NZS 4229:1999

Incorporating Amendment No. 1

New Zealand Standard

Concrete Masonry Buildings Not Requiring Specific Engineering Design

Superseding NZS 4229:1986

NZS 4229:1999

REPRESENTATION

This Standard was prepared under the supervision of the Masonry Committee (P 4210/4229) for the Standards Council established under the Standards Act 1988.

The Masonry Committee consisted of representatives of the following:

Building Research Association of NZ
Cement and Concrete Association of New Zealand
Firth Industries Ltd
Local Government New Zealand
New Zealand Concrete Masonry Association
NZ Institute of Architects
NZ Masonry Trades Employers Association
The Institution of Professional Engineers New Zealand

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AMENDMENTS

No	*Date of issue*	*Description*	*Entered by, and date*
1	October '99	Corrects errors on pages 51, 135 and 136.	} Incorporated in this reprint

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RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS

NZS 3101:1995	Concrete structures
NZS 3109:1997	Concrete construction
NZS 3112:1986	Methods of test for concrete
NZS 3402:1989	Steel bars for the reinforcement of concrete
NZS 3422:1975	Welded fabric of drawn steel wire for concrete reinforcement
NZS 3604:1999	Timber framed buildings
NZS 4203:1992	General structural design and design loadings for buildings
NZS 4210:1989	Masonry construction: Materials and workmanship
NZS 4230:- - - -	The design of masonry structures
Part 1:1990	Structures
NZS 4402:- - - -	Methods of testing soils for civil engineering purposes
Part 2:1986	Soil classification tests
NZS 4431:1989	Earth fill for residential development

JOINT AUSTRALIAN/NEW ZEALAND STANDARDS

AS/NZS 2699:- - - -	Built-in components for masonry construction
Part 1:1999	Wall ties
Part 2:1999	Connectors and accessories
Part 3:1999	Lintels and shelf angles
AS/NZS 4455:1997	Masonry units and segmental pavers

AMERICAN STANDARDS

ASTM C1116-95	Specification for fiber-reinforced concrete and shotcrete
ASTM E96-95	Test methods for water vapor transmission of materials

AUSTRALIAN STANDARD

AS 1650:1989	Hot-dipped galvanized coatings on ferrous articles

OTHER DOCUMENTS

Building Industry Authority
The New Zealand Building Code (NZBC)

Building Research Association of New Zealand
Report SC1043: Earthquake behaviour of combined masonry and timber framed walls

Cement & Concrete Association of New Zealand & NZ Concrete Masonry Association
New Zealand Concrete Masonry Manual

FOREWORD

This 1999 revision has involved a significant number of changes from the 1986 document primarily as a result of changes to the Loadings Standard NZS 4203:1992. More recent research testing on full scale wall specimens at the Universities of Auckland and Canterbury followed by finite element analysis of walls have contributed to this revision.

The research has provided a basis for the design of the limited range of masonry buildings described in this Standard.

The principal changes arising have been the use of partial filled masonry in all earthquake zones, increases in bond beam spans and the use of concrete floor diaphragms. However, where possible, the research and review data has been used to simplify the document rather than increasing the sophistication of choices.

The introduction of the New Zealand Building Act has also influenced the contents of clauses as well as the responsibilities in relation to workmanship. The revisions in the style of the companion document NZS 3604 have also been followed in order to assist the user who has commonality of interest in residential construction.

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SECTION 1

SECTION 1
SCOPE AND INTERPRETATION

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NEW ZEALAND STANDARD

CONCRETE MASONRY BUILDINGS NOT REQUIRING SPECIFIC ENGINEERING DESIGN

1 SCOPE AND INTERPRETATION

1.1 Scope

1.1.1
This Standard sets out construction requirements for concrete *masonry* buildings not requiring specific engineering design within the limitations specified by 1.1.3. It is intended as a means of compliance with the following requirements of the New Zealand Building Code (NZBC):

(a) Clause B1 Structure
Masonry walls constructed in accordance with this Standard and NZS 4210 will meet the requirements of B1.3.1, B1.3.2 and B1.3.4 for loads from B1.3.3(a), (b), (d), (f), (h) and (j) i.e. for loads arising from gravity, earth pressure, earthquake, wind, and human impact. Appendix C gives details of *masonry* walls that are retaining.

(b) Clause B2 Durability
Masonry walls constructed in accordance with this Standard will be durable for at least 50 years and will therefore meet B2.3.1(a) of the New Zealand Building Code.

(c) Clause E2 External Moisture
Construction in accordance with this Standard will ensure against damage to building components or dampness in the building as a result of external moisture entering through the *masonry* walls or the concrete slab-on-ground. This Standard ensures compliance with E2.3.2 and E2.3.3 of the New Zealand Building Code but in respect of walls and floors only. This Standard is not a complete solution to Clause E2 as it does not contain provisions for the other elements of the building envelope e.g. roofing, exterior joinery and flashings.

Where this Standard has provisions that are in non-specific or unquantified terms (such as where provisions are required to be appropriate, adequate, suitable and the like), then these do not form part of the means of compliance with the Building Code and must be to the approval of the Territorial Authority.

1.1.2
This Standard does not provide all the information relating to the use of timber components and reference to NZS 3604 is required.

1.1.3
This Standard applies only to buildings within its stated limitations, including but not limited to:

(a) Buildings shall be founded on *good ground*;

(b) Buildings shall be a Category IV or V building (see table 1.1);

(c) The total height from the lowest *ground level* to the highest point of the *roof* shall not exceed 10 m and no *storey* height shall exceed 3.0 m;

(d) The ratio of the total building height to minimum building width shall not exceed 2.5;

(e) The plan footprint floor area and configuration of construction shall comply with the limitations contained in figure 1.1 and shall not exceed:

(i) 600 m^2 for single *storey masonry* buildings

(ii) 250 m^2 for 2 *storey* residential *masonry* buildings

(iii) 350 m^2 for 2 *storey* residential buildings where the upper *storey* is constructed of timber and the *external wall* of the lower *storey* is of *masonry* supported on a concrete slab-on-ground, concrete or *masonry footings* or *masonry foundation walls*

(iv) 250 m^2 for 2 and 2 *storey* with attic buildings constructed with upper *storey* or *storeys* of timber supported on a lower *storey* of *masonry* with the top *storey* contained within a *roof* space.

(f) The live load on *suspended floors* shall not exceed:

(i) 1.5 kPa

(ii) 2.0 kPa for balconies.

(g) The live load on concrete slab-on-ground shall not exceed a uniformly distributed load of 3.0 kPa nor a concentrated load of 9.0 kN;

C1.1.3(h)
Steeper slopes will require modification of design tables and hence become specific engineering designs.

Roof slopes incorporating diaphragms are not to exceed 25^0 to the horizontal. (See section 9).

(h) The slope of any *roof* plane shall not be steeper than 45^o to the horizontal;

C1.1.3(j)
Where steel framed roofs are used they need to be the subject of specific engineering design.

(j) *Roofs* shall be of timber complying with NZS 3604;

(k) Suspended timber floors shall be of timber construction complying with NZS 3604 unless otherwise modified by this Standard;

(m) Suspended concrete floors used as a *diaphragm* shall meet the requirements of this Standard for horizontal loads and shall for the purposes of other *structural* functions be required to be specifically designed to NZS 3101. The maximum dead load of suspended concrete floors shall not exceed 4.5 kPa.

Table 1.1 – Classification of buildings (Based on table 2.3.1 of NZS 4203) (see 1.1.3)

Category	Description
I	Buildings dedicated to the preservation of human life or for which the loss of function would have a severe impact on society.
II	Buildings which as a whole contain people in crowds.
III	Publicly owned buildings which house contents of a high value to the community.
IV	Buildings not included in any other category.
V	Buildings of a secondary nature.

NOTE – Categories I, II and III are not included in this Standard.

1.2 Interpretation

1.2.1
The word "shall" identifies a mandatory requirement for compliance with the Standard. The word "should" refers to practices which are advised or recommended.

1.2.2
Where this Standard has non-specific requirements such as the words "suitable", "adequate", "acceptable" or other similar qualifiers like "as far as is reasonably practicable" then the method described shall be to the satisfaction of the *Territorial Authority.*

Also in this Standard, where reference is made to "the manufacturer's recommendations or instructions" or similar, these are outside the scope of this Standard as an Acceptable Solution to the *NZBC,* and shall be to the satisfaction of the *Territorial Authority*.

Where this Standard requires *specific engineering design* (SED) then this is outside the scope of the Standard as an Acceptable Solution to the *NZBC* and shall be to the satisfaction of the *Territorial Authority*.

Only use the values set out in clauses and tables and do not extrapolate the values.

1.2.3
Clauses prefixed by "C" and printed in italic type are intended as comments on the corresponding mandatory clauses. They are not to be taken as the only or complete interpretation of the corresponding clause, nor should they be used for determining in any way the mandatory requirements of compliance within this Standard. The Standard can be complied with if the comment is ignored.

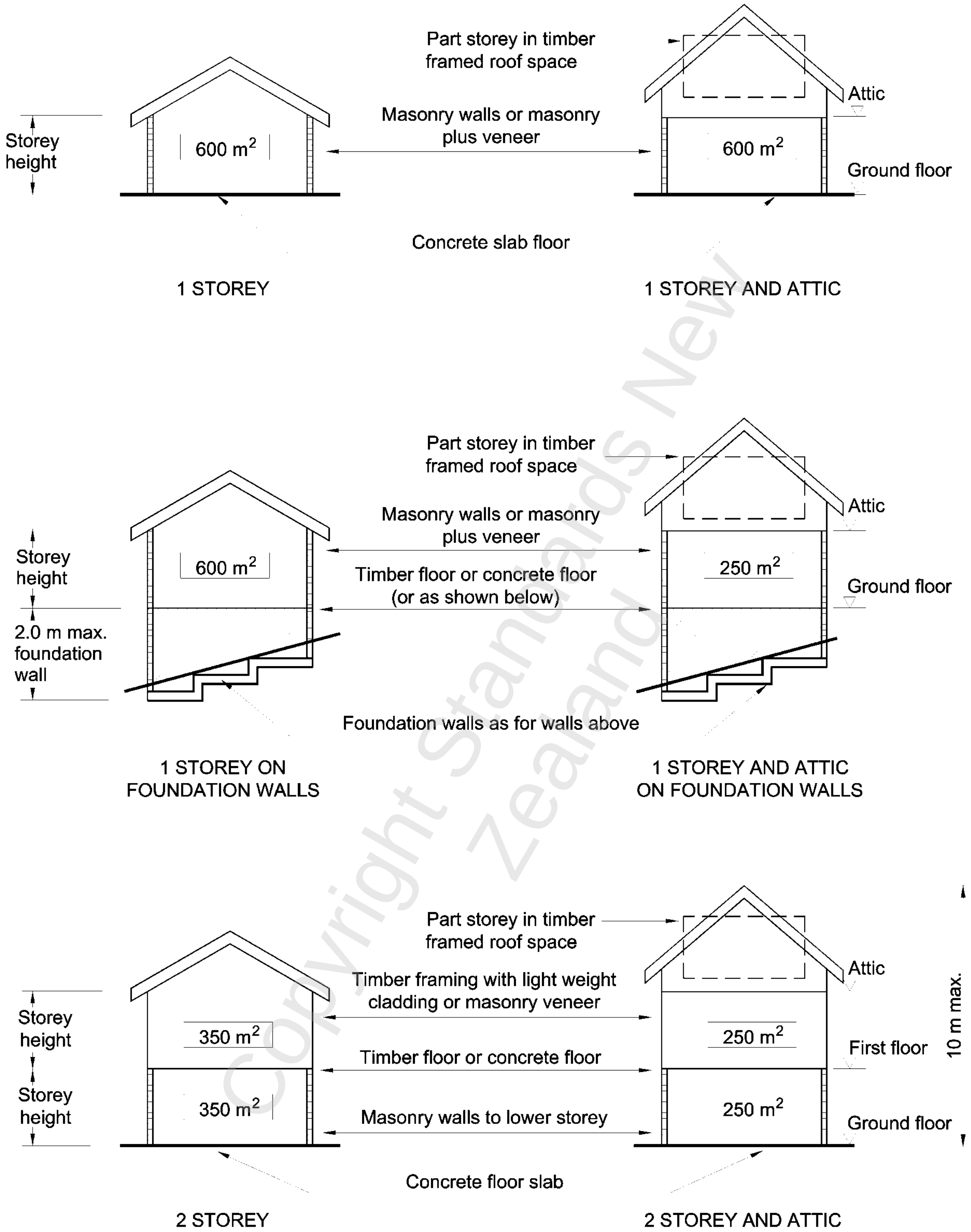
1.2.4
Where any clause in this Standard contains a list of requirements, provisos, conditions, or the like, then each and every item in that list is to be adopted in order to comply with this Standard unless the clause specifically states otherwise.

1.2.5
The full titles of reference documents, cited in this Standard are given in the list of related documents immediately preceding the Foreword.

1.2.6
The terms "Normative" and "Informative" have been used in this Standard to define the application of the Appendix to which they apply. A "Normative" Appendix is an integral part of a Standard whereas an "Informative" Appendix is only for information and guidance. Informative provisions do not form part of the mandatory requirements of the Standard nor do they form part of the Standard as an Acceptable Solution to the NZBC.

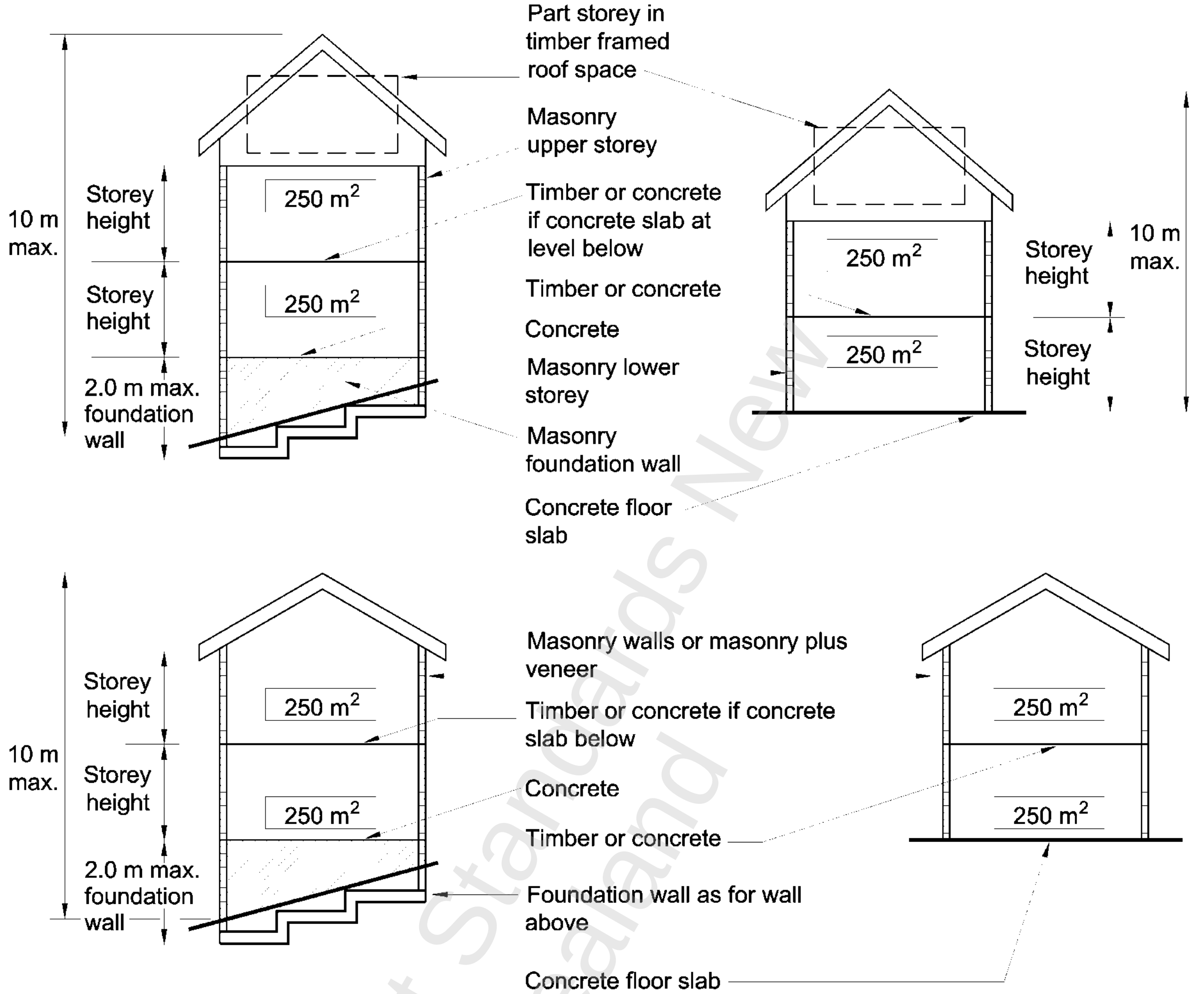
1.2.7
Unless inconsistent with the context, and subject to 1.3, terms defined in the New Zealand Building Code shall have the same meaning in this Standard.

1.2.8
Masonry units shown in the figures are diagrammatic and do not necessarily represent the actual types of the units.



NOTE -
(1) Max. plan footprint as shown: | 250 m² |
(2) Max. storey height 3.0 m.
(3) Max. part storey 40 % of actual wing or block.

Figure 1.1(a) – Building types covered by this Standard (see 1.1.3(e))



NOTE -
(1) Max. plan footprint as shown: 250 m^2
(2) Max. storey height 3.0 m.
(3) Max. part storey 40 % of actual wing or block.

Figure 1.1(b) – Building types covered by this Standard (continued) (see 1.1.3(e))

1.3 Definitions

1.3.1

For the purposes of this Standard the following definitions shall apply:

(a) Timber definitions are contained in NZS 3604;

(b) *Masonry* definitions are contained in this Standard.

BOND BEAM. A horizontal course of concrete *masonry* containing steel *reinforcement* and being fully grouted.

BOND BEAM, INTERMEDIATE. A *bond beam* situated anywhere except at the top of a wall.

BOND, RUNNING OR STRETCHER. The bond when the units of each course overlap the units in the preceding course by between 25 % and 75 % of the length of the units.

BOND, STACK. The bond when the units of each course do not overlap the units of the preceding course by the amount specified for *running or stretcher bond*.

BRACING. Any method employed to provide lateral support to a building.

BRACING CAPACITY. Strength of *bracing* of a whole building or of elements within a building. *Bracing capacity* is measured in "Bracing Units", BUs, and shall be determined from section 5.

BRACING DEMAND. The total number of *bracing units* representing a horizontal force imposed on a building by earthquakes or wind.

BRACING LINE. A line along or across a building for controlling the distribution of wall *bracing* elements.

BRACING UNIT (BU).

(a) A measure of horizontal force (*bracing demand*) on the building (1 kilonewton is equal to 20 *bracing units*).

(b) A measure of resistance to horizontal force (*bracing capacity*) of building elements.

CELL. A hole through or along a *masonry* unit in the plane of a wall where the least *dimension* of the hole exceeds one-third of the width of the unit.

COLUMN:

ISOLATED. A reinforced, vertical loadbearing member having a cross section with a ratio of depth to breadth of a value lying between 0.33 and 3.

WALL. A reinforced, vertical loadbearing member having a cross section with a ratio of wall width to wall length of a value lying between 0.70 and 4.

CONCRETE BLINDING or **SITE CONCRETE**. Concrete laid over exposed ground, to form a working surface or as a mass concrete sub-base.

CONTROL JOINT. A joint or gap constructed in *masonry* or concrete slabs-on-ground to control and absorb movements.

D. A deformed reinforcing bar of the stated diameter in millimetres. (e.g. Grade 300).

DAMP-PROOF COURSE (DPC). A layer of durable vapour barrier placed between building elements to prevent the passage of moisture from one element to another.

DAMP-PROOF MEMBRANE (DPM). Sheet material or coating having a low water vapour transmission and used to minimize water vapour penetration in buildings.

DESIGNER. A person who, on the basis of experience or qualifications, is competent to design *structural* elements of the structure under consideration to safely resist the design loads or effects likely to be imposed on the structure.

DIMENSION. Means nominal *dimensions* when used to describe *masonry* units or types of construction. Actual *dimensions* shall be used for the purpose of calculations.

FLOOR LIVE LOAD. The basic minimum uniformly distributed live load for floors as specified by 1.1.3(f).

FOOTING. That portion of a *foundation* bearing on the ground and any adjoining portion that is reinforced so as to resist the bearing forces. It may be spread out to provide an increase in bearing area or an increase in stability.

FOUNDATION. Those parts of a building transmitting and distributing loads to the ground, through a *footing*.

FOUNDATION WALL see **WALL**.

GABLE. The triangular part of an outside wall between the planes of the roof and the line of the eaves.

GOOD GROUND. Any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300 kPa (i.e. an allowable bearing pressure of 100 kPa using a factor of safety of 3), but excludes:

(a) Potentially compressible ground such as top soil, soft soils such as clay which can be moulded easily in the fingers, and uncompacted loose gravel which contains obvious voids;

(b) Expansive soils being those that have a liquid limit of more than 50 % when tested in accordance with NZS 4402 Test 2.2, and a linear shrinkage of more than 15 % when tested in accordance with NZS 4402 Test 2.6, and

(c) Any ground which could foreseeably experience movement of 25 mm or greater for any reason including one or a combination of:

land instability, ground creep, subsidence, seasonal swelling and shrinkage, frost heave, changing ground water level, erosion, dissolution of soil in water, and effects of tree roots.

GROUND LEVEL:

CLEARED GROUND LEVEL. The *ground level* after completion of site excavation and removal of all harmful material, but before excavation for *foundations*.

FINISHED GROUND LEVEL. The *ground level* after all backfilling, landscaping, and surface paving have been completed.

NATURAL GROUND LEVEL. The *ground level* before the site is cleared.

HD. A deformed high strength (Grade 430 or 500) reinforcing bar of the stated diameter in millimetres.

LINTEL. A horizontal member spanning an opening in a wall.

LOAD see **FLOOR LIVE LOAD**.

LOADBEARING. Refers to an element which serves in providing resistance to loads other than those induced by the weight of the element itself.

M. A steel bolt of the stated diameter in millimetres.

MASON. A person skilled in the construction of *masonry*.

MASONRY. Any construction in units of concrete, laid to a bond in and joined together with *mortar*.

MORTAR. The material in which *masonry* units are bedded.

PARTITION see **WALL**.

PILASTER or **PIER**. A member similar to a *column* except that it is bonded into a wall. The *thickness* of a *pilaster* includes the *thickness* of such a wall.

PLATE. A timber member continuous on top of a *masonry* wall to support and distribute the load from floors, walls, roofs or ceiling.

PUBLIC PLACE. Any place that, at any material time, is under the control of the *Territorial Authority* and is open to, or being used by the public, whether free or on any payment of a charge; and includes any road whether or not it is under the control of the *Territorial Authority.*

R. 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 support for sarking, purlins or roof covering.

REGISTERED MASON. A *Registered Mason* is a *Mason* who is accepted for registration by the New Zealand Masonry Trades Registration Committee and is the holder of a current registration certificate.

REINFORCEMENT. Any form of reinforcing rod, bar or mesh that complies with the relevant requirements of NZS 3109.

REINFORCED MASONRY. Any *masonry* in which reinforcing steel is so bedded and bonded that the 2 materials act together in resisting forces.

PARTIALLY FILLED REINFORCED MASONRY. All hollow *cells* containing steel *reinforcement* are filled with grout.

SOLID FILLED REINFORCED MASONRY. All hollow *cells* irrespective of whether they contain steel *reinforcement* or not are filled with grout.

ROOF. That upper part of the building having its upper surface exposed to the outside and at an angle of 45^o or less to the horizontal (see also 1.1.3(h)).

LIGHT ROOF. A *roof* with roofing material (cladding and any sarking) having a mass not exceeding 20 kg/m^2 of *roof* area.

Typical examples of light roofing are steel, copper, and aluminium *roof* claddings of normal *thickness*, butynol or fabric roofing etc.

HEAVY ROOF. A *roof* with roofing material (cladding and any sarking) having a mass exceeding 20 kg but not exceeding 60 kg/m^2 of *roof* area.

Typical examples of heavy roofing are concrete tiles, slates and the like.

PITCHED ROOF. A *roof* having its exterior surface at an angle of 10^o or more to the horizontal (that is, at a slope of 1 in 6 or steeper).

SKIN or **WYTHE**. A continuous vertical tier of *masonry* one unit in *thickness*.

SPACING or **SPACED**. The clear distance between supports measured along a member.

SPECIFIC ENGINEERING DESIGN. Requires calculation and design beyond the scope of this Standard.

STOREY. That portion of a building included between the upper surface of any floor and the upper surface of the next floor above, except that the topmost *storey* shall be that portion of a building included between the upper surface of the topmost floor and the ceiling or *roof* above.

STRUCTURAL. A term used to describe an element, or elements which provide resistance to actions from loads on a building.

STRUCTURAL DIAPHRAGM. A member such as a floor or ceiling as specified in this document capable of transferring loads in its own plane to boundary members.

SUSPENDED FLOOR. A floor which is not directly supported on ground.

TERRITORIAL AUTHORITY. A Territorial Authority as defined in the Local Government Act 1974 and includes a building certifier acting within the scope of their authority.

VENEER. A *skin* of concrete *masonry* or burnt clay *masonry* or natural stone of maximum mass of 220 kg/m^2, which is attached to and laterally supported by a *structural wall* of *masonry* or timber to NZS 3604.

WALL:

EXTERNAL WALL. An outer wall of a building.

FOUNDATION WALL. That part of the *foundation* comprising a concrete *masonry* wall supporting a building or part of a building, and not extending more than 2.0 m above the underside of the *footing*.

INTERNAL WALL. A wall other than an *external wall*.

LOADBEARING WALL. A wall supporting vertical loading from floors, ceiling joists, *roof*, or any combination thereof.

NON-LOADBEARING WALL. A wall other than a *loadbearing wall*.

STRUCTURAL WALL. Any wall which because of its position and shape contributes to the rigidity and strength of the building.

THICKNESS. The nominal *thickness* of *masonry* is designated 15 series, 20 series and 25 series, which equates to 140 mm, 190 mm and 240 mm of actual *thickness* respectively.

WALL BRACING PANEL. A section of wall above the *ground level* that performs a *bracing* function. This can be a *loadbearing* or *non-loadbearing* wall.

WING OR BLOCK. A wing or block is any part of the building which projects by more than 6 m from the remainder of the building.

WYTHE see **SKIN.**

SECTION 2

SECTION 2

GENERAL

NOTES

2 GENERAL

2.1 Materials

2.1.1
Masonry materials shall comply with the provisions of NZS 4210.

2.1.2
Concrete shall comply with the provisions of NZS 3109.

2.1.3
Masonry grout used for the filling of *cells* shall comply with the provisions of 12.5 and NZS 4210.

2.1.4
Reinforcing steel shall comply with the provisions of NZS 3402. Reinforcing mesh shall comply with the provisions of NZS 3422. Bends, hooks and other details of *reinforcement* shall be in accordance with NZS 3109.

2.1.5
Veneer wall ties and other metal components shall comply with the provisions of 12.5 and table 12.1.

2.1.6
Timber components and fixings shall comply with *structural* and durability provisions of NZS 3604.

2.2 Workmanship, construction and tolerances

2.2.1
Workmanship unless specifically covered in this Standard shall comply with NZS 4210.

2.2.2
Construction shall be carried out by a suitably qualified tradesperson.

C2.2.2
Masonry designated Grade B by NZS 4230 requires inspection by a designer which may include a Registered Mason.

Construction by a Registered Mason as qualified and registered by the Masonry Trades Registration Board is acceptable to most Territorial Authorities.

2.2.3
The permissible tolerances shall be as set out in NZS 4210.

2.3 Surface coatings

2.3.1
External vertical *masonry* walls, except *veneer* walls, shall be waterproofed by the application of a surface coating that shall extend at least 50 mm below the top level of an adjoining concrete floor slab.

2.3.2
An alkali resistant water based dispersion coating system, having a dry film *thickness* of between 180 and 250 µm (micrometres) shall be deemed to comply with this requirement.

2.3.3
This shall be achieved with 2 or 3 coats, depending on the product used and the texture of the surface.

2.3.4
The surface coating shall not be applied until the moisture content of the wall is below 70 % relative humidity and is suitable for the application of the paint system.

C2.3

Uncoated masonry walls cannot be assumed to be completely waterproof.

Moisture should be controlled firstly by trying to eliminate its entry, and secondly, by allowing it to dissipate without causing damage to building elements.

An acrylic system formulated below the critical pigment volume concentration (CPVC) is called up as the coating to prevent the entry of liquid water yet allow the ready transmission of water vapour.

The range of thickness relates to the surface texture of the masonry where an open texture may require the higher coating application.

Light coloured finishes are preferable to dark ones as dark colours absorb more heat and increase the likelihood of cracking with changes in temperature.

High build coatings can be an effective surface finish on masonry walls. Details on the suitability of high build coatings for specific uses can be obtained from specific manufacturers.

The method of testing Relative Humidity is to seal an RH meter on the surface to be painted for a period of 24 hours. If the reading at the end of that period is 70 % or less, then the surface is acceptable for painting.

2.4 Maintenance
The completed coating system shall be regularly maintained to ensure continued resistance to water entry. Maintenance shall include the removal of dirt, mould and other organic deposits, the repair of cracks or other defects, and repainting as necessary to preserve the waterproof finish.

SECTION 3

SECTION 3

SITE REQUIREMENTS

Figure

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3 SITE REQUIREMENTS

3.1 Soil bearing capacity and site profile requirements

3.1.1

The site requirements of this Standard are concerned with soil conditions under or adjacent to the building.

If a site does not comply with this clause the *foundations* only shall be the subject of specific engineering design.

Foundations on expansive soils are outside the scope of this Standard as an Acceptable Solution to the NZBC.

C3.1.1

NZS 3604 section 17 contains some information which may be of assistance to those designing foundations on expansive soils.

3.1.2

The *foundation* provisions of this Standard shall apply only for building sites such that:

(a) The *foundations* for the building are supported on *good ground* (see definition in 1.3);

(b) Any *foundation* for a building erected on a slope, shall be no nearer to any point on the slope than shown in figure 3.1;

(c) Fill, including hard fill, placed over undisturbed ground or certified fill, shall not exceed 600 mm in depth above *natural ground level*, if within 3 m of a *foundation*.

C3.1.2

(b) These provisions are to guard against erosion or frittering of soil that exposes the foundation and to avoid localized slip failures which threaten the foundation. Stability of the site as a whole is covered by 3.1.3.2(b).

(c) This limitation is required, as moderate depths of earth fill over a large area adjacent to building foundations can cause the underlying soil to consolidate to a depth of approximately twice the width of the fill.

Such consolidation can cause differential settlement of the building foundations and thus damage to the building. Typically, earth fills are placed adjacent to foundations for the construction of stairs, terraces, landscaping and built-up ground under concrete floor slabs.

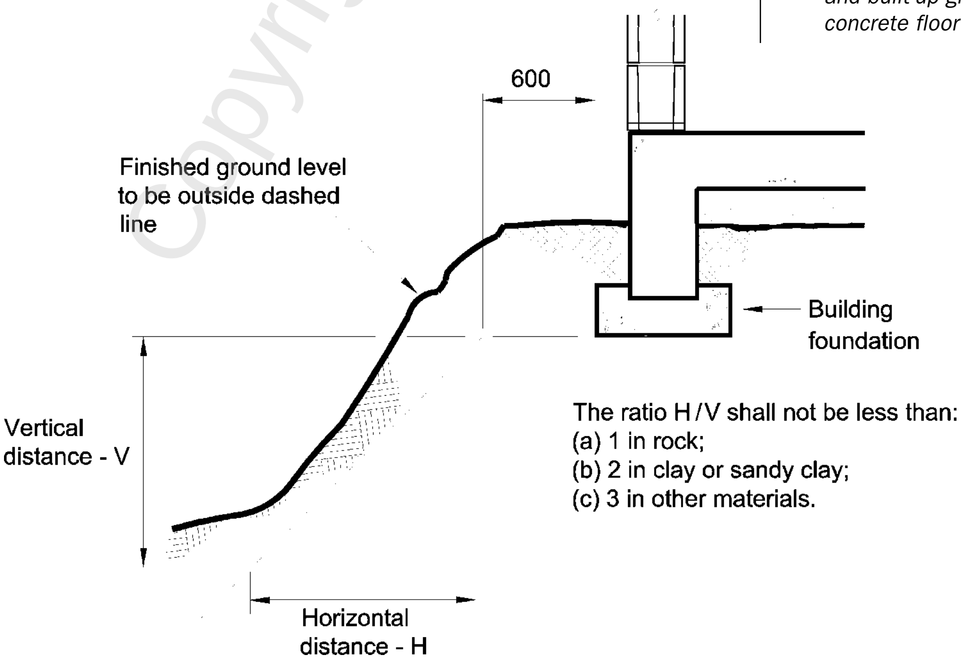


Figure 3.1 – Relationship of foundation to sloping ground surface (see 3.1.2(b)

3.1.3 Soil bearing capacity

C3.1.3.1
Good ground may also be verified by a subsoil investigation but this is outside the scope of this Standard.

Tests in accordance with 3.3 of NZS 3604 offer a comparatively simple method for establishing whether or not an ultimate bearing strength of 300 kPa may be assumed.

3.1.3.1
The soil supporting the *footings* shall be assumed to be *good ground* if all of the conditions of 3.1.3.2 are met and either:

(a) Adjacent established buildings of a similar type supported on *foundations* similar to those required by this Standard and on similar soils show no signs of unsatisfactory behaviour attributable to soil conditions; or

(b) Dynamic cone penetrometer (also called Scala Penetrometer) tests, in accordance with 3.3 of NZS 3604, have been performed establishing that the supporting soils are *good ground*.

3.1.3.2
The site and soil conditions requiring to be met are:

(a) Reasonable enquiry, the Project Information Memorandum (PIM) and site observation show no evidence of buried services and none are revealed by excavation for *footings*; and

(b) Reasonable enquiry, the PIM and site observation shows no indications or records of land slips having occurred in the immediate locality; and

(c) Reasonable enquiry shows no evidence of earth fill on the building site and no fill material is revealed by excavation for *footings*. This shall not apply where a certificate of suitability of earth fill for residential development has been issued in terms of NZS 4431 in respect of the building site and any special limitations noted on that certificate are complied with; and

(d) Excavation for *footings* does not reveal buried organic topsoil, soft peat or soft clay (see 3.2.1).

The test and the investigations required by this clause shall be performed by people with appropriate skills, to the approval of the *Territorial Authority*.

3.2 Soil types

3.2.1 *Soft peat, soft clay and expansive soils*

3.2.1.1
For the purposes of 3.1.3.2(d), peat or clay soil shall be regarded as soft if a natural chunk of the soil (not remoulded material or loose shavings) can be easily moulded in the fingers. (Soil that exudes between the fingers when squeezed in a fist shall be regarded as very soft).

3.2.1.2
For the purpose of 3.1.3.2(d) clays shall be regarded as expansive clays if their soil properties, in soil mechanic terms, exceed the values listed in the definition of *good ground* (b) in 1.3.

3.3 Bearing

3.3.1
All *foundations* shall bear on a solid bottom in undisturbed *good ground* material or upon firm fill where a certificate of suitability has been issued in terms of NZS 4431 (see 3.1.3.2(c))

Where *good ground* is at a depth greater than 600 mm, the excavation between the *good ground* and the *foundation* base at 600 mm depth shall be filled with 10 MPa concrete.

3.3.2
The minimum depths of *foundations* below the *cleared ground level* shall be:

(a) 150 mm in firm rock;

(b) 400 mm in clay (except expansive clays);

(c) 300 mm in other materials, subject to any special limitations noted on a certificate of suitability issued in terms of NZS 4431 in respect of the building site (see 3.1.3.2(c)).

C3.3.2
The depth of the foundation below ground level is not to be confused with the thickness of the footing as being the same requirement. "Cleared ground level" is used as the depth datum because this level is not usually altered by future landscaping, thus retaining the lateral support of the building.

C3.3.2(b)
Most clay soils are affected by moisture movement. Expansive clays exhibit significant potential movements and once defined on the site require alternative specific foundation design.

Reference should be made to section 17 of NZS 3604 for further information.

3.4 Site preparation

3.4.1
Before a building is erected on any site all rubbish, noxious matter and organic matter shall be removed from the area to be covered by the building.

3.4.2
Any subsoil drains severed during the excavation process shall be reinstated or diverted and the building area shall be permanently drained, to ensure freedom from surface water.

C3.4.2
Foundation excavations should be backfilled with non-plastic material free from organic material and compacted up to cleared ground level.

NOTES

SECTION 4

SECTION 4

BRACING DEMAND

Table

Figure

NOTES

4 BRACING DEMAND

4.1 General

4.1.1

Foundation walls and *masonry walls* shall be constructed to resist the greater *bracing demand* imposed on the building by horizontal wind forces calculated as described in 4.3 or earthquake forces for different zones (see 4.2) calculated as described in 4.4.

4.1.2

The construction requirements of *bracing* structures and their *bracing capacity* to resist the *bracing demand* are contained in section 5.

4.2 Earthquake zones

4.2.1

The zoning in figure 4.1 shall be used in the determination of the *bracing demands* for buildings located in different regions of New Zealand.

Table 4.1 sets out the earthquake zone for principal localities in New Zealand.

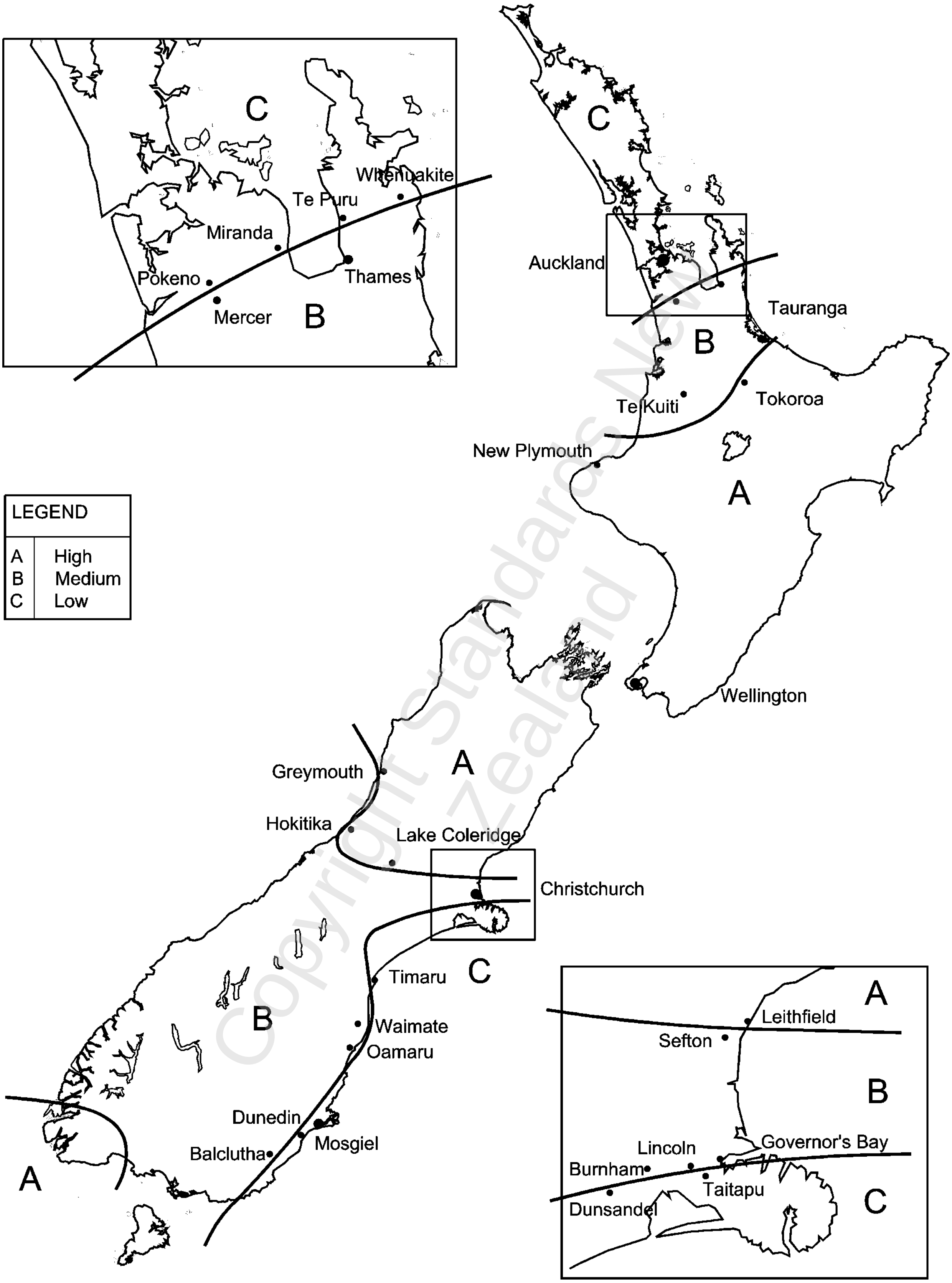


Figure 4.1 – Earthquake zones (see 4.2.1)

Table 4.1 – Earthquake zone (see 4.2.1)

Locality	Earthquake zone	Locality	Earthquake zone
North Island		**South Island**	
Kaitaia	C	Nelson	A
Whangarei	C	Blenheim	A
Dargaville	C	Christchurch	B
Helensville	C	Lyttleton	B
Auckland	C	Timaru	C
Thames	B	Oamaru	B
Paeroa	B	Westport	A
Coromandel	C	Greymouth	A
Whitianga	C	Hokitika	A
Hamilton	B	Dunedin	C
Waihi	B	Invercargill	B
Tauranga	B	Alexandra	B
Rotorua	A		
Taumarunui	A		
Taupo	A		
Gisborne	A		
Napier	A		
Hastings	A		
New Plymouth	A		
Wanganui	A		
Palmerston North	A		
Dannevirke	A		
Wellington	A		

4.3 Calculations of bracing demand – Wind

4.3.1

The minimum number of *bracing units* per lineal metre transverse to the wind direction shall be taken from table 4.2.

C4.3

Because in the majority of building applications permitted by this Standard, horizontal loading requirements are dominated by earthquake forces a simplified approach to the wind force determinations has been applied.

Where it is found that wind forces govern the design of a masonry building the design may be re-evaluated using the procedures described in NZS 3604 to determine the bracing demand from wind forces.

