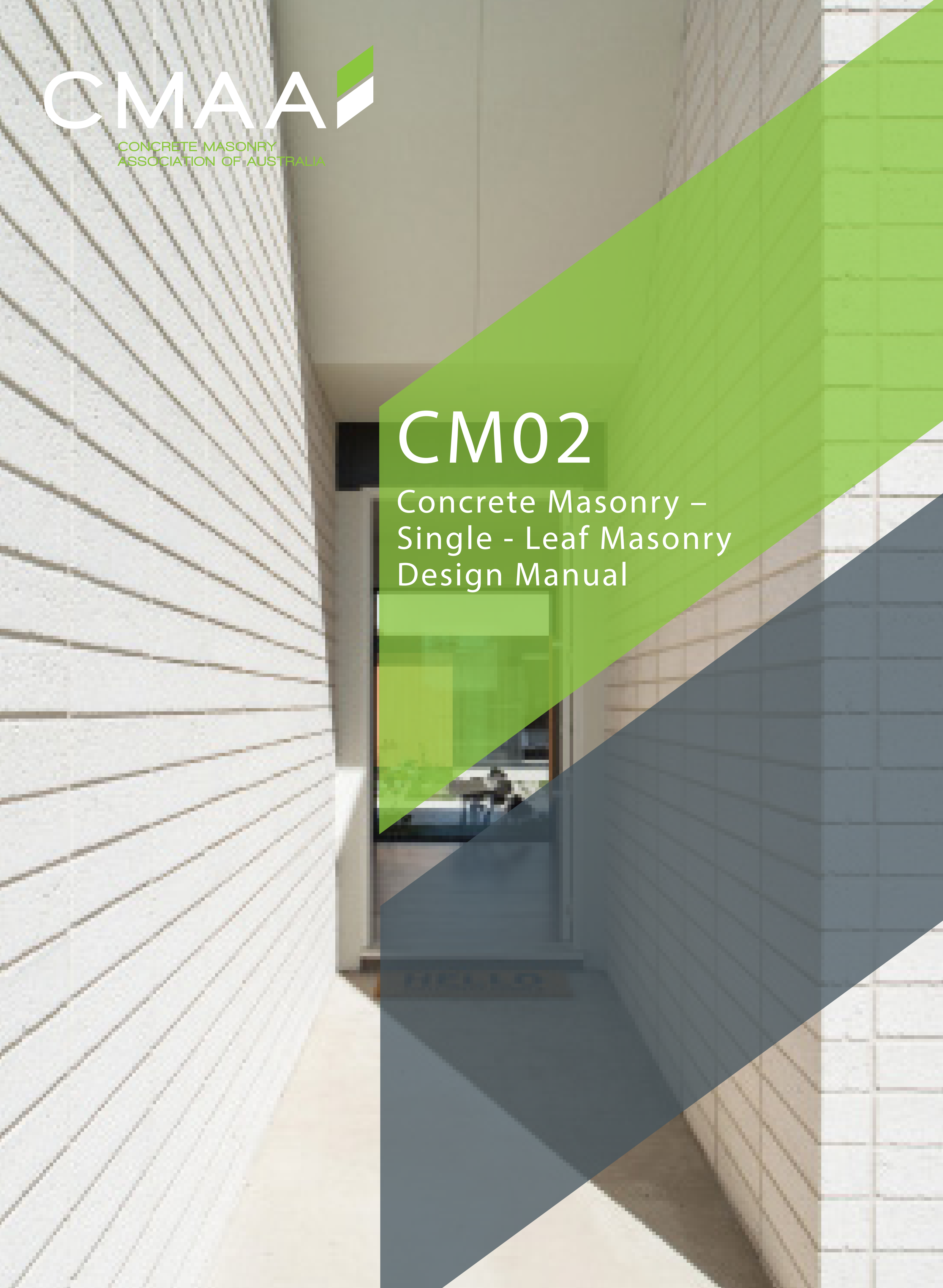

CMAA
CONCRETE MASONRY
ASSOCIATION OF AUSTRALIA

CM02

Concrete Masonry – Single - Leaf Masonry Design Manual

ABN 33 065 618 840

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The Standards referenced in this manual were current at the time of publication.

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Contents

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 National Construction Code 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

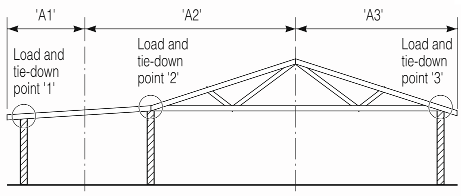


Figure 1.2 *Determination of Dimension "A"*

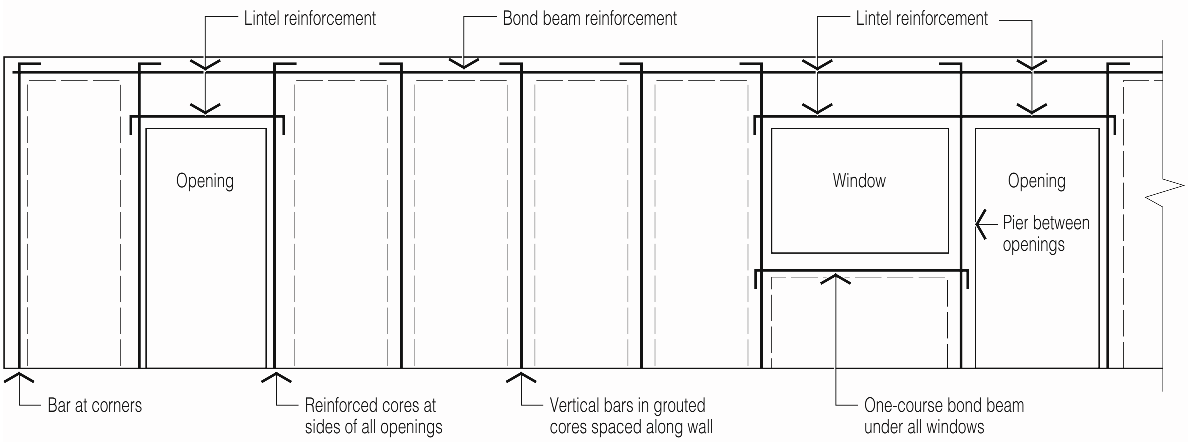


Figure 1.1 *Typical Wall and Reinforcement Layout*

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 1.6. Where an N16 bar is required in the details, 2-N12 bars may be used as an alternative.

