Steps for Design of Shear reinforcement

Given, load, l, Material, ASI.

Procedure:

(a) Calculate shear force (V_u) at the critical section of the beam

(b) Determine nominal stress $\tau_v = \frac{V_u}{bd}$

(c) Find τ_c

(d) Compare τ_v & $\tau_{c\,max}$, if $\tau_v > \tau_{c\,max}$ redesign

(e) compare τ_v & τ_c

(i) If $\tau_v < \tau_c$ → Nominal shear reinforcement is to be provided in the form of vertical stirrups

The spacing of vertical stirrups is given by, $\frac{A_{sv}}{b\,s_v} \geq \frac{0.4}{0.87 f_y}$, $\frac{b s_v}{A_{sv}} = \frac{0.87 f_y}{0.4}$, $s_v = \frac{0.87 f_y A_{sv}}{0.4 b}$

(ii) If $\tau_v > \tau_c$ — shear reinforcement is to be designed as follows

- calculate $V_{us} = V_u - \tau_c bd$
- If vertical stirrups are provided then

their spacing, $V_{us} = \frac{0.87 f_y \cdot A_{sv} \cdot d}{s_v}$

- If bent up bars are used, spacing,

$V'_{us} = 0.87 f_y A_{sv} \cdot \sin\alpha$.

(f) spacing of stirrups ⊁ 0.75d or 300mm which ever is less

(g) The spacing of stirrups can be varied along the length of the beam by calculating the distance from the supports up to which

Shear reinforcement is to be designed & in rest of the length min shear reinf. may provided.

1) An R.C.C. Beam 300 × 600 mm in section is (effective) it is reinforced with 5 - 25 mm ϕ bars subjected to a design shear force of 200 kN. Use M20 & Fe415

Given $b = 300mm$, $d = 600mm$

$V_u = 200 \times 10^3 N$, $A_{st} = 5 \times \frac{\pi}{4} \times 25^2$

$= 2454.3 mm^2$

Step 1 Nominal shear stress, $\tau_v = V_u / bd$

$= \frac{200 \times 10^3}{300 \times 600}$

For M20 -

$\tau_v = 1.11 N/mm^2$

From Table 20 of IS456, M20

$\tau_{c\,max} = 2.8 N/mm^2$

∴ $\tau_v < \tau_{c\,max}$ hence ok.

Step 2 Design shear strength of con τ_c

% of steel, $P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 2454.3}{300 \times 600}$

$P_t = 1.36\%$.

From Table 19 of IS456, $P_t = 1.365$.

1.25 = 0.67

1.5 = 0.72

~~= 0.67 +~~

$= 0.67 + \frac{0.72 - 0.67}{1.5 - 1.25} (1.36 - 1.25)$

$\tau_c = 0.69 N/mm^2$

∴ $\tau_v < \tau_c$, hence shear design is not req. but nominal reinforcement is to be provided

A simply supported R.C.C beam 250mm wide & 450mm deep is reinforced with a 4-18mm ϕ bars. Design the shear reinforcement the beam is subjected to a shear force of 150 kN at .

Given $b = 250mm$, $d = 450m$

$A_{st} = 4 \times \frac{\pi}{4} \times 18^2 = 1018 mm^2$

$V = 150 \times 10^3 N$.

(i) Factored shear force $(V_u) = 1.5 \times 150$

$= 225kN$.

(ii) Nominal shear stress (τ_v)

$\tau_v = \frac{V_u}{bd} = \frac{225000}{250 \times 450}$

$= 2 N/mm^2$

$\tau_{c max} = 2.8 N/mm^2$

$\tau_v < \tau_{c max}$, hence O.K.

(iii) Design shear strength of con (τ_c)

$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 1018}{250 \times 450}$

$P_t = 0.9\%$

$\tau_c = 0.56 + \frac{0.62 - 0.56}{1 - 0.75}(0.9 - 0.75)$

1.0 = 0.62
0.75 = 0.56

$\tau_c = 0.596 N/mm^2$

$\tau_v > \tau_c$, hence shear reinforcement is provided

(iv) Design of shear reinforcement

Shear taken by stirrups $= V_{us}$

$V_{us} = V_u - \tau_c bd$

= 225000 − 0.546 × 250 × 450

V_{us} = 157950 N

using 8mm ϕ 2 legged stirrups.

$A_{sv} = 2 \times \frac{\pi}{4} \times 8^2 = 100.5 mm^2$

Spacing of stirrups $S_v = \frac{0.87 f_y A_{sv} \cdot d}{V_{us}}$

$= \frac{0.87 \times 415 \times 100.5 \times 450}{157950}$

$S_v = 103 mm$

(v)* Spacing of nominal (min) shear reinforcement

$S_v = \frac{0.87 f_y A_{st}}{0.4 b}$

$= \frac{0.87 \times 415 \times 100.5}{0.4 \times 250}$

S_v = 362 mm

Check for spacing.

. spacing of stirrups should be min of the following

(i) 0.75d = 0.75 × 450 = 337 mm

(ii) 300 mm

(iii) 103 mm ≈ 100 mm, (iv) 362 mm

provide 2 legged 8mm ϕ stirrups @ 100 mm c/c through the length of the beam

An R.C.C beam 250mm x 400mm eff. is carrying a udl of 15kN/m. The beam is reinforced with 4 bars of 22mm dia. the clear span of 4m. Design the shear reinforcement use M20 & Fe 250 ($A_s = 1520\ mm^2$)

Factored shear stress (V_u) = w x load factor

Factored load = 15 x 1.5

W_u = 22.5 kN/m

= 22500 N/m

Factored S.F, $V_u = \frac{W_u l}{2}$

$= \frac{22500 \times 4}{2}$

$V_u = 45000N$.

Nominal shear stress (τ_v)

$\tau_v = \frac{V_u}{bd} = \frac{45 \times 10^3}{250 \times 400}$

$= 0.45\ N/mm^2$

$\tau_c\ max = 2.8\ N/mm^2$ (Table 20)

$\tau_v < \tau_c max$ hence o.k

Shear strength of con (τ_v – Table 19)

To Calculate τ_v, Calculate $P_t = \frac{100 A_{st}}{bd}$

$P_t = \frac{100 \times 1520}{250 \times 400} = 1.5\%$

for $p_t = 1.5\%$ & M20 con, $\tau_c = 0.72\ N/mm^2$

$\tau_v < \tau_c$, ∴ no shear reinf. is required. But IS code recommends that nominal shear reinf. must be req.

Nominal shear reinf:

use 8mm 2legged stirrups

$A_{sv} = 2 \times \frac{\pi}{4} \times 8^2 = 100.5\ mm^2$

Spacing of stirrups, $S_v = \frac{0.87 f_y A_{sv}}{0.4b}$

$$= \frac{0.87 \times 250 \times 100.5}{0.4 \times 250}$$

$S_v = 218mm$ say 210mm

check for spacing :- spacing of stirrups should be least of following

(i) $0.75d = 0.75 \times 400 = 300mm$

ii) 300mm

iii) $S_v = 210mm$

∴ provide 8mm 2 legged stirrups @ 210mm c/c.