



Masonry in small buildings

Part 1: Design



This Australian Standard® was prepared by Committee BD-004, Masonry Structures. It was approved on behalf of the Council of Standards Australia on 3 August 2015. This Standard was published on 18 August 2015.

The following are represented on Committee BD-004:

- Australian Building Codes Board
 - Australian Institute of Building Surveyors
 - Building Designers Association of Australia
 - Cement Concrete and Aggregates Australia—Cement
 - Concrete Masonry Association of Australia
 - Consult Australia
 - Engineers Australia
 - Galvanizers Association of Australia
 - Housing Industry Association
 - Masonry Contractors Association of NSW
 - Master Builders Australia
 - Think Brick Australia
 - University of Adelaide
 - University of Newcastle
-

This Standard was issued in draft form for comment as DR AS 4773.1:2015.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

Keeping Standards up-to-date

Australian Standards® are living documents that reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued.

Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments that may have been published since the Standard was published.

Detailed information about Australian Standards, drafts, amendments and new projects can be found by visiting **www.standards.org.au**

Standards Australia welcomes suggestions for improvements, and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at **mail@standards.org.au**, or write to Standards Australia, GPO Box 476, Sydney, NSW 2001.

Australian Standard®

Masonry in small buildings

Part 1: Design

Originated as part of AS CA32—1963.
Previous edition AS 4773.1—2010.
Second edition AS 4773.1:2015.
Reissued incorporating Amendment No. 1 (November 2016).

COPYRIGHT

© Standards Australia Limited

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968.

Published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001, Australia

ISBN 978 1 76035 210 3

PREFACE

This Standard was prepared by the Standards Australia Committee BD-004, Masonry Structures, to supersede AS 4773.1—2010.

This Standard incorporates Amendment No. 1 (November 2016). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to provide minimum requirements for the design of unreinforced and reinforced masonry, including built-in components, for use in small buildings such as houses and garages. This Standard is intended for the use of designers and specifiers of small buildings and is intended as a companion document to AS 4773.2, *Masonry in small buildings, Part 2: Construction*.

The objective of this revision is to provide clarifications and minor corrections.

The Committee acknowledges valuable assistance given by organizations and individuals experienced in various aspects of design and construction of masonry.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

This document includes commentary on some of the Clauses of the Standard. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE.....	6
1.2 GENERAL LIMITATIONS.....	6
1.3 NORMATIVE REFERENCES	9
1.4 MINIMUM INFORMATION TO BE PROVIDED	9
1.5 DEFINITIONS.....	11
SECTION 2 DESIGN CRITERIA	
2.1 SCOPE OF SECTION	14
2.2 DESIGN REQUIREMENTS.....	14
2.3 SERVICEABILITY, STRENGTH, STABILITY AND PREVENTION OF WATER PENETRATION	14
SECTION 3 MATERIALS	
3.1 SCOPE OF SECTION	17
3.2 MASONRY UNITS.....	17
3.3 MORTAR AND GROUT	17
3.4 BUILT-IN COMPONENTS.....	18
3.5 REINFORCEMENT	19
SECTION 4 DURABILITY	
4.1 SCOPE OF SECTION	20
4.2 MATERIAL SELECTION.....	20
4.3 EXPOSURE ENVIRONMENTS	20
4.4 ELEMENT LOCATIONS.....	23
SECTION 5 FIRE RESISTANCE	
5.1 SCOPE OF SECTION	24
5.2 GENERAL CRITERIA.....	24
5.3 FIRE-RESISTING MASONRY DESIGN CRITERIA.....	24
SECTION 6 WALL DESIGN	
6.1 SCOPE OF SECTION	26
6.2 GENERAL CRITERIA.....	26
6.3 VERTICAL SUPPORTS	26
6.4 HORIZONTAL SUPPORTS.....	26
6.5 LOAD WIDTH	28
6.6 DESIGN FOR UPLIFT	28
6.7 PIERS	34
6.8 MULLIONS.....	37
SECTION 7 MASONRY VENEER WALLS	
7.1 SCOPE OF SECTION	43
7.2 GENERAL CRITERIA.....	43
7.3 WALL TIES	43

SECTION 8 CAVITY MASONRY WALLS

8.1	SCOPE OF SECTION	45
8.2	EXTERNAL WALLS	45
8.3	INTERNAL WALLS	45
8.4	WALL TIES	48

SECTION 9 SINGLE-LEAF UNREINFORCED MASONRY WALLS

9.1	SCOPE OF SECTION	51
9.2	EXTERNAL WALLS	51
9.3	INTERNAL WALLS	55

SECTION 10 REINFORCED MASONRY WALLS

10.1	SCOPE OF SECTION	56
10.2	GENERAL CRITERIA.....	56
10.3	STARTER BARS	56
10.4	BOND BEAMS	57
10.5	VERTICAL REINFORCEMENT	61

SECTION 11 BRACING

11.1	SCOPE OF SECTION	64
11.2	LOCATION AND DISTRIBUTION OF BRACING.....	64
11.3	BRACING CAPACITIES OF WALLS AND PIERS.....	64
11.4	SUBFLOOR BRACING	67

SECTION 12 LINTELS

12.1	SCOPE OF SECTION	68
12.2	STEEL LINTELS	68
12.3	REINFORCED MASONRY LINTELS	71

SECTION 13 CONTROL JOINTS

13.1	SCOPE OF SECTION	73
13.2	GENERAL CRITERIA.....	73
13.3	ARTICULATION JOINTS	73
13.4	CONTRACTION JOINTS	74
13.5	EXPANSION JOINTS.....	75
13.6	DETAILS.....	76

SECTION 14 DETAILING

14.1	SCOPE OF SECTION	77
14.2	MORTAR JOINTS	77
14.3	UNREINFORCED WALL CONNECTIONS	77
14.4	REINFORCED WALL CONNECTIONS.....	77
14.5	SLIP JOINTS.....	78
14.6	ISOLATED SUBFLOOR PIERS	78
14.7	ARCHES	80
14.8	RESISTANCE TO MOISTURE PENETRATION.....	81
14.9	PARAPETS, CHIMNEYS AND CANTILEVERS	82

Page

APPENDICES

A	BASIS OF DESIGN.....	83
B	SPACING OF BRACING WALLS	88
C	DEEMED-TO-SATISFY DURABILITY CLASSIFICATION.....	91
D	REINFORCED MASONRY LINTEL TABLES.....	93
BIBLIOGRAPHY.....		103

STANDARDS AUSTRALIA

Australian Standard

Masonry in small buildings

Part 1: Design

S E C T I O N 1 S C O P E A N D G E N E R A L

1.1 SCOPE

This Standard specifies requirements for the design and specification of masonry in buildings of Class 1 and Class 10a, as defined in the National Construction Code (NCC), and constructed from clay, concrete, or calcium silicate masonry units and as follows:

- (a) Leaf thicknesses are 90 mm or greater.
- (b) The tops of all walls are laterally supported by a roof or floor structure acting as a diaphragm with the exception of parapets, chimneys and cantilevers in accordance with Clause 14.9 and fin walls in accordance with Table 9.1.
- (c) Walls are supported on concrete slabs, footings or suspended slabs complying with the NCC.
- (d) The geometric limitations specified in Clause 1.2.2.

