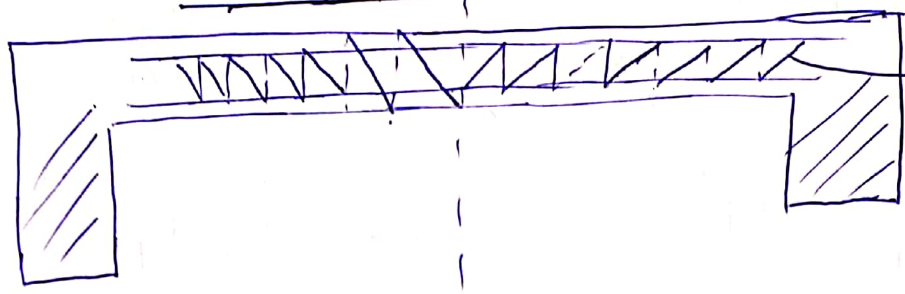
Department of Civil Engineering
Katihar Engineering College, Katihar

Instructor : Prof. RASHID MUSTAFA

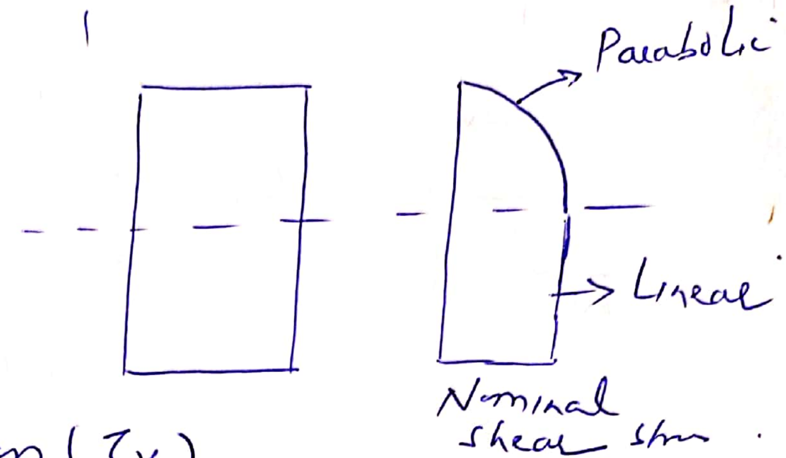
Subject : Design of Concrete Structure - I

Level : B. Tech VI th Semester.

Design In shear



$$\tau_v = \frac{V}{Bd}$$



Nominal shear stress (τ_v)

A/c to IS 456: 2000, nominal shear stress is defined as

$$\tau_v = \frac{V_u}{Bd}$$

⇒ Shear strength of Concrete (τ_c): Shear strength of Concrete depends on (Ac to IS 456:2000)

1. Grade of Concrete
2. Percentage of tensile Reinforcement (p_t)

⇒ Max^m shear strength of Concrete ($\tau_{c\,max}$)

