SECTION 10. DESIGN FOR SHEAR

Mortarless masonry members can be designed as unreinforced masonry or reinforced masonry. Even if the member contains reinforcement it must be designed as unreinforced if the reinforcement does not comply with the structural design requirements of AS 3700 Section 8. (refer AS 3700 Clause 7.1)

AS 3700 Clause 8.2 clarifies this as follows: "Masonry that includes reinforcement not complying with the requirements of this Section for a specific action shall be regarded as unreinforced for that action and designed in accordance with Section 7 ……."

Load-bearing ***mortarless*** walls are designed as unreinforced for compression but they are designed as reinforced for bending. They can also be designed as unreinforced for shear however it is strongly recommended that they should be designed as reinforced for shear and reinforced accordingly.

10.1 Design of unreinforced *mortarless* for shear

There are two components to the shear strength of unreinforced masonry; the shear bond strength (V_0), and the shear friction strength (V_1) (AS 3700 Clause 7.5). Shear friction strength only exists if the shear plane is under compression.

10.1.1 In-plane shear - other than earthquake loads

Shear capacity in horizontal planes: The following relationship must be satisfied for each combination of the design shear force (V_d) and the minimum simultaneously acting design compressive stress (f_d), but note this does not apply to a member being designed to withstand earthquake loads (AS 3700 Clause 7.5.4.1):

$$V_d \leq V_0 + V_1$$

Where: V_0 = $\Phi f'_{ms} A_d$ (shear bond strength of the shear section)

V_1 = $k_v f_d A_d$ (shear friction strength of the shear section)

Φ = 0.60 for shear (unreinforced masonry)

f'_{ms} = the characteristic shear strength of the masonry

= 1.25 f'_{mt} but not greater than 0.35 MPa and not less than 0.15 MPa for shear in the horizontal direction in a continuous horizontal mortar joint. (clearly very conservative for fully grouted hollow concrete blockwork)

= zero where there are no shear connectors and no header units crossing the shear plane for shear in the vertical direction or 1.25 f'_{mt} but not greater than 0.35 MPa where connectors in accordance with AS 3700 Clause 4.11 intersect the shear plane (again considered conservative for fully grouted hollow concrete blockwork laid in stretcher bond)

A_d = the design cross-sectional area of the shear resisting portion of the member i.e. the combined bedded area and grout area

k_v = a shear factor for calculating the frictional component of the shear capacity (refer AS 3700 Table 3.3)

= 0.3 at interface of masonry with concrete

f_d = the minimum design compressive stress on the bed joint under consideration that acts simultaneously with the shear force but not greater than 2 MPa

Shear capacity in vertical plane: The following relationship must be satisfied for members designed to withstand vertical shear forces (AS 3700 Clause 7.5.4.2):

$$V_d \leq V_0$$

Where: V_0 = $\Phi f'_{ms} A_d$ (shear bond strength of the shear section)

Φ = 0.60 for shear (unreinforced masonry)

f'_{ms} = the characteristic shear strength of the masonry

= 1.25 f'_{mt} but not greater than 0.35 MPa and not less than 0.15 MPa for shear in the horizontal direction in a continuous horizontal mortar joint. (clearly very conservative for fully grouted hollow concrete blockwork)

= zero where there are no shear connectors and no header units crossing the shear plane for shear in the vertical direction or 1.25 f'_{mt} but not greater than 0.35 MPa where connectors in accordance with AS 3700 Clause 4.11 intersect the shear plane (again considered conservative for fully grouted hollow concrete blockwork laid in stretcher bond)

A_d = the design cross-sectional area of the shear resisting portion of the member i.e. the combined bedded area and grout area

10.1.2 In-plane shear - earthquake loads

$$V_d \leq V_0 + V_{1e}$$

Where: V_0 = $\Phi f'_{ms} A_d$ (shear bond strength of the shear section)

V_{1e} = $0.9 k_v f_{de} A_d$ (shear friction strength of the shear section under earthquake actions)

Φ = 0.60 for shear (unreinforced masonry)

f'_{ms} = the characteristic shear strength of the masonry
= 1.25 f'_{mt} but not greater than 0.35 MPa and not less than 0.15 MPa for shear in a horizontal direction in a continuous horizontal mortar joint.