The Scope of this Standard does not cover the following:

- (i) Acoustics and energy efficiency.
- (ii) Construction or detailing of attachments such as basketball hoops, satellite dishes, shade structures and similar structures.
- (iii) Masonry constructed from autoclaved aerated concrete (AAC) units.
- (iv) Structures required to be designed for earthquake actions in accordance with AS 1170.4.
- (v) External walls constructed from horizontally cored units.

NOTES:

- 1 For acoustic and energy efficiency requirements, see the NCC.
- 2 For applications outside the scope of this Standard, the masonry should be constructed in accordance with AS 3700.
- 3 Information on the basis upon which the design details and tables in this Standard have been prepared is given in Appendix A.

1.2 GENERAL LIMITATIONS

1.2.1 Loading

Wind classifications and loads derived from AS 4055 are required for the use of the Tables in this Standard.

NOTES:

- 1 For wind loads on structures outside the limitations of Clause 1.2.2, AS/NZS 1170.2 should be used in conjunction with AS 3700.
- 2 The loads specified in AS 4055 include the appropriate combinations of permanent and wind actions.

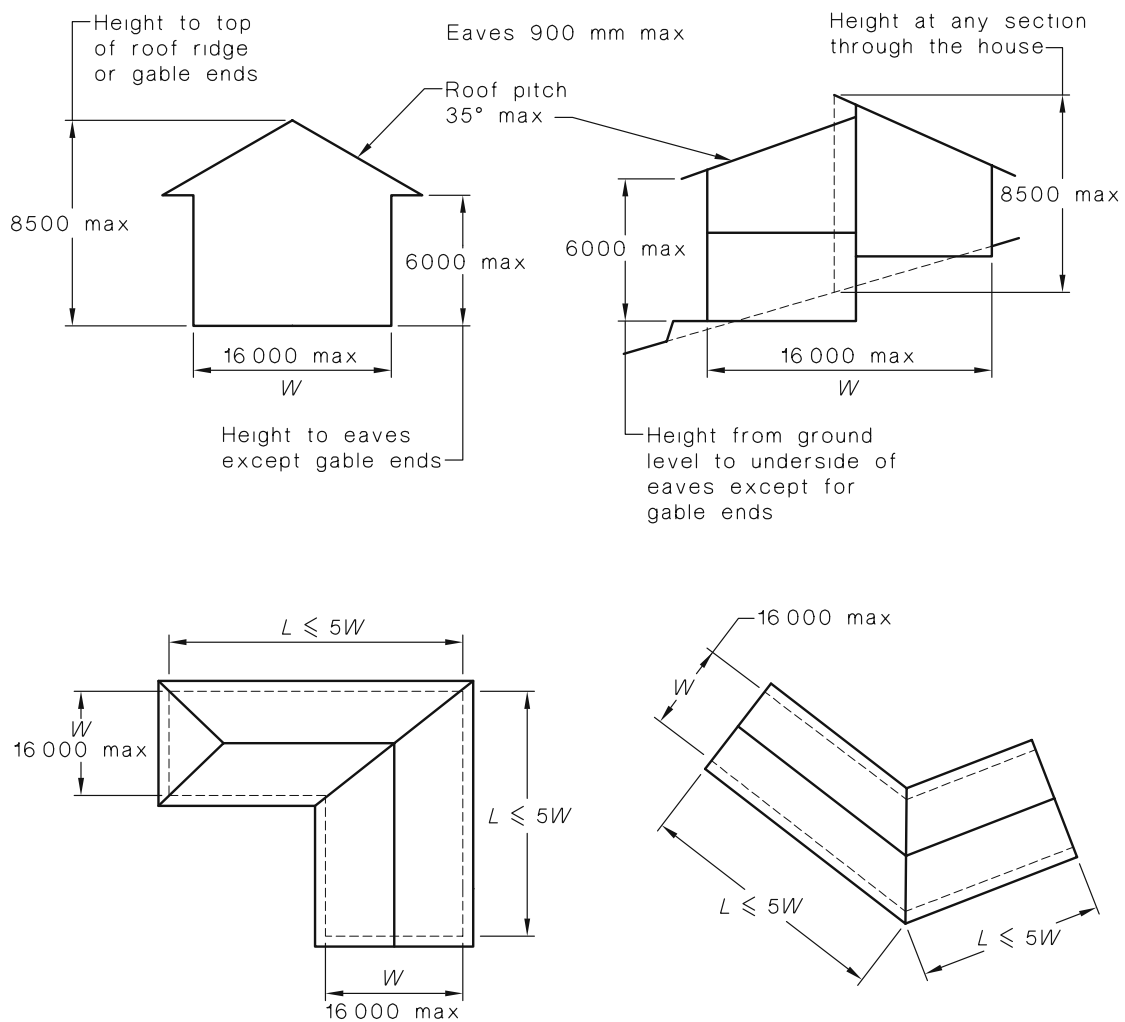
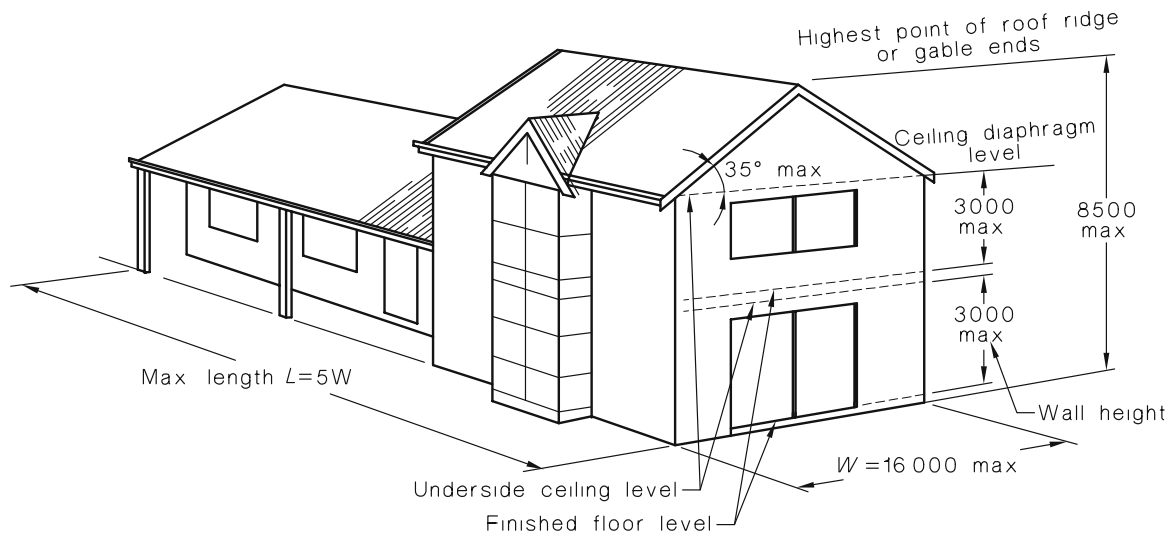
1.2.2 Limitations for building geometry

For the purpose of this Standard, the following limitations apply (see Figure 1.1):

- (a) The distance from ground level to the underside of eaves shall not exceed 6.0 m. The distance from ground level to the highest point of the roof, neglecting chimneys, shall not exceed 8.5 m; and the height of each storey, measured as floor to ceiling at external walls shall not exceed 3.0 m.
- (b) The width (*W*), including roofed verandas but excluding eaves, shall not exceed 16.0 m, and the length (*l*) shall not exceed five times the width.
- (c) The roof pitch shall not exceed 35°.
- (d) Eaves width shall not exceed 900 mm.
- (e) The building shall include a continuous ceiling that acts as a diaphragm.

