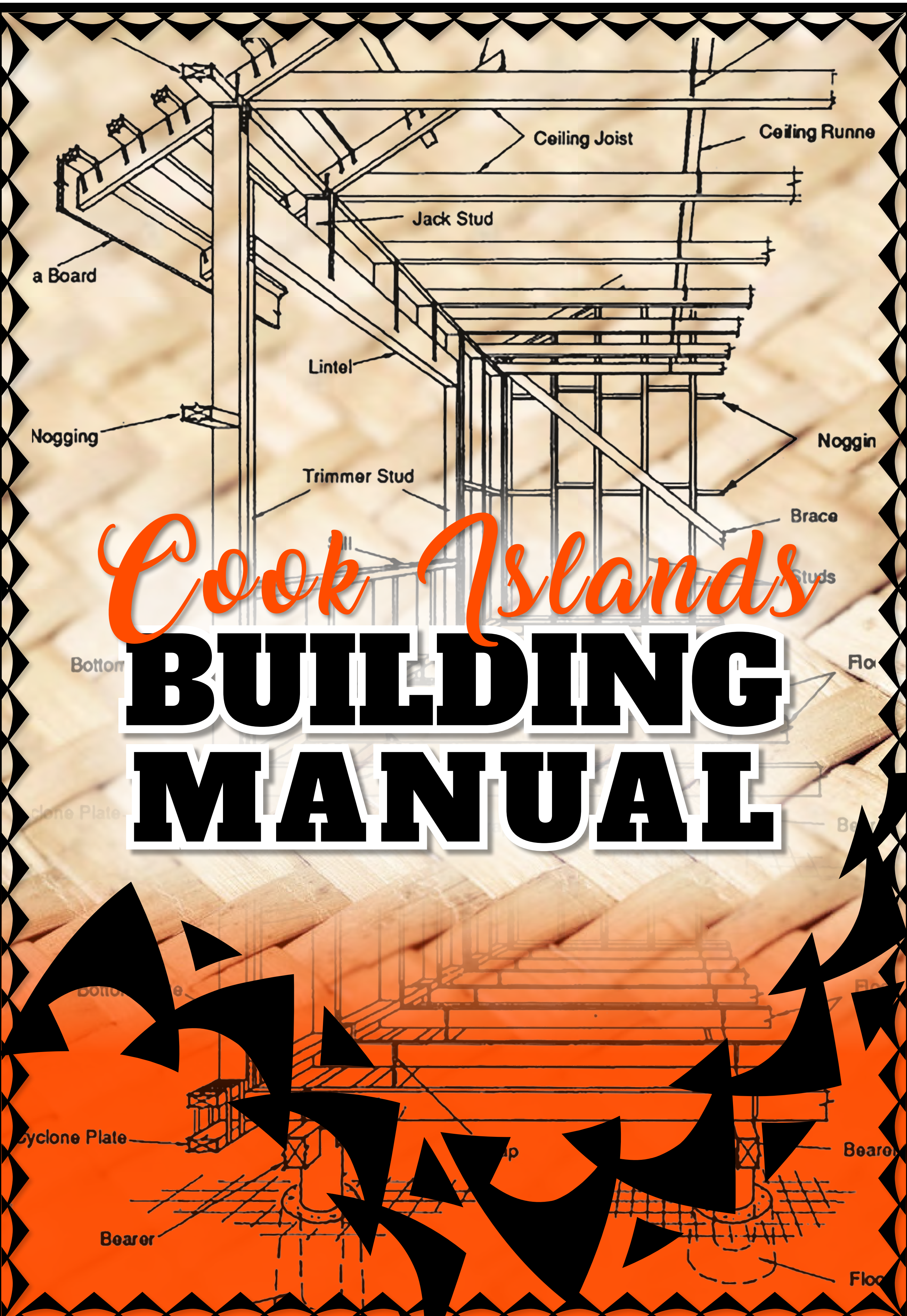
Cook Islands BUILDING MANUAL



Cook Islands BUILDING MANUAL

COOK ISLANDS
RAROTONGA 2019

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Preface

The introduction of the 1991 Building Code (the Code) and its accompanying Building Manual (the Manual), which this Manual replaces, were a major step forward for the Cook Islands. They empowered the Cook Islands Government through its agencies to ensure buildings comply with prescribed standards. This is significantly important for ensuring the safety of buildings as well as protecting the investment of those constructing them. The 1991 Code and Manual were however, one size fits all documents, prepared in Fiji for a number of Pacific Island Countries (Cook Islands Included), with the only difference between the Code and Manuals from country to country being the name of the country concerned.

In its years of operation, unfortunately however, the Code and also the Manual were largely unknown and inoperative in the Pa Enua, partially due to the lack of building inspectors outside Rarotonga and Aitutaki, which necessitated a wide exemption for residential buildings and partially due to the limited availability of the documents across the Pa Enua. Compliance in respect of Pa Enua residential buildings therefore was voluntary and limited except where compliance was a lending requirement for bank mortgages. The experience of Cyclone Pat in Aitutaki, 2010 clearly illustrated the importance of compliance, as complying houses were only damaged by debris from noncomplying houses.

The increasing frequency and strength of extreme weather events is now a fact of life in the Cook Islands and noncomplying buildings are a hazard. During the period since 1991 not only have new building materials using new technology been developed but also new sources of supply of these materials have come on stream.

The Code and Manual have now been extensively revised in close consultation with traditional leaders; communities; government agencies, including island governments and representatives of the Northern and Southern Group islands, the private sector, including consultant engineers, construction companies, builders, the tourism sector and building suppliers. There was a strong commitment to revising the Code and Manual to fit the Cook Island circumstances and to be fully applicable in the Pa Enua, without significant increases in the cost of building.

With regards to cyclone strengthening, the Code and therefore the Manual secures against cyclone intensity 3. This protection can be increased to cyclone intensity 4 at minimal cost by utilising tie-down procedures developed by the Cook Islands Red Cross. These procedures have accordingly been incorporated into the Code and Manual and the invaluable contribution of the Cook Islands Red Cross to cyclone safety is hereby acknowledged. An effort has also been made to establish ways of continuing to ensure the safety of building materials, with provision for exemptions for local produced timber, particularly in the Pa Enua.

The cost of Code compliance in respect to residential buildings will continue to be minimised by the use of this Manual. A residential building constructed in accordance with this Manual will fully comply with the Code and with tie-downs should withstand an intensity 4 cyclone. The extent and proactive nature of the consultation has enabled the production of a revised set of documents fit for purpose for the Cook Island, with this user-friendly Manual available throughout the Cook Islands to guide and instruct builders in the construction of houses and ensure Code compliance at minimal additional cost.

A manual such as this can only be useful within certain stated limitations. This one is no exception. However within these limitations it should be possible to use the Manual for the construction of safe, architecturally pleasing houses to reasonable levels of individual requirements.

Acknowledgment

The revision of the Cook Islands Building Code and Manual has been carried out under the auspices of Infrastructure Cook Islands (ICI), Minister responsible for Infrastructure Cook Islands, Secretary, Building Controller, senior staff of ICI. The work has been facilitated and Project Managed by several VSA (Volunteer Services Abroad) consultants.

The Wellington, New Zealand, office of BECA International Consultants Ltd as the contractor successful for this project has undertaken the revision of both the Code and the Manual and assisted with the consultation process. Independent consultant Graham Powell of Australia and New Zealand undertook a parallel review of the Act and its Regulations.

The consultation process was strongly supported by other government department officials, the communities and their leaders on all the islands in the Pa Enua, and a number of non-government agencies and organisations. The need for a revision was also discussed and supported by Members of the House of Ariki. Both the Cook Islands Building Code and Cook Islands Building Manual were endorsed by Cabinet and approved for the review of the Building Act 1990.

The Government of the Cook Islands is humbly grateful for the funding of the review provided to Emergency Management Cook Islands by the following donors partners; Secretariat of Pacific Communities, European Union, ACP-EU Building Safety and Resilience in the Pacific.

Introduction

OBJECTIVE

The Manual is intended for the use of para-professionals and professionals in the building industry for the speedy design of simple houses which conforms to the structural requirements of the National Building Code. Approval authorities may use the Manual for the confirmation of the adequacy of the structural details given in the proposals submitted to them. The use of the Manual is subject to the limitations stated in Clauses AI and CI and C2.

WHAT IS IN THE MANUAL?

The Manual gives simple directions and limitations in Section A and the design windspeed applicable to all likely locations of houses. Section B gives several tables and diagrams based on the design windspeed to facilitate the design of timber framed houses and parts of houses. Section C does the same for masonry houses. Section D gives foundation details for both timber and masonry houses. Typical construction details are shown in Section E. Possible modes of failure of houses during cyclones are illustrated in Section F. These diagrams also explain how to prevent such damage.

Miscellaneous details such as for the design of window shutters, retaining walls, lean-to houses, window glass selection, etc. are given in Section G. Section H gives some details for the construction of low-cost houses. The room sizes in this section are kept small enough to avoid the use of purlins for the roof. The small sizes also permit the use of partially grouted masonry wall which will resist the applicable forces. The Manual ends with an Appendix giving the design criteria used, typical calculations and details of timber classifications.

HOW TO USE THE MANUAL?

The several tables and diagrams might seem quite daunting to begin with. Simple flowcharts are included in the Manual to guide the new user.

Knowledge of the following basic information is necessary in order to use the Manual:

> **i)** The stress grades of the available timber. Where this information is not provided by the supplier or stamped on the pieces of timber an assessment of the stress grade can be made by using Table B2. However in order to use this table, sufficiently reliable information on the density of the timber must be available.
>
> **ii)** A knowledge of the joint groups of different timber species used is required for designing bracing and/or tie-down systems. There is no simple relationship between joint groups and other basic properties such as density. Therefore where the joint group is not known advice must be sought from the Department of Forestry or a conservative estimate made.

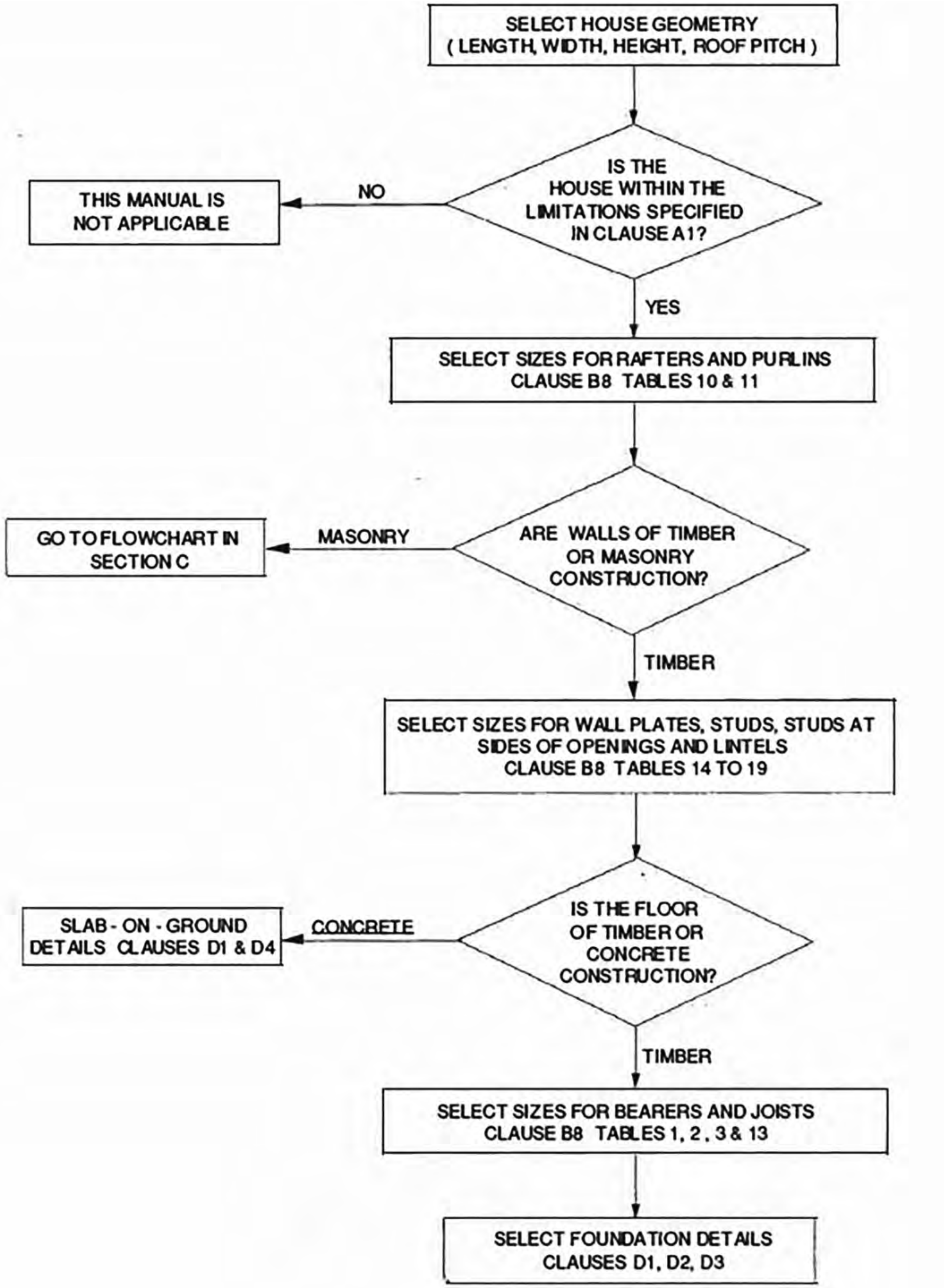
Where manufacturers of proprietary products are able to give test-based information on their products it may be used with the appropriate tables in the Manual.

FORMAT OF THE MANUAL

The Manual has been prepared with plenty of diagrams and tables and a minimum of text. These should convey the intent far more easily than words.

Section A
GENERAL

HOW TO USE THIS MANUAL



Section A —GENERAL

A1 LIMITATIONS

There is unlimited possibility for variation in the design and erection of houses. Site conditions, choice of materials, size, layout, location and a host of other factors can all vary. No manual can provide detailed information to cover all such variations. This manual is no exception. The following limitations therefore apply to the houses for which details are given:

(a) Plan - rectangles or simple combinations of rectangles.

(b) Height - not more than 6 m to eaves.

(c) Width - not to exceed 9 m inclusive of covered verandahs but excluding eaves.

(d) Eaves Overhang - limited to 900 mm.

(e) Roof Pitch - 25° maximum.

(f) Bracing Wall Spacing:

i) Must not exceed 5 m for timber framed houses or storeys.

ii) Must not exceed 5 m for masonry houses or storeys except as explained in Clause C3.6 and Figure C3.6.

(g) Roof construction - must be of a simple beam and rafter type with lightweight roof cladding.

(h) Rafter Spacing - limited to 900 mm, 1200 mm and 1560 mm.

(i) For masonry houses the floor area per storey must not exceed:

i) 600 m2 for single storey houses

ii) 200 m2 for two-storey houses or a single storey supported on foundation walls; and lower storey of masonry supported on a concrete slab-on-ground, or footings of concrete or masonry.

(j) Windows MUST be protected from debris by means of shutters such as those shown in Figure G1.1.

A2 BUILDING TERMINOLOGY

Figures A2.1, A2.2 and A2.3 illustrate the various members and components of timber framed and masonry houses.

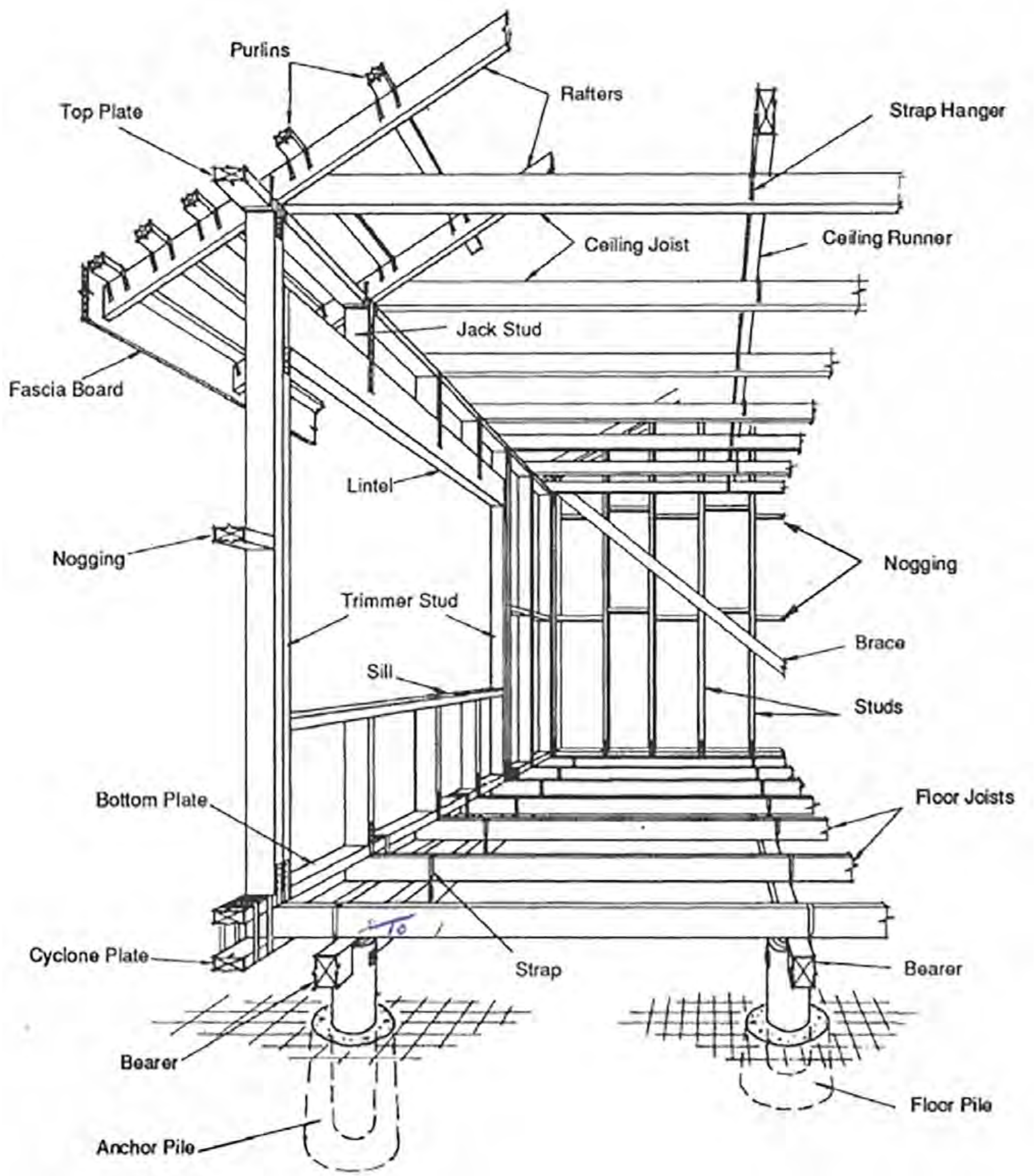
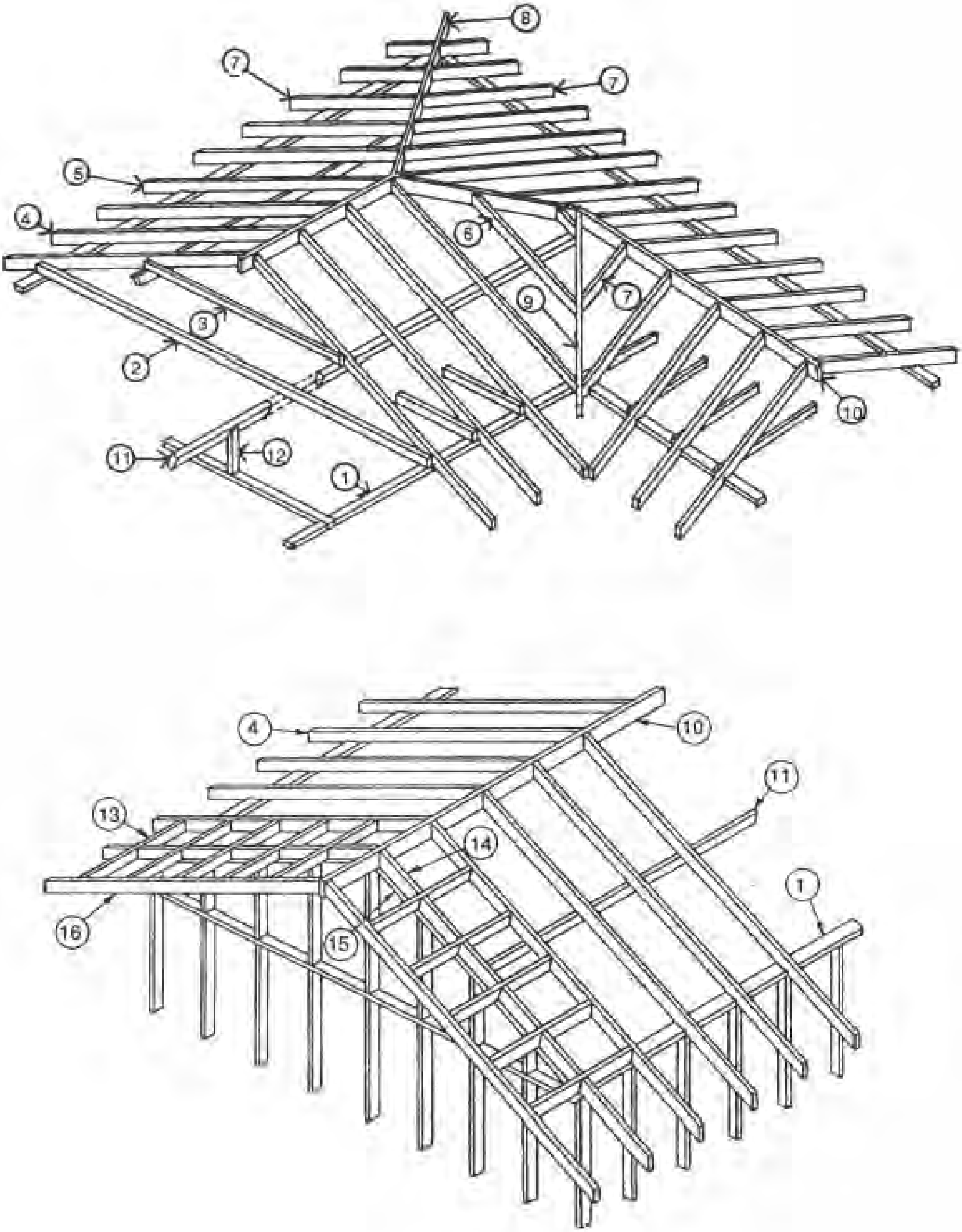


FIGURE A2.1: GENERAL FRAMING DETAILS FOR TIMBER HOUSES



1. Top Plate
2. Ceiling Joist
3. Collar Tie
4. Common Rafter
5. Jack Rafter
6. Cripple Rafter
7. Creeper Rafter
8. Hip Rafter
9. Valley Rafter
10. Ridgeboard
11. Underpurlin
12. Roof Strut
13. Outrigger
14. Nogging
15. Raking Plate
16. Barge or verge Rafter

FIGURE A2.2: ROOF FRAMING DETAILS

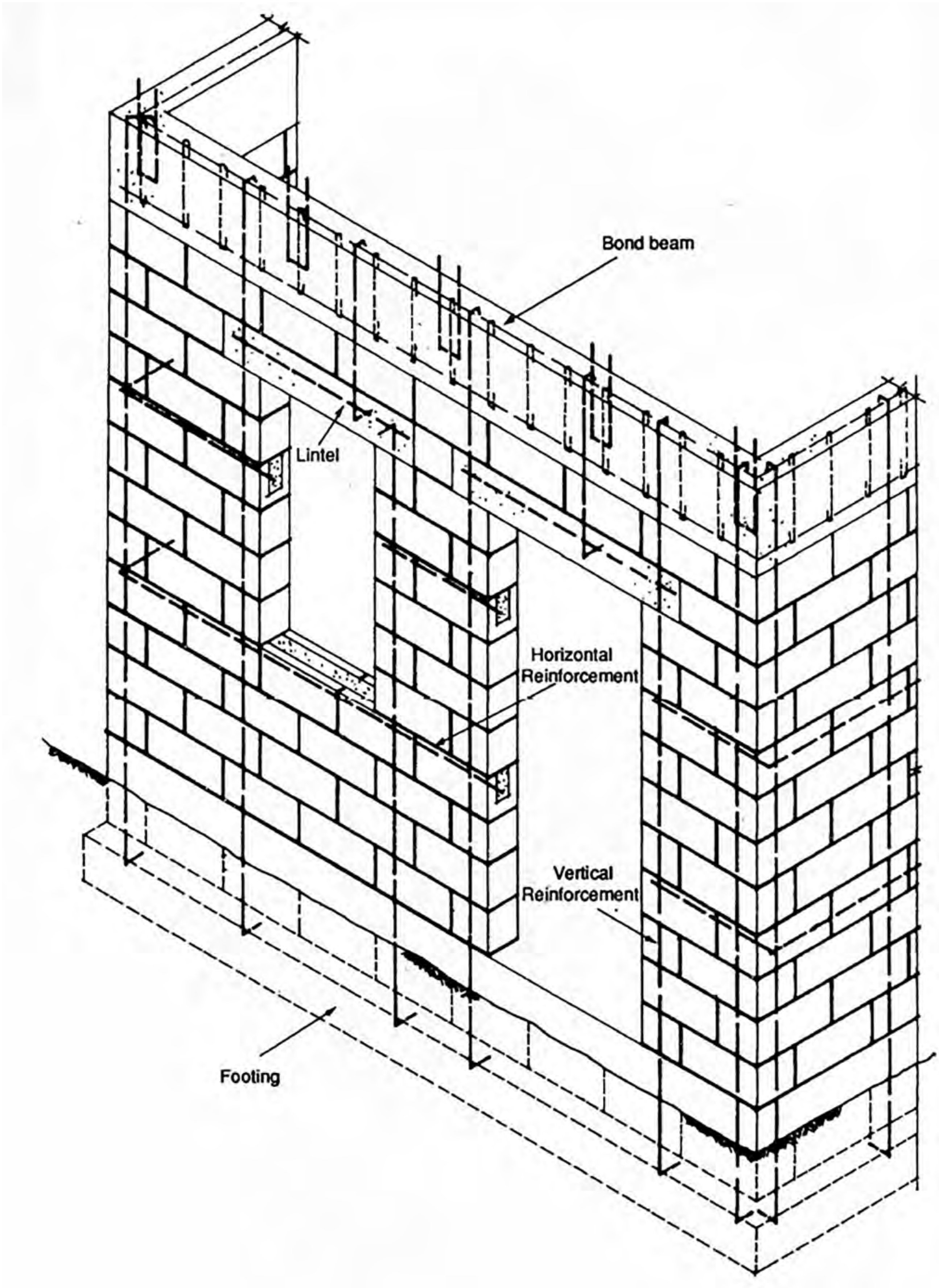


FIGURE A2.3: GENERAL CONSTRUCTION DETAILS FOR MASONRY HOUSES

A3 TERMS AND DEFINITIONS

The following technical words found in the Manual have been used with the specific meaning given against each.

BEARER a beam supported on foundation walls, piles, or piers and carrying floor joists.

BLINDING a base course of compacted granular material or lean concrete to provide an even surface on which construction can proceed

BOND, RUNNING the bond when the units of each course of masonry overlap the units in the preceding course by 50% of the length of the units.

BRACE

Diagonal Brace—a member of a framed house fixed diagonally and used to resist tension or compression or both.

Subfloor Brace—a bracing element below the ground floor level.

Wall Bracing—a section of wall above the ground level which performs a bracing function.

BRACING any method employed to provide lateral support to a house.

Bracing Line—a line along or across a house for controlling the distribution of wall bracing elements.

Bracing Unit—a measure of the performance of a wall bracing element. (100 BU's = 5 kN)

Bracing Panel *(Bracing Wall)*—a length of structural wall which is designed to resist the racking effects produced by lateral forces resulting from earthquakes or high winds. The capacity of a bracing panel to resist racking may be expressed in bracing units.

CALL DIMENSIONS the dimensions by which timber is sold. These are usually marginally different from the actual dimensions.

CLADDING the outside or exterior weathering surface of a house.

COLLAR TIE a member connecting paired rafters together below the level of the ridge board in a roof.

D refers to a deformed mild steel reinforcing bar of the stated diameter in millimetres.

DAMP-PROOF COURSE durable water-proof material placed between masonry, stone or concrete and timber or metal as a protection against moisture; or placed between block or stone courses to prevent the passage of moisture from a lower part of the structure to an upper part bearing on it.

DRAGON TIE a timber member fixed diagonally between two intersecting top plates to tie two walls together.

FOOTING construction through which the weight of a house is transferred to the ground.

FOUNDATION those parts of a house in direct contact with, and transmitting and distributing loads to the ground through a footing.

FRAMING TIMBER timber members to which lining, cladding, or decking is attached, which are depended upon for supporting the structure and for

	resisting forces applied to it.
GABLE	the triangular part of an outside wall between the planes of the roof and the line of the eaves
GROUT	the material used to fill cells or cavities in reinforced masonry.
JOINT GROUP	a group assigned to a piece or parcel of timber to indicate for purposes of joint design a set of basic working loads appropriate to that timber. Joint group is designated in the form of a number preceded by the letters J or JD indicating unseasoned or seasoned timber respectively.
JOIST	a horizontal framing member to which is fixed floor decking or ceiling linings and which is identified accordingly as a floor joist or ceiling joist.
LINTEL	a structural member over an opening in a wall to take the vertical downward and lateral loads above the opening and to transfer them to other structural members on either side of the opening.
M	refers to a bolt of the stated diameter in millimetres.
MASONRY	any construction using concrete blocks, laid to a bond and joined together with mortar.
MORTAR	the material in which masonry units are bedded and joined together.
NOGGING	a short member fixed between framing timbers.
NOTCH	trench or groove formed across the face of a piece of timber.
PILE	a column-like member used to transmit loads from the house and its contents to the ground. ***Anchor Pile—***a pile directly supporting a bearer, loadbearing walls and roof structures, which is embedded into the ground with concrete so as also to resist vertical uplift and horizontal forces. ***Braced Anchor Pile***—an anchor pile directly supporting a bearer and having a brace attached to it. ***Floor Pile—***a pile that does not have any brace attached to it and that is required to support one floor only but not load bearing walls.
PLATE	a timber member supported by a wall or bearers or joists to support and distribute the load from floors, walls, roofs or ceiling. ***Bottom Plate—***a plate placed under the ends of studs. ***Top Plate—***a plate placed over the ends of studs.
PURLIN	a horizontal member laid to span across rafters and to which the roof cladding is attached.
R	refers to a plain round reinforcing bar of the stated diameter in millimetres.
RAFTER	a framing timber normally parallel to the slope of the roof and providing a support for purlins, roof covering or sarking.
REINFORCEMENT	any form of reinforcing rod, bar, or welded fabric mesh used with concrete or masonry.
REINFORCED MASONRY	any masonry in which reinforcing steel is so bedded and bonded that the two materials act together in resisting forces.

ROOF that surface of a house intended to shelter any other part, or any space below it, against the elements, and in particular to discharge rainwater outside the confines of the house or space below.

SEASONED TIMBER timber brought to a state of equilibrium moisture content. Equilibrium moisture content is the moisture content at which timber neither gains nor loses any moisture under constant conditions of temperature and humidity.

SPACING the distance at which members are spaced measured centre to centre.

SPAN the clear distance between supports measured along the member.

STRESS GRADE a value assigned to a piece of timber to indicate, for purposes of structural design, the set of basic stresses appropriate to that piece. Stress grade is designated in the form of a number preceded by the letter 'F'.

STRINGER a horizontal framing timber on edge fixed to the side of a concrete or masonry wall to support the ends of joists or rafters.

STRUTTING short members fixed between joists to stiffen and prevent them from canting or buckling.

STUD vertical timber, forming part of a wall or partition on to which cladding may be fastened.

Loadbearing Stud—a stud in a loadbearing wall.

Trimming Stud—a stud located on the side of an opening.

Jack Stud—a stud of shorter height than the height from top plate to bottom plate of the wall.

THICKNESS unless otherwise specifically stated means the call dimension representing the narrow surface of a piece of timber (see also WIDTH)

VAPOUR BARRIER sheet material through which only very little water vapour can pass. This is used to minimise water vapour penetration in houses.

WALL

External Wall—an outer wall of a house.

Foundation Wall—that part of the foundation comprising a masonry or concrete wallsupporting a house or part of a house, and not extending more than 2.0 m above the underside of the footing.

Internal Wall—a wall other than an external wall, a partition.

Loadbearing Wall—a wall supporting vertical loads from floors, ceiling joists, roof, or any combination of these.

Non Loadbearing Wall—a wall other than a loadbearing wall.

Structural Wall—any wall which because of its position and shape is designed to contribute to the rigidity and strength of the house.

WEATHER BOARDING an exterior overlapping timber strip cladding which is fixed either horizontally, vertically or diagonally, whether rough sawn or machined or formed to any special section.

WIDTH unless otherwise specifically mentioned means the call dimension representing the wide surface of a piece of timber.

A4 DETERMINATION OF DESIGN WINDSPEED

The design winds peed for residential dwellings (Class 1 and 10 Buildings) in the Cook Islands is 49 m/s.

A5 CYCLONE DESIGN CRITERIA

The Cook Islands are susceptible to cyclones across all of the islands. The effects of cyclone winds on a residential dwelling are twofold. Firstly, the the overall buildings capacity to withstand the lateral wind forces on it. Insufficient lateral structure can cause significant damage to the total building structure. Secondly are the localized suction forces on the roof material. Lack of a strong connection can lead to roofing material being blown off of the building.

Critical aspects to consider during residential house construction are therefore:

(a) Good distribution of bracing in the walls throughout the house. These walls can either be reinforced masonry walls, or braced timber walls as per Section B of this manual.

b) Strong connections from the roofing material all the way down to the foundations. This requires solid connection of the roof material to the roof joists, from the roof joists to the main house frame and from the main frame to the foundations.

Category 3 Cyclones

The design requirements and construction details provided in this Home Building Manual are produced to the design wind speed for a Category 3 cyclone. By following the details shown throughout this manual therefore, the risk of damage to a domestic dwelling will be significantly reduced.

Category 4 Cyclones

The construction details provided in this Home Building Manual may not be sufficient to withstand the wind loads resulting from a Category 4 cyclone. In this instance, we would recommend adding supplementary tie-down strapping to the roof of a house.

Recommended detail for these tie-down details are given in the appended Red Cross manual 'The Tautu Roof Tie-Down Model Instructions Booklet'.

The recommendation is to have the tie-down straps at no greater than 2 m apart, and at a minimum of 500 mm from the edge of the roof. For a typical house, this would result in four straps across the width of the roof.

Category 5 Cyclones

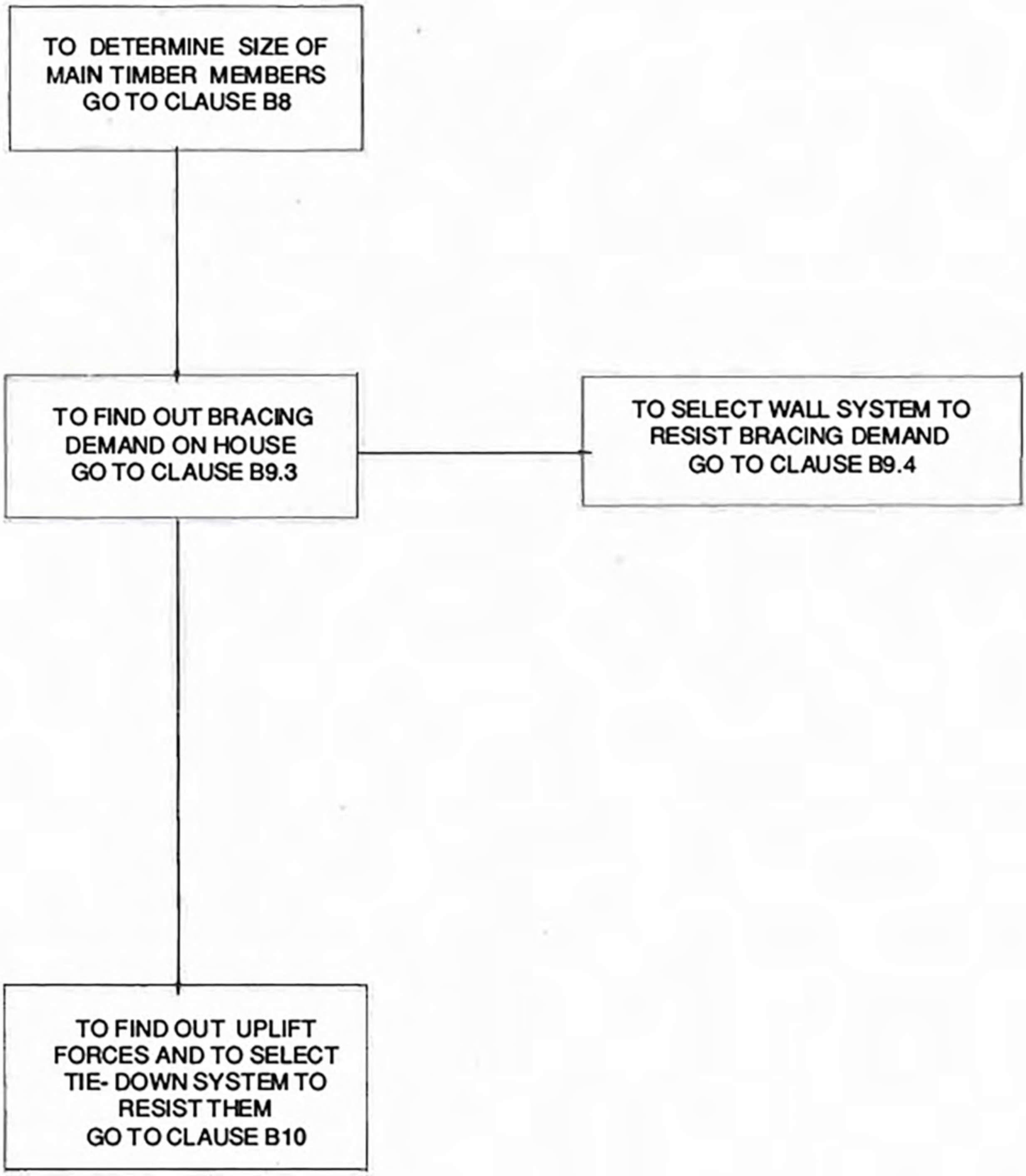
In the event of a Category 5 cyclone being forecast, the recommended course of action is to **take shelter in a purpose built and design cyclone shelter,** designed to protect the life safety of the local communities. Residential houses are unlikely to provide safe refuge and should not be occupied during a category 5 cyclone.

In this instance, damage to residential buildings can potentially be mitigated through equalisation of pressures between the inside and outside of a house. This can be accomplished through fixing open windows and doors throughout the building and removing and or protecting the internal fixtures, fittings and furniture.

Section B

TIMBER FRAMED HOUSES

Section B – TIMBER FRAMED **HOUSES**



B1 GENERAL

All timber members must be sized in accordance with Tables 1 to 20 as appropriate for the member, stress grade, and design situation. Care must be taken to ensure that the correct tables are used for the appropriate design wind speeds.

B2 ASCERTAINING STRESS GRADE

Many of the tables in the Manual are based on a knowledge of the stress grade (see definition) of the timber used. Where timber is not stress graded mechanically or visually the approximate stress grade can be determined from the density of the timber. Table B2 gives these approximate values for different timber densities whether of softwood or hardwood. These values may be used in the absence of more precise information, to refer to all the other tables to use which the relevant stress grade is required.

TABLE B2:

RELATIONSHIP BETWEEN DENSITY, STRENGTH GROUP AND STRESS GRADE

UNSEASONED TIMBERS

MINIMUM DENSITY VALUES AT 12 PERCENT MOISTURE CONTENT	1180	1030	900	800	700	600	500
STRENGTH GROUP	S1	S2	S3	S4	S5	S6	S7
STRESS GRADE	F17	F14	F11	F8	F7	F5	F4*

SEASONED TIMBERS

MINIMUM DENSITY VALUES AT 12 PERCENT MOISTURE CONTENT	1200	1080	960	840	730	620	520	420
STRENGTH GROUP	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8
STRESS GRADE	F27	F22	F17	F14	F11	F8	F7*	F5*

* Not applicable to hardwood timbers.

B3 JOINT GROUPS

A knowledge of the value of the joint group (see definition) of each timber member at any mechanical joint is required for the use of tables that relate to Clauses B9 and B10. When this information is not readily available, it will be necessary to seek the guidance of the Department of Forestry or some other reliable source of Information.

B4 NOMINAL FIXINGS

The minimum diameter of nails for use in nominal fixings must be 3.15 mm plain shank for hardwood, and 3.75 mm plain shank or 3.15 mm deformed shank for softwood. The minimum depth of penetration of nail into the final receiving member must be 10 times the nail diameter where driven into side grain and 15 times the nail diameter where driven into end grain. Not less than two nails must be provided at each joint unless shown otherwise in this Manual.

B5 POSITION OF BEARERS, JOISTS AND NOGGINGS

B5.1 Allowable offsets for Bearers

PERMISSIBLE CANTILEVERS AND OFFSETS FOR BEARERS AND JOISTS UNDER LOADBEARING WALLS		
Depth of Member (mm)	Maximum permissible cantilever as proportion of span (%)	Maximum permissible offset of internal loadbearing walls as proportion of span (%)
	Light Roof *	Light Roof *
< 125	10	20
125 - 200	15	30
201 - 275	17.5	35
> 275	20	37.5

* eg. metal sheet roofing.

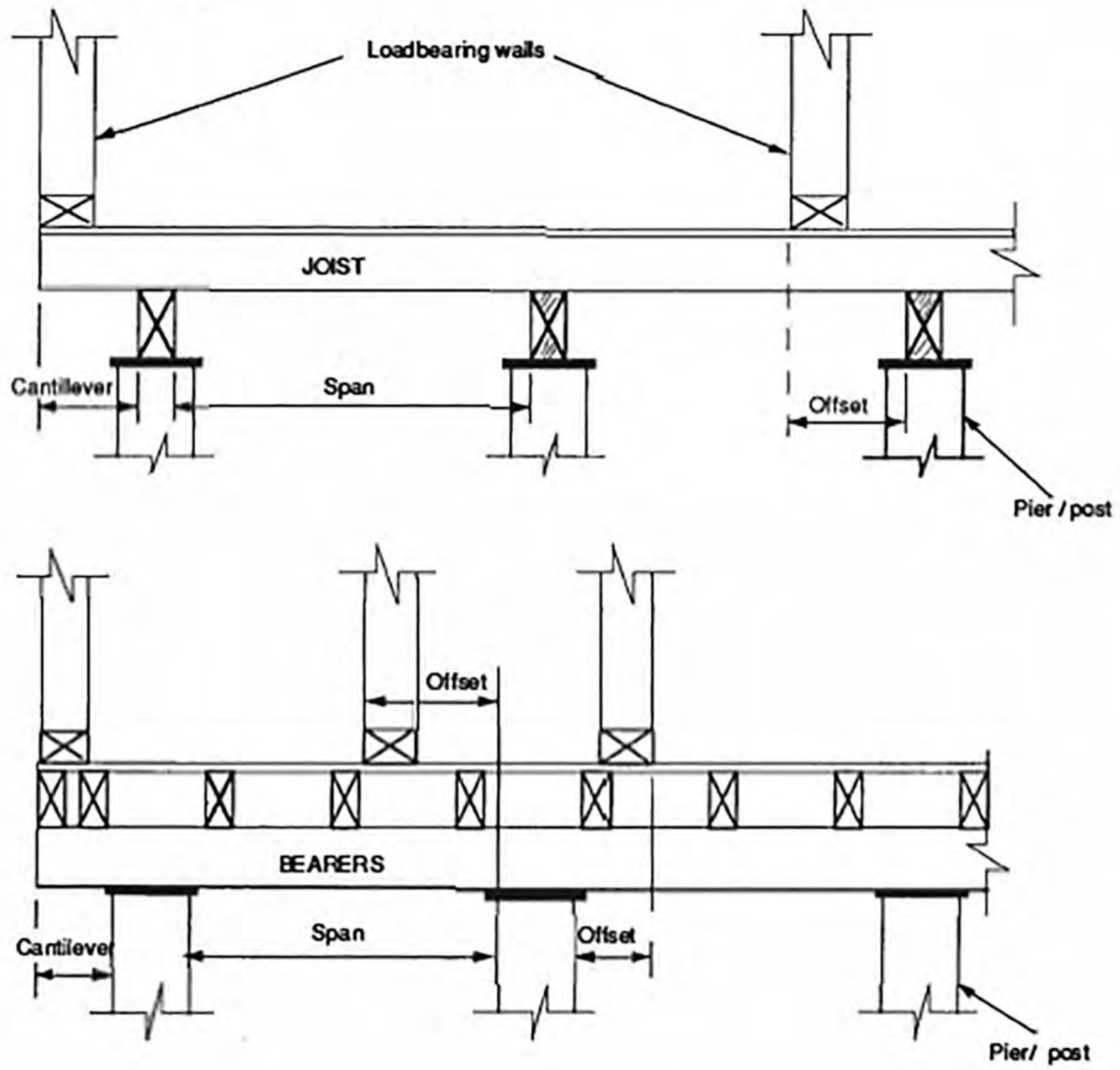
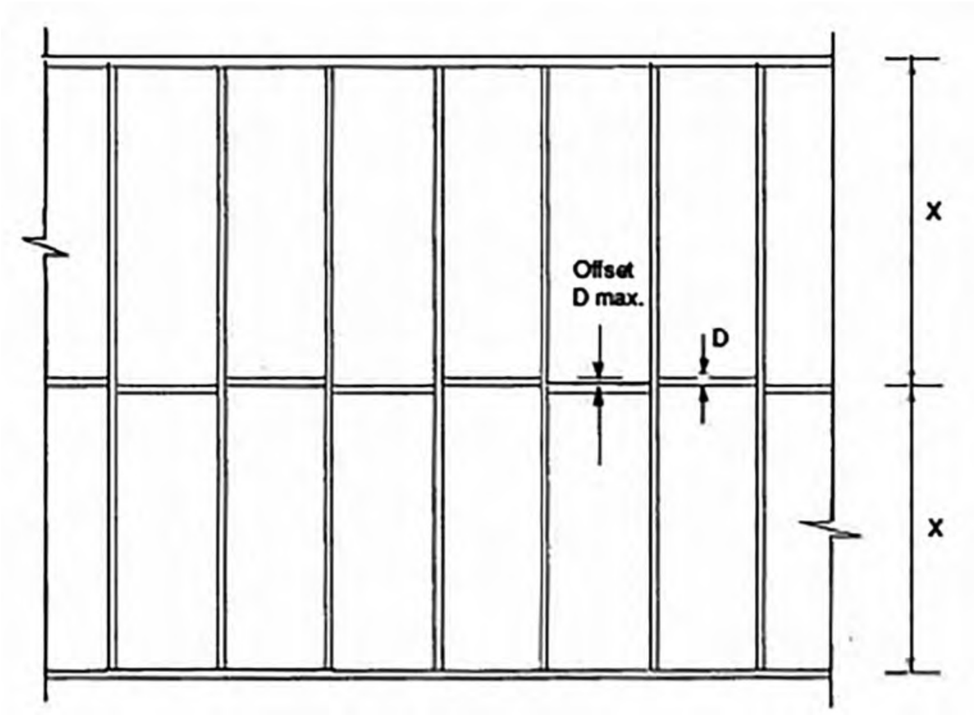


FIGURE B5.1: CANTILEVERS AND OFFSETS

B5.2 Position of Noggings



NOTE: The value of 'x' must not exceed 1350 mm.

FIGURE B5.2: POSITION OF NOGGINGS

B6 STIFFENING OF PLATES

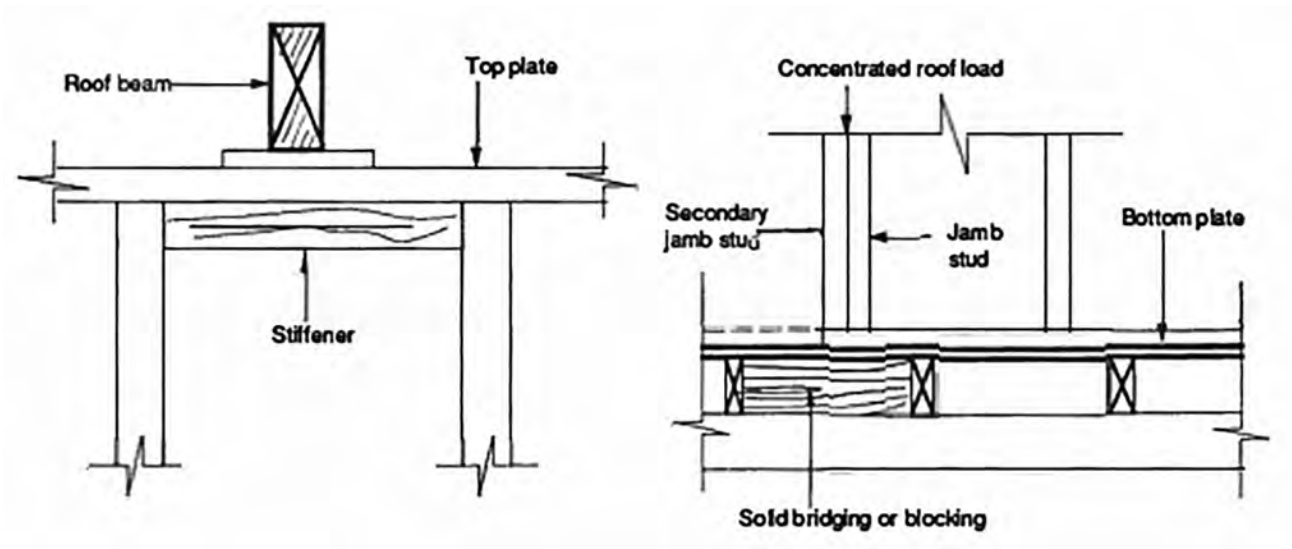


FIGURE B6: LOCAL STIFFENING OF PLATES

B7 HOUSE TYPES

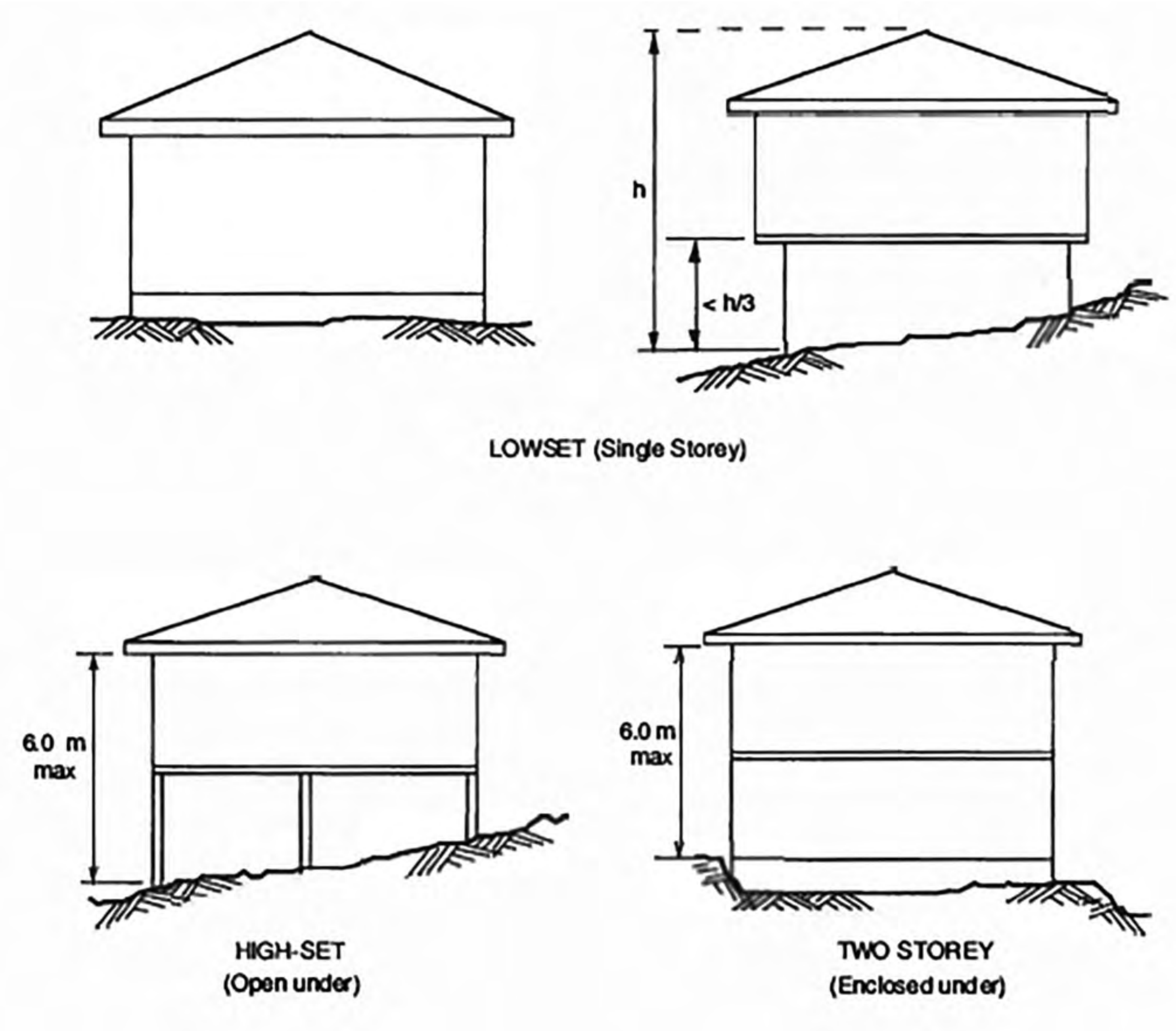


FIGURE B7: HOUSE TYPES

A high-set house is an elevated house with a clear, unwalled space underneath the first floor level, with a height from ground to underside of floor of at least one-third of the total height of the house.

B8 TIMBER MEMBER SIZES

B8.1 General

The following sets of tables provide the sizes of timber members corresponding to the design windspeed given in clause A4. The tables are numbered 1 to 20 and each table contains the member size for the various components of a timber framed house.

The tolerances permitted for the sizes given in the tables are as follows:

– for unseasoned timber of stress grades F4 to F7, not greater than 4 mm under the call dimension

– for other unseasoned timber, not greater than 3 mm under the call dimension

– for seasoned timber, negative tolerance is not permitted.

B 8.2

All timber dimensions are expressed with the value for depth first followed by that for the width. For example a purlin shown in any table as 50 x 75 means that it is laid flat with 50 mm depth and 75 mm width. If the reference is to 75 x 50, then the depth is 75 mm and width 50 mm.

B8.3 Application

To determine the member size to be used, the following steps need to be followed.

1. Select the table that corresponds to the member under consideration.

2. Determined the options to be used from those given in the tables (e.g. spacing, span, height, stress grade of timber, seasoning of timber, etc.).

3. Select the member size.

B8.4 Tables for Timber Members

The following list gives the table numbers for the various timber members of a house.

Table 1	BEARERS SUPPORTING SINGLE OR UPPER STOREY LOADBEARING WALLS
Table 2	BEARERS SUPPORTING FLOOR JOISTS ONLY
Table 3	FLOOR JOISTS
Table 4	STUDS - SINGLE OR UPPER STOREY
Table 5	STUDS AT SIDES OF OPENINGS
Table 6	STUDS - INTERNAL LOADBEARING WALLS
Table 7	TOP PLATES - SINGLE OR UPPER STOREY
Table 8	BOTTOM PLATES - SINGLE OR UPPER STOREY
Table 9	LINTELS - SINGLE OR UPPER STOREY
Table 10	RAFTERS
Table 11	PURLINS
Table 12	VERANDAH POSTS
Table 13	BEARERS SUPPORTING TWO STOREY LOADBEARING WALLS
Table 14	STUDS - LOWER STOREY O F TWO STOREYS
Table 15	STUDS - INTERNAL WALLS - LOWER STOREY O F TWO STOREYS
Table 16	STUDS AT SIDES OF OPENINGS - LOWER STOREY OF TWO-STOREY CONSTRUCTION
Table 17	TOP PLATES - LOWER STOREY O F TWO STOREYS
Table 18	BOTTOM PLATES - LOWER STOREY WALLS
Table 19	LINTELS - LOWER STOREY OF TWO STOREYS
Table 20	ROOF BEAMS - NON-TRAFFICABLE ROOFS

TABLE 1

BEARERS SUPPORTING SINGLE OR UPPER STOREY LOADBEARING WALLS MAXIMUM BUILDING WIDTH: 9000 MM

BEARER SPACING (mm)	BEARER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
1800	1500	150 x 75	150 x 75	125 x 75	125 x 75	140 x 70	120 x 70	120 x 70	120 x 70
	1800	175 x 75	175 x 75	150 x 75	150 x 75	170 x 70	140 x 70	140 x 70	120 x 70
	2100	200 x 75	200 x 75	175 x 75	175 x 75	190 x 70	170 x 70	170 x 70	140 x 70
	2400	225 x 75	225 x 75	200 x 75	200 x 75	220 x 70	190 x 70	170 x 70	170 x 70
	2700	250 x 75	250 x 75	225 x 75	225 x 75	240 x 70	220 x 70	190 x 70	190 x 70
	3000	275 x 75	275 x 75	250 x 75	250 x 75	-	240 x 70	220 x 70	220 x 70
	3300	300 x 75	300 x 75	275 x 75	275 x 75	-	-	240 x 70	240 x 70
	3600	-	-	300 x 75	300 x 75	-	-	-	240 x 70
3600	1500	175 x 75	150 x 75	150 x 75	150 x 75	170 x 70	140 x 70	120 x 70	120 x 70
	1800	200 x 75	175 x 75	175 x 75	175 x 75	190 x 70	170 x 70	140 x 70	120 x 70
	2100	225 x 75	200 x 75	200 x 75	200 x 75	220 x 70	190 x 70	170 x 70	140 x 70
	2400	250 x 75	225 x 75	225 x 75	225 x 75	240 x 70	220 x 70	170 x 70	170 x 70
	2700	275 x 75	250 x 75	250 x 75	250 x 75	-	240 x 70	190 x 70	190 x 70
	3000	300 x 75	275 x 75	275 x 75	275 x 75	-	-	220 x 70	220 x 70
	3300	-	300 x 75	300 x 75	300 x 75	-	-	240 x 70	240 x 70
	3600	-	-	-	-	-	-	-	-

TABLE 2

BEARERS SUPPORTING FLOOR JOISTS ONLY

BEARER SPACING (mm)	BEARER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
1800	1500	125 x 75	125 x 75	100 x 75	100 x 75	120 x 70	120 x 70	120 x 70	90 x 70
	1800	150 x 75	125 x 75	125 x 75	125 x 75	140 x 70	140 x 70	120 x 70	120 x 70
	2100	175 x 75	150 x 75	150 x 75	150 x 75	170 x 70	170 x 70	140 x 70	140 x 70
	2400	200 x 75	175 x 75	175 x 75	175 x 75	190 x 70	170 x 70	170 x 70	170 x 70
	2700	225 x 75	200 x 75	200 x 75	200 x 75	220 x 70	190 x 70	190 x 70	170 x 70
	3000	250 x 75	225 x 75	200 x 75	200 x 75	240 x 70	220 x 70	220 x 70	190 x 70
	3300	275 x 75	250 x 75	225 x 75	225 x 75	-	240 x 70	240 x 70	220 x 70
	3600	300 x 75	250 x 75	250 x 75	250 x 75	-	-	240 x 70	240 x 70
2400	1500	150 x 75	125 x 75	125 x 75	125 x 75	140 x 70	120 x 70	120 x 70	120 x 70
	1800	175 x 75	150 x 75	150 x 75	125 x 75	170 x 70	170 x 70	140 x 70	120 x 70
	2100	200 x 75	175 x 75	150 x 75	150 x 75	190 x 70	170 x 70	170 x 70	140 x 70
	2400	225 x 75	200 x 75	175 x 75	175 x 75	220 x 70	220 x 70	190 x 70	170 x 70
	2700	250 x 75	225 x 75	200 x 75	200 x 75	240 x 70	240 x 70	220 x 70	190 x 70
	3000	275 x 75	250 x 75	225 x 75	225 x 75	-	240 x 70	220 x 70	220 x 70
	3300	300 x 75	275 x 75	250 x 75	250 x 75	-	-	240 x 70	240 x 70
	3600	-	300 x 75	275 x 75	250 x 75	-	-	-	-
3000	1500	175 x 75	150 x 75	125 x 75	125 x 75	170 x 70	140 x 70	120 x 70	120 x 70
	1800	200 x 75	175 x 75	150 x 75	150 x 75	190 x 70	170 x 70	140 x 70	120 x 70
	2100	225 x 75	200 x 75	175 x 75	175 x 75	220 x 70	190 x 70	170 x 70	140 x 70
	2400	250 x 75	225 x 75	200 x 75	175 x 75	240 x 70	220 x 70	190 x 70	170 x 70
	2700	275 x 75	250 x 75	225 x 75	200 x 75	-	240 x 70	220 x 70	190 x 70
	3000	300 x 75	275 x 75	250 x 75	225 x 75	-	-	220 x 70	220 x 70
	3300	-	300 x 75	275 x 75	250 x 75	-	-	240 x 70	240 x 70
	3600	-	-	300 x 75	275 x 75	-	-	-	-

TABLE 3

FLOOR JOISTS
JOISTS SPACING: 450 MM CENTRES

MAX. SPAN (mm)	SPAN TYPE	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
1800	SINGLE	125 x 40	125 x 40	125 x 40	125 x 40	120 x 35	120 x 35	120 x 35	120 x 35
	CONT.	125 x 40	100 x 50	100 x 50	100 x 50	120 x 35	120 x 35	90 x 45	90 x 45
2100	SINGLE	150 x 40	125 x 50	125 x 50	125 x 40	140 x 35	120 x 45	120 x 45	120 x 35
	CONT.	125 x 40	125 x 40	125 x 40	125 x 40	120 x 35	120 x 35	120 x 35	120 x 35
2400	SINGLE	150 x 50	150 x 40	150 x 40	125 x 50	140 x 45	140 x 45	140 x 35	120 x 45
	CONT.	150 x 40	125 x 50	125 x 50	125 x 40	140 x 35	120 x 45	120 x 45	120 x 35
2700	SINGLE	175 x 40	150 x 50	150 x 50	150 x 50	190 x 35	190 x 35	140 x 45	140 x 45
	CONT.	150 x 50	150 x 40	150 x 40	125 x 50	140 x 45	140 x 35	140 x 35	120 x 45
3000	SINGLE	175 x 50	175 x 40	175 x 40	175 x 40	190 x 35	190 x 35	190 x 35	190 x 35
	CONT.	150 x 50	150 x 50	150 x 40	150 x 40	190 x 35	140 x 35	140 x 35	140 x 35
3300	SINGLE	175 x 50	175 x 50	175 x 50	175 x 50	190 x 35	190 x 35	190 x 35	190 x 35
	CONT.	175 x 50	175 x 50	150 x 50	150 x 50	190 x 35	190 x 35	190 x 35	140 x 45
3600	SINGLE	200 x 50	200 x 40	175 x 50	175 x 50	240 x 35	240 x 35	190 x 35	190 x 35
	CONT.	200 x 50	200 x 40	150 x 50	150 x 50	240 x 35	240 x 35	190 x 35	190 x 35

NOTES:

i. The sizes given apply only where roof loads are supported within the allowable offset distance for the joists.

ii. Where roof loads occur outside the allowable offset, floor joists must be strengthened by placing a double joist, one size greater than the appropriate tabled value, at the points where roof loads are transferred to the floor.

iii. For spans greater than 2400 mm, a floor joist size used at the maximum span given by the table may exhibit excessive "bounce". To avoid excessive "bounce", joists may be one size greater than the tabled values

TABLE 4

STUDS - SINGLE OR UPPER STOREY EXTERNAL WALLS INCLUDING GABLE ENDS

STUD SPACING (mm)	STUD HEIGHT (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
450	2400	100 x 40	100 x 40	75 x 50	75 x 40	90 x 35	90 x 35	70 x 45	70 x 45
	2700	100 x 40	100 x 40	100 x 40	100 x 40	90 x 45	90 x 35	90 x 35	90 x 35
	3000	100 x 50	100 x 50	100 x 40	100 x 40	90 x 70	90 x 70	90 x 45	90 x 45
600	2400	100 x 40	100 x 40	100 x 40	100 x 40	90 x 45	90 x 35	90 x 35	90 x 35
	2700	100 x 50	100 x 50	100 x 40	100 x 40	90 x 70	90 x 70	90 x 45	90 x 35
	3000	100 x 75	100 x 75	100 x 50	100 x 50	90 x 90	90 x 70	90 x 70	90 x 70
750	2400	100 x 50	100 x 40	100 x 40	100 x 40	90 x 70	90 x 70	90 x 45	90 x 35
	2700	100 x 75	100 x 75	100 x 50	100 x 40	-	90 x 70	90 x 70	90 x 45
	3000	100 x 100	100 x 75	100 x 75	100 x 75	-	-	90 x 70	90 x 70
900	2400	100 x 75	100 x 50	100 x 40	100 x 40	90 x 70	90 x 70	90 x 45	90 x 45
	2700	100 x 75	100 x 75	100 x 75	100 x 50	-	90 x 70	90 x 70	90 x 70
	3000	-	-	100 x 75	100 x 75	-	-	-	-

NOTES:

i. Larger sizes may be made up from smaller sections, i.e. 2/100 x 50 equals a 100 x 100.

ii. Studs supporting concentrations of load from beams and the like must be doubled common studs.

iii. No allowance has been made for notching.

TABLE 5

STUDS AT SIDES OF OPENINGS

STUD HEIGHT (mm)	OPENING WIDTH (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
2400	900	100 x 50	100 x 40	100 x 40	100 x 40	2/90 x 35	90 x 45	90 x 35	90 x 35
	1200	2/100 x 40	100 x 50	100 x 40	100 x 40	2/90 x 35	90 x 45	90 x 45	90 x 35
	1500	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	90 x 45	90 x 45
	1800	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	2/90 x 35	90 x 45
2700	900	2/100 x 40	100 x 50	100 x 40	100 x 40	2/90 x 35	2/90 x 35	90 x 45	90 x 45
	1200	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	2/90 x 35	90 x 45
	1500	2/100 x 40	2/100 x 40	2/100 x 40	100 x 50	2/90 x 45	2/90 x 35	2/90 x 35	2/90 x 35
	1800	2/100 x 50	2/100 x 40	2/100 x 40	100 x 50	2/90 x 45	2/90 x 45	2/90 x 35	2/90 x 35

TABLE 6

STUDS - INTERNAL LOADBEARING WALLS

<table>
<tr><th rowspan="2">STUD SPACING (mm)</th><th rowspan="2">STUD HEIGHT (mm)</th><th colspan="4">UNSEASONED</th><th colspan="4">SEASONED</th></tr>
<tr><th>F4</th><th>F5</th><th>F7</th><th>F8</th><th>F4</th><th>F5</th><th>F7</th><th>F8</th></tr>
<tr><td rowspan="7">450</td><td>2400</td><td colspan="4">75 x 40</td><td colspan="4">70 x 35</td></tr>
<tr><td>2700</td><td colspan="2">100 x 40</td><td colspan="2">75 x 50</td><td colspan="3">90 x 35</td><td>70 x 45</td></tr>
<tr><td>3000</td><td colspan="4">100 x 40</td><td colspan="3">90 x 45</td><td>90 x 35</td></tr>
<tr><td>3300</td><td colspan="4">100 x 50</td><td colspan="3">90 x 70</td><td>90 x 45</td></tr>
<tr><td>3600</td><td colspan="4">100 x 75</td><td colspan="3">90 x 90</td><td>90 x 70</td></tr>
<tr><td>3900</td><td>2/100 x 50</td><td colspan="3">100 x 75</td><td colspan="3">-</td><td>90 x 90</td></tr>
<tr><td>4200</td><td>-</td><td colspan="3">2/100 x 50</td><td colspan="4">-</td></tr>
<tr><td rowspan="7">600</td><td>2400</td><td colspan="2">75 x 50</td><td colspan="2">75 x 40</td><td>70 x 45</td><td colspan="3">70 x 35</td></tr>
<tr><td>2700</td><td colspan="4">100 x 40</td><td>90 x 45</td><td colspan="3">90 x 35</td></tr>
<tr><td>3000</td><td colspan="2">100 x 50</td><td colspan="2">100 x 40</td><td>90 x 70</td><td colspan="3">90 x 45</td></tr>
<tr><td>3300</td><td colspan="2">100 x 75</td><td colspan="2">100 x 50</td><td>-</td><td colspan="3">90 x 70</td></tr>
<tr><td>3600</td><td>2/100 x 50</td><td colspan="3">100 x 75</td><td colspan="3">-</td><td>90 x 90</td></tr>
<tr><td>3900</td><td>-</td><td colspan="3">2/100 x 50</td><td colspan="4">-</td></tr>
<tr><td>4200</td><td colspan="4">-</td><td colspan="4">-</td></tr>
</table>

NOTES:

i. Internal studs supporting concentrations of load from roof beams must be double the common stud taken from the above table.

ii. Studs are assumed to be not notched.

TABLE 7

TOP PLATES - SINGLE OR UPPER STOREY

<table>
<tr><th rowspan="2">BUILDING WIDTH (mm)</th><th rowspan="2">RAFTER SPACING (mm)</th><th colspan="4">UNSEASONED</th><th colspan="4">SEASONED</th></tr>
<tr><th>F4</th><th>F5</th><th>F7</th><th>F8</th><th>F4</th><th>F5</th><th>F7</th><th>F8</th></tr>
<tr><td rowspan="2">7500</td><td rowspan="2">900</td><td>75 x 75</td><td colspan="3">50 x 75</td><td colspan="2">70 x 90</td><td colspan="2">45 x 70</td></tr>
<tr><td colspan="4">50 x 100</td><td>70 x 90</td><td colspan="3">45 x 90</td></tr>
<tr><td rowspan="2">9000</td><td rowspan="2">900</td><td colspan="2">75 x 75</td><td colspan="2">50 x 75</td><td colspan="2">70 x 70</td><td colspan="2">45 x 70</td></tr>
<tr><td>75 x 100</td><td colspan="3">50 x 100</td><td>70 x 90</td><td colspan="3">45 x 90</td></tr>
</table>

TABLE 8

BOTTOM PLATES - SINGLE OR UPPER STOREY

<table>
<tr><th rowspan="2">BUILDING WIDTH (mm)</th><th rowspan="2">RAFTER SPACING (mm)</th><th colspan="4">UNSEASONED</th><th colspan="4">SEASONED</th></tr>
<tr><th>F4</th><th>F5</th><th>F7</th><th>F8</th><th>F4</th><th>F5</th><th>F7</th><th>F8</th></tr>
<tr><td rowspan="2">7500</td><td rowspan="2">900</td><td colspan="2">75 x 75</td><td colspan="2">50 x 75</td><td colspan="4">70 x 90</td></tr>
<tr><td colspan="4">50 x 100</td><td>70 x 90</td><td colspan="3">45 x 90</td></tr>
<tr><td rowspan="2">9000</td><td rowspan="2">900</td><td colspan="4">75 x 75</td><td colspan="4">70 x 70</td></tr>
<tr><td>75 x 100</td><td colspan="3">50 x 100</td><td>70 x 90</td><td colspan="3">45 x 90</td></tr>
</table>

NOTES: Bottom plates fully supported by solid noggin or a concrete slab may be a minimum of 45 x 70 mm.

TABLE 9
LINTELS - SINGLE OR UPPER STOREY

<table>
<tr><th rowspan="2">BUILDING WIDTH (mm)</th><th rowspan="2">OPENING WIDTH (mm)</th><th colspan="4">UNSEASONED</th></tr>
<tr><th>F4</th><th>F5</th><th>F7</th><th>F8</th></tr>
<tr><td rowspan="4">6000</td><td>900</td><td>150 x 50</td><td colspan="2">125 x 50</td><td>100 x 50</td></tr>
<tr><td>1200</td><td colspan="2">150 x 50</td><td colspan="2">125 x 50</td></tr>
<tr><td>1500</td><td colspan="3">150 x 50</td><td>125 x 50</td></tr>
<tr><td>1800</td><td colspan="3">175 x 50</td><td>150 x 50</td></tr>
<tr><td rowspan="4">9000</td><td>900</td><td>175 x 50</td><td>150 x 50</td><td colspan="2">125 x 50</td></tr>
<tr><td>1200</td><td>200 x 50</td><td>175 x 50</td><td>150 x 50</td><td>125 x 50</td></tr>
<tr><td>1500</td><td>200 x 50</td><td>175 x 50</td><td colspan="2">150 x 50</td></tr>
<tr><td>1800</td><td>225 x 50</td><td colspan="2">200 x 50</td><td>175 x 50</td></tr>
</table>

RAFTER TABLES

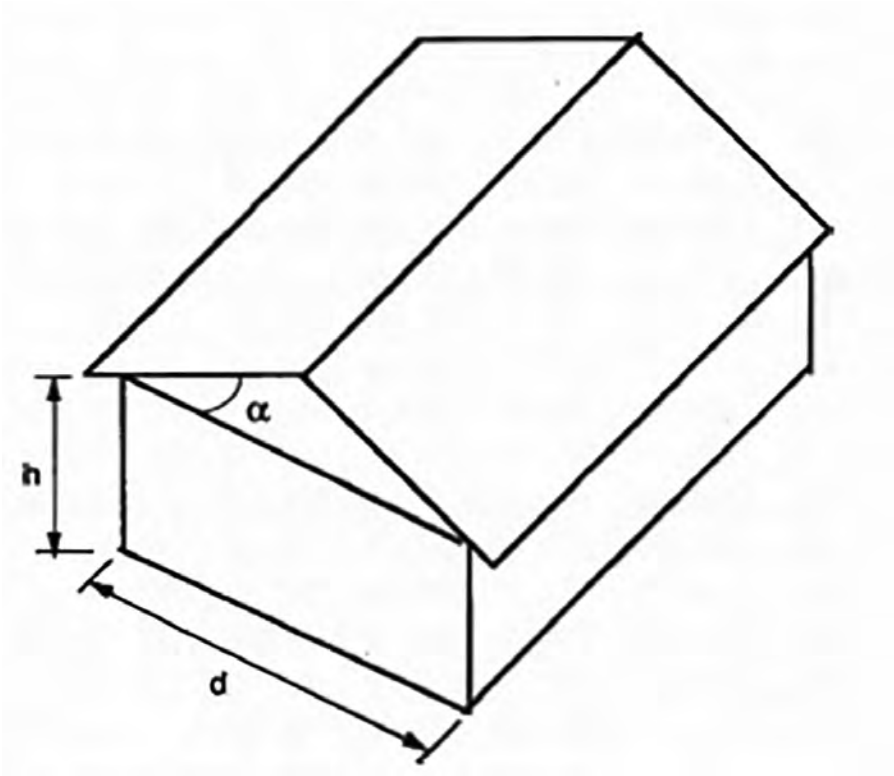


FIGURE: B8.3.1

TABLE B8.3.1:
APPROPRIATE TABLES FOR RAFTERS

APPROPRIATE TABLE	ASPECT RATIO h/d	ROOF PITCH α
10 - 1	0.25 0.5 1.0	15º, 20º, 25º 20º, 25º 25º
10 - 2	0.25 0.5 1.0	10º 15º 20º
10 - 3	0.5 1.0	10º 15º
10 - 4	1.0	10º

NOTES: Span of rafter is measured along the length of the rafter.

