

Structural

General

It is the purpose of design to ensure that the building be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground:

- a) Safely
- b) Without causing such deflection or deformation of any part of the building, or such movement of the ground, as will impair the stability of any part of another building.

In order to achieve the above requirements, the recommendations for the structural design of masonry are given in BS 5628: Parts 1 and 2. Additional guidance is given in BS 5628: Part 3 for walls subject to imposed lateral load only and internal walls or partitions not designed for imposed loading.

Where the building type is limited to:

- a) Residential buildings of not more than three storeys.
- b) Small single storey non-residential buildings.
- c) Small buildings forming annexes to residential buildings (including garages and out buildings).

Guidance is given in Approved Document A of the Building Regulations 2000 (2004 edition) (England and Wales) or Technical Standard C of the Building Standards (Scotland) Regulations.

Table 1: Partial safety factors for material strength

	Category of masonry units	Category of construction control	
		Special	Normal
Compression, (γ)m	Category 1	2.5	3.1
	Category 2	2.8	3.5
Flexure, (γ)m	Category 1 and 2	2.5	3.0

All aggregate concrete masonry units produced by Hanson are manufactured to Category 2 manufacturing controls. Fig. 1 gives guidance on the compressive strength of brick and block units for walls of one, two and three storey buildings in England and Wales, where the roof construction is of timber. Other factors, e.g. durability, may dictate the need for greater unit strength or thickness depending on location. If the building is greater than the sizing or loading limits given in the approved document, the design should be based on BS 5628: Parts 1 or 2 to ensure an adequate margin of safety against the ultimate limit state being reached.

When carrying out the design for vertical loads, it is necessary to consider the characteristics and partial safety factors for loading, together with the characteristic strength of the masonry and partial safety factors for the material strength Table 1. Information on the characteristic compressive strength of masonry is given in Table 2 (page 34) for the common sizes of concrete bricks and blocks laid in designation (iii) mortar, (M4).

Compressive strength of masonry units

Aggregate concrete masonry unit strength to BS EN 771-3

	Blocks	Bricks
Condition A	2.90N/mm ²	6.00N/mm ²
Condition B	7.30N/mm ²	9.00N/mm ²
Condition C	7.30N/mm ²	18.00N/mm ²

Where
 H_f Less than or equal to 1m, Condition A
 Where
 H_f Greater than 1m, Condition B

Notes

Figure 1

1 If H_s is not greater than 2.7m, the compressive strength of bricks or blocks should be used in walls as indicated by the key.

2 If H_s is greater than 2.7m, the compressive strength of bricks or blocks used in the wall should be at least Condition B, or as indicated by the key, whichever is the greater.

3 If the external wall is solid construction, the masonry units should have a compressive strength of at least that shown for the internal leaf of a cavity wall, in the same position.

4 The guidance given in the diagram, for walls of two and three storey buildings, should only be used to determine the compressive strength of the masonry units where the roof construction is of timber.

