



# **SNS COLLEGE OF TECHNOLOGY**

**AN AUTONOMOUS INSTITUTION**

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**COIMBATORE**

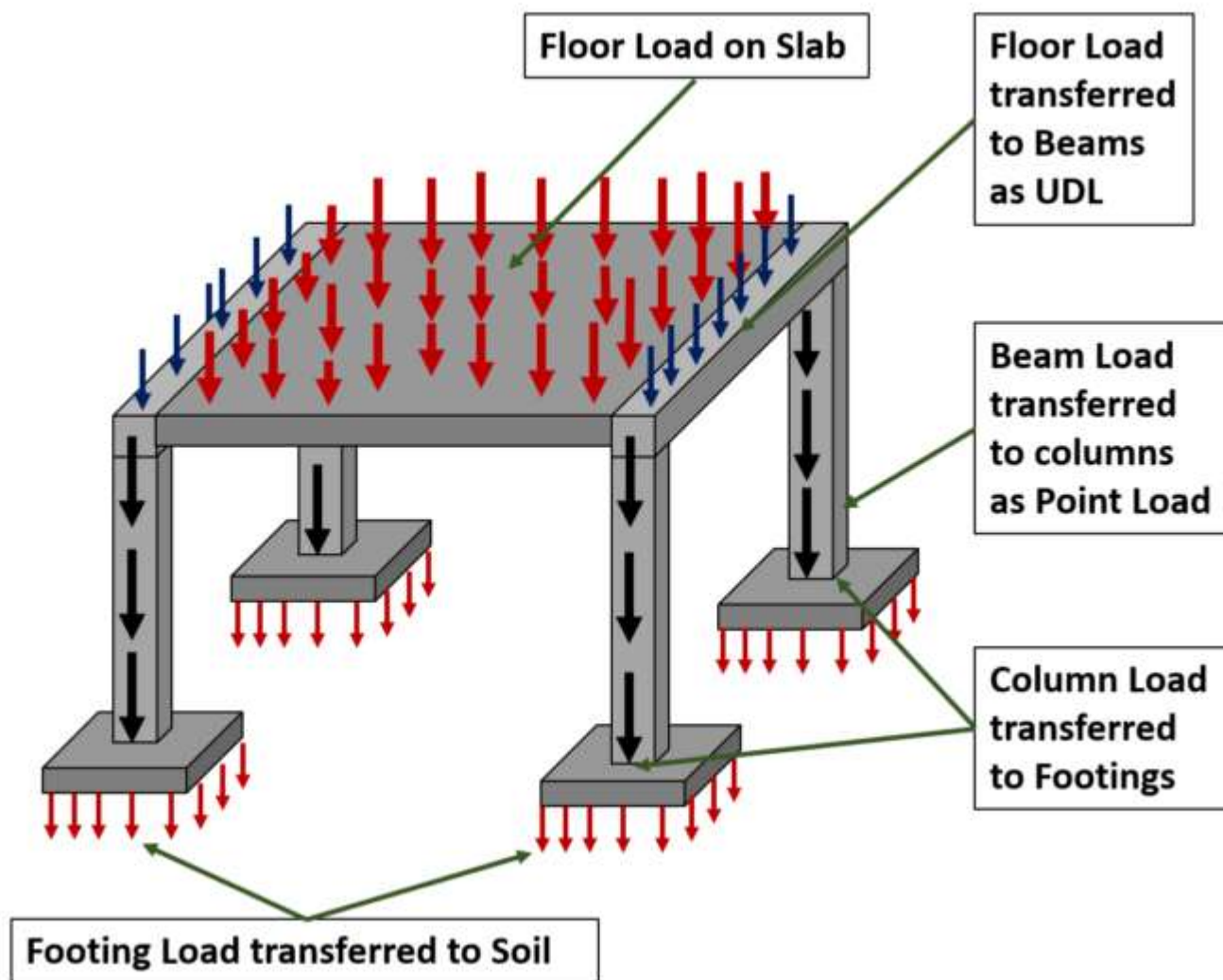
## **DEPARTMENT OF CIVIL ENGINEERING**

**19CET302-DESIGN OF RC STRUCTURAL ELEMENTS**

**III YEAR / V SEMESTER**

**Unit 2 : Limit state design of Beams**

### **Introduction**





## BEAM

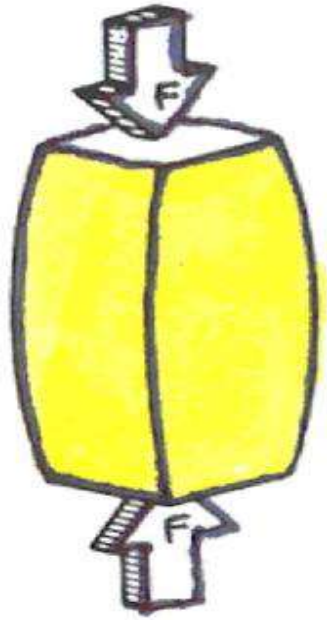
- A Beam is an inevitable horizontal or sloping the structure.
- The main function of the beam is designed to resist the external or internal load such as wall, slab and floors of the building and distribute the load to the foundation through the column.
- The horizontal beam carries an only transverse (vertical) load and the sloping beams
- carry both transverse and axial load.



## LIMIT STATE METHOD OF DESIGN



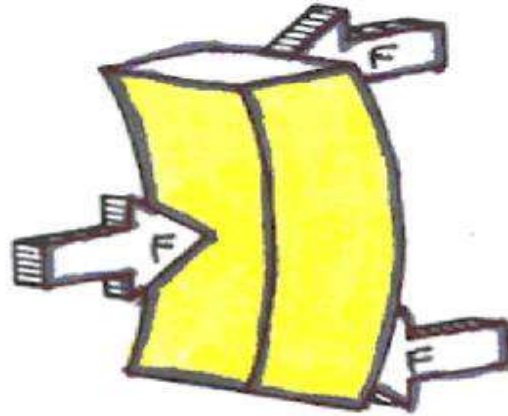
- The object of the design based on the limit state concept is to achieve an acceptable probability, that a structure will not become unsuitable in its lifetime use for which it is intended.