ASPECT RATIO h/d	ROOF PITCH (degrees)
0.25	15 20 25
0.5	20 25
1.0	25

TABLE 10-1

RAFTERS

RAFTER SPACING (mm)	RAFTER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
900	3000	175 x 50	150 x 50	150 x 50	150 x 50	170 x 45	140 x 45	140 x 45	120 x 45
	3600	175 x 50	175 x 50	175 x 50	175 x 50	170 x 45	170 x 45	140 x 45	140 x 45
	4200	225 x 50	200 x 50	200 x 50	200 x 50	190 x 45	170 x 45	170 x 45	170 x 45
	4800	250 x 50	225 x 50	225 x 50	200 x 50	220 x 45	220 x 45	190 x 45	190 x 45
	5400	275 x 50	250 x 50	250 x 50	225 x 50	240 x 45	220 x 45	220 x 45	220 x 45
1200	3000	175 x 50	175 x 50	150 x 50	150 x 50	170 x 45	170 x 45	140 x 45	140 x 45
	3600	200 x 50	200 x 50	200 x 50	175 x 50	190 x 45	170 x 45	170 x 45	170 x 45
	4200	225 x 50	225 x 50	225 x 50	200 x 50	220 x 45	190 x 45	190 x 45	170 x 45
	4800	275 x 50	250 x 50	250 x 50	225 x 50	240 x 45	220 x 45	220 x 45	220 x 45
	5400	300 x 50	275 x 50	275 x 50	250 x 50	270 x 45	240 x 45	240 x 45	220 x 45
1500	3000	200 x 50	175 x 50	175 x 50	150 x 50	190 x 45	170 x 45	140 x 45	140 x 45
	3600	225 x 50	200 x 50	200 x 50	200 x 50	220 x 45	190 x 45	170 x 45	170 x 45
	4200	250 x 50	250 x 50	225 x 50	225 x 50	240 x 45	220 x 45	190 x 45	190 x 45
	4800	275 x 50	275 x 50	275 x 50	250 x 50	270 x 45	240 x 45	220 x 45	220 x 45
	5400	-	300 x 50	300 x 50	275 x 50	-	270 x 45	270 x 45	240 x 45

ASPECT RATIO h/d	ROOF PITCH (degrees)
0.25	10
0.5	15
1.0	20

TABLE 10-2

RAFTERS

RAFTER SPACING (mm)	RAFTER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
900	3000	175 x 50	150 x 50	150 x50	150 x 50	170 x 45	140 x 45	140 x 45	120 x 45
	3600	175 x 50	175 x 50	175 x 50	175 x 50	170 x 45	170 x 45	140 x 45	140 x 45
	4200	225 x 50	200 x 50	200 x 50	200 x 50	190 x 45	170 x 45	170 x 45	170 x 45
	4800	250 x 50	225 x 50	225 x 50	200 x 50	220 x 45	220 x 45	190 x 45	190 x 45
	5400	275 x 50	250 x 50	250 x 50	225 x 50	270 x 45	220 x 45	220 x 45	220 x 45
1200	3000	175 x 50	175 x 50	150 x 50	150 x 50	170 x 45	170 x 45	140 x 45	140 x 45
	3600	200 x 50	200 x 50	200 x 50	175 x 50	220 x 45	170 x 45	170 x 45	170 x 45
	4200	225 x 50	225 x 50	225 x 50	200 x 50	240 x 45	220 x 45	190 x 45	170 x 45
	4800	275 x 50	250 x 50	250 x 50	225 x 50	270 x 45	240 x 45	220 x 45	220 x 45
	5400	300 x 50	275 x 50	275 x 50	250 x 50	290 x 45	270 x 45	240 x 45	220 x 45
1500	3000	200 x 50	175 x 50	175 x 50	150 x 50	190 x 45	170 x 45	170 x 45	140 x 45
	3600	225 x 50	200 x 50	200 x 50	200 x 50	220 x 45	220 x 45	190 x 45	170 x 45
	4200	275 x 50	250 x 50	225 x 50	225 x 50	270 x 45	240 x 45	220 x 45	190 x 45
	4800	300 x 50	275 x 50	275 x 50	250 x 50	290 x 45	270 x 45	240 x 45	220 x 45
	5400	-	300 x 50	300 x 50	275 x 50	-	290 x 45	270 x 45	240 x 45

ASPECT RATIO h/d	ROOF PITCH (degrees)
0.5 1.0	10 15

TABLE 10-3

RAFTERS

RAFTER SPACING (mm)	RAFTER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
900	3000	175 x 50	150 x 50	150 x 50	150 x 50	170 x 45	170 x 45	140 x 45	120 x 45
	3600	200 x 50	175 x 50	175 x 50	175 x 50	220 x 45	170 x 45	170 x 45	140 x 45
	4200	225 x 50	200 x 50	200 x 50	200 x 50	240 x 45	220 x 45	190 x 45	170 x 45
	4800	275 x 50	225 x 50	225 x 50	200 x 50	270 x 45	240 x 45	220 x 45	190 x 45
	5400	300 x 50	250 x 50	250 x 50	225 x 50	290 x 45	270 x 45	240 x 45	220 x 45
1200	3000	200 x 50	175 x 50	175 x 50	150 x 50	220 x 45	170 x 45	170 x 45	140 x 45
	3600	250 x 50	225 x 50	200 x 50	175 x 50	240 x 45	220 x 45	190 x 45	170 x 45
	4200	275 x 50	250 x 50	225 x 50	200 x 50	270 x 45	240 x 45	220 x 45	190 x 45
	4800	300 x 50	275 x 50	250 x 50	225 x 50	-	270 x 45	240 x 45	220 x 45
	5400	-	300 x 50	275 x 50	250 x 50	-	-	270 x 45	240 x 45
1500	3000	225 x 50	200 x 50	175 x 50	175 x 50	220 x 45	220 x 45	190 x 45	170 x 45
	3600	275 x 50	250 x 50	225 x 50	200 x 50	270 x 45	240 x 45	220 x 45	190 x 45
	4200	300 x 50	275 x 50	250 x 50	225 x 50	-	270 x 45	240 x 45	220 x 45
	4800	-	300 x 50	275 x 50	250 x 50	-	-	270 x 45	240 x 45
	5400	-	-	300 x 50	275 x 50	-	-	-	270 x 45

ASPECT RATIO h/d	ROOF PITCH (degrees)
1.0	10

TABLE 10-4

RAFTERS

RAFTE R SPACING (mm)	RAFTER SPAN (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
900	3000	200 x 50	175 x 50	150 x 50	150 x 50	190 x 45	170 x 45	170 x 45	140 x 45
	3600	225 x 50	200 x 50	175 x 50	175 x 50	220 x 45	190 x 45	170 x 45	170 x 45
	4200	275 x 50	225 x 50	200 x 50	200 x 50	270 x 45	220 x 45	220 x 45	190 x 45
	4800	300 x 50	275 x 50	250 x 50	200 x 50	290 x 45	270 x 45	240 x 45	220 x 45
	5400	-	300 x 50	275 x 50	225 x 50	-	290 x 45	270 x 45	240 x 45
1200	3000	225 x 50	200 x 50	175 x 50	175 x 50	220 x 45	190 x 45	170 x 45	170 x 45
	3600	275 x 50	250 x 50	225 x 50	200 x 50	270 x 45	240 x 45	220 x 45	190 x 45
	4200	300 x 50	275 x 50	250 x 50	225 x 50	-	270 x 45	240 x 45	220 x 45
	4800	-	300 x 50	275 x 50	250 x 50	-	-	270 x 45	240 x 45
	5400	-	-	300 x 50	275 x 50	-	-	-	270 x 45
1500	3000	250 x 50	225 x 50	200 x 50	175 x 50	270 x 45	220 x 45	220 x 45	190 x 45
	3600	300 x 50	275 x 50	250 x 50	225 x 50	290 x 45	270 x 45	240 x 45	220 x 45
	4200	-	300 x 50	275 x 50	250 x 50	-	-	270 x 45	240 x 45
	4800	-	-	300 x 50	275 x 50	-	-	-	270 x 45
	5400	-	-	-	300 x 50	-	-	-	-

TABLE 11

PURLINS

<table>
<tr><th rowspan="2">RAFTER SPACING (mm)</th><th rowspan="2">PURLIN SPACING (mm)</th><th colspan="4">UNSEASONED</th><th colspan="4">SEASONED</th></tr>
<tr><th>F4</th><th>F5</th><th>F7</th><th>F8</th><th>F4</th><th>F5</th><th>F7</th><th>F8</th></tr>
<tr><td rowspan="3">900</td><td>750</td><td colspan="2" rowspan="3">75 x 50</td><td colspan="2" rowspan="3">50 x 75</td><td rowspan="3">70 x 45</td><td colspan="3">45 x 70</td></tr>
<tr><td>900</td><td rowspan="2">70 x 45</td><td colspan="2" rowspan="2">70 x 35</td></tr>
<tr><td>1200</td></tr>
<tr><td rowspan="3">1200</td><td>750</td><td colspan="4" rowspan="2">75 x 50</td><td rowspan="3">90 x 45</td><td colspan="3" rowspan="3">70 x 45</td></tr>
<tr><td>900</td></tr>
<tr><td>1200</td><td>100 x 50</td><td colspan="3">75 x 50</td></tr>
<tr><td rowspan="3">1500</td><td>750</td><td colspan="3" rowspan="3">100 x 50</td><td rowspan="3">75 x 50</td><td colspan="3" rowspan="3">90 x 45</td><td rowspan="3">70 x 45</td></tr>
<tr><td>900</td></tr>
<tr><td>1200</td></tr>
</table>

TABLE 12

VERANDAH POSTS

POST HEIGHT (mm)	AREA OF ROOF SUPPORTED (square metres)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
2400	5	100 x 100	100 x 100	100 x 100	100 x 100	90 x 90	70 x 70	70 x 70	70 x 70
	10	100 x 100	100 x100	100 x 100	100 x 100	90 x 90	90 x 90	90 x 90	70 x 70
	20	-	100 x 100	100 x 100	100 x 100	-	90 x 90	90 x 90	90 x 90
2700	5	100 x 100	100 x 100	100 x 100	100 x 100	90 x 90	70 x 70	70 x 70	70 x 70
	10	100 x 100	100 x 100	100 x 100	100 x 100	90 x 90	90 x 90	90 x 90	90 x 90
	20	-	-	100 x 100	100 x100	-	-	90 x 90	90 x 90

TABLE 13

BEARERS SUPPORTING TWO STOREY LOADBEARING WALLS

BEARER SPACING (mm)	BEARER SPAN (mm)	STRESS GRADE			
		F4	F5	F7	F8
1800	1500	200 x 75	175 x 75	150 x 75	150 x 75
	1800	225 x 75	200 x 75	200 x 75	175 x 75
	2100	275 x 75	250 x 75	225 x 75	200 x 75
	2400	300 x 75	275 x 75	250 x 75	250 x 75
	2700	-	300 x 75	275 x 75	275 x 75
	3000	-	-	300 x 75	300 x 75
	3300	-	-	-	-
	3600	-	-	-	-
3600	1500	225 x 75	200 x 75	175 x 75	150 x 75
	1800	275 x 75	250 x 75	200 x 75	175 x 75
	2100	-	275 x 75	250 x 75	225 x 75
	2400	-	300 x 75	275 x 75	250 x 75
	2700	-	-	300 x 75	275 x 75
	3000	-	-	-	300 x 75
	3300	-	-	-	-
	3600	-	-	-	-

TABLE 14

STUDS - LOWER STOREY OF TWO STOREYS

STUD SPACING (mm)	STUD HEIGHT (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
450	2400	100 x 40				90 x 45	90 x 35		
	2700	100 x 50	100 x 40			90 x 70	90 x 45	90 x 35	
600	2400	100 x 50	100 x 40			90 x 70	90 x 45	90 x 35	
	2700	100 x 75	100 x 50	100 x 40		90 x 70		90 x 45	90 x 35

TABLE 15

STUDS - INTERNAL WALLS - LOWER STOREY O F TWO STOREYS

75 mm Nominal Frame

STUD HEIGHT (mm)	STUD SPACING (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
2400	450	75 x 50	75 x 40	75 x 40	75 x 40	70 x 45	70 x 35	70 x 35	70 x 35
	600	-	75 x 50	75 x 50	75 x 50	-	70 x 45	70 x 45	70 x 35
2700	450	-	-	75 x 50	75 x 50	-	-	-	70 x 45
	600	-	-	-	-	-	-	-	-

100 mm Nominal Frame

MAX. STUD HEIGHT (mm)	MAX. STUD SPACING (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
2700	600	100 x 40				90 x 35			

TABLE 16

STUDS AT SIDES OF OPENINGS – LOWER STOREY OF TWO STOREY CONSTRUCTION

STUD HEIGHT (mm)	OPENING WIDTH (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
2400	900	100 x 50	100 x 40	100 x 40	100 x 40	2/90 x 35	90 x 45	90 x 35	90 x 35
	1200	2/100 x 40	100 x 50	100 x 40	100 x 40	2/90 x 35	90 x 45	90 x 45	90 x 35
	1500	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	90 x 45	90 x 45
	1800	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	2/90 x 35	90 x 45
2700	900	2/100 x 40	100 x 50	100 x 40	100 x 40	2/90 x 35	2/90 x 35	90 x 45	90 x 45
	1200	2/100 x 40	2/100 x 40	100 x 50	100 x 40	2/90 x 35	2/90 x 35	2/90 x 35	90 x 45
	1500	2/100 x 40	2/100 x 40	2/100 x 40	100 x 50	2/90 x 45	2/90 x 35	2/90 x 35	2/90 x 35
	1800	2/100 x 50	2/100 x 40	2/100 x 40	100 x 50	2/90 x 45	2/90 x 45	2/90 x 35	2/90 x 35

TABLE 17

TOP PLATES - LOWER STOREY O F TWO STOREYS

MAXIMUM BUILDING WIDTH: 9000 MM

75 mm Nominal Frame

MAX. JOIST SPACING (mm)	MAX. STUD SPACING (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
450	450	75 x 75	75 x 75	50 x 75	50 x 75	70 x 70	70 x 70	45 x 70	45 x 70
450	600	75 x 75	75 x 75	50 x 75	50 x 75	70 x 70	70 x 70	45 x 70	45 x 70
600	450	75 x 75	75 x 75	50 x 75	50 x 75	70 x 70	70 x 70	45 x 70	45 x 70
600	600	75 x 75	75 x 75	75 x 75	75 x 75	70 x 70	70 x 70	70 x 70	70 x 70

100 mm Nominal Frame

MAX. JOIST SPACING (mm)	MAX. STUD SPACING (mm)	UNSEASONED				SEASONED			
		F4	F5	F7	F8	F4	F5	F7	F8
450	450	50 x 100	50 x 100	50 x 100	50 x 100	45 x 90	45 x 90	45 x 90	45 x 90
450	600	75 x 100	50 x 100	50 x 100	50 x 100	70 x 90	45 x 90	45 x 90	45 x 90
600	450	75 x 100	50 x 100	50 x 100	50 x 100	70 x 90	45 x 90	45 x 90	45 x 90
600	600	75 x 100	75 x 100	50 x 100	50 x 100	70 x 90	70 x 90	45 x 90	45 x 90

TABLE 18

BOTTOM PLATES - LOWER STOREY WALLS

MAXIMUM BUILDING WIDTH: 9000 MM
UPPER FLOOR JOIST SPACING: 450 MM

F4	F5	F7	F8
75 x 75		50 x 75	
75 x 100		50 x 100	

TABLE 19

LINTELS - LOWER STOREY OF TWO STOREYS

MAXIMUM WIDTH OF OPENING (mm)	UNSEASONED				SEASONED			
	F4	F5	F7	F8	F4	F5	F7	F8
900	150 x 75	150 x 75	150 x 75	150 x 75	140 x 70	120 x 45	120 x 45	120 x 45
1200	150 x 75	150 x 75	150 x 75	150 x 75	140 x 70	120 x 45	120 x 45	120 x 45
1500	150 x 75	150 x 75	150 x 75	150 x 75	190 x 70	140 x 70	140 x 70	120 x 45
1800	200 x 75	175 x 75	175 x 75	175 x 75	240 x 70	190 x 70	140 x 70	140 x 70
2100	225 x 75	200 x 75	200 x 75	200 x 75	240 x 70	190 x 70	190 x 70	190 x 70
2400	250 x 75	225 x 75	225 x75	200 x 75	-	240 x 70	240 x 70	190 x 70

VERANDAH BEAMS

The following sets of tables provide the sizes of timber members corresponding to the design windspeed given in clause A4. The tables are numbered 1 to 20 and each table contains the member size for the various components of a timber framed house.

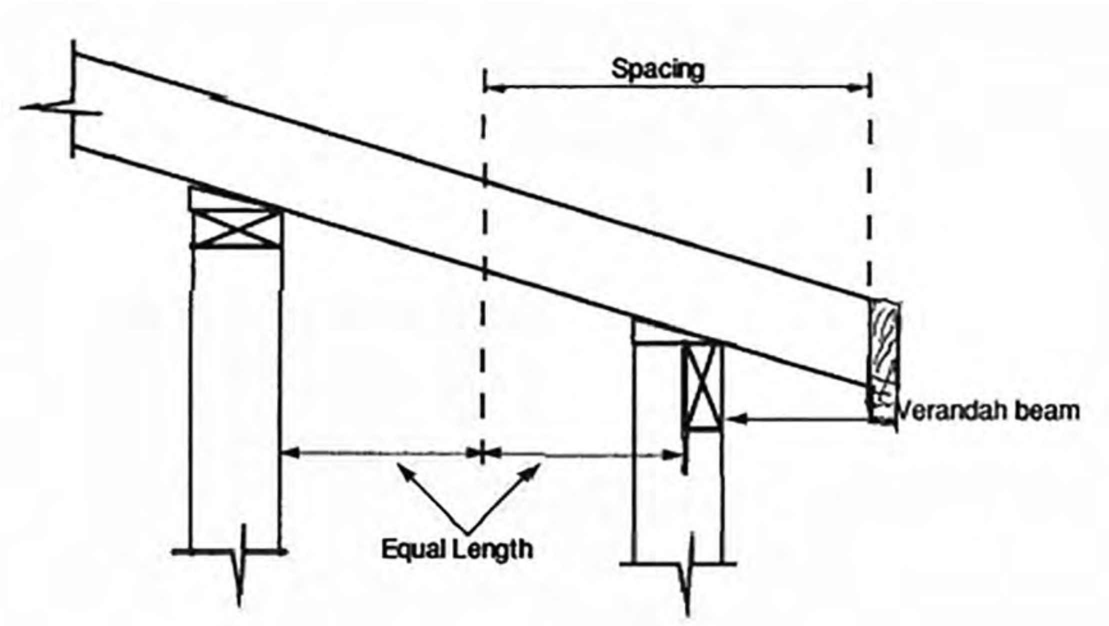


FIGURE B8.3.2: VERANDAH BEAM SPACING

TABLE 20

ROOF BEAMS - NON-TRAFFICABLE ROOFS

BEAM SPAN (mm)	BEAM SPACING (mm)	UNSEASONED			
		F4	F5	F7	F8
3000	2400	250 x 75	225 x 75	200 x 75	200 x 75
	3000	250 x 75	250 x 75	225 x 75	225 x 75
	3600	275 x 75	250 x 75	250 x 75	225 x 75
	4200	275 x 75	275 x 75	250 x 75	250 x 75
3600	2400	275 x 75	275 x 75	250 x 75	250 x 75
	3000	300 x 75	300 x 75	275 x 75	250 x 75
	3600	300 x 100	300 x 75	300 x 75	275 x 75
	4200	300 x 100	300 x 100	300 x 75	300 x 75
4200	2400	300 x 100	300 x 100	300 x 75	275 x 75
	3000	300 x 100	300 x 100	300 x 75	300 x 75
	3600	-	-	300 x 100	300 x 100
	4200	-	-	300 x 100	300 x 100

B9 BRACING

B9.1 Scope

The following clauses give the bracing demand on walls due to wind and provide connection details for walls as well as the bracing capacity of different wall systems.

B9.2 Application

1. Determine bracing demand for the storey type and direction from Clauses B9.3.2 and B9.3.3.

2. Select bracing capacity of sub-floor bracing from Figure B9.4.2.

3. Select bracing capacity of walls from Figure B9.4.3.

The total bracing capacity MUST be greater than or equal to the bracing demand required for that particular direction.

B9.3 Bracing Demand

B9.3.1 Bracing Demand

Bracing demand is the force exerted by wind on a house in the direction under consideration. Bracing demand is based on the area of wall against which the wind blows. The applicable demand is derived in the following manner. Consider one direction at a time. Assume that wind at right angles to building length is 'direction A' and wind at right angles to building width is 'direction B'.

B9.3.2 Determination of Bracing Demand for 'Direction A’

From Table B9.3(A) determine the bracing demand for wind at right angles to building length for the storey type under consideration.

B9.3.3 Determination of Bracing Demand for 'Direction B'

From Table B9.3(B) determine the bracing demand for wind at right angles to building width for the storey type under consideration.

B9.4 Bracing Capacity

B9.4.1 General

The bracing demand derived from Clause B9.3 for each of the two directions must be resisted by bracing walls in the matching direction as shown in Figure B9.4.1. The total bracing capacity of the walls for the direction under consideration must be equal to or greater than the bracing demand for that direction.

B9.4.2 Bracing capacity of sub-floor bracing types

Bracing capacity of sub-floor bracing types is given in Figure B9.4.2.

B9.4.3 Bracing capacity of wall systems

Bracing capacities of various wall systems are given in Figure B9.4.3.

B9.5 Fixing of Bracing Walls

B9.5.1 Fixing of Top of Bracing Walls

All timber framed bracing walls must be fixed to the roof frame and/or external wall frame with connections of equal or more strength to the bracing capacity of that wall. Refer to Figure B9.5.1 for details.

B9.5.2 Fixing of Bottom of Bracing Walls

The bottom plate of all timber framed bracing walls must be fixed at their ends and intermediately at 1200 mm centres to the floor frame with an appropriate connection determined from Figure B9.5.2.

TABLE B9.3(A)

TOTAL BRACING DEMAND (KN) – WIND FORCES
(TOTAL DEMAND = L X KN/M)

WIND AT RIGHT ANGLES TO HOUSE LENGTH					
STOREY TYPE	WIDTH W (m)	ROOF PITCH (degrees)			
		≤ 10	15	20	25
Single storey (Lowset)	4	2.1	2.1	2.3	2.9
	6	2.1	2.1	2.4	3.1
	8	2.1	2.1	2.4	3.2
	10	2.1	2.1	2.4	3.4
	12	2.1	2.1	2.5	3.6
Upper storey of two Storey	4	2.1	2.1	2.3	2.9
	6	2.1	2.1	2.4	3.1
	8	2.1	2.1	2.4	3.2
	10	2.1	2.1	2.4	3.4
	12	2.1	2.1	2.5	3.6
Upper storey of highset or sub - floor	4	2.3	2.3	2.5	3.1
	6	2.3	2.3	2.6	3.3
	8	2.3	2.3	2.6	3.5
	10	2.3	2.3	2.6	3.6
	12	2.3	2.3	2.7	3.8
Lower storey of two storey	4	6.0	6.0	6.7	7.9
	6	6.0	6.0	6.7	8.3
	8	6.0	6.0	6.8	8.7
	10	6.0	6.0	6.9	9.1
	12	6.0	6.0	6.9	9.5

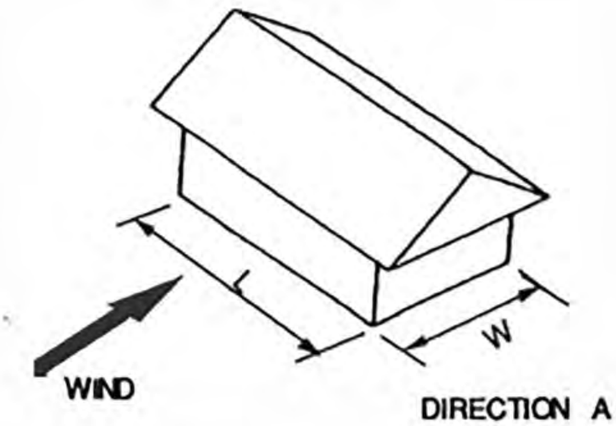
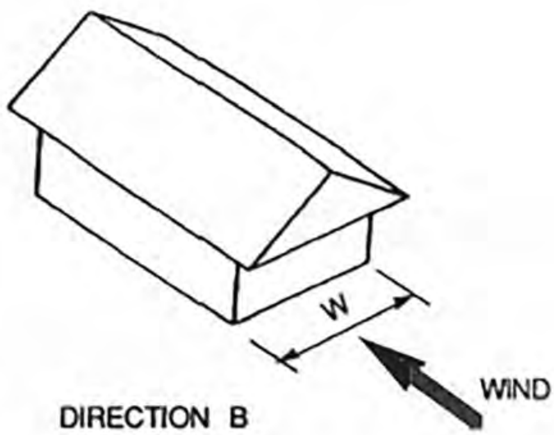
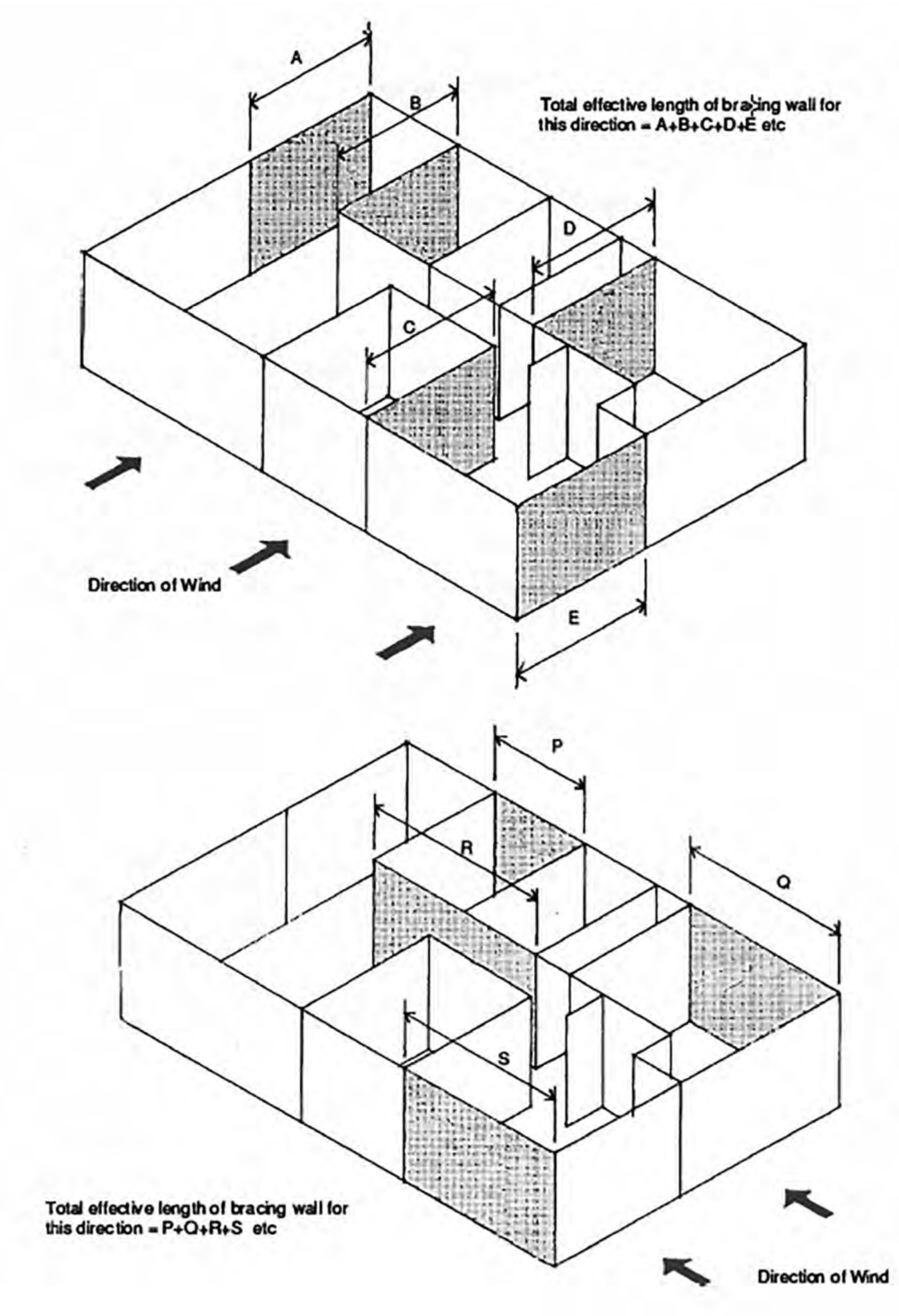


TABLE B9.3(B)

TOTAL BRACING DEMAND (KN) – WIND FORCES

WIND AT RIGHT ANGLES TO HOUSE WIDTH					
STOREY TYPE	WIDTH W (m)	ROOF PITCH (degrees)			
		≤10	15	20	25
Single storey (Lowset)	4	10.1	10.6	11.1	11.6
	6	16.0	17.1	18.2	19.3
	8	22.4	24.4	26.4	28.2
	10	29.4	32.5	35.5	38.5
	12	36.9	41.4	45.8	50.0
Upper storey of two Storey	4	10.1	10.6	11.1	11.6
	6	16.0	17.1	18.2	19.3
	8	22.4	24.4	26.4	28.2
	10	29.4	32.5	35.5	38.5
	12	36.9	41.4	45.8	50.0
Upper storey of highset or sub-floor	4	11.0	11.6	12.1	12.6
	6	17.5	18.7	19.9	21.0
	8	24.5	26.7	28.8	30.8
	10	32.1	35.5	38.8	42.0
	12	40.3	45.2	49.9	54.6
Lower storey of two storey	4	28.4	29.4	30.3	31.3
	6	44.2	46.5	48.6	50.7
	8	61.1	65.1	69.0	72.8
	10	79.1	85.4	91.4	97.3
	12	98.2	107.2	115.9	124.4





NOTES:

i. Internal bracing must be evenly distributed.

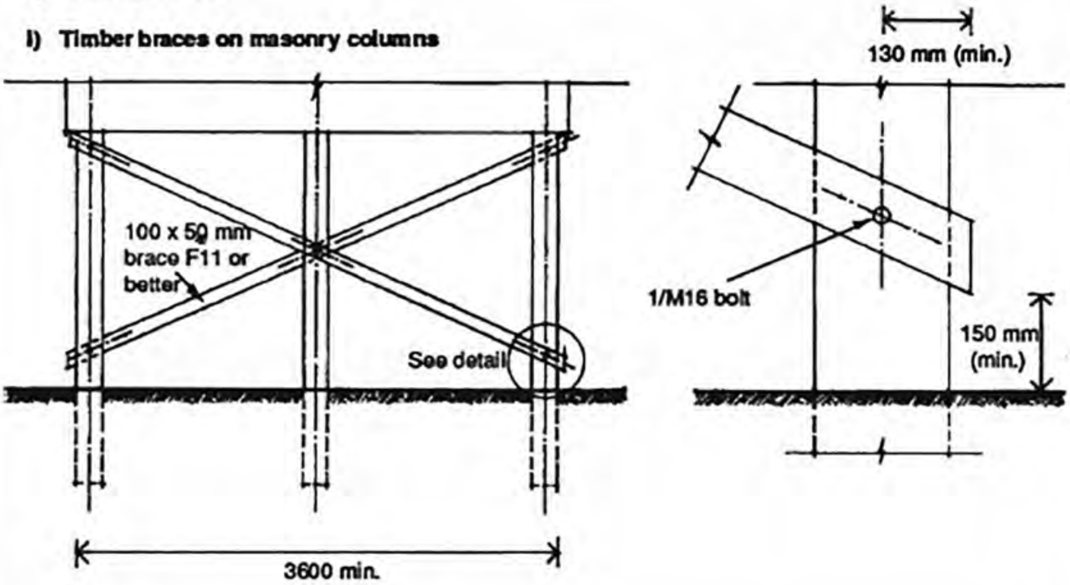
ii. Bracing walls must be provided in both directions.

FIGURE B9.4.1(A): LOCATION OF BRACING WALL

FIGURE B9.4.2	SUB-FLOOR BRACING TYPES	Bracing Capacity (kN)

B) BRACING SETS

i) Timber braces on masonry columns



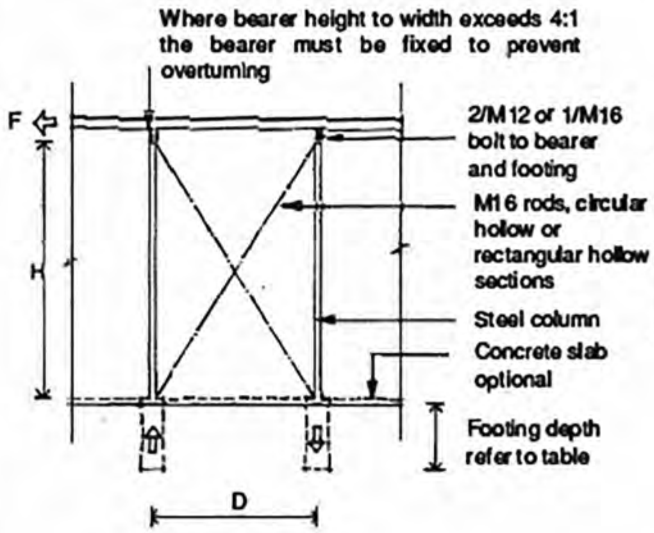
Bracing capacity: 10 kN per set

Notes

i) Where bearer height to width ratio exceeds 4:1, the bearer must be fixed to prevent overturning.

ii) Braces fixed to the same side of the posts must be half checked at crossing.

ii) Steel Braces on timber or steel columns

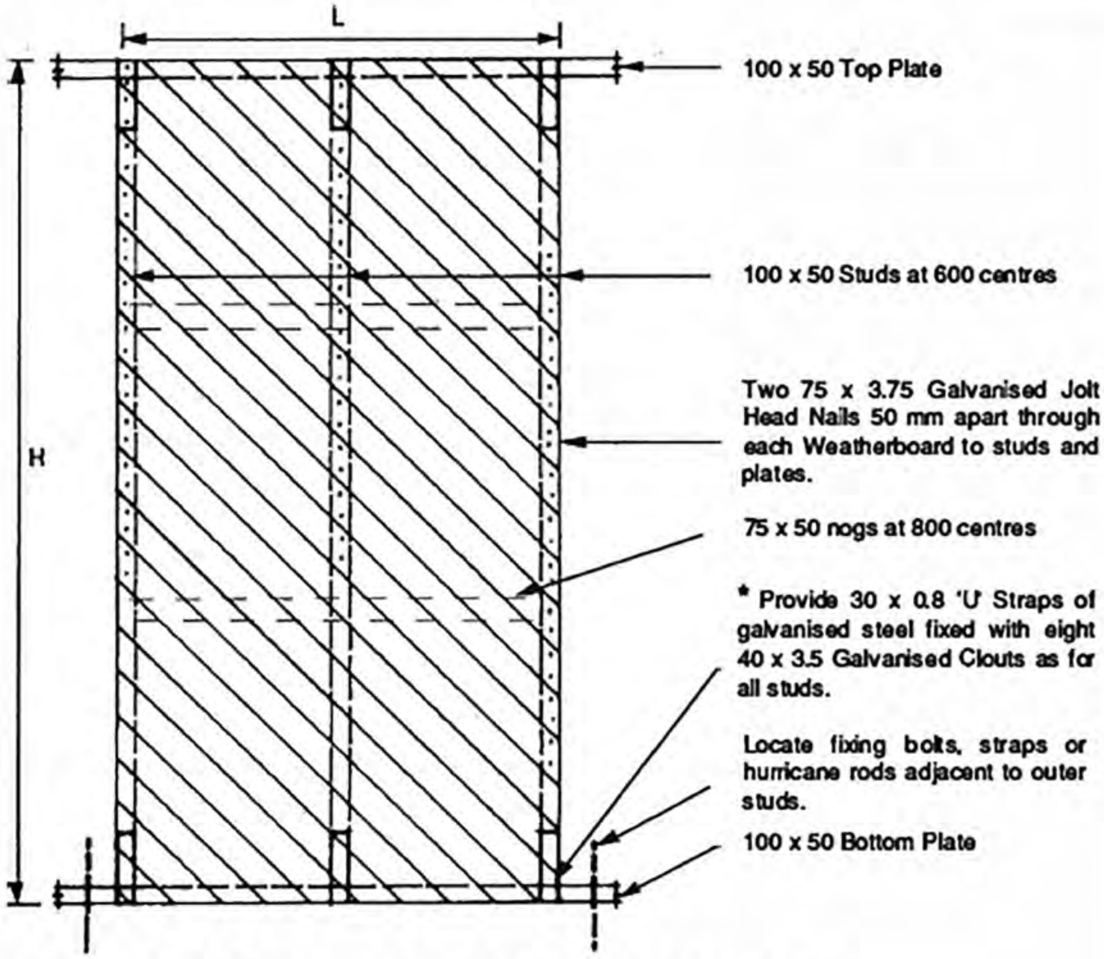


FOOTING DEPTH (mm)	MAX. TIE-DOWN FORCE 'U' (kN)
500	8.3
1000	15.0

FIGURE B9.4.3

WALL BRACING TYPES

(A)



WALL BRACING ELEMENTS CLAD WITH DIAGONAL WEATHERBOARDS

Bracing capacity of wall system (kN)

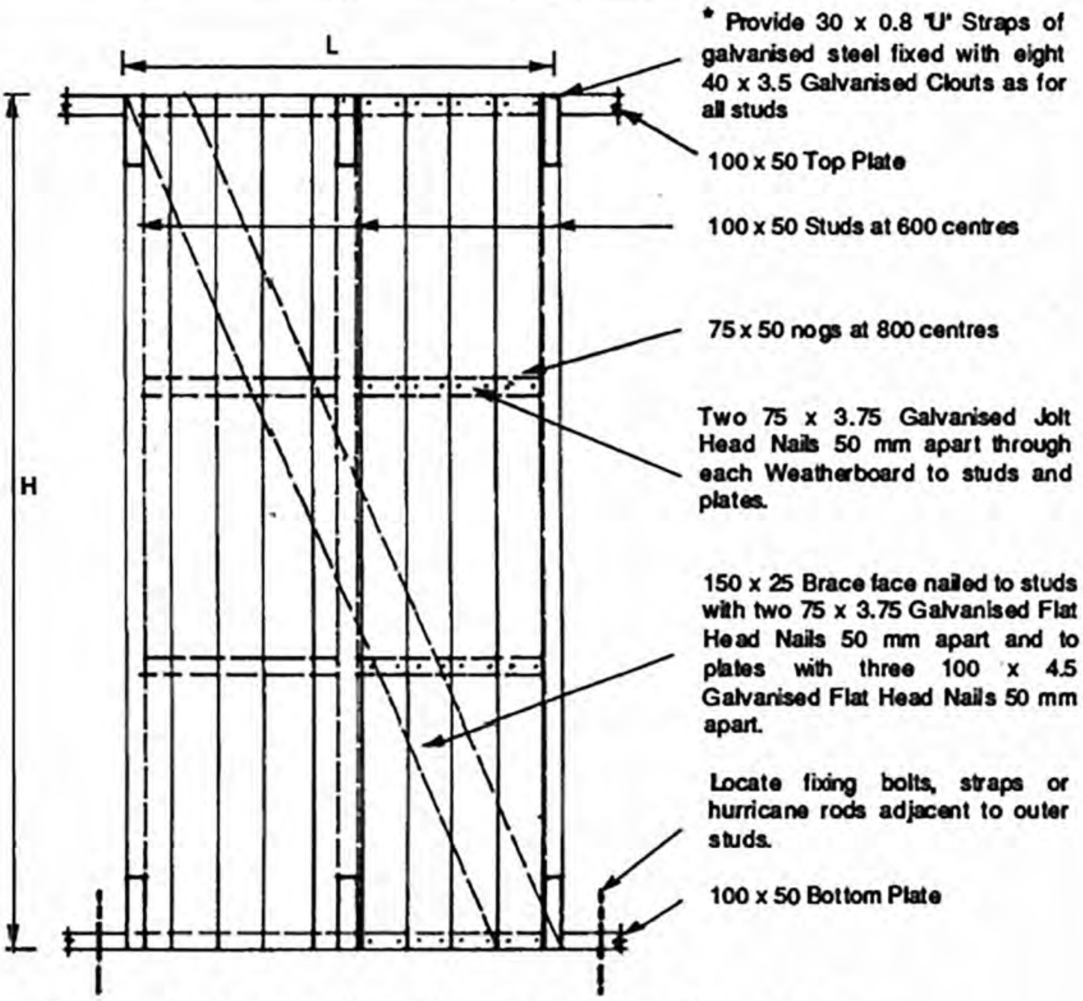
WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
1200	0.75	3.00
1500	0.94	3.75
1800	1.13	4.50
2100	1.31	5.25
2400	1.50	6.00
2700	1.69	6.75
3000	1.88	7.50

* Stud ties may be used as an alternative to galvanised steel 'U' straps.

FIGURE B9.4.3 continued

WALL BRACING TYPES

(B)



WALL BRACING ELEMENTS CLAD WITH VERTICAL WEATHERBOARDS

Bracing capacity of wall system (kN)

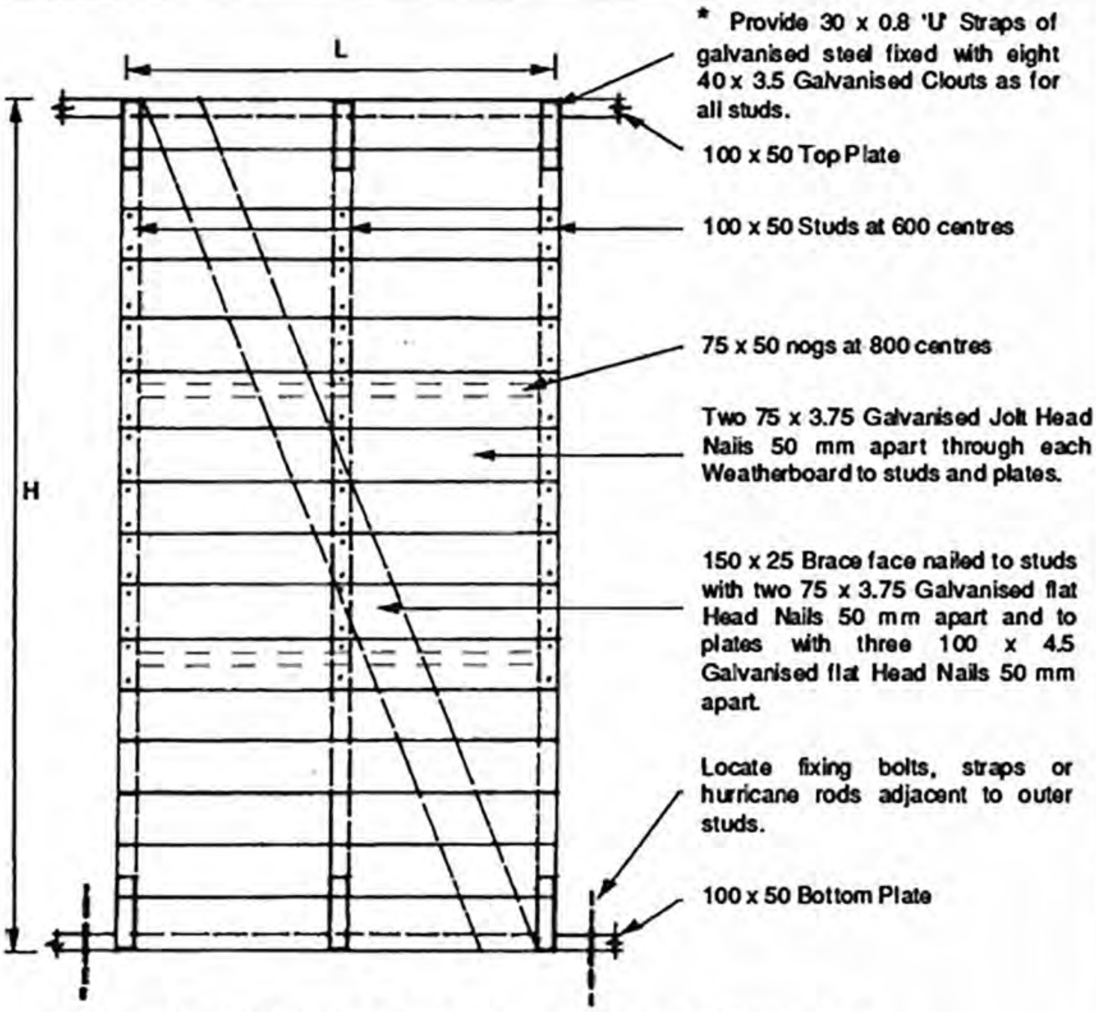
WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
1200	0.75	2.0
1500	0.94	2.5
1800	1.13	3.0
2100	1.31	3.5
2400	1.50	4.0
2700	1.69	4.5
3000	1.88	5.0

* Stud ties may be used as an alternative to galvanised steel straps.

FIGURE B9.4.3 continued

WALL BRACING TYPES

(C)



WALL BRACING ELEMENTS CLAD WITH VERTICAL WEATHERBOARDS

Bracing capacity of wall system (kN)

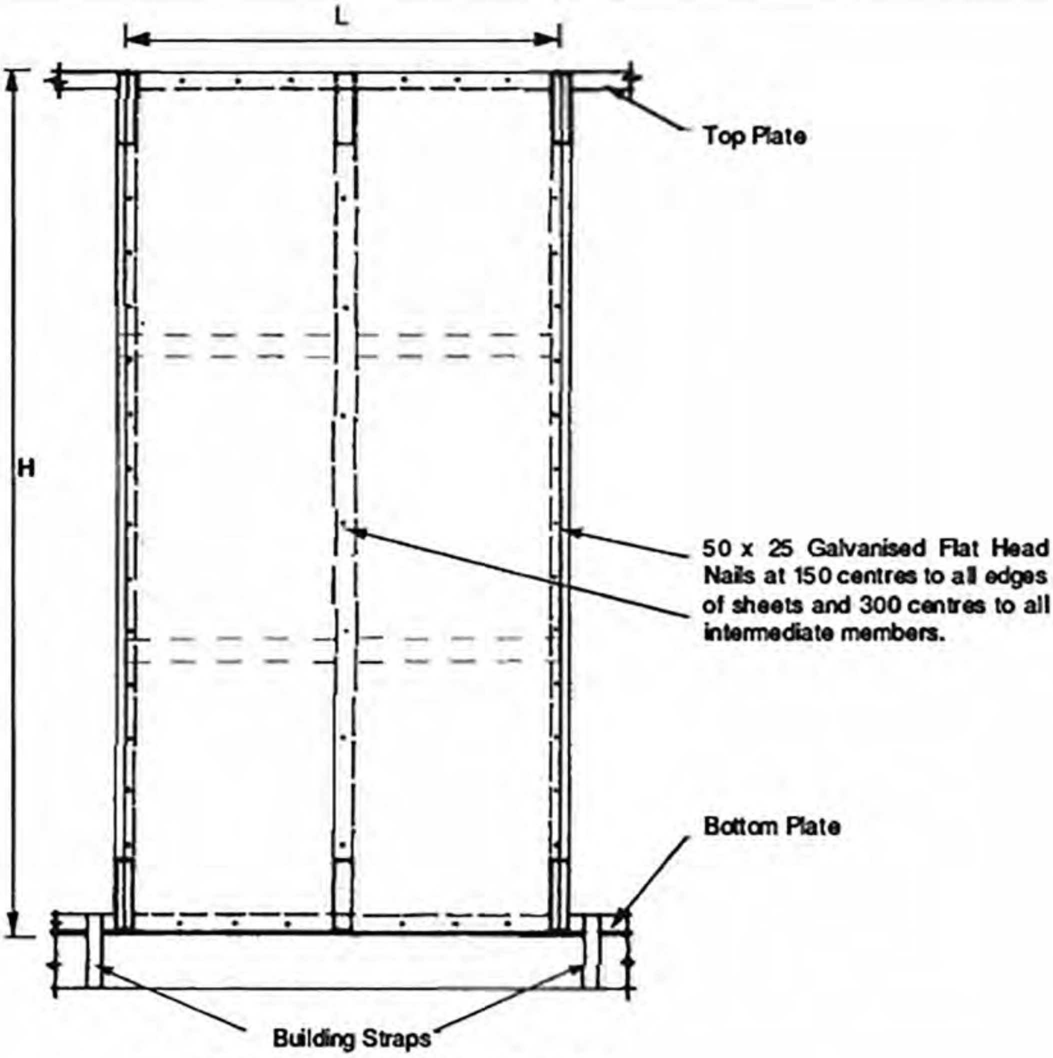
WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
1200	0.75	2.0
1500	0.94	2.5
1800	1.13	3.0
2100	1.31	3.5
2400	1.50	4.0
2700	1.69	4.5
3000	1.88	5.0

* Studs ties may be used as an alternative to galvanised steel straps.

FIGURE B9.4.3 continued

WALL BRACING TYPES

(D)



FULL HEIGHT WALL BRACING ELEMENT

SHEET WALL BRACING ELEMENTS (PLYWOOD, PARTICLE BOARD AND FIBRE CEMENT)

Bracing capacity of wall system (kN)

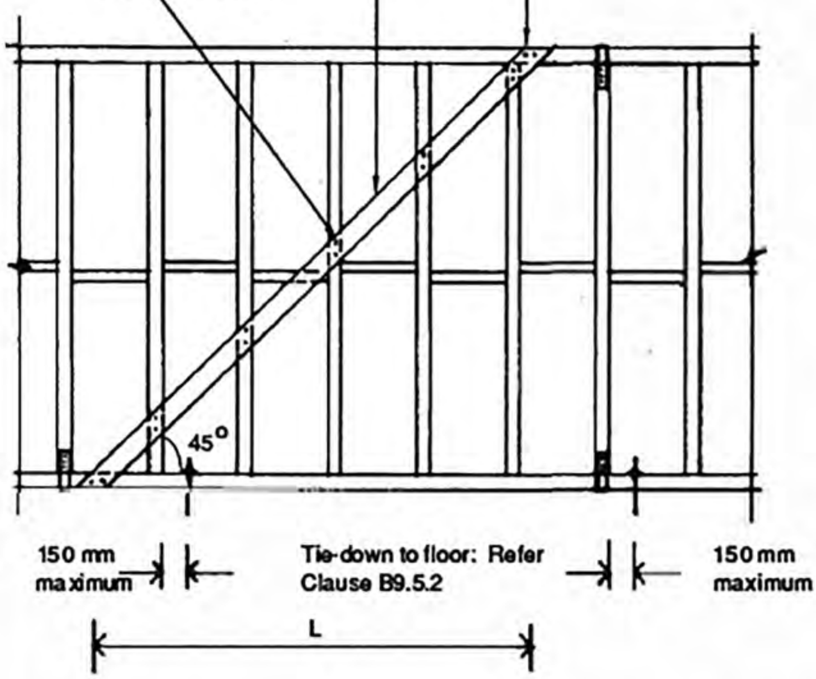
WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
1200	2.0	4.8
1500	2.5	6.0
1800	3.0	7.2
2100	3.5	8.4
2400	4.0	9.6
2700	4.5	10.8
3000	5.0	12.0

MINIMUM THICKNESS OF SHEET BRACING ELEMENTS

1. Plywood 7.5 mm
2. Fibre Cement Board 7.5 mm
3. Wood Based Products
   - Density 600 to 800 kg/m^3 9.0 mm
   - Density greater than 800 kg/m^3 4.5 mm

FIGURE B9.4.3 continued **BRACING TYPES**

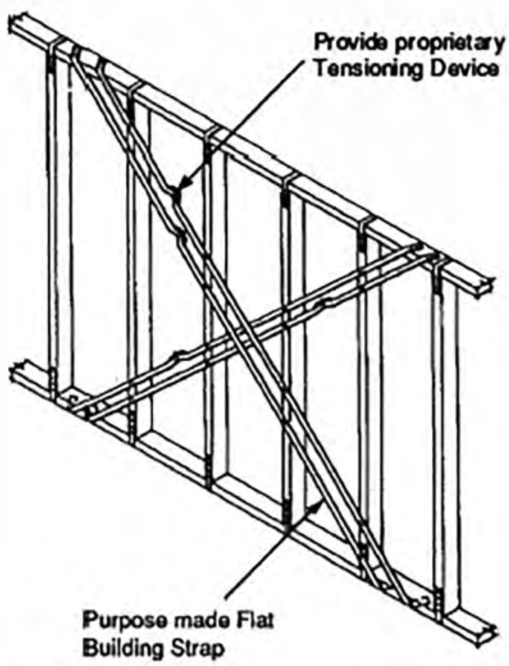
E) Timber braces



LENGTH OF BRACE (L) (mm)	BRACING CAPACITY (kN)
2400	2.4
2700	2.7

Notes:
i) The maximum depth of notch or sawcut must not exceed 20mm.
ii) Sawcuts are to be deemed to be notches.
iii) Cut-in braces may only be used on internal non-loadbearing bracing walls.

F) Metal braces



A number of metal braces are readily available at hardware stores. These are produced by various manufacturers who have had their products tested by the relevant Authorities.
To obtain design strengths of these braces, refer to manufacturers specifications.

FIGURE B9.5.1

FIXING OF BRACING WALLS TO ROOF FRAME, OR TO EXTERNAL WALL FRAME

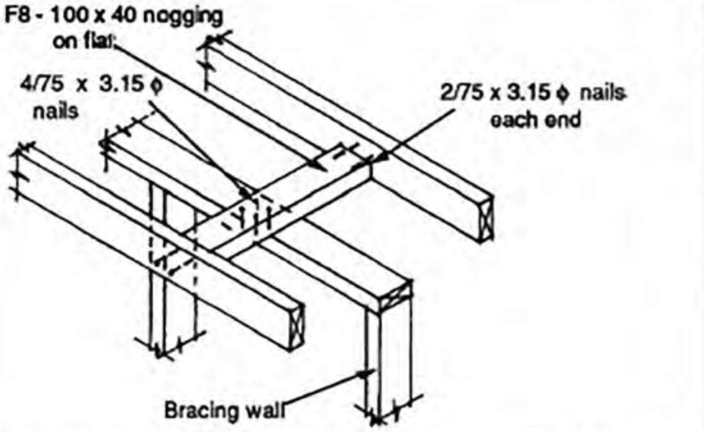
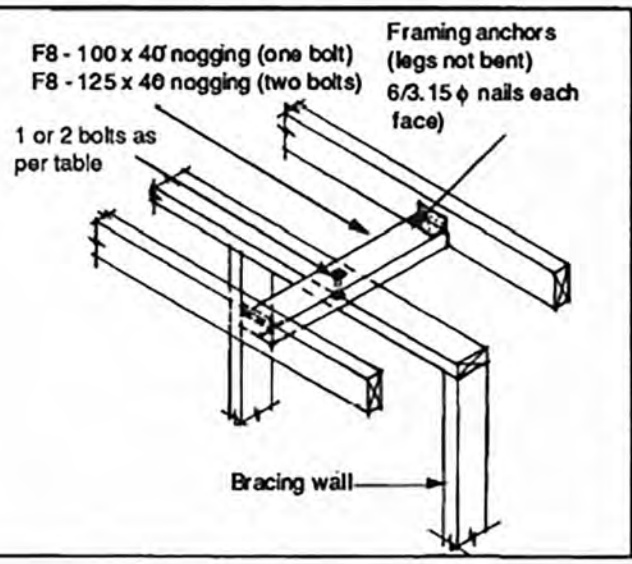
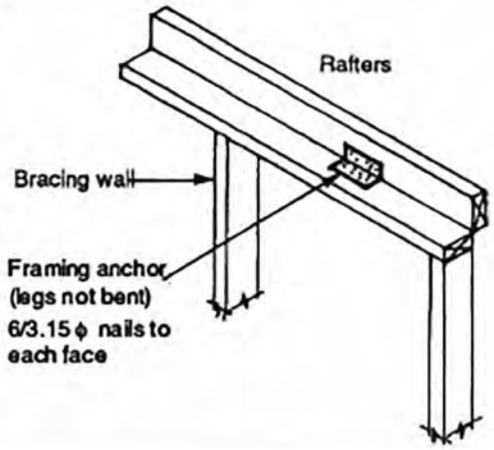
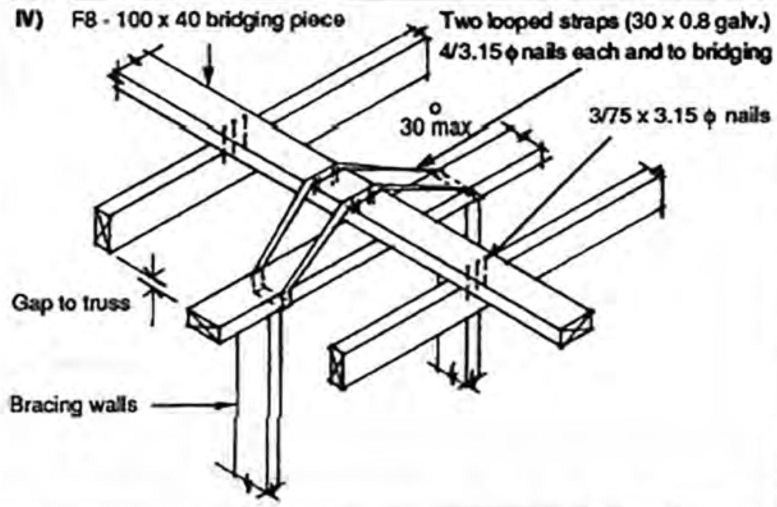
		Design Strength (kN)					
		Unseasoned timber			Seasoned timber		
		J2	J3	J4	JD2	JD3	JD4
Rafters or Trusses parallel to Bracing Wall							
I) 		1.8	1.3	0.94	2.3	1.8	1.3
II) 	Bolt Size						
	M10	3.9	2.5	1.6	4.6	3.5	2.6
	M12	4.6	3.0	1.9	5.6	4.2	3.1
	M16	6.2	4.0	2.5	7.6	5.6	4.2
	2/M10	7.8	5.0	3.2	8.0	7.0	5.2
	2/M12	8.0	6.0	3.8	8.0	8.0	6.2
III) 		4.9	3.5	2.5	6.6	5.2	3.7

FIGURE B9.5.1 continued

FIXING OF BRACING WALLS TO ROOF FRAME, OR TO EXTERNAL WALL FRAME

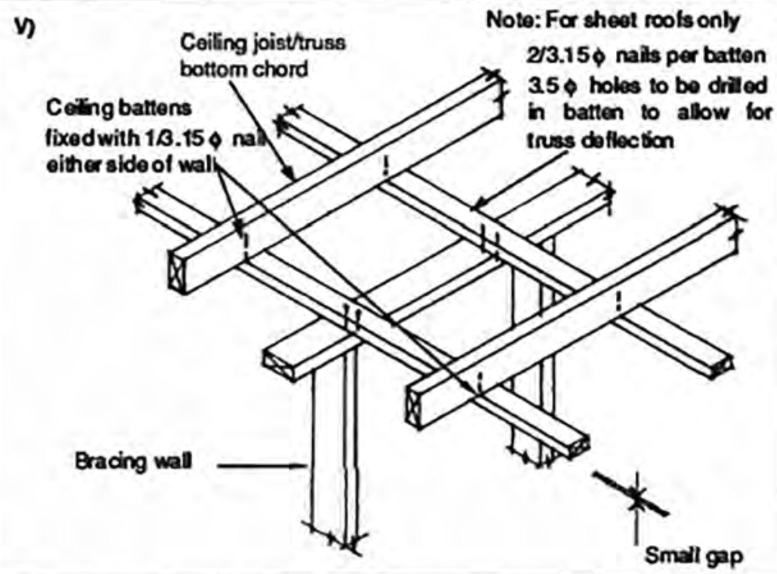
Rafters or Trusses parallel to Bracing Wall (cont.)

IV)



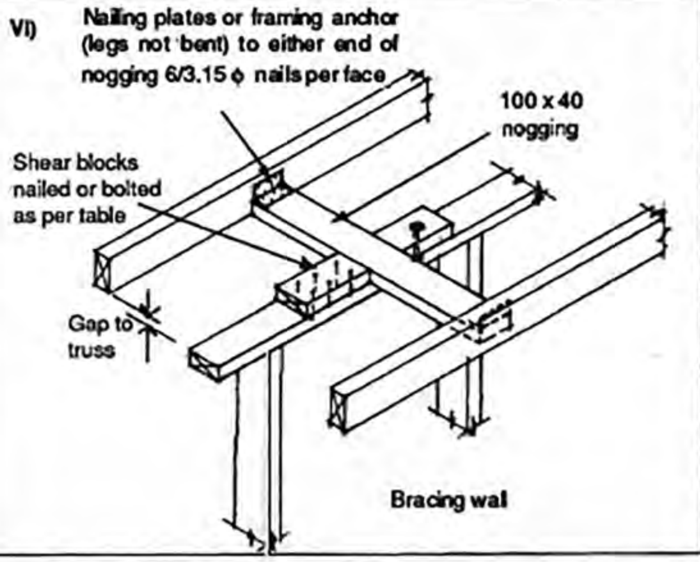
Design Strength (kN)	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
IV)	6.2	4.4	3.1	8.6	6.7	4.8

V)



Design Strength (kN)	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
V) PER BATTEN	1.5	1.1	0.8	2.0	1.5	1.1

VI)

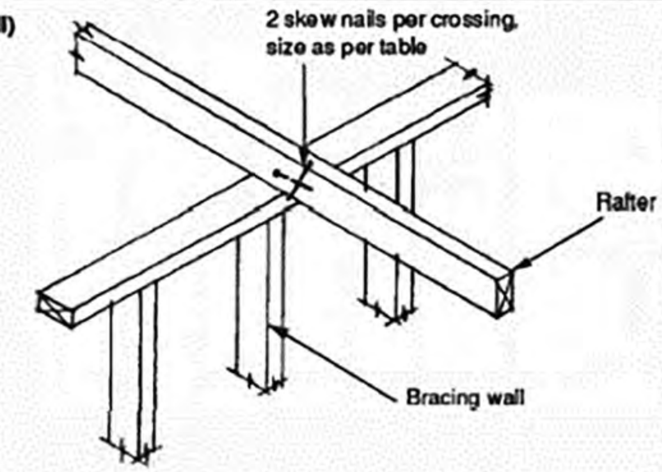


Nails	J2	J3	J4	JD2	JD3	JD4
4/3.15	3.1	2.2	1.6	3.9	3.1	2.2
4/3.75	4.2	3.0	2.1	5.3	4.2	3.0
6/3.15	4.1	2.9	2.1	5.4	4.3	3.1
Bolt Size						
M10	4.6	4.0	3.2	5.4	4.6	3.7
M12	6.6	5.0	4.0	7.0	5.4	4.4
M16	8.4	6.7	5.3	9.3	7.3	5.9

FIGURE B9.5.1 Continued

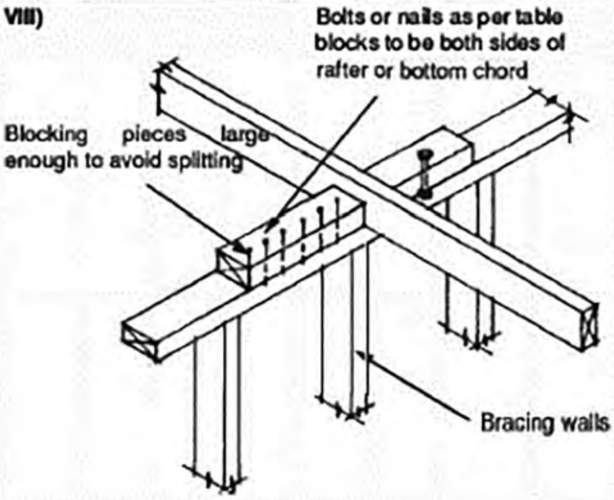
FIXING OF BRACING WALLS TO ROOF FRAME, OR TO EXTERNAL WALL FRAME

VII)



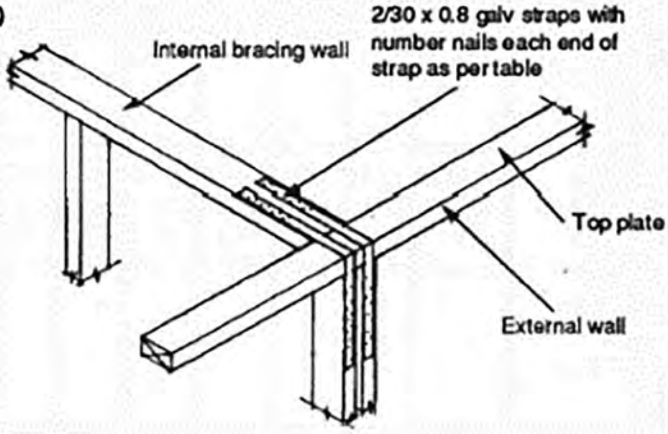
Nails	Design Strength (kN) Unseasoned timber J2	J3	J4	Seasoned timber JD2	JD3	JD4
2/3.15	1.5	1.1	0.8	1.1	0.9	0.7
2/3.75	2.1	1.5	1.1	2.7	2.1	1.5

VIII)



Nails	J2	J3	J4	JD2	JD3	JD4
4/3.15	3.1	2.2	1.6	3.9	3.1	2.2
4/3.75	4.2	3.0	2.1	5.3	4.2	3.0
6/3.15	4.1	2.9	2.1	5.4	4.3	3.1
Bolt Size						
M10	4.6	4.0	3.2	5.4	4.6	3.7
M12	6.6	5.0	4.0	7.0	5.4	4.4
M16	8.4	6.7	5.3	9.3	7.3	5.9

IX)



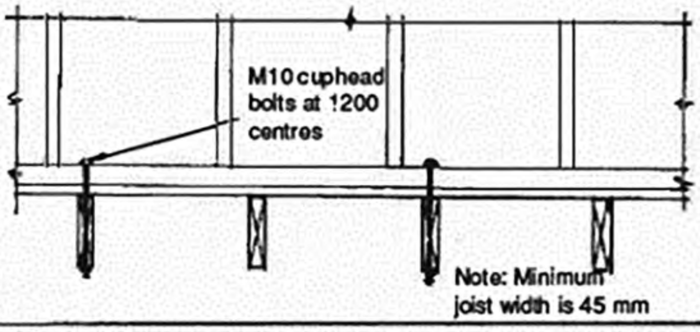
Nails	J2	J3	J4	JD2	JD3	JD4
4/3.15	7.4	5.3	3.7	9.4	5.3	4.4
6/3.15	9.7	7.0	4.9	13	10.3	7.4

Note: Where one strap is used, loads may be half of those tabled.

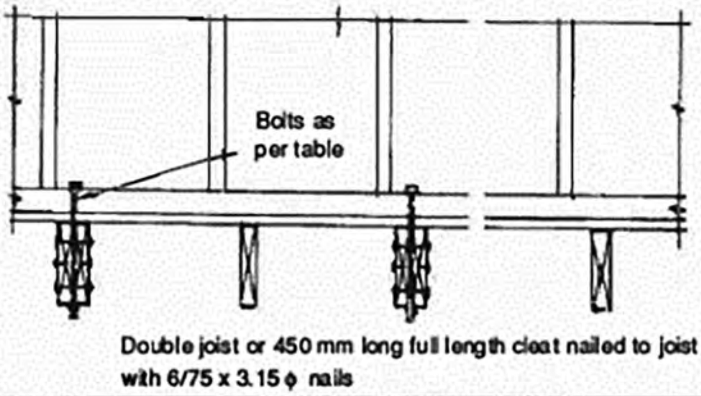
FIGURE B9.5.2

TIE-DOWN: BOTTOM OF BRACING WALLS

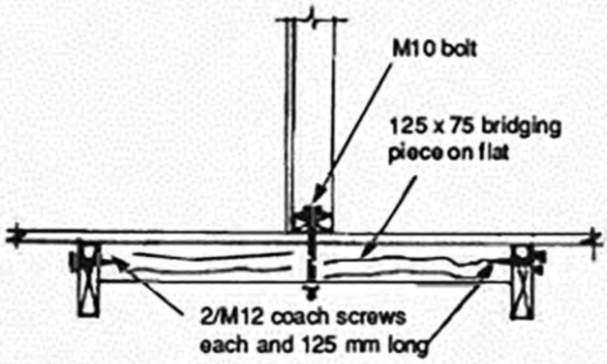
I)



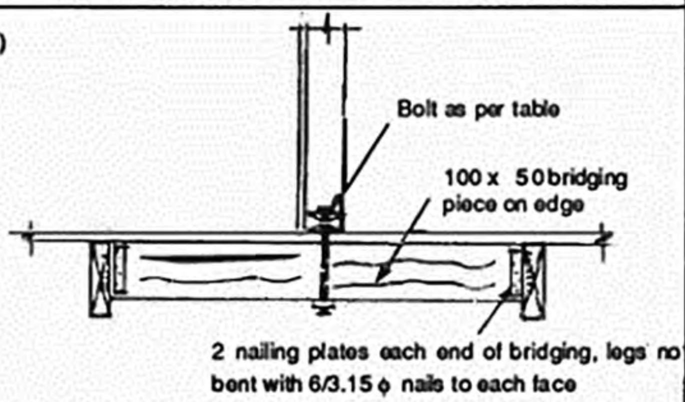
II)



III)

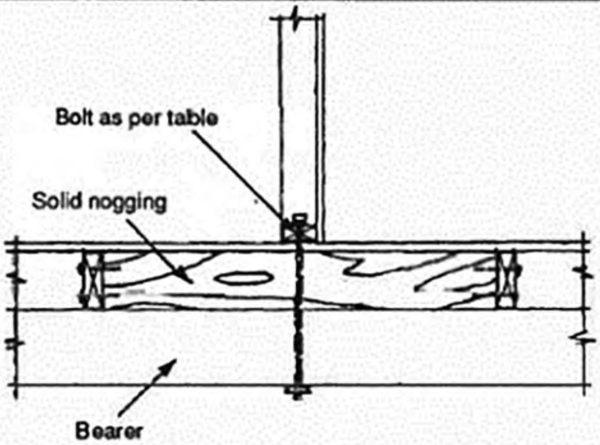
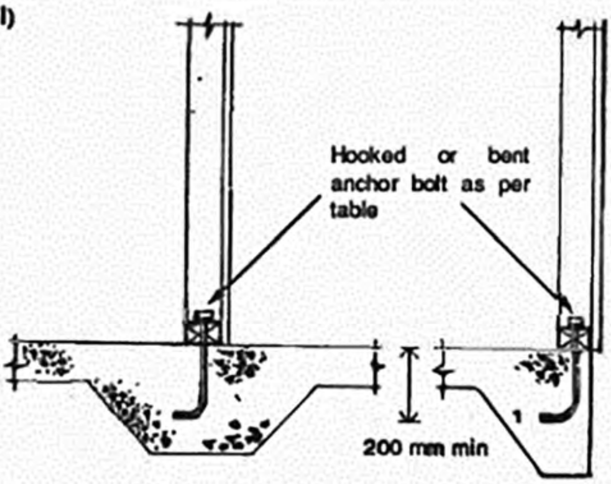
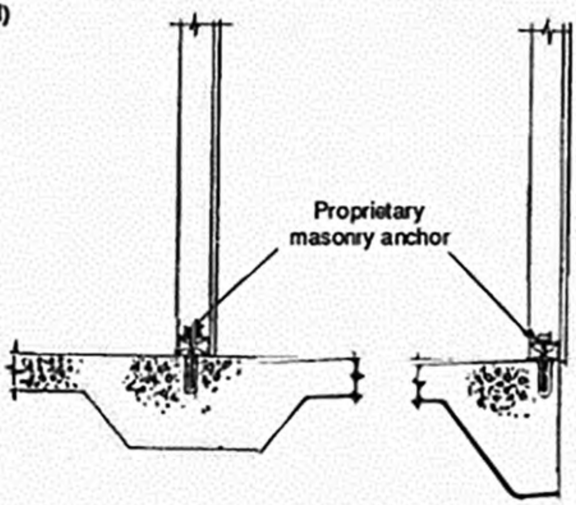


IV)



Design Strength (kN)

Detail	Bolts	Unseasoned timber J2	Unseasoned timber J3	Unseasoned timber J4	Seasoned timber JD2	Seasoned timber JD3	Seasoned timber JD4
I)	M10 Cup-head	8.6	5.6	3.5	11.3	8.4	6.2
			Per	Bolt			
II)	M10	11.5	10.6	6.7	11.5	11.5	11.5
	M12	17	16.5	10.5	17	17	17
			Per	Bolt			
III)		11.5	10.6	6.7	11.5	11.5	11.5
IV)	M10	11.5	10.6	6.7	11.5	11.5	11.5
	M12	17	14	10	17	17	15

<table>
<tr><td rowspan="3">FIGURE B9.5.2 continued
TIE-DOWN: BOTTOM OF BRACING WALLS</td><td rowspan="3">Bolts</td><td colspan="6">Design Strength (kN)</td></tr>
<tr><td colspan="3">Unseasoned timber</td><td colspan="3">Seasoned timber</td></tr>
<tr><td>J2</td><td>J3</td><td>J4</td><td>JD2</td><td>JD3</td><td>JD4</td></tr>
<tr><td rowspan="2">V)

</td><td>M10</td><td>11.5</td><td>10.6</td><td>6.7</td><td>11.5</td><td>11.5</td><td>11.5</td></tr>
<tr><td>M12</td><td>17</td><td>16.5</td><td>10.5</td><td>17</td><td>17</td><td>17</td></tr>
<tr><td rowspan="2">VI)

</td><td>M10</td><td>11.5</td><td>10.6</td><td>6.7</td><td>11.5</td><td>11.5</td><td>11.5</td></tr>
<tr><td>M12</td><td>17</td><td>16.5</td><td>10.5</td><td>17</td><td>17</td><td>17</td></tr>
<tr><td>VII)

</td><td></td><td colspan="6">REFER TO MANUFACTUERS SPECIFICATIONS</td></tr>
</table>

B10 TIE-DOWN

B10.1 Scope

The following clauses give the bracing demand on walls due to wind and provide connection details for walls as well as the bracing capacity of different wall systems.

This clause provides for structural connections to resist uplift and shear forces on floor, wall and roof framings. These details are in addition to nominal fixing.

Continuity of tie-down must be provided from the roof sheeting to the foundations.

B10.2 Application

To determine an appropriate structural tie-down detail, the following general steps are to be followed:

(a) From Fig. B10.3(A) determine the appropriate dimension 'A' for the member or joint considered.

(b) From Tables B10.5.1 to B10.11.4 determine the uplift forces to be resisted by each joint considered.

(c) Determine the appropriate joint group for the joint under consideration.

(d) Enter the appropriate design strength figure and establish a suitable tie-down detail.

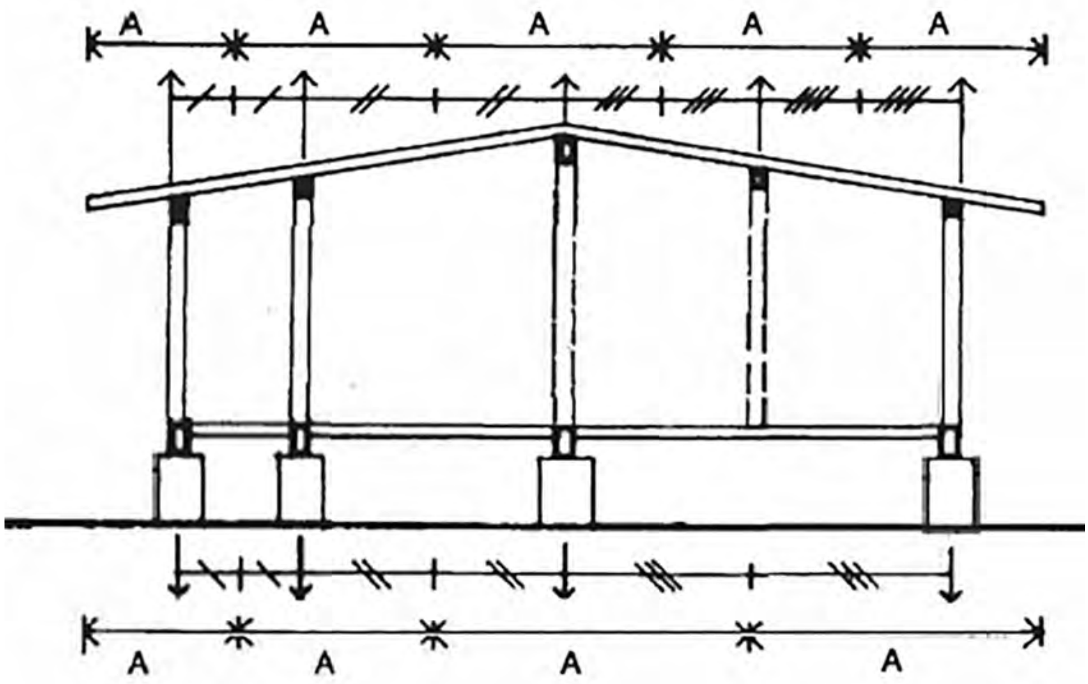
B10.3 Dimension 'A'

Dimension 'A' must be used to determine the tie-down requirements for each structural joint in floor framing, wall framing and roof framing excluding purlins.

NOTES:

i. Dimension 'A' is NOT to be used for determination.

ii. Dimension 'S' is at right angles to dimension 'A' and the method of measurement is shown in Figure B10.9(A).



NOTES: To determine dimension 'A' for floor joists and bearers, consideration should be given to the sharing of uplift load through internal partitions. The dimensions 'A' illustrated above for bearers and floor joists take this into account.

FIGURE B10.3(A): DIMENSION 'A' – RAFTERED ROOF

B10.4 General Connection Requirements

B10.4.1 Steel Washers

Bolt ϕ (mm)	Washer Size (mm)	
	Square	Round
M10 bolt	40 x 40 x 2.5 mm	45 mm dia. x 2.5 mm
M12 bolt	50 x 50 x 3 mm	55 mm dia. x 3 mm
M16 bolt	57 x 57 x 4 mm	65 mm dia. x 4 mm
M20 bolt	65 x 65 x 5 mm	75 mm dia. x 5 mm

B10.4.2 Drilling for Bolts

(a) Bolt holes in timber must be 1-2 mm greater in diameter than the bolt diameter.

(b) Bolt holes in steel must provide a snug fit, i.e. not greater than 0.5 mm larger than bolt diameter.

B10.4.3 Drilling for Coach Screws

(a) Hole for Shank = Shank Diameter + 1 mm.

(c) Hole for Thread = Root Diameter.

B10.5 Uplift Forces on Bearers

The uplift forces on bearers must be determined from Tables B10.5.1 to B10.5.4. For typical details and design strengths refer to Figure B10.5.

B10.6 Uplift Forces on Floor Joists

The uplift forces on floor joists are determined from Tables B10.6.1 to B10.6.4. For typical details and design strengths, refer to Figure B10.6.

B10.7 Bracing Demand on Walls

The bottom plate of all walls must be fixed to the floor frame or concrete slab in a manner sufficient to resist the bracing demand on the walls. Refer to Figure B9.5.2 for details.

B10.8 Uplift Forces on Rafters

The uplift forces on rafters are determined from Tables B10.8.1 to B10.8.4 and tie-down details to resist the uplift from Figures B10.8(A), B10.8(B), or B10.8(C) as appropriate.

B10.9 Uplift Forces on Roof Beams, Lintels, Verandah Beams and Verandah Posts

The uplift forces on roof beams, lintels, verandah beams and verandah posts are determined from Tables B10.9.1 to B10.9.4. The dimensions ‘A’ and ‘S’ required for using the tables are shown in Figures B10.3(A) and B10.9(A).

For typical tie-down details and design strengths refer Figure B10.9(B) to B 10.9(D).

B10.10 Uplift Forces on Purlins

The uplift forces on purlins are determined from Tables B10.10.1 to B10.10.4. For typical purlin to rafter tie-down details and design strengths refer to Figure B10.10.

210.11 Uplift Forces on Cladding fasteners

The uplift forces on cladding fasteners are determined from Tables B10.11.1 to B10.11.4 and the tie-down details to resist the uplift, from Figure B10.11.

