# CHAPTER-1

## INRODUCTION OF RCC

## WHAT IS RCC ? FULL FORM OF RCC

- RCC STAND FOR REINFORCED CEMENT CONCRETE . THIS CONCRETE MADE UP OF CEMENT , COARSE GRAVEL AND WATER AND STEEL BARS HELPS REFORCING MATERIAL
- FULL FORM OF RCC IS REINFORCED CEMENT CONCRETE


# WHAT IS PCC ? AND FULL FORM OF PCC


- PCC STANDS FOR PLAIN CEMENT CONCRETE . PCC IS A COMBINATION OF CEMENT ,SAND LIKE FINE AGGREGATE AND COARSE AGGREGATE .
- FULL FORM OF PCC IS PLAIN CEMENT CONCRETE .

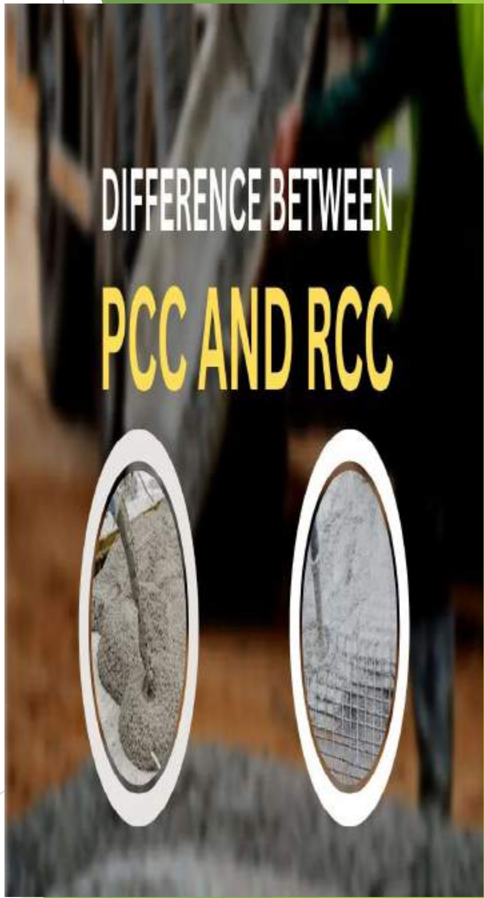
# DIFFERENCE BETWEEN RCC AND PCC ?

## RCC

- IT STANDS FOR REINFORCED CEMENT CONCRETE .
- IT CONTAINS STEEL ROD ,BAMBOO ,ALUMINIUM.
- TO IMPROVE TENSILE STRESS OF PCC , REINFORCEMENT IS PROVIDED .

## PCC

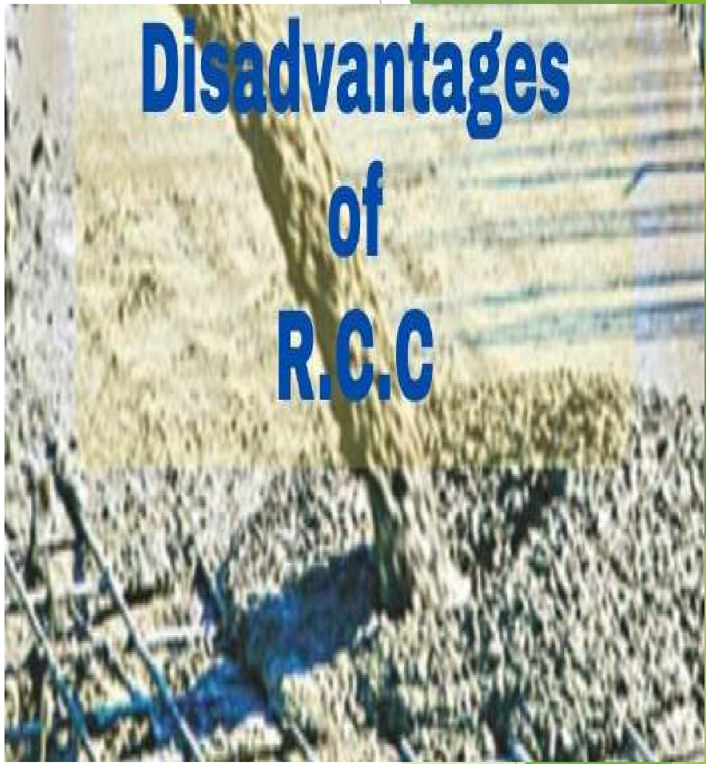
- IT STANDS FOR PLAIN CEMENT CONCRETE .
- IT DOES NOT CONTAIN STEEL ROD , BAMBOO , ALUMINIUM ETC .
- PCC HAS HIGH COMPRESSIVE STRENGTH AND LOW TENSILE STRENGTH .



## ADVANTAGES AND DISADVANTAGES OF RCC

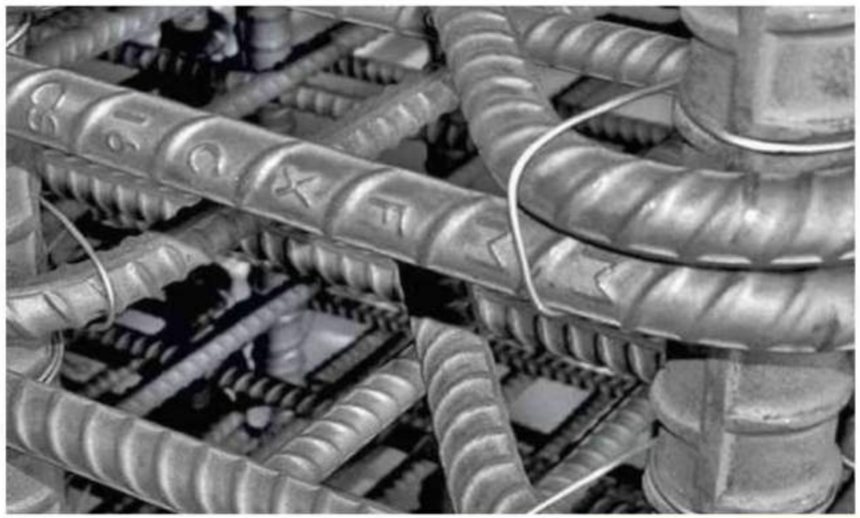
ADVANTAGES:

- **HIGH COMPRESSIVE STRENGTH**
- ADEQUATE TENSILE STRENGTH .
- DURABILITY .
- LOW MAINTAINANCE COST .
- DISADVANTAGES:
- TENSILE STRENGTH TO COMPRESSIVE STRENGTH RATIO .
- UNCERTAINLY OF FINAL STRENGTH .
- HIGH FORM COST .
- LARGER COLUMN SECTION .
- SHRINKAGE .



# CHARACTERSTICS OF REINFORCING MATERIAL

- IT SHOULD BE DURABLE .
- HIGH TENSILE STRENGTH .
- IT SHOULD DEVELOP A PERFECT BOND WITH CONCRETE SO THAT STRESSES ARE EASILY TRANSFERRED FROM ONE MATERIAL .
- IT SHOULD BR FREE FROM LOSE RUST .
- EASY T CUT ,EASY TO JOIN EASY TO BOND , EASY WORKABLE .
- IT SHOULD BE INERT WITH ANY TYPE F REACTION .
- MODULUS OF ELASTICITY IS HIGH .



# DIFFERENCE BETWEEN MILD STEEL AND HYSD

## FE250

- STEEL BAR . FE250 IS ALSO KNOWN AS MILD
- MILD STEEL IS A VERY COMMON TYPE OF CARBON STEEL WHICH HAS A LOW CARBON OF WEIGHT
- MODERATE .
- CMPARITIVELY LOW .
- COMPARITIVELY HIGH .
- HIGH .

