CONCRETE MASONRY ASSOCIATION OF AUSTRALIA

CM02

Concrete Masonry – Single-Leaf Masonry Design Manual

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CONTENTS

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1 Introduction

1.1 General

This design manual has been prepared for the Concrete Masonry Association of Australia for use by building designers. The information is intended primarily for single-leaf concrete masonry houses, but the tables are applicable to other buildings.

Designs for single-leaf buildings in this manual have been provided on two levels. The first level is simplified diagrams that are suitable for most houses or for initial designs. Where the house is more complex or it is required to fine-tune the design, then the Tabular Design is provided.

All design and construction should be in accordance with the relevant Australian Standards and the Building Code of Australia Volumes 1 or 2, as appropriate. The relevant Australian Standards are:

AS 4773.1 Masonry in small buildings- Design

AS 4773.2 Masonry in small buildings- Construction

AS 3700 Masonry structures

This manual is consistent with AS 3700, and (unlike AS 4773) covers both 140 and 190 mm thick walls.

1.2 Application of Designs

The design details in this manual are applicable to buildings complying with the following:

- The size of the building complies with the geometric limitations given in Australian Standard AS 4055 Wind loads for housing, except the floor-to-ceiling height, may go to 3.0 m with the appropriate increase in applied forces.
- The footings are in accordance with Local Authority requirements with starter bars cast in and lapping with all vertical reinforcement in the walls.
- Grouted reinforced cores provide the bending strength to resist the wind pressure on the external walls by spanning vertically between floors or a floor and a roof. Vertical wall reinforcement is anchored into bond beams. Figure 1.1 shows a typical layout of wall reinforcement
- Wind loads on openings are transferred to the side of the opening or to a central frame or mullions in the opening. Where there is no central frame or mullion, such as a roller door or similar, the effective "opening width" for wall design will be the full opening size. Where there is central frames or mullions, the "opening width" for wall design is the width of the panel adjacent to the edge of the opening.
  NOTE: Lintels are always designed to span the full opening width.
- Bond beams are provided at intermediate floor and roof levels. The floor and ceiling systems are connected to the bond beams and act as diaphragms to transfer the racking forces horizontally to bracing walls. Cathedral ceilings with a slope exceeding 35° and unlined ceilings do not act as a diaphragm unless wind bracing is provided.
- Uplift forces on the roof are resisted by connecting the roof to bond beams and lintels with connections designed to carry the uplift forces. The bond beams span between vertical reinforcement that transfers the uplift to the foundations. A typical bond beam/lintel layout is shown in Figure 1.1.
- The amount of load applied to the top of the wall is determined by the width of roof it supports. This width (called *Dimension "A"*) is determined in accordance with Figure 1.2.

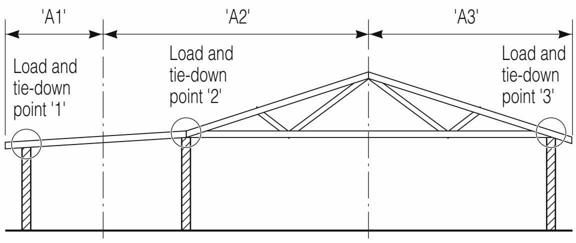


Figure 1.2 *Determination of Dimension "A"*

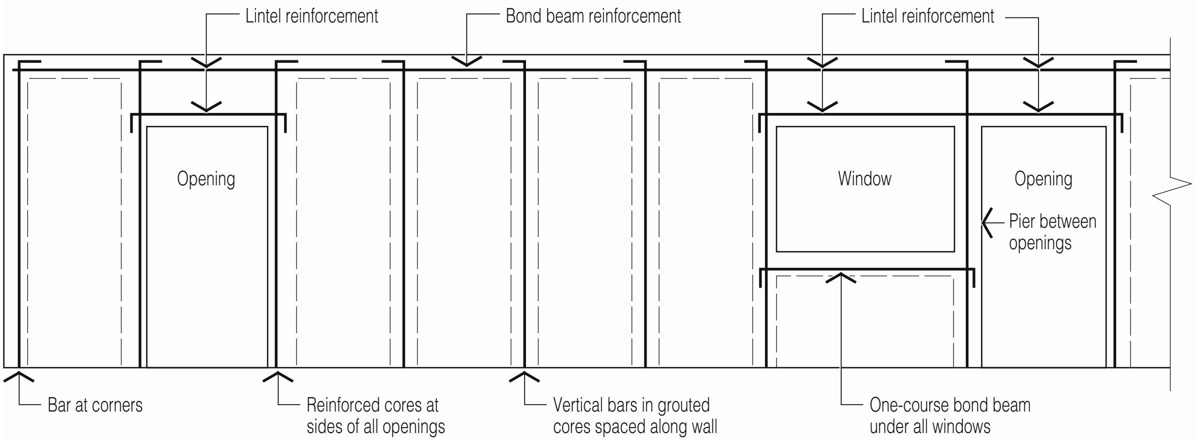


Figure 1.1 *Typical Wall and Reinforcement Layout*

1.3 Material Properties

The design tables in this Manual are based on materials with the following properties:

- Characteristic Unconfined Compressive Strength of concrete masonry units, f'_{uc} = 15 MPa
- Characteristic Compressive Strength of grout, f'_c = 20 MPa
- Yield Strength of reinforcement, f'_{sy} = 500 MPa
- Mortar Type, M3

1.4 Earthquake Loading

Buildings designed for wind loading N2 and greater will satisfy Earthquake Design Categories H1 and H2.

1.5 Typical Details

Typical details for various components are shown in **Figures 1.3** to **1.7**. Where an N16 bar is required in the details, 2-N12 bars may be used as an alternative.

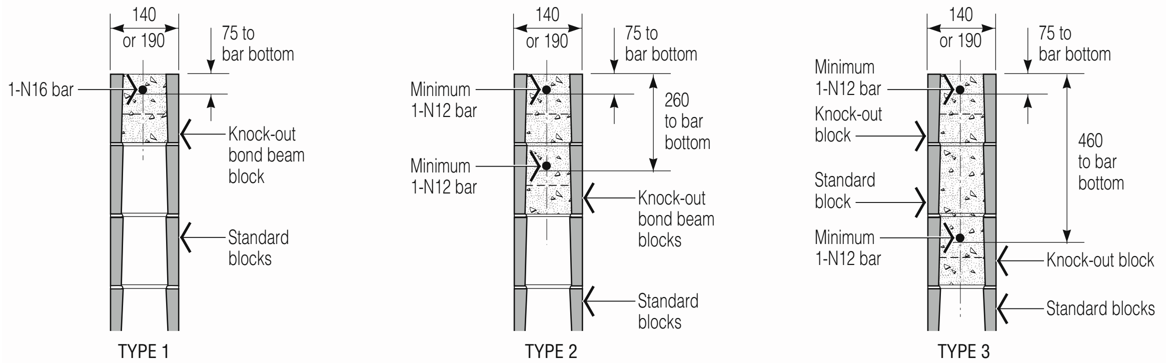


Figure 1.3 *Typical Details for Bond Beams Supporting a Roof*

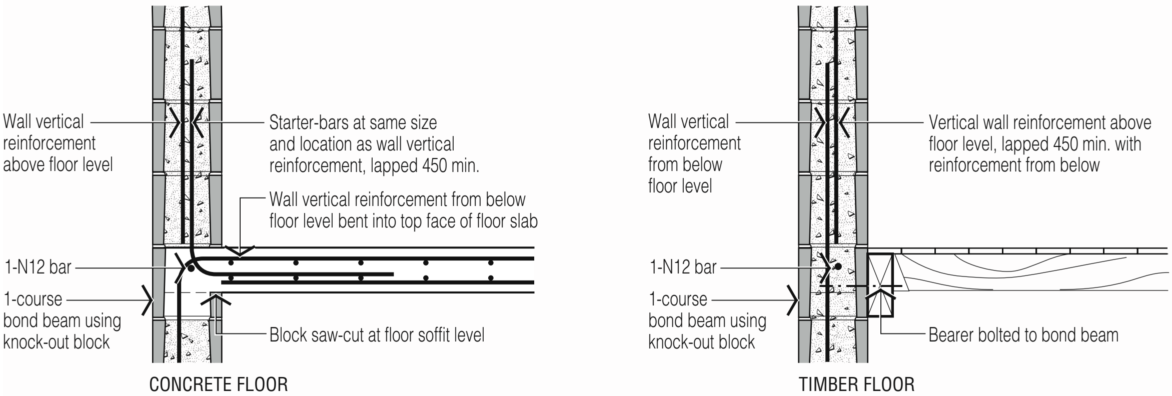


Figure 1.4 *Typical Details for Bond Beams Supporting a Floor*

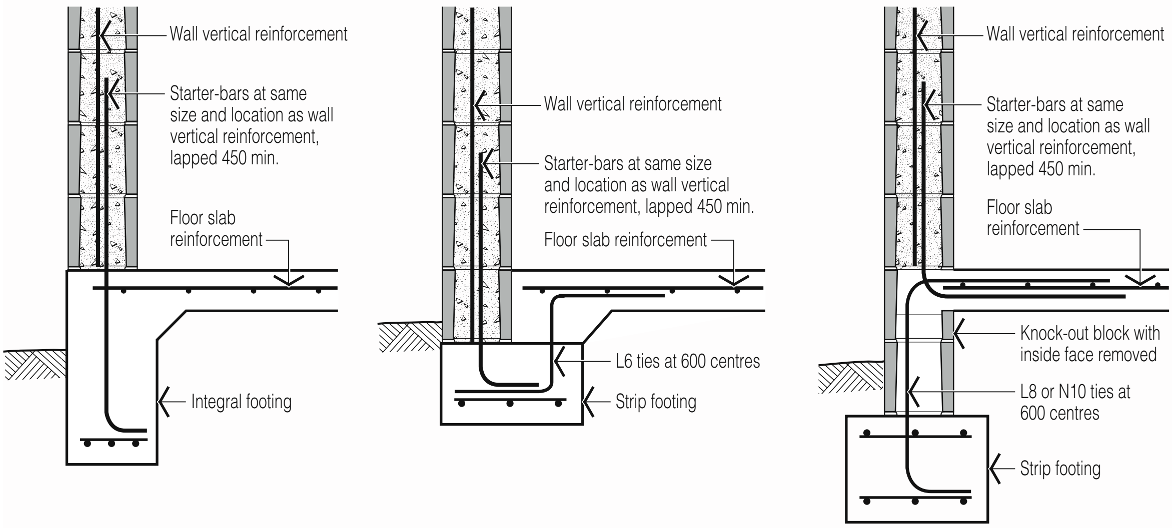


Figure 1.5 *Typical Details of Connections to Footings*

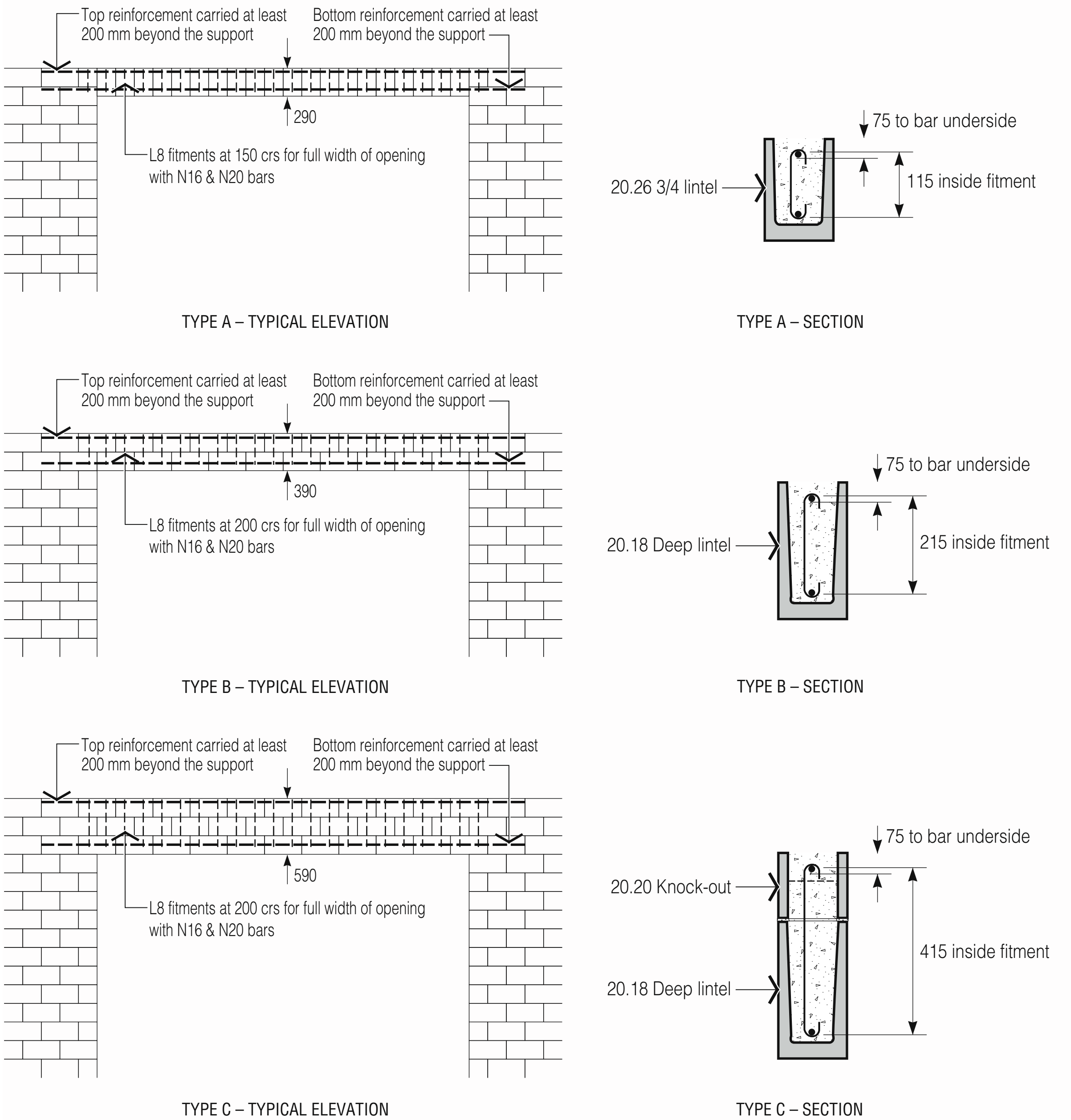


Figure 1.6 *Typical Lintels*
Refer to CMAA Data Sheet 3 - Concrete Masonry Lintels for the design and construction details of lintels.

2 Simplified Design of External Walls

External wall reinforcement may be detailed using Figures 2.1 to 2.14 for the wind classification and dimensional limitations as noted on the drawings and summarised in Table 2.1.