- A structure with appropriate degree of reliability should be able to withstand safety.
  - It should also be able to maintain the required structural integrity, during and after accident, such as fires, explosion & local failure. i.e. limit state must be considered in design to ensure an adequate degree of safety and serviceability
  - The most important of these limit states, which must be examined in design are as follows  
Limit state of collapse
    - **Flexure**
    - **Compression**
    - **Shear**
    - **Torsion**
- This state corresponds to the maximum load carrying capacity.



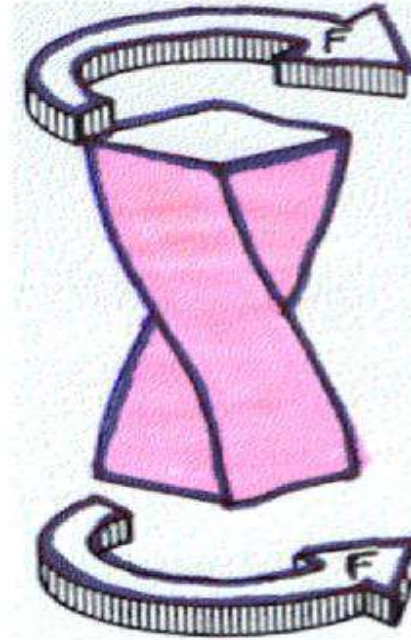
Compression



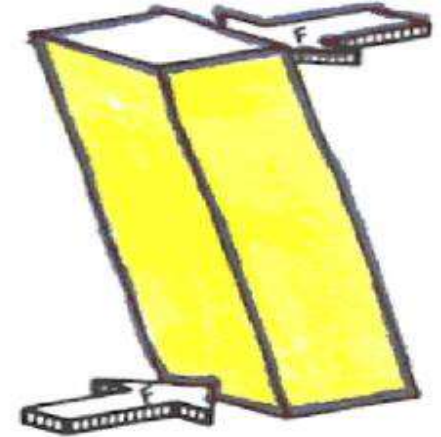
Tension



Bending



Torsion



Shearing

*Fig. Types of stresses*



# Limit State :

The acceptable limit for the safety and serviceability requirements before failure occur.