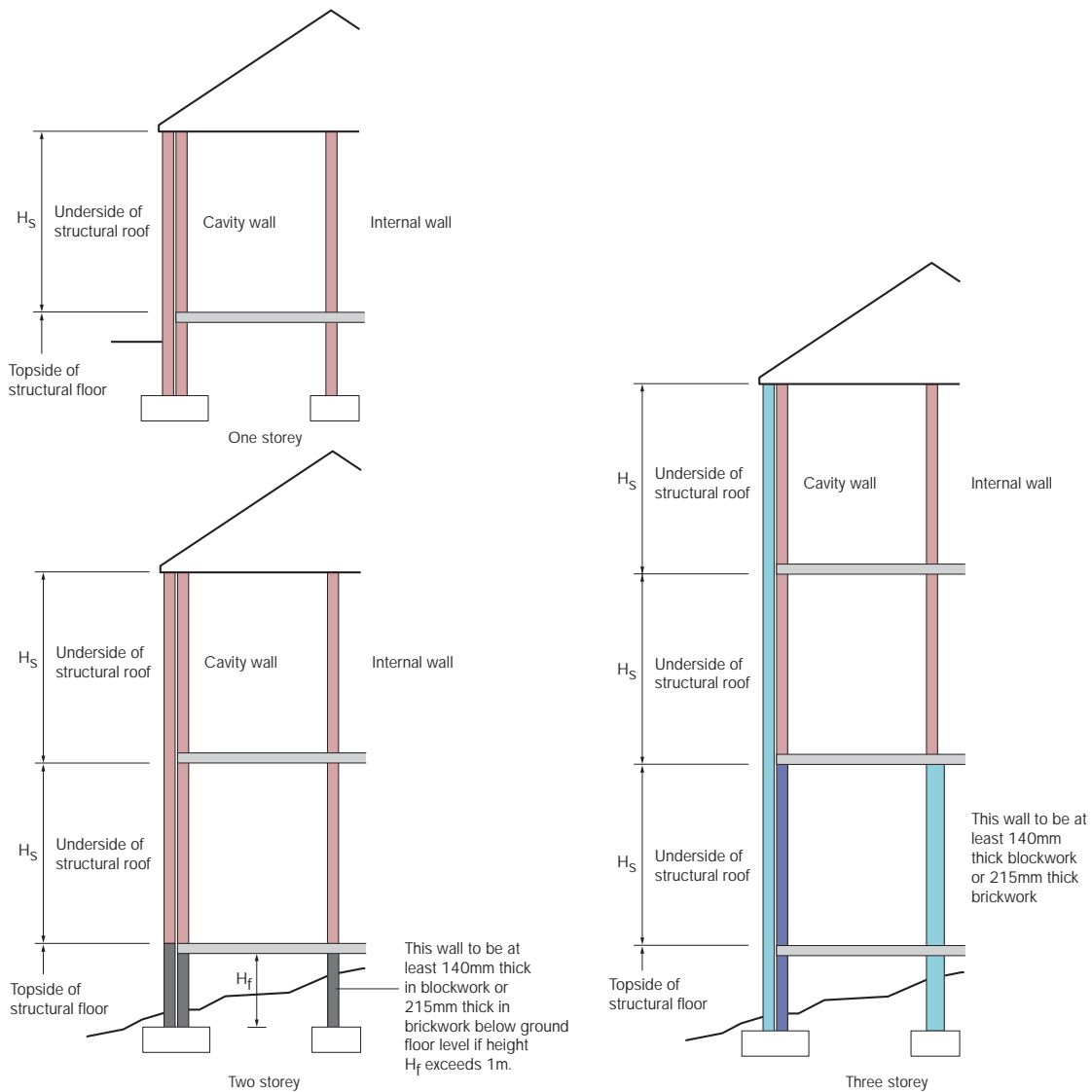


Fig. 1 Compressive strengths of masonry units

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Characteristic compressive strength of masonry, f_k

For normally bonded masonry, defined in terms of the shape and compressive strength of the masonry units and the classification of the mortar, the values given in Table 2 may be taken to be the characteristic compressive strength, f_k , of walls constructed under laboratory conditions, tested at an age of 28 days.