UPLIFT FORCES ON BEARERS (kN)

Table B10.5.1

THIS TABLE VALID FOR			
Aspect Ratio (height/d)	0.25	0.5	1.0
Roof Pitch (Degrees)	15, 20, 25	20, 25	25

Dimension "A" (mm)	Bearer Span (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	1800	NO UPLIFT	3.63
	2400		4.84
	3000		6.06
	3600		7.27
3600	1800		4.36
	2400		5.81
	3000		7.27
	3600		8.72
4200	1800		5.09
	2400		6.78
	3000		8.48
	3600		10.17
4800	1800		5.81
	2400		7.75
	3000		9.69
	3600		11.63

Table B10.5.2

THIS TABLE VALID FOR			
Aspect Ratio (height/d)	0.25	0.5	1.
Roof Pitch (Degrees)	10	15	2

Dimension "A" (mm)	Bearer Span (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	1800	NO UPLIFT	5.19
	2400		6.92
	3000		8.65
	3600		10.38
3600	1800		6.23
	2400		8.30
	3000		10.38
	3600		12.45
4200	1800		7.26
	2400		9.69
	3000		12.11
	3600		14.53
4800	1800		8.30
	2400		11.07
	3000		13.84
	3600		16.60

Table B10.5.3

THIS TABLE VALID FOR		
Aspect Ratio (height/d)	0.5	1.0
Roof Pitch (Degrees)	10	15

Dimension "A" (mm)	Bearer Span (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	1800	1.30	7.52
	2400	1.73	10.03
	3000	2.17	12.54
	3600	2.60	15.05
3600	1800	1.56	9.03
	2400	2.08	12.04
	3000	2.60	15.05
	3600	3.12	18.05
4200	1800	1.82	10.53
	2400	2.43	14.04
	3000	3.03	17.55
	3600	3.64	21.06
4800	1800	2.08	12.04
	2400	2.77	16.05
	3000	3.46	20.06
	3600	4.16	24.07

Table B10.5.4

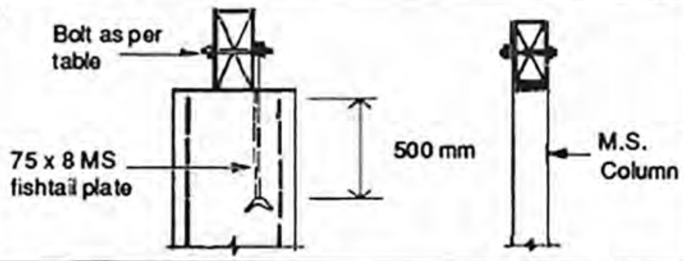
THIS TABLE VALID FOR	
Aspect Ratio (height/d)	1.0
Roof Pitch (Degrees)	10

Dimension "A" (mm)	Bearer Span (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	1800	3.63	9.86
	2400	4.84	13.14
	3000	6.06	16.43
	3600	7.27	19.71
3600	1800	4.36	11.83
	2400	5.81	15.77
	3000	7.27	19.71
	3600	8.72	23.66
4200	1800	5.09	13.80
	2400	6.78	18.40
	3000	8.48	23.00
	3600	10.17	27.60
4800	1800	5.81	15.77
	2400	7.75	21.03
	3000	9.69	26.28
	3600	11.63	31.54

FIGURE B10.5

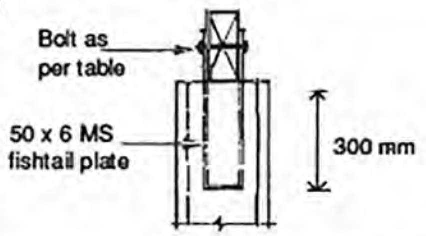
TIE-DOWN: BEARERS TO STUMPS/PIERS/POSTS

I)



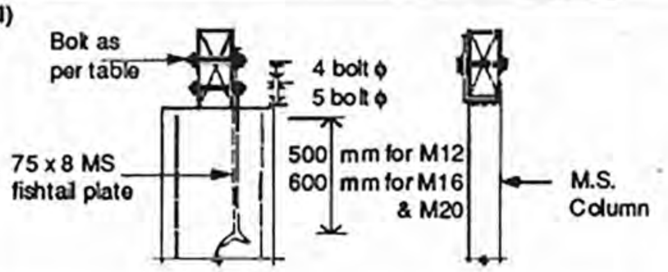
Bolts	Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
M10	4.7	3.8	2.7	6.0	5.8	4.8
M12	6.2	5.0	3.6	7.9	7.4	6.2
M16	8.0	6.4	4.6	10.3	9.6	8.0
M20	11	9.0	6.4	14.4	13.4	10.4

II)



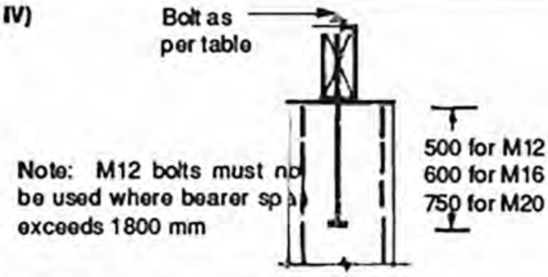
Bolts	Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
M10	7.8	5.0	3.2	9.2	7.0	5.2
M12	9.2	6.0	3.8	11.2	8.4	6.2
M16	12.4	8.0	5.0	15	11	8.4
M20	15.6	10	6.3	19	14	10.4

III)



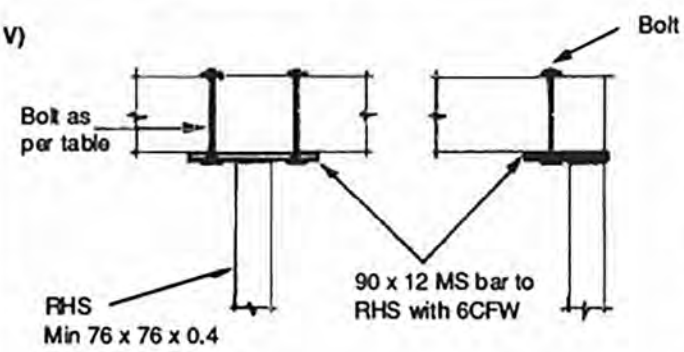
Bolts	Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
2/M10	9.4	7.6	5.4	12	11.6	9.6
2/M12	12.4	10	7.2	16	15	12.4
2/M16	16	12.8	9.2	20.6	19	16
2/M20	22	17.6	12.8	29	27	14.4

IV)



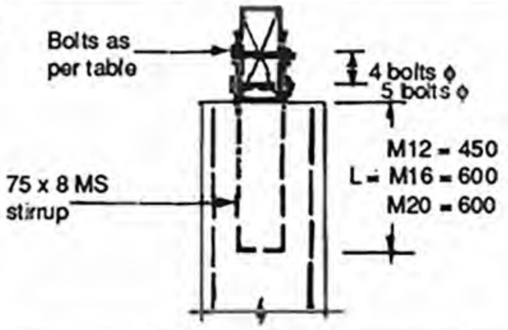
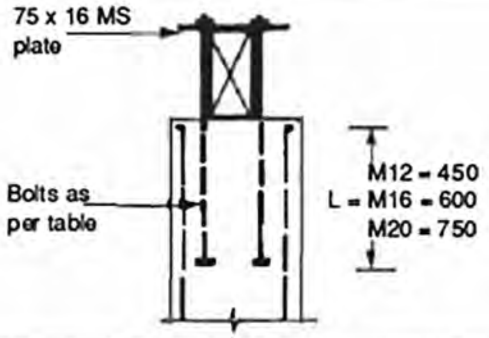
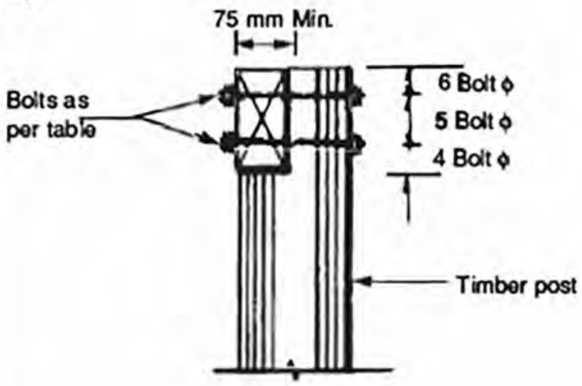
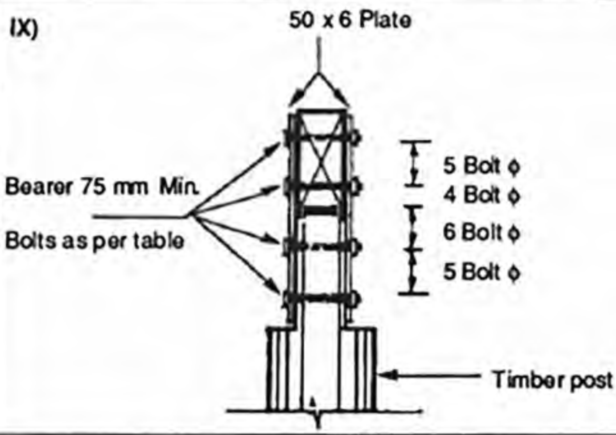
Bolts	Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
M10	11.5	10.6	6.7	11.5	11.5	11.5
M12	17	16.5	10.5	17	17	17
M16	32	21.5	14	32	24	17
M20	22	17.6	13	29	27	21

V)



Bolts	Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
M10	11.5	10.6	6.7	11.5	11.5	11.5
2/M10	23	21	13.4	23	23	23
M12	17	16.5	10.5	17	17	17
2/M12	34	33	21	34	34	34
M16	32	21.5	14	72	32	24
2/M16	64	45	27.4	64	64	48
M20	44	28	18	50	42	31
2/M20	88	56	36	100	85	63

Design Strength (kN)

FIGURE B10.5 continued TIE-DOWN: BEARERS TO STUMPS / PIERS / POSTS	Bolts	Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
VI) 	2/M12	18.4	12	7.6	22.4	17	12.4
	2/M16	25	16	10	30.4	22.4	17
	2/M20	31	20	12.6	37.6	28	21
VII) 	2/M10	23	23	23	23	23	23
	2/M12	34	34	24	34	34	34
	2/M16	59	37	24	64	53	39
	2/M20	59	37	24	70	53	39
VIII) 	M10	4.7	3.8	2.7	6.0	5.8	4.8
	M12	6.2	5.0	3.6	7.9	7.4	6.2
	M16	8.0	6.4	4.6	10.3	9.6	8.0
	M20	11	8.8	6.4	14.4	13.4	10.4
	2/M10	9.4	7.6	5.4	12	11.6	9.6
	2/M12	12.4	10	7.2	16	15	12.4
	2/M16	16	13	9.2	21	19.2	16
	2/M20	22	17.6	13	29	27	21
IX) 	2/M10	15.6	10	6.4	18.4	14	10.4
	2/M12	18.4	12	7.6	22.4	17	12.4
	2/M16	25	16	10	30.4	22.4	17
	2/M20	31	20	12.6	38	28	21

UPLIFT FORCES ON JOISTS (kN)

Table B10.6.1

THIS TABLE VALID FOR			
Aspect Ratio (h/d)	0.25	0.5	1
Roof Pitch (Degrees)	15, 20, 25	20, 25	25

DIMENSION "A" (mm)	JOIST SPACING (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	450	NO UPLIFT	0.91
3600			1.09
4200			1.27
4800			1.45

Table B10.6.2

THIS TABLE VALID FOR			
Aspect Ratio (h/d)	0.25	0.5	1
Roof Pitch (Degrees)	10	15	20

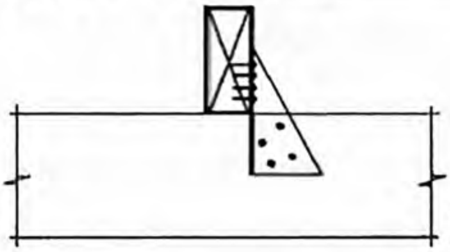
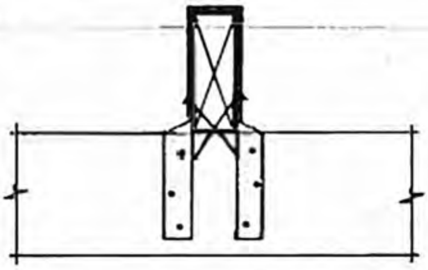
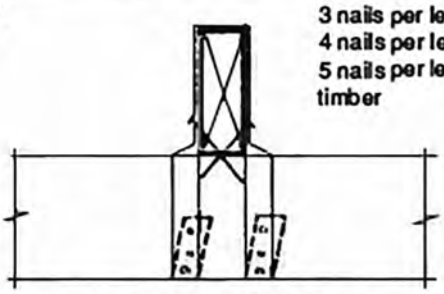
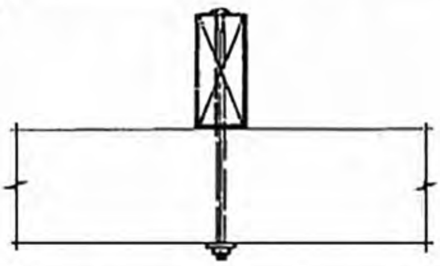
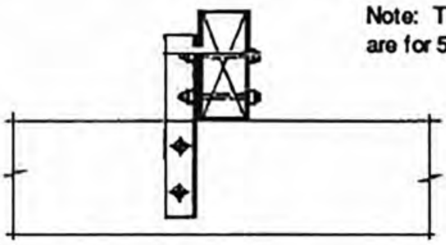
DIMENSION "A" (mm)	JOIST SPACING (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	450	NO UPLIFT	1.30
3600			1.56
4200			1.82
4800			2.08

Table B10.6.3

THIS TABLE VALID FOR			
Aspect Ratio (h/d)		0.5	1
Roof Pitch (Degrees)		10	15
DIMENSION "A" (mm)	JOIST SPACING (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	450	0.32	1.88
3600		0.39	2.26
4200		0.45	2.63
4800		0.52	3.01

Table B10.6.4

THIS TABLE VALID FOR			
Aspect Ratio (h/d)			1
Roof Pitch (Degrees)			10
DIMENSION "A" (mm)	JOIST SPACING (mm)	LOWSET HOUSES	HIGHSET HOUSES
3000	450	0.91	2.46
3600		1.09	2.96
4200		1.27	3.45
4800		1.45	3.94

FIGURE B10.6 TIE-DOWN: FLOOR JOISTS TO BEARERS		Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
I)  1 framing anchor with 4/3.15 ϕ nails each leg	No. Framing Anchors	J2	J3	J4	JD2	JD3	JD4
	1	3.7	2.6	1.9	4.7	3.7	2.6
	2	6.2	4.4	3.1	8.6	6.8	4.8
	4	11.4	8.1	5.8	16.4	13	9.2
II)  30 x 0.8 strap with 3/3.15 ϕ nails each end	No. of straps						
	1	4.9	3.5	2.5	6.6	5.2	3.7
	2	8.8	6.3	4.4	12.6	10	7.0
III)  3 nails per leg for J2 timber 4 nails per leg for J3 & JD4 timber 5 nails per leg for J4, JD5 & JD6 timber 30 x 0.8 G.I. strap 3.15 ϕ nails		7.2	7.2	7.2	7.2	7.2	7.2
IV)  M10 cuphead bolt Note: Joist to be 45 mm minimum width		8.6	5.6	3.5	11.3	8.4	6.2
V)  Note: These design strengths are for 50 mm wide joists. 50 x 50 x 4MS angle with bolts each end as per table	2/M10	9.5	7.5	5.0	12	10.6	8.0
	2/M12	12.5	9.5	6.0	16	13	9.6

UPLIFT FORCES ON RAFTERS (KN)

TABLE B10.8.1

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (deg.)
0.25	.15, 20, 25
0.5	20, 25
1	25

Dimension "A" (mm)	Rafter Spacing (mm)	UPLIFT FORCE (kN)
1800	900	1.38
	1200	1.84
	1500	2.30
2400	900	1.84
	1200	2.46
	1500	3.07
3000	900	2.30
	1200	3.07
	1500	3.84
3600	900	2.76
	1200	3.68
	1500	4.60
4200	900	3.22
	1200	4.30
	1500	5.37
4800	900	3.68
	1200	4.91
	1500	6.14

TABLE B10.8.2

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (deg.)
0.25	10
0.5	15
1	20

Dimension "A" (mm)	Rafter Spacing (mm)	UPLIFT FORCE (kN)
1800	900	1.85
	1200	2.46
	1500	3.08
2400	900	2.46
	1200	3.28
	1500	4.11
3000	900	3.08
	1200	4.11
	1500	5.13
3600	900	3.70
	1200	4.93
	1500	6.16
4200	900	4.31
	1200	5.75
	1500	7.19
4800	900	4.93
	1200	6.57
	1500	8.21

NOTES: Tie-down over internal walls must be taken directly to floor frame or concrete slab.

UPLIFT FORCES ON RAFTERS (KN)

TABLE B10.8.3

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (deg.)
0.5	10
1	15

Dimension "A" (mm)	Rafter Spacing (mm)	UPLIFT FORCE (kN)
1800	900	2.55
	1200	3.40
	1500	4.25
2400	900	3.40
	1200	4.53
	1500	5.66
3000	900	4.25
	1200	5.66
	1500	7.08
3600	900	5.10
	1200	6.79
	1500	8.49
4200	900	5.95
	1200	7.93
	1500	9.91
4800	900	6.79
	1200	9.06
	1500	11.32

TABLE B10.8.4

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (deg.)
1	10

Dimension "A" (mm)	Rafter Spacing (mm)	UPLIFT FORCE (kN)
1800	900	3.25
	1200	4.33
	1500	5.41
2400	900	4.33
	1200	5.77
	1500	7.22
3000	900	5.41
	1200	7.22
	1500	9.02
3600	900	6.50
	1200	8.66
	1500	10.83
4200	900	7.58
	1200	10.10
	1500	12.63
4800	900	8.66
	1200	11.55
	1500	14.44

NOTES: Tie-down over internal walls must be taken directly to floor frame or concrete slab.

FIGURE B10.8 (A)

TIE-DOWN: RAFTERS OR TRUSSES TO WALL FRAME/FLOOR FRAME/OR SLAB

Bolts	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
M10	11.5	10.6	6.7	11.5	11.5	11.5
M12	17	16.5	10.5	17	17	17
M16	32	22	14	32	32	24
2/M10	23	21	13.4	23	23	23
2/M12	34	33	21	34	34	34

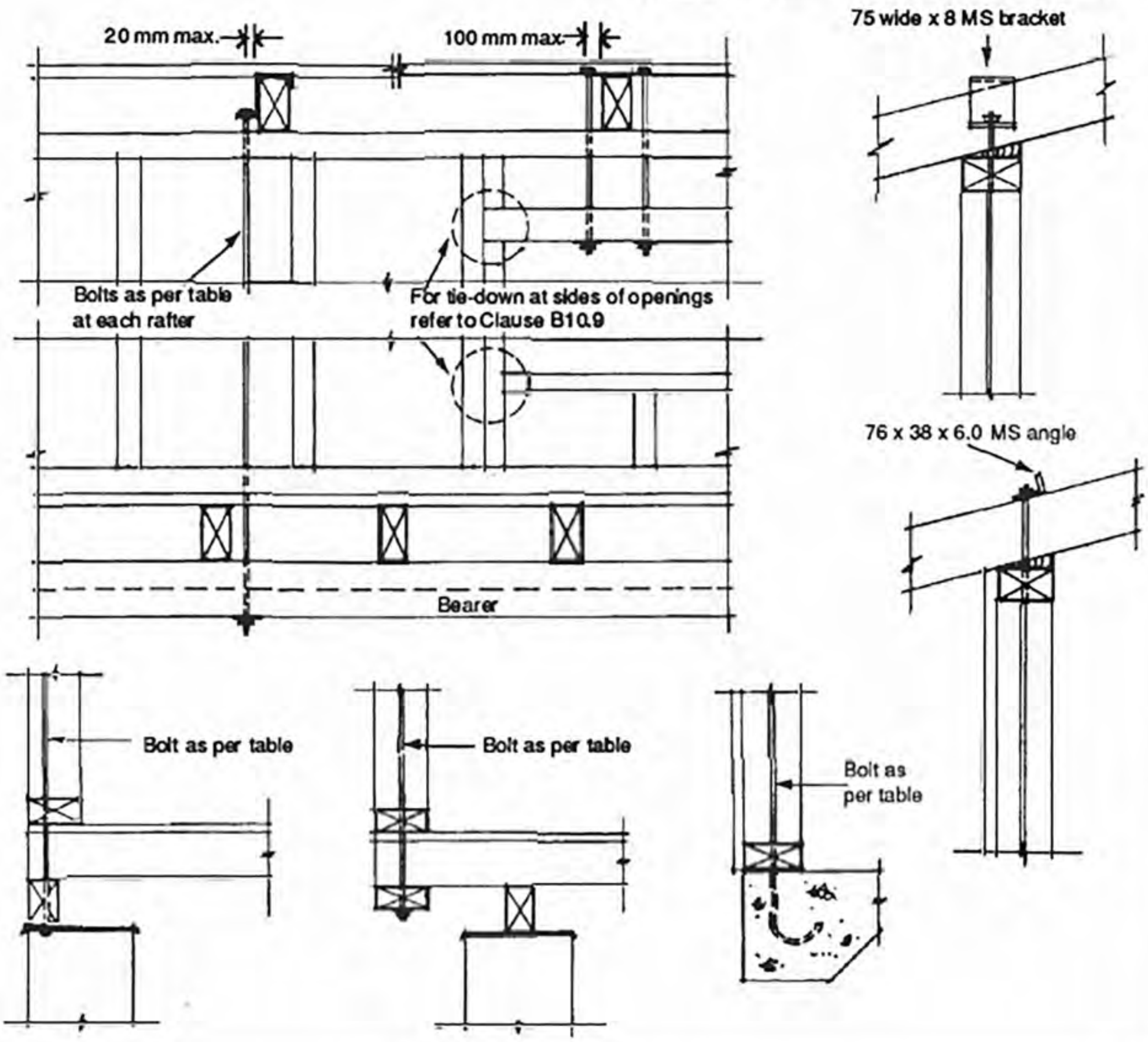


FIGURE B10.8 (B) **TIE-DOWN: RAFTER OR TRUSSES TO WALL FRAME/FLOOR FRAME/SLAB**	**Design Strength (kN)**					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
30 x 0.8 G.I. Strap 3/3.15 ϕ nails each end	4.9	3.5	2.5	6.6	5.2	3.7
30 x 0.8 G.I. Strap 4/3.15 ϕ nails each end	6.2	4.4	3.1	8.6	6.8	4.8
1 Framing Anchor 4/3.15 ϕ nails each end	3.7	2.6	1.9	4.7	3.7	2.6
2 Framing Anchors 4/3.15 ϕ nails each end	6.2	4.4	3.1	8.6	6.8	4.8
* M10 Cuphead bolt	8.6	5.6	3.5	11.3	8.4	6.2
* M10 bolt	11.5	10.6	6.7	11.5	11.5	11.5
*M12 bolt	17	16.5	10.5	17	17	17
30x0.8 G.I. Looped Strap-nails required each end are: 3/3.15 ϕ for J2, JD2, JD3, 4/3.15 ϕ for J3 & JD4, 5/3.15 ϕ for J4	7.2	7.2	7.2	7.2	7.2	7.2

* **Note :** Metal straps tying studs to plate may limit strength of tie-down

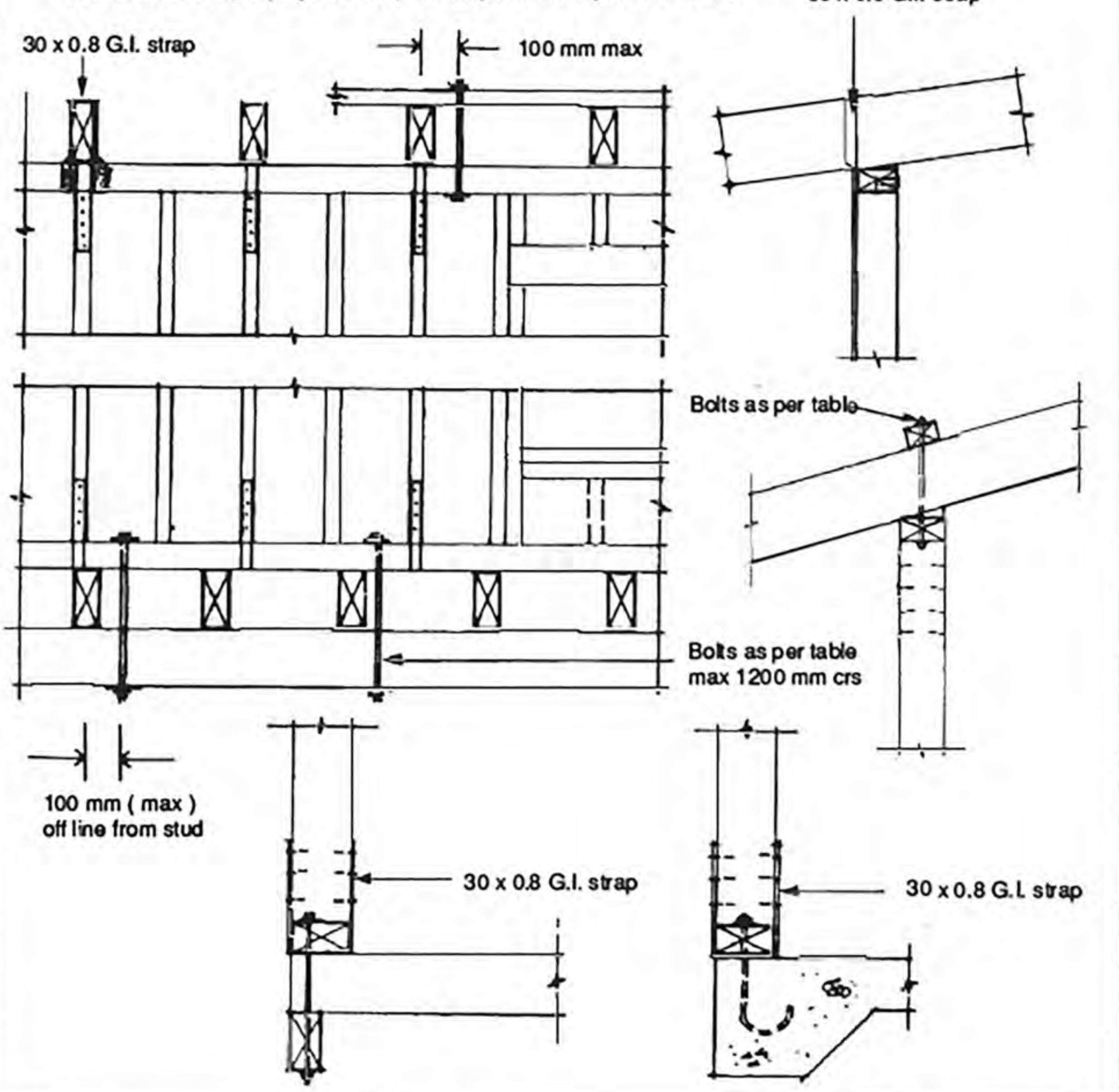
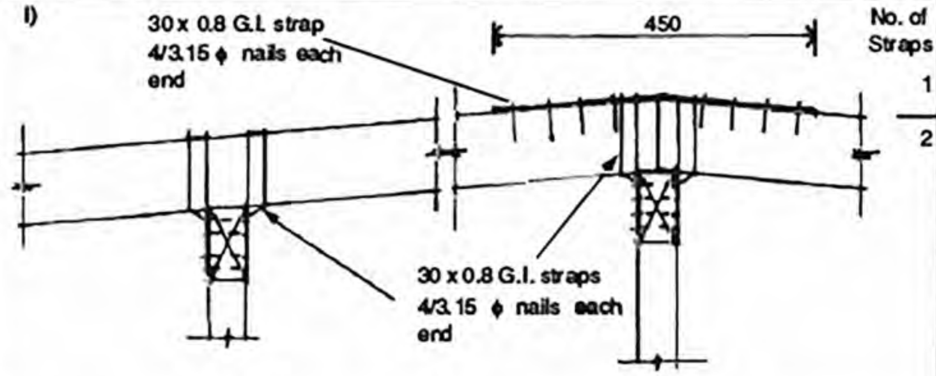


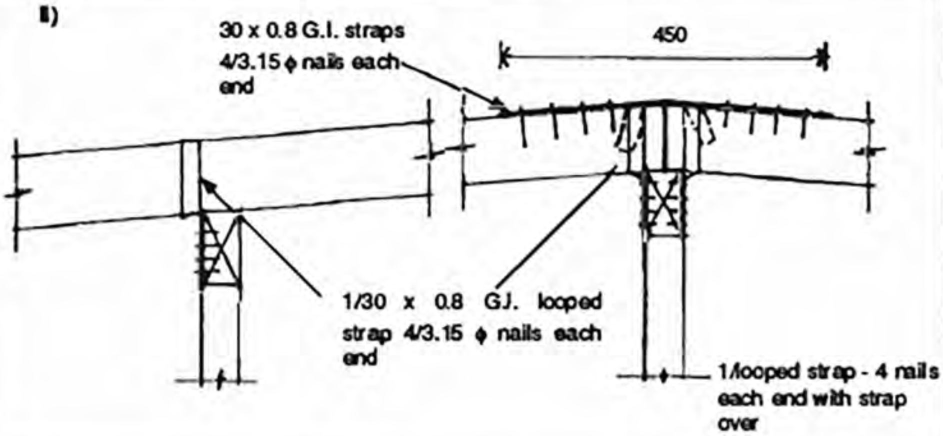
FIGURE B10.8 (C)

TIE-DOWN: RAFTERS OR TRUSSES TO ROOF BEAMS, LINTELS, VERANDAH BEAMS AND INTERNAL WALLS

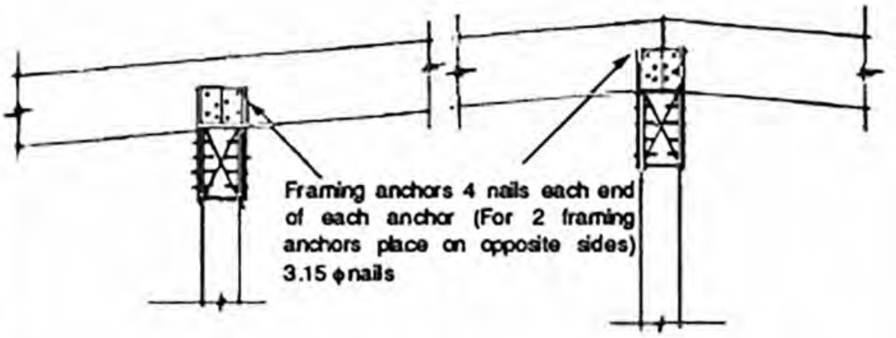
I)



II)



III)

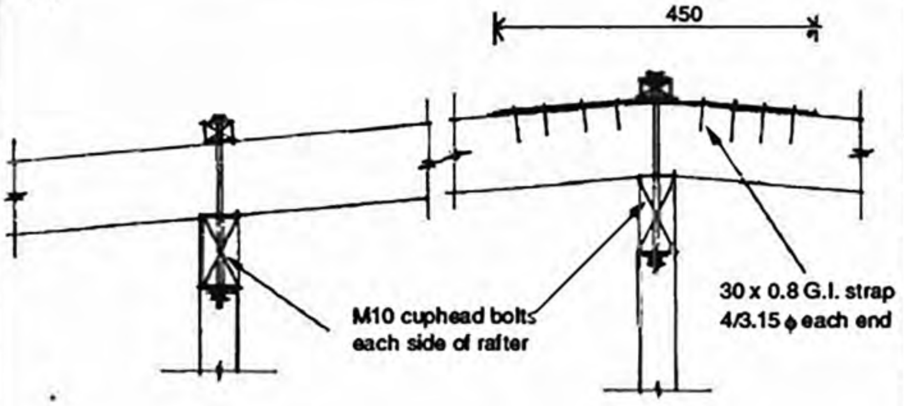


		Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
I)	No. of Straps 1	6.2	4.4	3.0	8.6	7.0	4.8
	2	11.4	8.0	5.8	16.4	13	9.2
II)		7.2	7.2	7.2	7.2	7.2	7.2
III)	No. of Framing Anchors 2	6.2	4.4	3.0	8.6	7.0	4.8
	4	11.4	8.0	5.8	16.4	13	9.2

FIGURE B10.8 (C) continued

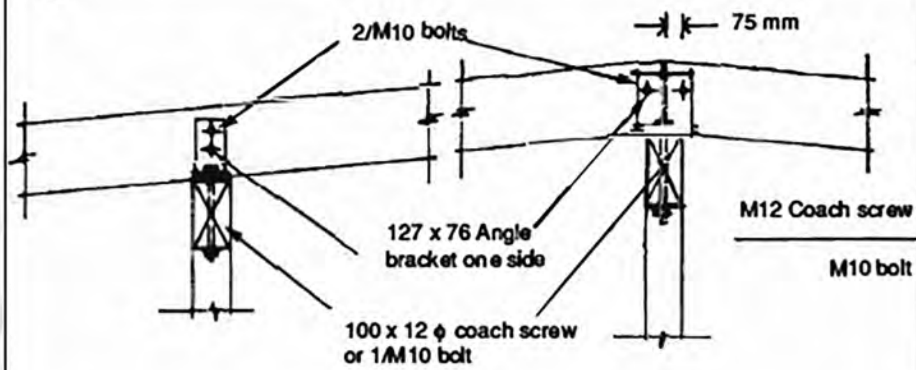
TIE-DOWN: RAFTERS OR TRUSSES TO ROOF BEAMS, LINTELS, VERANDAH BEAMS AND INTERNAL WALLS

IV)



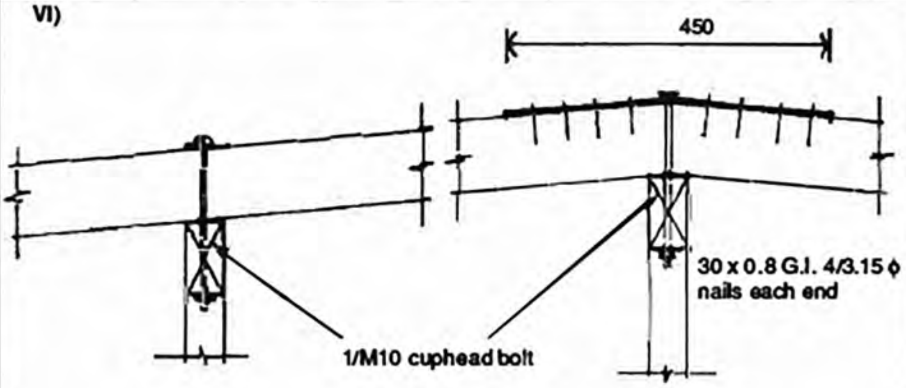
	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
IV)	17	11	7.0	22.6	17	12.4

V)



V)	J2	J3	J4	JD2	JD3	JD4
M12 Coach screw	8.2	6.0	4.0	10	7.5	5.1
M10 bolt	11.5	10.6	6.7	11.5	11.5	11.5

VI)

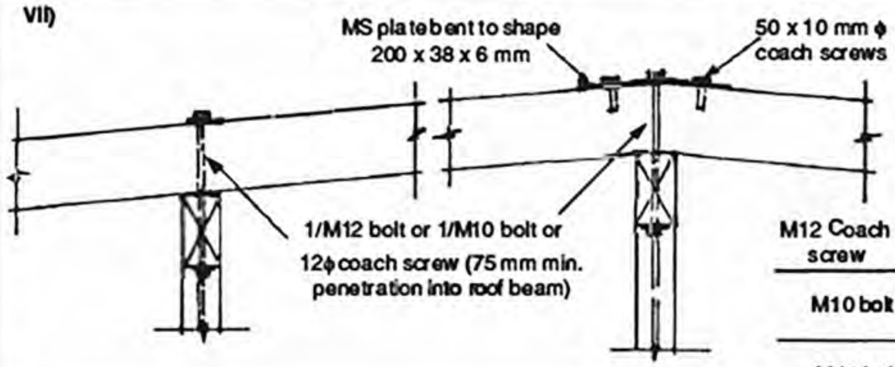


	J2	J3	J4	JD2	JD3	JD4
VI)	8.8	5.6	3.5	11.3	8.4	6.2

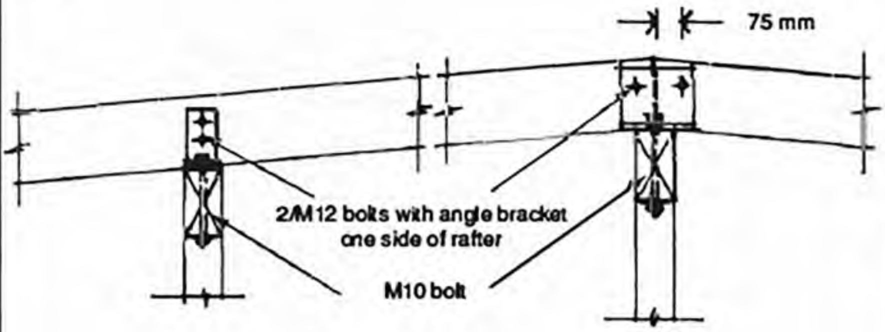
FIGURE B10.8 (C) continued

TIE-DOWN: RAFTERS OR TRUSSES TO ROOF BEAMS, LINTELS, VERANDAH BEAMS AND INTERNAL WALLS

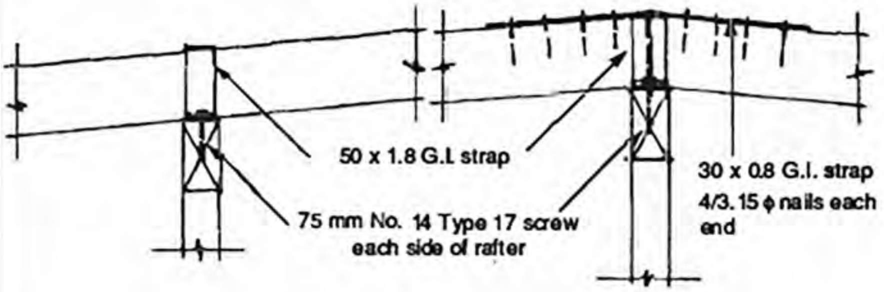
VII)



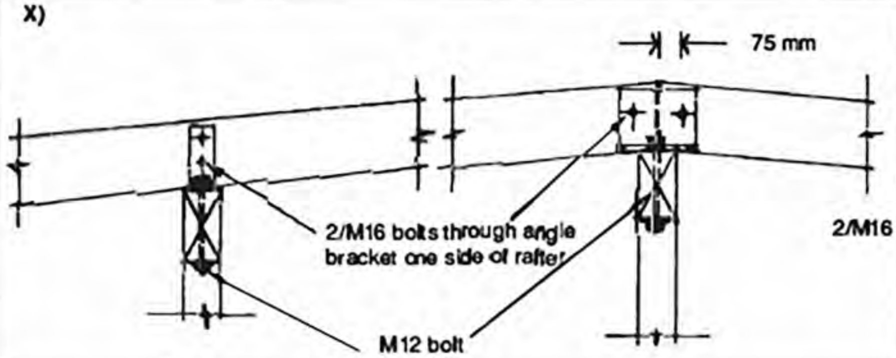
VIII)



IX)



X)

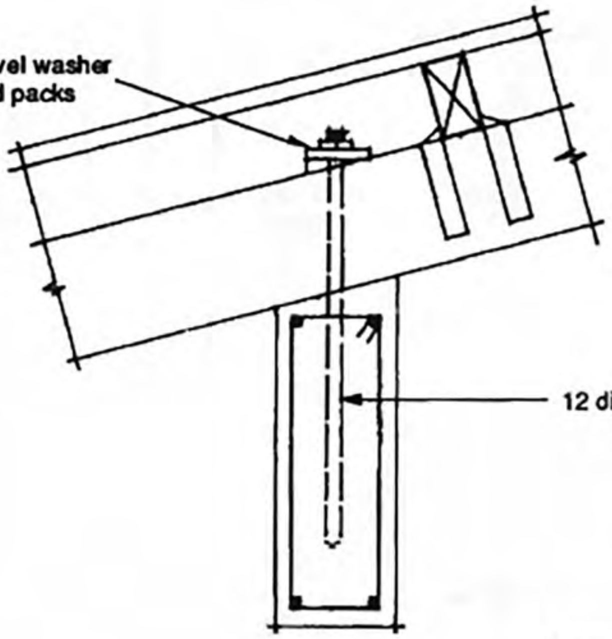


Detail	Fastener	Design Strength (kN) Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
VII)	M12 Coach screw	8.4	6.7	3.6	6.7	4.3	2.8
VII)	M10 bolt	11.5	10.6	6.7	11.5	11.5	11.5
VII)	M12 bolt	17	16.5	10.5	17	17	17
VIII)		10.4	8.0	5.0	11.5	11	8.0
IX)		7.0	5.0	3.6	8.5	6.1	5.0
X)	2/M16	16	13	9.0	17	17	16

FIGURE B10.8 (C) continued

TIE-DOWN OF RAFTER TO MASONRY WALL

XI)



	Design Strength (kN)					
	Unseasoned			Seasoned		
	J2	J3	J4	JD2	JD3	JD4
2/M10	23	21	13.4	23	23	23
2/M12	34	33	21	34	34	34

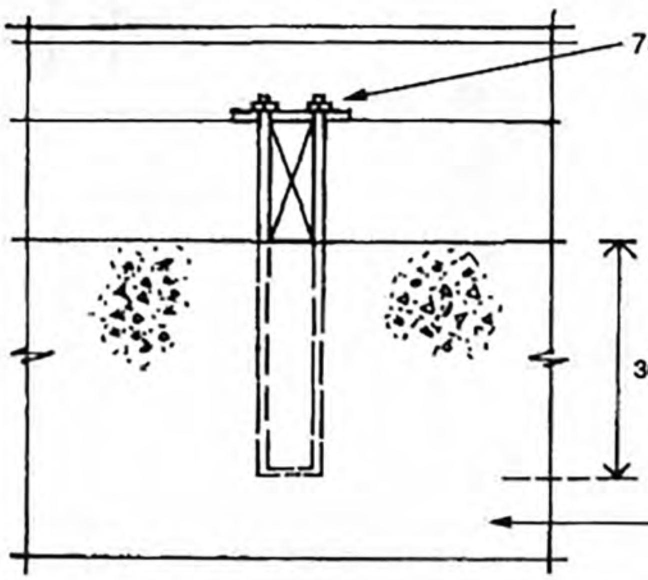
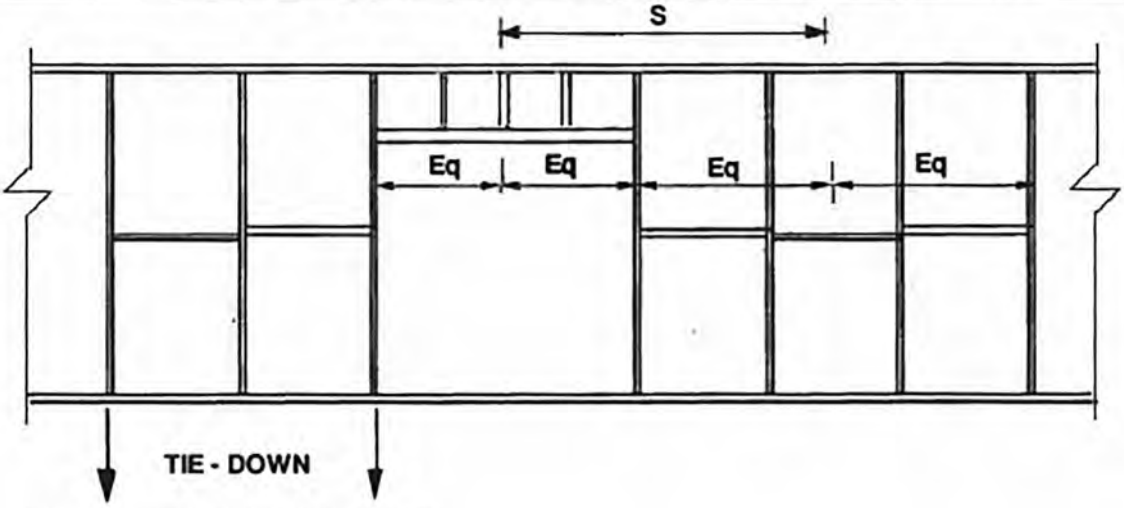
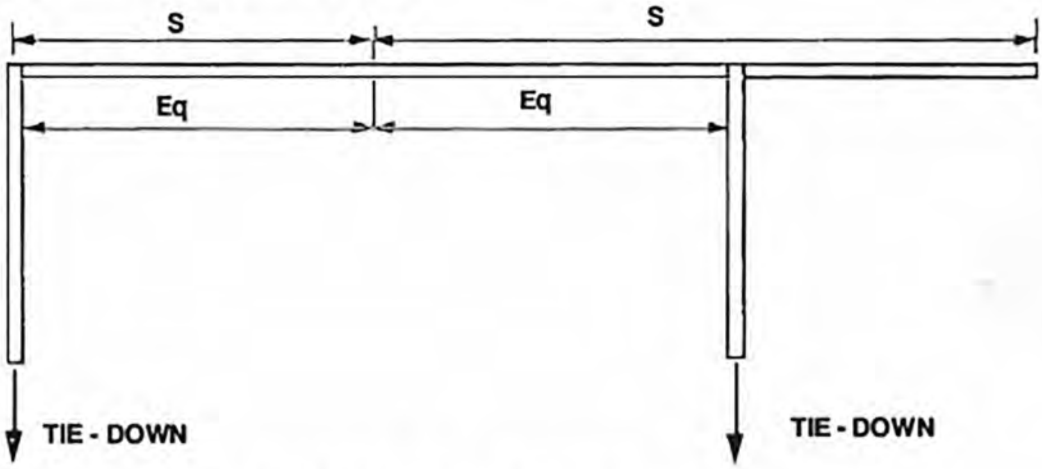


FIGURE B10.9 (A)

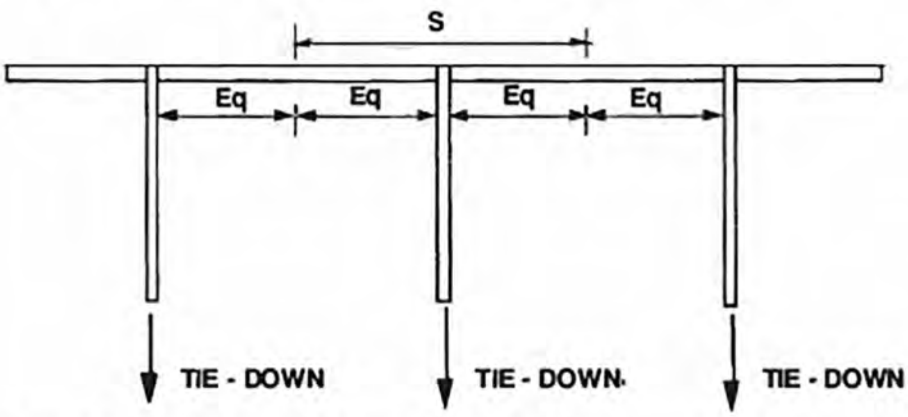
DIMENSION "S" FOR ROOF BEAMS, LINTELS, AND VERANDAH BEAMS



(I) TIE - DOWN AT JAMB STUDS



(II) TIE - DOWN OF ROOF BEAMS AND VERANDAH BEAMS



(III) TIE - DOWN FOR CONTINUOUS SPANS

Note: Dimension 'A' is at right angles to dimension 'S' and the method of measurement is shown in Figure B10.3(A)

UPLIFT FORCES ON ROOF BEAMS, LINTELS, AND VERANDAH PLATES

TABLE B10.9.1

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Deg.)
0.25	15, 20, 25
0.5	20, 25
1	25

AREA OF ROOF TO BE TIED DOWN DIMENSION "A" x DIMENSION "S"	UPLIFT FORCE (kN)
1	0.85
2	1.70
3	2.56
4	3.41
5	4.26
6	5.11
7	5.97
8	6.82
9	7.67
10	8.52
11	9.38
12	10.23

TABLE B10.9.2

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Deg.)
0.25	10
0.5	15
1	20

AREA OF ROOF TO BE TIED DOWN DIMENSION "A" x DIMENSION "S"	UPLIFT FORCE (kN)
1	1.14
2	2.28
3	3.42
4	4.56
5	5.70
6	6.84
7	7.98
8	9.12
9	10.27
10	11.41
11	12.55
12	13.69

TABLE B10.9.1

THIS TABLE IS VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Deg.)
0.5	10
1	15

AREA OF ROOF TO BE TIED DOWN DIMENSION "A" x DIMENSION "S"	UPLIFT FORCE (kN)
1	1.57
2	3.15
3	4.72
4	6.29
5	7.86
6	9.44
7	11.01
8	12.58
9	14.16
10	15.73
11	17.30
12	18.87

TABLE B10.9.2

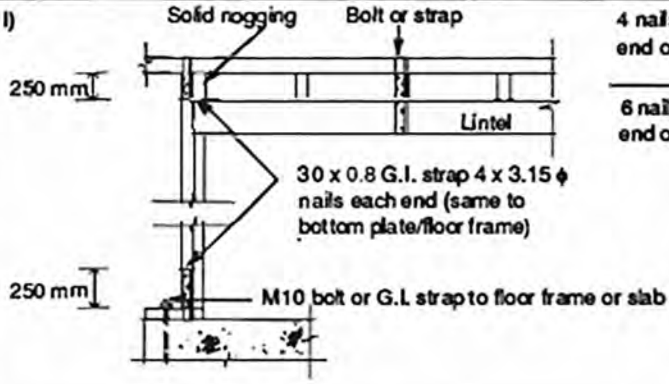
THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Deg.)
1	10

AREA OF ROOF TO BE TIED DOWN DIMENSION "A" x DIMENSION "S"	UPLIFT FORCE (kN)
1	2.00
2	4.01
3	6.01
4	8.02
5	10.02
6	12.03
7	14.03
8	16.04
9	18.04
10	20.05
11	22.05
12	24.06

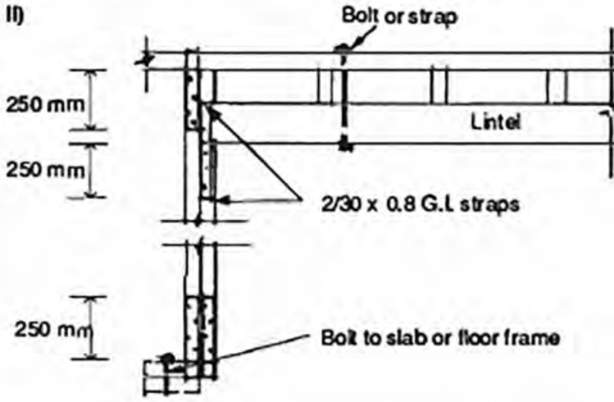
FIGURE B10.9 (B)

TIE-DOWN: LINTELS

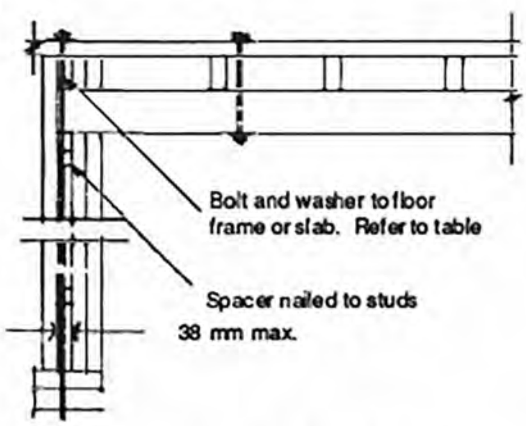
I)



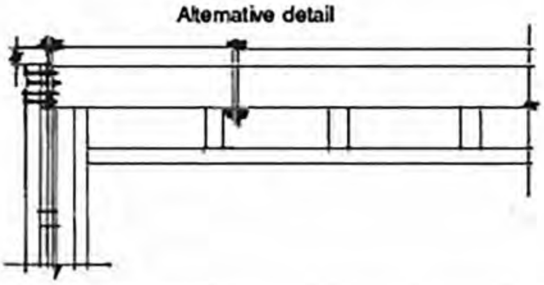
II)



III)



Alternative detail

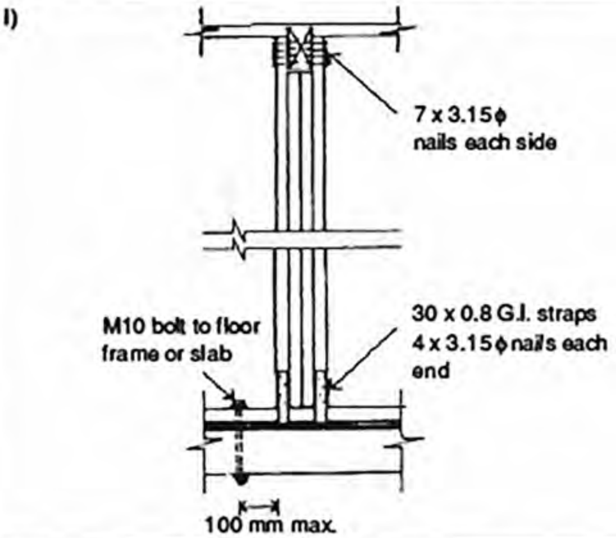


Detail	Fixing	Design Strength (kN): Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
I)	4 nails each end of strap	6.2	4.4	3.1	8.6	6.8	4.8
I)	6 nails each end of strap	8.8	6.3	4.4	12.6	10	7.0
II)	4 nails each end of strap	11.4	8.1	5.8	16.4	13	9.2
II)	(M10 Bolt)	11.5	10.6	6.7	11.5	11.5	11.5
II)	6 nails each end of strap	16.6	12	8.4	24	19	13.5
II)	(M12 Bolt)	17	16.5	10.5	17	17	17
III) Bolt Size	M10	11.5	10.6	6.7	11.5	11.5	11.5
III) Bolt Size	M12	17	16.5	10.5	17	17	17
III) Bolt Size	M16	32	21.5	14	32	32	24
III) Bolt Size	M20	44	28	18	50	42	31

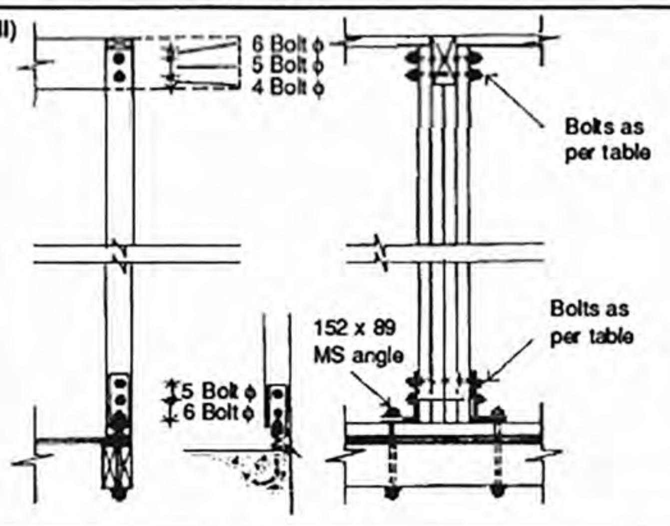
FIGURE B10.9 (C)

TIE-DOWN: ROOF BEAMS

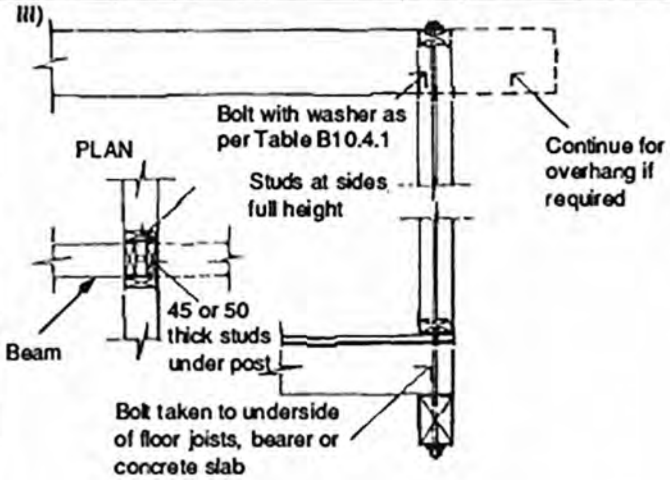
I)



II)



III)

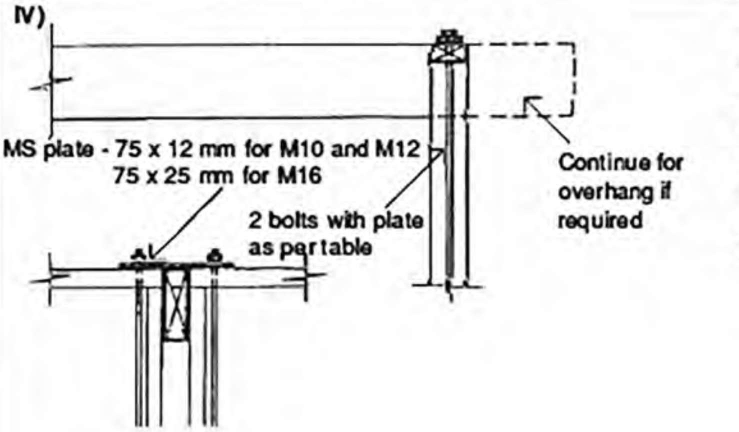


Detail	Bolts	Design Strength (kN) Unseasoned Timber J2	J3	J4	Seasoned Timber JD2	JD3	JD4
I)		11.4	8.0	5.8	16.4	13	9.2
II)	2/M10	15.6	10	6.4	18.4	14	10.4
	2/M12	18.4	12	7.6	22	17	12.4
III)	M10	11.5	10.6	6.7	11.5	11.5	11.5
	M12	17	16.5	10.5	17	17	17
	M16	32	21.5	14	32	32	24
	M20	44	28	18	50	42	31

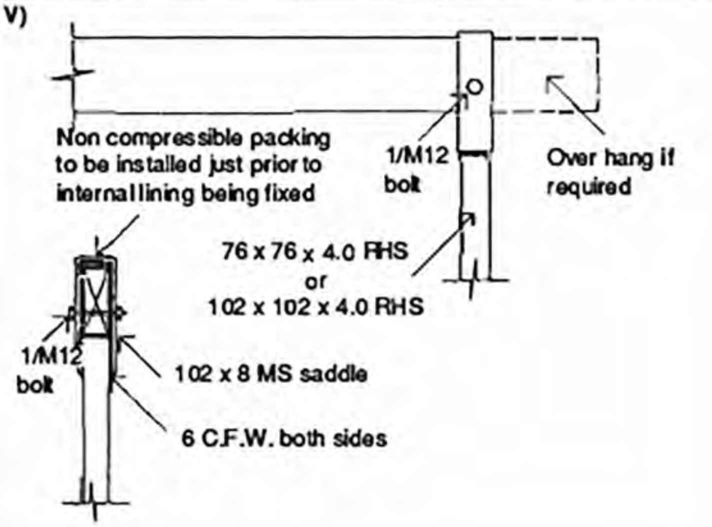
FIGURE B10.9 (C) continued

TIE-DOWN: ROOF BEAMS

IV)



V)

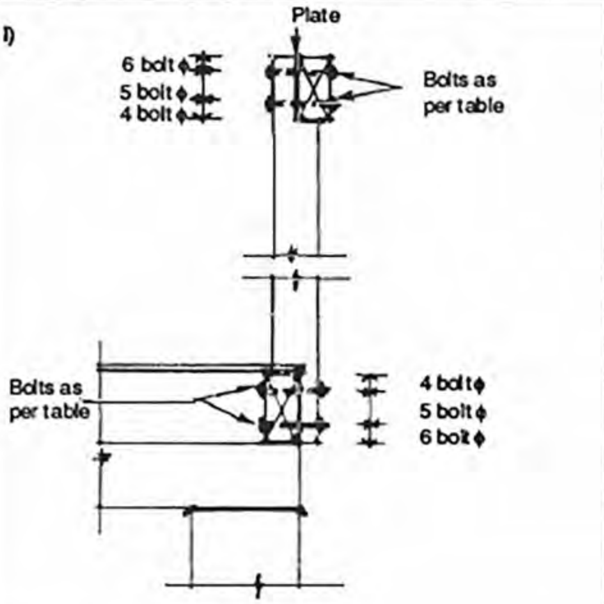


Detail	Bolts	Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
IV)	2/M10	23	21	13	23	23	23
IV)	2/M12	34	33	21	34	34	34
IV)	2/M16	59	37	24	64	53	39
IV)	2/M20	59	37	24	70	53	39
V)		79	50	32	92	68	51

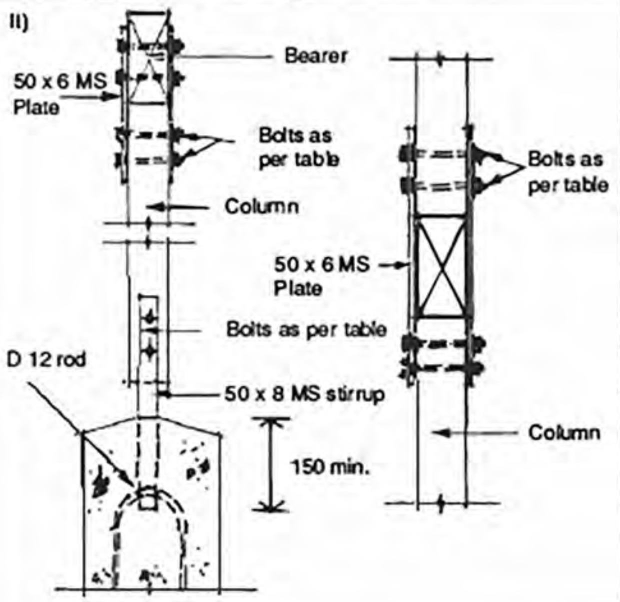
FIGURE B10.9 (D)

TIE-DOWN: VERANDAH BEAMS

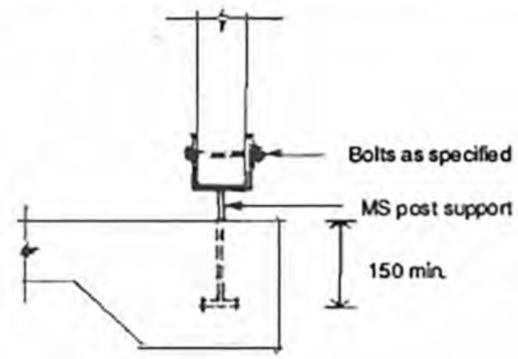
I)



II)



III)

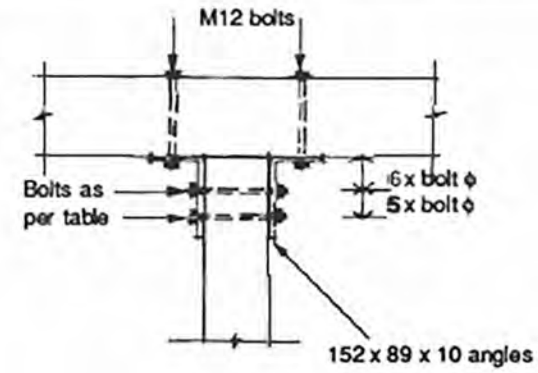


Detail	Bolts	Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
I)	M10	4.7	3.8	2.7	6.0	5.8	4.8
I)	M12	6.2	5.0	3.6	7.9	7.4	6.2
I)	M16	8.0	6.4	4.6	10	9.6	8.0
I)	2/M10	9.4	7.6	5.4	12	11.6	9.6
I)	2/M12	13	10	7.2	15.8	14.8	12.4
I)	2/M16	16	13	9.2	20.6	19	16
II)	M10	7.8	5.0	3.2	9.2	7.0	5.2
II)	M12	9.2	6.0	4.0	11.2	8.4	6.2
II)	M16	12.4	8.0	5.0	15	11	8.4
II)	2/M10	15.6	10	6.4	18.4	14	10.4
II)	2/M12	18.4	12	7.6	22.4	17	12.4
II)	2/M16	25	15	10	30.4	22.4	17
III)		REFER TO MANUFACTURERS SPECIFICATIONS					

FIGURE B10.9 (D) continued

TIE-DOWN: VERANDAH BEAMS

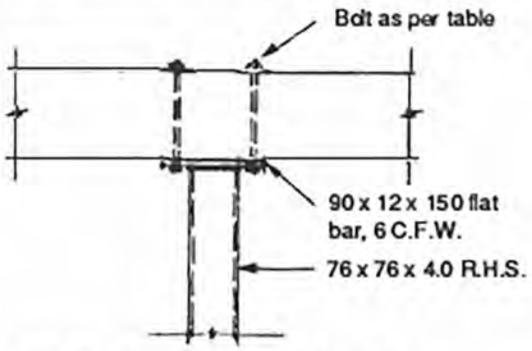
IV)



Note: The same or an equivalent detail is required at the bottom of the post

	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
2/M12	26.4	24	19	33.6	30	24
2/M16	46.4	43	21	34	34	34

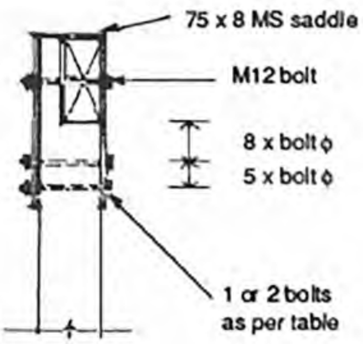
V)



Note: The sameor an equivalent detail is required at the bottom of the post

	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
2/M10	23	23	13.4	23	23	23
2/M12	34	33	21	34	34	34
2/M16	64	43	28	64	64	48
2/M20	88	56	36	100	85	63

VI)



Note: The same or an equivalent detail is required at the bottom of the post

	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
M10	9.0	8.4	6.6	11.6	10.4	8.4
2/M10	18	17	13	23	21	17
M12	13	12	9.6	17	15	12
2/M12	26.4	24	19	33.6	29.6	24
M16	23	21.6	17	29.6	27	21.6
2/M16	46.4	37	24	59	53	39
M20	36.4	33.6	24	46.4	41.6	33.6
2/M20	59	37	24	70	53	39

UPLIFT FORCES ON PURLINS (KN)

TABLE B10.10.1

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.25	15, 20, 25
0.50	20, 25
1.00	25

RAFTER SPACING (mm)	PURLIN SPACING (mm)	UPLIFT FORCE (kN)	
		General Area of Roof	Local Presssure Region *
900	750	0.68	1.16
	900	0.81	1.40
	1200	1.08	1.86
1200	750	0.90	1.55
	900	1.08	1.86
	1200	1.44	2.48
1500	750	1.13	1.94
	900	1.35	2.33
	1200	1.80	3.10

TABLE B10.10.2

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.25	10
0.50	15
1.00	20

RAFTER SPACING (mm)	PURLIN SPACING (mm)	UPLIFT FORCE (kN)	
		General Area of Roof	Local Presssure Region *
900	750	0.87	1.55
	900	1.05	1.86
	1200	1.39	2.48
1200	750	1.16	2.07
	900	1.39	2.48
	1200	1.86	3.31
1500	750	1.45	2.59
	900	1.74	3.10
	1200	2.32	4.14

TABLE B10.10.3

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.50	10
1.00	15

RAFTER SPACING (mm)	PURLIN SPACING (mm)	UPLIFT FORCE (kN)	
		General Area of Roof	Local Presssure Region *
900	750	1.16	2.14
	900	1.40	2.56
	1200	1.86	3.42
1200	750	1.55	2.85
	900	1.86	3.42
	1200	2.48	4.56
1500	750	1.94	3.56
	900	2.33	4.27
	1200	3.10	5.69

TABLE B10.10.4

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
1	10

RAFTER SPACING (mm)	PURLIN SPACING (mm)	UPLIFT FORCE (kN)	
		General Area of Roof	Local Presssure Region *
900	750	1.45	2.72
	900	1.75	3.26
	1200	2.33	4.35
1200	750	1.94	3.62
	900	2.33	4.35
	1200	3.10	5.80
1500	750	2.42	4.53
	900	2.91	5.44
	1200	3.88	7.25

NOTES:

i. It has been assumed that all glazed openings are protected by means of shutters such as shown in Section G.

ii. * Local Pressure Region is that area of the roof that is subject to higher wind uplift forces than the general roof area. Local Pressure region is within 900 mm of the edges of the roof and within 900 mm of either side of the ridge of the roof. Local Pressure is not applicable to the ridge of roofs with a pitch of less than 10 degrees.

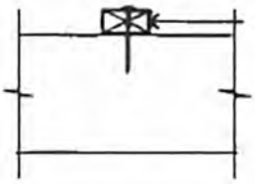
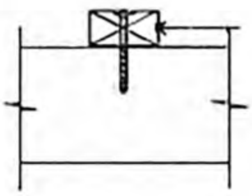
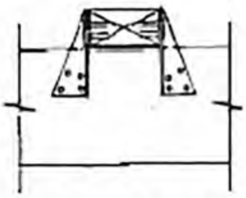
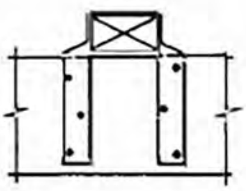
FIGURE B10.10 FIXING OF PURLIN TO RAFTER		Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
I)  75 x 50 purlin 1/100 x 3.75 ϕ nail (50 mm penetration into receiving member)		0.65	0.55	0.50	0.85	0.55	0.37
II)  75 x 50 purlin 1/90 mm No. 14 Type 17 screw (40 mm penetration into receiving member)		2.8	2.0	1.6	3.5	2.5	2.0
III)  ! framing anchor with 4 / 3.15 ϕ nails each leg	No. of Framing Anchors 1	3.7	2.6	1.9	4.7	3.7	2.6
	2	6.2	4.4	3.1	8.6	6.8	4.0
	4	11.4	8.1	5.8	16.4	13	9.2
IV)  30 x 0.8 G.I. strap with 3.15 ϕ nails each end of strap	No. of nails each end of strap 3	4.9	3.5	2.5	6.6	5.2	3.7
	4	6.2	4.4	3.1	8.6	6.8	4.8

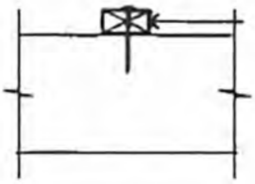
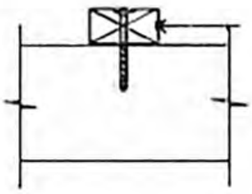
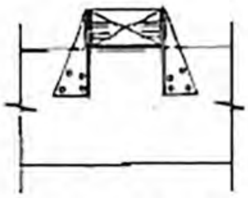
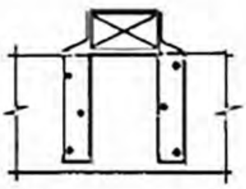
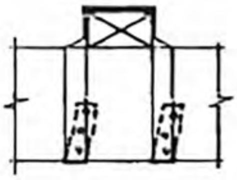
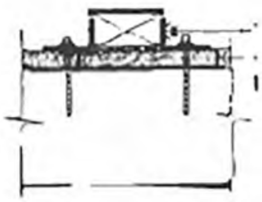
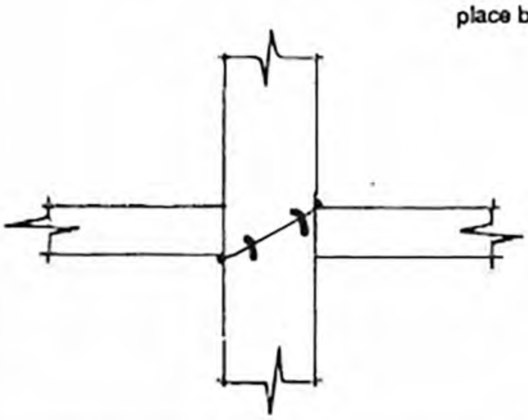
FIGURE B10.10 FIXING OF PURLIN TO RAFTER		Design Strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
I)  1/100 x 3.75 ϕ nail (50 mm penetration into receiving member)		0.65	0.55	0.50	0.85	0.55	0.37
II)  1/90 mm No. 14 Type 17 screw (40 mm penetration into receiving member)		2.8	2.0	1.6	3.5	2.5	2.0
III)  ! framing anchor with 4 / 3.15 ϕ nails each leg No. of Framing Anchors	1	3.7	2.6	1.9	4.7	3.7	2.6
	2	6.2	4.4	3.1	8.6	6.8	4.0
	4	11.4	8.1	5.8	16.4	13	9.2
IV)  30 x 0.8 G.I. strap with 3.15 ϕ nails each end of strap No. of nails each end of strap	3	4.9	3.5	2.5	6.6	5.2	3.7
	4	6.2	4.4	3.1	8.6	6.8	4.8

FIGURE B10.10 continued **FIXING OF PURLIN TO RAFTER**	Design Strength (kN)					
	Unseasoned Timber			Seasoned Timber		
	J2	J3	J4	JD2	JD3	JD4
V)  30 x 0.8 G.I. looped strap with 3.15ϕ nails each end of strap 3 nails each end for J2 timber 4 nails each end for J3 & JD4 timber 5 nails each end for J4, JD5 & JD6 timber	7.2	7.2	7.2	7.2	7.2	7.2
VI)  30 x 1.8 G.I. strap 1/75 mm No. 14 Type 17 screw at each end	7.0	5.0	3.6	8.5	6.1	5.0
VII)  No. 8 wire tightly knotted under rafter and held in place by 'U' nails  No. of loops 1	2.6	2.6	2.6	2.6	2.6	2.6
2	5.2	5.2	5.2	5.2	5.2	5.2

UPLIFT FORCES PER CLADDING FASTENER (KN)

TABLE B10.11.1

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.25	15, 20, 25
0.5	20, 25
1	25

PURLIN SPACING (mm)	FASTENER SPACING (mm)	UPLIFT FORCE (KN)	
		General Area of Roof	Local Pressure Region *
750	76	0.07	0.11
	190	0.16	0.27
	203	0.18	0.29
900	76	0.08	0.13
	190	0.20	0.32
	203	0.21	0.34
1200	76	0.11	0.17
	190	0.26	0.43
	203	0.28	0.46

TABLE B10.11.2

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.25	10
0.5	15
1	20

PURLIN SPACING (mm)	FASTENER SPACING (mm)	UPLIFT FORCE (KN)	
		General Area of Roof	Local Pressure Region *
750	76	0.08	0.14
	190	0.21	0.35
	203	0.22	0.37
900	76	0.10	0.17
	190	0.25	0.42
	203	0.26	0.45
1200	76	0.13	0.22
	190	0.33	0.56
	203	0.35	0.60

TABLE B10.11.3

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	Roof Pitch (Degrees)
0.5	10
1	15

PURLIN SPACING (mm)	FASTENER SPACING (mm)	UPLIFT FORCE (KN)	
		General Area of Roof	Local Pressure Region *
750	76	0.11	0.19
	190	0.27	0.47
	203	0.29	0.50
900	76	0.13	0.23
	190	0.32	0.57
	203	0.34	0.61
1200	76	0.17	0.30
	190	0.43	0.76
	203	0.46	0.81

TABLE B10.11.4

THIS TABLE VALID FOR	
Aspect Ratio (h/d)	1
Roof Pitch (Degrees)	10

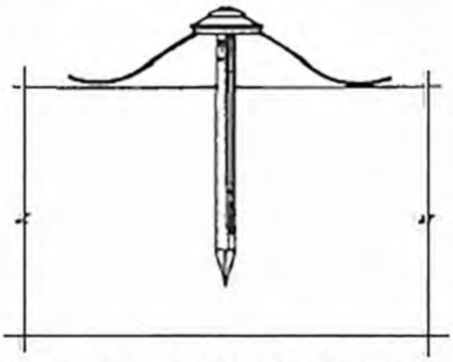
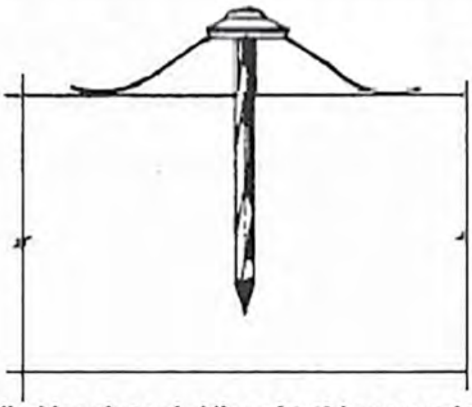
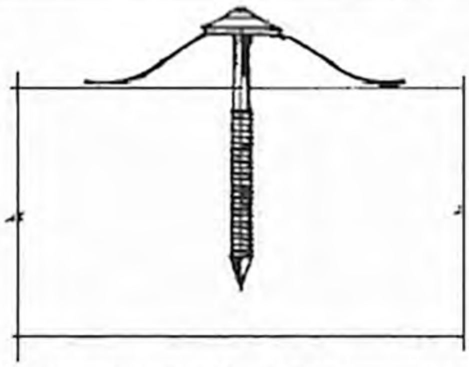
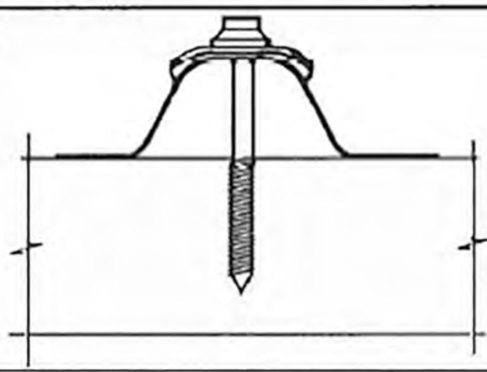
PURLIN SPACING (mm)	FASTENER SPACING (mm)	UPLIFT FORCE (KN)	
		General Area of Roof	Local Pressure Region *
750	76	0.13	0.24
	190	0.33	0.60
	203	0.35	0.64
900	76	0.16	0.29
	190	0.39	0.71
	203	0.42	0.76
1200	76	0.21	0.38
	190	0.53	0.95
	203	0.56	1.02

NOTES:

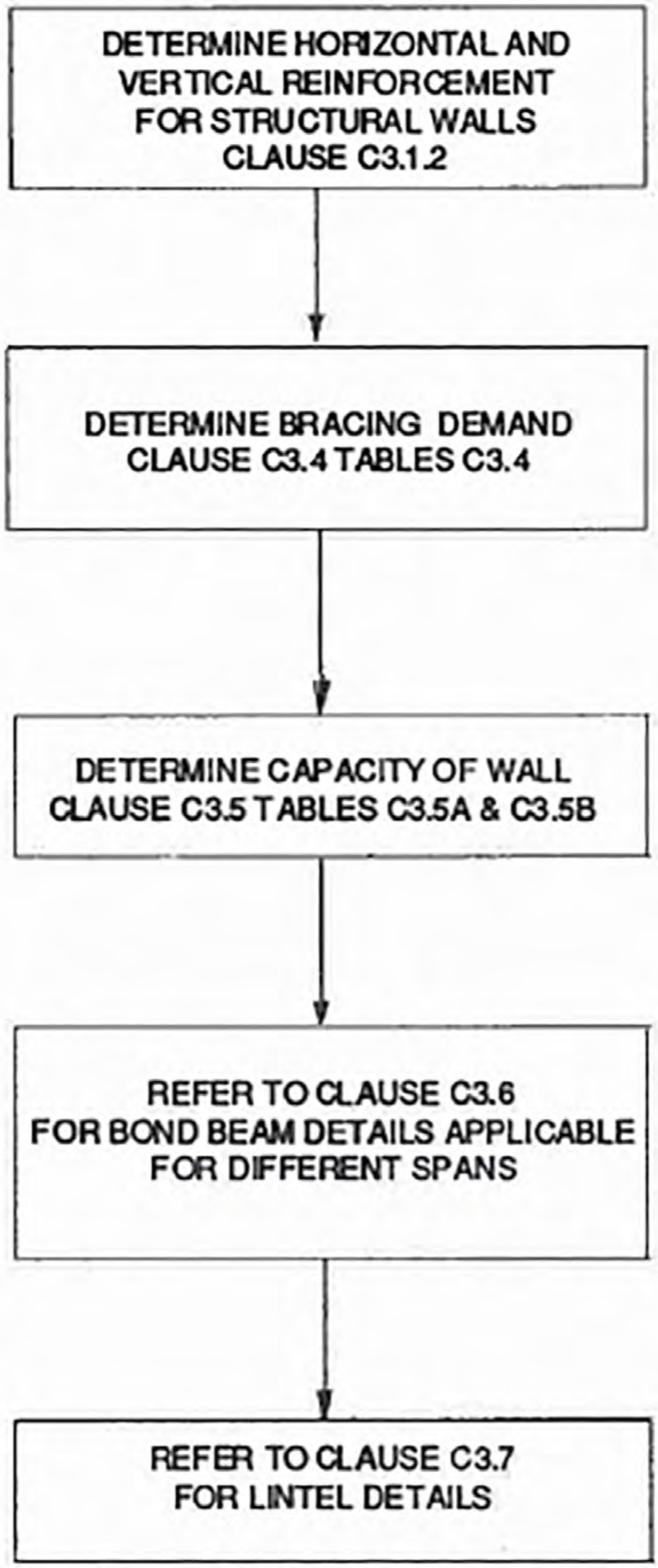
i. Fastener spacing of 76 mm is equivalent to fastening every crest of a corrugated iron roof.

ii. Fastener spacing of 1 90 mm is equivalent to fastening every crest of a ***Trimdek*** roof.
iii. Fastener spacing of 203 mm is equivalent to fastening every crest of a ***Kliplok*** roof.

iv. It has been assumed that all glazed openings are protected by means of shutters as shown in Section G.

