INTRODUCTION – MASONRY DESIGN INCORPORATING COMPRESSIVE STRESSES

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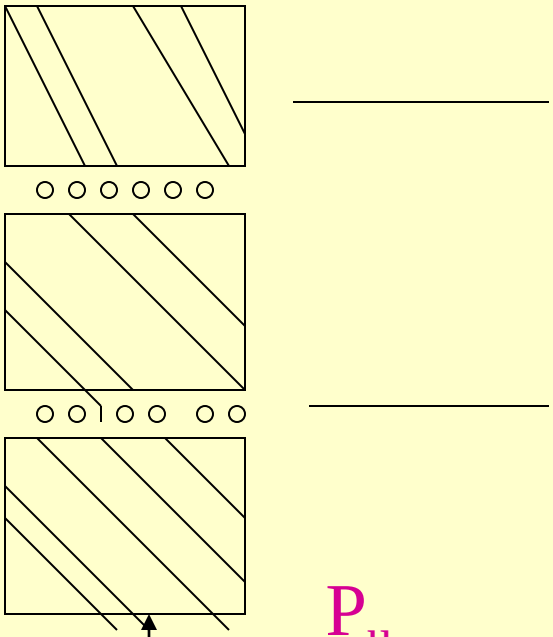
STRUCTURAL DESIGN FOR THE SMALL PRACTICE

MASONRY AS A COMPOSITE MATERIAL



masonry strength (f_b)

mortar strength (f_m)

P_u

P_u as a combination of masonry unit & mortor strengths

$f_k = k.f_b^{0.65} . f_m^{0.25}$ (EC6)

Table 1 - Mortar mixes from BS5628 Pt 1

Mortar designation	Types of mortar (proportion by volume)		Mean compressive strength at 28 days (N/mm^2)	
	Cement: lime: sand	Cement: sand with plasticiser	Preliminary (laboratory) tests	Site tests
(i)	1:0 to ¼: 3	-	16.0	11.0
(ii)	1:1/2:4 to 41/2	1:3 to 4	6.5	4.5
(iii)	1:1:5 to 6	1:5 to 6	3.6	2.5
(iv)	1:2:8 to 9	1:7 to 8	1.5	1.0

The inclusion of lime in our mortars is to be advocated as it improves workability, water retention and bonding properties. Lime mortar is softer and less rigid than cement, and can accommodate slight movement and settlement. Lime is more porous and allows the wall to breathe, reducing the effects of rising damp. Lime mortar takes longer to achieve strength and so limits the speed of rate of laying.

Table 2 gives the strengths of Maltese Mortars from tests carried out by Debattista (1985)

MORTAR CONSTITUENTS	PROPORTION BY VOLUME	COMPRESSIVE STRENGTH 28DAYS-N/mm^2	FLEXURAL STRENGTH	W/C
Cement, Carolline Sand, Fine Globigerina sand	1:2:10	1.86 (iv)	0.58	3.5
Cement, Carolline Sand, Fine Globigerina Sand	1:2:6	4.48 (iii)	1.30	2.0
Cement, carolline Sand, Coarse Globigerina sand	1:3:12	0.92	0.20	4.4
Cement, White lime, carolline Sand, course globigerina sand	1:1.14:2:4	1.43	0.29	2.5
White lime, fine globigerina sand	1:2	1.32	0.56	2.1

Table 3 - Characteristic Compressive stress f_k of 225mm thick masonry N/mm^2 for specified crushing strength – as per BS 5638 pt 1

Mortar Designation	*Globigerina*				*Coralline*
	Compressive Strength of Unit (N/mm^2)				
	15	***17.5***	***20***	***35***	***75****
I	8.6	9.6	10.6	16.3	27.4
II	7.6	8.4	9.2	13.4	22.6
III	7.2	7.7	8.3	12.2	
IV	6.3	6.8	7.4	10.4	

** as per BS 5628 pt2 (Source: Structural Integrity Handbook BICC)*

Cachia (1985) noted in testing highest franka crushing value of 32.9N/mm^2 and the corresponding lowest at 15N/mm^2

Table 4 - Characteristic Compressive stress f_k of 180mm thick masonry N/mm2 for specified crushing strength – as per BS 5628 pt1

Mortar Designation	*Globigerina*				*Coralline*
	Compressive Strength of Unit (N/mm^2)				
	15	***17.5***	***20***	***35***	***75****
I	9.9	11.0	12.2	18.7	31.6
II	8.7	9.6	10.5	15.4	24.8
III	8.2	8.8	9.5	14.0	
IV	7.2	7.8	8.5	12.0	

** as per BS5628 pt2* (Source: Structural Integrity Handbook BICC)

Table 5 – Blockwork Characteristic Strength f_k Data

Blockwork type mm	*Average Characteristic Strength N/mm2*	*Average Coefficient of variation %*	*Period*	*Best Year %*	*Worst Year %*
115	5.86	18.23	1991 1994	1992 13.37%	1991 25.29%
150	7.51	16.25	1991 1996	1993 12.58%	1991 20.28%
225 singlu	7.50	13.01	1991 -1996	1993 9.43%	1996 19.61%
225 dobblu	8.67	12.93	1991 -1996	1995 10.92%	1996 14.86%

Source: Grech (1997)

An important concept to introduce is shell bedding, with mortar laid on the 2 outer edges only. The design strength should be reduced by the ratio of the bedded area to the gross area.

