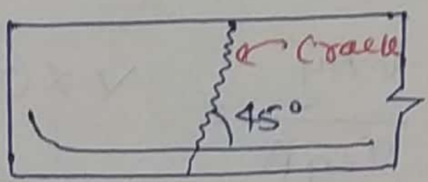
UNIT-II^{nd}

Behaviour of RC-Beam in shear

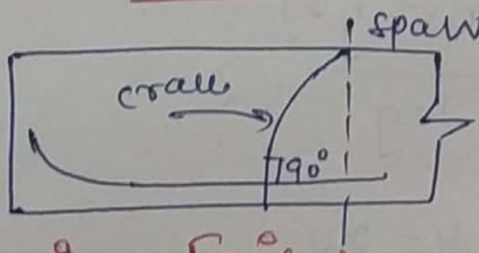
Introduction: shear force is present in beams where there is a change in bending moment along the span. It is equal to the rate of change of bending moment.

Mode of Failures in RCC-Beam:

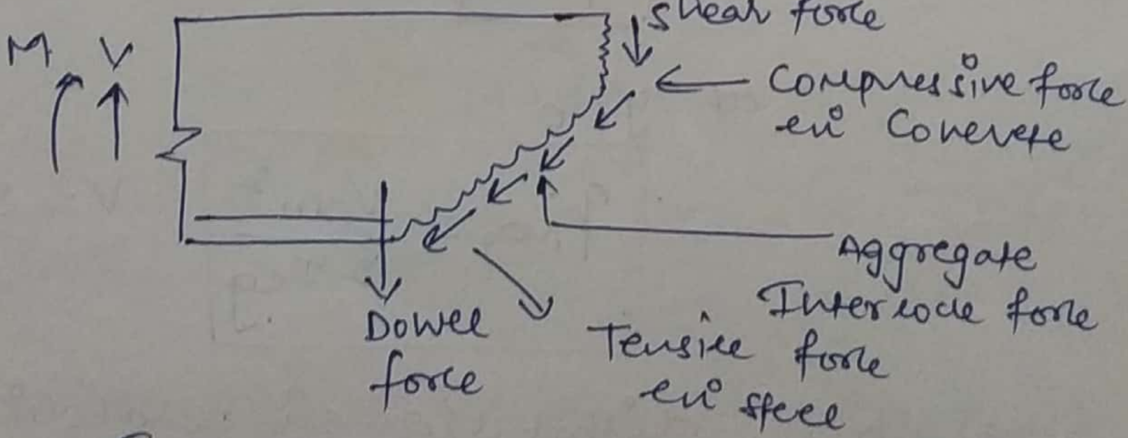
(i) Diagonal Tension Failure-



(ii) Flexure shear Failure-



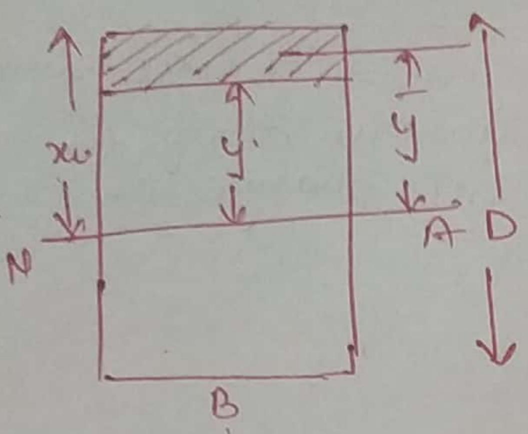
(iii) Diagonal compression Failure-



Force acting on the beam when Resisting shear force

$$\left\{ \tau_v = \frac{V_u}{bd} \right\}$$

Shear stress in Beam (S.S. distribution in RCC section) :-



q = shear stress

$S = V$ = shear force

Consider a simply supported Beam subjected to uniformly distributed load & consider a strip

$$q = \frac{V A \bar{y}}{I_{eq} B}$$

$$A = (x_u - y)B$$

$$\bar{y} = \left(\frac{x_u + y}{2}\right)$$

Then

$$q = \frac{V A \bar{y}}{I_{eq} B} = \frac{V \times (x_u - y)\cancel{B} \times \left(\frac{x_u + y}{2}\right)}{I_{eq} \cdot \cancel{B}}$$