FIGURE B10.11 FIXING OF ROOF CLADDING TO PURLINS		Design Withdrawal strength (kN)					
		Unseasoned Timber			Seasoned Timber		
		J2	J3	J4	JD2	JD3	JD4
I) 	1/65 x 3.75 ϕ plain shank nail (45 mm penetration into receiving member)	.59	.50	.45	.77	.50	.33
	1/75 x 3.75 ϕ plain shank nail (55 mm penetration into receiving member)	.72	.61	.55	.94	.61	.41
* Applicable only to cladding of 0.42 base metal thickness or greater.							
II) 	1/65 x 3.75 ϕ twisted shank nail (45 mm penetration into receiving member)	.59	.50	.45	.77	50	.33
	1/75 x 3.75 ϕ twisted shank nail (55 mm penetration into receiving member)	.72	.61	.55	.94	.61	.41
* Applicable only to cladding of 0.42 base metal thickness or greater.							
III) 	1/65 x 3.75 ϕ annular grooved nail (45 mm penetration into receiving member)	1.2	1.0	.95	1.6	1.0	.72
	1/75 x 3.75 ϕ annular grooved nail (55 mm penetration into receiving member)	1.4	1.3	1.2	1.9	1.3	.88
* Applicable only to cladding of 0.42 base metal thickness or greater.							
IV) 	No. 14 Type 17 screw with cyclone washer assembly (45 mm penetration into receiving member)	3.2	2.3	1.8	3.9	2.8	2.3

Section C
MASONRY HOUSES


DETERMINE HORIZONTAL AND
VERTICAL REINFORCEMENT
FOR STRUCTURAL WALLS
CLAUSE C3.1.2
DETERMINE BRACING DEMAND
CLAUSE C3.4 TABLES C3.4
DETERMINE CAPACITY OF WALL
CLAUSE C3.5 TABLES C3.5A & C3.5B
REFER TO CLAUSE C3.6
FOR BOND BEAM DETAILS APPLICABLE
FOR DIFFERENT SPANS
REFER TO CLAUSE C3.7
FOR LINTEL DETAILS

C1 TYPES OF HOUSES

C1.1 General

Masonry houses considered are restricted to 2 storeys in height and consist of the following:

(a) The footings can either be of reinforced masonry or of reinforced concrete.

(b) Some or all of the walls in any storey must be of partially or fully grouted concrete cored block masonry or 150 or 200 mm nominal thickness with the following limitations:

i) Timber framed walls must not vertically support masonry walls; and

ii) No masonry wall must be of lesser thickness than any masonry wall above it.

(c) Walls which are not of masonry must be of light timber framing to Section B.

(d) Ceilings, roof framing and upper storey floor must be of timber to Sections B and E, except that the ground floor may be of concrete slab-on-ground to Section D5.

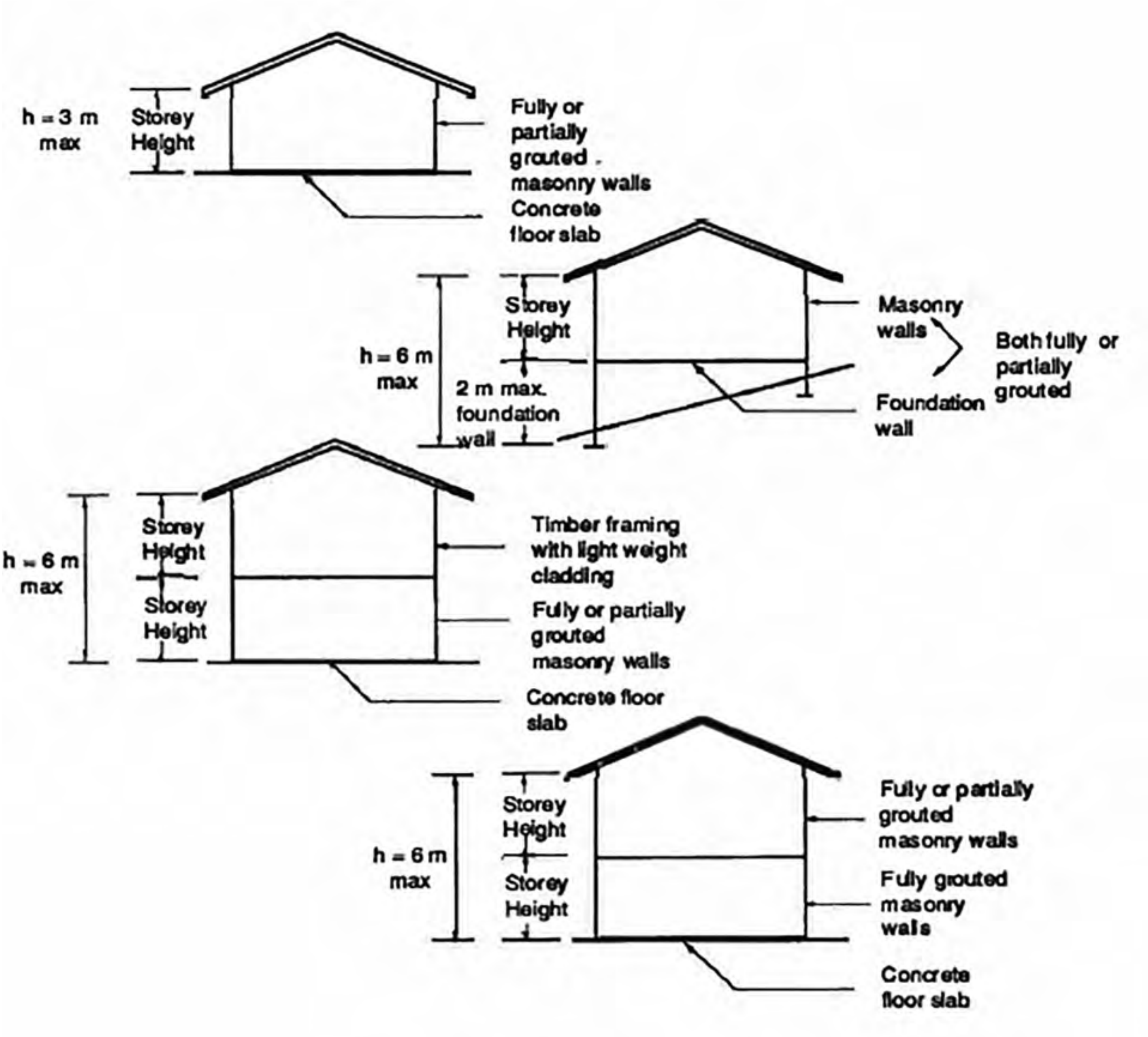


FIGURE C1.2: TYPES OF MASONRY HOUSES CONSIDERED

C1.2 Types of Houses

The types of houses considered are shown in Figure C1.2. These consist of walls of:

(a) fully-grouted masonry for both storeys or for a single storey or for a foundation wall and the single storey

(b) timber framed and lightly clad walls for the upper storey, supported on a lower storey of fully or partially grouted masonry

(c) partially grouted masonry for a single storey; and

(d) partially grouted masonry for a foundation wall and a single storey supported by it.

C2 MATERIALS AND WORKMANSHIP

C2.1 Materials

(a) All concrete must be 17.5 MPa but 10 MPa concrete may be used for sub-footing.

Mix ratios are given in Table C2.1 for locally produced 10 MPa and 17.5 MPa concrete.

(b) Concrete blocks must have a minimum compressive strength of 9 M Pa over the nett area. The actual dimensions of the concrete blocks must be 10 mm less than the nominal dimensions of 150 x 400 x 200, and 200 x 400 x 200 to allow for the thickness of mortar.

(c) All steel reinforcement and other embedded steel must be cleaned of any rust, dirt and oil before use. The epoxy coating of reinforcement and of all embedded steel is strongly recommended in areas close to the sea and other corrosive environment. The use of galvanised reinforcement and other embedded steel to retard corrosion must depend on an assurance that the cement used for the grout and mortar is free of calcium hydroxide. If this chemical is present it would attack the galvanising. Another precaution with the use of galvanised steel is that every item of steel used must be galvanised. This includes even wire ties. If this is not done galvanic corrosion can take place.

> **NOTE:** A patented chemical additive Z-12/C, is available for use with sea water and unwashed saline aggregate for making concrete of good quality and durability. Reinforcing bars do not easily corrode and destroy the concrete as would ordinarily be the case when using sea water and saline aggregates. The product is manufactured by Concrete Hitech (Holdings) Ltd., 15 Avenue Victor Hugo, 75116, Paris, France.

(d) The grout used must develop a compressive strength of 17.5 MPa at 28 days after pouring. The use of fine grout (only cement, sand and water) is allowed only for grout spaces of less than 60 mm. All larger grout spaces must be grouted with coarse grout consisting of cement, sand and 5 to 13 mm or 4 to 19 mm aggregate, and water. Coarse grout may contain suitable admixtures to improve workability.

Mix ratio for 1 7.5 MPa grout is given in Table C2.1.

TABLE C2:1

MIX RATIOS FOR CEMENT AND GROUT

COMPRESSIVE STRENGTH	MIX RATIOS BY VOLUME			
	WATER	CEMENT	SAND	COARSE AGGREGATE
10 MPa concrete	1	1	2.5	3 of 20 mm agg.
17.5 MPa concrete	0.9	1	3.2	3.3 of 20 mm agg.
17.5 MPa grout	1.1	1	3	2.7 of 10 mm agg.

NOTE: The quantity of water given is the maximum allowable and must be reduced with increase in moisture content of sand or aggregate.

(e) Mortar for masonry must consist of 1 part of cement, 3 parts of sand and sufficient water. It may also contain hydrated lime or a suitable admixture to improve workability. If lime is added, the sand-lime mixture must be allowed to stand for 24 hours before the cement is added and the mortar used. Mortar must not be used once 1½ hours have passed after the addition of cement to the mix. To produce mortar of consistently the right quality, the volumes of materials must be measured using buckets or gauge boxes and not shovelled direct from the stockpile or cement bag into the mixer. A dry bucket must be reserved for measuring cement quantities. The water must be added carefully from a measured container and not directly from the end of a hose pipe.

C2.2 Workmanship

The quality of workmanship must be of a standard conforming to good trade practice.

The accurate positioning of starter bars is very important in order to maintain the quality of the finished masonry.

Clean-out openings are desirable at the bottom row of blocks in the cells containing reinforcement. The strength of the masonry, particularly of bracing walls is very much dependent on the quality of g routing. The clean-out pocket would allow thorough cleaning of the cells before grouting.

Grouting must be done only after the mortar joints have gained enough strength to withstand the pressure of the grout and to allow thorough cleaning. The grout must be so rodded and worked that it fully fills the cavities without segregation. Horizontal grout joints must be 20 mm below the uppermost masonry units. The upper surface of the grout must be protected from weather.

The maximum lift of grout must be limited to 1200 mm if the grout space is not less than 50 mm in the least dimension. Otherwise the lift should be restricted to 400 mm.

Temporary bracing as required must be provided for masonry walls to resist lateral loads during construction.

In very hot and dry conditions the masonry blocks may be kept lightly damp before use. Mortar and grout must not be mixed in quantities that would dry out before use. The work may be kept damp by a light fog spray for 24 hours after laying.

C3 WALLS

C3.1 General

Walls serve the following functions:

(a) Provide an envelope to the living space and therefore privacy and protection from the elements ; and

(b) Where so designed (known as structural walls), take vertical downward loads from the roof and suspended floors, vertical uplift loads from wind acting through the roof membrane and horizontal loads from wind effects.

A1.1.1 The limitations on the number and height of storeys for 150 mm and 200 mm walls, are as follows:

(c) 150 mm or 200 mm fully grouted walls can be used up to a height of 2 storeys.

(d) Partially grouted walls of either thickness are limited to a single storey or the top storey of 2 storeys.

(e) The height of any storey must not exceed 3.0 m.

C3.1.1 All structural walls (see C3.2) must be centrally reinforced both vertically and horizontally to the details given in Table C3.1.2. It must be noted that there are further restrictions on the spacing of reinforcement for bracing panels (see C3.5 and Figure C3.5B).

Vertical bars must be provided:

(a) at all comers and ends of walls

(b) on each side of ·all wall openings 400 mm wide or more (see Fig. C3.1.2A & B) , and

(c) at either side of shrinkage control joints (see Fig. C3.1.3A).Temporary bracing as required must be provided for masonry walls to resist lateral loads during construction.

TABLE C3.1.2:
REINFORCEMENT FOR STRUCTURAL WALLS

Wall types	150mm Wall		200mm Wall	
	Vertical Reinforcement	Horizontal Reinforcement	Vertical Reinforcement	Horizontal Reinforcement
Fully grouted	D12@ 800 mm	D16@ 800 mm	D12 @ 800 mm	D16 @ 800 mm
Partially grouted	D12 @ 800 mm	BB	D12 @ 800 mm	4 D12 or 2 D16 @ 2800 mm

NOTE:

1. BB implies that the bond beams provided (see C3.6) serve the purpose.

2. In bracing panels (see C3.5) of fully g routed masonry the spacing of horizontal reinforcement must be the minimum of

(a) Half the panel's length or height, and

(b) The values in this table.

Vertical reinforcement must be located in the cells containing starter reinforcement from footings or from the lower structural wall. It must extend from the footing to the bond beam next above and from the lower to the upper bond beams.

Horizontal reinforcement is required just below all openings. This is also required above small openings over which lintels are not provided. Such horizontal reinforcement above and below openings must extend at least 600 mm beyond either side of the opening (see Figure C3.1.2A & B).

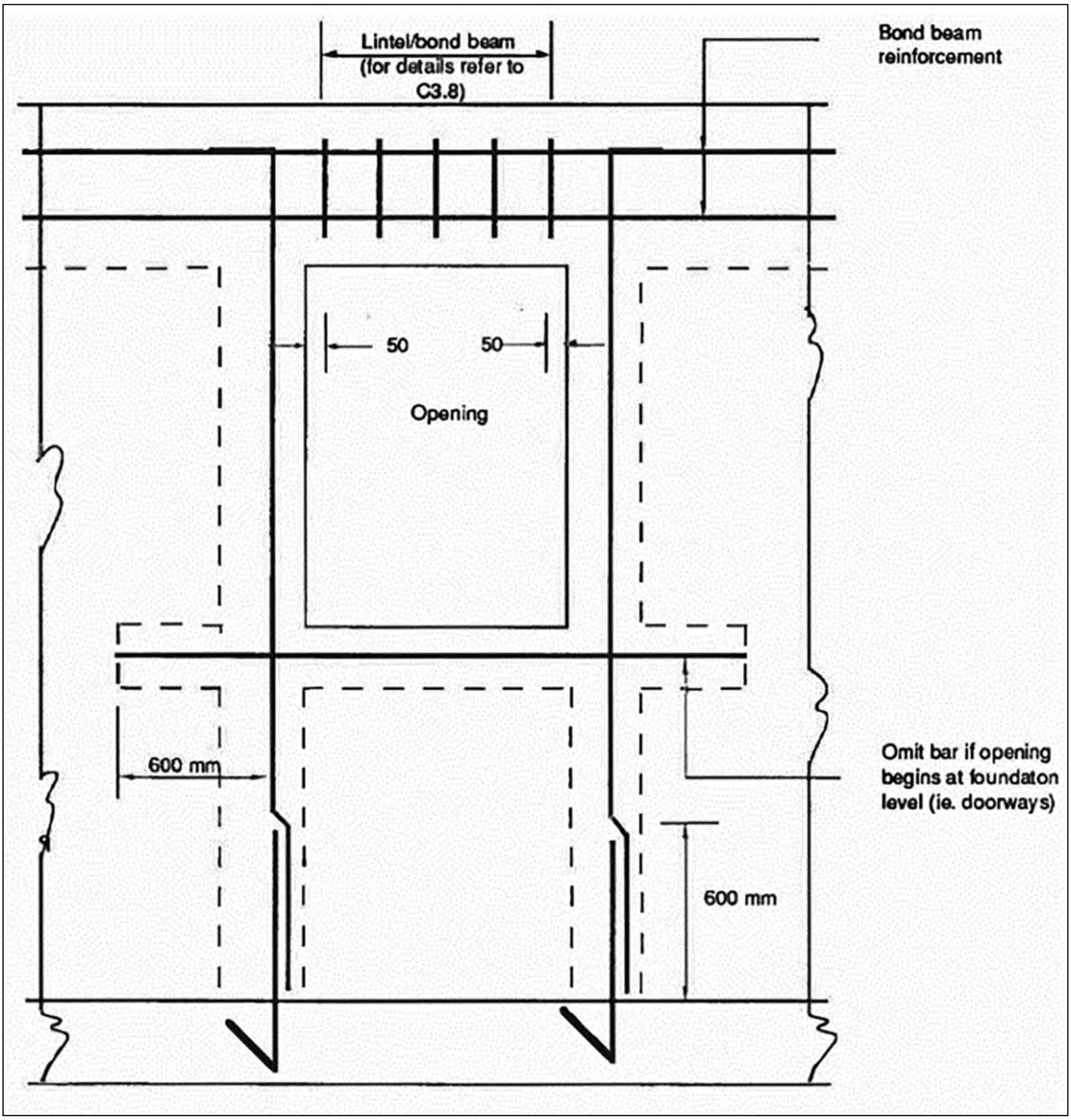


FIGURE C1.2: TYPES OF MASONRY HOUSES CONSIDERED

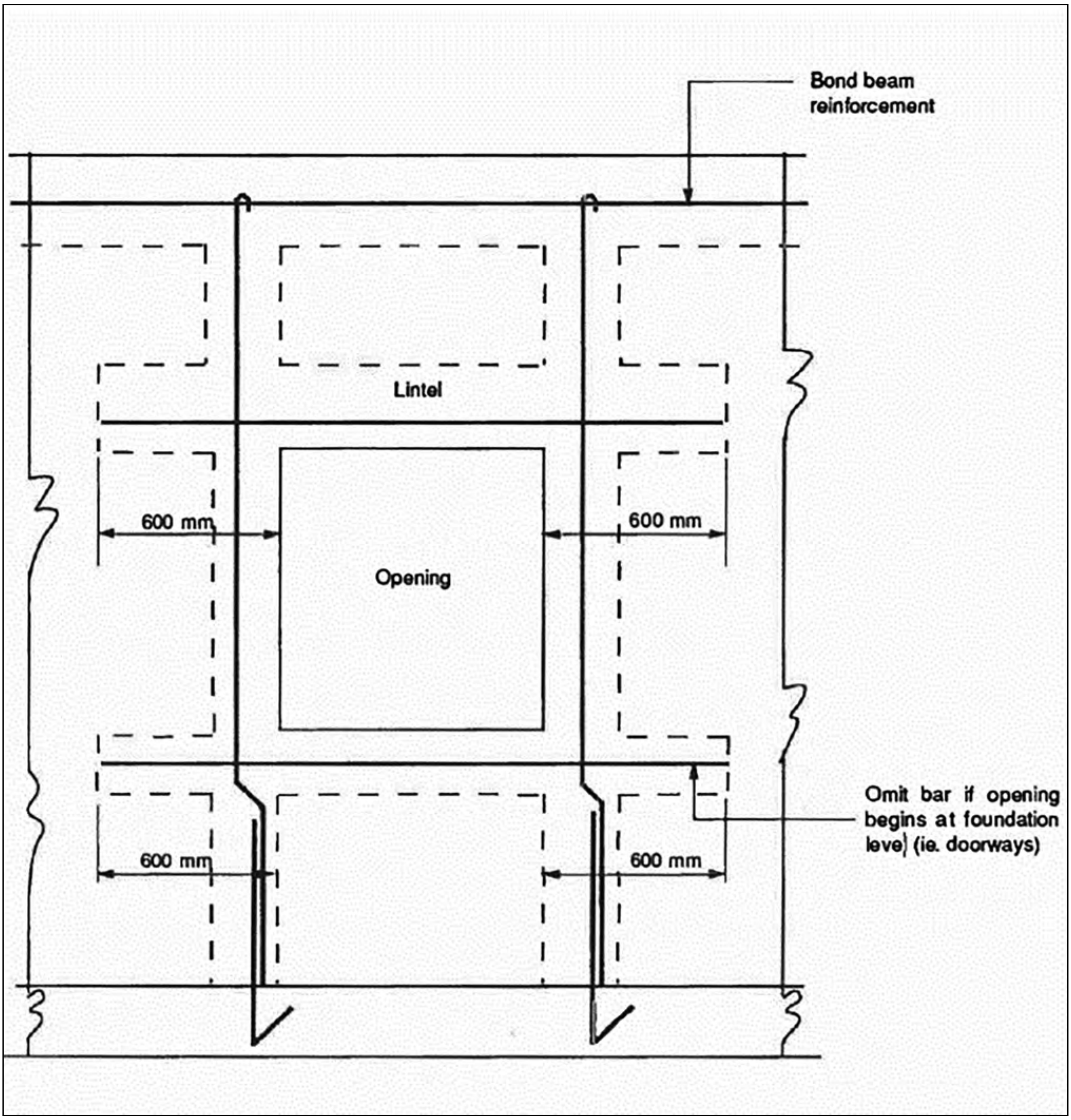


FIGURE C3.1.2B: REINFORCEMENT DETAILS AROUND OPENINGS IN WALLS

C3.1.2 Any wall in excess of 8 m length must have shrinkage control joints to the details of Figure C3.1.3A

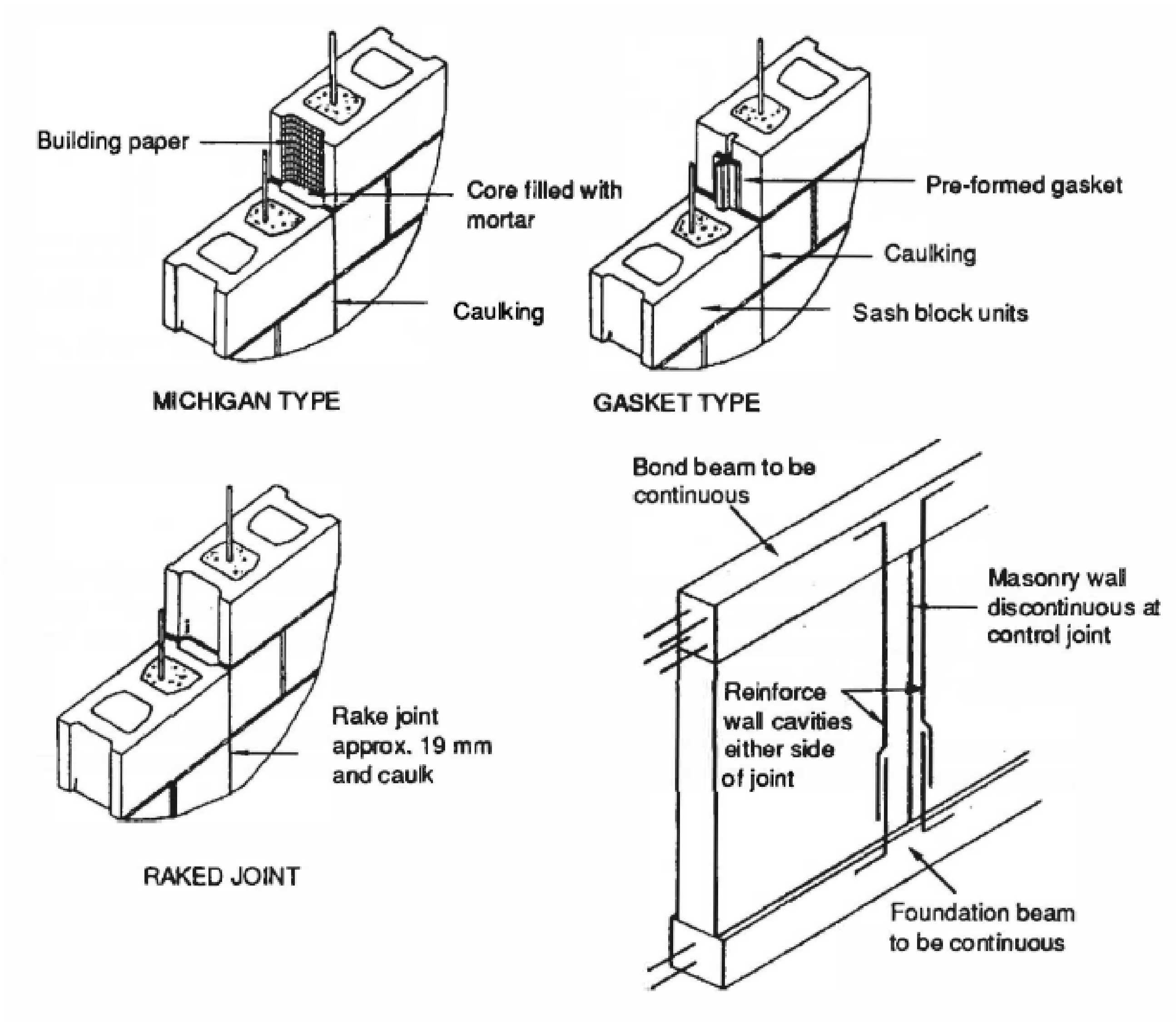


FIGURE C3.1.3A: SOME METHODS OF PROVIDING SHRINKAGE CONTROL JOINTS

The cavity on each side of the joint must be reinforced and grouted. The horizontal reinforcement for the wall must be discontinued at the joint. However, the horizontal reinforcement of bond beams and lintels must be continuous across the joint. The control joints on external walls must be weather and vermin proof.

Shrinkage control joints are to be located at:

- intervals of 5 to 8 m along straight walls
- major changes in wall height
- near return angles of walls in the case of floor plans other than a simple rectangle or square
- near wall intersections
- changes in wall thickness.

Some of these locations are illustrated in Figure C3.1.3B.

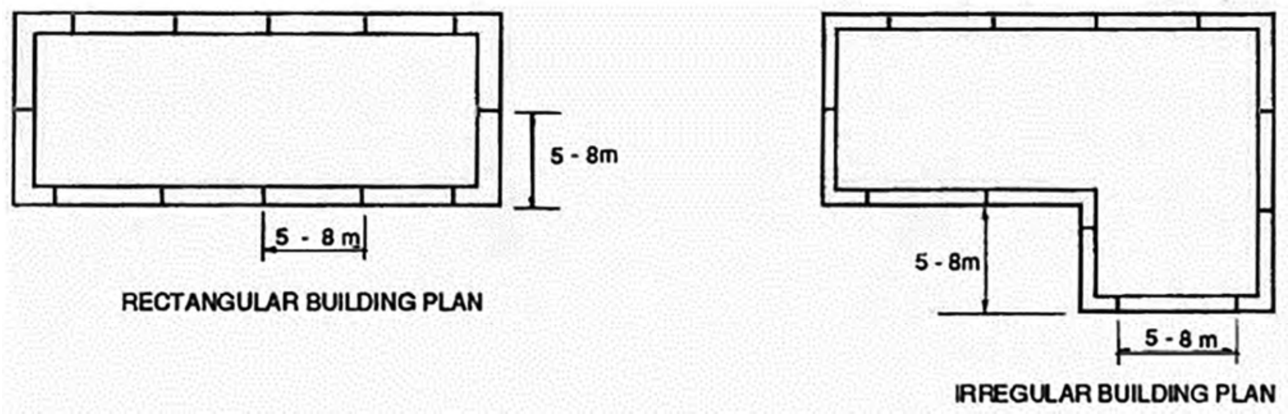
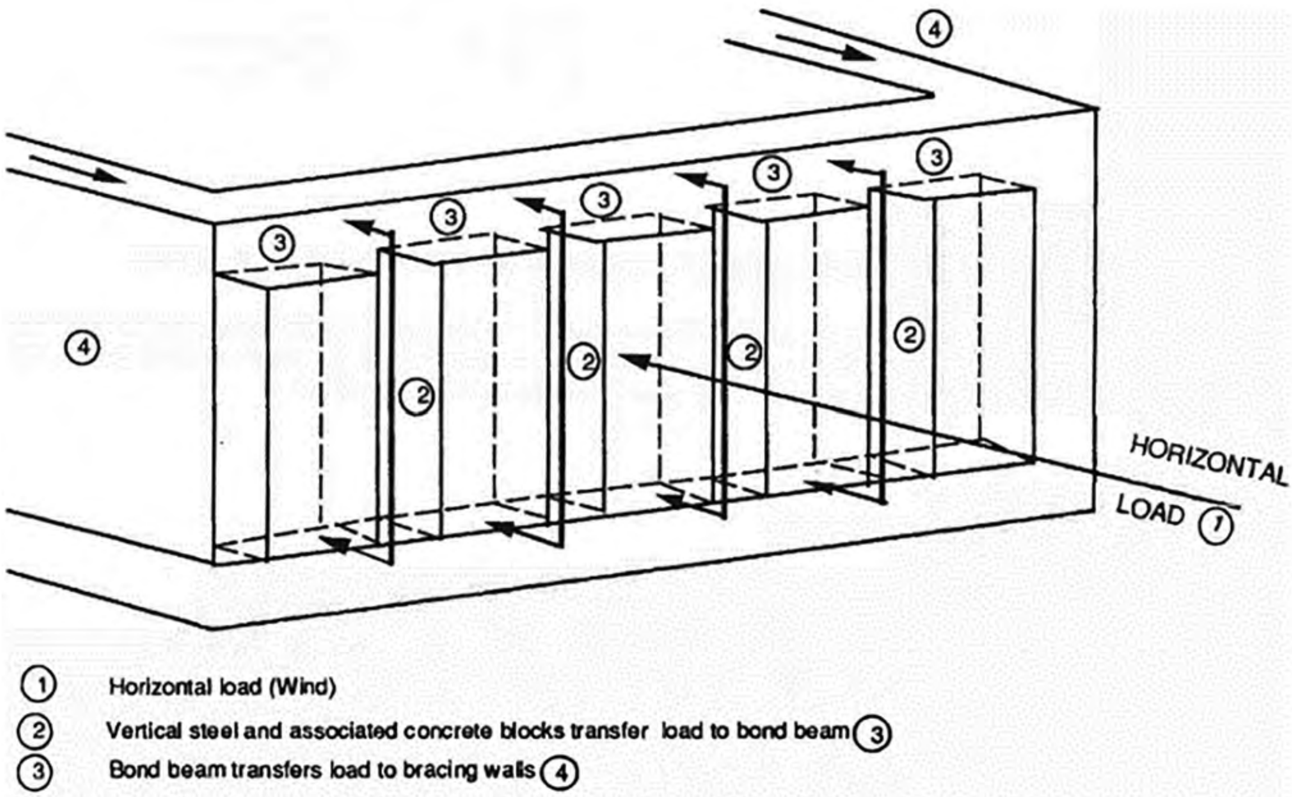


FIGURE C3.1.3B: LOCATION OF CONTROL JOINTS AGAINST SHRINKAGE

C3.2 Structural Walls

Structural walls including foundation walls are designed to take horizontal loads and need to have bond beams and bracing panels built into them. The function of the bond beam is to transfer horizontal loads to the bracing walls. These are walls containing bracing panels. The panels resist the racking loads transferred by the bond beams. Figure C3.2 explains the role of bond beams and bracing walls.

The details of walls in this manual are such that once the provisions for horizontal loads have been met by using the appropriate tables the walls would safely carry the required vertical loads, both downward and wind uplift.



NOTE: When the direction of the horizontal load changes by 90°, the roles of the bracing wall and the braced wall are reversed.

FIGURE C3.2: ROLE OF BOND BEAMS AND BRACING WALLS

C3.3 Materials for Structural Walls

The materials considered for structural walls are reinforced masonry of 150 mm or 200 mm nominal thickness hollow core concrete blocks. The walls are either fully or partially grouted.

C3.4 Bracing Demand

The demand for bracing arises from loads. Table C3.4 gives the bracing demand against wind loads, expressed in bracing units. (100 bracing units are equal to a strength of 5 kN. There is no need to apply this information in the use of this Manual).

C3.4.1 The bracing demand for wind has to be calculated for the two principal directions of the building. Use the following steps for these calculated:

STEP 1
Select from Table C3.4 the appropriate value of bracing demand per metre length of wall, depending on the type of storey, and the roof slope.

STEP 2
Multiply the appropriate value of unit bracing demand from Step 1, with the length in metres of the external wall facing the wind in each direction. This will give the total bracing demand against wind for each of the two directions.

STEP 3
Multiply the appropriate value of the unit bracing demand from Step 1 with twice the length of each line of external wall and four times the length of each line of external wall. The resulting figures would give the local bracing demand for the external and internal walls.

TABLE C3.4:

BRACING DEMAND (BRACING UNITS) - WIND

Location of Storey	Maximum Slope of Roof (degrees)	Minimum bracing units required per metre when exposed to design windspeed (m/s) of
Single or Top Storey	10	41
	15	41
	20	49
	25	71
Foundation Wall of One Storey	10	64
	15	64
	20	77
	25	112
Lower of Two Storeys	10	119
	15	119
	20	142
	25	207

C3.5 Bracing Panels

Tables C3.5A and C3.5B give details of the capacity of bracing panels. The bracing capacity in these tables is expressed in bracing units. (Like in Table C3.4 for the bracing demand). The total bracing capacity of walls in any storey in each direction must match or exceed the maximum bracing demand for that storey for the two directions. For wind loads, the demand is usually different for the two directions.

In using the Tables C3.5A and C3.5B for the calculations of the total bracing capacity of a wall, the following procedure is adopted:

(a) For each storey each length of wall between shrinkage control joints is divided into bracing panels.

(b) Where there are no openings (openings of less than 400 mm x 400 mm spaced at not less than 1.8 m are neglected) in a wall for the full length between the control joints, the height of the wall in the storey to the underside of the bond beam is considered to be the height of the panel and the length of the panel taken as the length between the control joints.

(c) Where there are openings between control joints such as doors and windows, the length of each panel is the length between adjacent openings. The height of each panel is the minimum height of the opening adjoining that panel.

(d) The points mentioned in (a), (b) and (c) are illustrated in an example in Figure C3.5A. The calculation of the bracing capacity of the total wall in the figure is as follows:

i) If it is a fully grouted wall, the use of Table C3.5A is appropriate. Further assuming that the nominal wall thickness is 150 mm, the capacity of each panel and of the total wall are as follows:

	length x height	bracing units
Panel 1	1.2 X 2.0	450
Panel 2	1.6 X 1.2	1500
Panel 3	2.0 X 1.2	2400
Panel 4	3.0 X 1.6	(3400 + 3850)/2 = 3625
Panel 5	1.8 X 1.6	(1500 + 2400)/2 = 1950
Panel 6	6.0 X 2.8	5950
Total for 150 mm fully grouted wall		= 15875 bracing units

ii) If it is a partially grouted wall, we have to use Table C3.5B. When we look at the table it is seen that the height allowed for partially grouted 150 mm walls is limited to 2.4 m whereas the height of the wall in the example is 2.8m. Therefore we can use only 200mm thick partially grouted walls. Using the table for the 200mm thick part the capacity is noted down as follows:

	length x height	bracing units
Panel 1	1.2 X 2.0	450
Panel 2	1.6 X 1.2	1500
Panel 3	2.0 X 1.2	2400
Panel 4	3.0 X 1.6	(3400 + 3850)/2 = 3625
Panel 5	1.8 X 1.6	(1500 + 2400)/2 = 1950
Panel 6	6.0 X 2.8	5950
Total for 150 mm fully grouted wall		= 15875 bracing units

It will be seen that although the partially grouted wall is 200 mm thick, its bracing capacity is less than 1/6 of the fully grouted 150 mm thick wall. It is an Indication of the extreme importance of the quality and throughness of grouting. If a “fully grouted wall” has many unfilled pockets or has dirt and grit contaminated pockets, the bracing strength of the wall will be far lower than the values given in Table C3.5(A)

(e) Where the bracing demand is such that a partially grouted set of bracing walls does not provide enough capacity and a fully grouted set of walls gives excessive capacity, It is permissible to use a suitable mix of fully grouted and partially grouted walls. However if in any particular wall some of the panels are fully grouted and some only partially grouted, the effect of the partially grouted panels must be neglected. For instance, in Figure C3.5A if the panels 2, 3 and 6 are fully grouted and the other panels only partially, then the total bracing capacity of the wall is only the sum of the capacities of panels 2, 3 and 6.

In order for a panel to qualify for the bracing capacity given in Tables C3.5A and B, the spacing of the horizontal reinforcement must be to the detail given in Figure C3.5B. The other details of reinforcement are as given in Table C3.1.2.

In order to check if the bracing capacity is adequate to meet the bracing demand, the following procedure must be followed:

STEP 1
Calculate the bracing capacity of each line of external and internal walls as illustrated earlier in this clause.

STEP 2
Check to see if the capacity of each line is more than the local demand for that line as was determined in the second part of Step 4 at Clause C3.4.2.

CO MMENT
If the capacity provided is not adequate, it may be increased by changing from partial to full grouting, increasing wall thickness, eliminating some openings or reducing their size, or a permitted combination of these.

STEP 3
Check to see if the sum of the capacity of all the lines of bracing walls in each principal direction is more than the demand for that direction as determined in the first part of Step 4 at Clause C3.4.2.

COMMENT
If the capacity is not adequate, it can be increased by corrective steps suggested in the comment

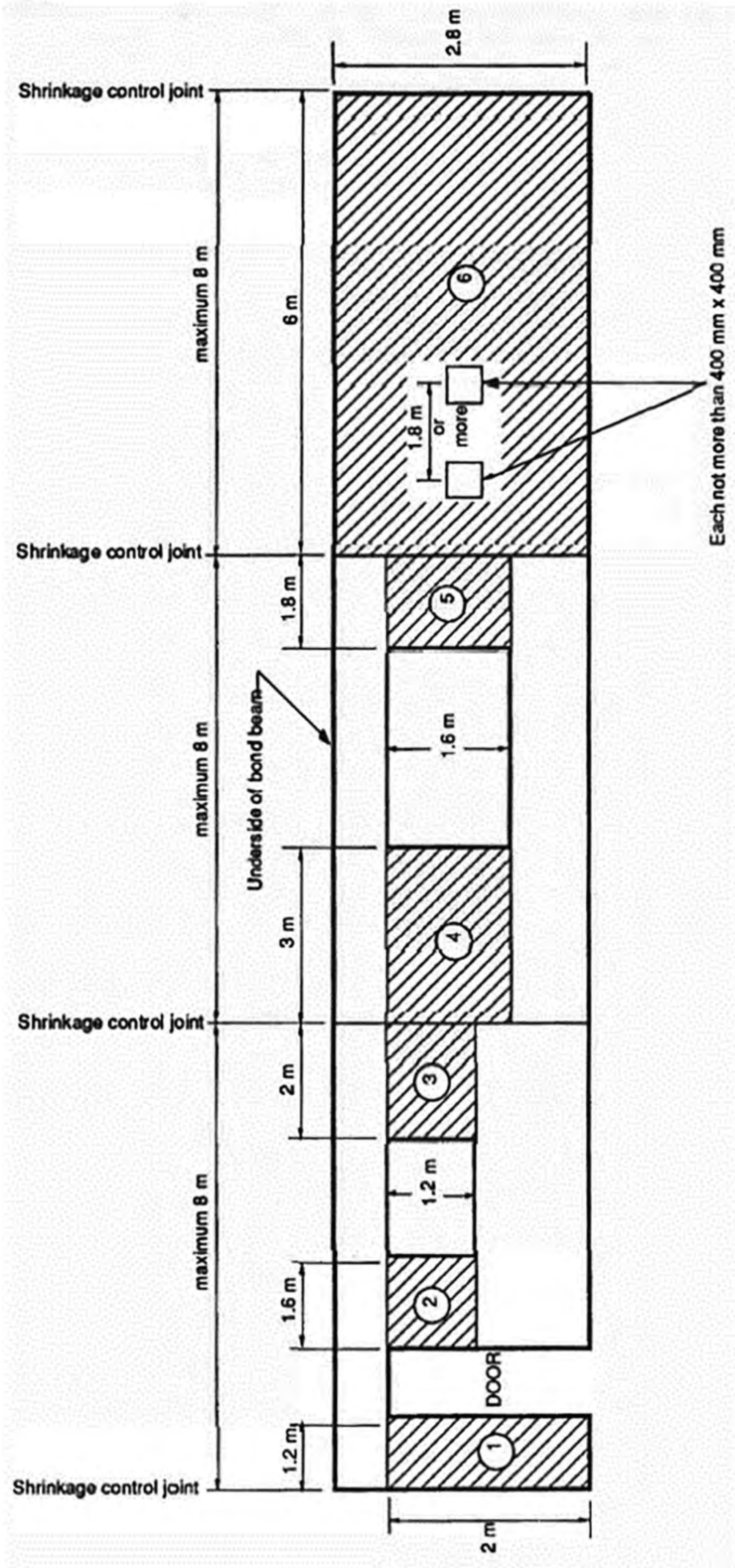
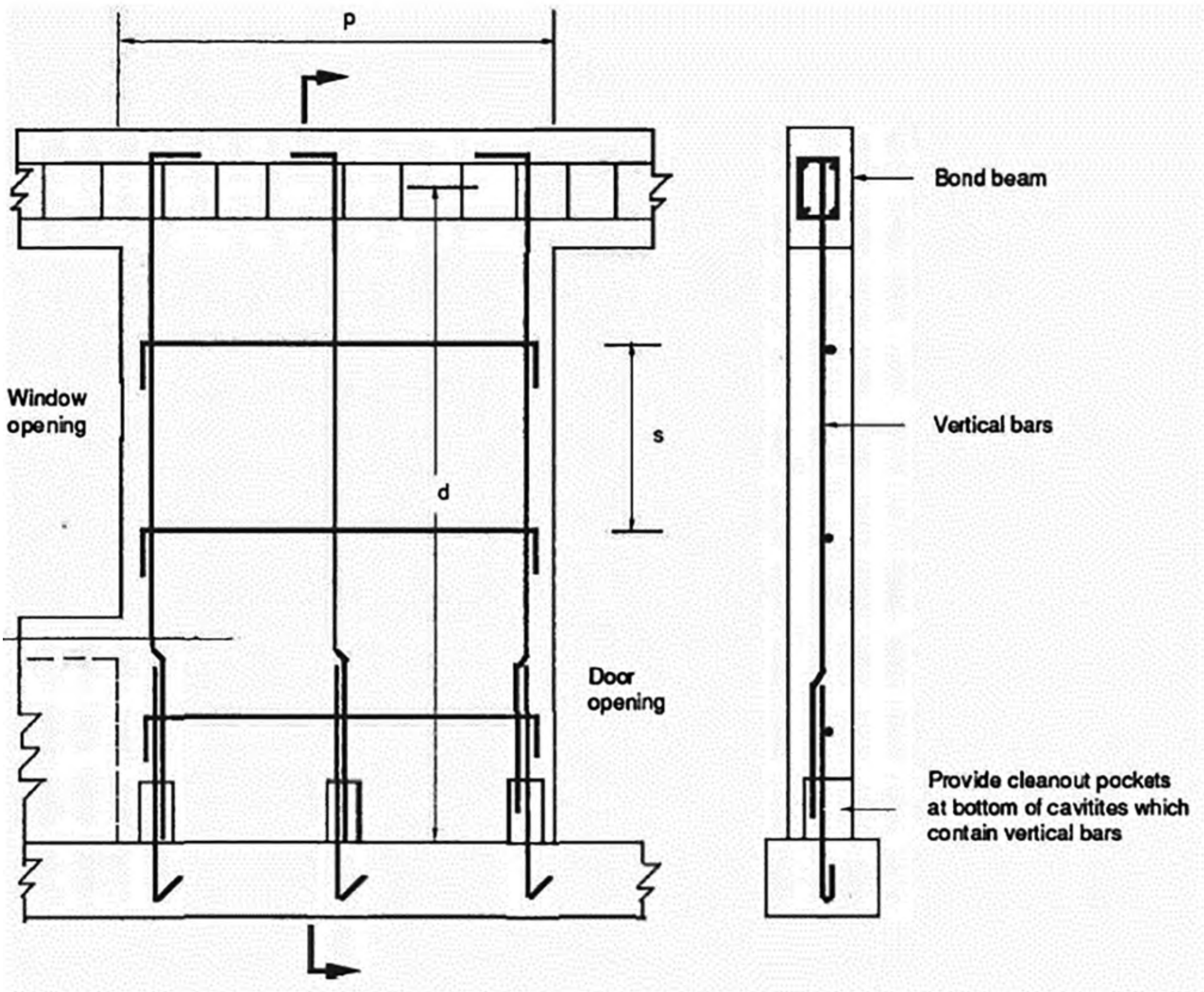


FIGURE C3.5A: EXAMPLES OF BRACING PANELS



NOTE: The value of s, the spacing of the horizontal bars in the panel must be no more than the least of p.2 or d/2 or the value give in Table C3.1.2..

FIGURE C3.5B: BRACING PANEL IN FULLY GROUTED MASONRY BETWEEN DOOR AND WINDOW OPENINGS

TABLE C3.5A:
CAPACITY OF FULLY GROUTED WALL BRACING PANELS IN BRACING UNITS

Panel height (m)	Length of panel (m)																		
	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0
Wall thickness 150 mm																			
0.8	800	1300	1600	2400	2900	3400	3850	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
1.0	600	1100	1550	2400	2900	3400	3850	4700	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
1.2	450	1000	1500	2400	2900	3400	3850	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
1.4	400	750	1300	2400	2900	3400	3850	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
1.6	300	650	1150	2400	2900	3400	3850	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
1.8	200	550	1000	1900	2750	3400	3850	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
2.0	150	450	950	1550	2250	3000	3750	4300	4800	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
2.2	100	350	750	1250	1850	2500	3200	3900	4650	5300	5750	6250	6700	7200	7700	8150	8650	9100	9600
2.4	100	300	600	1000	1550	2100	2750	3400	4050	4700	5400	6050	6700	7200	7700	8150	8650	9100	9600
2.6	50	250	500	850	1300	1800	2350	2950	3550	4150	4750	5400	6000	6600	7250	7850	8450	9050	9600
2.8 (max)	50	200	400	700	1100	1550	2050	2550	3100	3650	4250	4800	5400	5950	6550	7100	7650	8250	8800
Wall thickness 200 mm																			
0.8	1100	1600	2300	3250	3900	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
1.0	950	1500	2150	3250	3900	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
1.2	750	1300	2000	3250	3900	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
1.4	600	1000	1750	3250	3900	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
1.6	400	900	1550	3250	3900	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
1.8	300	750	1300	2600	3700	4550	5200	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
2.0	200	600	1250	2100	3050	4050	5100	5850	6500	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
2.2	150	500	1000	1700	2500	3400	4350	5300	6300	7150	7800	8450	9100	9750	10400	11100	11750	12400	13050
2.4	150	400	800	1400	2100	2850	3700	4600	5500	6400	7300	8200	9100	9750	10400	11100	11750	12400	13050
2.6	100	300	650	1150	1750	2450	3200	4000	4800	5600	6450	7300	8150	9000	9800	10650	11450	12300	13050
2.8	100	250	550	950	1500	2100	2750	3450	4200	4950	5750	6500	7300	8100	8850	9650	10400	11200	11950
3.0	50	200	450	800	1250	1800	2390	3050	3700	4400	5100	5850	6550	7300	8050	8750	9500	10200	10900

TABLE C3.5B:
CAPACITY OF PARTIALLY GROUTED WALL BRACING PANELS IN BRACING

Panel height (m)	Wall thickness 150 mm																		
	Length of panel (m)																		
	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0
0.8	100	150	200	300	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
1.0	100	150	200	300	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
1.2	50	150	150	300	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
1.4	50	100	150	300	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
1.6	50	100	100	300	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
1.8	50	50	100	250	350	450	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
2.0		50	100	200	300	400	500	550	600	700	750	800	850	900	1000	1050	1100	1150	1250
2.2		50	100	150	250	350	400	500	600	700	750	800	850	900	1000	1050	1100	1150	1250
2.4 (max)		50	100	150	200	300	350	450	550	650	700	800	850	900	1000	1050	1100	1150	1250
	Wall thickness 200 mm																		
0.8	150	200	300	400	450	550	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
1.0	100	200	250	400	450	550	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
1.2	100	150	250	400	450	550	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
1.4	50	150	200	400	450	550	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
1.6	50	100	200	300	450	550	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
1.8	50	100	150	250	350	500	600	700	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
2.0		50	100	200	300	400	550	650	750	850	900	1000	1100	1150	1250	1300	1400	1450	1550
2.2		50	100	150	250	350	450	550	700	800	900	1000	1100	1100	1250	1300	1400	1450	1550
2.4		50	100	150	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1450	1550
2.8		50	50	100	200	250	350	400	500	600	700	800	900	1000	1100	1200	1300	1350	1450
3.0 (max)		50	50	100	150	200	300	350	450	550	650	700	800	900	1000	1100	1150	1200	1350

C3.6 Bond Beams

Bond beams serve the following purpose:

(a) tie the masonry wall together

(b) transfer lateral loads on the walls in which they are located, to bracing walls at right angles to them

(c) provide the anchorage required for roof and floor members.

Bond beams must be provided at the top of all masonry walls and at lower levels corresponding to the location of the suspended floor in a two-storey house or a house with foundation walls. A bond beam is considered to be a "top bond beam" if it is not overlain by any masonry, timber frame, floor or other superstructure. Other bond beams are known as intermediate bond, beams, such as on top of foundation walls.

The requirements for intermediate bond beams are more stringent than for top bond beams.

The maximum span of a bond beam is normally 5 m. The span is the spacing of the bracing walls to which the bond beam transfers horizontal loads. However, a line of bracing walls is considered to function in a line if there is no offset greater than 2 m between panels in the same line of internal walls. (See Figure C3.6). When this happens, the maximum allowable span can be up to 7 m.

The details of top and intermediate bracing beams are given in Table C3.6.

Sloping bond beams must be provided at the top of gable shaped walls and be continuous with adjoining bond beams. The intersection of bond beams must be detailed as for footings shown in Figure D4.6.

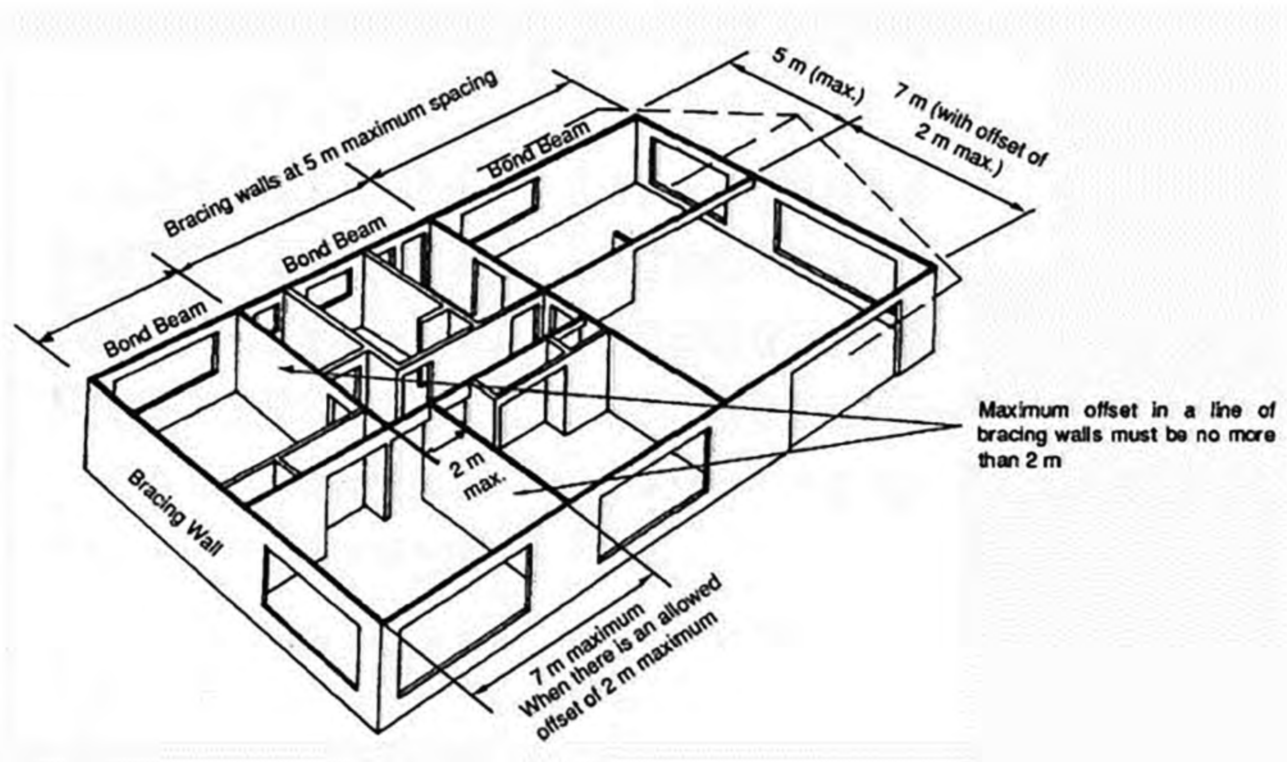


FIGURE C3.6: BRACING BEAMS AND BRACING WALLS

TABLE C3.6:

BOND BEAM SIZES
HEIGHT OF 3.0 M BETWEEN BOND BEAMS

Span (m)	Top Bond Beam	Intermediate Bond Beam
≤ 3	C 150 x 200 2 D12 or M/C 200 x 200 2 D12	C 150 x 200 2 D12 or M/C 200 x 200 2 D12
4	C 150 x 200 2 D12 or M/C 200 x 200 2 D12	C 150 x 200 2 D16 or C 200 x 200 2 D16
5	C 150 x 400 4 D12 or M/C 200 x 200 2 D16	M/C 150 x 400 4 D12 or M/C 200 x 200 2 D16
6*	C 150 x 400 4 D16 or C 200 x 400 4 D16	M/C 150 x 400 4 D16 or M/C 200 x 400 4 D12
7*	C 150 x 400 4 D16 or C 200 x 400 4 D16	M/C 150 x 400 4 D16 or M/C 200 x 400 4 D16

* Refer to Clause 3.6

NOTE: M stands for masonry bond beam
C stands for concrete (17.5 MPa) bond beam

All reinforcement to be placed as in sketch  *or* 

C3.7 Lintels

Lintels must be provided over all openings, such as doors and windows. The width of the lintel must be the same as the thickness of the wall. Lintels must bear at their ends for 200 mm. The span of the lintel is the clear width of the opening. Table C3.7 and Figure C3.7 give the dimensions and reinforcement for lintels of various spans.

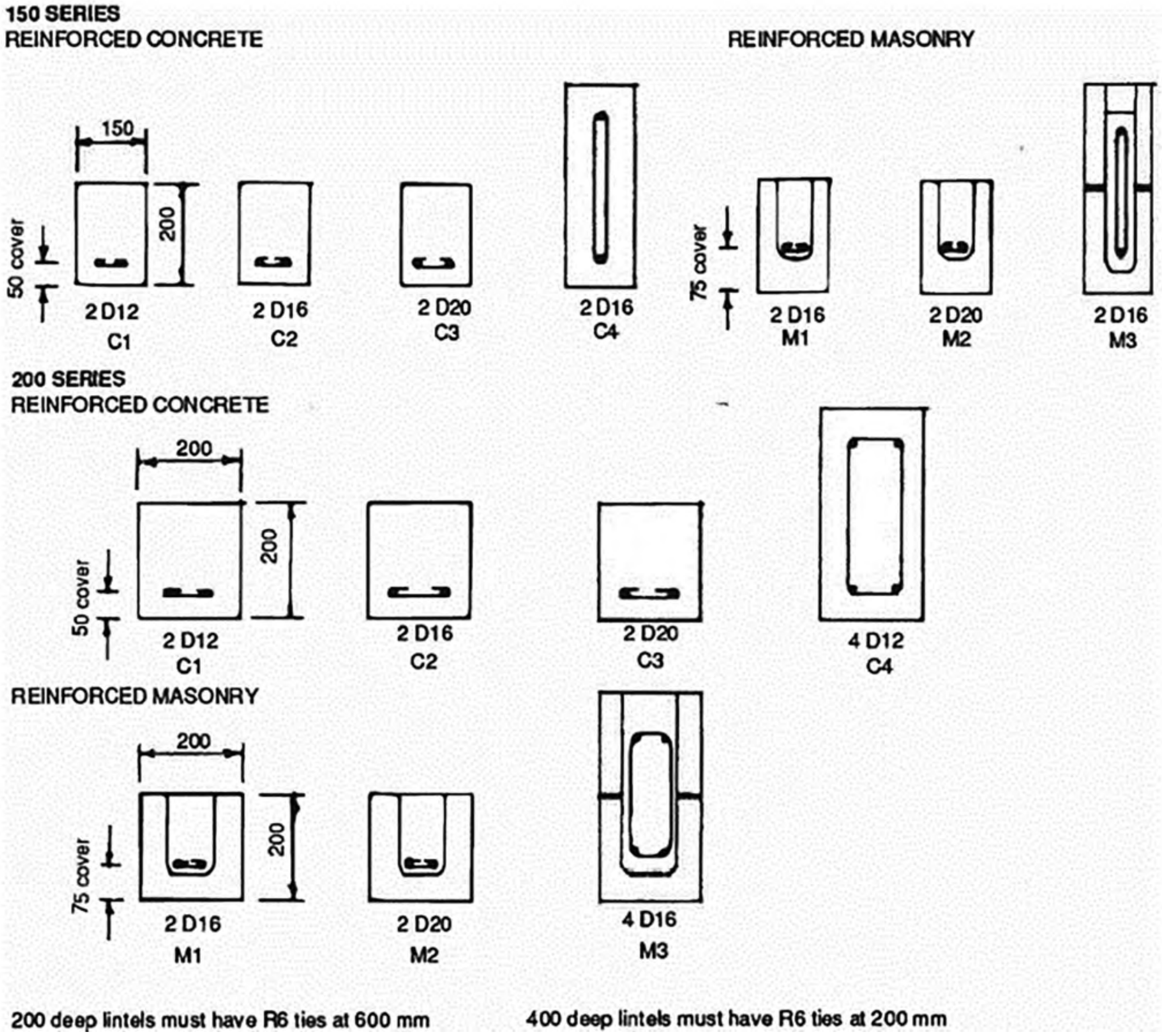


FIGURE C3.7: REINFORCED CONCRETE AND MASONRY DETAILS

TABLE C3.7:
LINTEL SIZES

Width of Lintel (mm)	Maximum Span of Lintel	LINTEL SUPPORTING				
		Light Roof Only	Light Roof and Light Timber Framed Wall	Light Roof, Light Timber Framed Wall and Floor	Light Roof and Masonry Wall Only	Light Roof, Masonry Wall and Timber Floor
150	1600	C1/M1	C1/M1	C1/M1	C2/M1	C2/M1
	2000	C2/M1	C1/M1	C1/M1	C2/M1	C2/M1
	2600	C3/M2	C2/M2	C2/M1	C2/M2	C2/M2
	3000	C4/M3	C3/M2	C3/M2	C4/M3	C4/M3
200	1600	C1/M1	C1/M1	C1/M1	C1/M1	C2/M2
	2000	C1/M1	C1/M1	C2/M2	C2/M1	C2/M2
	2600	C2/M2	C2/M2	C3/M2	C3/M2	C3/M2
	3000	C4/M3	C4/M3	C3/M3	C4/M3	C4/M3

C3.8 Combination of lintels and bond beams

In some cases it may become necessary to combine a bond beam and a lintel. Where the lintel is completely located within the middle 2/3 of the span of the bond beam, the combined beam/ lintel must be of the larger of the two individual sizes and must have not less than the maximum of the reinforcement for either. The disposition of the reinforcement must be similar to the example shown in Figure C3.8A so that the combination beam can take either the horizontal loads of the bond beam or the vertical loads of the lintel.

If the lintel is located in part or whole outside the middle 2/3 of the span of the bond beam, the reinforcement provided must be the sum of the reinforcement required for the bond beam and lintel. The disposition of the reinforcement must be as shown in Figure C3.8B.

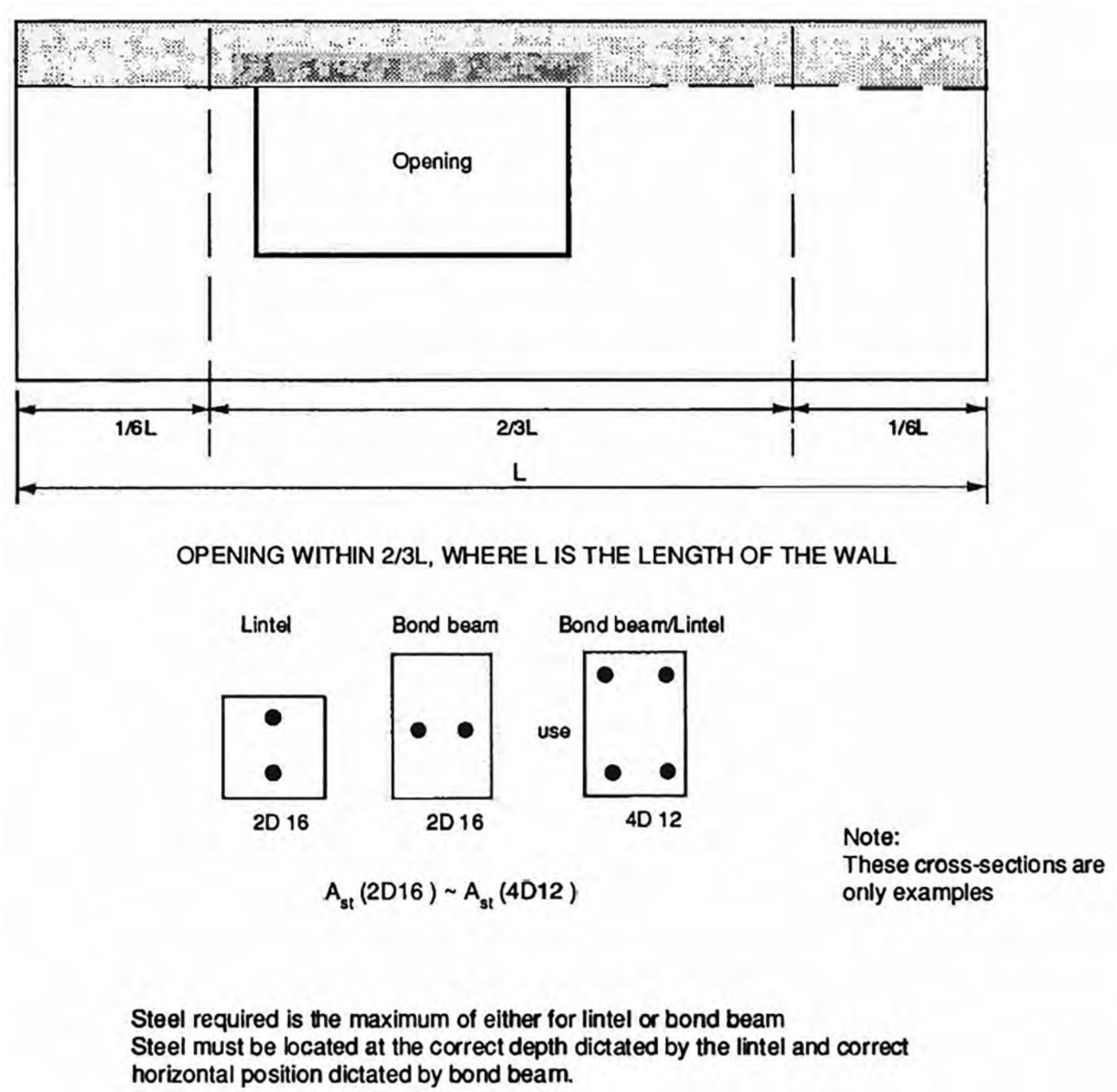


FIGURE C3.8B: PART OF LINTEL LOCATED OUTSIDE MIDDLE 2/3 OF BOND BEAM SPAN

Section D

FOUNDATIONS

Section D FOUNDATIONS

D1 GENERAL

D1.1 For Timber Floors

(a) The foundation and sub-floor framing system to resist vertical loads must be such that the ground floor joists are directly supported on bearers which are fixed to piles embedded in concrete into the ground.

(b) Anchor piles must be provided under all load bearing walls, so as to resist wind uplift loads.

(c) Floor piles must be used under all areas supporting only a floor.

(d) Dimensions of anchor piles and floor piles are given in Figure D3.

(e) It has been assumed that the minimum bearing capacity of the soil is 100 kPa (i.e. 1 Ton per sq. foot).

D1.2 For Concrete Floors and Footings

(a) Footings must be provided under all walls as described in Section D4.

(f) Compacted granular fill must be provided under footings and slab on ground floors.

(g) Dimensions and reinforcement details for footings are given in Section D4.

(h) Details for slab on ground floors are given in Section D5.

D2 SITE REQUIREMENTS

The site must be well drained and cleared of all organic material. The foundation must be well compacted and consist principally of granular material. Houses must not be built in potentially unstable locations such as in or near slopes which might slide during heavy rains or earth tremors.

In uneven but stable ground the base of any footing (or sub-footing) must be so located that it is at least 1.0 m horizontally away from the finished ground surface *(see Figure D2.1).*

Soil earth etc. must not be allowed to bear against any wall unless the wall and the associated footings have been specifically designed as retaining walls.

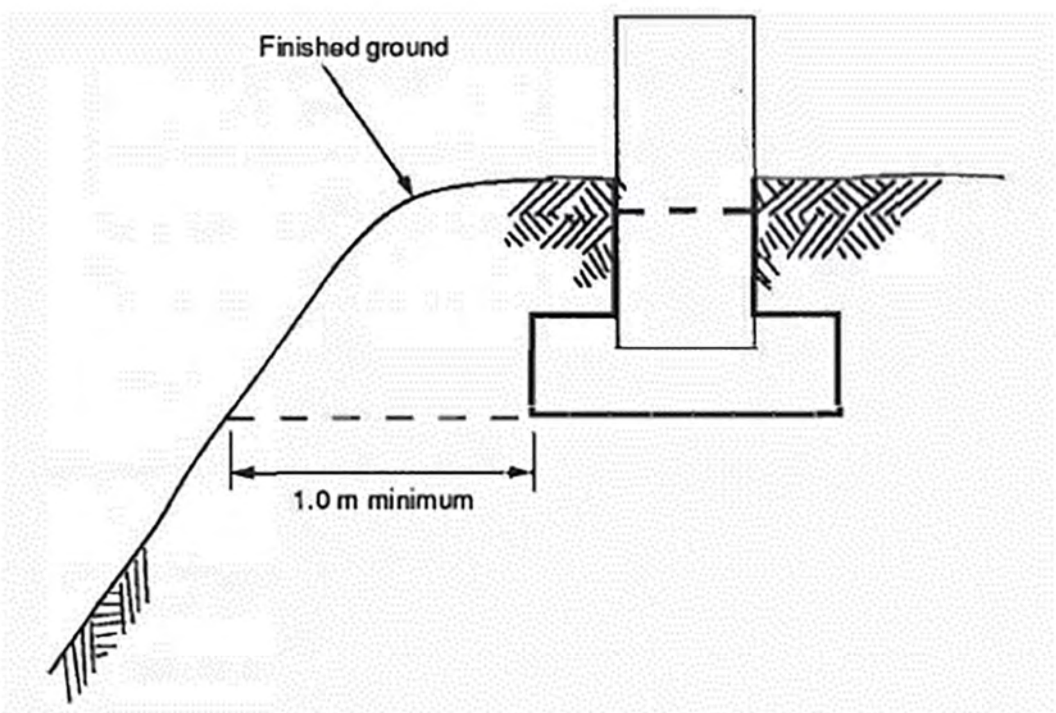


FIGURE D2.1: LOCATION OF FOOTINGS IN UNEVEN GROUND

D3 ANCHOR PILES AND FLOOR PILES

Dimensions for anchor piles and floor piles are given in Figure D3. An anchor pile is required to resist uplift loads and must be placed under all loadbearing walls. A floor pile is required to carry floor loads only.

FIGURE D3 ANCHOR PILES AND FLOOR PILES

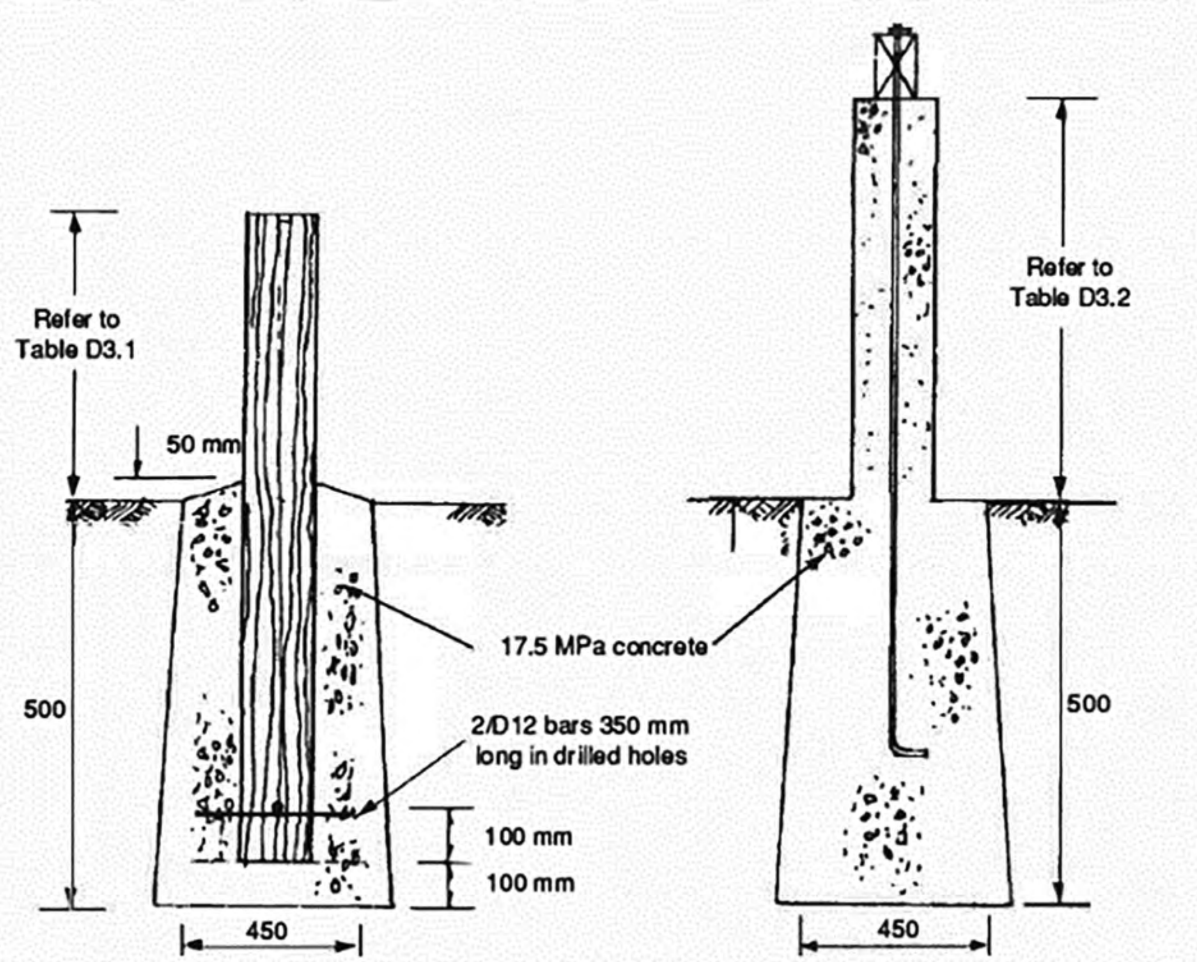


TABLE D3.1:
SIZE OF ROUND TIMBER PILES

COLUMN HEIGHT ABOVE GROUND LEVEL (mm)	COLUMN DIAMETER (mm)
1000	150
1800	200
2400	225

NOTE: Timber posts to be treated in accordance with Local Preservative treatment requirements.

TABLE D3.2:
SIZE OF REINFORCED CONCRETE AND MASONRY PILES

HEIGHT OF COLUMN ABOVE GROUND LEVEL (mm)	PLAN SIZE OF COLUMN (mm x mm)	REINFORCEMENT
≤ 2400	C 200 x 200 M 300 x 300	4 R10

D4 FOOTINGS

All masonry walls must be fully supported by a footing of reinforced masonry or reinforced concrete. The dimensions of reinforced concrete footings are given in Figure D4.1 and Table D4.1. The minimum thickness of footings must be 175 mm.

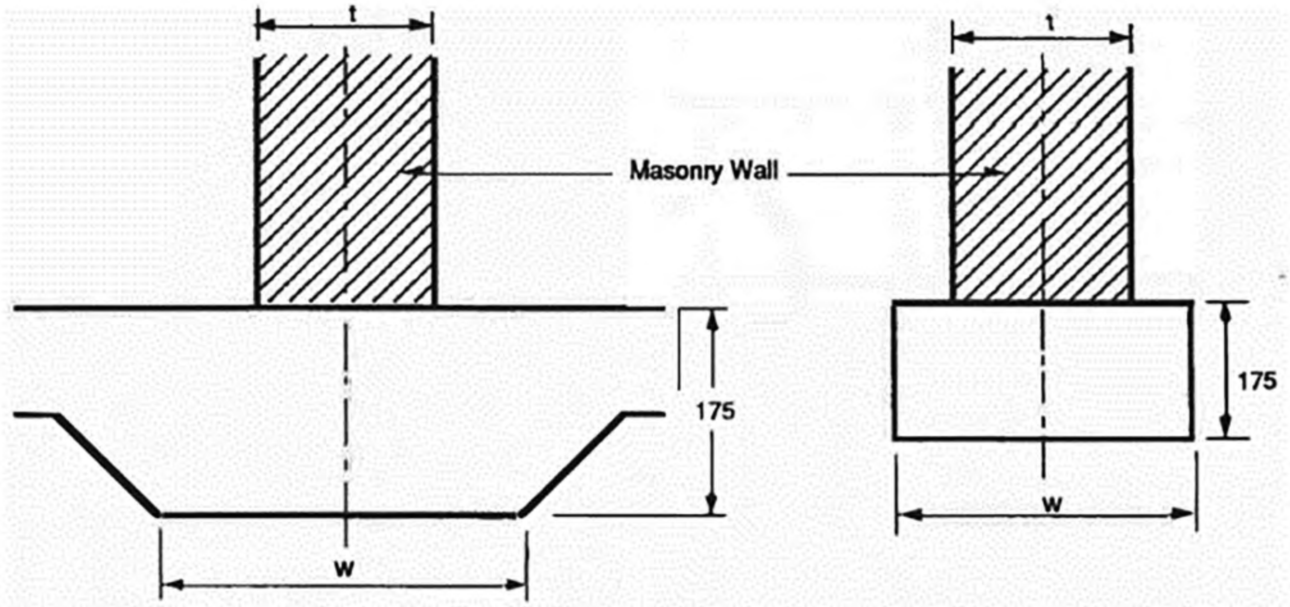


FIGURE D4.1: REINFORCED CONCRETE FOOTINGS

TABLE D4.1:
REINFORCED CONCRETE FOOTING DIMENSIONS

Wall thickness t (mm)	Footing width w (mm)	
	Single Storey	Double Storey
150	300	300
200	300	400

Dimensions of reinforced masonry footings are given in Figure D4.2.