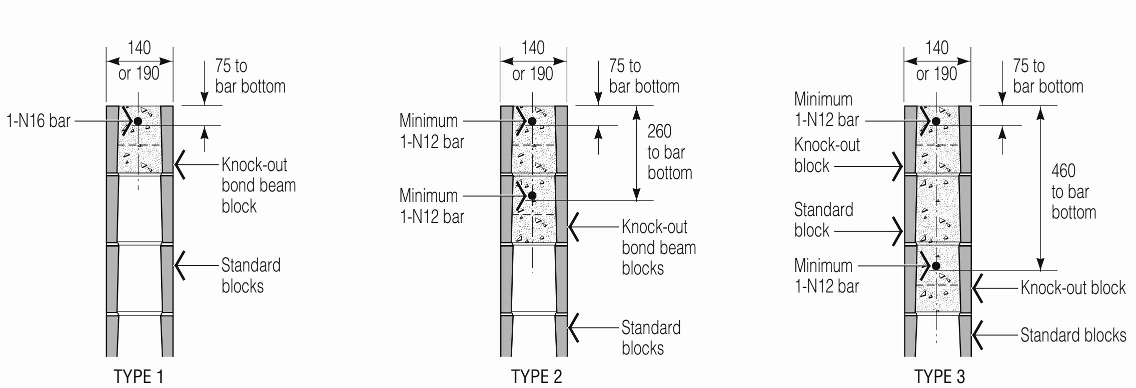


Figure 1.3 *Typical Details for Bond Beams Supporting a Roof*

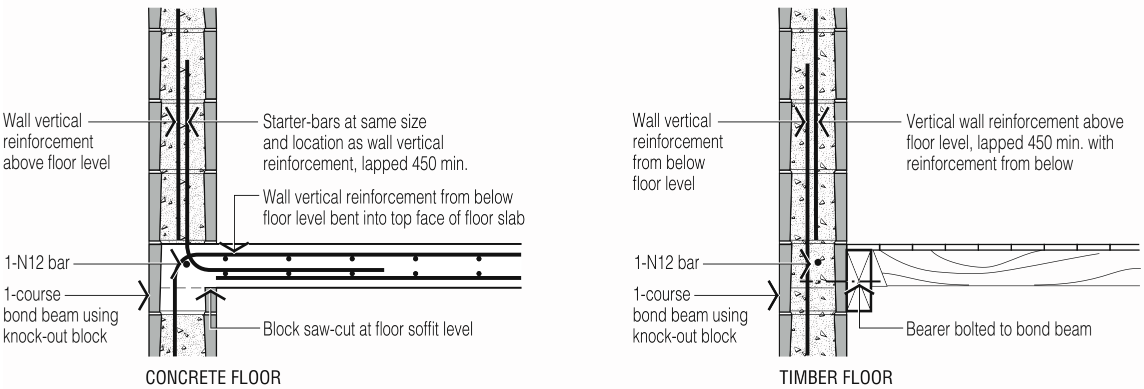


Figure 1.4 *Typical Details for Bond Beams Supporting a Floor*

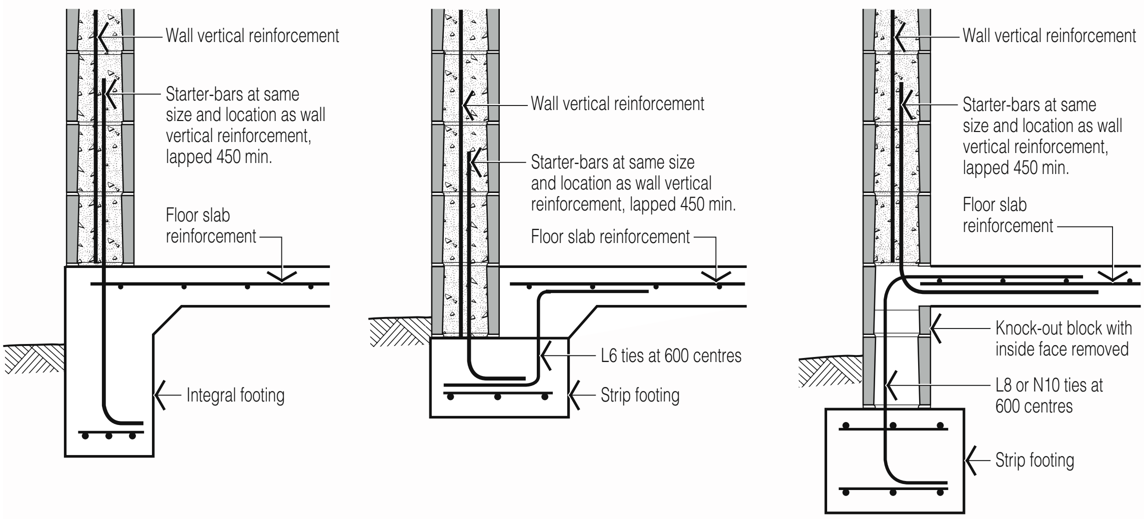


Figure 1.5 *Typical Details of Connections to Footings*

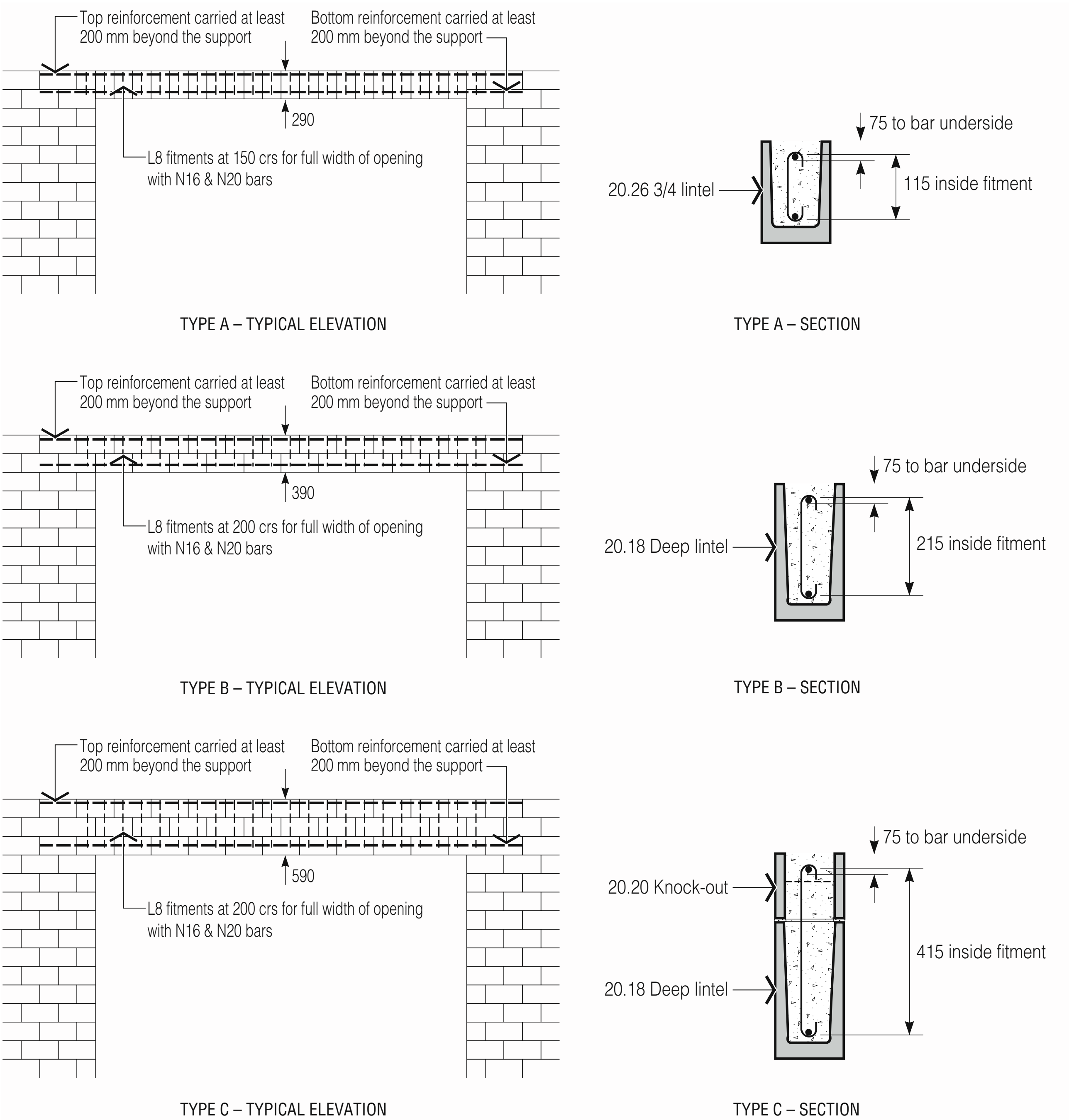


Figure 1.6 *Typical Lintels*
Refer to CMAA Data Sheet 3 - Concrete Masonry Lintels for the design and construction details of lintels.

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	7
2.2	140	N1, N2 & N3	2500	7
2.3	140	N1, N2 & N3	2700	8
2.4	140	N4 & C1	2400	8
2.5	140	N4 & C1	2700	9
2.6	140	N5 & C2	2500	9
2.7	140	N5 & C2	2700	9
2.8	190	N1, N2 & N3	2400	10
2.9	190	N1, N2 & N3	2500	10
2.10	190	N1, N2 & N3	2700	11
2.11	190	N4 & C1	2400	11
2.12	190	N4 & C1	2700	12
2.13	190	N5 & C2	2500	12
2.14	190	N5 & C2	2700	12

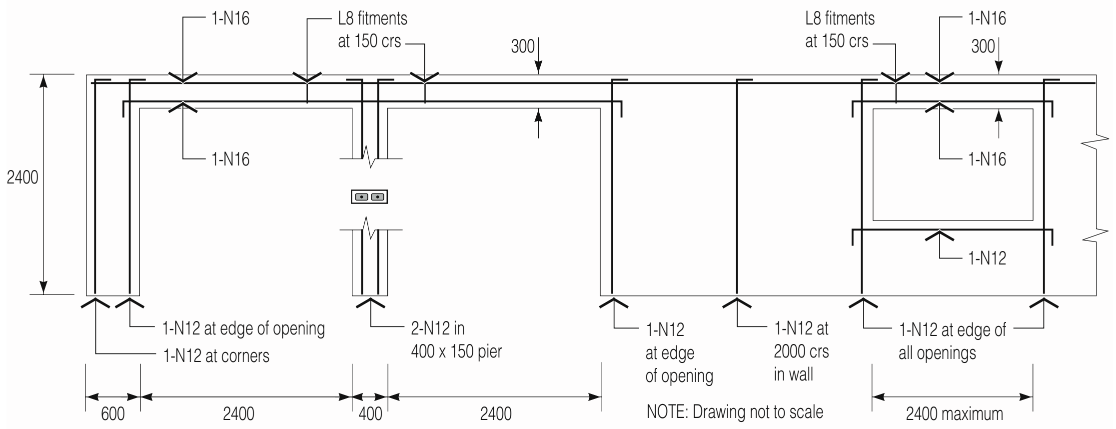


Figure 2.1 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2400-mm Wall Height*

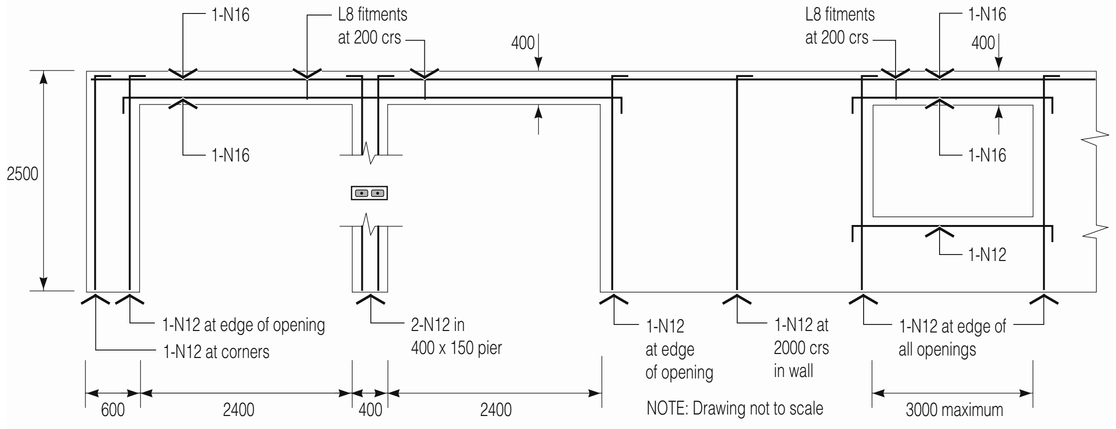


Figure 2.2 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2500-mm Wall Height*

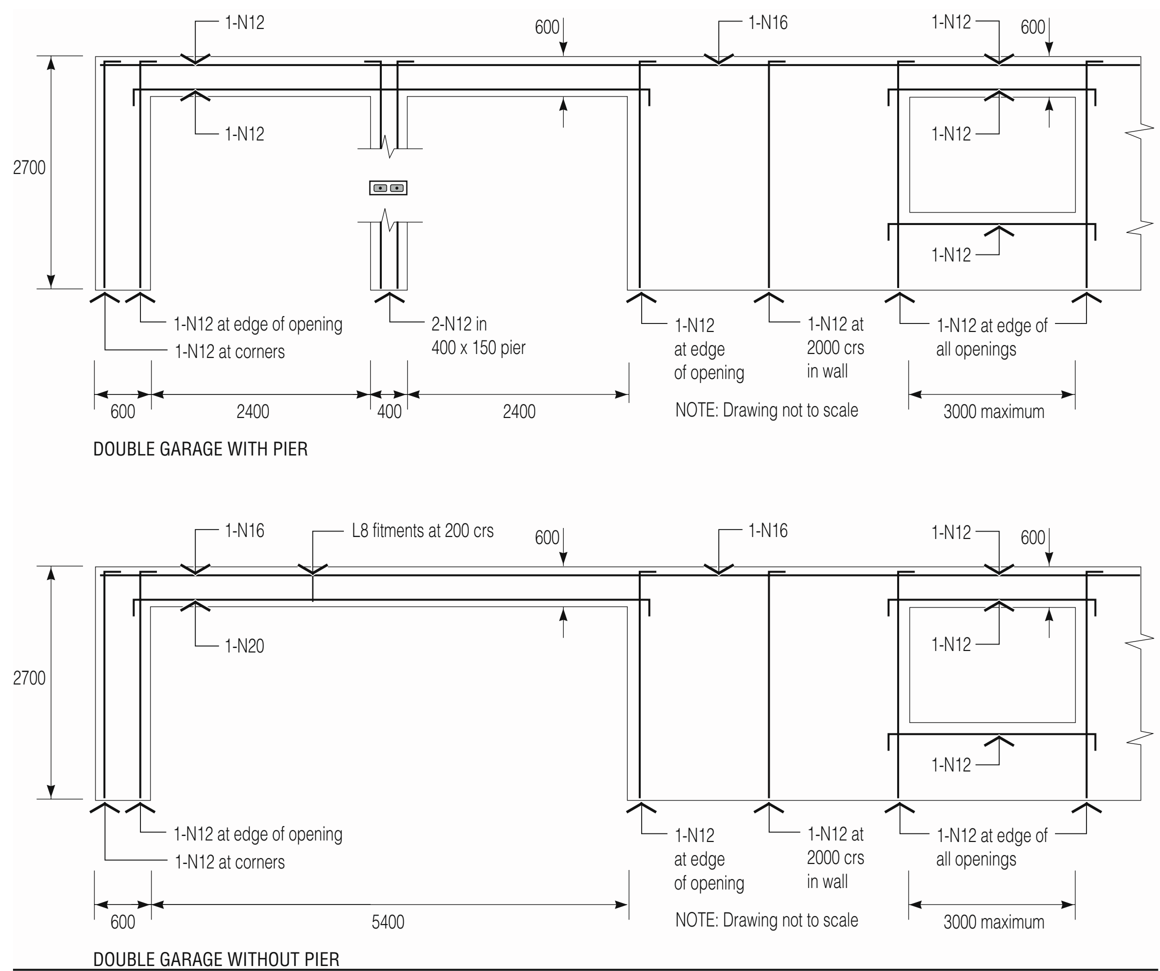


Figure 2.3 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N1, N2 and N3 and 2700-mm Wall Height*

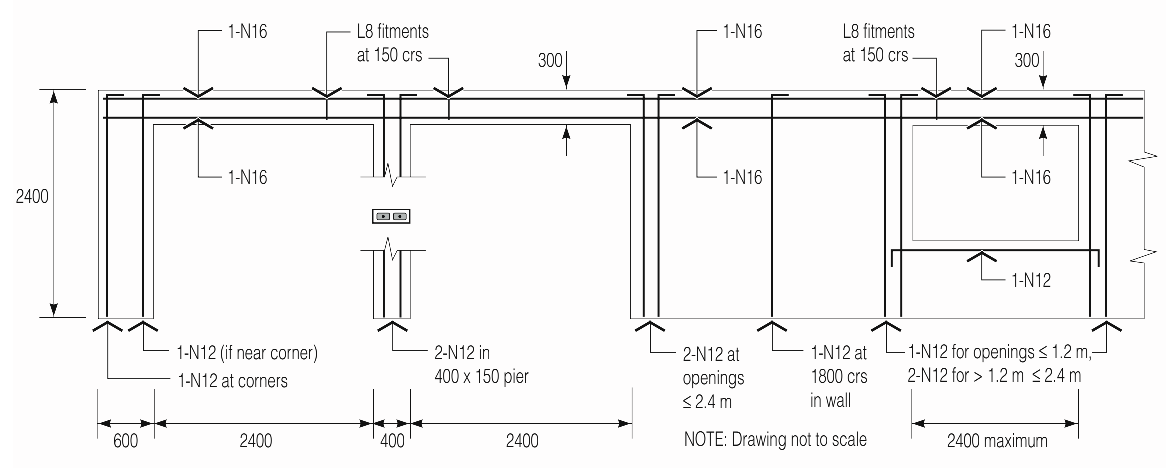


Figure 2.4 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N4 and C1 and 2400-mm Wall Height*

