Technical requirements for masonry construction

(Standards & BCA)

AS/NZS 4455.1:2008 Masonry units, pavers, flags and segmental retaining wall units - Masonry units

Type:

Type of masonry units can be brick, clay, concrete, calcium silicate, block, concrete or AAC.

Manufacturer:

Size:

Colour:

Feature colour:

Masonry durability

Requirement: Conform to AS 3700, Table 5.1.

Problems are being experienced with salt attack on brickwork below damp-proof course level on sites which had once been heavily fertilised. Exposure class bricks are normally readily available for such locations.

Mortar materials

Sand: Fine aggregate with a low clay content and free from efflorescing salts, selected for grading and colour for facework.

Proportions: Conform to BCA 3.3.1.6 and BCA Table 3.3.1.2.

Mortar type:

M3 applies generally except that M4 applies for:

- Interior elements subjected to saline wetting and drying.
- Elements below the damp-proof course or in contact with ground that are in aggressive soils.
- Elements in severe marine environments as defined by AS 3700 clause 5.2.5.
- Elements in saline or contaminated water including tidal and splash zones.
- Elements in especially aggressive environments.

Select mortar joints as tooled, raked, weatherstruck or others.

COMPONENTS

Wall ties

Standard: To AS/NZS 2699.1.

Non-seismic areas: Type A.

Seismic areas: Type B.

Wall tie application

Classification: To AS/NZS 2699.1.

Type: To BCA 3.3.3.2.

Spacing: To BCA Figure 3.3.3.1.

Flashings and damp-proof courses

Standard: To AS/NZS 2904.

Lintels

Cold-formed lintels: Proprietary cold-formed flat-based type designed to AS/NZS 4600.

Steel flats and angles: Sizes to BCA Figure 3.3.3.5.

Material: Mild steel galvanized to AS/NZS 4680.

Corrosion protection: To AS/NZS 2699.3, and BCA 3.4.4.4.

CAVITY WORK

Cavity clearance

General: Keep cavities clear at all times.

Cavity fill

General: Fill the cavity with mortar to 1 course above adjacent finished (ground) level. Fall the top surface towards the outer leaf.

Cavity width

General: Provide minimum cavity widths in conformance with the following:

- Masonry walls: 50 mm.
- Masonry veneer walls: 40 mm between the masonry leaf and the loadbearing frame and 25 mm minimum between the masonry leaf and sheet bracing.

Width of cavity may need to be increased if wall insulation is required to BCA 3.12.1.4.

AS 3700 Masonry Code

2.3 PERFORMANCE REQUIREMENTS

2.3.1 Durability

A masonry member or structure shall withstand the expected wear and deterioration throughout its intended life, taking into account the exposure environment and importance of the structure, without the need for undue maintenance.

2.3.2 Fire resistance

A masonry member or structure shall have a fire resistance so that the member can, for the required period, perform its structural function and if necessary prevent the spread of fire.

2.3.3 Serviceability

A masonry member or structure shall have a low probability of failure so as to be serviceable and fit for the purpose for which it was constructed throughout its intended life.

2.3.4 Strength

A masonry member or structure shall have a low probability of structural failure when subjected to the loads that can reasonably be expected throughout its intended life.

2.3.5Stability

A masonry member or structure shall have a low probability of instability when subjected to the loads that can reasonably be expected throughout its intended life.

2.3.6 Other requirements

A masonry member or structure shall have a low probability of failing to meet any other appropriate design requirement (e.g. resistance to water penetration) throughout its intended life.

Section 3 Design Properties

3.3.2 Compressive strength

The characteristic compressive strength of masonry (f'_m) shall be as follows:
(a) For masonry other than special masonry, one of the following:

(i) For masonry constructed with other than AAC units, the value of the characteristic compressive strength shall be taken as $f_m' = k_h f'_{mb}$
where

$f'_{mb} = k_m \sqrt{f'_{uc}}$

k_m = factor used to derive the characteristic compressive strength of masonry (see Table 3.1)

k_h = factor reflecting the influence of the ratio of masonry unit height to mortar bed joint thickness derived from Table 3.2

f'_{uc} = the characteristic unconfined compressive strength of masonry units in megapascals

The values of f'_{mb} in Table 3.1 are deemed to satisfy this formula.