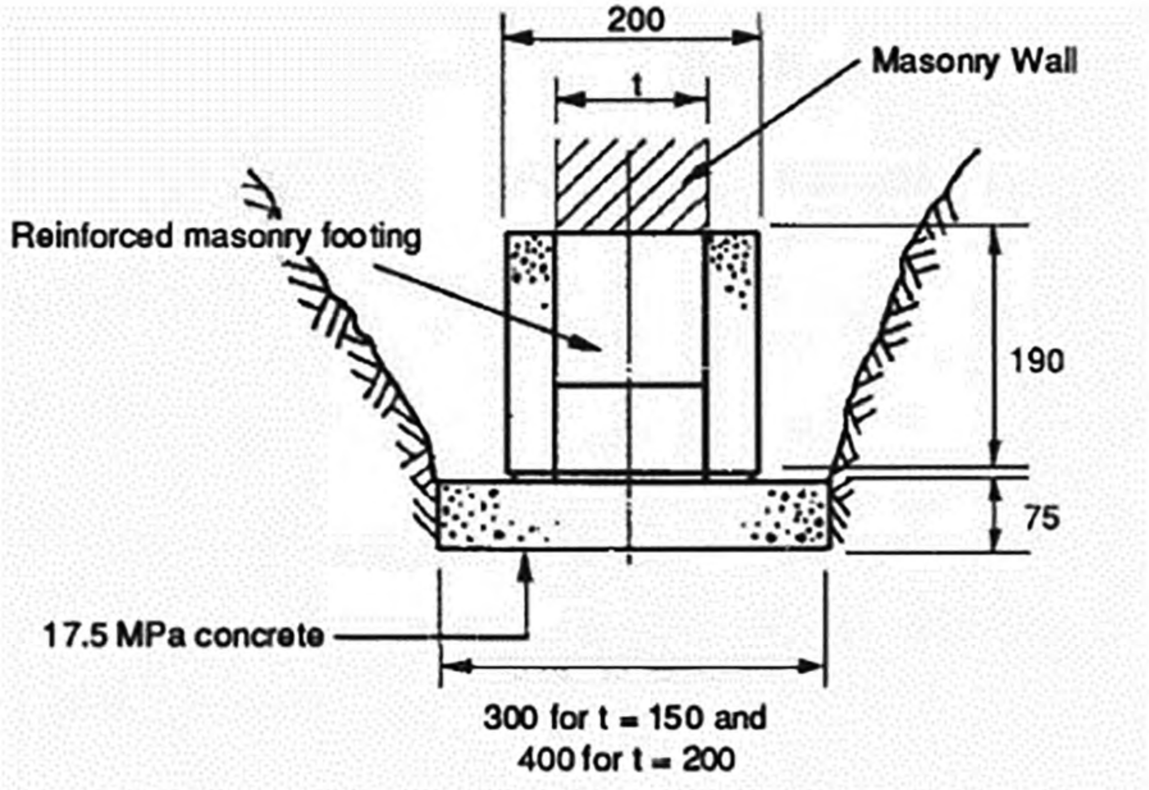


FIGURE D4.2: REINFORCED MASONRY FOOTING

Some site conditions may call for a sub-footing. When sub-footings are used, the dimensions of the main footings are altered. Dimensions of sub-footings in 10 MPa concrete are given in Figure D4.3. The figure also shows the changes to the dimensions of the main footings.

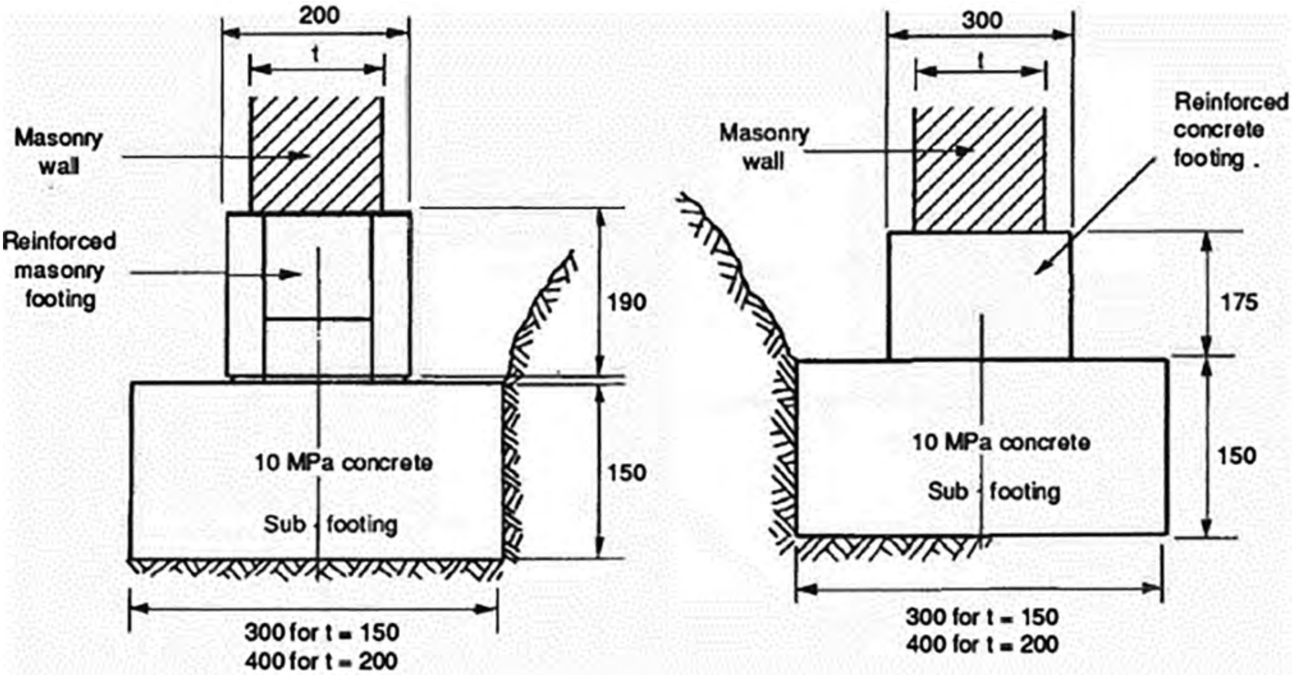


FIGURE D4.3: MASS CONCRETE SUB-FOOTING

The reinforcement to be provided for the footings is detailed in Figure D4.4. The reinforcement must be tied with R6 ties at 600 mm centres. The clear cover of 75 mm shown in the figures may be reduced to 50 mm in the case of masonry footings. The lap length of bars must be not less than 40 bar diameters for reinforcement concrete and 60 bar diameters for masonry footings.

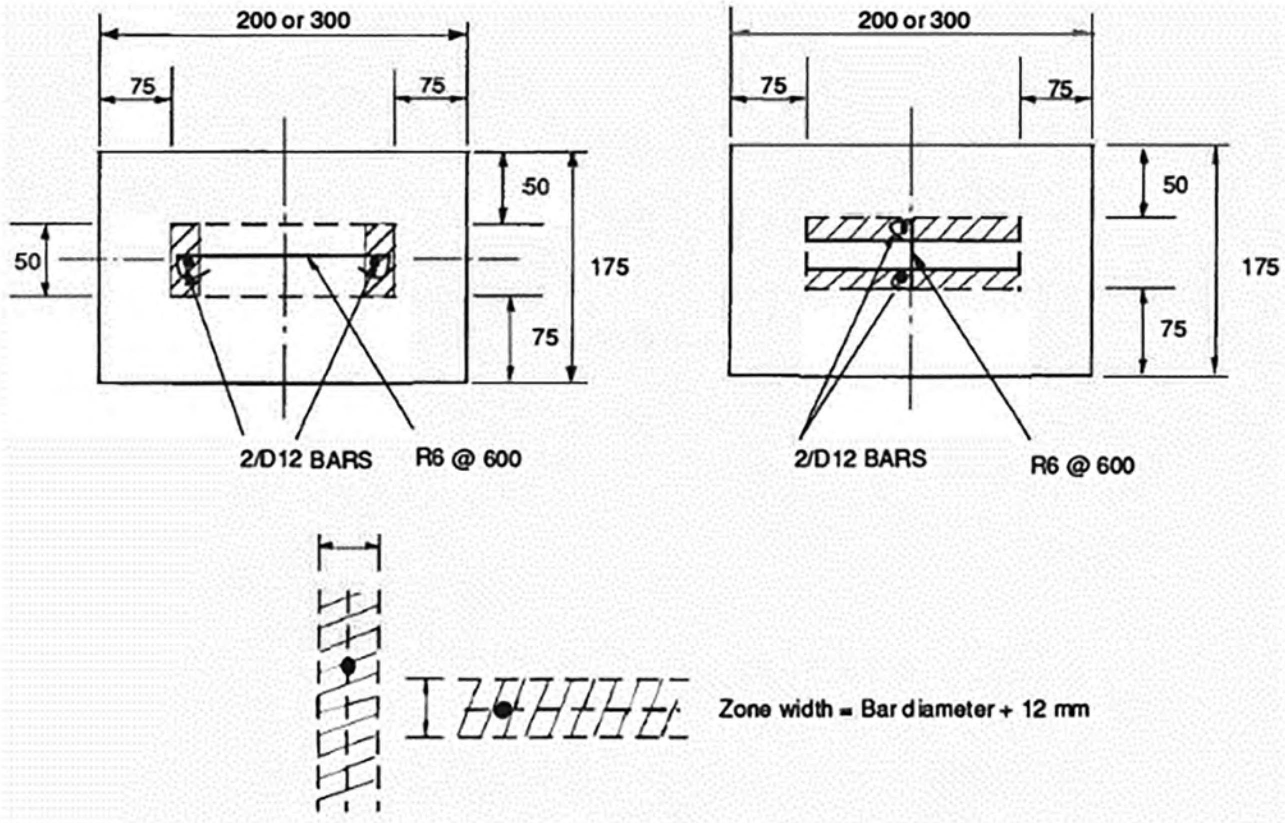


FIGURE D4.4: REINFORCEMENT DETAILS

Where steps in footings are required, the reinforcement must be as detailed in Figure D4.5.

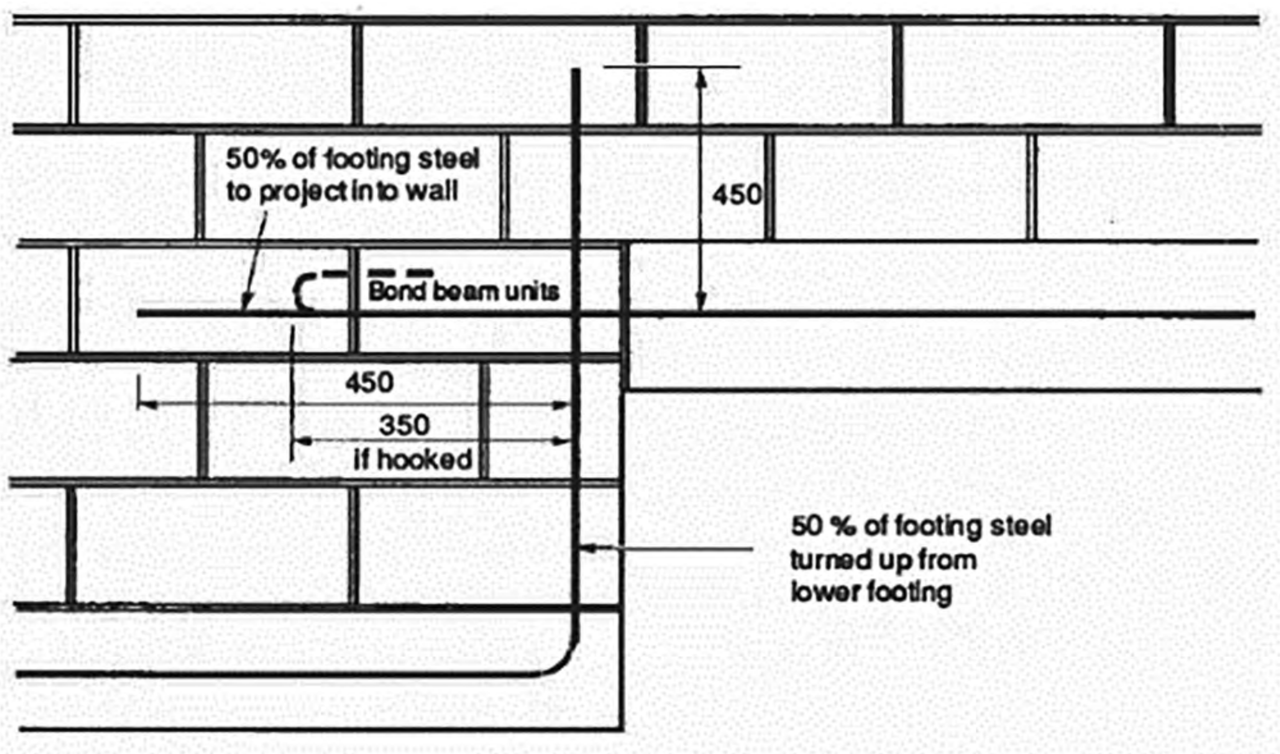


FIGURE D4.5: STEPPED FOOTING

At intersection of footings the arrangement of reinforcement must be as detailed in Figure D4.6.

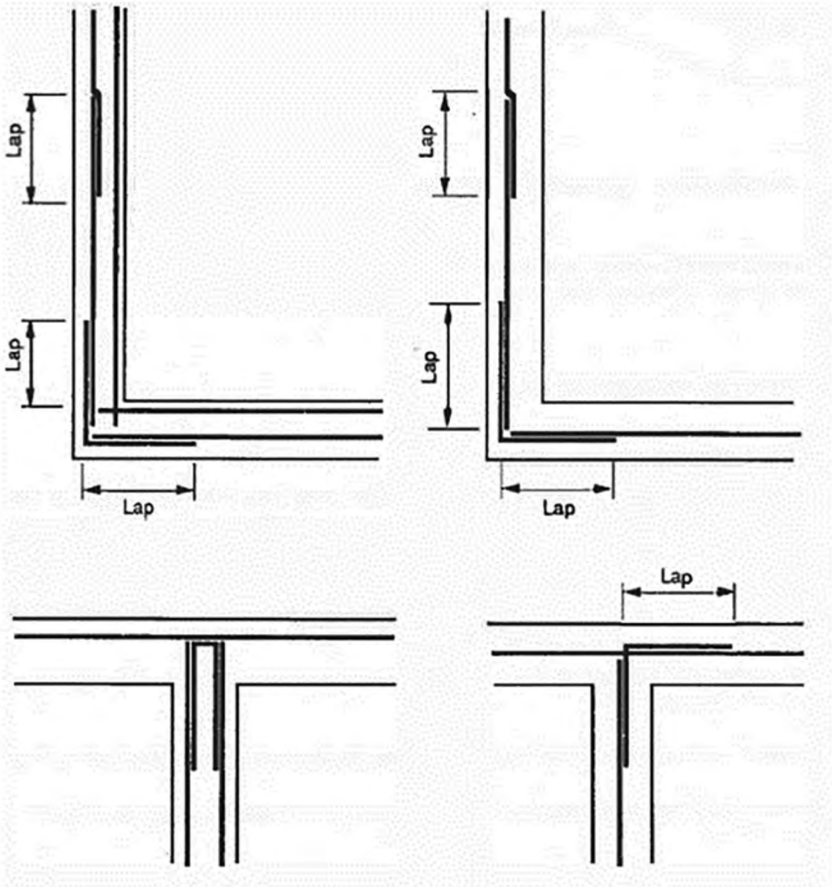


FIGURE D4.6: REINFORCEMENT AT FOOTING INTERSECTIONS

Vertical starter reinforcement of the diameter, type and spacing matching the wall reinforcement must be provided in every footing to a free standing height of not less than 600 mm. The starter reinforcement must be anchored and tied to the footing reinforcement with at least one 90° bend.

The footing of an isolated structural wall must be extended beyond the line of the wall till it becomes the footing of at least another masonry wall. For instance in the case of a transverse masonry bracing wall with one end free, the footing at the free end must continue till it supports another masonry wall (Fig. D4. 7).

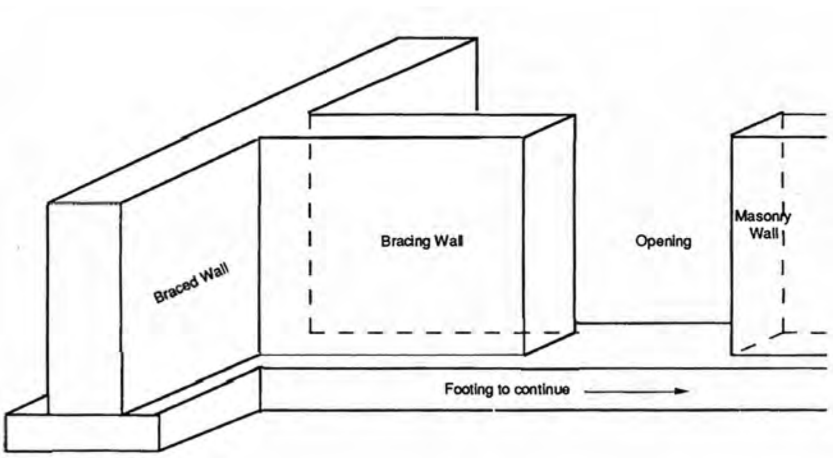


FIGURE D4.7: EXAMPLE OF FOOTING OF ISOLATED STRUCTURAL WALL

In the case of structural walls isolated at both ends, the footings must be not less than 300 mm wide and 400 mm deep and reinforced with 4D16 bars and R10 ties at 200 mm.

D5 CONCRETE SLAB-ON-GROUND FLOORS

D5.1 General

D5.1.1 The finished level of a concrete slab-on-ground floor must be a minimum height of 150 mm above the adjoining finished ground level for unpaved surfaces and 100 mm above the adjoining finished ground level for paved surfaces.

D5.1.2 The finished ground level adjoining the concrete slab-on-ground must be formed with a fall away from the building of not less than 1 in 25 for a distance of at least 1 m.

D5.1.3 Concrete slab-on-ground floors must have their edges thickened (see Fig. D5.1.5) along the entire perimeter of the wall.

D5.1.4 The grade of concrete for slab-on-ground concrete floors must be a minimum of 17.5 MPa.

D5.1.5 Slab-on-ground floors must have a continuous vapour barrier between the ground and the slab as shown in Figure D5.1 .5.

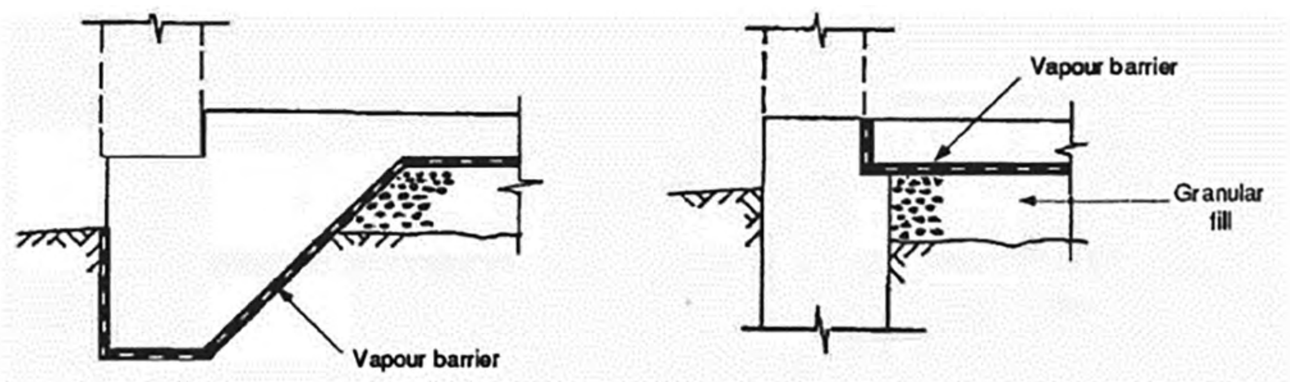


FIGURE D5.1.5: EDGE THICKENING OF CONCRETE SLAB-ON-GROUND FLOORS

D5.1.5 Slab-on-ground floors must have a continuous vapour barrier between the ground and the slab as shown in Figure D5.1 .5.

D5.1.6 The vapour barrier must be:

- **(a)** of acceptable durability and strength to withstand the conditions of installation and end use
- **(b)** laid on a suitably prepared surface for the type of material used as barrier.

Various vapour barriers are available. Typical examples are polyethylene sheet, reinforced polyethylene sheet, bituminous sheets, asphalt and rubber emulsions.

D5.2 Edge thickening

The edge thickening of ground slabs must comply with the requirements of Clause D4. In addition it must reinforced at the top with at least one D12 bar.

D5.3 Granular base

D5.3.1 Granular fill material where required must be placed in layers not exceeding 100 mm thick over the area beneath the proposed ground slab so that the total thickness of the granular base is not less than 100 mm nor more than 600 mm.

D5.3.2 Granular fill material must be gravel, or crushed rock or hard coral.

D5.3.3 The top surface of the granular base must be treated as necessary to protect the vapour barrier from damage.

D5.3.4 The rise of sub-soil water by capillary action must not be allowed to approach the ground slab. Where the depth to the sub-soil water level is less than 3.5 m in clay or silt, 2.25 m in fine sand or 0.8 m in coarse sand, it will be necessary to provide a capillary break beneath the ground slab. If the material beneath the slab is all gravel, crushed rock or hard coral to a minimum thickness of 100 mm and action is taken to prevent soil from clogging the pores between the pieces of gravel, there is no risk of capillary rise of water. If this is not the case, the capillary break provided must have the following grading:

<0 5.5 % to pass a 2.2 mm sieve.

100 % to pass a 19 mm sieve for any depth of fill or pass a 37.5 mm sieve for fill thickness in excess of 150 mm.

D5.4 Ground slabs

D5.4.1 Except as required for edge thickening and by D5.5 beneath internal loadbearing walls, the minimum thickness of a domestic ground slab must be:

> **(a)** 100 mm when placed on a vapour barrier laid directly on the granular fill, or
>
> **(b)** 75 mm when placed on a vapour barrier laid on a specially prepared granular base or concrete blinding. Refer to Figure D5.4.

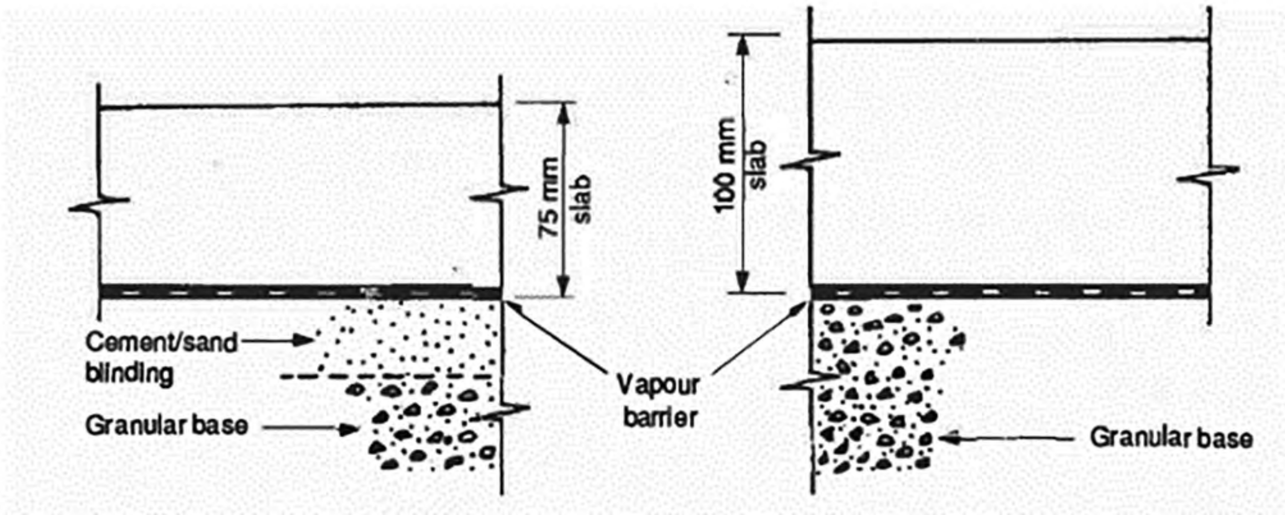


FIGURE D5.4: ALTERNATIVE CONSTRUCTION OF GROUND SLABS

D5.4.2 Ground slab reinforcement must extend to within 75 mm of the outside edge of the thickened slab when it is cast integrally with the ground slab. Also:

> **(a)** where the maximum plan dimension of concrete cast in one operation does not exceed 15 m: provide 668 (F52) welded reinforcing mesh lapped 225 mm at joints
>
> **(b)** where the maximum plan dimension of concrete cast in one operation exceeds 15 m but does not exceed 25 m provide either:
>
> > **i)** 665 (F62) welded reinforcing mesh lapped 225 mm at joints, or
> >
> > **ii)** D10 bars at 350 mm centres both ways tied at each fourth crossing ; and
>
> **(c)** where the thickened edge is cast separately from the ground slab and it supports more than one storey, the ground slab must be tied to it with R6 bars at not less than 600mm centres, anchored into the thickened edge and lapped not more than 300 mm with the slab reinforcement.

D5.4.3 Reinforcing steel must have a cover of 30 mm from the top surface of the ground slab and must be placed in such a manner as to avoid damage to the vapour barrier.

D5.5 Support of loadbearing internal walls

The slab beneath a loadbearing internal wall must be 175 mm thick over a minimum width of 300 mm and reinforced with 2/D12 bars as shown in Figure D5.5.

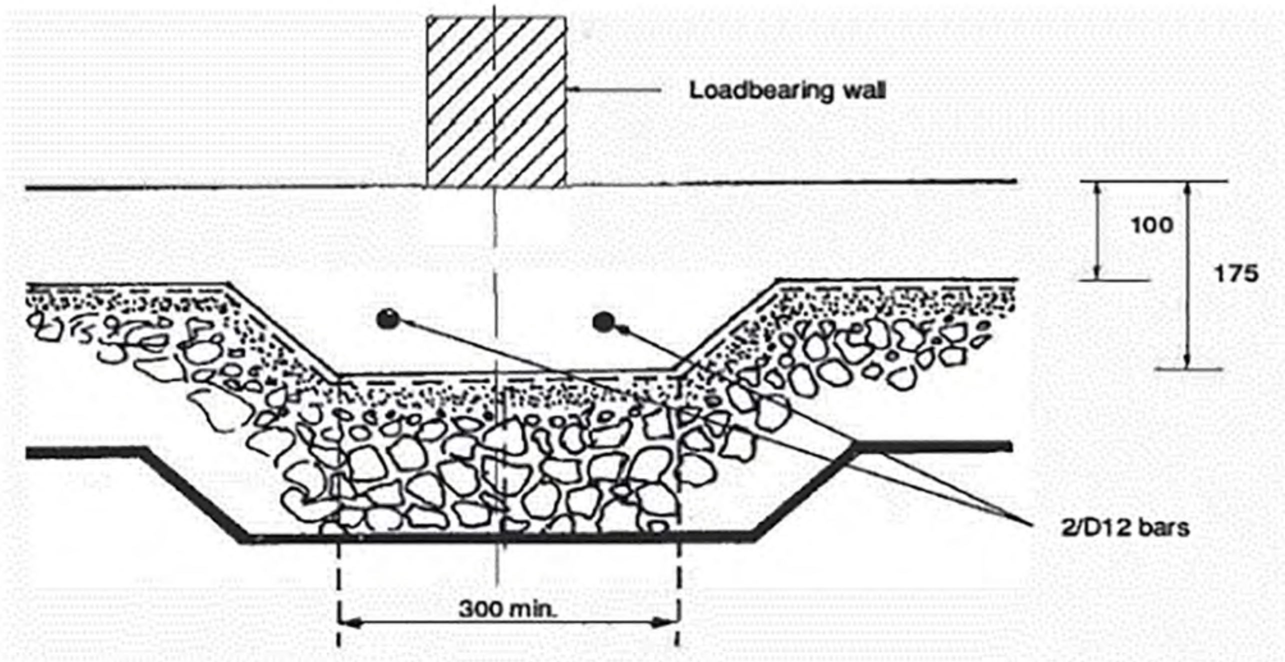


FIGURE D5.5: GROUND SLABS BENEATH INTERNAL LOADBEARING WALLS

Section E

CONSTRUCTION DETAILS

Section E – CONSTRUCTION DETAILS

E1 GENERAL

This section provides some construction details for houses. It is divided into three parts. E2 shows roof details, E3 wall details and E4 floor details. The details do not cover all contingencies and are necessarily general in nature. These would however satisfy a wide range of construction requirements.

E2 ROOF CONSTRUCTION DETAILS

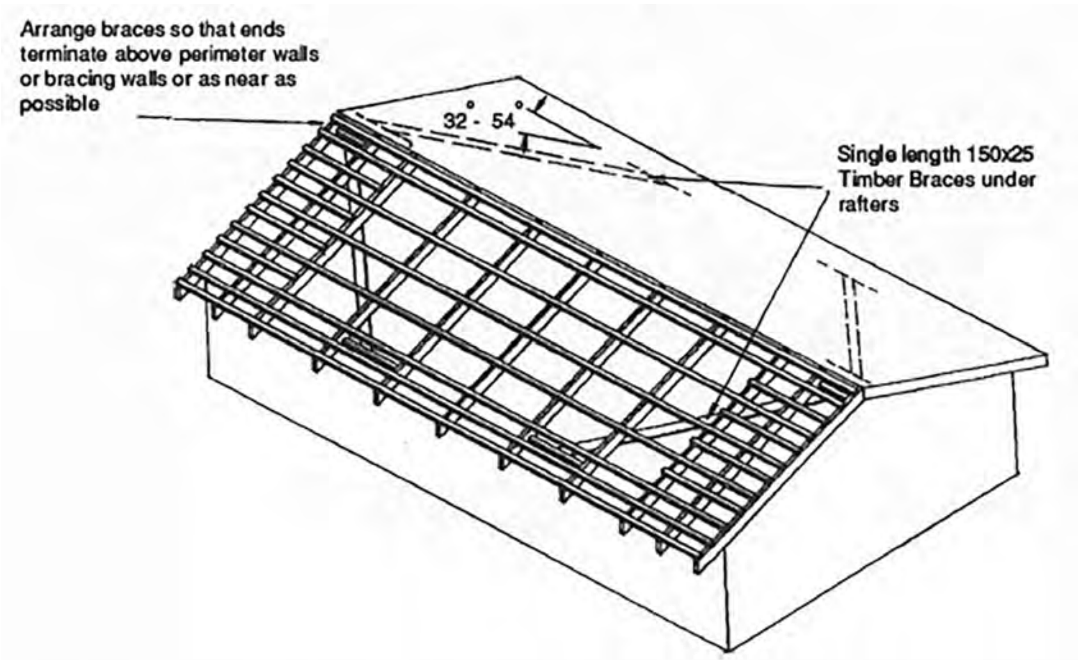


FIGURE E2.1: TIMBER BRACING FOR ROOFS CONSTRUCTED OF RAFTERS

Higher than average uplift pressures occur at the shaded area (Figure E2.2) along the edges and ridge of the roof during high winds. The associated rafters, purlins and fasteners are therefore spaced closer as shown in Figures E2.1, E2.3, E2.4 and E2.5.

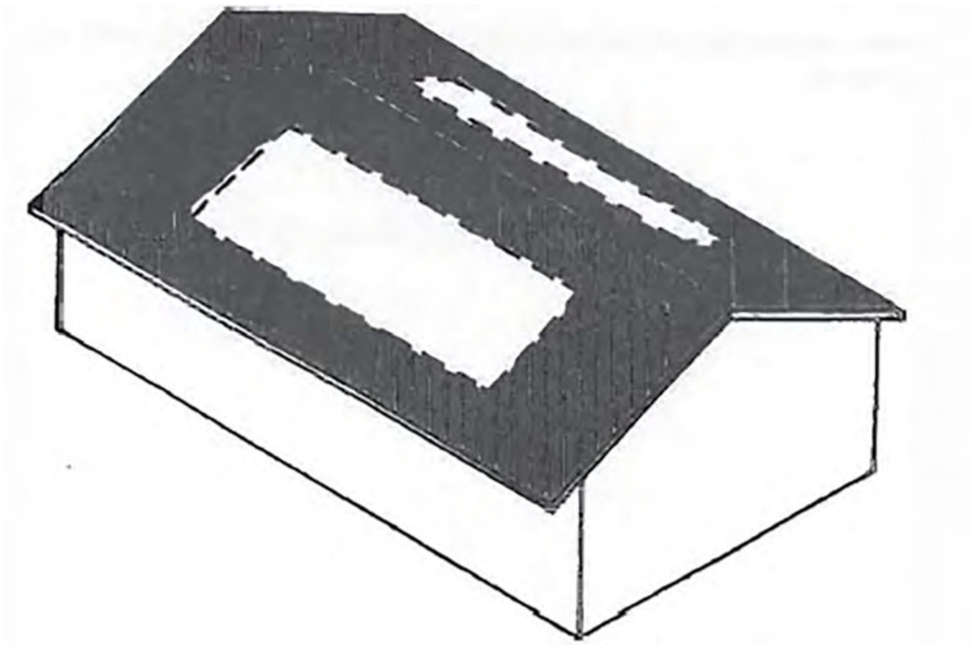
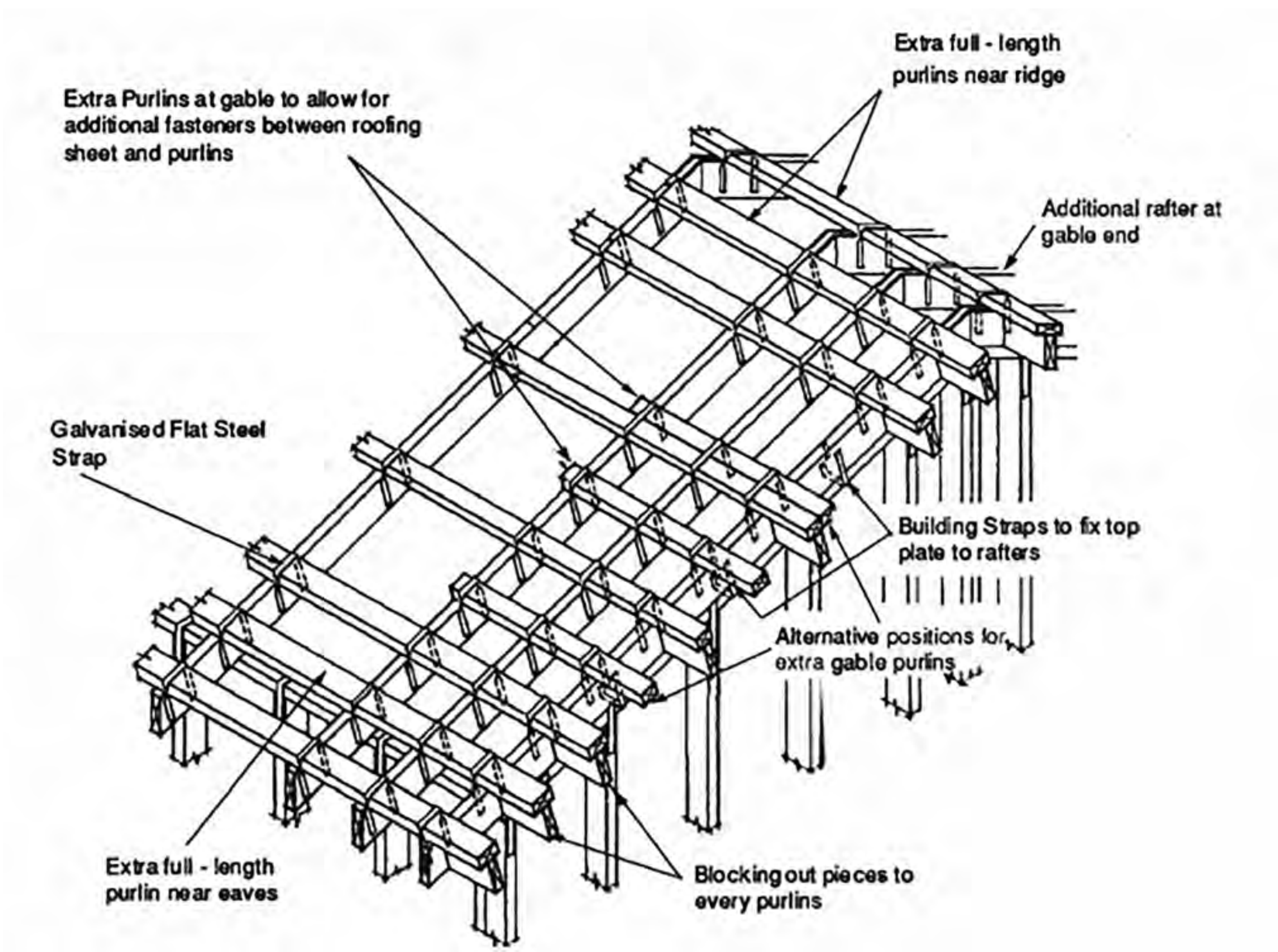


FIGURE E2.2: AREAS OF ROOF WHERE LOCAL PRESSURE FACTORS APPLY



NOTE:

i. It is preferable to locate the extra purlins at gables midway between the normal purlins. This will reduce the forces on the roofing sheets.

ii. Care to be taken to not split purlins when nailing, especially if purlins are smaller than 50 x 100.

iii. Select all fasteners on the basis of forces and capacities given in the relevant tables in

FIGURE E2.3: ROOF FRAMING AT GABLE END.

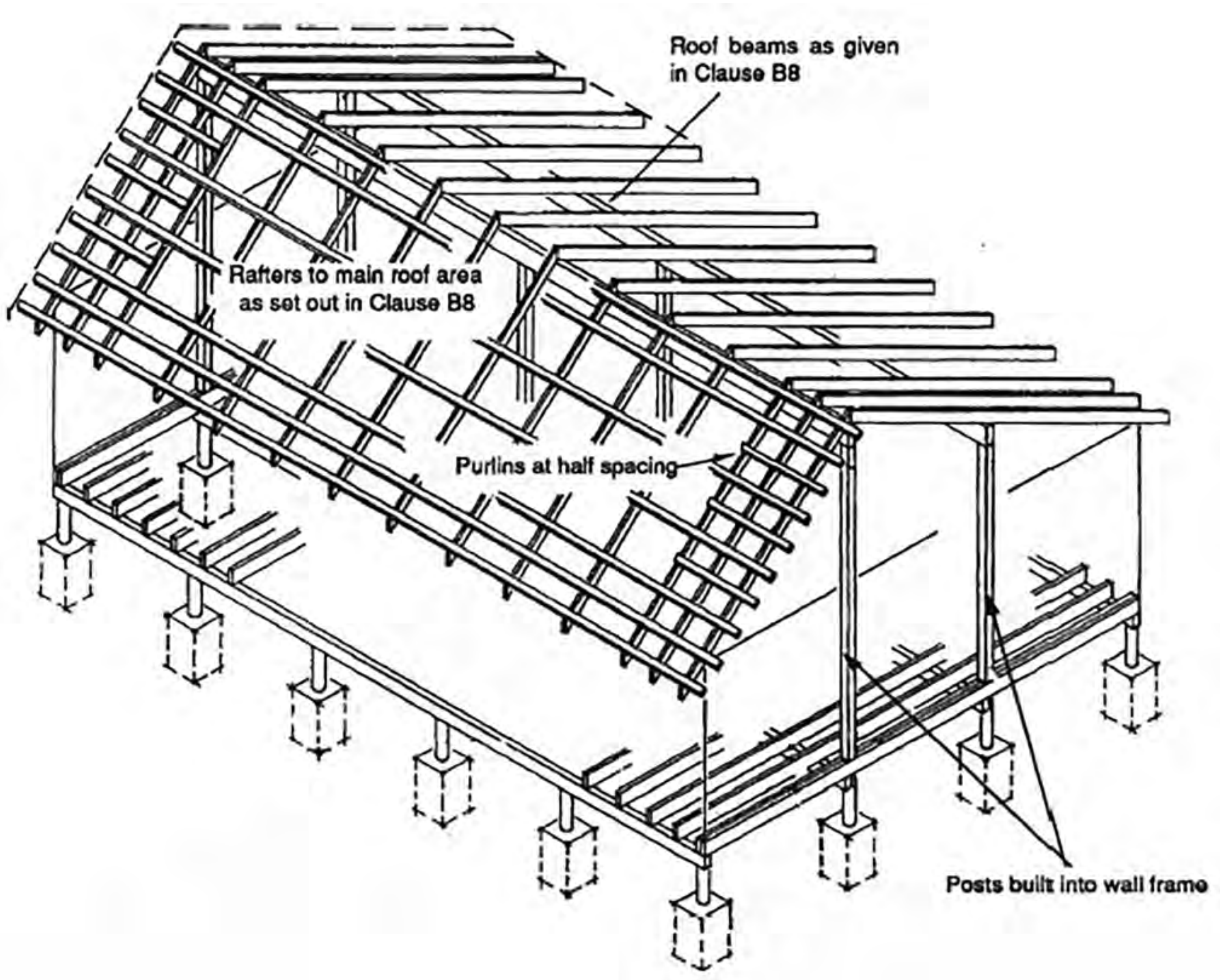


FIGURE E2.4: RAFTER ROOF FRAMING DETAILS

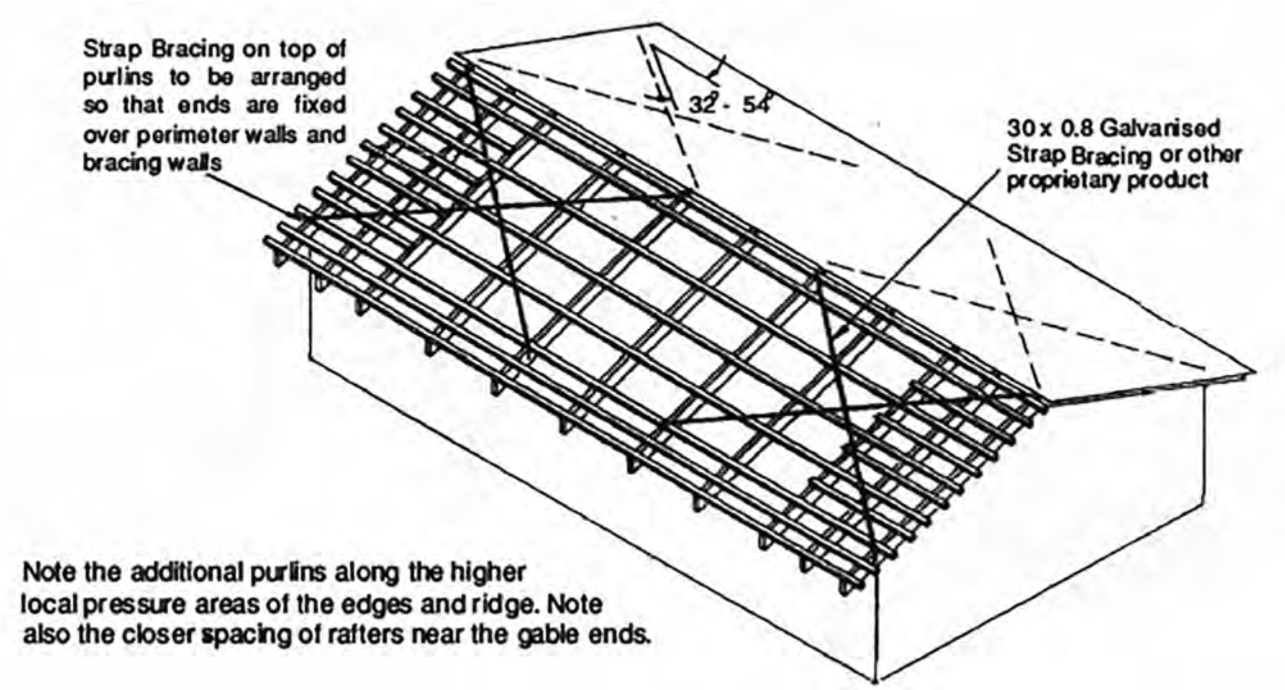


FIGURE E2.5: FLAT STRAP BRACING FOR ROOFS

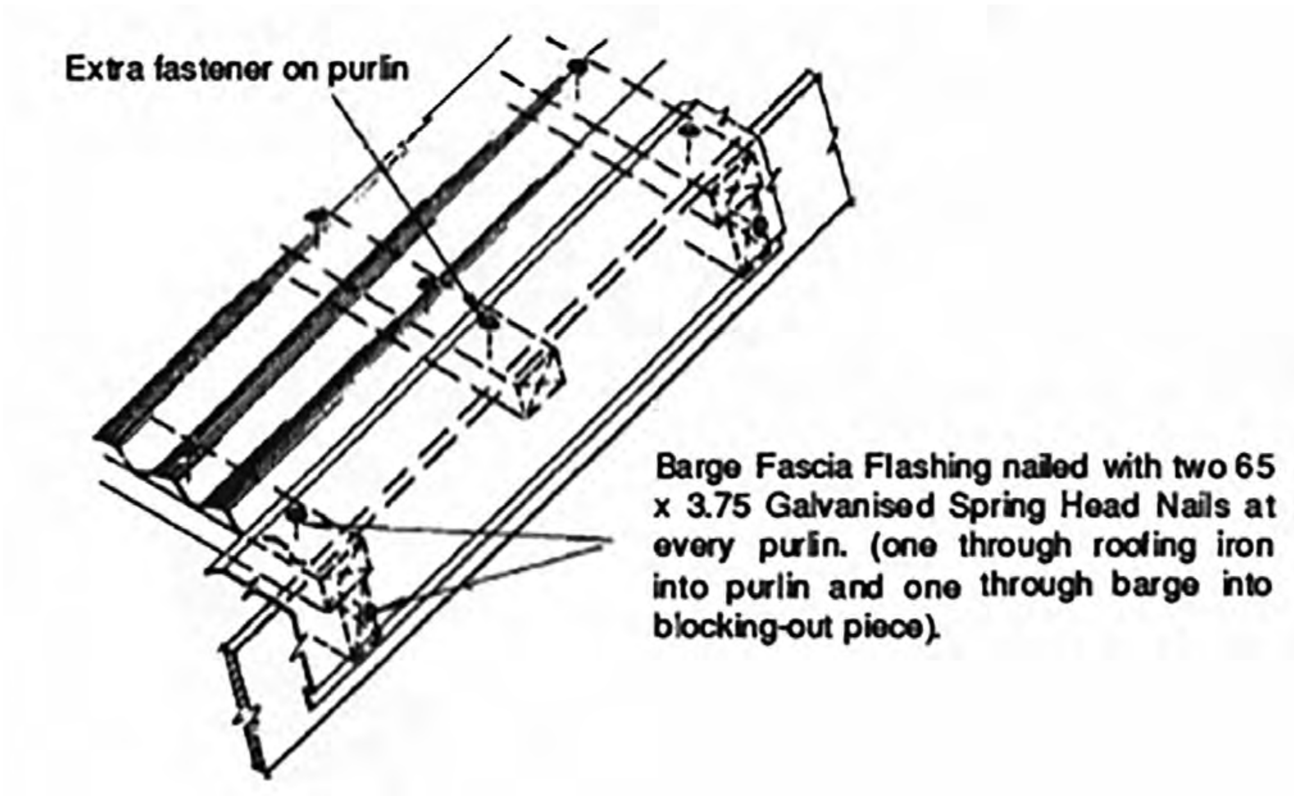
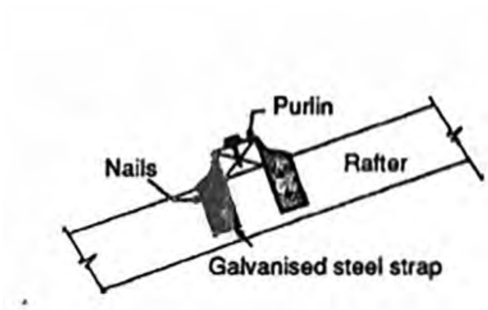


FIGURE E2.6: FIXING OF BARGE FLASHING AT GABLE END



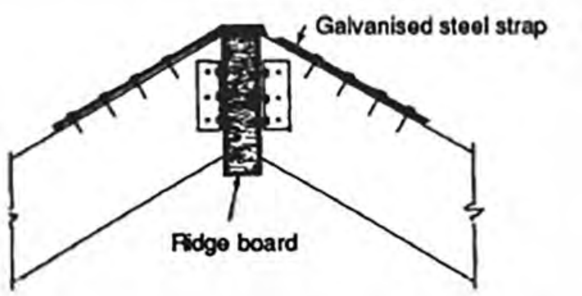
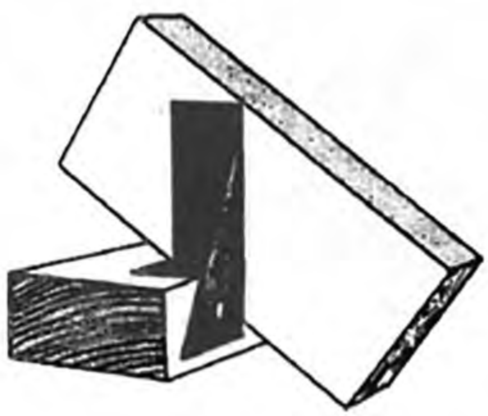


FIGURE E2.7: CONNECTION OF PURLINFIGURE E2.8: CONNECTION AT THE RIDGE



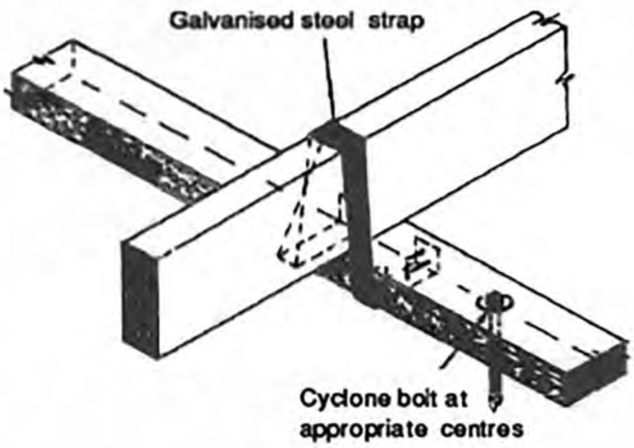


FIGURE E2.9: TRIP-L-GRIP CONNECTOR USED TO SECURE RAFTERS TO TOP PLATES

FIGURE E2.10: FIXING OF RAFTER TO THE TOP PLATE WITH GALVANISED STEEL STRAP

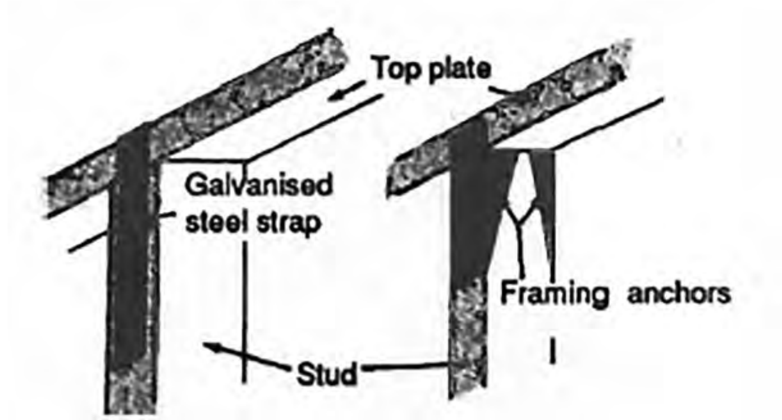


FIGURE E2.11: ANCHORING THE TOP PLATE TO THE STUDS

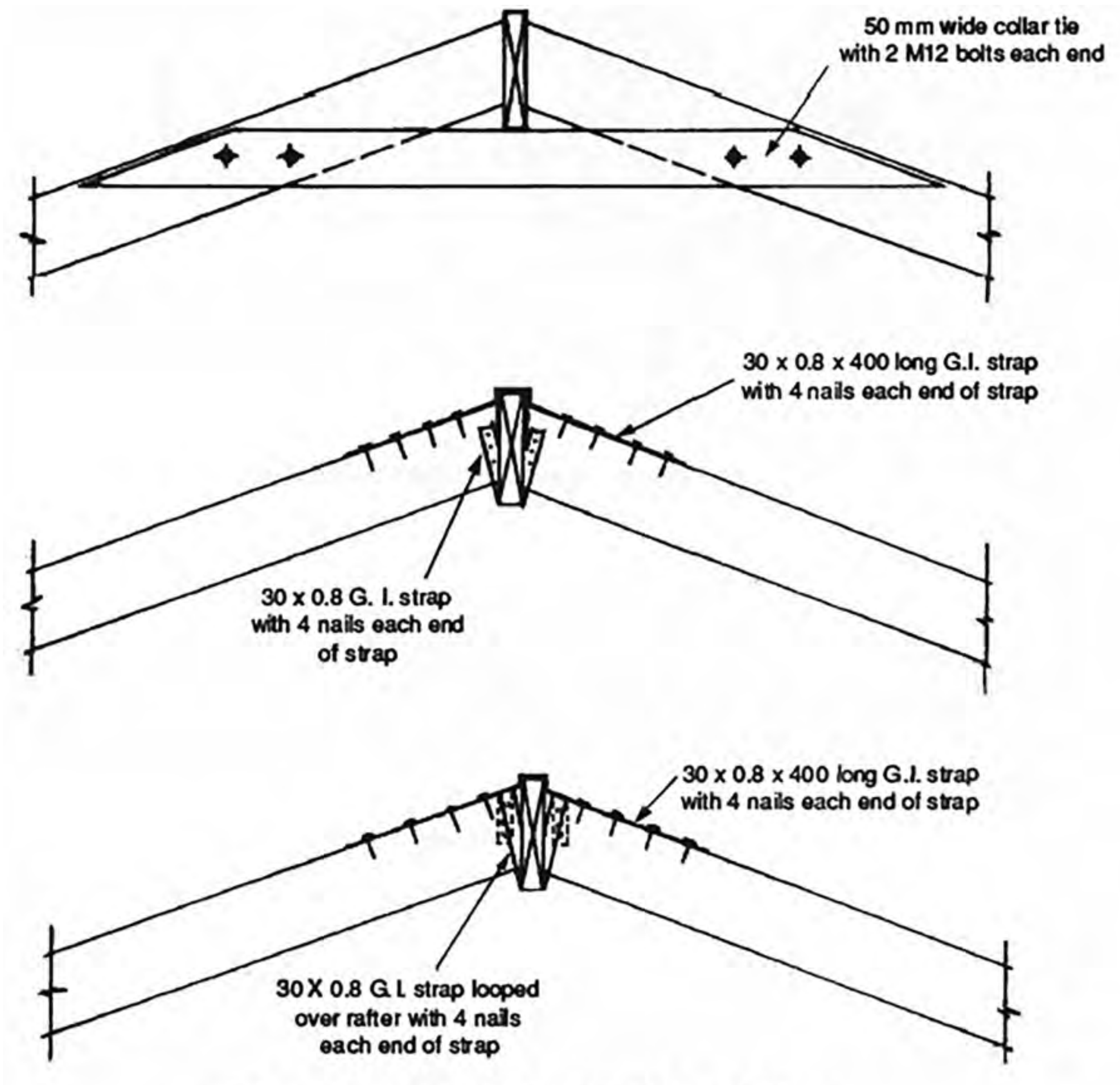


FIGURE E2.12 RIDGE BOARD TIE DOWN DETAIL

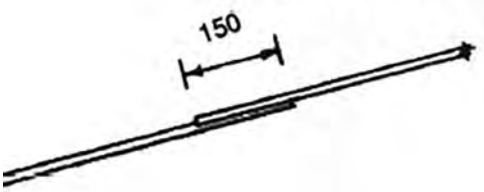


FIGURE E2.13: SHEET LAP DETAIL

FIGURE E2.14: RIDGE CAP DETAIL

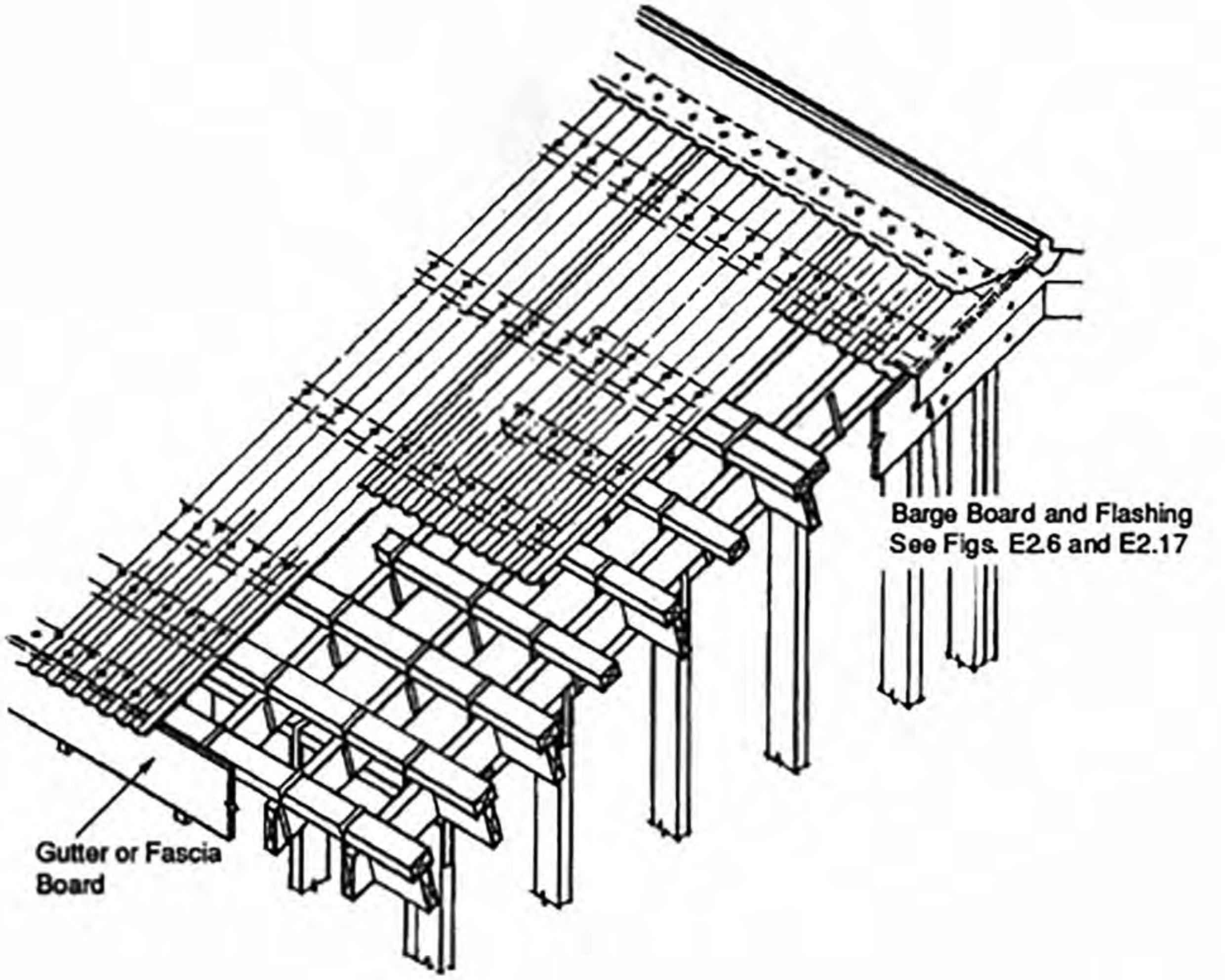


FIGURE E2.15: FIXING OF ROOF CLADDING

FIGURE E2.16: OVERLAP DETAIL

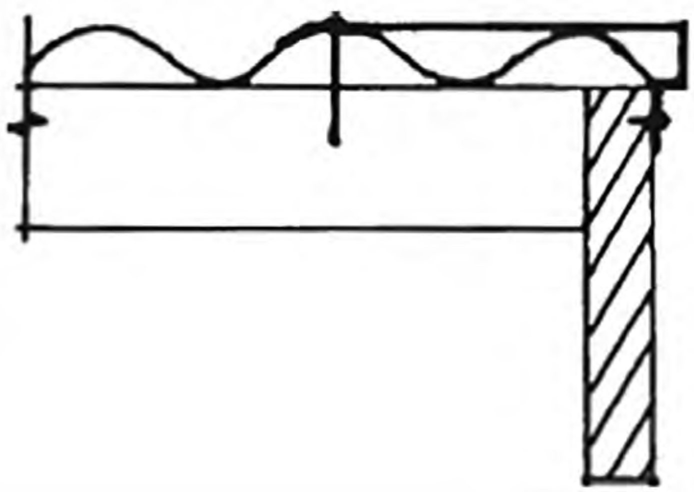


FIGURE E2.17: FLASHING DETAIL

E3 WALL CONSTRUCTION DETAILS

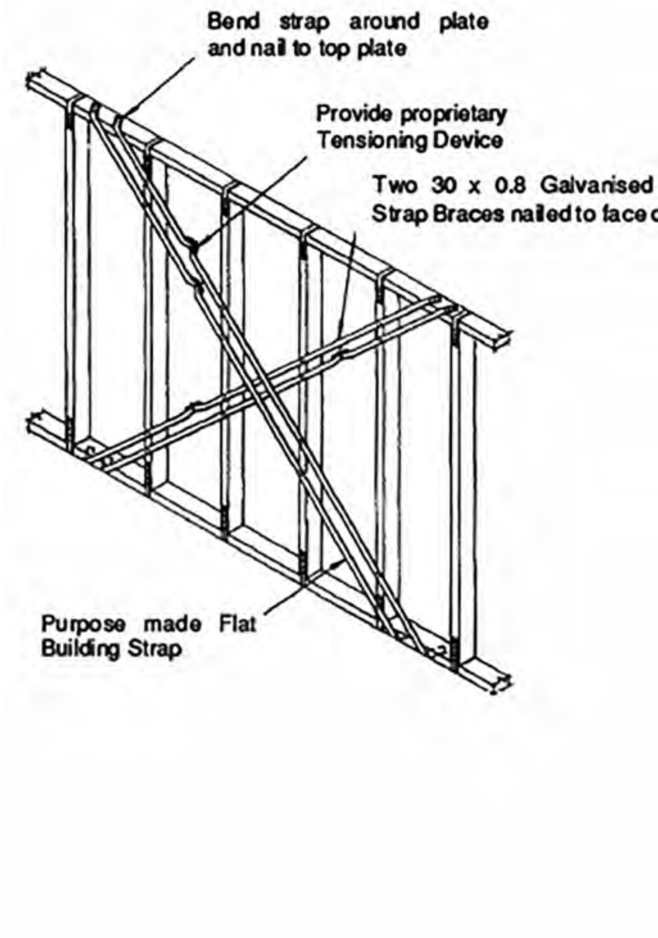


FIGURE E3.1: LOADBEARING AND NON-LOADBEARING WALLS WITH FLAT STRAP METAL BRACES (NOT LET IN)