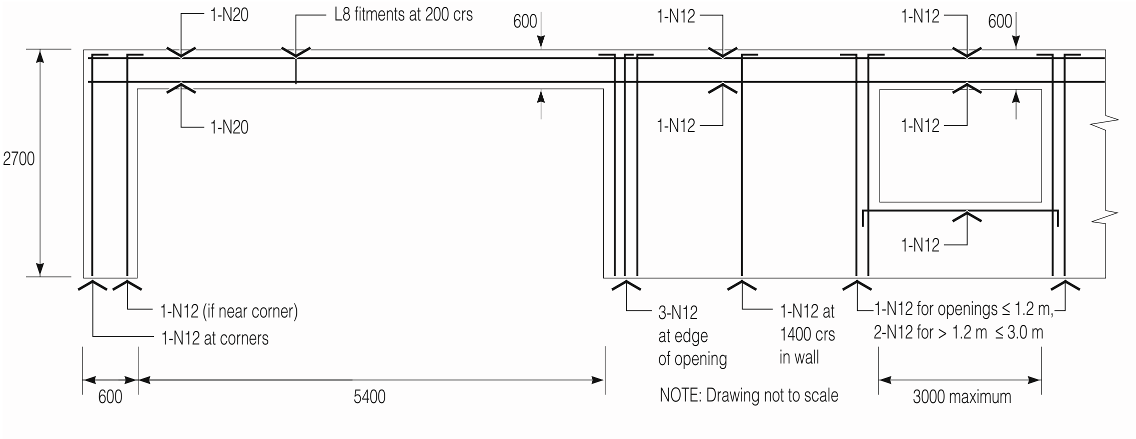


Figure 2.5 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N4 and C1 and 2700-mm Wall Height*

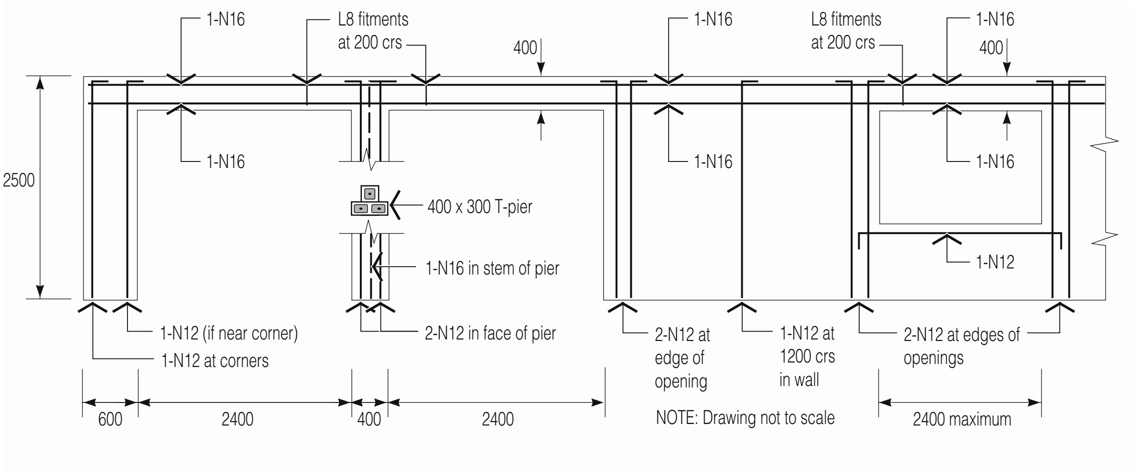


Figure 2.6 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N5 and C2 and 2500-mm Wall Height*

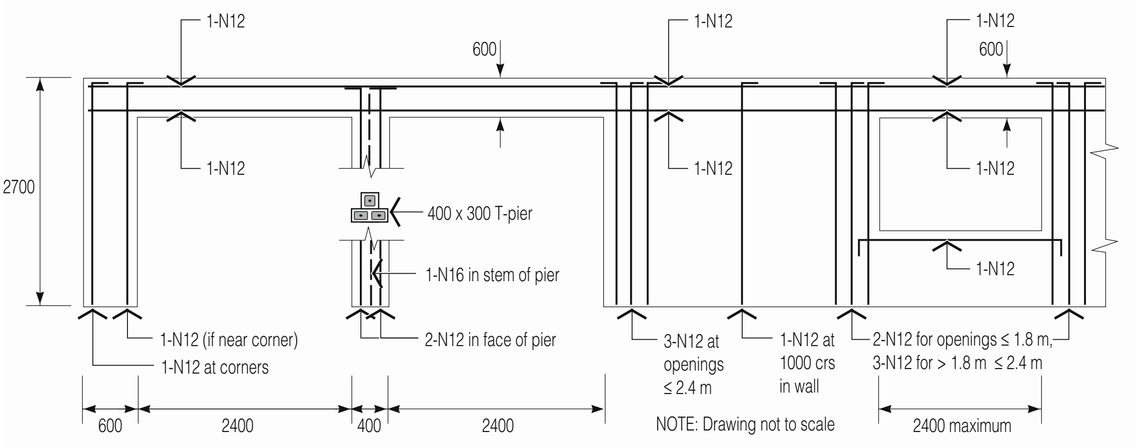


Figure 2.7 *Wall Reinforcement for 140-mm Leaf for Wind Classifications N5 and C2 and 2700-mm Wall Height*

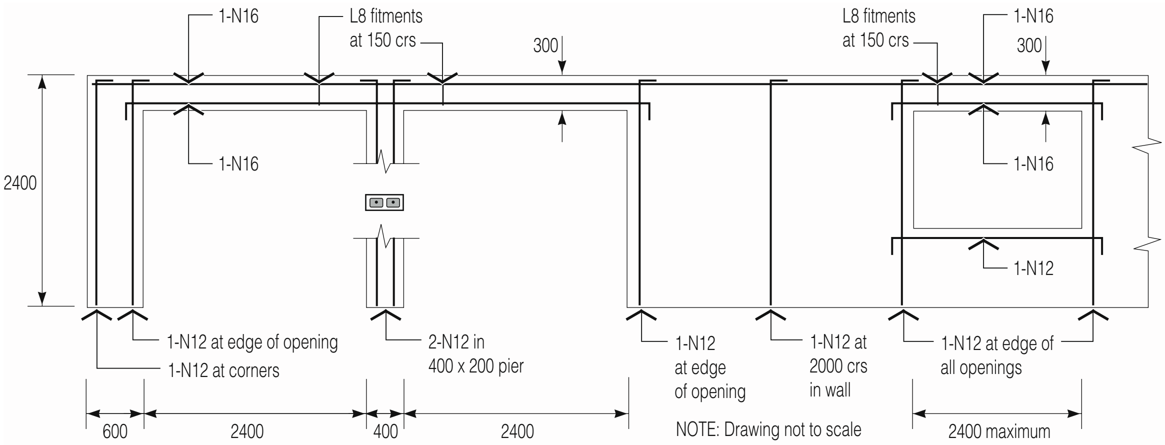


Figure 2.8 *Wall Reinforcement for 190-mm Leaf for Wind Categories N1, N2 and N3 and 2400-mm Wall Height*

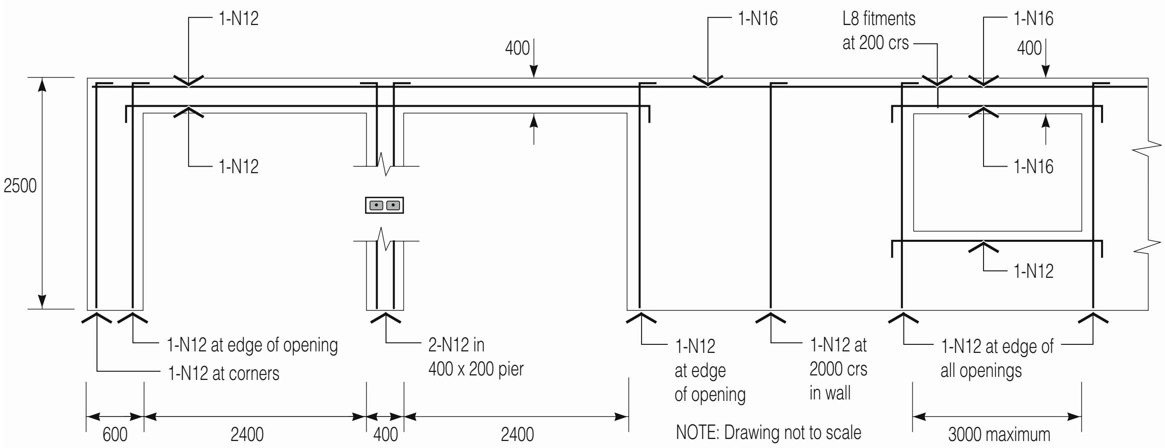


Figure 2.9 *Wall Reinforcement for 190-mm Leaf for Wind Categories N1, N2 and N3 and 2500-mm Wall Height*

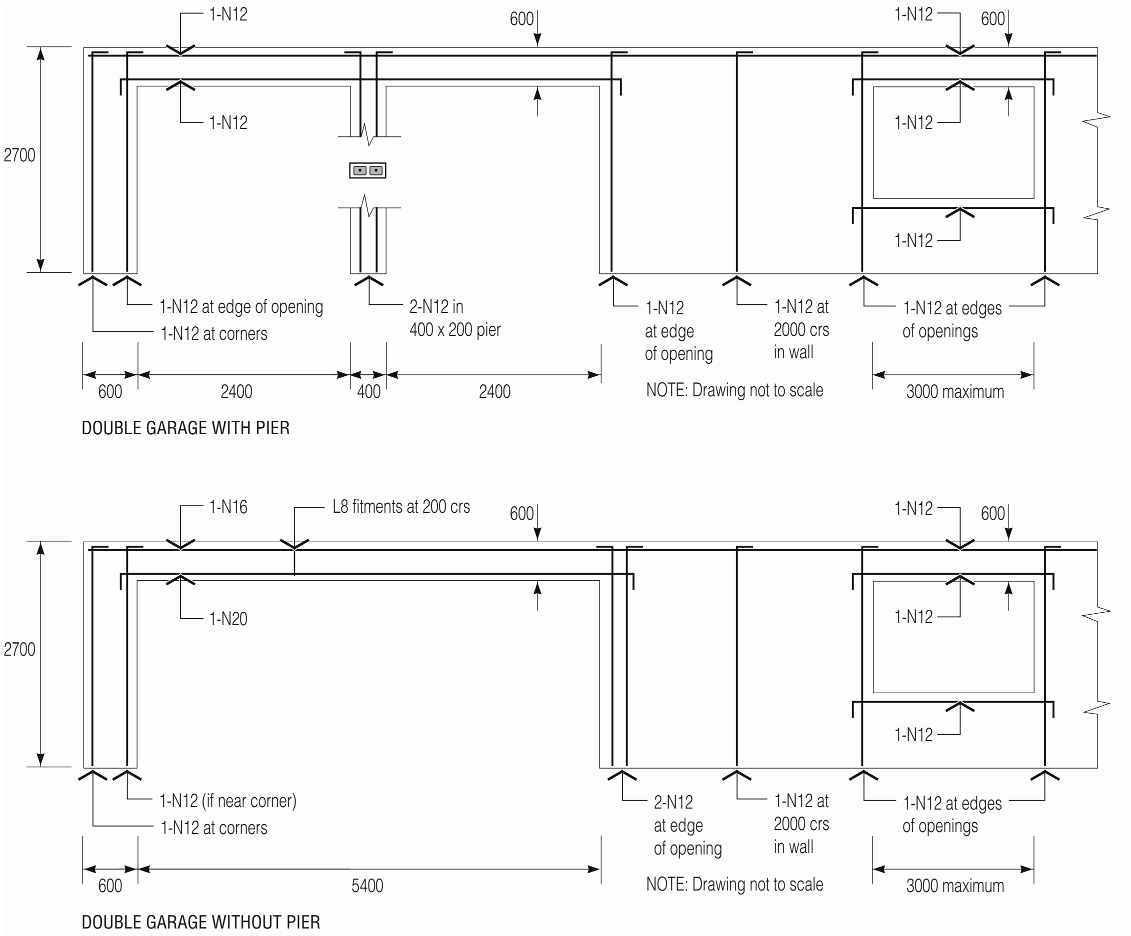


Figure 2.10 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N1, N2 and N3 and 2700-mm Wall Height*

