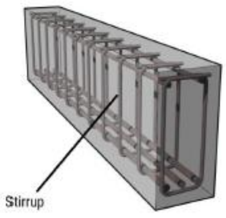
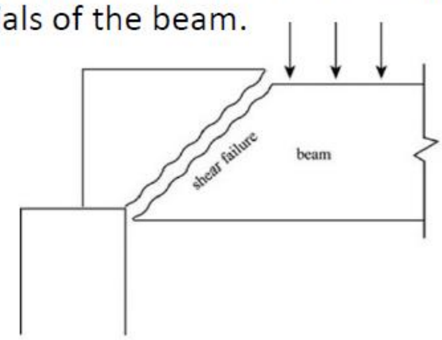
Design of Shear and torsion

Behaviour of RC members in Shear

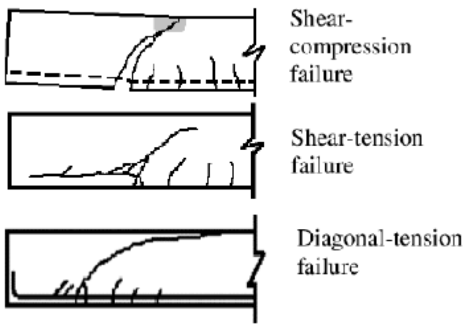
- Shear failure occurs when the beam has **shear resistance lower than flexural strength** and the shear force exceeds the shear capacity of different materials of the beam.





Different types of shear failure in beam

- Shear tension failure
- Shear compression failure
- Diagonal Tension Failure



NOMINAL SHEAR STRESS

$$\tau_v = \frac{V_u}{b\,d}$$

τ_v = nominal shear stress

V_u = shear force due to design load

b = breadth of the member, which for flanged sections shall be taken as the breadth of the web, b_w

d = effective depth

Nominal Shear Stress in Case Beams of Varying Depth

Beams of uniform width and varying depths are commonly used in practice. Cantilever beams continuous beam with haunches at support, footings etc. fall under this category. In case of beams of varying depth the nominal shear stress is calculated by the modified equation given below.

$$\tau_v = \frac{V_u \pm \frac{M_u}{d} \tan\beta}{bd}$$

Where τ_v, V, b and d has same meaning as above

M = bending moment at the section

β = *angle between the top and bottom edges of the beam.*

$$V_c = \tau_c . b . d$$

$$p = \frac{100 A_s}{bd}$$

Design shear strength of concrete, τ_c in N/mm^2

$(100 A_s/bd)$	Grade of concrete				
	M 20	M 25	M 30	M 35	M40 and above
≤ 0.15	0.28	0.29	0.29	0.29	0.30
0.25	0.36	0.36	0.37	0.37	0.38
0.50	0.48	0.49	0.50	0.50	0.51
0.75	0.56	0.57	0.59	0.59	0.60
1.00	0.62	0.64	0.66	0.67	0.68
1.25	0.67	0.70	0.71	0.73	0.74
1.50	0.72	0.74	0.76	0.78	0.79
1.75	0.75	0.78	0.80	0.82	0.84
2.00	0.79	0.82	0.84	0.86	0.88
2.25	0.81	0.85	0.88	0.90	0.92
2.50	0.82	0.88	0.91	0.93	0.95
2.75	0.82	0.90	0.94	0.96	0.98
≥ 3.00	0.82	0.92	0.96	0.99	1.01

Design of Shear Reinforcement

When τ_v exceeds τ_c given in Table 19, shear reinforcement shall be provided in any of the following forms:

a) Vertical stirrups,

b) Bent-up bars along with stirrups, and

c) Inclined stirrups.

Shear reinforcement shall be provided to carry a shear equal to $V_u - \tau_c\, bd$ The strength of shear reinforcement V_{us} shall be calculated as below:

a) For vertical stirrups:

$$V_{us} = \frac{0.87 f_y A_{sv} d}{s_v}$$

b) For inclined stirrups or a series of bars bent-up at different cross-sections:

$$V_{us} = \frac{0.8.7 f_y A_{sv} d}{s_v} (\sin\alpha + \cos\alpha)$$

c) For single bar or single group of parallel bars, all bent-up at the same cross-section:

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

The minimum shear reinforcement in the form of stirrups shall be provided such that:

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

where

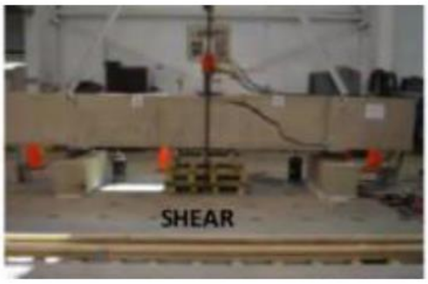
A_{sv} = total cross-sectional area of stirrup legs effective in shear,

s_v = stirrup spacing along the length of the member,

b = breadth of the beam or breadth of the web of the web of flanged beam b_w, and

f_y = characteristic strength of the stirrup reinforcement in N/mm^2 which shall not be taken greater than 415 N/mm^2.

Behaviour of rectangular RC beams in shear and torsion



$V_e = V_u + 1.6(T_u/b)$

where V_e = equivalent shear,

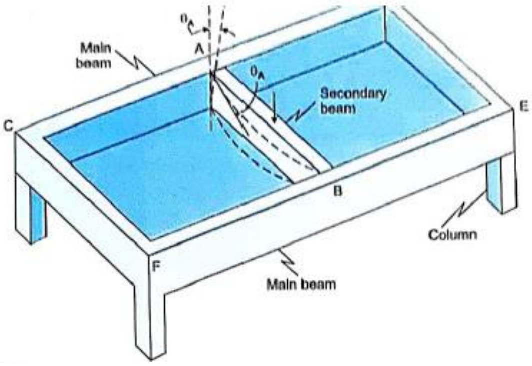
V_u = actual shear,

T_u = actual torsional moment,

b = breadth of beam.

(b) The equivalent nominal shear stress τ_{ve} is determined from:

$\tau_{ve} = (V_e / bd)$



, τ_{ve} shall not exceed τ_{cmax} given in Table 20 of IS 456

The longitudinal flexural tension reinforcement shall be determined to resist an equivalent bending moment M_{e1} as given below:

$$M_{e1} = M_u + M_t$$

where M_u = bending moment at the cross-section, and

$M_t = (T_u/1.7)\{1 + (D/b)\}$

where T_u = torsional moment,

D = overall depth of the beam, and

b = breadth of the beam.

The transverse reinforcement consisting of two legged closed loops enclosing the corner longitudinal bars shall be provided having an area of cross-section A_{sv} given below:

$$A_{sv} = \frac{T_u\, s_v}{b_1\, d_1 (0.87 f_y)} + \frac{V_u\, s_v}{2.5\, d_1 (0.87 f_y)}$$

However, the total transverse reinforcement shall not be less than the following:

$$A_{sv} \geq (\tau_{ve} - \tau_c)\, b\, s_v / (0.87 f_y)$$

where T_u = torsional moment,

V_u = shear force,

s_v = spacing of the stirrup reinforcement,

b_1 = centre to centre distance between corner bars in the direction of the width,

d_1 = centre to centre distance between corner bars,