A/c to IS 456: 2000, max^m shear strength of Concrete depends only

1. Grade of Concrete.

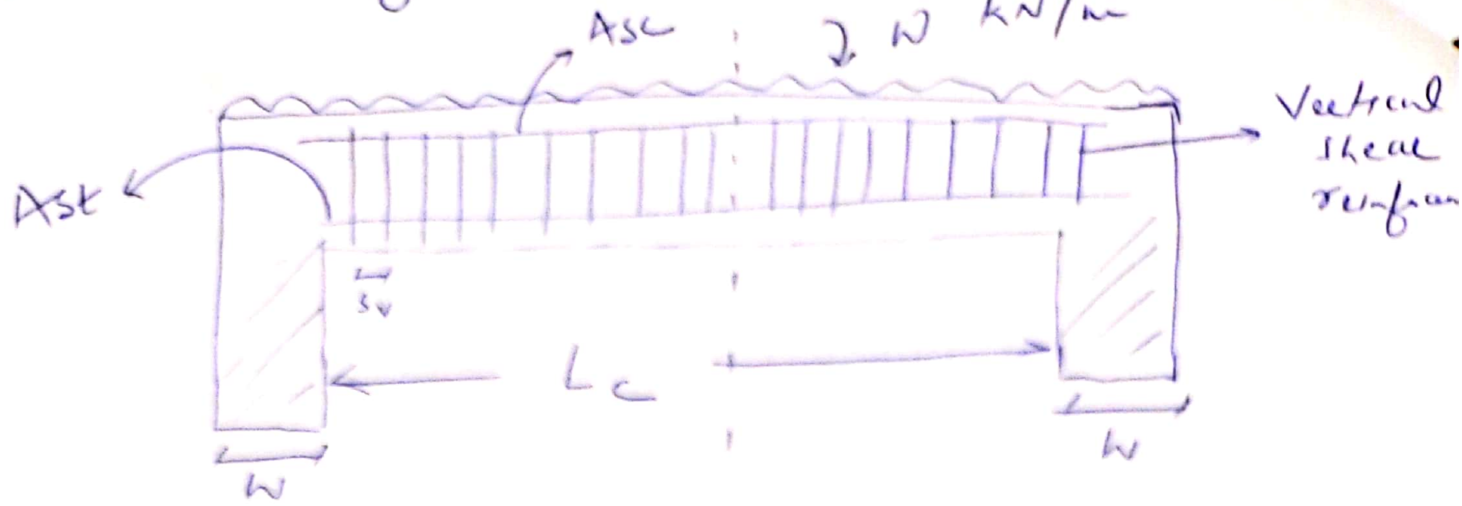
⇒ Let τ_c be the shear strength of Concrete

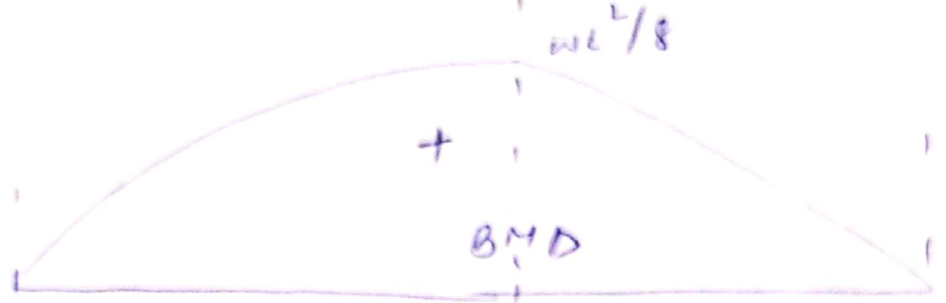
$$V_u = V_s + V_c$$

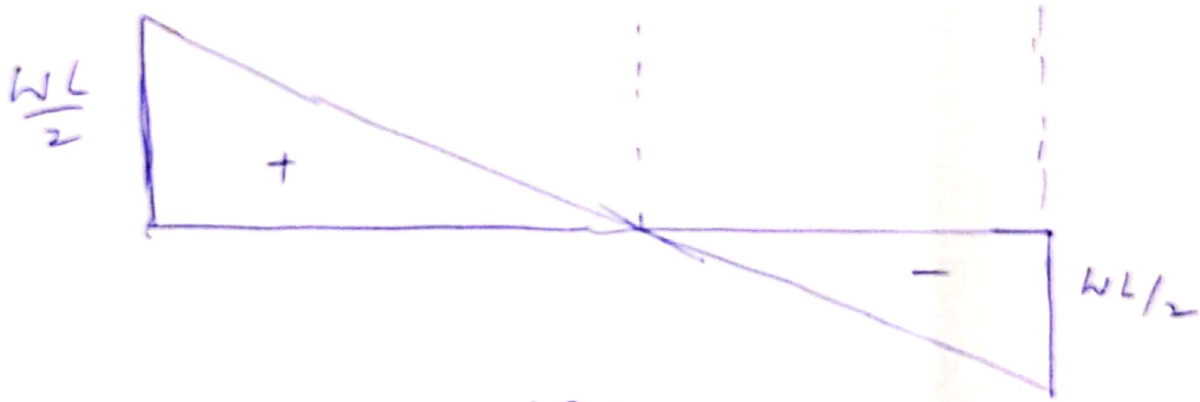
$$V_s = V_u - V_c$$

$$V_s = V_u - \tau_c \cdot Bd$$

Limit state of Collapse: Shear







SFD

$$V_x = \frac{WL}{2} - Wx$$

Max^m shear force $(V) = \frac{WL}{2}$ (at support)

⇒ There are three types of shear reinforcement

(i) Vertical shear reinforcement

(ii) Inclined "

(iii) Bent up bars.