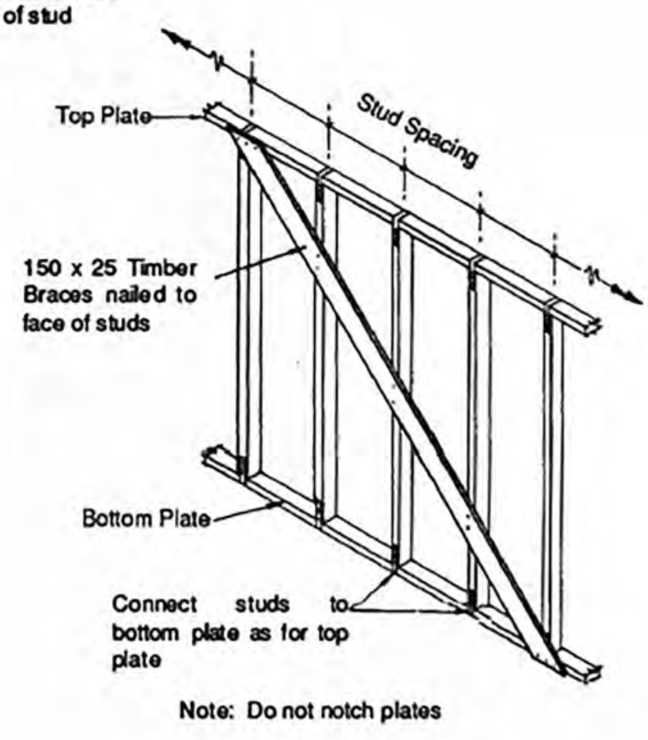


FIGURE E3.2: INTERNAL BRACED WALLS NOT SUPPORTING VERTICAL LOADS FROM ROOF OR FLOOR

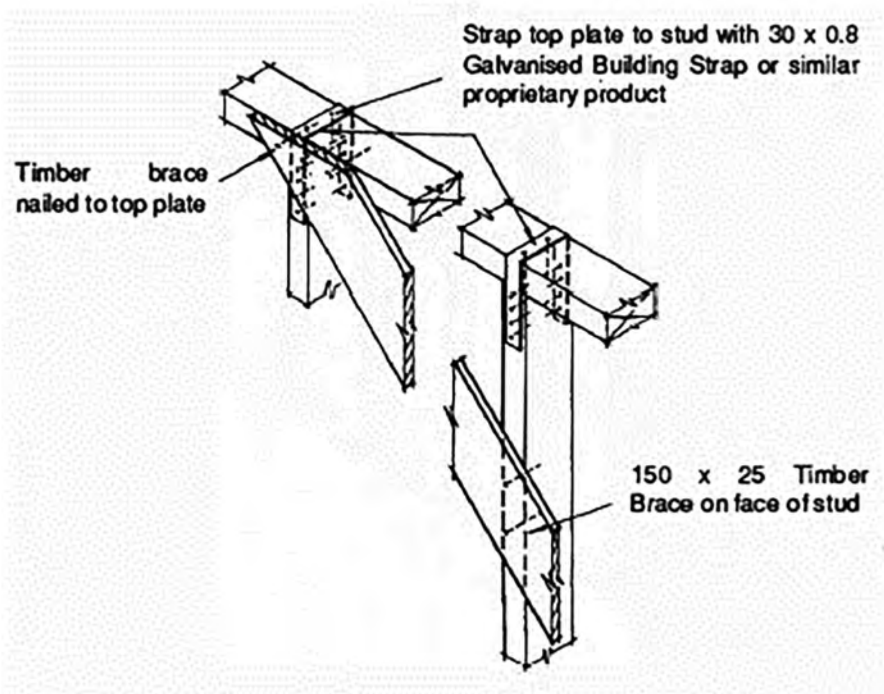


FIGURE E3.3: INTERNAL BRACED WALLS NOT SUPPORTING VERTICAL LOADS FROM ROOF OR FLOOR

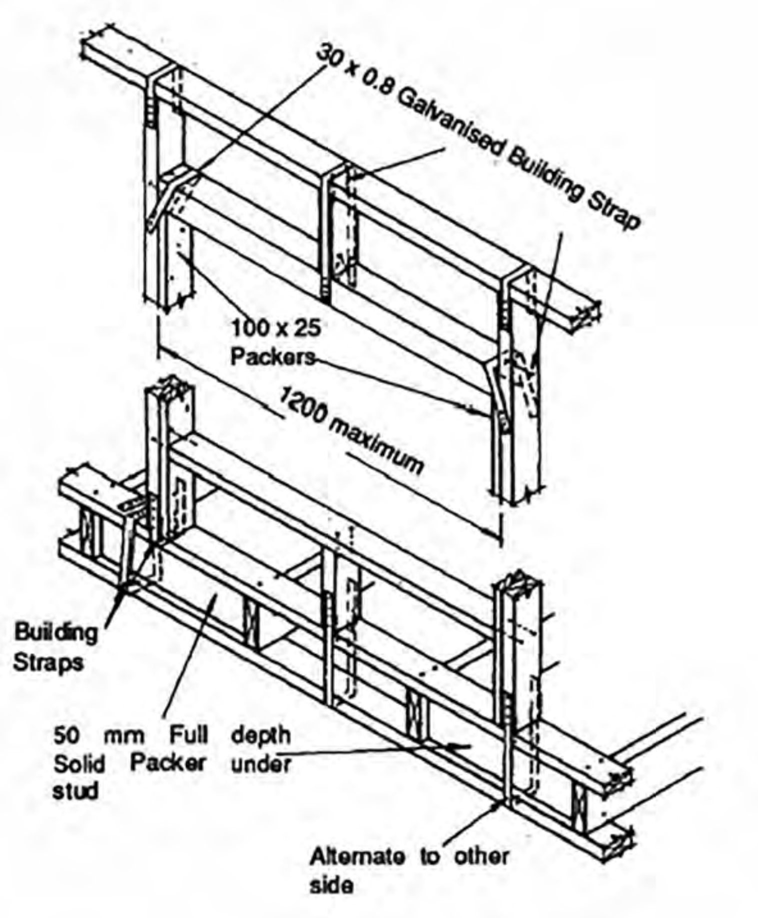


FIGURE E3.4: TIMBER LINTELS (SAWN) UP TO 1200 LINTEL SPAN

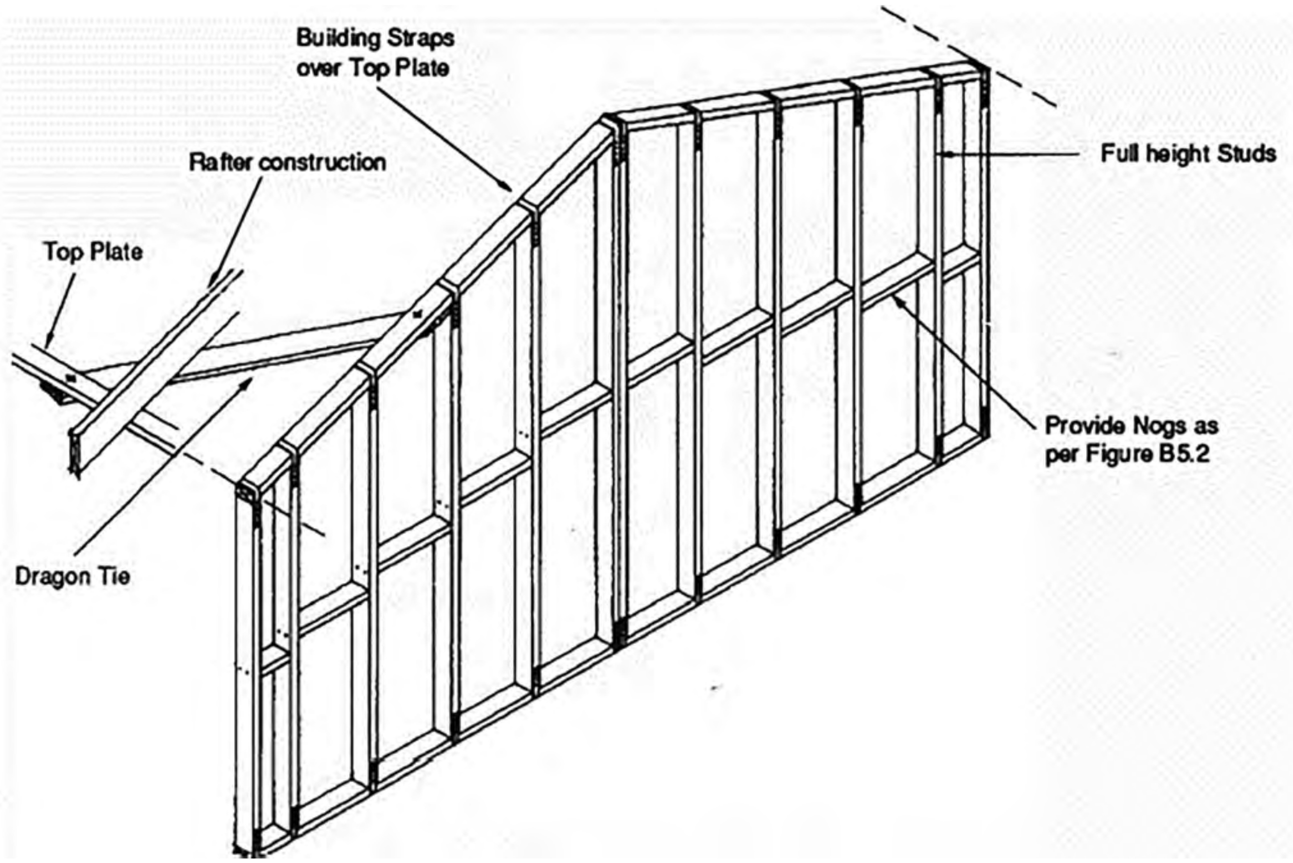


FIGURE E3.5: GABLE END WALLS

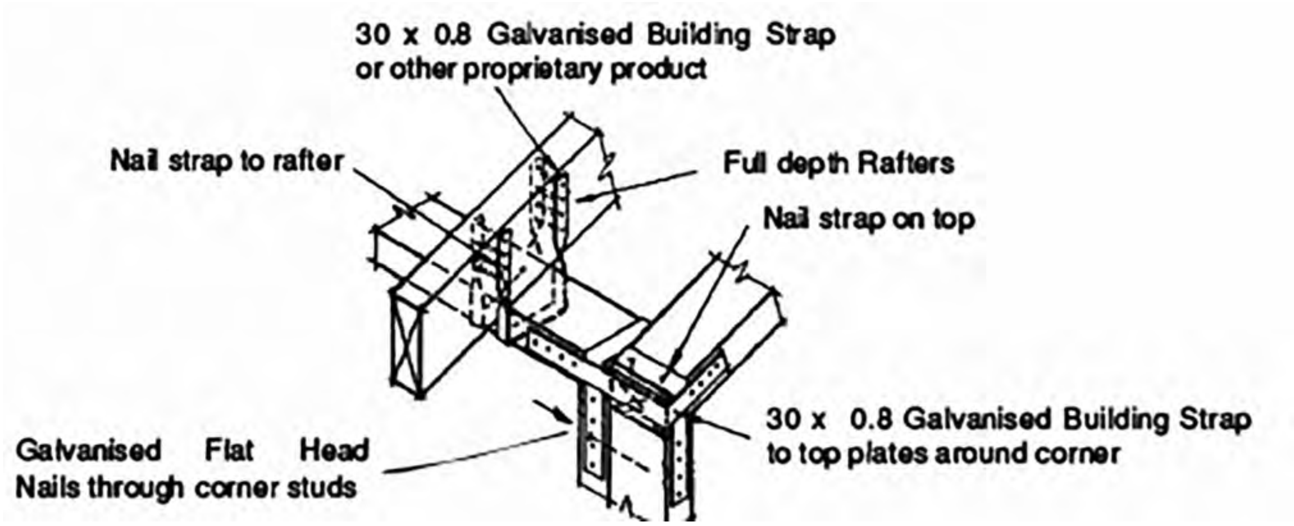


FIGURE E3.6: FIXING OF GABLE END WALLS TO SIDE WALLS AT TOP PLATE LEVEL

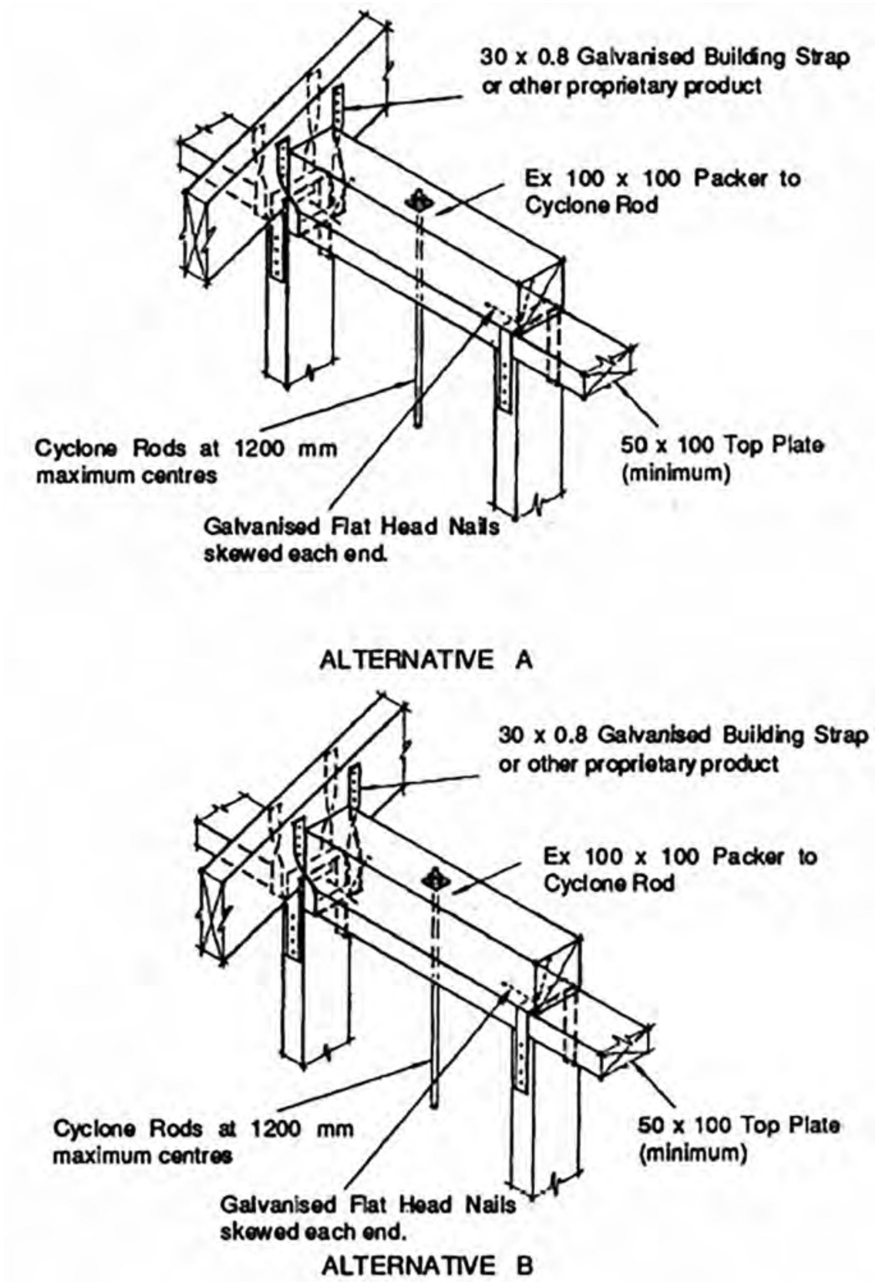


FIGURE E3.7: TOP PLATES SUPPORTI NG ROOFS OF BUILDINGS

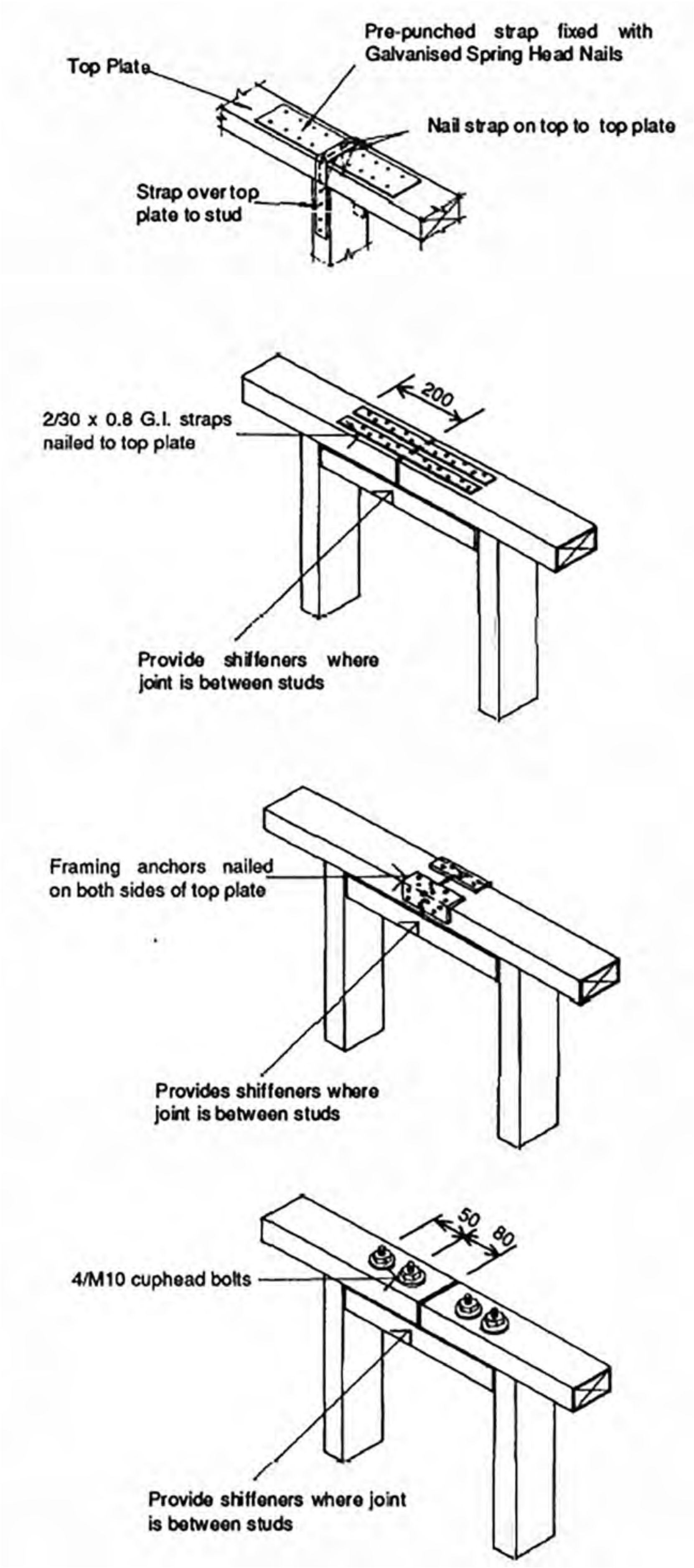


FIGURE E3.8: JOINTS IN TOP PLATES

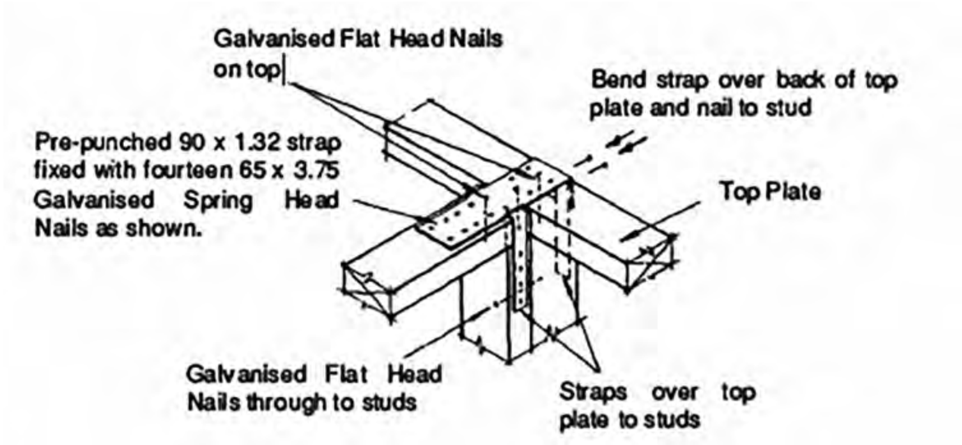


FIGURE E3.9: WALL INTERSECTION IN TOP PLATES

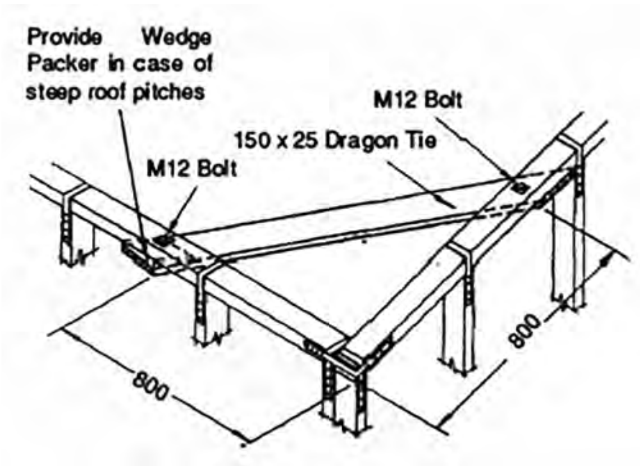


FIGURE E3.10: DETAIL OF DRAGON TIE CONNECTION

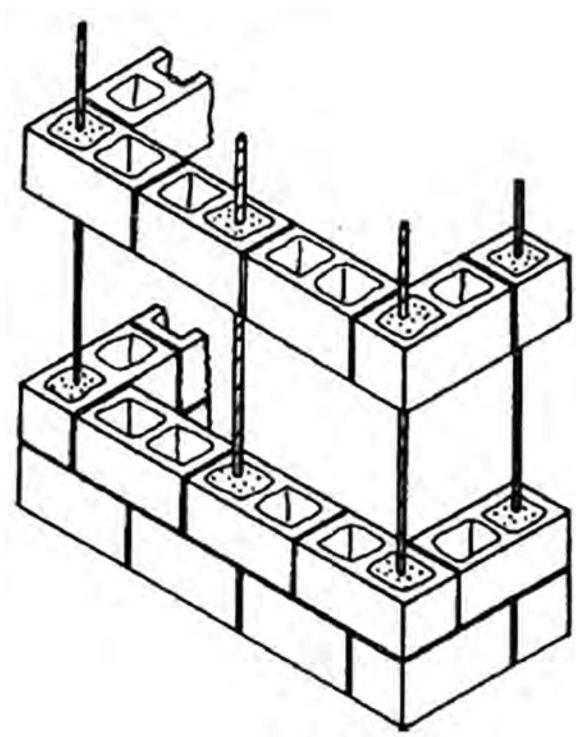


FIGURE E3.11: CORNER DETAIL FOR PARTIALLY GROUTED MASONRY WALL

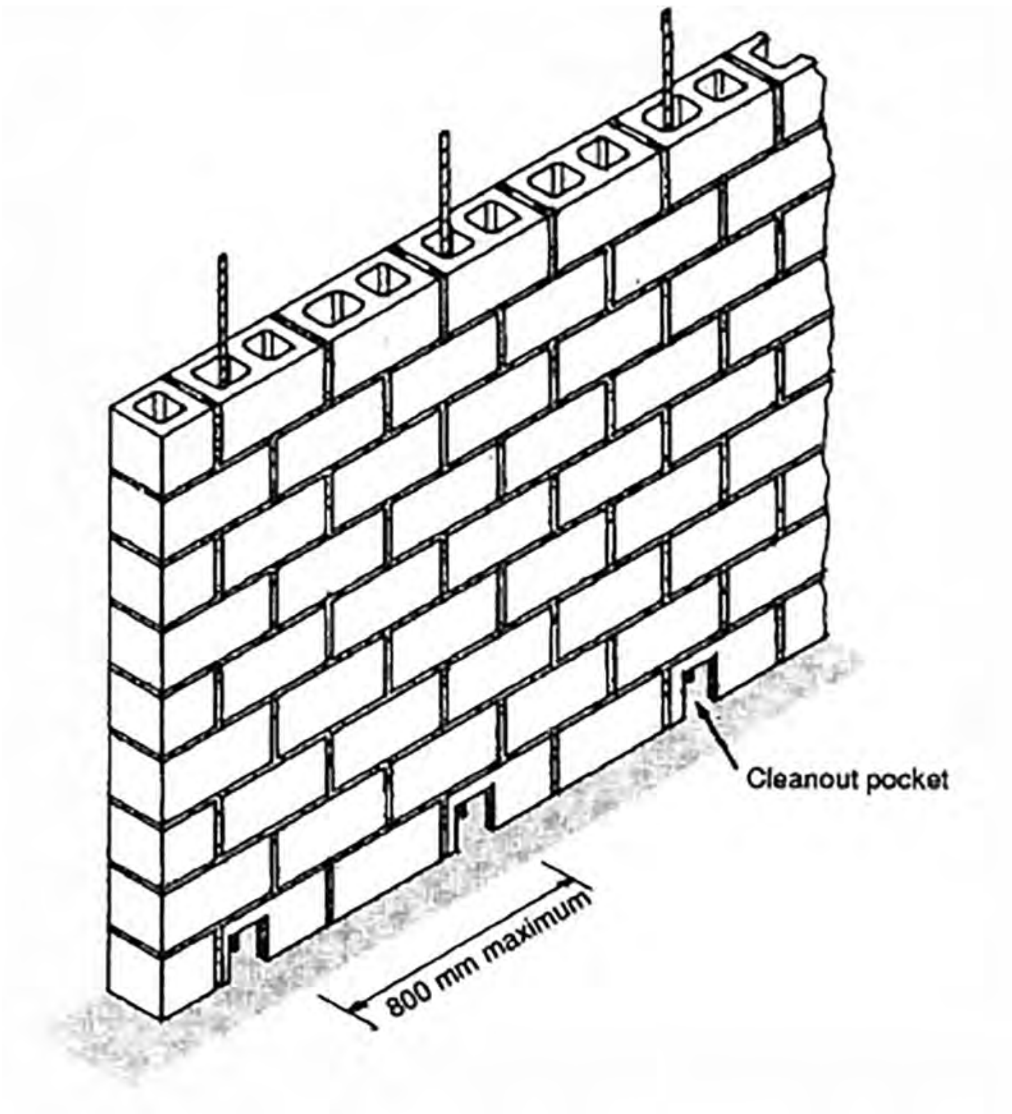


FIGURE E3.12: CLEANOUT POCKETS IN WALL FOR GROUT POURS

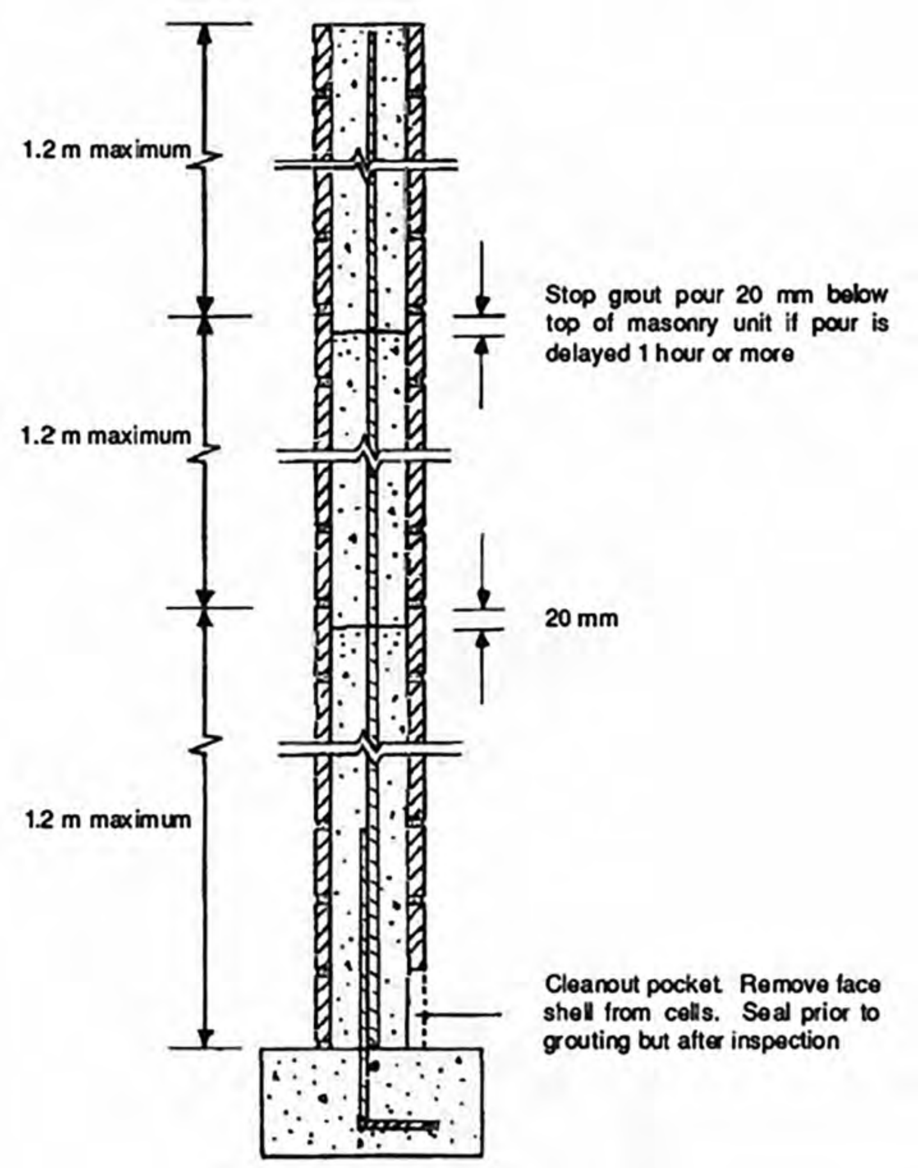


FIGURE E3.13: METHOD OF GROUTING BLOCK

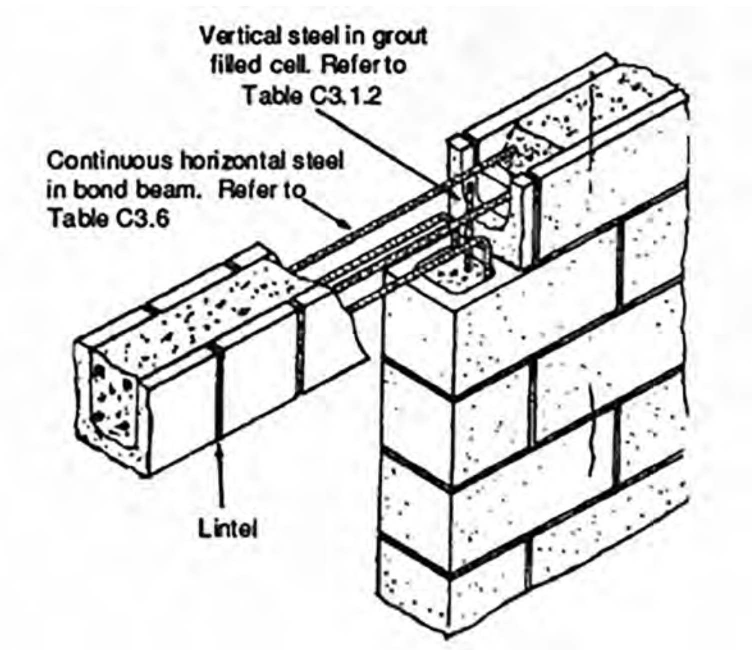


FIGURE E3.14: LINTELS AND BOND BEAM DETAILS

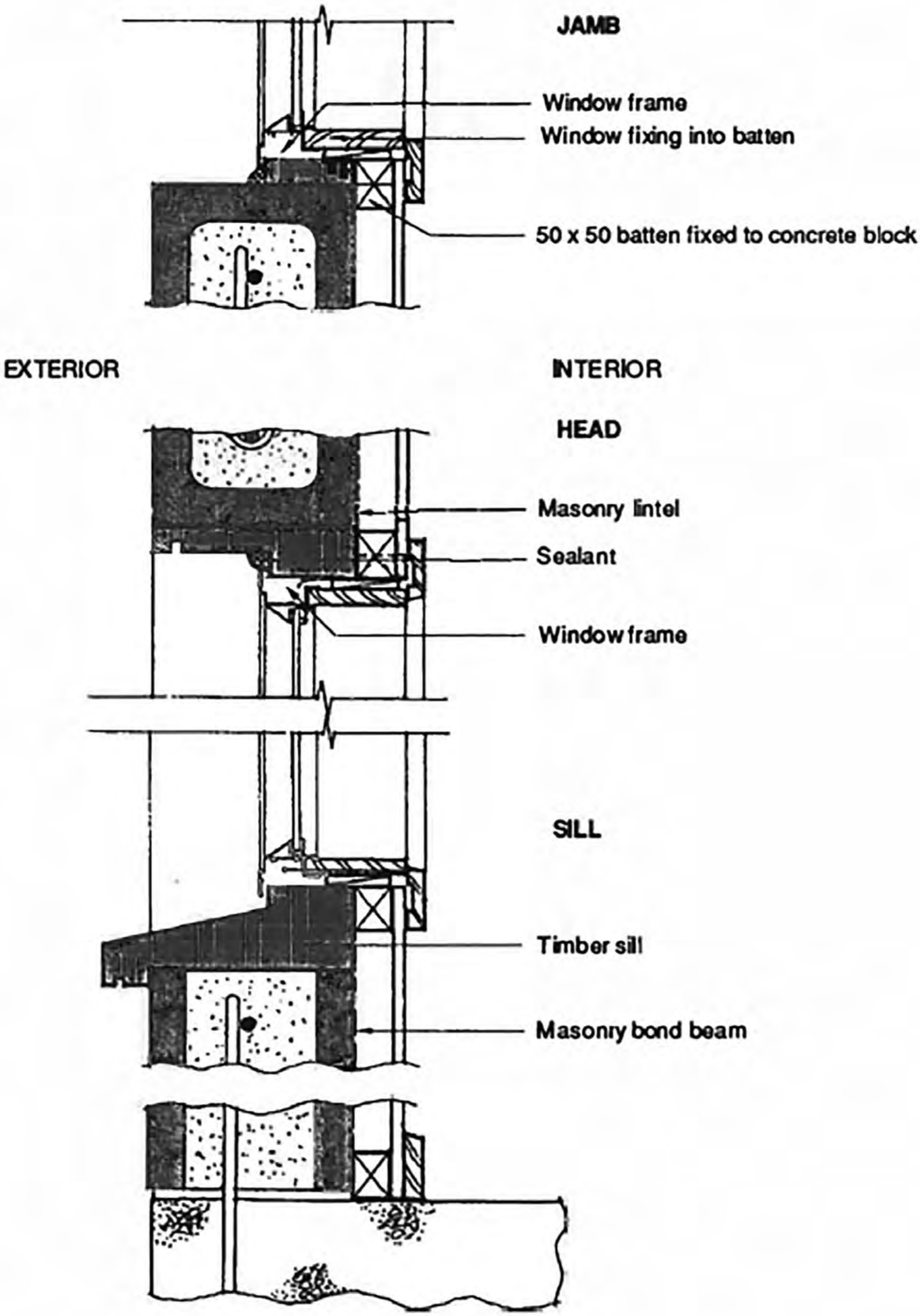


FIGURE E3.15: WINDOW DETAIL

E4 FLOOR CONSTRUCTION DETAILS

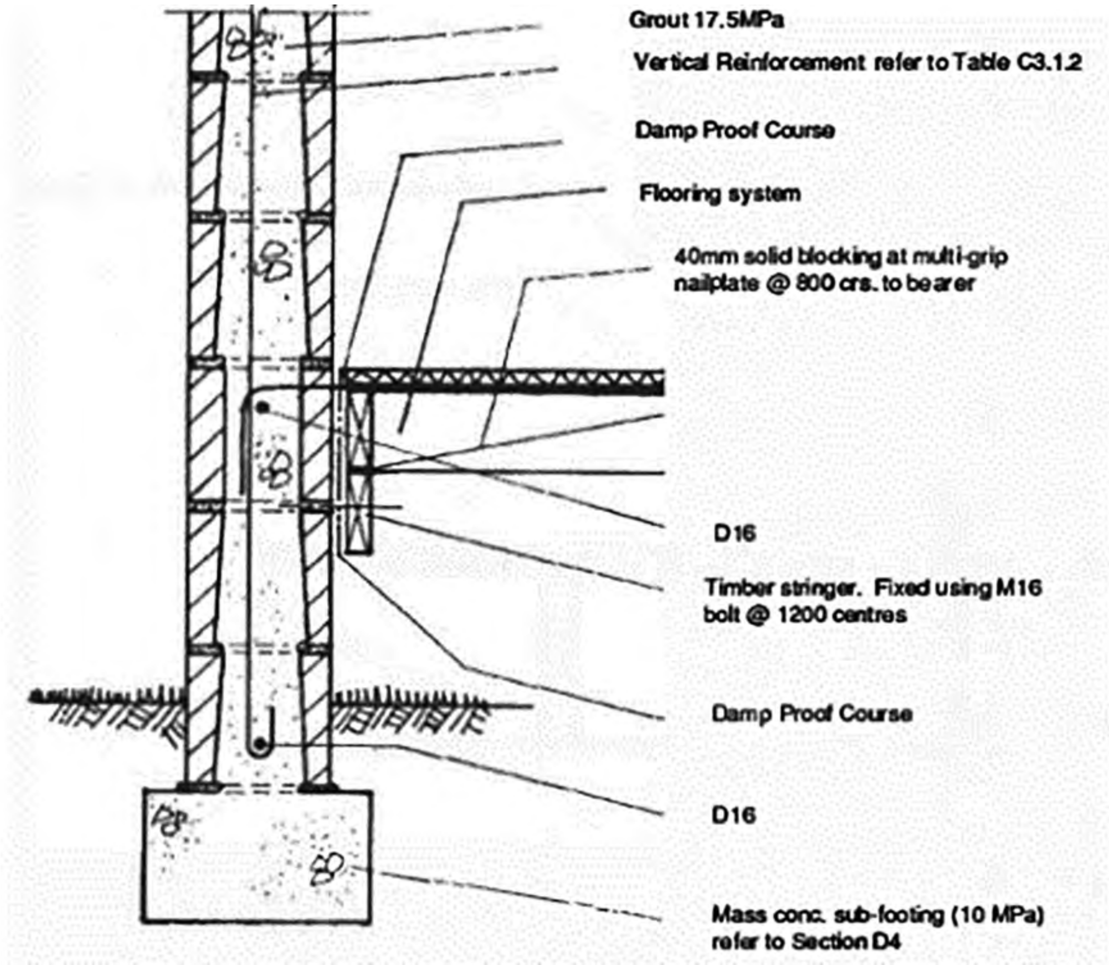


FIGURE E4.1: DETAIL OF CONCRETE MASONRY WALL – STRINGER SUPPORT

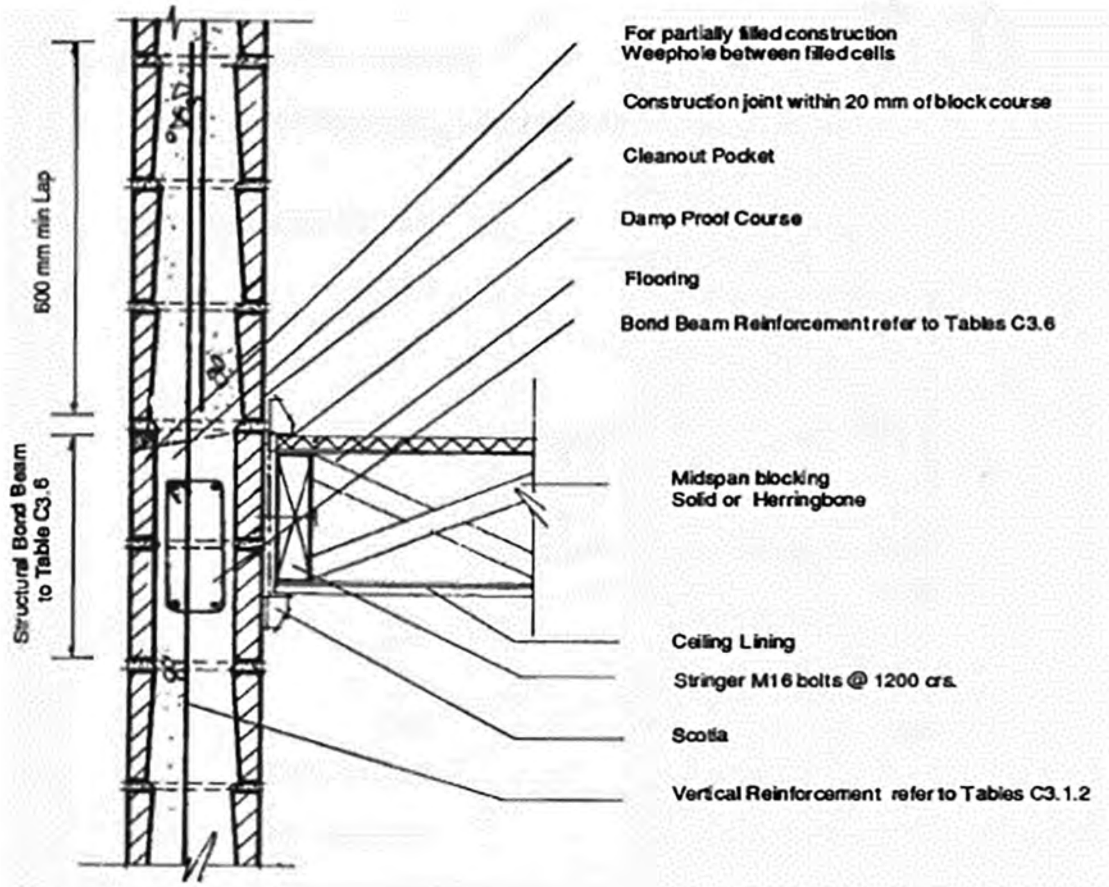


FIGURE E4.2: DETAIL OF FLOOR CONNECTIONS (PARALLEL TO JOISTS)

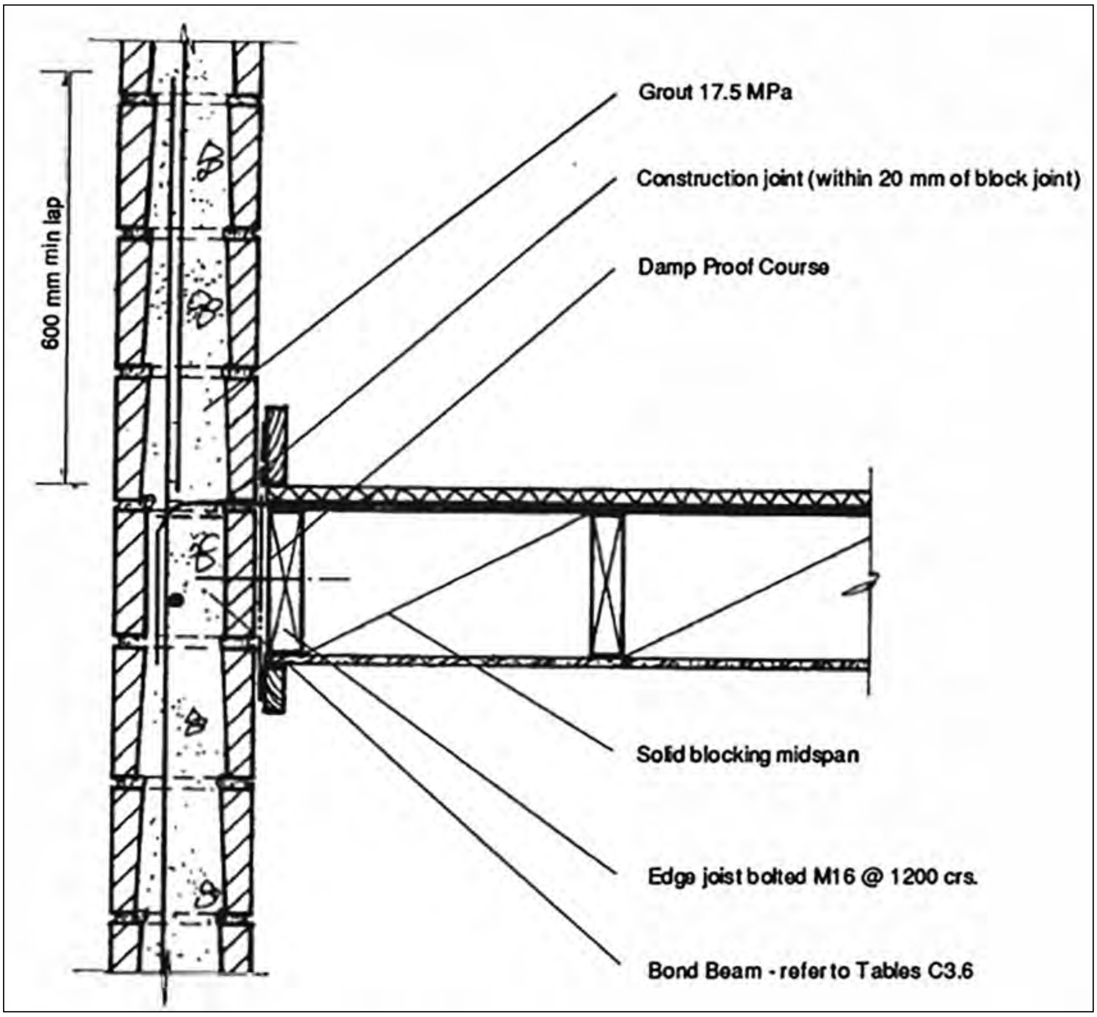


FIGURE E4.3: DETAIL OF BOUNDARY JOIST SUPPORT

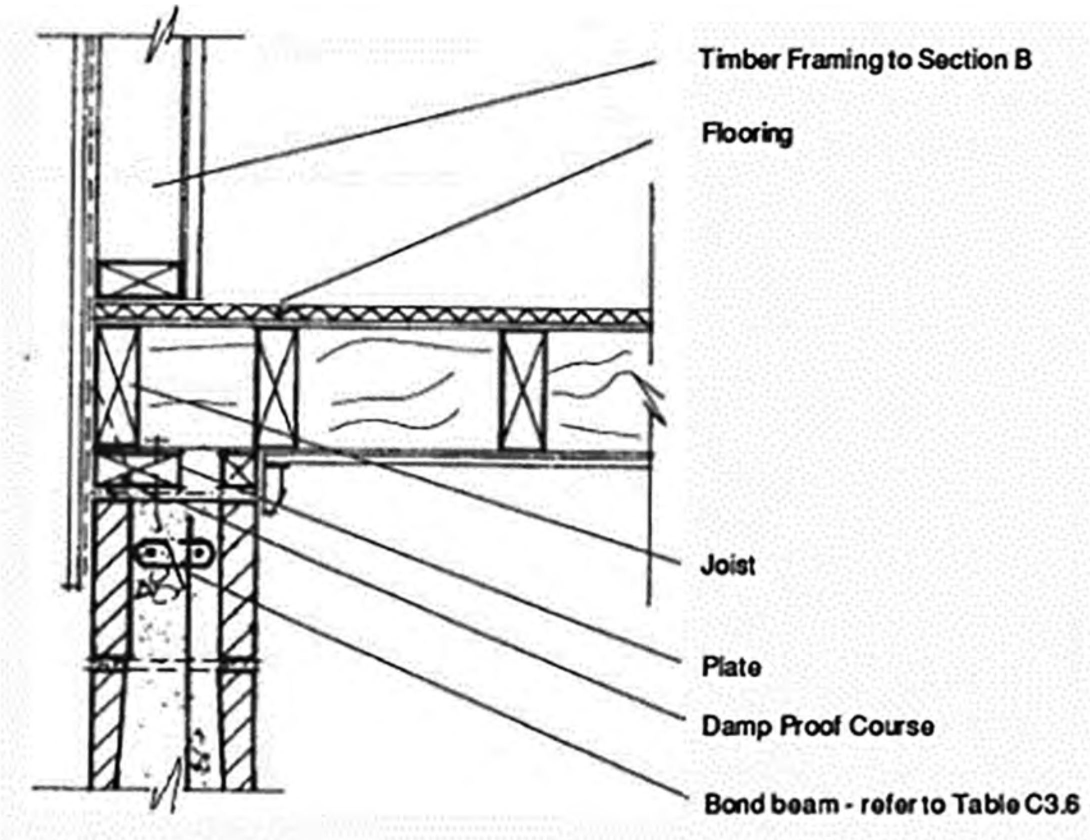


FIGURE E4.4: TIMBER FRAMED WALL ABOVE A CONCRETE MASONRY WALL

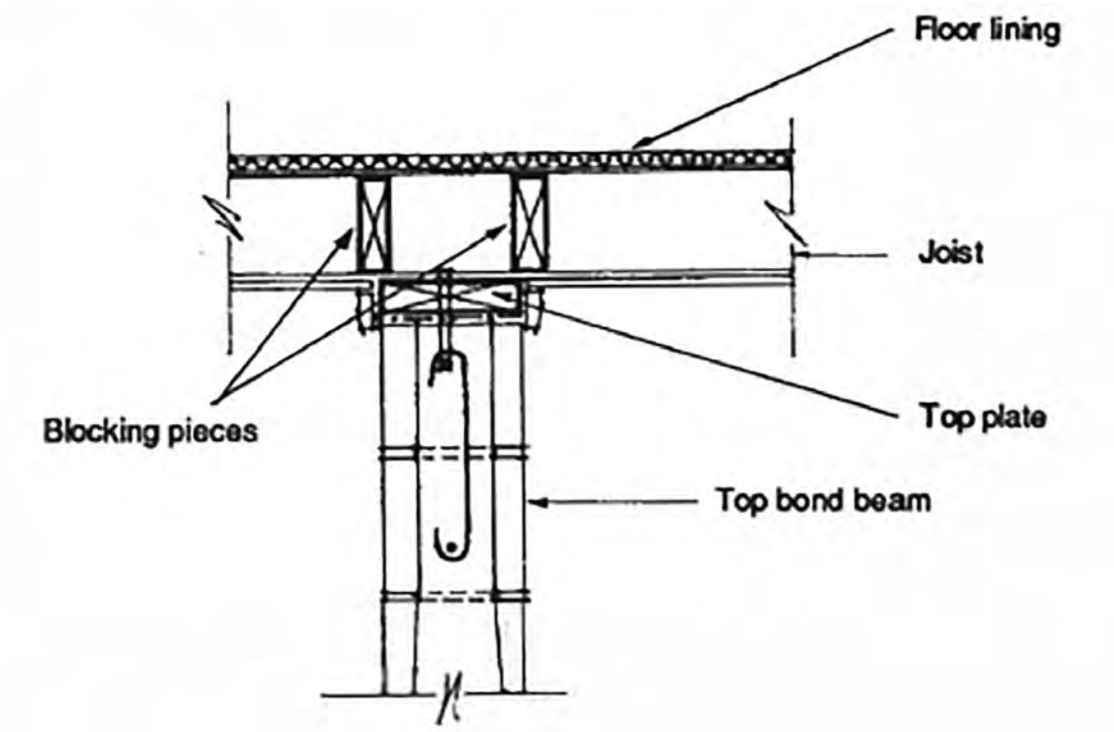


FIGURE E4.5: DETAIL OF MASONRY WALL WITH TIMBER FLOOR – PERPENDICULAR TO JOISTS

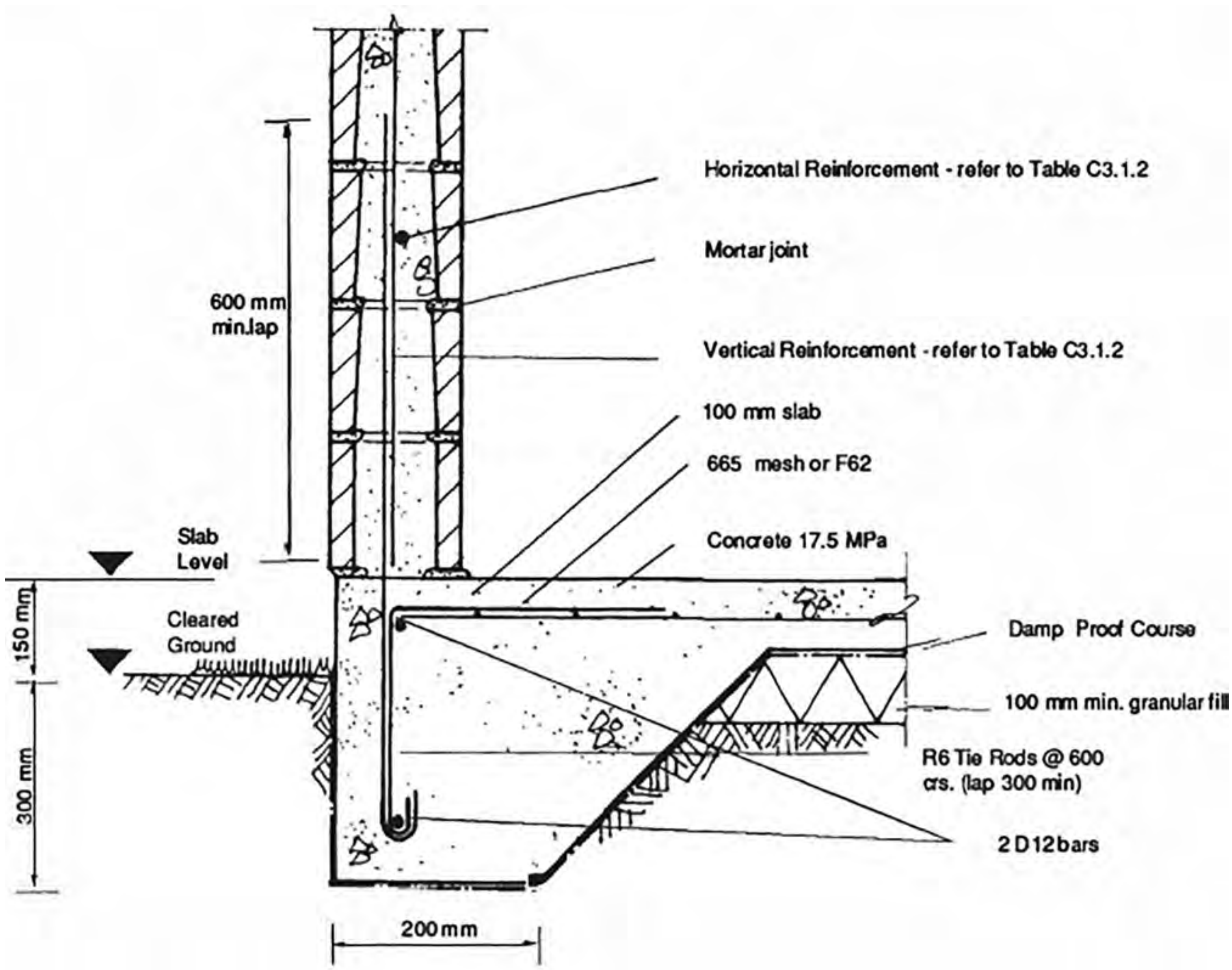


FIGURE E4.6: DETAIL OF FOOTING – IN LEVEL WITH SLAB

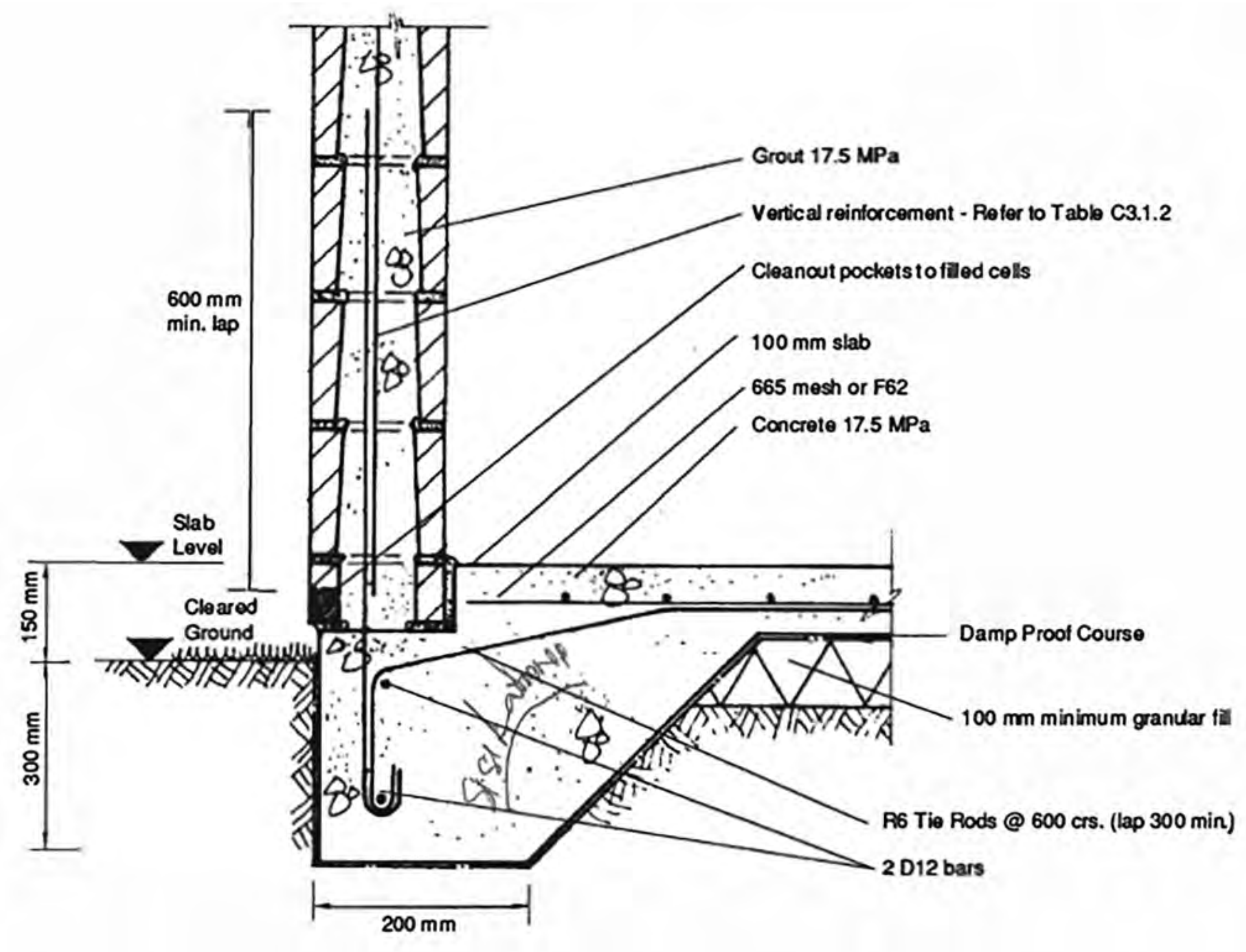


FIGURE E4.7: DETAIL OF STEP-DOWN FOOTING

Section F

HOUSE FAILURES & PRECAUTIONS

Section F – HOUSE FAILURES & **PRECAUTIONS**

F1 GENERAL

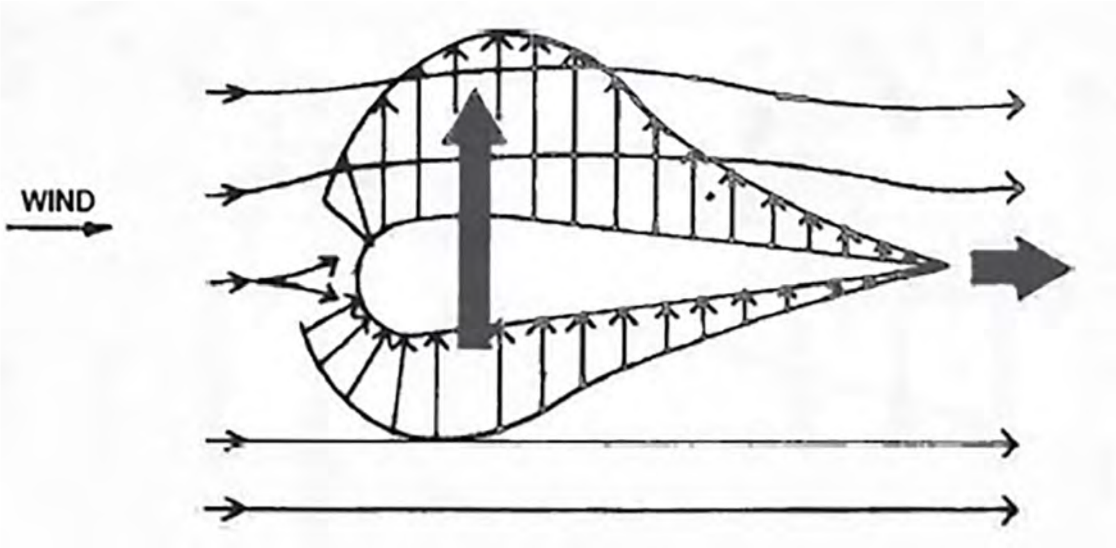


FIGURE F1.1: AIRCRAFT WING: EXPERIENCES HIGH VERTICAL (LIFT) FORCE AND SMALL HORIZONTAL (DRAG) FORCE

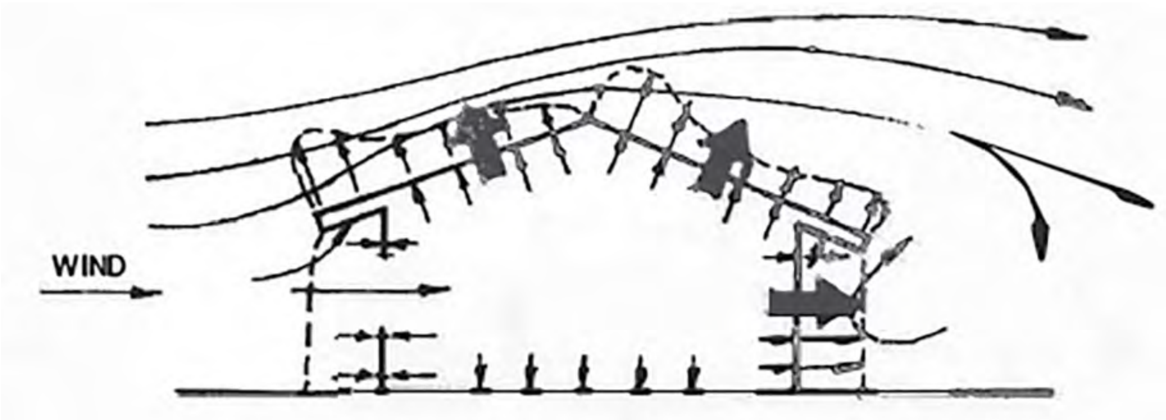


FIGURE F1.2: HOUSE: EXPERIENCES VERTICAL (UPLIFT) FORCES ON ROOF AND HORIZONTAL (SIDEWAYS) FORCES MAINLY ON WALLS

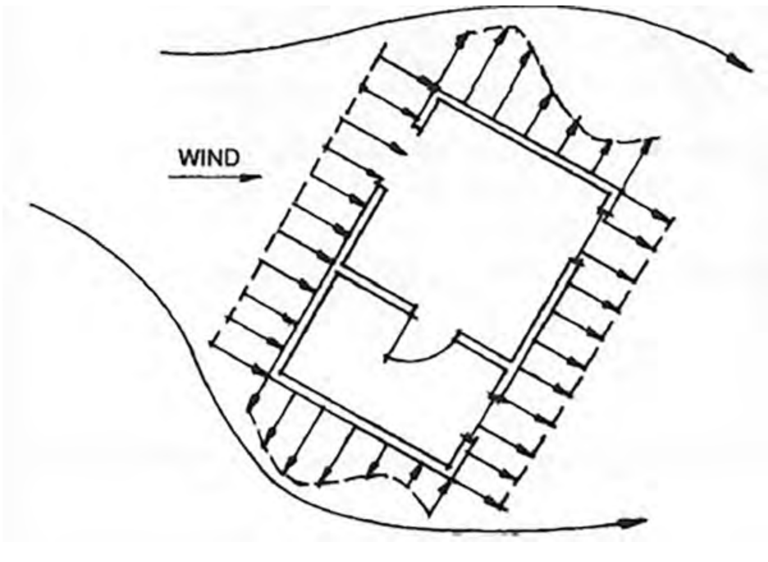


FIGURE F1.3: EXTERNAL PRESSURES ON WALLS OF A HOUSE

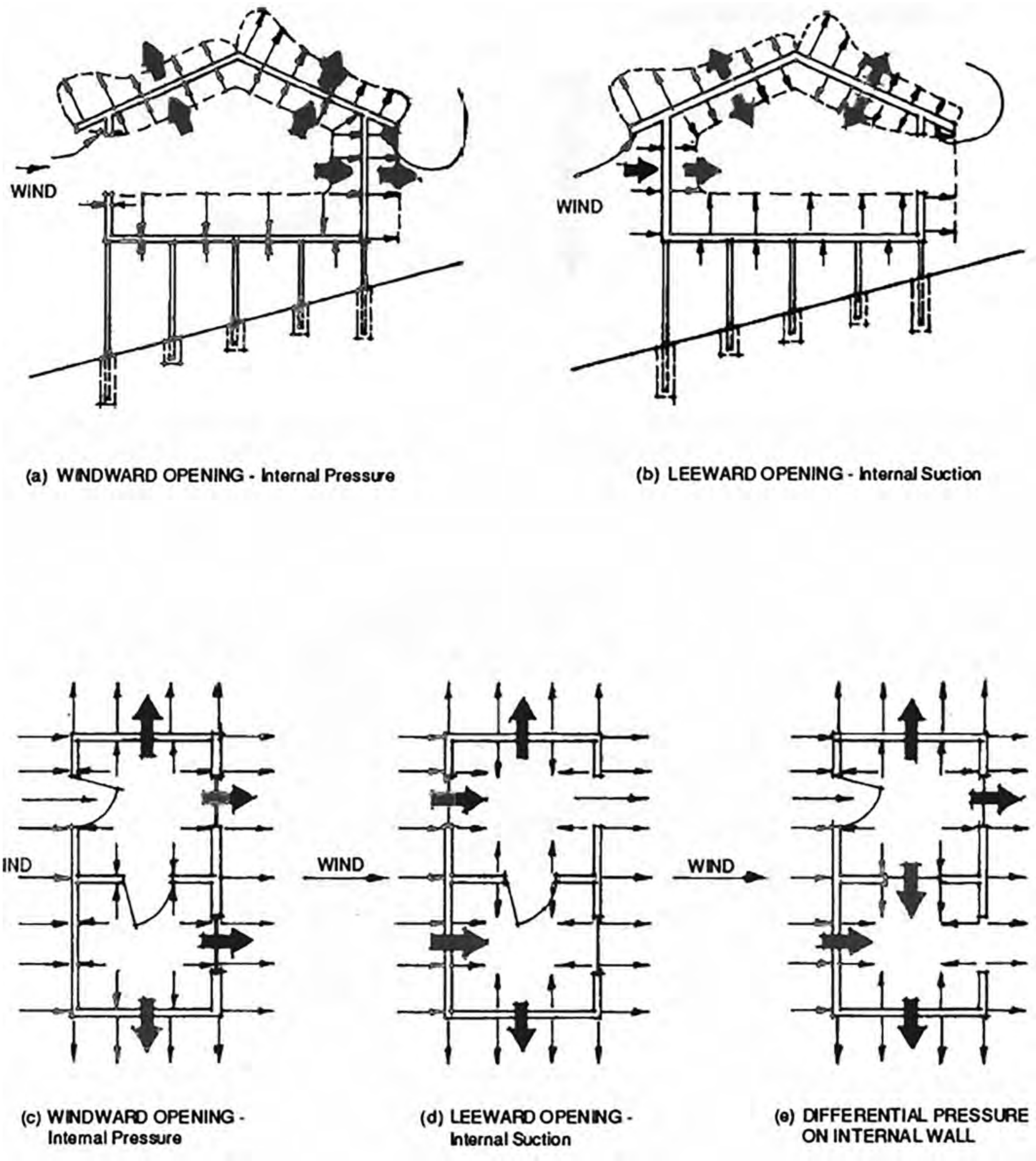
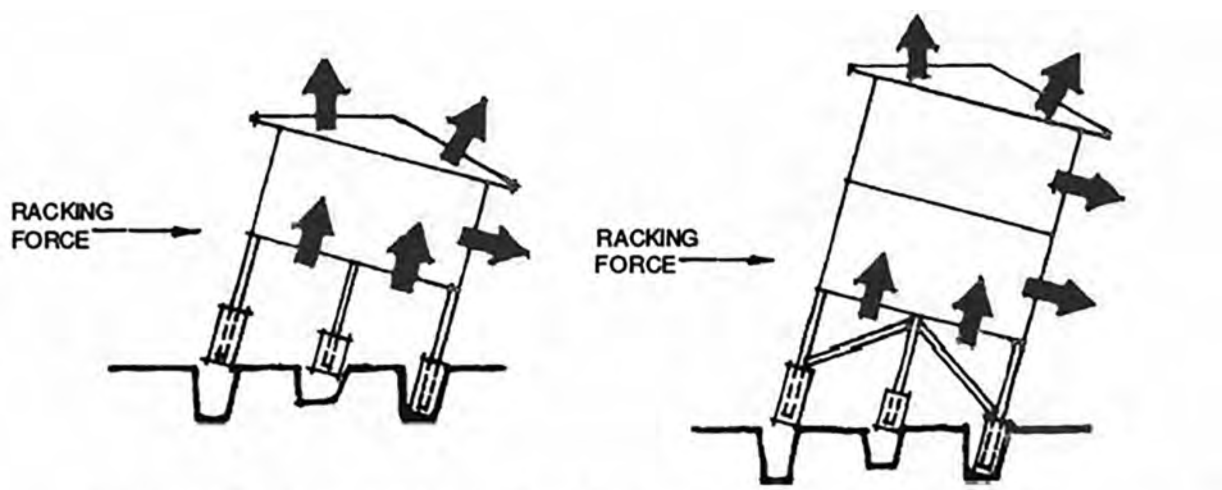


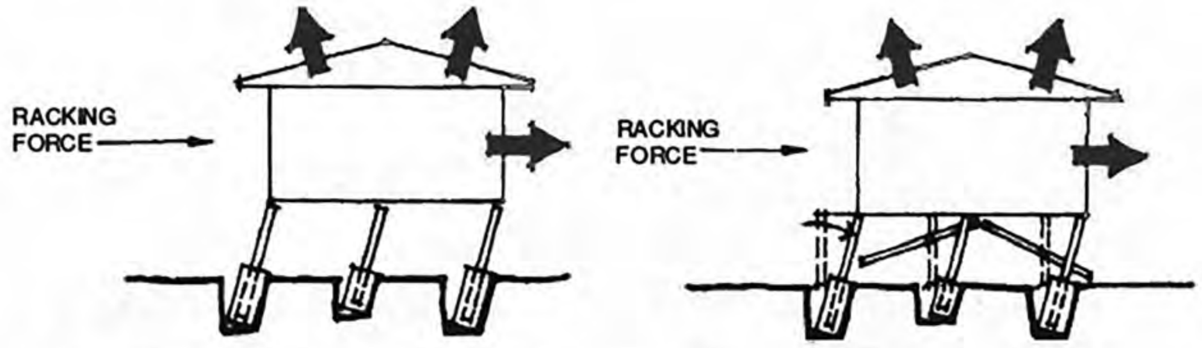
FIGURE F1.4: EFFECTS OF INTERNAL PRESSURES RESULTING FROM OPENINGS IN HOUSES

F2 FOUNDATION FAILURES



FAILURE: 1. Pile foundations have inadequate depth and weight to resist uplift
2. Pile foundations constructed in soft ground with inadequate shear friction resistance to prevent the pile from being pulled out of the ground.

REMEDY: Provide deep and heavy footings.



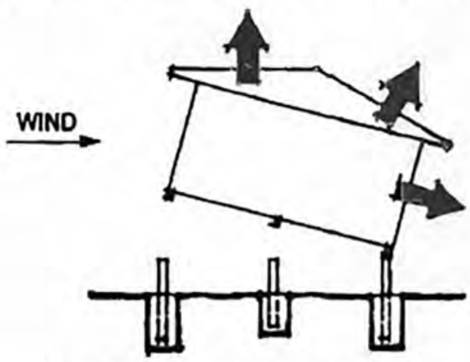
FAILURE: 1. Pile foundations at inadequate depth and width to resist overturning.

2. Pile foundations constructed in soft ground unable to resist overturning.

3. Pile height exceeds maximum allowed by this manual for cantilevered piles and are overloaded.

4. Piles, exceeding 1.2m, which are not laterally supported with diagonal braces.

REMEDY: Provide deep and wide foundations with bracing as required by this manual.



FAILURE: 1. Connections between bearers and piles fail.
2. Connections of braces to piles or sub-floor framing fail.

REMEDY: Provide adequate connections between bearers and piles and braces and piles.

F3 BEARER AND JOIST FAILURES

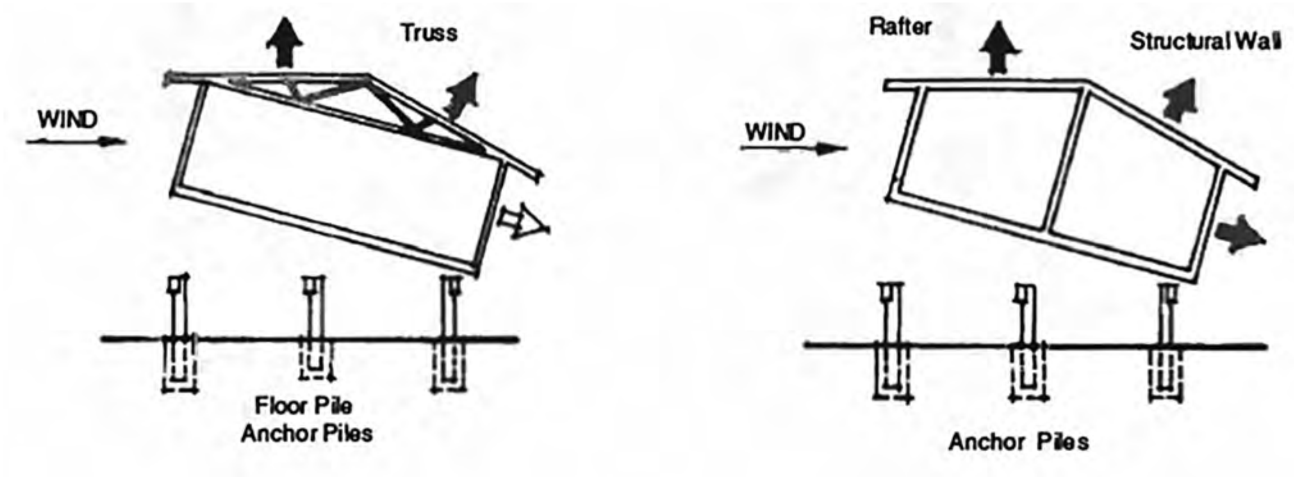


FIGURE F3.1: FAILURE OF FLOOR BEARER/JOIST CONNECTIONS

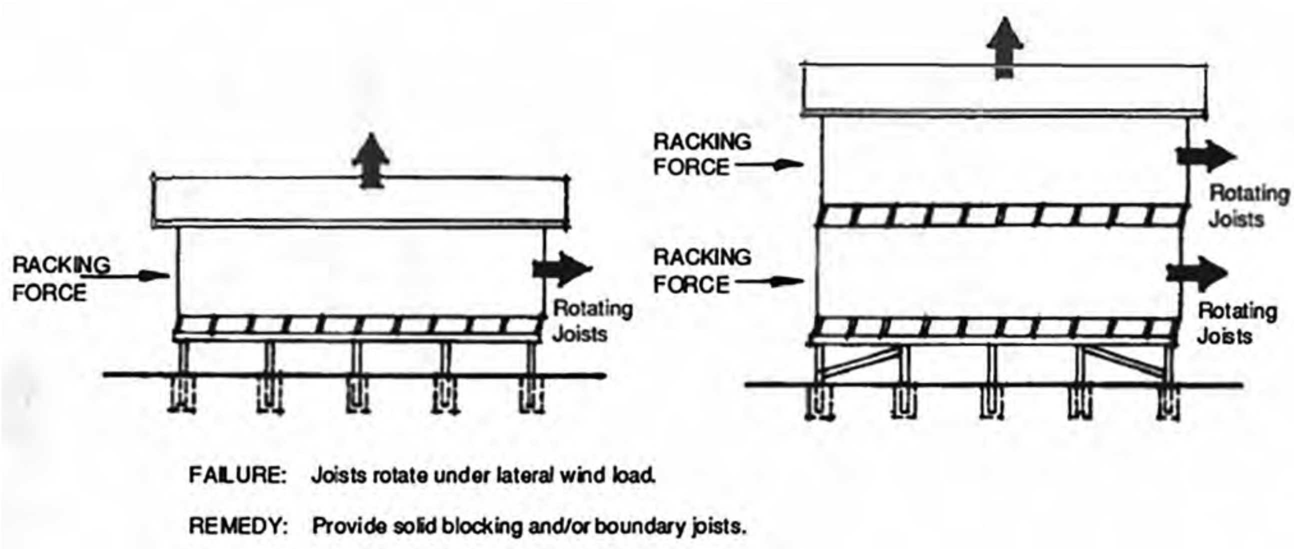


FIGURE F3.2: FAILURE OF FLOOR BY JOIST ROTATION

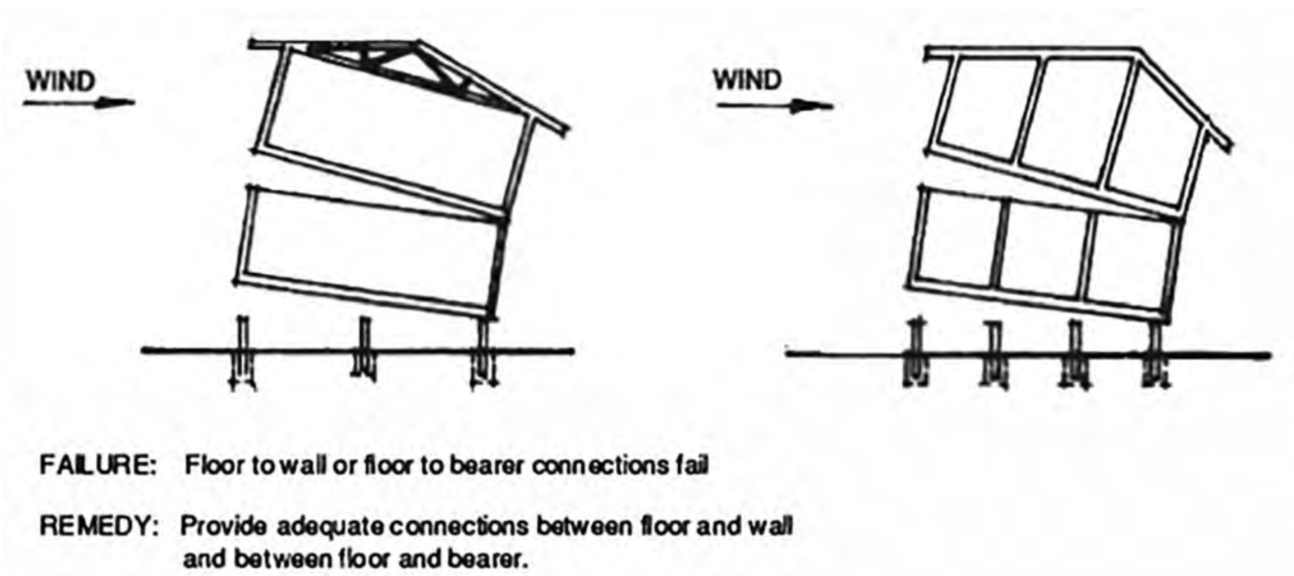
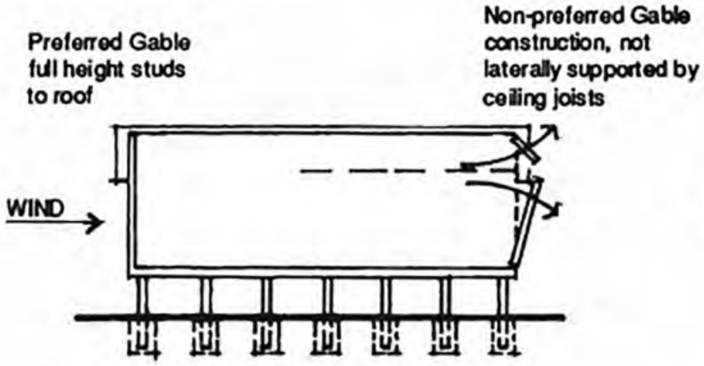
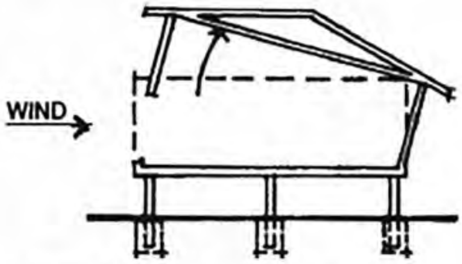


FIGURE F3.3: FAILURE OF FLOOR JOIST TO WALL AND BEARER CONNECTIONS

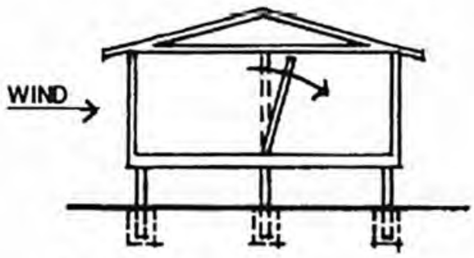
F4 FAILURE OF WALLS



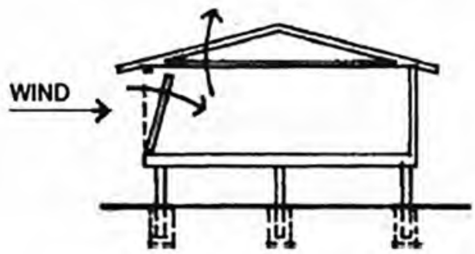
FAILURE: Gable end wall blows out.
REMEDY: Provide lateral support to gable end wall in line of ceiling joists.



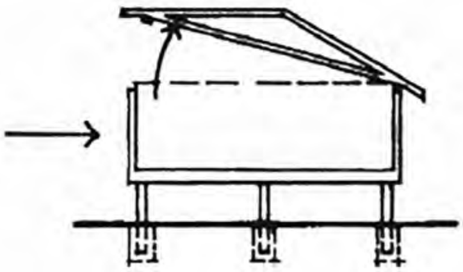
FAILURE: Roof and walls blow away.
REMEDY: Provide adequate fixing of bottom plates to studs



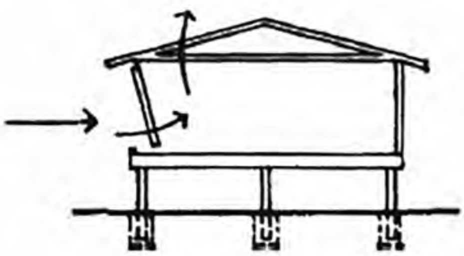
FAILURE: Internal wall blows over
REMEDY: Provide adequate fixing of internal walls at plate level.



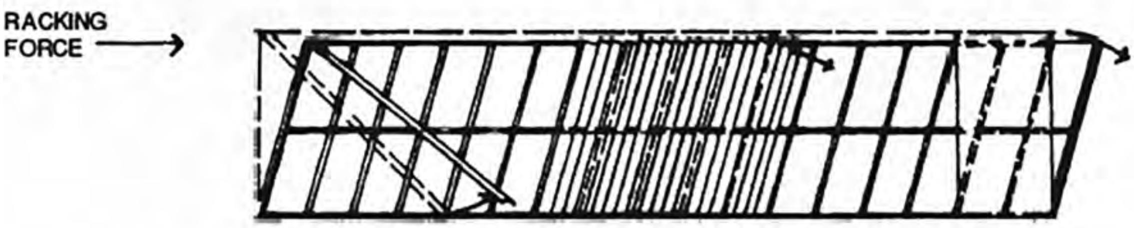
FAILURE: Wall blows over ands roof lifts
REMEDY: Provide adequate fixing of top plates to studs



FAILURE: Roof blows away leaving walls standing.
REMEDY: Provide adequate fixing of top plates to studs.

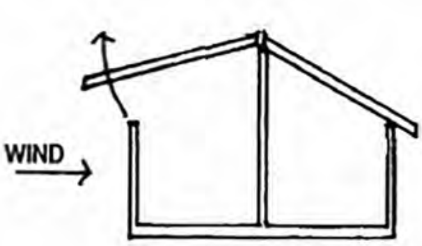


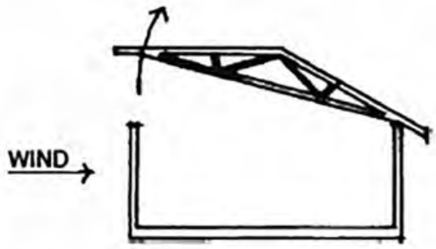
FAILURE: Wall blows inwards and roof lifts.
REMEDY: Provide adequate fixing of bottom plates to studs.



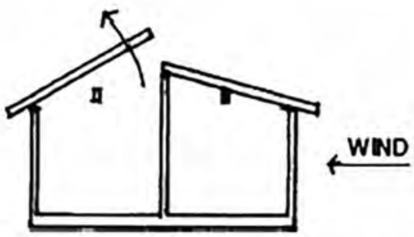
FAILURE: Wall collapses under racking load.
REMEDY: Provide the required number and type of braces with adequate nailing.

F5 FAILURE OF ROOF

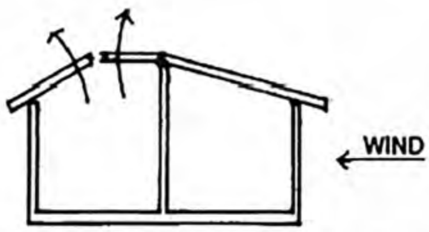




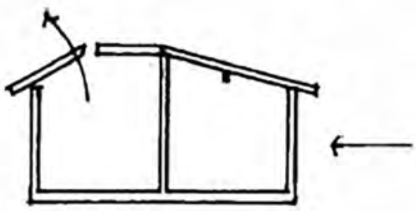
FAILURE: Tie down of rafter or truss to top plate inadequate for wind force
REMEDY: Fix securely at top plate



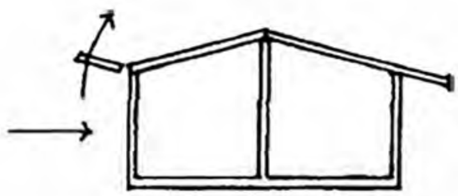
FAILURE: Tie down of rafter to ridge or under purlin inadequate
REMEDY: Fix securely at ridge and under purlin



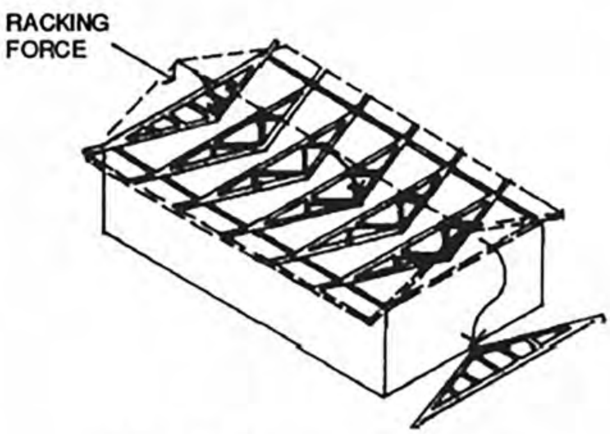
FAILURE: Breakage of rafter or other member
REMEDY: Provide members of correct size and number



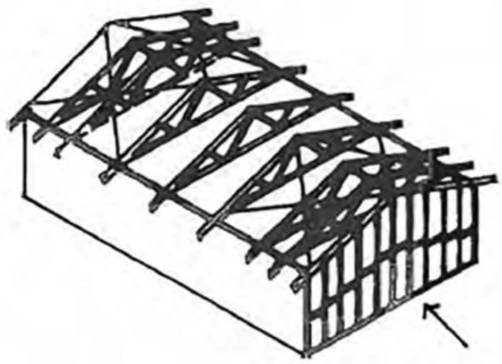
FAILURE: Under purlin inadequately tied down
REMEDY: Fix under purlins securely to structure



FAILURE: Cantilever rafter breaks at eave overhang
REMEDY: Provide rafters of correct size and spacing for cantilever

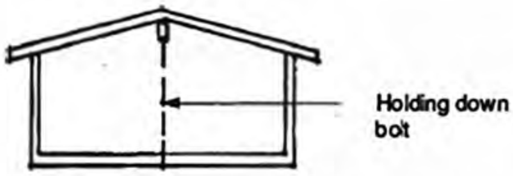


FAILURE: Trusses collapse longitudinally due to inadequate bracing.

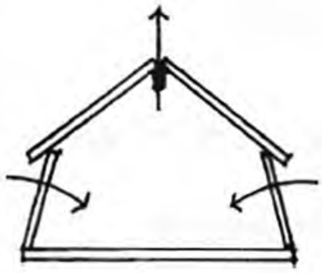


REMEDY: Provide adequate diagonal bracing and ensure cladding is correctly fixed as this provides a considerable amount of bracing.

FAILURE: Ridge Beam not tied down but walls are adequately supported

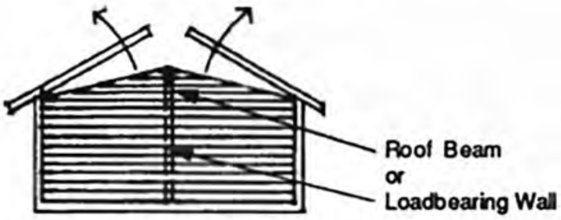


REMEDY: Tie Ridge Beam down to foundation structure

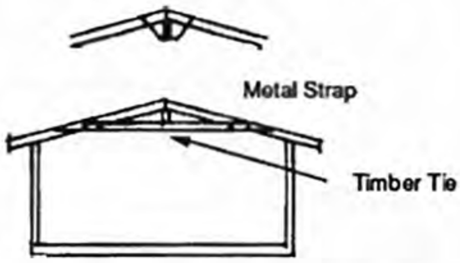


FAILURE: Ridge not tied down and walls inadequately supported

REMEDY: Form Truss in roof by nail plate fixings or provide bracing walls and adequate tie-down.

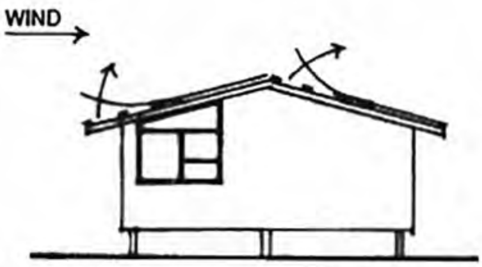


FAILURE: Roof not tied at ridge but walls are adequately supported

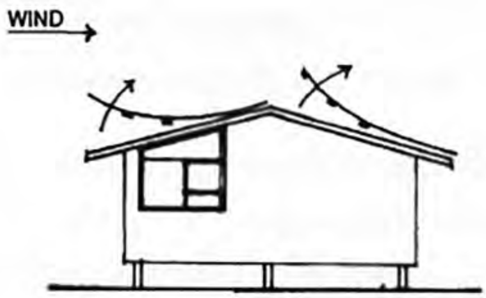


REMEDY: Tie Rafters together with straps or bolted timber tie

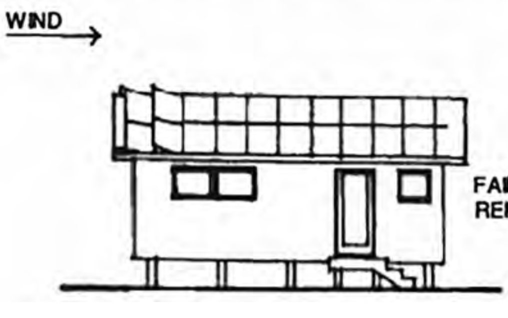
F6 FAILURE OF ROOF CLADDINGS



FAILURE: Wind lifts roofing off purlins
REMEDY: Provide more fasteners through roofing material



FAILURE: Wind lifts roofing and purlins together
REMEDY: Provide adequate fixing of purlins to rafters



FAILURE: Wind lifts roofing off purlins
REMEDY: Provide more fasteners through roofing material and a suitable fascia barge flashing adequately fixed. Do not use a rolled edge flashing

F7 CARE AND PRECAUTIONS

F7.1 Checklist for masonry construction

A Before grouting

1 Has all debris been removed from the base of the wall?

2 Check the wall for plumb. Tolerance 10 mm in 3 m (3/8 inch in 9 feet) within a storey.

3 Is the wall straight? Tolerance 5 mm in 10 m (1/4 inch in 33 feet); 10 mm any length over 10m. (Overall position of wall in house presumed checked at first course setting out).

4 Has reinforcement been tied to starter bars?

5 Reinforcement correctly located in wall or pier? Is there a minimum 6 mm clearance from reinforcement to the face of all shells of masonry?

6 Is vertical steel to within 50 mm or 1/4 the length on an individual grouted cell?

7 Is vertical steel adequately supported laterally to prevent movement during grouting? Support interval (height /bar diameter) not more than 1.2 m/10 mm; 2.4 m/12 mm; 3.6 m/16 mm.

8 Are minimum lap lengths of 300 grade reinforcement 400 mm for 10 mm, 480 mm for 12 mm and 640 mm for 16 mm?

9 After cleaning out cells, have clean out pockets been properly closed?

10 Is the grout as specified? Not too much water, but workable. Aggregate not too fine.

B After grouting

1 After filling and waiting:

Re-vibrate and top up.

Trowel down expanded grout top.

2 At construction joints, if required, lightly brush/wash the grout surface after initial set.

3 In hot weather, protect wall top from premature drying out.

4 Remove any grout spills on wall surface.

F7.2 Some precautions for builders, homeowners and occupants

F7.2.1 Construction phase

1 Use the correct member sizes, connector types and sizes etc. as required by this Manual.

2 Use reputable manufacturer's specifications and details where they vary from those shown or prescribed anywhere in this Manual.