## FE415

- FE450 IS ALSO KNOWN AS HYSD
- HIGH TENSILE IS ATYPE OF MILD CARBON STEEL HAS HIGH YIELD STRENGTH AND TENSILE STRENGTH .
- HIGHER THAN MORE MILD STEEL ORMS .
- VERY HIGH .
- COMPARITIVELY LOW .
- LOW .

# WHAT IS TMT ?

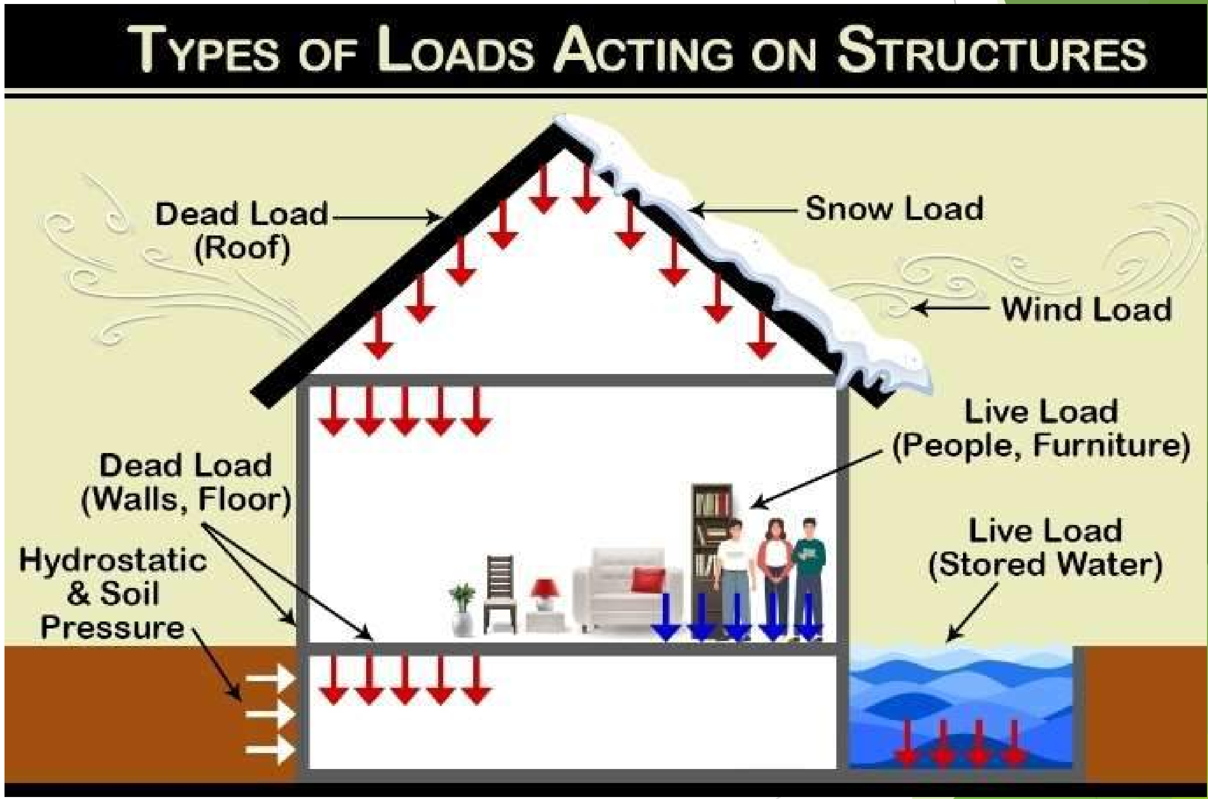
- THERMO MECHANICALLY TREATED BARS ARE HIGH STRENGTH REINFORCEMENT BARS HAVING HIGH – STRENGTH REINFORCEMENT BARS HAVING A TOUGH OUTER CORE AND A SOFT INNER CORE .


## ADVANTAGES OF TMT ?

- HIGH YIELD STRENGTH .
- BETTER AVAILAIBILITY .
- BETTER DURABILITY .
- BETTER CORROSION RESISTANT .

# TYPES OF LOADS :

- DEAD LOAD
- LIVE LOAD
- WIND LOAD
- SNOW LOAD
- SEISMIC LOAD



# DEFINE LOADS

1. DEAD LOAD = DEAD LOAD CONSIST OF PERMANENT STATIC WEIGHTS . THOSE THAT REMAIN RELATIVELY CONSTANT OVER TIME AND COMPRISE . FOR EXAMPLE ; BEAMS , WALLS , ROOF .
2. LIVE LOAD = REFERS TO THE TRANSIENT OR MOVING LOADS THAT STRUCTURES EXPERIENCE DUE TO HUMAN OCCUPANCY AND TEMPORARY FACTORS .
3. WIND LOAD = REFERS TO THE PRESSURE CAUSED BY THE WIND THAT IS DELIVERED TO A STRUCTURE .
4. SNOW LOAD =THE DOWNWARD FORCE ON A BUILDING;S ROOF EXERTED BY ACCUMULATED SNOW AND ICE .
5. SEISMIC LOAD = AAPLICATION OF A SEISMIC OSCILLATION TO A STRUCTURE .

# THANK YOU

# CHAPTER 2
# METHOS OF RCC

- **METHOD OF RCC**

COMPONENTS :

BEAM +PLINTH

COLUMN

SLAB

FOUNDATION

WALLS

IS 456-2000 GIVES RECOMMENDATION REGARDING PCC AND RCC DESIGN .

# METHOD OF RCC DESIGN

- TO DECIDE THE SIZE OF MEMBERS AND AMOUNT OF REINFORCEMENT .
- TO CHECK WHEATHER THE DESIGNED PERFOMANCE SAFELY AND SATISFY DURING ITS LIFE SPAN .
- VARIOUS METHID USE FOR RCC :

## METHODS OF RCC DESIGN

- WORKING STRESS METHOD
- LIMIT STATE METHOD

# DIFFERENCE WSM AND LSM

- WORKING STRESS METHOD
- IT IS OLDEST METHOD .
- IT IS BASED ON LINEAR ELASTC THEORY .
- IT IS DETERMINISTIC .
- IT IS UNECONOMICAL .
- THIS BASED ON BEHAVIOUR OF STRUCTURE UNDER SERVICE LOAD .
- IN THIS METHOD OF FOS ARE APPLIED TO YIELD STRESS
- SAFETY AGAINST ULTIMATE LOAD IS NOT KNOWN .

- LIMIT STATE METHOD
- IT IS RATIONAL METHOD .
- IT IS BASED ON NON – LINEAR STRESSS DISTRIBUTION .
- IT IS ECONOMICAL AS COMPARED TO MS .
- BASED ON MODT CRITICAL LIMIT STATE AND CHECK FOR OTHER LIMIT STATE .
- PARTIAL SFETY FACTORS ARE APPLIED TO STRESS AS WELL ASWORKING LOAD AND TO GET DESIGN STRESS AND DESIGN LOADS .
- IT SATISFIED ALL LIMIT STATE OF COLLAPSE AND SERVICEABILITY .