(ii) For AAC masonry with thin bed mortar, the value of the characteristic compressive strength shall be taken as ${}_{uc}f'_m = f'$.

For concrete and AAC units, ${}_{uc}f'$ shall be the 28-day strength. If tested at another age, an appropriate correction shall be made to obtain the 28-day strength.

The following is for students who want to know how engineers calculate the compressive strength of a brick wall. (go to the next section if this is too hard to understand)

Brick strength is defined as resistance to load per unit area and is expressed in mega Pascals (MPa).

The characteristic unconfined compressive strength is used by engineers in the design of masonry to calculate the strength of a wall. Brick manufacturer provides you with the characteristic unconfined compressive strength of masonry units.

The compressive strength of a brick wall however depends on the unconfined compressive strengths of the brick type, bedding type, mortar type and height of brick.

(eg Boral bricks usually have characteristic unconfined compressive strengths in the range 15 to 35 MPa.)

Example using Table 3.1:

Characteristic unconfined compressive is 25 MPa

Clay brick, full bedding, mortar type M3, brick height 76 mm

$f'_{mb} = 1.4x \sqrt{25} = 7$ *(see Table values)*

$f_m' = 1.0 \times 7 = 7$ *MPa*

The compressive strength according Table 3.1 and 3.2 of the brick wall is $\mathbf{f'_m = 7\ MPa}$

Please note that depending on the brick height the strength increase or decrease (see Table 3.2)

TABLE 3.1

CHARACTERISTIC COMPRESSIVE STRENGTH OF MASONRY (f'_{mb})

Type of masonry unit	Bedding type	Mortar classification (see Note 2)	Characteristic unconfined compressive strength of unit (f'_{uc}) MPa								k_m
			5	10	15	20	25	30	40	≥50	
Clay	Full	M2	2.5	3.5	4.3	4.9	5.5	6.0	7.0	7.8	1.1
Clay	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Clay	Full	M4	3.4	4.7	5.8	6.7	7.5	8.2	9.5	10.6	1.5
Clay	Face shell	M3	3.6	5.1	6.2	7.2	8.0	8.8	10.1	11.3	1.6
Concrete	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Concrete	Face shell	M3	3.6	5.1	6.2	7.2	8.0	8.8	10.1	11.3	1.6
Calcium silicate	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Calcium silicate	Full	M4	3.4	4.7	5.8	6.7	7.5	8.2	9.5	10.6	1.5

NOTES:

1 Linear interpolation may be used.

2 Mortar classification is given in Table 10.1.

TABLE 3.2

COMPRESSIVE STRENGTH FACTOR (k_h)

Ratio of masonry unit height to mortar bed joint thickness	0.0	3.0	7.6	12.0	≥19.0
Compressive strength factor (k_h)	0.0	0.60	1.00	1.15	1.30

NOTE: Linear interpolation may be used.

The strength of brickwork is a function of the strength of the masonry unit combined with strength of the mortar.

The tables provide the values for the strength of masonry that can be achieved using a clay brick of a particular strength coupled with either M3 or M4 mortar. The masonry strength is also reliant on the brick height.

Example using Table 3.2: A **162 mm** high clay unit with an f'_{uc} of 25 MPa laid with full bed M3 mortar will achieve a characteristic unconfined strength of the masonry, f'_m *of 8.7MPa* (k_h = 1.24 interpolation) compared to a 76 mm high brick, which has characteristic unconfined strength of the masonry, f'_m *of 7 MPa (se above).*

5.4 MORTAR

Mortar shall comply with the minimum classification requirements given in Table 5.1. Compositions of mortar deemed to satisfy the classifications are given in Table 10.1.

For situations not covered in Table 5.l or mortar compositions not covered in Table 10.1 mortars shall either-

(a) have a demonstrated satisfactory service history in similar situations when used with similar masonry units; or

(b) when tested under an appropriate testing regime, not have any predicted loss in serviceability or performance over the intended life.

10.4 MORTAR

10.4.1 General

Mortar (except for thin-bed mortar) shall consist of a mixture of cementitious material and sand (fine aggregate) to which water and any specified additives have been added.