## Types of limit state

### 1. Limit state of collapse or failure:

- Flexural (Bending)
- Compression
- Shear
- Torsion

Based on *imaginary behaviour* of structure

### 2. Limit state of serviceability:

- Deflection
- Cracking
- Vibration
- Fire resistance
- Etc.

Based on *actual behaviour* of structure

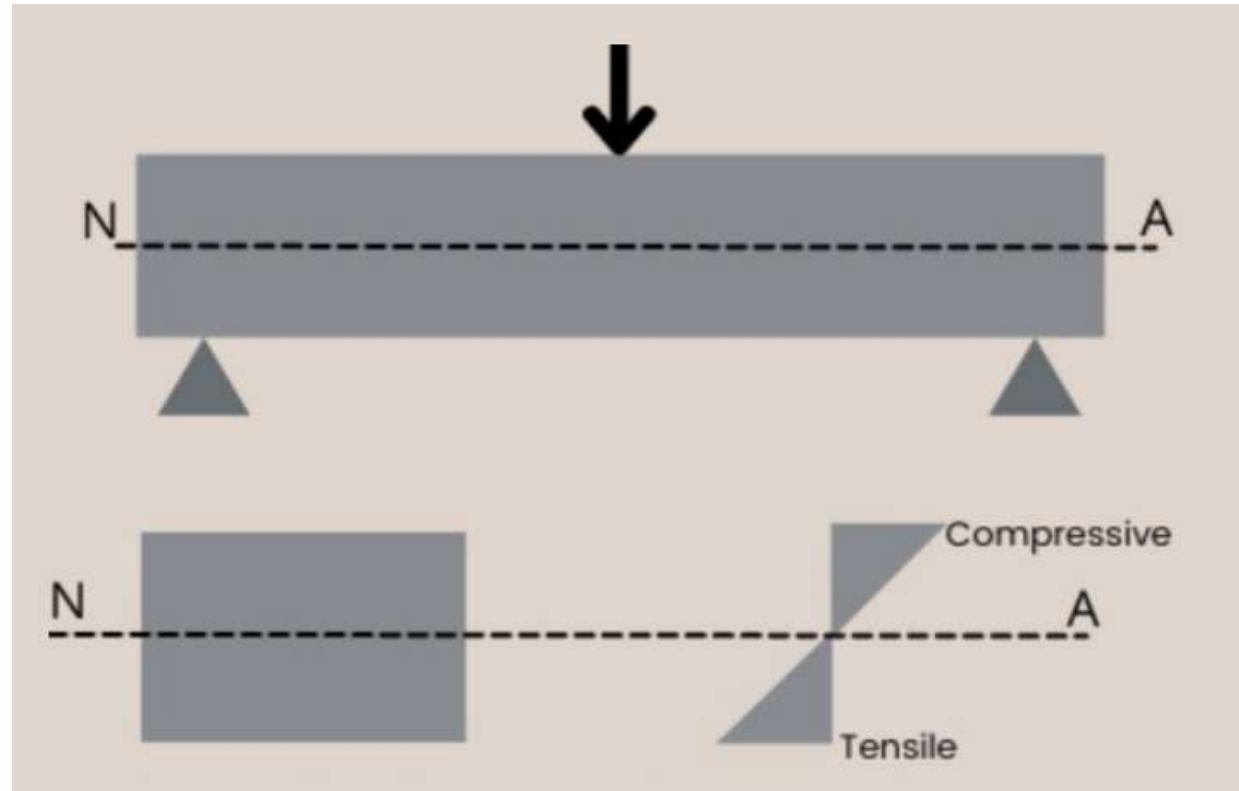


## Neutral Axis in Beam



The **neutral axis of a beam** is the line that passes through the centroidal depth of the beam where no longitudinal stress either compressive or tensile stress or no strain exists. The neutral axis is represented by a dotted line.