Table 4.2 – Wind bracing demand per lineal metre (see 4.3.1)

Single storey or upper storey : Minimum bracing demand (Bracing units per lineal metre)

Height to apex H, (m)	Roof height, h (m)	Storey height (m)	Across ridge	Along ridge
All heights up to 10 m	1	All heights up to 3.0 m	56	74
	2		80	93
	3		111	111
	4		160	130
	5		241	148
	6		278	167
	7		315	185
	8		352	204

Lower of 2 storeys : Minimum bracing demand (Bracing units per lineal metre)

Height to apex H, (m)	Roof height, h (m)	Storey height (m)	Across ridge	Along ridge
6	1	Up to 3.0	141	159
	2		128	141
	3		122	122
	4		134	104
7	1	Up to 3.0	178	196
	2		165	178
	3		159	159
	4		171	141
	5		215	122
8	1	Up to 3.0	215	233
	2		202	215
	3		196	196
	4		208	178
	5		252	159
	6		252	141
9	1	Up to 3.0	252	270
	2		239	252
	3		233	233
	4		245	215
	5		289	196
	6		289	178
	7		289	159
10	1	Up to 3.0	289	307
	2		276	289
	3		270	270
	4		282	252
	5		326	233
	6		326	215
	7		326	196
	8		326	178

NOTE –

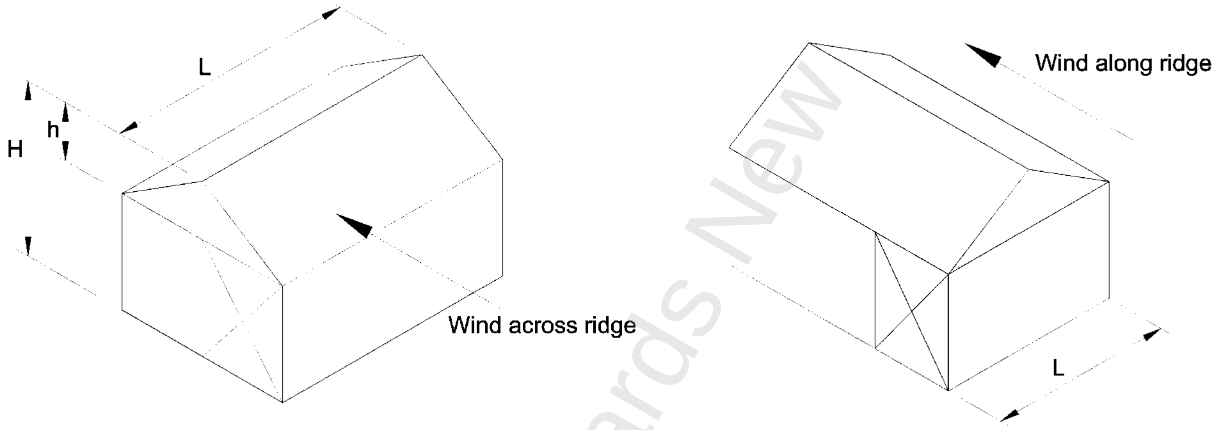
(1) The tabulated figures are the worst case figures used in NZS 3604.

(2) See figure 4.2 for clarification of height to apex, H and roof height, h.

4.4 Calculation of bracing demand – Earthquake

4.4.1

The minimum number of *bracing units* per square metre of floor area per *storey* shall be selected by reference to table 4.3 which covers the combinations of construction permitted by this Standard.



(A) ACROSS RIDGE
(shall be also used for hip roofs)

(B) ALONG RIDGE

NOTE - Braced walls are parallel to the wind direction and **L** is at right angles to the wind direction.

Figure 4.2 – Directions of wind and braced walls (see table 4.2)

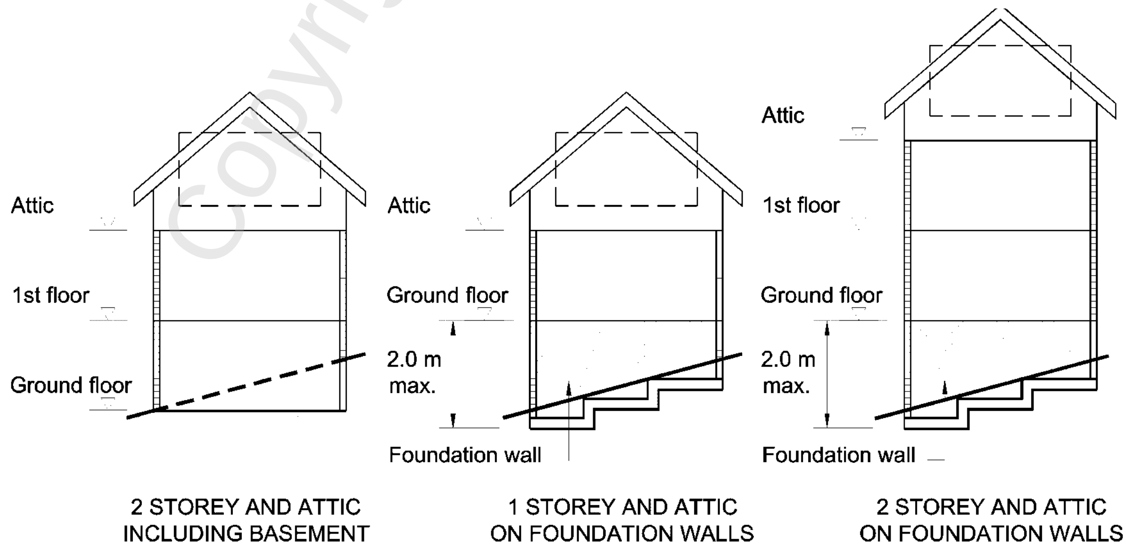


Figure 4.3 – Building storeys (see table 4.3)

Table 4.3 – Earthquake bracing demand

Single storey or top storey		**Concrete slab-on-ground**			
Building description (with light roof)	**Masonry wall series**	**Minimum bracing units /m^2 in earthquake zone**			
		A	B	C	For top storey timber construction see NZS 3604
Partial filled masonry	15	19	14	9	
	20	20	15	10	
	25	23	17	12	
For solid filled masonry	Multiply	x 1.4	x 1.4	x 1.4	
For heavy roof	Add	3	3	3	

Single storey or top storey		**Concrete slab-on-ground**			
Building description (with light roof)	**Masonry wall series**	**Minimum bracing units /m^2 in earthquake zone**			
		A	B	C	For top storey timber construction see NZS 3604
Veneer with partial filled masonry	15	27	20	13	
	20	28	21	14	
For solid filled masonry	Multiply	x 1.4	x 1.4	x 1.4	
For heavy roof	Add	3	3	3	

Building description (with light roof)		**Intermediate concrete floor**			**Intermediate timber floor**		
	Masonry wall series	**Minimum bracing units /m^2 in earthquake zone**			**Minimum bracing units /m^2 in earthquake zone**		
Bottom of 2 storey		A	B	C	A	B	C
Partially filled masonry for both storeys	15	82	61	41	46	35	23
	20	87	65	44	51	38	26
	25	96	72	48	60	45	30
For solid filled masonry	Multiply	x 1.3	x 1.3	x 1.3	x 1.3	x 1.3	x 1.3
For heavy roof	Add	3	3	3	3	3	3
1st storey partially filled masonry, no veneer with a 2nd storey timber with veneer	15	85	64	42	49	37	25
	20	86	65	43	51	39	27
	25	89	67	45	54	41	28
For solid filled masonry	Multiply	x 1.1	x 1.1	x 1.1	x 1.15	x 1.15	x 1.15
For heavy roof	Add	3	3	3	3	3	3
1st storey partially filled masonry, no veneer with a 2nd storey timber lightweight cladding	15	67	50	33	31	23	16
	20	68	51	34	33	25	17
	25	71	54	36	36	27	18
For solid filled masonry	Multiply	x 1.15	x 1.15	x 1.15	x 1.2	x 1.2	x 1.2
For heavy roof	Add	3	3	3	3	3	3

Table 4.3 – Earthquake bracing demand (continued)

Building description (with light roof)	**Masonry wall series**	**Intermediate concrete floor** Minimum bracing units /m^2 in earthquake zone			**Intermediate timber floor** Minimum bracing units /m^2 in earthquake zone		
Bottom of 2 storey		A	B	C	A	B	C
Veneer with partially filled masonry for both stories	15 20	106 111	80 83	53 56	70 75	53 56	35 38
For solid filled masonry	Multiply	x 1.2	x 1.2	x 1.2	x 1.2	x 1.2	x 1.2
For heavy roof	Add	3	3	3	3	3	3
Veneer with 1st storey partially filled masonry with a 2nd storey timber with veneer	15 20	93 95	70 71	46 47	57 59	43 44	29 30
For solid filled masonry	Multiply	x 1.1	x 1.1	x 1.1	x 1.15	x 1.15	x 1.15
For heavy roof	Add	3	3	3	3	3	3
Veneer with 1st storey partially filled masonry with a 2nd storey timber lightweight cladding	15 20	75 77	56 57	37 38	39 41	29 31	20 21
For solid filled masonry	Multiply	x 1.15	x 1.15	x 1.15	x 1.2	x 1.2	x 1.2
For heavy roof	Add	3	3	3	3	3	3

Foundation wall		**Minimum bracing units /m^2 in earthquake zone**					
		A	B	C	A	B	C
Foundations 2 m maximum height including concrete suspended floor at ground level	Any	215	161	107	179	134	90

NOTE –

(1) All values are based on using a 45° roof pitch.

(2) The heavy roof bracing demand is added directly to the partially filled values or the calculated values in respect of the solid filled masonry.

(3) All values relate to bracing demand for walls at lowest complete floor level.

(4) For bracing demands at first floor of 2 storey buildings use single storey figures or for a timber upper storey use bracing figures from NZS 3604.

(5) The foundation bracing demands are based on the maximum possible demands from combinations of construction permitted by this Standard, which includes an allowance for a suspended concrete slab.

(6) Veneer construction with 25 masonry wall series has not been included in this Standard and is, therefore, subject to specific engineering design.

NOTES

SECTION 5

SECTION 5

WALL BRACING CAPACITY

Table

NOTES

5 WALL BRACING CAPACITY

5.1 General

5.1.1
For the purpose of this section a *wall bracing panel* shall be any partial or solid filled *structural masonry* panel and rated at the number of *bracing units* given in table 5.1.

C5.1.1
Wall bracing elements of materials other than masonry may be used provided they are rated at a level having the equivalent strength and stiffness to the masonry wall bracing panels provided in this Standard.

5.1.2
The use of partial and solid filled *structural masonry* panels together in any *bracing* series shall be permitted and the *bracing capacity* of the series is the total summation of individual panel capacities from table 5.1.

C5.1.2
While at serviceability state levels the solid filled panel will attract higher loads, testing has demonstrated that at ultimate state the deflections are similar.

5.2 Bracing panels within structural walls

5.2.1
Structural walls shall be subdivided into *bracing* panels of various heights and lengths as dictated by wall openings, *control joints* and wall ends for the purpose of obtaining the contribution of each wall *bracing* element.

C5.2.1
An example calculation in Appendix A illustrates the principles of application of this clause.

Note that maximum lengths of bracing panels in long walls without openings are controlled by the maximum spacing of control joints specified in section 13.

5.2.2
The total *bracing capacity* for a *structural wall* shall be the summation of the *bracing capacities* for all the *bracing* panels within the wall.

5.2.3
The length of a *bracing* panel shall be that length along the wall between wall ends, openings and *control joints*.

5.2.4
Openings not more than 400 mm x 400 mm and spaced at 1.8 m centres or greater may be included in the length and height of a *bracing* panel.

5.2.5
The height of a *bracing* panel shall be the lesser of the height of the *structural wall* or the minimum height of any adjacent wall opening.

5.2.6
Panels less than 800 mm in length or greater than 3000 mm in height shall not be included in the *bracing* value of a wall.

5.3 Reinforcement of bracing panels

5.3.1

All *bracing* panels of partially filled *masonry* shall be reinforced both horizontally and vertically in accordance with table 8.2(a) and all *bracing* panels of solid filled *masonry* shall be reinforced both vertically and horizontally in accordance with table 8.2(b). The end of each horizontal bar shall be either hooked around the end vertical *reinforcement* or bent down beside it for a distance of not less than 250 mm.

5.4 Non-continuous walls

5.4.1

Where *bracing* panels are not contained within a continuous *structural wall*, additional lengths of *foundations* shall be provided in accordance with 6.8 to prevent the *wall bracing panel* from overturning.

5.5 Masonry frames

5.5.1

Masonry frames shall be the subject of specific engineering design and are outside the scope of this Standard.

C5.5.1

Such frames are often required when design constraints mean insufficient wall lengths are available to meet the bracing demand e.g. at a garage door opening.

Table 5.1 – Bracing capacity of panels (Bracing units) (see 5.1.1)

15 Series Partial Fill

Panel height (m)	Panel length (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**
0.8	385	650	1005	1425	1935	2505	2525	3110	3755	4455	5220	6040	6930	7870
1.0	330	560	865	1230	1670	2165	2185	2690	3245	3855	4520	5225	5995	6810
1.2	275	470	730	1035	1405	1825	1840	2265	2740	3250	3810	4415	5060	5750
1.4	245	420	650	930	1260	1635	1650	2030	2460	2920	3420	3960	4540	5160
1.6	215	370	575	820	1115	1445	1460	1800	2175	2580	3030	3505	4020	4575
1.8	195	335	525	750	1020	1325	1340	1650	1995	2370	2780	3220	3695	4200
2.0	180	305	480	680	925	1205	1220	1500	1815	2155	2530	2930	3360	3825
2.2	165	280	445	635	860	1120	1135	1400	1690	2005	2360	2730	3135	3565
2.4	155	260	410	585	800	1040	1050	1295	1565	1860	2185	2530	2905	3305
2.6	145	245	385	550	750	980	985	1220	1475	1755	2060	2385	2740	3115
2.8	130	230	360	515	705	915	925	1140	1380	1645	1930	2240	2570	2920
3.0	125	215	340	490	665	870	880	1085	1315	1560	1835	2125	2440	2780

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20 Series Partial Fill

Panel height (m)	Panel length (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**
0.8	390	655	1015	1445	1955	2535	2560	3145	3800	4510	5285	6120	7015	7970
1.0	335	565	875	1245	1690	2195	2215	2720	3290	3905	4580	5300	6080	6905
1.2	280	475	740	1050	1430	1855	1870	2300	2780	3300	3870	4480	5140	5840
1.4	250	425	660	940	1280	1665	1680	2065	2500	2965	3480	4030	4620	5255
1.6	220	375	585	835	1130	1475	1485	1830	2215	2635	3085	3575	4100	4660
1.8	200	345	535	765	1040	1350	1365	1680	2035	2420	2840	3285	3770	4285
2.0	180	310	485	695	945	1230	1245	1535	1855	2205	2590	3000	3440	3910
2.2	170	290	450	650	880	1150	1160	1430	1730	2060	2415	2800	3210	3655
2.4	155	270	420	600	820	1065	1075	1325	1605	1910	2240	2600	2980	3395
2.6	145	250	395	565	770	1005	1015	1250	1515	1800	2115	2450	2815	3200
2.8	135	235	370	530	720	945	950	1175	1420	1695	1990	2305	2645	3010
3.0	130	220	350	500	685	895	905	1115	1350	1610	1890	2195	2520	2865

NOTE – There is a change in the permitted bracing capacity of panels at lengths 3.0 m and larger. See Appendix A3.2.

Table 5.1 – Bracing capacity of panels (Bracing units) (continued) (see 5.1.1)

25 Series Partial Fill

Panel height (m)	Panel length (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**
0.8	390	660	1025	1465	1980	2565	2590	3180	3845	4560	5350	6195	7100	8070
1.0	335	570	885	1265	1715	2225	2240	2760	3335	3960	4640	5375	6160	7005
1.2	285	480	750	1065	1450	1880	1900	2335	2820	3350	3935	4555	5220	5940
1.4	250	430	670	955	1300	1690	1705	2100	2540	3020	3540	4100	4700	5345
1.6	220	380	595	850	1150	1505	1515	1865	2255	2685	3140	3640	4185	4760
1.8	200	350	545	780	1060	1380	1390	1715	2075	2470	2895	3355	3855	4380
2.0	180	320	495	710	970	1255	1270	1565	1900	2255	2645	3065	3520	4000
2.2	170	295	460	665	905	1175	1185	1460	1775	2110	2475	2865	3290	3740
2.4	160	275	425	615	835	1090	1100	1360	1650	1960	2300	2670	3060	3480
2.6	150	255	400	575	790	1030	1040	1280	1555	1850	2175	2520	2890	3290
2.8	140	235	375	540	740	970	980	1200	1460	1740	2045	2375	2720	3100
3.0	135	225	355	515	705	920	935	1150	1390	1660	1950	2260	2595	2955

15 Series Solid Fill

Panel height (m)	Panel length (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**
0.8	385	700	1020	1445	1965	2545	2570	3160	3815	4530	5310	6145	7050	8010
1.0	330	605	880	1250	1700	2205	2225	2740	3310	3930	4605	5340	6120	6955
1.2	280	510	740	1055	1435	1865	1880	2320	2805	3330	3905	4525	5190	5900
1.4	250	460	665	950	1290	1675	1695	2085	2520	3000	3515	4075	4675	5315
1.6	220	405	590	840	1145	1490	1500	1855	2240	2665	3125	3620	4160	4725
1.8	200	370	540	770	1050	1370	1380	1705	2060	2450	2880	3335	3825	4355
2.0	185	340	495	705	960	1250	1260	1555	1885	2240	2630	3045	3500	3980
2.2	170	315	460	655	895	1165	1180	1455	1760	2095	2460	2850	3270	3720
2.4	155	290	425	605	830	1080	1095	1350	1635	1945	2285	2650	3045	3460
2.6	145	270	400	575	780	1020	1035	1275	1545	1840	2160	2505	2880	3275
2.8	135	255	375	540	735	960	975	1200	1455	1730	2035	2360	2705	3085
3.0	130	240	355	510	700	915	925	1140	1385	1650	1940	2245	2580	2940

NOTE – There is a change in the permitted bracing capacity of panels at lengths 3.0 m and larger. See Appendix A3.2.

Table 5.1 – Bracing capacity of panels (Bracing units) (continued) (see 5.1.1)

20 Series Solid Fill

Panel height (m)	Panel length (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**
0.8	395	665	1040	1480	2010	2605	2625	3245	3920	4925	5780	6320	7250	8240
1.0	340	575	905	1285	1745	2265	2285	2825	3415	4290	5035	5510	6320	7190
1.2	285	485	765	1090	1485	1925	1945	2405	2910	3655	4285	4700	5395	6135
1.4	255	435	690	980	1340	1735	1760	2170	2630	3300	3870	4250	4880	5550
1.6	225	390	610	875	1195	1550	1570	1940	2350	2940	3460	3800	4365	4965
1.8	205	355	560	805	1100	1430	1445	1790	2170	2720	3195	3515	4040	4595
2.0	185	325	515	735	1005	1310	1325	1640	1990	2495	2930	3230	3710	4220
2.2	175	305	480	690	940	1225	1240	1540	1865	2335	2745	3030	3480	3960
2.4	160	280	445	640	875	1145	1160	1440	1740	2180	2560	2830	3255	3700
2.6	150	265	420	605	830	1080	1100	1360	1650	2065	2425	2685	3085	3515
2.8	145	250	395	575	780	1020	1035	1285	1560	1950	2295	2540	2920	3320
3.0	135	235	380	545	750	975	990	1230	1495	1860	2190	2430	2795	3180

25 Series Solid Fill

Panel height (m)	Panel length (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**
0.8	405	580	1065	1515	2055	2660	2685	3335	4030	5360	6295	6500	7460	8480
1.0	350	505	925	1320	1795	2325	2350	2915	3520	4680	5500	5690	6530	7430
1.2	295	425	790	1125	1530	1985	2010	2495	3020	4005	4705	4880	5605	6380
1.4	265	390	710	1015	1390	1800	1825	2260	2740	3625	4265	4440	5095	5800
1.6	235	350	630	905	1245	1610	1640	2030	2460	3250	3825	3990	4580	5220
1.8	210	320	585	840	1150	1495	1515	1880	2280	3015	3540	3705	4260	4845
2.0	190	295	535	770	1055	1375	1395	1735	2105	2775	3260	3420	3930	4480
2.2	180	275	505	725	990	1290	1310	1630	1980	2605	3070	3220	3705	4220
2.4	165	260	470	675	930	1210	1230	1530	1855	2440	2875	3025	3480	3960
2.6	160	245	445	640	880	1145	1165	1455	1765	2320	2730	2880	3315	3770
2.8	150	230	420	610	835	1085	1100	1380	1680	2195	2585	2740	3150	3580
3.0	140	215	400	580	800	1040	1055	1320	1610	2105	2480	2625	3020	3440

NOTE – There is a change in the permitted bracing capacity of panels at lengths 3.0 m and larger. See Appendix A3.2.

NOTES

SECTION 6

SECTION 6
FOOTINGS

Table

Figure

NOTES

6 FOOTINGS

6.1 General

6.1.1

Every *masonry* wall, whether *loadbearing* or *non-loadbearing*, shall be supported by a continuously *reinforced masonry* or reinforced concrete *foundation* of the *dimensions* and *reinforcement* given in this section.

C6.1.1

For cantilevered and retaining walls see Appendices B and C.

6.1.2

The *foundation footing* shall be formed symmetrically about the centre line of the wall. Where this is not possible, then the design shall be in accordance with Appendix B or shall become the subject of specific engineering design.

C6.1.2

Sometimes 6.1.2 cannot be complied with because a wall is to be built up to a boundary or for some other reason a footing can not be formed symmetrically. Then it will be necessary to consider alternative design methods.

6.1.3

The *foundation footing* shall have all soil bearing surfaces horizontal but may be stepped to accommodate variations in *cleared ground level* or variations in depth of formation level to provide a safe bearing pressure as defined in 3.3.

C6.1.3

Where the formation level is excavated to some depth and variation of position below ground, then the sub-footing or the trench fill method outlined in 6.5 may be used to bring the footing to a co-ordinated datum in relation to the foundation wall above the footing, e.g. coursing of blocks.

6.1.4

Balconies shall be subject to specific engineering design along with the *footing* supporting balconies.

6.2 Width of footings

6.2.1

Subject to 6.2.3, the width of a *footing* shall be determined from the sum of the loads that it supports (i.e. from walls, floors and *roof*) derived in 6.2.2.

6.2.2

The load on a *foundation* shall be calculated using the following procedure:

(1) Determine the wall height in metres.

(2) Multiply the wall height by the factored unit weight of the wall from table 6.1 to obtain the contributing weight to the *footing* (=A).

NOTE – For walls with a change of construction over the height, calculate the weights of the components and sum.

(3) Determine the span of the *roof* being supported by the wall (=distance between supporting walls).

(4) Enter figure 6.1 to determine the contributing weight to the *footing* (=B).

NOTE – If there is more than one span of *roof* supported on a wall then calculate the weights of the *roofs* individually from steps 3 and 4 and sum.

(5) At each storey, determine the suspended floor span on each side of the supporting wall (= the distance between supporting walls).

C6.2.2

The width of a footing is determined from the consideration of loads on the foundation, which consist of the following:

(a) The total weight of the wall in kN/m calculated from the summation of component weights.

(b) The floor live loads of the building limited by 1.1.3.

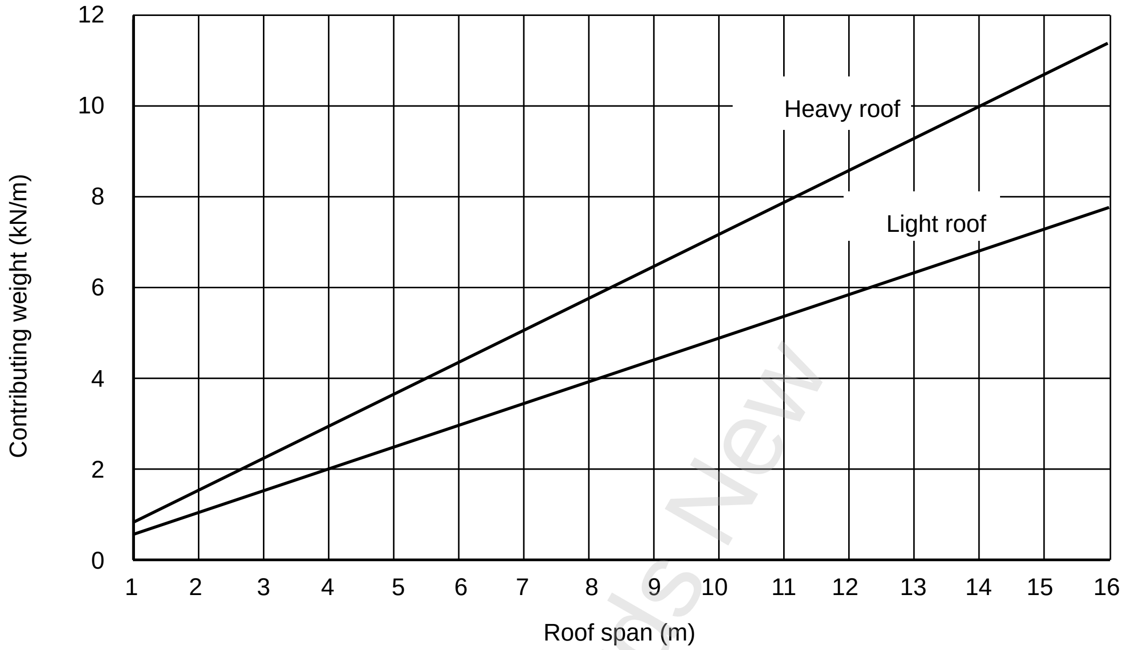
(c) The roof span supported by the wall.

(d) The roof covering (heavy or light).

Table 6.1 – Wall types and wall weights (see 6.2.2)

Form of construction (Type)	**Nominal wall thickness** (mm)	**Mass of wall** (kg/m^2)	**Unit weight of wall** (kN/m^2)	**Factored unit weight of wall** (kN/m^2) (Note below)
Single skin block density 1850 kg/m^3 Solid filled with grout	100 150 200 250 150 + 100 veneer 200 + 100 veneer	170 270 370 465 440 540	1.7 2.6 3.6 4.6 4.3 5.3	2.0 3.1 4.3 5.5 5.2 6.4
Single skin block density 1850 kg/m^3 fourth cores filled with grout (800 mm centres)	100 150 200 250 150 + 100 veneer 200 + 100 veneer	115 160 220 275 330 390	1.1 1.6 2.2 2.7 3.2 3.8	1.3 1.9 2.6 3.2 3.9 4.6
Single skin block density 2200 kg/m^3 Solid filled with grout	100 150 200 250 150 + 100 veneer 200 + 100 veneer	185 290 400 505 460 570	1.8 2.8 3.9 5.0 4.5 5.6	2.2 3.4 4.6 6.0 5.4 6.7
Single skin block density 2200 kg/m^3 fourth cores filled with grout (800 mm centres)	100 150 200 250 150 + 100 veneer 200 + 100 veneer	145 210 245 310 380 415	1.4 2.1 2.4 3.0 3.7 4.1	1.7 2.5 2.9 3.6 4.5 4.9
Timber frame + heavyweight cladding (e.g. clay or concrete masonry veneer)		242	2.4	2.9
Timber frame + medium weight cladding (e.g. stucco cladding)		102	1.0	1.2
Timber frame + lightweight cladding (e.g. weatherboards)		52	0.5	0.6

NOTE – Factored unit weight is to be used in this Standard (see Appendix A).



NOTE – The above roof weight values include maximum ceiling weight of 0.1 kPa.

Figure 6.1 – Roof weight contribution (see 6.2.2)

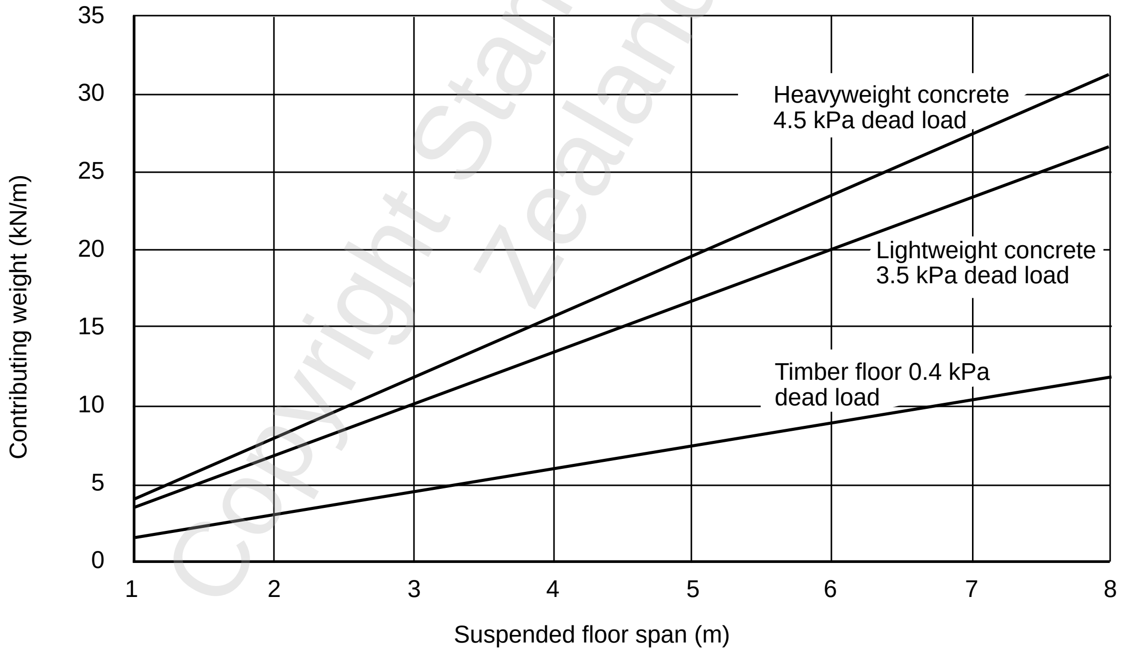


Figure 6.2 – Suspended floor weight contribution (see 6.2.2)

Notes to figure 6.2

(1) Graphs include live loads.

(2) The weight of a concrete floor will need to be ascertained from the specific design of that floor. Typically, constructions for the above concrete floor weights are:

(a) 4.5 kPa: *In situ* concrete slabs 190 mm thick or prestressed flat slabs with concrete toppings.

(b) 3.5 kPa: Prestressed beams with timber infills and concrete toppings or composite steel and concrete floors.

(3) Timber floors allow for 20 mm particle board flooring, floor framing and a 12 mm plasterboard ceiling lining.

Table 6.2 – Dimensions and reinforcement details for footings (see 6.3.1)

	Contributing load on footing (kN/m)				
	0 – 40	**41 – 60**	**61 – 75**	**76 – 90**	**91 – 100**
Width (mm)	300	450	550	650	750
Depth (mm)	200	250	300	350	400
Steel (Grade 300)	2/D12 R6 @ 600	2/D16 R6 @ 600	3/D16 R6 @ 600	4/D16 R6 @ 600	5/D16 R6 @ 600

NOTE –
(1) 2/D12 bars may be substituted for 1/D16 bar.
(2) Minimum width in sand to be 400 mm.
(3) Minimum width for supporting masonry walls plus masonry veneer to be 450 mm.

(e) The sum of loads transferred by floor spans supported by the wall (Maximum of 2 floors supported on each side of the wall). For this figure 6.2 has identified 3 types of floor:

(i) Heavyweight concrete floors (maximum dead load = 4.5 kPa). Systems such as pre-stressed flat slabs with structural topping and cast in situ floors.

(ii) Lightweight concrete floors (maximum dead load = 3.5 kPa). Systems such as pre-stressed beams with timber infill and structural topping and composite steel floors.

(iii) Timber floors.

C6.4
The maximum footing width commonly available with the construction technique described under this clause is 300 mm. However, by the provision of the sub-footing as given in 6.5, a much greater range of application is available.

(6) Enter figure 6.2 to determine the contributing weights to the footing (=C1 & C2 & C3 & C4).

NOTE – If there is more than one span of floor supported on a wall then calculate the weights of the floors individually from steps 5 and 6 and sum.

Where concrete floors are used, the weight of the floor must be known and the appropriate line used. Interpolation between the lines is allowed where the floor weights differ from those shown.

NOTE – Footings for walls which have floors cantilevering over the supporting wall must be the subject of specific engineering design.

(7) Sum the contributing weights to the footing (=A+B+ΣC) to obtain the total contributing weight.

(8) Using the total contributing load, determine the footing dimensions and *reinforcement* details from table 6.2.

6.2.3
When supported on sand the width of *footing* shall not be less than 400 mm.

6.3 Reinforced concrete footings

6.3.1
The *dimensions* shall be selected from table 6.2 as appropriate to the calculated vertical load except where a sub-footing complying with 6.5 has been used below the *footing*.

6.4 Reinforced masonry footings

6.4.1
For vertical loads up to 40 kN/m of *reinforced masonry footings* may be used provided that they shall comply with the requirements of figure 6.3.

6.4.2
The *reinforcement* and concrete grout shall be placed in the *footing* before proceeding with the construction of the wall.

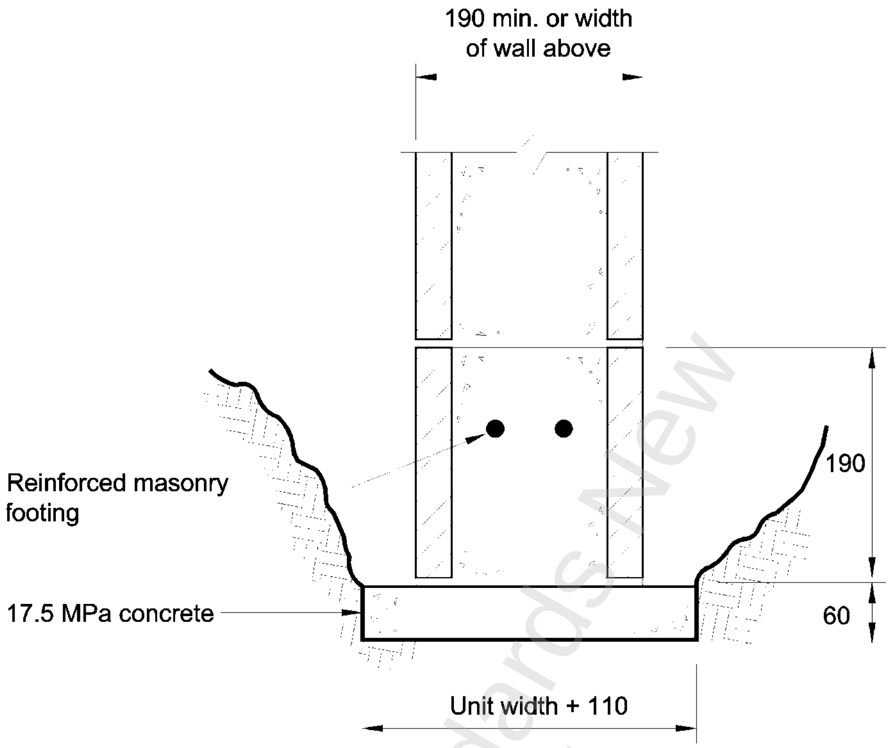


Figure 6.3 – Reinforced masonry footing (see 6.4.1)

6.5 Mass concrete sub-footings

6.5.1

Where a sub-footing is provided and it is required to spread the load from the reinforced concrete or *reinforced masonry footing* above, the sub-footing shall have:

(a) A width equal to that required from table 6.2.

(b) A minimum *thickness* of 200 mm or d_2 + 100 mm, whichever is the greater, where d_2 is the projection of the sub-footing from the face of the reinforced concrete or *reinforced masonry footing*. (See figure 6.4).

6.5.2

Where a sub-footing is provided and its width is equal to that of the reinforced concrete or *reinforced masonry footing* and equal to that width required from 6.2, then the minimum *thickness* shall be 50 mm.

6.5.3

The concrete used for sub-footings shall have a minimum compressive strength of 10 MPa as measured and tested in accordance with NZS 3109 and NZS 3112.

6.5.4

Every sub-footing shall have a reinforced concrete or *reinforced masonry footing* cast on top.

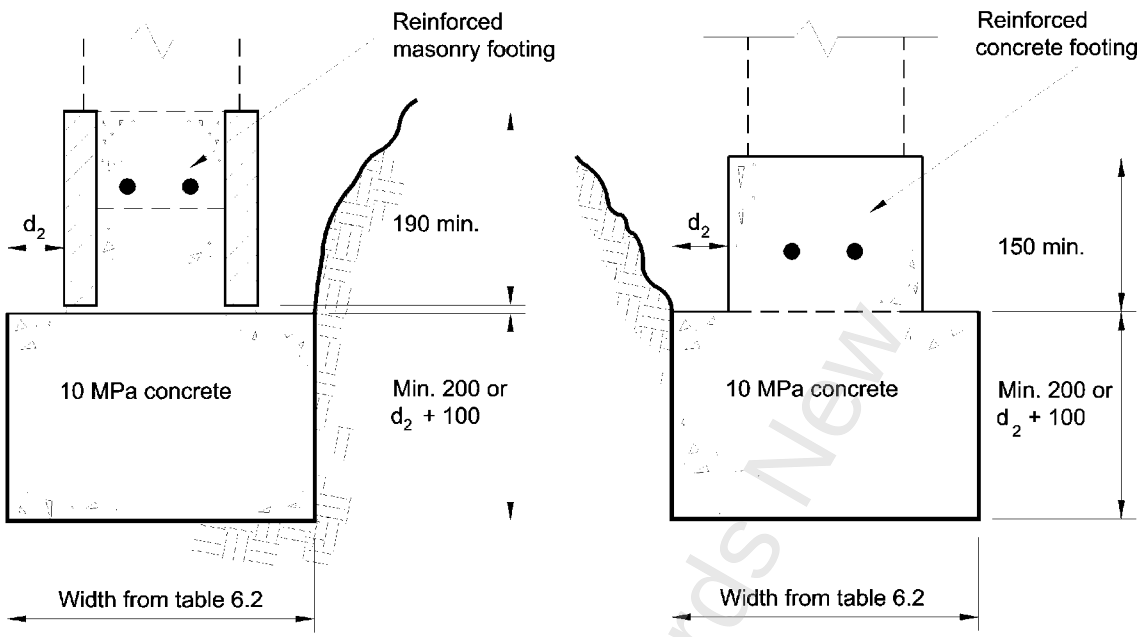
C6.5

The main advantage of the sub-footing or the trench fill technique is that it is a convenient way to allow for variations in formation level and to regulate the course heights or standard formwork heights in relation to the masonry walls constructed above.

The method also widens the scope for using reinforced masonry footings and simplifies the details for using thickened floor edge construction when founding in soils which require a foundation depth of 400 mm.

C6.5.1(b)

The width of the reinforced concrete footing may be reduced from the provisions of table 6.2 provided the requirements of (b) are met.



NOTE - Reinforcement complies with table 6.2.

Figure 6.4 – Mass concrete sub-footing (see 6.5.1(b))

6.6 Reinforcement of footings

6.6.1
Longitudinal *footing reinforcement* shall be as specified in table 6.2.

6.6.2
Footing reinforcement shall be tied with R6 at 600 mm centres and placed as shown in figure 6.5 or R10 at 600 mm centres as shown in figure 6.6.

Where *footing* concrete is protected by a *damp-proof membrane*, the 75 mm cover shown in figures 6.5 and 6.6 may be reduced to 50 mm.

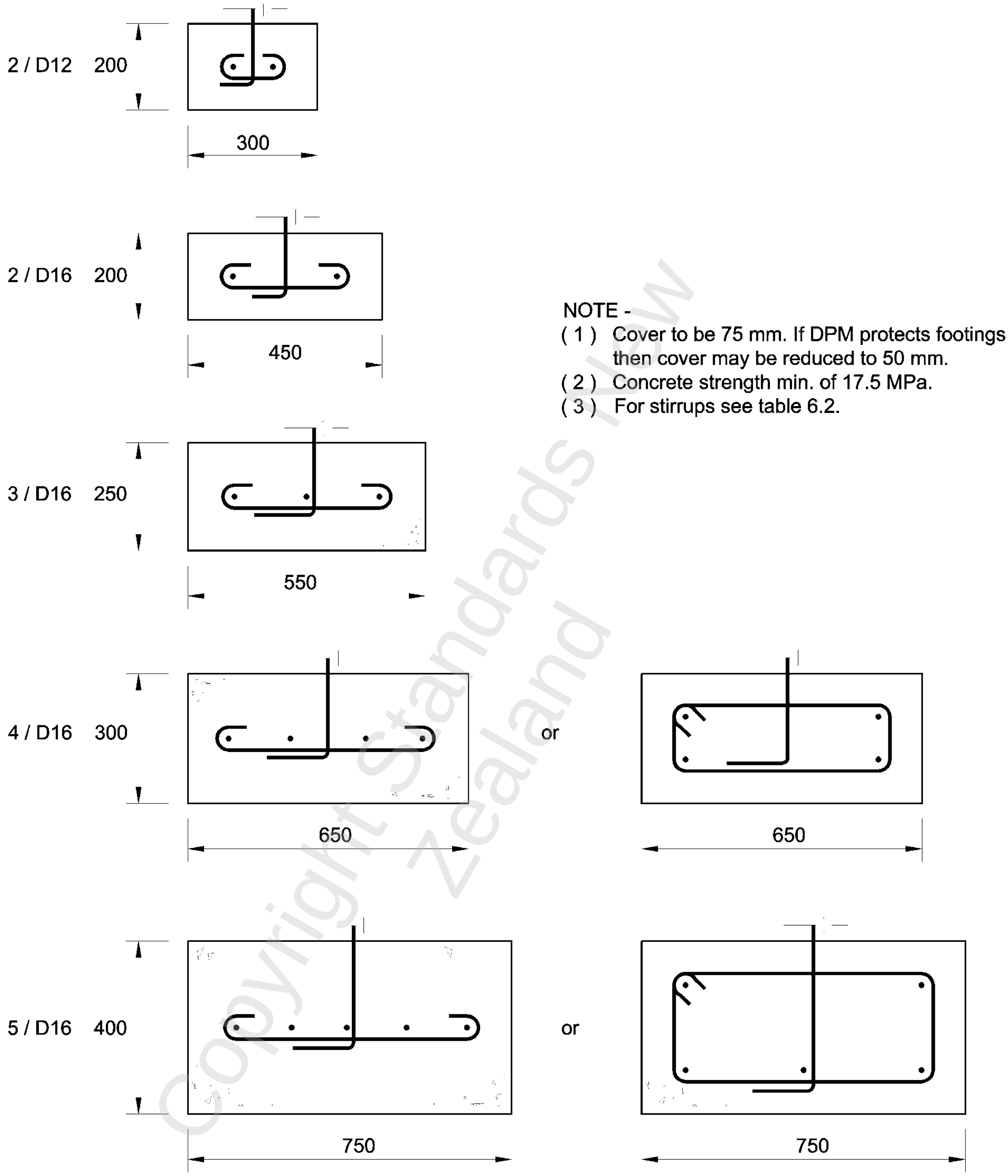
C6.6.2
It is recognized that some flexibility in placement will be required to suit tying of wall starter bars. Provided the reinforcement is placed "in the vicinity" of that shown in figures 6.5 and 6.6, and cover requirements are complied with, then placement will be deemed to be acceptable.

6.6.3
Continuity of *footing reinforcement* shall be maintained by lapping bars with a lap length of not less than 40 times the diameter of the bar.

6.6.4
Where the *footing* of a *foundation wall* is stepped an equivalent of 50 % of the area of *reinforcement* in the lower *footing* shall be turned up the vertical face of the step and extended 450 mm beyond the step intersection. Fifty percent of the upper *footing reinforcement* shall also project into the wall 450 mm beyond the intersection, or 350 mm if provided with a standard hook. (See figure 6.7).

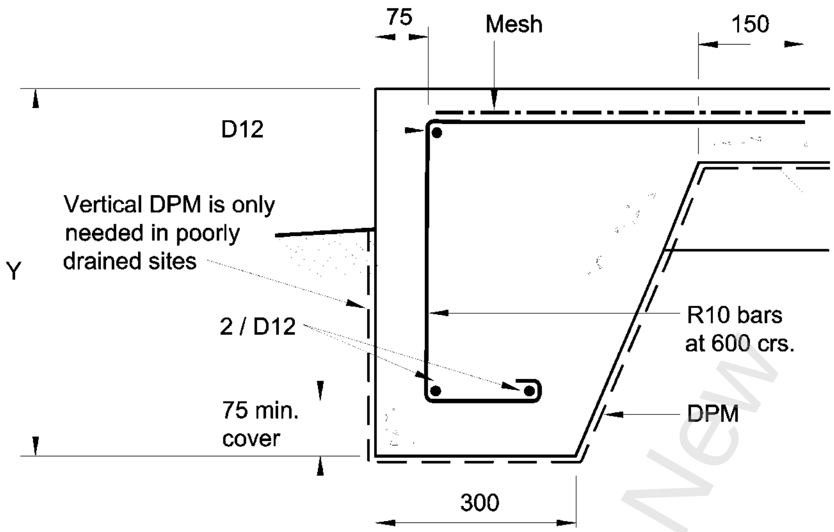
C6.6.4
The hooked overlap condition relates to the use of a masonry bond beam unit normally 400 mm in length.

