SECTION 11. DESIGN FOR SHEAR

As all ***mortarless*** walls are grouted and reinforced and can readily be designed to satisfy the provisions of IS 456:2000 for shear. IS 456:2000 Part 40 provides the rules for shear strength and shear reinforcement using the ultimate limit state of collapse method.

11.1 Shear resistance of reinforced *mortarless* members in bending

Clause 40.1 states that the nominal shear stress τ_v in beams of uniform depth is calculated thus:

$$\tau_v = V_u / bd$$

Where:

V_u = the shear force due to the design loads
b = the breadth of the beam which for a flanged section shall be the breadth of the web
d = the effective depth

The design shear strength of a ***mortarless*** beam is calculated using the design shear strength of concrete τ_c given IS 456:2000 Table 19 and for convenience this is Table is presented as a graph in Figure 11.1-1

Refer to Clause 40.1.1 for beams of varying depth but this will not generally apply to ***mortarless*** beams.

If τ_v is greater than τ_c then shear reinforcement must be provided (refer Clause 40.4). In ***mortarless*** beams the shear reinforcement is in the form of anchored vertical bars and these can be considered single leg stirrups. The shear reinforcement is to be designed to carry a shear force equal to $V_u - \tau_c bd$ and the strength of the shear reinforcement is calculated as follows:

$$V_{us} = (0.87\, f_y\, A_{sv}\, d) / s_v$$

Where:

A_{sv} = the total cross-sectional area of the stirrups within a distance sv
s_v = the spacing of the stirrups
f_y = the characteristic strength of the stirrup <u>but not greater</u> than 415MPa
d = the effective depth of the section

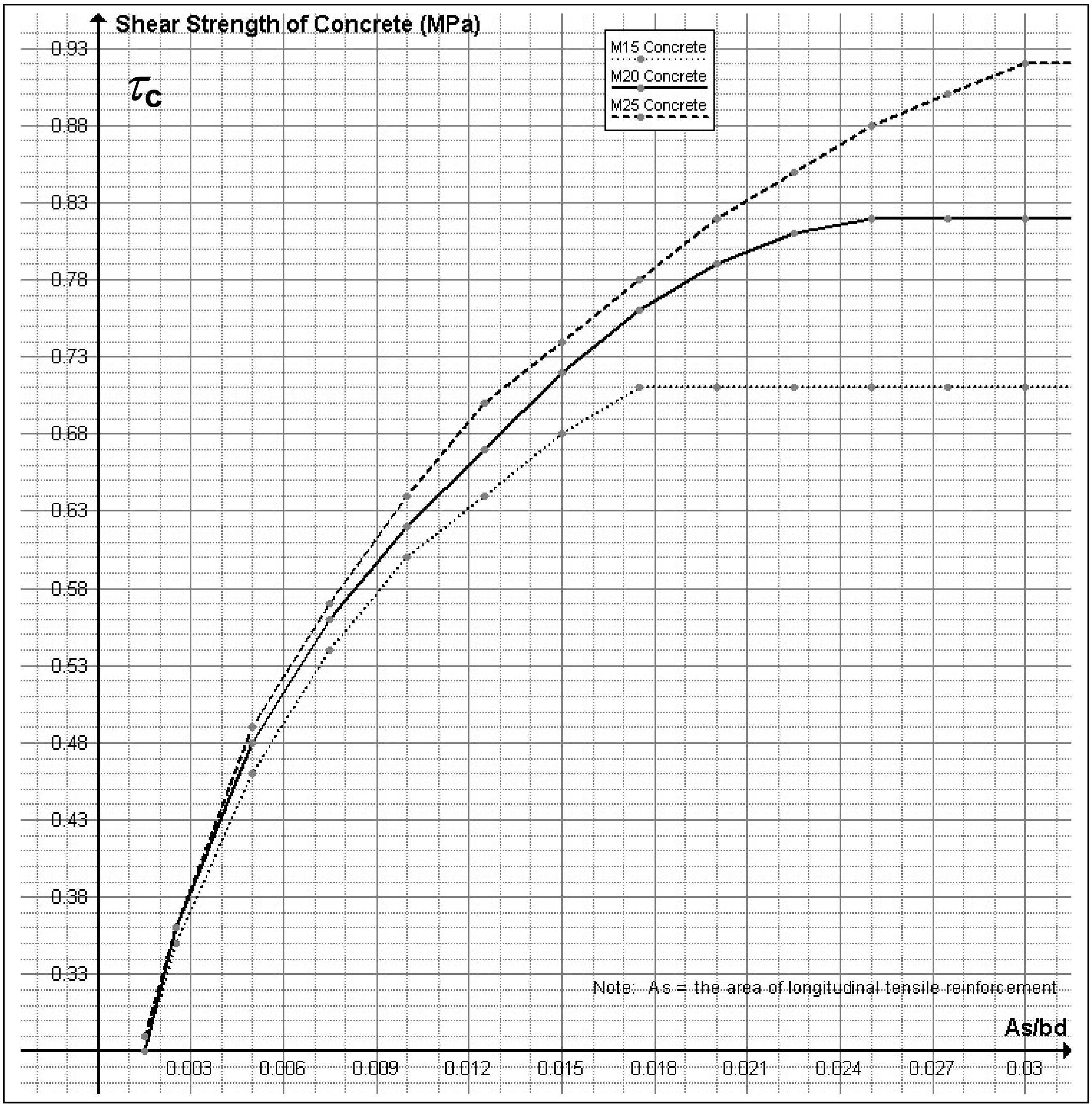
If τ_v is less than τ_c then minimum shear reinforcement must be provided in accordance with Clause 26.5.1.6 (IS 456:2000 Clause 40.3)