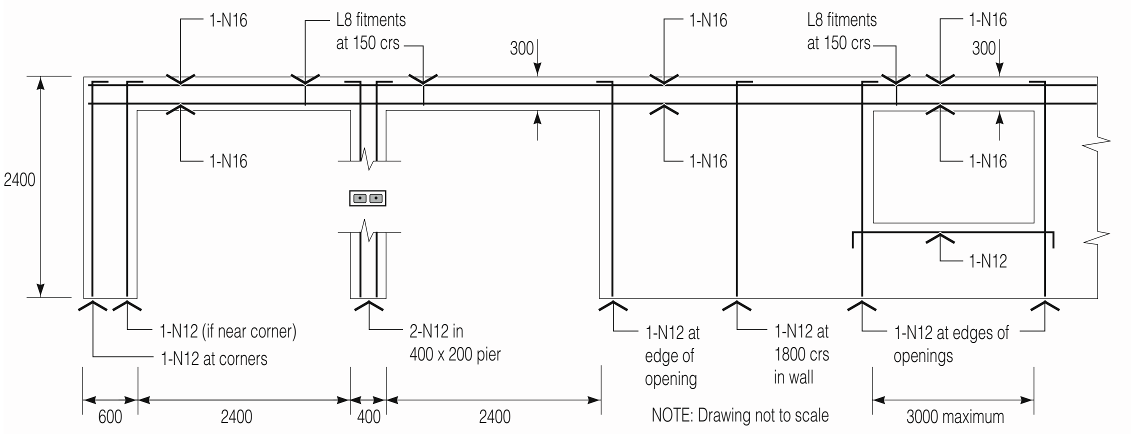


Figure 2.11 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N4 and C1 and 2400-mm Wall Height*

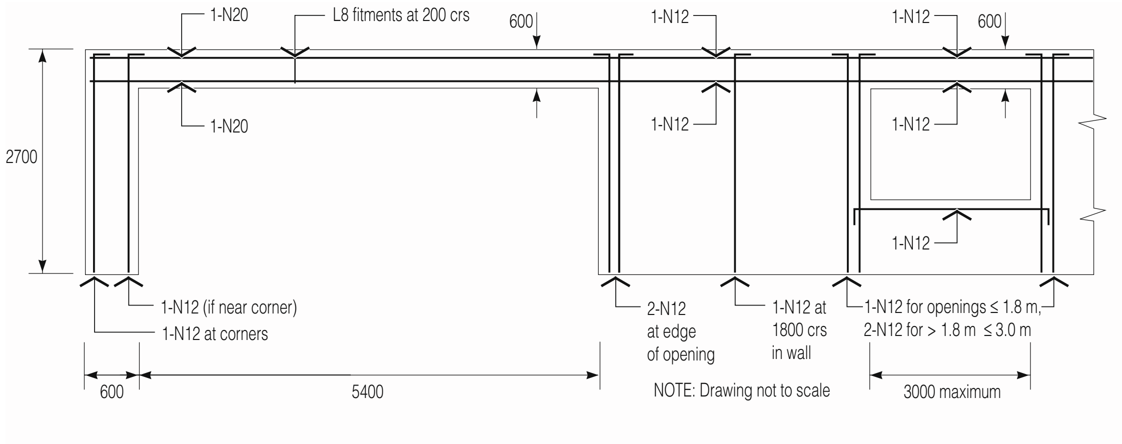


Figure 2.12 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N4 and C1 and 2700-mm Wall Height*

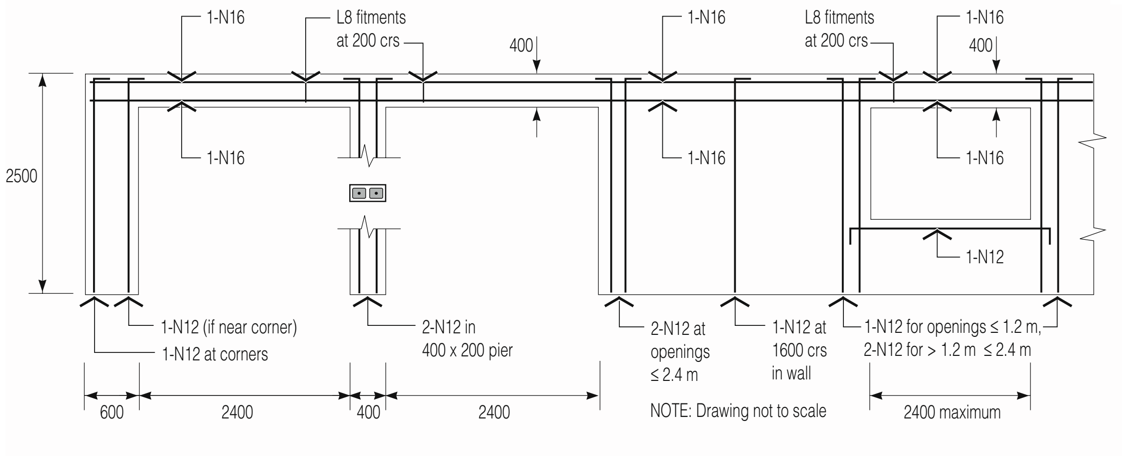


Figure 2.13 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N5 and C2 and 2500-mm Wall Height*

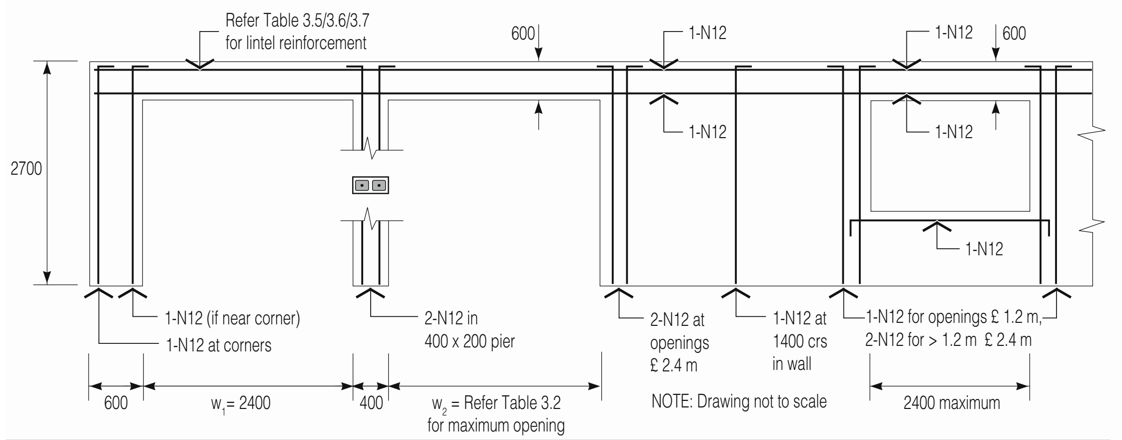


Figure 2.14 *Wall Reinforcement for 190-mm Leaf for Wind Classifications N5 and C2 and 2700-mm Wall Height*

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 14)	**Table 3.1** (page 14)	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 (page 14)	**Table 3.2** (page 14)	Where there is a pier between two openings, determine the size and reinforcement required in the pier by adding the opening widths together and referring to **Table 3.2**.

1.3 Reinforcement beside openings

DETAILING	DESIGN	COMMENTARY
Table 3.3 (page 15)	**Table 3.3** (page 15)	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.

1.4 Maximum reinforcement spacing adjacent to openings

DETAILING	DESIGN	COMMENTARY
Table 3.4 (page 15)	**Table 3.4** (page 15)	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.

1.5 Reinforcement at girder trusses

DETAILING	DESIGN	COMMENTARY
–	–	Place a vertical bar within 100 mm of all girder trusses.

Step 2 Reinforcement and Details of Lintels

2.1 Lintels supporting roofs

DETAILING	DESIGN	COMMENTARY
Figure 1.6 (page 6)	**Table 3.5** (page 16) **Table 3.6** (page 17) **Table 3.7** (page 18)	For standard trusses, the maximum amount of roof that can be carried is given in **Table 3.5** (metal 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 standard trusses, that can be carried by the lintel.

2.2 Lintels supporting floors

DETAILING	DESIGN	COMMENTARY
Table 3.8 (page 18)	**Table 3.8** (page 18)	The maximum amount of supported floor width to be carried by a lintel is given in **Table 3.8**.

Step 3 Reinforcement and Details of Bond Beams

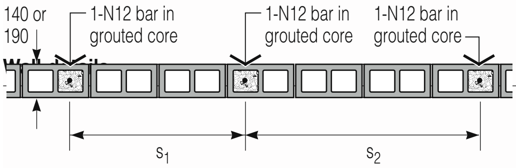
3.1 Bond beams supporting roofs

DETAILING	DESIGN	COMMENTARY
Figure 1.3 (page 5)	**Table 3.9** (page 18)	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 girder truss lands on the bond beam, a tie-down rod must be placed within 100 mm of the truss.

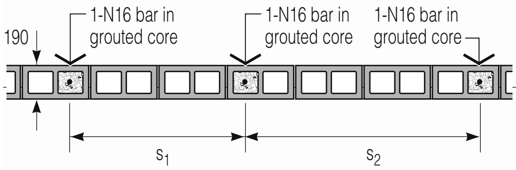
3.2 Bond beams supporting floors

DETAILING	DESIGN	COMMENTARY
Figure 1.4 (page 5)	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*

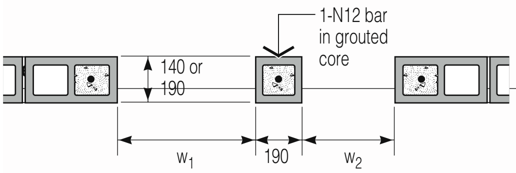


Wind Class.	140-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6
	Maximum sum of adjacent bar spacing, $s_1 + s_2$ (m)									
N2	4.0	4.0	4.0	4.0	3.8	4.0	4.0	4.0	4.0	4.0
N3	4.0	4.0	3.5	2.9	2.5	4.0	4.0	4.0	4.0	3.5
N4	3.7	2.9	2.4	2.0	1.7	4.0	4.0	3.4	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	–	–	–	–

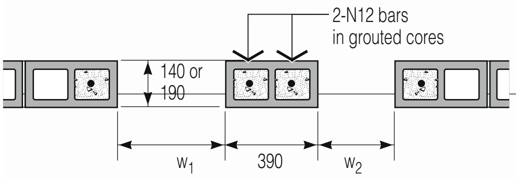


Wind Class.	140-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6
N2	–	–	–	–	–	4.0	4.0	4.0	4.0	4.0
N3	–	–	–	–	–	4.0	4.0	4.0	4.0	4.0
N4	–	–	–	–	–	4.0	4.0	4.0	4.0	3.8
N5	–	–	–	–	–	3.9	3.4	3.1	2.8	2.6
N6	–	–	–	–	–	2.9	2.5	2.3	2.1	1.9
C1	–	–	–	–	–	4.0	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