6.6.5
Reinforcement at intersections of *footings* shall be as detailed in figure 6.8.



NOTE -
(1) Cover to be 75 mm. If DPM protects footings then cover may be reduced to 50 mm.
(2) Concrete strength min. of 17.5 MPa.
(3) For stirrups see table 6.2.

Figure 6.5 – Reinforcement of footings (see table 6.2 and 6.6.2)



NOTE -
(1) Where maximum loading exceeds 40 kN / m then a conventional separate wall / footing is to be used.
(2) Where Y exceeds 600 mm an additional horizontal D12 bar shall be used at mid height.

Figure 6.6 – Edge thickened slab (see 6.6.2)

6.7 Vertical wall starter reinforcement

6.7.1

Vertical wall starter *reinforcement* of the same diameter, type, *spacing* and location as the wall vertical *reinforcement* shall be provided in every *footing* so as to penetrate the wall to a distance of not less than 600 mm.

6.7.2

Vertical wall starter *reinforcement* shall be tied and anchored by the provision of at least one 90^0 bend to a longitudinal bar contained in the *footing*. (See figure 6.5).

6.8 Transverse footings for isolated walls

6.8.1

Isolated transverse *structural walls* which are not part of a continuous wall shall be provided with a *footing* which shall extend beyond the wall to a *foundation* which is continuous and supports at least one other *masonry* wall.

6.8.2

The *footings* for isolated transverse *structural walls* shall be:

(a) Not less than 400 mm in depth and 300 mm in width;

(b) Reinforced with 4/D16 bars and R10 ties at 200 mm centres.

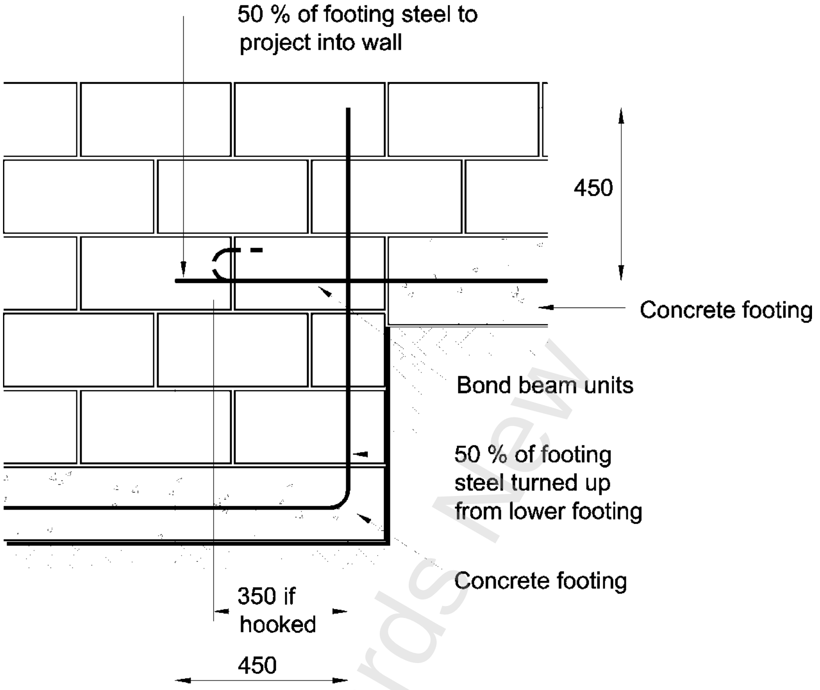
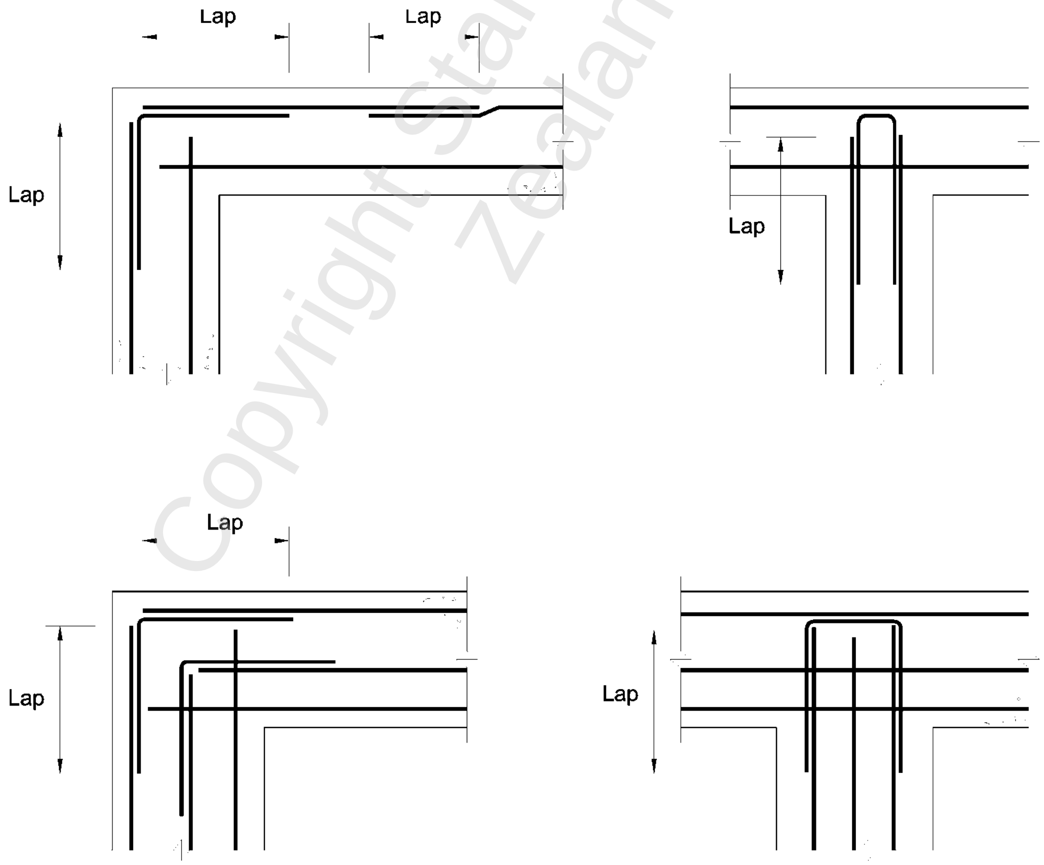


Figure 6.7 – Stepped footing (see 6.6.4)



NOTE - All lap lengths shall comply with 8.1.5.

Figure 6.8 – Reinforcement at footing intersections (see 6.6.5)

NOTES

SECTION 7

SECTION 7

FOUNDATION WALLS AND CONCRETE SLAB-ON-GROUND

Figure

NOTES

7 FOUNDATION WALLS AND CONCRETE SLAB-ON-GROUND

7.1 Foundation walls

7.1.1

Reinforced masonry foundation walls shall be constructed to the provisions set out in section 8.

7.1.2

No *foundation wall* shall be of lesser *thickness* than the *wall* above except where the *loadbearing wall* is constructed of timber and provides lateral support for a *masonry veneer*, in which case the top of the *foundation wall* shall be of sufficient width to support both the *veneer* and the timber frame.

7.1.3

Foundation walls subject to horizontal earth pressure shall comply with section 8 and Appendix C.

C7.1.3

Appendix C sets out details of the more commonly encountered conditions for retaining walls. Where specific soil, site conditions and loading are not covered by these conditions the wall will be required to be specifically designed.

7.1.4

Bond beams shall be provided at the top of all *masonry foundation walls* in accordance with section 10 where lateral support is provided by *bracing lines*.

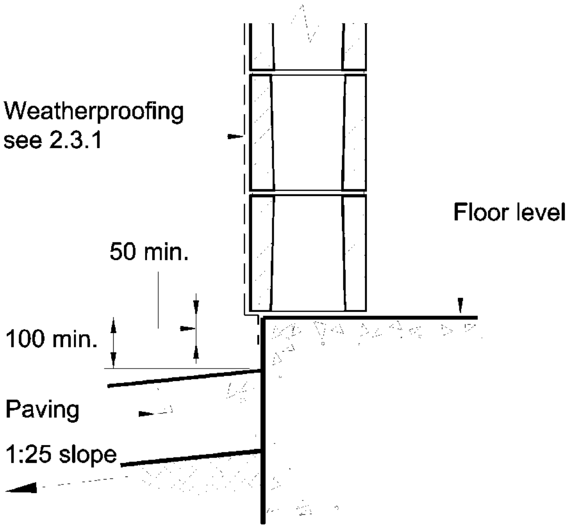
7.2 Slab-on-ground

7.2.1 Floor levels

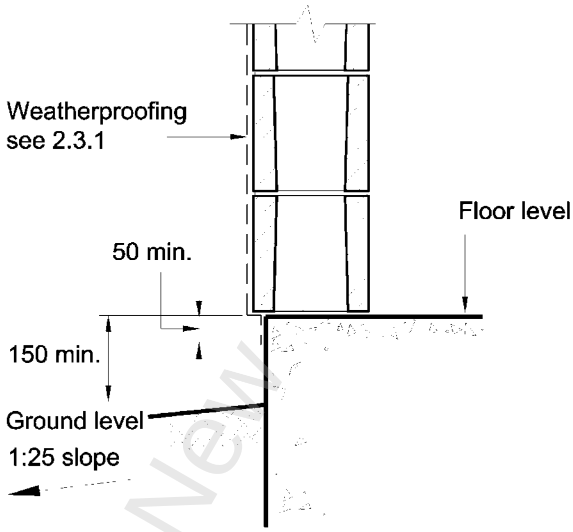
The finished level of a concrete slab-on-ground floor shall be a minimum height above the adjoining *finished ground level* of 150 mm or above paving of 100 mm in accordance with the provisions of figure 7.1.

C7.2.1

At a garage entrance, the minimum height may be reduced to 40 mm for this non-habitable area. Where the driveway slopes towards the slab-on-ground, then a drainage channel should also be provided to collect and dispose of surface water.



(A) PROTECTED WITH PAVING



(B) UNPROTECTED

NOTE - Maximum overhang of masonry wall over the concrete foundation is 20 mm.

Figure 7.1 – Minimum heights of finished concrete slab-on-ground floors above adjoining finished ground level (see 7.2.1)

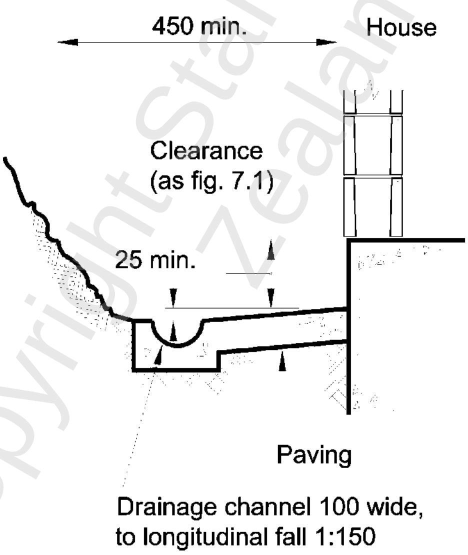


Figure 7.2 – Permanent paving adjoining buildings with slab-on-ground floors (see 7.2.2)

7.2.2
The *finished ground level* adjoining the concrete slab-on-ground shall be formed so as to carry water away from the building at a slope not less than 1 in 25 for a distance of at least 1 m from the building, or where site conditions do not allow such a 1 m wide strip to be formed, then permanent paving shall be laid to the falls and *dimensions* shown in figure 7.2.

7.2.3
The concrete *foundation* edge details shall be constructed to comply with figure 6.4.

7.3 Granular base

7.3.1

Granular rock fill material complying with 7.3.2 shall be placed in layers not less than 100 mm and not more than 150 mm thick over the area beneath the proposed slab-on-ground so that the total *thickness* of granular base is not less than 75 mm nor more than 600 mm.

C7.3.1
Specific engineering design is required if filling in excess of 600 mm.

7.3.2

Granular rock fill material shall be composed of rounded gravel, crushed rock, or scoria and:

(a) Not more than 5 % shall pass a 2.2 mm sieve;

(b) 100 % shall pass either:

(i) A 19 mm sieve for any fill *thickness*; or

(ii) A 37.5 mm sieve for a fill *thickness* exceeding 100 mm.

Fill material shall not be subject to deterioration nor significant expansion when in contact with water. Demonstration of these properties shall be to the satisfaction of the Territorial Authority.

Further the grading requirements for the 2.2 mm size can be waived where it can be shown that capillary water is unlikely to reach the underside of the slab. Such demonstration however is outside the scope of this Standard and must be to the satisfaction of the Territorial Authority.

C7.3.2
Proper grading of granular fill is important. Excessive fine material such as sand will cause problems with drainage, capillary action, compaction and settlement and must be avoided.

7.3.3

The top surface of the granular base shall be treated as necessary to receive the *damp-proof membrane* (DPM) in accordance with 7.4 to 7.7.

7.4 Damp-proof membrane

7.4.1

Every slab-on-ground floor shall incorporate a continuous *damp-proof membrane* (DPM) between the ground and the floor surface (see figure 7.3). The *damp-proof membrane* shall either be laid:

(a) Beneath the concrete ground slab on a surface suitable to receive the type of DPM material being used; or

(b) Over the concrete slab-on-ground and be protected by a concrete slab not less than 50 mm thick.

C7.4.1
A minimum slab thickness of 50 mm is required to resist vapour pressure and protect the DPM.

The requirement for an edge vapour barrier up to the face of external slab edge can be dispensed with in well drained sites.

7.4.2

The *damp-proof membrane* (DPM) shall:

(a) Have a water vapour flow resistance not less than 90 MNs/g when tested in accordance with ASTM E96 utilizing standard test conditions at 23 °C;

(b) Be of acceptable durability and strength to withstand the conditions of installation and end use.

C7.4.2
Various damp-proof membranes are available. Typical examples are polythene sheet, bituminous sheets and rubber emulsions. The specification details set out in this section are deemed to satisfy the requirements of 7.4.2.

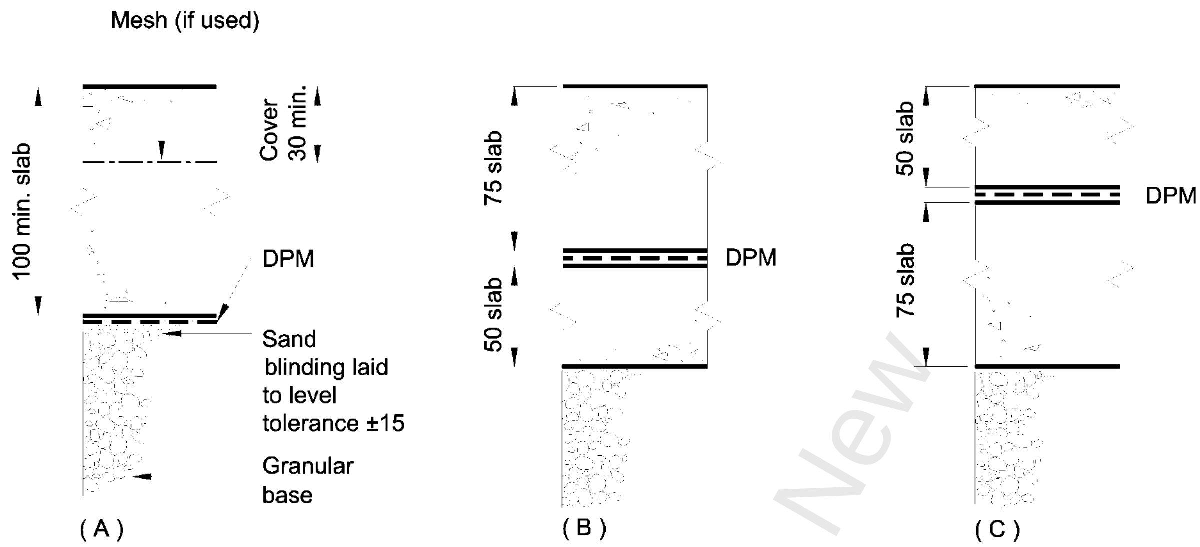


Figure 7.3 – Construction of slabs-on-ground (see 7.4.1)

7.4.3
Any *damp-proof membrane* material and its receiving surface specified in 7.5 to 7.8 inclusive shall be accepted as complying with 7.4.2.

7.4.4
More than one type of *damp-proof membrane* material may be used provided that there shall be adequate lapping between different materials.

7.4.5
Any penetrations through the *damp-proof membrane* shall be sealed.

C7.4.5
Penetrations by services or by reinforcing steel may be sealed by taping or by the use of a wet-applied damp-proof membrane material or by other means appropriate to the type of material.

7.4.6
Damp-proof membrane materials shall be repaired or replaced if necessary before concrete is placed over them.

7.5 Bituminous sheet damp-proof membranes

7.5.1
Bituminous sheet *damp-proof membrane* (DPM) material shall:

(a) Have a hessian or fibreglass core;

(b) Be not less than 3 mm thick;

(c) Have heat-bonded lap joints not less than 50 mm wide;

(d) Be protected from damage.

C7.5.1
Vertical faces cannot be exposed in any situation where the sheet might suffer damage.

7.5.2
Bituminous sheet *damp-proof membrane* material shall be laid over:

(a) A smooth-surfaced blinding layer not less than 10 mm *thickness* of coarse sand or a sand cement slurry; or

(b) Heavyweight building paper.

7.6 Polyethylene (polythene) sheet damp-proof membranes

C7.6
Polyethylene is usually referred to as "polythene" in the New Zealand building industry.

7.6.1
Polyethylene sheet *damp-proof membrane* (DPM) material shall:

(a) Be either:

(i) A single unprotected layer of polyethylene not less than 0.25 mm thick; or

(ii) A multi-layer laminate in which one or more layers of polyethylene having an aggregate *thickness* not less than 0.1 mm thick are incorporated with layers of other material that provide adequate protection to the polyethylene;

(b) Have heat-sealed joints not less than 50 mm wide or lap joints not less than 150 mm wide sealed with pressure-sensitive plastic tape not less than 50 mm wide provided that such tape need not be used with self-sealing polyethylene sheets;

(c) Be protected from damage.

C7.6.1
Vertical faces cannot be exposed in any situation where the sheet might suffer damage.

7.6.2
Where the granular surface is likely to cause intrusions into the vapour barrier polyethylene sheet, the vapour barrier material shall be protected by:

(a) Surface blinded with sand to form a smooth layer or a cement sand screed can be used; or by

(b) Heavyweight building paper.

C7.6.2
The important issue is that the vapour barrier is not damaged by intrusions from below during the concreting operations.

Thick layers of uncompacted sand are an unsatisfactory support method for the slab. A nominal 5-10 mm thickness of sand to fill gaps in the base course material plus a base course tolerance ±15 mm results in a maximum compacted thickness of 25 mm.

7.7 Rubber emulsion damp-proof membranes

7.7.1
Rubber emulsion *damp-proof membrane* (DPM) material shall:

(a) Contain not less than 10 % rubber latex;

(b) Be applied in at least 2 coats at right angles to each other and in accordance with the manufacturer's specification to the approval of the Territorial Authority.

C7.7.1
The information supplied by the manufacturer should take account of the shrinkage cracking that will occur in the supporting concrete layer.

7.7.2
Rubber emulsion *damp-proof membrane* (DPM) material shall be laid on a layer of concrete not less than 50 mm thick.

7.8 Slab-on-ground construction

7.8.1 General

C7.8.1
Steel reinforcement can be used in single storey structures to enable larger joint spacing and reduce the risk of cracking. (The term reinforcement specifically refers to steel reinforcement in compliance with NZS 3422 (wire mesh) or NZS 3402. Any reference to fibre reinforcement will be explicitly stated).

The use of concrete slabs on ground shall be divided into the following applications:

(a) When supporting more than one *storey*, the slab shall be reinforced in accordance with 7.8.3, 7.8.4 and 7.8.5.4;

(b) When supporting one *storey* the slab shall be selected from one of the following:

  (i) Reinforced as in (a)

  (ii) Unreinforced in accordance with 7.8.5.2

  (iii) Polypropylene reinforced in accordance with 7.8.5.3

(c) Where the slab forms a thickened perimeter *foundation*, it shall be continuously reinforced to comply with 6.6.

(d) Concrete shall conform with the requirements of NZS 3109 and the minimum specified compressive strength of concrete at 28 days shall be:

  (i) 17.5 MPa for unreinforced concrete applications, for reinforced concrete either not exposed to weather or exposed to the weather in Zone 2 and Zone 3 as shown in figure 4.1 of NZS 3604;

  (ii) 20 MPa for reinforced concrete exposed to weather, at least 500 m from mean high tide mark in Zone 1 as shown in figure 4.1 of NZS 3604;

  (iii) 25 MPa for reinforced concrete exposed to weather and within 500 m of the mean high tide mark.

7.8.2 *Slab thickness and dimensions*

C7.8.2
A reduction of the slab thickness can be considered by specific engineering design if steel fibre reinforcement is used, in which case the slab thickness must be taken in accordance with the manufacturer's specifications. It should be noted that the maximum joint spacing is a function of slab thickness and that special care must be taken in determining the bay dimensions of the slab. Certain composite construction will create 2 separate concrete layers totalling 125 mm.

7.8.2.1 *Slab thickness*
Except as required by 7.11.1 beneath certain *loadbearing walls*, the minimum *thickness* of a slab-on-ground shall be:

(a) 100 mm when placed on a bituminous or polyethylene sheet *damp-proof membrane* (DPM) laid on a specifically prepared granular base (see figure 7.3);

(b) 75 mm when laid on rubber emulsion *damp-proof membrane* (DPM) over a 50 mm of concrete slab (see figure 7.3);

(c) 75 mm when vapour barrier laid over this lower layer of concrete and protected by 50 mm of concrete (see figure 7.3).

7.8.2.2 ***Dimensions***
The maximum continuous length of slab reinforced in accordance with 7.8.3 shall not exceed 18 m.

7.8.3 *Concrete slab reinforcement*

Reinforcing steel in slab-on-ground shall extend to within 75 mm of the outside edge of the slab (including the *foundation wall* when it is cast integrally with the slab-on-ground) and consist of a minimum of 2.27 kg/m^2 welded reinforcing mesh complying with NZS 3422, lapped by 225 mm at sheet joints, for a slab having a maximum *dimension* of 18 m.

C7.8.3
Welded wire 665 mesh will provide the minimum reinforcement required by 7.8.3.

Alternative forms of mesh may be used providing they meet the mass/m^2 in each direction. Equivalent bar steel may be used with D10 bars at 350 centres, but mesh is preferred. Continuous slabs longer than 18 m in length are outside the scope of this section and should be the subject of specific engineering design. It is possible to use a free joint between adjacent slabs which may total up to a length greater than 18 m, e.g. 24 m may be formed by 2/12 m long slabs.

In the controlled applications of this Standard, minor shrinkage cracking is of no structural consequence but care should be taken to follow the bay size requirements to ensure shrinkage cracking does not appear in areas where special thin or hard finishes are to be applied, e.g. vinyl sheeting or ceramic/stone tiles.

7.8.4 *Cover from top surface*

Reinforcing steel shall have a cover of 30 mm from the top surface of the slab-on-ground and shall be placed in such a manner as to avoid damage to the *damp-proof membrane* (DPM).

7.8.5 *Shrinkage control joints*

7.8.5.1 *General*

Shrinkage control in concrete slabs shall be provided by forming full depth construction joints or by shrinkage *control joints*. Shrinkage *control joints* induce cracking along a line and shall be a saw cut after hardening or comprise a device cast into the slab during construction.

The saw cut shall be cut to a depth of a quarter of the depth of the slab, being cut no later than 24 hours in summer, or 48 hours in winter, after the slab has been cast.

Cast in devices are not specifically covered by this Standard and the details of their design and installation must be submitted to and approved by the Territorial Authority.

C7.8.5.1
A shrinkage control joint must permit the concrete slab to shrink and allow movement. This can be done by saw cutting to create a weakness to encourage the crack to form at this point or by including a debonded construction joint device within the slab during construction. Anchorage of such devices must not damage the damp-proof membrane (DPM). Typically the depth of cut will be 25 mm with a single saw blade width of approximately 5 mm.

Some variations in time for cutting need to be considered for special weather, particularly temperature conditions.

Special techniques are also available to cut the joint in the concrete's plastic state.

C7.8.5.2

When the spacing of construction joints is wider than 3 m, it is necessary to introduce contraction joints to maintain shrinkage control at 3 m intervals.

Movement cracks will show through vinyl floor coverings and ceramic tiles. Accordingly it is important not to have joints running through areas which are likely to have such floor finishes, e.g. kitchen, bathroom, toilet, etc.

7.8.5.2 ***Unreinforced concrete slabs***

Shrinkage *control joints* in unreinforced concrete slabs shall be formed as follows:

(a) Restrict the maximum plan *dimension* of concrete between shrinkage *control joints* to 3 m as defined in 7.8.5.1;

(b) The bay *dimensions* formed by shrinkage *control joints* shall be limited to a maximum ratio of length: width of 1 to 1.3. Any panels formed which exceed this value shall be reinforced as specified in 7.8.3 and 7.8.4.

(c) Supplementary steel shall be placed as shown in figure 7.4 if construction joints are not used at these positions.

C7.8.5.3

Specific design or approved polypropylene producer statements may permit alternative bay sizes using different types of polypropylene fibre and dosage rates.

Steel fibre concrete slabs may be used but they are the subject of specific engineering design and the approval of the Territorial Authority.

When the spacing of construction joints is wider than 4 m, it is necessary to introduce contraction joints to maintain shrinkage control at 4 m intervals.

7.8.5.3 ***Fibre reinforced slabs : polypropylene***

Where normal unreinforced concrete slabs are constructed with the addition of polypropylene fibres complying with ASTM C1116, the following shall apply:

(a) Minimum fibre dosage rate shall be 0.68 kg/m^3;

(b) The maximum joint *spacing* given in 7.8.5.2 can be increased up to 4.0 m;

(c) The bay *dimensions* formed by either construction or contraction joints shall be limited to a maximum ratio of length: width of 1 to 1.5. Any panels formed which exceed this value shall be reinforced as specified in 7.8.3.

(d) Supplementary steel shall be placed as shown in figure 7.4;

(e) The mixing and construction of the slab shall be strictly in accordance with the supplier's specifications which shall meet the requirements of ASTM C1116.

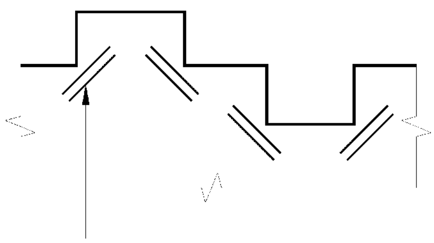


Figure 7.4 – Supplementary steel (see 7.8.5.2)

7.8.5.4 ***Reinforced concrete slabs***

Shrinkage *control joints* in reinforced concrete ground slabs shall comply with the following criteria:

(a) *Control joints* shall be positioned to coincide with major changes of plan. See figure 7.5.

(b) Supplementary steel shall be placed as shown in figure 7.4;

(c) The bay *dimensions* formed by either construction or contraction joints shall be limited to a maximum ratio of length to width of 1 to 2;

(d) *Foundation walls* constructed separately from the ground slab and supporting more than one *storey* shall be tied to the ground slab by R10 bars at not less than 600 mm centres lapped 300 mm with the slab reinforcing and anchored into the *foundation wall* (see figure 7.6).

C7.8.5.4

The slab reinforcement and control joints provided will not totally eliminate the formation of non-structural shrinkage cracks.

Supplementary shrinkage control joints should be used such that intermediate bay sizes do not exceed 6 m for slabs where there is exposed concrete or where finishes may be damaged by the formation of controlled shrinkage cracks.

Where significant areas of direct wearing concrete, vinyl and ceramic tiles are to be used, it is recommended that specific engineering design be used which would consider reducing the maximum bay dimension and a preference to produce a bay shape that is approximately square.

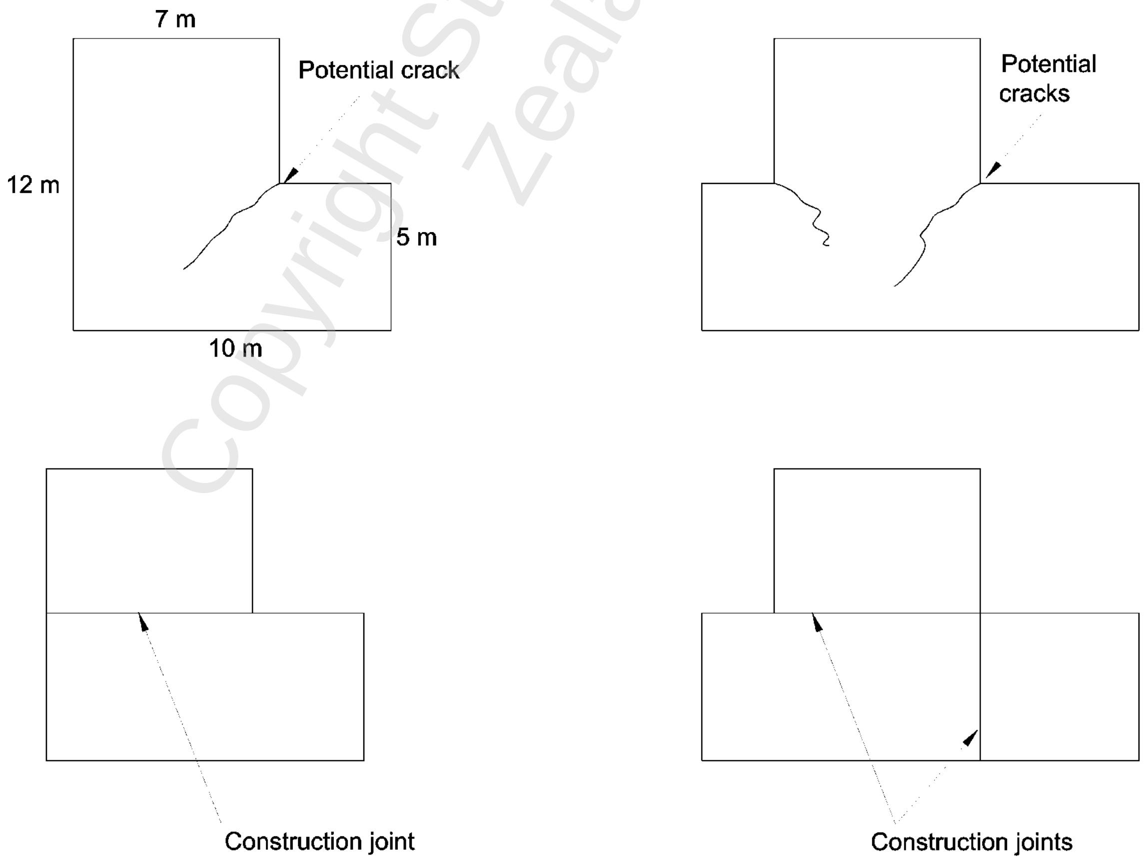
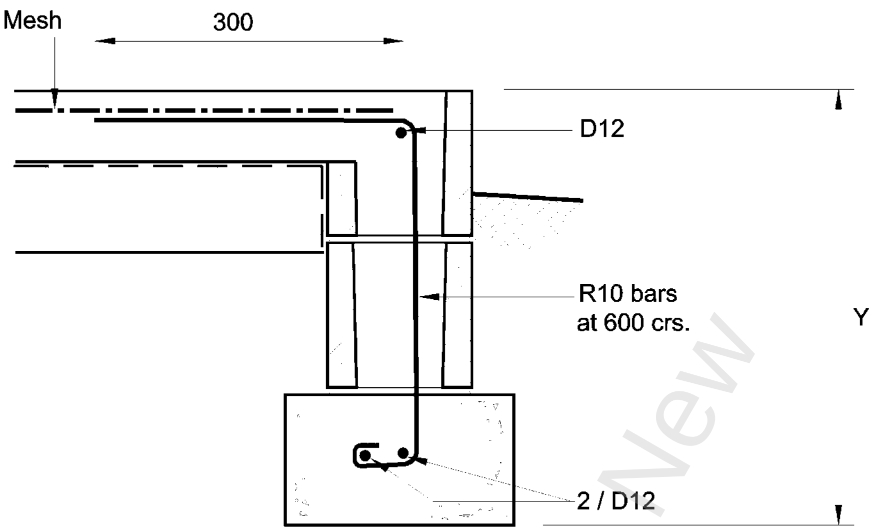


Figure 7.5 – Positioning control joints to reduce shrinkage cracks (see 7.8.5.4(a))



NOTE -
(1) For single storey construction tying steel between the floor and foundation may be omitted provided the slab is contained within foundation walls.
(2) Where Y exceeds 600 mm an additional horizontal D12 bar shall be used at mid height.

Figure 7.6 – Tied foundation (see 7.8.5.4(b))

7.9 Bearing

7.9.1
Clause 3.3.1 shall apply to the *foundation walls* but not to the slab-on-ground itself. The depth shall be measured from the *cleared ground level* outside the *foundation wall* and not from the *cleared ground level* beneath the slab-on-ground.

C7.9.1
The cleared ground level beneath the slab will need to be such that:

(a) The granular fill material can be placed on solid bottom or firm fill where a certificate of suitability has been issued in terms of NZS 4431 (see 3.3.1); and

(b) The thickness of granular fill complies with 7.3.1; and

(c) The finished floor level complies with 7.2.1.

7.9.2
Bearing of *footings* on *good ground* shall be as required in 3.1.2. Bearing of the granular fill for the ground slab itself need not be on *good ground* except where the following is encountered at formation level:

(a) Organic top soil;

(b) Soft or very soft peat;

(c) Loose uncompacted sand;

(d) Fill material without a "Statement of suitability" in terms of NZS 4431;

(e) Expansive clay as 3.2.1.2.

7.10 Underfloor thermal insulation

7.10.1
Where thermal insulating material is included in a floor slab, it may be placed in any appropriate position to achieve the desired effect provided that no reduction of any concrete *thickness dimension* given by this Standard shall be permitted.

7.11 Support of loadbearing internal walls

7.11.1
The slab beneath a *loadbearing internal wall* that supports one of the following:

(a) Two timber floors and a *light roof*; or

(b) One suspended timber floor and a *heavy roof*; or

(c) A concentrated load from trusses or beams supporting a total *roof* area not exceeding a tributary area of 20 m^2;

shall be 200 mm thick over a minimum width of 450 mm and reinforced with 2/D12 bars as shown in figure 7.7. In the case of (c) above the minimum length of floor thickening is to be 450 mm.

C7.11.1
The requirements of this clause cover loadbearing walls only and shall not be used to satisfy point loadings which require specific engineering design. All internal walls of a single storey structure supporting only a roof and ceiling rafters can be loadbearing without slab thickening.

7.11.2
Where concrete *suspended floors* have been used a separate *foundation* and *footing* complying with section 6 shall be provided.

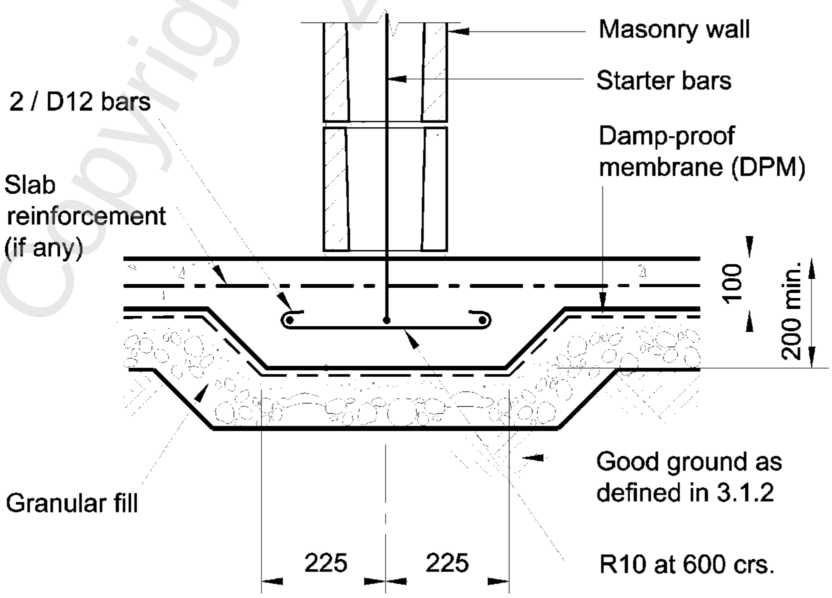


Figure 7.7 – Support of loadbearing internal walls (see 7.11.1)

NOTES

SECTION 8

SECTION 8
WALLS

Table

Figure

NOTES

8 WALLS

8.1 General

8.1.1
The *wall* system of each *storey* shall consist of:

(a) *Structural masonry walls* with or without *loadbearing* light timber framing to resist vertical loads complying with 8.2, combined with

(b) *Structural masonry walls* to resist horizontal loads complying with 8.4.

8.1.2
No *masonry wall* shall be of a lesser *thickness* than a wall it supports.

8.1.3
All *cells* containing *reinforcement* in *partially filled structural masonry* shall be filled with grout in accordance with NZS 4210.

8.1.4
Cells and cavities in *solid filled structural masonry* walls shall be filled with grout in accordance with NZS 4210.

8.1.5
Joints in reinforcing steel shall be lapped for a minimum length of 40 bar diameters.

8.1.6
Bond beams complying with section 10 shall be provided at the top of all *structural masonry walls* and at floor and ceiling levels.

8.2 Wall systems to resist vertical loads

8.2.1
Wall systems to resist vertical loads shall be a combination of the following types:

(a) *Structural walls* constructed of solid or partially filled *masonry* or both with *reinforcement* complying with 8.3.2;

(b) *Loadbearing* timber framing in accordance with NZS 3604 which may be supported on *masonry* walls;

(c) *Reinforced masonry lintels* complying with section 11;

(d) *Reinforced masonry* or concrete *foundation walls* and *footings*.

Except that when a suspended concrete floor is used it shall not be supported by a *loadbearing* timber frame.

8.2.2
No *masonry wall* shall be supported on a timber structure.

8.2.3
The vertical load capacity of the wall system shown in table 8.1 shall not be exceeded.

C8.2.3
It is important to check that loads imposed from lintels with other direct loading conditions on the wall do not exceed the capacities in table 8.1 for wall sections between openings.

Table 8.1 – Vertical load capacity of wall (see 8.2.3)

	Partial fill			**Solid fill**		
	Load capacity (kN)			**Load capacity** (kN)		
	Wall series			**Wall series**		
Wall length mm	15	20	25	15	20	25
800 nominal	55	71	88	57	78	98
1000 nominal	68	90	113	72	98	223
1200 nominal	81	107	133	86	117	148

8.3 Structural walls

8.3.1
All *structural walls* shall be centrally reinforced both horizontally and vertically in accordance with tables 8.2(a) or 8.2(b).

C8.3.1
Note there is no difference in the vertical reinforcement detailing. The spacing of the horizontal reinforcing for the solid fill situation is reduced to 1.2 m which permits an increase in the bracing capacity of the wall.

8.3.2
Vertical bars as specified in tables 8.2(a) and 8.2(b) shall be provided:

(a) At all corners and ends of walls;

(b) On each side of wall openings exceeding 400 mm in width;

(c) Either side of shrinkage *control joints*.

8.3.3
All vertical reinforcing steel shall extend from the *foundation* or lower *bond beam* to the upper *bond beam*.

8.3.4
All vertical *reinforcement* shall be located in the same *cell* as the starter bar provided from the *footing* or lower *structural wall*.

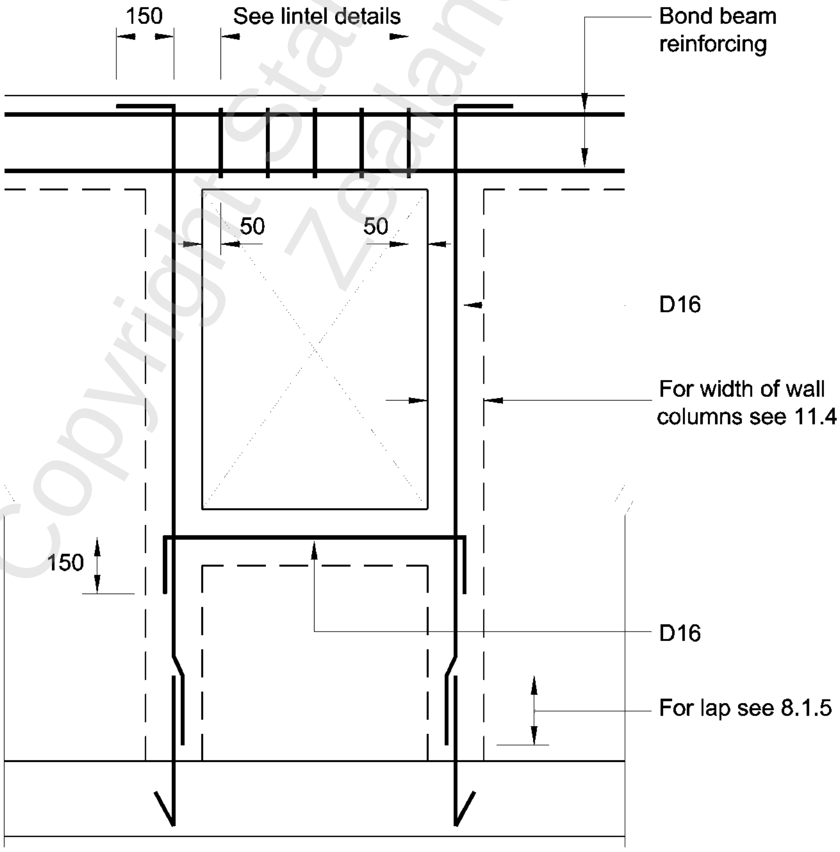
8.3.5
Horizontal *reinforcement* steel immediately above and below openings shall be provided and shall be anchored as shown in figure 8.1.

Table 8.2(a) – Reinforcement for partially filled masonry structural walls (see 8.3.1 and 8.3.2)

	Vertical reinforcement				Horizontal reinforcement			
	Max. spacing of vertical bars (mm)	Block used			Max. spacing of horizontal bars (mm)	Block used		
		15 series	20 series	25 series		15 series	20 series	25 series
All seismic zones	800	D12	D12	D12	2800	D16	D16	D16

Table 8.2(b) – Reinforcement for solid filled masonry structural walls (see 8.3.1 and 8.3.2)

	Vertical reinforcement				Horizontal reinforcement			
	Max. spacing of vertical bars (mm)	Block used			Max. spacing of horizontal bars (mm)	Block used		
		15 series	20 series	25 series		15 series	20 series	25 series
All seismic zones	800	D12	D12	D12	1200	D12	D12	D16



NOTE - When the bond beam does not combine to form the lintel, separate lintel steel (see section 11) shall be used over the opening.

Figure 8.1 – Reinforcement above and below openings (see 8.3.5)

8.4 Systems to resist horizontal forces

8.4.1

All *masonry* buildings shall be braced to resist horizontal wind and seismic forces.

8.4.2

Horizontal forces in the plane of *suspended floor* and *roof* levels shall be resisted by one of the following methods:

(a) *Bond beams* spanning between *structural walls*, containing *bracing* panels (see figure 8.2);

(b) *Structural diaphragms* (see figure 8.3);

(c) A combination of (a) and (b) above.