From the neutral axis, the upper part of the beam is under compressive stress and the lower part of the neutral axis of the beam is under tensile stress. Hence the moment of area of any structure with respect to the neutral axis is always zero due to this from the neutral axis or centroidal axis for a beam subjected to the same simple bending moment.





## WHAT IS EFFECTIVE DEPTH?



### Effective depth

Effective depth of a beam is the distance between the centroid of the area of tension reinforcement and the topmost compression fibre.

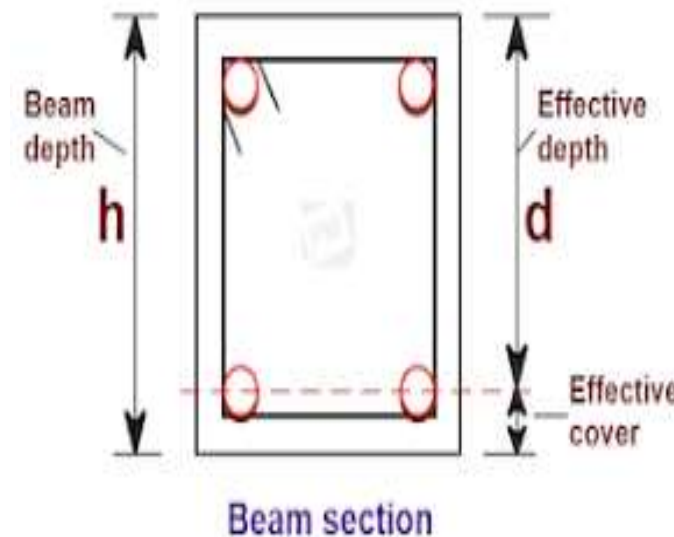
### WHAT IS EFFECTIVE COVER?

- Effective cover is taken as distance taken from bottom concrete fiber section from the center level of the reinforcement

***Effective cover = overall depth – effective depth (OR) clear cover + (diameter of bar/2) .***

### WHAT IS CLEAR COVER?

☐ Clear cover is the distance measured from the exposed concrete surface (Without plaster and other finishes) to the nearest surface of the reinforcing bar.

