Part E: Repairing and rebuilding multi-unit residential buildings

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17. Introduction

17.1 Background

Part E addresses the special conditions required for the repair and rebuild of one and two storey multi-unit buildings (MUBs), and in particular situations involving the replacement of only part of the block. There are many of these units in Christchurch, often in the eastern parts of the city. All technical categories are covered with specific solutions provided for TC3.

This guidance addresses technical issues, providing advice and solutions that assist practitioners to comply with the Building Act and Building Code. Depending on their insurance policies, homeowners may have additional entitlements that are not addressed. While some information is provided on different ownership arrangements, multi-unit ownership can be complex and each situation will need to be resolved on a case specific basis between all unit owners and their insurers.

Where possible, the MUB guidance is consistent with Parts A to D for detached houses. It highlights that the whole block needs to be considered as one building. Damage assessment and repair strategies need to consider the whole building performance as well as that of individual units.

The main differences between Part E and the rest of the residential guidance involve consideration of party (fire) walls between units and the interaction between individual units. Some of the decision criteria and solutions provided have been slightly modified in recognition that unit footprints are generally smaller and more regular in shape.

Those familiar with the residential guidance will find Part E has many common threads and follows a similar approach as the guidance for detached houses. Use this guidance when preparing consent applications to improve the quality of the applications, which will assist the building consent authorities with their processing. This will also contribute to a quicker recovery.

Multi-unit residential buildings of two storeys or more and three household units or more fall within the scope of needing to be assessed for earthquake-prone buildings (refer Building Act s 122). These buildings may require Detailed Engineering Evaluations to be undertaken.

17.2 Scope

This guidance applies to single and double storey MUBs. For practical reasons it has not been possible to cover all potential multi-unit building arrangements. To cover the most common building arrangements, this guidance addresses attached units built in a straight line. The concepts developed in this guidance should also be applicable to other multi-unit configurations not specifically within the scope of this document but will depend on case-specific circumstances.

This guidance addresses assessment, repair, and replacement of MUBs in Canterbury with the following characteristics:

› they are one or two storeys, and

› they are located on TC1, TC2, and TC3 sites, and

› the ownership is horizontal, ie, vertical inter-tenancy walls.

The technical aspects of buildings in the Port Hills and associated foothills are not addressed. While many of the principles of this guidance may be adopted, the MUBs that fall within this group will require case-by-case consideration, including reference to the MBIE guidance relating to the Port Hills entitled *Guidance for building in toe slump areas of mass movement in the Port Hills (Class II and Class III)*[1].

The following table details MUB characteristics used for assessment, repair, and rebuild of MUBs in Canterbury.

Driver	Description
Constructed form	› There can be two, three, or more units all physically connected. › There can be one, two, or more storeys in a single building. **Note:** This guidance only applies to one or two storey buildings. › Abutting units are separated by fire and acoustically-rated, inter-tenancy walls. › Foundation construction types within MUBs vary and include Types A, B, C as per section 2, Type B buildings with Type C internal garages (assumed to be Type B for assessment purposes), and mixed (eg, Type B buildings with Type C extensions). › Although they may have been originally constructed to NZS 3604/ Light Timber Frame Buildings, the building will often incorporate stiff and/or heavy elements (eg, block or brick masonry, inter-tenancy walls), that perform several purposes (eg, have structural, fire-rating, and acoustic functions). Many MUB buildings in Canterbury also predate NZS 3604. › There can be both domestic and commercial uses within a building. **Note:** This guidance only applies to the residential MUBs.

1 Refer to www.dbh.govt.nz/supplementary-guidance-port-hills-index

Driver	Description
Building geometry	› MUB footprints vary between regular, offset, and branched arrangements. Typically the length to width aspect ratio (L/B) is large, ie, large length compared to width. **Note:** This guidance only applies to MUBs in a straight line. › The individual unit's foundation size typically depends on the number of bedrooms in the unit, but will generally be small, eg, from 50m² (1 bedroom) to 100m² (3 bedrooms).
Ownership	› MUBs have different title types (eg, single title, unit title, strata title, cross lease, fee-simple, company share). › MUBs can include horizontal ownership (where each unit has a ground floor area) and vertical ownership (where some unit/s are supported by unit/s below). **Note:** This guidance only applies to horizontal ownership.
Insurance	› Insurance arrangements will depend on the property ownership type. Refer to section 17.5 for detail, particularly for unit titles.
Foundation and superstructure damage	Damage may often vary: › due to the structural behaviour of the MUB as a whole › according to the geotechnical conditions across the site › along the building and can be concentrated in particular units/areas › due to experiencing different seismic loading and/or ground responses during the Canterbury earthquake sequence subject to the location in the building (eg, height).
Site conditions	› MUBs covered in this guidance are located anywhere in TC1, TC2, and TC3 sites on flat residential land. Because of their size, the site conditions may vary significantly along the building footprint.

For MUBs, some of the provisions for detached houses have been further developed, and in some cases, altered. These modifications reflect the various features of MUBs that generally differ from detached houses, including:

- they typically have much smaller floor plate dimensions and areas (eg, 50m² to 100m²) and are usually regular in layout
- there are many physical constraints, including the connection to adjacent units and the limited site area surrounding the building
- there are legal constraints arising both from the common elements of land and building aspects that require pragmatic solutions.

17.3 General principles

There can be challenges in finding appropriate solutions for MUBs where parts of the building, under different ownership, may require different physical treatments. As well as the legal complexities involved, there are technical and regulatory issues in relation to the repaired building's performance in future earthquakes that need careful consideration. This is particularly true where repairs result in different foundations systems within a MUB.

The following sections highlight some of the key regulatory and legal considerations in relation to MUBs. However there are a range of matters that are outside the scope of this guidance that may require separate investigation by the professional advisors involved in designing the repair or rebuild of the MUBs, including:

› the need to understand property law complexities for multi-unit building ownership (refer to section 17.5)

› the need for any resource consent arising from the proposed repair or rebuild

› insurance issues

› reaching multi-unit homeowner agreement for achieving the repair or rebuild

› flood management solutions.

17.4 Regulatory requirements

17.4.1 Treating the building 'as a whole'

The principal regulatory requirements for specifying repairs and rebuilding aspects of residential buildings are outlined in section 8.2. The key Building Act provisions are:

› Section 17 of the Building Act, which requires that all new building work (including new building work that is repair work for existing buildings) complies with the Building Code

› Section 112(1)(b) of the Building Act, which provides that a building consent authority must not grant a building consent for the alteration of an existing building (or part of an existing building) unless after the alteration the building will continue to comply with the other provisions of the Building Code to at least the same extent as before the alteration (ie, the building cannot perform any worse after the alteration).

The definition of building means a permanent immovable structure and refers to the whole of a building (refer to section 8(1)(a) of the Building Act). Where section 112(1)(b) refers to 'the building' continuing to comply to at least the same extent as before the alteration, it is referring to the 'whole building' and it is the performance of the whole building (ie, all the units in the building) that must be considered when assessing the effect the proposed alteration will have on the building.

This principle is in accordance with the approach adopted for weathertightness issues where it was found to be efficient to address the whole building performance.

A consequence of this approach is that when considering compliance with section 112 of the Building Act, this 'whole building' definition requires consideration of a repair (eg, relevelling and/or partial replacement) to extend across the whole building.

Nett benefit

The 'whole building' concept is fundamental when establishing compliance. The compliance test that extends from section 112 of the Building Act is that when considering Building Code Clause B1:

> *if there is a nett benefit to the whole building from parts that perform structurally better after alteration notwithstanding other parts that could structurally perform to a lesser extent after alteration, then the repair complies.*

The test (normally qualitative) applies by comparing the structural performance of the whole of building pre-repair (that is, not pre-earthquake), and the state it will be in post-repair.

Note: It is not possible to use improved performance with respect to one code clause, eg, Fire Safety, as a means to offset lesser performance under B1, Structure.

Assessment

Treating a MUB as a whole building leads to the following assessment principles:

› The engineer should assess each individual unit and assess the building as a whole, ie, each unit's interior and the whole building's exterior.

› The engineer should identify the damage mechanism across the whole building and determine whether the damage in one unit is related to damage in one or more of the other units.

› The assessment should be based on the predominant building foundation type, ie, for a mixed foundation type building such as a Type B with concrete slab on ground internal garage, the building should be assessed as a Type B building.

Repairs and rebuilds

The 'whole building' approach enables the complete rebuilding of one or more units within a block to be considered as an alteration to the building. In general, for multi-unit residential buildings,

> *the introduction of a section of newer more resilient foundation means the overall structural performance of the whole building will be better than before the alteration, even though in some future events there may be a possible negative impact of the new section on elements of the existing structure.*

For example, consider the case of a building that before the earthquake was uniform in construction. In the earthquake, part of the building foundation is significantly damaged and other parts require only minor repairs. The significantly damaged part of the building foundation is replaced with a more resilient foundation and new superstructure, all tied into the remainder of the building. The whole building is now made up of pre-existing units that have demonstrated better resilience than the replaced parts together with new works that are built to a higher specification than the damaged component. The building as a whole therefore has greater resilience. Even where there is the possibility of damage at the junction between old and new if the two parts of the structure perform slightly differently, the potential for damage at Serviceability Limit State (SLS) is low and would be readily repairable. Overall a better performance for the building is achieved.

From a structural perspective, the objective is to restrict damage in future moderate earthquakes (SLS) to being readily repairable (refer to section 8.2.3).

For further explanation of performance expectations at SLS and Ultimate Limit State (ULS), the concepts of readily repairable, and other regulatory considerations, refer to section 8.2.

17.4.2 Flood risk and floor levels

Building Code Clause E1 requires buildings and site work to be constructed in a way that protects people and other property from the adverse effects of surface water. Building Code Clause E1.3.2 requires floor levels to be above the one in 50-year flood level.

As outlined in section 8.4, Building Code Clause E1.3.2 will not apply to relevelling and repair work involving part of a foundation because the Building Code requirement in Clause E1.3.2 only applies to a building as a whole. Therefore, a building will not need to be raised under the Building Code to meet one in 50-year flood level requirements unless the foundations for the whole building need to be replaced.

Relevelling and foundation repair work, including partial foundation rebuilding, should not make the flooding vulnerability of the whole building worse than it was prior to the repair. Therefore, the requirement of section 112 of the Building Act to comply to at least the same extent as before the repair with respect to Building Code Clause E1 is satisfied.
For additional RMA requirements for floor levels, refer to section 8.4

However, the full rebuilding of one or more units in a building represents substantial work in respect of the unit and that will be, in the majority of cases, substantial in relation to the whole building. It will require significant investment. It will not generally be practical to rebuild the replacement unit in a block at a higher level than the existing units, where the whole block is below the one in 50-year flood level (or, within the Christchurch City Council Flood Management Area, the higher of 11.8m above Christchurch datum in tidal areas or the one in 200-year flood level). However, on a case-by-case basis, it may be possible to reconfigure the block so that the unit(s) needing to be rebuilt are rebuilt elsewhere. This, however, is not a requirement of the Building Act and is an issue for homeowners, councils, EQC, and insurers to resolve. Alternatively, area-wide flood protection may be possible.

Full rebuilds need to fully comply with the requirements of Building Code, including minimum floor level heights per Clause E1.3.2. For further foundation rebuild details, refer to section 5 (TC1 and TC2), section 15 (TC3), and section 22 (MUBs).

17.5 Building ownership and legal considerations

17.5.1 Overview

It is important to establish the ownership obligations before commencing work. There are legal factors in regards to MUBs that are not present in detached houses on their own titles. The ownership type has a bearing on whether repairs will be isolated or taken across whole structures. The latter approach is the recommended option but may not always be possible.

Resolving cost obligation/recovery of costs from owners/insurers of individual units is beyond the scope of this guidance.

17.5.2 Individual title to shared property

Multi-unit developments have complex ownership structures that need to be understood to determine where building consents and changes to titles might be required as a result of repairs or rebuilding work.

The differing types of shared property ownership include:

1. **Cross lease complex** – where a number of people share in the ownership of a piece of land and the owners lease their units from each-other on long-term leases. A memorandum of lease details the specific arrangements in each complex. The buildings shown on a cross lease title are often referred to as 'flats' and cross lease plans are commonly called 'flats plans'. This plan is also attached to the certificate of title held by Land Information New Zealand (LINZ).
2. **Unit title complex**[3] – where each person owns their own unit and shares the common property with other owners. A MUB with more than nine units must have a body corporate committee that administers the complex and is responsible for managing the common property. The units are shown on a unit plan that is attached to the certificate of title held by LINZ.
3. **Company-share complex** – where the MUB is owned by a company, and each owner has the right to use a unit through ownership of particular shares in that company.
4. **Fee-simple** – where each owner owns their own unit and land, but has rights in relation to common parts of the MUB on other properties (such as party walls) through easements or other legal interests.

2 Refer to sections 75 and 84 Unit Titles Act 2010 and sections 12,15 and 16 Unit Titles Act 1972

Cross lease complex

Cross lease ownership of the land is complicated. Every cross lease property is described in a flats plan that is held at LINZ. The flats plan shows the building footprint, as well as any restrictive areas and common areas. If changes are made to the building footprint, the flats plan will need to be updated. Where land is subject to a cross lease, the lessees' obligations will mostly be found in the terms of each lease, the terms of which may vary between properties. There are no relevant regulatory requirements that apply governance obligations on lessees. A cross lease contains reciprocal obligations between the lessees. Insurance will not necessarily be common with all or any two leased units. Collective processes (such as body corporates) are unlikely to be in place.

It is the owner's (or the owner's insurer if the rebuild work is covered by an insurance policy) responsibility to have the flats plan updated, when any changes are made to the building footprint. The flats plan is often reviewed at time of sale in conjunction with the cross lease. If there has been a change to the building footprint[3] and the flats plan has not been updated then the owner will have a defective title and this will have implications if the property is to be sold. As part of updating the flats plan the written consent of all of the other owners in the multi-unit complex is required. In order to deposit a new flats plan redefining the property a resurvey, new flats plan, and new cross lease are required. A subdivision consent is required from the council before the new flats plan and cross lease are lodged with LINZ. Building consent will also be required from the council. There are surveying, council, and legal costs associated with updating a flats plan.

Unit title complex

A unit title complex is documented and a body corporate created on the deposit of a unit plan at the initial registration of the title.

Where there is a small boundary adjustment between units that does not materially affect the common property or another unit, the unit plan can be amended. All other redevelopment changes require the cancellation of the existing unit plan and replacement with a new unit plan as well as additional documentation requirements under the Unit Titles Act 2010. In both situations, the district plan rules need to be checked and approval from other unit holders, usually via the body corporate, is required. A subdivision consent from the council is required before the unit plan and accompanying information can be lodged with LINZ. There are surveying, legal, and council costs involved in changing the unit plan.

The body corporate must insure 'all buildings and other improvements' on the base land to full insurable value, which is generally done under a single policy called the principal insurance policy.

The principal insurance policy does not prevent a unit owner from taking out insurance against destruction or damage of units. Therefore you may end up with several different insurance policies relating to one building.

3 Any departure from the building footprint shown on the flats plan is, technically, a defect in title. Whether or not the flats plan is corrected is usually a decision made by the owner.

No of units	Description
Ten or more	Where more than nine units are joined, under Unit Titles Act 2010 there must be a body corporate committee in place to manage the building (unless the body corporate, by special resolution, decides not to form a body corporate committee). The body corporate or the body corporate committee (using delegated powers from the body corporate) must establish and regularly update a long-term maintenance plan and among other obligations must insure all buildings and other improvements on the land to their full insurable value. The Unit Titles Act 2010 also specifies funding to cover administration and repair of damage. The body corporate is responsible for dealing with the insurer in the event of claims. When damage has occurred, the body corporate (through the body corporate committee) generally will keep unit owners informed about developments with the claim. Unit owners may have separate insurance for their unit (and most will have their own contents insurance). The insurer will mostly deal with the body corporate committee, although only the body corporate can apply insurance monies in or towards reinstatement. The insurance policy will detail how claims are made and resolved.
Nine or less	Where there are nine or less owners, a body corporate committee can be formed, but often is not. Unit title owners in this situation may find that for practical, insurance, maintenance, and financial purposes, there are advantages in ensuring a body corporate committee is in place. For these MUBs there will be a range of management regimes from body corporates that have taken out insurance; to scenarios, where the owners have taken individual responsibility for insurance; and other scenarios where there is no insurance at all. Common property issues will be addressed in the Unit Titles Act, the unit plan and the body corporate rules. But these issues may not be well understood by an owner. The Ministry's experience with the resolution of weathertight home issues is that owners of units in buildings comprising less than nine units and who have not formed a body corporate committee have had long delays in achieving claim resolution. The main reason for this is individual unit owners have needed to deal with separate insurance companies, and there is no mechanism to reach consensus agreement on repair. There is a strong requirement for goodwill between neighbours to agree on actions and payments.

Company-share complex

Management of issues relating to reinstatement and rebuild are less complex due to the fact that there is a company structure in place.

Fee-simple

Any common ownership issues will be included on the property title.

17.5.3 Multiple owners, allotments and consent documentation

Building consents can either apply to work within one unit of a MUB (ie, from individual unit owners) or to all work across more than one unit in a building (ie, from all unit owners collectively).

Building consent authorities do not require a separate building consent application from every owner where there is more than one landowner for the same building or parcel of land.

In a cross lease situation, the unit's owner for the purposes of a building consent can be taken as the individual cross lease owner (refer to DBH Determination 2009/45). This approach relies on the component of the definition of 'owner' in section 7 of the Building Act referring to the entitlement to the rack rent.

Similarly, in unit title situations, the building's owner can be taken as the unit proprietors who hold a stratum estate in freehold and are entitled to the rack rent of the land (refer to DBH Determination 2011/068).

Building consent authorities have discretion as to how to handle and process a building consent involving multiple units within one building (refer to DBH Determination 2009/56):

> *The nature and extent of the building work described in a building consent and the management of the building consent process clearly fall within the discretionary powers of the building consent authority.*

Given the need to treat the MUB 'as a whole' for an appropriate application of sections 17 and 112 of the Building Act as outlined in section 17.4.1, it is desirable for consent documentation to cover all work to be undertaken in the building where practicable.

17.5.4 Consent requirements

Repair or rebuild work for a multi-unit development will require a building consent unless the work is exempt from the requirement in accordance with section 41 of the Building Act. Schedule 1 to the Building Act, Exempt building work, lists details of building work that does not require a building consent. Even though the work may not require a building consent, the work undertaken still needs to comply with the Building Code. For details on exemptions, refer to the MBIE guidance *Building work that does not require a building consent (March 2014)*[4].

Partial rebuilds (refer to section 20) are alterations to the building and will require a building consent.

Any application for a building consent for repair or rebuild will begin with an assessment for compliance with the district plan rules. This will indicate the need for any resource consent under the Resource Management Act 1991.

4 www.dbh.govt.nz/UserFiles/File/Publications/Building/Guidance-information/pdf/building-work-consent-not-required-guidance-3rd-edition.pdf

Although existing use rights will be taken into account, it is likely that land use consent might be required where there is a change to the units on the site as part of a rebuild process. Section 8.4.2 outlines the elements that need to be met for existing use rights to apply. In all cases, compliance will need to be checked against the full range of district plan rules, including for building bulk and location, setbacks, vehicle access, and outdoor living to determine if land use consent is required. This applies even if the units are replicated.

Examples of cases when land use consent may be required are where:

- repair or rebuild solutions involve changes to building bulk, location requirements, and land use (eg, the raising of a unit to meet council flood requirements may encroach into a height recession plane)
- there are more extensive changes proposed to the multi-unit development (eg, a new unit has been added or the arrangement of units on the site has changed).

Christchurch City Council has a multi-unit design document that guides the design and layout of new multi-unit developments in some of the living zones within the City[5].

Where the repair or rebuild of a multi-unit development changes the footprint of buildings on a site then the owner may wish to update the flats plan to ensure the title is accurate. In order to alter the flats plan/unit plan, a subdivision application needs to be lodged with the council. Because unit plans require body corporate agreement, anything from minor amendments to major changes will require formal documentation and submission through the council.

5 Refer to http://resources.ccc.govt.nz/files/Homeliving/buildingplanning/forms/P332_UrbanDesignGuideL3Zones.pdf

18. Assessment process

18.1 Overview

The flowchart in Figure 18.1 and Table 18.1 summarise the suggested assessment process for determining whether a MUB needs individual unit repairs, partial rebuild and repairs, or full foundation rebuild.

The assessment process should consider both the building as a whole (refer to section 17.4.1) and each individual unit. The principal objective is to establish the primary damage mechanism affecting the building.

Figure 18.1: Process overview

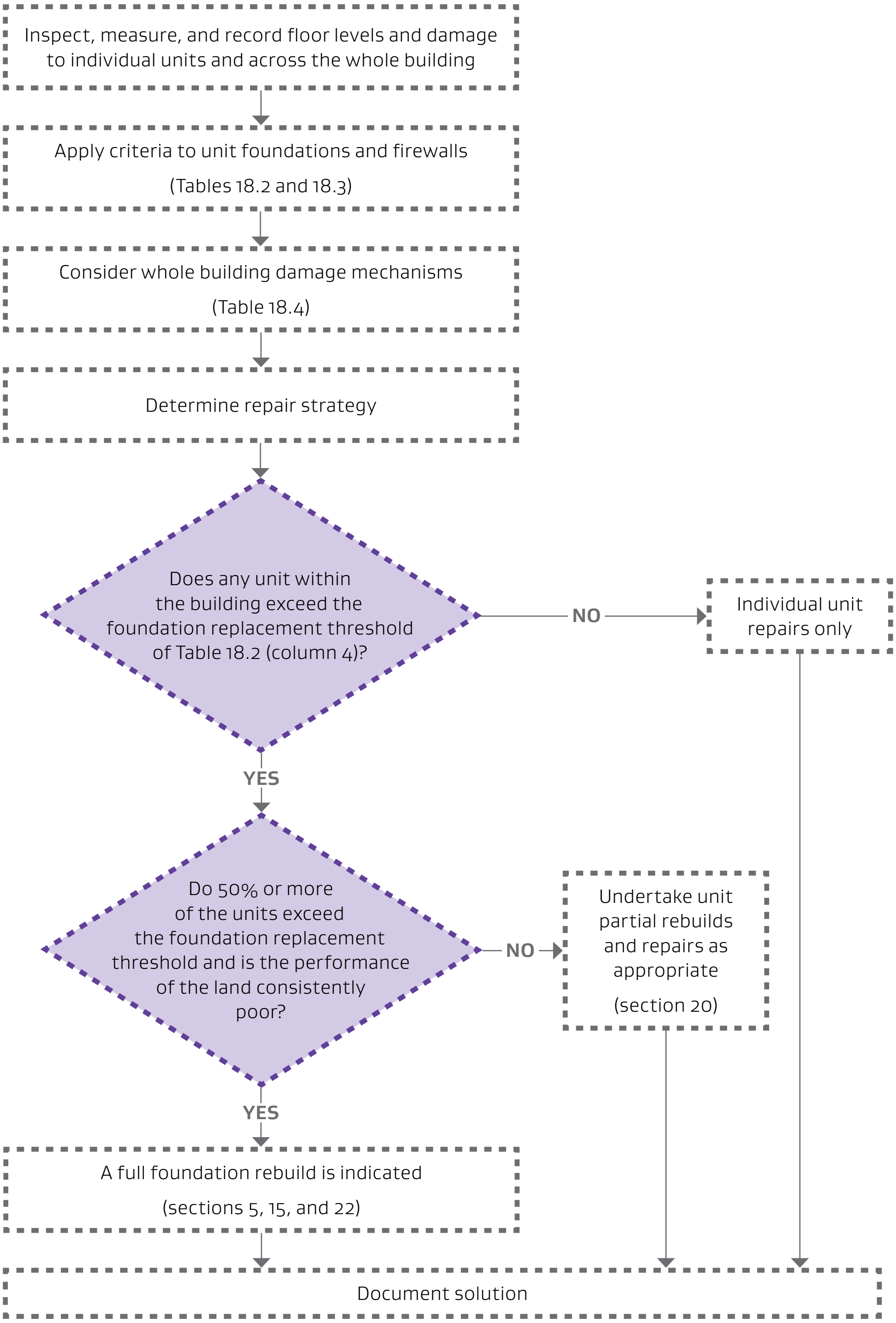


Table 18.1: Overall MUB assessment and repair process

Step	Individual unit	Whole building
1. Inspect, measure, record	Inspect each individual unit including: › Record internal floor levels and any damage, eg, cracks › Record in-plane and out-of-plane tilt for each firewall and any damage › Record evidence of superstructure damage such as racking and verticality of walls	› Inspect the whole building, including foundation and superstructure for damage and surrounding land for indications of performance, eg, land cracking › Produce plan with levels along the whole building **Note:** Relate levels to a single datum and refer to Table 18.2, Note a
2. Apply criteria	› Apply individual foundation criteria to each unit (refer to Table 18.2)	› Apply MUB overall building criteria across the whole building and determine damage mechanism (refer to Tables 18.2 and 18.4) › Apply firewall criteria to all firewalls (refer to Table 18.3) › Quantify extent of superstructure damage across the whole building
3. Identify repair strategies and decide solution	› Identify repair strategy for individual unit foundations › Identify repair strategy for each firewall	Identify repair strategy for the whole building foundation (repair/relevel or rebuild)
4. Document solution	Synthesise and document most appropriate repair strategy for building as a whole **Note:** This will detail the nature of the foundations for rebuilds along with repair/relevel solutions for remaining foundations, if retained	

18.2 Building assessment criteria

The assessment process looks at the building as a whole and considers the guidance on a threshold level of damage leading to repair and replacement decisions. Where the performance or geometry of the building varies significantly along the length it may be appropriate to analyse the building in distinct sections. This must only be done with due regard to any impact on the whole building.