Table 6 - Characteristic Compressive stress f_k of 225 thick concrete hollow blockwork in N/mm^2

Mortar Designation	*Compressive Strength of Unit (N/mm^2)*							
	2.8	***3.5***	***5.0***	***7.0***	***10***	***15***	***20***	***35***
I	2.0	2.5	3.6	4.4	5.1	6.3	7.4	11.4
II	2.0	2.5	3.6	4.2	4.8	5.6	6.4	9.4
III	2.0	2.5	3.6	4.1	4.7	5.3	5.8	8.5
IV	2.0	2.5	3.1	3.7	4.1	4.7	5.2	7.3

Table 7 - Characteristic Compressive stress f_k of 150 thick concrete hollow blockwork in N/mm^2

Mortar Designation	*Compressive Strength of Unit (N/mm^2)*							
	2.8	***3.5***	***5.0***	***7.0***	***10***	***15***	***20***	***35***
I	2.6	3.2	4.6	5.4	5.9	6.7	7.4	11.4
II	2.6	3.2	4.6	5.2	5.5	6.0	6.4	9.4
III	2.6	3.2	4.6	5.1	5.3	5.6	5.8	8.5
IV	2.6	3.2	4.1	4.5	4.7	5.0	5.2	7.3

LOAD BEARING PROPERTIE OF MASONRY WALL PANELS

a) **The horizontal bed joins should be filled completely with mortar. Incompletely filled bed joints may reduce the strength of masonry panels by 33%. Failure to fill vertical joints has little effect on the compressive strength but are undesirable for weather and force, exclusion and sound insulation.**

b) **Mortar bed joints should not be thicker than 10mm. Bedjoints of 16 –19mm thickness, result in a reduction of compressive strength of up to 25% as compared with 10mm thick joints.**

c) **Before laying mortar the block is to be well wetted to reduce its suction rate, plus a proportion of lime in the mortar mix will help the mortar mix to retain its water. A high absorbent block will result in a weaker mortar, with a resulting weaker wall panel.**

Table8 - Partial Safety factors γ_m for material strength for normal design loads.

Material	*Special Category*	*Normal Category*	*BS 5628*
Masonry			
Compression	2.5	3.1	Pt1
Compression/flexure	2.0	2.3	Pt 2
Flexure	2.8	3.5	Pt1
Shear	2.5	2.5	Pt1
Shear	2.0	2.0	Pt 2
Bond	1.5	1.5	Pt2
Strength of steel	1.15	1.15	Pt 2
Wall ties	3.0	3.0	Pt 1

DESIGN LOADS IN KN/M FOR NORMAL CATEGORY – $f_k t/\gamma_M$

Table 9 - Design axial loads for various wall types

Material	*Crushing strength N/mm2*	*Mortar type IV KN/m*	*Mortar type III KN/m*	*Mortar type II KN/m*
225 franka	20	537	602	
225 qawwi	75			1640
180 franka	20	493	551	
150 franka	20	469	522	
225 block dobblu	8.5	283	319	
225 block singlu	7	268	297	
150 block	7	217	246	
115 block	5	163	185	
225 infilled block	15	457	522	551
225 infilled block with 12mm bar at 225 centres	15			944
225 infilled block with 20mm bar at 225 centres	15			1206

The above table demonstrates the low load bearing capacity of concrete b/w of crushing strength 7N/mm^2, as being approximately 50% for equivalent thick franka of crushing strength 20N/mm^2.
(Source – Structural Integrity Handbook BICC)

SEISMIC ZONING

Table 10 – Return Periods for Earthquake Intensity of the Maltese Islands

MM – Earthquake Intensity	*Return Period (years)*	*Base Shear Design % of g*
VI	333	2 –5
VII	1800	5 –10
VIII	100,000	10- 20

Source – CAMILLERI DH (2000)

Design grd. acceleration for a return period of [475] yrs (EC8) taken between 0.05g – 0.08g.

Defined as a low seismicity zone as <0.10g (EC8)

< 0.10g, but > 0.4g EC 2 provisions to be catered for

MASONRY DESIGN CRITERIA FOR ZONES OF LOW SEISMICITY (EC8)

1. Shear walls in manufactured stones units

$t \geq [175]mm$

$h_{ef}/t \leq [15]$

2. A min of 2 parallel walls is placed in 2 orthogonal directions. The cumulative length of each shear wall > 30% of the length of the building. The length of wall resisting shear is taken for the part that is in compression.
3. For a design ground acceleration < 0.2g the allowed no of storeys above ground allowed is [3] for unreinforced masonry and [5] for reinforced masonry, however for low seismieity a greater no allowed.
4. Mortar Grade (III), (M5) although lower resistance may be allowed. Reinforced masonry type IV (M10). No need to fill perp. Joints.