$$\left\{ q = \frac{V (x_u^2 - y^2)}{2 I_{eq}} \right\}$$

at $y = x_u$

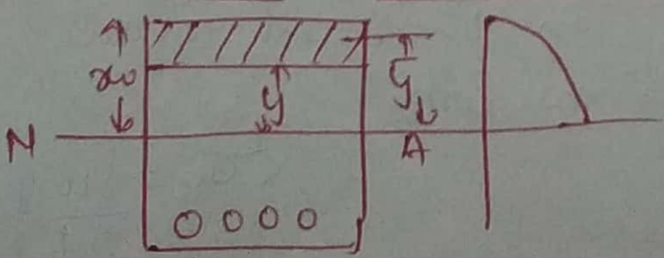
$$\boxed{q = 0}$$

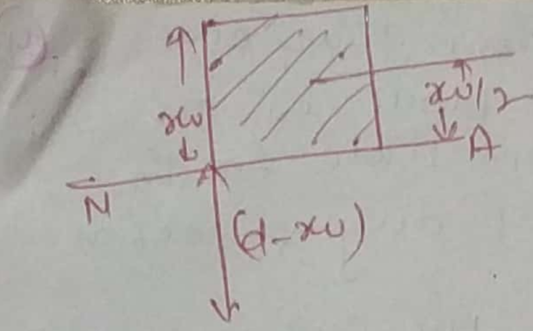
at $y = 0$

$$\boxed{q_{max} = \frac{V x_u^2}{2 I_{eq}}}$$

V = shear force

Shear stress distribution in parabolic above N.A.:-

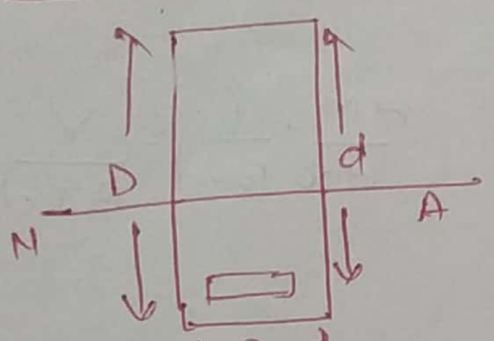




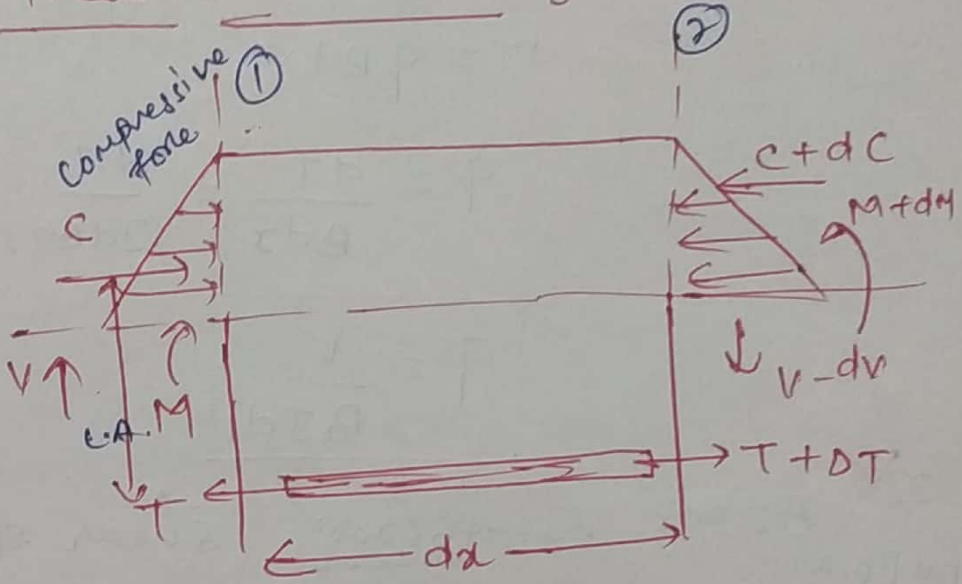
$$I_{NA} = \frac{B x_u^3}{12} + B x_u \left(\frac{x_u}{2}\right)^2$$