3 Make sure that all joints are firmly held together.

4 Where there are trusses, use nail plates on both sides of the joints.

5 Tighten all bolts correctly - not loose nor overtight.

6 Use the correct sizes of washers with the bolts (refer to Table B10.4.1).

7 Keep available or have in place strong shutters for all glazed openings to prevent glass breakage by flying debris.

8 Use prefabricated metal connectors and wherever possible predrilled metal straps.

9 Use appropriately treated timber for external and internal use. Where in doubt ask Dept. of Forestry or other reputable source.

10 Tie all reinforcing rods properly.

11 Provide clean out pockets in blocks for grouting.

12 Compact grout properly in cores by either using a mechanical vibrator or rodding.

13 When site mixing of concrete or grout use the correct mixture of cement, clean water, and aggregate.

F7.2.2 During the cyclone season

1 Put window shutters in place as soon as a cyclone warning is issued.

2 Keep yard clear of any potential flying debris.

3 Trim down branches of trees which may break during a cyclone and become flying debris.

4 Keep clear of all glazed openings during a cyclone.

5 Stock up food supplies for use during/after a cyclone.

6 Keep a battery operated radio to listen to broadcasts regarding the cyclone.

7 If the house is in a flood prone area, move to higher ground before flooding occurs

8 If the house is in an area known to cause mudslides, vacate house and move to firm ground.

F7.2.3 Precautions against fire

1 Where a fire service is available keep their telephone number handy.

2 Discuss with family members the appropriate sequences of action in case a fire should occur. Discuss scenarios such as what to do if there is a fire in the kitchen or a bedroom and how to prevent the occurrence of such fires. Also determine common assembly spot after escaping.

3 Keep the house and yard tidy. Do not allow tall grass and shrubs to grow close to any combustible facing of walls etc.

4 Store liquid fuels in small quantities in air-tight containers and clearly label them. Many serious fires have occurred by the mistaken use of lawn mower fuel in kerosene stoves.

5 Keep matches out of reach of children.

6 Do not ever smoke in bed.

7 Check electrical appliances periodically. If there are any kinks, frayed ends, cracked/cut insulation, etc; replace immediately. Discoloured switches and sockets may indicate faults. If hot to touch they are faulty. Get them checked/ replaced.

F7.2.4 In the event of a fire

1 Where there is a fire service call them promptly.

2 Alert others around you.

3 Evacuate the house and assist others. Assemble at a pre-arranged open area. This will help to check that all those present have escaped.

4 With any fat-fire or fire in a sauce pan, cover with a lid. Do not try to carry it outside. With oil and fat fires do not use water to put them out.

5 With electrical fires, switch off and disconnect any plug. Do not use water to put them out.

6 If smouldering fire is discovered in any mattress or cushion etc: try to remove it outdoors and douse with plenty of water.

7 If caught in smoke, get close to the floor and crawl to escape. Inhaling any smoke will quickly disorient/incapacitate a person and lead to fatality.

8 If unable to escape from fire outside a room, plug all cracks/crevice/openings with wet blanket or clothing and stay close to the floor. If water is available, keep the floor wet.

F7.3 Warning against unsafe practices

Some methods of construction and some actions of residents could endanger lives or result in damage. These are listed in the form of prohibitions.

A1.1.1 Construction phase

1 Do not flatten roofing sheets when hammering nails or driving screws.

2 Do not leave gaps or allow slackness between joints and connections. Make all connections tight.

3 Do not use clouts on metal connectors.

4 Do not use undersized members or connectors.

5 Do not use nail plates on only one side of a truss.

6 Do not punch holes in metal straps with a nail or other sharp object. These tear far more quickly than straps with holes pre-punched by the manufacturer.

7 Do not use any other brand of preformed metal connectors if a particular brand is specified.

8 Do not build a low-set house in an area known to be flood-prone.

9 Do not rely only on skew nailed joints.

10 Do not nail metal straps in one line; stagger the nails.

11 Do not leave loose debris near buildings.

12 Do not leave wide gaps in window shutters.

13 Do not use untreated timber for external use.

In the event of a cyclone

14 Do not stand near glazed openings during a cyclone.

15 Do not wander out after the cyclone. The lull may be temporary. Wait for radio announcement.

16 Do not go near broken down power lines.

In the event of a fire

17 Do not use the lift, if in a high-rise building at the time.

18 Do not return to the building until the all clear signal is given.

19 Do not use a hose reel on an electrical or oil/fat fire.

20 Do not run from the building, walk quickly instead to a safer place.

21 DO NOT GO SIGHTSEEING IN THE EVENT OF ANY OF THE ABOVE.

F8 WHAT CAN GO WRONG IN A CYCLONE AND WHAT TO DO

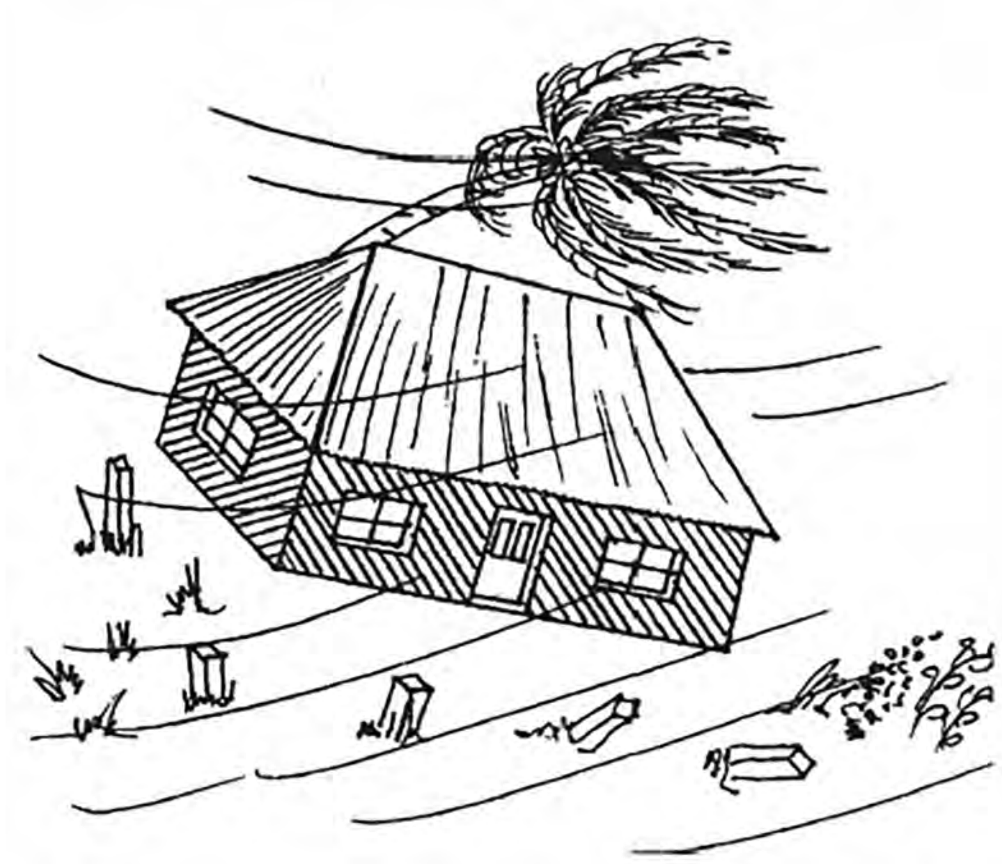


FIGURE F8.1: STRONG WINDS WILL BLOW HOUSES OFF THEIR FOUNDATIONS

FIGURE F8.2: WINDS WILL BLOW AWAY THE ROOF SHEETING

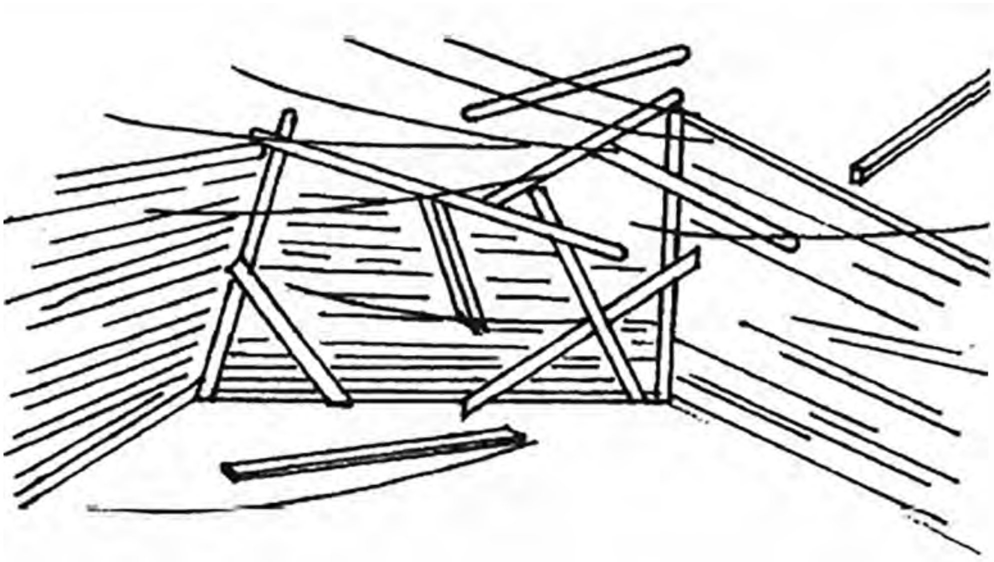


FIGURE F8.3: POORLY BRACED AND JOINTED HOUSES WILL BREAK UP

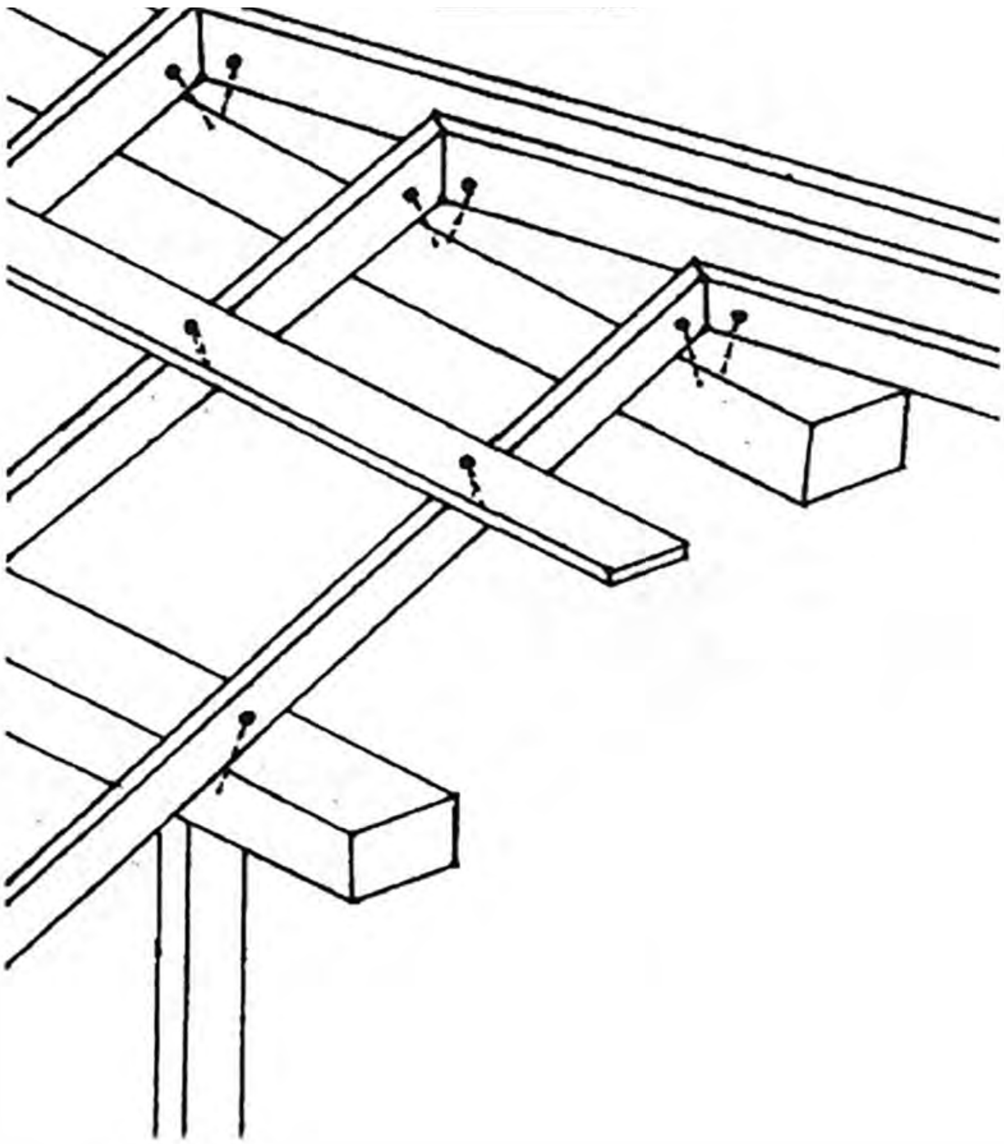


FIGURE F8.4: DO NOT DEPEND ON THE NAILS ALONE TO KEEP YOUR ROOF UNLESS YOU HAVE USED SPECIAL PURPOSE ANCHOR NAILS OR SCREWS BOTH WITH CYCLONE WASHERS

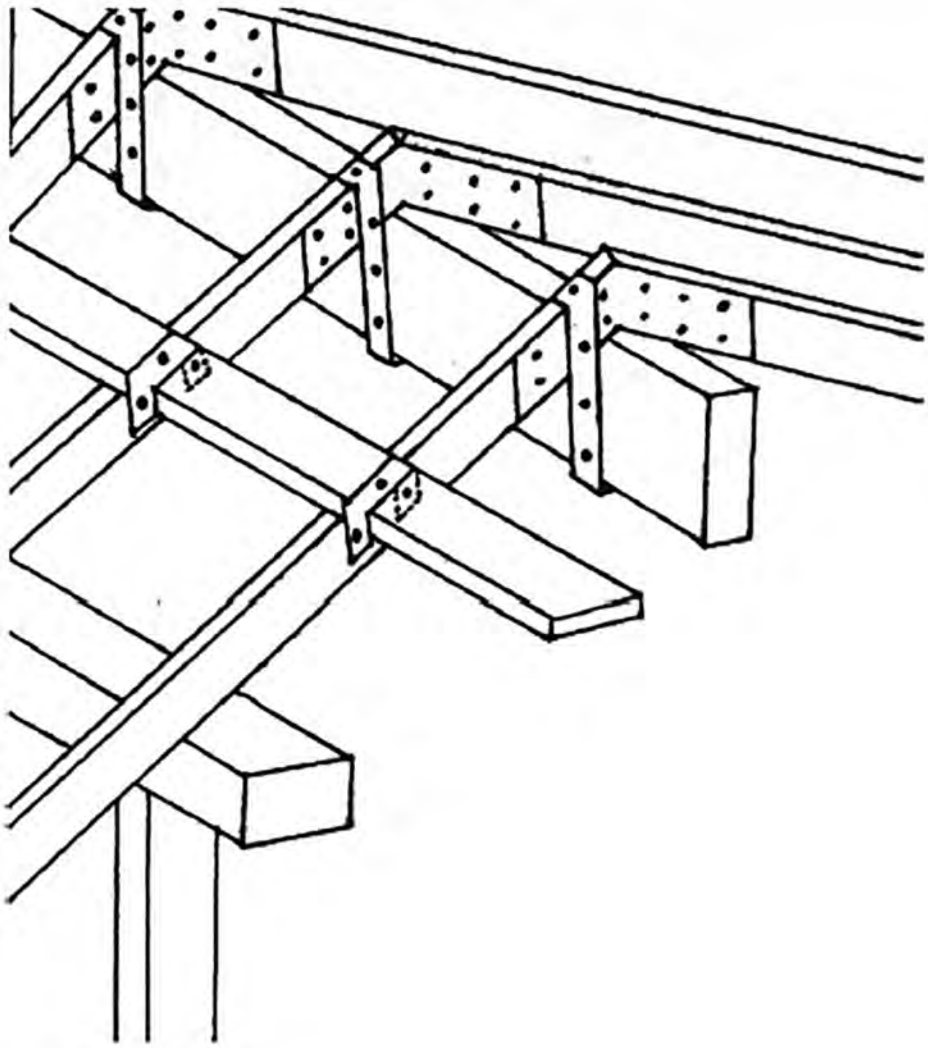


FIGURE F8.5: USE GALVANISED PRE-DRILLED METAL STRAPS LIKE THESE OR USE NO. 8 WIRE TO FIRMLY TIE UP JOINTS

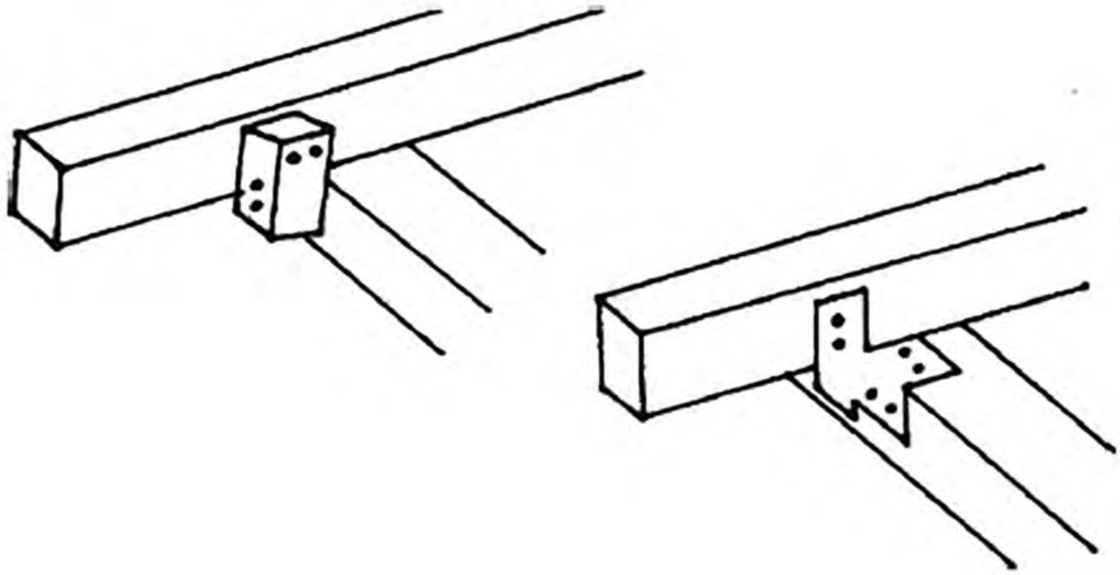


FIGURE 8.6: USE TIMBER OR METAL CLEATS TO HOLD DOWN RAFTERS

FIGURE F8.7: BUILD YOUR HOUSE ON A FIRM SITE

FIGURE F8.8: CUT INTO EARTH IF YOU BUILD A HOUSE ON A STEEP SLOPE

FIGURE F8.9: IT IS UNWISE TO BUILD A HOUSE ON A STEEP SLOPE

FIGURE F8.10: IF THE SUPPORTS ARE NOT BRACED, THE HOUSE CAN BE BLOWN OFF ITS SUPPORTS

FIGURE F8.11: BRACE THE SUPPORTS AS SHOWN AND TIE DOWN

FIGURE F8.12: TIE YOUR HOUSE PROPERLY TO THE POSTS

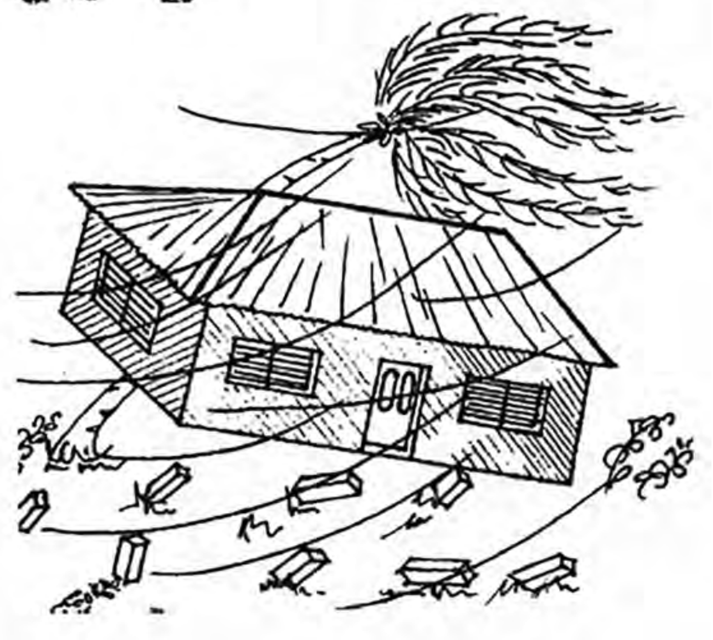


FIGURE F8.13: HOUSE THAT IS NOT PROPERLY TIED DOWN WILL BLOW OFF THE POSTS

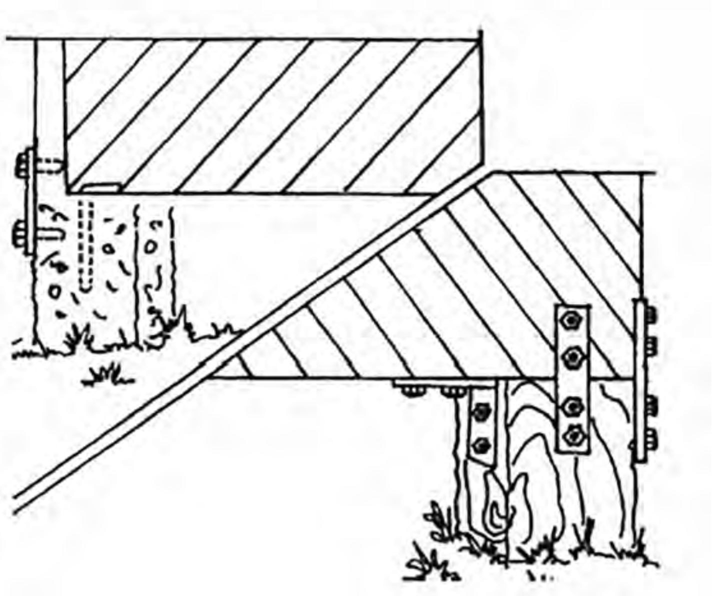


FIGURE F8.14: USE METAL STRAPS AND BOLTS TO TIE THE HOUSE TO THE POSTS

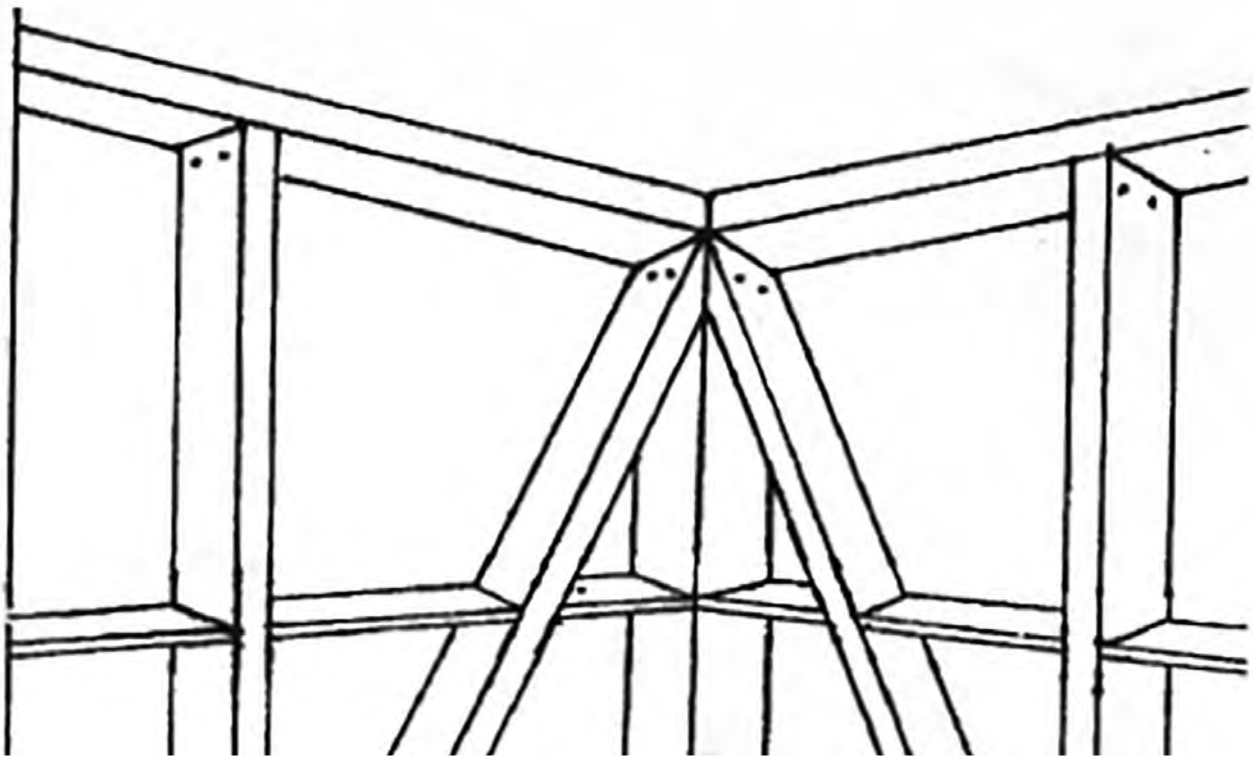


FIGURE F8.15: WALLS MUST BE BRACED IN THE CORNERS

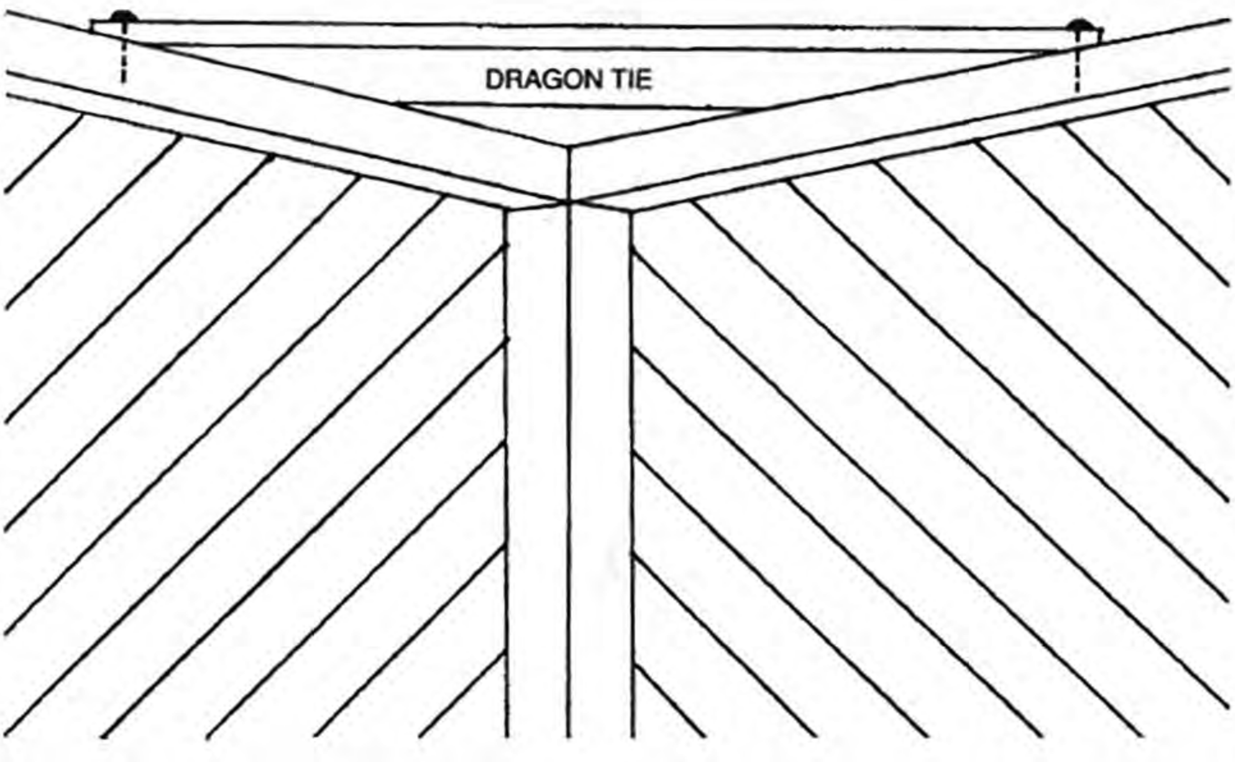


FIGURE F8.16: USE A DRAGON TIE TO BRACE EXTERNAL WALLS

FIGURE F8.17: GLASS WINDOWS AND DOORS WILL BREAK DURING A CYCLONE

FIGURE F8.18: PROTECT ALL GLASS WINDOWS AND DOORS WITH PROPER CYCLONE SHUTTERS

FIGURE F8.19: OVERHANGS MUST BE AS SHORT AS IS NECESSARY

FIGURE F8.20: LONG OVERHANGS WILL CAUSE A ROOF TO BLOW OFF IN A CYCLONE

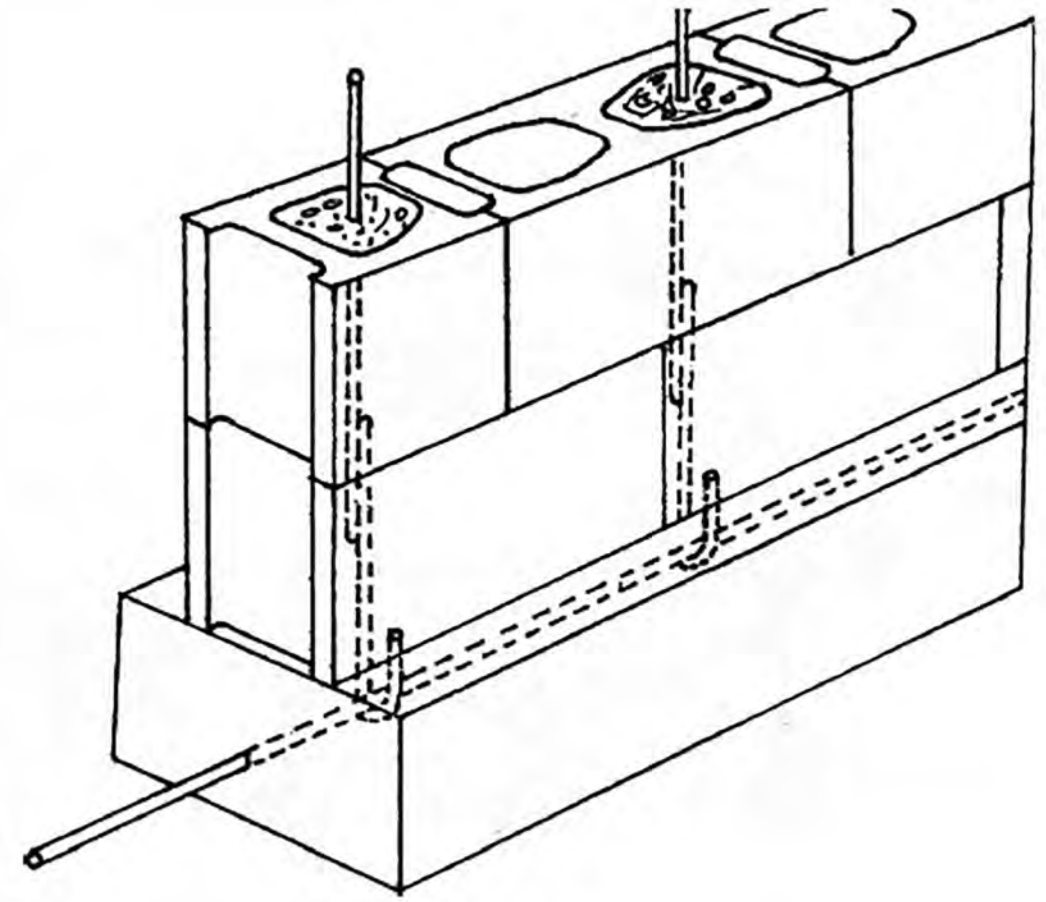


FIGURE F8.21: ANCHOR STARTER BARS INTO FOOTING. PROVIDE ADEQUATE LAP LENGTH FOR REINFORCEMENT. GROUT AROUND BARS FULLY

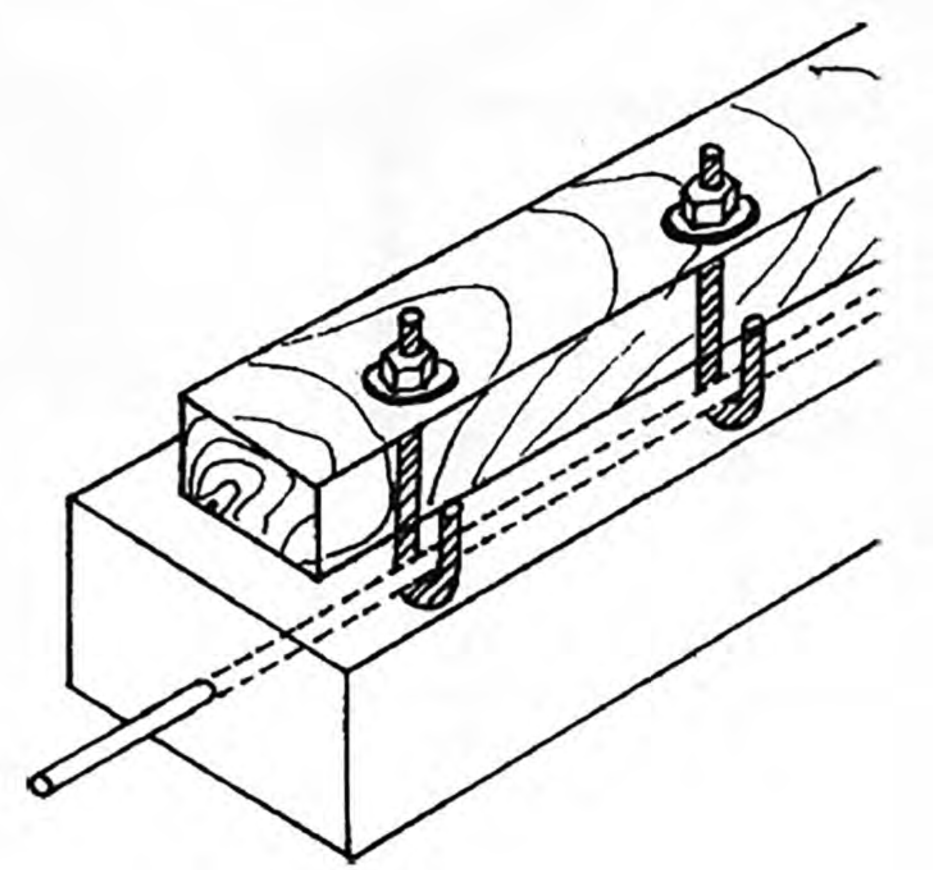


FIGURE F8.22: BOTTOM PLATE MUST BE PROPERLY ANCHORED TO THE FOOTING

F9 BRACING AND CONNECTIONS

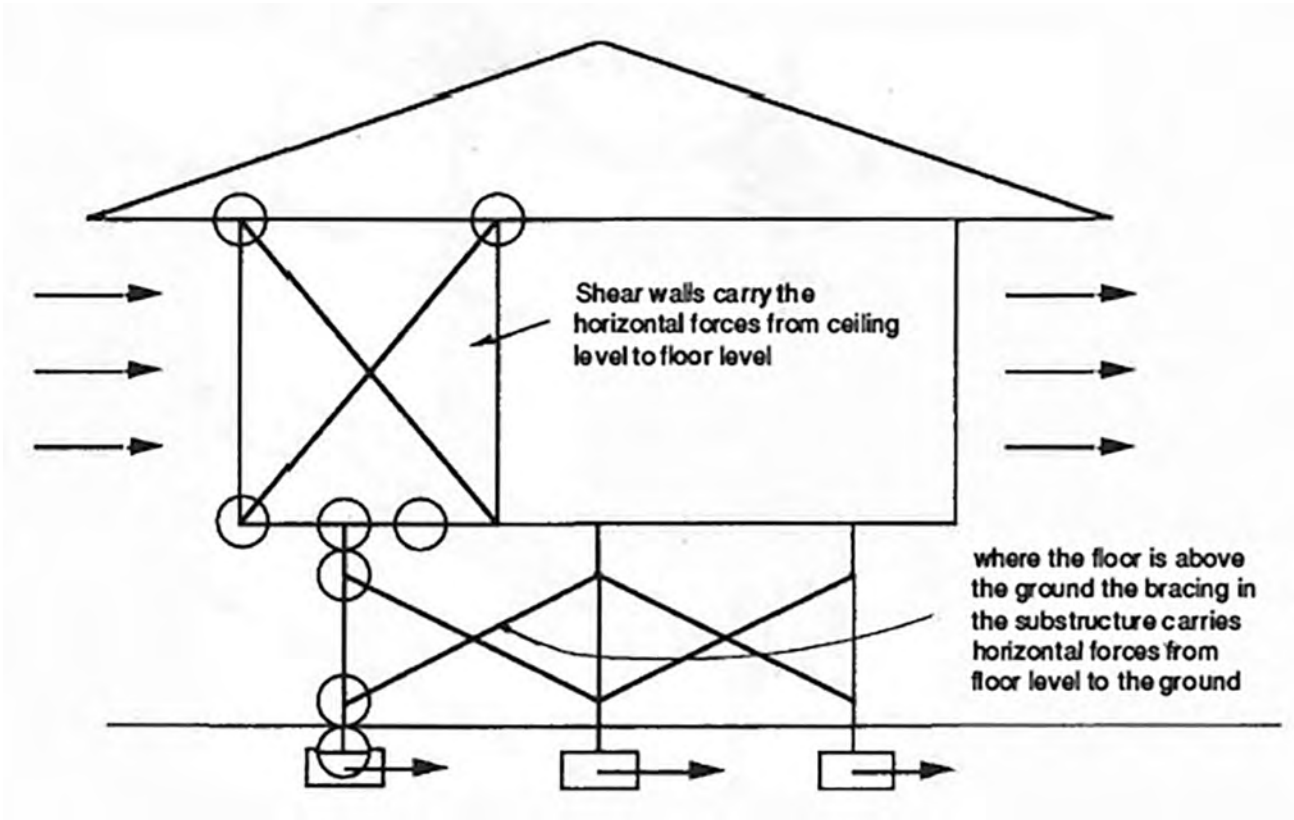


FIGURE F9.1: BRACE WALLS AND SUB-FLOOR TO AVOID FAILURE DUE TO HORIZONTAL FORCES

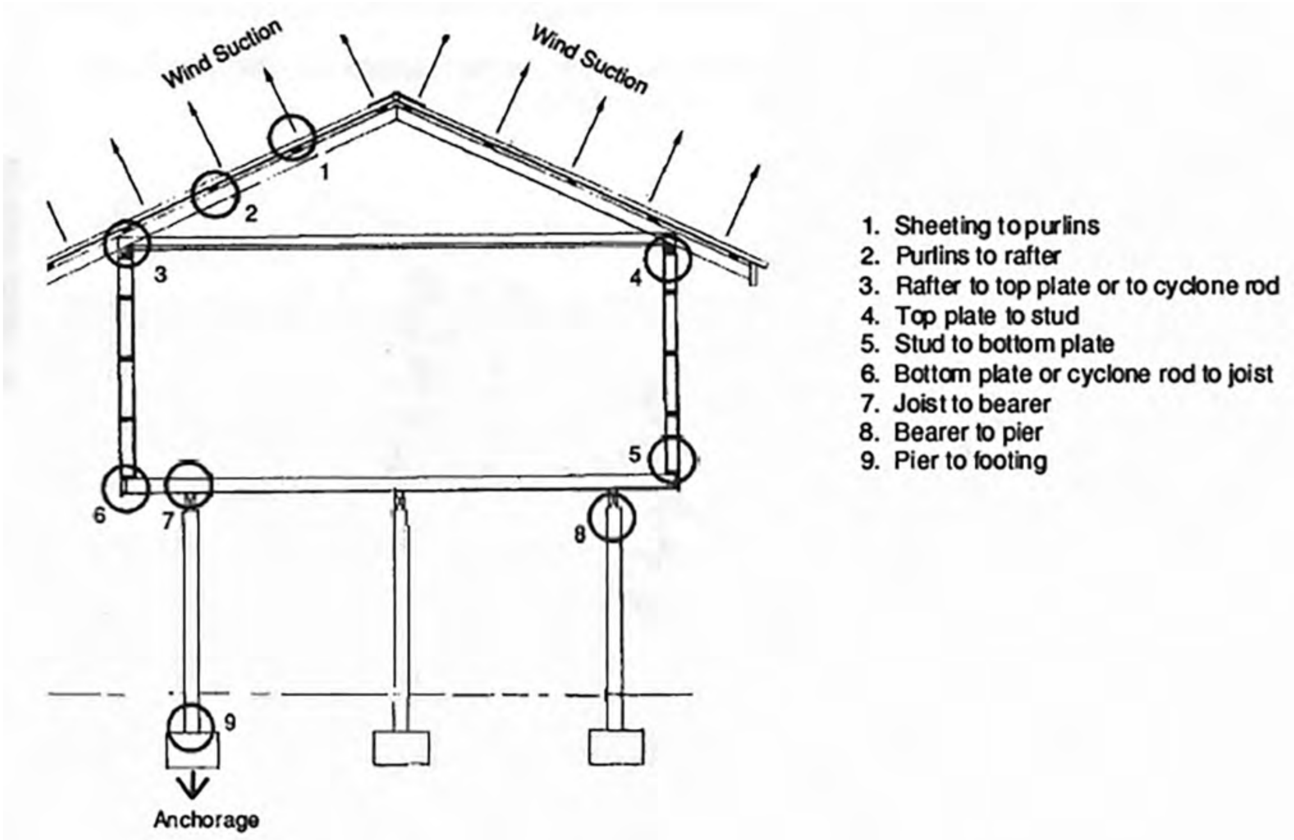


FIGURE F9.2: MAKE SURE THAT ALL JOINTS IN A VERTICAL STRENGTH CHAIN ARE PROPERLY CONNECTED

Section G
MISCELLANEOUS

Section G — MISCELLANEOUS

G1 WINDOW SHUTTERS

G1.1 General

All windows MUST be protected from flying debris during cyclones by means of shutters. Figure G1.1 shows two different types of shutters that can be used to protect windows from flying debris. Timber used to construct the shutters must be of a fairly good quality and must not contain too many knots and other detects.

Shutters in front of glass windows or doors not only protect the glass from flying debris, but shield the glass to some extent from the pressure of the wind. Preventing the glass from breaking will stop the sudden rush of wind inside which could result in the explosive break-up of the house. Shutters must be firmly fixed in place when a cyclone warning is issued. They must be stored in a proper manner if they are not permanently fixed in place. If shutters are stored during non-cyclonic periods, it would help to number them with the windows also match-marked. This would allow prompt and correct installation of the shutters once a cyclone warning is received.

G1.2 Impact test for Shutters

Shutters must be so constructed as to resist impact by a 4 kg piece of timber of 100 mm x 50 mm cross-section, striking it at any angle at a speed of 15 m/s.

FIGURE G1.1 WINDOW SHUTTER DETAIL

I)

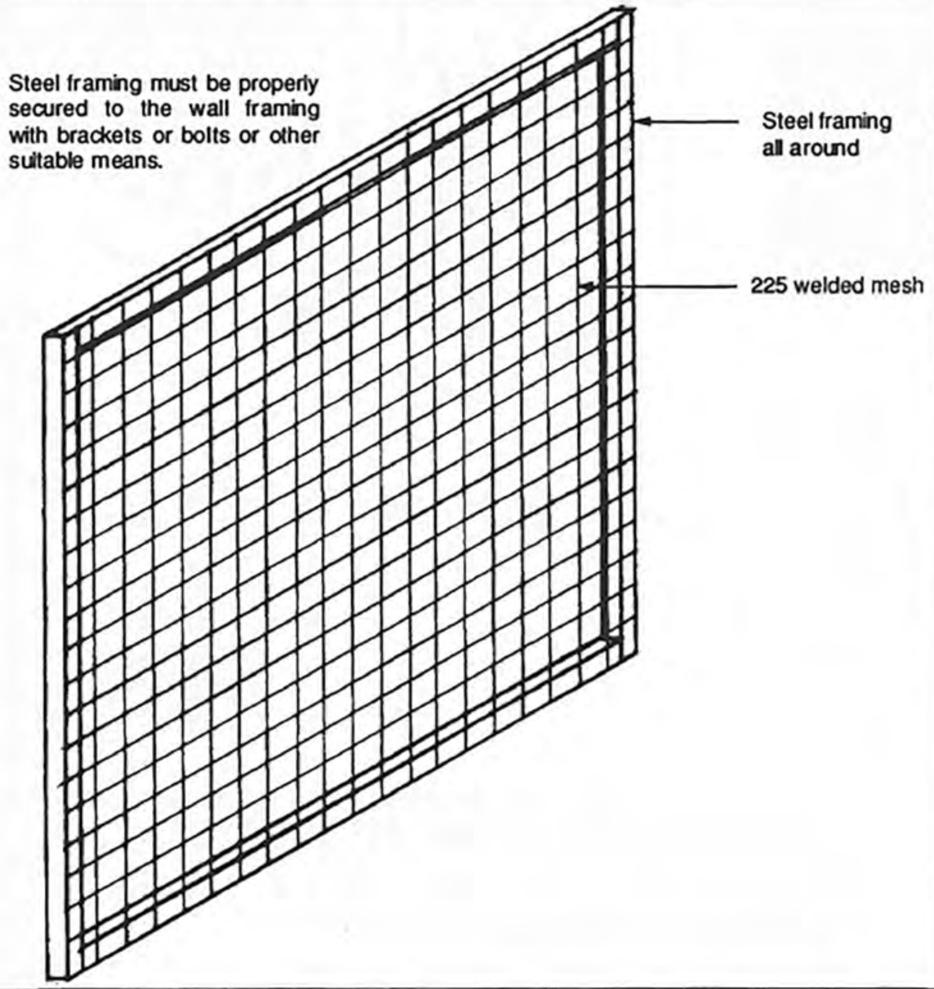
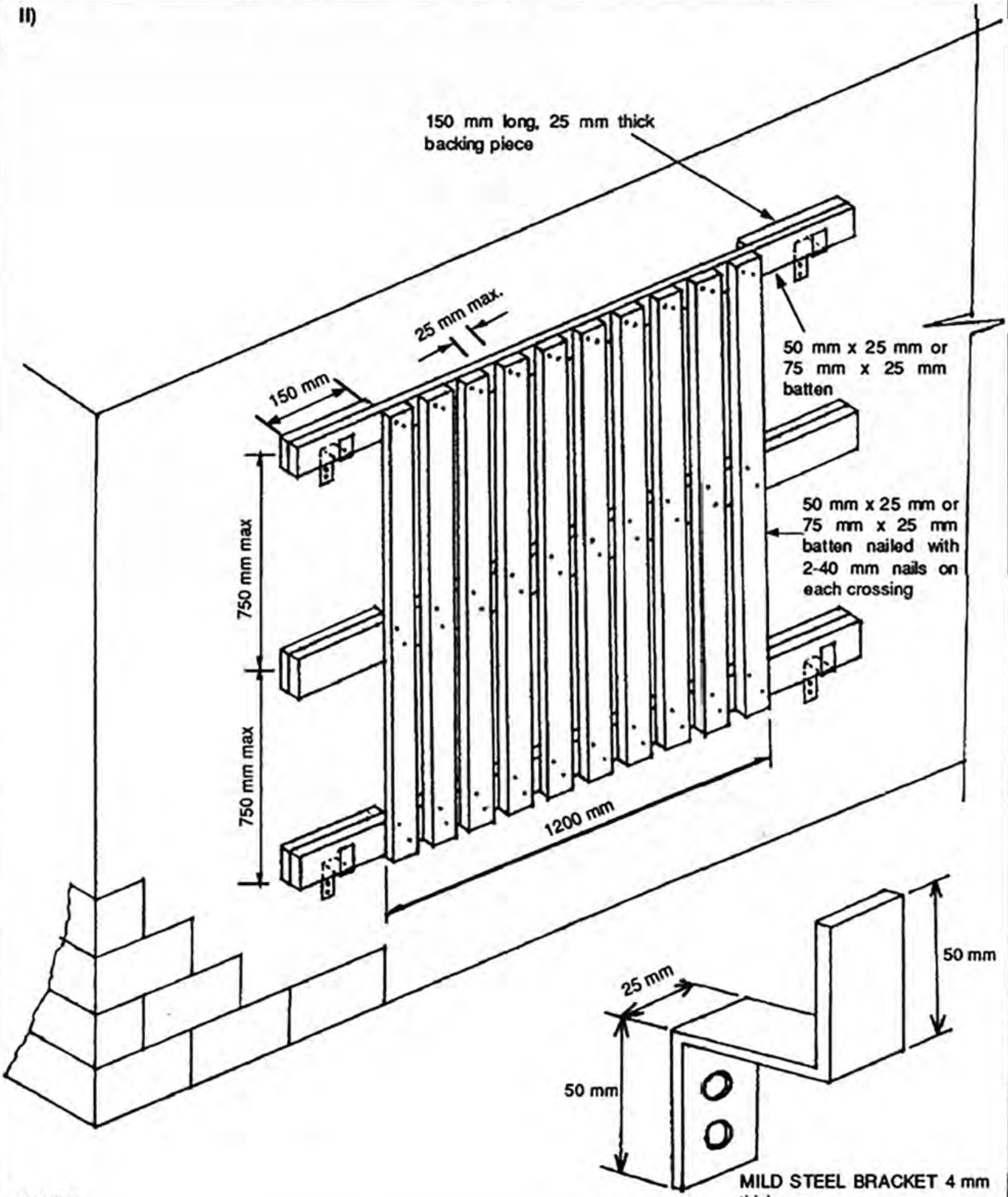


FIGURE G1.1 continued **SHUTTER AND BRACKET DETAIL**

II)

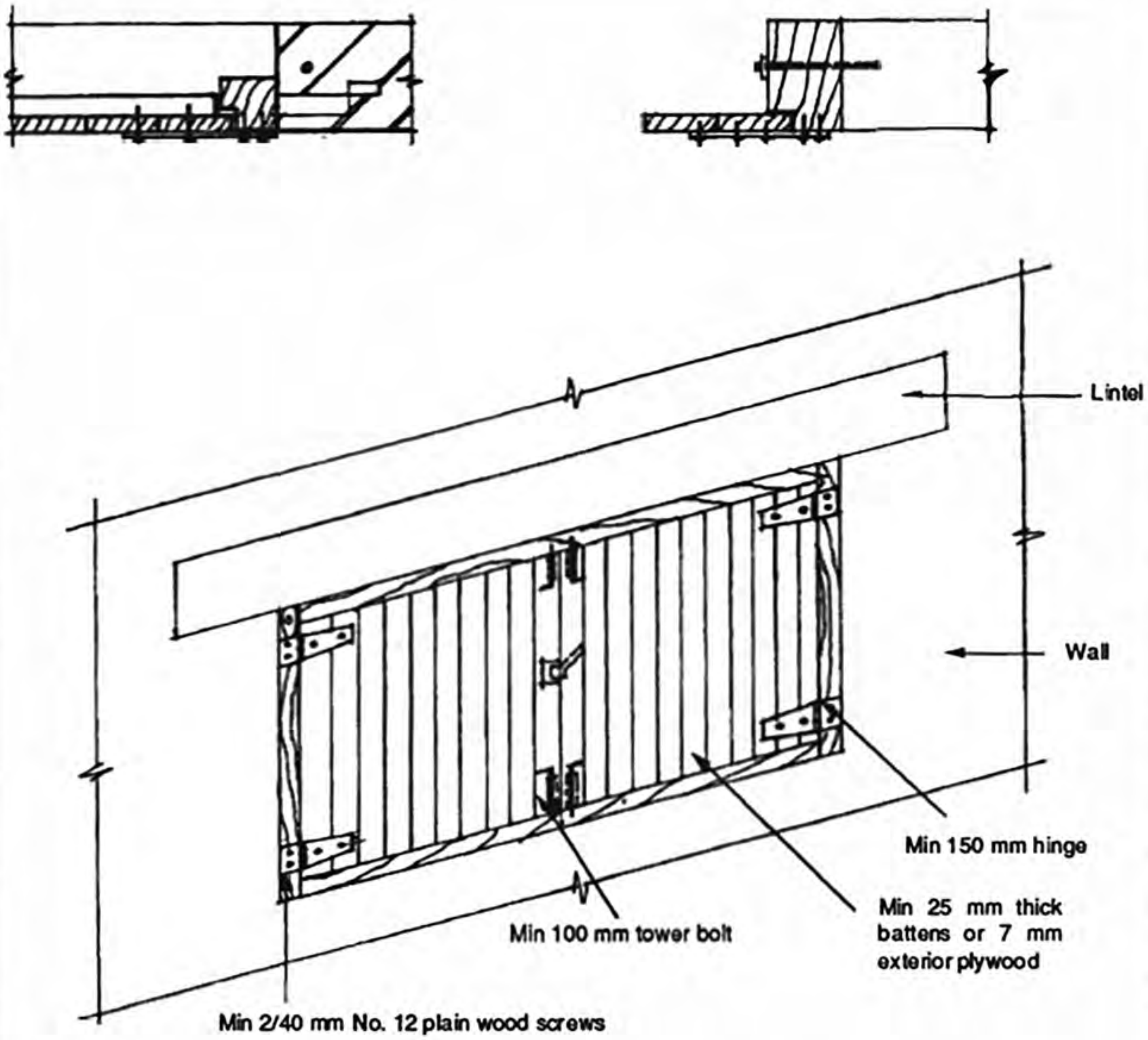


NOTES:

1. Cross bracing is required when the vertical and horizontal dimensions exceed those given above.
2. 100 mm tower bolts may be used where brackets cannot be fixed to the wall
3. Mild steel brackets must be fixed to the concrete wall using 2-8 mm dyna bolts or equal.
4. A minimum of 4 brackets must be used with every shutter.
5. Shutter bracket MUST be of 4 mm thick mild steel and MUST be a minimum width of 25 mm.
6. For shutters of ≥ 1500 mm height, additional brackets MUST be used.
7. Battens MUST be spaced no more than 25 mm apart.

FIGURE G1.1 Continued **HINGED SHUTTER DETAIL**

III)



Notes:

1. Holes for tower bolts to be 1-2 mm greater than the bolt diameter.
2. Hole for tower bolt must be deep enough to accommodate the tower bolt fully.
3. Tower bolts on the upper edge of the window must be locked in place to ensure that they do not fall open under repeated wind loading conditions.
4. For windows which hinge open vertically, 2 tower bolts must be used on the bottom of the window to secure it in place.
5. Butt hinges may also be used.

G1.3 Timber framed doors

In cyclonic areas, all glazed doors must be protected by means of shutters that pass the test given in Clause G1.2. A better and more-simpler way is to have timber-framed doors which do not have any glass area. Figure G1.3 shows typical details of timber-framed doors and various types of hinges.

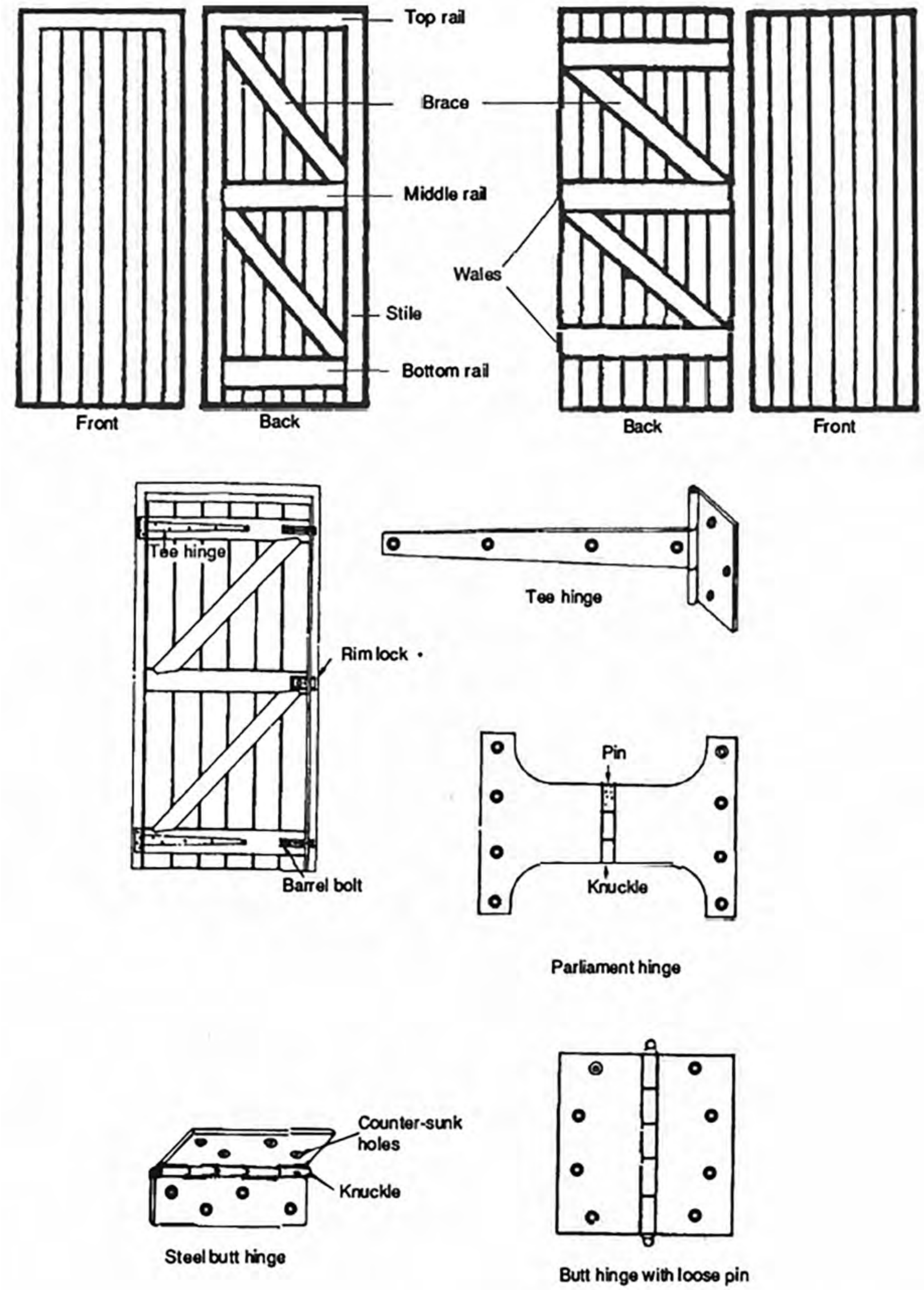


FIGURE G1.3: TYPICAL EXTERNAL DOORS AND HINGES

G2 LEAN-TO HOUSES

G2.1 General

Lean-to houses are fully-enclosed houses with monoslope (single-slope) roofs.

G2.2 Design

The design of lean-to houses is the same as the design of gable-ended roof houses.

G2.3 Application

1. Select the table that corresponds to the member under consideration.
2. From the options available, select the correct sizes of members.

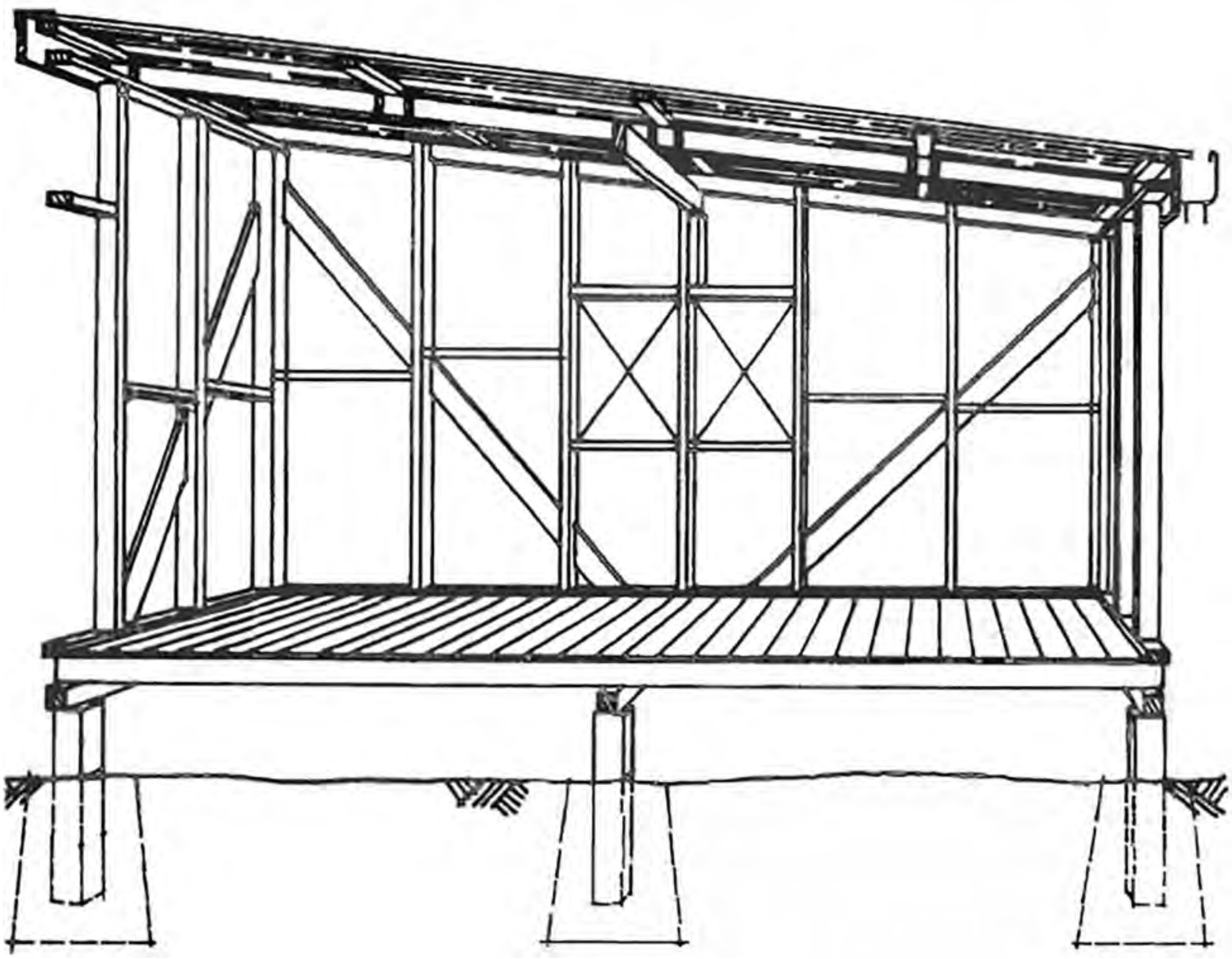


FIGURE G2.1: LEAN-TO BUILDING

G3 LEAN-TO GARAGE DETAILS

G3.1 Member sizes for garages

1	Purlins:	@ 1200 mm maximum centres	
	F4	75 x 50	
2	Rafters:	@ 1200 mm maximum centres	
	F4	150 X 50	
	F5-F8	125 X 50	
3	Beams: F4-F8		125 X 75
4	Posts	100 X 100	

G3.2 Tie-down details

1 Cladding/Purlins:

Nail on every crest

2 Purlin/Rafter

Strap with 3/3.15f nails per leg

3 Rafter/Beams

Strap rafter to beam with 30 x 0.8 G.I. strap with 3/3.15 f, nails per leg.

4 Beam/Post

Tie-down beam to post with 2/M12 bolt and 50 x 6 mm M.S. plate on both sides.

5 Post/Footing

Tie post to footing with 2/M12 bolts with 50 x 8 mm M.S. stirrups - refer to Figure

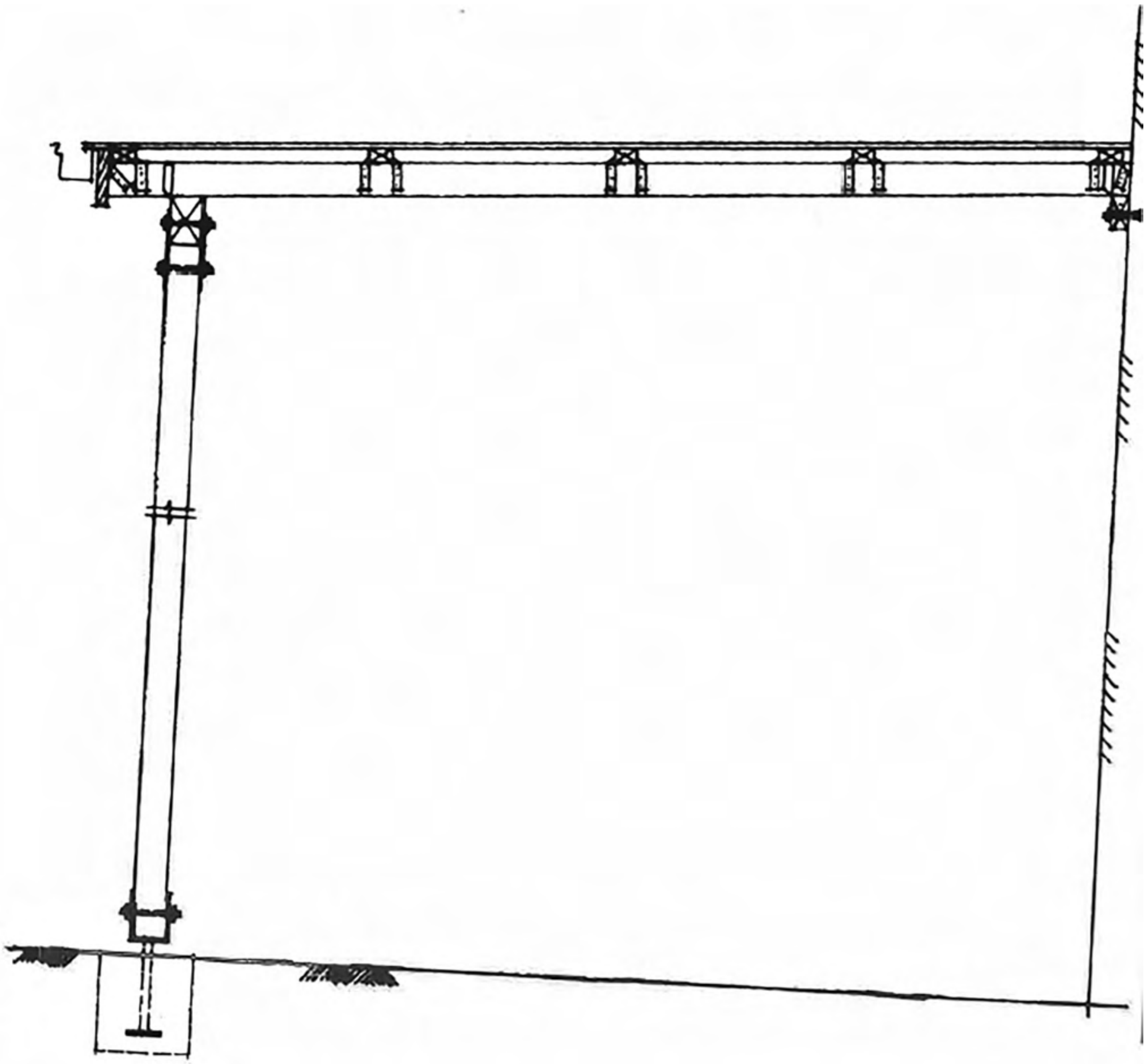


FIGURE G3.1: LEAN-TO GARAGE CROSS-SECTION

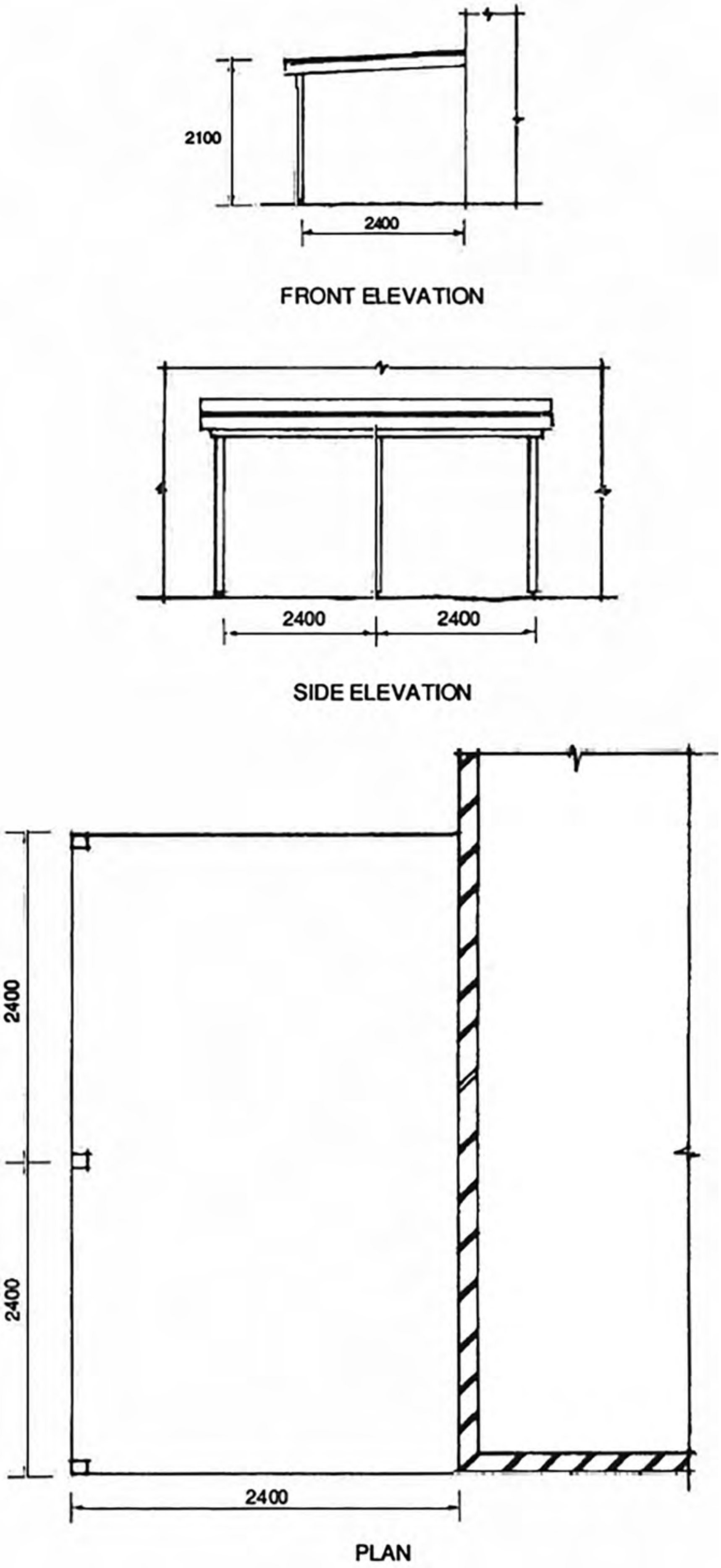


FIGURE G3.2: LEAN-TO GARAGE PLAN AND ELEVATIONS

G4 DETAIL OF STEPS

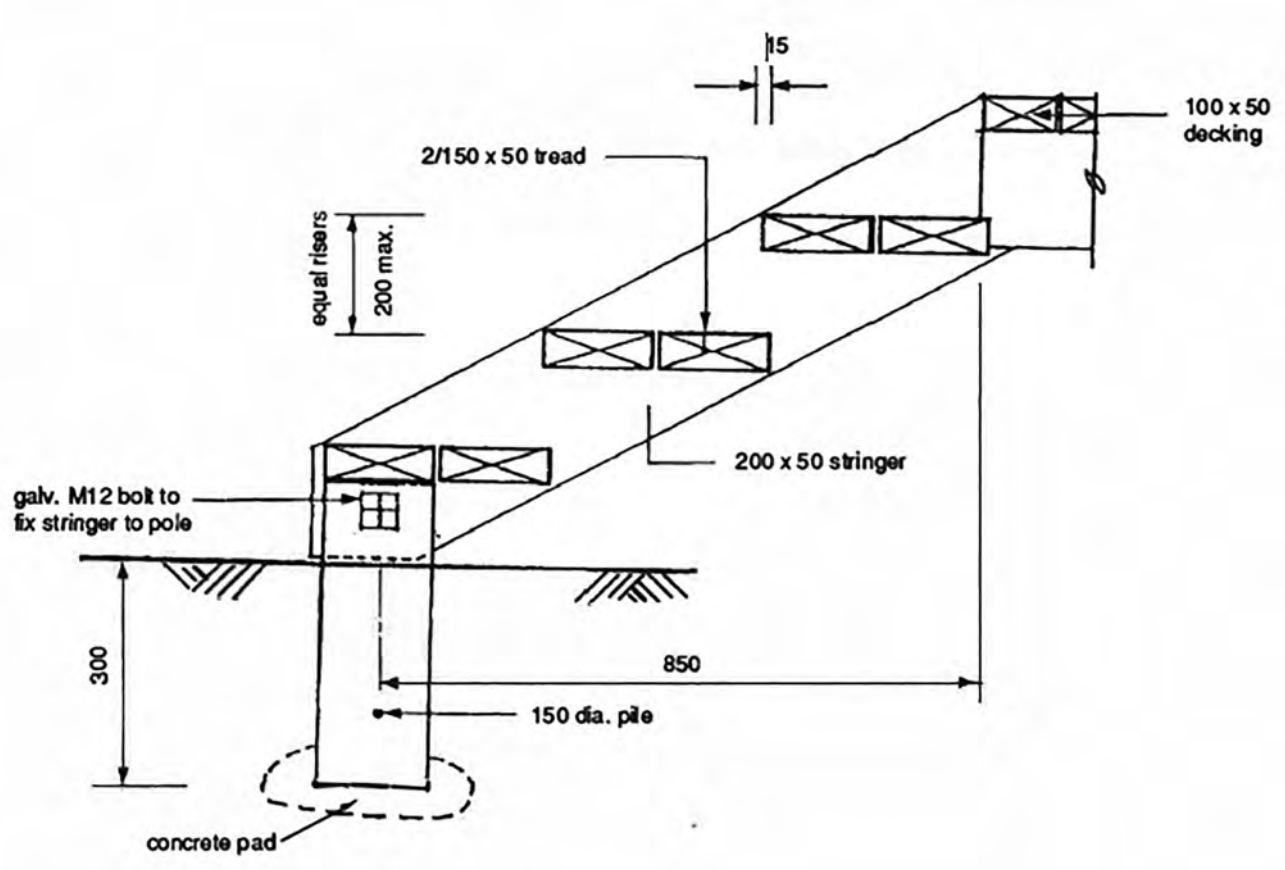


FIGURE G4.1: DETAIL OF TIMBER STEPS

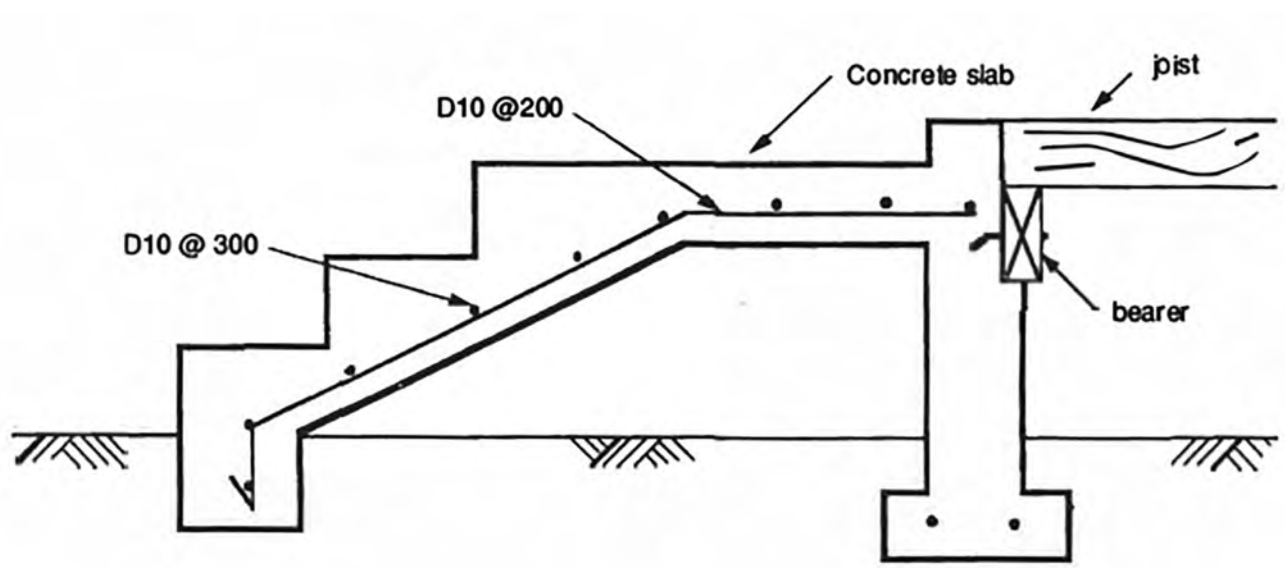


FIGURE G4.2: DETAIL OF CONCRETE STEPS

G5 WINDOW GLASS THICKNESS FOR HOUSES

G5.1 Scope

The minimum required thickness and maximum allowable areas for window glass for use in houses are given.

The details do not provide for safety against human impact. The glass considered is ordinary window glass.

G5.2 Determination of area of glass

TABLE G5.1

ALLOWABLE AREA OF GLASS SUPPORTED ON ALL FOUR EDGES					
Glass Thickness (mm)	3	4	5	5.5	6
Allowable area (mm²)	0.60	1.05	1.60	1.85	2.25

G5.3 Determination of length of glass

TABLE G5.2

ALLOWABLE SPANS OF GLASS SUPPORTED ON TWO OPPOSITE EDGES					
Glass Thickness (mm)	3	4	5	5.5	6
Allowable span (mm)	0.29	0.39	0.50	0.54	0.60

G5.4 Maximum lengths for louvre blades of clear and patterned glass

TABLE G5.3

Nominal thickness of glass (mm)	Maximum blade length (mm)		
	Less than 100 wide	100 to 155 wide	155 to 225 wide
3	400	500	*
4	500	600	*
5	600	750	750
5.5	650	900	900
6	750	900	900

* Not to be used in this thickness

G6 RETAINING WALLS

G6.1 Scope

Some standard design details for reinforced concrete masonry retaining walls are given. Professional engineering advice must be sought where loading conditions or soil types are likely to be outside the limits shown.