NOTES:

- 1 Atria exceeding these dimensions are outside the scope of this Standard.
- 2 Where the geometry lies outside the limitations of this Section, the design may be carried out in accordance with AS 3700.



DIMENSIONS IN MILLIMETRES

FIGURE 1.1 BUILDING GEOMETRY

1.3 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard.

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

1397	Continuous hot-dip metallic coated steel sheet and strip—Coatings of zinc and zinc alloyed with aluminium and magnesium
1684	Residential timber-framed construction (series)
1720	Timber structures (series)
2870	Residential slabs and footings
3600	Concrete structures
3700	Masonry structures
4055	Wind loads for housing
4773	Masonry in small buildings
4773.2	Part 2: Construction

AS/NZS

2699	Built-in components for masonry construction
2699.1	Part 1: Wall ties
2699.2	Part 2: Connectors and accessories
2699.3	Part 3: Lintels and shelf angles (durability requirements)
4455	Masonry units, pavers, flags and segmental retaining wall units
4455.1	Part 1: Masonry units
4456	Masonry units and segmental pavers and flags
4456.4	Method 4: Methods of test—Determining compressive strength of masonry units
4534	Zinc and zinc/aluminium-alloy coatings on steel wire
4600	Cold-formed steel structures
4671	Steel reinforcing materials
4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
NCC	National Construction Code
NASH	National Association of Steel Frame Housing Standard for Residential and Low-rise Steel Framing Part 1: Design criteria

1.4 MINIMUM INFORMATION TO BE PROVIDED

The following information shall be shown on the drawings or in the specifications:

- (a) Site information:
 - (i) Site address.
 - (ii) Wind classification in accordance with AS 4055.
 - (iii) Soil classification in accordance with AS 2870.
 - (iv) Exposure environment (see Clause 4.3).

- (b) Masonry units:
 - (i) Type (e.g. clay, concrete, calcium silicate).
 - (ii) Category (e.g. cored, solid, hollow, horizontally cored).
 - (iii) Work sizes, including the face shell width for hollow units.
 - (iv) Characteristic unconfined compressive strength (f'_{uc}).
 - (v) Salt attack resistance grade.
 - (vi) Coefficient of expansion or drying contraction, as appropriate.
 - (vii) Mortar joint finish and depth of raking (if any).
- (c) Mortar class or mix proportions.
- (d) Grout characteristics (if used):
 - (i) Compressive strength (f'_c).
 - (ii) Cement content.
 - (iii) Maximum aggregate size.
 - (iv) Workability and site mix proportions (if applicable).
- (e) Wall tie and accessory classes for strength and durability.
- (f) Reinforcement grade (if used).
- (g) Masonry bond pattern.
- (h) Principal dimensions of the masonry, including the positions of supports, piers, openings, length of returns and all features affecting the strength and stability of the structure.
- (i) Positions and details (including where appropriate, dimensions, durability rating, and material types) of the following:
 - (i) Subfloor or cavity ventilation.
 - (ii) Termite barriers.
 - (iii) Damp-proof courses.
 - (iv) Flashings.
 - (v) Slip materials.
 - (vi) Control joints.
 - (vii) Lintels.
 - (viii) Roof anchorage.
 - (ix) Reinforcement.
 - (x) Bracing walls.
 - (xi) Connectors.
- (j) Statement that the construction is required to be in accordance with AS 4773.2.

CI.4 *It may not be necessary for all items of information to be provided for every project. Items are only required if they are necessary for construction of a particular project.*

1.5 DEFINITIONS

For the purposes of this Standard, the definitions below apply.

1.5.1 Characteristic compressive strength

The unconfined compressive strength exceeded by 95% of the masonry units.

1.5.2 Damp-proof course (DPC)

A barrier of impermeable material laid in the foundation walls of a building near the ground to prevent moisture or dampness from rising into the building.

1.5.3 Horizontal support

A structural member or system resisting the horizontal out-of-plane component of loads applied to masonry.

1.5.4 Masonry unit

A preformed component intended for use in bonded masonry construction. The term includes the following:

- (a) *Solid unit* A unit without cores but which may contain recesses (commonly called frogs) not greater than 10% of gross volume and intended to be laid with full bed joints.
- (b) *Cored unit* A unit with cores intended to be laid with its cores vertical and with full bed joints.
- (c) *Hollow unit* A unit with cores intended to be laid with its cores vertical and with face-shell-bedded joints.
- (d) *Horizontally cored units* A unit with cores intended to be laid with its cores horizontally and with full bed joints.

1.5.5 Wall chasing

Recess cut into an existing wall to accommodate services.