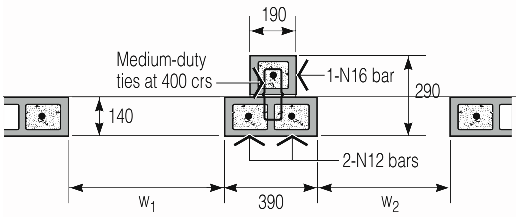
Table 3.2 *Selection and Detailing of Pier Reinforcement*



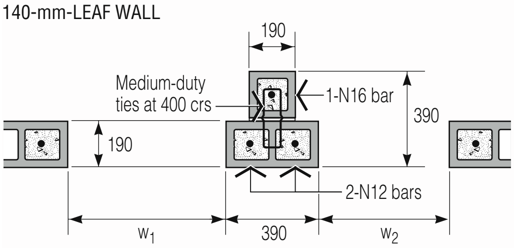
Wind Class.	140-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6	190-mm-leaf wall, Wall height (m) 2.4	2.7	3.0	3.3	3.6
	Maximum allowable sum of openings, $w_1 + w_2$ (m)									
N2	5.7	4.5	3.7	3.0	2.5	10.5	8.3	6.7	5.6	4.7
N3	3.7	2.9	2.3	–	–	6.7	5.3	4.3	3.6	3.0
N4	2.5	–	–	–	–	4.5	3.6	2.9	2.4	2.0
N5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

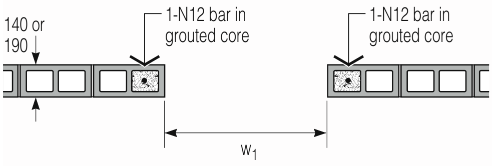
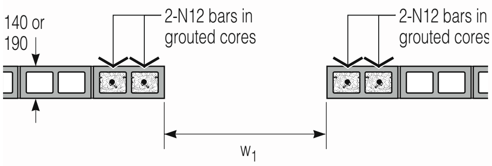
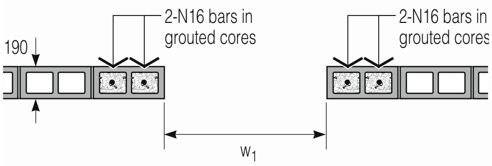
Opening details	Wind Class.	Maximum allowable opening size, w_1 (m)									
		140-mm-leaf wall					190-mm-leaf wall				
		Wall height (m)					Wall height (m)				
		2.4	2.7	3.0	3.3	3.6	2.4	2.7	3.0	3.3	3.6
	N2	5.4	5.4	4.6	3.7	3.0	5.4	5.4	5.4	5.4	4.6
	N3	4.6	3.5	2.8	2.2	1.7	5.4	5.3	4.2	3.4	2.7
	N4	2.9	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*

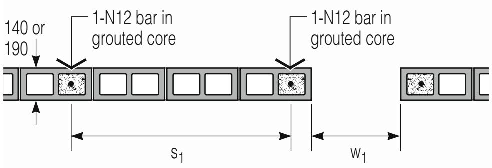
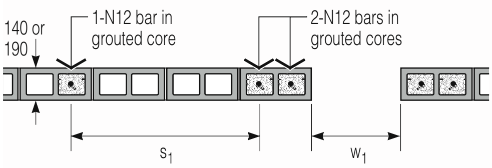
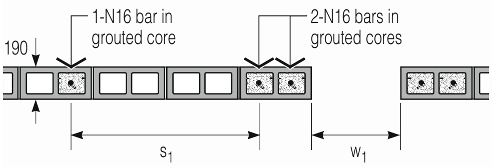
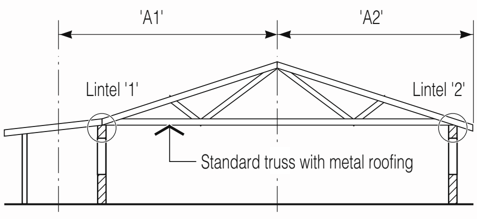
Wall and opening details	Wind Class.	Maximum adjacent bar spacing plus opening, $s_1 + w_1$(m)									
		140-mm-leaf wall					190-mm-leaf wall				
		Wall height (m)					Wall height (m)				
		2.4	2.7	3.0	3.3	3.6	2.4	2.7	3.0	3.3	3.6
	N2	7.4	6.2	5.0	4.1	3.4	7.4	7.4	7.2	5.9	5.0
	N3	5.0	3.9	3.2	2.6	2.1	7.3	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*

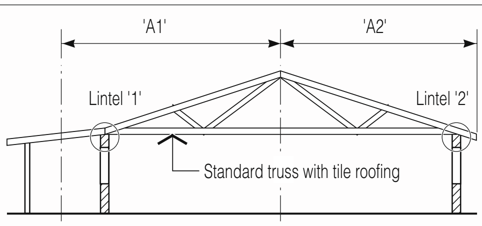
		Maximum allowable value of dimension 'A' (m)																	
		140-mm-wide lintels									**190-mm-wide lintels**								
Wind	**Opening**	**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**			**Type A(1) with:**			**Type B(1) with:**			**Type C(1) with:**		
class.	(m)	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20	N12	N16	N20
N1	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	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
N2	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	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
and	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
C1	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	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
and	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
C2	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 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	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
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 and C1	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
	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
	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 and C2	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
	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
	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

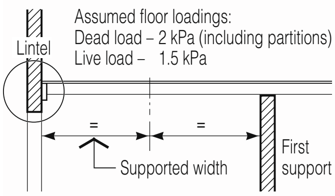
Table 3.7 *Selection of Lintels Supporting Girder Roof Trusses*

Wind class.	Opening (m)	Maximum supported roof area, including standard trusses (m^2) – 140-mm-wide lintels: Type B[1] with: N16	Type B[1] with: N20	Type C[1] with: N16	Type C[1] with: N20	190-mm-wide lintels: Type B[1] with: N16	Type B[1] with: N20	Type C[1] with: N16	Type C[1] with: 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 6) for details

Table 3.8 *Selection of Lintels Supporting a Timber Floor*

Determination of supported width

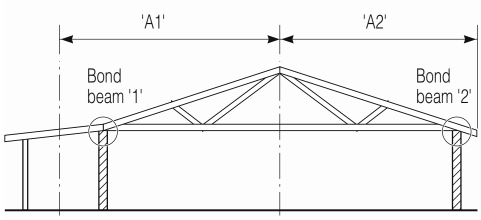


Opening (m)	Maximum supported width (m) – 140-mm-wide lintels: Type BB[1] with: N16	Type BB[1] with: N20	Type CC[1] with: N16	Type CC[1] with: N20	190-mm-wide lintels: Type BB[1] with: N16	Type BB[1] with: N20	Type CC[1] with: N16	Type CC[1] with: N20
0.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1.2	3.0	3.0	3.0	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 1.6 (page 6) for details

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

Determination of dimension 'A'



Wind Class.	Maximum allowable value of dimension 'A' (m) – 140-mm-leaf wall: Bond beams[1] Type 1	Type 2	Type 3	190-mm leaf-wall: Bond beams[1] 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 5) 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 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 (i.e. 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 1684.

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 and C1	4	5.9	6.6	7.4	7.5	6.4	5.1	4.4	4.2
	6	8.9	9.0	9.0	9.0	8.8	6.7	5.6	5.1
	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 and C2	4	3.9	4.3	4.9	5.0	4.3	3.4	2.9	2.8
	6	5.9	6.6	7.3	7.4	5.8	4.4	3.7	3.4
	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 and C3	4	2.7	3.0	3.4	3.5	3.0	2.3	2.0	1.9
	6	4.1	4.6	5.1	5.1	4.1	3.1	2.6	2.4
	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.

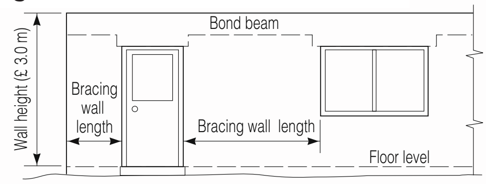
Table 4.2 *Bracing Capacity (kN) of Typical Bracing Walls(1) up to 3.0-m High*

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

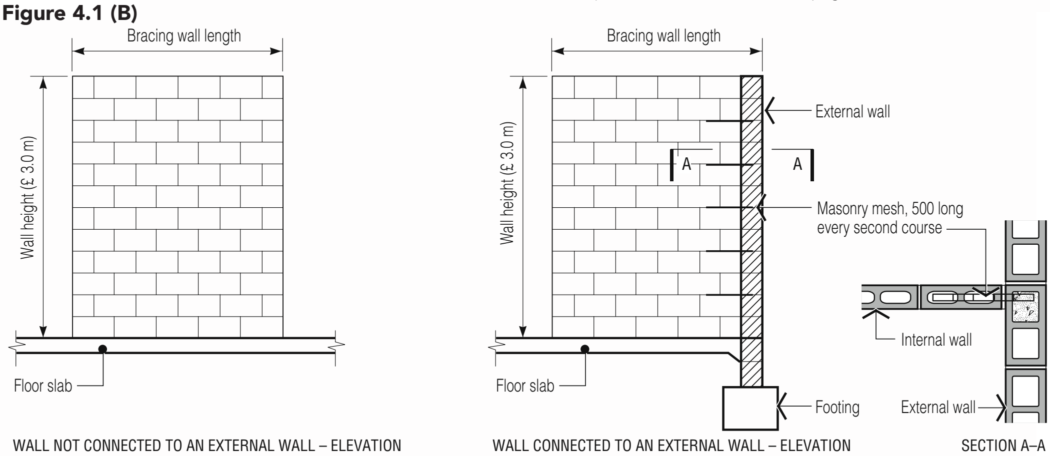
These values have been calculated in accordance with AS 3700, and are consistent with AS 3700 Table 12.11. AS 4773.1 has different (more conservative) values, shown on the next page.

Figure 4.1 (A)



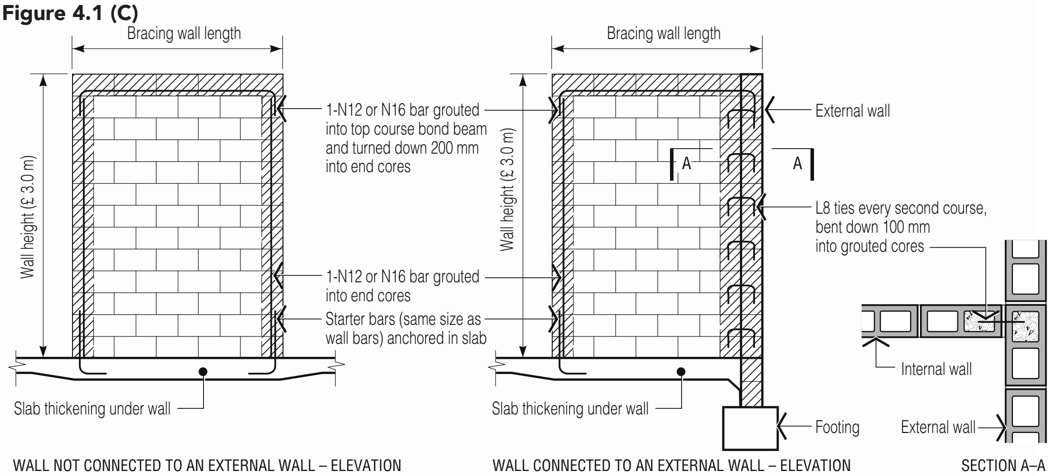
BRACING LENGTH FOR EXTERNAL REINFORCED WALLS

Figure 4.1 (B)



INTERNAL WALLS WITHOUT TIE-DOWNS (UNREINFORCED)

Figure 4.1 (C)