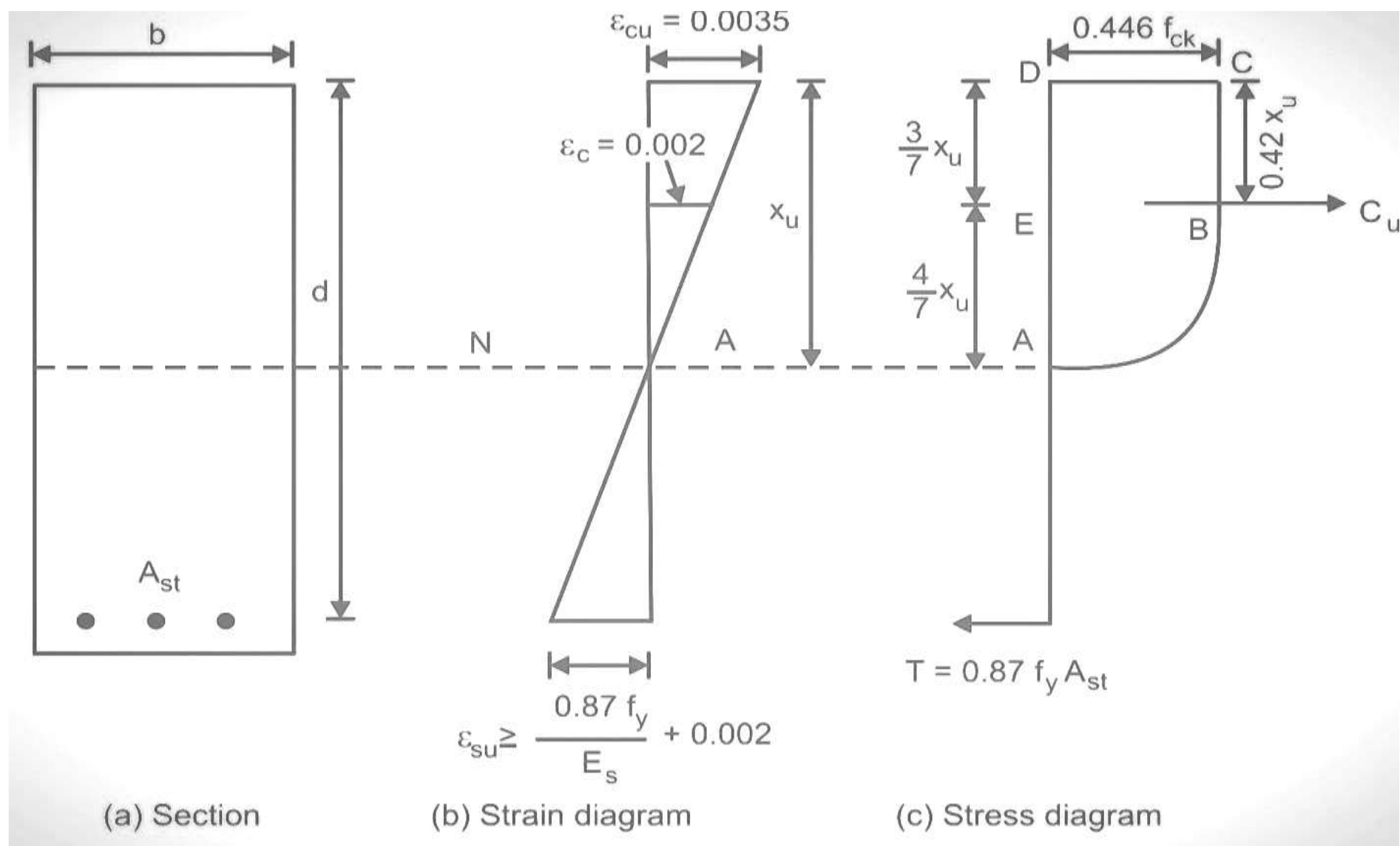






## **WHY EFFECTIVE COVER IS PROVIDED?**

- ☐ To protect the steel reinforcement bars (rebars) from environmental effects to prevent their corrosion;
- ☐ To provide thermal insulation, which protects the reinforcement bars from fire, and;
- ☐ To give reinforcing bars sufficient embedding to enable them to be stressed without slipping.