For earthquake classifications H1, H2 and H3, the details given for wind category N2 are suitable. The lintel details are only suitable for standard roof truss loading. Where there is either floor loadings or girder-truss loadings, use lintel design tables (Tables 3.8 and 3.9) in Chapter 3 of this manual.

Where the building geometry is other than shown, design should be in accordance with Chapter 3.

Table 2.1 *Summary of Design Parameters*

Figure number	**Leaf thickness** (mm)	**Wind Classification**	**Wall height** (mm)	**Page number**
2.1	140	N1, N2 & N3	2400	5
2.2	140	N1, N2 & N3	2500	5
2.3	140	N1, N2 & N3	2700	6
2.4	140	N4 & C1	2400	6
2.5	140	N4 & C1	2700	7
2.6	140	N5 & C2	2500	7
2.7	140	N5 & C2	2700	7
2.8	190	N1, N2 & N3	2400	8
2.9	190	N1, N2 & N3	2500	8
2.10	190	N1, N2 & N3	2700	9
2.11	190	N4 & C1	2400	9
2.12	190	N4 & C1	2700	10
2.13	190	N5 & C2	2500	10
2.14	190	N5 & C2	2700	10

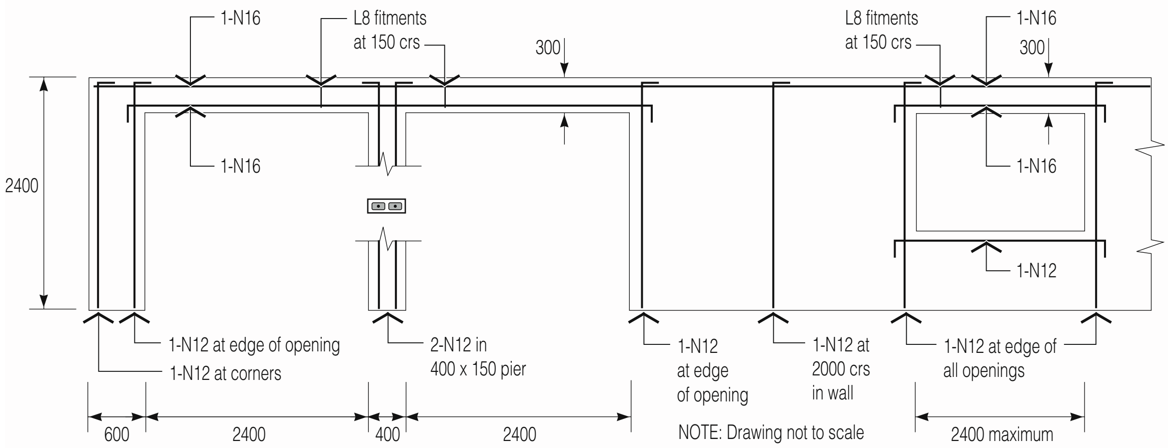


Figure 2.1 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2400-mm Wall Height*

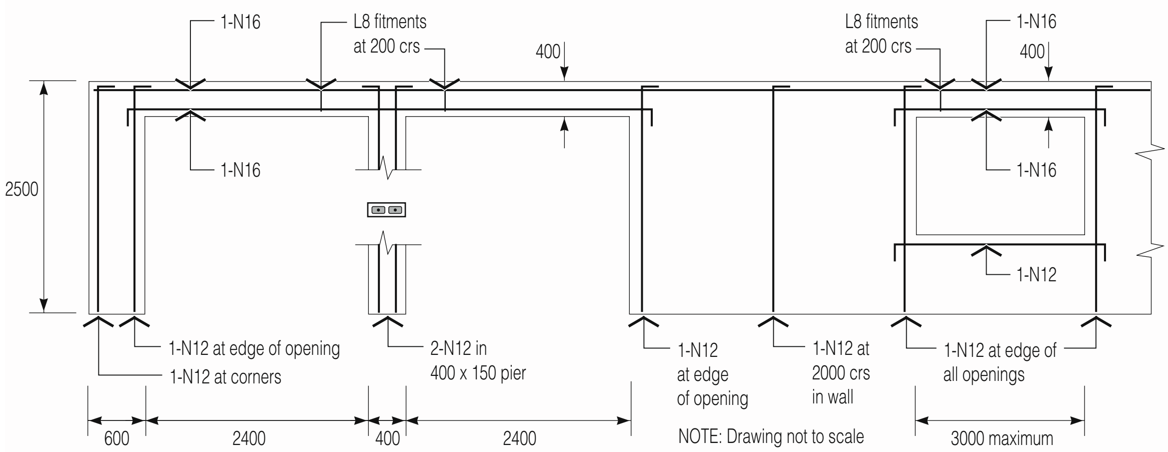


Figure 2.2 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2500-mm Wall Height*

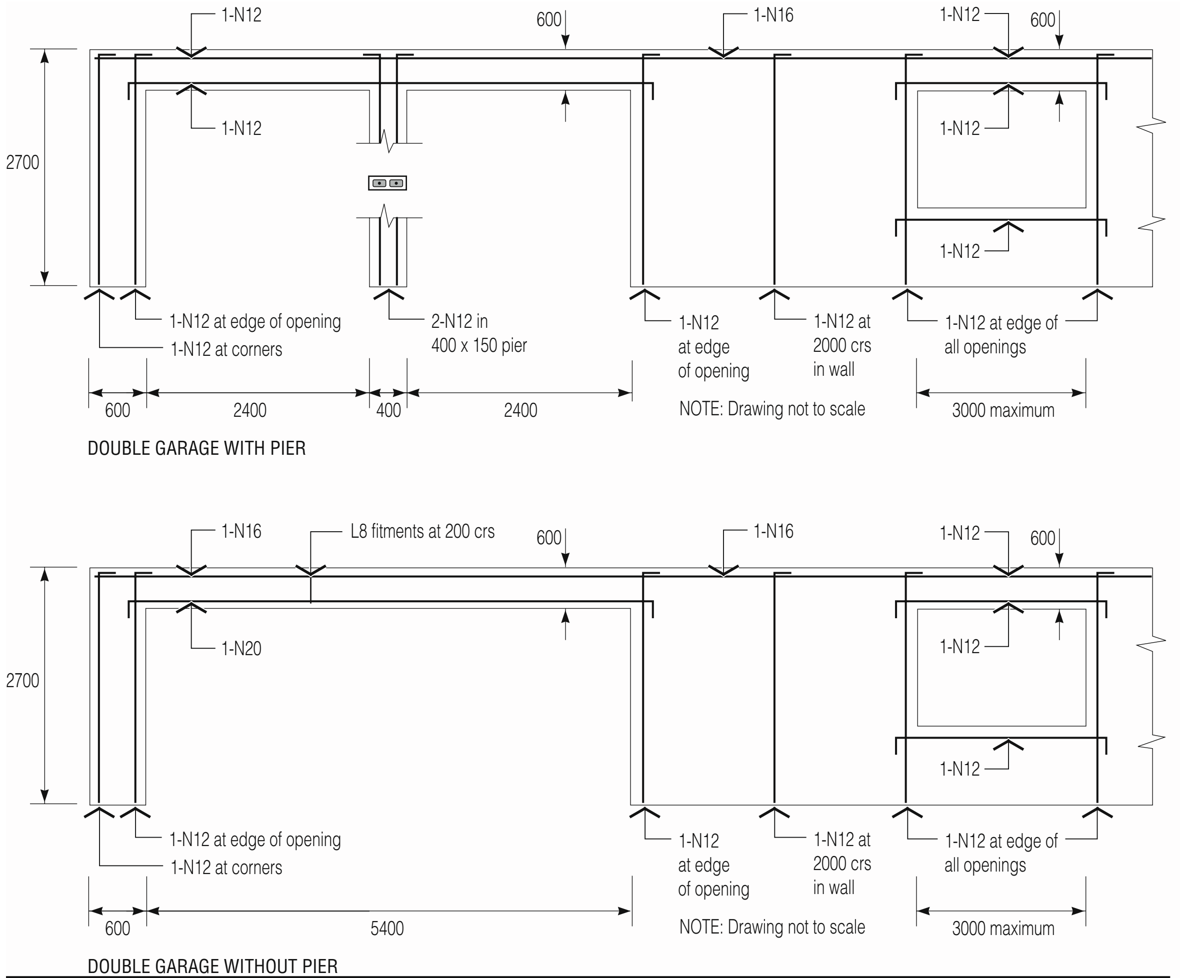


Figure 2.3 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2700-mm Wall Height*

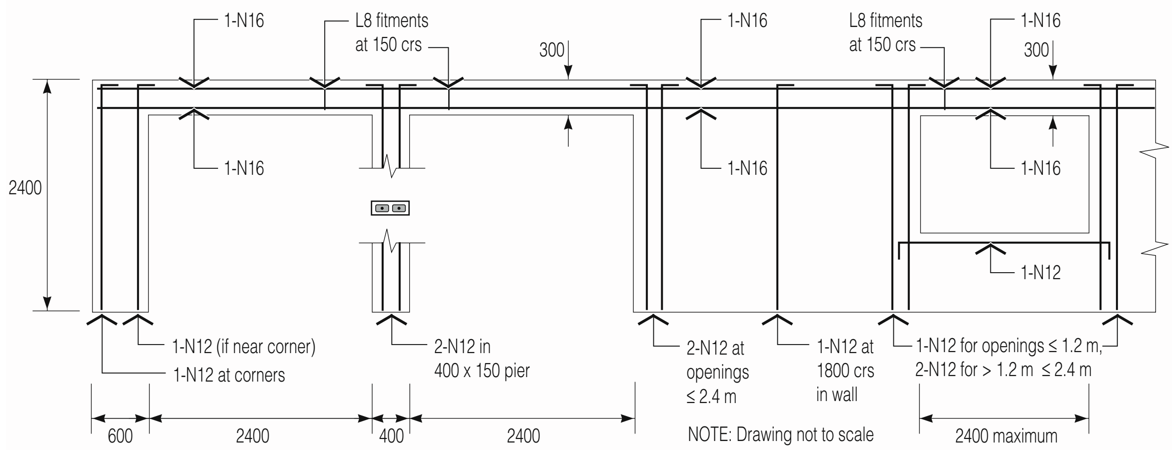


Figure 2.4 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N4 and C1 and 2400-mm Wall Height*

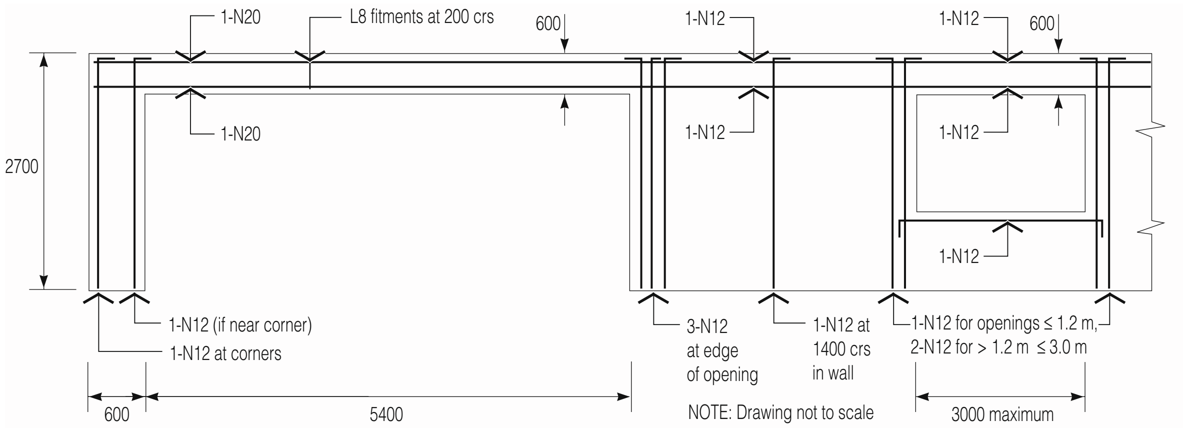


Figure 2.5 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N4 and C1 and 2700-mm Wall Height*

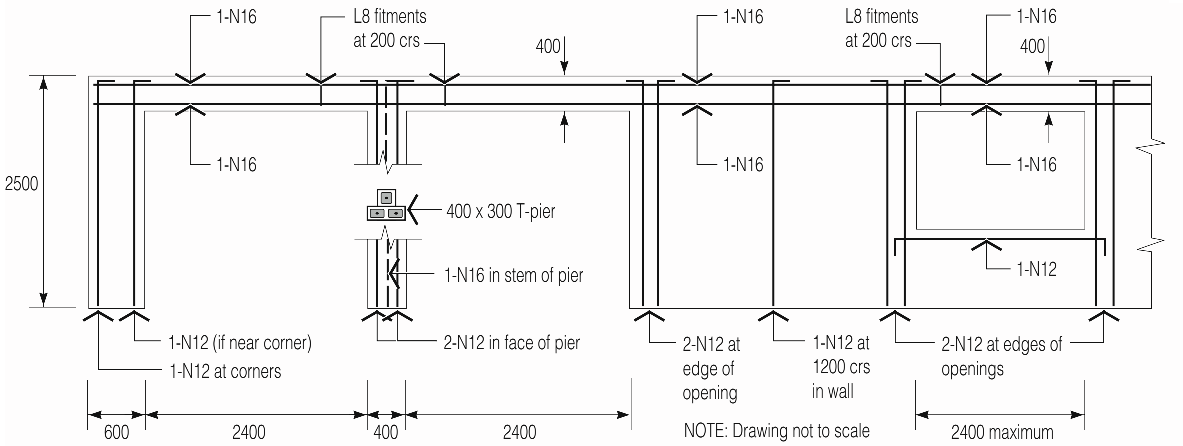


Figure 2.6 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N5 and C2 and 2500-mm Wall Height*

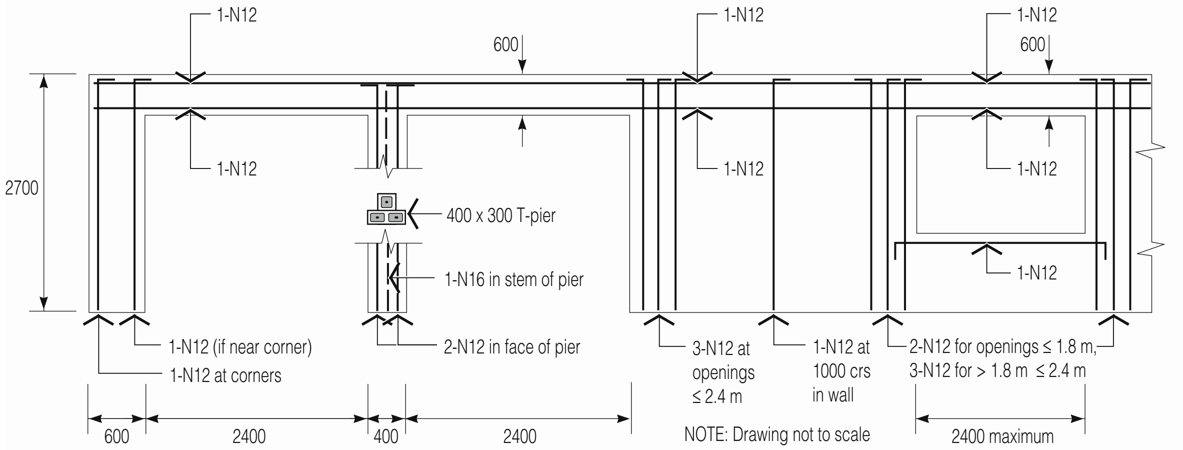


Figure 2.7 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N5 and C2 and 2700-mm Wall Height*