INTERNAL WALLS WITH TIE-DOWNS

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

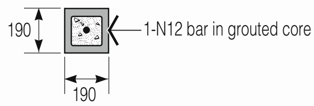
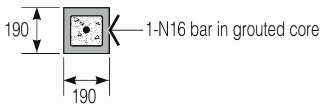
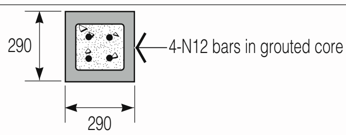
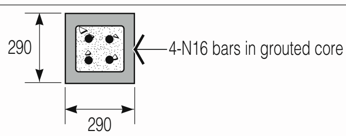
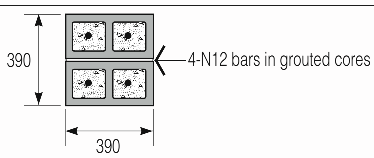
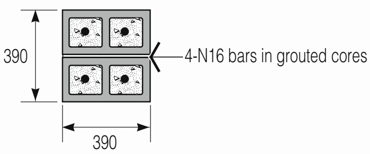
Wall length (m)	Walls reinforced with tie-downs (2) N12 tie-downs Bracing capacity, kN		N16 tie-downs	
	90	110	140	190
0.4	2.4	2.6	3.8	4.1
0.6	4.3	4.5	7.0	7.3
0.8	6.2	6.5	10.0	11.0
1.0	8.3	8.7	14.0	14.0
1.2	10.0	11.0	17.0	18.0
1.8	17.0	18.0	28.0	29.0
2.4	25.0	27.0	39.0	41.0
3.0	33.0	36.0	51.0	55.0
4.0	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 1684, 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

5. Connection Details

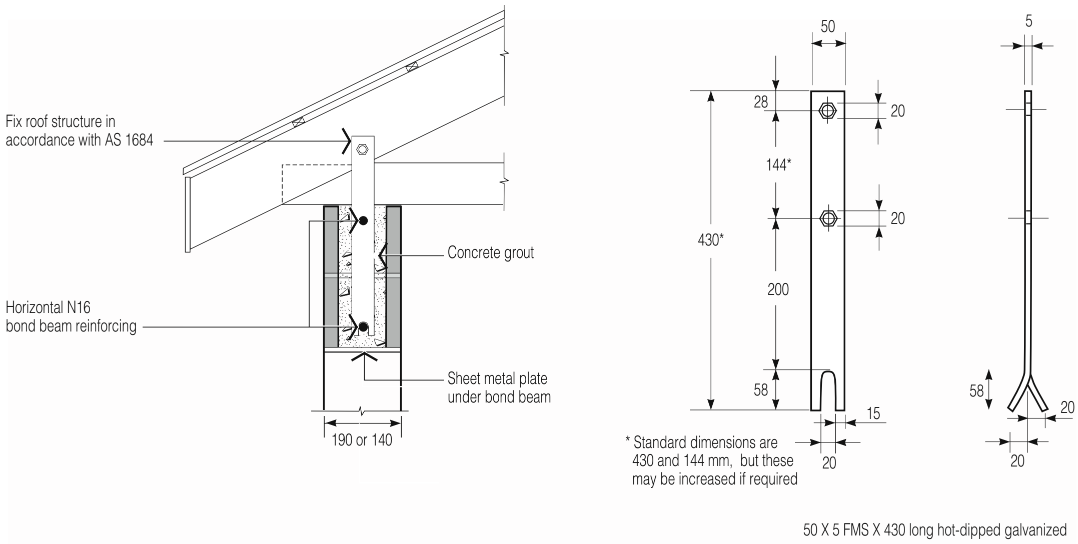
5.1 Truss Tie-Down

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.

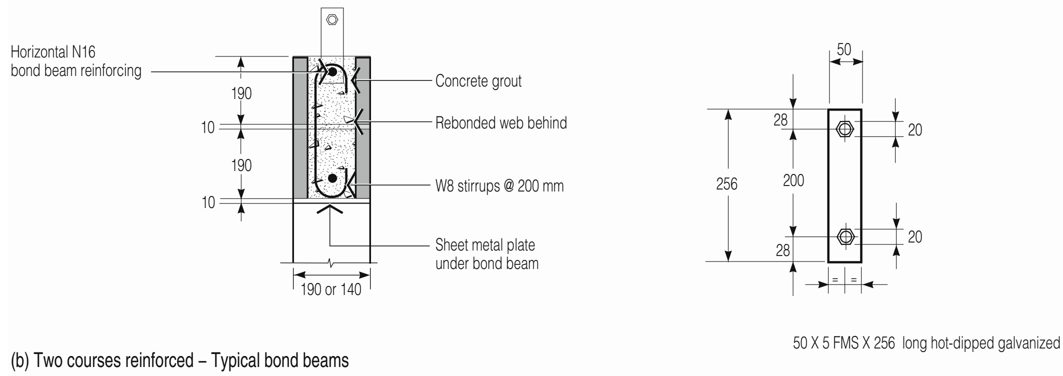
Table 5.1 *Anchorage Capacities in Single Leaf Reinforced Concrete Masonry Walls*

	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

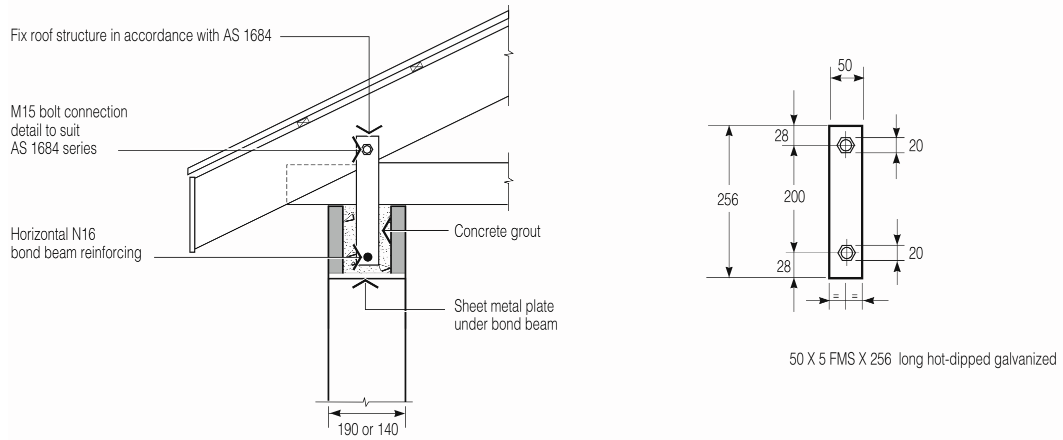
These tables have been calculated by the Concrete Masonry Association of Australia from the results of sponsored tests, viz. Cyclone Testing Station School of Engineering James Cook University Report No TS 636 June 2006 Strength Limit State Uplift Load Design Capacities of Bond Beam Truss Hold Down Connections.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



(a) Long fishtall cleats deep anchorage



(b) Two courses reinforced – Typical bond beams



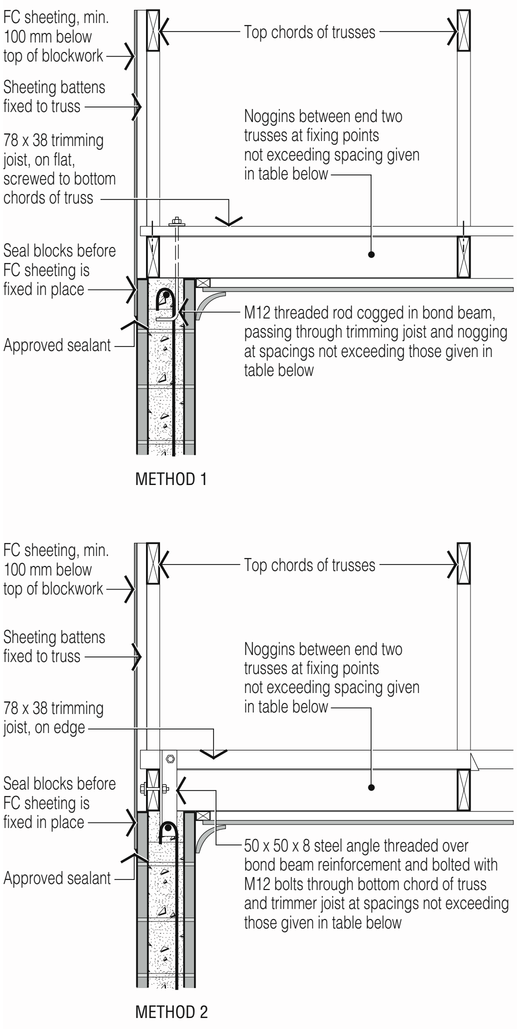
(c) Single height bond beams

Figure 5.1 *Anchorage details for reinforced concrete bond beams*

5.2 Fixing to Gable Ends

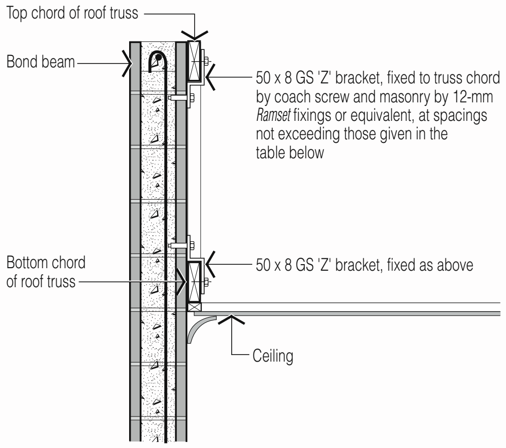
Gable walls must be supported by the roof diaphragm by anchoring of end roof trusses at regular centres. The attached end truss must then be braced back to internal trusses with trimming joists. Typical details and design capacities are given in the following Figures:

- 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.

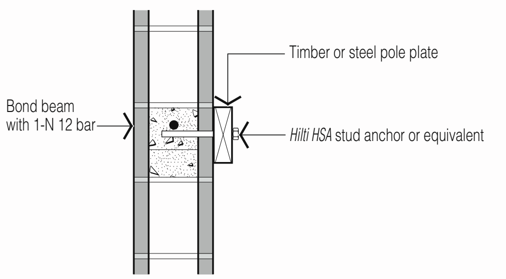


Figure 5.4 *Pole Plate Fixing for Timber Floor*

6. Integrated reinforced masonry and footing systems

6.1 Deemed to Comply Construction For Stiffened Rafts - Concrete Masonry Requirement - AS2870 Section 3

The beam sizes of Figure 6.1 and Table 6.2 provide adequate stiffness to ensure that non-structural wall systems placed on the slab are not subjected to excessive deflection; however, in AS 2870, Clause 3.2.5 permits a reduction in these beam sizes to 300mm × 300mm with 3-L11TM reinforcement, if reinforced hollow concrete blockwork walls are structurally connected to the beams and act with them to resist movement.

In this case the walls must be 190mm single-leaf hollow concrete blockwork, reinforced with at least N12 bars at not more than 2.0m centres, tied into the footings with starter bars and incorporate a continuous bond beam with at least two N12 bars around the top of the wall, see Figure 6.2. The walls should be adequately waterproofed.

This construction behaves as a ‘stiff box’. Articulation of the bond beams should not be included since it destroys the continuity. When using this detail, care must be taken to ensure the adequacy and continuity of internal beams, particularly at re-entrant corners where internal beams are deeper than the external beams. Figure 6.3 shows a typical section and detail at a re-entrant corner, more information can be found in AS2870 Section C3.

Method

1. Using Table 6.4 (AS 2870 Section 2 for more information), determine the site classification.
2. Using Table 6.1, determine the equivalent construction.
3. Using Table 6.2, determine the required width and depth of internal beams or footings, their maximum spacing and the required slab reinforcement.
4. Using Table 6.2 design the external beams. Alternatively, where a reinforced single leaf masonry wall is constructed directly above and structurally connected to a concrete edge beam, the edge beam may be reduced to 300mm x 300mm with 3-L8TM reinforcement. Detail the connection as per Figure 6.1 and Figure 6.2.
5. Detail the structure in accordance with AS 2870, Section 5.

Notes:

1. Internal and external beams must be arranged to form an integral structural grid (see Clause 5.3.8 and 5.3.9 in AS2870).
2. For external beams wider than 300mm an extra bottom bar or equivalent reinforcement is required for each 100mm additional width.
3. A 10% increase in spacing is permitted where the spacing in the other direction is 20% less than the allowed distance.