**Fig . stress strain profile for beam**



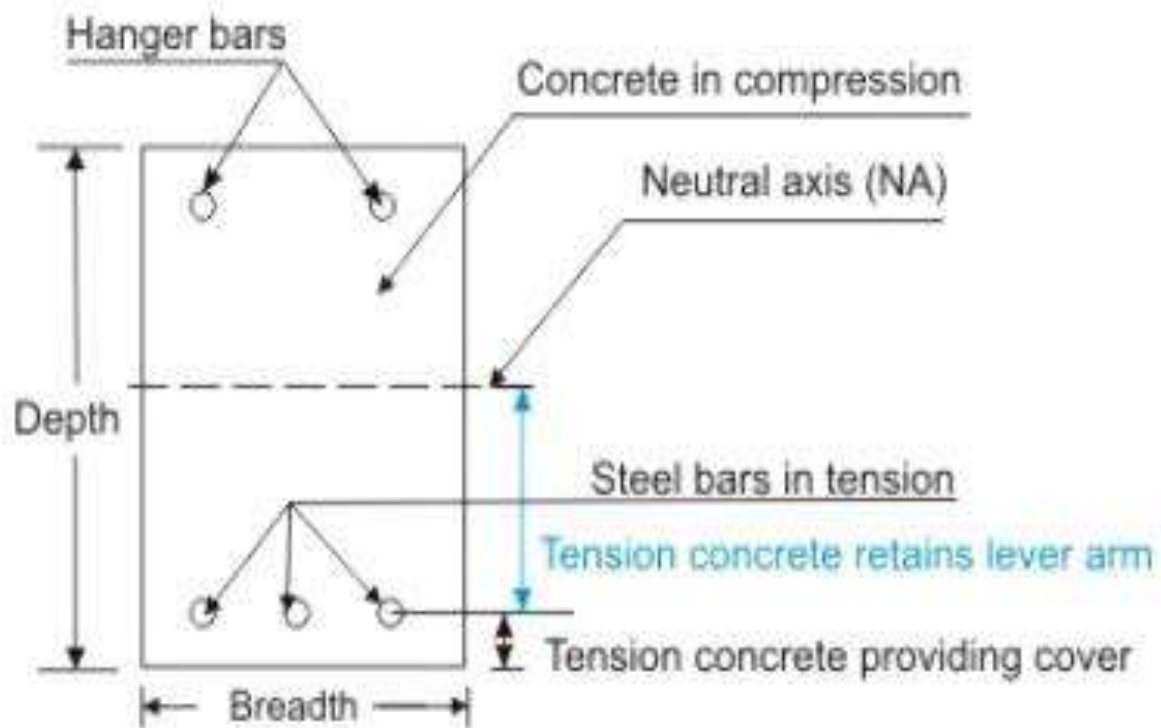
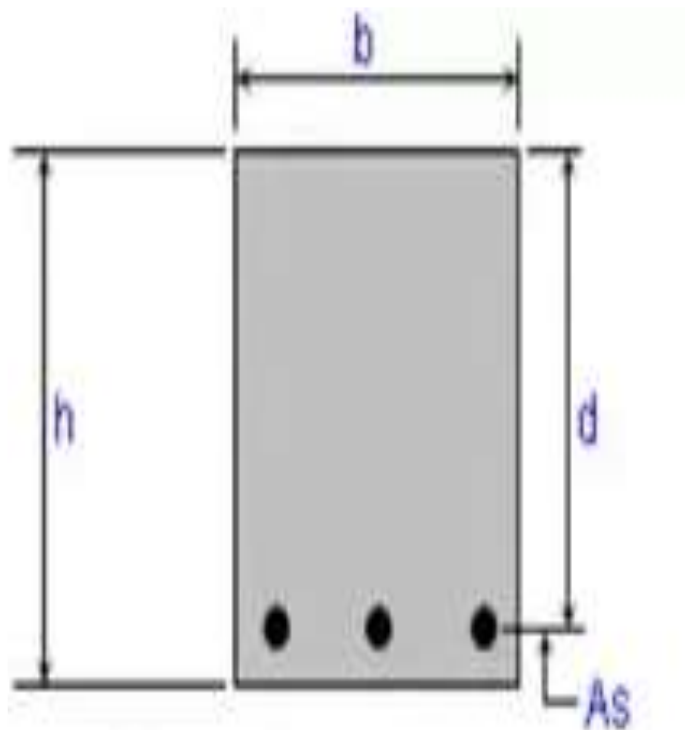
# TYPES OF REINFORCED CONCRETE BEAMS

- ☐ Singly reinforced beam
- ☐ Doubly reinforced beam
- ☐ Singly or doubly reinforced flanged beams
- ☐ Continuous beams



## SINGLY REINFORCED BEAM

- The beam that is longitudinally reinforced only in tension zone, it is known as singly reinforced beam.
- In such beams, the final bending moment and the stress because of bending are carried by the reinforcement, while this compression is carried by the concrete.
- But it is not possible to provide reinforcement only in the tension zone, because we need to tie the stirrups.
- Therefore, two rebars/ holding bars are used in the compression zone to tie the stirrups, and the rebars act as false members only to hold the stirrups





