SECTION 8. DESIGN OF *mortarless* MASONRY MEMBERS FOR BENDING

8.1 Unreinforced *mortarless* members in bending:

As all ***mortarless*** walls and piers are fully grouted and at least lightly reinforced, it makes sense to capitalise on the situation and install sufficient reinforcement to design them as reinforced masonry members for flexure. If the amount of relevant reinforcement does not meet minimum requirements however, the wall or pier can be designed as unreinforced in which case any reinforcement is simply ignored when calculating the bending strength.

Unreinforced ***mortarless*** members can be designed for vertical bending, horizontal bending or two-way bending as appropriate in accordance with the requirements of BS 5628-1:2005 Clause 32.

Note that the Australian Code AS 3700 only permits the design of unreinforced ***mortarless*** masonry members for bending if the out-of-plane forces causing bending are of a transient nature. Note also that ***mortarless*** masonry with less than the minimum reinforcement for bending is considered unreinforced for design purposes.

8.2 Reinforced *mortarless* walls subject to bending transverse to the plane of the wall:

All ***mortarless*** masonry walls and piers must be fully grouted and therefore as stated above it is only logical that at least the minimum reinforcement for bending should be installed and the masonry designed as reinforced for bending. When this is so BS 5628-2:2005 Clause 8.2 applies, but note that this clause is applicable to the design of elements subjected only to bending. (BS 5628-2:2005 Clause 8.3 gives recommendations for the design of members subjected simultaneously to substantial vertical and horizontal loading or to eccentric vertical loads where the resultant eccentricity exceeds 0.05 times the thickness of the member in the direction of the eccentricity - refer to Section 9 of this Manual for the design of members subjected to combined bending and compression.)

Clause 8.2.4.1 requires the following assumptions be made when analysing a cross section to determine its design moment of resistance:

a) Plane sections remain plane…….;
b) Compressive stress distribution is represented by an equivalent rectangle…..;
c) The maximum strain in the outermost compression fibre at failure is 0.0035;
d) The tensile strength of the masonry is ignored;
e) Th charcteristic strength of reinforcing steel ……; and
f) The span to effective depth ratio of the member is not less than 1.5.

The Code does permit designing a member to Clause 8.2 for bending only ignoring the effect of the axial force, provided there is only a small axial thrust on the member. The condition is that the axial force does not exceed $\mathbf{0.1}\, f_k\, A_m$ where A_m is the cross-sectional area of the masonry. (refer Clause 8.2.4.1) This amounts to 125 kN/m for walls constructed with 200 Mortarless Grade 15 masonry units and 155 kN/m for walls constructed with 200 Mortarless Grade 20 masonry units.

Effective span

The effective span of a simply supported or continuous member is the smaller of:

- the distance between the centres of the supports, and
- the clear distance between the supports plus the effective depth.

The effective span of a cantilever is the smaller of:

- the distance between the end of the cantilever and the centre of its support, and
- the distance between the end of the cantilever and the face of its support plus half the effective depth.

Limiting span to effective depth ratios

The limiting span to effective depth ratios recommended in BS 5628-2:2005 Clause 8.2.3 are as follows:

- 35 for simply supported walls,
- 45 for continuous walls, and
- 18 for cantilever walls with percentage of reinforcement up to and including 0.5%.

If the span to effective depth ratios exceed these values then detailed calculations may be required to check that the limit states of deflection and cracking are not reached.

Cantilevered walls that are reinforced to resist lateral loading and that are not part of a building have a limiting span to effective depth ratio of 24, again provided the amount of reinforcement is not greater than 0.5%.

Design of singly reinforced rectangular members:

BS 5628-2:2005 Clause 8.2.4.2.2 provides the following formula for the design moment of resistance, M_d, of a singly reinforced ***mortarless*** masonry member (wall or beam):

$$M_d = Q\, b\, d^2$$

Where: Q = the moment of resistance factor

= $2c\,(1-c)\, f_k / \gamma_{mm}$ but not greater than $0.4\, f_k / \gamma_{mm}$

b = the width of the section

d = the effective depth

c = the lever arm factor z/d

= $1 - (0.5\, A_s\, f_y\, \gamma_{mm}) / (b\, d\, f_k\, \gamma_{ms})$

A_s = the cross-sectional area of the primary reinforcing steel;

f_k = the characteristic compressive strength of the masonry;

f_y = the characteristic tensile strength of the reinforcing steel;

γ_{mm} = the partial safety factor for strength of masonry;

γ_{ms} = the partial safety factor for strength of steel.

For the design of flanged members refer BS 5628-2:2005 Clause 8.2.4.3.1.

When reinforcement spacing is greater than 3 x the thickness of the blockwork, then the design width for bending should be considered as 3 x the thickness of the blockwork. This has been taken into account when calculating the values in the design tables in Part 2a of this Design Manual.

8.3 Reinforced *mortarless* walls subject to bending in the plane of the wall:

This applies to walls or parts of walls that are acting as beams, for example lintel beams and wall beams. BS 5628-2:2005 outlines the recommended approach which is summarised as follows:

- The analysis and design of the walls should follow the code recommendations for beams;
- Where the slenderness ratio exceeds 12 in any direction, it is also essential to take account of the slenderness at right angles to the plane of the wall by calculating the maximum compressive stress in the wall and checking that it complies with the provisions for slender columns.

8.4 Reinforced *mortarless* beams:

The limiting span to effective depth ratios for beams are as follows:

- 20 for simply supported beams,
- 26 for continuous beams, and
- 7 for cantilever beams.

The distance between lateral restraints should not exceed the lesser of

60 b_c and **250** b_c^2 **/ 2**

where: b_c is the width of the compression face midway between restraints and
d is the effective depth.

For cantilever beams these limiting ratios are reduced to **25** b_c and **100** b_c^2 **/ 2**

BS 5628-3:2005 also requires that all reinforced masonry lintels comply with BS EN 845-2, and that they have sufficient concrete cover to adequately protect the reinforcement.