# FACTOR OF SAFETY

- FOS = FOS REFERS TO THE LOAD CARRYING CAPACITY OF A SYSTEM BEYOND WHAT THE SYSTEM ACTUALLY SUPPORTS
- FOS = 1.78(FOR STEEL )
- 3 (FOR CONCRETE)

# THANK YOU

GROUP
1

RCC

# (FLANGED BEAMS- T BEAM)

# LIMIT STATE OF COLLAPSE IN FLEXURE

# INTRODUCTION

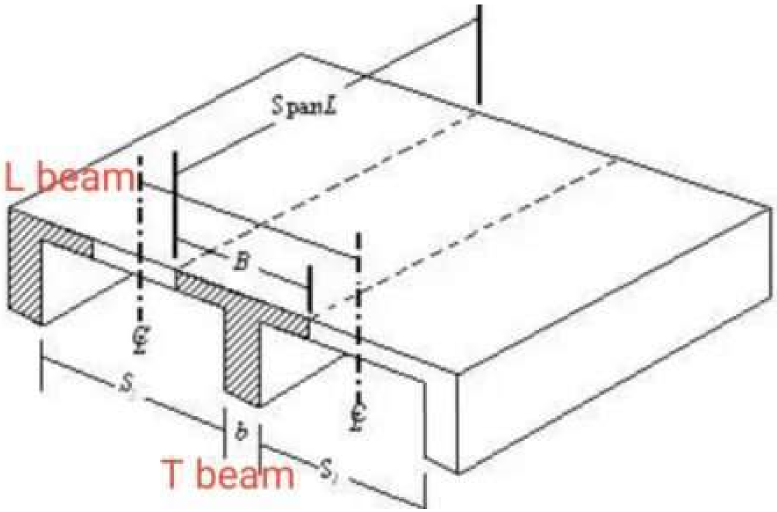
In a RCC ,beam , concrete below the neutral axis does not resist any bending moment but simply hold the tensile reinforcement. Also ,some portion of the concrete just above the neutral axis carries only very little compressive force because the intensity of compressive stress there is of very small magnitude. This suggests that the section of beam should be such that it has greater width at the top (compression side ) in comparison to the width below the neutral axis. Such a section is known as is known as a T-Beam.

# T-BEAM

The Beam consists of a flange and rib in the form of a T,generally made of RC concrete or metal is known as T-Beam.

The Top part of the slab which acts along the beam to resist the compressive stress is called flange.

The part which lies below the slab and resist the  shear stress is called Rib.



# T-beam and stress distribution diagram

Where ,B=Effective wifth of the flange

Br=width of the rib,

Ds=Thickness of the flange slab

D=Effevtive depth of T-beam

D=Overall depth of T-beam

# DIFFERENT TERMS USED IN A T-BEAM

**1. Thickness of the flange :** The thickness of the flange of the T – beam is equal to the thickness or the overall depth of the slab forming the flange of the beam.

**2. Breadth of the web:** breadth of the web is the width of the beam supporting the slab . It should be sufficient enough to accommodate the tensile reinforcement in the beam with suitable spacing between the bars.

The ratio of width of web to the depth of web is kept as 1/3 to 2/3.

But from architectural point of view,the width of web should be kept equal to the width of the column supporting the beam.

# OVERALL DEPTH OF THE BEAM

- The overall depth of the beam depends upon the span as well as loading condition. In the case of simply supported beams, it may be assumed to be 1/12to1/15 of the span. For continuous beams, the overall depth is assumed as follows :For light loads=1/15to1/20 of the span

# AXIALLY LOADED COLUMN

## 14.1 COLUMN

A Column is the most important component of every reinforced concrete structure. It is a vertical compression member which transform the load of superstructure to the foundations safely.

A Column is defined as a vertical compression member, the effective length of which exceeds three times the least lateral dimension.

A Vertical compression member whose effective length is length is less than three times the least lateral dimension is called a pedestal. A pedestal may be cast with plain cement concrete.

# 14.2 CLASSIFICATION OF COLUMNS

Column are classified based on the following different criteria:

1. On the basis of materials of construction

a. Timber columns

b. Masonry columns

c. Steel columns

d. R.C.C columns

2. On the basis of shape of columns

a. Square columns

b. Rectangular columns

c. Circular columns

d. Hxagonal columns

# 3. ON THE BASIS OF LINE OF ACTION OF LOADS

a. Axially loaded columns : Axially loaded columns are those in which the line of actions of loads is along the longitudinal axis or centroid of the column.

b. Eccentrically loaded columns: Eccentrically loaded columns are those in which the line of actions of loads is away from the longitudinal axis of the column.

## 4. ON THE BASIS OF LENGTH OF COLUMNS

a. Short column: A column is considered as a short column when its slenderness ratio of effective length to its least lateral dimension is less then or equal to 12 .

Hence for a short column, $\frac{lef}{b} \leq 12$

b. Long column: A column is considered sa a long column when its slenderness ratio greater than 12.

Hence for a long column, $lef/b > 12$

## 14.3 EFFECTIVE LENGTH OF A COLUMN

The effective length of a column is defined as that length of the column which take part in buckling under the action of loads. This is denoted by “lef“.

THE clear distance between the two ends of a column is known as actual length and it is denoted by‘$l$ ’.The effective length of a column is not necessarily its actual length .

IS: 456- 2000 Annexure – E gives the values of effective length for various end conditions of a column in terms of its unsupported length, which is reproduced .

# 14.4 CONCEPT OF SHORT AND LOND COLUMNS

A column is considered as short when both the slenderness ratios are ratio are less than or equal to 12. when either or both the slenderness ratios are more than 12, the column is considered to be a long column.

For a short column

$a. \quad \frac{lex}{D} \leq 12$ b. $\frac{ley}{b} \leq 12$

For a long column

$a. \quad \frac{lex}{D} > 12$ b. $\frac{ley}{b} > 12$

Where $lex -$ Effective length of the column w.r.t X-X axis

$lex -$ Effective length of the column w.r.t Y-Y axis

D – Depth of the column w.r.t X-X axis

b – Width of the column section w.r.t X-X axis

# WHY STEEL REINFORCED IS REQUIRED IN A COLUMN WHEN CONCRETE ITSELF IS STRONG IN COMPRESSION ?

Although concrete is very strong in compression and a column can be made up of plain concrete yet it is always advisable to use reinforced cement concrete column instead of plain concrete column due to the following reasons:

i. We know that one unit area of steel can take 'm' times of load as taken by same area of concrete. Therefore, the section of an R.C.C column required for a particular load will be much thinner than of plain concrete column.

ii. A minimum area of steel is always provided in the column whether it is required for carrying load or not.

iii. Steel reinforced provide ductility to the column so as to prevent sudden failure of the column.

iv. Steel reinforced reduces the effect of creep and shrinkage. Creep and shrinkage tend to increase the longitudinal steel stresses and reduces the concrete stresses.

# 14.5 REINFORCEMENT IN COLUMNS

There are types of steel reinforcements in a column :

1. Longitudinal reinforcement
2. Transverse reinforced

- Longitudinal reinforced: The steel bars provided longitudinal in a column are known as longitudinal reinforcement. Its is also called main steel.

FUNCTIONS OF LONGITUDINAL REINFORCEMENT IN A COLUMN

i. To share the vertical compressive loads alongwith concrete, therby, reducing the overall size of the column.

ii. To prevent sudden brittle failure of the column.

- Transverse reinforcement: the transverse reinforcement is provided along the lateral direction of the column in the form of ties or spirals enclosing the main steel.

FUNCTIONS OF TRANSVERSE REINFORCEMENT IN A COLUMN

i. To hold the longitudinal reinforcement in position at the time of concreting.

ii. To prevent longitudinal bucking of main steel.

1.LONGITUDINAL REINFORCEMENT {As per clause 26.5.3.1}

The cross –sectional area of longitudinal reinforcement shall be not less than 0.8% nor more than 6% of the gross –sectional area of column.