Due to the wide variety and combination of MUBs, it is not practical to provide a blanket threshold for a whole-of-building rebuild. Where ground movement has resulted in significant damage in all or in part of a building, complete replacement may be warranted on some sites while on others repair may be sufficient. Where the majority of the foundation of the whole building is damaged as a consequence of the Canterbury earthquake sequence, the foundation performance in future earthquakes could be similar and so a replacement of all of the building's foundations is likely to be necessary.

The recommendations in Part E are focussed on single and two storey MUBs with horizontal ownership where the units are generally smaller than detached houses. The principles of Table 2.3 (refer to section 2) have been adapted to apply to such MUBs. Table 18.2 incorporates the existing criteria of Table 2.3 with additional criteria (in red italics) that result from the need to consider both the whole building and individual units when assessing MUBs. The tilt criteria for piles in Table 2.2 also apply to MUBs with Type A and Type B foundations.

The assessment of foundation damage is based on the predominant foundation of a building. Engineering judgement is required to assess the relationship with secondary foundation types (eg, garage slab, porch, patio) and the implications of repairs and/or replacement of such structures.

The solution should consider, where appropriate, the need for the removal of ejected material from beneath a building and that may require the building to be lifted.
Note: This is not applicable for Type C[6] buildings.

The indicator criteria in Table 18.2 provide guidance and should not be treated as absolutes, as emphasised by the dotted vertical lines between the columns.

For example, issues arising from the ownership arrangement or damage to firewalls may lead the adoption of a different approach to that indicated in Table 18.2.

6 Type C is defined in section 2.1 as slab-on-grade

Table 18.2: Indicator criteria for floor/foundation relevel, repair, or rebuild in MUBs

This table draws on Table 2.3 in section 2, using indicator criteria appropriate for multi-unit buildings within the scope of Part E.

Column 1	Column 2	Column 3	Column 4	Column 5
Floor type	**NO foundation relevel considered necessary** [Note l]	**Foundation relevel and/or repair indicated** [Note j]	**Foundation rebuild indicated for individual unit (partial rebuild)**	**Foundation rebuild indicated for whole building**
Type A Timber-framed suspended timber floor structures supported only on piles	The slope between any two points >2m apart is <0.5% (1 in 200) *within a single unit* [Note a*, g, and q*] **and** The variation in the level over the floor plan *within a single unit* is <50mm **and** *The slope along the whole building is <0.5% (1 in 200) [Note d]* **and** *Firewalls do not require repairs, refer to Table 18.3*	The variation in floor level is >50mm and <100mm *within a single unit [Note q]* **or** *The slope along the whole building is >0.5% (1 in 200) [Note d]* **or** *<50% of piles within any single unit require replacement [Note m]* **or** *1 or more firewalls require replacement – partial foundation replacement of individual unit*	The variation in floor level is >100mm *within a single unit* [Note c *and q*] **or** The floor has stretched >20mm *within a single unit [Note e]* **or** ≥50% of piles *within any single unit* require replacement [Note m]	*This will relate to the degree of total damage and the number of unit foundations requiring replacement exceeding economic repairs [Note f and n]*

Column 1	Column 2	Column 3	Column 4	Column 5
Floor type	**NO foundation relevel considered necessary** [Note l]	**Foundation relevel and/or repair indicated** [Note j]	**Foundation rebuild indicated for individual unit (partial rebuild)**	**Foundation rebuild indicated for whole building**
Type B Timber-framed suspended timber floor structures with perimeter concrete foundation	The slope between any two points >2m apart is <0.5% (1 in 200) *within a single unit* [Note a, *g, and q*] **and** The variation in the level over the floor plan *within a single unit* is <50mm **and** *The slope along the whole building is <0.5% (1 in 200) [Note d]* **and** *Firewalls do not require repairs, refer to Table 18.3*	The variation in floor level is >50mm and <100mm *within a single unit* [Note b, *and q*] **or** *The slope along the whole building is >0.5% (1 in 200) [Note d]* **or** *1 or more firewalls require replacement – partial foundation replacement of individual unit [Note p]*	The variation in floor level is >100mm *within a single unit* [Note c, *and q*] **or** The floor has stretched >20mm *within a single unit* [Note e] **or** *≥50% of piles and/or the perimeter beam within any single unit require replacement [Note m]*	*This will relate to the degree of total damage and the number of unit foundations requiring replacement exceeding economic repairs [Note f and n]*

Column 1	Column 2	Column 3	Column 4	Column 5
Floor type	**NO foundation relevel considered necessary** [Note l]	**Foundation relevel and/or repair indicated** [Note j]	**Foundation rebuild indicated for individual unit (partial rebuild)**	**Foundation rebuild indicated for whole building**
Type C Timber-framed dwelling on concrete floor	The slope between any two points >2m apart is <0.5% (1 in 200) *within a single unit* [Note a *and g*] **and** The variation in the level over the floor plan is <50mm *in a single unit* **and** *The slope along the whole building is <0.5% (1 in 200) [Note d]* **and** There is no distress in floor coverings **and** Services are functioning **and** *Firewalls do not require repairs, refer to Table 18.3*	*The slope along the whole building is >0.5% (1 in 200) [Note d]* **or** The variation in floor level is >50mm and <150mm *within a single unit* **or** *1 or more firewalls require replacement – partial foundation replacement of individual unit*	The variation in floor level is >150mm *within a single unit* **or** There is irrepairable damage to buried services *within a unit's footprint* **or** *The floor has stretched >20mm within a single unit [Note e]* **or** *>50% of the concrete slab within any single unit requires replacement [Note m]*	*This will relate to the degree of total damage and the number of unit foundations requiring replacement exceeding economic repairs [Note f and n]*

Explanatory notes to Table 18.2

Note	Commentary
a	Floor and superstructure damage repair may still be required, even if these indicator limits are not exceeded. Floor slopes are normally established by recording levels at the intersections of grid lines spaced at approximately 2m in both directions and at obvious high spots and low spots.
b	For veneer cladding to Type B construction, there may be a need to rebuild the veneer.
c	Pile packing in Type A and B construction is considered to be unstable at greater than 100mm *without specific design details*.
d	*Engineering judgement is required to assess whether any planar tilt of the floor plate (refer to Table 18.4, damage mechanism 2) has implications on the performance of the building, or parts thereof (more likely to be related to services or firewalls). If not, then for Column 2 cases it is likely that foundation relevelling is not necessary to repair the building, or for Column 3 cases relevelling will be required. If there are overall performance implications, a foundation rebuild (partial or full) may be necessary.*
e	*The presence of firewalls makes the response of MUBs to lateral stretch somewhat different to the response of a detached house. For example, if a gap has opened between the firewalls of a single unit (Types A, B, or C foundations) then there will be no benefit in attempting to pull the foundation together again. Instead, consideration should be given to adjusting the superstructure roof and wall framing to accommodate the gap that has been created at the foundation (refer to Table 18.3). Individual circumstances will determine whether the foundation can be repaired or should be rebuilt.*
f	This is an economic decision for all foundation types (A, B, or C) on a particular property. *This decision may be influenced by the number of units and/or firewalls in a building requiring replacement, and the practicality of rebuilding those units and firewalls. In some instances, due to construction practicality, the replacement of a middle unit may necessitate the replacement of adjacent unit/s as a consequence and may lead to a total constructional loss.*
g	Any abrupt changes in floor level may require at least local relevelling, depending on the type of floor covering.
h	*Units* will have different degrees of damage, and in some cases the rebuilding of foundations may only be needed in the vicinity of the damage.
i	More restrictive limits may be appropriate if there is concern that distortions in the floor from earthquake damage may cause superstructure damage over time. For example: › Damage to partitions (gravity load bearing and/or non-gravity load bearing) supported by a floor or foundation that undergoes angular distortion. **Note:** Damage limits applicable to specific types of partition are given in other standards (eg, AS 2870 Table 8.1, ISO 4356 Annex D Table 1). AS/NZS 1170.0 Table C1 also provides guidance on acceptable deflection limits for wall linings. › Damage to external cladding leading to contravention of the various Building Code performance requirements (eg, Clause E2).
j	Foundation rebuilds are triggered by excessive differential settlements settlements *(particularly abrupt changes)* or excessive floor stretches, as covered in Table 18.2. However, the size of crack widths determines only whether or not a structural repair is required and this indicator criterion is already covered in the last column of Table 2.2.

Note	Commentary
k	The indicator criteria provide guidance; they are not absolutes, as suggested by the dotted vertical lines between the columns.
l	The column title that states 'NO foundation relevel considered necessary' is intended to indicate 'if all of the criteria below are met'. Accordingly, all of the criteria listed below the title, which are actually upper limits on slopes and levels below which the floor must be performing, must be satisfied (therefore 'AND' is used). When a relevel or rebuild is triggered by any of the situations described in the columns to the right of column 2, the recommendation is to at least regain all of the maximums stated in column 2.
m	*If ≥50% of a concrete slab or ≥50% of the perimeter beam and/or ≥50% of the piles within any individual unit require replacement, the extent of the damage is such that it is recommended that all of the foundations of these affected unit/s should be replaced.* *If the number of units affected is less than half of those in the building, this results in a partial rebuild (alteration) of the building.*
n	*If ≥50% of the units require rebuilding and where the performance of the land is consistently poor (refer to Table 18.4, notably damage mechanisms 3, 4, 5, and 8 but may include others), a foundation rebuild for the building is recommended.*
p	*Replacement with a timber-framed, fire-rated, inter-tenancy wall may negate the need for a partial foundation replacement as the firewall can be truncated at floor level and the timber-framed firewall constructed from the floor level up.*
q	*Excludes step change for garages, etc.*

18.3 Buildings that exceed threshold criteria

If 50% or more of the units within a building exceed the foundation rebuild threshold criteria for individual units in Table 18.2 and the overall damage mechanism indicates that the land has performed poorly, a full rebuild of the entire building's foundation is recommended. Where 50% or more of the units require the foundation to be rebuilt, it is likely that the land has generally not performed well and that more robust foundations are required.

There may be cases where the damage mechanism of the building shows that the 50% threshold could be exceeded without the need to rebuild the foundations of the whole building. In making this assessment, the number and extent of areas proposed for repair within units needs to be considered together with the number of units within a building that exceed these limits. In considering rebuilding it is also important to assess superstructure damage and functional performance impacts.

A partial or full foundation replacement will in most cases require a full superstructure rebuild because there is limited opportunity to lift a MUB superstructure (or part) to enable replacement of just the foundations. This is in contrast to detached houses where lifting of the superstructure is normally more practical.

For full foundation rebuilds, refer to section 5 (TC1 and TC2), section 15 (TC3), and section 22 (MUBs).

18.4 Firewall assessment criteria

Generally MUBs have filled and reinforced concrete block, unreinforced concrete block, or brick masonry (URM) inter-tenancy walls/firewalls separating the units.

Firewalls (inter-tenancy walls) are typically integrated into the MUB construction, but differ from the adjacent construction in that they are:

- rated in terms of their fire resistance and acoustic performance
- typically constructed in heavy materials
- often incorporate special building features, eg, chimneys
- often laterally supported on each side by the adjoining structure, eg, typically plasterboard-lined and braced timber-framed construction.

> For the purposes of this guidance, firewalls are divided into two broad categories:
>
> - **Type F1:** Constructed integrally with a Type C foundation
> - **Type F2:** Constructed with independent strip or perimeter beam-type foundation, with a Type A or B foundation on either side, or not mechanically tied into a Type C foundation

Firewalls should be assessed against the firewall criteria outlined in Table 18.3. Firewall damage differs in type and extent from the adjacent foundations. Careful assessment of the firewall's status, particularly in relation to the surrounding structure, is required before deciding on the repair/replacement approach.

The indicator criteria in Table 18.3 provide guidance and should not be treated as absolutes, as emphasised by the dotted vertical lines between the columns.

Heavy firewalls can cause or exacerbate localised settlements and deformations in MUB foundations. Firewalls can be subjected to damage within the roof cavity. It will be necessary to assess the damage to each individual firewall within a MUB, and undertake repairs or replacement, as required.

For explanations of terms used in Table 18.3, refer to appendix E2.

Table 18.3: MUB firewall damage indicator criteria

Do nothing	Repair/partial rebuild of firewall indicated	Replacement of firewall indicated
In-plane tilt <0.25% [Note a, b, and c] **and** Out-of-plane tilt is lesser of <1 in 240 (eg, 10mm over 2.4m) or 20mm over the total firewall height [Note a and b] **and** No visible cracking of firewall [Note d] **and** The fire resisting capability of the firewall, particularly around its edges, is not compromised	In-plane tilt >0.25% [Note a, b, and c] **or** Out-of-plane tilt is >1 in 240 (eg, 10mm over 2.4m) or >20mm over the total firewall height **or** Isolated cracking constrained to mortar courses >0.5mm and ≤2mm [Note d] **or** Partial collapse of the firewall above ceiling [Note e]	Widespread cracking to the firewall >2mm [Note d] **or** Firewall repair/relevel not considered to be practical/ economically viable

Explanatory notes to Table 18.3

Note	Commentary	
a	The firewall in-plane tilt criteria relates to firewall damage that deviates from the damage to the adjacent foundations, ie, differential movement of the firewall from the adjacent foundations. Careful consideration is required to adequately assess the full extent of repairs recommended to a building's foundation, and relevelling firewalls may often be recommended when relevelling adjacent foundations as the firewall may have settled uniformly with the foundations.	
b	The firewall type needs to be determined for assessment and repair/rebuild. Firewalls are divided into two broad categories. Treatment is therefore likely to be different.	
	Type F1	Replacement of an F1 firewall founded on a Type C foundation is likely to require partial replacement of the concrete slab foundation immediately adjacent to the firewall. The new firewall foundation should be tied back into the existing concrete slab. In some cases where the replacement of the firewall with a timber-framed, fire-rated, inter-tenancy wall is undertaken, it may not be necessary to replace the slab. Relevelling of both the firewall and the existing adjacent foundations may be an option. Relevelling up to 150mm of a firewall with a Type C foundation is considered achievable/economical and therefore practical. The repairs need to ensure that the lateral support of the firewall remains and the fire purposes of the wall remain intact.
	Type F2	Differential settlement of a firewall with respect to the adjacent floor is a common damage feature for Type F2 firewalls. Often, it may be possible for Type A and B timber subfloors to be repaired by detaching and refixing the framing higher into the firewall. The firewall may be left in its settled state and repairs undertaken to the top of the firewall to ensure it retains its fire resistance. These repairs need to ensure that the lateral support of the firewall remains and the fire purposes of the wall remain intact. Isolated relevelling of the adjacent floors may be practical.
c	It is assumed that at up to 0.25% in-plane tilt there will be: › total vertical settlement of the firewall of <25mm › gradient issues with the floors either side of the firewall. This criterion is 0.25% of in-plane tilt of the firewall that is additional to the tilt of the adjacent foundations (refer to note a).	
d	An assessment of the structural integrity of the firewall should include the following: › assessing the location and size of cracks (where visible). Widespread cracking of the firewall may indicate the wall has been structurally compromised beyond repair and/or that it has compromised fire resistance. **Note:** Cracks will require a repair that is fire resistant › determining whether steel reinforcement is present › estimating the likely structural performance of the firewall during a future seismic event, ie, SLS and ULS limits › estimating the likely structural performance of the firewall after a fire burnout to ensure it will remain stable. **Note:** If an end wall is on a boundary or within 1m of a boundary the end walls need to be fire rated and be self-supporting in a fire burnout situation.	
e	Partial collapse of firewalls can occur. Often partial collapses occur in the roof cavity where there is less confinement of the firewall. It is considered practical to partially replace a firewall with a timber-framed, fire-rated wall in the roof cavity. For repair details, refer to section 21.5.	

18.5 Damage mechanism

During the assessment of a MUB, the characterisation of damage to the building as a whole is described as the 'damage mechanism' within the building. Identifying the principal damage mechanism within a building is necessary to develop a suitable repair strategy. It is essential that damage mechanisms are understood before a repair or rebuild is contemplated.

Typical damage mechanisms and repair solutions are identified in Table 18.4. Damage mechanisms referred to in this recommendation focus on foundation/firewall movement along the building length rather than across the building width to identify the interaction between each individual unit.

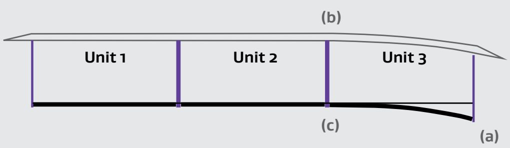
Some damage mechanisms can be more difficult to identify/determine on an individual unit basis, but can generally be more easily identified when assessing the whole building as damage levels will often vary from unit to unit. For example in Table 18.4 damage mechanism 3 illustrates that while superstructure damage to a single unit within a MUB has occurred, another portion of the building has also settled excessively resulting in a whole building repair strategy.

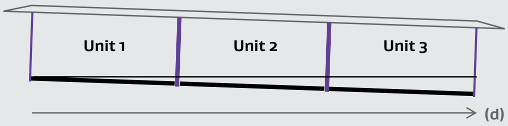
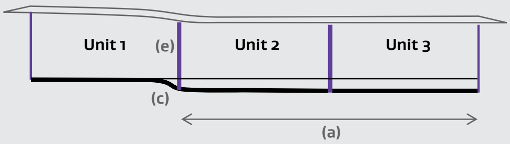
Damage types generally include:

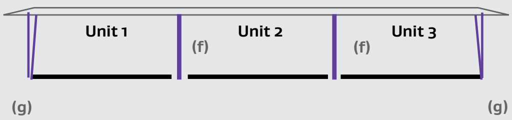
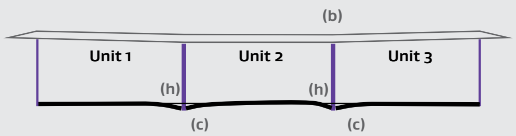
- hogging
- sagging
- differential settlement or uniform settlement of a portion of the building.

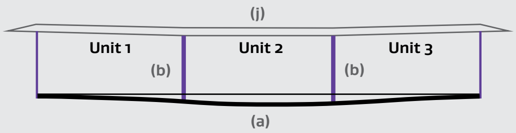
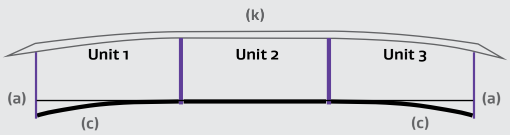
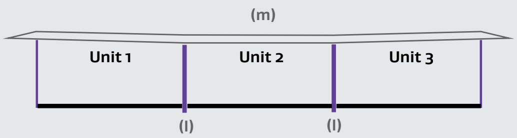
> **Note:** The distortion effects within the superstructure in these cases may be significant, and may require the introduction of relief points, eg, repairable zones, before repairs can be made. Also, the verticality and racking of walls other than firewalls need to be assessed when considering a repair or rebuild approach.

Table 18.4: Typical MUB foundation damage mechanisms

Damage Mechanism	Analysis	Potential Solution
1. End unit settlement  **Typical indicators:** (a) Evidence of foundation settlement relative to land or nett settlement (uniform settlement of a portion of the building) of the land that is more difficult to observe (b) Distress in walls and ceiling (c) Cracking in ring beam (Type B) or concrete slab (Type C)	Unit 3 has localised foundation damage, negligible foundation damage to units 1 and 2.	Relevel foundation of unit 3 and repair cracking or rebuild end unit.

Damage Mechanism	Analysis	Potential Solution
2. Gradual settlement of whole building (planar tilt)  **Typical indicators:** (d) Relatively linear increase in recorded foundation settlement along the building. Evidence of foundation settlement relative to land or nett settlement (uniform settlement of a portion of the building) of the land that is more difficult to observe	Units 2 and 3 have a degree of gradual settlement relative to the original level. If the slope is greater than 0.5% over the entire building foundation then the foundations of unit 2 and/or 3 may need to be replaced. **Note:** Unit 3 may have inadequate ground clearance. [Note 1]	Relevel foundations of all units.
3. Uniform settlement of a portion of the building  **Typical indicators:** (a) Evidence of foundation settlement relative to land or settlement (uniform settlement of a portion of the building) of the land that is more difficult to observe (c) Cracking in ring beam (Type B) or concrete slab (Type C) (e) Distress in superstructure	Units 2 and 3 may not appear to exceed slope or differential settlement criteria; however they have a degree of uniform settlement relative to the original level.	Relevel foundations of all units. Repair cracking in ring beam (Type B) or slab (Type C). If units 2 and 3 have settled too low for relevelling to be practical (Type A, B, or C) then the majority of units require replacement. This means the building should be replaced. However, it may be possible to separate units 2 and 3 from unit 1 and relevel them. [Note 1]

Damage Mechanism	Analysis	Potential Solution
4. Stretch  **Typical indicators:** (f) Separation along construction joint between concrete slab (Type C) and firewall (g) All firewalls out of vertical as stretch not accommodated by superstructure	Check if stretch exceeded on individual unit basis. Check if stretch has damaged superstructure to neighbouring units. If so, consider replacing the whole building foundation. Stretching of a building's foundation can influence the verticality of the firewalls and end walls. Stretch may be repaired locally if the damage to the superstructure of the building can be repaired and the firewall out-of-plane tilt is within the acceptable tolerance.	If stretch is minor (ie, <20mm per unit) and stresses in the roof and/or walls can be locally relieved, repair unit foundations and repair superstructure on an individual basis. **or** If stretch results in significant additional stress in the roof and walls consider replacing part or whole of building.
5. Firewall settlement  **Typical indicators:** (b) Distress in walls and ceiling (c) Cracking in ring beam (Type B) or concrete slab (Type C) (h) Localised settlement in floor	Check firewall verticality.	Relevel floor adjacent to firewall or for a small area breakout and replace (Type C). Relevel firewall, replace if more practical. It may be possible to leave the firewall in place and extend height to marry back in with the roof structure. Repair superstructure.

Damage Mechanism	Analysis	Potential Solution
6. Dishing (sagging)  Typical indicators: (a) Evidence of foundation settlement relative to land or nett settlement (uniform settlement of a portion of the building) of the land that is more difficult to observe (b) Distress in walls and ceiling (j) Deformation of roofline	Unit 2 may not appear to exceed slope or differential settlement criteria; however it has a degree of uniform settlement relative to the original foundation level. [Note 1]	Relevel foundations of all units, as required, if outside the Table 18.2 criteria. If unit 2 has settled greater than 100mm or 150mm (Type A/B or C respectively) then unit 2 foundation may need to be replaced.
7. Hogging  **Typical indicators:** (a) Evidence of foundation settlement relative to land or nett settlement (uniform settlement of a portion of the building) of the land that is more difficult to observe (c) Cracking in ring beam (Type B) concrete slab (Type C) (k) Deformation of roofline	Units 1 and 3 may also have a degree of uniform settlement relative to the original level. [Note 1]	Relevel foundations of units 1 and 3.
8. Punching settlement  **Typical indicators:** (l) Foundation of firewall may form section of floor adjacent to wall and have settled creating a step down (m) Distress in walls and ceiling adjacent to the firewall	Differential settlement of the firewall where the adjacent foundations have not been 'pulled' down (eg, mechanism 5) indicates the firewalls are Type F2, ie, not integrally tied into the foundations of the building. This can often result in the need for isolated or alternative repairs to the firewalls, refer to section 18.4.	Relevel firewall, replace if more practical. It may be possible to leave the firewall in place and extend height to marry back in with the roof structure. Repair superstructure.

Explanatory note to Table 18.4

Note	Commentary
1	Overall building settlement relative to the surrounding land can result in localised issues such as ponding water adjacent to the building. If the extent of settlement relative to the surrounding land has resulted in the building's floor clearance above the ground level being significantly compromised, refer to section 2.6 for further information. Site work may be needed even if the settlement of the building has been relatively uniform, ie, negligible slopes of the foundations. Additionally, nett settlement of the land or settlement of the building relative to the surrounding land may result in services no longer functioning correctly. This needs to be addressed.

18.6 Geotechnical investigations

If partial or full foundation rebuilds are required on TC1 or TC2 sites, shallow geotechnical investigations should be carried out in accordance with section 3.4.1. Deep geotechnical investigations are expected to be carried out for TC3 sites.

The scope of deep geotechnical investigation must be determined by the geotechnical professional responsible for giving advice on the property in question.

There will be two general sources of deep geotechnical information:

› single or isolated MUB site investigation

› area-wide investigation, considering other information available using the Canterbury Geotechnical Database.

Geotechnical investigations for MUBs in TC3 should generally be undertaken in accordance with section 13 (refer to Figure 13.1), with adaptations and engineering judgement as appropriate for MUB situations. The long, linear nature of MUBs is such that ground conditions may vary more significantly under a MUB than under the normally more compact area of a detached house.

If heavy cladding and/or roof are to be retained, the following are additional considerations:

1. If a partial rebuild of a heavy MUB is undertaken, it is recommended that deep investigations are completed on the site to determine the replacement foundations in accordance with the requirements for a foundation rebuild. Information from area-wide investigations or from neighbouring properties is not generally expected to be sufficient, and investigations on the property are recommended.
2. If designers are considering retaining heavy cladding and/or roofing, assessment of the building's performance in relation to the land during the Canterbury earthquake sequence is critical. If the existing heavy building did not settle in relation to the land, this will generally indicate that similar performance could be expected in the future from similar earthquakes.
3. When assessing liquefaction settlements for MUBs with heavy cladding and/or roof, due consideration should be given to the depth in the soil column where the majority of the settlement is occurring. When a suitable overlying thickness of soil is present, the retention of the heavier cladding and/or roofing is generally more acceptable. In contrast, sites where the non-liquefying curst is thin, retaining heavy cladding and/or roofing is not recommended without suitable foundation modifications.

19. Foundation repairs and relevel

19.1 Overview

Foundation repairs and relevels of individual MUB units should generally be undertaken in accordance with section 4 (TC1 and TC2) and section 14 (TC3).