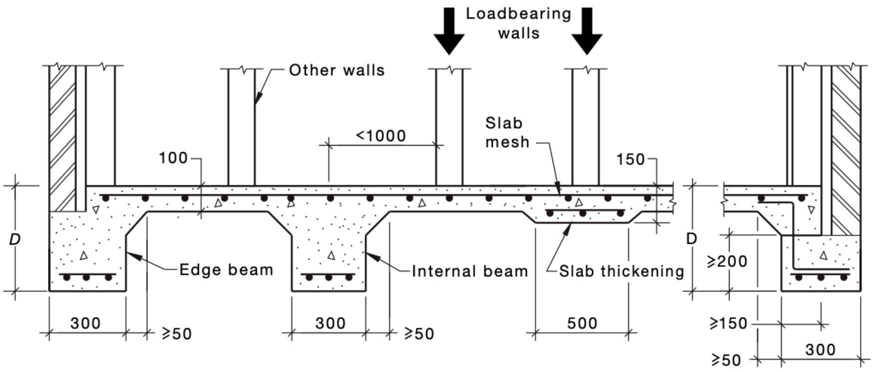
6.2 Designed by Engineering Principals using AS2870 Section 4

If the designer wishes to achieve more economical designs for houses with reinforced superstructures than in the methods mentioned previous, the following design methodology can be taken instead.

Method

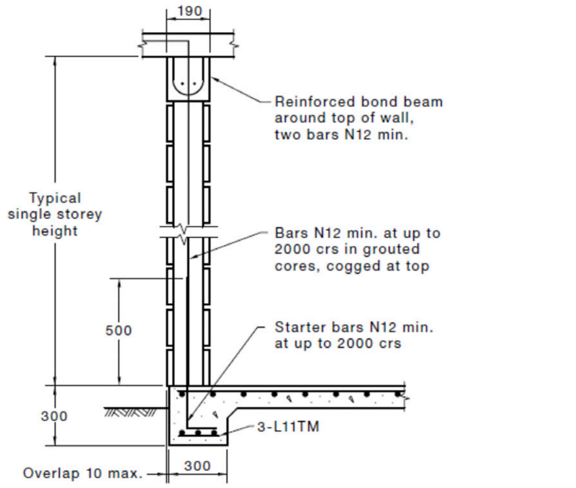
1. Using Table 6.3 determine the characteristic surface movement y_s for the soil.
2. Determine the required house geometry and specifically the wall layout.
3. Determine the moment capacity, shear capacity, bending stiffness and shear stiffness of various combinations of the following:
   a. Walls + Slab + Beams at continuous walls.
   b. Walls + Slab at continuous walls (without beams).
   c. Walls + Slab + beams with openings.
   d. Walls + Slab with openings (without beams).
   e. Beams + Slabs (no walls).
   f. Slabs (no beams or walls).
4. Using Figure 6.4 determine the edge distance over which the soil shrinkage or expansion will occur.
5. Enter relevant data such as: structure geometry, capacities, and edge distances into a grillage program with spring supports (to imitate a compressible soil mound). To simulate the shrinkage or expansion of the soil at the rim, use vertical supports that can shorten and lengthen around the edge. Alternatively, a simpler solution can be achieved by assuming that parts of the structure cantilever or span distances corresponding to the calculated edge distances.
6. Perform an analysis to calculate moments, shears and deflections. Theses calculations should be done for both a shrinking soil and for an expanding soil.
7. Check the shear and moment capacities of each combination (mentioned in Step 3) to span without cracking, particularly at door and window openings (Table 6.5).
8. Check the deflections at all openings and other strategic points to ensure that doors and windows can still open without causing cladding to crack (Table 6.5, refer back to AS2870 for serviceability requirements).
9. Detail the structure in accordance with AS 2870, Section 5.

Figure 6.1 - Stiffened Raft Designs



Taken from AS2870 - Figure 3.1

Figure 6.2 - Typical Detailing for Footing and Single-leaf Reinforced Masonry Wall Combinations

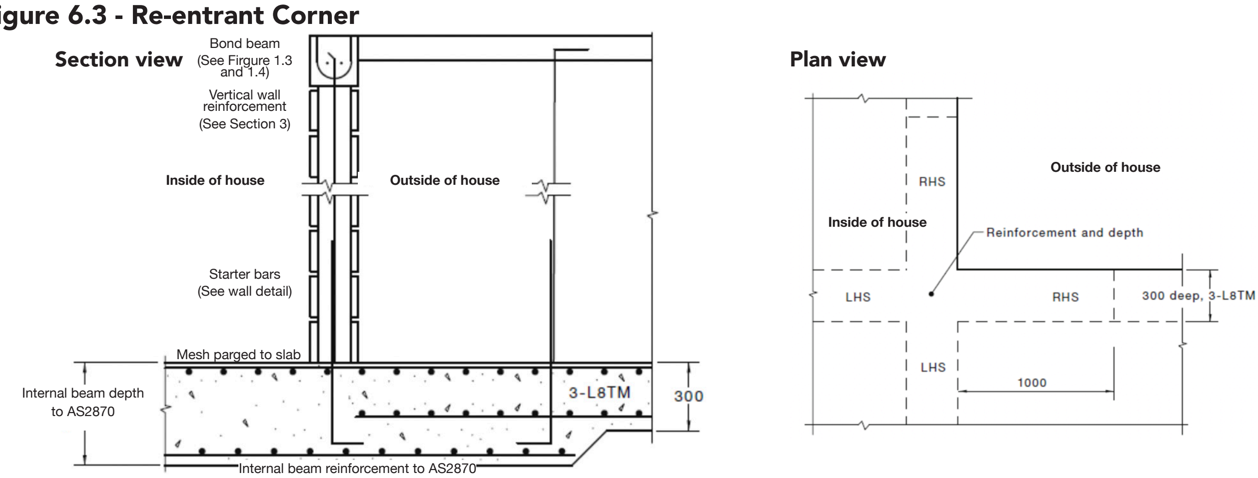


NOTE: Waterproofing is required to exterior face walls constructed and reinforced in accordance with AS 3700. Footings are suitable for openings up to 1800 mm. For wider openings, use established concrete and reinforced concrete masonry analysis methods to determine the required footing sizes.

DIMENSIONS IN MILLIMETRES

Taken from AS2870 - Figure C3.3

Figure 6.3 - Re-entrant Corner



Taken from AS2870 - Figure C3.4

Figure 6.4 - Soil Structure Interaction Analysis for Stiffened Rafts - Taken from AS2870 Appendix F4

This process has been adapted from Appendix F4 from AS2870:

1. Find the design value of differential mound movement (y_m).

   $\mathbf{y_m = 0.7\ y_s}$

   Assuming the Walsh Method.

2. Find the edge distance for centre heave (e_c)

   $\mathbf{e_c = H_s / 8 + y_m / 36}$

   Note: y_m is in millimetres

3. Find the edge distance for edge heave (e_e)

   $\mathbf{e_e = 0.2\ L < 0.6 + y_m / 25}$

Where the depth of design suction charge (H_s) can be determined by the following table taken from AS2870 Table 2.4:

Soil Suction Change of Profiles for Certain Locations

Location	Change in suction at the soil surface (Δu) pF	Depth of design soil suction change (H_s) m
Adelaide	1.2	4.0
Albury/Wodonga	1.2	3.0
Brisbane/Ipswich	1.2	1.5–2.3 (see Note)
Gosford	1.2	1.5–1.8 (see Note)
Hobart	1.2	2.3–3.0 (see Note)
Hunter Valley	1.2	1.8–3.0 (see Note)
Launceston	1.2	2.3–3.0 (see Note)
Melbourne	1.2	1.8–2.3 (see Note)
Newcastle	1.2	1.5–1.8 (see Note)
Perth	1.2	1.8
Sydney	1.2	1.5–1.8 (see Note)
Toowoomba	1.2	1.8–2.3 (see Note)

NOTE: The variation in H_s depends largely on climatic variation.

Table taken from AS2870

Some typical edge distances for slabs determined using H_s = 1.5m and a linear soil profile is:

SITE CLASSIFICATION	DESIGN SURFACE MOVEMENT, y_s mm	DESIGN EDGE DISTANCE FOR CENTRE HEAVE, e_c m	DESIGN EDGE DISTANCE FOR EDGE HEAVE, e_e m
S	0 to 20 (10)	0.5	1.0
M	20 to 40 (30)	1.0	1.5
H	40 to 60 (55)	1.5	1.5

Table 6.1 - Equivalent Types of Constructions

Actual construction		Equivalent construction
External walls	**Internal walls**	
Single–leaf masonry		
Reinforced single-leaf masonry	Articulated masonry on Class A and Class S sites, or framed	Articulated masonry veneer
Reinforced single-leaf masonry	Articulated masonry or reinforced single–leaf masonry	Masonry veneer
Reinforced single-leaf masonry	Masonry	Articulated full masonry
Articulated single-leaf masonry	Articulated masonry	Articulated full masonry
Articulated single-leaf masonry	Masonry	Articulated full masonry
Other single-leaf masonry	Framed	Articulated full masonry
Other single-leaf masonry	Masonry	Full masonry
Mixed construction		
Full masonry	Framed	Articulated full masonry
Articulated full masonry	Framed	Masonry veneer
Articulated rendered or sheet clad frame	Framed	Articulated masonry veneer
Precast concrete panels		
Reinforced concrete panel	Framed	Articulated masonry veneer
Earth wall construction		
Infill panels of earth wall construction	Framed earth wall construction	Articulated masonry veneer
Loadbearing earth wall construction	Load bearing earth wall construction	Articulated full masonry

Taken from AS2870 - Table 3.1

Table 6.2 - Classification by Characteristic Surface Movement (y_s)

Site class	Type of construction	Edge and internal beams				
		Depth (*D*) mm	Bottom reinforcement		Top bar reinforce-ment	Max beam spacing cc m
			Mesh	Bar alternative		
Class A	Clad frame	300	3-L8TM	2N12	—	—
	Articulated masonry veneer	300	3-L8TM	2N12	—	—
	Masonry veneer	300	3-L8TM	2N12	—	—
	Articulated full masonry	400	3-L8TM	2N12	—	—
	Full masonry	500	3-L8TM	2N12	—	—
Class S	Clad frame	300	3-L8TM	2N12	—	—
	Articulated masonry veneer	300	3-L8TM	2N12	—	—
	Masonry veneer	300	3-L11TM	3N12	—	—
	Articulated full masonry	500	3-L11TM	3N12	2N12	—
	Full masonry	700	2x3-L11TM	3N16	2N16	5
Class M	Clad frame	300	3-L11TM	3N12	—	6
	Articulated masonry veneer	400	3-L11TM	3N12	—	6
	Masonry veneer	400	3-L11TM	3N12	—	5
	Articulated full masonry	625	3-L11TM	3N12	2N12	4
	Full masonry	950	2x3-L11TM	3N16	2N16	4
Class M-D	Clad frame	400	3-L11TM	3N12	—	5
	Articulated masonry veneer	400	3-L11TM	3N12	1N12	4
	Masonry veneer	500	3-L12TM	3N12	2N12	4
	Articulated full masonry	650	3-L12TM	2N16	2N16	4
	Full masonry	1050	2x3-L11TM	3N16	3N16	4
Class H1	Clad frame	400	3-L11TM	3N12	—	5
	Articulated masonry veneer	400	3-L11TM	3N12	1N12	4
	Masonry veneer	500	3-L11TM	3N12	3N12	4
	Articulated full masonry	750	2x3-L11TM	3N16	2N16	4
	Full masonry	1050	2x3-L12TM	3N16	3N16	4
Class H1-D	Clad frame	400	3-L11TM	3N12	1N12	4
	Articulated masonry veneer	500	3-L11TM	3N12	2N12	4
	Masonry veneer	650	2x3-L11TM	3N16	1N16	4
	Articulated full masonry	800	2x3-L11TM	3N16	2N16	4
	Full masonry	1100	2x3-L12TM	3N16	3N16	4
Class H2	Clad frame	550	3-L11TM	3N12	2N12	4
	Articulated masonry veneer	600	3-L12TM	3N12	2N12	4
	Masonry veneer	750	2x3-L11TM	3N16	2N16	4
	Articulated full masonry	1000	2x3-L11TM	3N16	2N16	4
	Full masonry	—	—	—	—	—
Class H2-D	Clad frame	550	2x3-L11TM	3N16	2N16	4
	Articulated masonry veneer	700	2x3-L11TM	3N16	2N16	4
	Masonry veneer	750	2x3-L11TM	3N16	2N16	4
	Articulated full masonry	1000	2x3-L11TM	3N16	2N16	4
	Full masonry	—	—	—	—	—