G6.2 Retaining wall types

TYPE 1: Is used when the allotment is below the level of a neighbouring property and is to be built as close as possible to the boundary.

TYPE 2: Is used when filling against a neighbouring boundary.

G6.3 Construction methods

Construction without supervision.

The work is carried out by competent tradesmen and is self-supervised.

G6.4 Material specifications

Concrete for footings Concrete must be to grade 17.5 MPa.

Grout Concrete for grout must have a minimum compressive strength of 17.5 MPa.

Mortar for laying blocks Mortar for laying blocks must have a minimum compressive strength of 12.5 MPa.

Reinforcing steel Reinforcing steel must be deformed mild steel bars of 275 MPa grade.

G6.5 Limitations

1 The walls are not designed against forces from heavy equipment or large vehicles on the retained soil but allows for light traffic such as passenger cars.

2 A drainage layer of suitable granular material must be provided at the back of the wall with a perforated pipe at the base discharging to the open.

3 Surface water must be prevented from accumulating at the wall and overloading the drainage system.

4 Soil behind retaining wall has been assumed to be firm clay.

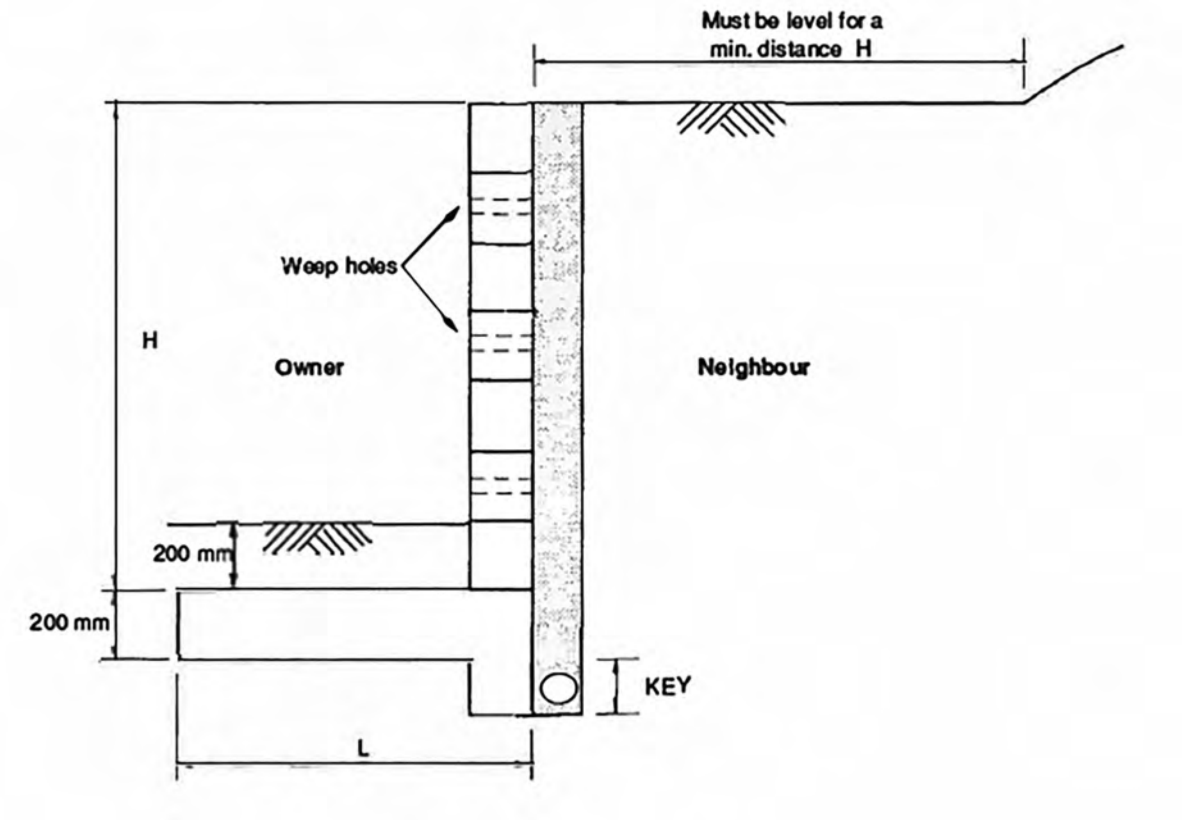


FIGURE G6.1: TYPE 1 RETAINING WALL

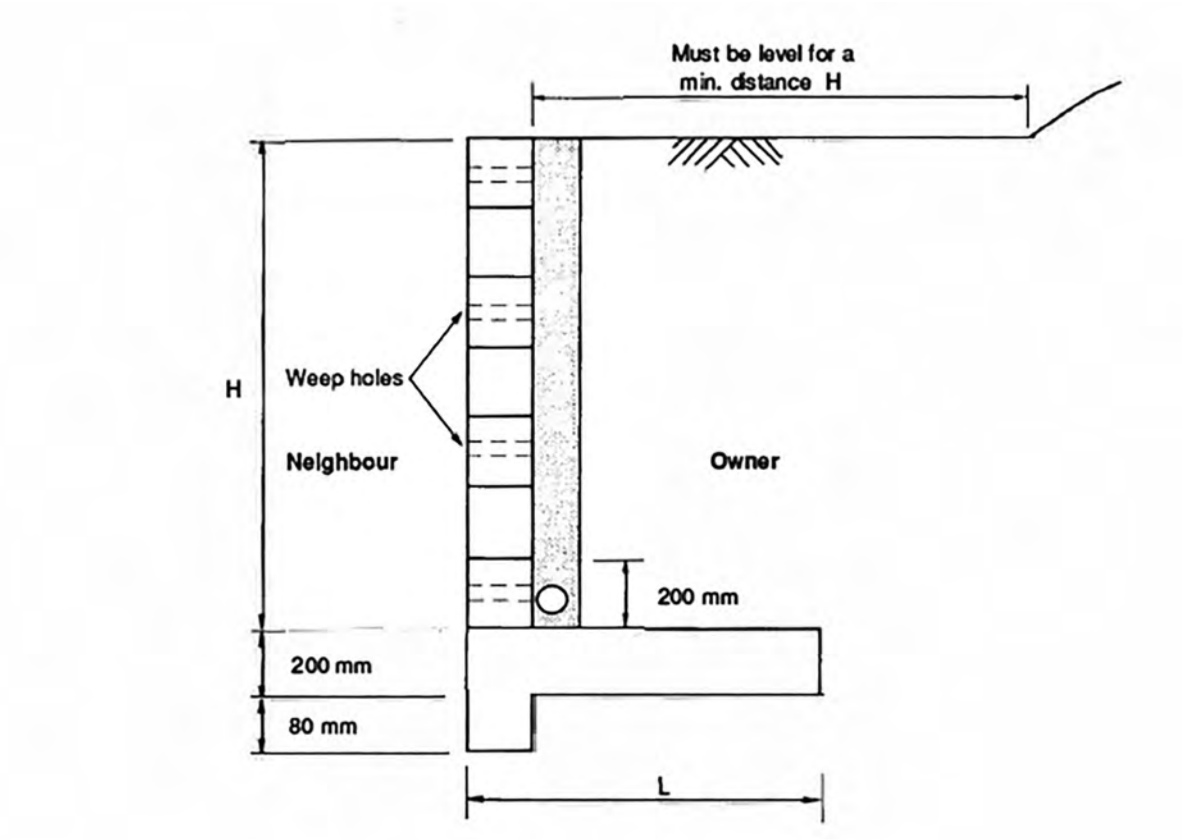


FIGURE G6.2: TYPE 2 RETAINING WALL

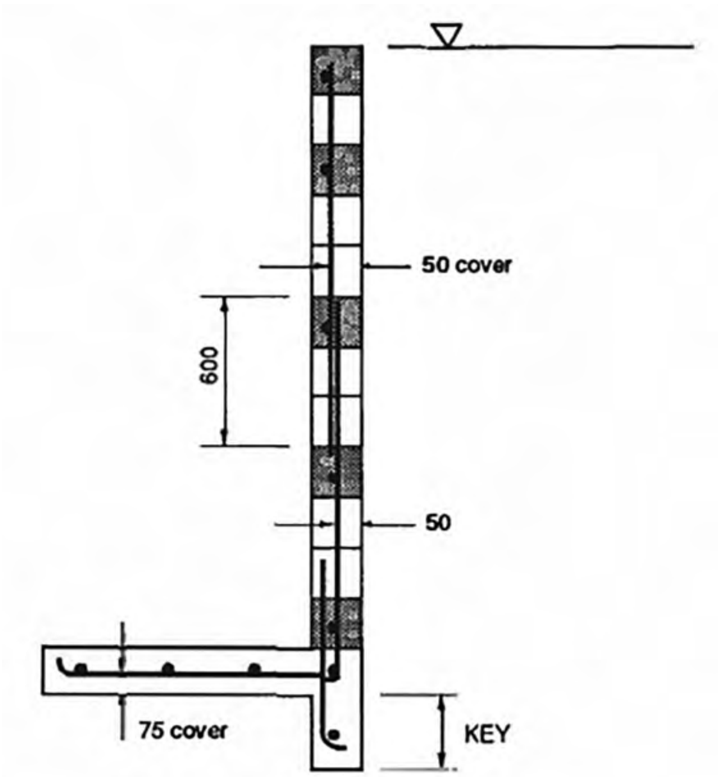


FIGURE G6.3: REINFORCEMENT DETAILS FOR TYPE 1 RETAINING WALLS

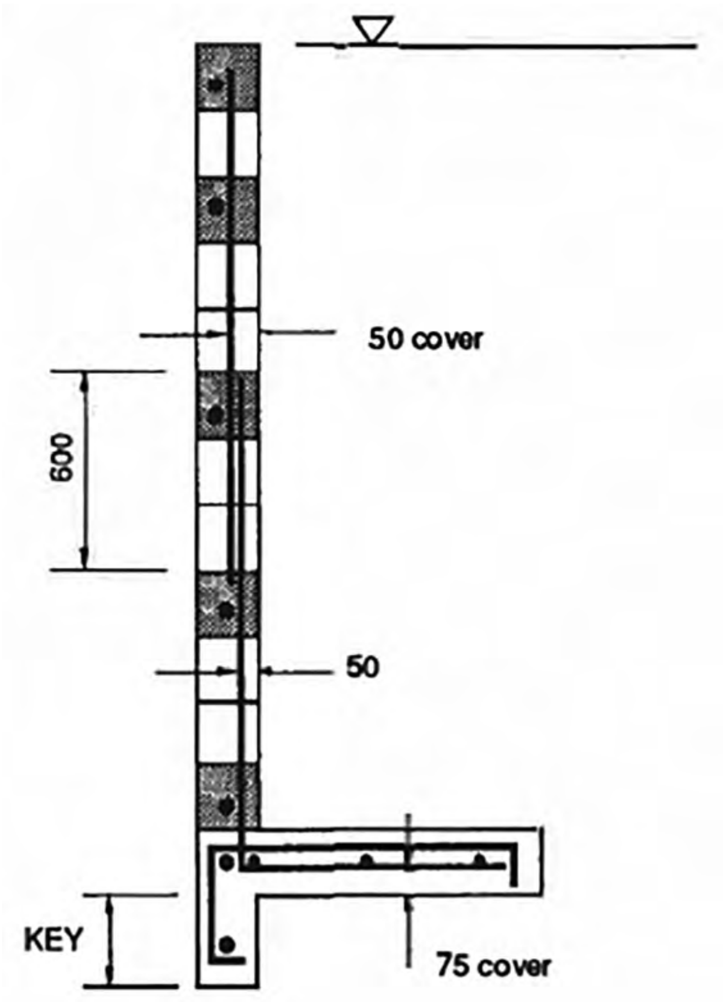


FIGURE G6.4: REINFORCEMENT DETAILS FOR TYPE 2 RETAINING WALLS

TABLE G6.1 TYPE 1 RETAINING WALL - WITH ALLOWANCE FOR LIGHT TRAFFIC

WALL THICKNESS	HEIGHT (mm)	VERTICAL REINFORCEMENT	HORIZONTAL REINFORCEMENT	WIDTH OF FOOTING (L) (mm)	DEPTH OF KEY (K) (mm)	TRANSVERSE FOOTING REINFORCEMENT	LONGITUDINAL FOOTING REINFORCEMENT	KEY REINFORCEMENT
150	1200	D16 - 600 #	D12 - 600	1200	80	**	D12 - 300	D12 - 400
200	1200	D12 - 600	D12 - 600	1100	80	**	D16 - 300	D12 - 400
	1500	D16 - 600	D12 - 600	1450	175	**	D16 - 300	D12 - 400

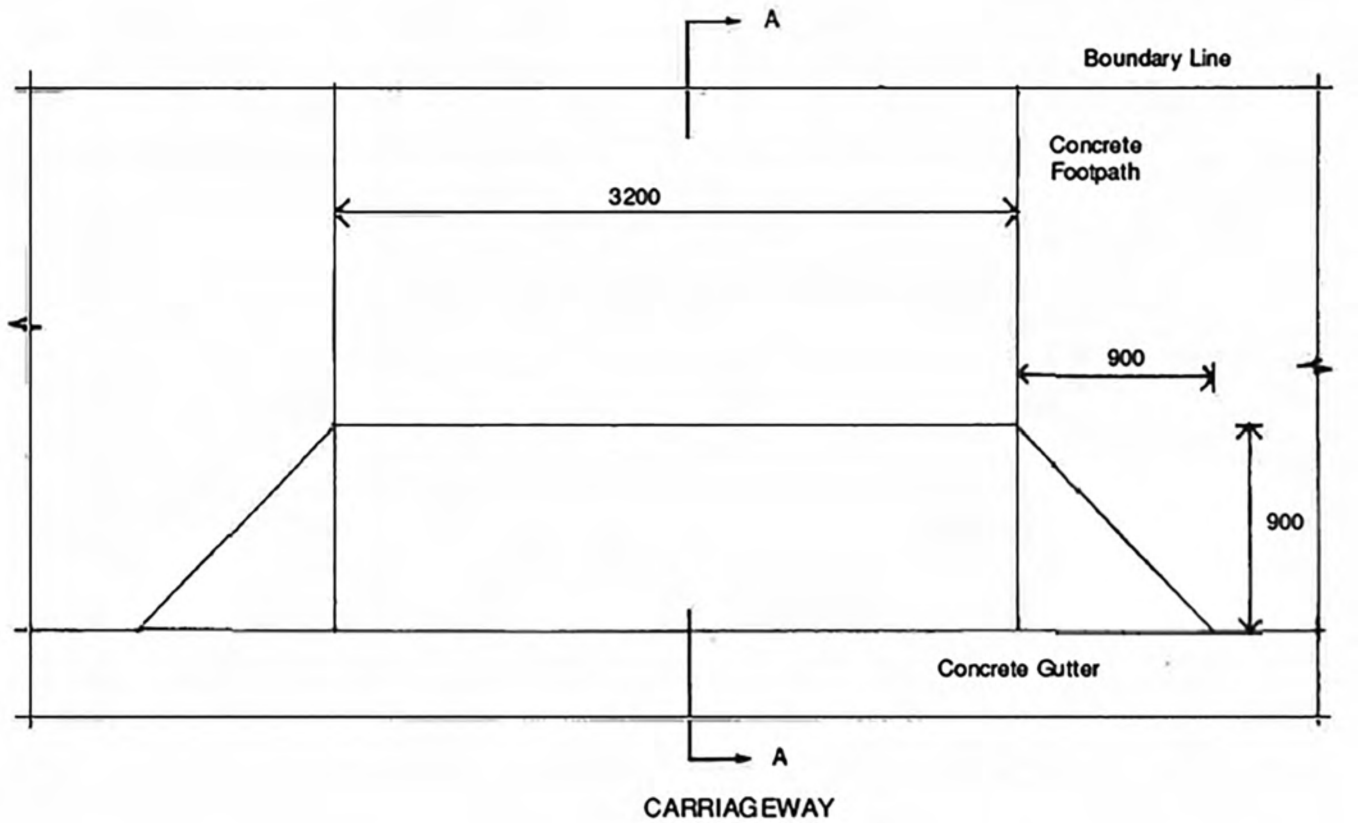
TABLE G6.2 TYPE 2 RETAINING WALL - WITH ALLOWANCE FOR LIGHT TRAFFIC

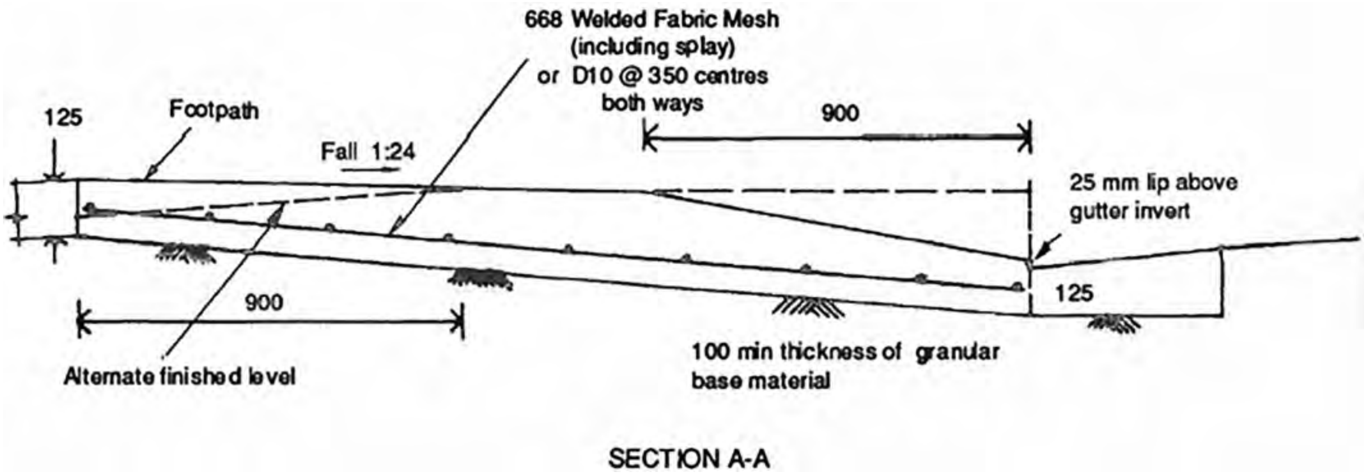
WALL THICKNESS	HEIGHT (mm)	VERTICAL REINFORCEMENT	HORIZONTAL REINFORCEMENT	WIDTH OF FOOTING (L) (mm)	DEPTH OF KEY (K) (mm)	TRANSVERSE FOOTING REINFORCEMENT	LONGITUDINAL FOOTING REINFORCEMENT	KEY REINFORCEMENT
150	1200	D16 - 600 #	D12 - 600	700	80	**	D12 - 300	D12 - 300
200	1200	D12 - 600	D12 - 600	700	80	**	D16 - 300	D12 - 300
	1500	D16 - 600	D12 - 600	875	80	**	D16 - 300	D12 - 300

\# fill all cells

** as for vertical reinforcement

G7 DRIVEWAY CONSTRUCTION DETAILS



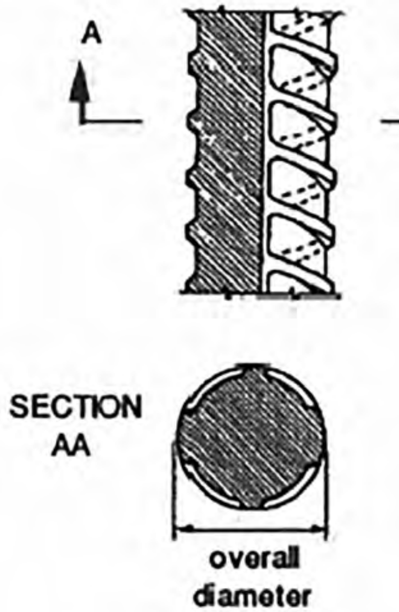


NOTES:

- **i.** S play to be 1500 x 1500 for kerb height greater than 200 mm.
- **ii.** Concrete to be to grade 25 MPa.
- **iii.** All dimensions in millimetres.

G8 REINFORCEMENT BAR DETAIL

TABLE G8.1:
EQUIVALENT BAR DIAMETERS METRIC/IMPERIAL



Imperial	Metric
1/4"	D6
3/8"	D10
#4	D12
#5	D16
#6	D20

TABLE C8.2:
HOOK AND COG ALLOWANCES FOR BENT BARS AND FITMENTS

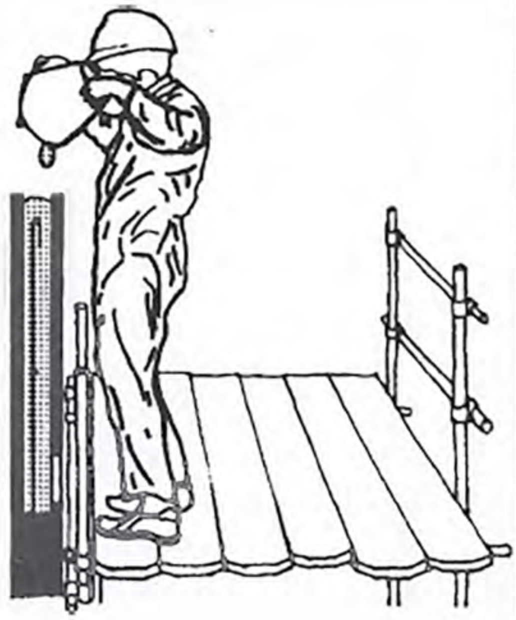
BAR SIZE (mm)	DIMENSIONS (mm)		
	r	a	b
12	30	70	180
16	40	70	300
20	50	80	400
24	60	100	580

TABLE G8.3:
MINIMUM LAP LENGTH (MM) FOR DEFORMED BARS IN COMPRESSION

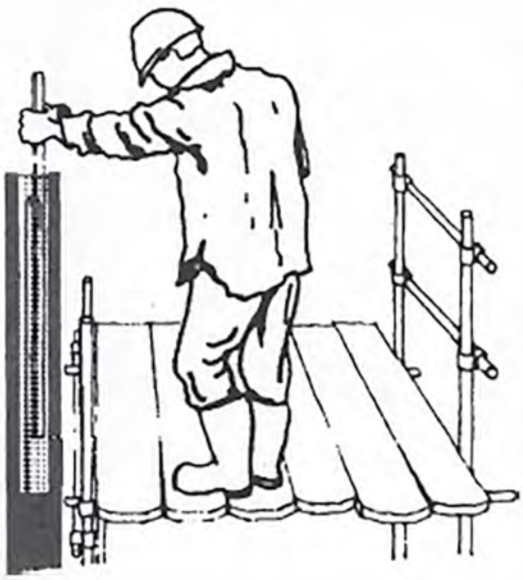
BARSIZE (mm)	LAP LENGTH (mm)
12	400
16	400
20	450
24	550
28	650
32	725

G9 LOW – LIFT METHOD OF GROUTING

Step 1. Clean out grout space and remove debris. 1200 mm maximum lift when grout space is 50 mm or more. 400 mm maximum lift when grout space is less than 50 mm.



Step 2. Block cleanout pockets and pour in grout.



Step 3. Consolidate the grout. Rodding is allowed for low-lifting. A broom handle is satisfactory for this function

Step 4. Prepare construction joint by washing off loose concrete and dust soon after grout has set.

Section H
LOW-COST HOUSES

Section H
LOW-COST HOUSES

H1 LIMITATIONS

MAXIMUM BUILDING HEIGHT 2700

MINIMUM BUILDING HEIGHT 2400

BUILDING WIDTH 5100

BUILDING LENGTH 4800

External and internal walls may be of either timber or masonry construction; however, all walls in a house to this design must wholly be of either and not a combination of the two.

H2 PLAN

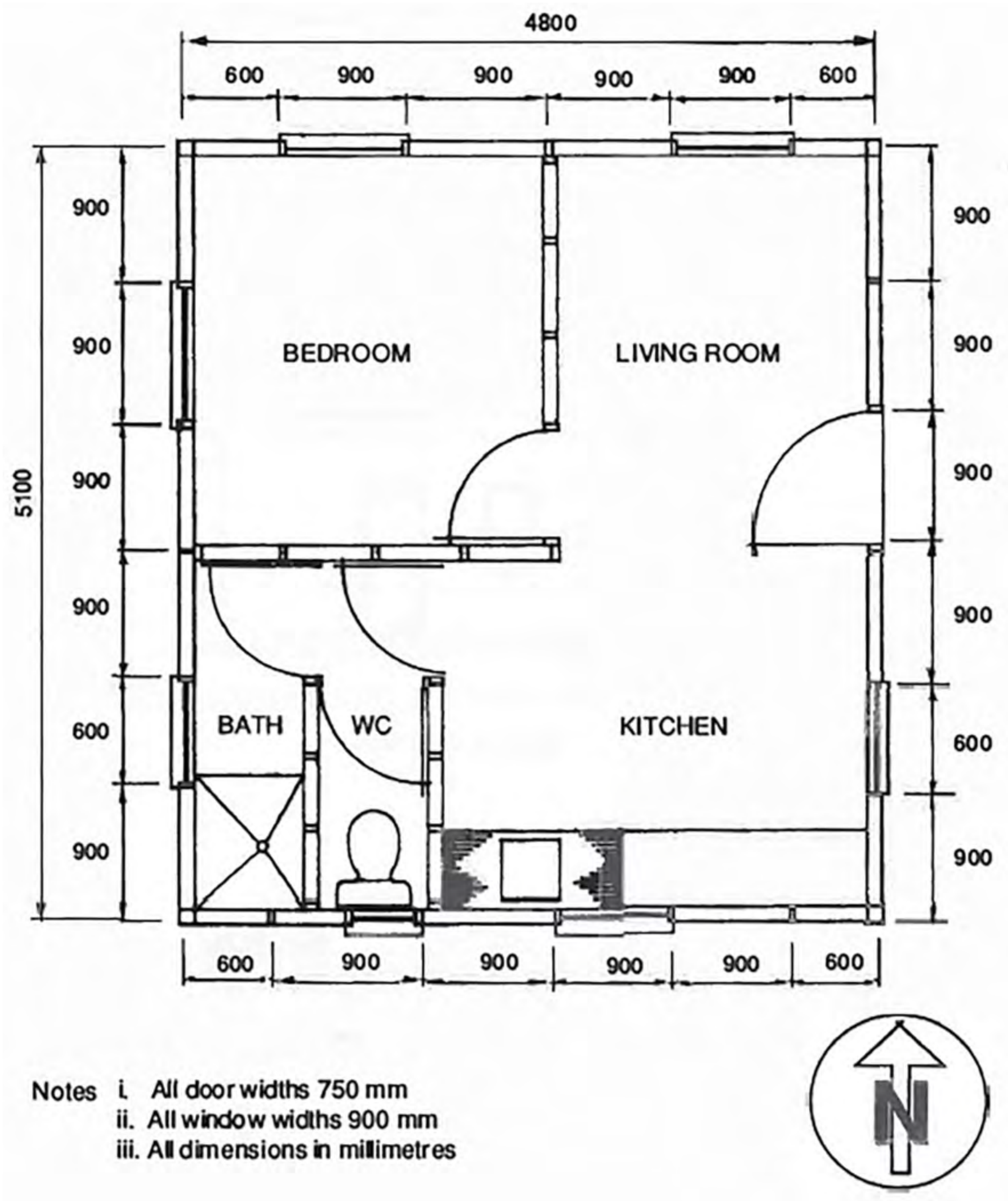
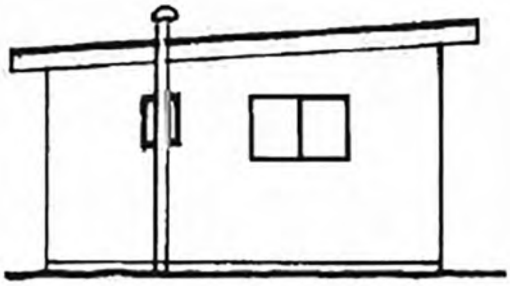
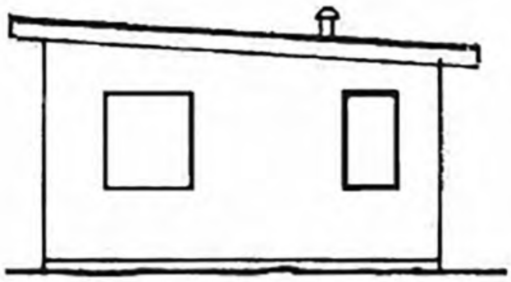


FIGURE H2: PLAN AND DIMENSIONS OF HOUSE

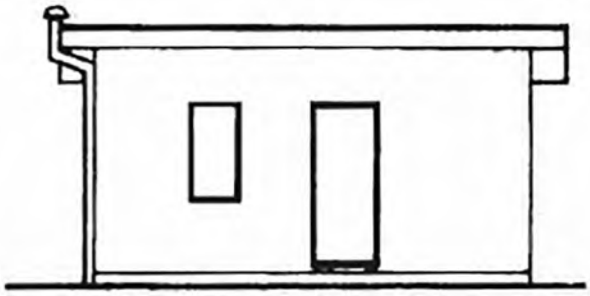
H3 ELEVATIONS



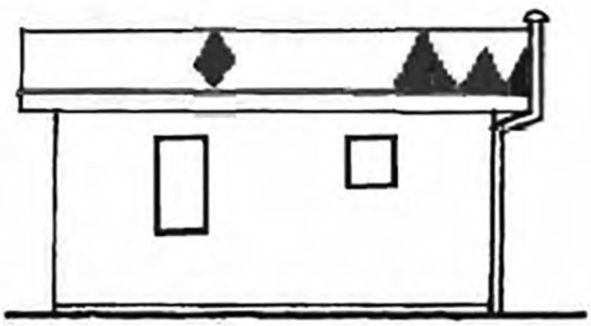
SOUTH ELEVATION



NORTH ELEVATION



EAST ELEVATION



WEST ELEVATION

FIGURE H3: ELEVATIONS

H4 FOUNDATION DETAILS

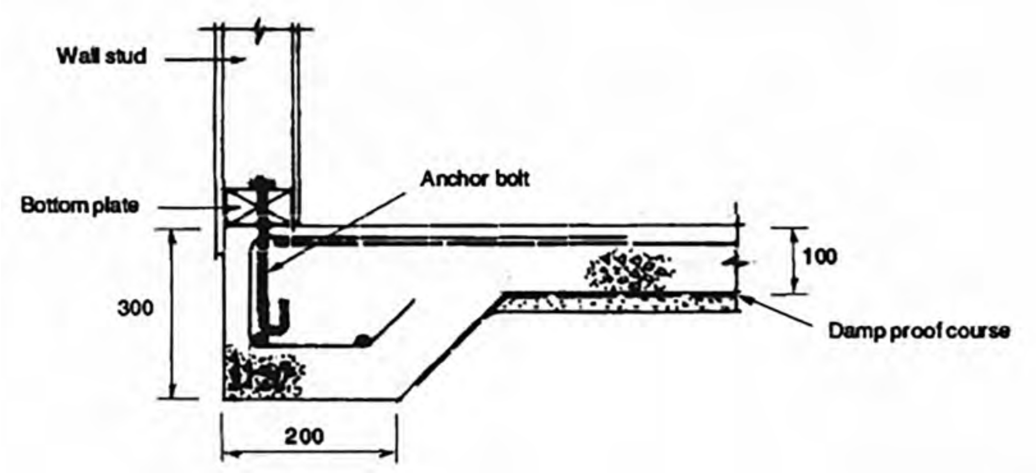


FIGURE H4.1: EXTERNAL WALL FOOTING

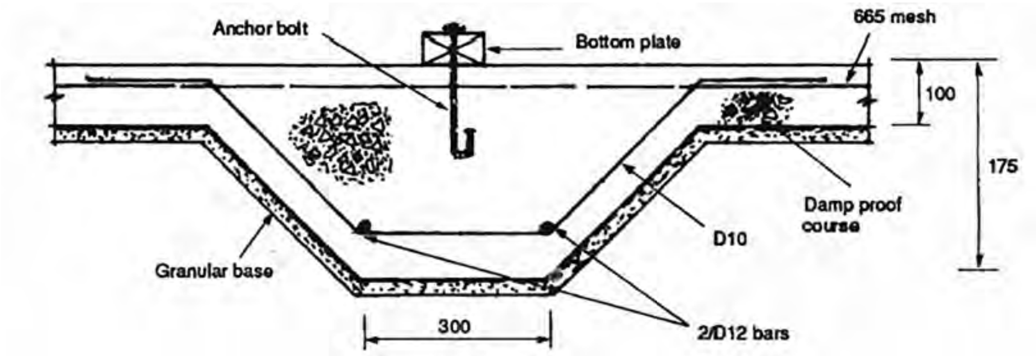


FIGURE H4.2: INTERNAL WALL FOOTING

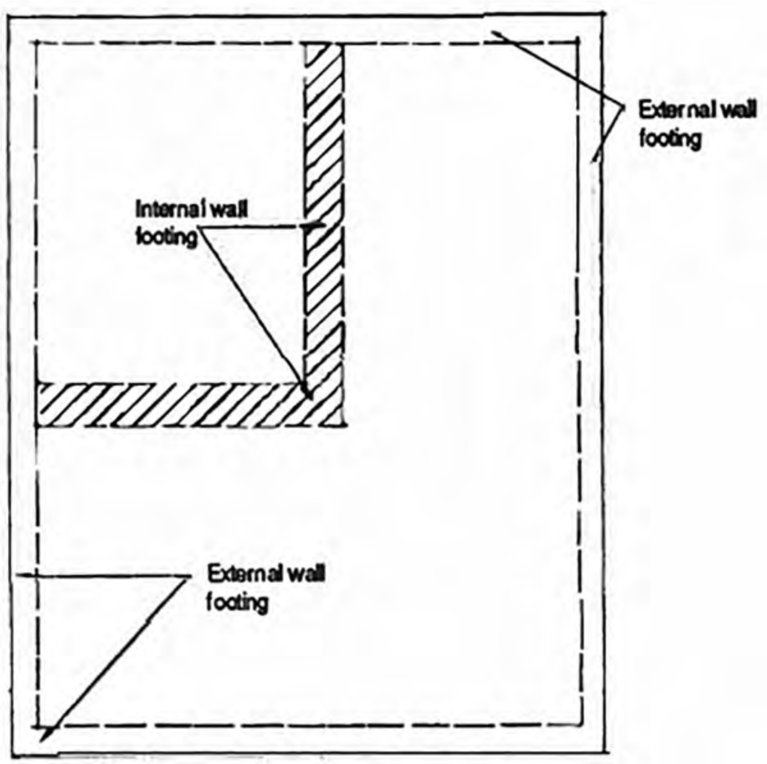


FIGURE H4.3: FOOTING PLAN

H5 BRACING

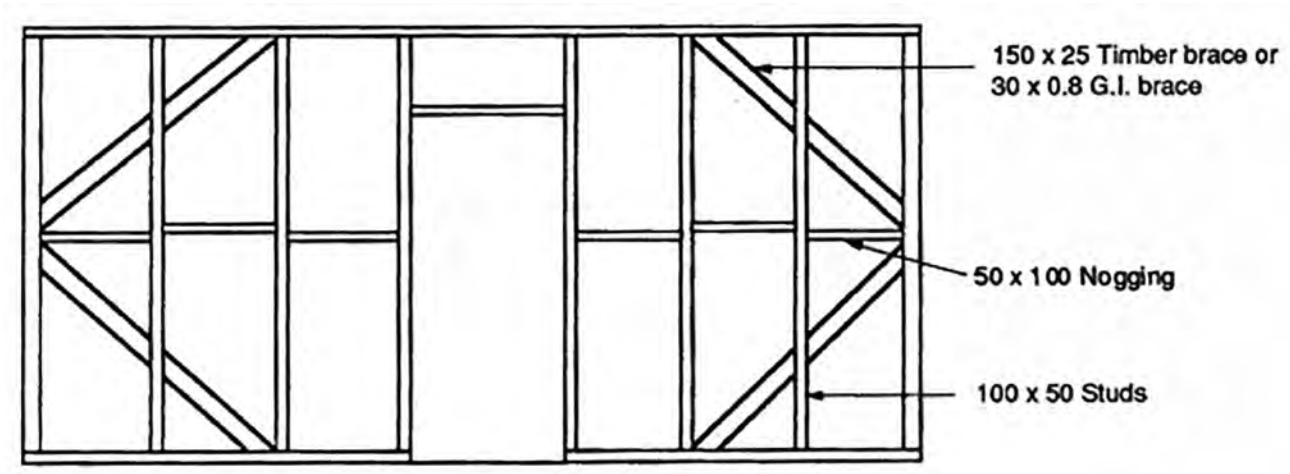


FIGURE H5.1: TYPICAL KNEE BRACING DETAIL FOR ALL CORNERS OF WALL – ELEVATION

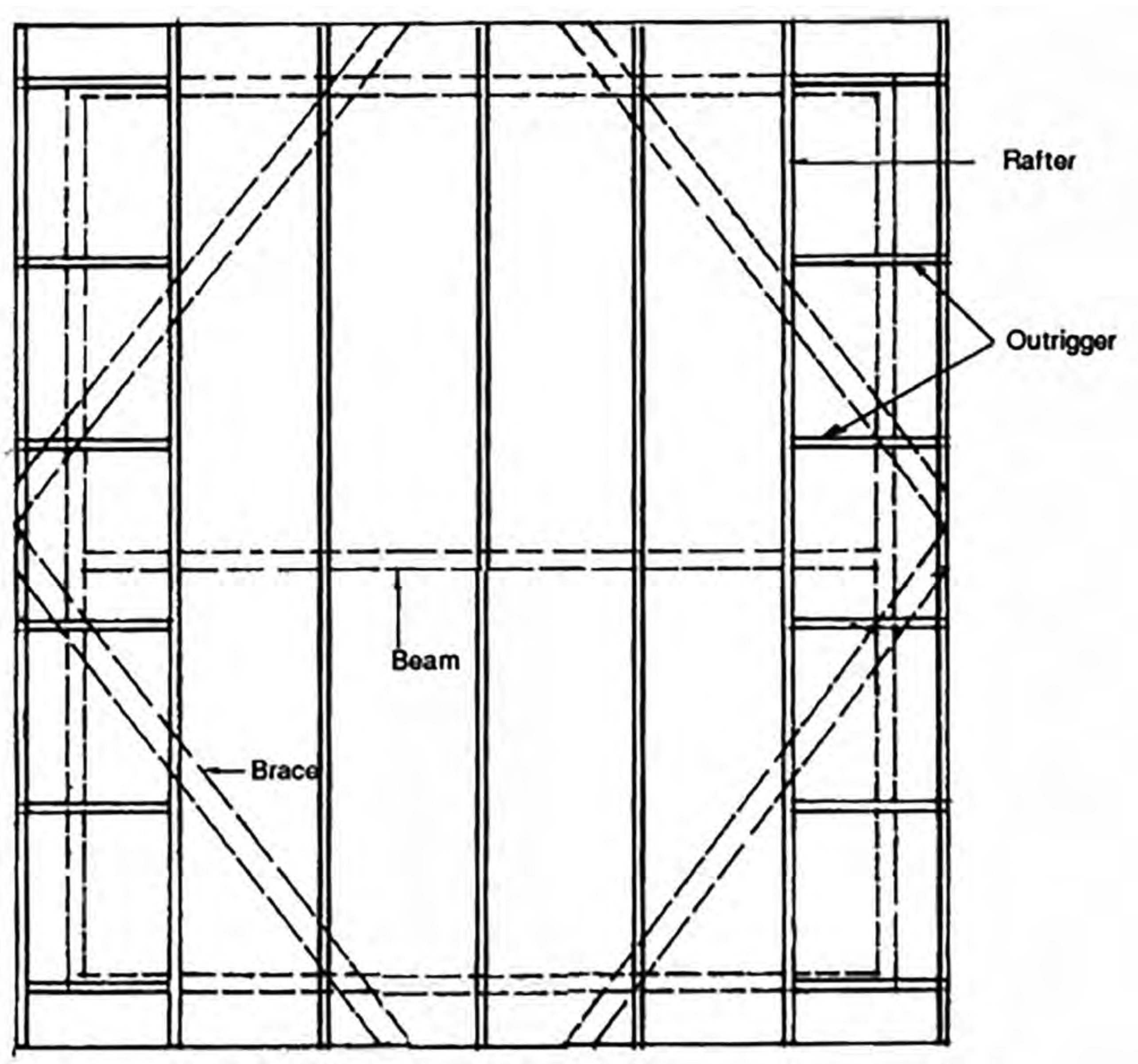


FIGURE H5.2: ROOF BRACING – PLAN

H6 MISCELLANEOUS

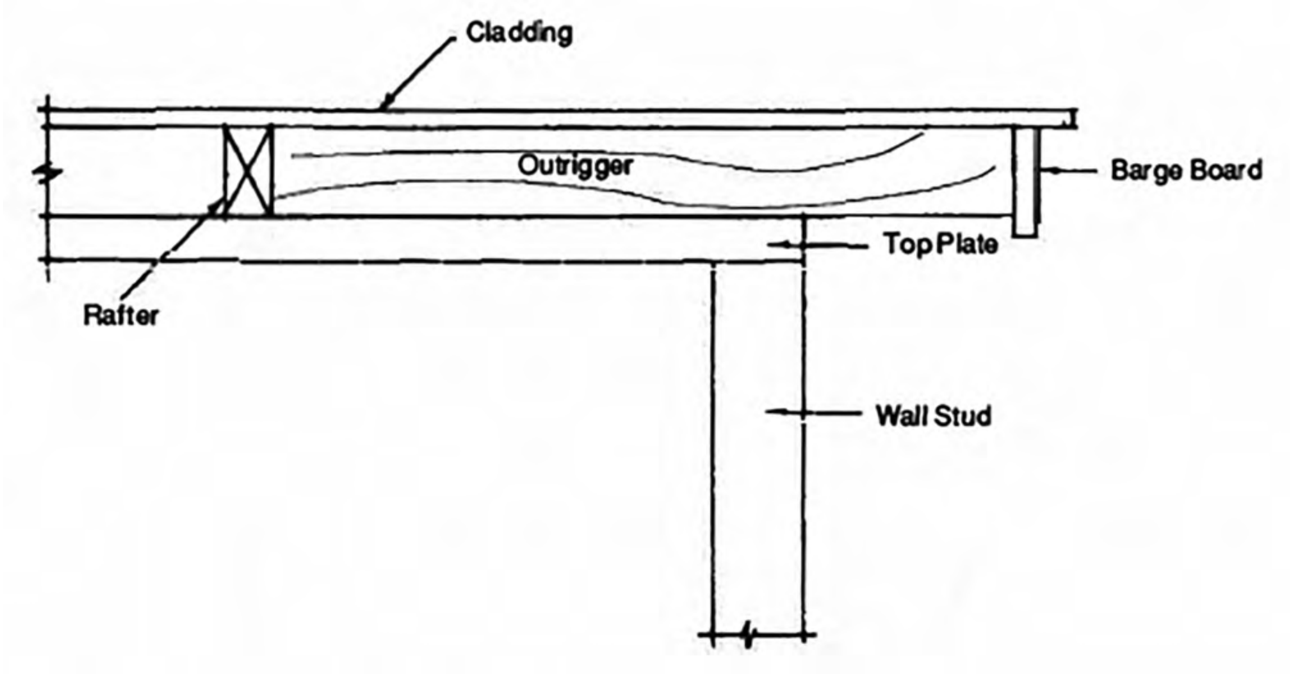


FIGURE H6.1: OUTRIGGER DETAIL

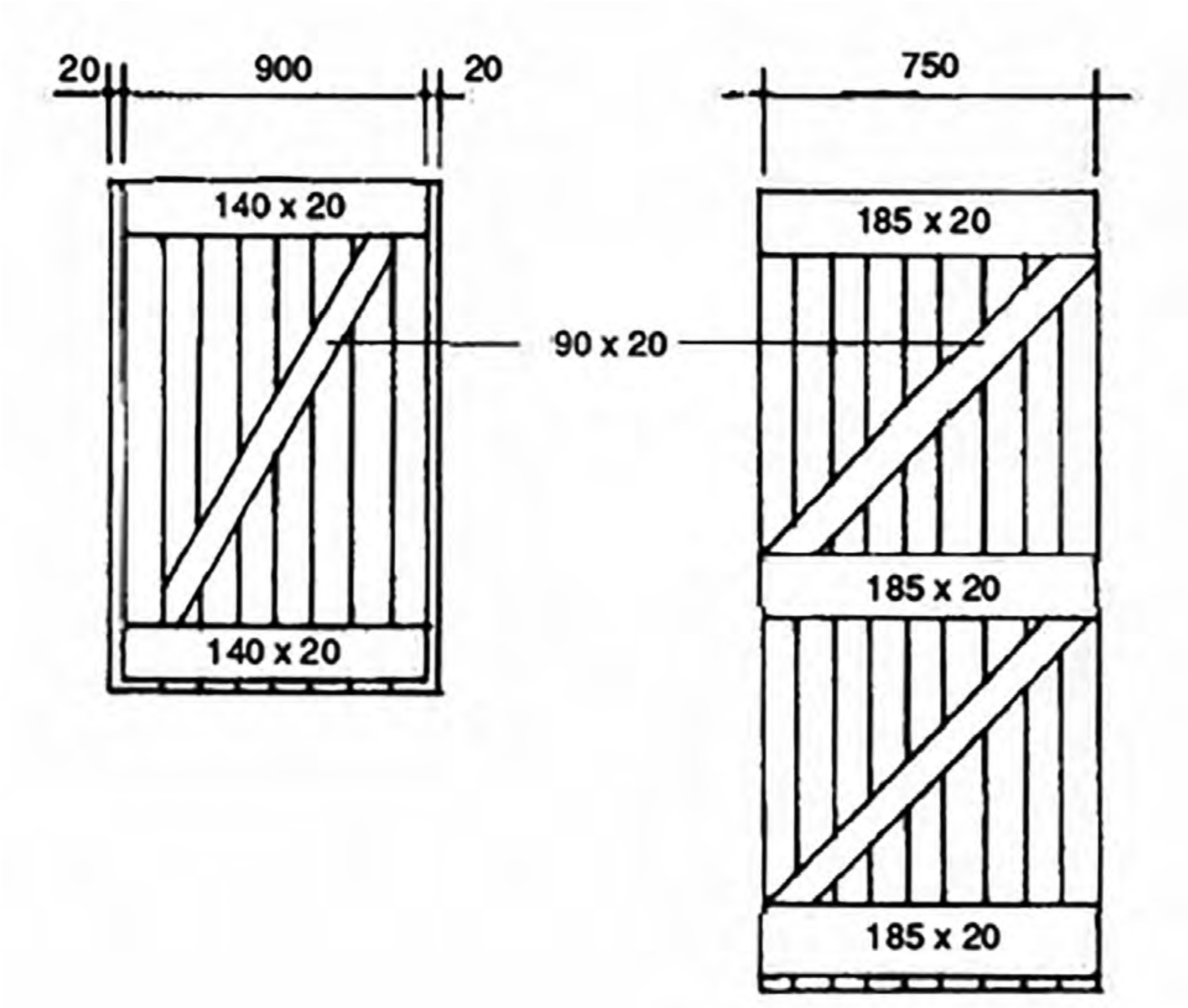


FIGURE H6.2: DOOR AND WINDOW DETAIL

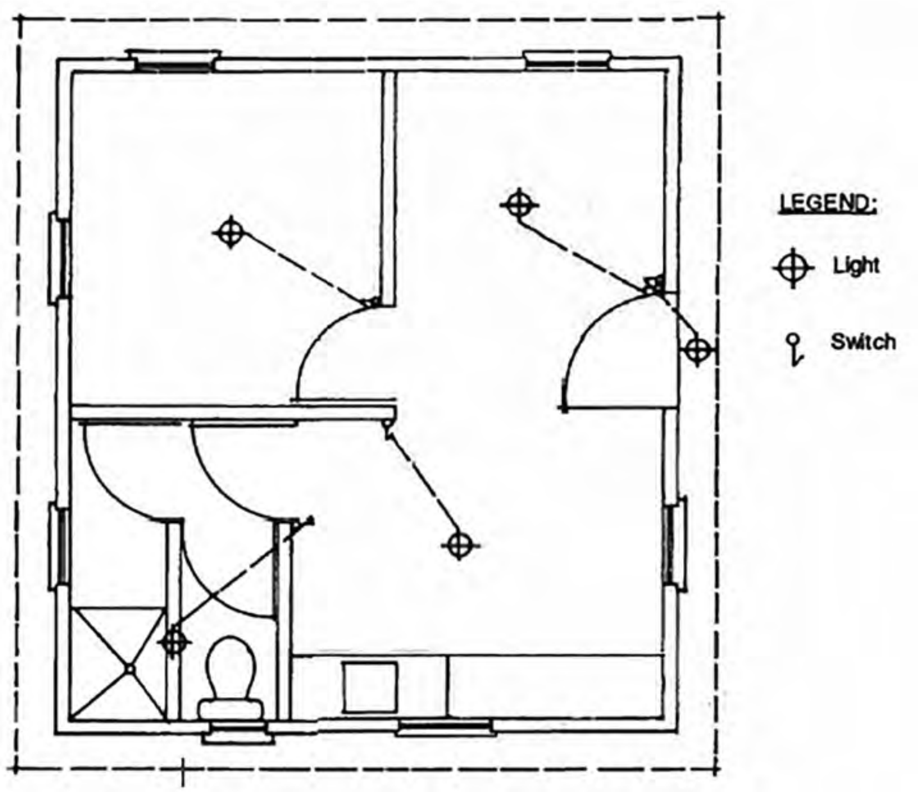


FIGURE H6.3: ELECTRICAL WIRING LAYOUT

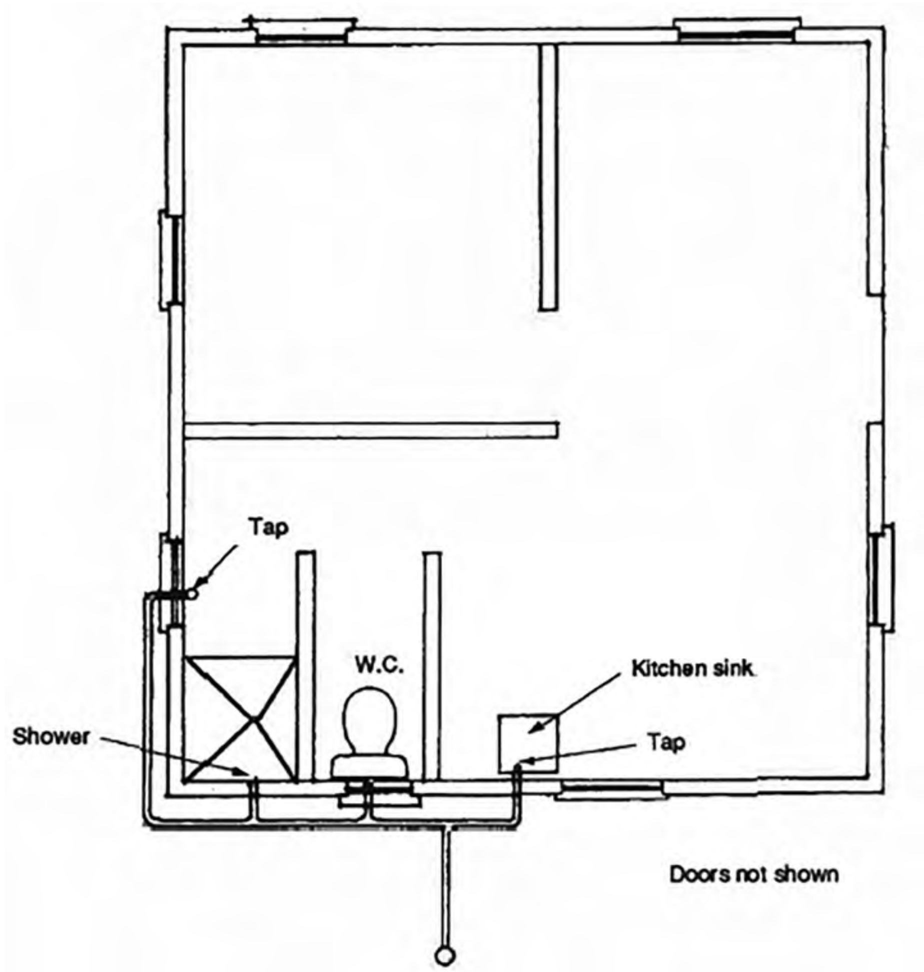


FIGURE H6.4: PLUMBING DETAIL

Please correct your copy of the Home Building Manual by cutting and pasting the following corrections.

FIGURE B9.4.3 (A)

Bracing capacity of wall system (kN)

WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
≤1800	2.0	8.0
2100	1.7	7.0
2400	1.5	6.0
2700	1.3	5.3
3000	1.2	4.8

CUT ALONG THIS LINE

FIGURE B9.4.3 (B)

Bracing capacity of wall system (kN)

WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
≤1800	2.0	5.3
2100	1.7	4.6
2400	1.5	4.0
2700	1.3	3.6
3000	1.2	3.2

CUT ALONG THIS LINE

FIGURE B9.4.3 (C)

Bracing capacity of wall system (kN)

WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
≤1800	2.0	5.3
2100	1.7	4.6
2400	1.5	4.0
2700	1.3	3.6
3000	1.2	3.2

CUT ALONG THIS LINE

FIGURE B9.4.3 (D)

Bracing capacity of wall system (kN)

WALL HEIGHT (H) (mm)	WALL LENGTH (L) (mm)	
	1200	2400
≤1800	5.3	12.8
2100	4.6	11.0
2400	4.0	9.6
2700	3.6	8.5
3000	3.2	7.7

CUT ALONG THIS LINE

H7 MEMBER SIZES (ALL IN MILLIMETRES)

H7.1 Roof

Cladding:	Lightweight (e.g. sheet roof cladding)		
Rafters:	Stress grades:	F4	F5-F8
	Call dimensions:	150 X 50	1 25 X 50
	Spacing (mm):	900	
Beams:	Stress grades:	F4	F5-F8
	Call dimensions:	200 X 75	175 X 75
Purlins:	Not required		

H7.2 Timber framed walls

Top plate:	50 X 100		
Bottom plates:	50 X 100		
Noggings:	50 X 100		
Internal wall studs:	Call dimensions:	100 X 40	
	Spacing (mm):	600	
Studs:	Stress grades:	F4-F7	F8
	Call dimensions:	100 X 75	100 X 50

If the external wall is of timber construction then the internal walls must also be of timber construction for the bedroom.

H7.3 Masonry walls

1 50 mm partially reinforced masonry blockwall

Vertical Reinforcement:	D 12 @ 800 mm centres
Horizontal Reinforcement:	4 D 12 bars in 150 x 400 concrete bond beam at top and bottom of wall
Lintel:	150 x 200 concrete or masonry with 2 D 12 bars
	R6 ties @ 600 mm centres
Intermediate bond beam:	Not required

If the external wall is of masonry construction then the internal walls must also be of masonry construction for the bedroom.

H7.4 Other wall types

Corrugated iron roofing sheets may be used for external wall cladding of houses to this design. However the noggings must be spaced no further than 900 mm. Alternate troughs must be fastened to the noggins with 40 x 3.75 f nails with large washers. The internal walls for the bedroom must be of timber or masonry construction.

Houses constructed to this detail will also satisfy the limitations given at Clause H1 at page H-1.

H7.5 Floor

Slab on ground.

100 mm thick slab on compacted granular fill reinforced with F62 (665) mesh or D10 bars at 350 mm centres both ways. Refer to Figures H4.1 and H4.2 for details.

H7.6 Corner bracing of walls

Knee brace every corner of wall with either 150 x 25 timber brace or 30 x 0.8 galvanised straps as shown in Figure H5.1.

H7.7 Roof bracing

150 x 25 timber braces or 30 x 0.8 galvanised straps or suitable proprietary product as shown in Figure H5.2.

H8 TIE-DOWN

H8.1 Cladding to rafter

Nail every crest of cladding within 1200 mm of roof edges. Nail every alternate crest in other areas. In cyclonic winds, damage is expected to occur to sheet metal cladding if nails are used. To avoid this load spreading, washers in conjunction with nails must be used or use Type 17 No 14 hot dip galvanised screws with load spreading washers.

NOTE: Load spreading washers for nails are manufactured by Hylton Parker (Pty) Ltd. NZ.

H8.2 Rafter to wall

Use 30 x 0.8 G.I looped strap with 6/3.15 f nails each end of strap. Refer to Figure H8.2.

H8.3 Top plate to stud

Use 30 x 0.8 G.I. strap with 6/3.15 f, nails at each end of strap. Refer to Figure H8.3.

88.4 HB.4 Bottom plate to foundation

Bottom plate must be bolted to the footing at 900 mm centres as shown in Figure H8.4.

H8.5 HB.5 Beams to studs

75 x 8 mm M.S saddle bolted to double studs with 1 M12 bolt as shown in Figure H8.5.

NOTE: Beam must be supported on double studs. Studs must be nailed together with 100 x 4.5

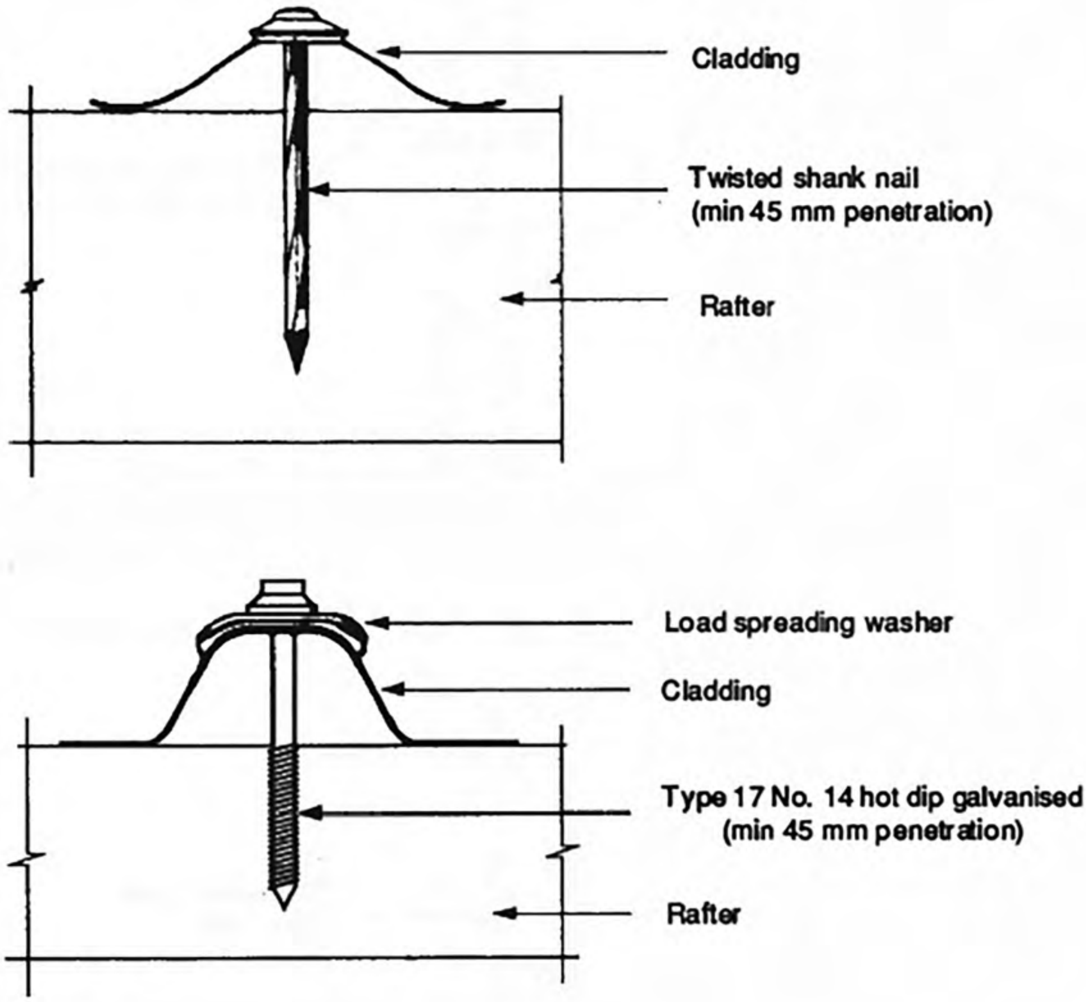


FIGURE H8.1 FIXING OF CLADDING TO RAFTER

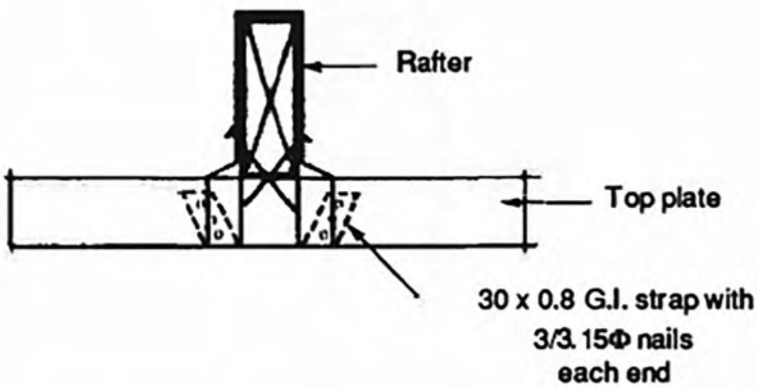


FIGURE H8.2: FIXING OF RAFTER TO TOP PLATE

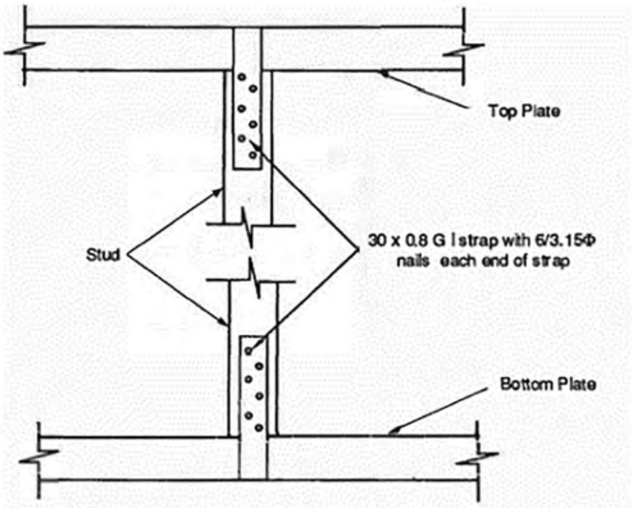


FIGURE H8.3: FIXING OF STUD TO TOP AND BOTTOM PLATE

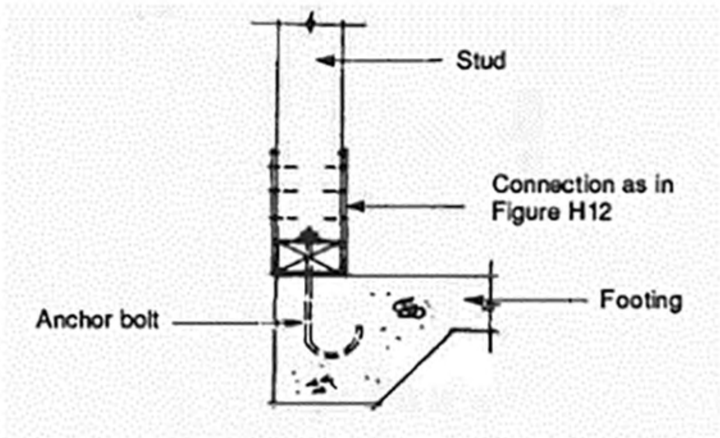


FIGURE H8.4: FIXING BOTTOM PLATE TO FOOTING

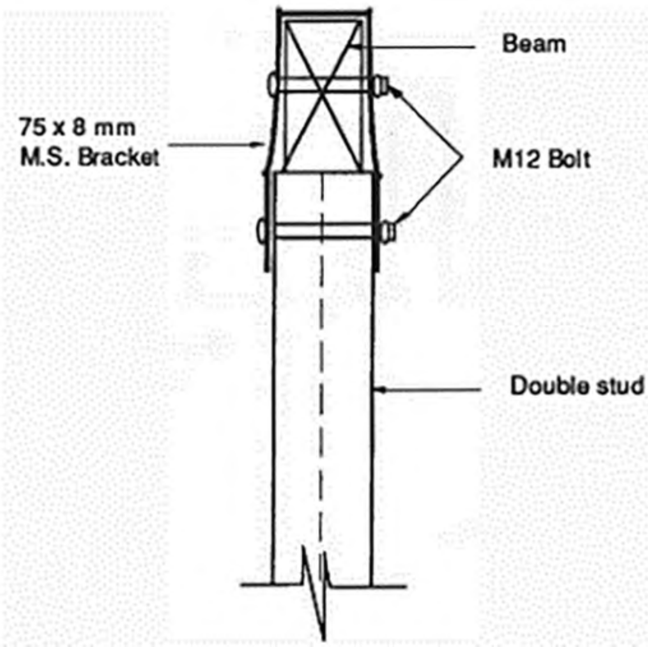


FIGURE H8.5: FIXING BEAM TO STUD

Section APPENDICES

Section APPENDICES

APPENDIX I—DESIGN CRITERIA

1 GENERAL

The calculations in this manual have been based on the following codes:

(a) The design loads contained in NZS 4203: General Structural Design and Design Loadings for Buildings, Sections 1 and 2

(b) The wind loads contained in AS 1170 Part 2, Wind Forces, Sections 1 and 3

(c) AS1 720, SAA Timber Structures Code, Part 1 - 1988 edition

(d) NZS 4230(P) Design of Masonry Structures

(e) NZS 4229 Code of practice for MASONRY BUILDINGS not requiring specific design.

2 DERIVATION OF DESIGN WIND LOADS

The wind loads used in the preparation of this manual have been derived from the Australian Wind Loading Code, AS 1170 Part 2, 1989. Sections 1 and 3 have been used to calculate the design windspeeds that act on the building.

2.1 Design WIndspeed

The design windspeed is derived by multiplying the basic windspeed for permissible stress methods by the various multiplying factors for terrain category, shielding, topography and structure importance.

$$V_z = V_p \times M_{(z,cat)} \times M_s \times M_t \times M_i$$

where:

V_z = the design wind gust speed at height z, in metres per second

V_p = the basic windspeed for permissible stress methods

$M_{(z,cat)}$ = a gust windspeed multiplier for a terrain category at height z

M_s = a shielding multiplier

M_t = a topographic multiplier for gust wind speeds

M_i = a structure importance multiplier

2.2 Multiplying Factors

(a) Terrain and Structure Height Multiplier ($M_{(z,cat)}$)

The terrain and structure height multiplier has been derived from Table 3.2.5.1, AS 1170 Part 2 1989, based on terrain category 2.

(b) Shielding Multiplier (M_s)

The shielding multiplier has been assumed to be 1.0.

(c) Topographic Multiplier (M_t)

The value for topography has been based on an escarpment with an upwind slope of 1:10.

(d) Structure Importance Multiplier (M_i)

It has been assumed that this manual will be used for construction of normal houses. As such a structure importance multiplier of 1 .0 has been used throughout.

2.3 Dynamic Wind Pressures

$q_z = 0.6 \times V_z^2 / \times 10^{-3}$

where: q_z = the free stream gust dynamic wind pressure at height, z, in kilopascals

V_z = the design gust windspeed at height z, in metres per second.

2.4 External Pressure Coefficient (Cpe)

These are derived from Tables 3.4.3.2, 3.4.3.2(B), and 3.4.3.2(C) for roofs. For walls these are derived

from Tables 3.4.3.1, 3.4.3.1 (B), and 3.4.3.1 (C). (All tables from AS 1170 Part 2).

2.5 Internal Pressure Coefficient (Cp)

Internal pressure coefficient has been taken as + 0.3.

APPENDIX II—EXAMPLES

1 CALCULATION OF BRACING WALL REQUIREMENTS

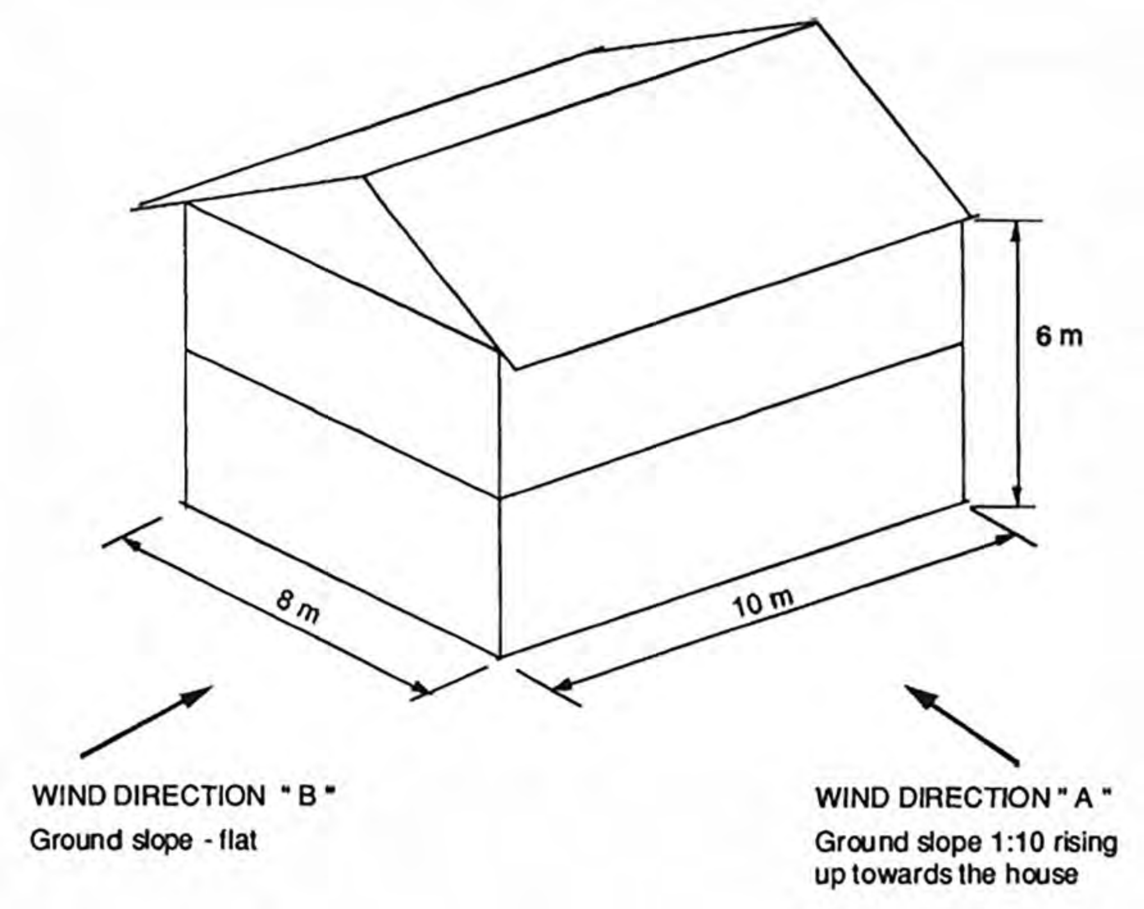
Building Geometry and Site Conditions

Length: 10 m

Width: 8 m

Height: 6 m

Roof Pitch: 10° for wind direction "A" and 0° for direction "B" (see figure below)



2.1 UPPER STOREY

(a) For wind direction "A"

~ From Table B9.3(A)

Bracing Demand	=	2.1 kN/m	
For 10 m length	=	10 x 2.1	**~ 21 kN**

(b) For wind direction "B"

~ From Table B9.3(B)

Bracing Demand for 8 m width **~ 22.4 kN/m**

2.2 LOWER STOREY

(a) For wind direction "A"

From Table B9.3(A)

Bracing Demand	=	6.0 kN/m	
For 10 m length	=	10 x 6	**~ 60 kN**

(b) For wind direction "B"

From Table B9.3(B)

Bracing Demand for 8 m width **~ 61.1 kN**

2 STRESS GRADES OF LOCALLY AVAILABLE TIMBERS IN COOK ISLANDS

PINE (SEASONED)	No 1 framing	F8
PINE (SEASONED)	No 2 framing	F7

3 JOINT GROUPS OF LOCALLY AVAILABLE TIMBERS IN COOK ISLANDS

PINE (SEASONED)	JD4
PINE (UNSEASONED)	J4

LIST OF REFERENCES

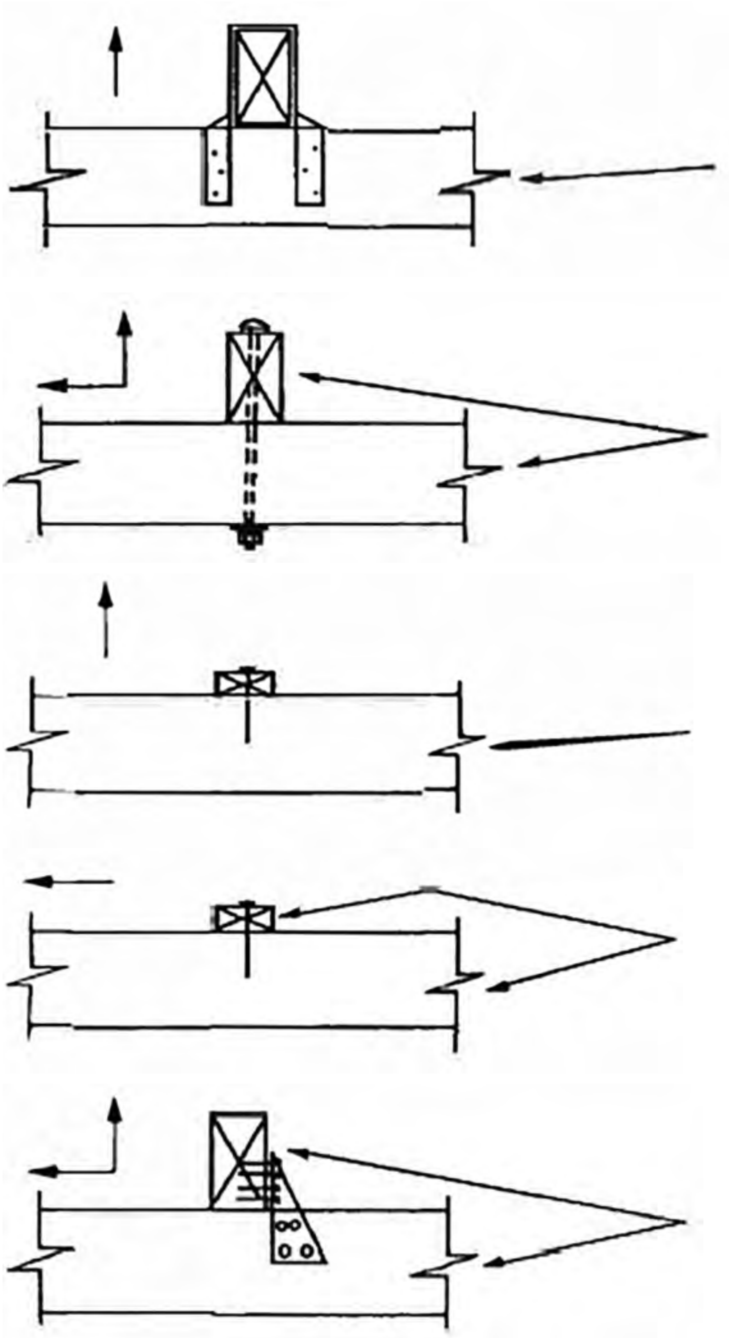
1. AS 1170.2 (1989) SAA Loading Code - Wind loads
2. AS 1684 (1979) SAA Timber Framing Code
3. AS 1720.1 (1988) SAA Timber structures code - Design methods
4. AS 2858 (1986) Timber - Softwood - Visually graded for structural purposes
5. AS 2878 (1986) Timber - classification into strength groups
6. NZS 3101 (1982) The design of concrete structures
7. NZS 3108 (1983) Concrete production - ordinary grade
8. NZS 3422 (1975) Welded fabric of drawn steel wire for concrete reinforcement
9. NZS 4203 (1984) General structural design and design loadings for buildings
10. NZS 4210P (1981) Masonry buildings - Materials and workmanship
11. NZS 4223 (1989) Glazing in buildings
12 NZS 4229 (1986) Concrete masonry buildings not requiring specific design
13. NZS 4230P (1985) The design of masonry structures
14. Queensland timber framing manual (1987), TRADAC
15. New Zealand concrete masonry manual (1986), Cement and Concrete Association of NZ
16. Basic guide to concrete construction (1985), Cement and Concrete Association of Aust.
17. Low - rise domestic and similar framed structures, part 1 - Design criteria (1978), CSIRO
18. Fiji Pine code of practice for light timber buildings not requiring specific design (1985) Dept. of Forestry, Fiji

APPENDIX III—TIMBER CLASSIFICATION

1 JOINT GROUPS

Pieces of timber are allocated Joint groups (see Terms and Definitions} to designate their structural properties at mechanical joints. The smaller the numerical value of a joint group rating, the greater its joint strength. For example a joint group rating of J2 indicates stronger joint properties than a rating of J3 or J4.

When a joint consists of pieces of timber with different joint group ratings, generally the timber with the lowest rating determines the rating of the joint as a whole. However the manner in which the forces are transmitted through the joint must also be taken into consideration. The examples in Figure 1-1 illustrate this.



Joint Group (J, JD rating} is based on this member as Design Strength is controlled by the nails working in shear.

Joint Group (J, JD rating) to be based on the weaker of either member as Design Strength is controlled by shear or bearing of the bolt in both members.

Joint Group (J, JD rating} is based on this member as Design Strength is controlled by the shank of the nail or screw in withdrawal. (This assumes that no prior failure occurs in bearing of the screw or nail head against the timber piece on top).

Joint Group (J, JD rating) is based on the weaker of either member as the Design Strength is controlled by the nails or screws in shear in both members.

Joint Groups (J, JD rating) is based on the weaker of either member as the Design Strength is controlled by the nails in both members.

NOTE: Arrows to the left indicate the direction of load.

FIGURE 1-1: ILLUSTRATIONS OF JOINT GROUPS

INFRASTRUCTURE COOK ISLANDS

Te Tango Angaanga o te Kuki Airani