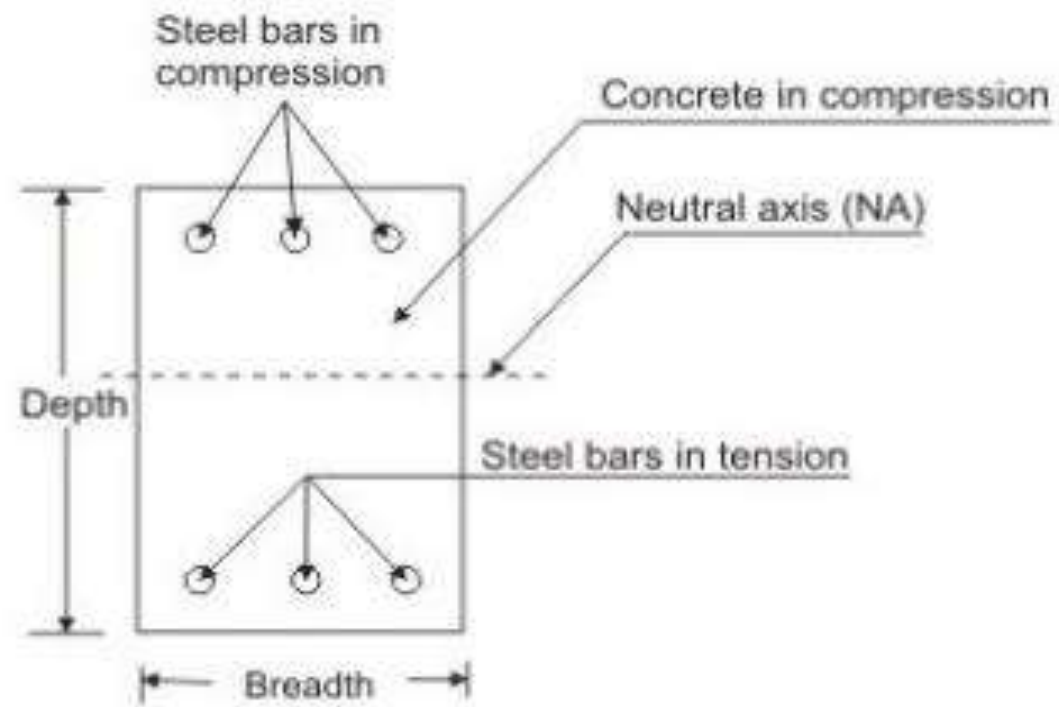
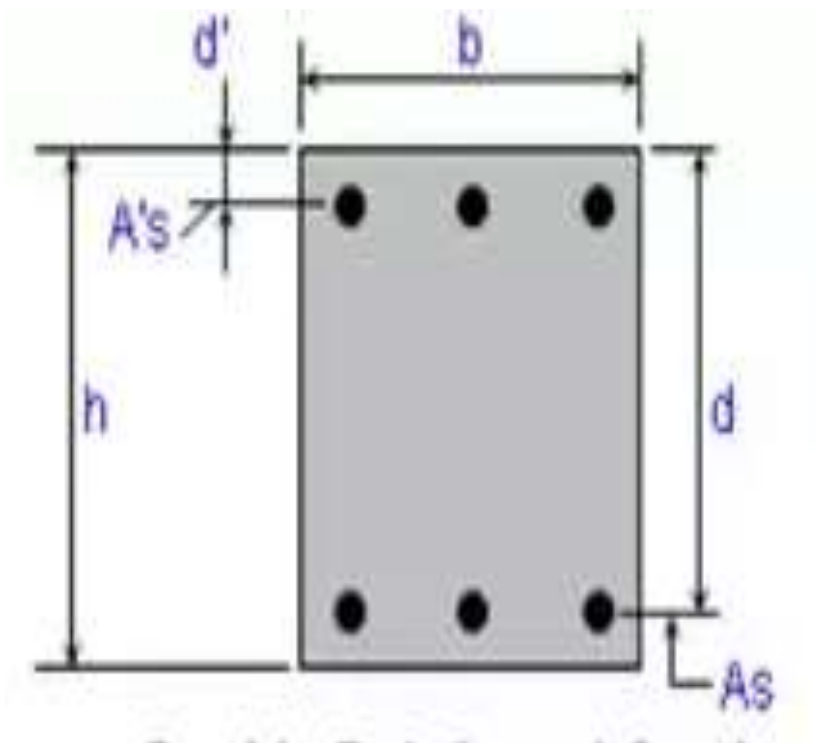
## DOUBLY REINFORCED BEAM