Taken from AS2870 - Figure 3.1

Table 6.3 - Classification by Characteristic Surface Movement (y_s)

Characteristic surface movement (y_s) mm	Site classification in accordance with Table 6.4
$0 < y_s \leq 20$	S
$20 < y_s \leq 40$	M
$40 < y_s \leq 60$	H1
$60 < y_s \leq 75$	H2
$y_s > 75$	E

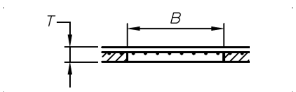
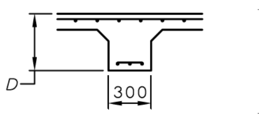
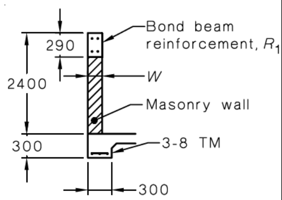
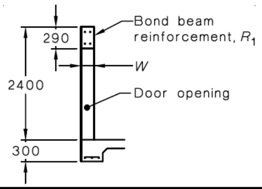
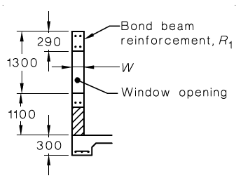
Taken from AS2870 - Table 2.3

Table 6.4 - Classification Based on Site Reactivity

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Taken from AS2870 - Table 2.1

Table 6.5 - Section Properties

Description	Variables	Area A (m^2)	Moment of inertia I (m^4)	Footing condition H=hogging S=sagging	Shear capacity V_{cap} (kN)	Moment capacity M_{cap} (kN)
Concrete slab 	T = 100 mm B = 1000 mm	0.100	0.000045	—	—	—
Concrete beam 	D = 300 mm	0.090	0.000226	H S	38 27	36 14
	D = 400 mm	0.120	0.000601	H S	44 38	50 36
	D = 500 mm	0.150	0.001270	H S	47 41	63 46
	D = 600 mm	0.180	0.002300	H S	48 45	77 67
	D = 700 mm	0.210	0.003740	H S	48 55	91 141
Reinforced masonry with no openings, plus 300 x 300 beam 	W = 190 mm R_1 = 4-N12 R_1 = 4-N16	0.545	0.150000	H and S H and S	125 142	210 372
	W = 140 mm R_1 = 2-N12 R_1 = 2-N16	0.426	0.111000	H and S H and S	97 108	105 187
Reinforced masonry with door openings, plus 300 x 300 beam 	W = 190 mm R_1 = 4-N12 R_1 = 4-N16	0.145	0.000285	H and S H and S	39 41	296 529
	W = 140 mm R_1 = 2-N12 R_1 = 2-N16	0.131	0.000270	H and S H and S	35 36	148 265
Reinforced masonry with window openings, plus 300 x 300 beam 	W = 190 mm R_1 = 4-N12 R_1 = 4-N16	0.354	0.021400	H and S H and S	57 59	296 539
	W = 140 mm R_1 = 2-N12 R_1 = 2-N16	0.285	0.015800	H and S H and S	45 46	148 269

7. Basement Walls

7.1 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 7.1, with concrete floor
- Figure 7.2, with timber floor.

7.2 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.

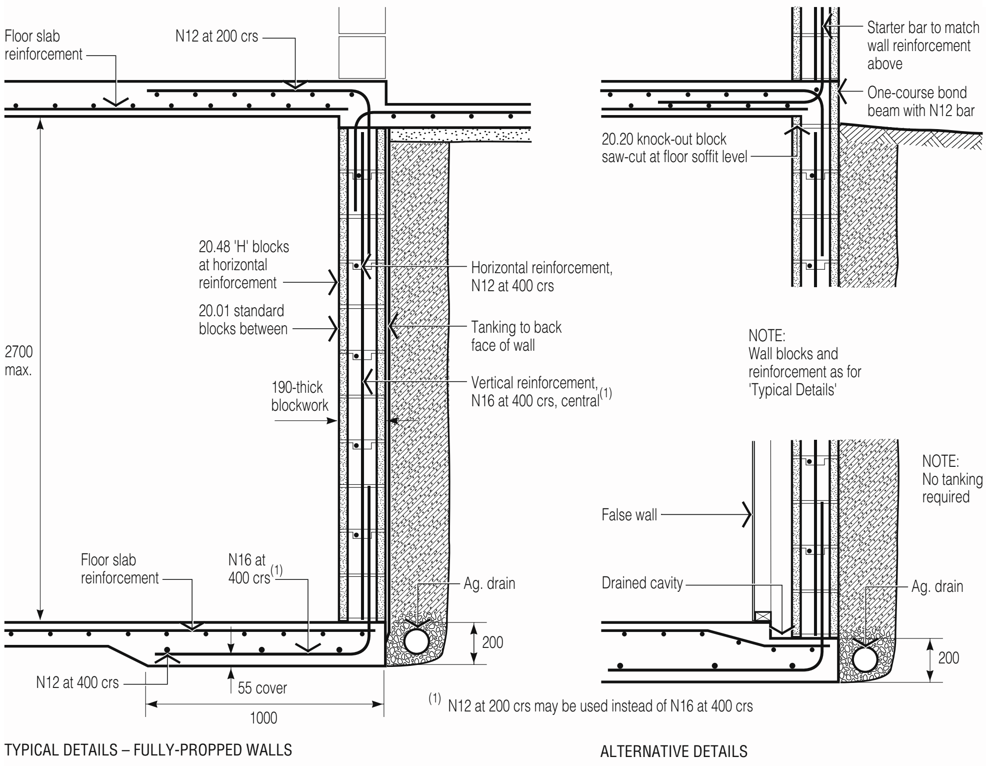


Figure 7.1 *Typical Basement Wall Supporting a Concrete Floor*

7.3 Taking

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 7.1 and 7.2).

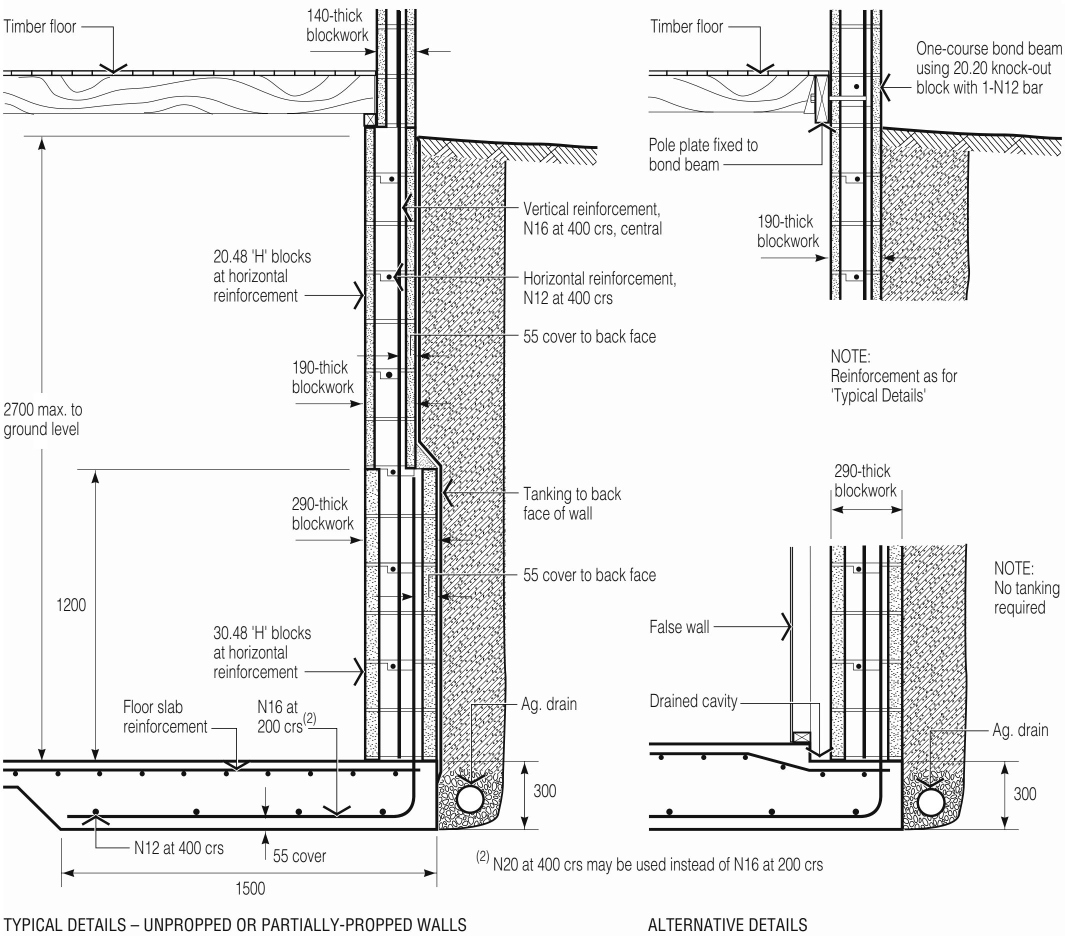


Figure 7.2 *Typical Basement Wall Supporting a Timber Floor*

8. Weatherproofing Recommendations for Housing

8.1 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.

8.2 Weatherproofing Application

A weatherproof paint system, complying with the National Construction Code, 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:

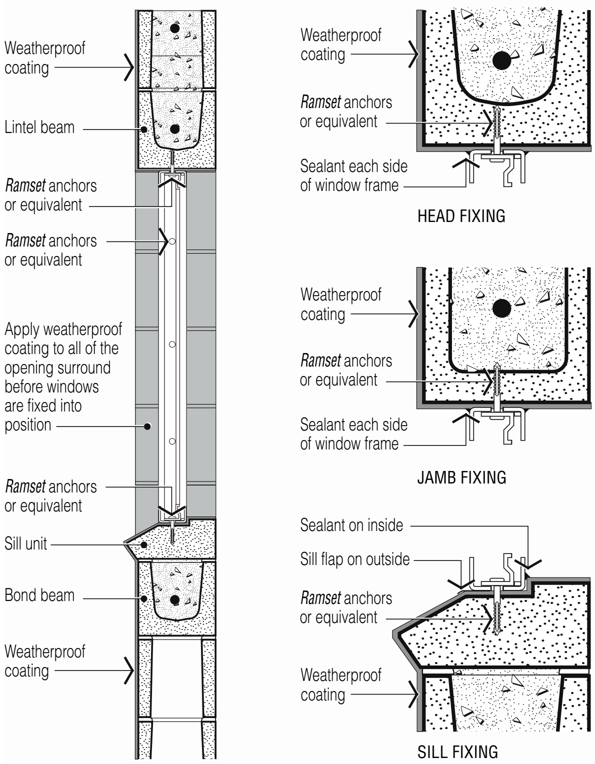
- Three coats of 100% acrylic-based exterior paint. The first coat must be worked thoroughly into the masonry surface by brush to ensure complete coverage of all voids.
- A three-coat system, where the first coat is waterproof cement-based paint worked into the surface, and then two coats of 100% acrylic-based 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.

8.3 Window Installation

Post fitting of windows is recommended in accordance with Figure 8.1.



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 8.1 *Installation of Windows*

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