C8.4.2

Bond beams or diaphragms are needed to transfer wind or seismic forces on the face of a wall or loads from parts of the structure above the bond beam or diaphragm, to walls which run parallel to the direction of the force.

It should be noted for (c) that due to other provisions of this Standard, the bond beam/bracing line method can only be used in storeys below those using the diaphragm method.

8.4.3

Structural walls to resist horizontal forces in any *storey* shall contain *wall bracing panels* complying with 8.4 in the following walls:

(a) *External walls* as required by 8.6; and

(b) *Internal walls* on *bracing lines* as required by 8.7; or

(c) *Walls* supporting the 4 edges of a *structural diaphragm* complying with 8.8.

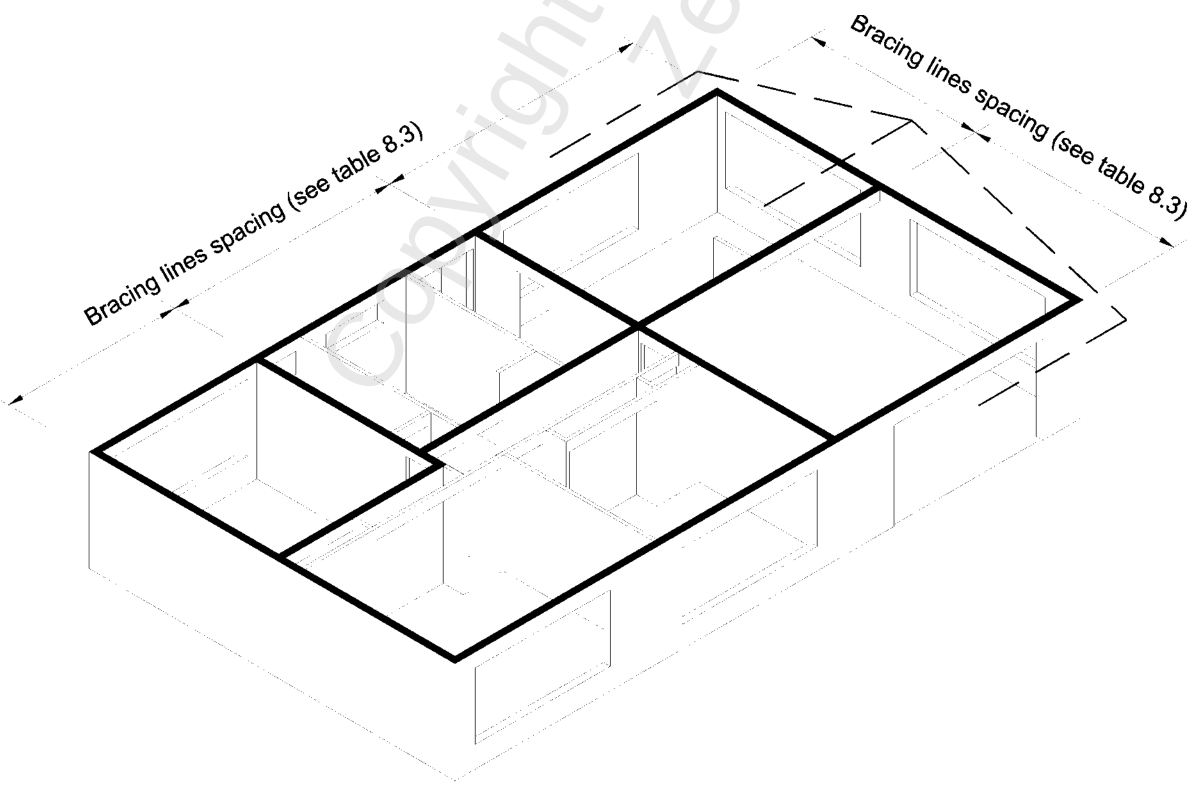


Figure 8.2 – Bracing line support system (see 8.4.2(a))

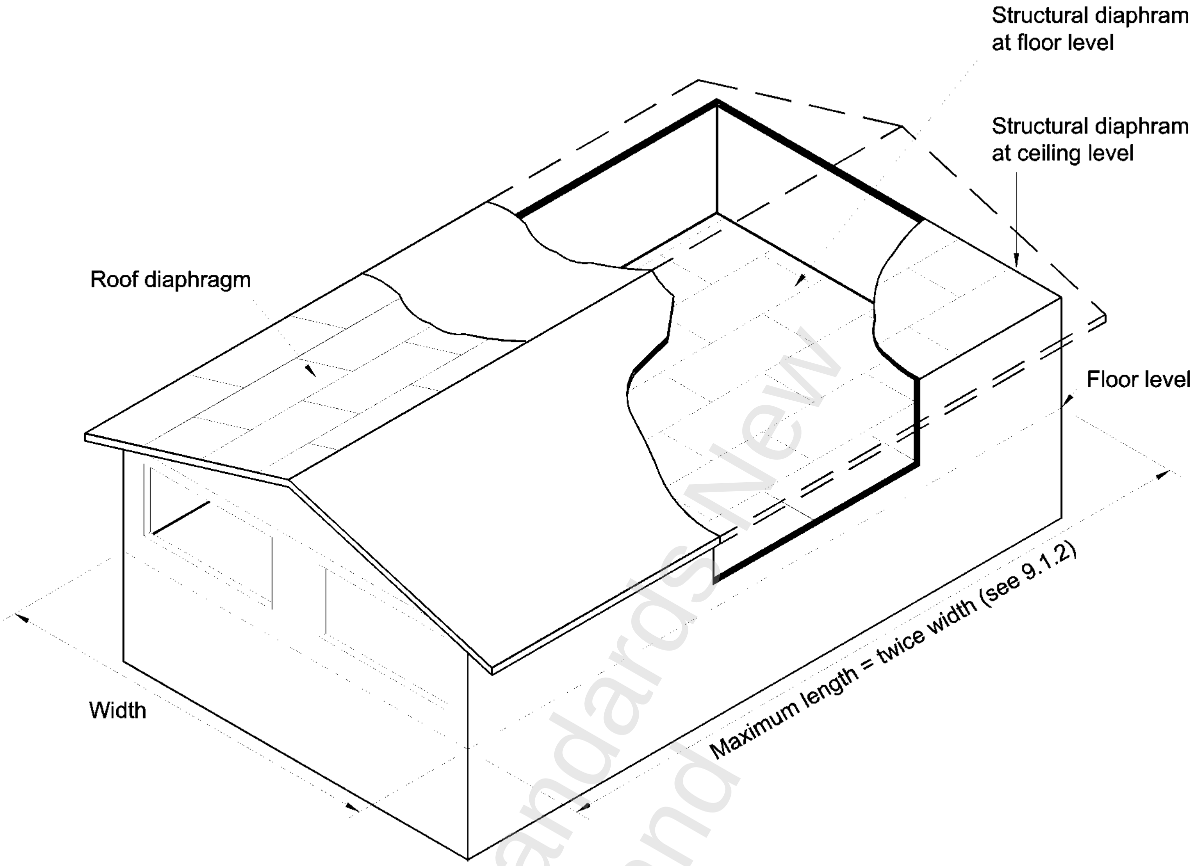


Figure 8.3 – Structural diaphragm support systems (see 8.4.2(b))

8.5 Bracing units and elements

8.5.1

Each individual *wall bracing panel* shall be rated at the capacity in *bracing units* given in section 5. Each *bracing line* consisting of a number of panels shall be rated as the sum of the individual panels as described by the *bracing line* capacity calculation process in section 5.

C8.5.1

The calculation procedures for determining bracing demand and capacity are set out in sections 4 and 5.

8.5.2

The total *bracing capacity* of all *wall bracing panels* in each of 2 directions at right angles to each other in any *storey* shall be not less than the greater of:

(a) The *bracing demand* in *bracing units* /m^2 given by table 4.3 for earthquake multiplied by the gross floor plan area in m^2 of the *storey* being considered;

(b) The *bracing demand* in *bracing units* /m given by table 4.2 for wind multiplied by the maximum horizontal *dimension* of the *roof* above the *storey* being considered measured at right angles to the wall *bracing* elements being considered.

C8.5.2

The total number given by table 4.3 for earthquake bracing demand will be the same for each of the 2 directions that are to be considered in each storey. The total number given by table 4.2 wind bracing demand will be different for the 2 directions (except for square buildings).

8.5.3

The total *bracing capacity* of all *wall bracing panels* in each of 2 directions at right angles to each other in any one *storey* shall be at least equal to the requirements of 4.3 and 4.4. Where in any building consisting of wings or blocks that are not at right angles to each other, this requirement shall be satisfied individually for each such wing or block. Where the limiting shape and size of *diaphragms* restrict their use in buildings consisting of wings or blocks then *diaphragms* shall be considered for each individual wing or block separately for the purposes of *bracing*.

8.6 Wall bracing elements in external walls not connected to a structural diaphragm

8.6.1

Each *external wall* not connected to a *structural diaphragm* and exceeding 2.4 m in length shall contain a total number of *bracing units* not less than that required for a 2 m wide tributary floor area or wall length for the *storey* being considered calculated as follows:

(a) For Earthquake: The length of the wall in metres multiplied by the tributary floor width (2 m minimum) multiplied by the number of *bracing units* required in table 4.3.

(b) For Wind: The greatest width of either 2 m or half the spacing to the next parallel *bracing line* multiplied by the number of *bracing units* from table 4.2.

C8.6.1

This clause requires a minimum bracing capacity equivalent to that needed to laterally support a floor or roof width of 2 m at any external wall.

The tributary floor width is half the distance between the adjacent bracing lines directly bearing on the wall or 2 m minimum.

8.6.2

For the purpose of 8.6.1 only, where offsets occur along the side of a building, the wall length shall be taken as the total length of all parallel *external walls* that are offset not more than 2 m from one another.

C8.6.2

The length of an external wall is normally measured between any 2 adjacent corners, but for the purpose of 8.6 it is measured between adjacent corners of return walls which do not exceed 2 m in length.

8.7 Wall bracing elements in internal walls on bracing lines

8.7.1

Bracing lines shall be parallel to *external walls* except as provided by 8.5.3.

8.7.2

Bracing lines in any *storey* shall not be set at centres greater than those shown in table 8.3, provided that there need be no *bracing lines* within the area covered by a *structural diaphragm* complying with section 9 supported by walls complying with 8.8.

8.7.3

Bracing lines in each *storey* shall be considered separately but shall coincide with those of the *storey* below unless a concrete *suspended floor* is being used and that floor shall be specifically designed to cope with all loads resulting from the offset walls.

C8.7.3

Bracing walls on an upper storey may be shorter than the corresponding bracing walls on the storey below.

8.7.4
Each internal wall not connected to a *structural diaphragm* and exceeding 3 m in length shall contain a total number of *bracing units* not less than that required for a 4 m wide tributary floor area or wall length, for the *storey* being considered and is calculated as follows:

(a) Earthquake: The length of the wall in metres multiplied by the tributary floor width (4 m minimum) multiplied by the number of *bracing units* required by table 4.3.

(b) Wind: The greatest width of either 4 m or half the spacing to the next parallel *bracing line* multiplied by the number of *bracing units* from table 4.2.

C8.7.4
This clause defines the minimum width of floor to be laterally supported by any one bracing line.

8.7.5
Each *bracing line* shall contain either or both of the following:

(a) *Wall bracing panels* in *structural walls* on the *bracing line*;

(b) Pairs of *wall bracing panels* in *structural walls* parallel to the *bracing line* such that one wall *bracing* element is on each side of the *bracing line* and each wall *bracing* element is not more than 1 m from the *bracing line*.

8.7.6
Walls of length less than 12 times their nominal *thickness* may be laterally supported at one end only.

8.8 Structural diaphragms

8.8.1
A *structural diaphragm* system with *masonry* walls to resist horizontal loads shall be directly supported by the *masonry* walls in the *storey* being considered and shall be:

(a) A combination of a floor *diaphragm* complying with 9.3 and a ceiling *diaphragm* complying with 9.2; or

(b) A floor *diaphragm* complying with 9.3; or

(c) Where a *bracing* system has been used to first floor only, a ceiling *diaphragm* complying with 9.2.

8.8.2
Except as provided in 8.8.4, the *structural walls* along each edge of the *diaphragm* and parallel to the direction of the loading being considered shall contain not less than 60 % of the total number of *bracing units* required for the *storey* or part *storey* covered by the *diaphragm.*

C8.8.2
This provision has been included to strengthen outer walls against torsionally induced seismic forces.

8.8.3
Where 2 *diaphragms* are connected to a common wall, as shown in figure 8.4, then the maximum *bracing* value of that wall shall be not less than 40 % of the sum of the requirements of the 2 *diaphragms*.

C8.8.3
Two diaphragms can be connected to one common wall or in the case of an L-shape building which can be broken into 2 diaphragms, the re-entry wall can support 2 diaphragms.

Table 8.3 – Maximum spacing for bracing lines (see 8.7.2)

Storey height up to 2.6 m (1)	Construction type Wall series	Maximum spacing in m (Bracing lines) Earthquake zones		
		A	B	C
Single storey Partial filled	15	7.2	8.0	8.0
	20	9.0	9.0	9.0
	25	9.0	9.0	9.0
	15 + 100 mm veneer	6.2	7.4	8.0
	20 + 100 mm veneer	7.6	8.0	8.0
Single storey Solid filled	15	6.8	8.0	8.0
	20	7.6	8.0	9.0
	25	9.0	9.0	9.0
	15 + 100 mm veneer	6.0	7.0	8.0
	20 + 100 mm veneer	7.0	7.4	8.0
Two storey Partial filled	15	5.6	6.6	8.0 (2)
	20	7.0	8.0	8.0 (2)
	25	8.0	8.0	8.0
	15 + 100 mm veneer	4.8	5.4	6.6
	20 + 100 mm veneer	6.0	7.0	8.0
Two storey Solid filled	15	5.2	6.0	7.4
	20	6.0	7.0	8.0 (2)
	25	7.0	8.0	8.0
	15 + 100 mm veneer	4.4	5.2	6.4
	20 + 100 mm veneer	5.2	6.2	7.4

NOTE –

(1) For a storey height greater than 2.6 m and less than 3.0 m the maximum spacings shall be reduced by 8 % i.e. values in the table are to be multiplied by 0.92.

(2) A maximum spacing permitted is 8.0 m.

(3) Where a permitted offset to 8.7.5 occurs, it shall not cause the bond beam span to exceed the maximum values in table 10.1.

(4) Bond beams (types B2 and B3) capacities are detailed in section 10 table 10.1.

(5) Where it is found that required spans are greater than those given, the use of the diaphragm method may be appropriate.

8.8.4

Walls supporting one edge of a *diaphragm* and parallel to the direction of loading being considered shall not contain less than 30 % of the total number of *bracing units* (see figure 8.5) required for the *storey* or part *storey* covered by the *diaphragm*, provided that:

(a) The opposite wall contains at least 100 % of the total number of *bracing units* required by the *diaphragm* for loading parallel to these walls; and

(b) The adjacent perpendicular walls supporting each of the other edges of the *diaphragm* each contain at least 60 % of the total number of *bracing units* required in (a), or if this is not possible that these walls be reinforced with D16 bars instead of D12 bars, at the same spacings required by tables 8.2(a) and 8.2(b).

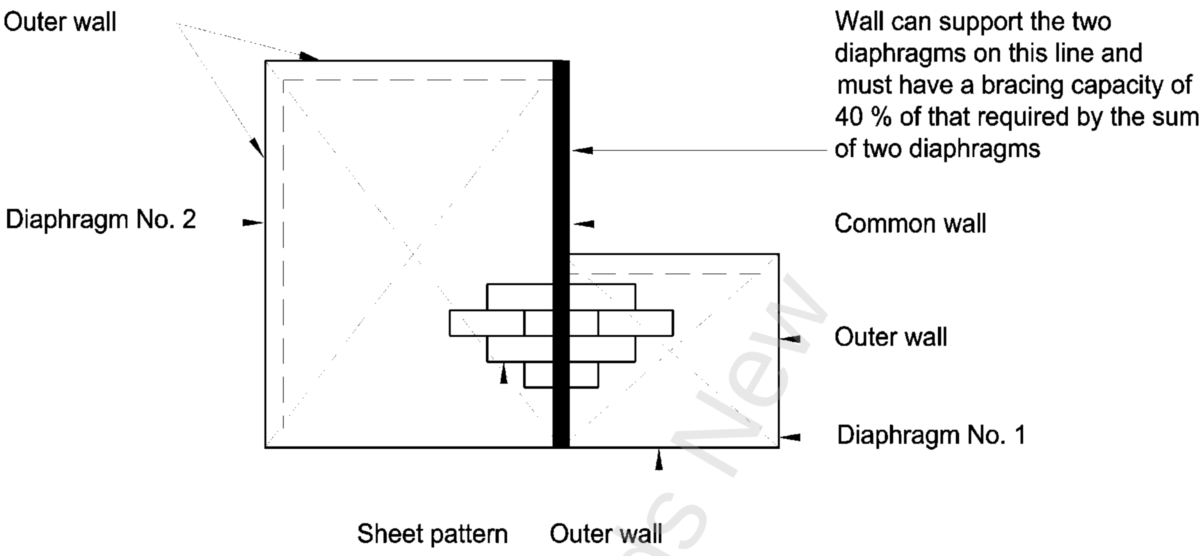


Figure 8.4 – Two diaphragms braced by a common wall (see 8.8.3)

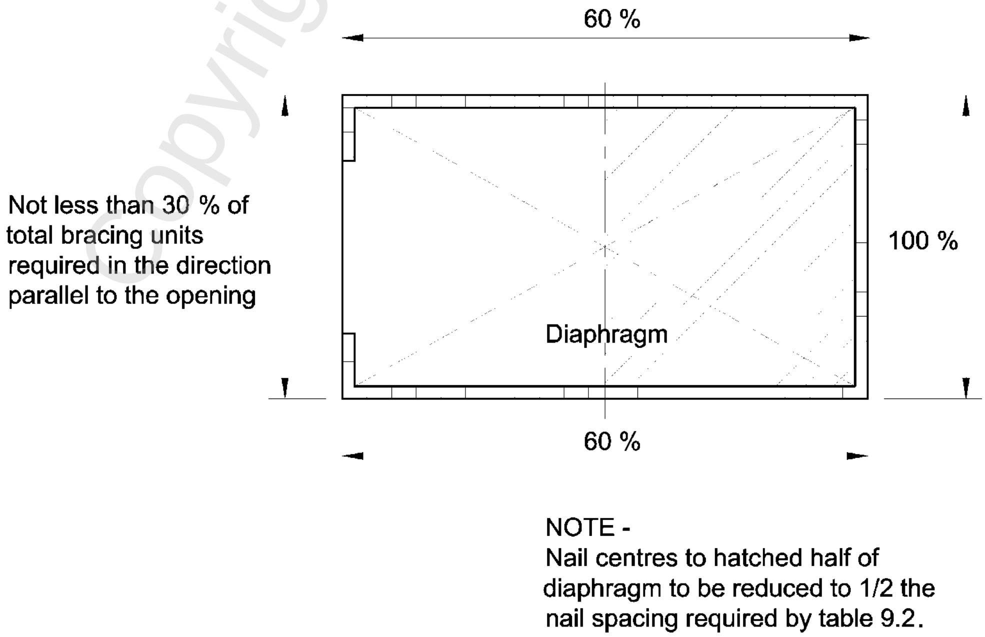


Figure 8.5 – One wall containing 30 % of total bracing units (see 8.8.4)

NOTES

SECTION 9

SECTION 9
DIAPHRAGMS

Table

Figure

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9 DIAPHRAGMS

9.1 General

9.1.1

All *structural diaphragms* supporting *masonry* walls against horizontal forces shall be constructed in accordance with this section.

Diaphragms shall be constructed as follows:

(a) Timber and plasterboard *diaphragms*:
Clauses 9.1.2 to 9.3.4 for all horizontal loading conditions including for loads arising from *cavity wall* construction i.e., 2 leafs of *masonry* 100 mm + 150 mm or 100 + 200 mm.

(b) Concrete *diaphragm*:Clause 9.4.

9.1.2

Timber and plasterboard *structural diaphragms* complying with 9.2 and 9.3 shall in addition be constructed as follows (see figures 8.3 and 9.1):

(a) *Diaphragm* or part of a *diaphragm* shall have a length not exceeding 2 times its width except when the *diaphragm* is supporting a solid filled 200 mm or 250 mm wall, when the length shall not exceed 1.5 times its width;

(b) The length and width of a *diaphragm* as referred to in (a) shall be between supporting walls at right angles to each other;

(c) The floor decking shall consist of a sheet flooring material complying with 9.3.2 over the entire area of the *diaphragm*;

(d) The minimum sheet size shall be 2400 mm x 1200 mm except where the building *dimensions* prevent the use of a complete sheet;

(e) Each sheet shall be fastened along each edge to boundary members with nails at the centres specified in 9.2 and 9.3 and shall also be fastened to every intermediate framing member at 300 mm centres. Joints in sheet material shall be made over supports. 100 mm x 50 mm timbers fixed between joists with their top surfaces set to a common level shall be provided as necessary for this purpose.

(f) Fastenings shall be not less than 10 mm from sheet edges.

C9.1.2
This clause requires more stringent requirements for structural diaphragms than those provided in NZS 3604 for supporting masonry foundation walls where the upper storeys are constructed of light timber frame.

9.2 Roof and ceiling diaphragms

9.2.1

Roof and sloping ceiling *diaphragms* shall not be of greater *dimensions* nor steeper than as provided in 9.2.2 or 9.2.3.

C9.2
This clause refers to the slope (if any) of the ceiling, not the roof. However, sloping ceilings are generally at the same slope as the roof above.

Where for special reasons a ceiling diaphragm system is required at a steeper pitch, specific engineering design must be used.

C9.2.2

Where ceiling or roof diaphragms exceed this dimension they become the subject of specific engineering design.

Note that 2.1.6 refers users to NZS 3604 for the specification of timber and wood-based products.

9.2.2

Roof and sloping ceiling *diaphragms* not steeper than 25° to the horizontal and not exceeding 16 m long under *light* or *heavy roofs* shall be of:

(a) Plywood not less than 6 mm thick three-ply; or

(b) Any other wood-based product not less than 4.5 mm thick having a density not less than 880 kg/m^3; or

(c) Any other wood-based product not less than 6 mm thick having a density not less than 600 kg/m^3; or

(d) High density plasterboard lining not less than 9.5 mm thick and having a density of not less than 880 kg/m^3 and be nail fixed in accordance with table 9.1;

(e) Plywood shall be H3 treated where used in situations where it is likely to become wet in service;

(f) The durability of wood-based products shall be demonstrated to the satisfaction of the Territorial Authority.

9.2.3

Roof and ceiling *diaphragms* steeper than 25^0 to the horizontal shall be the subject of specific engineering design.

9.2.4

Horizontal ceiling *diaphragms* not exceeding 16 m long under *light* or *heavy roofs* shall comply with 9.2.2.

C9.2.5

For equivalency of shot fired nailing see NZS 3604.

9.2.5

Nail fixing shall comply with table 9.1.

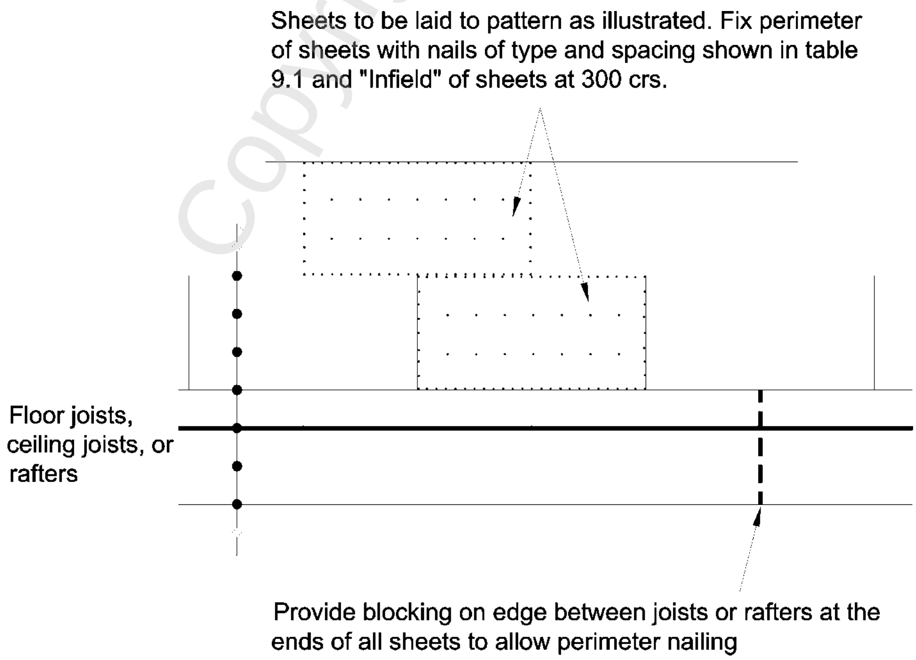


Figure 9.1 – Diaphragm construction (see 9.1.2)

Table 9.1 – Nail fixing for ceiling and roof diaphragms (see 9.2.5)

Masonry wall series	Storey height		Max. length/width ratio
	Up to 2.6 (m)	> 2.6 to 3.0 (m)	
	Nail dia. x centres	Nail dia. x centres	
15 P	2.5 x 150	2.5 x 150	2
15 S	2.5 x 150	2.5 x 150	2
20 P	2.5 x 150	2.5 x 150	2
20 S or 15 P + 100 veneer	2.5 x 150	2.5 x 100 2.5 x 150	2 1.5
25 P	2.5 x 150	2.5 x 150	2
25 S or 15 S + 100 veneer or 20 P + 100 veneer	2.5 x 150 2.5 x 150	2.5 x 100	1.5 2
20 S + 100 veneer	2.5 x 100	2.5 x 100	2

"P" means partially filled and "S" means solid filled.

NOTE –

(1) Interior fixings of the sheet material to be nailed at 300 mm centres.

(2) When using the special conditions permitted by 8.8.4, the nailing centres shall be required to be halved on half the *diaphragm* area adjoining the wall required to carry 100 % of the *bracing demand*.

(3) Minimum length of nails shall be 30 mm or 2.5 times the *thickness* of the *diaphragm* sheets, whichever is greater.

9.2.6 *Connection of roof and ceiling diaphragms to masonry walls*

9.2.6.1
Roof and ceiling *diaphragms* shall be connected to either a horizontal *bond beam* at eaves level or a sloping *bond beam* at the top of a sloping *gable* end wall.

9.2.6.2
Roof or ceiling *diaphragms* shall be connected to a *bond beam* as shown in figures 9.2, 9.3 and 9.4.

C9.2.6
Closed coupled roofs are not detailed in figures 9.2 to 9.4 because it is considered that specific engineering design is required for using such roofs as diaphragms.

9.3 Timber floor diaphragms

9.3.1
The maximum *dimension* of any timber floor *diaphragm* shall be 16 m.

C9.3.1
Where timber diaphragms are in excess of this dimension they become the subject of specific engineering design.

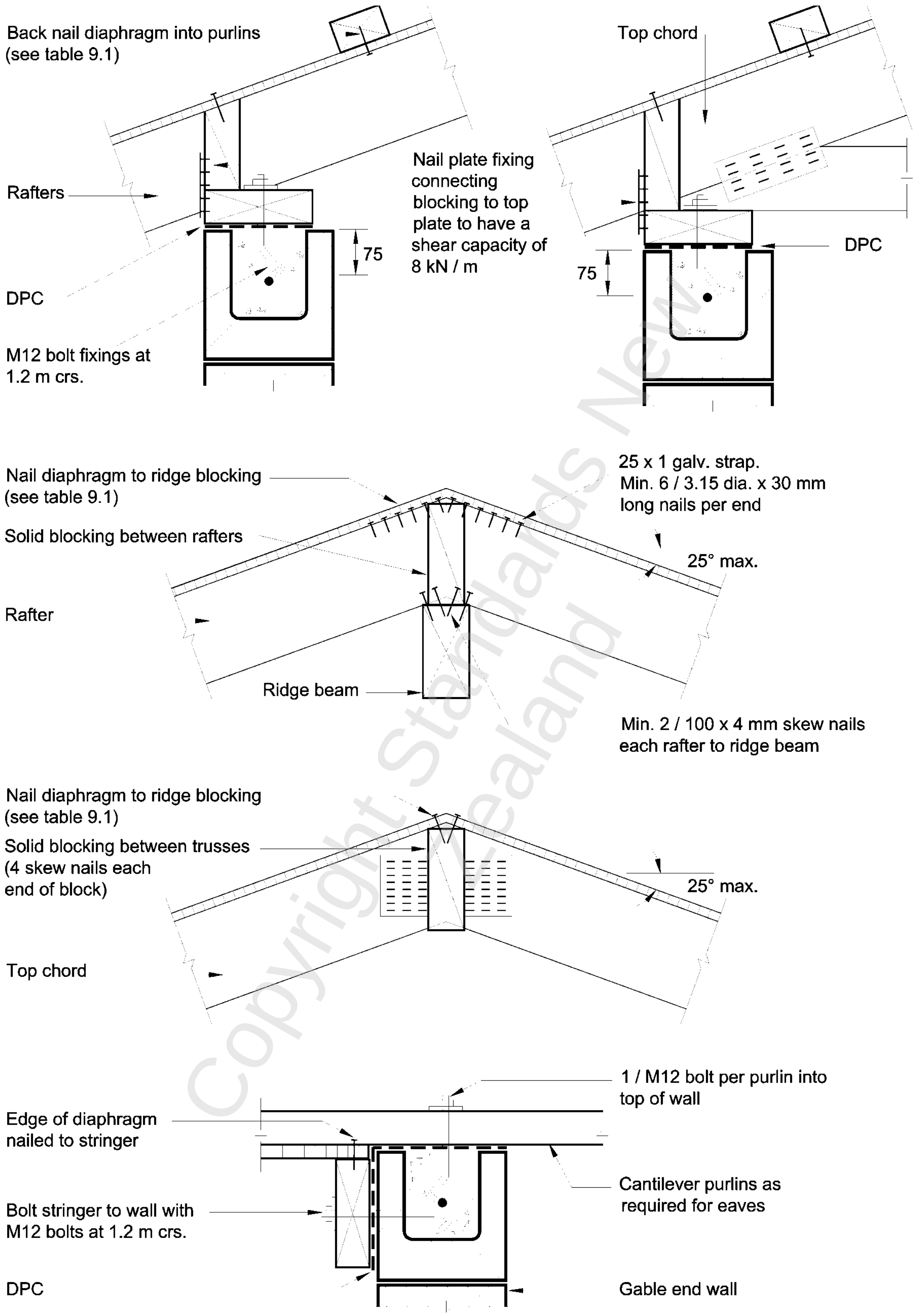
9.3.2
Sheet material shall be:

(a) Plywood not less than 18 mm in *thickness*; or

(b) Any other wood-based product not less than 18 mm thick having a density of not less than 600 kg/m^3;

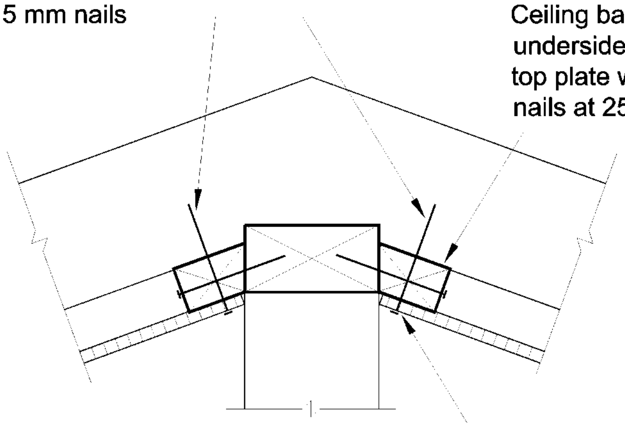
(c) Plywood shall be H3 treated where used in situations where it is likely to become wet in service;

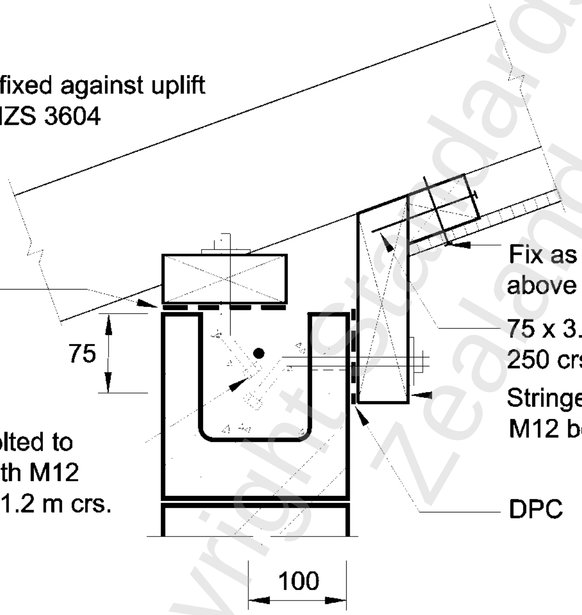
(d) The durability of wood-based products shall be demonstrated to the satisfaction of the Territorial Authority



NOTE -
(1) Minimum embedment length of all M12 bolts shall be 75 mm.
(2) The length of the bolt is determined by the thickness of the members to be attached.
(3) Use mild steel galvanized washers, 50 x 50 x 3 mm between bolt head and timber member.

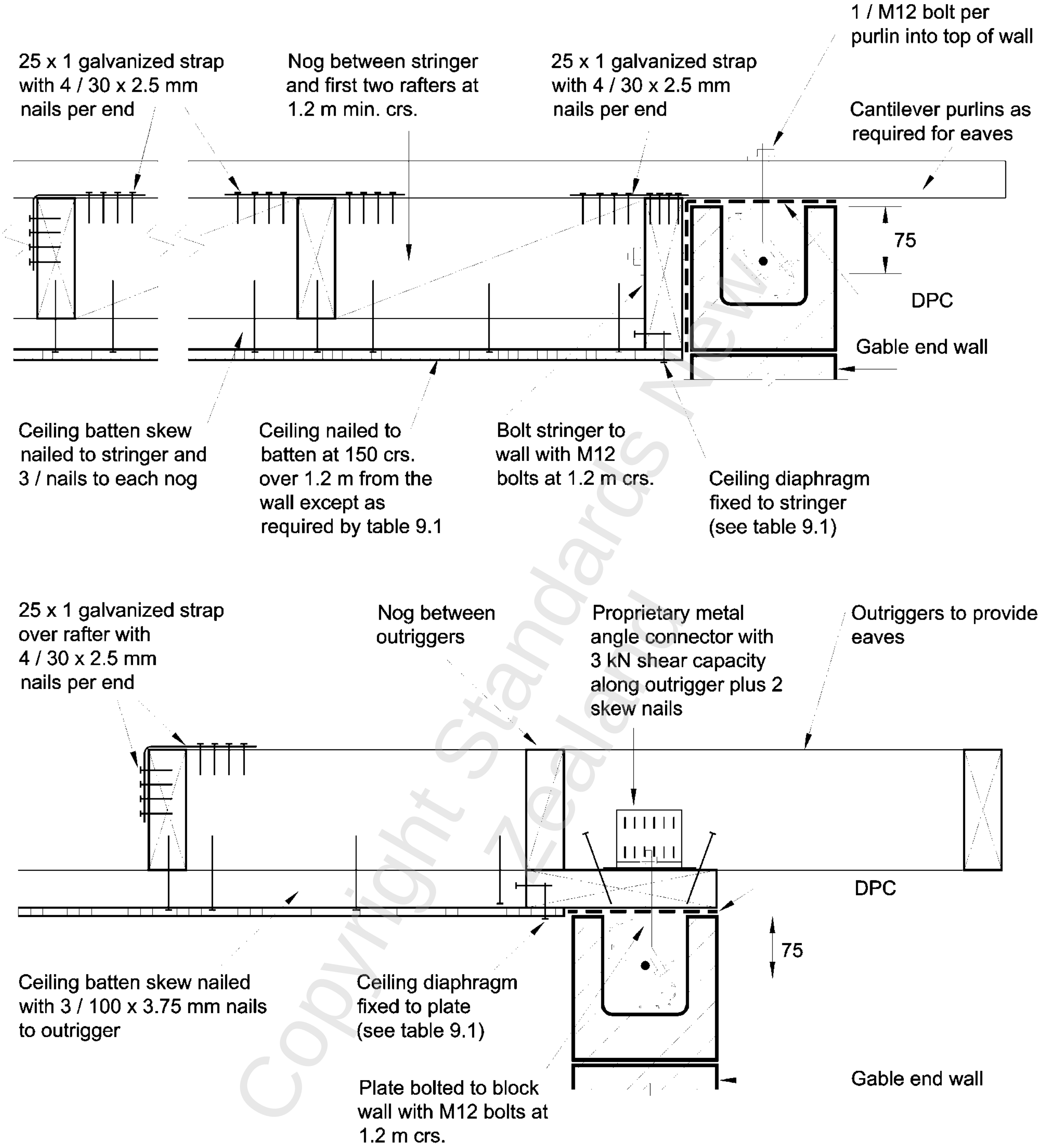
Figure 9.2 – Roof diaphragms (see 9.2.6.2)





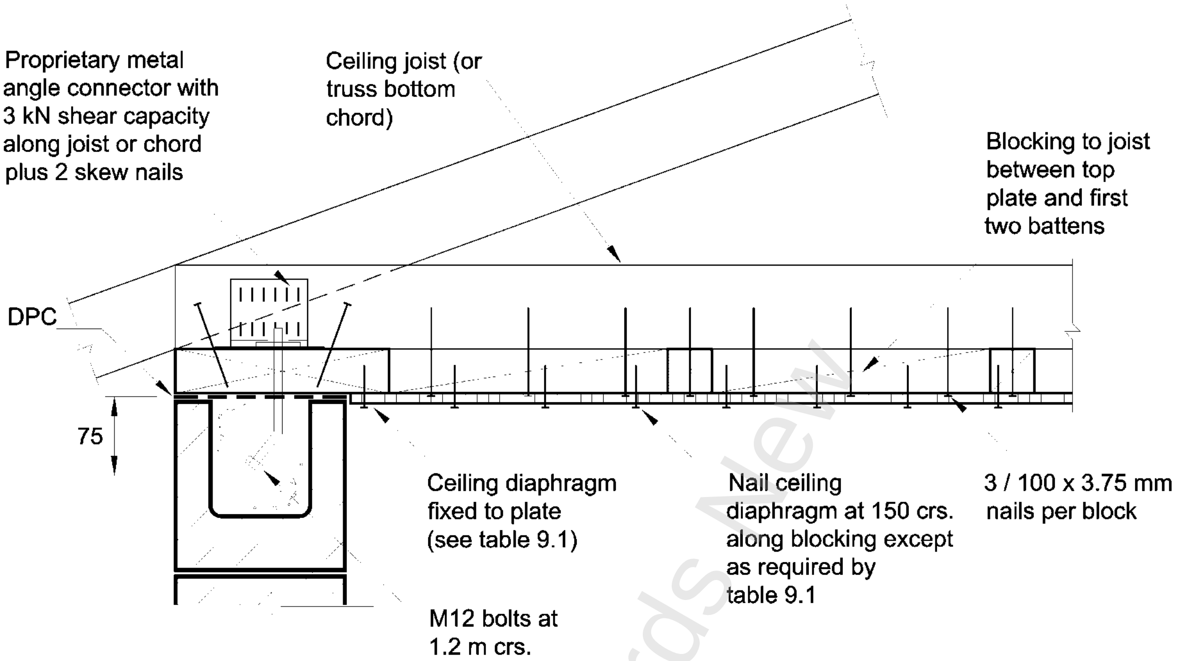
NOTE -
(1) Minimum embedment length of all M12 bolts shall be 75 mm.
(2) The length of the bolt is determined by the thickness of the members to be attached.
(3) Use mild steel galvanized washers, 50 x 50 x 3 mm between bolt head and timber member.
(4) In the case of a battened ceiling with high density plasterboard ceiling lining, pack between plasterboard and rafters at not more than 1.2 m crs. for a slope distance of 1.2 m from the walls and ridge. Nail packing to rafter with 3 / 100 x 3.75 mm nails between battens. Nail ceiling to packing at 150 crs. except as required by table 9.1.

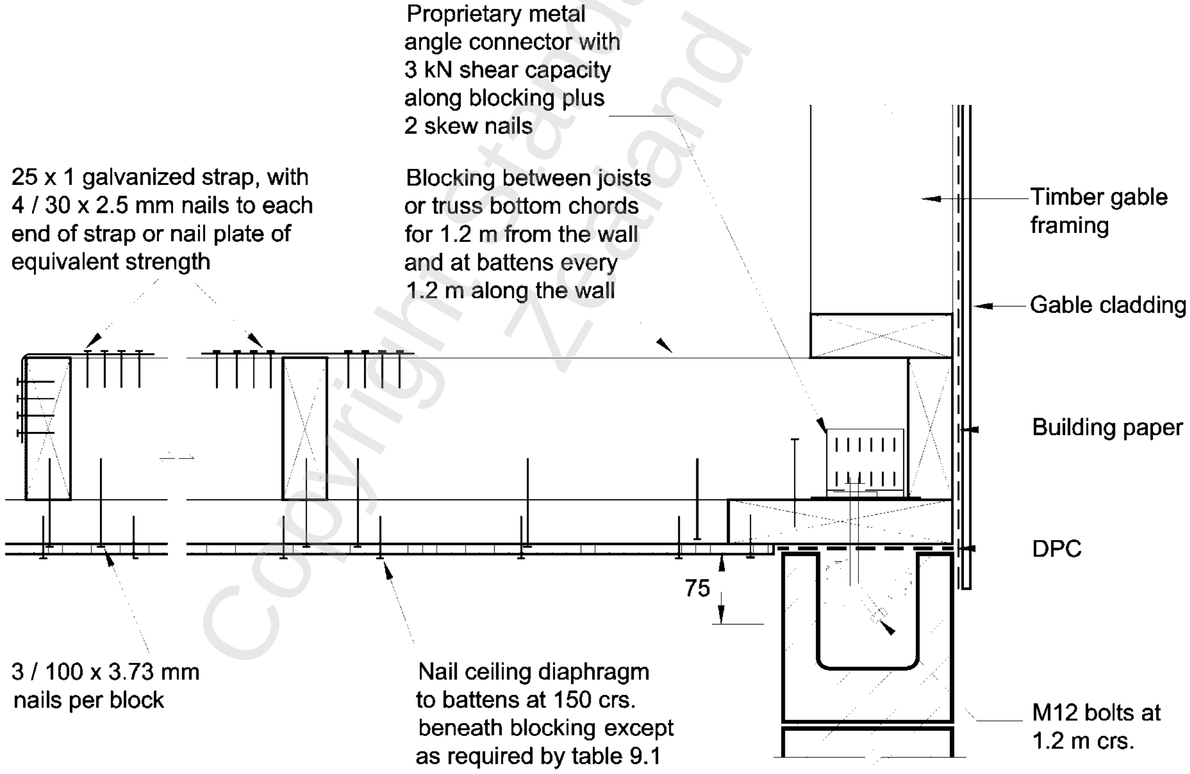
Figure 9.3 – Sloping ceiling diaphragms – sheet material on battened rafters (see 9.2.6.2)



NOTE -
(1) Minimum embedment length of all M12 bolts shall be 75 mm.
(2) The length of the bolt is determined by the thickness of the members to be attached.
(3) Use mild steel galvanized washers, 50 x 50 x 3 mm between bolt head and timber member.

Figure 9.3 – Sloping ceiling diaphragms – sheet material on battened rafters (continued) (see 9.2.6.2)





NOTE -
(1) Minimum embedment length of all M12 bolts shall be 75 mm.
(2) The length of the bolt is determined by the thickness of the members to be attached.
(3) Use mild steel galvanized washers, 50 x 50 x 3 mm between bolt head and timber member.