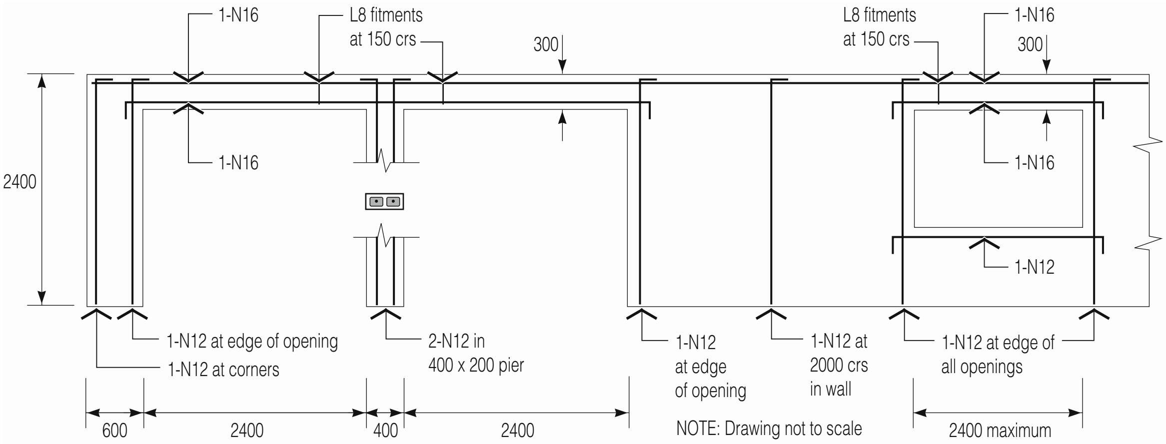


Figure 2.8 *Wall Reinforcement for 190-mm Leaf for Wind Categories N1, N2 and N3 and 2400-mm Wall Height*

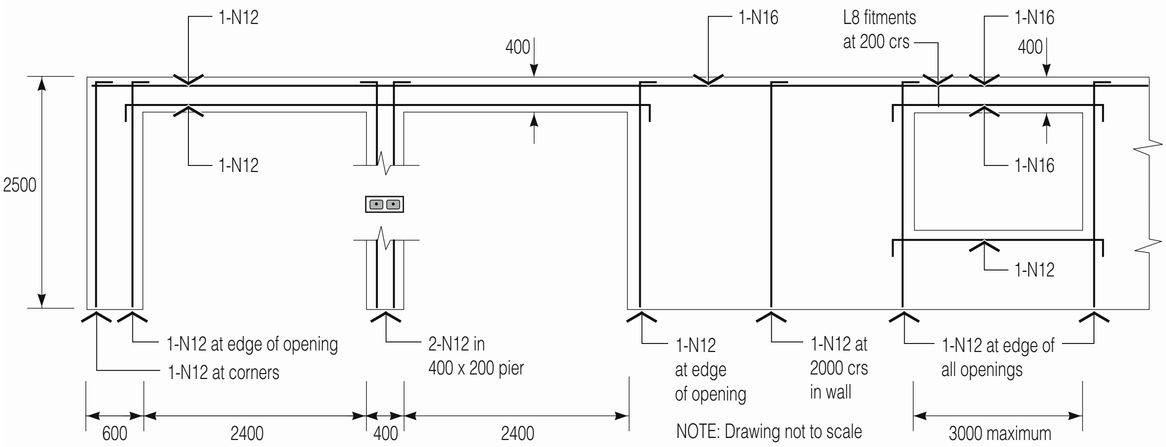


Figure 2.9 *Wall Reinforcement for 190-mm Leaf for Wind Categories N1, N2 and N3 and 2500-mm Wall Height*

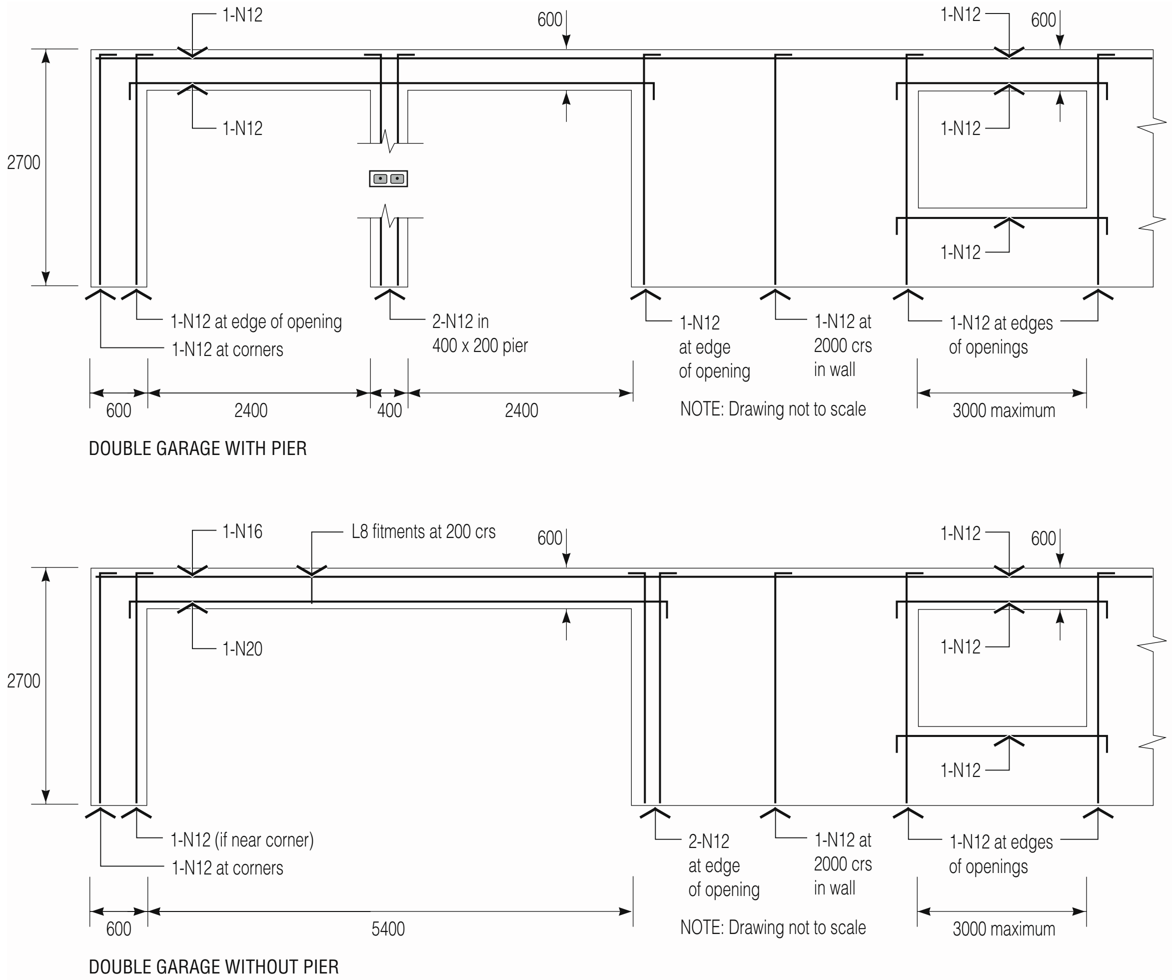


Figure 2.10 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N1, N2 and N3 and 2700-mm Wall Height*

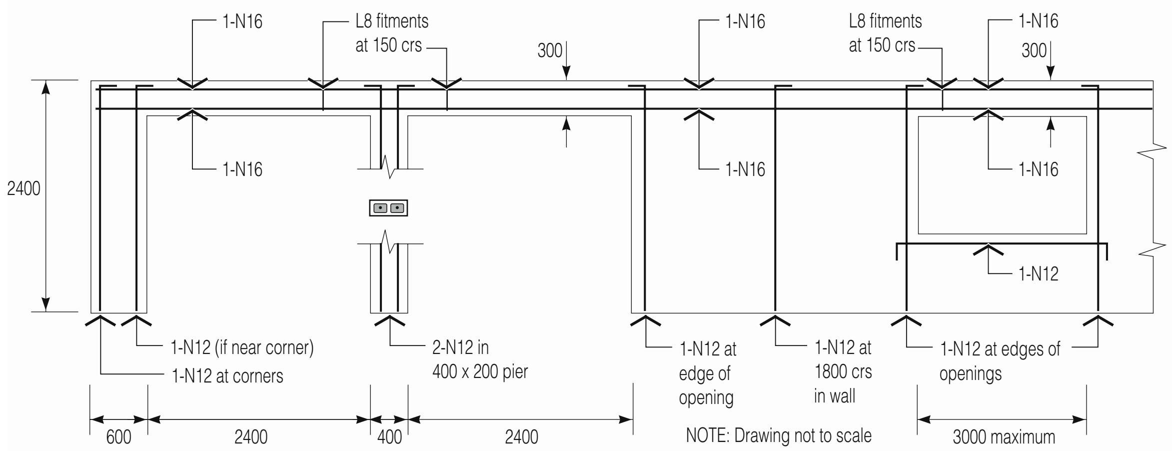


Figure 2.11 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N4 and C1 and 2400-mm Wall Height*

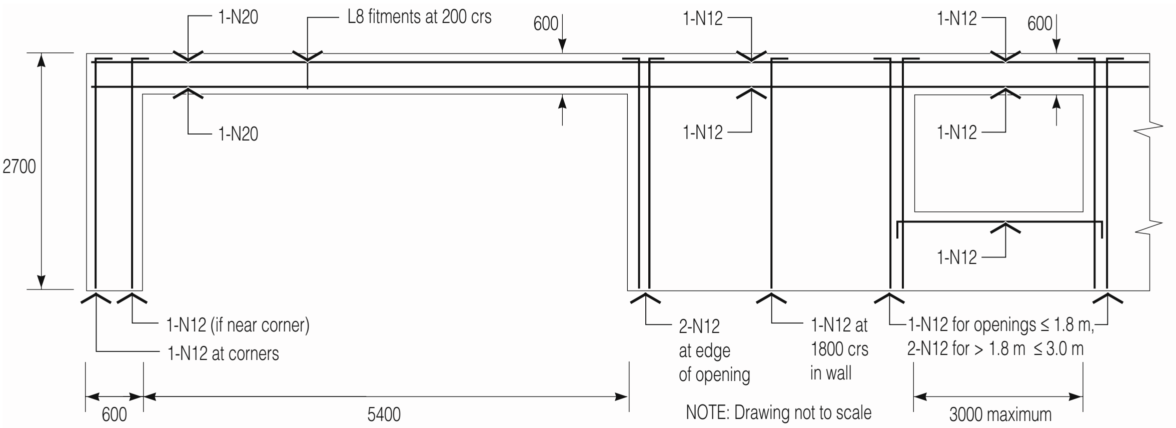


Figure 2.12 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N4 and C1 and 2700-mm Wall Height*

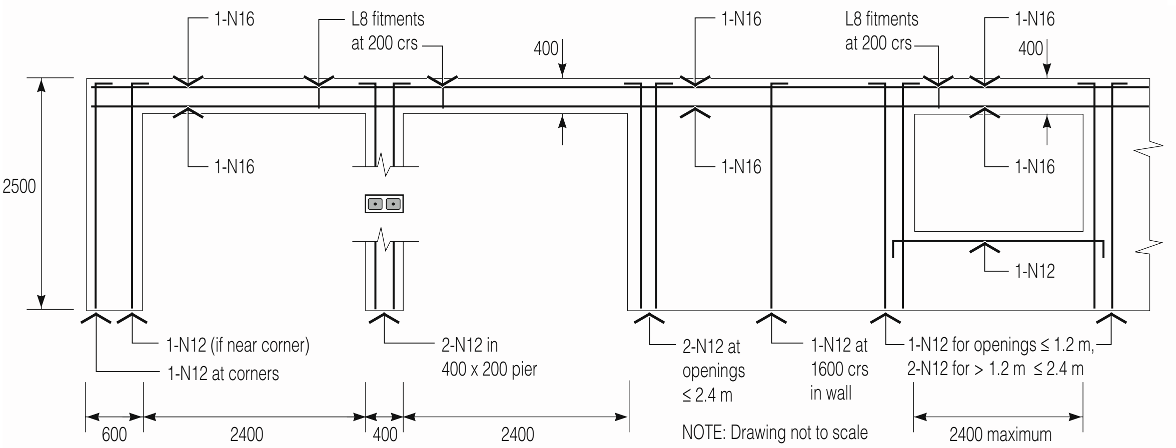


Figure 2.13 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N5 and C2 and 2500-mm Wall Height*

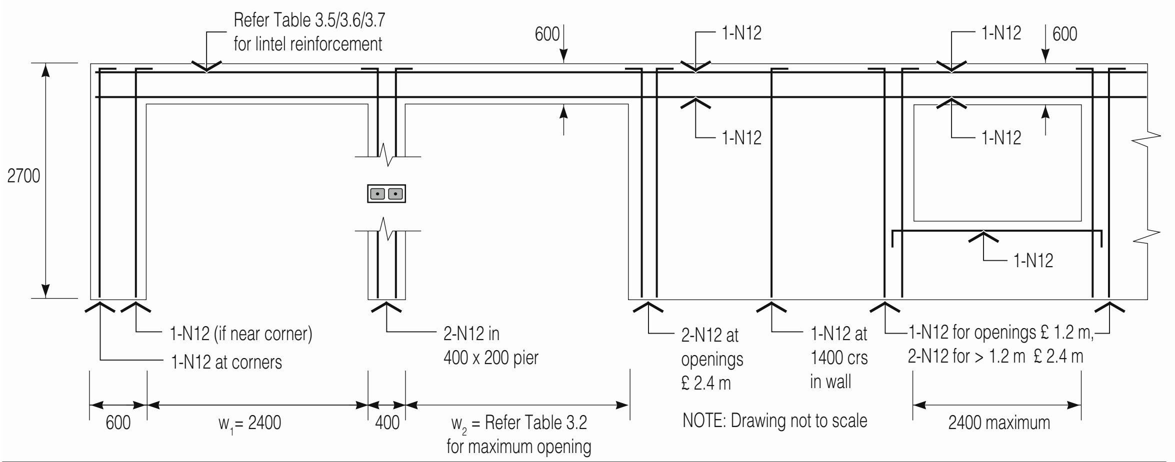


Figure 2.14 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N5 and C2 and 2700-mm Wall Height*

3 Tabular Design of External Walls

The member sizes, reinforcement and general detailing can be determined from the Figures and Tables referred to in the following steps:

Step 1 Size and Distribution of Vertical Reinforcement

1.1 Maximum reinforcement spacing along walls

DETAILING	DESIGN	COMMENTARY
Table 3.1 (page 12)	**Table 3.1** (page 12)	The amount of wall supported by a reinforced core is half the distance to the adjacent reinforced cores. The distance to the next rod can be determined by adding it to the distance from the previous rod, then checking that the sum does not exceed the maximum allowable given in **Table 3.1**. Note the spacing between rods can be different.