Table 2: Characteristic compressive strength of masonry, f_k , in N/mm²

Block size	Aspect ratio	Unit strength N/mm ²							
		3.60	7.30	10.40	15.00	17.50	22.50	24.00	30.00
Group 1 Units (void content \leq 25%) in designation (iii) Mortar (M4)									
440 x 215 x 75	2.87	3.50	6.40	8.20	9.43	10.10	12.00	-	14.50
440 x 215 x 90	2.39	3.50	6.40	8.20	9.43	10.10	12.00	-	14.50
440 x 215 x 100	2.15	3.50	6.40	8.20	9.43	10.10	12.00	-	14.50
440 x 215 x 140	1.54	2.91	5.35	6.85	7.89	8.46	10.03	-	12.10
440 x 215 x 150	1.43	2.77	5.10	6.53	7.52	8.06	9.56	-	11.53
440 x 215 x 190	1.13	2.38	4.41	5.65	6.52	6.99	8.27	-	9.96
440 x 215 x 200	1.08	2.32	4.30	5.51	6.35	6.81	8.06	-	9.70
440 x 215 x 215	1.00	2.21	4.11	5.27	6.09	6.53	7.71	-	9.29
215 x 215 x 190	1.13	-	4.41	5.65	6.52	6.99	8.27	-	9.96
290 x 215 x 140	1.54	-	5.35	6.85	7.89	8.46	10.03	-	12.10
290 x 140 x 215	0.65	-	3.31	4.25	4.92	5.28	6.21	-	7.46
440 x 65 x 190	0.34	-	-	-	-	-	-	5.08	-
215 x 65 x 103	0.63	-	-	4.19	-	-	6.13	-	-
440 x 65 x 140	0.46	-	-	3.69	-	-	-	-	-
Group 2 units (void content $>$ 25% but \leq 60%) in designation (iii) mortar (M4)									
440 x 215 x 140	1.54	2.91	5.15	6.11	-	-	-	-	-
440 x 215 x 150	1.43	2.77	4.92	5.88	-	-	-	-	-
440 x 215 x 190	1.13	2.38	4.30	5.24	-	-	-	-	-
440 x 215 x 215	1.00	2.21	4.03	4.96	-	-	-	-	-
Group 1 units laid flat in designation (iii) mortar (M4), strength tested upright									
440 x 215 x 100	0.47	2.50	4.10	5.20	6.37	7.00	8.10	-	9.60
Units (void content \leq25%) laid to form a collar jointed wall in designation (iii) mortar (M4)									
Wall width	Aspect ratio	Unit strength N/mm ²							
		3.60	7.30	10.40	15.00	17.50	22.50	30.00	
190mm (2 x 90)	1.13	2.40	4.00	5.10	6.30	7.00	8.30	10.30	
215mm (2 x 100)	1.00	2.40	4.00	5.10	6.30	7.00	8.30	10.30	

Reinforced masonry

When considering reinforced masonry design, guidance is given in BS 5628: Part 2. A particular application of this form of construction is the formation of lintels over openings, where the block pattern is to be maintained. In order to achieve this, trough lintel or bond team units (half length trough lintels used where a fair faced soffit is required) are laid on temporary formwork with an extra unit at each end to form the bearing. The void achieved is then filled with the necessary reinforcement and infill concrete to withstand the applied load.

The whole assembly is allowed to cure before the formwork is struck.

A typical example is shown in Fig. 2.

Table 3 gives guidance on the maximum spans for single layer reinforced masonry trough lintels used in internal applications. Where it is necessary to have greater spans, the use of double layer reinforced sections should be considered (as illustrated).

Bond beams can also be used:

- a) As horizontal beams to distribute loads to columns
- b) As heads of walls to distribute vertical loads
- c) Below large panel openings to assist with movement control.

The reinforcement quantities in the table are for guidance only, exact detail and specification should be approved by a structural engineer.

Table 3: Maximum spans for single layer reinforced masonry above openings

Trough lintel (face size)				
Full length	Half length	Width mm	Maximum span (m)	Reinforcement (high yield)
440 x 215	215 x 215	100	2.4	1 x 12mm
440 x 215	215 x 215	140	2.2	1 x 12mm
440 x 215	215 x 215	190	2.2	1 x 12mm
440 x 215	215 x 215	215	2.1	1 x 12mm

The maximum spans indicated above have been based on:

1. Loads assessed in accordance with BS 5977: Part 1 (no additional loads or openings in load triangle or interaction zone other than masonry above).
2. Mortar designation (ii) (M6)
3. Block strength 7.3N/mm²
4. Concrete infill
 - (a) 1:0-1/4:3:2 cement:lime:sand:10mm max. size aggregate.
 - (b) Concrete grade C30 215mm
5. Minimum bearings 215mm