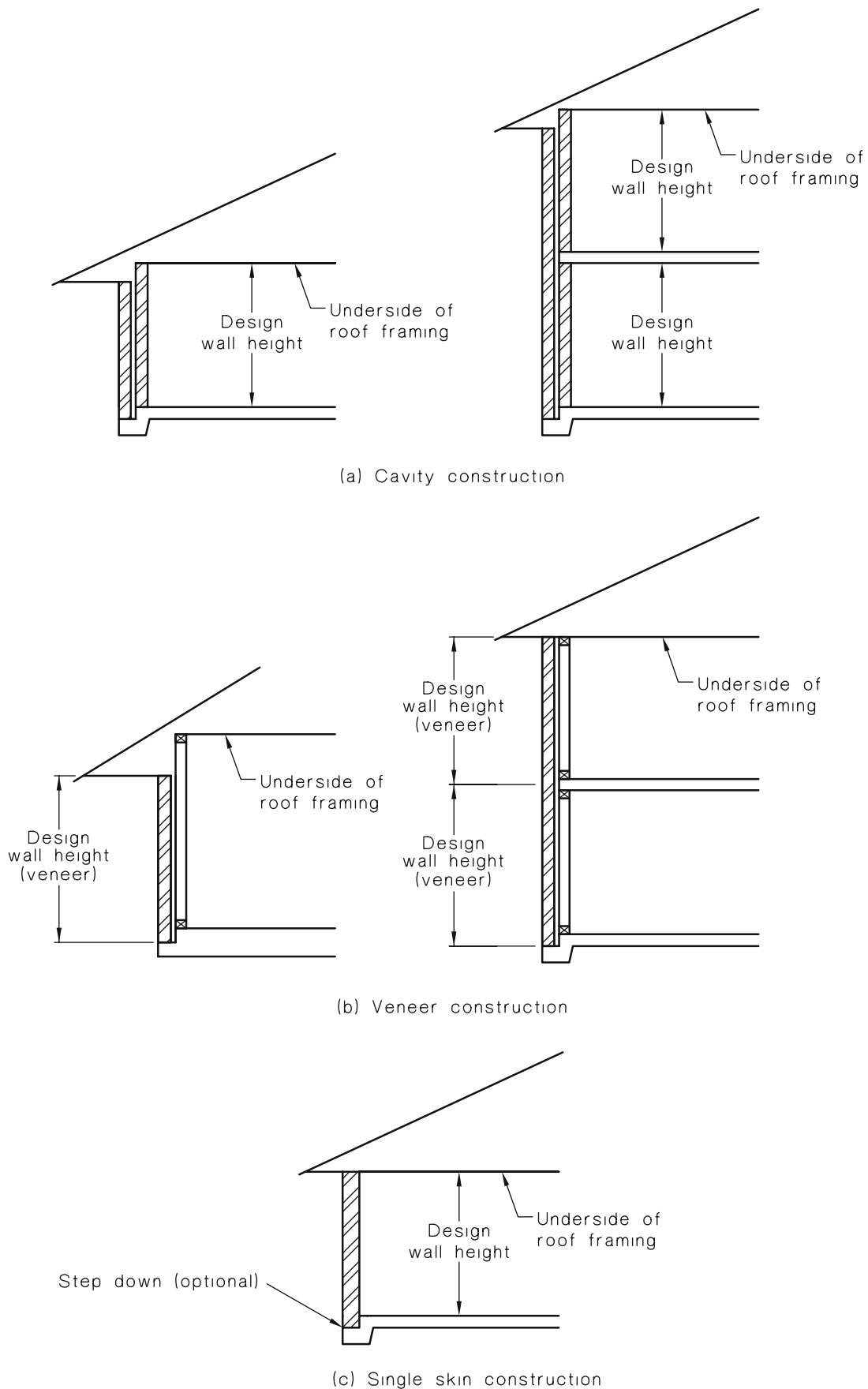
1.5.6 Wall height

Height as defined in Figure 1.2.

1.5.7 Wall panel length

The clear distance between lateral supports or the distance between the support and a free edge, where lateral supports provide resistance to lateral movement.

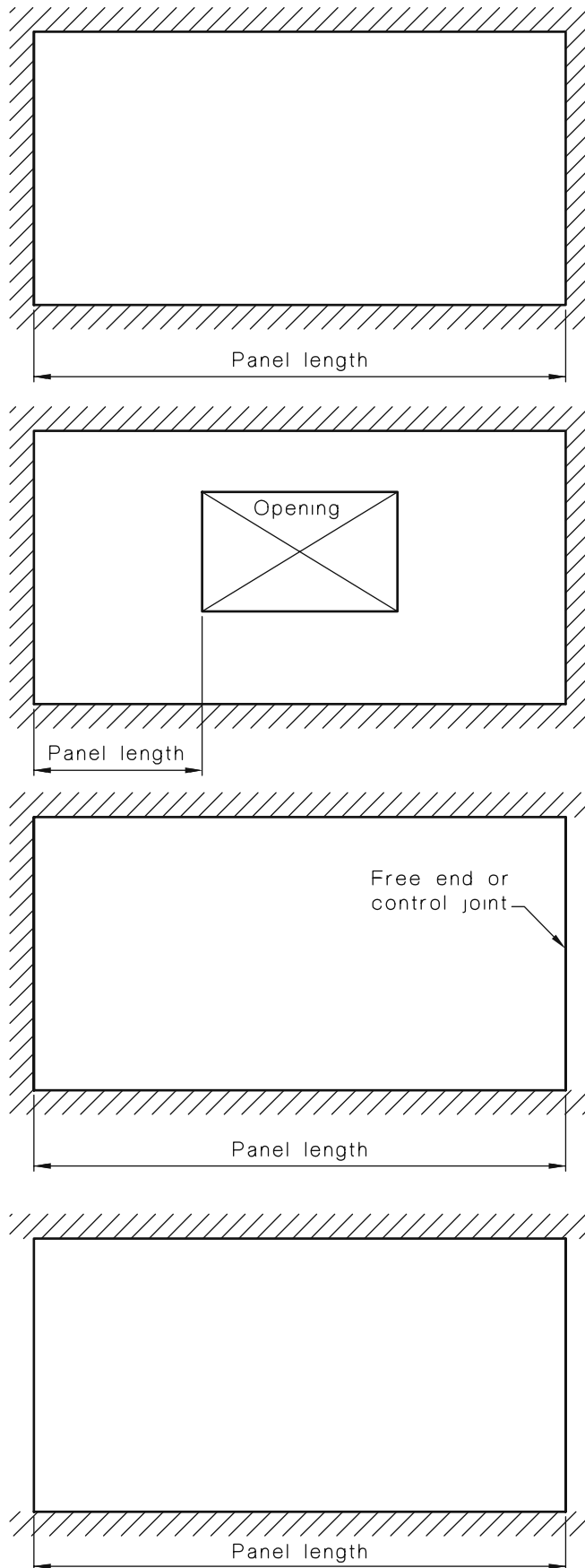
NOTE: See Figure 1.3 for the relevant case.



NOTES:

- 1 Battens and ceiling lining should be ignored in defining the underside of the roof framing.
- 2 Wall height is taken from the top of the slab with or without rebate (as shown).

FIGURE 1.2 DESIGN WALL HEIGHT



(a) Wall supported on four sides with no opening

(b) Wall with an opening supported on four sides

NOTE: Openings less than 600 mm high may be ignored

(c) Wall supported on three sides with one free end

(d) Wall supported at top and bottom spanning one-way

FIGURE 1.3 DESIGN WALL PANEL LENGTH

SECTION 2 DESIGN CRITERIA

2.1 SCOPE OF SECTION

This Section sets out general design criteria for masonry. Particular requirements for structural design are set out in Sections 6, 7, 8, 9 and 10.

NOTE: The aim of design should be to provide a structure that is durable, fire resistant, serviceable, and has adequate strength and stability while serving its intended function and satisfying other relevant requirements, such as resistance to water penetration and robustness.

2.2 DESIGN REQUIREMENTS

2.2.1 Design for durability

A masonry member or structure shall be designed for durability in accordance with Section 4.

2.2.2 Design for serviceability

A masonry member or structure shall be designed for serviceability as set out in Clauses 2.3.1 and 2.3.2, in accordance with Section 6, 7, 8 or 9, as appropriate.

2.2.3 Design for strength

A masonry member or structure shall be designed for strength as set out in Clauses 2.3.1 and 2.3.3, in accordance with Section 6, 7, 8, 9 or 10.

2.2.4 Design for stability

A masonry member or structure shall be designed for stability as set out in Clauses 2.3.1 and 2.3.4, in accordance with Section 6, 7, 8, 9 or 10.

2.2.5 Design for fire resistance

A masonry member or structure shall be designed for fire resistance in accordance with Section 5.

2.2.6 Design for prevention of water penetration

A masonry member or structure shall be designed for other requirements as set out in Clause 2.3.5, and in accordance with Sections 11, 12, 13 and 14.

2.3 SERVICEABILITY, STRENGTH, STABILITY AND PREVENTION OF WATER PENETRATION

2.3.1 General

Design for serviceability, strength and stability shall—

- (a) provide for all loads and forces to be transferred through the structure to the foundation;
- (b) provide for compatibility between each masonry member and the structural members giving vertical and, where required, lateral support to that masonry member; and
- (c) be based on the material properties of the masonry in accordance with Section 3.