Figure 9.4 – Horizontal ceiling diaphragms (see 9.2.6.2)

C9.3.3
For equivalency of shot fixed nailing see NZS 3604.

9.3.3
Nail fixing shall comply with table 9.2 and figure 9.1.

9.3.4 *Connection of timber floor diaphragms to masonry walls*

9.3.4.1
All floor timber *diaphragms* shall be provided with a boundary joist of *dimensions* not less than the attached joists.

9.3.4.2
Where a floor *diaphragm* is fixed to the face of *structural walls* it shall be bolted and anchored to the wall as detailed in figure 9.5(A), (B) and (C).

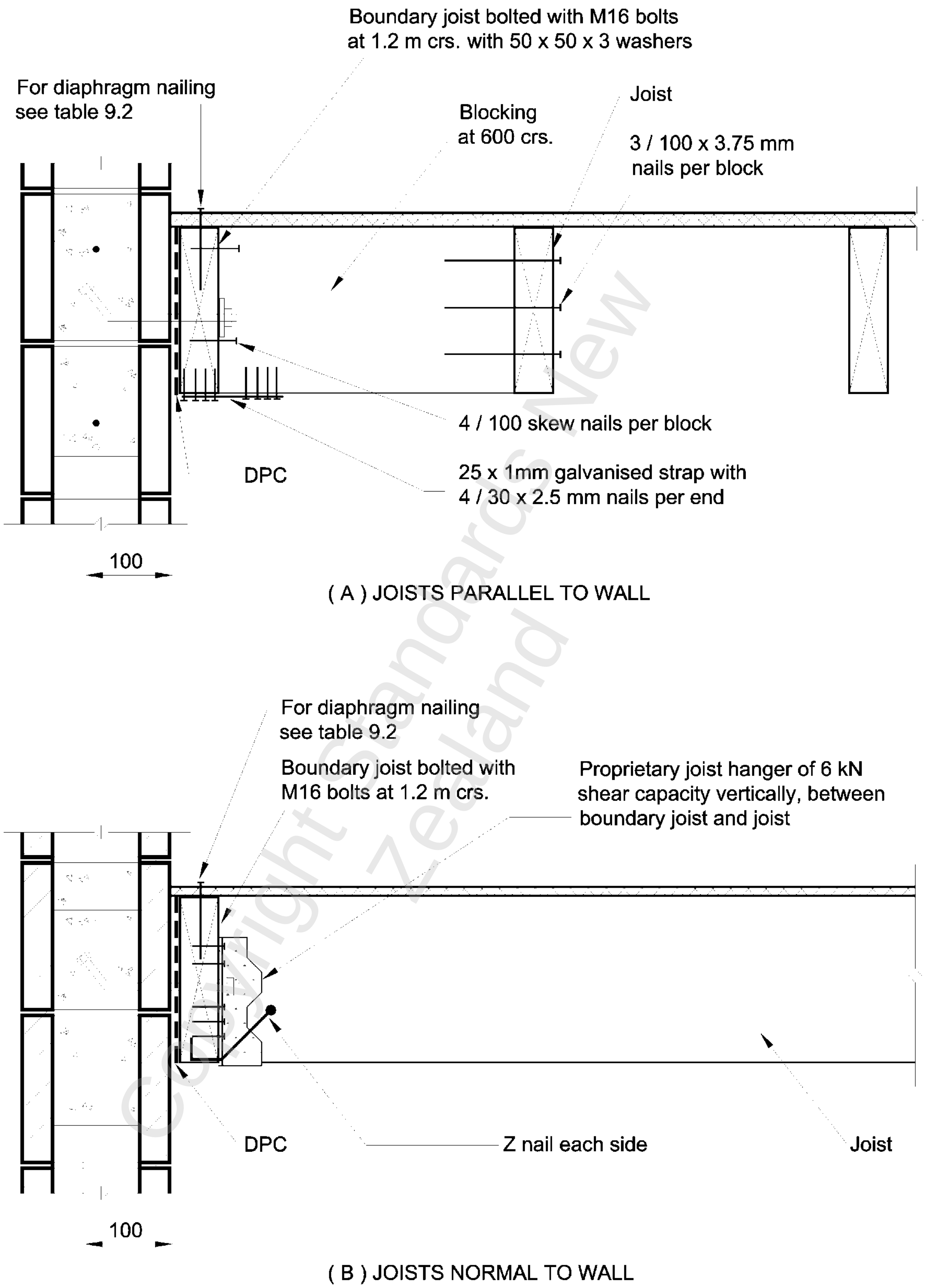
9.3.4.3
Where a floor *diaphragm* is supported on top of a *structural wall* a continuous timber *plate* shall be bolted to the top of the wall to which the boundary joists shall be fixed. Connection of floor *diaphragms* to the tops of walls shall be as detailed in figure 9.5(D), (E) and (F).

Table 9.2 – Nail fixing for floor diaphragm (see 9.3.3)

Masonry wall series	Storey height		Max. length/width ratio
	Up to 2.6 (m)	> 2.6 to 3.0 (m)	
	Nail dia. x centres	Nail dia. x centres	
15 P	2.8 x 150	2.8 x 150	2
15 S	2.8 x 150	2.8 x 100 3.15 x 150	2
20 P	2.8 x 100 3.15 x 150	2.8 x 100 3.15 x 150	2
20 S or 15 P + 100 veneer	2.8 x 100 3.15 x 150	2.8 x 100 3.15 x 150	1.5
25 P	2.8 x 100 3.55 x 150	2.8 x 100 3.55 x 150	2
25 S	3.15 x 100	3.55 x 100	2
or 15 S + 100 veneer or 20 P + 100 veneer	2.8 x 100	3.15 x 100	1.5
20 S + 100 veneer	2.8 x 100	3.15 x 100	1.5

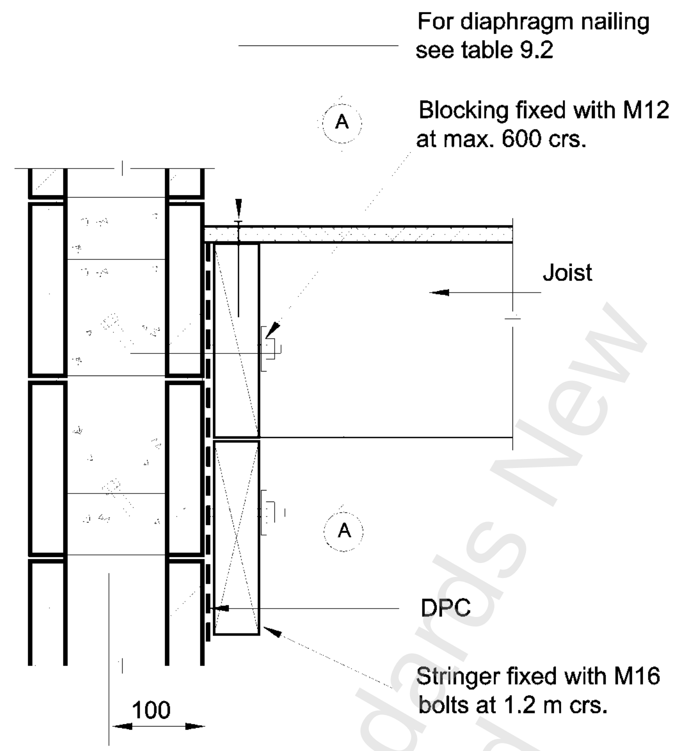
"P" means partially filled and "S" means solid filled.

NOTE –
(1) Interior fixings of the sheet material to be nailed at 300 mm centres.
(2) When using the special conditions permitted by 8.8.4, the nailing centres shall be required to be halved on half the *diaphragm* area adjoining the wall required to carry 100 % of the *bracing demand*.
(3) Minimum length of nails shall be 60 mm or 2.5 times the *thickness* of the *diaphragm* sheets, whichever is greater.

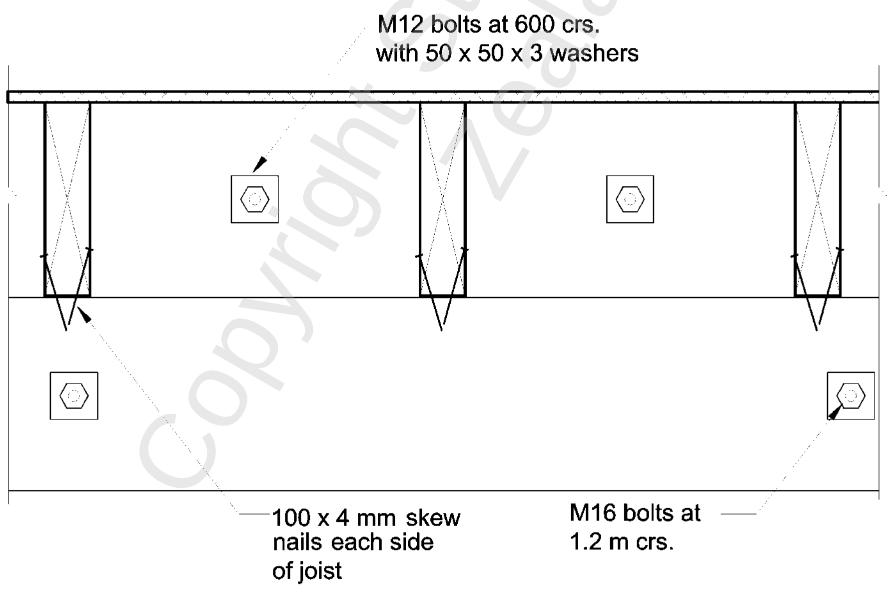


NOTE -
(1) Minimum embedment length of all M12 bolts shall be 75 mm.
(2) The length of the bolt is determined by the thickness of the members to be attached.
(3) Use mild steel galvanized washers, 50 x 50 x 3 mm between bolt head and timber member.

Figure 9.5 – Timber floor diaphragms connections (see 9.3.4.2)



(C) JOISTS NORMAL TO WALL



SECTION A - A

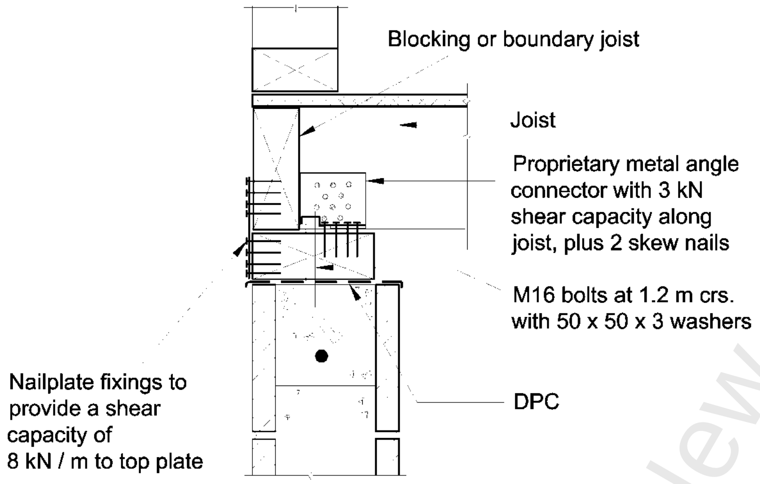
Figure 9.5 – Timber floor diaphragms connections (continued) (see 9.3.4.2)

NOTE –

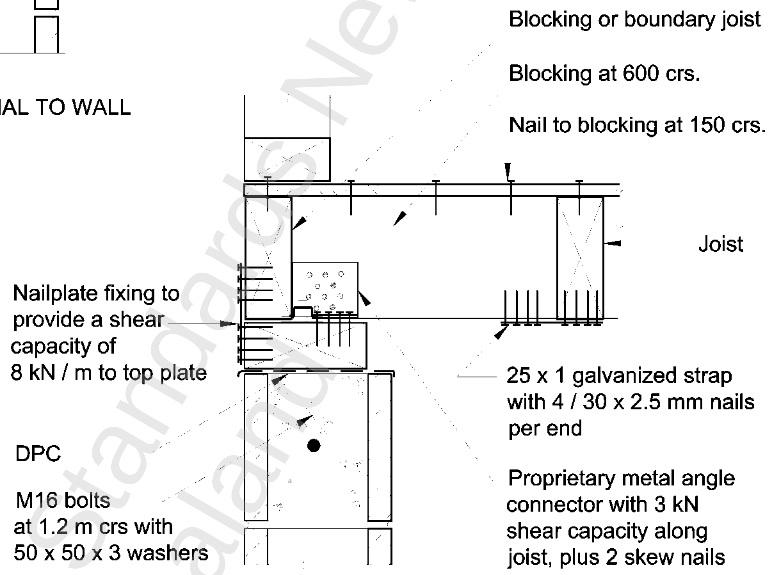
(1) Minimum embedment length of all M12 bolts shall be 75 mm.

(2) The length of the bolt is determined by the thickness of the members to be attached.

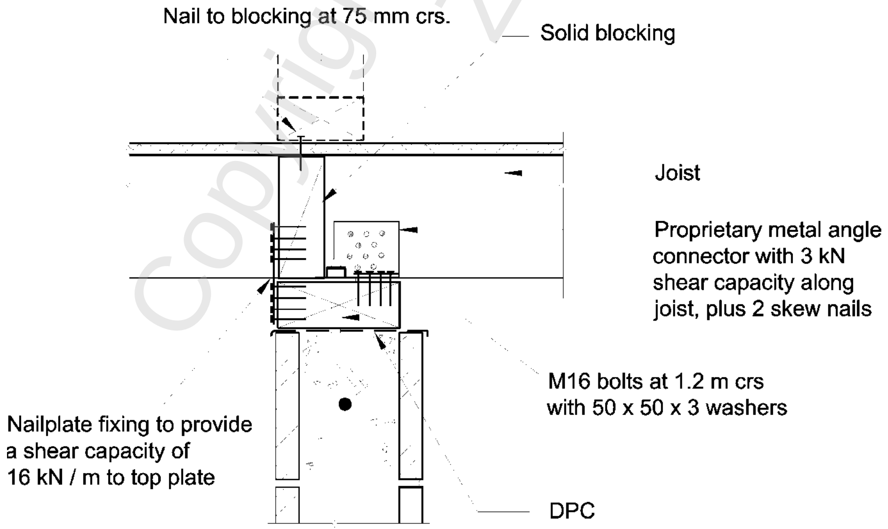
(3) Use mild steel galvanized washers 50 mm x 50 mm x 3 mm between bolthead and timber member.



(D) JOISTS NORMAL TO WALL



(E) JOISTS PARALLEL TO WALL



(F) JOISTS NORMAL TO WALL

Figure 9.5 – Timber floor diaphragms connections (continued) (see 9.3.4.3)

NOTE –

(1) Minimum embedment length of all M12 bolts shall be 75 mm.

(2) The length of the bolt is determined by the thickness of the members to be attached.

(3) Use mild steel galvanized washers 50 mm x 50 mm x 3 mm between bolthead and timber member.

9.4 Concrete diaphragms

9.4.1
Concrete *structural diaphragms* shall be constructed as follows:

(a) A *diaphragm* or part of a *diaphragm* shall have a length not exceeding 3.0 times its width;

(b) The length and width of a *diaphragm* as referred to in (a) shall be between supporting walls at right angles to each other;

(c) The concrete floor or *in situ* topping over a precast concrete floor system shall include a minimum amount of steel mesh *reinforcement* of 2.0 kg/m^2 (665 mesh);

C9.4.1(c)
Additional reinforcement may be required by the proprietary floor supply for the purposes of shrinkage control.

(d) The concrete floor or *in situ* topping shall be connected to the supporting *bracing* walls by D12 bars at 800 mm as shown in figure 9.6.

9.4.2
The design of the concrete floor to meet strength and serviceability criteria for resisting gravity loads is outside the scope of this standard.

C9.4.2
Concrete floors designed to NZS 3101 and NZS 4203 are acceptable. Other designs will need to demonstrate compliance with the New Zealand Building Code to the satisfaction of the Territorial Authority.

9.5 Openings in diaphragms

9.5.1 *Timber*

9.5.1.1
Openings in *diaphragms* shall be trimmed with continuous boundary members on all sides of openings. Boundary members shall be as specified below:

(a) The *bond beam* on adjoining *structural walls* where the sides of the opening are supported on *masonry*;

(b) Trimmer and trimming joists as required by 7.1.6 of NZS 3604 for openings in floors;

(c) *Rafters* and trimming *rafters* as required by 13.2 of NZS 3604 for openings in roofs or ceilings.

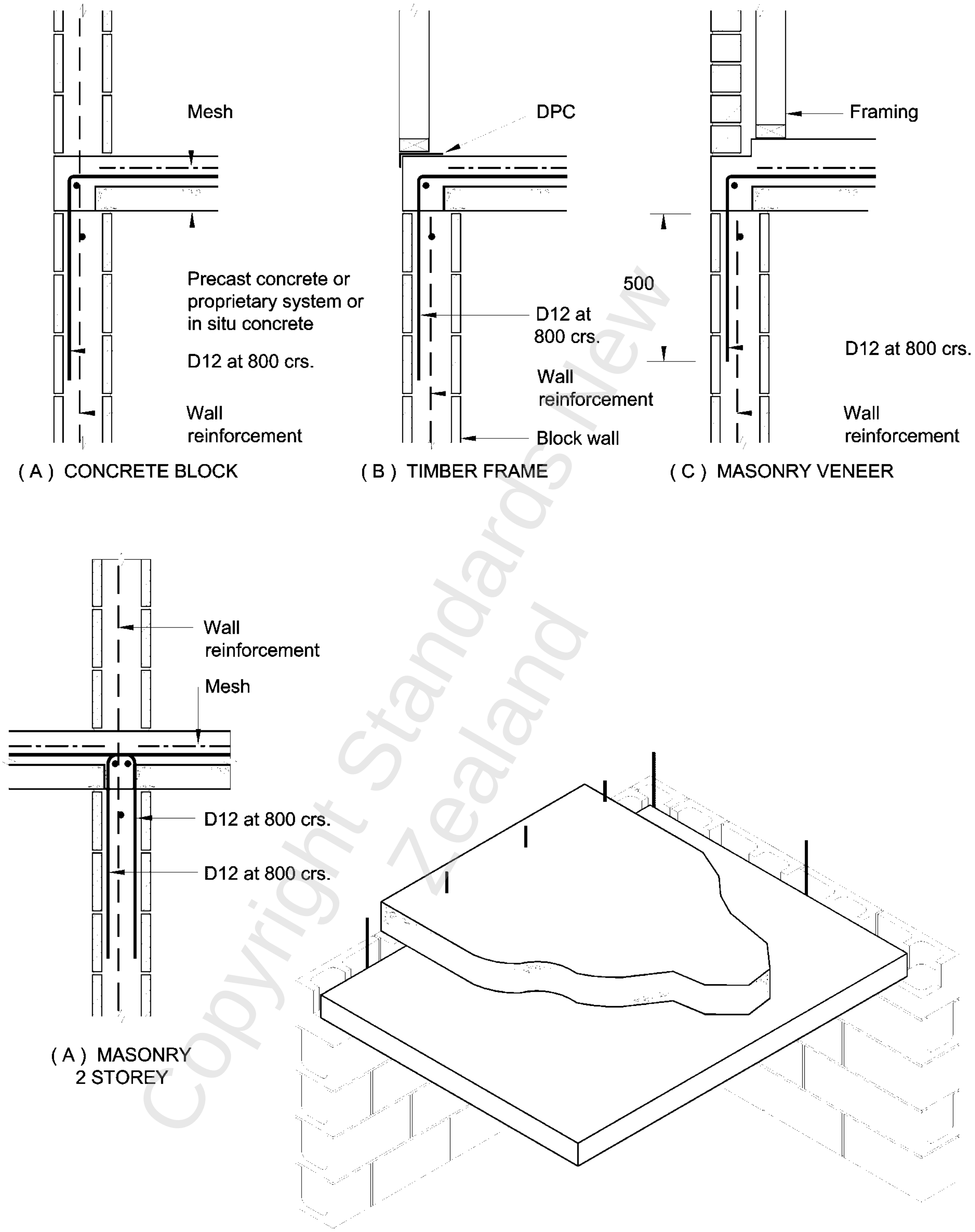


Figure 9.6 – Concrete floor diaphragm details (see 9.4.1)

9.5.1.2

Except as provided in 9.5.1.3, the *dimensions* of any single opening in a *diaphragm* in each of the 2 principal directions at right angles shall not exceed the following percentages of the respective parallel overall *dimensions* of the *diaphragm*:

(a) Where the opening is located wholly within the middle half area of the *diaphragm* as defined in figure 9.7 .... 40 %

(b) Where the opening is located other than wholly within the middle half area of the *diaphragm* .... 20 %

In addition the sum of the areas of all openings in a *diaphragm* shall not exceed the following percentages of the total area of the *diaphragm* (inclusive of openings):

(A) Where all the openings are located wholly within the middle half area of the *diaphragm* .... 16 %

(B) Where any opening is located other than wholly within the middle half area of the *diaphragm* .... 4 %

9.5.1.3

Diaphragms with openings which do not comply with 9.5.1.2 shall be subject to specific engineering design.

9.5.2 Concrete

The provision of openings in a concrete *diaphragm* shall require specific engineering design.

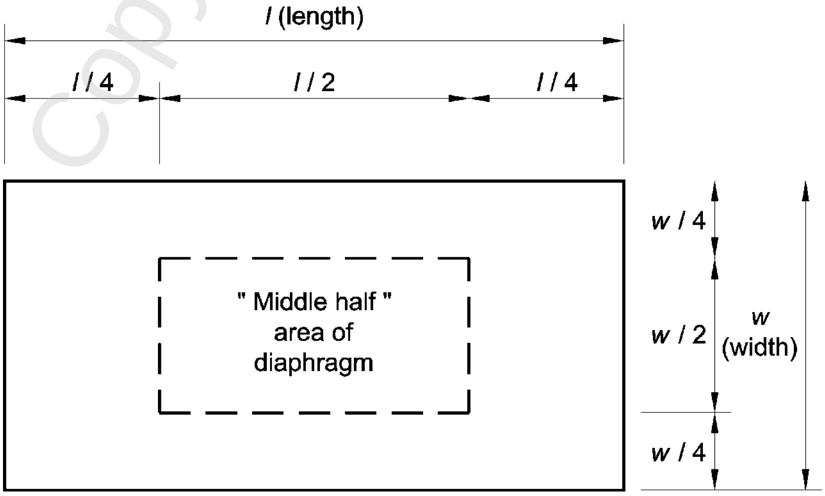


Figure 9.7 – Location of openings in diaphragm (see 9.5.1.2(a))

SECTION 10

SECTION 10
BOND BEAMS

Table

Figure

NOTES

10 BOND BEAMS

10.1 General

10.1.1

All *masonry* walls shall be provided with *bond beams* at top courses and connections with floors, ceilings and *roofs* in order to:

(a) Transfer lateral loads by spanning between adjacent transverse *structural walls* or other specifically designed lateral supporting structures;

(b) Provide anchorage of floor and *roof* members;

(c) Tie the *masonry* walls together;

(d) Provide a continuous boundary member to *structural diaphragms*.

10.1.2

Bond beams shall be constructed of *reinforced masonry*. The beam width shall be not less than the wall *thickness*.

10.2 Bracing line support systems

10.2.1

For *bracing line* support systems continuous *bond beams* shall be provided at the tops of all walls and at floor levels. *Dimensions* and steel layout shall be as shown in table 10.1 and figure 10.1.

10.2.2

For wall heights 800 mm and less, a single D16 trimming bar shall be used in the top course of blockwork.

C10.2.2

This clause relaxes the bond beam requirements for low rise walls such as parapets.

10.2.3

Where *bracing line* construction is adopted, the *roof* structure shall be fixed to the *bond beams* which comply with figure 10.1.

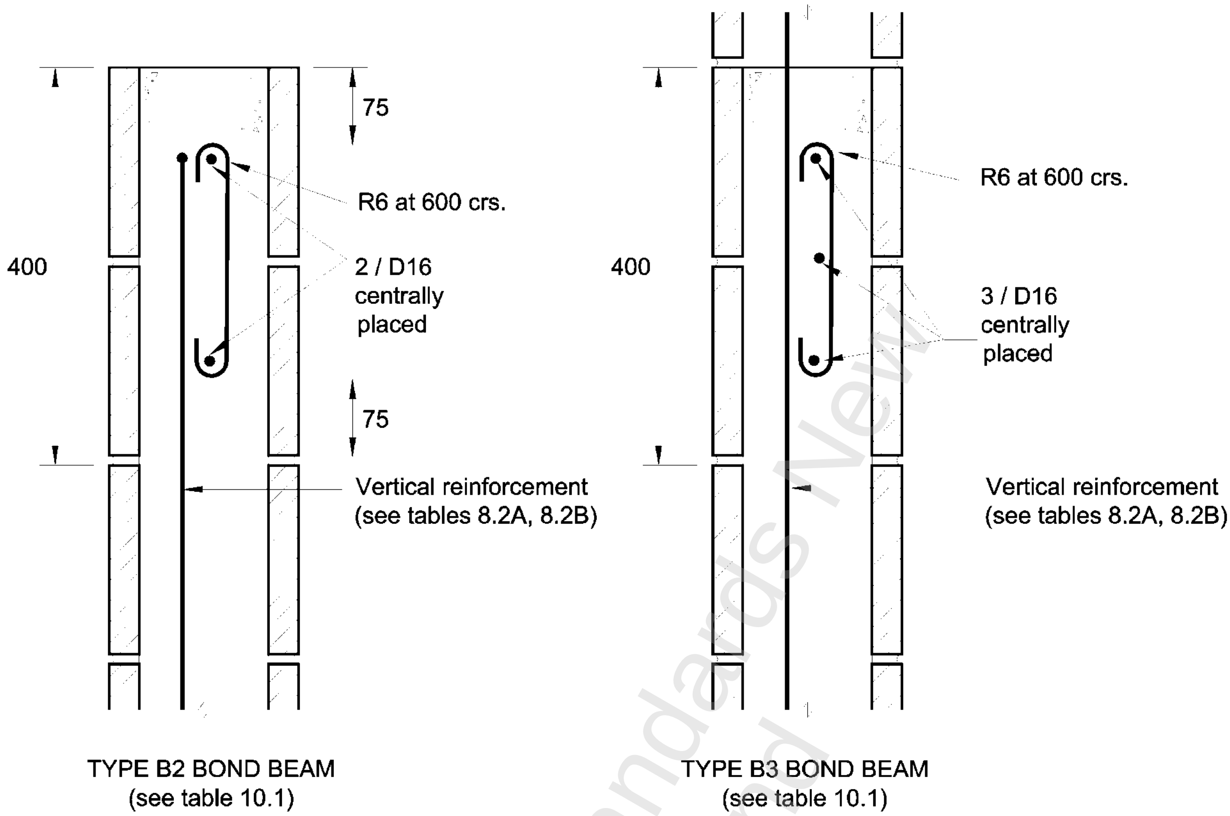


Figure 10.1 – Bond beam details – Bracing line system (see 10.2.1)

Table 10.1 – Bond beam – maximum spans (see 10.2.1)

Bond beam type	Storey height up to 2.6 m (1)	Construction type: Wall series	Maximum spacing in m (Bracing lines) – Earthquake zones: A	B	C
B2 See figure 10.1	Single storey Partially filled	15	7.2	8.0	8.0
		20	9.0	9.0	9.0
		25	9.0	9.0	9.0
		15 + 100 mm veneer	6.2	7.4	8.0
		20 + 100 mm veneer	7.6	8.0	8.0
	Single storey Solid filled	15	6.8	8.0	8.0
		20	7.6	8.0	9.0
		25	9.0	9.0	9.0
		15 + 100 mm veneer	6.0	7.0	8.0
		20 + 100 mm veneer	7.0	7.4	8.0
B3 See figure 10.1	Two storey Partially filled	15	5.6	6.6	8.0
		20	7.0	8.0	8.0
		25	8.0	8.0	8.0
		15 + 100 mm veneer	4.8	5.4	6.6
		20 + 100 mm veneer	6.0	7.0	8.0
	Two storey Solid filled	15	5.2	6.0	7.4
		20	6.0	7.0	8.0
		25	7.0	8.0	8.0
		15 + 100 mm veneer	4.4	5.2	6.4
		20 + 100 mm veneer	5.2	6.2	7.4

NOTE –

(1) For storey height greater than 2.6 m and less than 3.0 m the maximum spans shall be reduced by 8 % i.e. values in the table to be multiplied by 0.92.

(2) Where a permitted offset to 8.7.5 occurs, it shall not cause the bond beam to exceed these maximum span values.

(3) Bond beam span is measured between the centre lines of the supporting bracing walls.

10.3 Structural diaphragm systems

10.3.1

Bond beams shall be provided as a continuous boundary member for all *structural diaphragms* and shall be reinforced with at least 1/D16 bar.

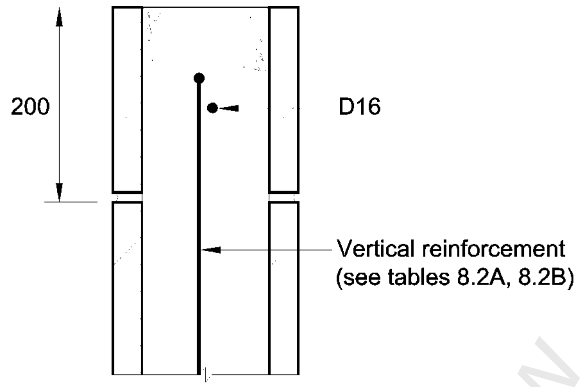
10.3.2

The depth of *bond beams* for use with *structural diaphragms* shall not be less than 200 mm as per figure 10.2. Two/D12 reinforcing bars can be substituted for 1/D16 reinforcing bar.

10.4 Intersection of bond beams

10.4.1

The intersection of *bond beams* shall be as detailed in figure 10.3.



NOTE - Refer to 10.3.

TYPE B1 BOND BEAM

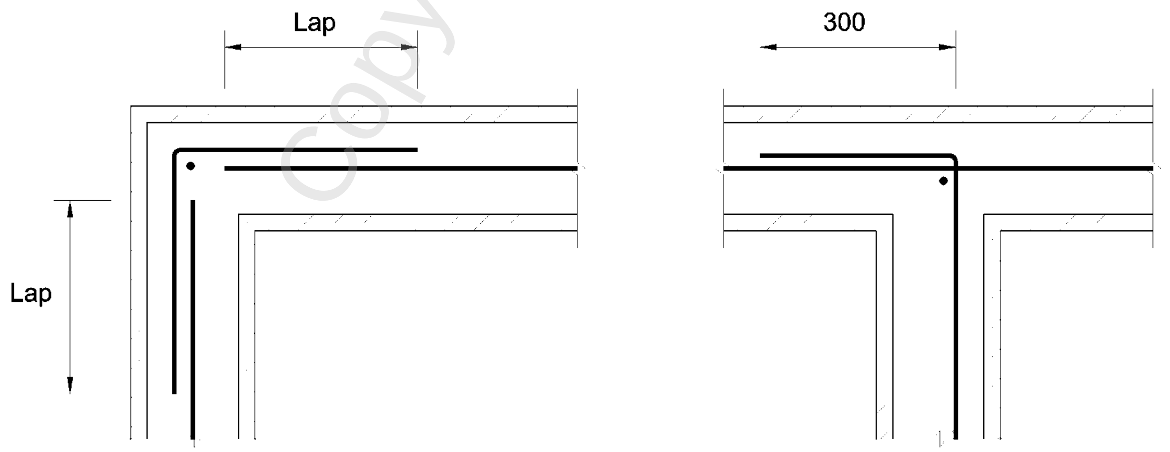
Figure 10.2 – Bond beam details – Diaphragm system (see 10.3.2)

10.5 Gable shaped walls

10.5.1
A raking *bond beam* Type B2 shall be provided at the top of every *gable* shaped wall and shall be connected to and continuous with other adjoining *bond beams*.

10.5.2
The size of raking *bond beams* shall be determined from table 10.1 in accordance with the sloping distance between *bracing lines*.

10.5.3
An *intermediate bond beam* Type B3 shall be provided at the top of the wall immediately beneath the *gable* shaped wall and be connected to, and continuous with adjoining *bond beams*.



NOTE -
(1) Laps to be in accordance with 8.1.5.
(2) For 4 bar bond beams see figure 6.6 for lapping requirements.

Figure 10.3 – Bond beam intersections (see 10.4.1)

SECTION 11

SECTION 11
LINTELS AND COLUMNS

Table

Figure

NOTES

11 LINTELS AND COLUMNS

11.1 General

11.1.1
Lintels shall be provided over all openings and shall be constructed of *reinforced masonry*.

C11.1.1
See also 8.3.5 and figure 8.1.

11.1.2
The width of the *lintel* shall not be less than the total *thickness* of the supported wall.

11.1.3
Point loads on *lintels* are not covered by this Standard.

C11.1.3
Point loads occur when a load from a beam or column is not uniformly distributed over the entire span of the lintel. The most common type of point load is a steel beam supporting a timber floor which may become supported near the mid-span of a lintel. Since the design of the steel beam will require specific design the modification of the lintel design to carry the point load can be considered at this time.

Rafters or trusses landing on lintels are considered to be uniformly distributed loads.

11.1.4
Isolated single *columns* are not covered by this Standard except as provided for in 11.5.

11.2 Size and reinforcement of lintels

11.2.1
Lintels shall be reinforced in accordance with tables 11.1 and 11.2.

C11.2.1
If a solution is not found on these tables then specific engineering design will be required. Lintel dimensions and span are usually determined from architectural considerations.

11.2.2
Determine the sum of the loads on the *lintel* from table 6.1 (wall weight) and figures 6.1 (*roof* load) and 6.2 (*suspended floor* load). This total load shall then be used to determine the steel required from tables 11.1 and 11.2.

If the *lintel* is supporting loading from both sides (e.g. in an interior wall) both contributing weights must be summed to determine the loading on the *lintel*.

11.2.3
Lintels around corners shall be a minimum of 390 mm deep and shall span no more than 1.4 m (see figure 11.1). Loadings shall be from a *roof* load only. The span of the *roof* loading the *lintel* shall not exceed 12 m. Longitudinal reinforcing shall be 2/D16 bars with R6 shear reinforcement at 200 crs.

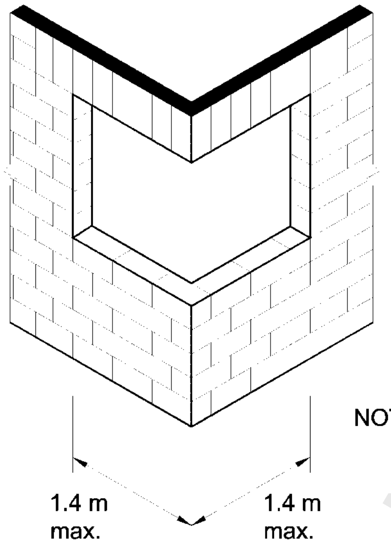


Figure 11.1 – Maximum lintel span at corner (see 11.2.3)

C11.2.4

Figure 11.1 details the reinforcing layout for masonry lintels. Tables 11.1 and 11.2 specify the reinforcement requirements depending on load and span. Each cell in tables 11.1 and 11.2 has 2 lines. The first line specifies the longitudinal reinforcement requirements. The second line details the shear steel (stirrups) spacing. All shear steel is R6 plain bar.

11.2.4

The location of *reinforcement* in *lintels* from tables 11.1 and 11.2 shall be as follows:

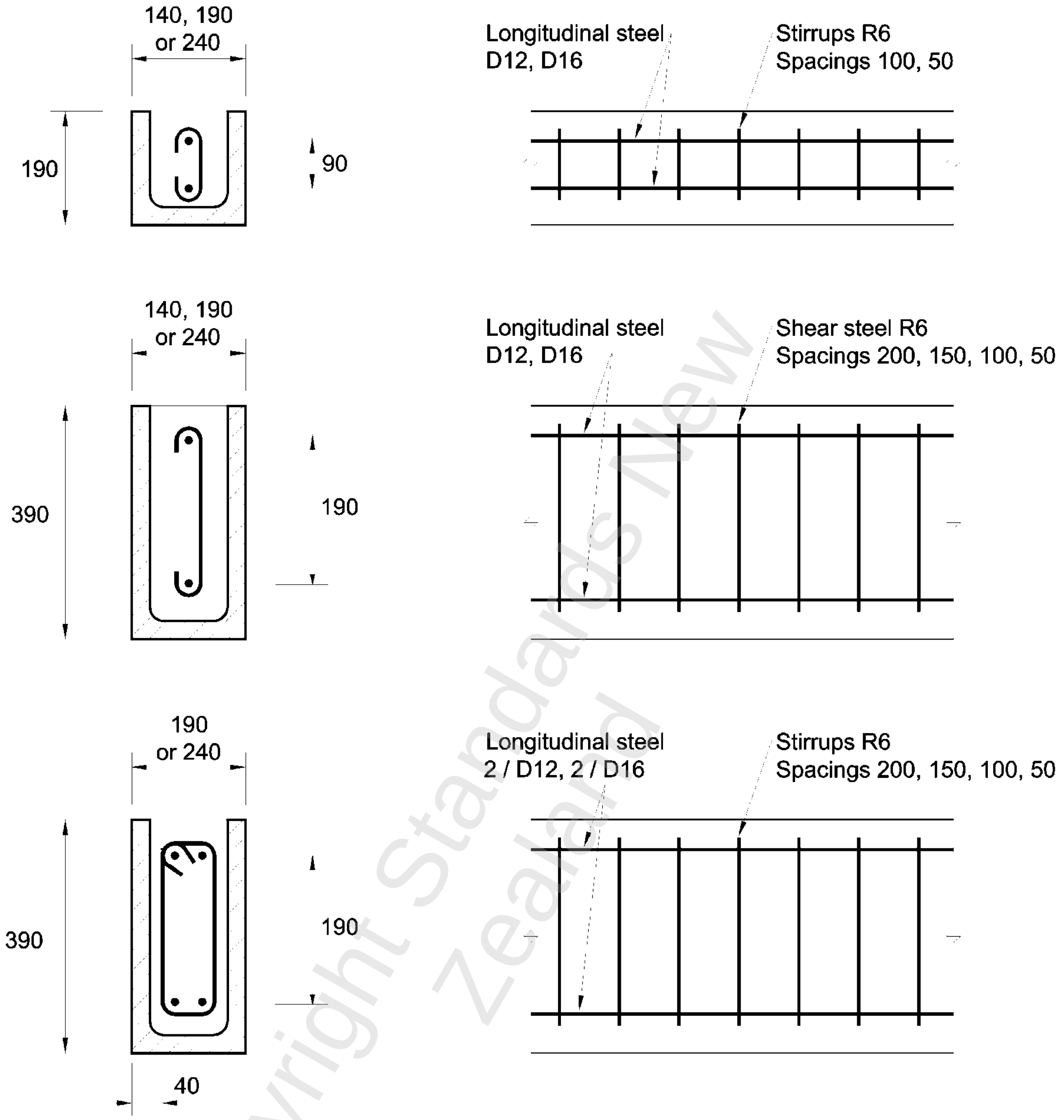
(a) Where 2 bars are required in 190 mm deep *lintels*, they shall be placed one above the other as per figure 11.2;

(b) Where 2 bars are required in 390 mm deep *lintels*, one bar shall be placed at the bottom and one at the top of the *lintel*.

11.3 Combination of lintels and bond beams

11.3.1

Where it is necessary to combine a *lintel* with a *bond beam* in a wall of a building, the *reinforcement* shall be continued across the combined member and shall be the maximum amount required by either the *lintel* or the *bond beam*.



NOTE – For selection of steel see tables 11.1(a), 11.1(b), 11.2(a) and 11.2(b).

Figure 11.2 – Lintel reinforcement layouts (see 11.2.4)

Table 11.1(a) – 190 mm deep lintels: 15 Series (see 11.2.1 and 11.2.2)

Load (kN/m)	15 Series 190 mm deep														
	Clear span (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2										2/D16 R6@100	2/D16 R6@100	2/D16 R6@100	-	-	-
4								2/D16 R6@100	2/D16 R6@100	-	-	-	-	-	-
6		ALL 2/D12 R6@100				2/D16 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-
8						2/D16 R6@100	-	-	-	-	-	-	-	-	-
10					2/D16 R6@100	-	-	-	-	-	-	-	-	-	-
12					2/D16 R6@50	-	-	-	-	-	-	-	-	-	-
14				2/D16 R6@100	-	-	Beyond the scope of this Standard					-	-	-	-
16				2/D16 R6@50	-	-						-	-	-	-
18				2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-
20			2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
22			2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
24			2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
26		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
28		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
30		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
32		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-
34		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-
36		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE – R10@100 mm can replace R6@50 mm

Table 11.1(b) – 190 mm deep lintels: 20 Series (see 11.2.1 and 11.2.2)

	20 Series 190 mm deep														
Load (kN/m)	**Clear span** (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2											2/D16 R6@100	2/D16 R6@100	2/D16 R6@100		-
4								2/D16 R6@100	2/D16 R6@100	4/D12 R6@100	-	-	-	-	-
6		ALL 2/D12 R6@100					2/D16 R6@100	4/D12 R6@100		-	-	-	-	-	-
8						2/D16 R6@100	4/D12 R6@100	-	-	-	-	-	-	-	-
10					2/D16 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-	-
12					2/D16 R6@100	-	-	-	-	-	-	-	-	-	-
14				2/D16 R6@100	2/D16 R6@50	-			Beyond the scope of this Standard		-	-	-	-	-
16				2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-
18				2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-
20			2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-
22			2/D16 R6@50	4/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-
24			2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
26		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
28		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
30		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
32		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-
34		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-
36		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE – R10@100 mm can replace R6@50 mm.

Table 11.1(c) – 190 mm deep lintels: 25 Series (see 11.2.1 and 11.2.2)

25 Series 190 mm deep															
Load (kN/m)	**Clear span** (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2												2/HD12 R6@100	2/HD12 R6@100	2/D16 R6@100	-
4								2/HD12 R6@100	2/HD12 R6@100	2/D16 R6@100	-	-	-	-	-
6		ALL 2/D12 R6@100					2/HD12 R6@100	2/D16 R6@100	-	-	-	-	-	-	-
8						2/HD12 R6@100	4/D12 R6@100	-	-	-	-	-	-	-	-
10					2/HD12 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-	-
12					2/HD12 R6@100	-	-	-	-	-	-	-	-	-	-
14				2/HD12 R6@100	2/D16 R6@50	-	Beyond the scope of this Standard				-	-	-	-	-
16				2/HD12 R6@100	4/D12 R6@100	-	-	-	-	-	-	-	-	-	-
18				2/HD12 R6@50	-	-	-	-	-	-	-	-	-	-	-
20				2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-
22			2/HD12 R6@50	4/D12 R6@100	-	-	-	-	-	-	-	-	-	-	-
24			2/HD12 R6@50	4/D12 R6@100	-	-	-	-	-	-	-	-	-	-	-
26			2/HD12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
28			2/HD12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
30			2/HD12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
32		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
34		2/D12 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-	-	-
36		2/D12 R6@50	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE – R10@100 mm can replace R6@50 mm.