1.2 Reinforcement in piers between openings

DETAILING	DESIGN	COMMENTARY
Table 3.2	**Table 3.2**	Where there is a pier between two openings, determine the size and reinforcement required in the

1.3 Reinforcement beside openings

(page 12)	(page 12)	pier by adding the opening widths together and referring to **Table 3.2**.
DETAILING	**DESIGN**	**COMMENTARY**

1.4 Maximum reinforcement spacing adjacent to openings

Table 3.3 (page 13)	**Table 3.3** (page 13)	The maximum opening size depends on the wind area and the reinforcement beside the opening. Use **Table 3.3** to determine the reinforcement size and details.

1.5 Reinforcement at girder trusses

DETAILING	DESIGN	COMMENTARY

Step 2 Reinforcement and Details of Lintels

2.1 Lintels supporting roofs

Table 3.4 (page 13)	**Table 3.4** (page 13)	The maximum distance to the first rod from the side of an opening depends on the opening size and the reinforcement at the edge of the opening. Use **Table 3.4** to determine to determine spacing.
DETAILING	**DESIGN**	**COMMENTARY**
–	–	Place a vertical bar within 100 mm of all girder trusses.
DETAILING	**DESIGN**	**COMMENTARY**
Figure 1.6	**Table 3.5**	For standard trusses, the maximum amount of roof that can be carried is given in **Table 3.5** (metal

2.2 Lintels supporting floors

(page 4)	(page 14) **Table 3.6** (page 15)	roofs) and **Table 3.6** (tile roofs). Where possible, girder trusses landing on a lintel should be avoided, even over small openings, and not permitted over long openings. Where girder trusses landing on lintels cannot be avoided, **Table 3.7** gives the maximum area of roof, including any

Step 3 Reinforcement and Details of Bond Beams

3.1 Bond beams supporting roofs

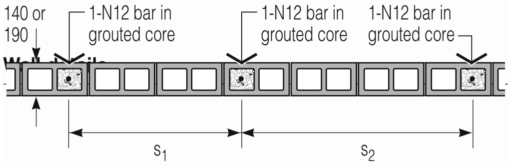
	Table 3.7 (page 16)	standard trusses, that can be carried by the lintel.
DETAILING	**DESIGN**	**COMMENTARY**
Figure 3.1 (page 16)	**Table 3.8** (page 16)	The maximum amount of supported floor width to be carried by a lintel is given in **Table 3.8**.

3.2 Bond beams supporting floors

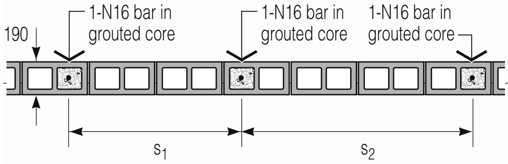
DETAILING	DESIGN	COMMENTARY
Figure 1.3 (page 3)	**Table 3.9** (page 16)	Roof bond beam acting vertically transfers uplift forces from the roof trusses to the vertical reinforcement. The minimum number of courses in a bond beam supporting a roof depends on the wind area and the span of the roof trusses. For standard roof trusses see **Table 3.9**. If a

DETAILING	DESIGN	COMMENTARY
		girder truss lands on the bond beam, a tie-down rod must be placed within 100 mm of the truss.
Figure 1.4 (page 3)	Use 1-N12 bar	Bond Beams supporting floors need only to provide positive attachment for the floor. Normally one course deep with 1-N12 bar will be sufficient.

Table 3.1 *Selection and Detailing of Maximum Reinforcement Spacing Along Walls*

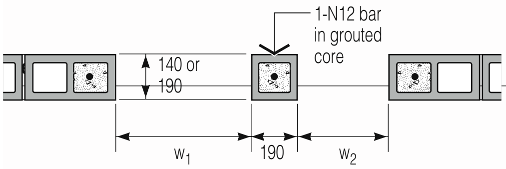


Wind Class.	**Maximum sum of adjacent bar spacing, $s_1 + s_2$ (m)** 140-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6
N2	4.0	4.0	4.0	4.0	3.8	4.0	4.0	4.0	4.0	4.0
N3	4.0	4.0	3.5	2.9	2.5	4.0	4.0	4.0	4.0	3.5
N4	3.7	2.9	2.4	2.0	1.7	4.0	4.0	3.4	2.8	2.3
N5	2.5	2.0	1.6	1.3	1.1	3.3	2.8	2.3	1.9	1.6
N6	1.9	1.5	1.2	–	–	2.4	2.1	1.7	–	–
C1	4.0	3.2	2.6	2.2	1.8	4.0	4.0	3.7	3.1	2.6
C2	2.8	2.2	1.8	–	–	3.6	3.1	2.5	2.1	1.7
C3	1.9	–	–	–	–	2.4	2.1	1.7	–	–
C4	–	–	–	–	–	1.8	–	–	–	–

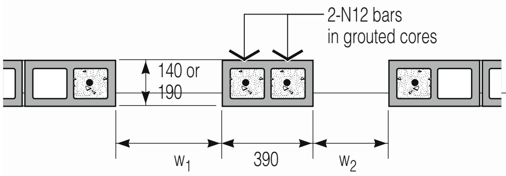


Wind Class.	140-mm-leaf wall 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall 2.4	2.7	3.0	3.3	3.6
N2	–	–	–	–	–	4.0	4.0	4.0	4.0	4.0
N3	–	–	–	–	–	4.0	4.0	4.0	4.0	4.0
N4	–	–	–	–	–	4.0	4.0	4.0	4.0	3.8
N5	–	–	–	–	–	3.9	3.4	3.1	2.8	2.6
N6	–	–	–	–	–	2.9	2.5	2.3	2.1	1.9
C1	–	–	–	–	–	4.0	4.0	4.0	4.0	4.0
C2	–	–	–	–	–	4.0	3.7	3.4	3.1	2.8
C3	–	–	–	–	–	2.9	2.5	2.3	2.1	1.9
C4	–	–	–	–	–	2.1	1.9	1.7	1.5	1.4

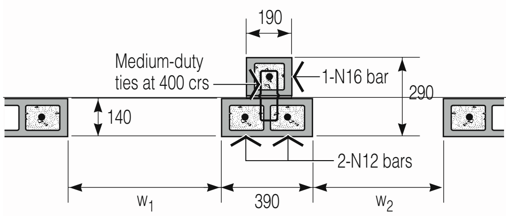
Table 3.2 *Selection and Detailing of Pier Reinforcement*



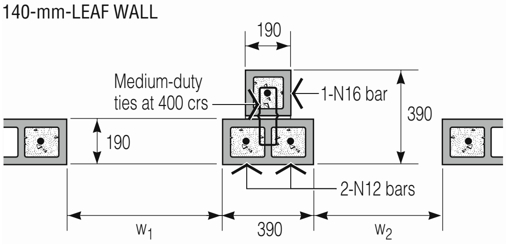
Wind Class.	**Maximum allowable sum of openings, $w_1 + w_2$ (m)** 140-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6
N2	5.7	4.5	3.7	3.0	2.5	10.5	8.3	6.7	5.6	4.7
N3	3.7	2.9	2.3	–	–	6.7	5.3	4.3	3.6	3.0
N4	2.5	–	–	–	–	4.5	3.6	2.9	2.4	2.0
N5	–	–	–	–	–	3.1	2.4	–	–	–
N6	–	–	–	–	–	2.3	–	–	–	–
C1	2.7	2.1	–	–	–	5.0	3.9	3.2	2.6	2.2
C2	–	–	–	–	–	3.3	2.6	2.1	–	–
C3	–	–	–	–	–	2.3	–	–	–	–
C4	–	–	–	–	–	–	–	–	–	–



Wind Class.	140-mm-leaf wall 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall 2.4	2.7	3.0	3.3	3.6
N2	8.3	6.6	5.3	4.4	3.7	10.8	9.2	7.5	6.2	5.2
N3	5.3	4.2	3.4	2.8	2.4	7.5	5.9	4.8	4.0	3.3
N4	3.6	2.8	2.3	–	–	5.0	4.0	3.2	2.7	2.2
N5	2.4	–	–	–	–	3.4	2.7	2.2	–	–
N6	–	–	–	–	–	2.5	–	–	–	–
C1	3.9	3.1	2.5	2.1	–	5.5	4.4	3.5	2.9	2.5
C2	2.7	2.1	–	–	–	3.7	2.9	2.4	–	–
C3	–	–	–	–	–	2.5	–	–	–	–
C4	–	–	–	–	–	–	–	–	–	–



140-mm-LEAF WALL



190-mm-LEAF WALL

Wind Class.	140-mm-leaf wall 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall 2.4	2.7	3.0	3.3	3.6
N2	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
N3	10.8	10.8	10.8	10.8	10.3	10.8	10.8	10.8	10.8	10.8
N4	10.3	9.2	8.3	7.5	6.9	10.8	10.8	10.5	9.6	8.8
N5	7.0	6.2	5.6	5.1	4.7	8.9	7.9	7.1	6.5	6.0
N6	5.2	4.6	4.2	3.8	3.5	6.6	5.9	5.3	4.8	4.4
C1	10.8	10.1	9.1	8.3	7.6	10.8	10.8	10.8	10.5	9.7
C2	7.7	6.8	6.1	5.6	5.1	9.7	8.7	7.8	7.1	6.5
C3	5.2	4.6	4.2	3.8	3.5	6.6	5.9	5.3	4.8	4.4
C4	3.9	3.4	3.1	2.8	2.6	4.9	4.4	3.9	3.6	3.3

Table 3.3 *Selection and Detailing of Reinforcement Beside Openings*

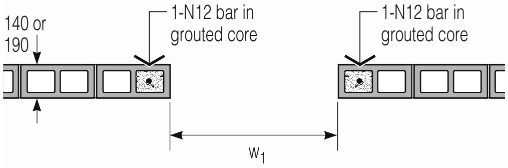
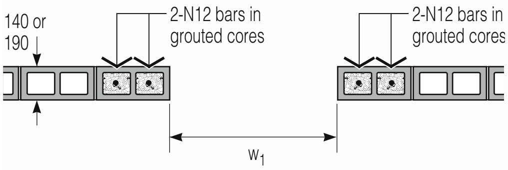
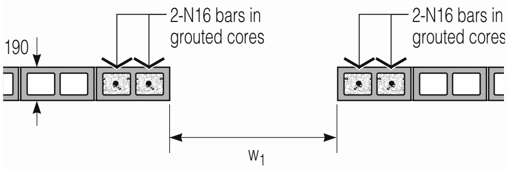
Opening details	Wind Class.	Maximum allowable opening size, w_1 (m) – 140-mm-leaf wall – Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall – Wall height (m) 2.4	2.7	3.0	3.3	3.6
	N2	5.4	5.4	4.6	3.7	3.0	5.4	5.4	5.4	5.4	4.6
	N3	4.6	3.5	2.8	2.2	1.7	5.4	5.3	4.2	3.4	2.7
	N4	2.9	2.2	1.7	1.3	1.0	4.5	3.4	2.6	2.1	1.7
	N5	1.9	1.3	1.0	–	–	2.9	2.2	1.7	1.3	1.0
	N6	–	–	–	–	–	2.0	1.4	1.1	–	–
	C1	3.3	2.5	1.9	1.5	1.1	5.0	3.8	3.0	2.4	1.9
	C2	2.0	1.5	1.1	–	–	3.2	2.4	1.8	1.4	1.1
	C3	1.2	–	–	–	–	2.0	1.5	1.1	–	–
	C4	–	–	–	–	–	1.3	0.9	–	–	–
	N2	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	N3	5.4	5.4	5.4	4.3	3.5	5.4	5.4	5.4	5.4	5.4
	N4	5.4	4.3	3.3	2.6	2.0	5.4	5.4	5.3	4.2	3.4
	N5	3.7	2.7	2.0	1.5	1.1	5.4	4.4	3.4	2.6	2.0
	N6	–	–	–	–	–	4.0	3.0	2.2	1.6	1.2
	C1	5.4	4.9	3.8	2.9	2.3	5.4	5.4	5.4	4.7	3.8
	C2	4.0	3.0	2.2	1.7	1.2	5.4	4.7	3.7	2.8	2.2
	C3	2.5	1.8	1.2	–	–	4.1	3.0	2.2	1.7	1.2
	C4	–	–	–	–	–	2.7	1.9	1.4	1.0	–
	N2	–	–	–	–	–	5.4	5.4	5.4	5.4	5.4
	N3	–	–	–	–	–	5.4	5.4	5.4	5.4	5.4
	N4	–	–	–	–	–	5.4	5.4	5.4	5.4	5.4
	N5	–	–	–	–	–	5.4	5.4	5.4	4.9	3.9
	N6	–	–	–	–	–	5.4	5.4	4.2	3.3	2.6
	C1	–	–	–	–	–	5.4	5.4	5.4	5.4	5.4
	C2	–	–	–	–	–	5.4	5.4	5.4	5.2	4.2
	C3	–	–	–	–	–	5.4	5.4	4.2	3.3	2.6
	C4	–	–	–	–	–	5.0	3.8	2.9	2.2	1.7

Table 3.4 *Selection and Detailing of Maximum Reinforcement Spacing Adjacent to Openings*