19.2 Repair or replace

In accordance with Table 18.2, elements within individual units such as perimeter foundation beams or groups of isolated piles supporting suspended floors may be repaired or replaced with a comparable foundation to the extent that is reasonably practicable, such as:

- <50% of a perimeter foundation beam
- <50% of isolated subfloor piles
- <50% of concrete slab.

Where the limits above are exceeded in an individual unit, all of that unit's foundation should be replaced with a stiffer and/or stronger foundation.

Additional inspection and assessment is recommended where the replacement of an internal concrete garage slab occurs within a Type B unit. If the concrete slab is not an integral component of the building's foundations, ie, is separated from the structure on either side, it is advisable to consider it as an isolated component and replace, if necessary, with a suitably proportioned (possibly stiffened) concrete slab connected to the adjacent foundation.

For indicative illustrations of these foundation repair limits, refer to Figures 19.1 and Figure 19.2.

Figure 19.1: Type B foundation repair limit example

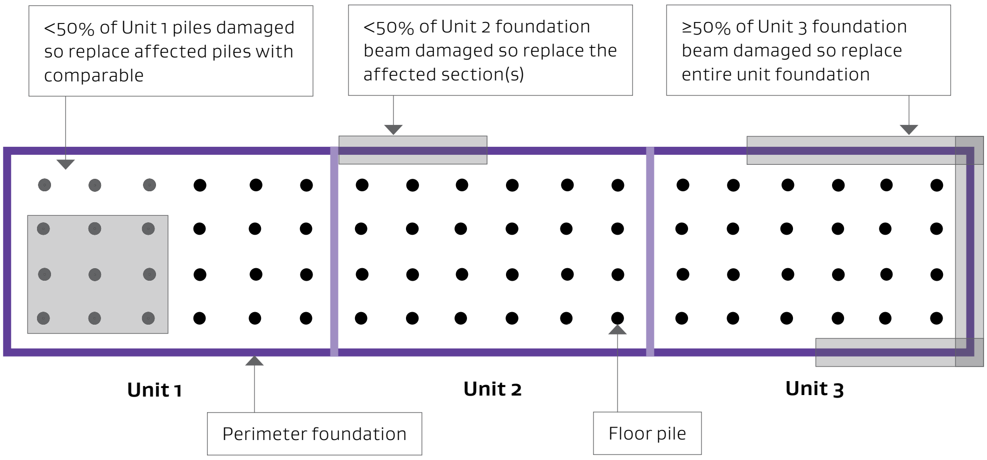
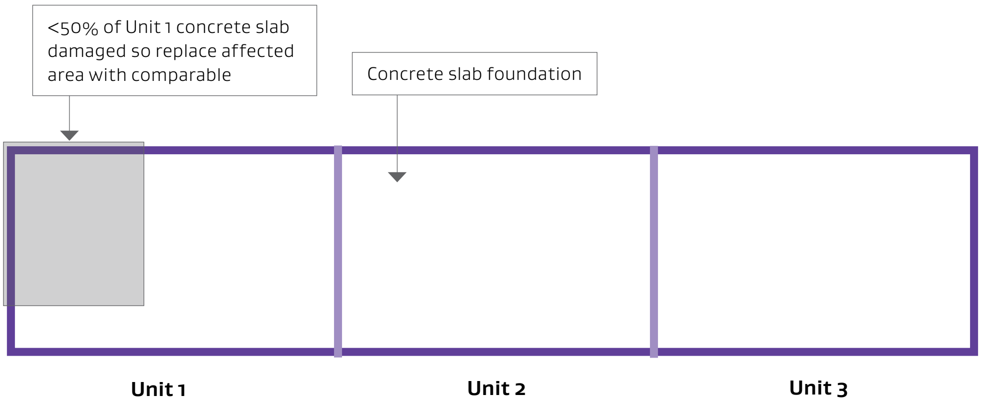


Figure 19.2: Type C foundation repair limits example



19.2.1 Replacement of heavy cladding in TC3

For detached houses, in certain circumstances, the replacement of heavy claddings and/or roofing materials with lightweight ones is recommended when carrying out repairs. For MUBs, if there is evidence that the building, in part or whole, has settled excessively relative to the land due the weight of a heavy roof and/or wall cladding, these elements should be removed and replaced with lighter-weight materials. This may require some architectural input to preserve the aesthetics of the building as a whole. However, where units did not settle in relation to surrounding land due to the earthquakes, it is more appropriate to retain heavy elements.

19.3 Relevelling

Section 4 and Appendix A1 outline methods that can be used to relevel foundations and firewalls. When relevelling a portion of the building consider the effects on the rest of the building, as well the added complications arising from the presence of masonry firewalls.

When relevelling a firewall, consider whether the firewall is a Type F1 or Type F2 (refer to section 18.4 for definitions of the firewall types). A Type F1 firewall will either have to be lifted with the adjacent floors or it will need to be disconnected from the adjacent unit foundation. Alternatively for small settlements, the firewall could be left in place and the floor levelled with a floor levelling compound. It may be possible to leave Type F2 firewalls in their settled state and lift the floors adjacent to them. A check must be made of the roof and ceiling space for damage as small changes can have an impact on acoustic or fire performance.

Depending on the firewall's length, structural integrity, strength and stiffness, lifting of a firewall foundation may require jacking points along the extent of the firewall, or could alternatively be achieved by jacking at either end of the firewall.

After foundation relevelling, Type C floor slabs may need to be reinstated:

- It is imperative to maintain or restore the under-slab vapour barrier[7].
- It is also important to create full support under the slab. There are a number of options to consider, including cement grout or urethane injection after lifting.

Alternatively the floor slab can be demolished and rebuilt (either partially or in whole), with a new damp-proof membrane.

7 The under-slab vapour barrier provides moisture protection to a Type C foundation. As it is usually immediately against the underside of the concrete it is easily damaged during and through slab activity.

20. Partial foundation rebuild and repair

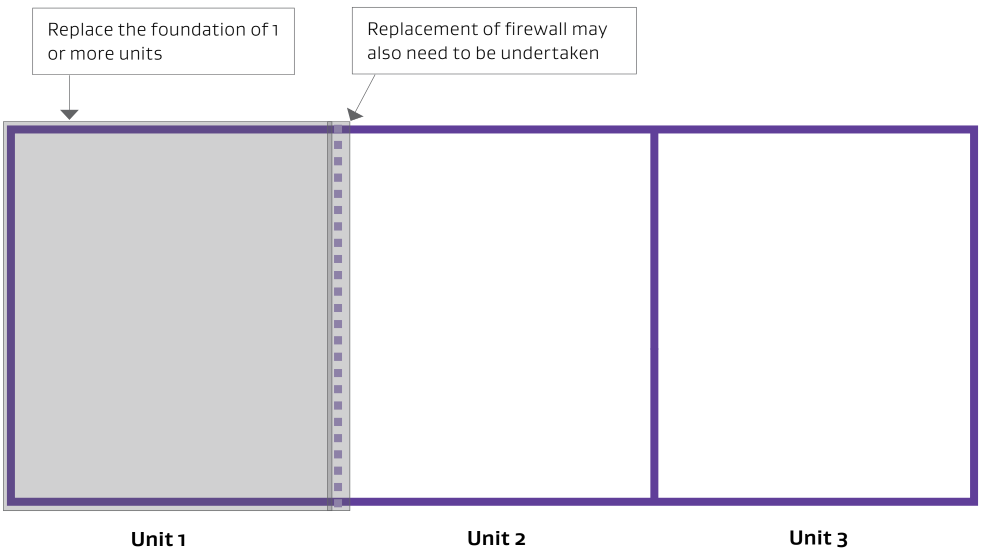
20.1 Overview

A partial foundation rebuild for a MUB is where one or more unit foundations, within the building, is fully replaced, with other units retaining their existing foundation and superstructure (with or without repairs).

A partial foundation rebuild is indicated when the damage threshold to the foundation of an individual unit in Table 18.2 is exceeded. This includes:

- ≥50% of floor piles (Type A)
- ≥50% of a perimeter foundation beam (Type B)
- ≥50% of isolated subfloor piles (Type B)
- ≥50% of a concrete slab (Type C).

Figure 20.1: Partial foundation rebuild example



Firewall foundation replacement is covered in section 21.5 and full foundation replacement is covered in section 22.

20.2 Partial rebuild considerations

20.2.1 Managing difference in structural performance

Managing the difference in structural performance between new and existing sections of the building is important because, in a future SLS event, there is potential for foundation and superstructure deformation to occur due to differences in response (including induced ground settlement) between new and existing foundation types.

In general, it will be easier to rebuild the foundation of an end unit of a block than the foundation of a central unit because it will have only one junction with the existing structure.

Design strategies for the interface between the new and existing sections typically involve either:

- concentrating and controlling potential superstructure deformation (as a result of differing performance in SLS events) at the junction between the new and existing superstructure by building in future repair capability (introducing repairable zones); or
- separating the building into individual sections where significant differential movement between the new and existing sections under SLS acdtions needs to be accommodated.

Repairable zones

The potential for differences in structural performance is generally considered low for TC1 and TC2 sites but may be an issue for TC3 sites. Accordingly standard junction details have been developed (refer to section 23) to accommodate some performance differences. The proposed superstructure junction details in section 23 are relatively simple and it is recommended that they be used in all TCs. More resilient foundation types can be adopted for partial rebuild in TC3 and any difference in performance is addressed by the superstructure standard details. Junctions between new and existing concrete foundations are designed to be mechanically fixed.

Structural separation

Deep ground improvement and/or deep piled foundations should only be used when the replacement part of the building is structurally separated from the remainder. This will allow the new structure to behave independently of the existing structure (ie, completely separate structures).

20.2.2 Gravel layers for partial foundation rebuilds

Some foundation solutions in section 5.3 and 15.4 make use of compacted and reinforced gravel layers under the foundation elements.

Gravel layers are generally not required to manage liquefied ejecta in TC1 and TC2 areas but can enhance the performance of foundations in those areas.

The SLS performance of partial rebuilds on TC3 sites can be improved with the use of compacted gravel layers. The principal purpose of these layers is to reduce the potential future differential settlements by providing a stiffer layer than the previously existing natural soils. This helps control liquefaction ejecta emitting from the ground immediately adjacent to the foundations and also provides some pore pressure relief during liquefaction events. This becomes more important with more liquefaction-prone land, or where heavy cladding and/or roof materials are chosen (in order to be consistent with adjacent units).

MUBs typically have smaller floor plate dimensions than detached houses, and therefore are less vulnerable to differential settlements. They also have other significant constraints compared to detached houses, specifically connections to adjacent units. Using gravel layer depths as specified in section 15 poses problems for MUBs with regard to the stability of excavations close to adjacent units. Additionally if thicker gravel layers are utilised under one unit it can lead to significant performance incompatibility issues with attached units.

Gravel layer thickness for MUBs can generally be reduced in comparison to detached houses, to limit incompatibility effects with adjacent units and also to aid in constructability. Using repairable zones is considered a suitable trade-off for the reduction in gravel thickness, and to keep unit performance relatively compatible. Where the gravel layer thickness is reduced below 400mm, geotextile is recommended to at least minimise liquefied ejecta passing into the gravels.

For partial rebuilds of MUBs where a TC3 Type 2 surface structure is specified the accompanying gravel layer may either be removed or modified to limit performance incompatibility issues (for limitations, refer to Table 20.1).

20.2.3 Retaining and rebuilding firewalls

For partial rebuilds, the retention of existing inter-tenancy firewalls associated with the unit being rebuilt will depend on the damage assessment carried out per section 18.3. If replacement is required, refer to section 21.5.

20.3 Partial foundation rebuild solutions

20.3.1 Overview

The foundation solutions available for MUB partial foundation rebuilds are selected from sections 4 and 5 (TC1 and TC2) and sections 14 and 15 (TC3), and include modifications specifically for MUBs.

The partial foundation rebuild solutions recommended are summarised as follows:

- **TC1:** NZS 3604 Type A, B and C (refer to section 5)
- **TC2:** NZS 3604 enhanced Type B perimeter foundation with shallow piles (refer to section 5)
- **TC2:** enhanced foundation slabs options 2, 3, and 4 (refer to section 5)
- **TC3** modified Type 2 surface structure solutions (refer to Table 20.1)
- **TC3** perimeter wall with shallow piles (refer to Figure 14.3 and Table 20.1)

Some of the foundation replacement solutions for partial rebuilds of MUBs in TC2 and TC3 areas provided in Table 20.1 are different from those for detached houses, particularly the allowance to maintain the weights of key elements, ie, cladding and roofing materials, and the reduction in thickness of the gravel layer below structures. This is primarily due to the following reasons:

- The complexities of ownership in MUBs mean that at times, unless all parties agree, cladding and roofing weights may not be reduced.
- Where an excavation is required to repair a MUB foundation adjacent to a unit, the risk of deeper excavation close to a remaining unit could cause unnecessary additional damage. Accordingly there is a need to limit excavation depths, thereby limiting gravel raft thicknesses.
- MUBs typically have smaller floor spans and are more regular than detached houses.
- Surface structure under-slabs have been stiffened to allow thinner gravel layers.

In addition, these multi-unit foundation configurations have been subjected to additional analysis during preparation of Table 20.1. Solutions have been modelled and meet the deflection criteria from section 5.4[8].

8 1 in 400 in the case of no support over 4m (ie, 5mm sag at the centre of a 4m length simply supported slab) and; 1 in 200 for the case of no support of a 2m cantilever at the extremes of the floor (ie, 10mm at the end of the cantilevered floor of a 2m length).

20.3.2 Heavy cladding and roofing considerations

It is important to take into account the extent of building settlement in relation to the land from the recent Canterbury earthquake sequence when considering specifying heavy cladding and roofing in the section of the building where the foundation is being rebuilt.

If ground conditions permit, specifying heavy cladding in MUBs can be accommodated in some cases with surface foundation structures in TC3. This approach is acceptable if it is impractical to replace heavy elements with light elements, and satisfactory performance can be achieved by providing some degree of compensation in the design of the foundation and repairable zones.

Table 20.1 indicates a range of acceptable foundation configurations for both light/medium and heavy weight claddings and light and heavy roofing.

Retaining heavier-weight cladding is considered unavoidable in many partial rebuild situations due to construction practicalities and ownership constraints. However, this is not considered appropriate for full rebuild situations in TC3 or for some of the TC2 options (refer to Table 7.2). For full rebuild guidance, refer to section 5, section 15, and section 22.

Specific engineering design is required for MUBs outside the scope of this guidance such as three (or more) storey structures and where there is potentially significant vertical land settlement in TC3 (>100mm at SLS) if specifying heavy cladding.

20.3.3 Partial rebuild options

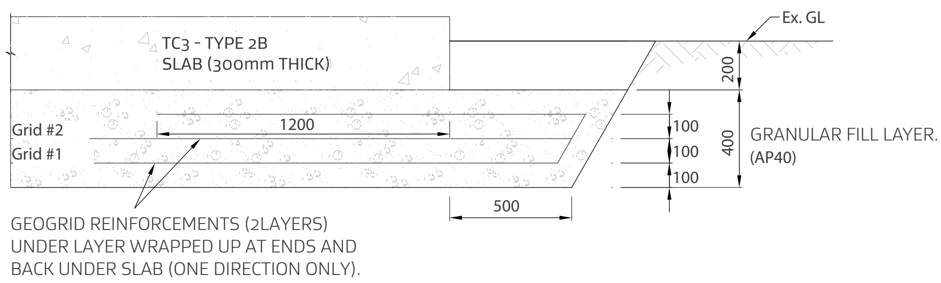
Partial foundation rebuild options within MUBs across foundation types and technical categories are shown in Table 20.1.

Engineering judgement is required when using Table 20.1. Site observations and, where appropriate, judgement may prevail over calculated settlements and land performance, ie, building settlement relative to land. The use of repairable zones and careful consideration of the junction details are required to compensate for potential variations in behaviour between the rebuilt portion and the existing portion of the building. The provisions in Table 20.1 for replacing heavy cladding with light cladding relate only to the unit/s with foundations that are being rebuilt and not to the entire MUB (refer to section 20.3.2).

The following gravel layers are designed for use for MUBs in TC3 as specified in Table 20.1 for various situations:

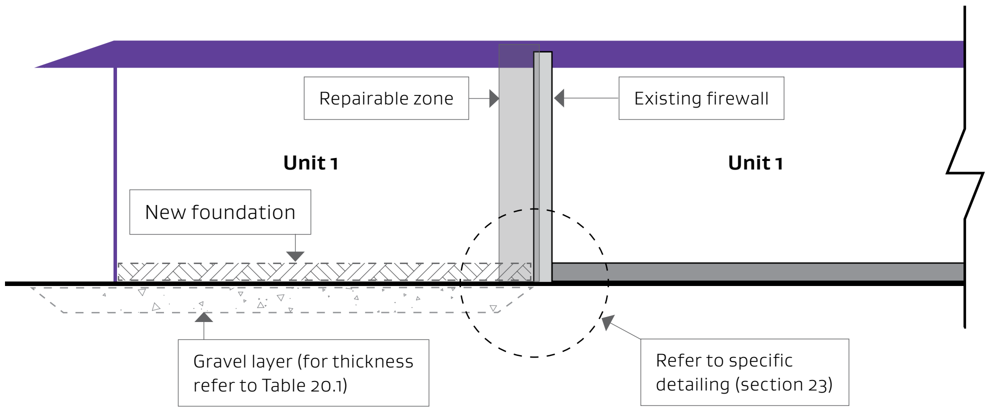
› 200mm thick with a single layer of geotextile located at the base of the gravel layer
› 300mm thick with a single layer of geotextile located at the base of the gravel layer
› 400mm with two layers of tri-axial geogrid and cement stabilisation with 5% cement by weight (refer to Figure 20.2 for exposed edge detail).

Figure 20.2: Detail of a 400mm thick gravel layer with geogrid

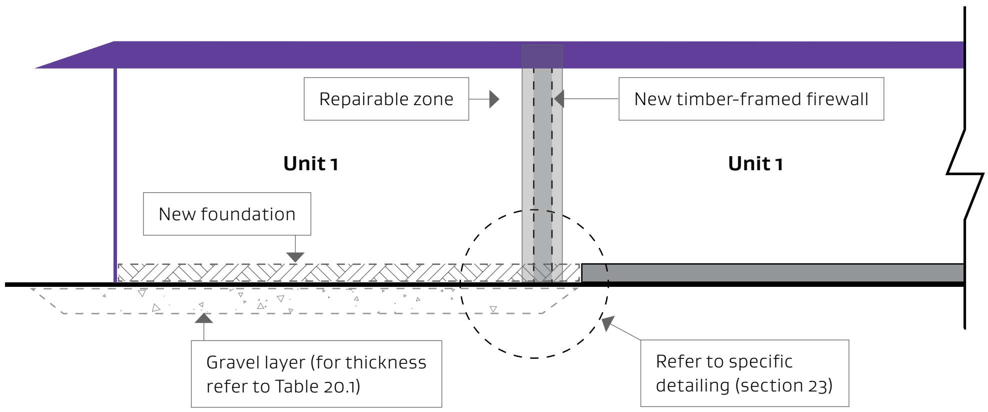


The schematics in Figure 20.3 show a simplified illustration of a shallow gravel raft. Careful detailing will be required on a site-by-site basis. When the firewall requires replacement, proper consideration of the replacement firewall is required to ensure the loading of the firewall is not placed solely on the edge of a gravel layer and is either cantilevered from the foundation, or the gravel layer is extended so the maximum thickness of the raft is beneath the firewall.

Figure 20.3: Schematic illustrations of a gravel layer in a partial foundation rebuild



Note: Firewall not requiring replacement, gravel layer to extend to the firewall.



Note: Firewall requires replacement, gravel layer to extend beneath the firewall.

Table 20.1: Partial foundation rebuild options within MUBs for Type A, B, and C foundation types in TC1, TC2, and TC3

Row	Technical category	Building cladding weight	Vertical settlement (SLS)	Lateral Stretch (ULS) of ground across building footprint	Type A and B Timber floor foundation (1–2 storeys)	Type C Concrete slab foundation (1–2 storeys)
1	**TC1**	Light-medium **and** Heavy	0–15mm	Nil	NZS 3604 Type A or Type B foundation	NZS 3604 Type C foundation
2	**TC2**	Light-medium	0–50mm	Minor <100mm	NZS 3604 Type A foundation or enhanced Type B foundation	TC2 concrete raft foundation options 1-4
3		Heavy			Enhanced Type B foundation [Note 1]	TC2 concrete raft foundation options 2 and 4
4	**TC3**	Light-medium	<100mm	Minor to moderate <200mm **and** Moderate to major 200-500mm	TC3 Type 2A-300 surface structure from section 15 (with no raft beneath) [Note 2 and 4] **or** Where <200mm lateral stretch and <30% of overall perimeter for Type B, consider using an enhanced perimeter foundation (refer to Fig. 14.3) [Note 3]	TC2 concrete raft foundation option 2 or option 4 [Note 1, 4, and 7]
5		Light-medium	>100mm	Minor to moderate <200mm **and** Moderate to major 200-500mm	TC3 Type 2A-300 surface structure from section 15 with a 200mm gravel raft with geotextile [Note 2 and 4]	TC2 concrete raft foundation option 2 or option 4 with a 200mm gravel raft with geotextile [Note 1, 4, and 7]

Row	Technical category	Building cladding weight	Vertical settlement (SLS)	Lateral Stretch (ULS) of ground across building footprint	Type A and B Timber floor foundation (1-2 storeys)	Type C Concrete slab foundation (1-2 storeys)
6	**TC3**	Heavy	<100mm	Minor to moderate <200mm **and** Moderate to major 200-500mm	**Either:** Specify light roof and heavy cladding and use TC3 Type 2A-300 surface structure from section 15 with a 300mm gravel layer with geotextile [Note 4, 5, and 6] **or** Specify light roof and light or medium weight cladding and refer to row 5	**Either:** Specify light roof and heavy cladding and use TC2 concrete raft foundation option 2 or option 4 with a 400mm gravel raft with two layers of geogrid [Note 4, 5, and 7] **or** Specify light roof and light or medium weight cladding and refer to row 5
7			>100mm	Minor to moderate <200mm **and** Moderate to major 200-500mm	Specific engineering design, eg, relevellable concrete slab with ground improvement [Note 5 and 8]	Specific engineering design, eg, relevellable concrete slab with ground improvement [Note 5 and 8]

Explanatory notes to Table 20.1

Note	Commentary
1	Rebuilding using heavy cladding and roofing is considered acceptable for partial rebuilds on this land due to the practicality and other contraints imposed on MUBs. This is not appropriate for full rebuild situations. For full rebuild guidance, refer to section 5, section 15, and section 22.
2	Existing Type A foundation systems can use Type 1 surface structures for partial rebuild provided the lateral stretch (ULS) of ground across the building footprint is less than 200mm.
3	An exterior perimeter foundation wall as detailed in Figure 14.3 with shallow piles may be used for partial rebuild of a Type B foundation in TC3 where the replacement perimeter wall makes up <30% of the total exterior perimeter of the whole building. This is restricted to situations where: › the roof is lightweight and the cladding is light or medium weight, and › <200mm lateral stretch is expected, and › <100mm SLS vertical settlement expected, and › the land and the inter-tenancy wall(s) associated with the unit have not performed poorly (refer to damage mechanisms 3, 5 and 8 of Table 18.4).
4	TC3 Type 2 surface structures are capable of withstanding lateral stretch up to 500mm (ULS). The selected TC2 concrete slab foundation solutions are also considered capable of withstanding lateral stretch up to 500mm (ULS). Accordingly there is no distinction of solutions based on ULS lateral stretch.
5	Heavy cladding and/or roofing material are not recommended for TC3 land on these foundation systems. To enable the use of a shallow foundation system on a site with poor ground conditions, specification of light or medium weight roofing and/or cladding is required. The foundation solutions in this guidance are on the basis that light roofing will be used on rebuilds in TC3. A heavy clad building on land of this nature will most likely require ground improvement or deep piles. These solutions are only suitable for whole of building treatments and are not advisable for partial rebuilds.
6	It is recognised that retaining heavy cladding on this TC3 surface structure will compromise relevellability. In the event of future seismic settlement the wooden floor may still be able to be relevelled independently but the heavy cladding may need to be rebuilt.
7	Concrete slab foundations used in TC3 should have sufficient strength to be relevelled from the perimeter after future SLS earthquakes. Refer to Tables 20.2 and 20.3 for configurations of TC2 option 2 and 4 concrete slabs. **Note:** Relevant only for end units of a MUB.
8	Designers must consider the likely interaction between existing and new foundations. Deep-piled, partial replacements are not recommended.

20.4 Future relevellability

The partial rebuild solutions are based on structural connection at slab level between new and old. Any need for future relevelling of rebuilt units will need to be done as part of an overall MUB relevelling operation unless the rebuilt unit is at the end of the MUB. Slab reinforcing details in Tables 20.2 and 20.3 will assist that procedure and are also applicable where the partial rebuild involves the creation of a full structural separation.

Table 20.2: Constraints and reinforcement for TC2 option 2 (300mm slab) foundation configuration when used in TC3

Foundation type	Relevel access conditions	Maximum dimensions	Bottom reinforcing required	
			Short span	Long span
TC2 option 2 (300mm) used in TC3 Refer to Table 15.2	All four edges	10m x 10m	HD12-150	HD12-150
	Three edges	10m x 10m	HD16-175	HD16-250
	Three edges (8m side inaccessible)	8m x 10m	HD16-200	HD12-250
	Long edges only (ie, 8m span)	8m x 10m	HD16-200	HD12-250

Table 20.3: Constraints and reinforcement for TC2 option 4 (385mm waffle slab) foundation configuration when used in TC3

Foundation type	Relevel access conditions	Maximum dimensions	Rib reinforcement required		Perimeter beam reinforcement required	
			Bottom bar	Stirrups	Bottom bars	Stirrups
TC2 option 4 (385mm) used in TC3 Refer to Table 15.2	All four edges	10m x 10m	HD12	R10-125	As per Figure 5.11	As per Figure 5.11
	Three edges	10m x 10m	2HD12 or 1HD20	R10-125	4 HD16	R10-125
	Three edges (8m side unsupported)	8m x 10m	HD16	R10-125	3 HD16	R10-125
	Long edges only (ie, 8m span)	8m x 10m	HD16	R10-125	4 HD16	R10-125

20.5 Conceptual partial rebuild solutions in TC3

20.5.1 Type B partial foundation replacement option

Figures 20.4 and 20.5 provide conceptual partial rebuild solutions for Type B foundations in TC3 that are based on surface structure options from section 15.4.