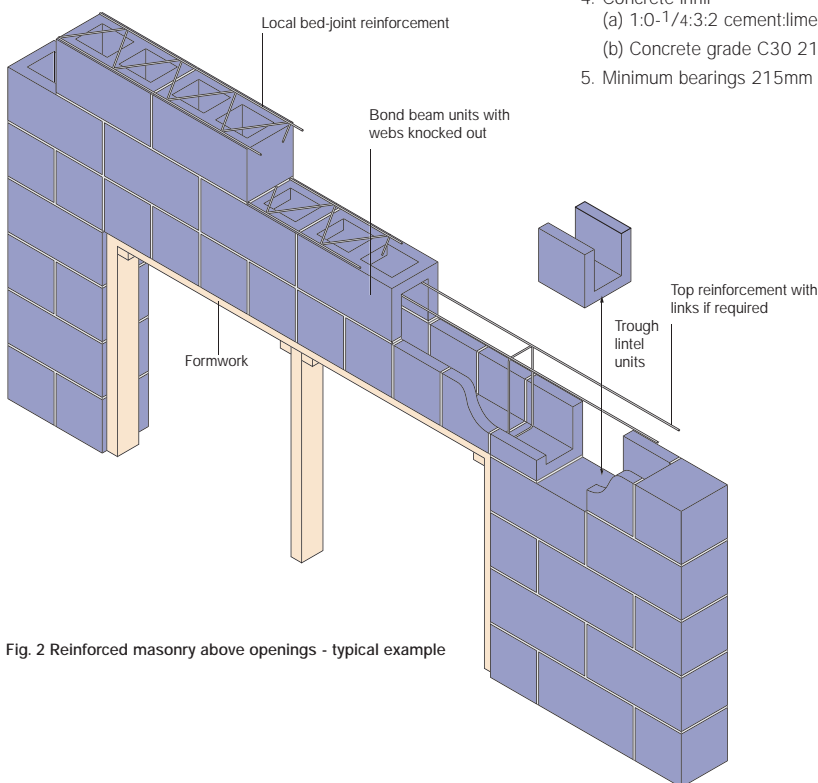


Fig. 2 Reinforced masonry above openings - typical example

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Internal walls or partitions not designed for imposed loading

When an internal wall or partition is not intended to carry an imposed load, it should be laterally restrained by horizontal or vertical, continuous or intermittent supports. The length or height of the wall in relation to its thickness should be within the limits given in Figs. 3, 4 and 5, page 37.

Consideration should also be given to the following, which may affect stability:

- a) Openings
- b) Accommodation of movement
- c) Chasing
- d) Exceptional lateral loading
- e) Wind load

Where walls are to be plastered and the plaster thickness is included in the wall thickness calculation, the wall may require temporary bracing prior to plastering.

The type of restraint employed should allow for the movement of the wall due to shrinkage or thermal changes, together with any deflection of the structure, without inducing unacceptably high stresses which may result in cracking and potential instability.

Mortars

The specification and choice of the mortar is a fundamental determinant of the structural and visual properties of a blockwork wall.

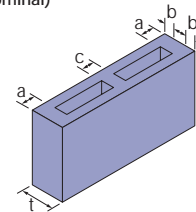
For all Hanson aggregate blocks used in normal construction, a mortar designation (iii) (M4) as shown in Table 4 is suggested.

Table 4: Mix design (by volume) for mortar designation (iii) (M4)

Cement:lime:sand	1:1:5-6
Masonry cement:sand	1:4-5
Cement: sand with plastisizer	1:5-6

Higher strength mortars may be necessary in certain applications as a safeguard for durability or for design considerations, but they may increase the risk of cracking. Further information on recommended designs of mortar for use in various locations and different conditions of exposure is given in BS 5628: Part 3.