NOTE: Design for serviceability, strength and stability should be in accordance with accepted principles of mechanics.

2.3.2 Design for serviceability

A masonry member or structure shall be designed to allow movements to be controlled or isolated so that damage to the masonry, the building and its components is avoided and the structural and other requirements are satisfied.

The movements to be allowed for shall include the following:

- (a) The expansion characteristics of clay masonry and the shrinkage characteristics of concrete masonry and calcium silicate masonry.
- (b) Thermal movements.
- (c) Deflections, shortening, shrinkage, creep and similar deformations in adjacent or associated materials.
- (d) Foundation movements.
- (e) Deformation due to construction loads or construction sequences.

If subjected to design loads or design building movement, masonry shall experience no damage, a low incidence of damage category 1 or an occasional incidence of damage category 2. The classification of damage with reference to walls is given in Table 2.1. Masonry is deemed to meet this performance requirement if it complies with this Standard and AS 4055 for the appropriate wind class and is constructed on concrete footings and/or concrete slabs complying with AS 2870 for the appropriate site classes nominated therein.

2.3.3 Design for strength

A masonry member or structure shall be designed to prevent failure under the worst combinations of actions. The wind actions used in this Standard shall be as specified in AS 4055.

2.3.4 Design for stability

The structure (as a whole) and its parts shall be designed to prevent instability due to overturning, uplift and sliding under the worst combination of actions. The wind actions used in this Standard are as specified in AS 4055.

2.3.5 Design for prevention of water penetration

Where moisture penetration is required to be prevented, a masonry member or structure shall be designed, constructed and protected against passage of moisture in accordance with Clause 14.8.

TABLE 2.1
CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks that do not need repair	<1 mm	1
Cracks noticeable but easily filled Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather tightness often impaired	5 mm to 15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15 mm to 25 mm but also depends on number of cracks	4

NOTES:

- 1 This Table (including notes) is reproduced from AS 2870.
- 2 Crack width is the main factor by which damage to walls is categorized. The width may be supplemented by other factors, including serviceability, in assessing category of damage.
- 3 In assessing the degree of damage, account shall be taken of the location in the building or structure where damage occurs, and the function of the building or structure.
- 4 Where the cracking occurs in easily repaired plasterboard or similar clad-framed partitions, the crack width limits may be increased by 50% for each damage category.
- 5 Local deviation of slope, from the horizontal or vertical, of more than 1/100 will normally be clearly visible. Overall deviations in excess of 1/150 are undesirable.
- 6 Account should be taken of the past history of damage in order to assess whether it is stable or likely to increase.

S E C T I O N 3 M A T E R I A L S

3.1 SCOPE OF SECTION

This Section sets out the requirements for materials of masonry units, mortar, grout, damp-proof courses, flashings, built-in components and reinforcement.

3.2 MASONRY UNITS

3.2.1 General

All masonry units shall be fired clay, concrete or calcium silicate units complying with AS/NZS 4455.1.

The salt attack resistance grade of masonry units shall comply with the durability requirements of Section 4.

3.2.2 Unreinforced loadbearing masonry

For unreinforced loadbearing masonry, the units shall have a minimum characteristic unconfined compressive strength as follows:

- (a) 5 MPa for solid or cored units.
- (b) 10 MPa for hollow units.

3.2.3 Unreinforced non-loadbearing masonry

For unreinforced non-loadbearing masonry, the units shall have a minimum characteristic unconfined compressive strength as follows:

- (a) 3 MPa for solid or cored units.
- (b) 10 MPa for hollow units.
- (c) 2.5 MPa for horizontally cored units.

3.2.4 Reinforced masonry

For reinforced masonry, the units shall have a minimum characteristic unconfined compressive strength of 15 MPa.

3.3 MORTAR AND GROUT

3.3.1 Mortar composition

Mortar shall consist of a mixture of cement, sand and water, with the addition of lime and admixtures (if specified). The mixes shall be as shown in Table 3.1 and selected in accordance with the durability requirements of Section 4.

For reinforced masonry, the mortar class shall be either M3 or M4.

TABLE 3.1
MORTAR MIXES

Mortar class	Mix proportions by volume					Mortar suitability		
	Cement (GB/GP)	Masonry cement	Building lime	Sand	Water thickener	Fired clay	Concrete	Calcium silicate
M2	1	0	2	9	No	✓	×	×
M3	1	0	1	6	Optional	✓	✓	×
	1	0	0	5	Yes	✓	✓	✓
	0	1	0	4	Yes	✓	✓	×
M4	1	0	0.5	4.5	Optional	✓	✓	×
	1	0	0	4	Yes	✓	✓	✓
	1	0	0–0.25	3	Optional	✓	✓	×
	0	1	0	3	Yes	✓	✓	×

LEGEND:

✓ = satisfactory

× = unsatisfactory

Type GP = general purpose portland cement.

Type GB = general purpose blended cement.

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 C 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's or supplier's instructions. For further information, refer to AS 4773.2.

3.3.2 Grout composition

Grout shall consist of a mixture of cement, sand, and aggregate (screened gravel or crushed rock). A mortar mix to which water has been added (slurry) shall not be used as a substitute for grout.

Site-mixed grout shall consist of the following mix proportion, by volume:

1 part cement : 2 parts sand : 4 parts aggregate.

For reinforced masonry, the grout shall have a compressive strength of at least 20 MPa with at least 300 kg of cement per cubic metre.

3.4 BUILT-IN COMPONENTS**3.4.1 Wall ties**

Wall ties shall comply with AS/NZS 2699.1 and the durability requirements of Section 4.

3.4.2 Connectors and accessories

Built-in connectors, bolts and fixings shall comply with AS/NZS 2699.2 and the durability requirements of Section 4.

3.4.3 Lintels

All lintels shall comply with the durability requirements of Section 4.

Steel lintels shall be manufactured from steel having yield strength not less than 250 MPa.

3.4.4 Mullions

All mullions shall comply with the durability requirements of Section 4.

Steel mullions shall be manufactured from steel having yield strength not less than 250 MPa.

3.5 REINFORCEMENT

Reinforcement shall be Grade 500N in accordance with AS/NZS 4671.

SECTION 4 DURABILITY

4.1 SCOPE OF SECTION

This Section sets out the durability requirements for masonry materials, accessories and built-in items for a range of defined exposure environments.

4.2 MATERIAL SELECTION

Masonry materials, accessories and built-in items shall be selected and combined to satisfy the durability requirements of Table 4.1 for the relevant exposure environment in accordance with Clause 4.3 and location in accordance with Clause 4.4.

In the application of Table 4.1, 'built-in components' includes anchors, connectors, ties, straps, bolts and fixings, bedjoint mesh and reinforcement that does not rely on grout cover for protection.

Where grout is required to provide protection to steel reinforcement in grouted cavities and cores, the steel shall be surrounded by grout complying with Clause 3.3.2 to provide a cover, measured from the face of the grout to the surface of the reinforcement in accordance with Table 4.1.