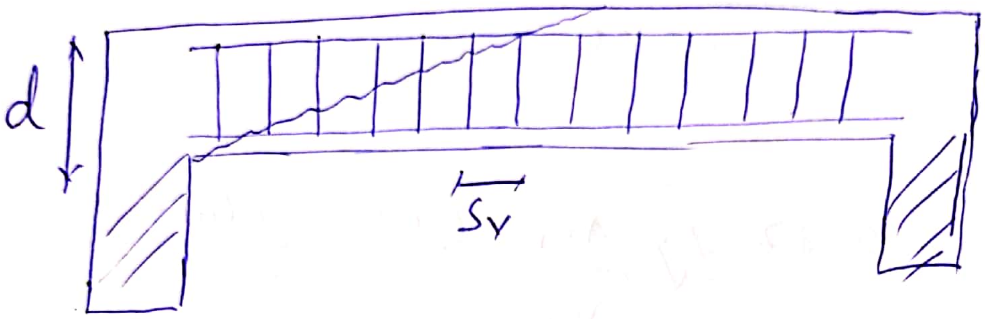
shear reinforcement are designed for remaining SF.

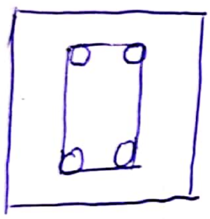
$$V_s = V - V_c$$

$$= \tau_v \cdot Bd - \tau_c \cdot Bd$$

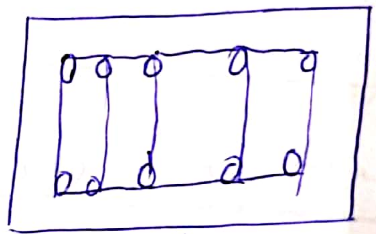
$$V_s = (\tau_v - \tau_c)\, Bd$$

(a) Vertical shear reinforcement





2-legged shear reinforcement



5 legged shear reinforcement

$$A_{sv} = n \times \frac{\pi}{4} \times \phi^2$$

spacing of shear reinforcement (S_v)

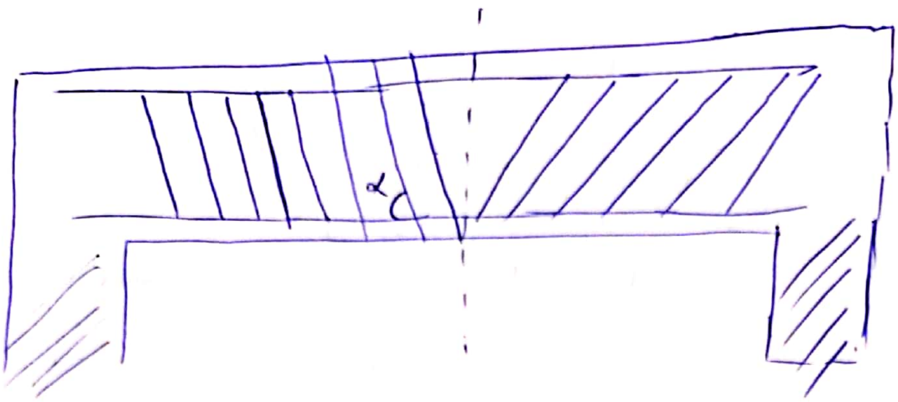
$$S_v = \frac{A_{sv} \cdot \sigma_{sv} \cdot d}{V_s} \rightarrow \text{WSM}$$