The details at the interface between the old and new foundations are complex and require careful consideration. The perimeter foundation should be tied into the existing foundation to achieve a more integrated performance.

Ventilation requirements

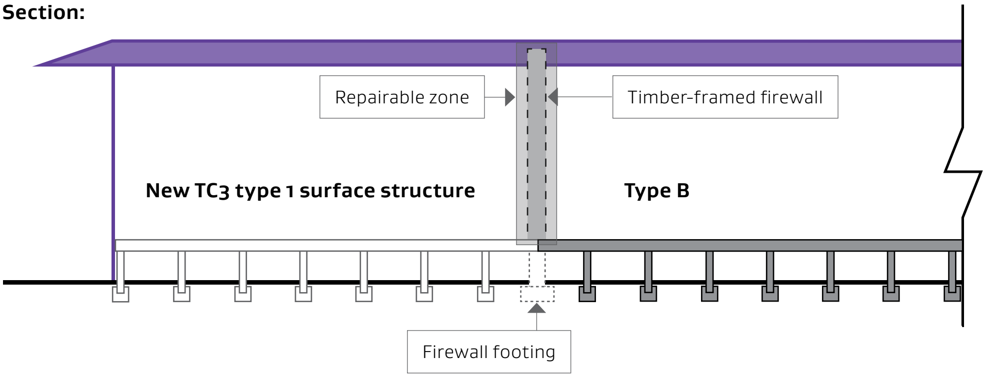
Observation of existing Type 2 MUB underfloor conditions has identified that the requirements for optimum ventilation are not always evident in the as-built stock. This can be rectified during the partial rebuild or full replacement activities.

Each unit must have self-sufficient, sub-floor ventilation. The firewalls are typically not penetrated leaving middle units with limited ventilation unless the exterior walls have substantial ventilation voids. Accordingly it is recommended to treat the NZS 3604 ventilation requirement of 3500mm^2 per m^2 as a minimum or use the alternatives set out in section 6.14 of NZS 3604. It is also important to place the ventilation to take into account likely points of interference, considering the highly likely impact of future cover-up and blocking by gardens, patios, driveways, decks, and porches.

If the above criteria cannot be achieved then a damp-proof ground cover will be required as per NZS 3604 Clause 6.14.3.

Figure 20.4: TC3 Type 1 surface structure constructed against an existing Type B foundation

Section:



Side Elevation:

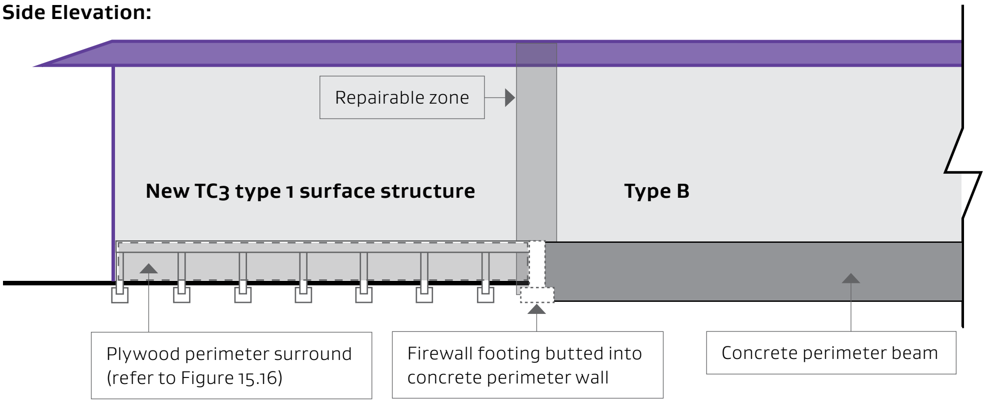


Figure 20.5: TC3 Type 2 constructed against an existing Type B foundation

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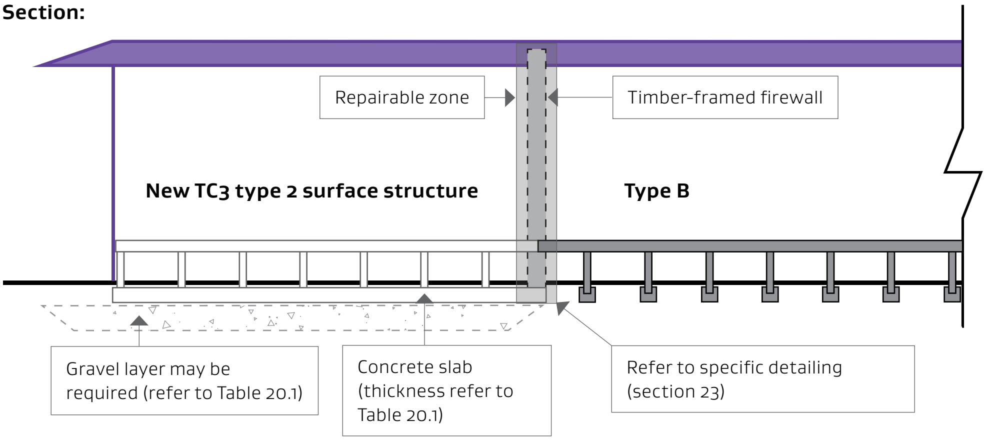
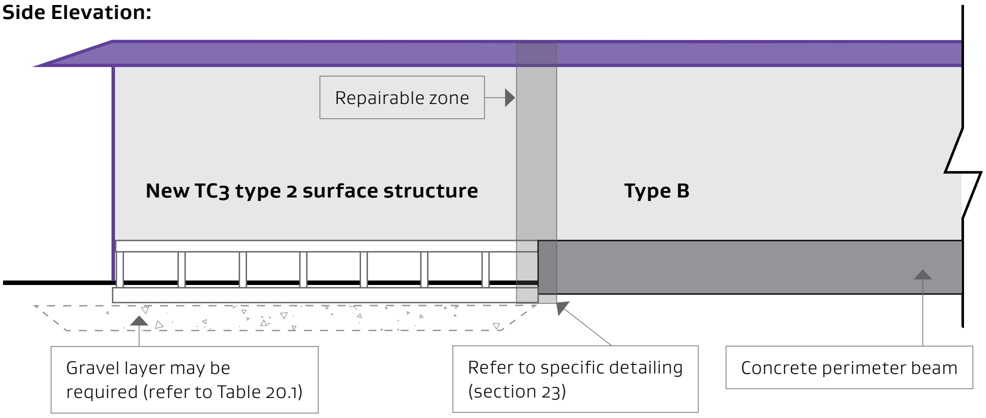


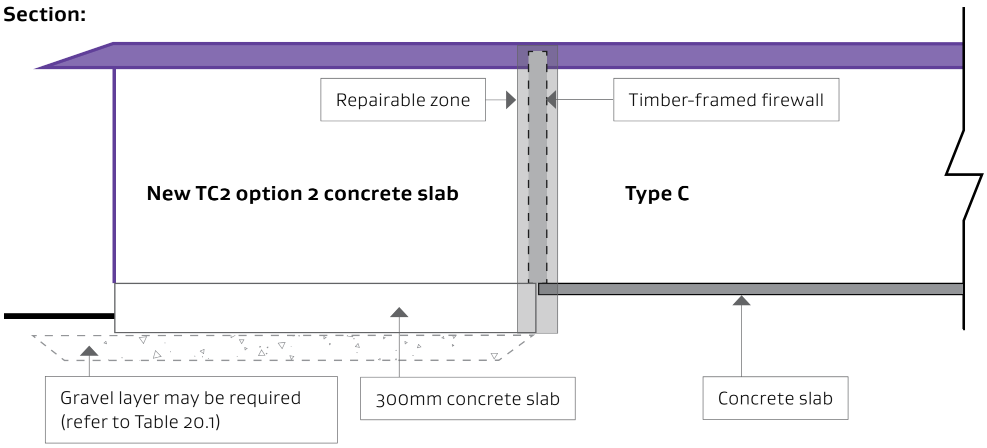
Side Elevation:

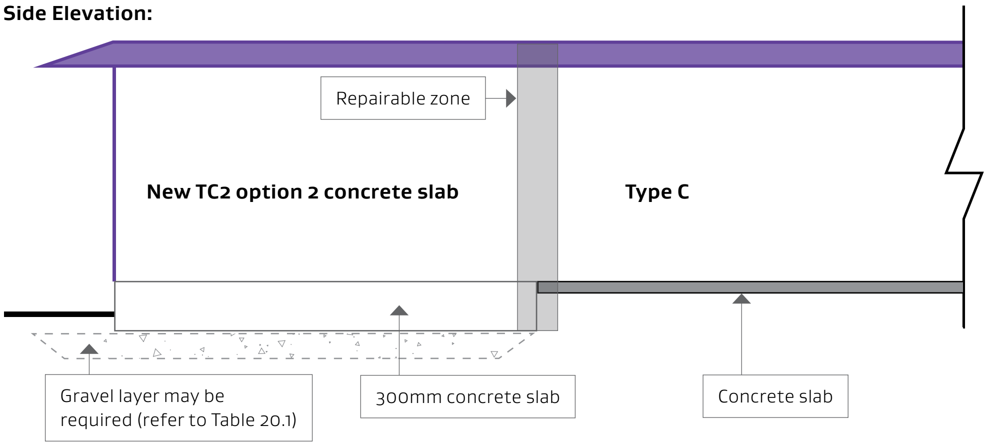


20.5.2 Type C partial foundation replacement option

The edge of the existing slab in common with the new work will need to be repaired if it is undermined as a result of excavation for the new slab and under-course.

Figure 20.6: TC2 option 2 constructed in TC3





20.5.3 Alignment of cladding to slab edge

When a Type 2A or 2B surface structure is specified in a detached house or multi-unit, an alternative edge solution that aligns the edge of the slab in the same vertical plane as the cladding line is possible. This is an alternative to Figures 15.19 to 15.21 in section 15 where it is indicated that the slab should extend 500mm beyond the exterior row of piles and the cladding line set inside this.

Where there is a 500mm slab extension it is not practical to cantilever the floor joists to align with the cladding line. This slab design was developed on the principle that the timber piles cantilevered from the slab, thus providing the lateral support for the superstructure under wind and earthquake loading. All piles are therefore expected to introduce a bending action to the slab under lateral loading.

The alternative solves the structural requirement by introducing reinforcing steel hairpins (refer figure 23.34) to allow the pile to be placed closer to the slab edge. Adjusting the floor joist, bearer sizes and adding a row of piles to reduce spans means that the overhang of the joist on the bearer (the cantilever) at 150mm aligns with the slab edge line.

This is suitable for both single and two storey MUBs (and houses) with light roofs and either light or medium weight wall cladding.

Water should not be allowed to pond beneath the floor of the completed building foundation. Therefore, the top surface of the slab should be set at a level that is higher than the surrounding land (expected to be more than 50mm).

An alternative detail for Type 2A and 2B slabs has been developed as shown in Figure 20.7. This detail should be read in conjunction with Figures 15.19 to 15.21.

Figure 20.7: Alternate detail for Type 2A and 2B slabs

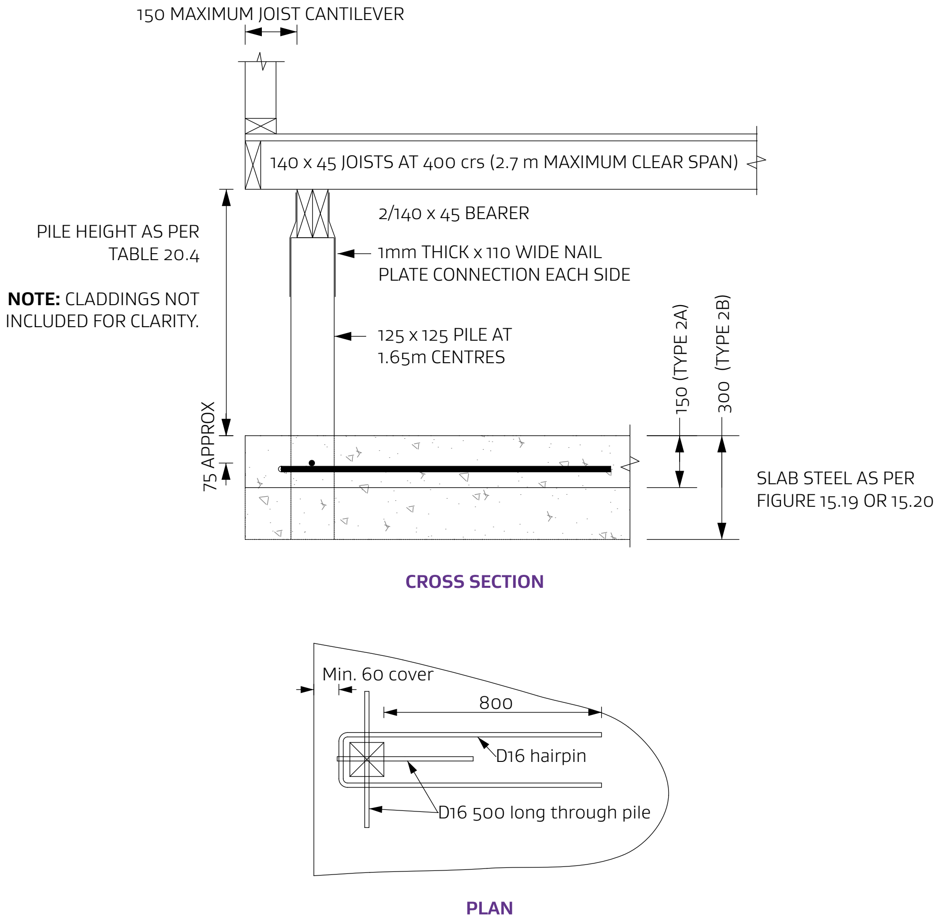


Table 20.4: Maximum distance between top of slab and underside of joist (m)

	Type 2A (150mm slab)	Type 2B (300mm slab)
Single storey light weight wall/light roof	1.00	1.15
Single storey medium weight wall/light roof	1.00	1.00
Two storey light weight wall/light roof	0.75	0.75
Two storey medium weight wall/light roof	0.60	0.60

20.5.4 Re-evaluation of the need for a Type 2 plywood skirt

It has been determined that a plywood skirt (as shown in Fig 15.21) is not necessary for stiffening the Type 2A-300 and 2B foundations in either detached houses or multi units. The need for a plywood skirt on Type 2A-150 foundations will be reviewed based on further field observations.

The plywood skirt was specified in figure 15.21 for Type 2A and 2B foundation designs because of a concern that there may be some 'shrinkage slop' of the piles in the slab. Observations of some as-built Type 2A-300 foundations have shown that the piles are well anchored in the slab and therefore there is no need for the plywood skirt

Provision must still be made for ventilation of the subfloor space in accordance with NZS 3604 requirements.

> **Note:** The plywood skirt is still applicable where a Type 1 foundation is used.

20.5.5 Special case for multi units with low floors on Type A and B foundations

In Canterbury there are a substantial number of MUBs with Type A or B foundations with floor levels that are not high enough to provide a crawl space underneath (450mm below floor joists). Many units have finished floor levels set at two or three steps with a door sill above ground (nominal 400-450mm). This means that a new timber floor with the required subfloor clearance cannot be used to provide a finished floor level common with adjacent units.

For rebuilt unit foundations and floors, there are two options to produce a practical solution for units with a lack of crawl space when reinstating floor levels aligned with the remaining units:

1. Set the Type 2B lower slab into the ground, setting the base slab lower than the adjacent land. **Note:** This option is not recommended in areas prone to flooding.
2. Change timber floor to a concrete slab founded nominally at ground level with a top surface managed to align with existing floor level. The slab approach will deliver a concrete floor that has the advantage of eliminating the need for ventilation.

For both options, there will be no difference to the superstructure details in section 21.

A waffle-slab will provide a practical partial rebuild solution and will minimise the additional weight imposed on the ground. A waffle slab solution, if chosen, would need to be specifically designed. Details of the floor level matching slab are included in section 23.

21. Superstructure repair

21.1 Overview

Superstructure repair can generally be undertaken in accordance with section 7.
The following topics cover superstructure considerations that are specific to MUBs.

21.2 Partial superstructure replacement

21.2.1 Interconnection principles

For a single-level MUB, consideration needs to be given to the structural implications of connecting a new and robust superstructure into an existing superstructure that is less resilient, and is unlikely to fully meet the current materials or loading standards.

The principal aspects to be considered are:

1. the appropriate detailing of the junctions to accommodate the relative movement that could occur under future SLS events
2. the lateral strength and stiffness of the new and existing sections.

21.2.2 Junction detailing for movement

The potential for relative movement between the rebuilt units and existing units (ie, those only requiring repairs) is considered to be limited for MUBs of regular structural configuration and with units of less than 100m^2. Even if there was a degree of movement that gave rise to minor damage from a regulatory perspective the negative impacts of this would be outweighed by the structural benefit to the building as a whole from the improved resilience of the new unit(s). Refer to section 17.4.1.

This means that in most cases it will be sufficient to provide bracing to the rebuilt unit(s) that corresponds to the requirements for that unit, and not to provide any additional bracing to the existing (remaining) units.

In terms of the junction between new and existing sections, section 23 provides junction details that feature a measure of repairability in the unlikely event of future relative movement under serviceability conditions. This follows the readily repairable principles outlined in section 8.2.3.

There will be occasional situations where a seismic separation is warranted. These situations will typically arise where, for example, a completely different foundation system is adopted for the rebuilt unit(s), or where the floor and roof levels of the rebuilt units are different from the remaining unit(s), or where regularity limits for TC3 surface structures are exceeded.

Each of these cases will need to be treated on its own merits.

Seismic separations will need specific design and detailing to ensure that the following performance aspects are addressed:

› seismic clearances and/or transfer of impact forces due to seismic deformation
› loss of function, eg, weathertightness, fire resistance or acoustic rating.

The introduction of seismic separations may result in the need for new lines of support, eg, additional load-bearing walls.

21.2.3 Lateral strength and stiffness

Older timber-framed buildings are likely to have been braced differently than current timber-framed structures. Before the introduction of NZS 3604, reliance was placed on diagonal timber braces to provide lateral restraint. In most cases the bracing in the remaining (less damaged) units will still be effective. However, they may not be as stiff as they were before the Canterbury earthquake sequence, because of loosening of nail fixings as a result of the earthquakes. If inspection of the remaining units indicates that these units have demonstrated more lively behaviour in service level loads (wind or earthquake), it may be necessary to refix some of the sheet wall lining elements in those units. For refixing criteria, refer to Table 7.1.

The bracing in any rebuilt unit will need to be designed to current standards, and should take into account only the mass contribution from the new unit and adjacent party walls. The attachment to the remaining units may mean that in SLS events the new bracing will be called on first to resist seismic actions until it becomes more flexible and the load is distributed to the diagonal bracing elements in the existing units. Such action is likely to give rise to only minor damage that can be readily repaired if suitable junction detailing is used. Refer to section 23.

21.3 Reinforced and unreinforced masonry MUBs

The principles for timber-framed structures cannot be applied to masonry structures. This section is MUB specific and should be read in conjunction with sections 7.7 and 7.8.

Existing MUBs can have:

› masonry block superstructures; these can be reinforced, unreinforced, or partially reinforced
› unreinforced brick firewalls
› masonry block firewalls that are also reinforced/unreinforced or partially reinforced.

This section focuses on masonry block superstructures.

Sections 7.7 and 7.8 provide direction on assessing the structural integrity of masonry walls and superstructure.

Any repairs to earthquake-damaged, unreinforced-concrete-block masonry needs to focus on adding structural basketing reinforcement and providing alternative load paths for any potential loss of gravity support. Refer to section 7.8.

Potential repair solutions for an unreinforced concrete block masonry structure could involve a partial replacement with a:

- timber-framed structure with concrete block veneer
- lightweight wall (no veneer)
- concrete block wall built to current standards (NZS 4229, NZS 4230).

Establishing an appropriate connection between the rebuilt portion and the existing structure requires careful consideration, whether it is a reinforced concrete block construction (built to meet NZS 4229), or a timber-framed structure with concrete block veneer cladding (built to meet NZS 3604).

If it is deemed practical to carry out a partial replacement of the masonry wall, balancing the stiffness of the new element with the existing should be undertaken.

When tying the rebuilt structure into the existing, it is recommended that the foundation reinforcement be continued to a location in the building foundation where, in a future seismic event, the interface is not in an area with points of high structural demand, ie, at the inter-tenancy wall line.

The expectation is that any replacement firewalls will be timber framed. Where a block wall is being reinstated, it is expected to be tied in to the exterior walls and may not warrant the introduction of a repairable zone.

21.4 Junction detailing

The objective of detailing the junctions between new and existing units is to accommodate any minor movement and provide for easy repair following future SLS events. The detailing of junctions between new and existing units requires a consistent approach throughout the superstructure. Elements to consider are:

- roof fabric (eg, specifically designed joints and flashings to ensure continued weathertightness) capable of accommodating the movement that may occur across the joints at future times without undue deformation
- roof structure (eg, tile battens discontinuous)
- ceiling structure (eg, ceiling joists discontinuous)
- wall fabric (eg, specifically designed joints and flashings to ensure weathertightness even when movement may occur across the joints at future times)
- wall structure (eg, top plates discontinuous).

Consideration of the external cladding across a repairable zone should be given. Access to such components should be considered during the design of these zones. It may be undesirable to truncate weatherboards or brick cladding at the junction due to the repercussions on the aesthetic appeal of the building. However, suitable architectural detailing may lessen the impact of a break. These details can be incorporated into the design of a repairable zone to withstand expected SLS deformation with negligible damage.

Details illustrating how junctions might be achieved are shown in section 23. The proposed superstructure detailing at junctions is relatively simple and it is recommended that they be used in all partial rebuilds in TC1, TC2, and TC3.

21.5 Firewall repair/rebuild

21.5.1 Overview

On TC2 and TC3 sites, new firewalls constructed as part of foundation rebuilds (partial or full) should be in the form of a timber-framed, fire-rated, inter-tenancy wall regardless of any superstructure weight constraints on foundation choice.

It may also be possible to truncate the existing firewall at the foundation/floor level and build a timber-framed firewall on the existing base. This will remove the requirement in some situations for a foundation repair adjacent to the firewall. However, the face load stability of the replacement wall must be ensured with stabilising elements suitably designed, proportioned, and fire rated. Meeting B1/AS1 and C/AS design requirements is one approach that satisfies the stability requirements.

Note: Masonry firewall vulnerabilities such as localised foundation deformation within a building have been highlighted following the Canterbury earthquake sequence. Replacing existing heavy masonry firewalls with timber-framed firewalls is recommended (when replacement is indicated using Table 18.3 or required for partial rebuilds).

21.5.2 Lateral stability

Unless built as a freestanding element, lateral support from two sides is a feature of firewalls and is essential in MUBs because the wall must remain stable in fire burnout conditions, ie, when fire burnout on one side of the wall leads to loss of lateral support from that side.

Replacing earthquake-damaged firewalls will require that particular attention be given to the maintenance of these performance characteristics, particularly where new repairable zones are being introduced.

Due to the requirement to cover off the fire burnout case, some specific design modifications may be required to satisfy the lateral stability of evacuation and escape routes for fire-rated construction (Building Code Clause C4 compliance). In some cases, these may dictate that:

› the existing heavy-masonry, acoustic, fire-rated wall is demolished (notwithstanding its post-earthquake condition); and

› a replacement acoustic, fire-rated wall is constructed in timber framing incorporating structural support specifically designed to satisfy the face load stability requirements in post-fire conditions.

21.5.3 Firewall remedial details

Figures 21.1 and 21.2 provide an example detail of a partial firewall replacement within the roof cavity.