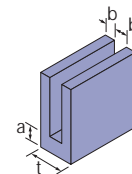
Table 5: Internal and external dimensions of moulded blocks (all dimensions nominal)



Block dimensions: hollow/cellulars

Work size	Width mm (t)	140c	140	150	190	215
440 x 215mm	a	30	45	40	45	45
	b	30	45	40	45	45
	c	50	40	40	50	50

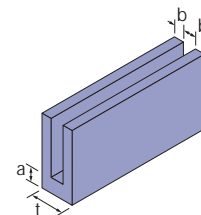
Voids vary in size depending on manufactured base. In cellular blocks, the void does not pass through the whole unit, leaving on average a 25mm bottom thickness.



Half length trough lintels (fair faced soffit)

Work size	Width mm (t)	100	140	190	215
215 x 215mm	a	45	45	45	45
	b	30	45	45	45

Other sizes are available, cut from solid units.



Full length trough lintels (not suitable for fair faced soffit)

Work size	Width mm (t)	100	140	190	215
440 x 215mm	a	45	45	45	45
	b	30	40	40	45

Other sizes are available, cut from solid units.

Void content (%)

440 x 215mm	
140mm Cellular	38%
140mm Hollow	26%
150mm Hollow	34%
190mm Hollow	36%
215mm Hollow	40%

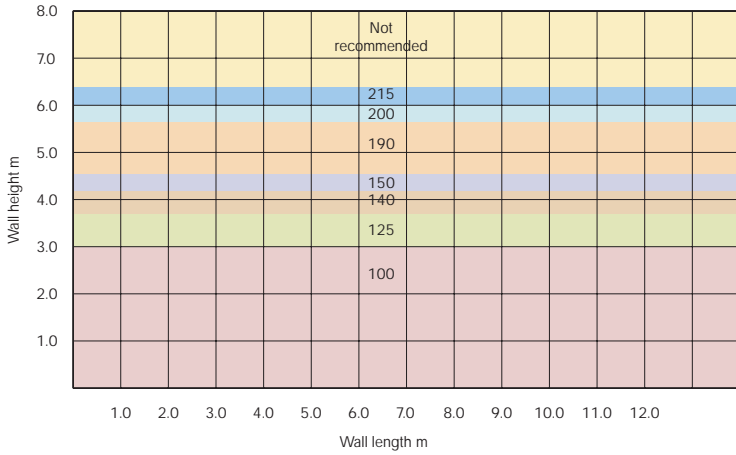


Figure 3: Recommended block width non-loadbearing unplastered walls restrained at the top only

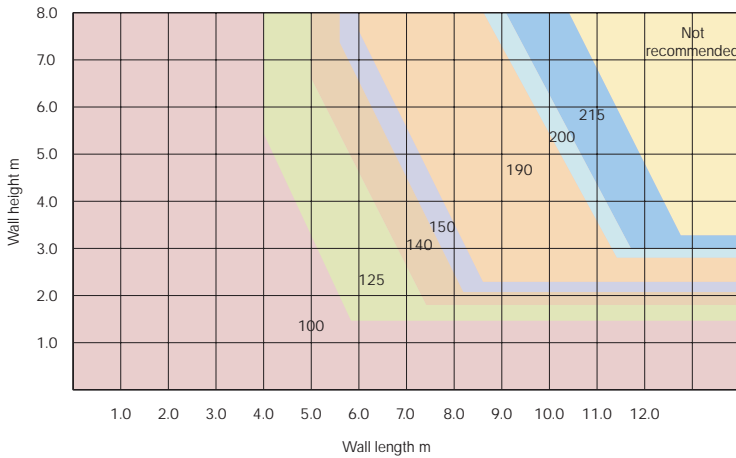


Figure 4: Recommended block width non-loadbearing unplastered walls restrained at the ends but free at the top