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Table 11.2(a) – 390 mm deep lintels: 15 Series (see 11.2.1 and 11.2.2)

15 Series 390 mm deep															
Load (kN/m)	**Clear span** (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2															
4											-		2/D16 R6@200	2/D16 R6@200	2/D16 R6@200
6		ALL 2/D12 R6@200									2/D16 R6@200	2/D16 R6@200	2/D16 R6@200	-	-
8									2/D16 R6@200	2/D16 R6@200	2/D16 R6@200	-	-	-	-
10								2/D16 R6@200	2/D16 R6@200	2/D16 R6@150	-	-	-	-	-
12								2/D16 R6@150	2/D16 R6@150	-	-	-	-	-	-
14							2/D16 R6@150	2/D16 R6@150	-	-	-	-	-	-	-
16						2/D12 R6@150	2/D16 R6@150	2/D16 R6@100	-	-	-	-	-	-	-
18						2/D16 R6@150	2/D16 R6@100	-	-	-	-	-	-	-	-
20					2/D12 R6@150	2/D16 R6@100	2/D16 R6@100	-	-	Beyond the scope of this Standard				-	-
22					2/D12 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-	-
24				2/D12 R6@150	2/D16 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-	-
26				2/D12 R6@150	2/D16 R6@100	2/D16 R6@50	-	-	-	-	-	-	-	-	-
28				2/D12 R6@100	2/D16 R6@100	-	-	-	-	-	-	-	-	-	-
30			2/D12 R6@150	2/D12 R6@100	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-
32			2/D12 R6@150	2/D12 R6@100	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-
34			2/D12 R6@150	2/D16 R6@100	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-
36			2/D12 R6@100	2/D16 R6@50	2/D16 R6@50	-	-	-	-	-	-	-	-	-	-

NOTE – R10@100 mm can replace R6@50 mm and R10@20mm can replace R6@100 mm.

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Table 11.2(b) – 390 mm deep lintels: 20 Series (see 11.2.1 and 11.2.2)

20 Series 390 mm deep															
Load (kN/m)	**Clear span** (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2															
4													2/D16 R6@200	2/D16 R6@200	2/D16 R6@200
6		ALL 2/D12 R6@200									2/D16 R6@200	2/D16 R6@200	2/D16 R6@200	4/D16 R6@200	4/D16 R6@200
8									2/D16 R6@200	2/D16 R6@200	2/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200
10								2/D16 R6@200	2/D16 R6@200	2/D16 R6@150	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	-
12								2/D16 R6@200	2/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	-	-
14							2/D16 R6@200	2/D16 R6@150	4/D16 R6@200	4/D16 R6@200	4/D16 R6@200	4/D16 R6@150	-	-	-
16							2/D16 R6@150	2/D16 R6@150	4/D16 R6@200	4/D16 R6@200	4/D16 R6@150	-	-	-	-
18						2/D16 R6@200	2/D16 R6@150	4/D16 R6@200	4/D16 R6@200	4/D16 R6@150	-	-	-	-	-
20						2/D16 R6@150	2/D16 R6@100	4/D16 R6@200	4/D16 R6@150	4/D16 R6@150	-	-	-	-	-
22					2/D12 R6@150	2/D16 R6@100	4/D16 R6@150	4/D16 R6@150	4/D16 R6@150	-	-	-	-	-	-
24					2/D16 R6@150	2/D16 R6@100	4/D16 R6@150	4/D16 R6@150	4/D16 R6@100	-	-	-	-	-	-
26					2/D16 R6@100	2/D16 R6@100	4/D16 R6@100	4/D16 R6@100	-	Beyond the scope of this Standard				-	-
28				2/D12 R6@150	2/D16 R6@100	4/D16 R6@100	4/D16 R6@100	4/D16 R6@100	-	-	-	-	-	-	-
30				2/D12 R6@150	2/D16 R6@100	4/D16 R6@100	4/D16 R6@100	4/D16 R6@100	-	-	-	-	-	-	-
32				2/D12 R6@100	2/D16 R6@50	4/D16 R6@100	4/D16 R6@100	-	-	-	-	-	-	-	-
34			2/D12 R6@150	2/D12 R6@100	2/D16 R6@50	4/D16 R6@100	4/D16 R6@100	-	-	-	-	-	-	-	-
36			2/D12 R6@150	2/D16 R6@100	4/D16 R6@50	4/D16 R6@50	4/D16 R6@50	-	-	-	-	-	-	-	-

NOTE – R10@100 mm can replace R6@50 mm and R10@200 mm can replace R6@100 mm.

Table 11.2(c) – 390 mm deep lintels: 25 Series (see 11.2.1 and 11.2.2)

25 Series 390 mm deep															
Load (kN/m)	**Clear span** (m)														
	0.6	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**	**4.2**	**4.6**	**5.0**	**5.4**	**5.8**	**6.2**
2															
4													2/HD12 R6@200	2/HD12 R6@200	2/HD12 R6@200
6		ALL 2/D12 R6@200									2/HD12 R6@200	2/HD12 R6@200	2D16 R6@200	2/HD16 R6@200	2/HD16 R6@200
8									2/HD12 R6@200	2/HD12 R6@200	2D16 R6@200	2/HD16 R6@200	2/HD16 R6@200	2/HD16 R6@200	4/D16 R6@200
10								2/HD12 R6@200	2/HD12 R6@200	2/D16 R6@200	2/HD16 R6@200	2/HD16 R6@200	4/HD12 R6@200	4/D16 R6@200	4/HD16 R6@200
12								2/HD12 R6@200	2/D16 R6@200	2/HD16 R6@200	2/HD16 R6@150	4/HD12 R6@200	4/D16 R6@200	4/HD16 R6@200	4/HD16 R6@200
14							2/HD12 R6@200	2/D16 R6@200	2/HD16 R6@200	2/HD16 R6@150	4/HD12 R6@200	4/D16 R6@200	4/HD16 R6@200	4/HD16 R6@150	-
16							2/HD12 R6@200	2/D16 R6@150	2/HD16 R6@150	4/HD12 R6@200	4/D16 R6@200	4/HD16 R6@150	4/HD16 R6@150	-	-
18						2/HD12 R6@200	2/D16 R6@150	2/HD16 R6@100	2/HD16 R6@100	4/D16 R6@200	4/HD16 R6@150	4/HD16 R6@150	-	-	-
20						2/HD12 R6@200	2/D16 R6@150	2/HD16 R6@100	4/HD12 R6@200	4/D16 R6@150	4/HD16 R6@100	-	-	-	-
22						2/HD12 R6@150	2/HD16 R6@100	2/HD16 R6@100	4/D16 R6@150	4/HD16 R6@100	4/HD16 R6@100	-	-	-	-
24					2/HD12 R6@200	2/D16 R6@100	2/HD16 R6@100	4/HD12 R6@150	4/D16 R6@150	4/HD16 R6@100	-	-	-	-	-
26					2/HD12 R6@150	2/D16 R6@100	2/HD16 R6@50	4/HD12 R6@150	4/HD16 R6@100	4/HD16 R6@100	Beyond the scope of this Standard				-
28					2/HD12 R6@100	2/D16 R6@100	2/HD16 R6@50	4/D16 R6@100	4/HD16 R6@100	4/HD16 R6@100	-	-			
30				2/D12 R6@150	2/HD12 R6@100	2/HD16 R6@50	2/HD16 R6@50	4/D16 R6@100	4/HD16 R6@100	-	-	-	-	-	-
32				2/D12 R6@150	2/HD12 R6@100	2/HD16 R6@50	4/HD12 R6@100	4/HD16 R6@100	4/HD16 R6@50	-	-	-	-	-	-
34				2/D12 R6@100	2/D16 R6@100	2/HD16 R6@50	4/D16 R6@100	4/HD16 R6@100	4/HD16 R6@50	-	-	-	-	-	-
36				2/HD12 R6@100	2/HD16 R6@50	2/HD16 R6@50	4/D16 R6@100	4/HD16 R6@50	-	-	-	-			

NOTE – R10@100 mm can replace R6@50 mm and R10@200 mm can replace R6@100 mm.

C11.4
Wall columns are different from columns in that while they contain vertical reinforcement they do not contain a reinforcing cage. Wall columns are allocated no bracing capacity.

11.4 Wall columns

11.4.1
Wall *columns* within the *thickness* of the wall shall be solid filled.

11.4.2
The size of the wall *column* shall be determined from the loads carried by each *lintel* on to the *column* from tables 11.1 and 11.2 and by reference to load capacities in table 11.3.

11.4.3
The loads from the end of *lintels* are determined by multiplying half the clear span of *lintel* and the load (kN/m) for each *lintel* and then summing the loads.

11.4.4
The clear height of a wall column shall not exceed 2.8 m.

11.4.5
No more than 2 wall columns shall be used in sequence subject also to the limitations of figure 11.3.

11.4.6
A wall bracing panel having a minimum length of 800 mm shall be provided on each side of a pair of wall columns.

11.4.7
Reinforcement shall be placed in the outermost cells of the column as required by 8.3.2 and figure 8.1.

Table 11.3 – Capacity of wall columns (see 11.4.2)

Length (mm)	**Load capacity** (kN)		
	Wall thickness		
	15	20	25
190	14	19	24
390	29	38	48
590	43	58	72

11.5 Columns

11.5.1

The requirement for an isolated column not subject to potential damage from vehicles, Type 1, supporting *lintel* loads arising from roof only shall be as follows:

(a) 190 mm x 190 mm minimum dimensions;

(b) Raking of joints shall not be permitted;

(c) Reinforced with 1/D16 bar centrally placed throughout the height, lapped with *lintel* steel at the head of the column and embedded into a concrete footing 500 mm square by 200 mm thick or into a reinforced concrete foundation beam;

(d) Maximum loading on the column determined from *lintel* tables 11.1 and 11.2 shall not exceed 25 kN nor shall the span of any *lintel* on to the column exceed 2.8 m;

(e) Clear height of the column shall not exceed 2.4 m.

11.5.2

The requirement for a single column, Type 2, supporting *lintel* loads arising from roof, floor, wall and/or combination of these loads shall be as follows:

(a) 390 mm x 190 mm minimum dimension. When used at a garage entrance the 390 mm dimension shall be parallel to the direction of vehicular movement.

(b) Reinforced with 4/D12 bars and R6 links at 200 mm centres, lapped with *lintel* steel at the head of the column and embedded into a concrete footing 900 mm square by 200 mm thick reinforced with D16 bars at 150 centres each way or into a reinforced foundation beam;

(c) Maximum loading on the column determined from *lintel* tables 11.1 and 11.2 shall not exceed 90 kN;

(d) Clear height of the column shall not exceed 2.8 m.

C11.5

Columns of this type are allocated no bracing capacity. The full bracing demand must be met by walls in the bracing line or alternatively by masonry frames to specific engineering design.

C11.5.1

Where the column location is considered vulnerable to vehicle damage a Type 2 column should be used.

C11.5.1(c)

A D16 bar needs to securely held in position at the mid-height of the column to prevent displacement during grouting.

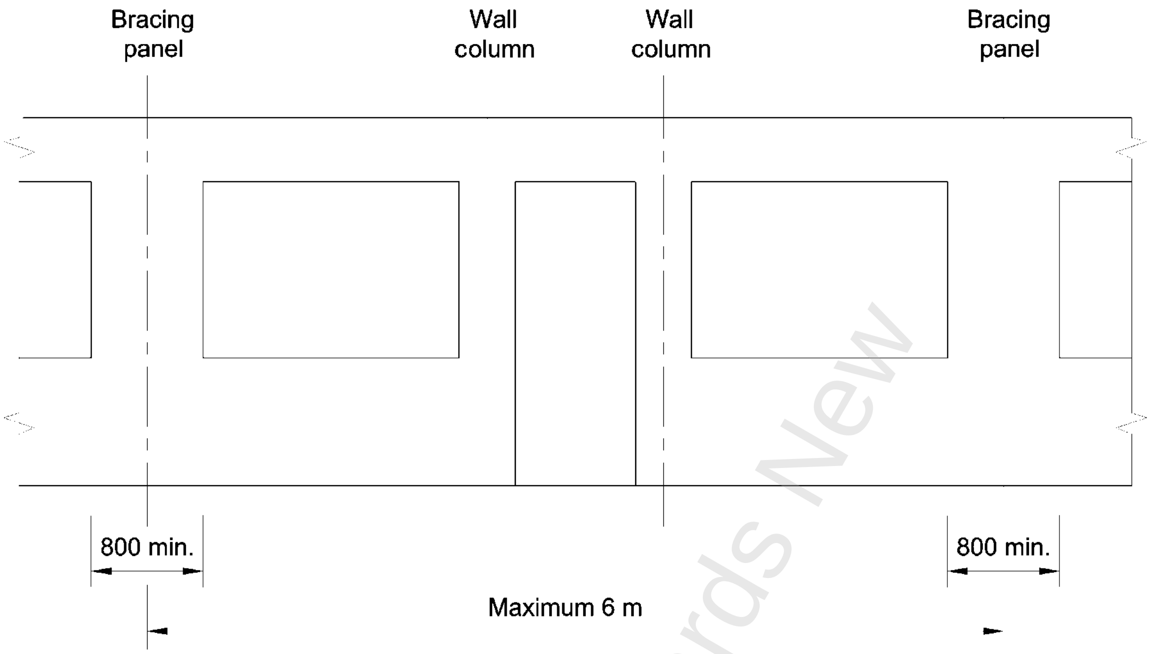


Figure 11.3 – Wall column spacing (see 11.4.5)

SECTION 12

SECTION 12

MASONRY VENEER WALL COVERING

Table

NOTES

12 MASONRY VENEER WALL COVERING

12.1 Scope

This clause covers this Standard's requirements for *masonry veneer* exterior cladding.

(a) The maximum height of *veneer* shall be 6 metres measured from the top of a supporting concrete *masonry* or reinforced concrete *foundation* or a slab edge *foundation* except that, if at a *gable* end, the overall height can be increased to 10 metres.

C12.1(a)
See figure 1.1(b).

(b) Where construction adjoins a *public place* or egress and the *veneer* is in excess of 6 m in height the *veneer* construction shall be the subject of specific engineering design.

(c) Where a timber framed upper *storey* has been used then the maximum height above the *masonry* substructure shall not exceed the provisions of NZS 3604.

(d) The maximum mass of *veneer* covered by this Standard is 220 kg/m^2.

12.2 General

12.2.1

The materials and workmanship of *masonry veneer* shall be in accordance with NZS 4210.

12.2.2

No length of a *veneer* wall or return shall be less than 230 mm, measured from the external face of the *veneer*.

12.2.3

The *masonry* units shall have a minimum nominal work width of 70 mm as determined by AS/NZS 4455.

12.3 Foundation

12.3.1

The *veneer* shall not overhang the supporting *foundation* by more than 20 mm.

12.4 Cavities

12.4.1

The cavity between *masonry veneer* and the exterior face of the *masonry* structure shall not be less than 40 mm or more than 75 mm.

C12.4.1
It is important to maintain the minimum cavity width of 40 mm as cumulative construction tolerances could reduce the cavity width below 40 mm, which is unacceptable.

12.4.2

Pipes and services shall not be placed in the cavity other than passing directly through the cavity to the exterior.

12.4.3
The cavity shall be drained from the bottom by providing weep holes, a minimum of 75 mm in height by the width of the vertical *mortar* joint at centres not exceeding 800 mm.

C12.4.3
Where the first course is less than 75 mm in height, the spacing of weep holes should be decreased to give a ventilation area of 1000 mm^2 /m wall length.

12.4.4
The cavity shall be ventilated to the outside by the provision of weep holes at the bottom, as defined in 12.4.3 and either similar vents as defined in 12.4.3 at the top; or a continuous 10 mm gap between the top course and soffit board. The cavity shall be sealed off from the floor and *roof* space.

12.4.5
Stepped joints on top of concrete or concrete block walls supporting *veneers*, which are adjacent to habitable spaces, shall be provided with moisture-proof flashings over the full surface of the stepped joint to prevent water from the *veneer* and cavity entering the building. Joints shall be sealed against moisture penetration.

12.4.6
Flashings at openings shall be provided as required in 12.7.

12.5 Wall ties

12.5.1
Masonry veneer shall be attached to a *structural* backing by wall ties.

12.5.2
Ties to be used for compliance with this Standard shall be stiff ties tested to the provisions of AS/NZS 2699:Part 1 for the specific cavity width and comply with the durability provisions of table 12.1.

C12.5.2
Details of zones are set out in section 4 of NZS 3604.

12.5.3
Wall ties and their fixings shall be spaced in accordance with the requirements of NZS 4210.

C12.5.3
The spacing depends upon the mass of the veneer, the earthquake zoning and type of tie (medium or heavy duty).

Table 12.1 – Protection for masonry veneer ties and lintels supporting masonry veneer using AS / NZS 2699 (see 12.5.2)

Location		Protection / material of ties	Protection / material of lintels
Sea spray zone	R4*	316 or 316L stainless steel	316 or 316L stainless steel
Geothermal hot spots	R5*	Specific engineering design(†)	Specific engineering design(†)
Elsewhere	R3*	470 g/m^2 galvanized coating or 304 stainless steel	600 g/m^2 galvanized coating or 304 stainless steel

* The durability ratings (R) used in AS/NZS 2699 are as given in the "Location" column of the table.

† Cavities in veneer construction within 50 m of geothermal hot spots present an aggressive environment and ties and lintels therefore require special investigation and testing. AS/NZS 2699 provides a means of testing the material and protection of ties and lintels. However, such testing is outside the scope of this Standard and the proposed design needs to be submitted to and approved by the Territorial Authority. However, specific coating methods given by AS/NZS 2699 in zones R4 and R3 are considered to be acceptable alternative protection methods to those shown in the above table.

C Table 12.1

Table 12.1 is table 4.4 from NZS 3604.

12.5.4

Wall ties shall be installed so that they are contained within the *mortar* bed with *mortar* above and below the tie. Mortar less than 24 hours old shall not be subject to vibration.

C12.5.4

The previous practice of dry placing onto the top of the veneer and placing the mortar bed across the top of the tie is no longer acceptable. The mortar bed must be prelaid and the tie placed into the wet mortar followed by flushing of mortar over the top surface of the tie.

12.5.5

Wall ties shall be of such length that:

(a) They have an embedment length of at least half the width of the *veneer;*

(b) They have an end cover in the bed joint of not less than 15 mm.

12.6 Openings

12.6.1

Openings with *masonry veneer* above shall be spanned by steel *lintel* angles or flats protected against corrosion to the provisions of table 12.1 and for the *structural* sizes required to table 12.2.

12.6.2

Steel *lintel* angles or flats shall have a minimum seating of 100 mm for spans up to and including 2 m and 200 mm for spans over 2 m.

C12.7

This Standard does not provide flashing details and all proposals must be submitted to and approved by the Territorial Authority as part of a building consent application.

12.7 Flashings

Flashings shall be provided as follows:

(a) Across the top of openings;

(b) Where different exterior cladding materials abut.

Table 12.2 – Veneer lintel table – Steel angles and flats (see 12.6.1)

Maximum lintel span (mm)	**Thickness of veneer** (mm)					
	70 mm			**90 mm**		
	Maximum height of veneer supported (mm)					
	350	**700**	**2000**	**350**	**700**	**2000**
800	60 x 10	60 x 10	60 x 10	80 x 10	80 x 10	80 x 10
2000	60 x 60 x 6	60 x 60 x 6	60 x 60 x 6	60 x 60 x 6	60 x 60 x 6	80 x 80 x 6
2500	60 x 60 x 6	80 x 80 x 6	80 x 80 x 6	60 x 60 x 6	80 x 80 x 6	80 x 80 x 6
3000	60 x 60 x 6	80 x 80 x 6	125 x 75 x 6	80 x 80 x 6	80 x 80 x 8	90 x 90 x 10
3500	80 x 80 x 6	80 x 80 x 6	125 x 75 x 6	80 x 80 x 8	90 x 90 x 10	125 x 75 x 10
4000	80 x 80 x 8	125 x 75 x 6	125 x 75 x 10	80 x 80 x 10	125 x 75 x 6	150 x 90 x 10
4500	125 x 75 x 6	125 x 75 x 6	–	125 x 75 x 6	125 x 75 x 10	–
4800	125 x 75 x 6	125 x 75 10	–	125 x 75 x 6	125 x 75 x 10	–

NOTE –

(1) 60 x 10 and 80 x 10 are steel flats, all other table references are steel angles.

(2) Stainless steel sections of equivalent section modulus are a permitted alternative.

SECTION 13

SECTION 13
SHRINKAGE

Figure

NOTES

13 SHRINKAGE

13.1 Shrinkage control joints

13.1.1

Longitudinal shrinkage stresses in concrete *masonry* shall be controlled by providing vertical *control joints* at not more than 6 m centres.

Vertical *control joints* shall be located:

(a) Within 600 mm of return angles in T and U-shaped floor structures;

(b) Within 600 mm of L shaped corners or by restricting the spacing to the next control joint to 3.2 m maximum (see figure 13.1);

(c) At changes in wall height, exceeding 600 mm;

(d) At changes in wall *thickness*.

C13.1.1

Generally working range spacing of 5 to 6 m is recommended with the upper limit used in special cases. Wider spacing can be achieved by considering specific engineering design.

This Standard requires reinforcement and solid filling around each opening and may require the installation of a wall column. Hence it is necessary to position control joints away from these areas.

13.1.2

Reinforcement in *bond beams* and *lintels* shall be continuous through *control joints*.

13.1.3

Horizontal *reinforcement* defined in table 8.2(b) shall be discontinuous at *control joints* (see figure 13.2).

13.1.4

Cavities either side of *control joints* shall be vertically reinforced and grouted.

13.1.5

Control joints shall be weatherproof when located on *external walls*. Details of how the joint is proposed to be weatherproofed shall be submitted to and approved by the *Territorial Authority* as part of the building consent application.

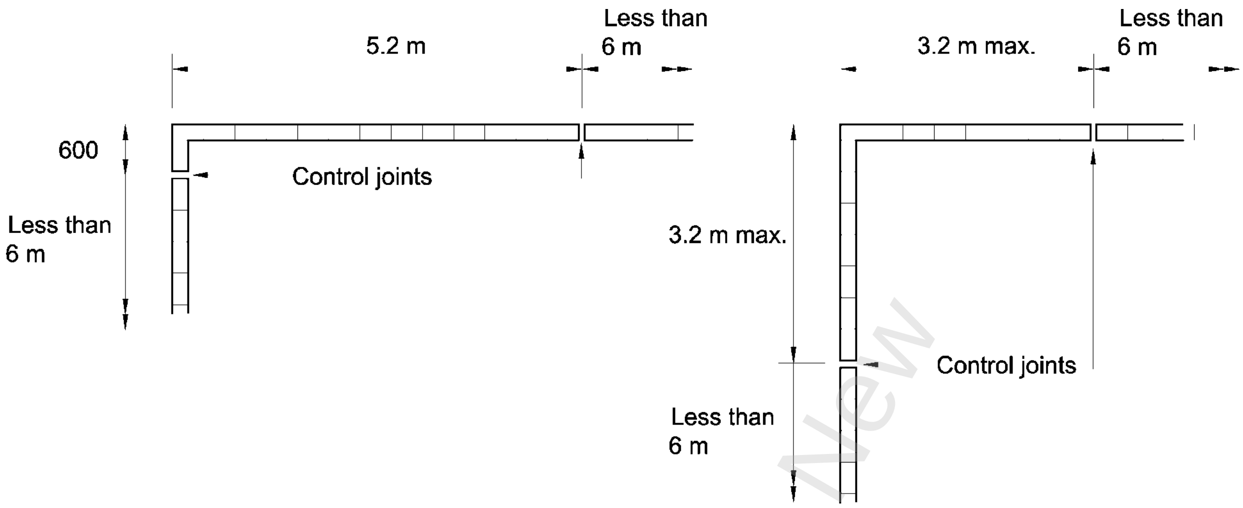


Figure 13.1 – Location of control joints for shrinkage (see 13.1.1)

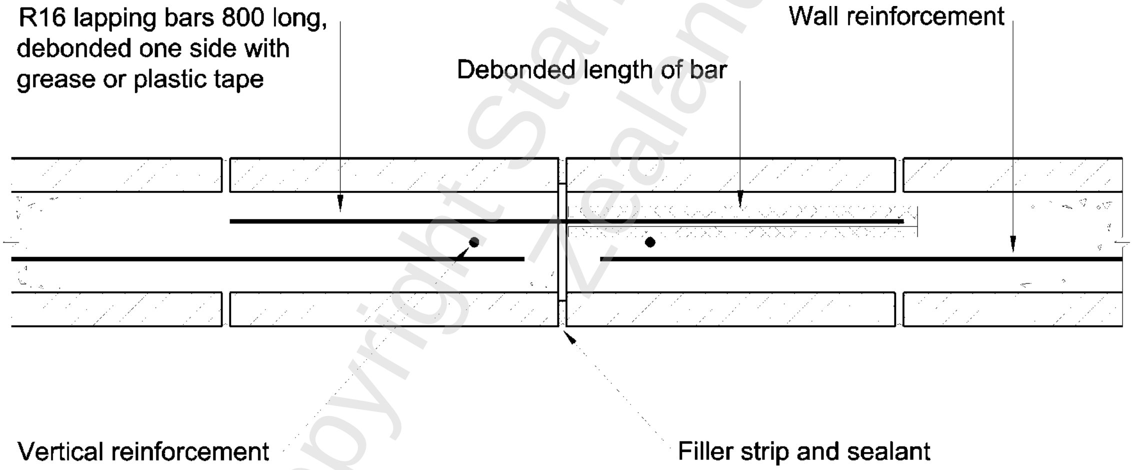


Figure 13.2 – Control joint detail (see 13.1.3)

APPENDIX A,B & C

APPENDIX

Table

Figure

APPENDIX A
DESIGN EXAMPLES
(Informative)

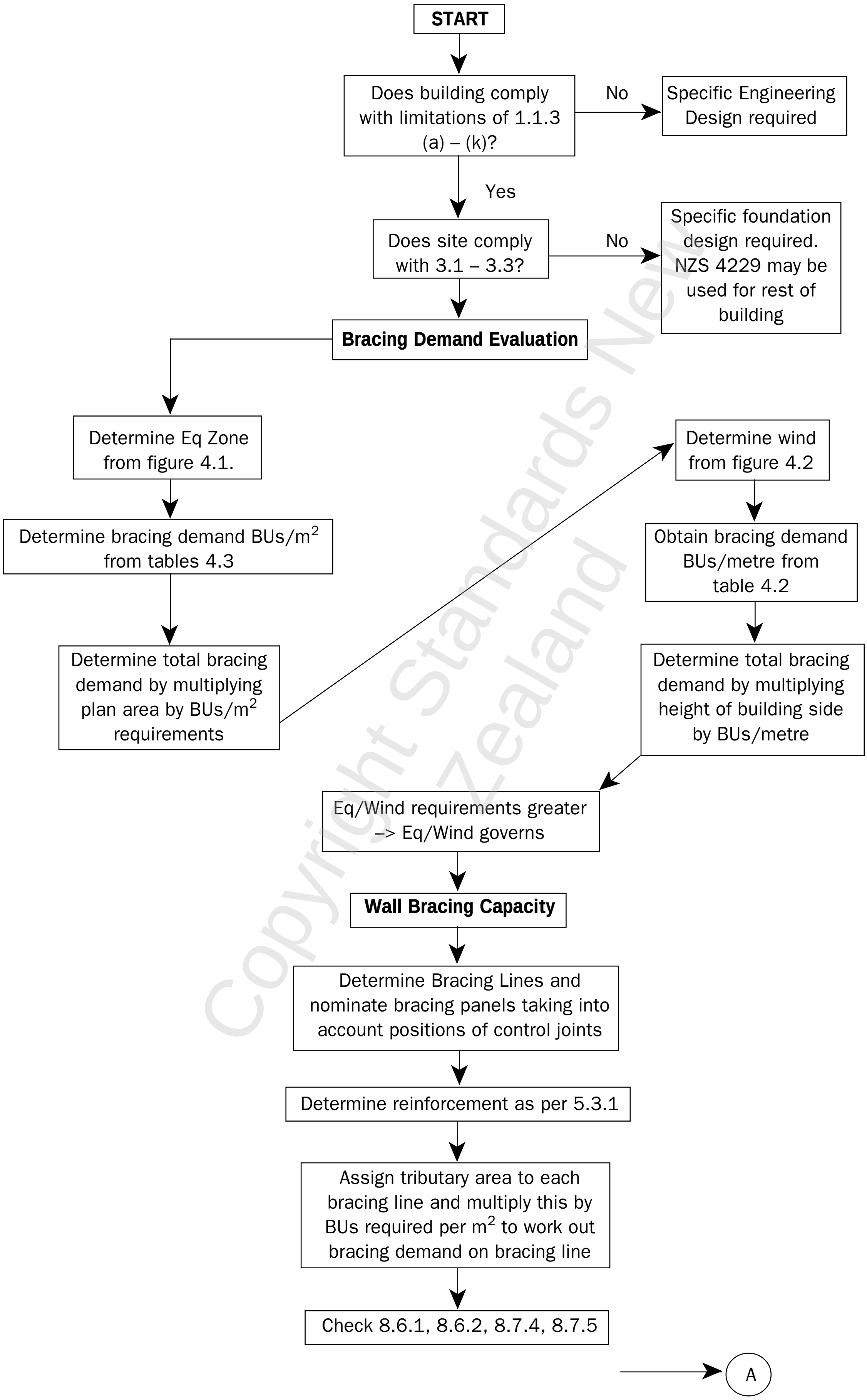
A1 Flow charts

A set of flow charts for a single *storey* structure and a 2 *storey* structure illustrating the design procedures for using the Standard are included.

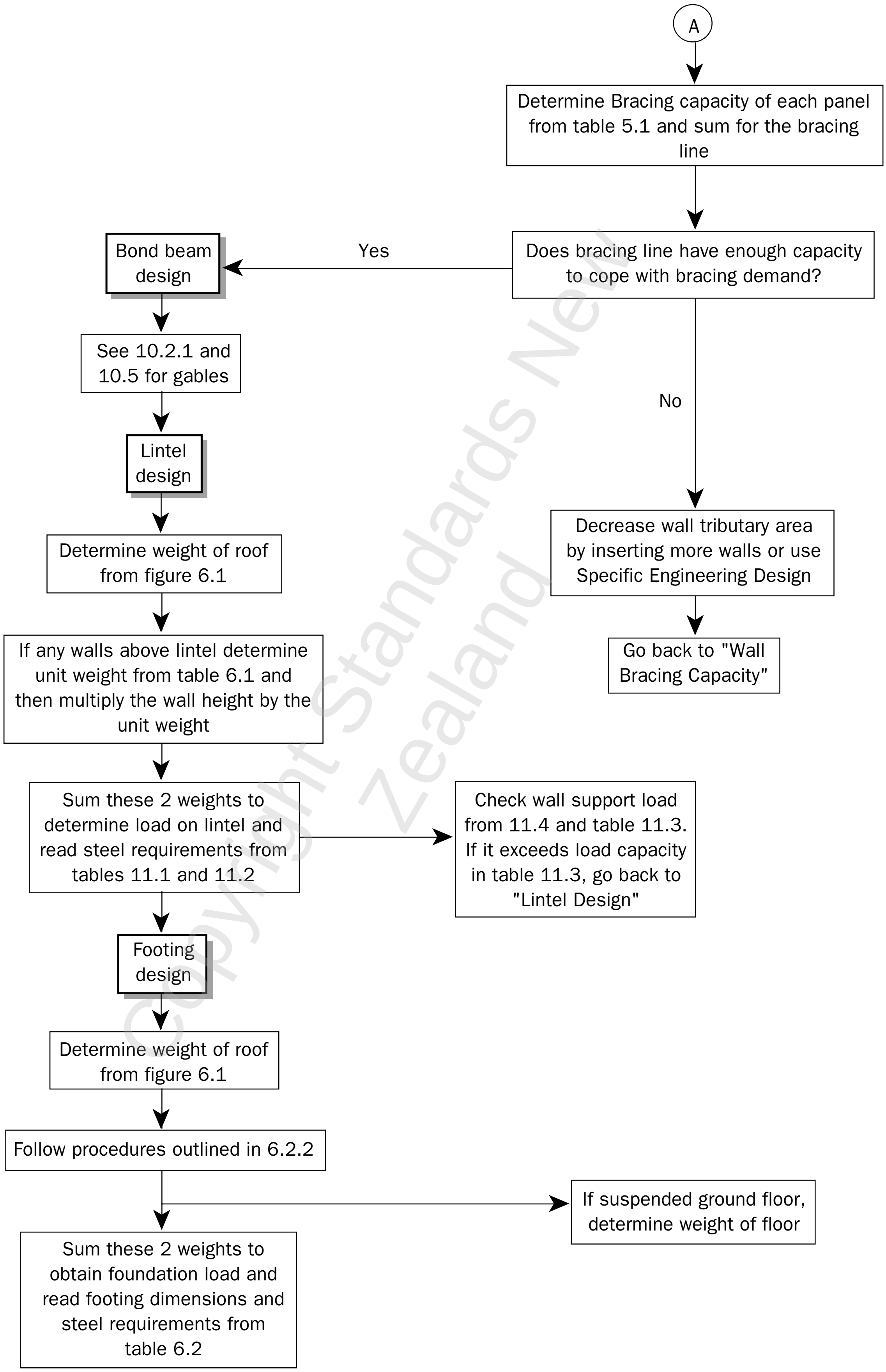
Referenced clauses/sections are included in these charts.

Following the flow charts, examples showing part of the design/ calculation process are included.