NOTE: Horizontal reinforcement in reinforced hollow unit masonry may be supported on the webs of recessed-web hollow units, provided the reinforcement is completely surrounded by grout except where it is in contact with the masonry units.

Where recessed web, flush-ended hollow blocks are used, the reinforcement shall be supported clear of the webs to permit the covers required by Table 4.1 to be achieved at all positions along the reinforcement, including within perpendicular joints.

4.3 EXPOSURE ENVIRONMENTS

4.3.1 Severe marine

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

TABLE 4.1
DURABILITY REQUIREMENTS

Exposure environment	Location		Masonry units salt attack resistance grade (see Note 1)	Mortar class		Built-in components durability class (see Note 2)	Reinforcement cover mm (see Note 3)
All	Interior	Normal	Protected	Clay units	M2	R1	5
				Concrete or calcium silicate units	M3	R1	5
		Subject to non-saline wetting and drying	General purpose	M3		R3	15
		Subject to saline wetting and drying	Exposure	M4		R4	25
	Exterior-coated—waterproof coating, above a DPC and protected by roof, eave or coping, with properly flashed junctions		Protected	Clay units	M2	R1	5
				Concrete or calcium silicate units	M3	R1	5
	Below a DPC or in contact with the ground	Protected from water ingress by an impermeable membrane	Protected	Clay units	M2	R2	15
				Concrete or calcium silicate units	M3	R2	15
		Non-aggressive soils	General purpose	M3		R3	15
		Aggressive soils	Exposure	M4		R4	25
Mild	Exterior		Protected	Clay units	M2	R1	5
				Concrete or calcium silicate units	M3	R1	5
Moderate	Exterior		Protected	Clay units	M2	R1	5
				Concrete or calcium silicate units	M3	R1	5
Industrial	Exterior		Exposure	M4		R4	25
Marine (see Note 4)	Exterior		General purpose	M3		R3	15
Severe marine (see Notes 5 and 9)	Exterior		Exposure	M4		R4	25
Special (see Notes 6 and 9)	Exterior		(see Note 6)	(see Note 6)		R5	(see Note 6)

NOTES TO TABLE 4.1:

- 1 Means for determining salt attack resistance grades for masonry units are given in AS/NZS 4455.1.
- 2 Durability classes shown in Appendix C shall be deemed to satisfy this requirement for all built-in components except lintels. For durability classes of lintels, refer to AS/NZS 2699.3.
- 3 Cover requirements shall be satisfied where grout cover is relied upon to provide durability protection otherwise use the durability class in column five of Table 4.1 above.
- 4 All external elements in contact with freshwater or subject to non-saline wetting and drying shall be treated as for a marine environment.
- 5 All external elements in contact with saline or contaminated water or subject to saline wetting and drying shall be treated as for a severe marine environment.
- 6 Requirements for especially aggressive environments depend on the nature of the corrosive agents and cannot be defined. Units, mortars, covers or coatings shown by test, or known by experience, to be resistant to the particular corrosive agent shall be used.
- 7 M2 mortar is not permitted for concrete and calcium silicate masonry. There are also limitations on the constituents of M3 and M4 mortars for calcium silicate masonry (refer to Table 3.1).
- 8 This table does not exclude the use of materials which otherwise comply with the requirements of AS/NZS 2699 Parts 1-3.
- 9 Up to 200 m from a surf coast as specified in AS 4312 is considered to be an especially aggressive environment and in external walls lintels are required to have a durability classification of R5. Currently available examples of R5 lintels are stainless steel grade ASTM A240 316 or ASTM A240 316L (UNS S31600 or S31603 respectively). This does not preclude lintels from other materials provided they comply with AS/NZS 2699.3 durability classification R5.

4.3.2 Marine

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

NOTE: Sheltered bays such as Port Phillip Bay and Sydney Harbour are considered to be non-surf coast.

4.3.3 Industrial

Industrial environments are those within 1 km of industrial areas producing significant acidic pollution. The only areas within this category are around major industrial complexes.

NOTE: There are only a few such regions in Australia; for example, around Port Pirie.

4.3.4 Moderate

Moderate environments include areas with light industrial pollution or very light marine influence, or both.

NOTE: Typical areas are suburbs of cities on sheltered bays such as Melbourne, Adelaide and Hobart (except those areas near the coast) and most inland cities.

4.3.5 Mild

Environments remote from the coast, industrial activity and the tropics shall be regarded as mild environments.

NOTE: Sparsely settled regions such as outback Australia are typical examples, but the category also includes rural communities other than those on the coast.

4.4 ELEMENT LOCATIONS

For the application of Table 4.1, the following locations shall be used:

(a) *Interior locations:*

- (i) Elements that are above a damp-proof course and enclosed within the building except during construction.
- (ii) The masonry units and mortar in the inner leaf of a cavity wall.

(b) *Exterior locations:*

- (i) The exposed leaf of a cavity or veneer wall.
- (ii) The cavity space in an exposed cavity or veneer wall.
- (iii) Wall ties in a cavity or veneer wall.
- (iv) Roof tie-down straps in a cavity or veneer wall.
- (v) Lintels embedded in either leaf of a cavity wall.

Exterior coated locations are those that are protected by a weather-resistant coating in accordance with Clause 14.8.1. In addition to the coating, these elements shall have properly flashed junctions with other building elements.

An impermeable membrane for protection of locations below a damp-proof course or in contact with the ground shall be a continuous waterproof sheet membrane such as that used for protection of slabs on the ground.

NOTE: Painted water-resistant systems are not adequate for this purpose.

SECTION 5 FIRE RESISTANCE

5.1 SCOPE OF SECTION

This Section sets out general criteria for fire resistance of a masonry wall to fulfil its required functions (loadbearing and/or separating function) for a specified fire exposure, for a specified time.

NOTE: The fire resistance levels (FRL) for structural adequacy, integrity and insulation (expressed in that order) for structures, parts and elements of construction are specified in the NCC.

5.2 GENERAL CRITERIA

Where movement joints or edge clearances are required for walls designed to resist fire, they shall be filled with a non-combustible material that allows the movement joint to function.

NOTE: For panel walls that are to provide fire resistance where edge isolation is necessary, additional consideration should be given to the edge detail.

5.3 FIRE-RESISTING MASONRY DESIGN CRITERIA

5.3.1 General

Fire-resisting masonry walls shall be designed to have a fire resistance period (FRP) for each of structural adequacy, integrity and insulation not less than the required fire resistance level (FRL).

5.3.2 External walls

Where external walls are required to have a FRL the following shall apply:

- (a) Veneer walls, where the frame is isolated from the fire source by the masonry, are deemed to have a fire resistance of 60/60/60.
- (b) For cavity walls, the loadbearing leaf shall comply with Table 5.1. There are no requirements for non-loadbearing leaf.
- (c) Single leaf walls shall comply with Table 5.1.

5.3.3 Internal walls

Where an internal wall is required to have a FRL of 60/60/60, it shall be proportioned in accordance with Table 5.1.

5.3.4 Floors providing lateral support to walls

Top supports for a fire-rated wall shall be—

- (a) a floor with an FRL equal to or greater than the wall on at least one side; or
- (b) non-fire-rated floors attached independently on both sides.

