SECTION 7. DESIGN OF *mortarless* MASONRY MEMBERS FOR COMPRESSION

Mortarless masonry walls and piers cannot be designed as reinforced masonry for the compression loads because reinforcement in compression members must be restrained in two directions by ties at close centres. For example in 140 thick walls it would be necessary to install ties at 140mm centres on all vertical bars, and in 200 thick walls it would be necessary to install ties at 200mm centres. This is simply not possible in masonry walls. Tied column cages may be appropriate in larger freestanding masonry piers or columns, however there is no masonry unit manufactured in the ***mortarless*** range at present for such piers or columns.

Mortarless walls and piers should therefore generally be designed as core filled but unreinforced in compression. Any vertical reinforcement can simply be ignored in the calculation of compression capacity.

BS 5628-2:2005 Clause 8.6.5.3 however does permit a small contribution from the main bars in reinforced masonry columns in which there are no ties when the area of the main reinforcement is greater than 0.25% of the area of the masonry, and not more than 25% of the design axial load resistance of the reinforcement is to be used.

Design of <u>unreinforced</u> *mortarless* masonry in compression:

The design strength of an unreinforced member in compression is dependent on the following:

- Slenderness
- Effective eccentricity at the top
- Characteristic compressive strength of the masonry
- Cross sectional area of the masonry.

When a wall or isolated pier is required to carry a vertical (compression) load, the bending moment resulting from the worst combination and disposition of design loads shall be considered at the top of the member by regarding the compression load as acting at an effective eccentricity e_x.

BS 5628-1:2005 Clause 28.2.2 states that the design vertical load resistance of a fully grouted unreinforced ***mortarless*** masonry <u>wall</u> per unit length is given by:

$$N_d = \frac{ß\, t\, f_k}{\gamma_m}$$

Where $ß$ is a capacity reduction factor allowing for the effects of slenderness and eccentricity (refer BS 5628-1:2005 Table 7)
f_k is the characteristic strength of the masonry
γ_m is the appropriate partial safety factor for the material
t is the thickness of the wall (see note below)

BS 5628-1:2005 Clause 28.2.3 states that the design vertical load resistance of a fully grouted unreinforced ***mortarless*** masonry column is given by:

$$N_d = \frac{ß\, b\, t\, f_k}{\gamma_m}$$

Where
- $ß$ is a capacity reduction factor allowing for the effects of slenderness and eccentricity
- f_k is the characteristic strength of the masonry
- γ_m is the appropriate partial safety factor for the material
- b is the width of the column
- t is the thickness of the column (see note below)

For both of the above formulae, values for the capacity reduction factor ***ß*** are given in BS 5628-1:2005 Table 7, and *t* is taken as the equivalent bedded thickness of the wall or column.

Design for compression in *mortarless* shear walls

When a wall is also acting as a shear wall, in plane bending should also be considered. When a horizontal force is resisted by more than one shear wall, the load may be distributed between the walls in proportion to their flexural stiffness about an axis perpendicular to the plane of the wall. (BS 5628-1:2005 Clause 26) The in-plane bending moment will result in non-uniform compression in the wall and the wall should be designed for the maximum resulting compression force. (BS5628-1:2005 Clause 28.1)

Increased stresses at concentrated loads (bearing stress)

BS 5628-1:2005 Clause 30 permits stresses to be increased locally "provided either that the element applying the load is sensibly rigid, or that a suitable spreader is introduced". The local design bearing strength allowed by the code is either $1.25\, f_k / \gamma_m$ or $1.50\, f_k / \gamma_m$ depending on the location and geometry of the bearing. (This compares with a maximum compressive strength for short columns of $1.0\, f_k / \gamma_m$ which reduces dramatically for more slender columns)

Design of reinforced *mortarless* masonry in compression:

BS 5628-2:2005 Clause 8.4 states that reinforced masonry walls or columns subjected to axial loading or vertical loading having a resultant eccentricity not exceeding 0.05 times the thickness of the member in the direction of the eccentricity may be designed in accordance with BS 5628-1:2005 Clause 25* (taking no account of the reinforcement), or designed using the methods given in BS 5628-2:2005 Clause 8.3. (* it is obvious 'Clause 25' should read 'Clause 28').

If the latter approach is used and if the slenderness ratio of the element exceeds 12, then:

- the design axial force N_d should be determined in accordance with 8.3.3.1.1b), and
- the design moment of resistance M_d should be determined in accordance with 8.3.3.1.1b), and
- the increase in moment due to slenderness (M_a) should be determined in accordance with 8.3.3.1.3.

If the slenderness ratio of the element does not exceed 12 then there is no requirement to design the member for an increase in moment due to slenderness.

If the resultant eccentricity exceeds 0.05 times the bedded thickness of the member in the direction of the eccentricity, then the latter approach is no longer optional; it must be used.

Table C1 below schedules the ***mortarless*** block properties and the characteristic strength of fully grouted masonry.

Table C2 below schedules the basic compressive capacity of fully grouted ***mortarless*** masonry with grade 15 and grade 20 ***mortarless*** blocks and various grout strengths.

Table C1: Properties of *mortarless* masonry units:

Mortarless Block	O/A width mm	Chamfer Width (ext) mm	Chamfer Width (int) mm	Bedded Width mm	Core Width mm	A_b sq.mm./m	A_c sq.mm./m	A_d sq.mm./m	f'_{uc} MPa	f_k MPa
140	140	0	14	114	86	28000	86000	114000	15	9.2
									20	11.0
150	150	0	17	124	90	34000	90000	124000	15	8.8
									20	10.5
200 Chamfered	200	14	12	160	136	24000	136000	160000	15	7.2
									20	8.9
200	200	0	19	174	136	38000	136000	174000	15	7.2
									20	8.9

Where: A_b = the plan area of the masonry unit face shells
A_c = the plan area of the core fill grout
A_d = the design area of the grouted masonry
f'_{uc} = the unconfined compressive strength of the masonry unit
f_k = the characteristic strength of the grouted masonry

Table C2: Basic design vertical load resistance of *mortarless* masonry walls and columns:

			N_d (kN/m) (when $ß$ = 1.0)	
Mortarless Block	f'_{uc} MPa	f_k MPa	**Grout strength** (cube strength)	
			15 MPa +	**20 MPa +**
140	15	9.2	300	300
	20	11.0	N/A	358
150	15	8.8	311	311
	20	10.5	N/A	372
200 Chamfered	15	7.2	329	329
	20	8.9	N/A	406
200	15	7.2	358	358
	20	8.9	N/A	442

Where: $$N_d = \frac{ß\, b\, t\, f_k}{\gamma_m}$$, and

$b\ t$ = A_d (the design area of the grouted masonry allowing for raking effect)
f'_{uc} = the unconfined compressive strength of the masonry unit
f_k = the characteristic strength of the grouted masonry