2. TRANSVERSE REINFORCEMENT {As per clause 26.5.3.2}

Lateral tiles



Diameter of lateral ties: the diameter of the lateral ties shall be not less than

i. ¼ * diameter of the largest longitudinal bar

OR

ii. 6 mm

## 14.6 TYPES OF R.C.C COLUMN ON THE BASIS OF TRANSVERSE REINFORCEMENT

1. Column with lateral ties
2. Column with helical reinforcement

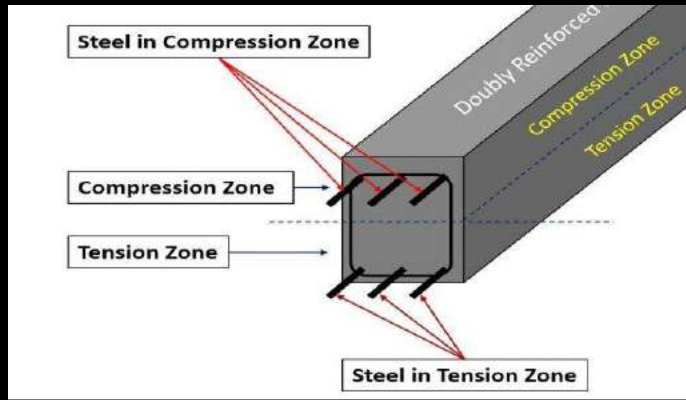
- Column with lateral ties: In this type of arrangement, the longitudinal bars are tied laterally at suitable intervals wih the help of ties as shown in fig 14.8

2. Column with helical reinforcement: In this type of arrangement, the longitudinal bars are tied continuously with the help of reinforcement as shown in fig 14.9

The column with helical reinforcement are better in providing lateral support to bars as compared to lateral ties thus increasing the buckling resistance and ductility of the column.

THANKYOU

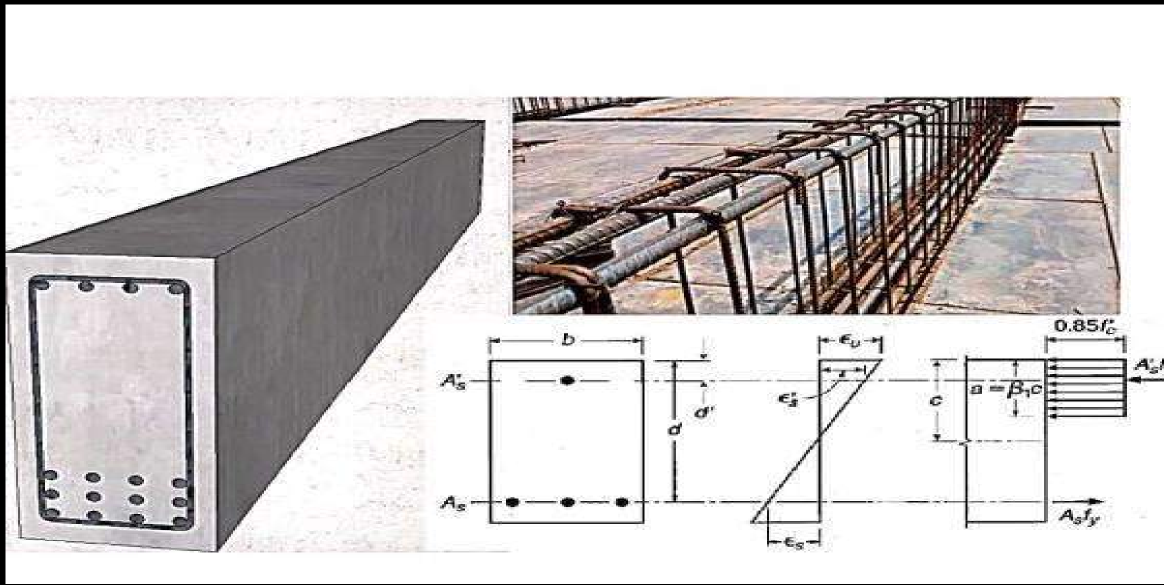
THEORY AND DESIGN OF DOUBLY REINFORCED BEAM BY LIMIT STATE METHOD




# DOUBLY REINFORCED BEAM

# DOUBLY REINFORCED BEAMS

The R.C.C. beams reinforced with steel both in tension and compression zones are called doubly reinforced beam .



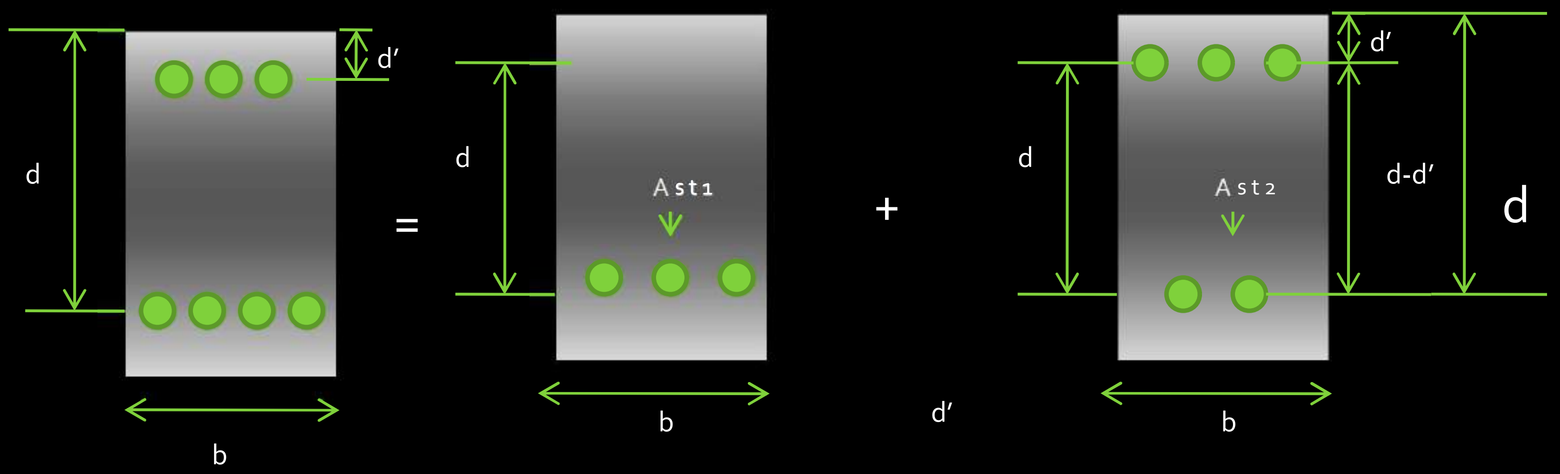

## CONDITIONS UNDER WHICH DOUBLY REINFORCED BEAM ARE USED :-

A doubly reinforced beam is generally provided under the following conditions :-

I. When the depth of beam is restricted due to any constraints like availability of head room , architectural or some other reason.
II. When the factored bending moment due to external loading is greater than the limiting value of MOR of a singly reinforced beam and the size of the beam is pre-determined.
III. When the external loads may occur on either face of the member i.e. the loads are altering or reversing and may cause tension on both faces of the member.
IV. When member is subjected to accidental or sudden lateral loads .
V. In case of continuous beams , the section at supports are generally designed as doubly reinforced sections.
VI. In seismic prone areas , due to want of ductility the compression steel is provided .