In LSM

$$S_v = \frac{0.87 f_y A_{sv} \cdot d}{V_s}$$

$V_s \rightarrow V_u - \tau_c \times Bd$

(b) Inclined shear reinforcement



$$S_v = \frac{A_{sv} \cdot \sigma_{sv} \cdot d(\sin\alpha + \cos\alpha)}{V_s}$$ → WSM

$$S_v = \frac{0.87 f_y A_{sv} d(\sin\alpha + \cos\alpha)}{V_s}$$ → LSM

(c) Bent up Bars

$$V_{sb} = 0.87 f_y A_{sv} \sin\alpha$$

⇒ Max^m spacing of shear reinforcement

(I) 0.75 d → Vertical stirrups
(II) d → Inclined "
(III) 300 mm

} whichever is less.

⇒ Min^m shear reinforcement

$$\frac{A_{sv}}{b S_v} \geq \frac{0.4}{0.87 f_y}$$

$$S_v \geq \frac{0.4\, b\, S_v}{0.87 f_y}$$

Where f_y is the characteristic yield strength of steel & should not exceed $415\ N/mm^2$

⇒ **Need of shear reinforcement**

(I) If $\tau_v < 0.5\,\tau_c$
No need of shear reinforcement

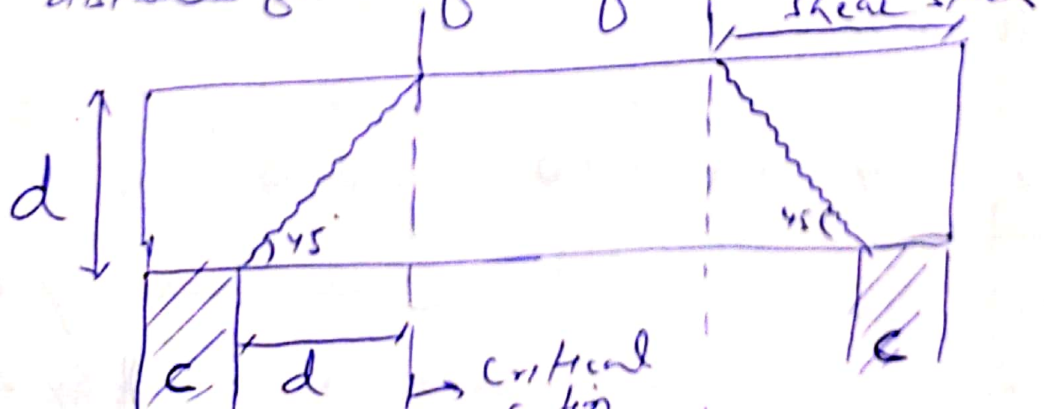
(II) If $\tau_v \leq \tau_c$
Min^m shear reinforcement is req^d

(III) If $\tau_v > \tau_c$
shear reinforcement is req^d

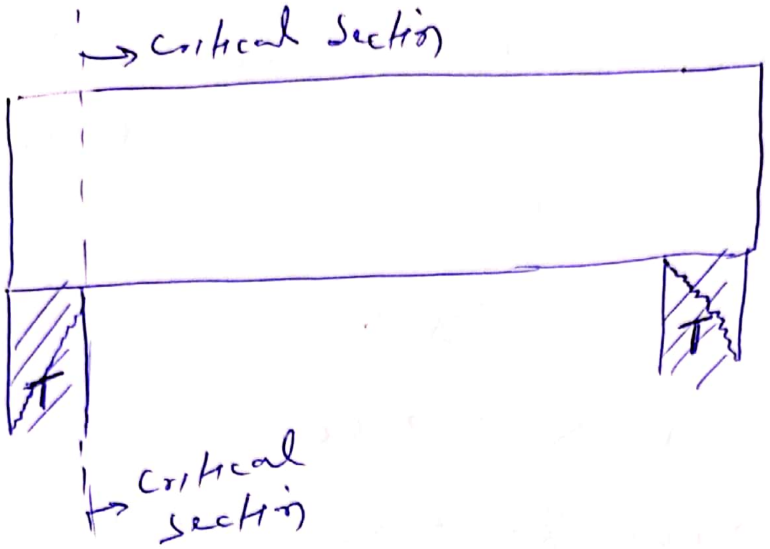
(IV) If $\tau_v > \tau_{c\,max}$
Redesign the section

⇒ **Critical section for shear**

(I) If the beam is creating compression at the support, critical section is at "d" distance from face of support.