A_d = the design cross-sectional area of the shear resisting portion of the member i.e. the combined bedded area and grout area

k_v = a shear factor
= 0.3 at interface of masonry with concrete

f_{de} = the minimum design compressive stress on the bed joint for earthquake induced shear

= $0.9G_g/A_d$ where G_g is the gravity load, or

= $0.8G_g/A_d$ where the gravity load acting on the masonry member contributes to the resistance but not to the induced lateral earthquake loads on the masonry

= refer to AS 1170.0 for other cases

10.2 Design of reinforced *mortarless* for shear

Rules for the design of reinforced ***mortarless*** members in shear are given in AS 3700 Clause 8.7.

All walls subject to in-plane forces must also be checked for bending and overall stability.

10.2.1 Walls subject to in-plane shear where $H/L \leq 2.3$ (i.e. long walls)

$$V_d \leq \Phi(f_{vr} A_d + 0.8 f_{sy} A_s)$$

Where: V_d = The design shear force acing on the cross section

Φ = 0.75 for shear (reinforced masonry)

f'_{vr} = the effective shear strength
= (1.50 – 0.5 H/L) MPa

A_d = the design cross section area of the member

f_{sy} = the design yield strength of the reinforcement

A_s = The cross sectional area of reinforcement as follows:
(i) If $H/L > 1.0$, then $A_s = A_{sh}\, L/H$ (where A_{sh} = total area of anchored horizontal reinforcement)
(ii) If $H/L \leq 1.0$, then A_s = the lesser of the total cross-sectional area of horizontal reinforcement or the total cross-sectional area of vertical reinforcement.

Note however that the reinforcement must comply with the following:

a) It must be located symmetrically in the cross-section

b) Vertical reinforcement must be placed at centres not exceeding 0.75*H* and in any case not greater than 2000 mm

c) Horizontal reinforcement must be placed at centres not exceeding 0.75*L* and in any case not greater than 3000 mm

d) The vertical reinforcement must be such that $A_s \geq 0.0013\, A_d$ and the horizontal reinforcement must be such that $A_s \geq 0.0007\, A_d$. If the reinforcement does not meet these requirements then the wall must be designed as for unreinforced masonry in shear.

e) Reinforcement with a cross-sectional area of at least 100 mm^2 must be included within 300mm of edges parallel to the main reinforcement unless the wall reinforcement is anchored into an abutting reinforced concrete member, in which case edge reinforcement can be omitted.

Where the wall is not externally supported against overturning, it must be anchored to provide resistance to overturning and shear forces such that:

$$V_d \leq \Phi [k_{sw} P_v L/2 + f_{sy} A_{sv} (L - 2l')] / H$$

Where:

V_d = The design shear force acting on the cross-section of the wall

Φ = 0.75 for shear (reinforced masonry)

k_{sw} = $1 - P_v / (A_d f'_m)$

P_v = the applied uniform vertical load

f'_m = the characteristic compressive strength of the masonry

A_b = the bedded area of the masonry cross-section

A_{sv} = the cross-sectional area of the fully anchored shear reinforcement perpendicular to the direction of the applied shear

f_{sy} = the design yield strength of the reinforcement

L = the length of the member in the direction of the shear load

l' = the distance from the centroid of the reinforcement under consideration to the tensile end of the member

H = the height of the member perpendicular to the direction of the shear load.

10.2.2 Walls subject to in plane shear where $H/L > 2.3$ (i.e. short walls)

The wall must be designed in accordance with the requirements for out-of-plane shear in walls

10.2.3 Walls subject to out-of-plane shear

$$V_d \leq \Phi [f'_{vm} b_w d + f_{vs} A_{st} + (f_{sy} A_{sv} d) / s]$$

but not greater than $4 \Phi f'_{vm} b_w d$

Where: V_d = The design shear force acing on the cross section

Φ = 0.75 for shear

f'_{vm} = the characteristic shear strength of the masonry = 0.35 MPa

b_w = the width of the web of the shear resisting area of the masonry wall
= b for a solid rectangular cross-section

d = the effective depth of the cross section

f_{vs} = the design shear strength of the main reinforcement = 17.5 MPa

A_{st} = The cross sectional area of the fully anchored longitudinal reinforcement in the tension zone of the cross-section under consideration, or $0.02 b_w d$, whichever is less.

f_{sy} = the design yield strength of the reinforcement

A_{sv} = the cross-sectional area of the shear reinforcement

s = the spacing of the shear reinforcement

10.2.4 Shear in beams

A reinforced ***mortarless*** beam subject to shear should be designed in accordance with the requirements for out-of-plane shear in walls (refer 10.2.3 above). When shear reinforcement is required it must meet the following requirements:

- it must be spaced at not more than $0.75D$ or 600mm centres, whichever is less, and
- it must be in accordance with the requirements of AS 3600 for shear reinforcement.