# ANALYSIS OF DOUBLY REINFORCED BEAM SECTION

A doubly reinforced beam section has MOR greater than that of a balanced section. Therefore, a doubly reinforced beam subjected to a moment can be analysed by considering it to consist of two sections




SECTION SUBJECTED TO MOMENT

SECTION 1

RESISTING MOMENT

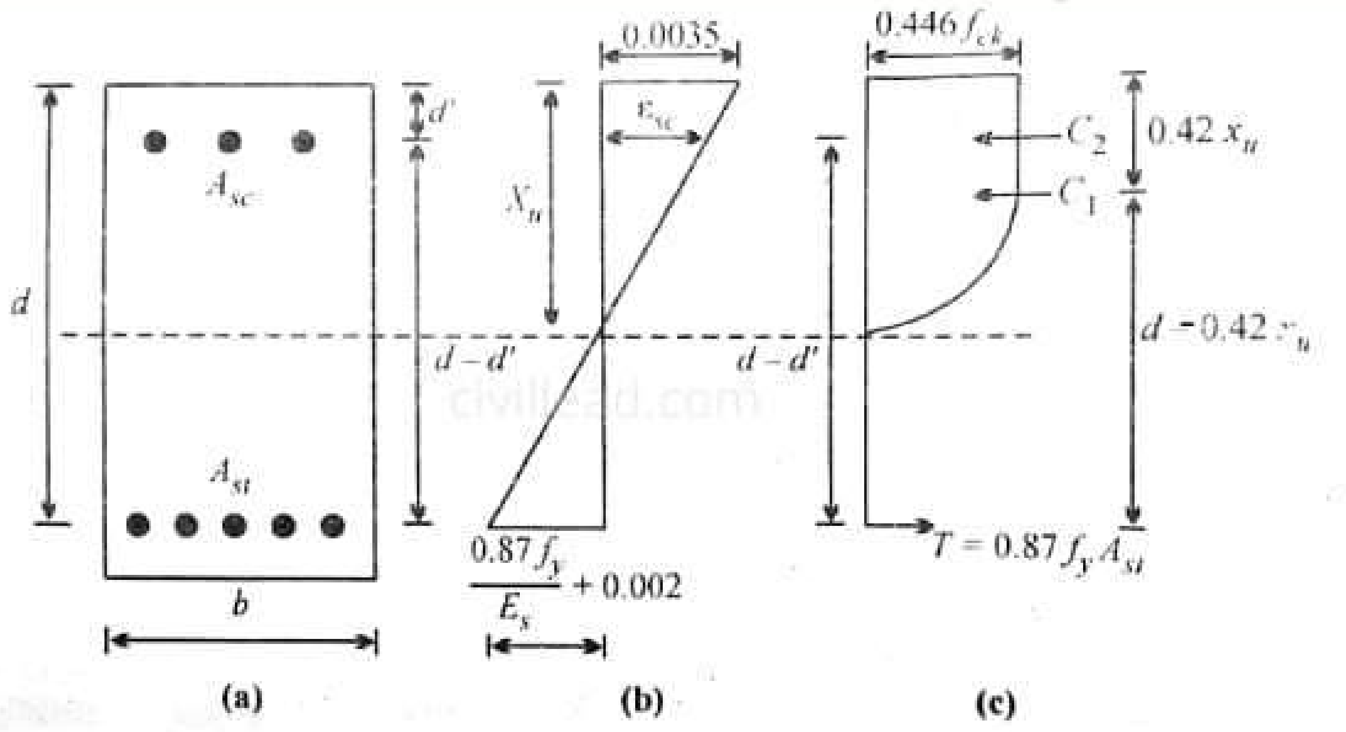
SECTION 2

RESISTING BALANCE MOMENT

DOUBLY REINFORCED BEAM

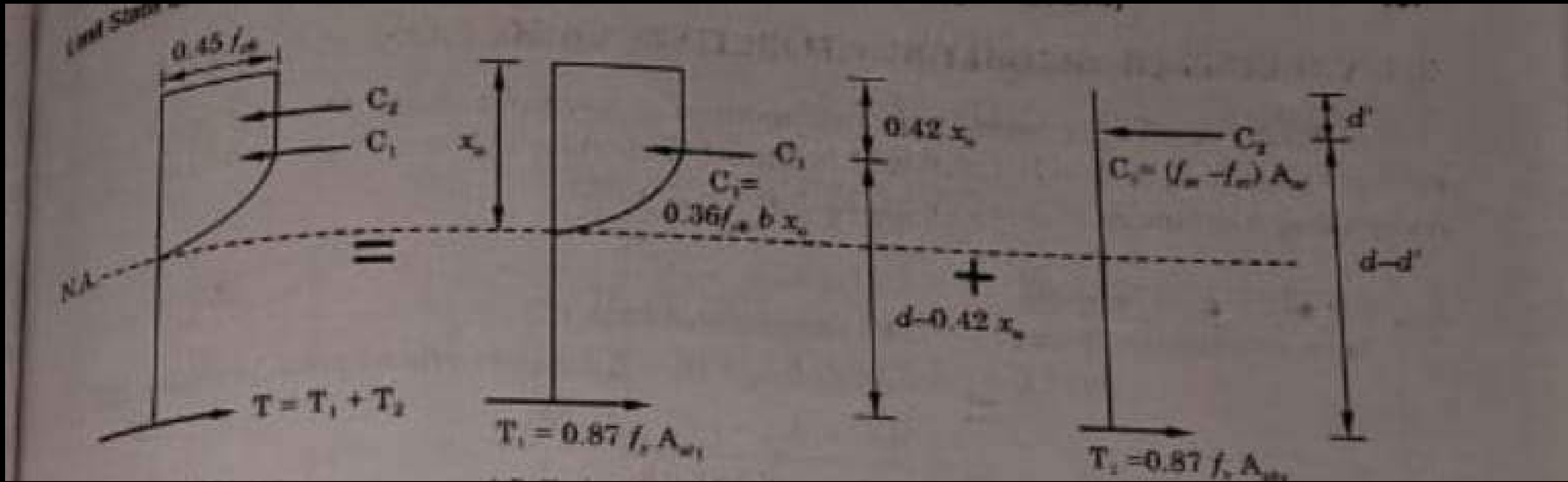
SECTION 1 :- It consists of a singly reinforced balanced section having area of steel1 and limiting MOR

SECTION 2 :- It consists of compression steel and additional tensile steel 2 corresponding to Ast .




Doubly Reinforced Beam

a) SECTION
b) STRAIN DIAGRAM
c) STRESS DIAGRAM




C] STRESS DIAGRAM          d] BALANCED SECTION          E]ADDITION SECTION RESISTING

Let us consider a doubly reinforced beam section as shown in above fig.

Where, b= Width of the beam

d = Effective depth of the beam

d'= Effective cover to compression steel

(Depth of compression reinforcement from compression face)

Xn= Depth of neutral axis

Ast = area of steel in tension = Ast1+Ast2

Ac = area of compression

fsc= stress in steel in compression

fcc= stress in concrete at the level of compression steel

=0.45fck          For $\frac{d'}{d} < 0.2$

## DEPTH OF NEUTRAL AXIS OF A DOUBLY REINFORCED BEAM

The depth of neutral axis of a doubly reinforced beam section is obtained by equating the total compressive force and total tensile force

Total compressive force (C) = C1 + C2
Where

C1= Compressive force provided by concrete
C2 = Compressive force provided by steel in compression zone

$$C_1 = 0.36 f_{ck} \cdot b \cdot x_u$$

$$C_2 = f_{sc} A_{sc} - f_{cc} A_{sc} = (f_{sc} - f_{cc}) A_{sc}$$

(The term $f_{cc} \cdot A_{sc}$ accounts for the loss of concrete area occupied by compression steel).