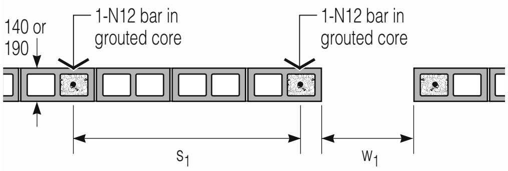
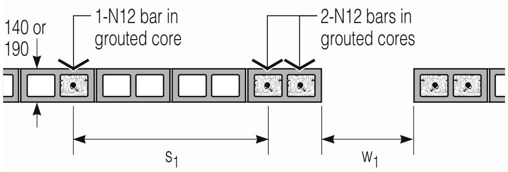
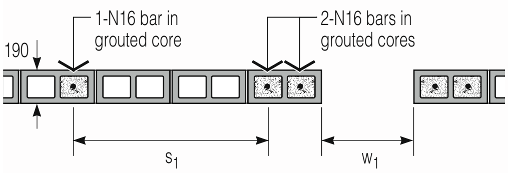
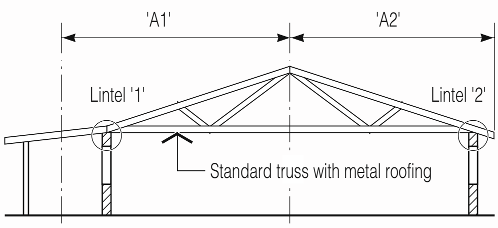
Wall and opening details	Wind Class.	Maximum adjacent bar spacing plus opening, $s_1 + w_1$(m) – 140-mm-leaf wall – Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall – Wall height (m) 2.4	2.7	3.0	3.3	3.6
	N2	7.4	6.2	5.0	4.1	3.4	7.4	7.4	7.2	5.9	5.0
	N3	5.0	3.9	3.2	2.6	2.1	7.3	5.7	4.6	3.8	3.1
	N4	3.3	2.6	2.1	1.7	1.4	4.9	3.8	3.0	2.5	2.1
	N5	2.3	1.7	1.4	–	–	3.3	2.6	2.1	1.7	1.4
	N6	–	–	–	–	–	2.4	1.8	1.5	–	–
	C1	3.7	2.9	2.3	1.9	1.5	5.4	4.2	3.4	2.8	2.3
	C2	2.4	1.9	1.5	–	–	3.6	2.8	2.2	1.8	1.5
	C3	1.2	–	–	–	–	2.4	1.9	1.5	–	–
	C4	–	–	–	–	–	1.7	1.3	–	–	–
	N2	7.4	7.4	7.4	7.4	6.3	7.4	7.4	7.4	7.4	7.4
	N3	7.4	7.4	5.8	4.7	3.9	7.4	7.4	7.4	7.1	5.9
	N4	6.2	4.7	3.7	3.0	2.4	7.4	7.4	5.7	4.6	3.8
	N5	4.1	3.1	2.4	1.9	1.5	6.2	4.8	3.8	3.0	2.4
	N6	–	–	–	–	–	4.4	3.4	2.6	2.0	1.6
	C1	6.9	5.3	4.2	3.3	2.7	7.4	7.4	6.3	5.1	4.2
	C2	4.4	3.4	2.6	2.1	1.6	6.7	5.1	4.1	3.2	2.6
	C3	2.9	2.2	1.6	–	–	4.5	3.4	2.6	2.1	1.6
	C4	–	–	–	–	–	3.1	2.3	1.8	1.4	–
	N2	–	–	–	–	–	7.4	7.4	7.4	7.4	7.4
	N3	–	–	–	–	–	7.4	7.4	7.4	7.4	7.4
	N4	–	–	–	–	–	7.4	7.4	7.4	7.4	6.5
	N5	–	–	–	–	–	7.4	7.4	6.5	5.3	4.3
	N6	–	–	–	–	–	7.4	5.8	4.6	3.7	3.0
	C1	–	–	–	–	–	7.4	7.4	7.4	7.4	6.8
	C2	–	–	–	–	–	7.4	7.4	7.0	5.6	4.6
	C3	–	–	–	–	–	7.4	5.9	4.6	3.7	3.0
	C4	–	–	–	–	–	5.4	4.2	3.3	2.6	2.1

Table 3.5 *Selection of Lintels Supporting Standard Trusses with Metal Roofing Material*

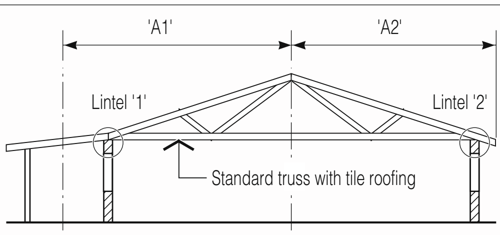
		Maximum allowable value of dimension 'A' (m)																	
		140-mm-wide lintels									**190-mm-wide lintels**								
Wind	**Opening**	**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**			**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**		
class.	(m)	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20
N1 and N2	0.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.2	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.8	8.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	2.4	6.3	9.0	9.0	7.7	9.0	9.0	9.0	9.0	9.0	7.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	3.0	5.0	8.5	8.5	6.1	9.0	9.0	9.0	9.0	9.0	5.0	9.0	9.0	6.1	9.0	9.0	9.0	9.0	9.0
	3.6	–	–	–	4.2	8.3	9.0	8.4	9.0	9.0	–	–	–	3.7	8.2	9.0	7.6	9.0	9.0
	4.2	–	–	–	2.7	5.6	6.3	5.5	9.0	9.0	–	–	–	2.1	5.4	8.5	4.7	9.0	9.0
	4.8	–	–	–	–	–	–	3.7	8.5	9.0	–	–	–	–	–	–	2.9	7.8	9.0
	5.4	–	–	–	–	–	–	2.5	6.4	9.0	–	–	–	–	–	–	1.6	5.7	9.0
N3	0.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.2	8.2	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.8	6.6	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	2.4	5.3	9.0	9.0	7.7	9.0	9.0	9.0	9.0	9.0	6.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	3.0	4.5	8.3	8.3	6.1	9.0	9.0	9.0	9.0	9.0	5.0	9.0	9.0	6.1	9.0	9.0	9.0	9.0	9.0
	3.6	–	–	–	4.2	8.3	9.0	8.4	9.0	9.0	–	–	–	3.7	8.2	9.0	7.6	9.0	9.0
	4.2	–	–	–	2.7	5.6	6.3	5.5	9.0	9.0	–	–	–	2.1	5.4	8.5	4.7	9.0	9.0
	4.8	–	–	–	–	–	–	3.7	8.5	9.0	–	–	–	–	–	–	2.9	7.8	9.0
	5.4	–	–	–	–	–	–	2.5	6.4	9.0	–	–	–	–	–	–	1.6	5.7	9.0
N4 and C1	0.9	7.4	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.2	5.7	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	7.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.8	4.6	9.0	9.0	6.7	9.0	9.0	9.0	9.0	9.0	6.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	2.4	3.6	8.0	8.0	5.3	9.0	9.0	8.4	9.0	9.0	4.8	8.7	9.0	7.7	9.0	9.0	9.0	9.0	9.0
	3.0	3.1	5.7	5.7	4.5	8.8	9.0	7.8	9.0	9.0	3.9	6.3	7.8	5.6	8.3	9.0	8.2	9.0	9.0
	3.6	–	–	–	3.9	6.6	8.6	6.6	9.0	9.0	–	–	–	3.7	7.0	9.0	7.0	9.0	9.0
	4.2	–	–	–	2.7	5.0	6.3	5.1	8.3	9.0	–	–	–	2.1	5.3	7.5	4.7	8.7	9.0
	4.8	–	–	–	–	–	–	3.7	6.7	9.0	–	–	–	–	–	–	2.9	7.1	9.0
	5.4	–	–	–	–	–	–	2.5	5.7	8.1	–	–	–	–	–	–	1.6	6.1	8.7
N5 and C2	0.9	4.3	9.0	9.0	6.7	9.0	9.0	9.0	9.0	9.0	5.7	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.2	3.4	9.0	9.0	5.3	9.0	9.0	9.0	9.0	9.0	4.4	9.0	9.0	7.0	9.0	9.0	9.0	9.0	9.0
	1.8	2.7	8.1	8.1	3.9	9.0	9.0	7.2	9.0	9.0	3.5	8.7	9.0	5.2	9.0	9.0	9.0	9.0	9.0
	2.4	2.1	4.7	4.7	3.1	7.3	9.0	5.5	9.0	9.0	2.8	5.1	6.4	4.1	7.0	9.0	7.4	9.0	9.0
	3.0	1.8	3.4	3.4	2.6	5.2	6.8	4.6	8.7	9.0	2.3	3.7	4.6	3.3	5.5	7.9	5.4	9.0	9.0
	3.6	–	–	–	2.3	3.9	5.0	3.9	6.5	9.0	–	–	–	2.5	4.1	5.9	4.1	6.8	9.0
	4.2	–	–	–	2.0	2.9	3.8	3.0	4.9	7.1	–	–	–	2.0	3.1	4.4	3.2	5.1	7.5
	4.8	–	–	–	–	–	–	2.5	4.0	5.7	–	–	–	–	–	–	2.6	4.2	6.0
	5.4	–	–	–	–	–	–	2.1	3.4	4.8	–	–	–	–	–	–	1.6	3.6	5.1
N6	0.9										4.1	9.0	9.0	6.3	9.0	9.0	9.0	9.0	9.0
	1.2										3.2	9.0	9.0	5.1	9.0	9.0	9.0	9.0	9.0
	1.8										2.5	6.3	7.9	3.8	9.0	9.0	6.9	9.0	9.0
	2.4										2.0	3.7	4.6	3.0	5.5	8.0	5.3	9.0	9.0
	3.0										1.6	2.7	3.3	2.4	3.9	5.7	3.9	6.5	9.0
	3.6										–	–	–	1.8	3.0	4.3	3.0	4.9	7.2
	4.2										–	–	–	1.4	2.3	3.2	2.3	3.7	5.4
	4.8										–	–	–	–	–	–	1.9	3.0	4.4
	5.4										–	–	–	–	–	–	1.6	2.6	3.7
C3	0.9										3.8	9.0	9.0	5.8	9.0	9.0	9.0	9.0	9.0
	1.2										2.9	9.0	9.0	4.7	9.0	9.0	9.0	9.0	9.0
	1.8										2.3	5.8	7.3	3.5	8.7	9.0	6.4	9.0	9.0
	2.4										1.9	3.4	4.2	2.7	5.1	7.4	4.9	8.4	9.0
	3.0										1.5	2.4	3.0	2.2	3.6	5.3	3.6	6.0	8.9
	3.6										–	–	–	1.7	2.7	3.9	2.7	4.5	6.6
	4.2										–	–	–	1.3	2.1	2.9	2.1	3.4	5.0
	4.8										–	–	–	–	–	–	1.8	2.8	4.0
	5.4										–	–	–	–	–	–	1.5	2.4	3.4
C4	0.9										2.7	9.0	9.0	4.3	9.0	9.0	8.8	9.0	9.0
	1.2										2.1	7.1	9.0	3.4	9.0	9.0	7.4	9.0	9.0
	1.8										1.7	4.2	5.3	2.5	6.3	9.0	4.6	9.0	9.0
	2.4										1.4	2.5	3.1	2.0	3.7	5.4	3.6	6.1	9.0
	3.0										1.2	1.8	2.2	1.6	2.7	3.8	2.6	4.4	6.5
	3.6										–	–	–	1.2	2.0	2.9	2.0	3.3	4.8
	4.2										–	–	–	1.0	1.5	2.1	1.5	2.5	3.6
	4.8										–	–	–	–	–	–	1.3	2.0	2.9
	5.4										–	–	–	–	–	–	1.1	1.7	2.5



(1) See **Figure 1.6** (page 4) for details

Table 3.6 *Selection of Lintels Supporting Standard Trusses with Tile Roofing Material*