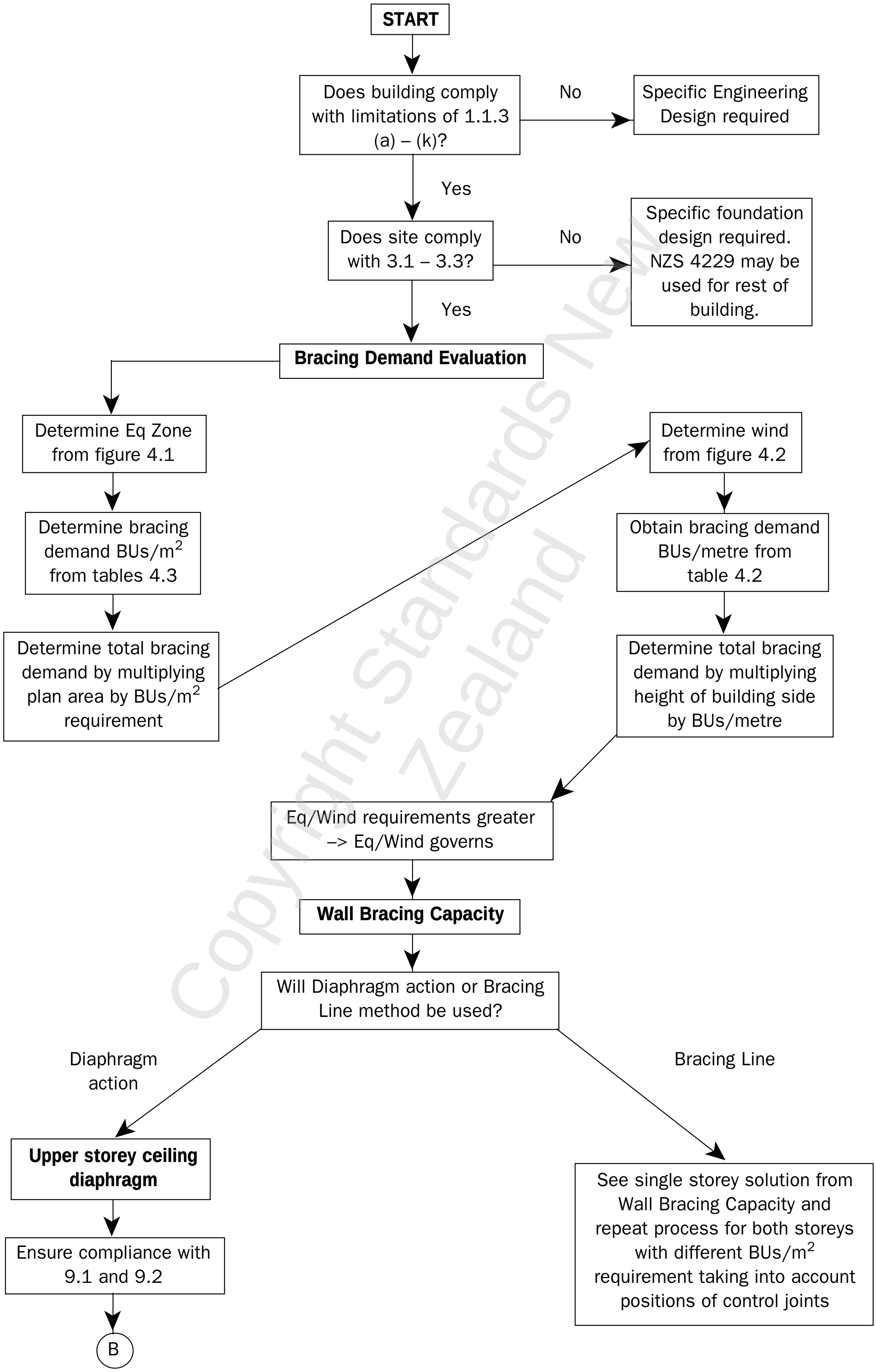
4229 FLOW CHART – SINGLE STOREY



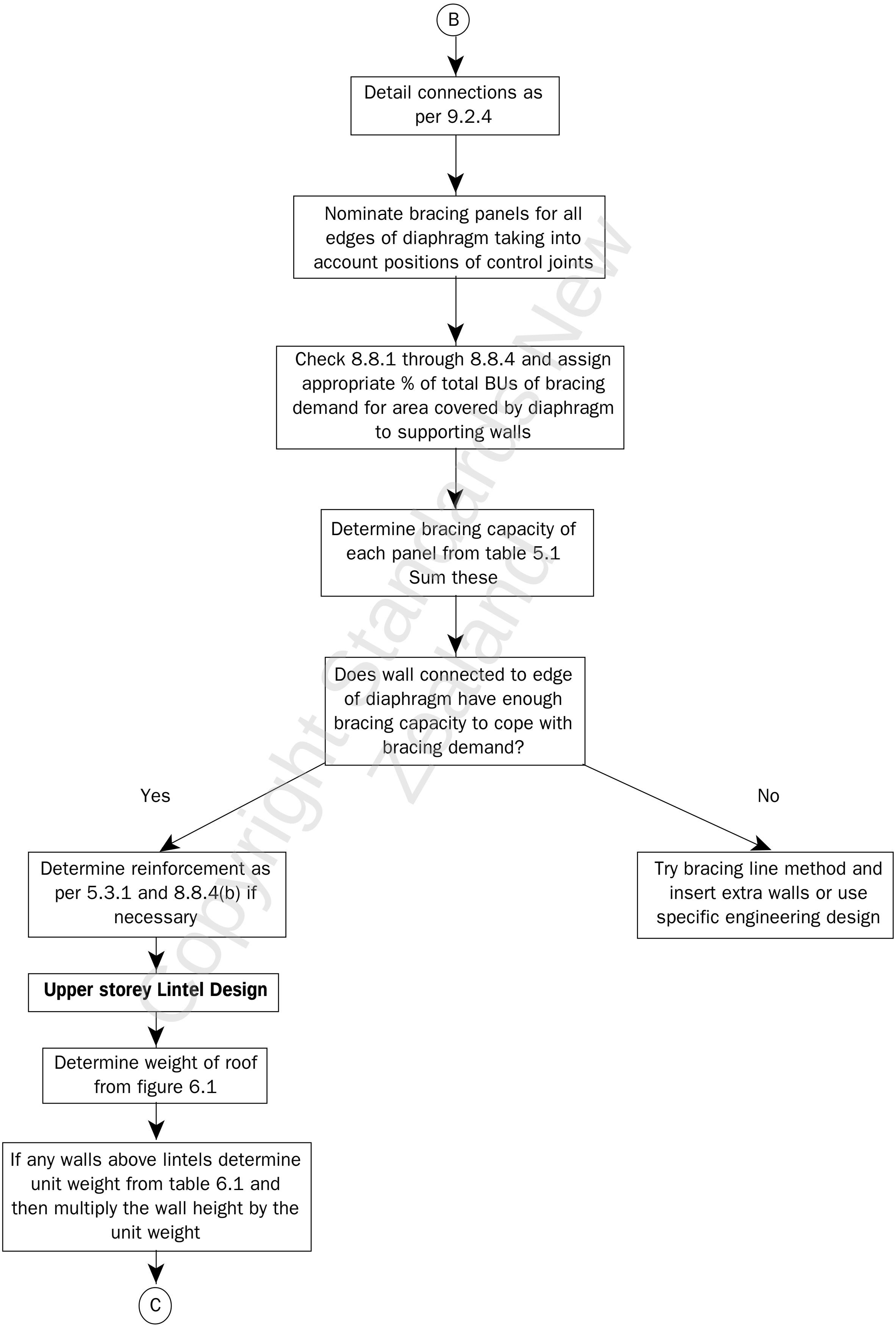
4229 FLOW CHART – SINGLE STOREY



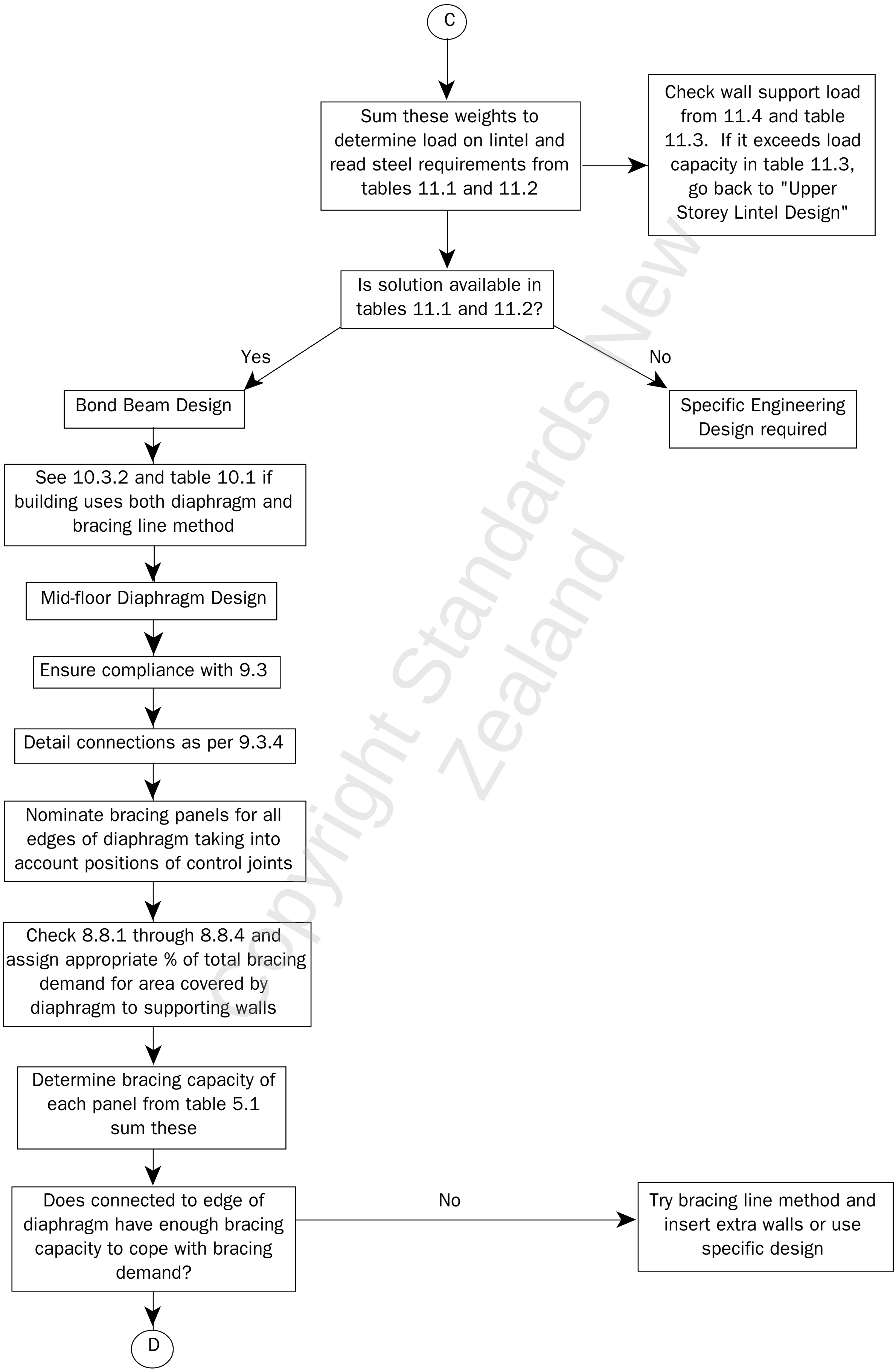
4229 FLOW CHART – DOUBLE STOREY



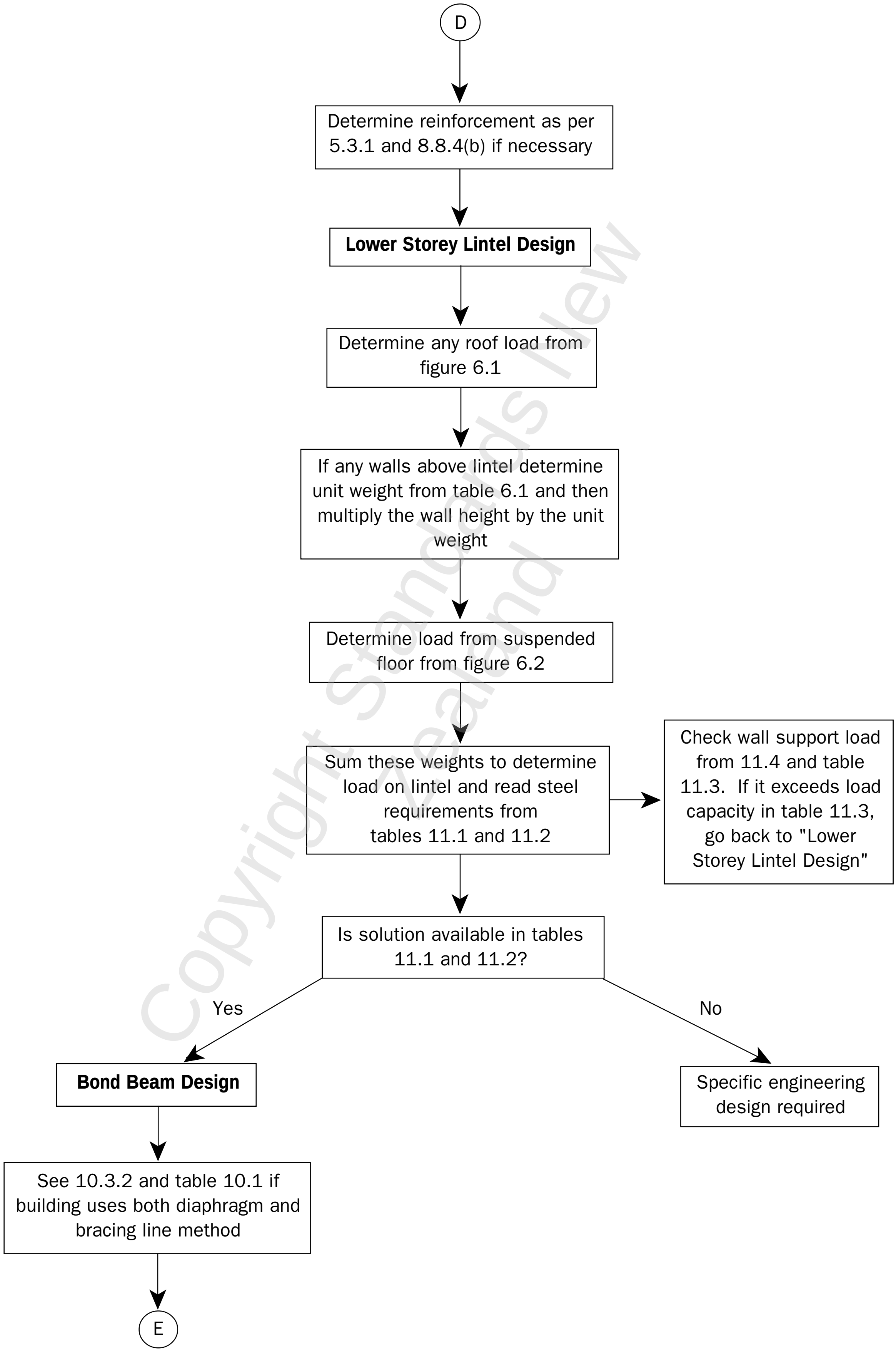
4229 FLOW CHART – DOUBLE STOREY



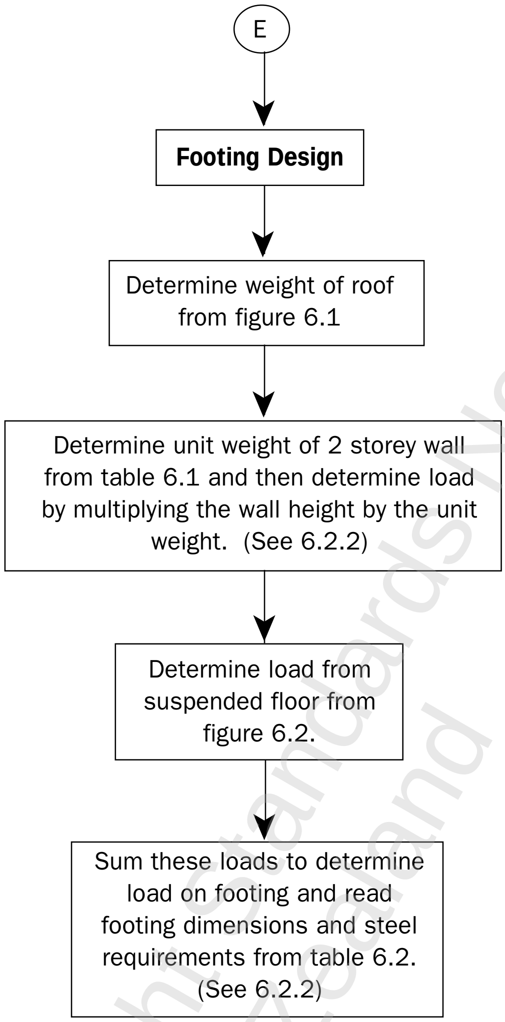
4229 FLOW CHART – DOUBLE STOREY



4229 FLOW CHART – DOUBLE STOREY



4229 FLOW CHART – DOUBLE STOREY



A2 SINGLE STOREY CONSTRUCTION

A2.1 Calculation sheet

Reference to NZS 4229:1999

House: Single storey with concrete slab-on-ground floor   Level: ______

Date: ________

Earthquake Zone: (A) B C   *Figure 4.1*

Walls: External 20 series (partial) / solid filled, no veneer

Internal 20 series (partial) / solid filled, no veneer

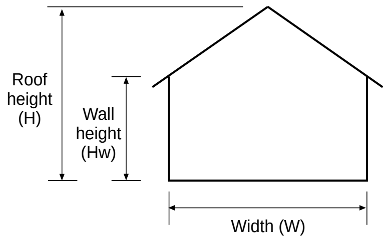
Roof: (Heavy) / Light   Roof slope: $<45^0$

Floor area (A) 98 m^2 Building length (L) = 14 m (maximum length)

Building width (W) = 7 m

Wall height (Hw) = 2.4 m

Roof height, (H) = 3.0 m



A2.2 Bracing demand

From table 4.3 determine EL for single store condition.

Basic earthquake load EL = 20

Heavy roof = 3

Total EL = 23 BUs/m^2

Total earthquake bracing = 23.0 BUs/m^2 (EL) x 98 m^2 (A) = 2254 BUs

Wind load WL = 111 BUs/m across ridge

= 111 BUs/m along ridge

Figure 4.2
Table 4.2

Total wind bracing = 111 BUs/m (WL) x 14 m (L) = 1554 BUs

Therefore (Earthquake) / Wind governing

Total bracing required = 2254 BUs.

Lateral stability from DIAPHRAGM / (BRACING LINE) system

A2.3 Bond beam design

From 10.2.1 and table 10.1 span max. = 9 m

Maximum bond beam span = 6 m

Span less than 8 m? = Yes

Use B2 bond beam

1/D16 top and bottom, 390 mm deep

A2.4 Lintel design

From figure 6.1

Roof span = 7 m   Load = 5 kN/m for heavyweight

No walls above lintel, so load is 5 kN/m.

Longest lintel span is 3.2 m. From table 11.2(b), required steel is 2/D12, R6 @ 200.

Load at wall support = $\frac{3.2 \times 5}{2}$ = 8.0 kN

From 11.4 and table 11.3, max. load 19 kN for solid fill 190 width i.e. O.K.

Note that lintel is at the same level of bond beam.

Therefore, use bond beam steel for lintel.

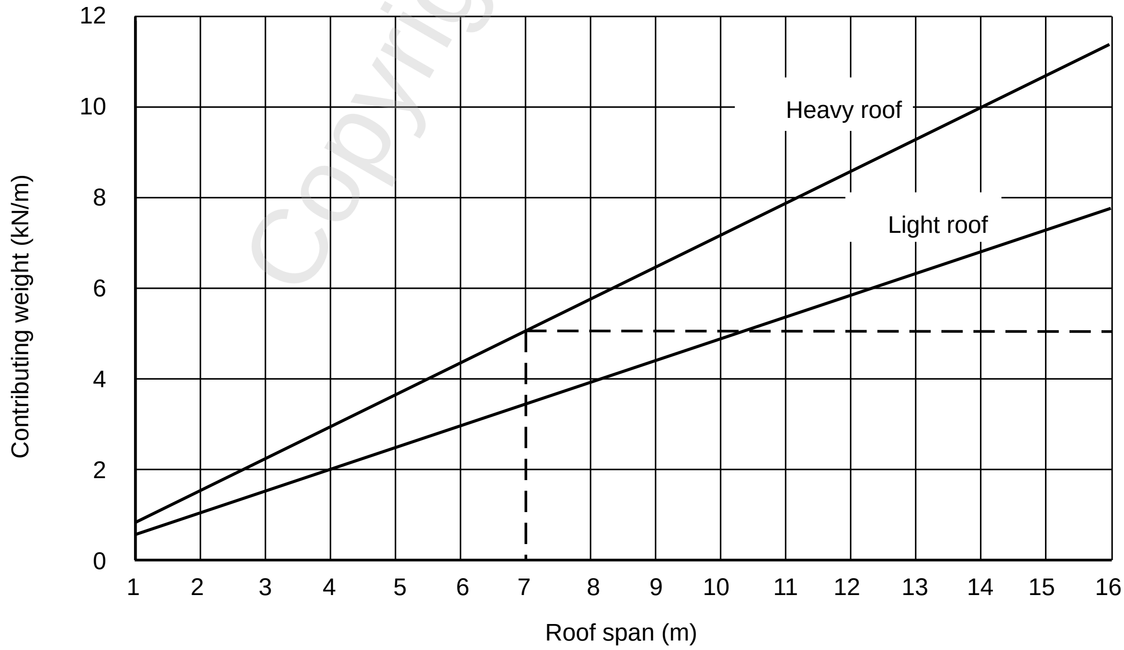


Figure A1 – Roof weight (see A2.4)

A2.5 Footing design

Roof weight = 5.0 kN/m (figure 6.1)

Wall weight = 2.2 kN/m (table 6.1), 20 series partial fill

Wall height = 2.4 m

Wall load = 2.2 kN/m x 2.4 m = 6.5 kN/m

Total load = 6.5 + 5.0 = 11.5 kN/m

From table 6.2, the solution is 300 mm wide x 200 mm deep footing with 2/D12, R6 @ 600 mm.

A2.6 Bracing capacity

A2.6.1 *Line A*

Distance to line B = 4 m

Tributary width minimum for external wall 2 m

Bracing Units required for Bracing Line A

= 2 m (Tributary width) x 14 m (Length) x 23.0 (BUs/m^2) = 644 BUs required.

Clause 8.6.1

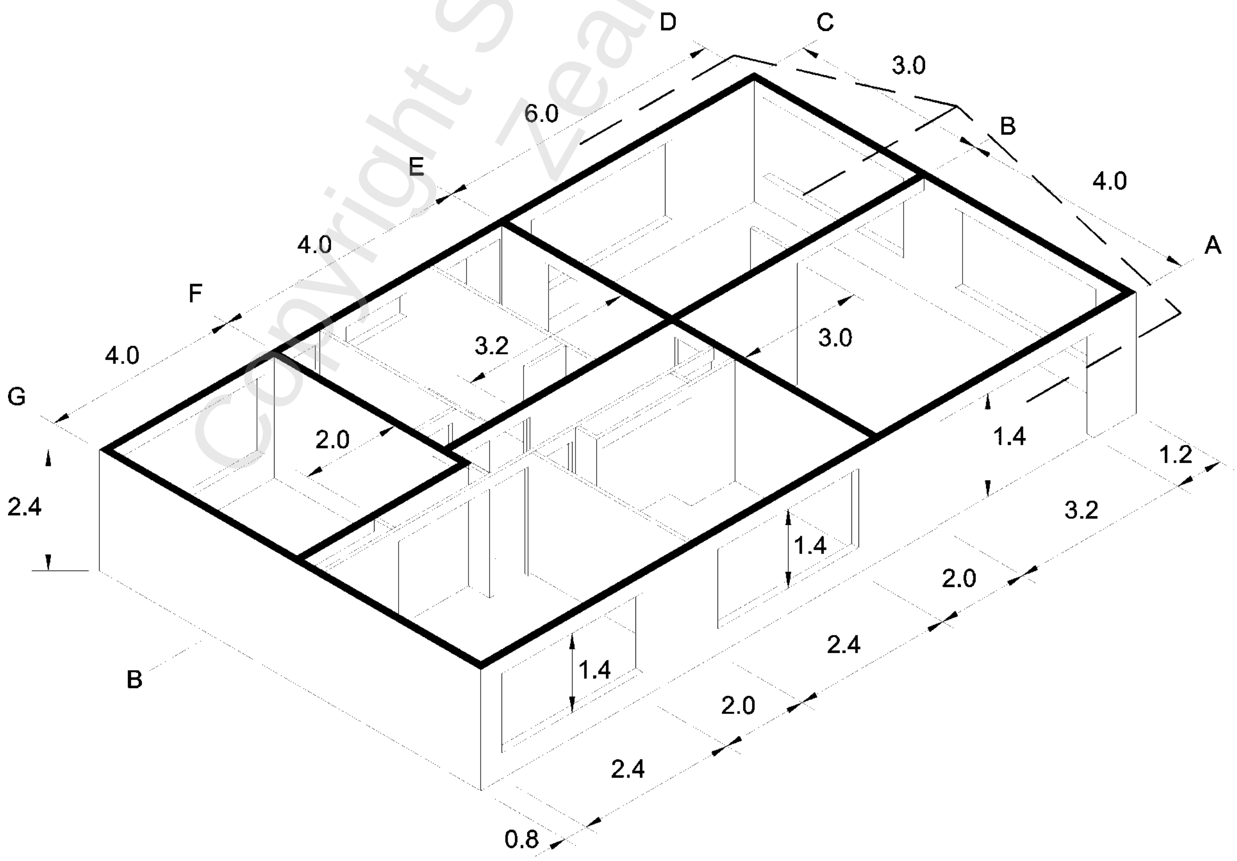


Figure A2 – Bracing capacity example (see A2.6)

Bracing capacity

Line A	Panel Height	Panel Length	Block Series	Fill	BU's capacity	BU Demand
	1.4	0.8	20	Partial	250	644
	1.4	2.0	20	,,	940	
	2.0	2.0	20	,,	695	
	2.0	1.2	20	,,	310	
					2195	

BUs from table 5.1

A2.6.2 *Line B*

Clause 8.7.4

Tributary width = 3/2 (To C) + 4/2 (To A) = 3.5 m

Tributary minimum width = 4 m

Bracing demand for line B = 4 x 14 x 23.0 = 1288 BUs

Bracing capacity

Line B	Panel Height	Panel Length	Block Series	Fill	BU's Capacity	BU Demand
	2.0	2.0	20	Partial	695	1288
	2.0	3.0	20	Partial	1395	
	2.0	3.2	20	Partial	1245	
					3335	

A2.6.3 *Line C*

Distance to line B = 3 m

Clause 8.6.1

Tributary width minimum for external wall 3/2 m but minimum of 2 m required.

Bracing units required for Bracing Line C = 2 m (Tributary width) x 14 m (length) x 20.0 (BUs/m^2)

= 644 BUs required

Bracing Capacity

Line C	Panel Height	Panel Length	Block Series	Fill	BUs Capacity	BU Demand
	2.0	3.0	20	Partial	1395	644

No need to consider other panels.

A2.6.4 *Line D*

Tributary width is 3 m.
Bracing demand for line D = 3 x 7 x 23.0 = 983

Bracing capacity

Line D	Panel Height	Panel Length	Block Series	Fill	BU's Capacity	BU Demand
	2.0	1.2	20	Partial	310	483
	2.0	1.2	20	Partial	310	
					620	

A2.6.5 *Lines E & F*

BU demand for E = 5 x 7 x 23.0 = 805

BU demand for F is similar but lower than E.
Both walls have panels 1.6 m long x 2 m high, each providing a bracing capacity of 485 BU.
Hence o.k.

A2.6.6 *Line G*

BU demand similar to D. Capacity for panel 2.4 (height) and 6.0 (length) = 3395 which exceeds 420 demand.

A2.6.7 *Calculation notes*

When using *bracing line* approach and having calculated the *bracing demand* for each line, it may be quicker to identify whether a principal single panel in the line can provide the total *bracing capacity* to meet the demand on the line.

In the example used, a total run of 4.4 m x 2.0 m high in both directions would provide a *bracing capacity* equal to the demand. Clearly this was available by inspection.

A2.6.8 *Diaphragm method*

When using a *diaphragm* approach, there will be fewer support lines resulting in increased *bracing demands* on these walls probably requiring more detailed evaluation of a series of panels.

The building example in figure A2 is considered with no internal *bracing* walls and stability would need to be provided by a ceiling *diaphragm*.

Bracing demand will be as before i.e. 2254 BUs for earthquake forces and 1544 for wind forces.

Clause 8.8.2 requires each *external wall* to carry 60 % of the *bracing demand*. Hence each wall line A, C, D and G must carry 2254 x 60 % = 1352 BUs.

From previous calculations:

Line A has BU capacity of 2195 BUs
Line C has BU capacity of 1395 BUs
Line D has BU capacity of 620 BUs
Line G has BU capacity of 3395 BUs

Bracing demand exceeds the capacity for line D and hence alterations to openings would need to be made to increase capacity to 1352.

The ceiling *diaphragm* nailing requirements can be selected from table 9.1.

Wall type is 20 series, partially filled.
Length to width ratio is 2.0.
Wall height is 2.4 m.

Minimum nailing around ceiling *diaphragm* sheets is 2.5 mm dia. nails at 150 mm centres.

Interior fixing of sheets is at 300 mm centres.

A3 DERIVATION OF TABLES

A3.1 General

A3.1.1

The following Standards documents have been used in the preparation of this Standard.

NZS 4203: 1992 General structural design and design loadings for buildings.
NZS 4230: 1990 Code of practice for the design of masonry structures (in part)
NZS 3604: 1999 Timber framed building construction.

The following research papers were used to develop alternative wall design strategies for building types covered by this Standard from those used in NZS 4230:

Brammer, D.R. The Lateral Force-Deflection Behaviour of Nominally Reinforced Concrete Masonry Walls, ME Thesis, April 1995, Dept. of Civil and Resource Engineering, University of Auckland.

Davidson, B.J. In-plane Cycling Loading of Nominally Reinforced Masonry Walls with Openings, January 1995, Auckland UniServices Ltd. Report.

Kelly, T.E. Holmes Consulting Group, Face Load Testing of Masonry Walls, Analysis of Response, June 1997, Report prepared for the Cement & Concrete Association of NZ.

Kelly, T.E. Holmes Consulting Group, Face Load Testing of Masonry Walls, Supplementary Analysis of Wall with Central Opening, June 1997, Report prepared for the Cement & Concrete Association of NZ.

Kelly, T.E. Holmes Consulting Group, Face Load Testing of Masonry Walls, Supplementary analysis of 9.0 m x 6.4 m high wall.

Singh, Shivas S. The performance of a Partially Grouted Reinforced Concrete Masonry Wall and Ribraft Floor Under Simulated Seismic Loading, ME Thesis, September 1996, Dept. of Civil Engineering, University of Canterbury.

Zhang, Xudong. Out-of-plane Performance of Partially Grouted Reinforced Concrete Masonry Walls under Simulated Seismic Loading, ME Thesis, September 1996, Dept. of Civil Engineering, University of Canterbury.

A3.1.2

Because wind generally is not a dominant load feature for most small *masonry* buildings, a simplified approach has been used assuming non-directional wind speed 48 m/s, terrain multiplier 1.0, shielding multiplier 0.9 and topographic multiplier 1.0. For more detailed wind evaluations for residential buildings, reference should be made to NZS 3604.

A3.1.3

This document does not seek to fully detail timber component requirements necessary in some of the *structural* systems used. The Standard has identified any special provisions which are different to NZS 3604, but for installation information reference is required to NZS 3604.

A3.1.4

The lateral load provisions of this Standard have been prepared on the assumption that partially filled heavyweight 20 Series concrete *masonry* units are used. Correction factors of other *masonry* units are provided. Total horizontal force has been calculated from NZS 4203 assuming:

- $\mu = 2$
- Period of vibration < 0.6 seconds
- Site subsoil category (c) (flexible or deep soil sites)
- $S_p = 0.67$
- R = 1.0
- Z = As appropriate for Zones A (1.2), B (0.9), C (0.6)
- $L_u = 1.0$

A3.1.5

A summary of design parameters used is shown in tables A3.1 and A3.2.

Table A3.1 – Design parameters (see A3.1.5)

Design strengths used	
Compression f'_m	8.0 MPa
Maximum shear provided by masonry	0.24 MPa
Strength reduction factor	
Flexure, with or without axial tension	0.80
Axial tension	0.80
Bearing on masonry	0.60
Shear and shear friction	0.70

Table A3.2 – Basic load data (see A3.1.5)

Heavy roof	Concrete tiles, timber roof truss and ceiling	0.84 kPa
Light roof	Steel sheeting/tiles, timber truss and ceiling	0.46 kPa
Timber floor	Sheeting, joists and ceilings	0.40 kPa
Concrete floor		4.50 kPa
Timber partitions	Non-loadbearing	0.20 kPa (on building plan area)
All live loads as per NZS 4203		

A3.2 Bracing tables

A3.2.1 Bracing demand

The *bracing unit* (BU) demand table 4.3 which expresses the BU demand in units per m^2 was developed from considering a 7 m^2 box building. The weights (see table A3.2) of walls, *suspended floor*s and *roofs* were calculated and expressed in a square metre of building plan format.

The wall weights were based upon partial grout filling using heavy weight *masonry* (2200 kg/m^3). No allowance has been included for using 1600 – 1800 kg/m^3 *masonry*.

A *roof* pitch of 45^0 was used to calculate the *roof* weight and also an allowance for using up to 40 % of the *roof* plan area as a habitable attic with 1.5 kPa live load was included.

Where *masonry* walls are to be solid filled, a multiplication factor has been included with table 4.3.

A3.2.2 Bracing capacity

The *bracing capacity* table 5.1 was primarily developed from the research test programme listed in A3.1.1 (particularly Brammer, D.R), considering the *masonry* performance once the nominal shear strength of the masonry had been exceeded.

An example of developing the wall capacity calculations is shown below:

Calculation of Yield Force F_y

L	=	2600	mm
H	=	2400	mm
d_1	=	2500	mm
d_2	=	1700	mm
d_3	=	900	mm
b_w	=	140	mm
A_s	=	113	mm^2
E_s	=	200	GPa
ε_y	=	0.0015	
f'_m	=	8	MPa
f_y	=	300	MPa
Self weight	=	22	kN

Taking 1 reinforcing bar only:

T_1 = $A_s.f_y$ = 33.9 kN
C = T_1 + self wt = 55.9 kN = $0.85.f'_m.a.b_w$
Solve for a
a = 58.7 mm
c = 58.7/0.85 = 69.1 mm
ε_{s2} = 0.0010
ε_{s3} = 0.0005
f_{s2} = 200 MPa
f_{s3} = 102.5 MPa

Including second rebar
1st iteration:

T_2 = $A_s.f_y + A_{sn}.f_{sn}$ = 68.1 kN
C = T_2 + self wt = 90.1 kN

a = 94.6 mm
c = 111.3 mm
ε_{s2} = 0.0010
ε_{s3} = 0.0005
f_{s2} = 199.5 MPa
f_{s3} = 99.1 MPa

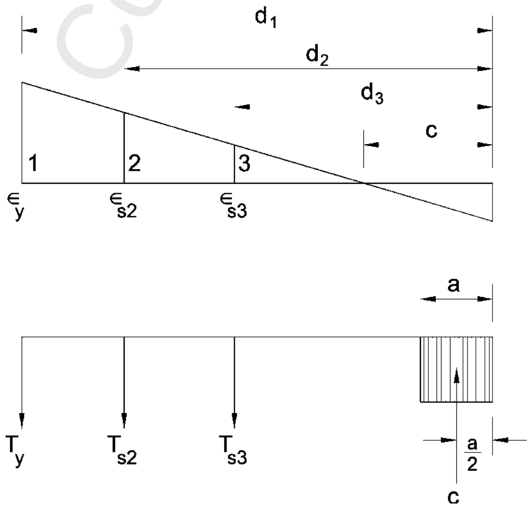


Figure A3 – Strain and force diagram (see A3.2.2)

2nd iteration:

$T_2 = A_s.f_y + A_{sn}.f_{sn} = 67.7$ kN
$C = T_2 + \text{self wt} = 89.7$ kN

$a = 94.2$ mm
$c = 110.8$ mm
$\varepsilon_{s2} = 0.0010$
$\varepsilon_{s3} = 0.0005$
$f_{s2} = 199.5$ MPa = previous calculation
$f_{s3} = 99.1$ MPa

$$M_i = T_y [d_1 - \frac{1}{2} a] + T_{s2} [d_2 - \frac{1}{2} a] + T_{s3}[d_3 - \frac{1}{2} a]$$
$$= 130.1 \text{ kN.m}$$

Calculate lateral yield force:

$$F_y.(H + 200 \text{ mm}) - 0.8 [\text{self wt} (\frac{1}{2} L - \frac{1}{2} a) + M_i] = 0$$

Therefore $F_y = 48$ kN

The Brammer, D.R. research paper recommended that for wall lengths over 3000 mm, the ideal strengths obtained from the calculation process, demonstrated in this case for 2600 mm, should be rated at 80 % of the ideal strength. This factor has been applied to the bracing values in table 5.1.

In this example the term (H + 200 mm) is used in place of the actual H of the wall. This is to account for the fact that the load will be applied to the *bracing* panel from the centre of the *bond beam*, effectively increasing the height of the *bracing* panel by 200 mm. The flexural strength reduction factor of 0.8 is included in the final equation for clarity and not in the main calculation.

A3.3 Bond beams and lintels

A3.3.1 Bond beams

For the evaluation in the *bracing line* support method it was decided to use a full scale testing programme to measure actual performance of the *bond beam*, see A3.1.1. A 9 m span 400 mm deep *bond beam* with 2/D16 bars vertically above one another was tested at Canterbury University which deflected 0.8 mm at the ultimate limit state code loading. Further testing at 0.76 g lateral load caused the deflection to extend to 7.5 mm. These results were comparable with the computer model analysis carried out by Holmes Consulting Group.

The ultimate limit state performance of the *bond beams* tested was approximately 3 times that predicted by conventional section analysis. Tables 8.3 and 10.1 were developed principally from the test results by using a factor of 2 on conventional section analysis with adjustments for horizontal loading conditions arising from veneer for example and in 2 storey construction from the intermediate floor. Such development of the values in the tables is only permissible within the limited building parameters set by this Standard. Such span values should not be applied to other masonry structures outside the jurisdiction of the Standard without specific engineering design considering the applicability of the test data to the particular project.

A3.3.2 Lintels

The design of *lintels* was based on NZS 4230 using table A3.1 to generate the *lintel* tables. Arching effects for *lintels* with *masonry* above was not included.

Lintels have been designed assuming fixed ends i.e. $wL^2/12$ for moments and $wL^4/384EI$ for deflections have been used. Creep has been accounted for by doubling ultimate limit state deflections. Deflections have been limited to the lesser of span/250 or 12 mm. Span/250 is NZS 4203's recommendation for deflection limits for beams with line of sight across the soffit. 12 mm has been recommended as the largest acceptable deflection before problems would be encountered on opening wide span doors and windows.

A3.3.3 Columns

The design of columns was based on NZS 4230 except that a minimum dimension of 190 mm x 190 mm was considered acceptable for the range of buildings covered by this Standard. Additional load restrictions were imposed on the Type 1 column which utilizes a single D16 bar. The permitted load of 25 kN is less than half the theoretical calculated value.

A3.4 Diaphragms

A3.4.1

The design of *structural diaphragms*, both timber and concrete, has been based on the maximum *dimensions* permitted by this Standard.

A3.4.2 Concrete

The *structural* design of the concrete floor is not covered by this Standard. It requires specific design.

A3.4.3 Timber

The *structural* design of the timber floor using sheet materials such as particle board and plywood are based upon the loading conditions of this Standard but require construction to be carried out as required by NZS 3604, incorporating any additional requirements such as nailing centres from this Standard. Connection details between the *diaphragm* and the supporting *bracing* walls have been specifically designed for this Standard in consultation with proprietary suppliers. Acknowledgement is made to Able Cooke Ltd.

A3.5 Foundations

A3.5.1

For simplicity of design, the *foundation* selection section contains conservative approximations of contributing weight. Figures 6.1 and 6.2 include the ultimate limit state load factors from NZS 4203 in the determination of contributing floor and *roof* weight to the *foundation*. The dead load factor of 1.2 has been similarly included in table 6.1. The *footing dimensions* in table 6.2 are based on a maximum *foundation* pressure of 100 kPa.

A3.6 Cantilevered walls

A3.6.1

For lateral loads see A3.1.4.

A3.6.2

For design parameters see A3.1.5 and tables A3.1 & A3.2.

A3.7 Masonry retaining walls

A3.7.1

Generic retaining wall parameters used are contained in the New Zealand Concrete Masonry Manual Part 6.1.

NOTES

APPENDIX B
CANTILEVERED WALLS
(Normative)

B1 Scope

B1.1
This Appendix sets down the *structural* requirements for free-standing cantilevered concrete *masonry* walls in the following situations:

(a) Not more than 2 *storeys* in height up to a maximum of 4.8 m;

(b) Not more than 3.2 m in height when used as a free standing garden or boundary wall.

C B1.1
The primary consideration for this section is to design walls that fit within a structural building concept where for example the walls would not be expected to be "free standing" against wind for any great length of time.

Hence for free standing walls such as garden or boundary walls a lower height restriction has been imposed.

For free standing garden or boundary walls up to 1.8 m in height reference could be made to details included in the NZ Masonry Manual.

B2 General

B2.1
Cantilevered *masonry* walls shall be of 20 series blocks and be:

(a) Constructed in *running bond*;

(b) Centrally reinforced both vertically and horizontally in accordance with B3; and

(c) Provided with a *foundation* to support the wall against horizontal loads, in accordance with B4.

B2.2
All construction in this Appendix shall be the subject of specific inspection by the *Designer*.

C B2
Walls supported by return walls should be in accordance with section 8 of this Standard, provided they are part of a masonry building.

C B3

Walls supported by return walls should be provided with bond beams in accordance with table 10.1. The maximum spacing between return walls should not exceed the spans of the bond beam used as permitted in table 10.1.

B3 Walls

B3.1

Walls shall be centrally reinforced in accordance with B3.2 and B3.3 depending upon:

(a) The block density of the *masonry* units and whether the wall is constructed of partially filled or solid filled *masonry*;

(b) The type of lateral supporting system;

(c) The height of the wall above the *foundation*;

(d) The seismic zone in which the wall is located.

B3.2

Cantilevered walls shall be reinforced in accordance with tables B4(a), B4(b), B5(a) or B5(b) as appropriate.

B3.3

Where vertical bars are required to be lapped, the lap shall be not less than 40 bar diameters and shall extend at least to the height required by the figures.

Horizontal bars shall have staggered laps of not less than 40 bar diameters.

B4 Foundations

B4.1 General

B4.1.1

Foundations shall resist vertical loads and provide resistance to overturning forces due to seismic and wind loads on the wall by one of the following *foundation* types:

(a) Cast *in situ* concrete piles, see figure B1;

(b) Strip *footings*, centrally placed or to one side of the wall (see figures B2(a) and B2(b));

(c) Floor slabs constructed integrally with the concrete or *masonry footing* (see figure B3 and table B3);

(d) Conventional *footings* being part of a *masonry* building to which lateral support *bracing* panels are fixed.

B4.2 Concrete pile foundations

B4.2.1
A strip *foundation* supported by cast *in situ* concrete piles shall be not less than 350 mm wide by 350 mm deep and be reinforced longitudinally with 4/D12 bars with R6 stirrups at 100 mm centres (see figure B1).

B4.2.2
Cast *in situ* concrete piles shall be centrally reinforced and be at a diameter, *spacing* and length as set out in table B1.

B4.3 Strip foundations

B4.3.1
Strip *foundations* may be formed to one side of the cantilever wall or be centrally placed under it.

B4.3.2
Foundation dimensions and *reinforcements* shall be in accordance with tables B2(a) and B2(b) and figures B2(a) and B2(b).

B4.4 Foundations constructed in conjunction with floor slabs

B4.4.1
Floor slabs supporting centrally reinforced cantilevered walls shall be reinforced to 7.8.3 and 7.8.4 and shall be the thickness as detailed in figure B3.

B4.4.2
Floor slabs shall be built as an integral part of the *foundation* and wall as detailed in figure B3.

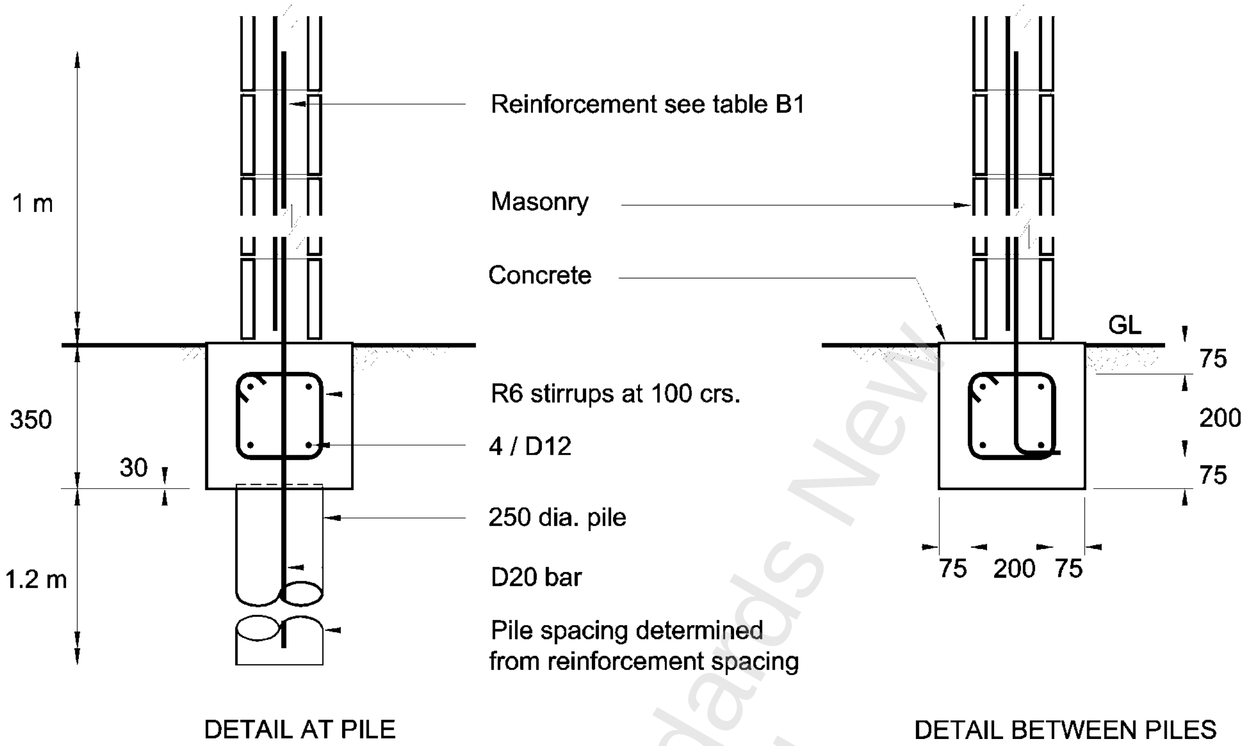


Figure B1 – For use in conjunction with table B1 (see B4.1.1(a))

Table B1 – Cast in situ concrete piles centrally reinforced to support cantilevered walls (solid or partially filled) (see B4.2.2)

All earthquake zones				
Spacing of vertical wall reinforcement at base of wall	**Spacing of piles**	**Diameter of piles**	**Depth of piles**	**Reinforcement for piles**
200	800	350	1200	D20
400	1200	350	1200	D20
600	1200	300	1200	D20
800	1600	300	1200	D20

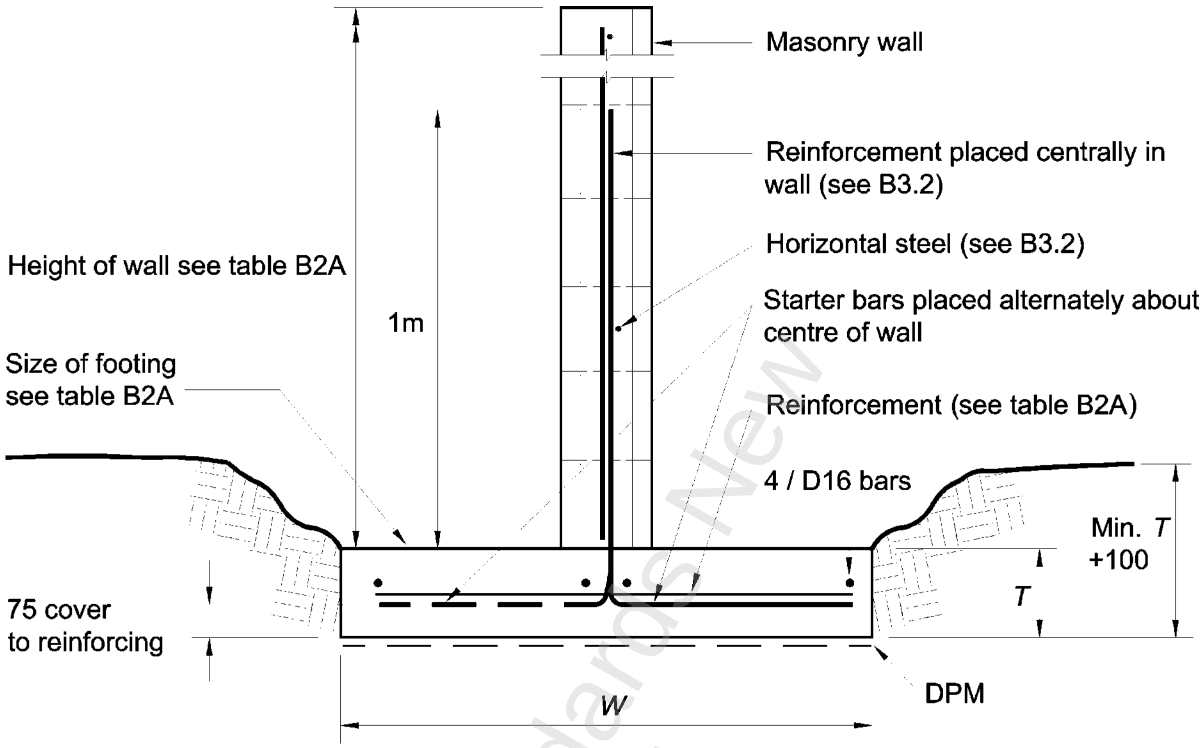


Figure B2(a) – For use in conjunction with table B2(a) (see B4.3.2)

Table B2(a) – Strip footing centrally placed under cantilevered walls (solid or partially filled) (see B4.3.2)

	Zone A		Zone B		Zone C	
Maximum height of wall (mm)	**Footing W X T** (mm)	**Reinforcement in footing**	**Footing W X T** (mm)	**Reinforcement in footing**	**Footing W X T** (mm)	**Reinforcement in footing**
2000	900 X 200	D12 @ 600	800 x 200	D12 @ 800	700 x 200	D12 @ 800
2400	1100 X 200	D12 @ 400	1000 X 200	D12 @ 400	800 X 200	D12 @ 600
2800	1300 X 200	D16 @ 600	1100 X 200	D12 @ 400	1000 X 200	D12 @ 400
3200	1500 X 200	D16 @ 400	1300 X 200	D16 @ 600	1100 X 200	D12 @ 400
3600	1600 X 200	D20 @ 600	1400 X 200	D16 @ 400	1200 X 200	D16 @ 600
4000	1800 X 200	D20 @ 400	1600 X 200	D20 @ 600	1400 X 200	D16 @ 400
4400	2000 X 200	D20 @ 200	1800 X 200	D20 @ 400	1500 X 200	D20 @ 600
4600	2200 X 200	D20 @ 200	1900 X 200	D20 @ 400	1500 X 200	D20 @ 400

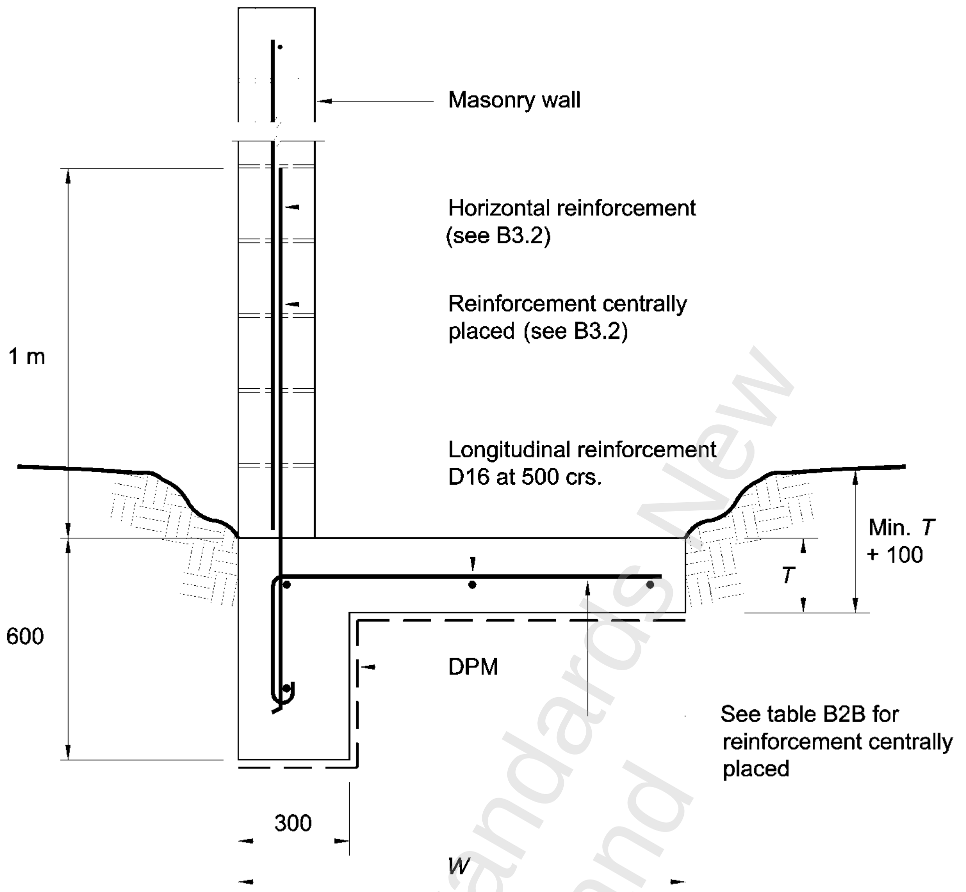


Figure B2(b) – For use in conjunction with table B2B (see B4.3.2)

Table B2(b) – Strip footing for cantilevered walls (solid or partially filled) where footing is on one side of wall (see B4.3.2)

Spacing of vertical wall reinforcement at base of wall (mm)	**All earthquake zones**	
	Footing W X T (mm)	**Reinforcement in slab**
* D12 @ 200 cs	1700 X 300	D12 @ 200
D12 @ 400 cs	1400 X 300	D12 @ 400
D12 @ 600 cs	1300 X 300	D12 @ 600
D12 @ 800 cs	1200 X 300	D12 @ 800

* D16 at 400 mm cs, may be used provided lap is increased to 640 mm.