The depth of neutral axis decreases with increase in compression steel

| Sr. No . | Types of Problems | DATA GIVEN | DATA DETERMINE |
|---|---|---|---|
| 1 | Calculate the ultimate moment of resistance | Grade of Concrete & Steel, Size of beam & Reinforcement provided | If $Xu = Xu\ max \rightarrow$ Balanced<br>If $Xu < Xu\ max \rightarrow$ Under Reinforced<br>If $Xu > Xu\ max \rightarrow$ Over Reinforced<br>Equating the ,<br>Total Compressive Force = Total Tensile Force<br>$0.36 * fck * b * Xu + Asc * fsc = 0.87 * fy * Ast$<br>From this equation find Xu.<br><br>$Mu = 0.36 * fck * b * Xu * (d - 0.42 * Xu) + Asc * fsc * (d - d')$<br><br>This equation is valid for Balanced & Under Reinforced Section.<br><br>If the section is Over Reinforced, then take Xu = Xu max, in above equation & use the same equation for finding Mu. Do not increase the depth of the beam, for over reinforced section. |

Where,

d = effective depth of beam in mm = distance between the extreme compression fibre to the centroid of the tensile reinforcement

d' = distance between the extreme compression fibre to the cenroid of the compression reinforcement in mm

b = width of beam in mm

Xu = depth of actual neutral axis in mm from extreme compression fibre

Xu,max = depth of critical neutral axis in mm from extreme compression fibre

Ast = total area of tensile reinforcement in mm2

fck = characteristic compressive strength of concrete in Mpa

fy = characteristic strength of steel in Mpa

Mu,lim = limiting M.R. of a section without compression reinforcement in kN.m

Mu = ultimate M.R. of a section in kN.m

Asc = area of compression reinforcement in mm

# GROUP PRESENTATION
# ON
# PRE-STRESSED CONCRETE

# agenda

INTRODUCTION

CONCEPT OF PRE-STRESSING

MATERIALS USED IN PRESTRESSED CONCRETE

ADVANTAGES AND DISADVANTAGES

METHODS OF PRE-STRESSING

# INTRODUCTION

In ordinary reinforced concrete, the compressive stresses are taken by concrete and the tensile stresses and taken by steel.

# PRESTRESSED CONCRETE

Prestressed concrete is a system devised to provide sufficient pre - compression in the concrete beam by tensioned steel wires, cables , or rods that under working conditions the concrete has no tensile stresses or the tensile stresses are so low that no visible cracking occurs.

**This process of introducing the stresses before the application of external forces to a member is known as prestressing.**

# CONCEPT OF PRE-STRESSING

The principle behind prestressed concrete is that compressive stresses induced by high-strength steel tendons in a concrete member before loads are applied will balance the tensile stresses imposed in the member during service.

fig,. Shows a simply supported prestressed concrete beam of rectangular section prestressed by a tendon through its centroidal axis.

Let P= Prestressed force introduced by the tendon
A=Cross – sectional area of the beam
M= B.M. dua to loads on the beam
Z= Section modulus of the beam

Stresses introduced in concrete by the prestressing force =P/A (Compressive in the whole section)
Bending stresses due to moment= M/Z (Compressive at the top and tensile at the bottom)

# MATERIALS USED IN PRESTRESSED CONCRETE

The materials used in prestressed concrete are :

1) Steel
2) Concrete

# STEEL:

High strength concrete is used for prestressing. Ordinary mild steel and deformed bars used in RCC are not used in PSC (prestressed concrete) because their yield strength is very high. In the prestressed concrete loss of prestressed is the magnitude of about 20% due to various factor.

**Steel Used For Prestressing is Available In Three Forms.**

- Single Wire (also called as tendons).
- Group of Wires (also called as Strands or cables).
- Steel Bars.

# (a) Single wires (tendons):

Prestressing steel is generally used in the form of individual wires of high tensile strength called tendons. Tendons are available in various diameters ranging from 1.5 mm to 8 mm.

# (b) Group of wires (Strands) :

Tendons may also be used in the form of cables known as wire strands. A strand is produced by spinning six individual wires around a central straight wire. The overall diameter of a strand varies from 7 mm to 17 mm.

# (c) Steel bars :

High tensile steel bars of diameter ranging from 10 mm to 32 mm are used in prestressed concrete.

# 2.Concrete

Since high tensile strength steel is used in prestressed concrete, therefore. The concrete used should also be of good quality and high strength so that full strength of steel can be utilised.

The IS : 456-2000 recommends a minimum concrete mix of M 40 for pre-tensioned system and M 30 for post-tensioned system. High strength concrete is used in prestressed concrete due to the following reasons :(i) Use of high strength concrete results in smaller sections of members. It reduces the selfweight of the members and consequently longer spans become technically and economically feasible.

- (i) High strength concrete offers high resistance in tension, shear and bond.
- (ii) High strength concrete has higher value of modulus of elasticity which helps in reducing deflection.
- (iii) In high strength concrete, creep and shrinkage is less and due to this there is less loss of prestressing force.

# ADVANTAGES OF PRESTRESSED CONCRETE

advantages : **Following are the advantages of prestressed concrete** :

a) Prestressed concrete sections are thinner and lighter than R.C.C. sections because high strength steel and concrete are used in PSC.
b) PSC sections need about l/3rd the quantity of steel and 1/4th the quantity of concrete as compared to R.C.C.
c) Thinner sections in PSC results in lesser weight and hence overall economy
d) Due to lesser self weight and thinner sections, PSC is used for heavy loaded structures, long span bridges and flyovers.
e) There is less deflection in PSC members.
f) In PSC. whole concrete area is effective in resisting loads. While in R.C.C. structures, concrete below the neutral axis is neglected.

# DISADVANTAGES

Following are the disadvantages of prestressed concrete :

(i) Cost of materials used in PSC is very high. High tensile steel is about three times costlier than mild steel.

(ii) PSC requires specialized tensioning equipements which are very costly.

(iii) PSC construction require very good quality control and supervision.

(iv) Prestressed sections are brittle because high tension steel is used. High strength steel have higher carbon content.

(v) Very long and slender PSC members are difficult to transport.

(vi) Prestressed concrete sections are less fire resistant.

# DIFFERENCE BETWEEN PRE –TENSIONING AND POST TENSIONING

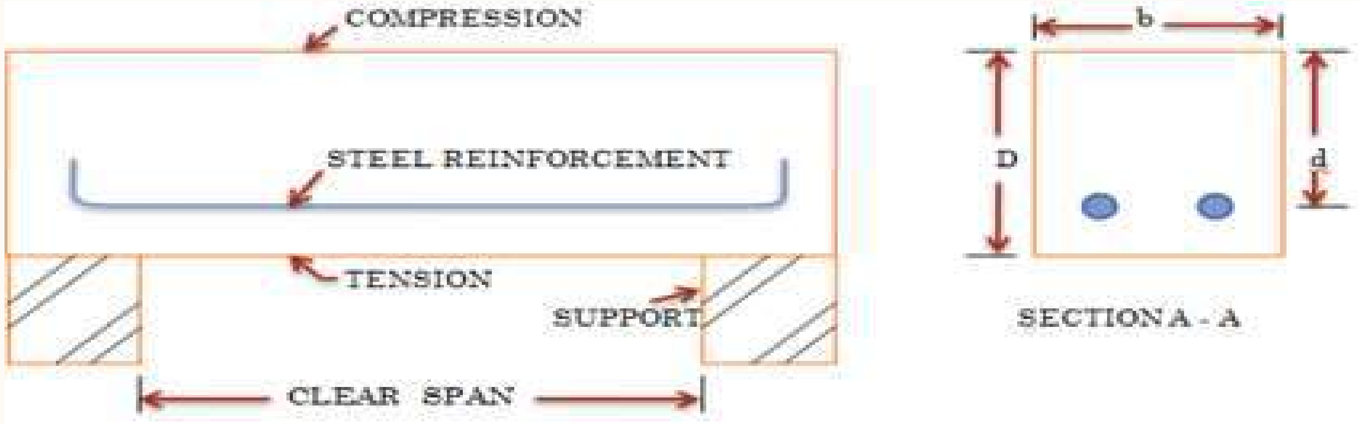
| Pre – tensioning Method | Post – tensioning Method |
|---|---|
| 1. This method is employed in factory thus suitable for precast construction works. | 1. This method can be employed in factories as well as on the site. |
| 2. Loss of prestress is more. | 2. Loss of prestress is comparatively less. |
| 3. Size of member is restricted because heavier and longer members are difficult to transport. | 3. Size of member is not restricted . So long span bridges can be constructed by this method . |
| 4. This method is cheaper. | 4. This method is costlier because of use of sheathing etc. |