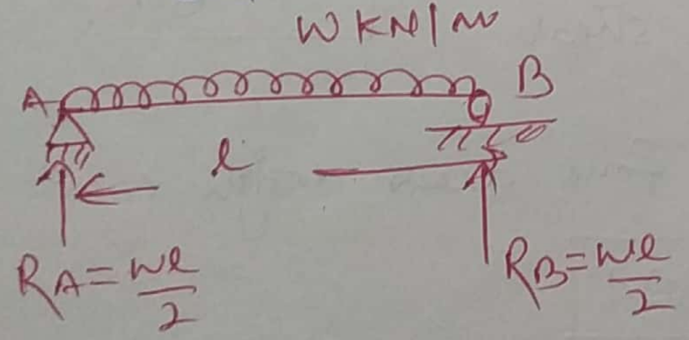
$$I_{NA} = \frac{B x_u^3}{3}.$$

Case-II. Shear stress below N.A.:



This is the X-section of Beam



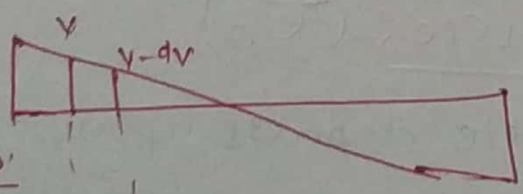


At section 1-1 moment

$$M = C\,Jd = T\,Jd \quad \text{---} (1)$$

At section 2-2 moment

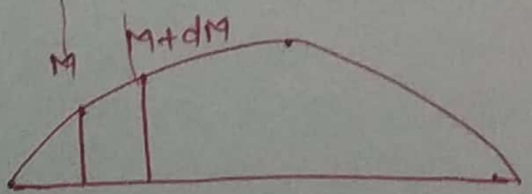
$$M + dM = (C + dC)\,Jd = (T + dT)\,Jd \quad \text{---} (2)$$



S.F.D.

From eq^n (2) - eq^n (1)

$$dM = dC\,Jd = dT\,Jd$$



B.M.D.

$$\boxed{dT = \frac{dM}{Jd}} \qquad \boxed{dC = \frac{dM}{Jd}}$$

C = Compressive force

T = Tensile force

This dT force is unbalanced force that pull the reinforcement and concrete block in one direction This dT force is responsible for shear stress but any two surfaces of any x-section.

NOTE-: shear stress at all the section below The NA is constant of shear stress at section x- x is equal to q.

$$dT = qBdx$$

$$q = \frac{dT}{Bdx} = \frac{dM}{JdBdx} = \frac{dM}{dx} \cdot \frac{1}{BJd} = \frac{V}{BJd}$$

$$\boxed{q = \frac{V}{BJd}}$$

As per IS:- 456:2000 shear stress $\boxed{\tau_v = \frac{V_u}{Bd}}$

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τ_v = Nominal shear stress

& V_u = shear force due to design load

$$\boxed{V = \tau_v \times Bd}$$

Shear strength of Concrete:- (τ_c)

shear strength of concrete depends upon

I) grades of concrete

II) % of Tension Reinforcement

$$\boxed{P = \frac{Ast}{Bd} \times 100}$$

P/73 use T/19

NOTE-: τ_{cmin} for M_{20} = 0.28

Max^M shear stress in Concrete :- (τ_{cmax})

P/73 :- (T/20)

1) Max^M shear stress for M20 = 2.8
ii) In any case shear stress develop τ_v in the section should not be more than τ_{cmax}.

$$\boxed{\tau_v \ngtr \tau_{cmax}}$$

iii) If τ_v is greater than τ_{cmax} is oney option is to revise the section change B or d. So that $\tau_v < \tau_{cmax}$.

$$\boxed{\tau_{cmax} = 0.62\sqrt{f_{ck}}}$$

Minimum shear Reinforcement :-

If $\tau_v < \tau_c$, then min^M or nominal shear reinforcement in the form of stirrups shall be provided in all the beam of such as

$$\frac{(A_{sv})_{min}}{S_v} \geq \frac{0.4\,b}{f_y}$$

Max^M Shear Reinforcement :-

Max^M. area of tension reinforcement should not exceed 4% of the gross cross sectional area 0.04 b D, where D = over all depth of section.

Design of shear Reinforcement :-