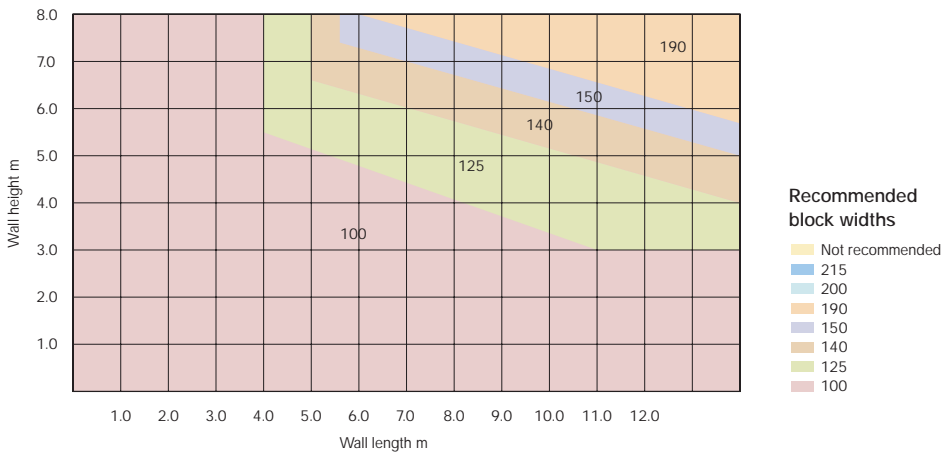


Figure 5: Recommended block width non-loadbearing unplastered walls restrained at the ends and top

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Radius walls

Standard blocks can be laid in stretcher bond to form circular or curved walls. The length and thickness of the block will determine the width of the perpend on the outer face and the overhang between successive courses for a particular radius.

Fig. 6 and Table 6 give guidance on curved walls based on the size of the unit with a nominal 10mm perpend joint on the internal face. To limit the size of the external perpend joint, the joint on the internal face can be reduced, or the block cut on the splay.

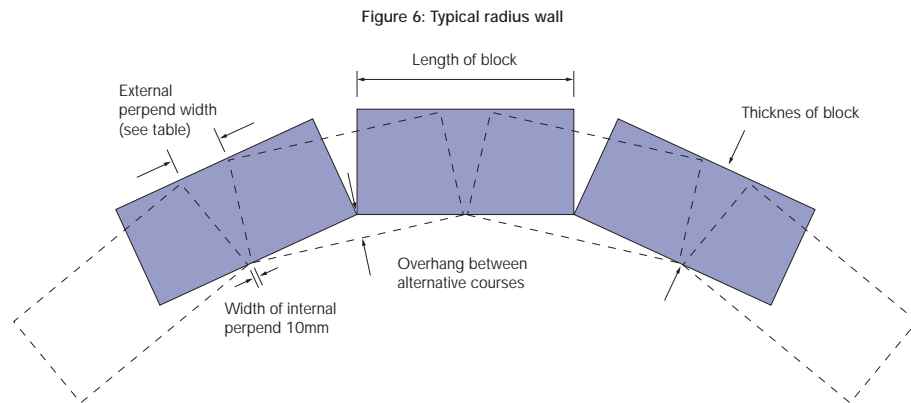


Table 6: Overhang and perpend joint widths for radius walls

Wall radius mm	Work size: 440 x 215mm				Work size: 215 x 215mm			
	W = 100	L = 440	W = 140	L = 440	W = 100	L = 215	W = 140	L = 215
	Overhang	Perpend	Overhang	Perpend joint	Overhang	Perpend joint	Overhang	Perpend joint
600	44	86	46	120	10	50	11	68
800	32	68	33	93	8	40	8	53
1000	25	56	26	76	6	34	6	44
1200	21	48	21	65	5	29	5	29
1400	18	43	18	57	4	27	4	34
1600	16	39	16	51	4	24	4	31
1800	14	36	14	46	3	23	3	28
2000	12	33	13	42	3	22	3	26
2500	10	28	10	36	2	19	2	23
3000	8	25	8	31	2	18	2	21
3500	7	23	7	28	2	17	2	19
4000	6	21	6	26	1	16	1	18
4500	5	20	5	24	1	15	1	17
5000	5	19	5	23	1	15	1	16
5500	4	18	4	22	1	14	1	16
6000	4	18	4	21	1	14	1	15

W= Width L= Length