# SINGLY REINFORCED BEAM

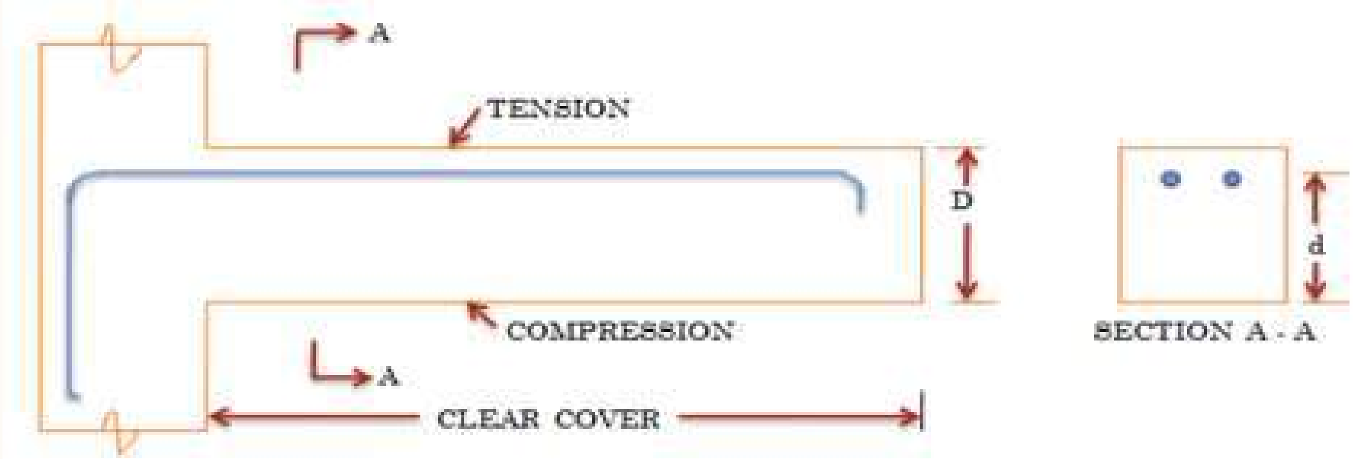
IN LIMIT STATE OF METHOD

# SINGLY REINFORCED BEAM

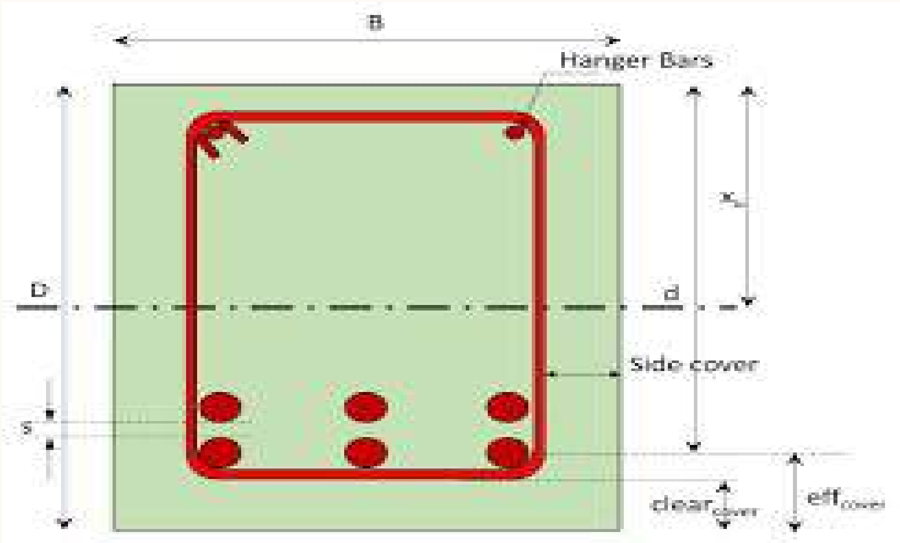
The R.C.C. beams in which the steel reinforcement is provided only in tension zone, are known as singly reinforced beam. Ina singly reinforced beam, the tension  developed due to bending moment is mainly resisted by the steel reinforcement and the compression is resisted by the concrete alone.




Simply Supported Beam




Cantilever Beam




Section of a Singly Reinforced Beam

In Fig. the section has

B = Width of the Beam

d = Effective depth of the Beam

D = Overall depth of the Beam

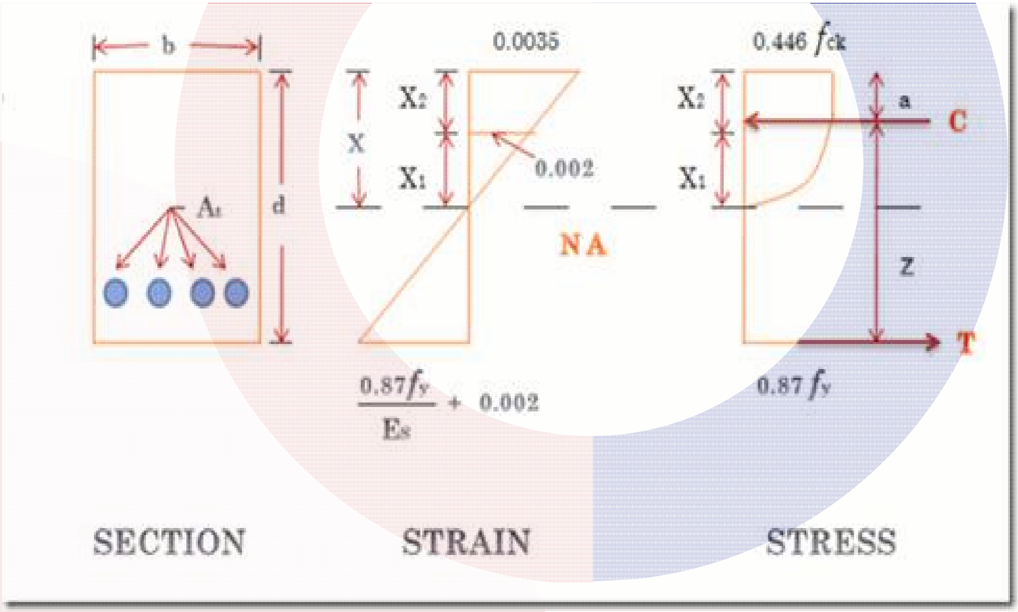
$X_u$ = Depth of neutral axis below the compression edge

$A_{st}$ = Cross-Section area of steel in compression

Effective Cover (d) = Distance between centre of main steel bars and bottom most edge of the beam

Clear Cover (Nominal Cover) = Distance between bottom of stirrups bottom most edge of the beam

# STRESS AND STRAIN DISTRIBUTION IN A SINGLY REINFORCED BEAM




<u>STRESS DISTRIBUTION</u> : It had a parabolic shape from A to B and then linear from B to C above the neutral axis.

i. Stress at neutral axis (point A) = 0

ii. Stress at 0.002 strain (point B) = $\frac{0.67 f_{ck}}{1.5} = 0.45 f_{ck}$

i. Stress at extreme fibre ( point C ) = $0.45 f_{ck}$

ii. Below the neutral axis, the maximum stress in steel = $\frac{f_y}{1.15} = 0.87 f_y$

<u>STRAIN DISTRIBUTION</u> : The strain at any point on the cross-section is proportional to its distance from the neutral axis. It gives a linear strain distribution across the extreme fibres.