TABLE 5.1
MAXIMUM WALL HEIGHT TO SATISFY FRL

Wall type	Maximum height of wall between supports, mm (see Note 1)
	Required FRL
	60/60/60
90 mm clay solid or cored units	2 700
90 mm concrete solid, cored or hollow units with over 45% basalt	2 700
110 mm concrete solid, cored or hollow units with under 45% basalt	2 640
110 mm concrete solid, cored or hollow units with over 45% basalt	3 300
110 mm clay solid or cored units	3 300
150 mm clay solid or cored units	4 500
140 mm hollow units	3 540
140 mm hollow units (core filled)	3 540
190 mm concrete hollow units	4 810
140 mm vertically reinforced (see Note 2)	4 500
190 mm vertically reinforced (see Note 2)	5 300

NOTES:

- 1 The height is measured floor to floor or floor to ceiling where the floor or ceiling is attached and provides lateral support (see Figure 1.2).
- 2 Reinforced vertically with not less than N12 bars at 2.0 m centres.
- 3 The wall heights shall also satisfy the requirements given in Tables 9.1 and 9.3.

SECTION 6 WALL DESIGN

6.1 SCOPE OF SECTION

This Section sets out general design criteria for masonry members and structures, including joints, bonding and tying, connections and lintels.

6.2 GENERAL CRITERIA

Walls shall be designed to comply with Section 7, 8, 9 or 10, as appropriate. Where horizontally cored units are used, consideration shall be given in design to the influence of chasing for services on the wall panel load capacity.

NOTE: Provision of alternative means for running services that minimize the need to chase is recommended.

Design for bracing capacity shall be carried out in accordance with Section 11.

6.3 VERTICAL SUPPORTS

Where vertical supports are required, vertical supports shall be:

- (a) Cross-walls or masonry returns of length at least 600 mm and properly bonded or tied to the supported wall.
- (b) Reinforced piers or reinforced cores of hollow blockwork in accordance with Clause 6.7.2.
- (c) Steel or timber framing that has been designed to withstand horizontal loadings in accordance with AS/NZS 4600 and AS 1684.2, AS 1684.3 and AS 1684.4.
- (d) Steel mullions designed in accordance with Clause 6.8.

An untied wall joint shall be regarded as a free end.

6.4 HORIZONTAL SUPPORTS

Except for parapets, chimneys and cantilevers in accordance with Clause 14.9 and fin walls in accordance with Table 9.1, all masonry walls shall be supported at both top and bottom by horizontal supports.

The following horizontal supports shall be used:

- (a) Concrete roof or floor slabs complying with AS 3600 or AS 2870, as appropriate, with or without a slip joint.
- (b) Timber floors and roof structures complying with AS 1684 (series) or AS 1720 (series).
- (c) Steel floor and roof structures complying with AS/NZS 4600.
- (d) Steel floor and roof structures complying with NASH.
- (e) Cornices securely attached to the ceiling structure in accordance with Figure 6.1.

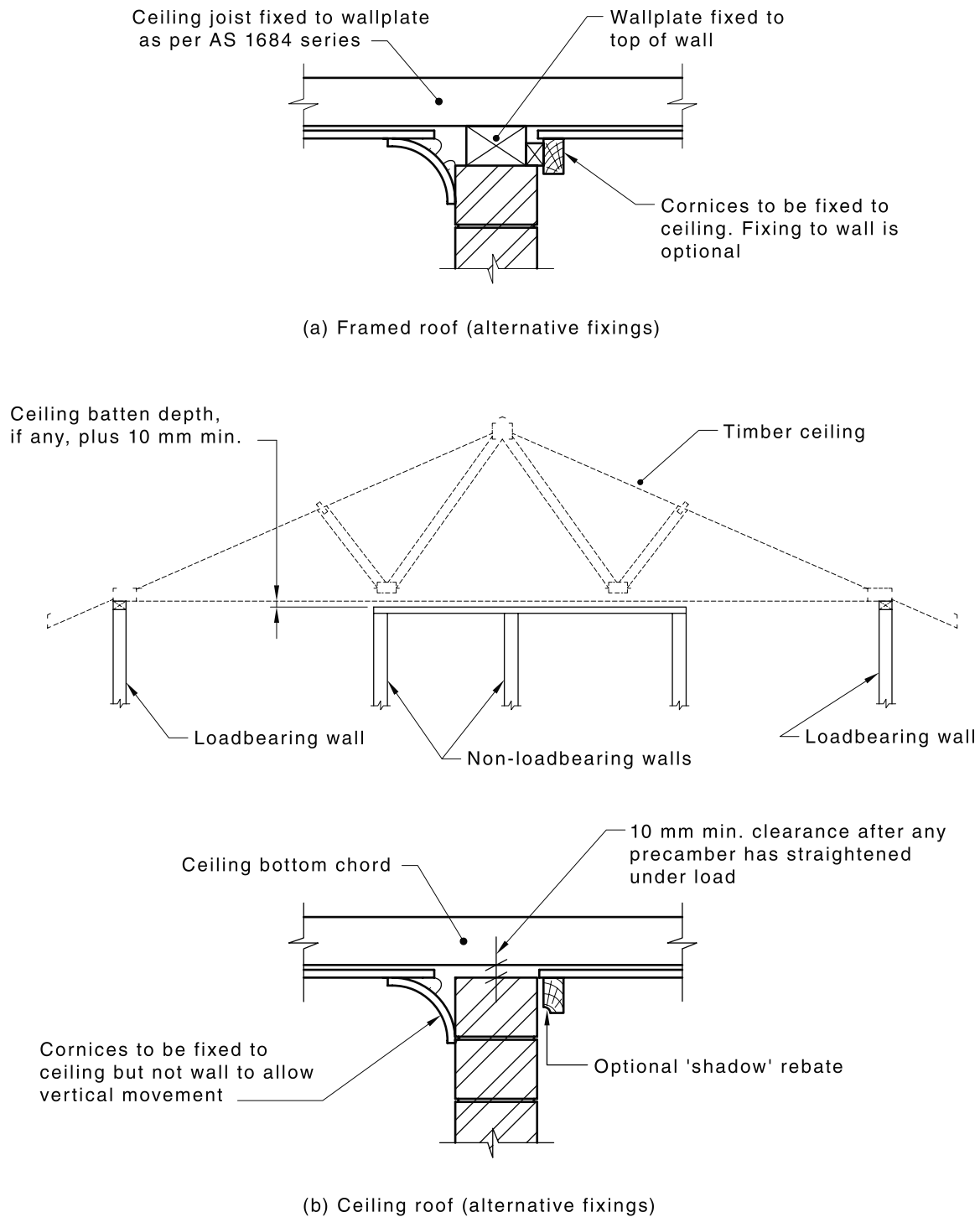
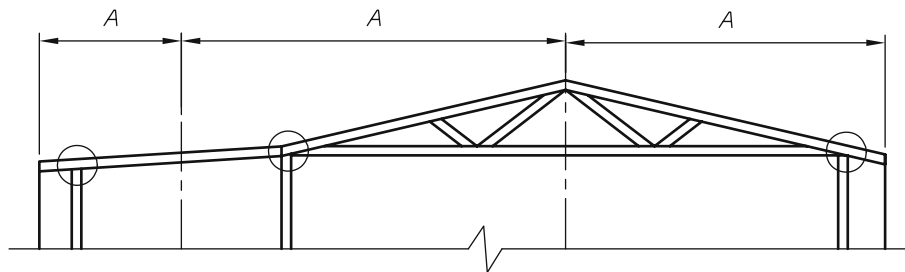


FIGURE 6.1 CORNICE DETAILS PROVIDING LATERAL SUPPORT FOR INTERNAL WALLS

6.5 LOAD WIDTH

The load width (A) required for selection of connections in accordance with Clause 6.6 and lintels in accordance with Clauses 12.3 and 12.4 shall be determined in accordance with Figure 6.2.