		Maximum allowable value of dimension 'A' (m)																	
		140-mm-wide lintels									**190-mm-wide lintels**								
Wind	**Opening**	**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**			**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**		
class.	(m)	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20
N1	0.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
and	1.2	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
N2	1.8	4.9	9.0	9.0	6.2	9.0	9.0	9.0	9.0	9.0	6.4	9.0	9.0	8.0	9.0	9.0	9.0	9.0	9.0
	2.4	3.7	7.4	7.4	4.5	9.0	9.0	9.0	9.0	9.0	4.6	8.5	9.0	5.7	9.0	9.0	9.0	9.0	9.0
	3.0	2.9	4.9	4.9	3.6	7.0	7.7	7.2	9.0	9.0	2.9	5.6	6.7	3.5	7.1	9.0	6.9	9.0	9.0
	3.6	–	–	–	2.5	4.8	5.3	4.9	9.0	9.0	–	–	–	2.2	4.8	7.3	4.4	9.0	9.0
	4.2	–	–	–	1.5	3.3	3.7	3.2	6.7	9.0	–	–	–	1.2	3.1	5.0	2.7	6.4	9.0
	4.8	–	–	–	–	–	–	2.2	5.0	8.1	–	–	–	–	–	–	1.7	4.6	7.9
	5.4	–	–	–	–	–	–	1.5	3.8	6.4	–	–	–	–	–	–	0.9	3.3	6.1
N3	0.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.2	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	1.8	4.9	9.0	9.0	6.2	9.0	9.0	9.0	9.0	9.0	6.4	9.0	9.0	8.0	9.0	9.0	9.0	9.0	9.0
	2.4	3.7	7.4	7.4	4.5	9.0	9.0	9.0	9.0	9.0	4.6	8.5	9.0	5.7	9.0	9.0	9.0	9.0	9.0
	3.0	2.9	4.9	4.9	3.6	7.0	7.7	7.2	9.0	9.0	2.9	5.6	6.7	3.5	7.1	9.0	6.9	9.0	9.0
	3.6	–	–	–	2.5	4.8	5.3	4.9	9.0	9.0	–	–	–	2.2	4.8	7.3	4.4	9.0	9.0
	4.2	–	–	–	1.5	3.3	3.7	3.2	6.7	9.0	–	–	–	1.2	3.1	5.0	2.7	6.4	9.0
	4.8	–	–	–	–	–	–	2.2	5.0	8.1	–	–	–	–	–	–	1.7	4.6	7.9
	5.4	–	–	–	–	–	–	1.5	3.8	6.4	–	–	–	–	–	–	0.9	3.3	6.1
N4	0.9	8.2	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
and	1.2	6.4	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.3	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
C1	1.8	4.9	9.0	9.0	6.2	8.2	9.0	9.0	9.0	9.0	6.4	9.0	9.0	8.0	9.0	9.0	9.0	9.0	9.0
	2.4	3.7	7.4	7.4	4.5	6.5	9.0	9.0	9.0	9.0	4.6	8.5	9.0	5.7	9.0	9.0	9.0	9.0	9.0
	3.0	2.9	4.9	4.9	3.6	5.5	7.7	7.2	9.0	9.0	2.9	5.6	6.7	3.5	7.1	9.0	6.9	9.0	9.0
	3.6	–	–	–	2.5	4.7	5.3	4.9	9.0	9.0	–	–	–	2.2	4.8	7.3	4.4	9.0	9.0
	4.2	–	–	–	1.5	3.3	3.7	3.2	6.7	9.0	–	–	–	1.2	3.1	5.0	2.7	6.4	9.0
	4.8	–	–	–	–	–	–	2.2	5.0	8.1	–	–	–	–	–	–	1.7	4.6	7.9
	5.4	–	–	–	–	–	–	1.5	3.8	6.4	–	–	–	–	–	–	0.9	3.3	6.1
N5	0.9	4.9	9.0	9.0	7.6	9.0	9.0	9.0	9.0	9.0	6.4	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
and	1.2	3.8	9.0	9.0	6.1	9.0	9.0	9.0	9.0	9.0	5.0	9.0	9.0	8.0	9.0	9.0	9.0	9.0	9.0
C2	1.8	3.1	9.0	9.0	4.5	9.0	9.0	8.2	9.0	9.0	4.0	9.0	9.0	5.9	9.0	9.0	9.0	9.0	9.0
	2.4	2.4	5.3	5.3	3.5	8.3	9.0	6.3	9.0	9.0	3.2	5.8	7.3	4.7	8.7	9.0	8.4	9.0	9.0
	3.0	2.1	3.8	3.8	3.0	5.9	7.7	5.2	9.0	9.0	2.6	4.2	5.2	3.5	6.2	9.0	6.1	9.0	9.0
	3.6	–	–	–	2.5	4.4	5.3	4.4	7.4	8.0	–	–	–	2.2	4.8	6.7	4.4	7.7	9.0
	4.2	–	–	–	1.5	3.3	3.7	3.2	5.6	6.0	–	–	–	1.2	3.1	5.0	2.7	5.9	8.5
	4.8	–	–	–	–	–	–	2.2	4.5	4.9	–	–	–	–	–	–	1.7	4.6	6.9
	5.4	–	–	–	–	–	–	1.5	3.8	4.1	–	–	–	–	–	–	0.9	3.3	5.8
N6	0.9										4.5	9.0	9.0	7.0	9.0	9.0	9.0	9.0	9.0
	1.2										3.5	9.0	9.0	5.6	9.0	9.0	9.0	9.0	9.0
	1.8										2.8	6.9	8.7	4.1	9.0	9.0	7.6	9.0	9.0
	2.4										2.2	4.0	5.0	3.3	6.0	8.2	5.8	9.0	9.0
	3.0										1.9	2.9	3.6	2.6	4.3	6.3	4.3	7.2	9.0
	3.6										–	–	–	2.0	3.3	4.7	3.3	5.4	7.9
	4.2										–	–	–	1.2	2.5	3.5	2.5	4.1	5.9
	4.8										–	–	–	–	–	–	1.7	3.3	4.8
	5.4										–	–	–	–	–	–	0.9	2.8	4.0
C3	0.9										4.1	9.0	9.0	6.4	9.0	9.0	9.0	9.0	9.0
	1.2										3.2	7.6	8.0	5.1	9.0	9.0	9.0	9.0	9.0
	1.8										2.5	6.0	6.3	3.8	9.0	9.0	6.9	9.0	9.0
	2.4										2.0	3.7	4.6	3.0	5.5	7.5	5.3	9.0	9.0
	3.0										1.7	2.7	3.3	2.4	4.0	5.7	3.9	6.6	9.0
	3.6										–	–	–	1.8	3.0	4.3	3.0	4.9	7.2
	4.2										–	–	–	1.2	2.3	3.2	2.3	3.7	5.4
	4.8										–	–	–	–	–	–	1.7	3.0	4.4
	5.4										–	–	–	–	–	–	0.9	2.6	3.7
C4	0.9										2.9	7.0	7.3	4.5	9.0	9.0	9.0	9.0	9.0
	1.2										2.3	5.4	5.7	3.6	9.0	9.0	7.9	9.0	9.0
	1.8										1.8	4.3	4.5	2.7	6.7	6.9	4.9	9.0	9.0
	2.4										1.4	2.6	3.3	2.1	3.9	5.4	3.8	6.5	9.0
	3.0										1.2	1.9	2.4	1.7	2.8	4.1	2.8	4.7	6.9
	3.6										–	–	–	1.3	2.1	3.0	2.1	3.5	5.2
	4.2										–	–	–	1.0	1.6	2.3	1.6	2.7	3.9
	4.8										–	–	–	–	–	–	1.4	2.2	3.1
	5.4										–	–	–	–	–	–	0.9	1.9	2.6



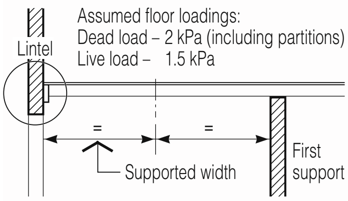
(1) See **Figure 1.6** (page 4) for details

Table 3.7 *Selection of Lintels Supporting Girder Roof Trusses*

		Maximum supported roof area, including standard trusses (m²)							
		140-mm-wide lintels				190-mm-wide lintels			
	Opening	Type B(1) with:		Type C(1) with:		Type B(1) with:		Type C(1) with:	
Wind class.	(m)	N16	N20	N16	N20	N16	N20	N16	N20
N1 and N2	0.9	33	34	75	80	36	38	76	89
	1.2	30	31	58	65	31	34	59	72
	1.8	20	22	40	54	21	30	40	59
	2.4	15	16	30	45	15	23	30	46
	3.0	12	13	23	36	12	17	23	37
N3	0.9	33	34	75	80	36	38	76	89
	1.2	30	31	58	65	31	34	59	72
	1.8	20	22	40	54	21	30	40	59
	2.4	15	16	30	45	15	23	30	46
	3.0	12	13	23	36	12	17	23	37
N4 and C1	0.9	28	28	60	61	30	31	64	68
	1.2	25	26	50	51	28	29	50	57
	1.8	20	22	35	44	21	27	36	48
	2.4	16	16	27	40	17	23	28	42
	3.0	12	13	22	33	12	17	23	34
N5 and C2	0.9	18	18	39	40	20	20	41	44
	1.2	16	17	32	33	18	19	33	37
	1.8	13	16	22	28	14	18	23	31
	2.4	10	14	17	26	11	16	18	27
	3.0	–	11	14	21	–	13	15	23

(1) See **Figure 1.6** (page 4) for details

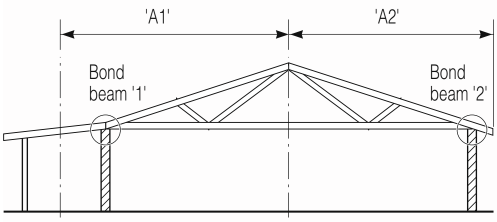
Table 3.8 *Selection of Lintels Supporting a Timber Floor*



		Maximum supported width (m)							
		140-mm-wide lintels				190-mm-wide lintels			
Determination of	**Opening**	Type BB(1) with:		Type CC(1) with:		Type BB(1) with:		Type CC(1) with:	
supported width	(m)	N16	N20	N16	N20	N16	N20	N16	N20
	0.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	1.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	1.8	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	2.4	2.3	2.6	3.0	3.0	2.8	3.0	3.0	3.0
	3.0	1.7	1.9	2.9	3.0	2.1	2.2	3.0	3.0
	3.6	1.4	1.5	2.2	2.3	1.7	1.8	2.4	2.7
	4.2	–	–	1.8	1.9	–	–	1.8	2.2
	4.8	–	–	1.5	1.6	–	–	1.4	1.8
	5.4	–	–	1.2	1.4	–	–	1.1	1.6

(1) See **Figure 1.7** (page 4) for details

Table 3.9 *Selection of Bond Beams Supporting Standard Truss Roofs*



		Maximum allowable value of dimension 'A' (m)					
		140-mm-leaf wall			190-mm leaf-wall		
Determination of	**Wind**	Bond beams(1)			Bond beams(1)		
dimension 'A'	**Class.**	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
	N2	9	9	9	9	9	9
	N3	7	9	9	9	9	9
	N4	–	9	9	5	9	9
	N5	–	6	9	–	7	9
	N6	–	4	7	–	5	9
	C1	–	9	9	5	9	9
	C2	–	6	9	3.5	9	9
	C3	–	4	7	–	5	9
	C4	–	–	5	–	–	7

(1) See **Figure 1.3** (page 3) for details

4 Bracing Design

4.1 Method

Bracing walls of sufficient number and strength must be located through the building to resist the racking forces from the wind and earthquake. The sum of the capacities of all bracing walls in each direction must exceed the total racking force in the relevant direction. The bracing walls can be either all masonry, other wall types or a combination of both. The external walls will act as bracing walls in either direction.

4.2 Racking Forces

Determine the racking forces imposed on the building in both directions from **AS 4055** for the appropriate wind classification.

4.3 Bracing Wall Location

Bracing walls must be distributed approximately evenly along the length and width of the building. The maximum distance between bracing walls supporting a roof (ie, for single-storey or for the upper-storey of multi-level houses) is given in
Table 4.1 for the various wind classifications.
Where bracing walls cannot be spaced to comply with **Table 4.1**, then additional cross bracing needs to be included in the ceiling to distribute the racking forces.

Note, these tables are extracts from Australian Standard AS 3700.

For the lower-storey of two-storey houses, the spacing of bracing walls should not exceed 9.0 m (as specified in AS 4055).

Table 4.1 *Spacing of Bracing Walls Under Roofs*

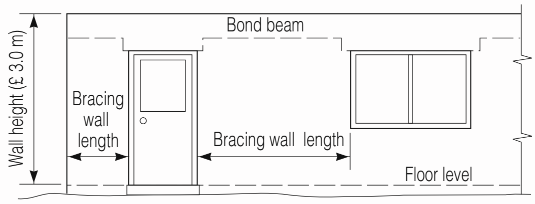
		Maximum spacing of bracing walls (m)							
		Roof slope (degrees)							
Wind Class.	**Building width** (m)	0	5	10	15	20	25	30	35
N1	4	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.9
	6	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	8	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	10	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	12	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	14	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	16	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
N2	4	9.0	9.0	9.0	9.0	9.0	7.8	6.7	6.4
	6	9.0	9.0	9.0	9.0	9.0	9.0	8.6	7.9
	8	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.8
	10	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	12	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	14	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	16	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
N3	4	5.9	6.6	7.4	7.5	6.4	5.1	4.4	4.2
and	6	8.9	9.0	9.0	9.0	8.8	6.7	5.6	5.1
C1	8	9.0	9.0	9.0	9.0	9.0	7.6	6.7	5.7
	10	9.0	9.0	9.0	9.0	9.0	8.4	7.9	6.2
	12	9.0	9.0	9.0	9.0	9.0	9.0	7.9	6.6
	14	9.0	9.0	9.0	9.0	9.0	9.0	8.3	6.7
	16	9.0	9.0	9.0	9.0	9.0	9.0	8.6	6.9
N4	4	3.9	4.3	4.9	5.0	4.3	3.4	2.9	2.8
and	6	5.9	6.6	7.3	7.4	5.8	4.4	3.7	3.4
C2	8	7.9	9.0	9.0	9.0	6.7	5.0	4.4	3.8
	10	9.0	9.0	9.0	9.0	7.4	5.5	5.2	4.1
	12	9.0	9.0	9.0	9.0	7.9	5.9	5.2	4.3
	14	9.0	9.0	9.0	9.0	8.2	6.1	5.5	4.4
	16	9.0	9.0	9.0	9.0	8.6	6.5	5.7	4.6
N5	4	2.7	3.0	3.4	3.5	3.0	2.3	2.0	1.9
and	6	4.1	4.6	5.1	5.1	4.1	3.1	2.6	2.4
C3	8	5.5	6.3	6.7	6.5	4.7	3.5	3.1	2.6
	10	6.8	7.9	8.3	7.8	5.1	3.9	3.6	2.9
	12	8.2	9.0	9.0	8.6	5.5	4.1	3.7	3.0
	14	9.0	9.0	9.0	9.0	5.7	4.3	3.8	3.1
	16	9.0	9.0	9.0	9.0	6.0	4.6	4.0	3.2

4.4 Bracing Wall Capacities

The capacities of masonry acting as bracing walls are given in the following Tables:

- Table 4.2 for walls that comply with the details shown in Figure 4.1.
- Table 4.3 for walls consistent with AS 4773.1 Table 11.1(B).
- Table 4.4 for reinforced piers.

The bracing capacities given in Tables 4.2 to 4.4 rely on the tie-down reinforcement being effectively fixed into the foundations and the foundations being of sufficient size to resist overturning.



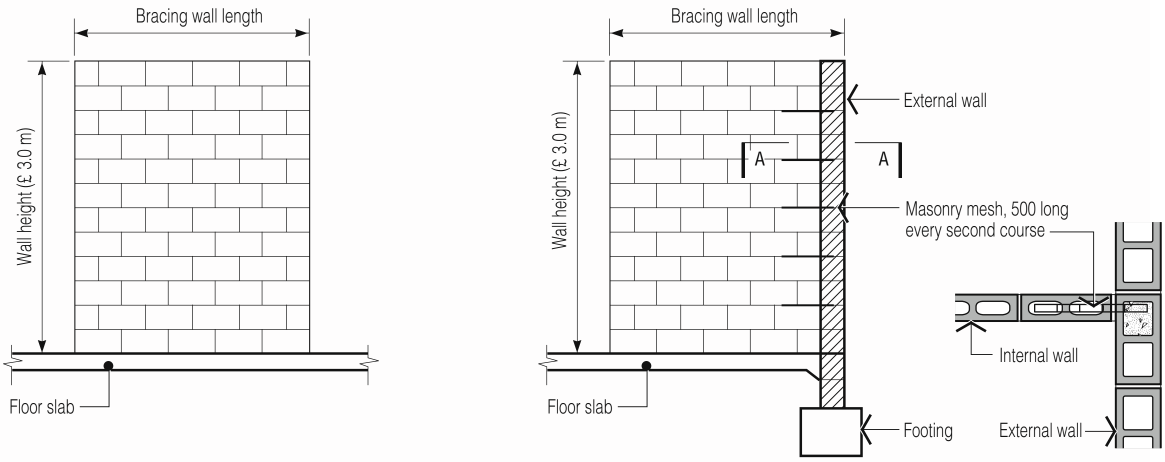
BRACING LENGTH FOR EXTERNAL REINFORCED WALLS

Table 4.2 *Bracing Capacity (kN) of Typical Bracing Walls[(1)] up to 3.0-m High*

Wall length (m)	Unreinforced walls, Leaf thickness (mm) 90	110	140	190	Walls reinforced with tie-downs: N12 tie-downs, Leaf (mm) 140	190	N16 tie-downs, Leaf (mm) 140	190
0.4	0.1	0.1	0.1	0.1	2.9	3.0	5.2	5.2
0.6	0.2	0.2	0.3	0.3	5.8	5.9	10.3	10.4
0.8	0.4	0.4	0.5	0.6	8.8	8.9	16.0	16.0
1.0	0.6	0.7	0.7	0.9	12.0	12.0	21.0	21.0
1.2	0.8	1.0	1.1	1.3	15.0	15.0	26.0	26.0
1.8	1.9	2.1	2.4	2.9	24.0	25.0	42.0	43.0
2.4	3.3	3.8	4.3	5.1	34.0	35.0	59.0	60.0
3.0	5.2	5.9	6.7	7.9	44.0	46.0	76.0	77.0
4.0	9.2	11.0	12.0	14.0	62.0	64.0	104.0	107.0
5.0	14.0	17.0	19.0	22.0	81.0	85.0	135.0	139.0
6.0	21.0	24.0	27.0	32.0	101.0	107.0	166.0	172.0
7.0	28.0	32.0	37.0	43.0	122.0	130.0	199.0	207.0
8.0	37.0	42.0	48.0	56.0	144.0	154.0	232.0	242.0
9.0	47.0	53.0	61.0	71.0	168.0	181.0	267.0	280.0
10.0	58.0	66.0	75.0	88.0	192.0	208.0	303.0	318.0

(1) As detailed in Figure 4.1

These values have been calculated in accordance with AS 3700, and are consistent with AS 3700 Table 12.11. AS 4773.1 has different (more conservative) values, shown on the next page.