The various salient features of the diagram are:

i. Strain at neutral axis = 0

ii. Maximum ( Ultimate ) strain in concrete at extreme fibre ($E_{cu}$) = 0.0035

iii. Strain at constant stress of 0.67 $f_{ck}$ ( $E_c$ ) = 0.002

iv. Ultimate strain in steel corresponding to maximum stress at failure ($E_{su}$) = $\underline{0.87 f_y}$ + 0.002

# MAXIMUM DEPTH OF NEUTRAL AXIS

A compression failure is brittle failure.
The maximum depth of neutral axis is limited to ensure that tensile steel will reach its yield stress before concrete fails in compression, thus a brittle failure is avoided.

The limiting values of the depth of neutral axis xm for different grades of steel from strain diagram.

# " DESIGN OF SINGLY REINFORCED RECTANGULAR BEAM – LIMIT STATE METHOD "

The Limit State Method, adopted by IS:456-1978 & 2000 is nothing but the modification of the ultimate load method. This takes into account the drawbacks of ultimate load theory. In LSM, the attention is given to the ‘acceptable limit’ before failure as against the ULT which gives the load factor on failure load of the structure. In the method of design based on LSM, the structure shall be designed to withstand safely all loads liable to act on it throughout its life & also satisfy the serviceability requirements.

**The acceptable limit for the safety and serviceability requirements before failure occurs is called limit state.**

A structure is said to be reached its limit state or failure conditions, when the structure as a whole or in part becomes unfit for use, for one reason or another, during its expected life.

**Limit State Design** is a philosophy of design where one designs a structure so that it will not reach any of the specified limit states for failures during the expected life of a structure. In general, the structure shall be designed on the basis of the most critical limit state and shall be checked for other limit states.

The **design values** are derived from the characteristic values through the use of partial safety factors, one for material strength & the other for loads are used.

## LIMIT STATE OR FAILURE CONDITIONS

LIMIT STATE OF COLLAPSE
OR
ULTIMATE LIMIT STATE

- FLEXURE – CL. 38
- COMPRESSION – CL. 39
- SHEAR – CL. 40
- TORSION – CL. 41

SERVICEABILITY LIMIT STATE

DURABILITY CL. 8
OVERALL STABILITY CL. 20
FIRE RESISTANCE CL. 21
DEFLECTION CL. 42
CRACKING CL. 43

# FOLLOWING STEPS :-

Step 1. calculate design constants corresponding to given grade of steel and concrete assuming the section to be designed as a balanced section.

Step 2. assume suitable depth and breadth of the beam and calculate effective span of the beam .

Effective depth (d) may be assumed as span/10

Breadth (b) of the beam may be taken as D/2 to 2/3D

Step 3. Calculate the self weight the beam per meter length and add it to th iven superi-

Mposed load to find the total u.d.l. per metre length of the beam.

Self weight of the beam/meter = (b * D * l ) * 25000 N/m

where b and D are breath and total depth of the beam in meter respectively.

25000 N/m^3 is the unit weight of R.C.C.

**Characteristic Load:** The maximum working load that the structure has to withstand and for which it is to be designed. Loads that have been successfully used so far in the elastic design procedures are at present accepted as the characteristic load. The specified values to be used are laid down in IS:875-1987.

**Characteristic Strength:** The strength that one can safely assume for the materials (concrete & steel)

**Partial Safety Factor for Load (□ f):** Overload factor for which the structure has to be designed. The load to be used for ultimate strength design is known as **'factored load'**.

So, **factored load = characteristic load * partial safety factor for load**

| Sr. No. | Load Combination | Ultimate Limit State | Serviceability Limit State |
|---|---|---|---|
| 1 | DL + LL | 1.5 (DL + LL) | DL + LL |
| 2 | DL + WL | | |
| | i) DL contribute to stability | 0.9 DL + 1.5 WL | DL + WL |
| | ii) DL assists overturning | 1.5 (DL + WL) | DL + WL |
| 3 | DL + LL + WL | 1.2 (DL + LL + WL) | DL + 0.8 LL + 0.8 WL |

**PARTIAL SAFETY FACTOR FOR MATERIALS (□ M):** ACCORDING TO IS:456-2000 CL. 36.4.2 P-68

DESIGN STRENGTH = M TH STICSTRENGCHARACTERI⌈

| SR. NO. | MATERIAL | ULTIMATE LIMIT STATE | SERVICEABILITY LIMIT STATE |
|---|---|---|---|
| 1 | CONCRETE | 1.50 | EC = 5000 * MPA FCK |
| 2 | STEEL | 1.15 | ES = 2 X 105 MPA |

Step4. Calculate the maximum bending moment (M).

$M = wl^2/8$ for a simply supported beam.

$M = wl^2/ 2$ for a cantilever beam.

Step5. Calculate the effective depth by equating the moment of resistance ($M=Rbd^2$) to the maximum bending moment b(M)

$$Rbd^2 = M$$

$$d = M/ Rb$$

Total depth of the beam (D) = d + effective cover.

If the calculated overall depth is slightly less than or equal to assumed overall depth, then proceed further. Otherwise assume another higher value of depth of beam and adopt the same procedure again.

Step 6. Calculate the area of steel required by the formula:

$$Ast = m/ost\ j.d$$

Selected the diameter of the bar and find the number of bars.

Number of bars = Ast / Area ofone bar

Calculate actual Ast provided

Step7. Calculate the minimum area of steel (as) by the formula :

$$As = 0.85bd / fy$$

check that actual Ast provided is not less than As

Step8. Check for shear and design shear reinforcement .

Check for development length .

Step9. Check for deflection as explained below:

i. Calculate the percentage of steel provided. pt = 100Ac / bd

ii. Calculate value of fs.  Fs = 0.58fy [Ast (required)/Ast (provided)]

iii. Calculate the modification factor (kt) corresponding to the value of 'pt' and 'f1'

iv. Calculate (l/d)max = 208 kt

v. Calculate (l/d)provided

vi. If(l/d) provided < (l/d)max . Then O.K.

Step 10. For beams having overall depth more than 750 mm provide side face reinforcement on both the face.

As = 0.1% of web area = 0.1/ 100 * bD .

Calculate the number of bars and these should be distributed equally on both the faces of the beam at a spacing not exceeding 300mm or web thickness whichever is less.

Step 11. Draw a neat sketch showing all the design parameters.

# ASSUMPTIONS FOR LIMIT STATE OF COLLAPSE (FLEXURE):



1) plane section normal to the axis remains plane even after bending. i.e. strain at any point on the cross section is directly proportional to the distance from the N.A.

2) maximum strain in concrete at the outer most compression fibre is taken as 0.0035 in bending.

3) the tensile strength of the concrete is ignored.

4) the relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoidal, parabola or any other shape.

5) the stresses in the reinforcement are derived from representative stress – strain curve for the type of steel used.

6) the maximum strain in tension reinforcement in the section at failure shall not be less than + 0.002 (= + 0.002) Es *15.1fy Es fy *87 .0

- Section in which, tension steel also reaches yield strain simultaneously as the concrete reaches the failure strain in bending are called, **'Balanced Section'.**
- Section in which, tension steel also reaches yield strain at loads lower then the load at which concrete reaches the failure strain in bending are called, **'Under Reinforced Section'.**
- Section in which, tension steel also reaches yield strain at loads higher then the load at which concrete reaches the failure strain in bending are called, **'Over Reinforced Section'.**