but not held in position nor restrained against rotation at the other end

Unsupported Length

The unsupported length, l, of a compression member shall be taken as the clear distance between end restraints (visible height of column). Exception to this is for flat slab construction, beam and slab construction, and columns restrained laterally by struts (Ref. IS:456-2000),

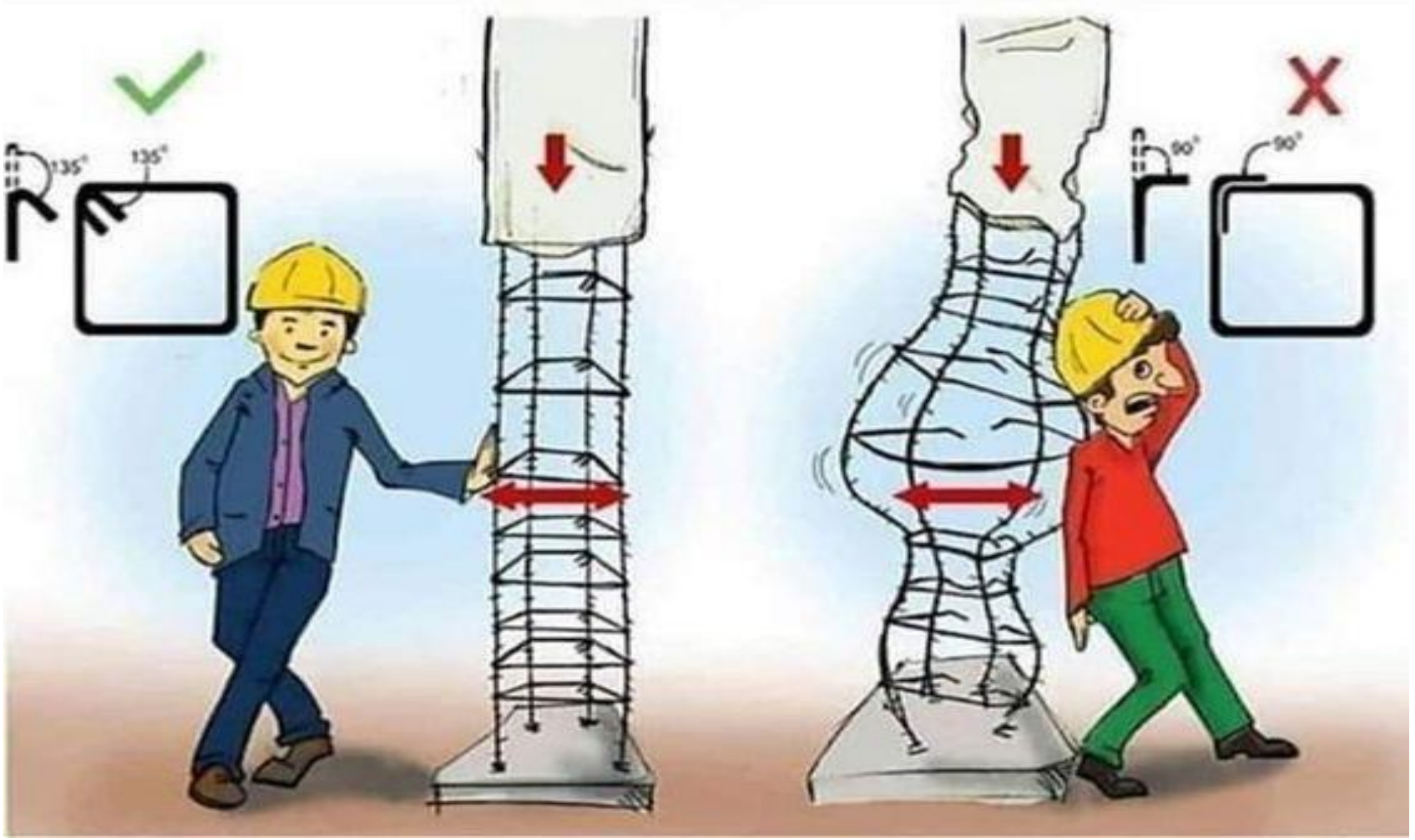
LIMIT STATE OF COLLAPSE: COMPRESSION

Assumptions

1. The maximum compressive strain in concrete in axial compression is taken as 0.002.
2. The maximum compressive strain at the highly compressed extreme fibre in concrete subjected to axial compression and bending and when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at the least compressed extreme fibre.

In addition the following assumptions of flexure are also required

3. Plane sections normal to the axis remain plane after bending.
4. The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.
5. The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoid, parabola or any other shape which results in prediction of strength in substantial agreement with the results of test.
6. An acceptable stress strain curve is given in IS:456-200. For design purposes, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor y of 1.5 shall be applied in addition to this.
7. The tensile strength of the concrete is ignored.
8. The stresses in the reinforcement are derived from representative stress-strain curve for the type of steel used. Typical curves are given in IS:456-2000. For design purposes the partial safety factor equal to 1.15 shall be applied


135°
135°
90°
90°

THANK YOU