NOTE: Circles indicate the wall containing the connection or lintel.

FIGURE 6.2 DETERMINATION OF LOAD WIDTH

6.6 DESIGN FOR UPLIFT

Roofs shall be connected to masonry walls to resist the net uplift pressures given in Section 4 of AS 4055.

The connections given in Tables 6.1(A), 6.1(B) and 6.2, and shown in Figures 6.3 and 6.4, are deemed to satisfy this requirement, provided the load width (A) is in accordance with Clause 6.5.

For unreinforced masonry in wind classes greater than N3 (including all cyclonic wind classes), the roof shall be independently tied to the footing with tie-down rods.

TABLE 6.1(A)
ROOF CONNECTIONS FOR TILED ROOF

Connection	Wall thickness mm	Maximum load width (A), m, for wind class						Connection capacity kN
		N1	N2	N3	N4	N5	N6	
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 1200 mm spacings [see Figure 6.3(a)]	90	8.9	8.9	5.8	n/a	n/a	n/a	6.5
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	90	8.9	8.9	6.8	n/a	n/a	n/a	3.8
Strap 30 × 0.8 mm embedded 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	90	8.9	8.9	7.3	n/a	n/a	n/a	4.1
Strap 30 × 0.8 mm attached to bar 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	90	8.9	8.9	7.8	n/a	n/a	n/a	4.3
Strap 30 × 0.8 mm attached to bar 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	90	8.9	8.9	8.8	n/a	n/a	n/a	4.9
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 1200 mm spacings [see Figure 6.3(a)]	110	8.9	8.9	5.8	n/a	n/a	n/a	6.5
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	110	8.9	8.9	8.3	n/a	n/a	n/a	4.6
Strap 30 × 0.8 mm embedded 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	110	8.9	8.9	8.9	n/a	n/a	n/a	5.0
Strap 30 × 0.8 mm attached to bar 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	110	8.9	8.9	8.9	n/a	n/a	n/a	5.3
Strap 30 × 0.8 mm attached to bar 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	110	8.9	8.9	8.9	n/a	n/a	n/a	6.0

LEGEND:

n/a = not appropriate.

NOTES:

- 1 Strap size 25 × 1.0 mm may be substituted for 30 × 0.8 mm.
- 2 The durability of the strap shall be in accordance with Table 4.1.

TABLE 6.1(B)
ROOF CONNECTIONS FOR SHEET ROOF

Connection	Wall thickness mm	Maximum load width (A), m, for wind class						Connection capacity kN
		N1	N2	N3	N4	N5	N6	
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 1200 mm spacings [see Figure 6.3(a)]	90	8.9	7.3	4.1	n/a	n/a	n/a	6.5
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	90	8.9	8.5	4.8	n/a	n/a	n/a	3.8
Strap 30 × 0.8 mm embedded 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	90	8.9	8.9	5.1	n/a	n/a	n/a	4.1
Strap 30 × 0.8 mm attached to bar 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	90	8.9	8.9	5.4	n/a	n/a	n/a	4.3
Strap 30 × 0.8 mm attached to bar 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	90	8.9	8.9	6.1	n/a	n/a	n/a	4.9
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 1200 mm spacings [see Figure 6.3(a)]	110	8.9	7.3	4.1	n/a	n/a	n/a	6.5
Strap 30 × 0.8 mm embedded 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	110	8.9	8.9	5.8	n/a	n/a	n/a	4.6
Strap 30 × 0.8 mm embedded 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(a)]	110	8.9	8.9	6.2	n/a	n/a	n/a	5.0
Strap 30 × 0.8 mm attached to bar 600 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	110	8.9	8.9	6.7	n/a	n/a	n/a	5.3
Strap 30 × 0.8 mm attached to bar 900 mm down wall at maximum 600 mm spacings [see Figure 6.3(b)]	110	8.9	8.9	7.5	n/a	n/a	n/a	6.0

LEGEND:

n/a = not appropriate.

NOTES:

- 1 Strap size 25 × 1.0 mm may be substituted for 30 × 0.8 mm.
- 2 The durability of the strap shall be in accordance with Table 4.1.

TABLE 6.2
REINFORCED MASONRY TIE-DOWNS

Roof type	Wall thickness mm	Design anchorage capacity, (ϕP) kN per cleat	Maximum load width (A), m, for wind class						
			N1	N2	N3	N4, C1	N5, C2	N6, C3	C4
Tiled roof									
Two courses reinforced, with 'long fishtail cleats' [see Figure 6.4(a)]	190	30.7	8.9	8.9	8.9	8.9	8.8	5.6	4.0
Two courses reinforced, with 'long fishtail cleats' [see Figure 6.4(a)]	140	23.3	8.9	8.9	8.9	8.9	6.7	4.3	3.0
Two courses reinforced, with W8 stirrups at maximum 200 mm centres [see Figure 6.4(b)]	190	22.0	8.9	8.9	8.9	8.9	6.3	4.0	2.9
Two courses reinforced, with W8 stirrups at maximum 200 mm centres [see Figure 6.4(b)]	140	13.0	8.9	8.9	8.9	6.2	3.7	2.4	1.7
Two courses reinforced, with no deep anchorage [see Figure 6.4(c)]	190	13.1	8.9	8.9	8.9	6.3	3.8	2.4	1.7
two courses reinforced, with no deep anchorage [see Figure 6.4(c)]	140	11.3	8.9	8.9	8.9	5.4	3.3	2.1	1.5
Sheet roof									
Two courses reinforced, with 'long fishtail cleats' [see Figure 6.4(a)]	190	30.7	8.9	8.9	8.9	8.9	7.8	5.2	3.8
Two courses reinforced, with 'long fishtail cleats' [see Figure 6.4(a)]	140	23.3	8.9	8.9	8.9	8.9	5.9	3.9	2.9
Two courses reinforced, with W8 stirrups at maximum 200 mm centres [see Figure 6.4(b)]	190	22.0	8.9	8.9	8.9	8.6	5.6	3.7	2.7
Two courses reinforced, with W8 stirrups at maximum 200 mm centres [see Figure 6.4(b)]	140	13.0	8.9	8.9	8.1	5.1	3.3	2.2	1.6
Two courses reinforced, with no deep anchorage [see Figure 6.4(c)]	190	13.1	8.9	8.9	8.2	5.1	3.3	2.2	1.6
Two courses reinforced, with no deep anchorage [see Figure 6.4(c)]	140	11.3	8.9	8.9	7.1	4.4	2.9	1.9	1.4