- The beam that is reinforced with steel in the tension and compression zone is known as the doubly reinforced beam.
- The doubly reinforced beams have compression reinforcement in addition to the tension reinforcement, and this compression reinforcement can be on both sides of the beam (top or bottom face), depending on the type of beam, that is, simply supported or cantilever, respectively



# DOUBLY REINFORCED BEAM





## WHY A DOUBLY REINFORCED BEAM?

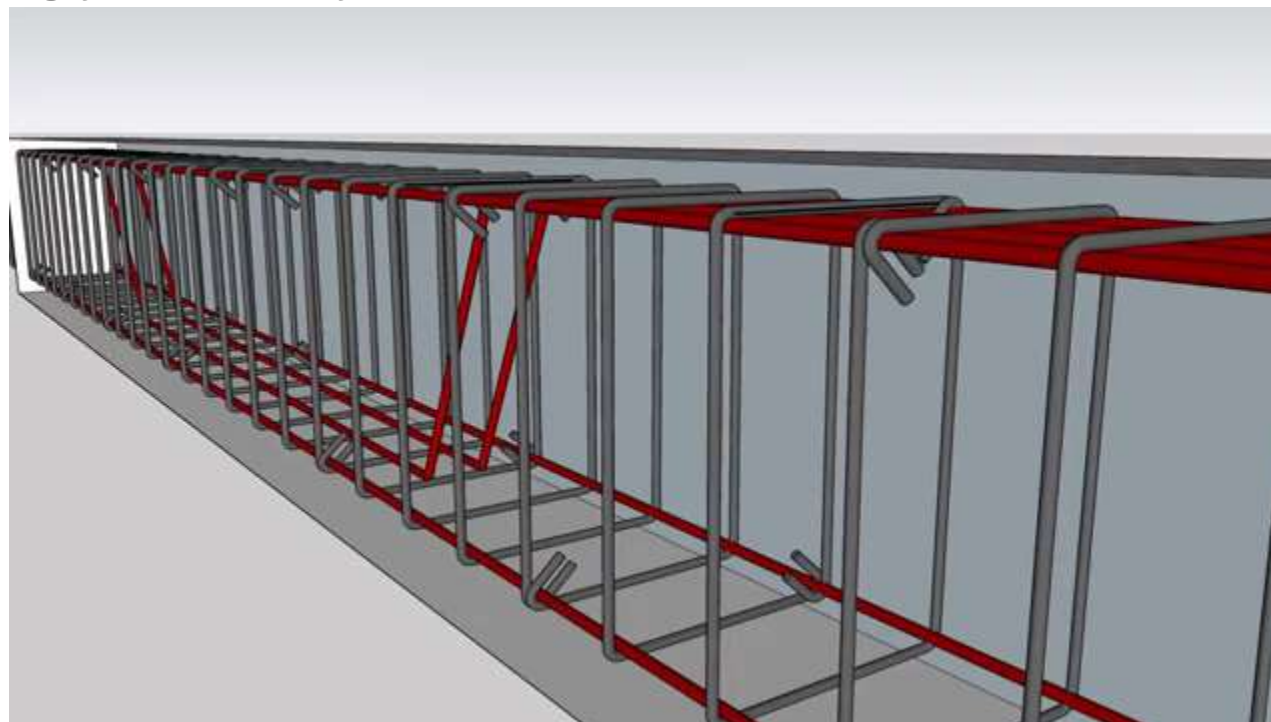
- ☐ This type of beam will be considered necessary when, due to the consideration of headroom or architecture, the depth of the beam is restricted.
- ☐ And when the singly reinforced section is insufficient to resist the bending moment on the section additional tension and compression reinforcement are designed based on steel beam theory.
- ☐ The doubly reinforced beam (DRB) section is used where the span is more, where cross section will also be increased.
- ☐ Depth can be reduced and the  $A_{st}$  can be increased.
- ☐ In DRB, the top and bottom reinforcement must be designed





## Case study

### Singly v/s Doubly Reinforced Beams





# THANK YOU