Thin-bed mortar is a proprietary material purpose-made to bond masonry. The ingredients shall be proportioned to produce a mortar that will have the following characteristics:

(a) Adequate workability to permit the masonry units to be properly placed

(b) The ability, in conjunction with the masonry units, to provide the structural properties and appropriate durability required for the given situation.

Mortars shall be identified by the volumetric proportions of their main ingredients and shall be classified, depending on their proportions, as Ml to M4.

TABLE 10.1

DEEMED-TO-SATISFY MORTAR COMPOSITIONS

Mortar class	Mix proportions by volume					Mortar suitability			
	Cement (GB/GP)	Masonry cement	Building lime	Sand	Water thickener (see Note 3)	Fired clay	Concrete	Calcium silicate	AAC
M1 (see Note 5)	0	0	1	3	No	✓	×	×	×
	1	0	3	12	No	✓	×	×	×
M2	1	0	2	9	No	✓	×	×	×
M3	1	0	1	6	Optional	✓	✓	×	×
	1	0	0	5	Yes	✓	✓	✓	×
	0	1	0	4	No	✓	✓	×	×
M3	Thin-bed mortar for use with AAC (see Note 4)								
M4	1	0	0.5	4.5	Optional	✓	✓	×	×
	1	0	0	4	Yes	✓	✓	✓	×
	1	0	0 to 0.25	3	Optional	✓	✓	×	×
	0	1	0	3	No	✓	×	×	×

✓ satisfactory

× unsatisfactory

NOTES:

1 Mortar mixes are designated by the proportions of their ingredients following an initial letter, the chief cementing agent being given as unity, e.g. C 1:L 0.5:S 4.5 or L 1:S3.

2 Volumes refer to materials in the dense-packed condition.

3 The water thickener referred to in this Table is cellulose based. The particular cellulose-based product used is to be specifically suited for this application, and used in accordance with the manufacturer or supplier's instructions.

4 The thin-bed mortars referred to in the Table are proprietary materials purpose made for use with AAC.

5 Type Ml should be used only in restoration work to match existing construction (see Appendix F).

10.4.2 Materials

10.4.2.1 Cement and building lime

Cement and building lime shall comply with the following Standards:

(a) Portland (Type GP) and blended (Type GB) cements AS 3972.
(b) Limes for building AS 1672.1.
(c) Masonry cement AS 1316.

10.4.2.2 Sand

Sand shall be free from materials deleterious to the mortar and to embedded items and be chosen to produce mortar that meets the requirements of AS3700.

10.4.2.3 Water

Water shall be free from harmful quantities of materials that are deleterious to the masonry, the reinforcement or any embedded items.

10.4.2.4 Admixtures

Admixtures used in mortar shall comply with the following:

(a) Admixtures other than the following types shall not be used unless tests have demonstrated that masonry incorporating the admixtures will comply with the requirements of this Standard '"for compressive strength, flexural strength arid durability of the masonry:
    (i) Plasticizers or workability agents, including air-entraining agents complying with AS 1478.l.
    (ii) Cellulose-type chemical water thickeners.
    (iii) Colouring pigments complying with BS EN 12878.
    (iv) Set-retarding chemical agents complying with AS 1478.l.
    (v) Bonding polymers.

10.4.3 Mortar durability

Mortars complying with the proportions given in Table 10.1 are deemed to satisfy the durability requirements of Clause 2.3.1 for the situations set out in Table 5.1 below.

10.4.4 Structural properties of mortar

Mortars complying with proportions given in Table 10.1 are deemed to satisfy the structural requirements of Clause 10.4.1 (b) except where specific criteria have been set, in which case testing shall be carried out in accordance with Appendices C and D to confirm that the masonry achieves the required strength.

5.2 EXPOSURE ENVIRONMENTS

5.2.1 Mild environment

Environments remote from the coast, industrial activity and the tropics as described in Paragraph E2 of Appendix E shall be regarded as mild environments.

5.2.2 Exterior environment

The exposed leaf of an external cavity or masonry veneer wall and the cavity space shall both be regarded as being in an exterior environment.

5.2.3 Interior environment

All internal leaves including the internal leaf of a cavity wall shall be regarded as an interior environment.