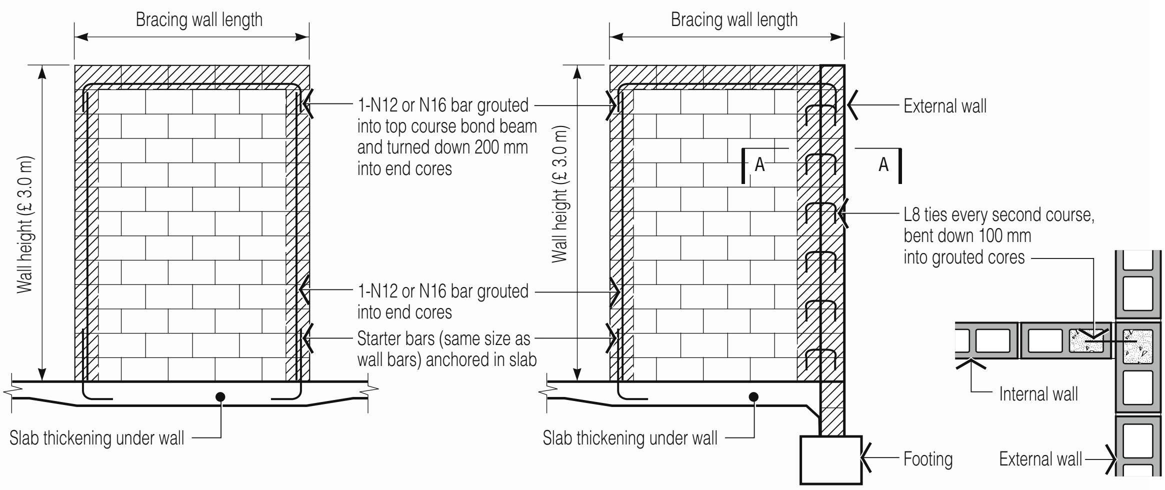


WALL NOT CONNECTED TO AN EXTERNAL WALL – ELEVATION

WALL CONNECTED TO AN EXTERNAL WALL – ELEVATION

SECTION A–A

INTERNAL WALLS WITHOUT TIE-DOWNS (UNREINFORCED)



WALL NOT CONNECTED TO AN EXTERNAL WALL – ELEVATION

WALL CONNECTED TO AN EXTERNAL WALL – ELEVATION

SECTION A–A

INTERNAL WALLS WITH TIE-DOWNS

Single-Leaf Masonry
Design Manual

Table 4.3 *Bracing Capacity (kN) Consistent with AS 4773.1 Table 11.1(B) for Walls up to 3.0-m High*

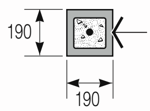
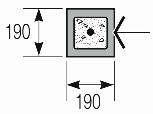
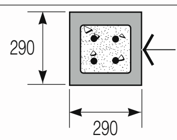
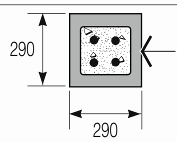
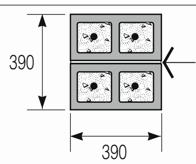
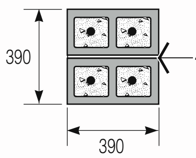
Wall length (m)	Walls reinforced with tie-downs (2) N12 tie-downs		N16 tie-downs	
	Bracing capacity, kN			
	90	110	140	190
0.4	2.4	2.6	3.8	4.1
0.6	4.3	4.5	7.0	7.3
0.8	6.2	6.5	10.0	11.0
1.0	8.3	8.7	14.0	14.0
1.2	10.0	11.0	17.0	18.0
1.8	17.0	18.0	28.0	29.0
2.4	25.0	27.0	39.0	41.0
3.0	33.0	36.0	51.0	55.0
4.0	48.0	54.0	73.0	79.0
5.0	65.0	74.0	97.0	106.0
6.0	85.0	97.0	122.0	135.0
7.0	106.0	123.0	150.0	168.0
8.0	129.0	151.0	180.0	202.0
9.0	154.0	183.0	211.0	240.0
10.0	181.0	216.0	245.0	280.0

(1) The shear connections to the structure above shall be detailed to resist the applied shear force and spaced not more than 1200 mm centres.

(2) Reinforced with tie-down means that the wall contains at least two vertical reinforcing bars in accordance with Clause 10.5. At least one bar shall be located no more than 100mm from each end of the wall.

(3) Note: This table is more conservative than calculations made in accordance with AS 3700, and shown in Table 4.2 on the previous page.

Table 4.4 *Bracing Capacity of Reinforced Piers with Wind in Either Direction*

Pier details	Bracing capacity of reinforced pier (kN) Pier Height (mm) 600	1200	1800	2400	3000	3600
	4.8	2.4	1.6	1.2	1.0	0.8
	4.8	2.4	1.6	1.2	1.0	0.8
	19.6	13.5	9.0	6.7	5.4	4.5
	22.0	19.7	13.1	9.8	7.9	6.6
	30.9	19.0	12.7	9.5	7.6	6.3
	35.5	32.8	21.8	16.4	13.1	10.9

Single-Leaf Masonry
Design Manual

5 Connection Details

5.1 Truss Tie-Down

Trusses must be tied down to the top bond beam to prevent both uplift and horizontal movement. Typical details and capacities are shown in Table 5.1.

Table 5.1 *Anchorage Capacities in Single Leaf Reinforced Concrete Masonry Walls*

	Reinforced concrete masonry wall thickness mm	Design Anchorage Capacity, φP kN per cleat	Permissible load width (A) of sheet roof that may be anchored, m						
			N1	N2	N3	N4 C1	N5 C2	N6 C3	C4
			Design uplift pressure, kPa						
Sheet Roof									
Two courses reinforced, with "long fishtail cleats"	190	30.7	8.9	8.9	8.9	8.9	7.8	5.2	3.8
Two courses reinforced, with "long fishtail cleats"	140	23.3	8.9	8.9	8.9	8.9	5.9	3.9	2.9
Two courses reinforced, with W8 stirrups at approximately 200 mm centres	190	22.0	8.9	8.9	8.9	8.6	5.6	3.7	2.7
Two courses reinforced, with W8 stirrups at approximately 200 mm centres	140	13.0	8.9	8.9	8.1	5.1	3.3	2.2	1.6
Two courses reinforced, with no deep anchorage	190	13.1	8.9	8.9	8.2	5.1	3.3	2.2	1.6
Two courses reinforced, with no deep anchorage	140	11.3	8.9	8.9	7.1	4.4	2.9	1.9	1.4
Tiled Roof									
Two courses reinforced, with "long fishtail cleats"	190	30.7	8.9	8.9	8.9	8.9	8.8	5.6	4.0
Two courses reinforced, with "long fishtail cleats"	140	23.3	8.9	8.9	8.9	8.9	6.7	4.3	3.0
Two courses reinforced, with W8 stirrups at approximately 200 mm centres	190	22.0	8.9	8.9	8.9	8.9	6.3	4.0	2.9
Two courses reinforced, with W8 stirrups at approximately 200 mm centres	140	13.0	8.9	8.9	8.9	6.2	3.7	2.4	1.7
Two courses reinforced, with no deep anchorage	190	13.1	8.9	8.9	8.9	6.3	3.8	2.4	1.7
Two courses reinforced, with no deep anchorage	140	11.3	8.9	8.9	8.9	5.4	3.3	2.1	1.5

These tables have been calculated by the Concrete Masonry Association of Australia from the results of sponsored tests, viz. Cyclone Testing Station School of Engineering James Cook University Report No TS 636 June 2006 Strength Limit State Uplift Load Design Capacities of Bond Beam Truss Hold Down Connections. AS 4773.1 and AS 4773.2 have adopted similar tables and details.

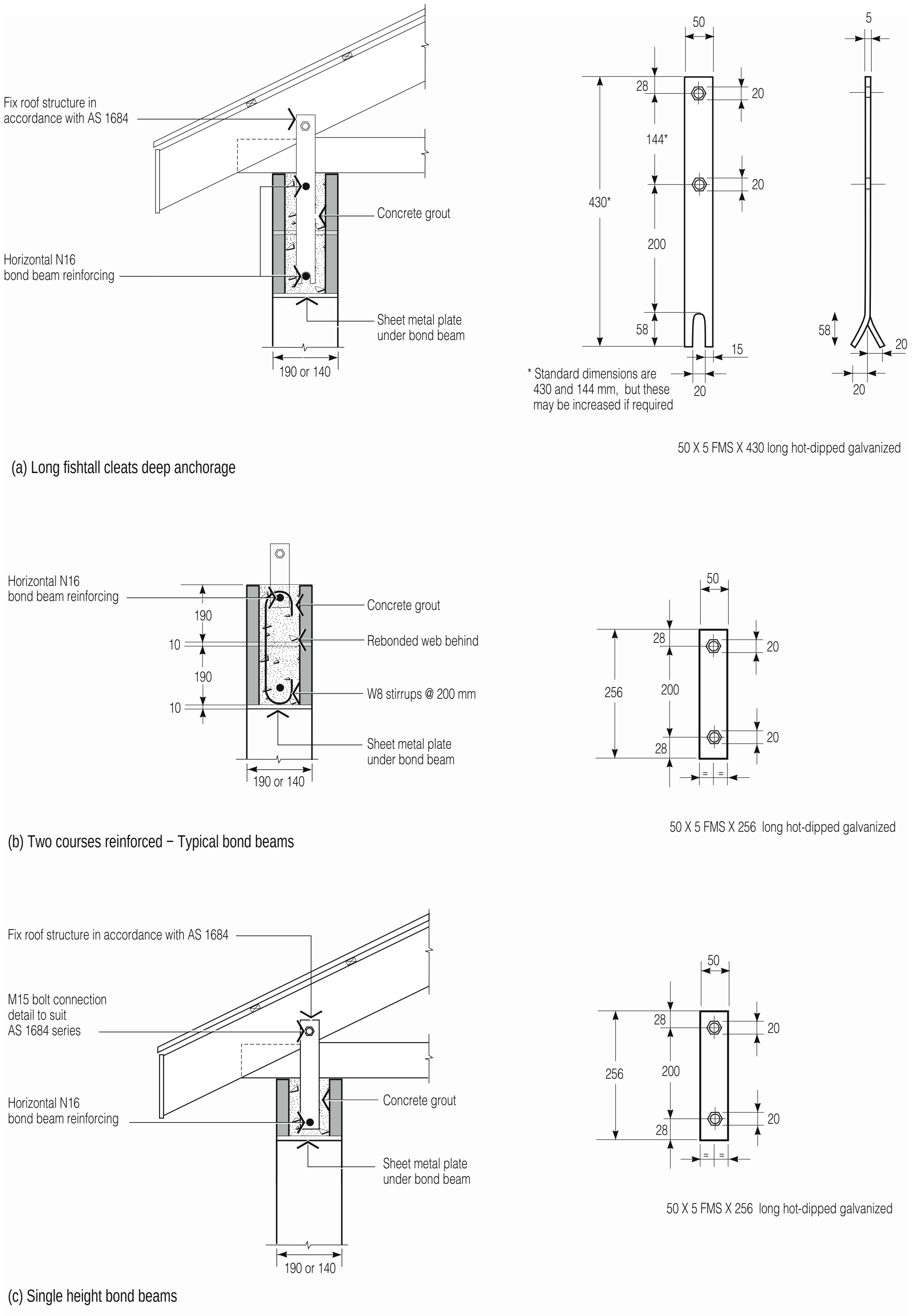
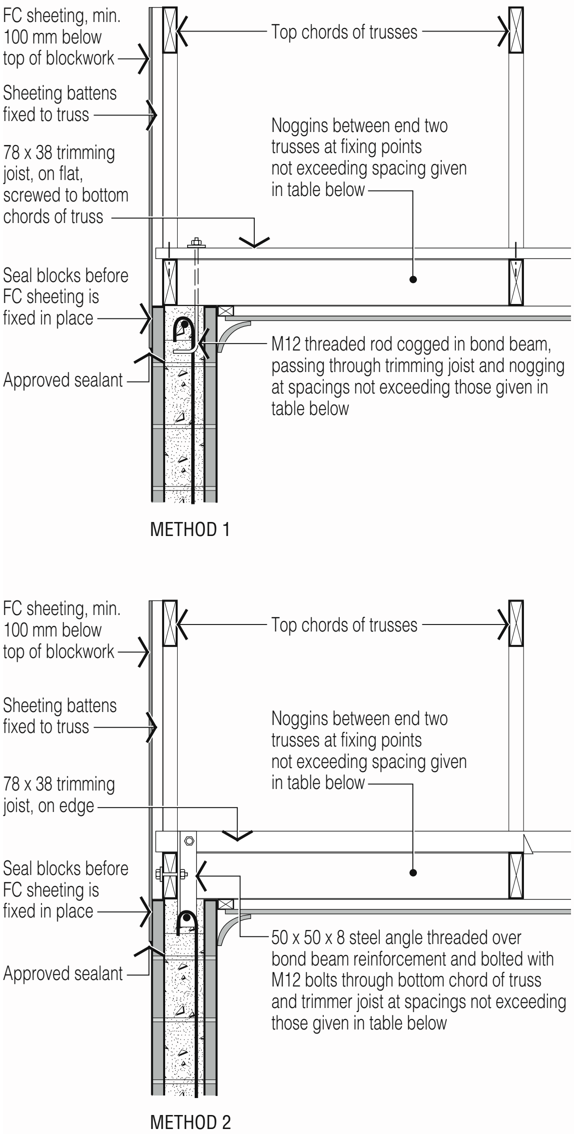


Figure 5.1 *Anchorage details for reinforced concrete bond beams*

5.2 Fixing to Gable Ends

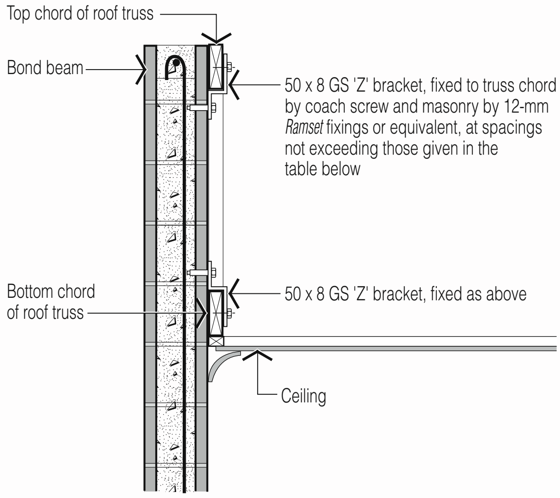
Gable walls must be supported by the roof diaphragm by anchoring of end roof trusses at regular centres. The attached end truss must then be braced back to internal trusses with trimming joists. Typical details and design capacities are given in the following Figures:

- Figure 5.2, for timber gable fixings
- Figure 5.3, for block gable fixing.