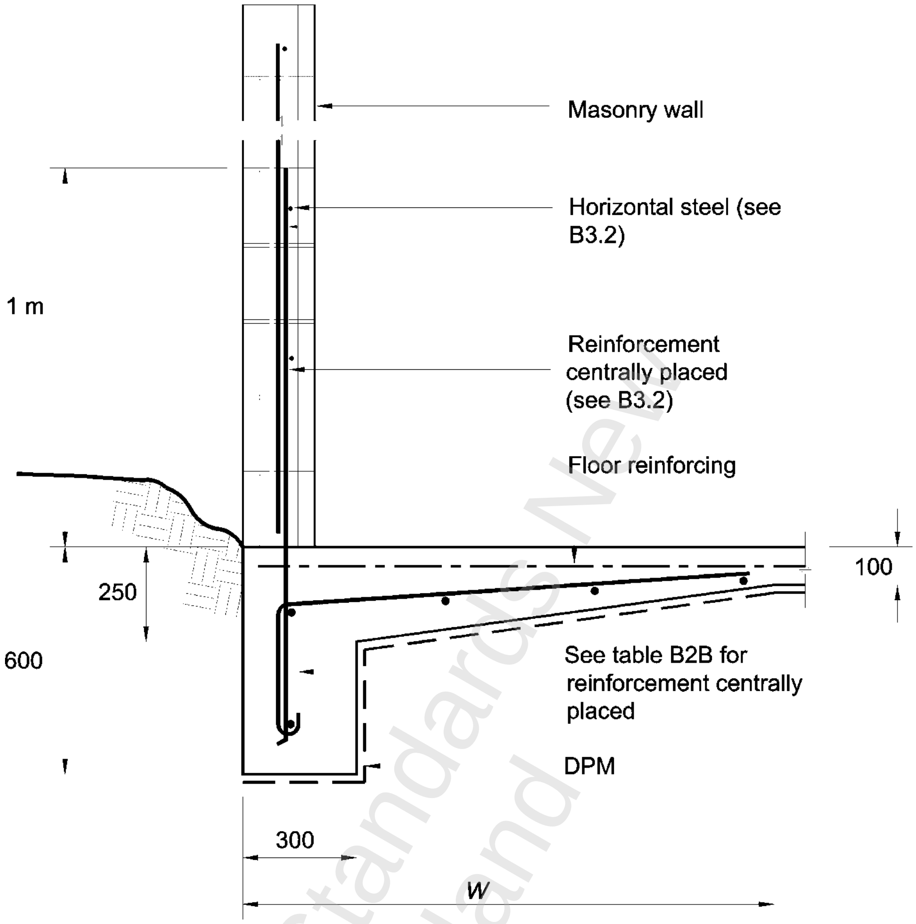


Figure B3 – For use in conjunction with table B3 (see B4.1.1(c))

Table B3 – Strip footing consisting of floor slab on one side of a cantilevered wall (see B4.1.1(c))

Spacing of vertical wall reinforcement (mm) **at base of wall**	**All earthquake zones W** (mm)
* D12 @ 200 cs	2500
D12 @ 400 cs	2000
D12 @ 600 cs	1600
D12 @ 800 cs	1400

*D16 at 400 mm cs may be used providing lap is increased to 640 mm.

Table B4(a) – Maximum spacing (mm) of D12 bar reinforcement for 200 mm cantilevered walls constructed of partially filled masonry (block density 1750 kg/m^3) (see B3.2)

Height (maximum) of wall (mm)	Zone A		Zone B			Zone C		
			Bond beam			Bond beam		
	Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	No. of horiz. bars	Vert. steel spacing	Horiz. steel spacing	No. of horiz. bars	Vert. steel spacing
2000	600	600	2000	4	600	2000	4	800
2400	600	600	2400	4	600	2400	4	800
2800	600	600	2800	4	600	2800	4	800
3200	600	600	1600	4	600	1600	4	800
3600	600	400	1800	4	600	1800	4	800
4000	NA	NA	2000	4	400	2000	4	600
4400	NA	NA	NA		NA	2400	4	400

NOTE – 2/D16 can be substituted for 4/D12 provided bars are placed one on each side of the bond beam.

Table B4(b) – Maximum spacing (mm) of single D12 or D16 bar reinforcement for 200 mm cantilevered walls constructed of solid filled masonry (block density 1750 kg/m^3) (see B3.2)

Bar size	Height (maximum) wall (mm)	Zone A		Zone B		Zone C	
		Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	Vert. steel spacing
D12	2000	600	600	800	800	1000	800
	2400	600	600	800	800	1000	800
	2800	600	400	800	600	1000	800
D16	3200	600	400	800	400	1000	600
	3600	600	400	800	400	1000	400
	3800	600	400	800	400	1000	400
	4000	600	400	800	400	1000	400
	4400	NA	NA	800	400	1000	400
	4600	NA	NA				

NOTE – 2/D16 can be substituted for 4/D12 provided bars are placed one on each side of the bond beam.

Table B5(a) – Maximum spacing (mm) of D12 or D16 bar reinforcement for 200 mm cantilevered walls construction of partially filled masonry (block density 2200 kg/m^3)
(see B3.2)

Bar size	Height (maximum) of wall (mm)	Zone A		Zone B			Zone C		
				Bond beam			Bond beam		
		Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	No. of horiz. bars	Vert. steel spacing	Horiz. steel spacing	No. of horiz. bars	Vert. steel spacing
D12	2000	600	600	2000	4	600	2000	4	800
	2400	600	600	2400	4	600	2400	4	800
	2800	600	600	2800	4	600	2800	4	800
	3200	600	400	1600	4	400	1600	4	800
D16	3600	NA	NA	1800	4	400	1800	4	600
	4000	NA	NA	NA	4	NA	2000	4	400

NOTE – 2/D16 can be substituted for 4/D12 provided bars are placed one on each side of the bond beam.

Table B5(b) – Maximum spacing (mm) of single D12 or D16 bar reinforcement for 200 mm cantilevered walls constructed of solid filled masonry (block density 2200 kg/m^3)
(see B3.2)

Bar size	Height (maximum) wall (mm)	Zone A		Zone B		Zone C	
		Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	Vert. steel spacing	Horiz. steel spacing	Vert. steel spacing
D12	2000	600	600	800	800	1000	800
	2400	600	400	800	600	1000	800
	2800	600	400	800	400	1000	600
D16	3200	600	400	800	400	1000	400
	3600	600	400	800	400	1000	400
	3800	600	400	800	400	1000	400
	4000	NA	NA	800	400	1000	400
	4400	NA	NA	NA	NA	1000	400
	4600	NA	NA	NA	NA	1000	400

NOTE – 2/D16 can be substituted for 4/D12 provided bars are placed one on each side of the bond beam.

NOTES

APPENDIX C
MASONRY RETAINING WALLS
(Normative)

C1 Scope

C1.1
The details of retaining walls contained in this Appendix are based upon the *masonry* design requirements of NZS 4230 related to Grade B and that the *masonry* shall be solid filled.

C1.2
Specific engineering design shall be provided if one or more of the following conditions exist:

(a) Height above limits specified in figures C1.1 to C1.8;

(b) Surcharge above limits specified in figures C1.1 to C1.8;

(c) Soil types not listed in C2.1;

(d) Ultimate bearing pressure of soil less than 300 kPa;

(e) Hydrostatic water head exists.

CC1.2
Clause C4 is specifically included to ensure that water behind walls can be freely discharged.

C1.3
Retaining walls shall comply with the following provisions as appropriate:

(a) Vertical superimposed load between 0 – 50 kN/m, use the details contained in figures C1.1/C1.2 or figures C1.3/C1.4.

(b) Vertical superimposed load between 51 – 100 kN/m, use the details contained in figures C1.5/C1.6 or figures C1.7/C1.8.

(c) Vertical superimposed loads over 100 kN/m shall require specific engineering design.

CC1.3
The vertical loading figures are obtained from the design process of section 6.

C1.4
Where construction sequences create the installation of a floor *diaphragm* at the top of the retaining wall prior to backfilling then such walls are not detailed in the Standard and become the subject of specific engineering design.

CC1.4
The propping by diaphragm/floor of the top of retaining walls contained in this Appendix creates a design condition not included in these details.

Additional soil forces need to be considered as does the positioning of reinforcement. For these reasons such walls must require specific engineering design.

C2 Materials

C2.1 Soil types

Five different soil type characteristics have been used to compile the design details.

Type	Unit weight kN/m^3	Coefficient of friction
1. Loose gravel	16.7	30
2. Dense gravel	19.6	30
3. Gravelly sand	16.7	35
4. Sandy gravel	19.6	35
5. Pumice soil	12.7	30

C2.2

For clay soil, the wall designs in figures C1.1 to C1.8 shall only be used where the clay material has been excavated to the limits shown.

Where such excavation is not considered to be acceptable then the retaining wall shall be deemed to require specific engineering design.

CC2.2

Considerable variations in pressures on the retaining wall can arise from clay subsoil conditions. Such detail design is outside the scope of this Standard. The 45^0 excavation line is considered to be the acceptable limiting factor.

Reference can be made to the NZ Concrete Masonry Manual for clay soils and timber/veneer loading conditions on the retaining wall.

C2.3 Concrete for footings

Concrete shall comply with NZS 3109 for concrete having a minimum compressive strength of 17.5 MPa at 28 days.

C2.4 Concrete for infilling

Concrete infill grout shall comply with NZS 4210, having a minimum compressive strength of 17.5 MPa at 28 days and a spread within the range 450 to 530 mm when tested in accordance with the appropriate test requirements of NZS 3112: Part 1.

C2.5 Reinforcing steel

Reinforcing steel shall be deformed bars conforming to NZS 3402.

CC2.5

Note that grade 500 steel may be substituted for grade 430 on a one for one basis.

C3 Retaining wall selection

C3.1

The appropriate wall type from figures C1.1 to C1.8 shall be selected considering:

(a) Height of retained soil;

(b) Surcharge loading condition.

CC3.1

Other wall types and conditions are shown in the NZ Concrete Masonry manual and other proprietary supplied information.

CC3.1b

A load surcharge of 2.5 kPa has been taken for a condition where a domestic driveway abuts the retaining wall.

C3.2
Construction and *reinforcement* shall follow the provision of the selected figure.

C4 Drainage

C4.1
Retaining walls shall be provided with a free falling drainage system that will prevent the build-up of water pressure behind the wall.

Construction of the drainage system shall be as follows:

(a) A perforated or porous pipe of 100 mm diameter shall be laid to a minimum fall of 1:150 and the invert at the highest point shall be a minimum of 50 mm below the concrete floor slab level.

(b) The pipe shall be covered with a self draining granular material to the height of the retaining wall.

(c) The pipe shall be arranged to provide for open discharge.

C5 Water and vapour proofing

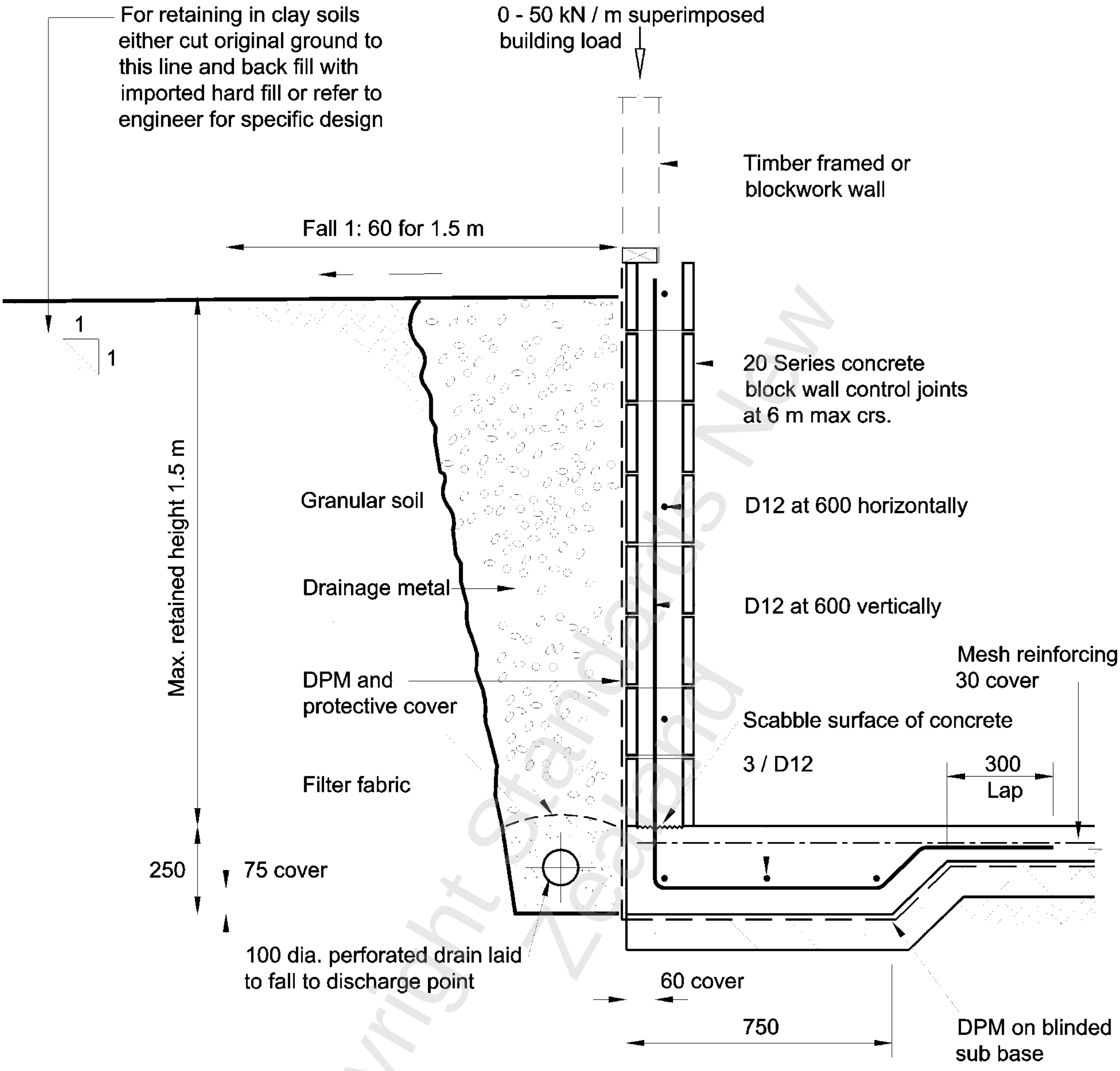
C5.1
Where the retaining wall forms part of a habitable structure, it shall be provided with:

(a) Drainage as in C4.1.;

(b) A waterproof vapour barrier system that complies with the requirements of 7.4.2;

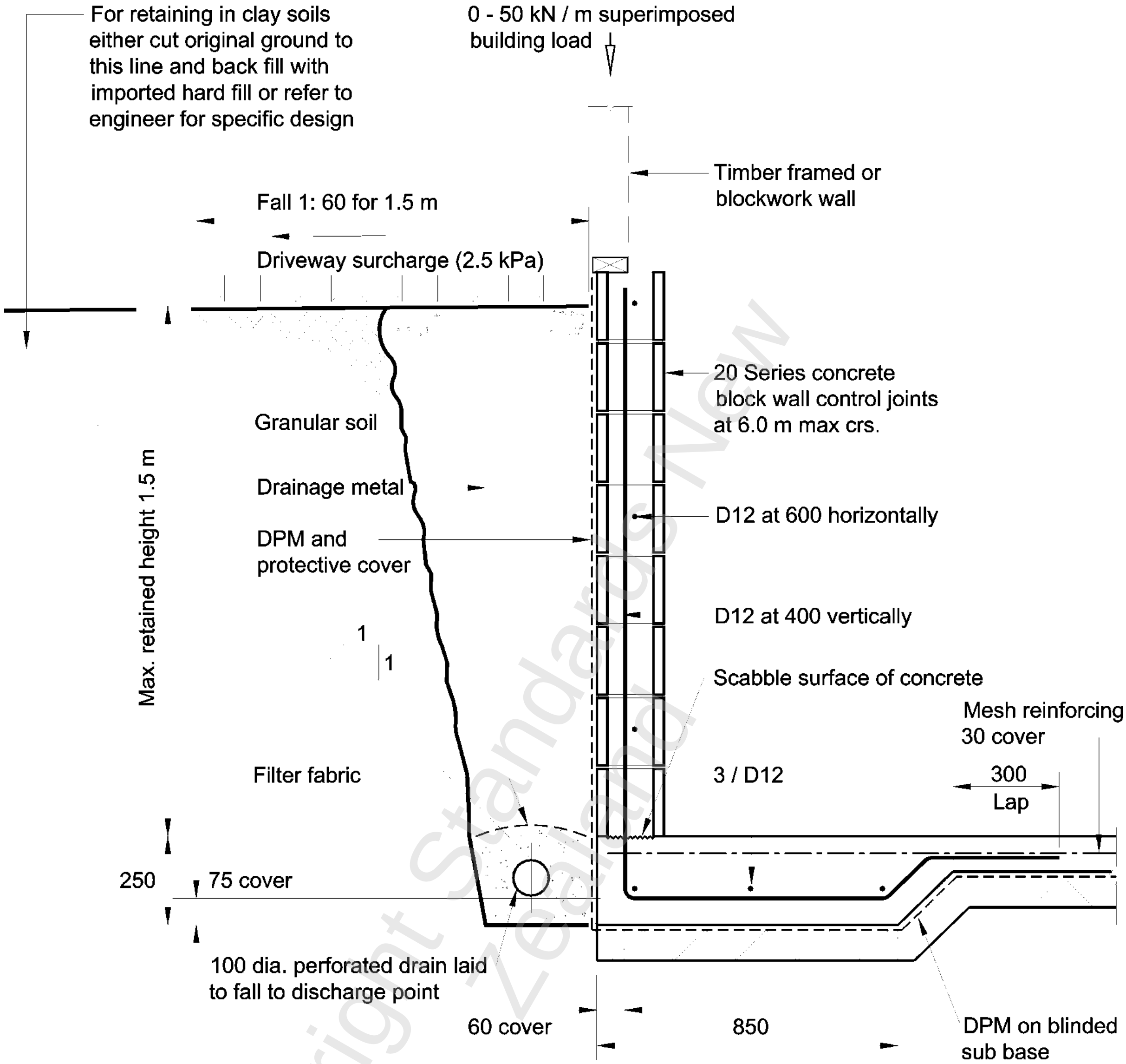
(c) The vapour barrier shall be fully protected from damage during the backfilling process.

CC5.1
The damp-proof membrane is required to prevent water vapour passing through the wall. When using the requirements of 7.4.2 it is important that drainage of water from the face of the wall must be provided.



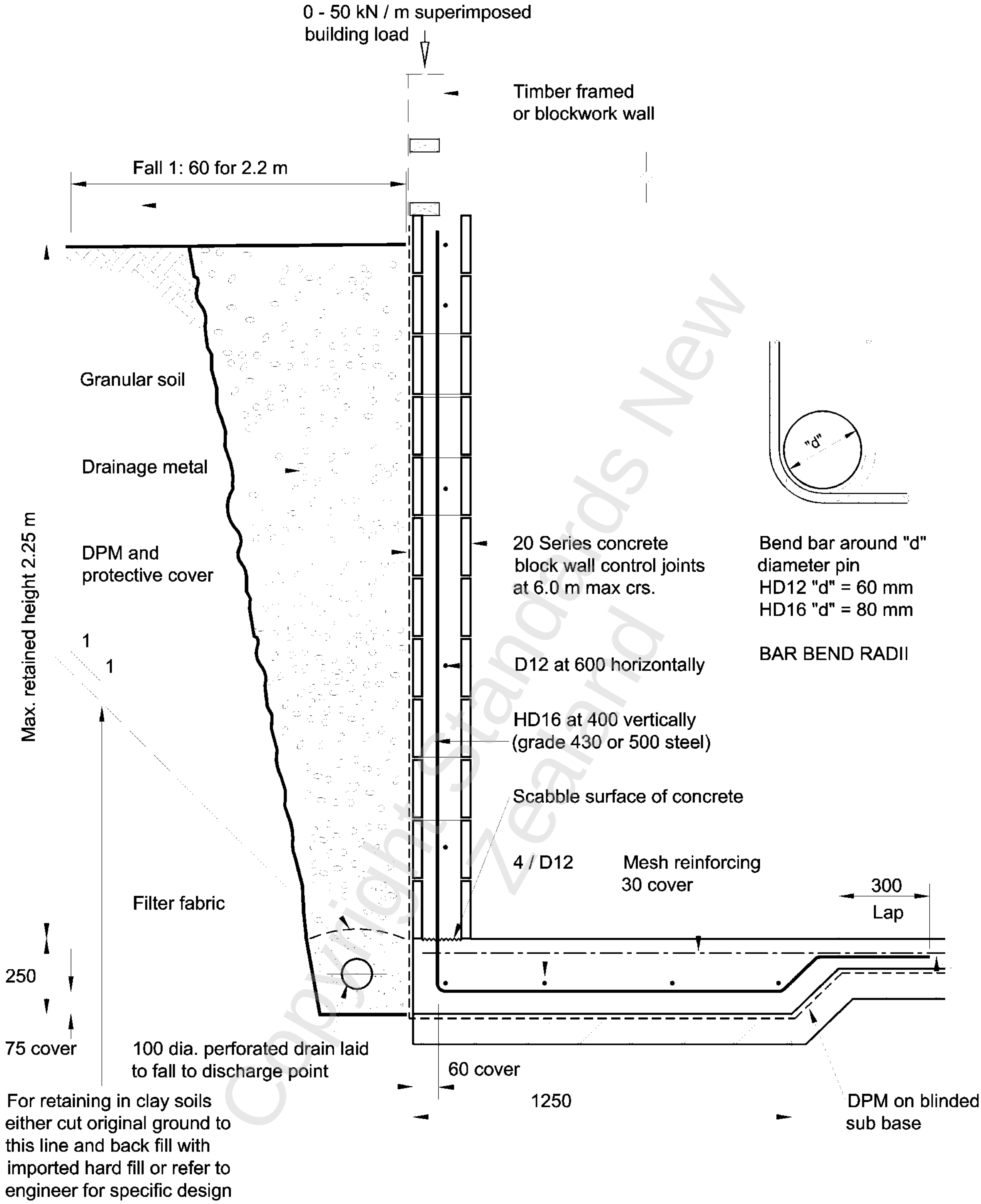
NOTE -
(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.
(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.1 – 1.5 m high granular soil without surcharge, 0 – 50 kN / m (see C1.2 and C1.3)



NOTE -
(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.
(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.2 – 1.5 m high granular soil with surcharge, 0 – 50 kN / m superimposed load
(see C1.2 and C1.3)

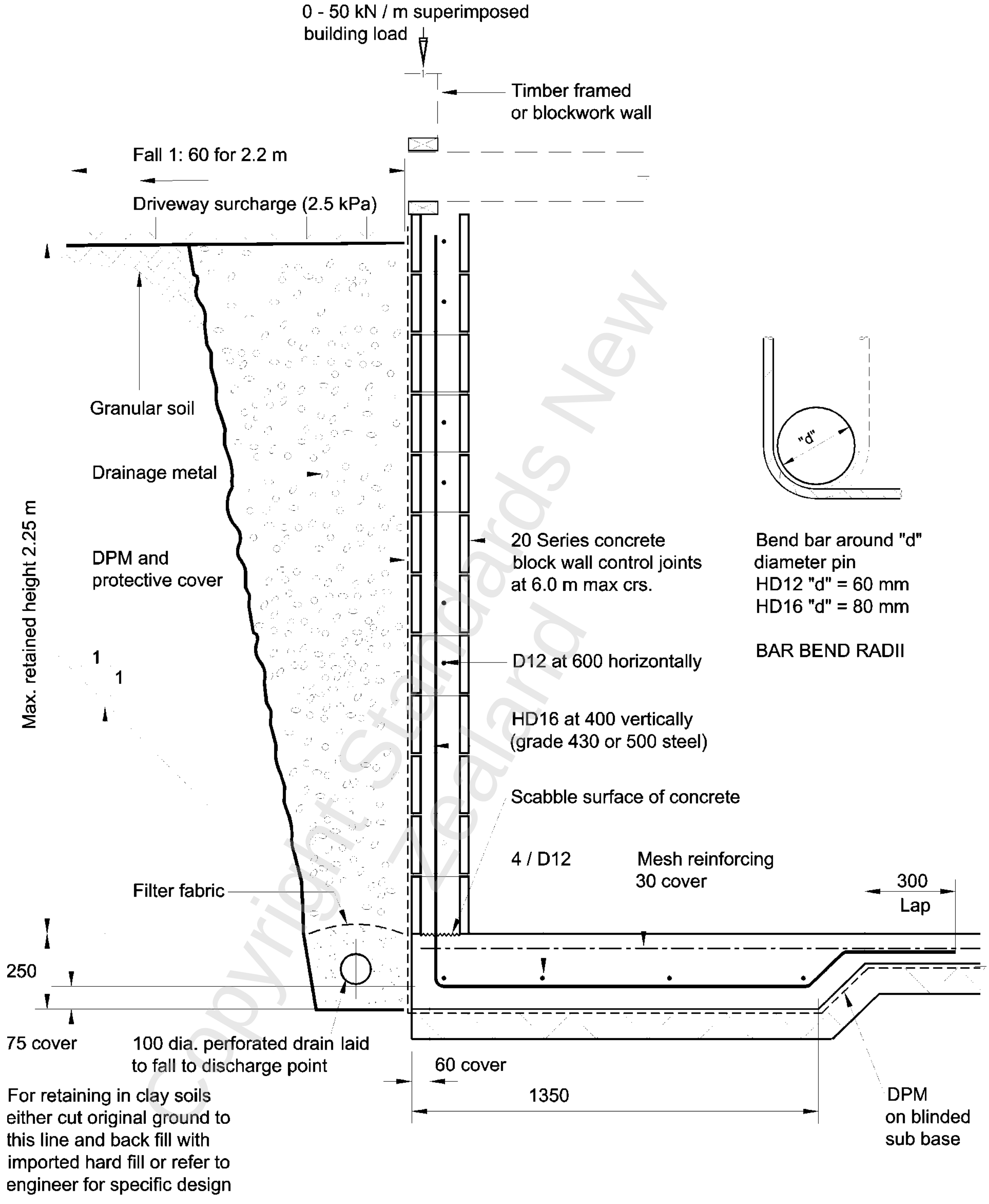


NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.3 – 2.25 m high granular soil without surcharge, 0 – 50 kN / m superimposed load
(see C1.2 and C1.3)

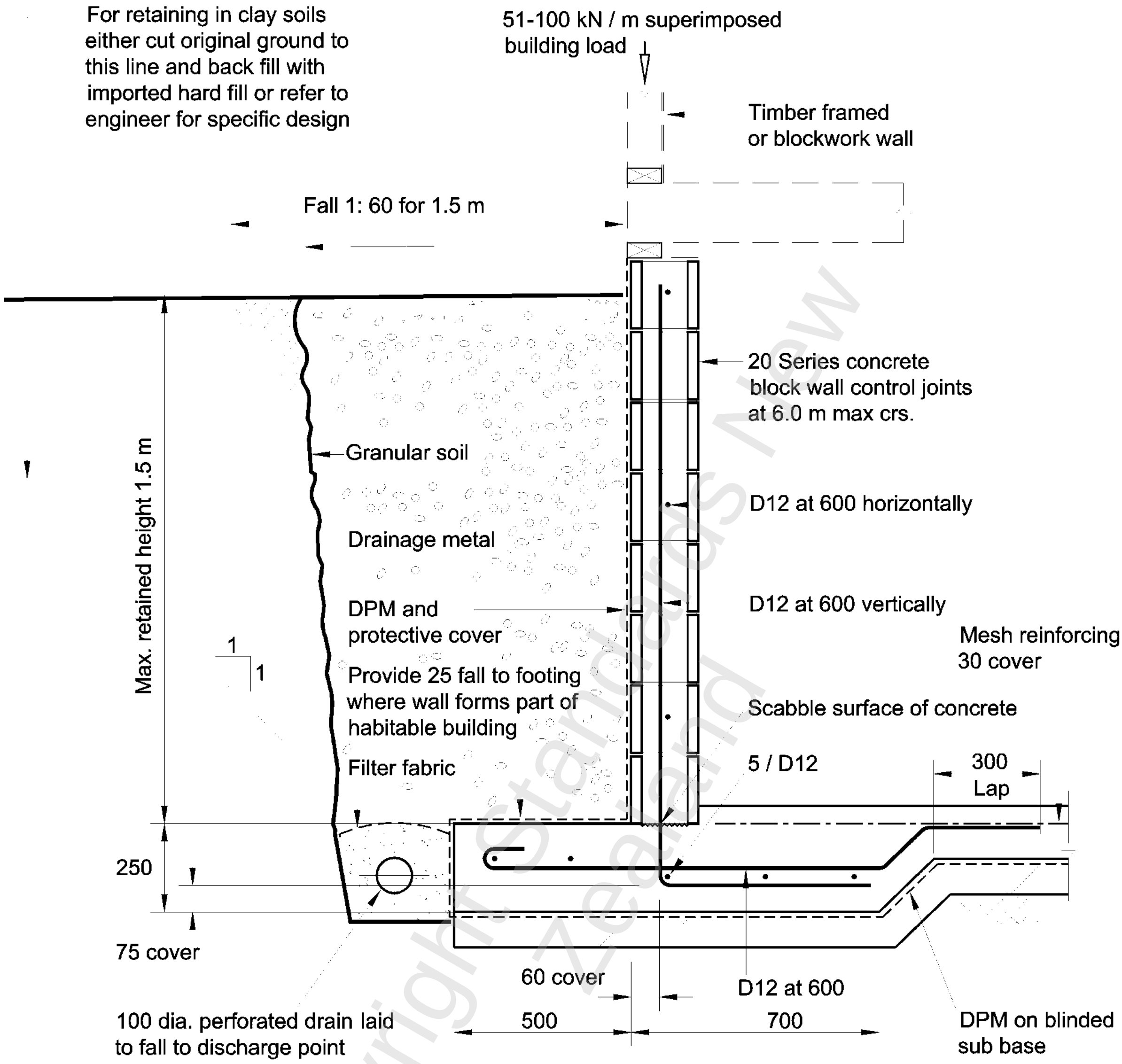


NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.4 – 2.25 m high granular soil with surcharge, 0 – 50 kN / m superimposed load
(see C1.2 and C1.3)

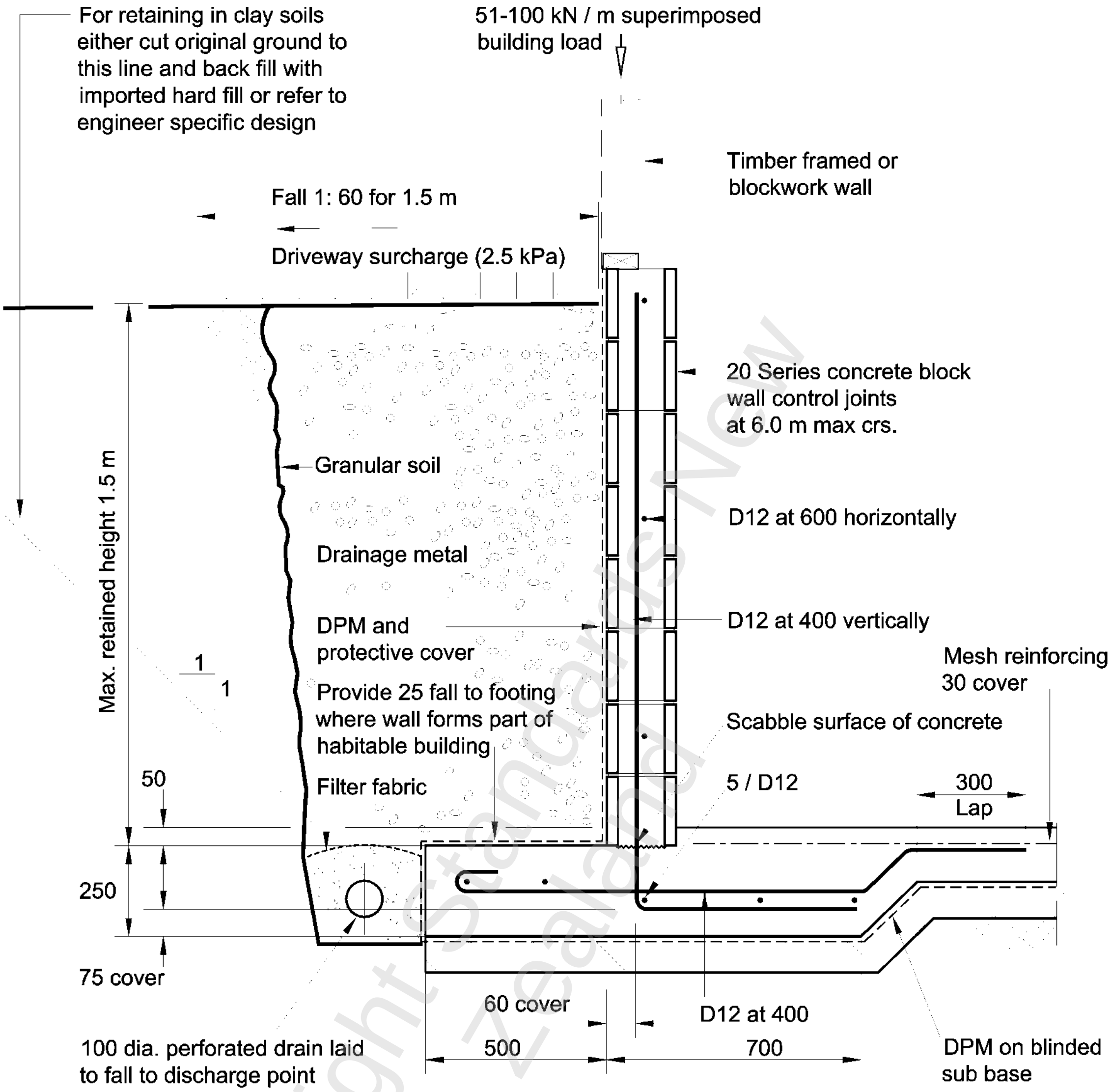


NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.5 – 1.5 m high granular soil without surcharge, 51 – 100 kN / m superimposed load
(see C1.2 and C1.3)

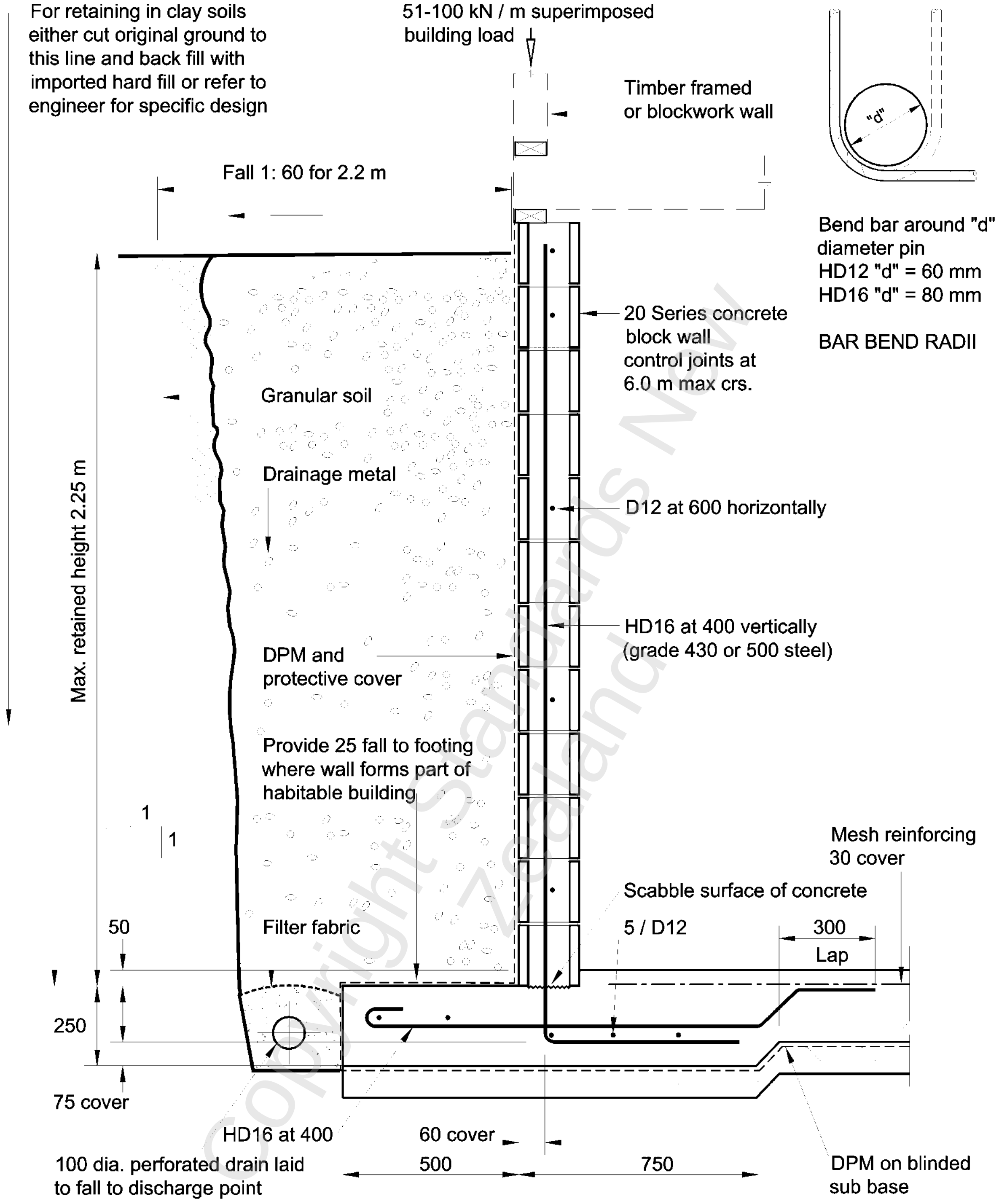


NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.6 – 1.5 m high granular soil with surcharge, 51 – 100 kN / m superimposed load
(see C1.2 and C1.3)



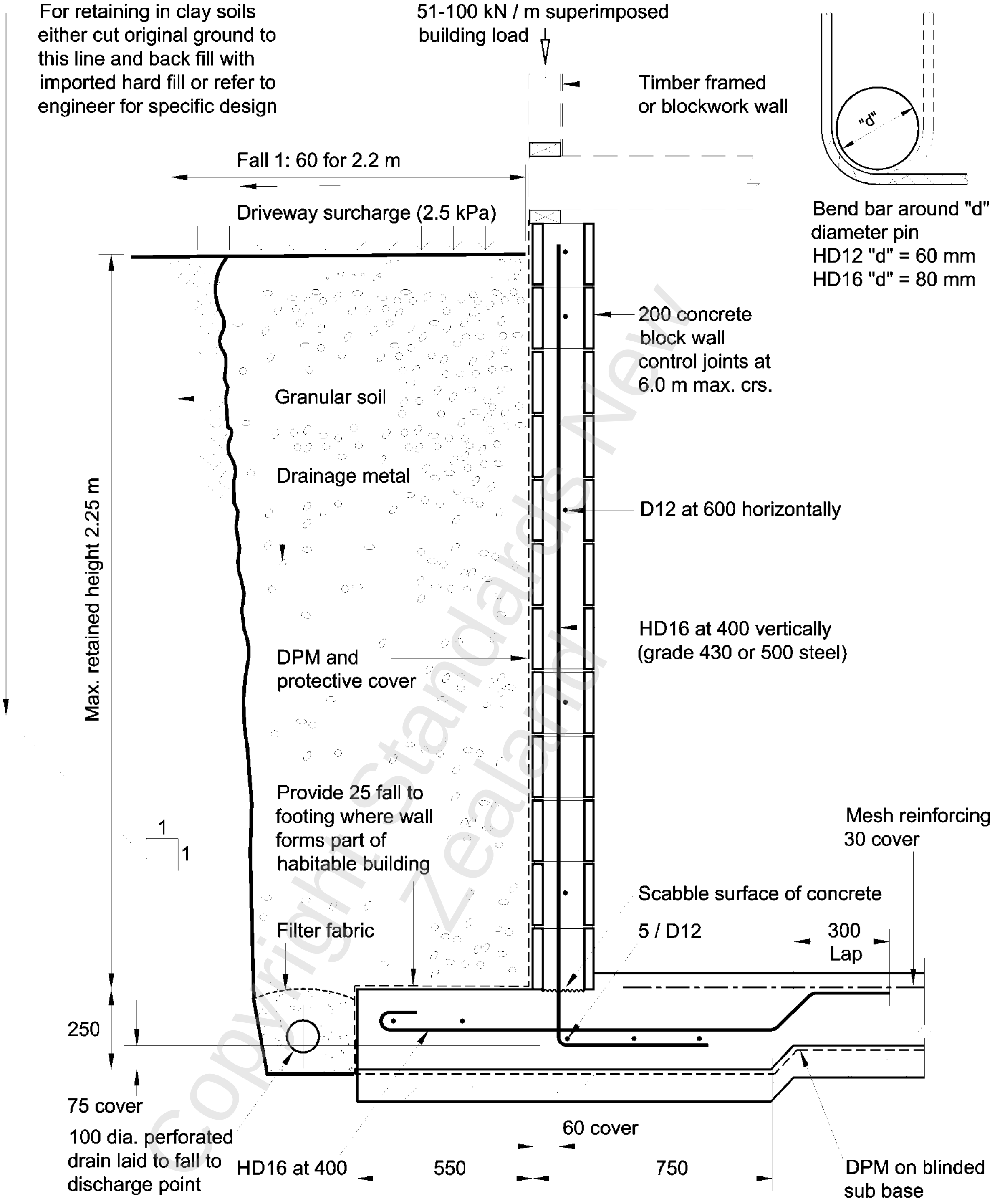
NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.7 – 2.25 m high granular soil without surcharge, 51 – 100 kN / m superimposed load

(see C1.2 and C1.3)



NOTE -

(1) It is important for bending strength that the vertical steel is positioned and secured so that it has 60 mm cover to the face of the wall retaining the earth.

(2) Bars designated D are deformed grade 300, bars designated HD are deformed grade 430, deformed grade 500 may be substituted for grade 430.

Figure C1.8 – 2.25 m high granular soil with surcharge, 51 – 100 kN / m superimposed load

(see C1.2 and C1.3)

NOTES

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