Figure 21.1: Unreinforced brick masonry block demolition detail

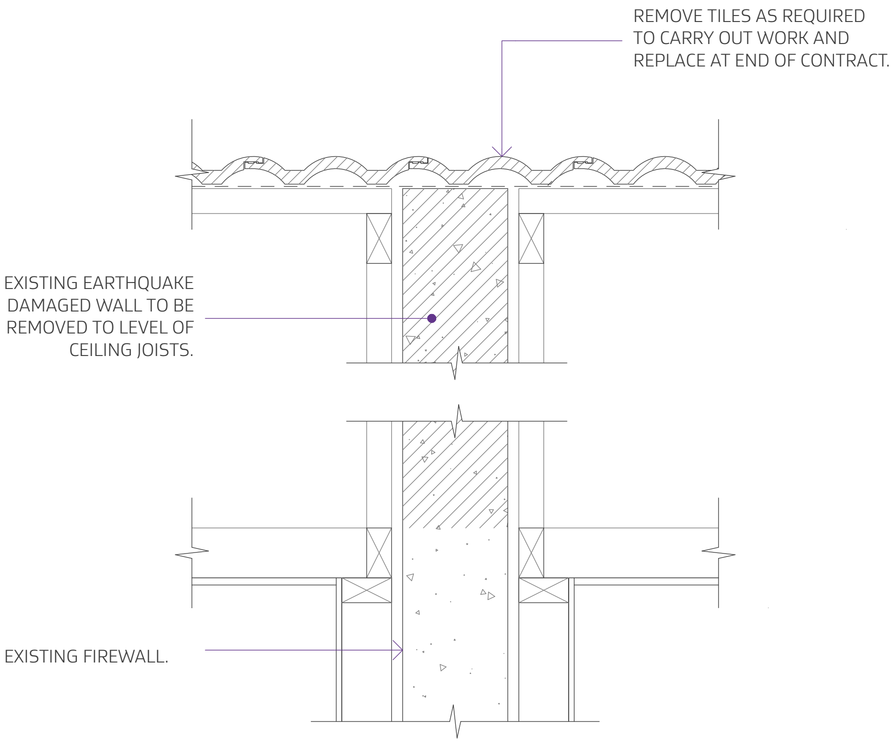
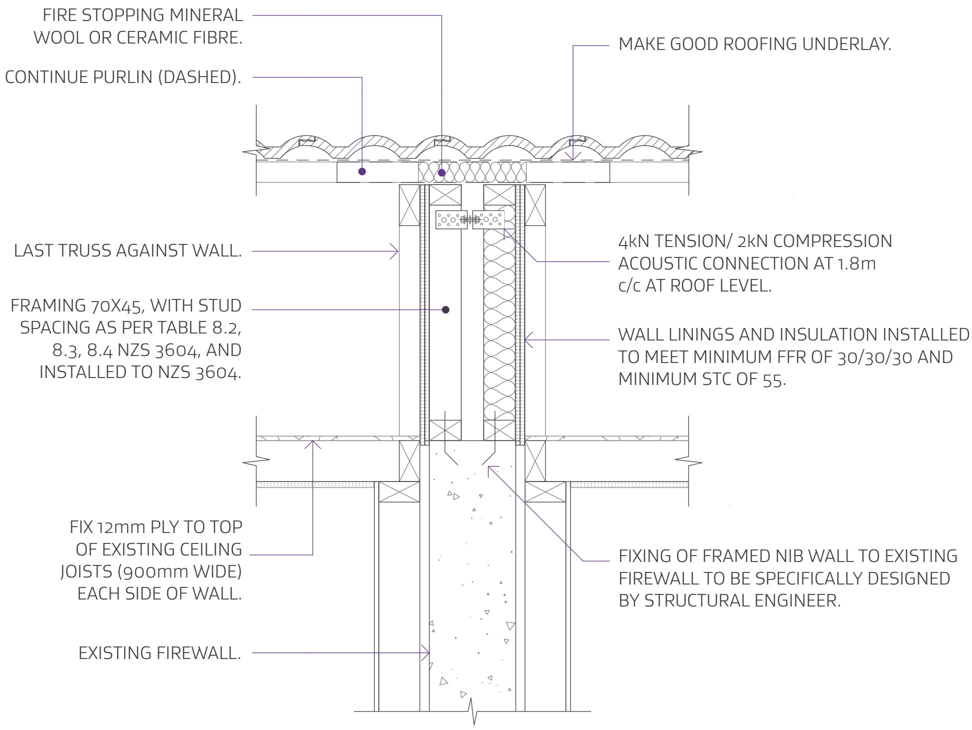


Figure 21.2: Unreinforced brick masonry block remedial detail



22. Full foundation rebuild

22.1 Overview

Full foundation rebuilds of an entire MUB or the construction of new MUBs can generally be undertaken in accordance with section 5 (TC1 and TC2) and section 15 (TC3). For specific guidance section references, refer to section 22.4.

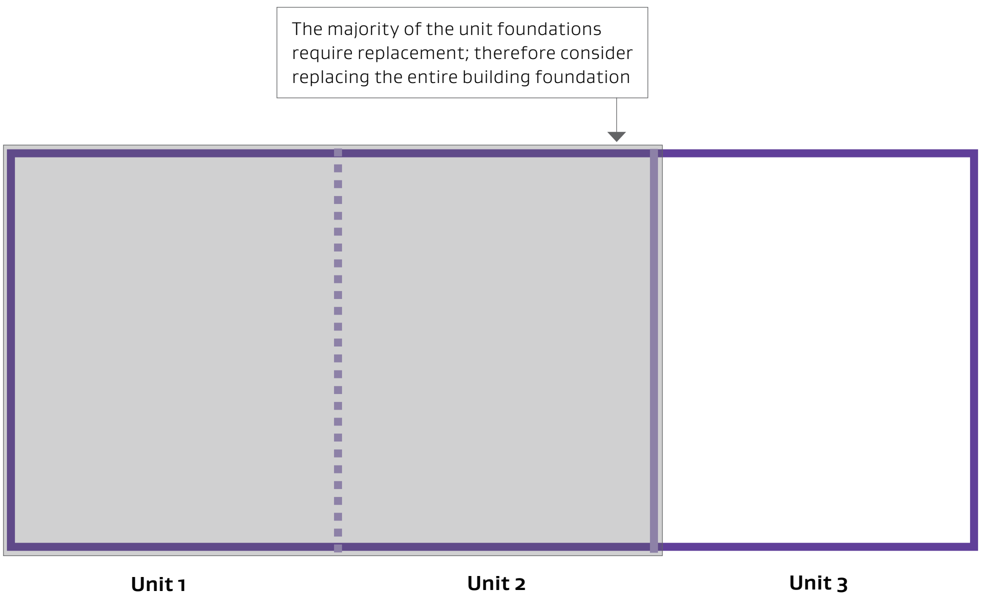
No specific engineering design principles need to be employed for TC1 beyond what is in section 5. For TC2 the deflection criteria in section 5.4 (TC2) must be adhered to. The deflection criteria in section 5.4 also apply for TC3.

When replacing the foundations of whole buildings on TC2 and TC3 sites generally the recommendation regarding using light and/or medium cladding as per section 7 will apply. This may result in either lighter-weight construction or more resilient foundations being required to support heavier construction.

When a total foundation rebuild is undertaken, a single foundation design should be adopted across the whole building, ie, avoid multiple foundation types within one building.

Figure 22.1 illustrates an example of when a full foundation rebuild is recommended.

Figure 22.1: Full foundation rebuild example



22.2 Geotechnical information and investigations

With regard to geotechnical investigations for full foundation rebuilds of an entire MUB or the construction of new MUBs, refer to Part C. In cases of long aspect ratio MUBs that might traverse a greater variation in ground conditions than a more compact detached house, the CPEng geotechnical engineer may consider that additional investigation points are warranted.

22.3 Design principles for TC3

The design principles outlined in section 11.2 (and supplementary guidance, in particular for TC3) remain applicable when rebuilding MUBs. It is noted that:

1. All surface structures must be a regular shape. For information on restrictions for cut outs and projections, refer to supplementary guidance: *Regular Structural Plan Shapes in TC3 (September 2013)*[9].
2. The maximum aspect ratio is 2:1 for Type 1 surface structures and all site ground improvement foundations. The maximum aspect ratio can be increased from 2:1 to 3:1 for Type 2 and Type 3 surface structures provided additional reinforcing steel is included. For more information, refer to the supplementary guidance: *Regular Structural Plan Shapes in TC3 (September 2013)*.

   Note: The concrete foundation solutions for long narrow rectangular blocks of units may be specifically designed to allow the aspect ratio of 3:1 to be exceeded without raising the potential for damage in a future SLS event.

   Note: For concrete under-slabs in Type 2A and 2B foundations, experience has shown that the piles are sufficiently retained in the concrete so that the plywood skirt can be eliminated. For maximum heights to the underside of joists, refer to Table 20.4.
3. The recommended maximum plan area is 150m^2 for Type 1 surface structures. The area limitation is likely to preclude the use of Type 1 surface structures on full rebuilds of most MUBs.
4. Specific engineering design is required for any buildings that extend beyond the scope of these design principles.

Coordination of replacement solutions is recommended across the units so that a suitable foundation solution is implemented across the whole building. If the building was originally a mixed foundation type, for example a Type B building with a Type C extension, then it is recommended to replace it with a uniform foundation system across the whole building.

9 Refer to www.dbh.govt.nz/UserFiles/File/Publications/Building/Guidance-information/pdf/canterbury-regular-structural-plan-shapes-tc3-supplementary-guidance.pdf

22.4 Foundation rebuild references

Rebuilding information by technical category is described in Table 22.1.

Table 22.1: Full foundation rebuilds

TC1	Use current building standards and specifications.
TC2 and TC3	Refer to sections 5 and 15. For design principles, refer to section 11.2. Where proposed roof/cladding weight and/or number of storeys exceed the stated limitations, specific engineering design is required.

23. Junction details for partial rebuilds

23.1 Introduction

The principles set out in section 17 have a practical impact on the way repair and rebuild solutions are constructed. There are many combinations of material and geometry that will arise in the application of the repairable zone principle making it impractical to depict them all here. Instead this section contains selected details to illustrate application of the principle to some of the most common circumstances. In addition to structural considerations, there are also matters related to weathertightness, fire-rating, acoustic performance and sub-floor ventilation to address.

Note: The details in this section are not ready for either consenting or construction use. In particular, details have been simplified to illustrate only those aspects of the junction that are specific to MUBs and therefore some standard items are either not labelled or not shown. For example, typical or common construction design and detailing for compliance with acceptable solutions such as E2/AS1 or industry standards such as NZS 3604 need to be added to these details or documented elsewhere by the designer. Product specification has also been left up to the designer and is anticipated to be driven by compatibility requirements with remaining units. Therefore the designer has to take these details as a starting point and add to them to produce a site-specific construction detail that is suitable for building consent application and construction while complying with this guidance.

The proposed superstructure detailing at junctions is relatively simple and it is recommended that they be used in all partial rebuilds in TC1, TC2, and TC3.

There is obvious repetition across these details in order to illustrate the principles behind the detailing and to enable on-site construction to be consistent across different projects. There will be numerous situations where these details cannot be directly applied. The designer is expected to apply the principles behind these details to derive their own project-specific details that are consistent with this guidance as well as meeting other Building Act and Building Code compliance requirements.

There is a strong preference for replacing heavy cladding with a lighter alternative during any rebuilding. However, it is also understood that this may not always be possible.

Designers should include, with their construction documentation and consent application, the manufacturer's documentation for the specific system that they will use.

Note: The New Zealand Building Code Clause G6, Airborne and Impact Sound, is being reviewed. A new clause is being drafted. It is anticipated that the clause will become operational at the end of 2014.

Where STC (Sound Transmission Class) is noted on the details it should be kept in mind that the revised Clause G6 changes both the metric (STC) to the ISO airborne sound reduction measure DnT,w (weighted standardised level difference) and the performance level to DnT,w no less than 53dB. This is approximately 3dB higher than the minimum FSTC (Field sound transmission class) performance requirement.

Details affected are Figure 23.8, Figure 23.9, Figure 23.10, Figure 23.11, Figure 23.12, Figure 23.15 to Figure 23.22, and Figure 23.24.

This section has been further subdivided to group material by topic:

- Existing floor and firewall details
- Partial rebuild slab to existing slab connection details
- Partial rebuild slab and firewall connection details
- Partial rebuild firewall details
- Partial rebuild against retained firewall details
- Type 2A surface structure details
- Floor-level driven slab solution details

23.2 Existing floor and firewall details

Figure 23.1: Existing foundation (timber framed floor)

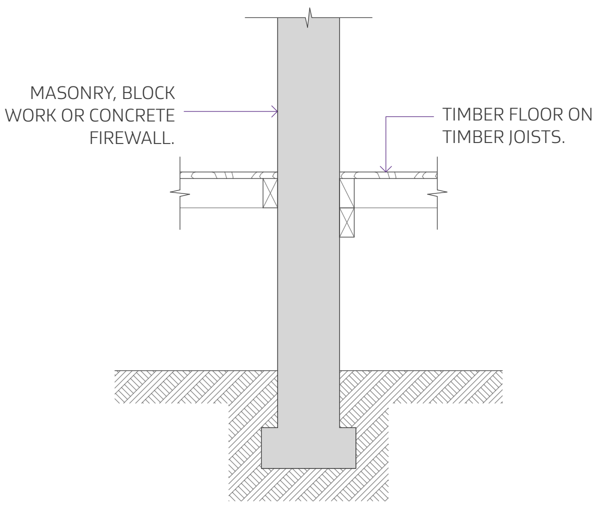


Figure 23.2: Existing possible concrete slab configurations

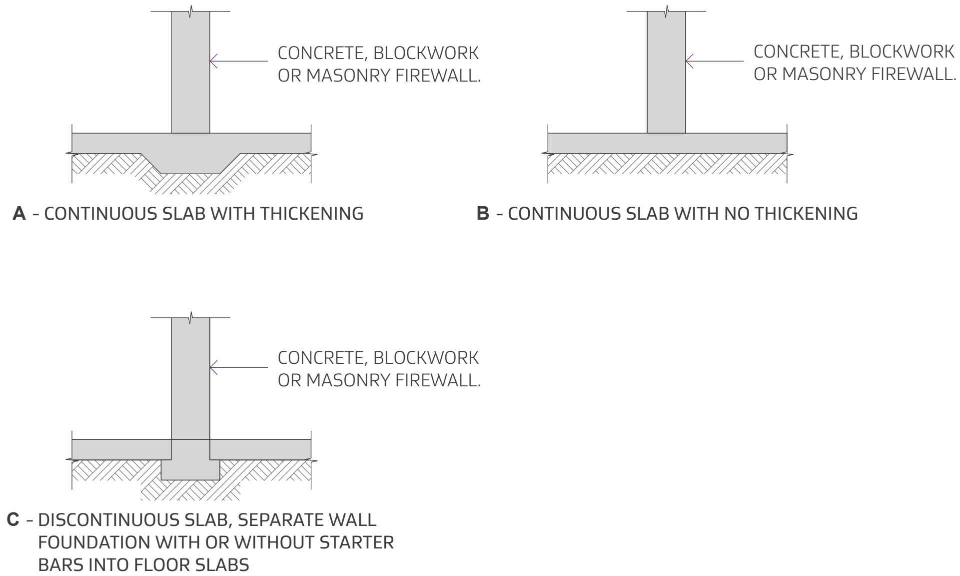
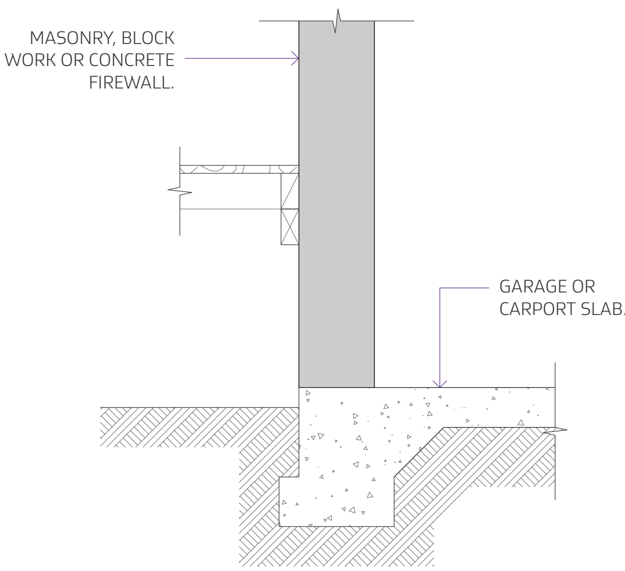
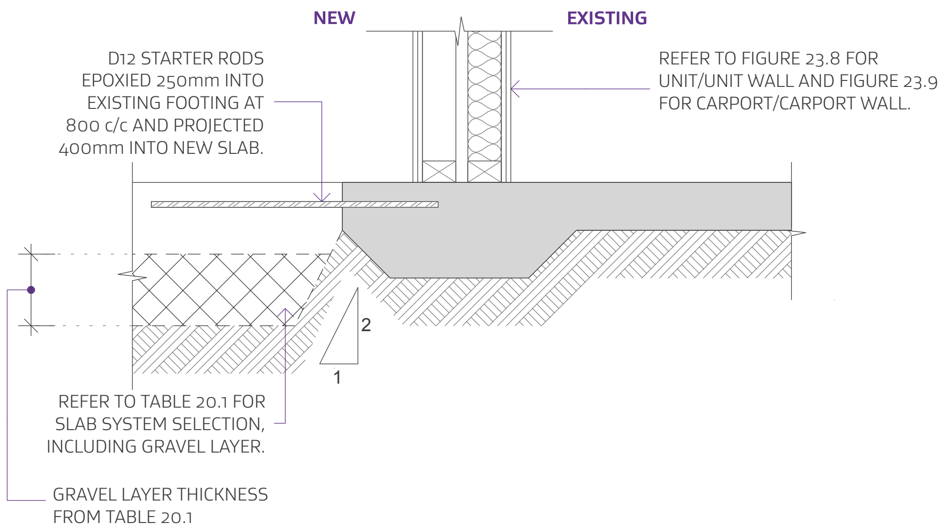


Figure 23.3: Existing foundation (timber framed floor/concrete slab)



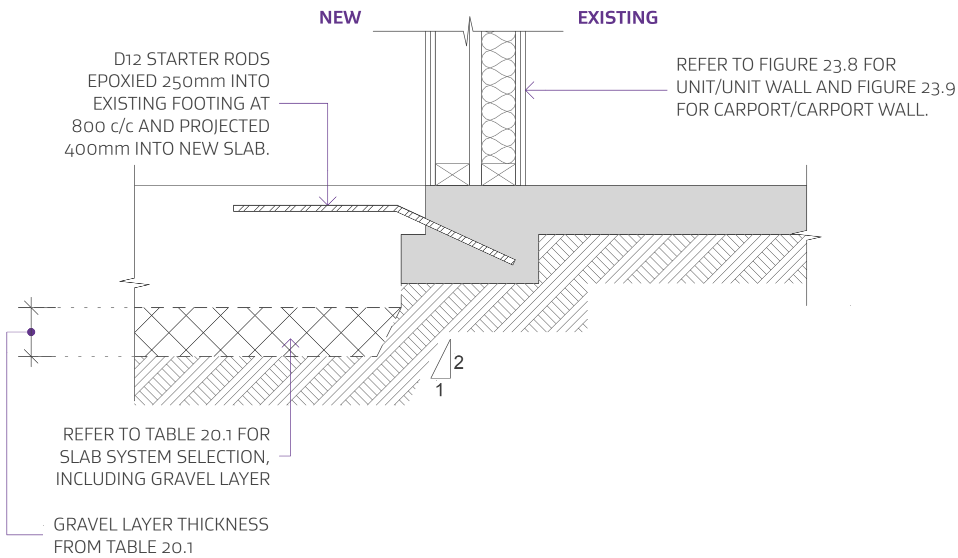
23.3 Partial rebuild slab to existing slab connection details

Figure 23.4: Footing retained (configuration A)



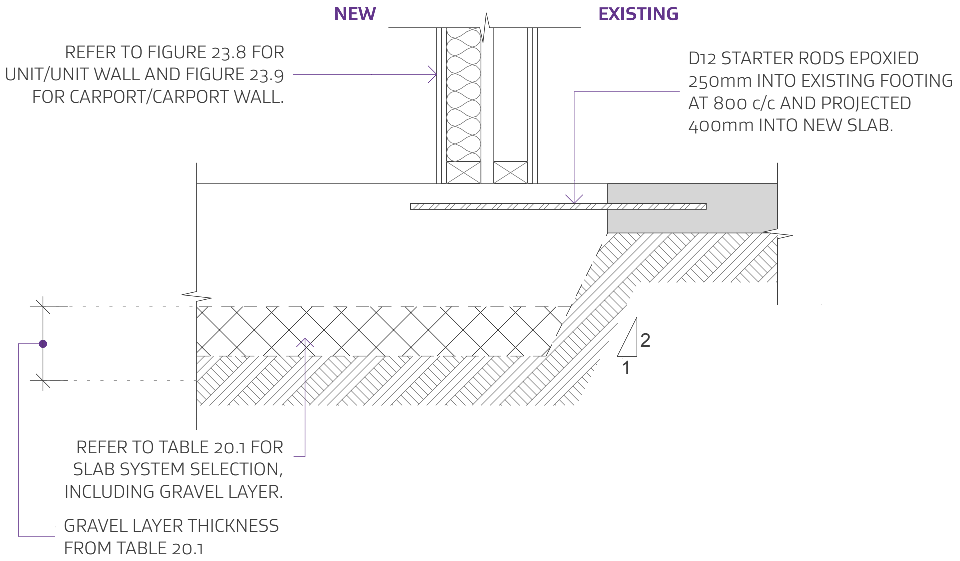
Note: If a masonry wall is required, specific design of the new slab edge will be necessary.

Figure 23.5: Footing retained (configuration C)



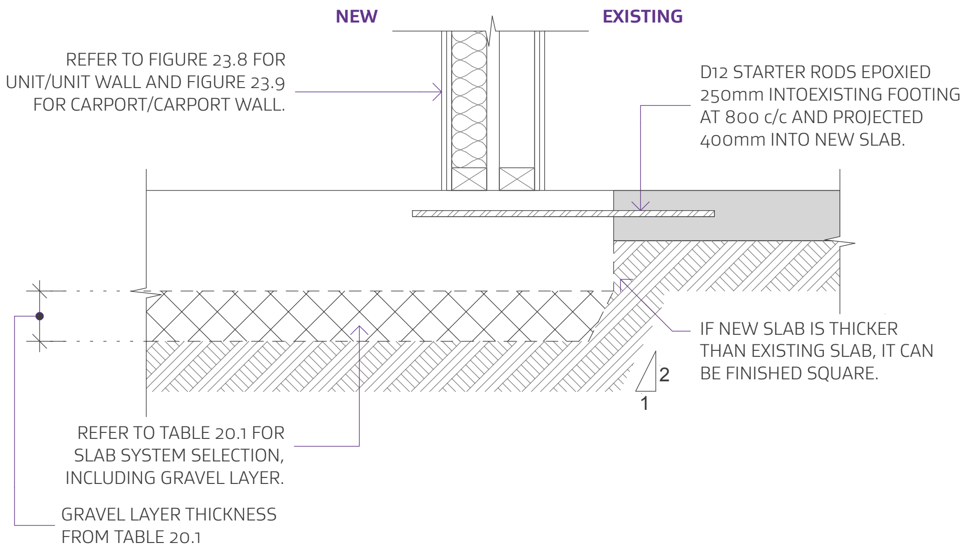
Note: If a masonry wall is required, specific design of the new slab edge will be necessary.

Figure 23.6: New footing (all configurations)



Note: It may be appropriate to retain an existing masonry wall provided the wall is intact. Refer to Table 18.3.

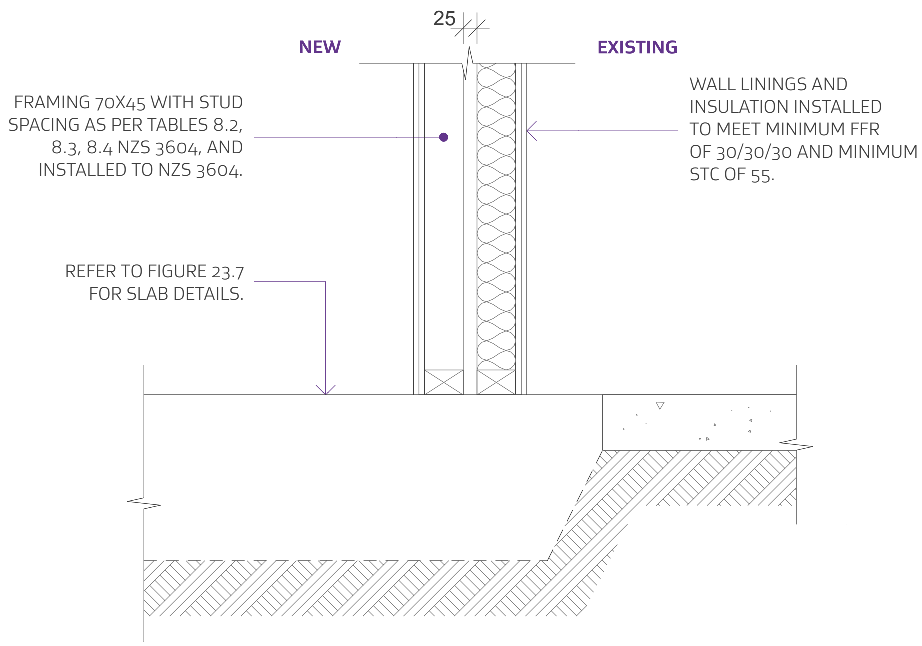
Figure 23.7: Alternative edge configuration



Note: It may be appropriate to retain an existing masonry wall provided the wall is intact. Refer to Table 18.3.

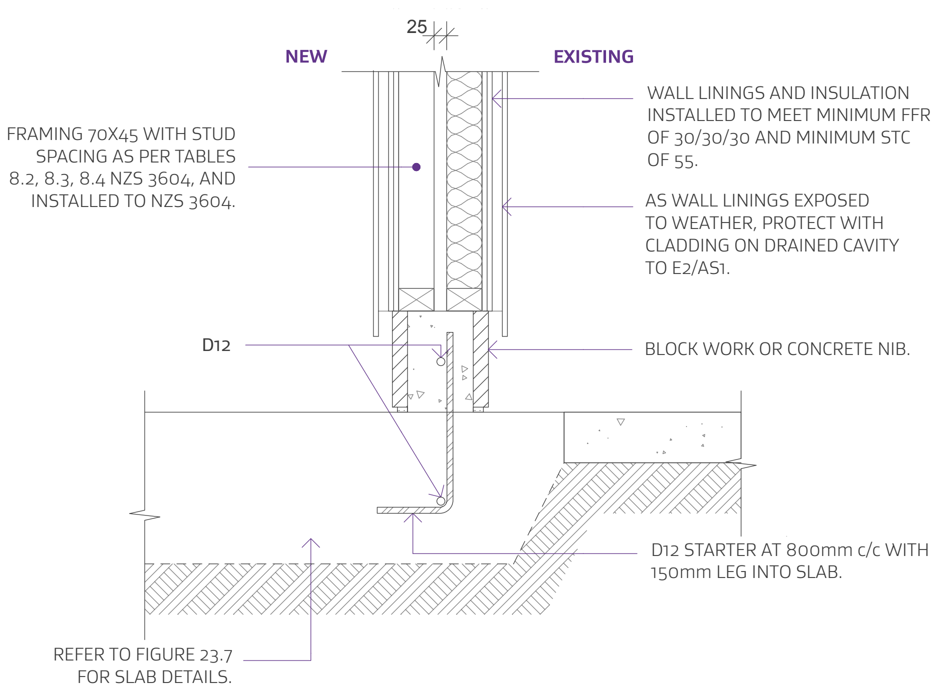
23.4 Partial rebuild slab and firewall connection details

Figure 23.8: Suggested double stud wall (concrete slab)



Note: This detail will apply for all internal situations, including garages.