$$A_{sv} \geq (0.46\, b\, s_v) / f_y \qquad (f_y \text{ not to be greater than 415MPa})$$

except that no shear reinforcement is required if $\tau_v < 0.5\, \tau_c$ and the member is "of minor structural importance such as lintels".

Clause 26.5.1.5 states that the maximum spacing of shear reinforcement (vertical stirrups) is to be the lesser of 0.75d and 300mm. Due to the nature of ***mortarless*** masonry units the spacing of shear reinforcement must be 200mm, 400mm or greater in increments of 200mm. This means that the minimum effective depth of a ***mortarless*** beams that is to have shear reinforcement is 267mm and as a consequence it means that the minimum overall depth of a ***mortarless*** beam that is to have sear reinforcement is 600mm (3 courses).

Figure 11.1-1



In the above Figure 11.1-1 τ_c is the shear strength of ***mortarless*** beams and slabs that don't have shear reinforcement, i.e. it is the shear strength of the concrete.

11.2 Shear resistance of reinforced *mortarless* walls subject to in-plane horizontal load

IS 456:2000 Clause 32.4 provides the rules for in-plane shear strength of walls designed as shear walls in a structure. Depending on the geometry of the particular wall panel being considered, the horizontal or vertical reinforcement in the wall will contribute to the strength of the wall in resisting in-plane horizontal loads.

In situations where the shear strength of the concrete is not greater than the design horizontal load then the adequacy of the reinforcement must be checked.

IS 456:2000 Clause 32.4.3 is to be used for the calculation of the shear strength of the concrete in the wall and there are two considerations:

1. When $H_w/L_w \leq 1$ then $\tau_{cw} = 0.2\sqrt{f_{ck}}\,(3.0 - H_w/L_w)$

2. When $H_w/L_w > 1$ then $\tau_{cw} = 0.2\sqrt{f_{ck}}\,(3.0 - H_w/L_w)$ or

   $\tau_{cw} = 0.45\sqrt{f_{ck}}\,((H_w/L_w)+1)/((H_w/L_w)-1)$ whichever is the less <u>but not less than</u> $0.15\sqrt{f_{ck}}$

IS 456:2000 Clause 32.4.4 states that shear reinforcement be provided to carry a shear force equal to

$$V_u - \tau_{cw}\, t_d(0.8L_w)$$

It further states that when designing using the Limit State of Collapse method, the strength of the shear reinforcement shall be calculated as per Clause 40.4 with

$$A_{sv} = P_w\, t_d\,(0.8L_w)$$

where:

P_w shall be the lesser of A_{sv}/A_c or A_{sh}/A_c when $H_w/L_w \leq 1$
and
$P_w = A_{sh}/A_c$ when $H_w/L_w > 1$

and where:

t_d = the design thickness of the wall
A_{sv} = the cross sectional area of the vertical reinforcement
A_{sh} = the cross sectional area of the horizontal reinforcement
A_c = the corresponding cross sectional area of the concrete
H_w = the height of the wall
L_w = the length of the wall

11.3 Shear resistance of reinforced *mortarless* walls subject to out-of-plane horizontal load

Shear stress in a ***mortarless*** wall might need to be checked if the wall is subjected to significant out-of-pane lateral loads. In such circumstances the wall should be designed in the same way as a slab but consideration should be given to any permanent axial compression loads as these will increase the shear capacity of the concrete. It is most important however to only consider permanent axial compression loads when checking shear capacity.

Clause 40.2.1 states that the design shear strength of the concrete in solid slabs shall be $\tau_c k$ where:

k = 1.10 for 250 thick slabs
= 1.15 for 225 thick slabs
= 1.20 for 200 thick slabs
= 1.25 for 175 thick slabs
= 1.30 for 150 thick slabs and all thinner slabs.

τ_c is as given in Fig 11.1-1 above.

Clause 40.2.2 states that when the cross section is subject to an axial compressive stress then the value of τ_c can be increased by a multiplier of $1+(3P_u/A_g f_{ck})$ but not greater than 1.5.

Clause 40.2.3.1 states that for solid slabs the nominal shear stress in the concrete shall not exceed:

1.25MPa for M15 concrete
1.40MPa for M20 concrete
1.55MPa for M25 concrete
1.75MPa for M30 concrete