(ii) If the beam is creating tension in the support, critical section is at the face of support.



⇒ Bond and Development length

$$\text{Bond stress } (\tau_{bd}) = \frac{V}{\Sigma 0 \cdot J \cdot d}$$

→ Bond stress is also called longitudinal shear stress b/w steel & concrete.

→ For the reinforcement to be safe in bond, provide more number of reinforcement of small diameter.

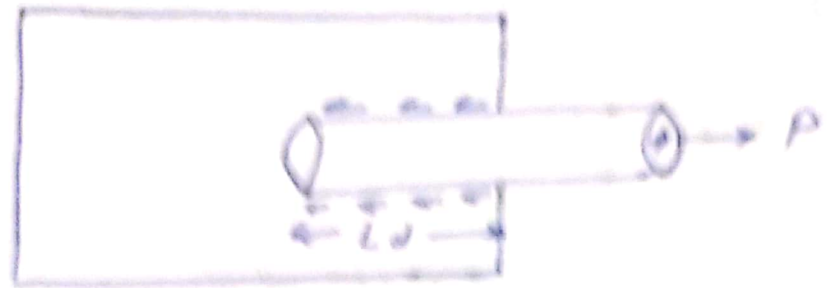
→ For Mild steel reinforcement in Tension

	M15	M20	M25	M30	M35	M40	M45	M50
WSM	0.60	0.80	0.90	1.0	1.1	1.2	1.3	1.4
LSM	–	1.2	1.4	1.5	1.7	1.9	1.9	1.9

(i) For HYSD/other type → Increase above value by 60%.

(ii) For Bar in Compression → Increase above value by 25%.

Development length (Ld)



Development length is the minimum length of steel reqd to be embedded in concrete, so that strength of reinforcement in bond is not less than the strength of reinforcement in tension.

Strength in Tension

$$= \frac{\pi}{4} \times \phi^2 \times \sigma_{st} \quad \text{—— (1)}$$

or $\frac{\pi}{4} \phi^2 \times 0.87 f_y$

Strength of reinforcement in bond

$$= \tau_{bd} \times \pi \times \phi \times L_d \quad \text{—— (2)}$$

Equate (1) & (2)

$$\frac{\pi}{4} \cdot \phi^2 \cdot \sigma_{st} = \tau_{bd} \times \pi \times \phi \times L_d$$

$$\boxed{L_d = \frac{\phi \cdot \sigma_{st}}{4 \tau_{bd}}} \quad \text{or} \quad \boxed{L_d = \frac{0.87 f_y \phi}{4 \tau_{bd}}}$$

→ $(L_d)_{HYSD} > (L_d)_{\text{Mild steel}}$

→ As per IS code (Page 44)

For +ve reinforcement

$$\boxed{L_d \leq \frac{M_1}{V} + L_0}$$

$M_1 \rightarrow$ Moment of resistance of the section assuming all reinforcement are stressed upto σ_{st} or $0.87 f_y$

$= \sigma_{st} \times A_{st} \times J d \longrightarrow$ WSM

$= 0.87 f_y A_{st} J.d \longrightarrow$ LSM

$V \rightarrow$ Shear force at support

$L_o \rightarrow$ sum of anchorage of reinforcement beyond centre of support.

$= \left(\frac{L_s}{2} - x'\right)$ $[x' \rightarrow \text{cover}]$

→ If end of the reinforcement are confined by a compression reaction, the value of $\frac{M_1}{V}$ may be increased by 30%.

$$L_d \leq 1.30 \frac{M_1}{V} + L_o$$

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and Happy Learning