Figure 23.9: Suggested double stud wall (Nib wall)



Note: This detail will apply for all situations where wall linings are exposed to weather.

Note: For any configuration with non-habitable spaces both sides of wall, the acoustic insulation is not required (refer clause G6.2 of Building Code).

Figure 23.10: Suggested double stud wall (timber framed floor)

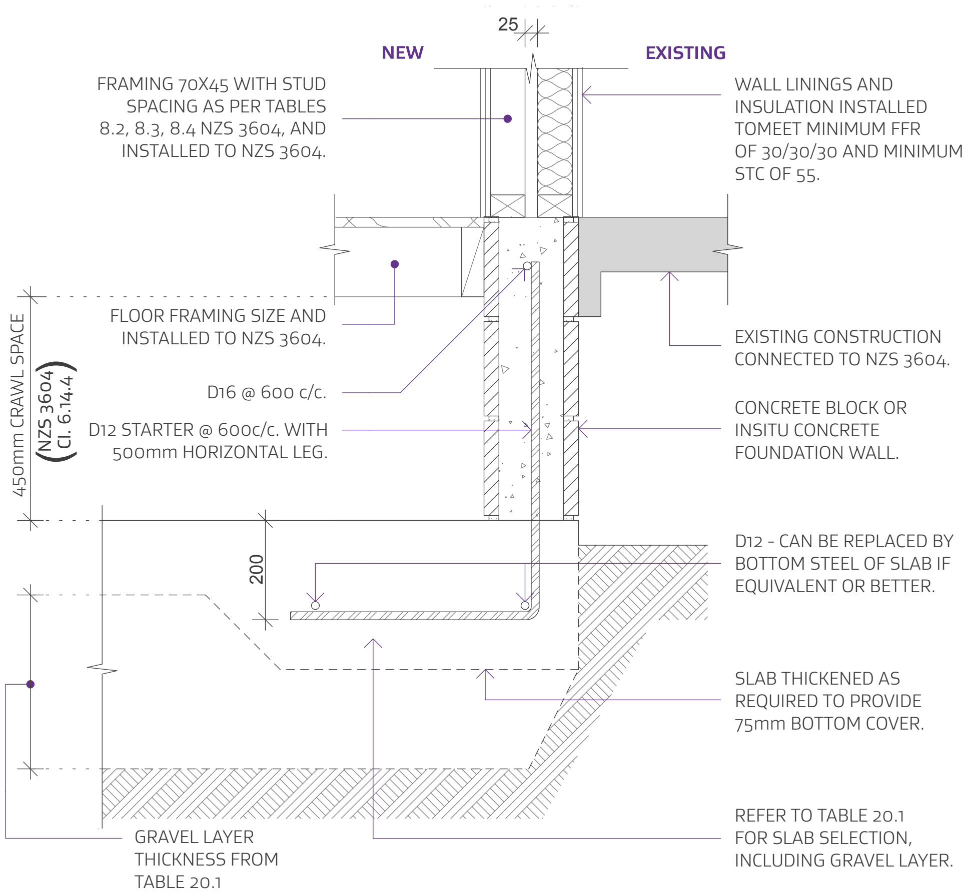


Figure 23.11: Suggested double stud wall (new timber framed floor/existing concrete slab)

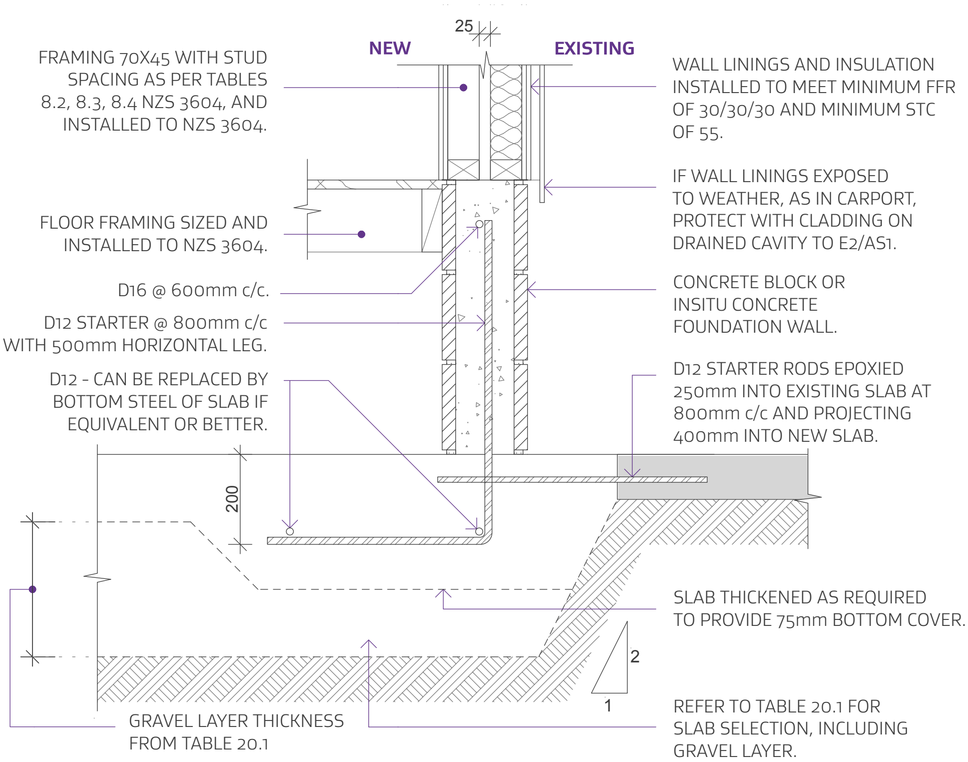


Figure 23.12: Suggested double stud wall (existing timber framed floor/new concrete slab)

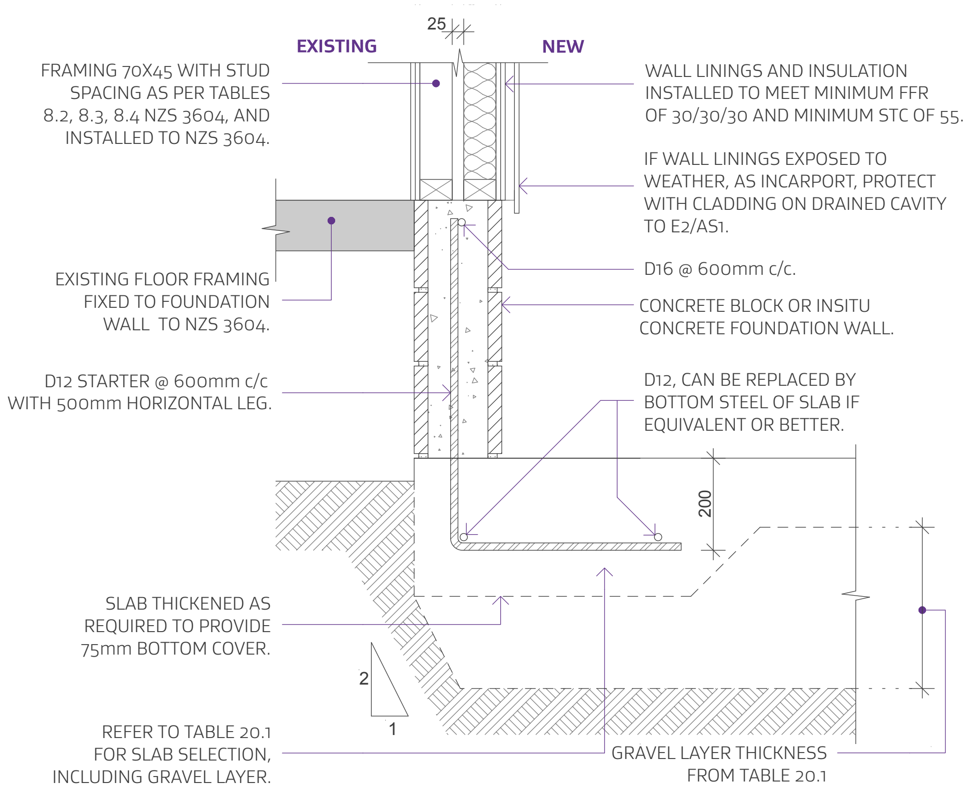


Figure 23.13: Foundation junctions surface structure slabs and Type B existing (plan section)

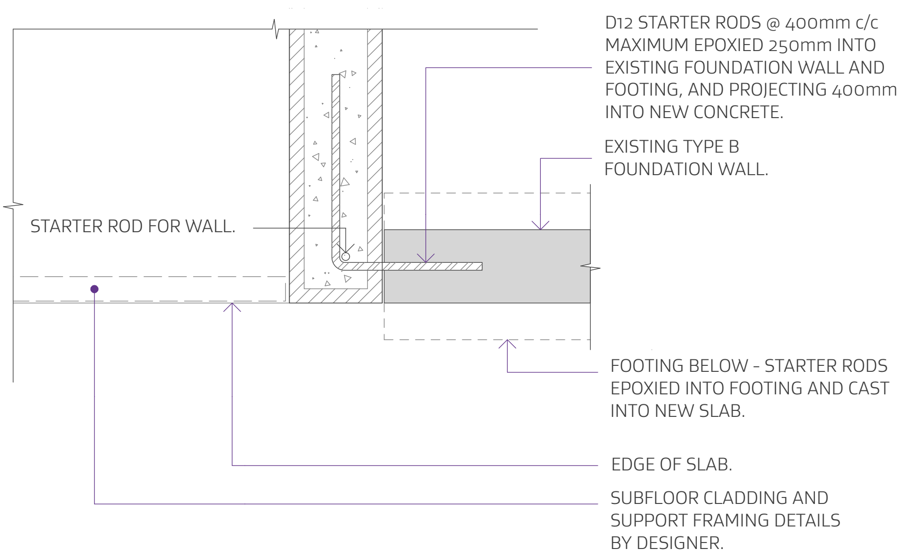
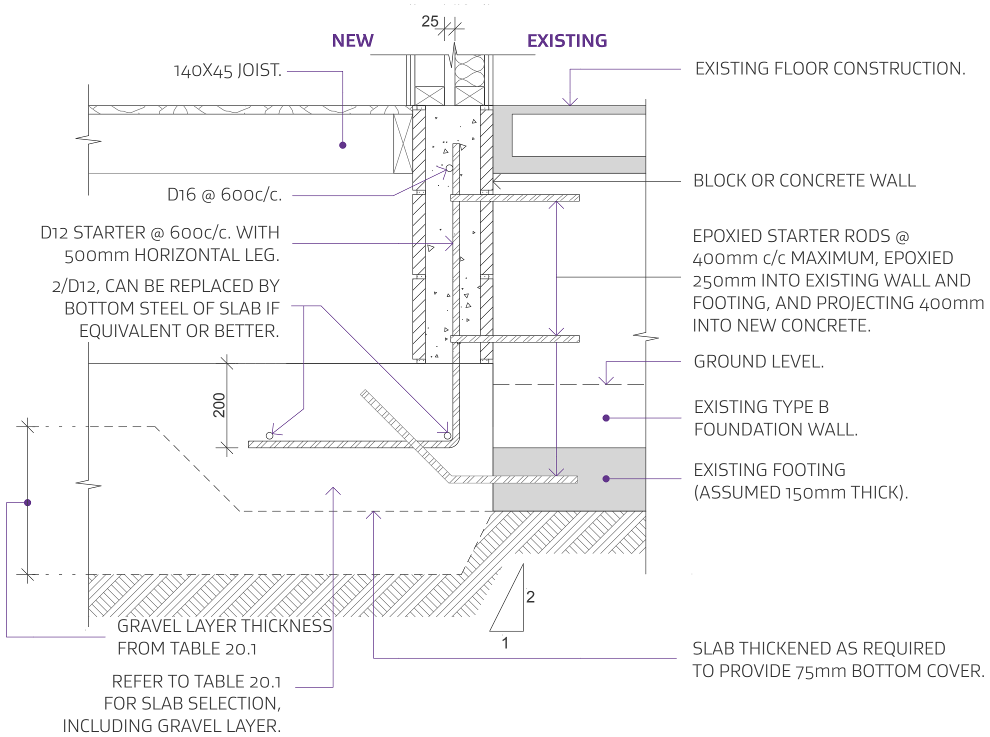


Figure 23.14: Foundation junctions surface structure slabs and Type B existing (elevation section)



23.5 Partial rebuild firewall details

23.5.1 Double storey wall details

Figure 23.15: Two storey first floor detail

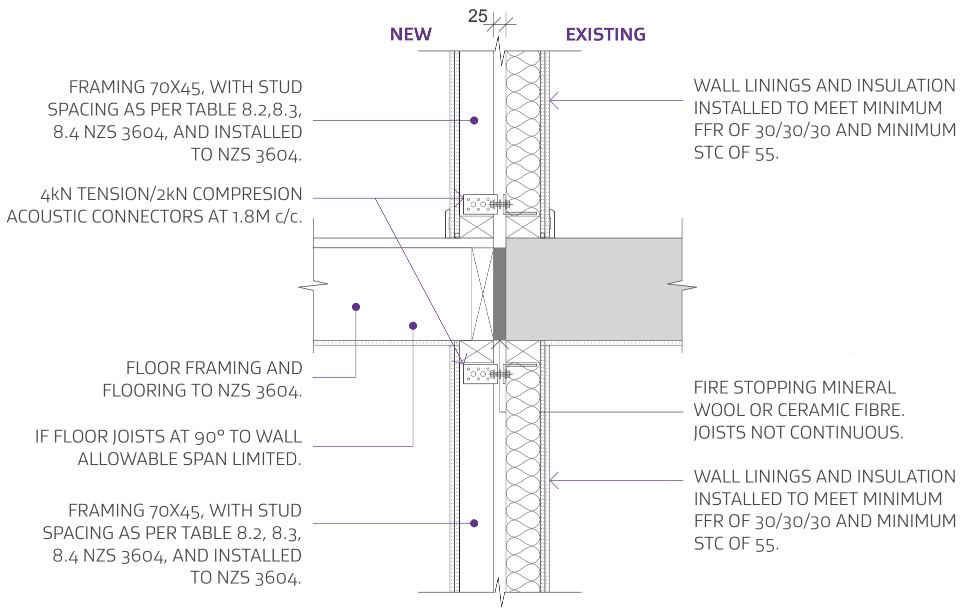
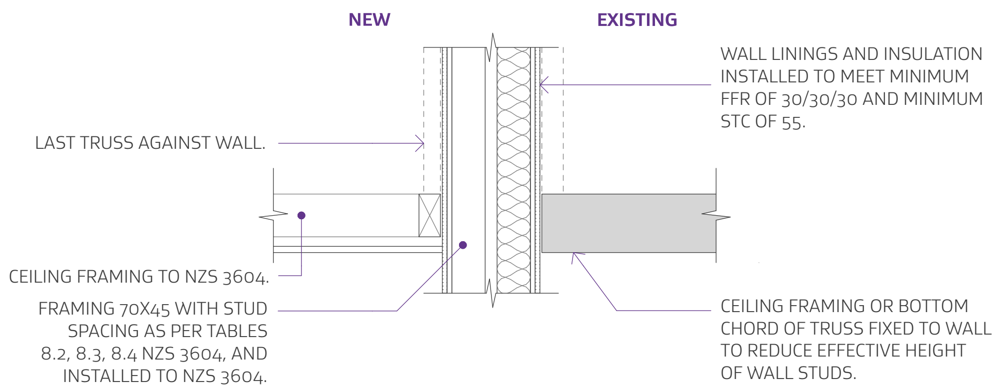


Figure 23.16: Suggested double stud wall at ceiling level



23.5.2 Exterior wall and roof junction details

Figure 23.17: Suggested double stud wall with corrugated roof

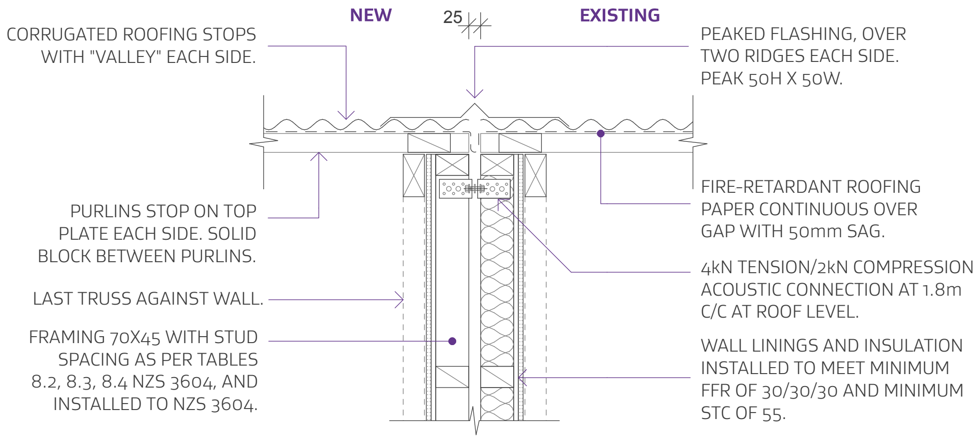


Figure 23.18: Suggested double stud wall with concrete tile roof

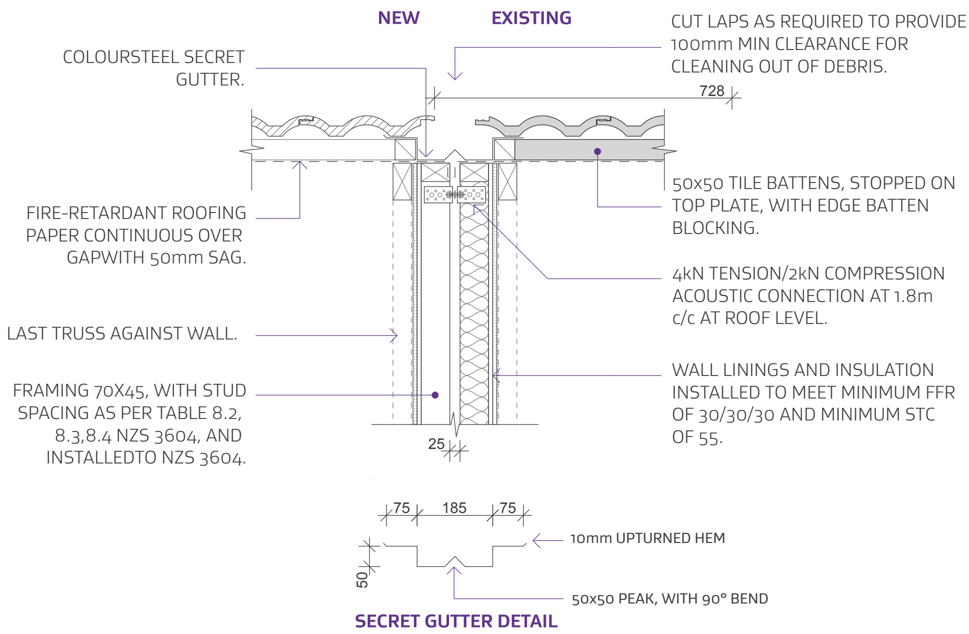


Figure 23.19: Exterior wall junction (veneer cladding)

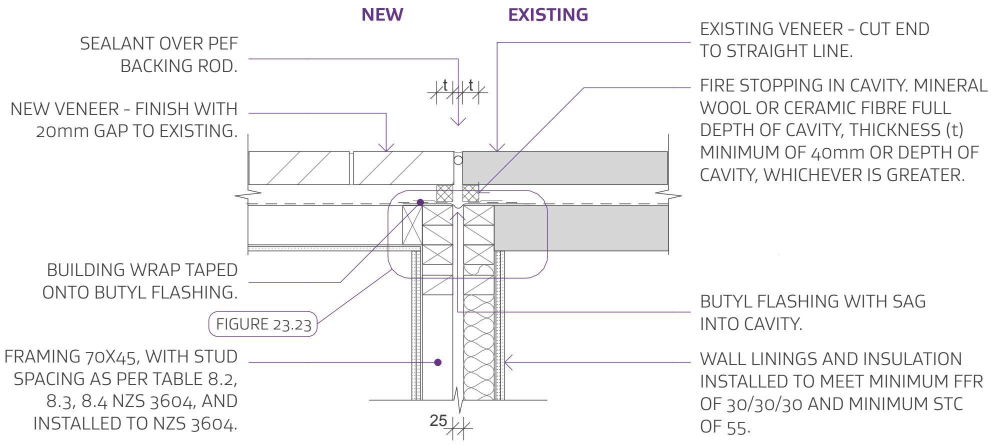
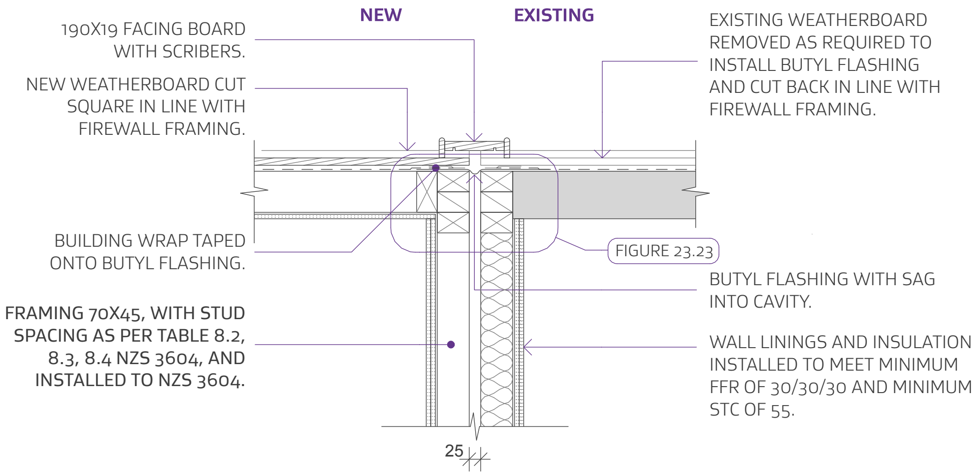


Figure 23.20: Exterior wall junction (weatherboard cladding)



Note: Use similar detail for vertical board cladding.