Wind Classification	Maximum spacing of fixings (m)
N1	3.6
N2	3.6
N3	3.6
N4 and C1	2.4
N5 and C2	1.8
N6 and C3	1.2

Figure 5.2 *Timber Gable End Fixing*



Wind Classification	Maximum spacing of fixings (m)
N1	3.6
N2	3.6
N3	2.4
N4 and C1	1.8
N5 and C2	1.2
N6 and C3	0.9

Figure 5.3 *Blockwork Gable Fixing*

5.3 Timber Floor Fixing

A pole plate supporting a timber floor must have sufficient anchors to carry the shear load imposed by the floor. Typical fixing is shown in Figure 5.4.

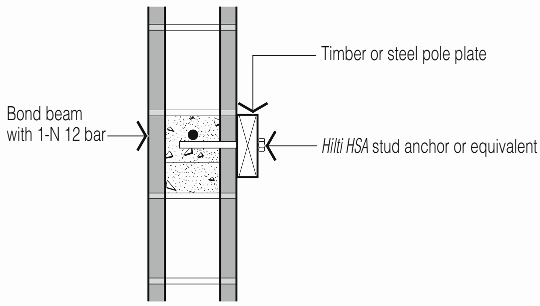


Figure 5.4 *Pole Plate Fixing for Timber Floor*

6 Basement Walls

6.1 General

The foundation slab of a basement can be modified to provide an efficient footing for a retaining wall. In addition, a concrete floor slab will provide a "prop" to the top of the wall, simplifying the wall details compared to a timber floor. All backfill must be with granular material. Details of typical basement walls are shown in the following Figures:

- Figure 6.1, with concrete floor
- Figure 6.2, with timber floor.

6.2 Drainage

As with all retaining walls it is critical that the backfill is prevented from becoming saturated. Steps to be taken to achieve this include:

- A drainage system within the backfill. This should preferable take the form of a 300-mm width of gravel immediately behind the wall with a continuous agricultural pipe located at the base of the wall. The pipe must discharge beyond the ends of the wall or be connected to the stormwater drain.
- Sealing the backfill surface. This can be done by placing a compacted layer of low-permeability material over the backfill and sloping the surface away from the house.

It is also important to prevent hydrostatic pressure under the floor slab. Where there is the possibility of groundwater under the slab, then a subfloor drainage system is advisable.

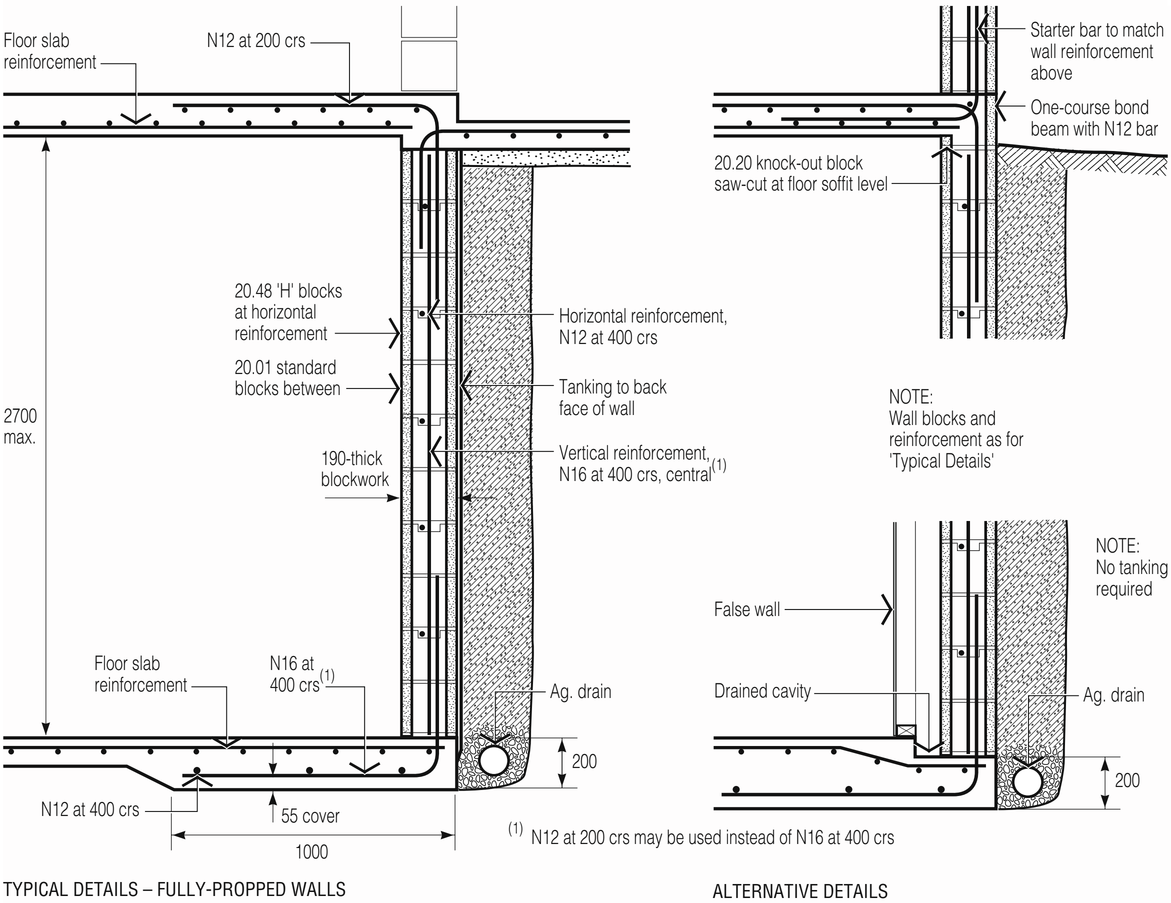


Figure 6.1 *Typical Basement Wall Supporting a Concrete Floor*

6.3 Tanking

Where it is required that the basement be kept dry, a proper tanking system needs to be installed behind the wall before backfilling. An alternative to this is to provide a drain and a false wall in front of the wall (see **Figures 6.1** and **6.2**).

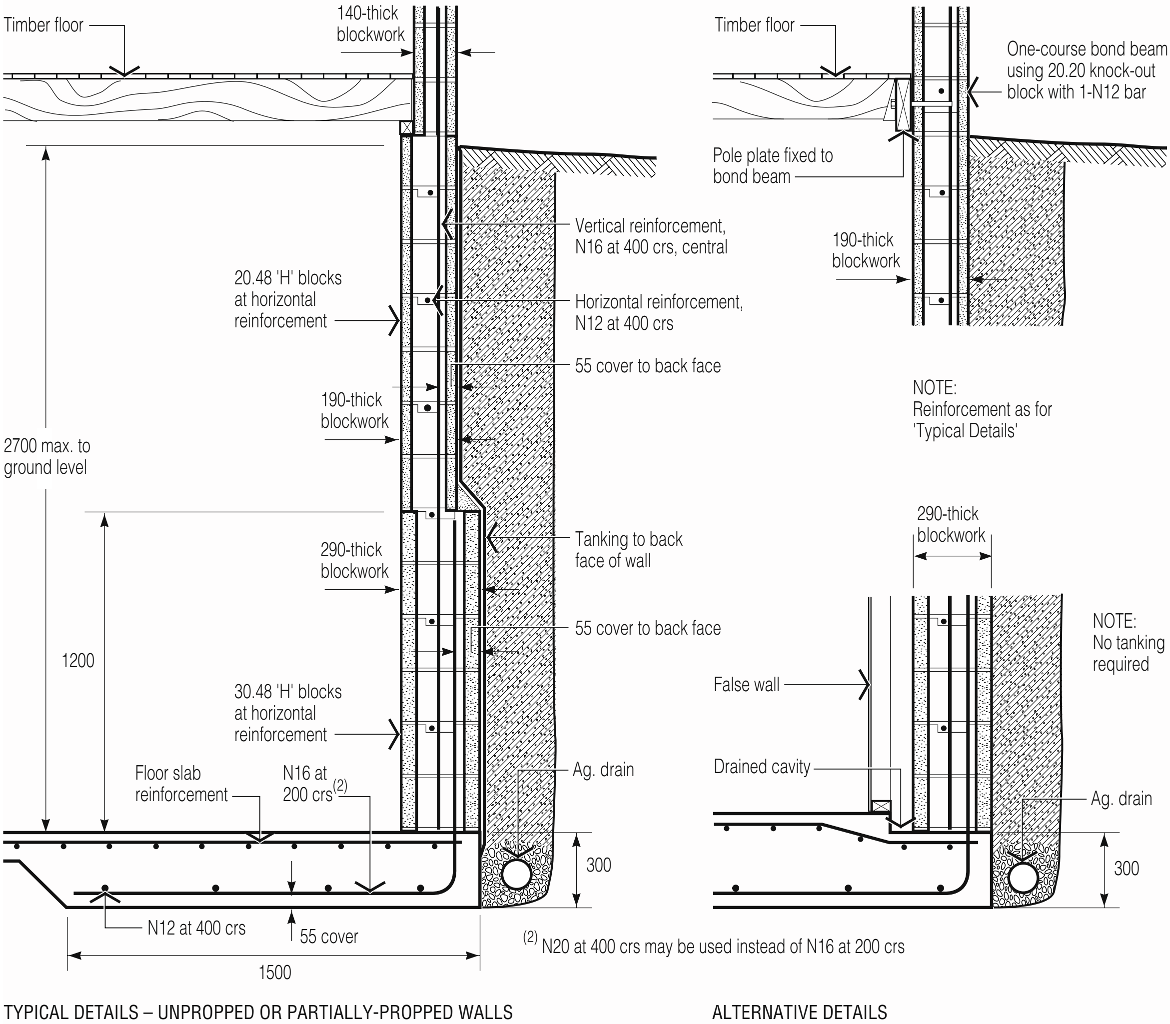


Figure 6.2 *Typical Basement Wall Supporting a Timber Floor*

7 Weatherproofing Recommendations for Housing

7.1 Joint Finishing

It is essential that all mortar joints be filled to the depth of the face shell and the surface compressed by tooling, leaving no voids. Ironing with an ironing tool of 12-mm diameter, 450-mm long, is generally satisfactory. Particular care needs to be taken around openings and window sills to ensure joints are properly filled.

7.2 Weatherproofing Application

A weatherproof paint system, complying with the Building Code of Australia, AS 4773.1 and AS 4773.2 must be applied to external walls (of habitable rooms), constructed of reinforced concrete masonry single leaf walls.

It is also recommended that the weatherproofing be applied before fixing downpipes, etc and before the windows are installed. The weatherproofing needs to be taken around the window reveals. All coatings must be applied strictly in accordance with the manufacturer's instructions.

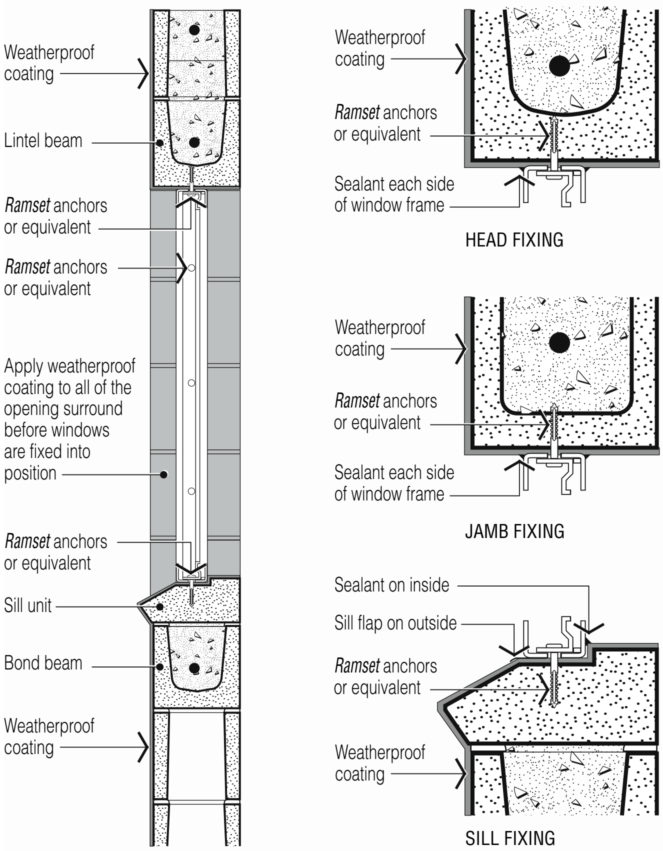
Some alternative coating systems available include:

- Three coats of 100% acrylic-based exterior paint. The first coat must be worked thoroughly into the masonry surface by brush to ensure complete coverage of all voids.
- A three-coat system, where the first coat is waterproof cement-based paint worked into the surface, and then two coats of 100% acrylic-based paint are further applied.
- Rendering with a proprietary cement-based high-build waterproof render, followed by an elastomeric acrylic polymer coating. It should be noted that this will obscure the masonry surface.
- Clear water repellent coatings, provided there is a weatherproof overhang at least 1.5 m wide.

All mortar joints must be tooled, and must be free of holes and cracks. To achieve this, the masonry surface may be bagged or rendered before painting. Paint systems must be regularly maintained. AS/NZS 2311 provides guidance on paint systems and practices.

7.3 Window Installation

Post fitting of windows is recommended in accordance with Figure 7.1.



RECOMMENDED PROCEDURE

1. Weatherproof all of the external wall, including window reveals, before the windows are fixed
2. Fix windows with *Ramset ED642* anchors, or equivalent. Before the anchor is inserted, the hole should be filled with sealant
3. Seal the whole perimeter of the window frame on the inside and the jamb and head sections on the outside, with *Sikaflex 15LM* or equivalent
4. Door frames are to be fixed and sealed as set out for windows, except the anchors should be *Ramset ED655* or equivalent.

Figure 7.1 *Installation of Windows*

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