5.2.4 Marine environment

100 m to 1 km for a non-surf coast and 1 km to 10 km for surf coast shall both be regarded as marine environment. The distances specified are from the mean high-water mark.

TABLE 5.1

DURABILITY REQUIREMENTS

Exposure environment	Masonry units	Mortar	Minimum durability classification of built-in components (see Notes 2 and 3)	Minimum cover to reinforcement and tendons in grouted cavities or cores (mm) (see Clause 5.7.2 and Note 4)
	Minimum salt attack resistance grade (see Note 1)	Minimum classification		
1 Elements in mild environments (see Clause 5.2.1)	Protected	M2	R0	5
2 Elements in interior environments that are—				
(a) above a damp-proof course and enclosed within a building except during construction	Protected	M2	R1	5
(b) subject to non-saline wetting and drying	General purpose	M3	R3	15
(c) subject to saline wetting and drying	Exposure	M4	R4	20
3 Elements above the damp-proof course in non-marine exterior environments. Elements above the damp-proof course in other exterior environments, with a waterproof coating, properly flashed junctions with other building elements and a top covering (roof or coping) protecting the masonry	Protected	M2	R1	5
4 Elements below the damp-proof course or in contact with the ground that are—				
(a) protected from water ingress by an impermeable membrane	Protected	M2	R2	5
(b) in non-aggressive soils	General purpose	M3	R3	15
(c) in aggressive soils	Exposure	M4	R4	20
5 Elements in marine environments (see Clause 5.2.4)	General purpose	M3	R3	15
6 Elements in severe marine environments (see Clause 5.2.5)	Exposure	M4	R4	30
7 Elements in—				
(a) freshwater	General purpose	M3	R3	20
(b) saline or contaminated water including tidal and splash zones	Exposure	M4	R5	30
8 Elements in especially aggressive environments, e.g. subject to attack by corrosive liquids or gases	Exposure	M4	R5	30
9 Elements in especially aggressive environments, e.g. subject to attack by corrosive liquids or gases	*	*	*	*

* Units, mortars, covers or coatings shown by test, or known by experience, to be resistant to the particular corrosive liquid or gas

BCA Requirements

Extract of Part 3 (How to use Section 3)

Explanatory information:

This is a non mandatory guide on how to use Section 3 of the Housing Provisions.

3.1 Introduction

Section 3, Parts 3.1 to 3.12 are ***Deemed-to-Satisfy Provisions*** that are considered to be acceptable forms of construction that meet the legislative requirements for complying with the Housing Provisions (ie they comply with the Performance Requirements listed in Section 2 of the Housing Provisions*).*

There is no obligation to adopt any particular option contained in Section 3 of the Housing Provisions, if it is preferred to meet the Performance Requirement in some other way.

However, if one of the options described in Section 3 is not complied with, then the appropriate authority must be satisfied that the Performance Requirements have been met.

3.2 The scope of these provisions

The ***Deemed-to-Satisfy Provisions*** (described as “acceptable construction practice” or “acceptable construction manuals”) are indicative of some of the most common forms of national construction practice. In general, either the "acceptable construction practice" or the "acceptable construction manual" may be used as options when proposing a ***Deemed-to-Satisfy*** solution.
Situations where it is necessary for a mixed application of the "acceptable construction practice" and the "acceptable construction manual" may be identified by reference to differing components of the Performance Requirement (see *1.0.7(b)*).

3.3 Suitability of Alternative Solutions

The options described in Section 3 are typical examples. They are certainly not the only means available of complying with the Housing Provisions. The performance nature of this document provides flexibility and allows the use of alternative construction methods even though they may not be specifically described in an acceptable construction manual or as acceptable construction practice.

Alternative Solutions may be used provided they comply with the Performance Requirements listed in Section 2 (for further explanation see *Part 1.0*).

Part 3.3 Masonry

3.3 Definitions
3.3.1 Unreinforced Masonry
3.3.2 Reinforced Masonry
3.3.3 Masonry Accessories
3.3.4 Weatherproofing of Masonry
3.3.5 Earthwall Construction

If you want more detailed information on the different part of the above headings contact Central's Online Databases http://www.central.wa.edu.au/Library/Pages/onlinedatabases.aspx and select Building Code of Australia. Login and password details can be obtained from the library.