Figure 23.21: Exterior wall junction (sheet cladding)

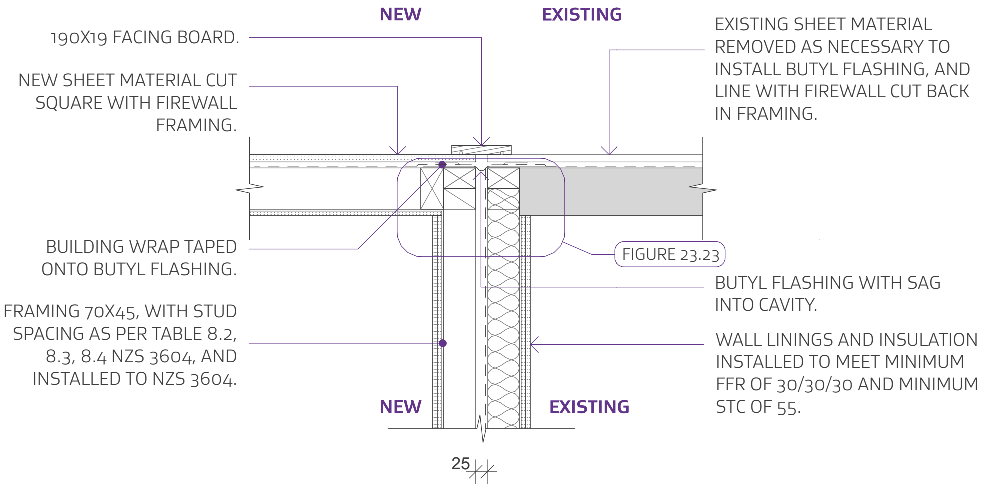


Figure 23.22: Exterior wall junction (weatherboard to veneer)

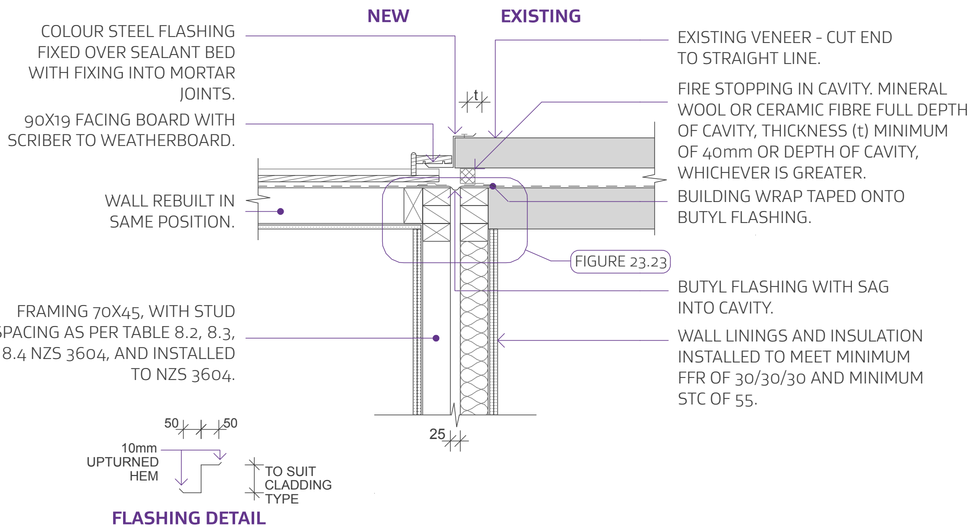


Figure 23.23: Butyl wall flashing and fire stopping

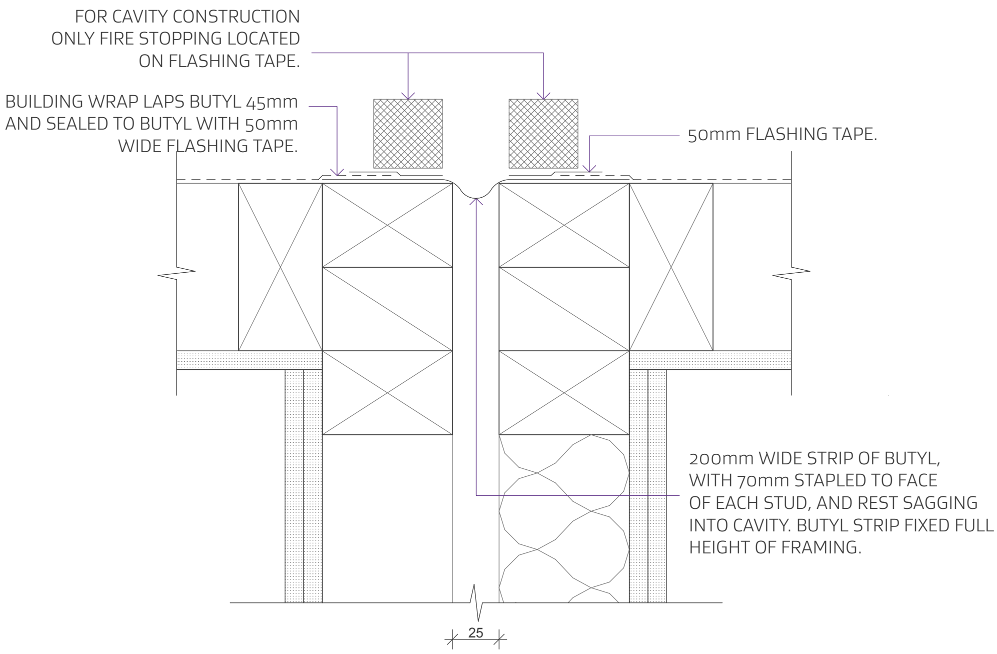


Figure 23.24: Exterior wall junction (offset framing)

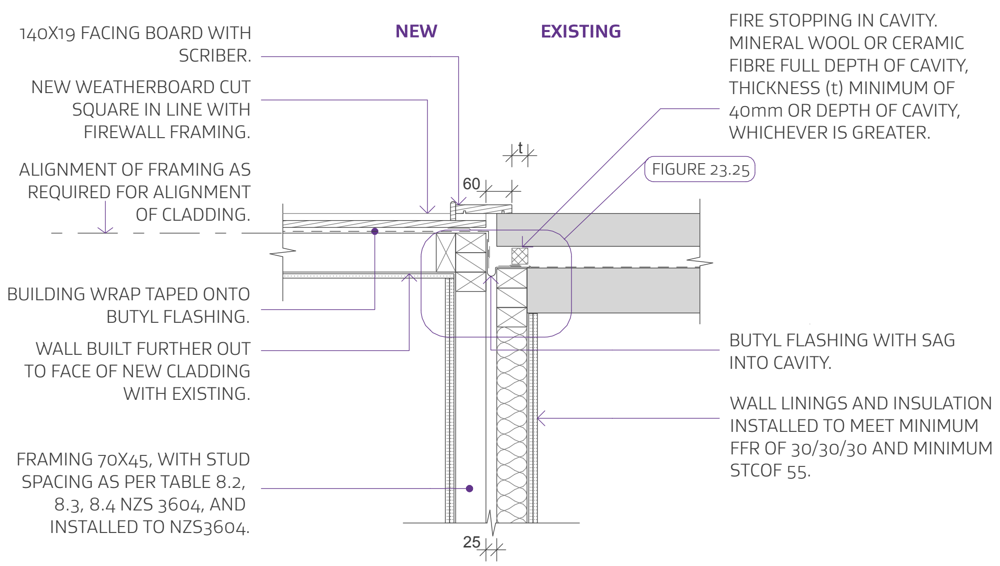


Figure 23.25: Butyl wall flashing

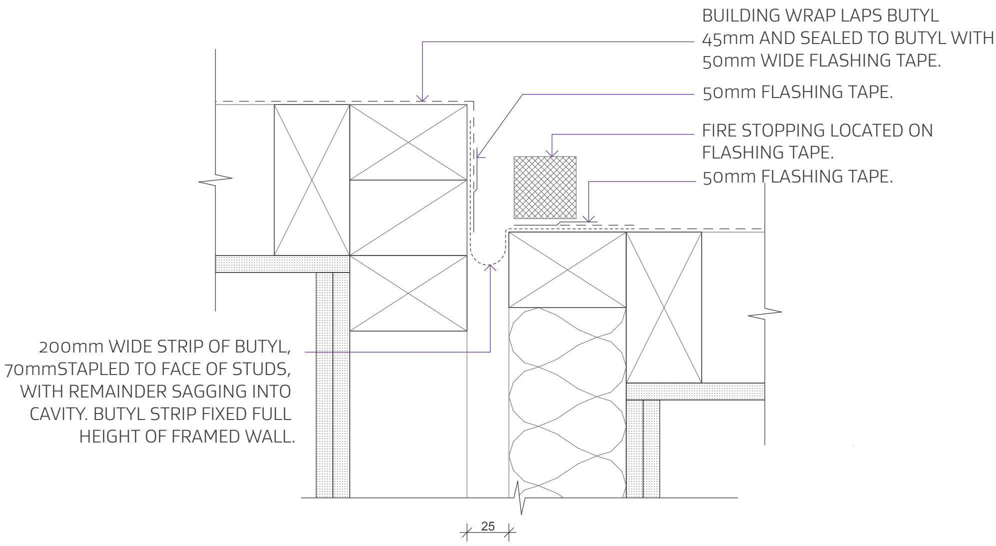


Figure 23.26: Soffit reflected plan

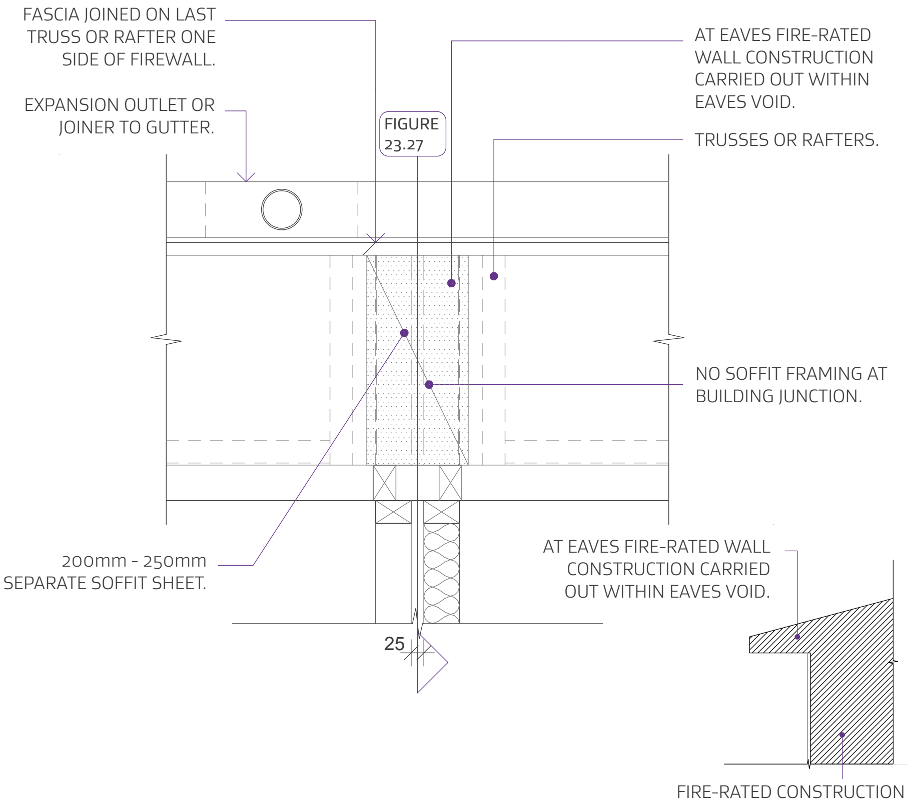
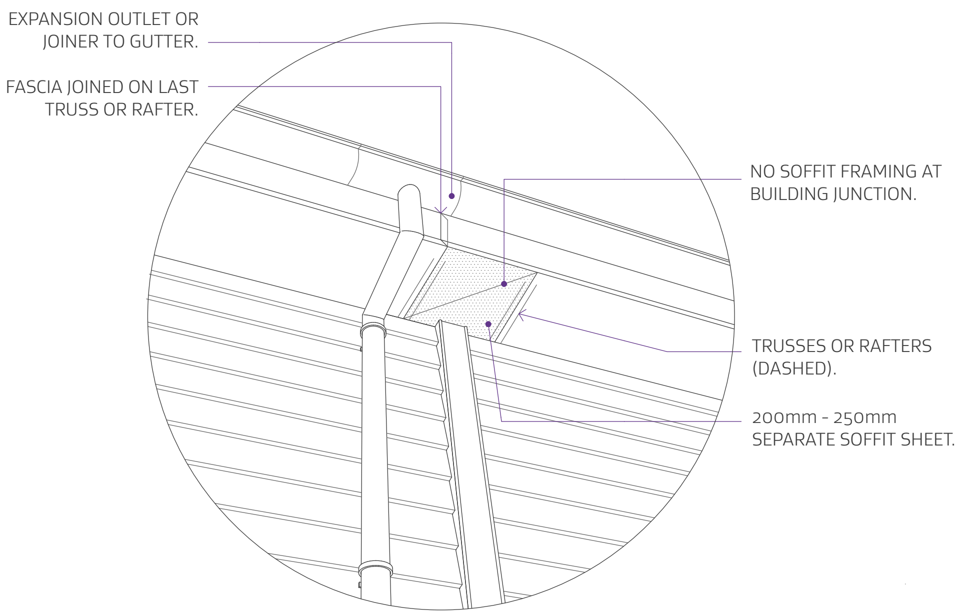


Figure 23.27: Soffit reflected perspective



23.6 Partial rebuild against retained firewall details

Figure 23.28: Retained firewall with corrugated roof

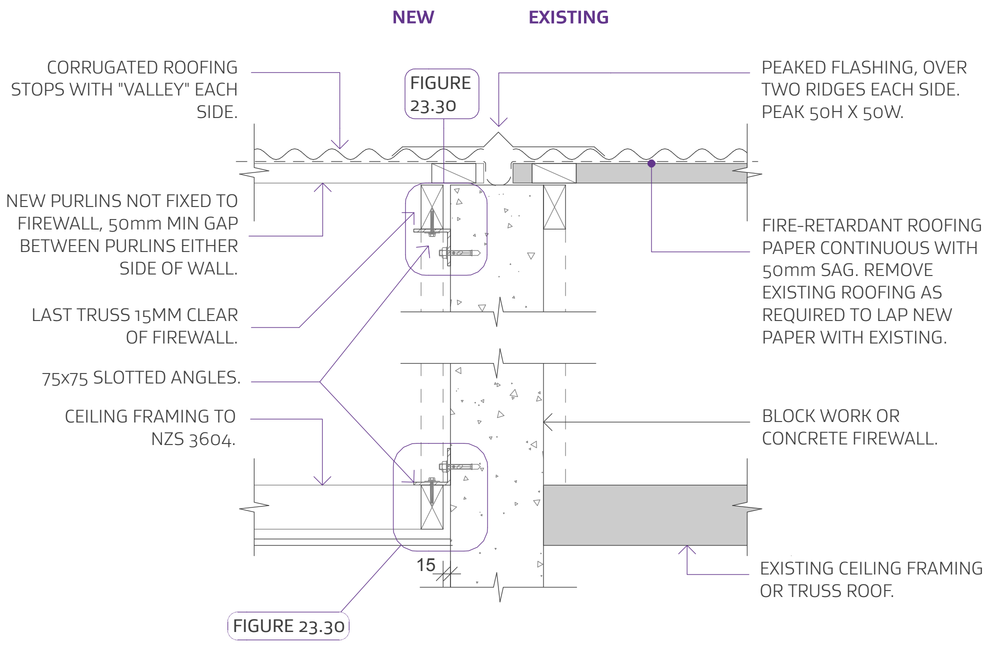


Figure 23.29: Retained firewall with concrete tile roof

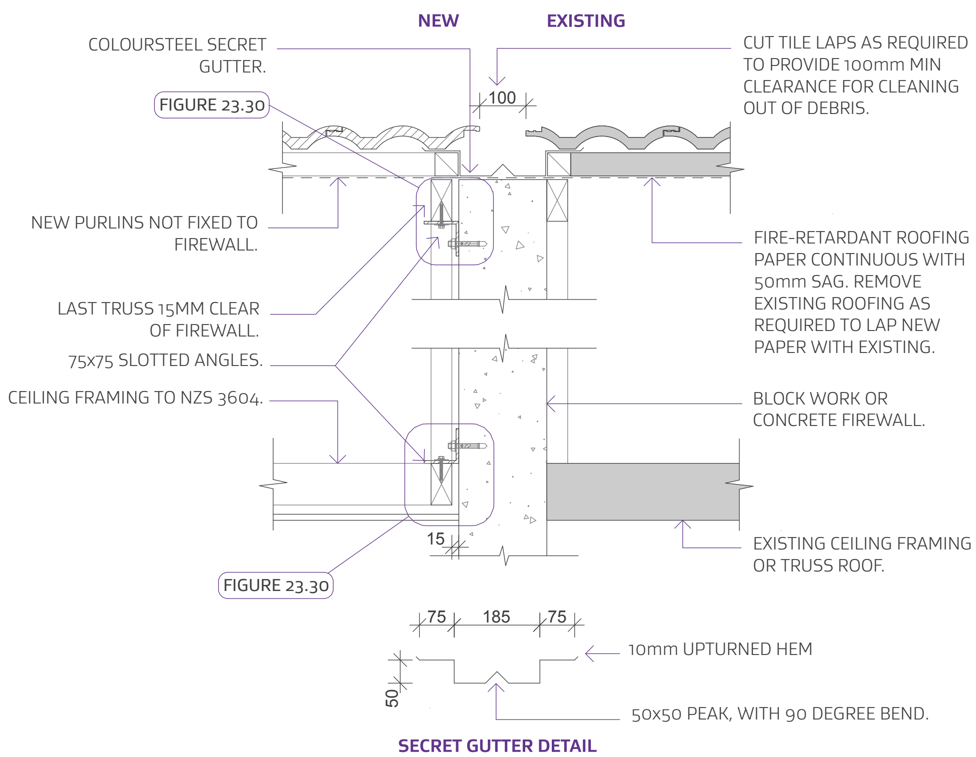


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Figure 23.30: Angle connection

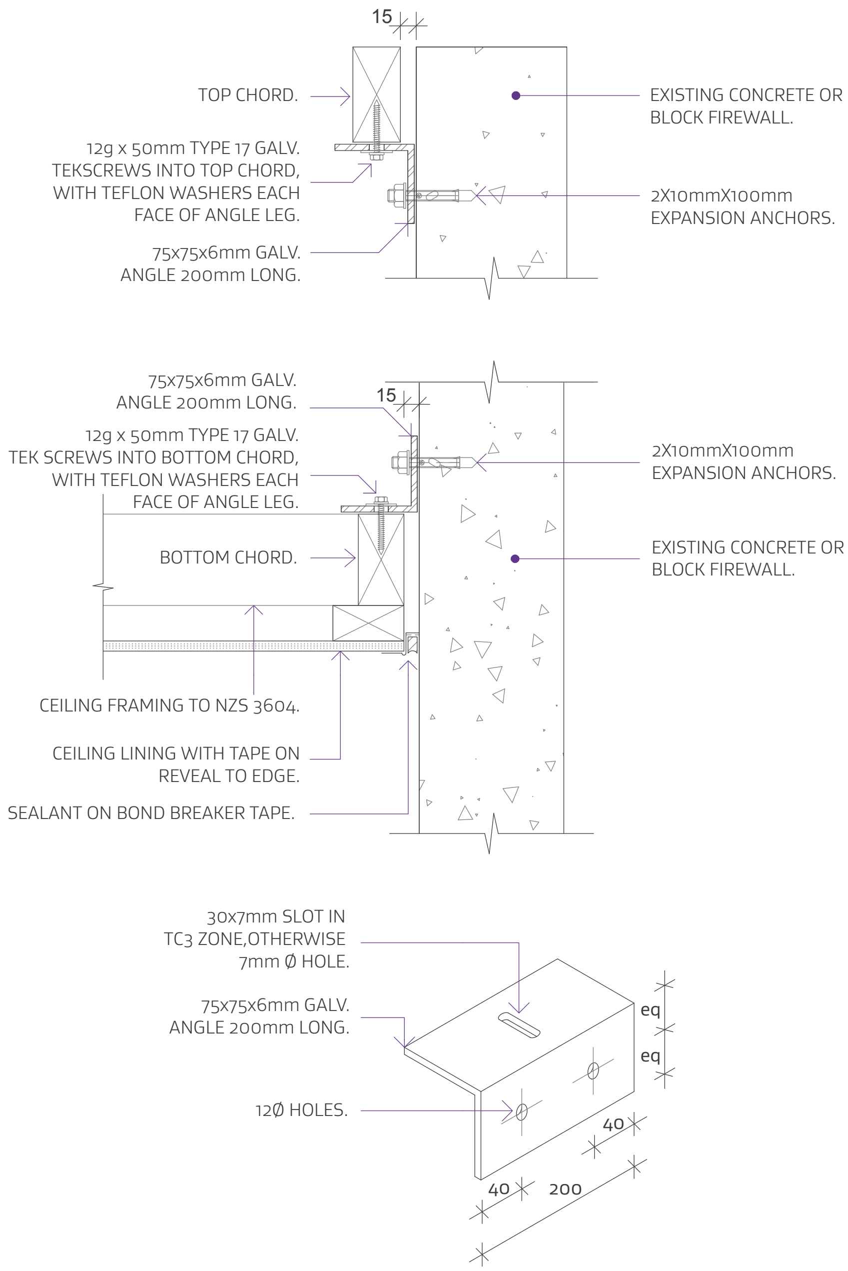
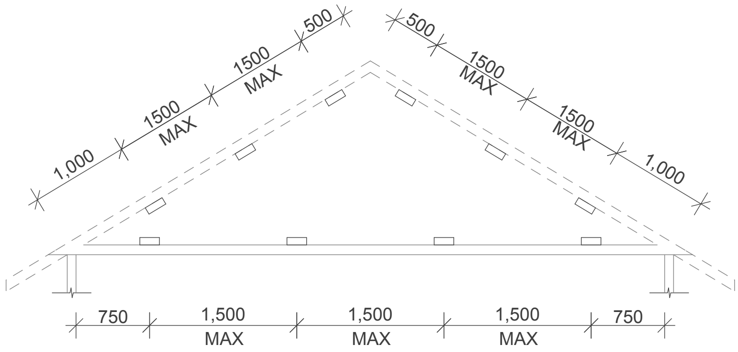
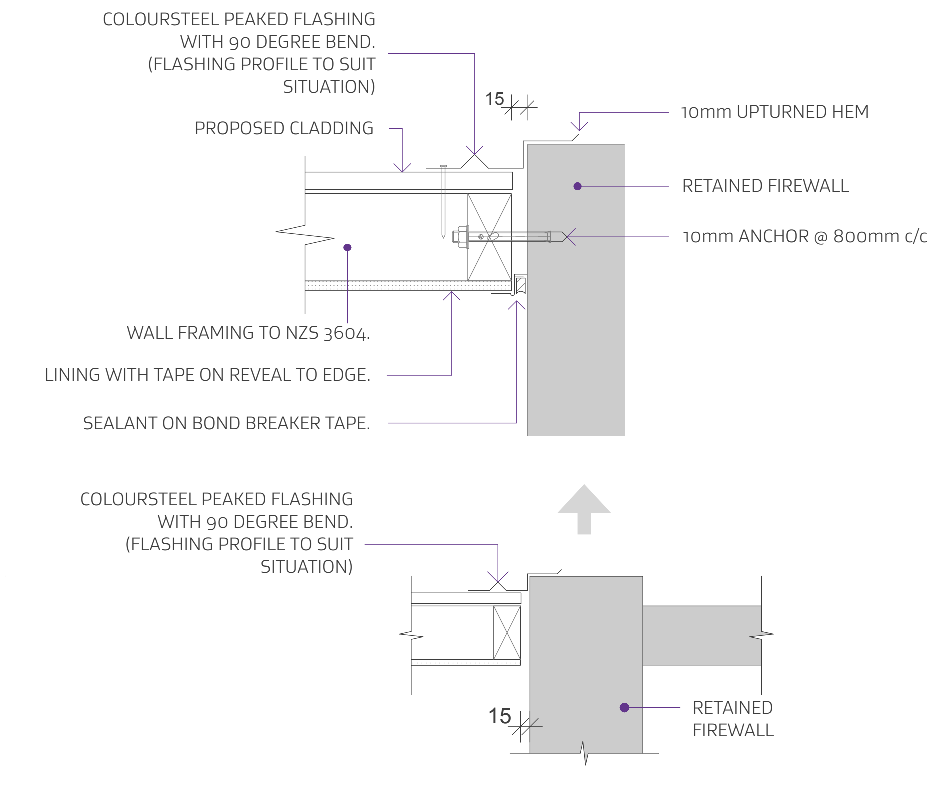


Figure 23.31: Angle location



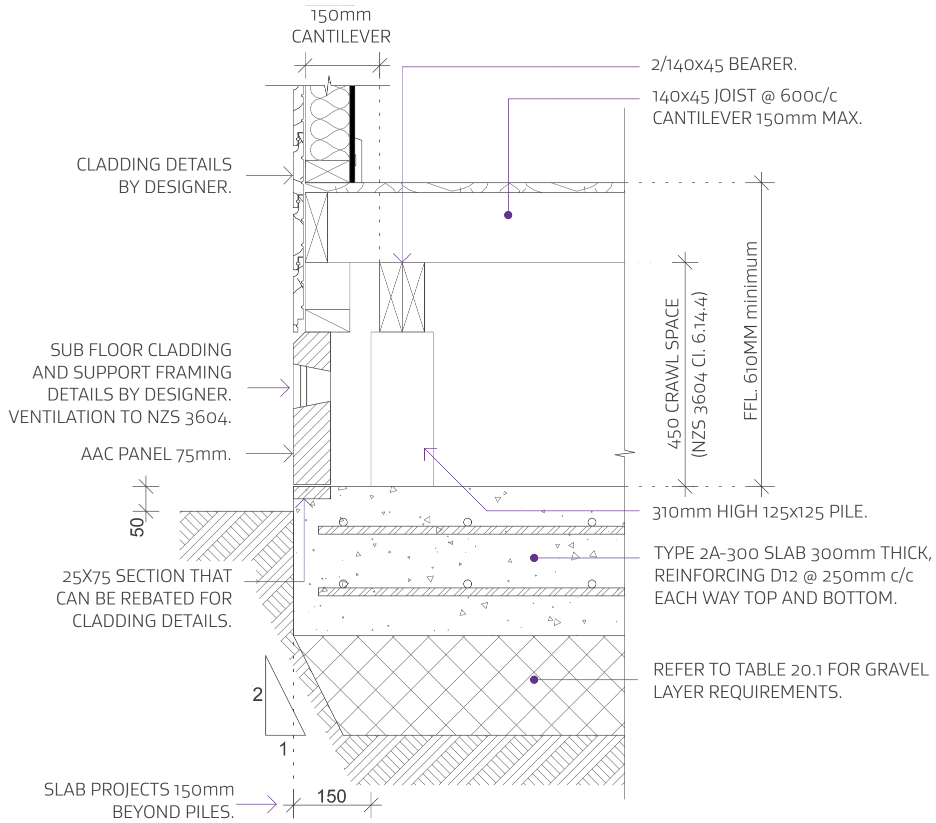
Note: Angles to be placed at 1.5m c/c maximum, starting 500mm from ridge along the top chord, and 750mm from the exterior walls along the bottom chord.

Figure 23.32: Retained firewall junction (wall junction)



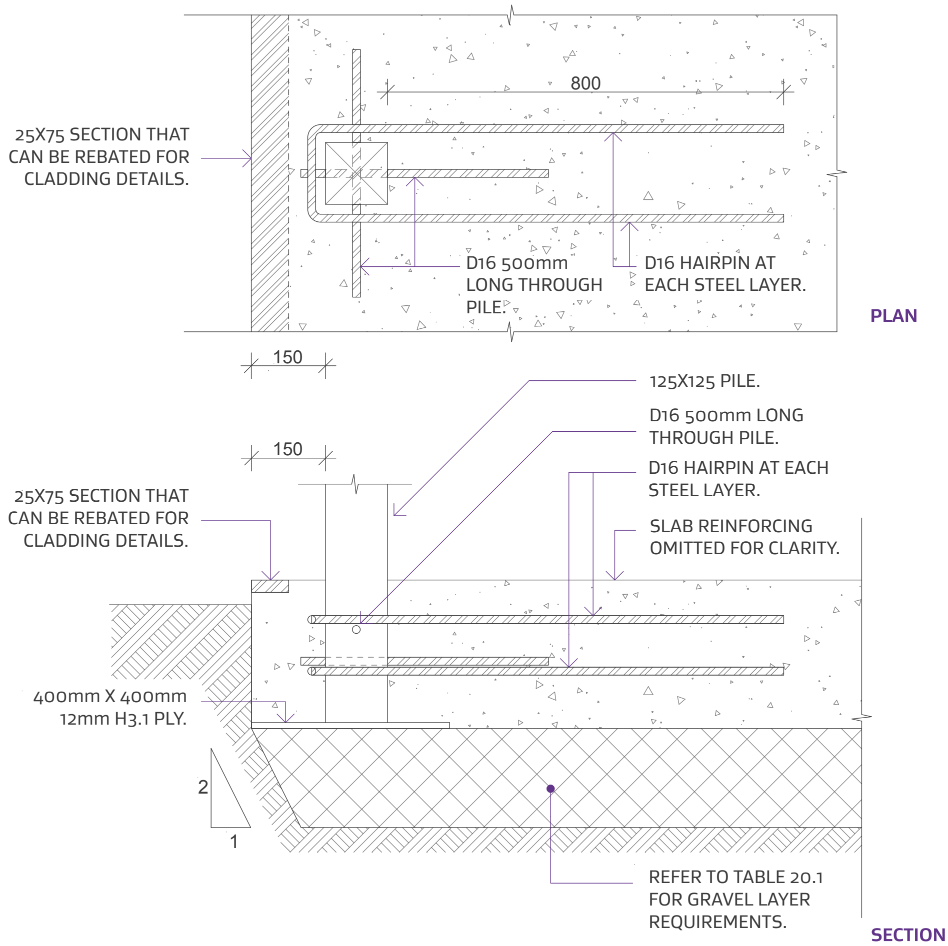
23.7 Type 2A surface structure details

Figure 23.33: Type 2A-300 surface structures detail



Note: This reinforcing applies to a slab with an aspect ration of no more than 2:1. For aspect ratios up to 3:1 the steel in the perimeter 1m of the slab and running parallel to the foundation edge shall be increased to D16 bars.

Figure 23.34: Type 2A-300 edge pile detail



23.8 Floor-level driven slab solution details

Figure 23.35: Suggested double stud wall (high slab)

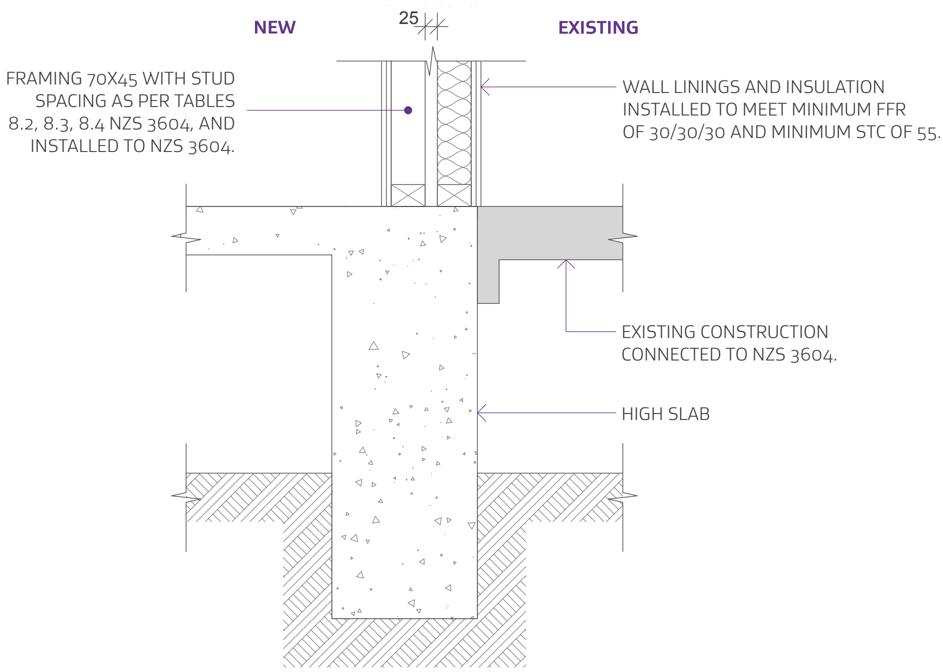


Figure 23.36: Suggested double stud wall (new high slab/existing concrete slab)

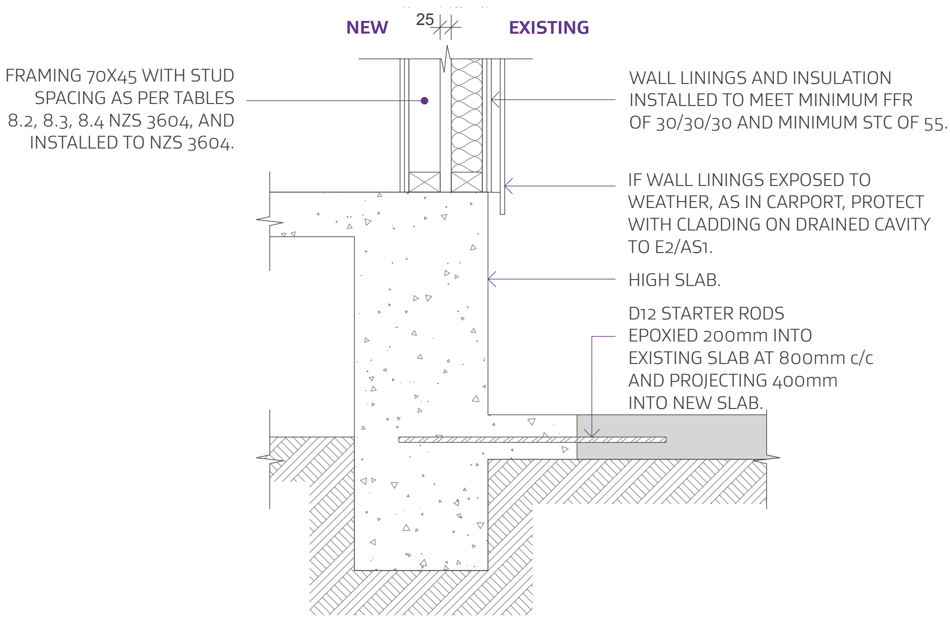


Figure 23.37: Foundation junctions high slab and Type B existing (plan section)

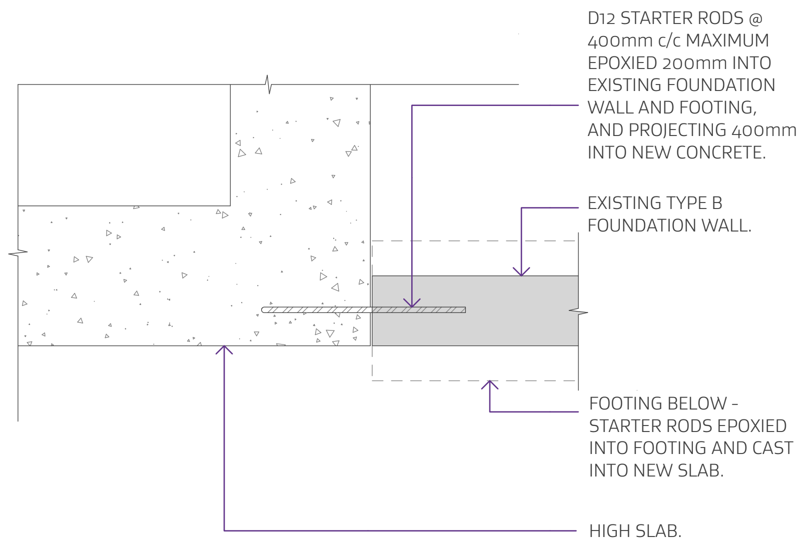
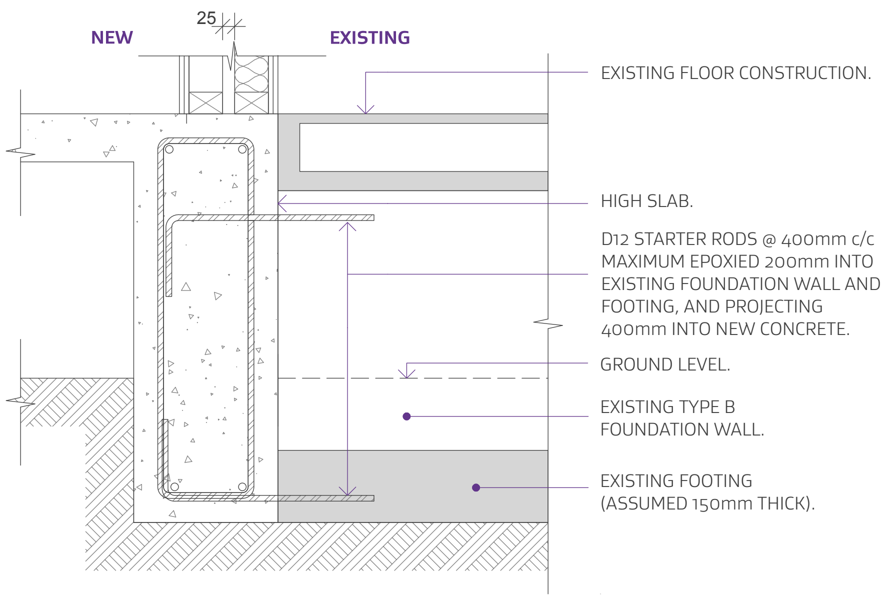


Figure 23.38: Foundation junctions high slab and Type B existing (elevation section)



Appendix E1: Garages within the building structure

Garages and carports within the building structure are a feature of many MUBs. They are generally located between units and often two garages for adjacent units will have a common firewall between them. Typical arrangements are shown in Figure E1.1. The garage floors are usually concrete slabs that are either accessed by steps down from the adjacent living area of a Type B dwelling or at the same level when it is a Type C dwelling.

For partial rebuilds the garage slab may be retained or an under-slab carried through. In either case where garages are integral to the building structure and located side by side (refer to Figure E1.3) the garage-to-garage wall will be built as both the acoustic firewall and the repairable zone (refer to Figure E1.4). For units with one integral garage between units the repairable zone wall will occur at the adjacent unit to garage wall (refer to Figure E1.2).

For full foundation rebuilds in TC3, continuity of the foundation beneath the living area and the garages is essential. If the living areas are to have a suspended timber floor then a Type 2A-150, 2A-300, or 2B foundation is suitable, depending on the calculated SLS vertical settlement. For these foundation options, the under-slab can extend through the garage areas. Alternatively a full replacement of existing Type C foundations may be achieved with a relevellable slab option for the better parts of TC3 (refer to section 15.4.8). A small step down from the living area into the garage area may be incorporated to control ingress of surface water but this is not essential.

Special provisions are recommended at the intersections of the walls and roof between the living and garage area when the unit floor foundation is a Type 2A-150 or 2A-300 and the garage is located on the end of a block of units. In this case, provision should be made for lateral differential movement of the cladding elements at the garage to unit wall line using the repairable zone details. This is especially true when the roof plane for the garage is at a different level from the unit.

Figure E1.1: Plan view of typical integrated MUB garages

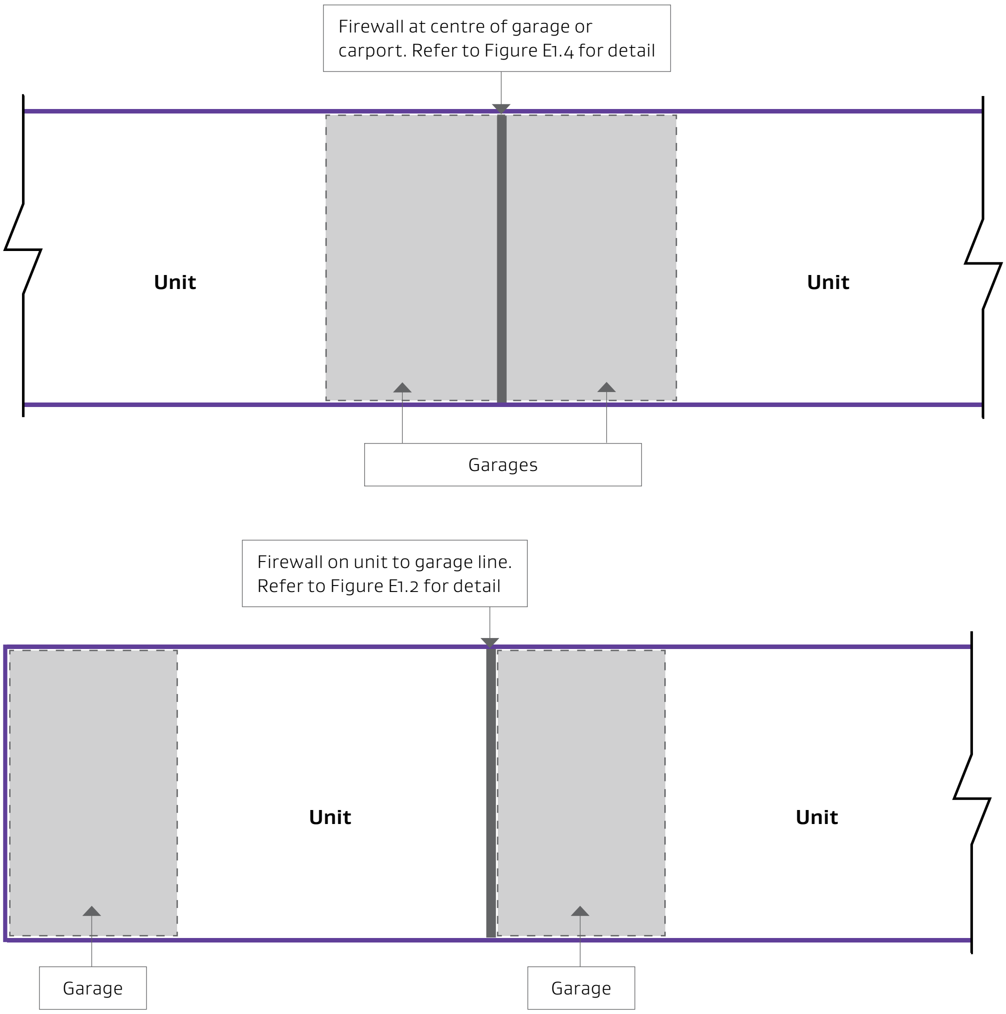


Figure E1.2: Garage/timber subfloor wall junction details for TC3 type 2A structure with repairable zone

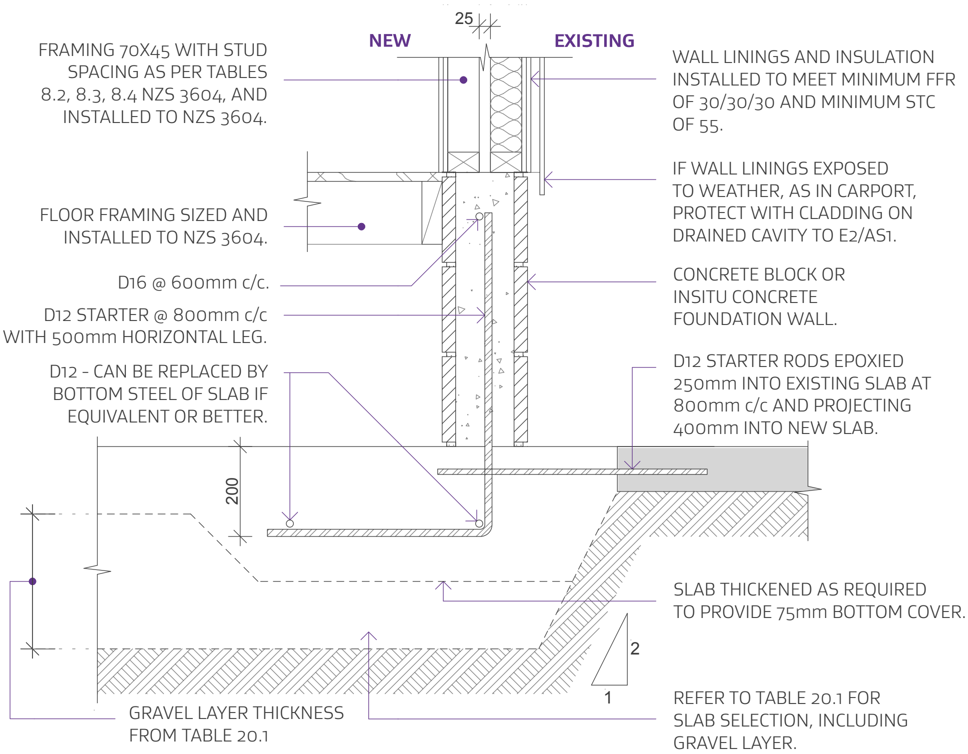
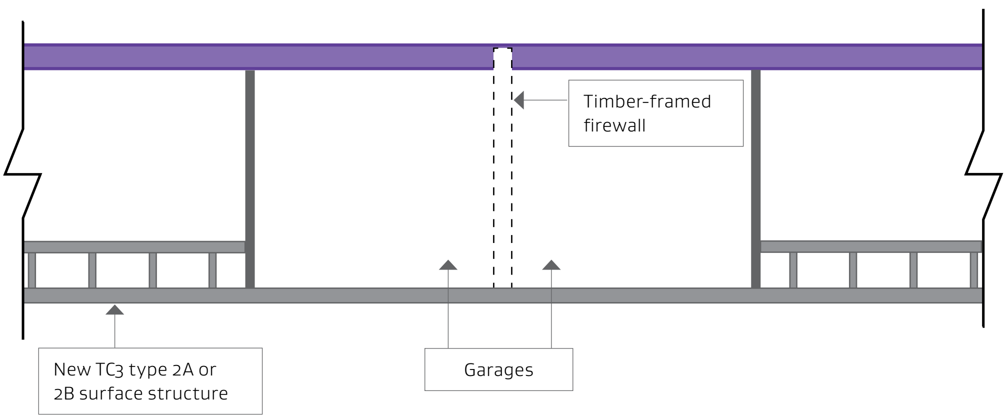
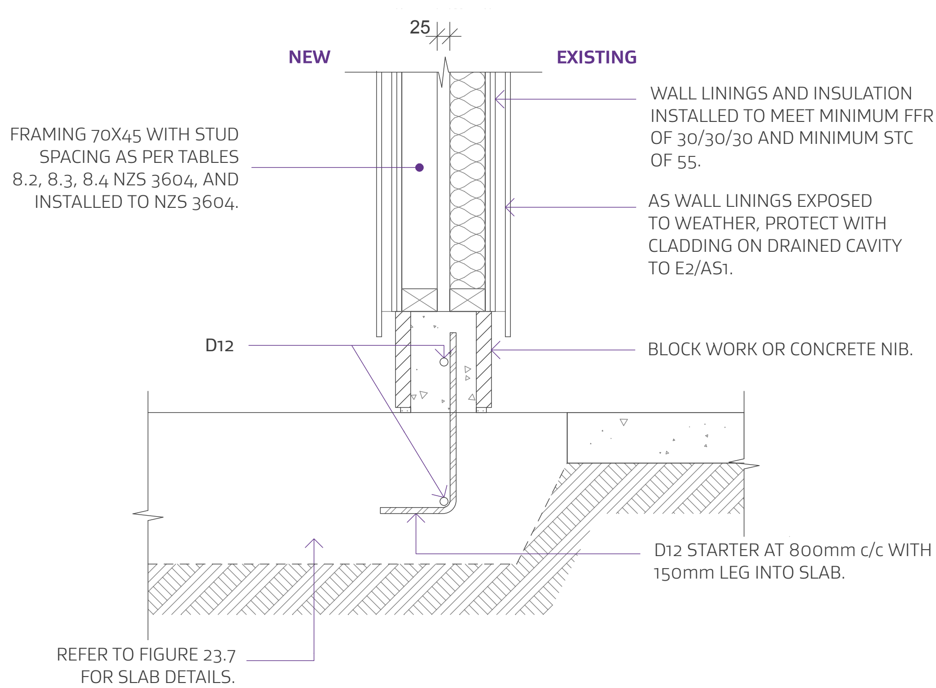


Figure E1.3: TC3 Type 2A-150, 2A-300 surface structure with garage in middle

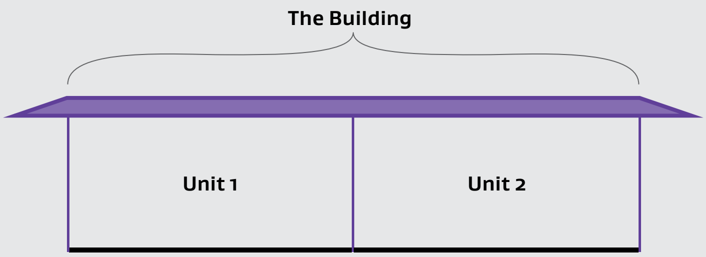


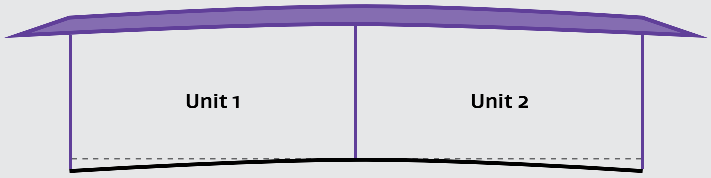
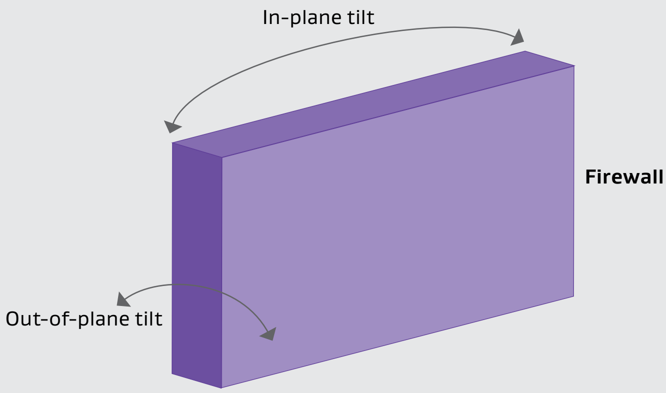
Typical details for the garage to garage junction are shown in Figure E1.4.

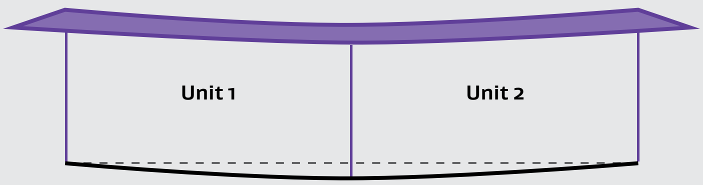
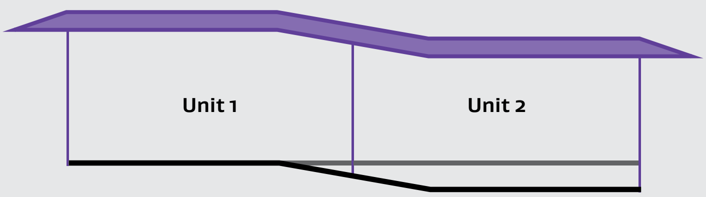
Figure E1.4: Garage/garage wall junction details with repairable zone



Appendix E2: Definitions

Term/Acronym	Definition
The Act	This refers to the Building Act 2014.
Building	This refers to the building as a whole, as defined by section 8 of the Building Act 2014 incorporating buildings having multiple titles and/or separate living arrangements rather than a standalone, single-titled detached house. 
Comparable	Similar to the extent that performance will be the same.
Complete or substantial replacement	The removal of the whole or a major proportion of an existing building and replacement with new foundations and superstructure.
Damage mechanism	The characterisation of damage to the whole building. Refer to section 18.4.
Determination	Formal decision after an application under section 177 of the Building Act.
Differential settlement	Varying foundation settlement along or across a building as referenced to level surface.
FFL	Finished floor level(s).
Firewall	A wall between fire cells that is rated to arrest fire transmission. Normally at the party wall boundary.
FMA	Flood management areas, as defined by the Christchurch City Council District Plan.
Heavy building	A building is considered heavy when it comprises either heavy cladding and/or roof. For definitions of heavy, medium, and lightweight cladding and roofing, refer to the glossary of terms.

Term/Acronym	Definition
Hogging	This term is used to describe foundation movement (edge settlement). 
Horizontal ownership	Ownership distributed laterally along the building, ie, each unit has a ground floor area and a portion of the roof, and can be one or more storeys in a single unit.
In-plane/out of plane tilt	Used to express movement of a firewall. 
Light building	A building is considered 'light' when both its roof is light and the cladding is of light or medium weight material. Refer to the glossary of terms for weight limits.
Mixed foundation	When a single building has more than one foundation type, for example a Type B building with a Type C extension or a Type B building with an internal concrete slab (Type C) garage. In the instance of a Type B building with an internal concrete slab (Type C) garage, the garage will typically be less than 25% of the entire foundation footprint. In this situation the predominant foundation type is Type B and the building foundation may be assumed to be Type B for the purposes of assessment.
MUB	Multi-unit building. A building with more than one residential unit.
Nett structural benefit test	A process of performance evaluation whereby the benefits of the new works proposed to be undertaken within parts of a building are compared to the detrimental effects of those works to the building as a whole.
On the flat	This term is used to distinguish the areas on the Canterbury Plains from areas in the Port Hills.

Term/Acronym	Definition
Partial rebuild	A partial rebuild for a MUB is where one or more units within a building (foundation or superstructure) require replacement, with other units retaining their existing foundation and superstructure (with or without repairs).
Planar tilt	A gradual or cumulative settlement of a building resulting in the whole building tilting uniformly. Refer to differential settlement.
Sagging/dishing	This term is used to describe foundation movement (settlement) where the middle of the building has settled more relative to the end or edge portions of the building. 
Settlement relative to surrounding land	When the building has settled into the land often resulting in the land sloping towards the building.
Site performed poorly (section 14.2.1)	This term is used when making an assessment of whether the site and building have performed well or poorly, factors to consider include: › Were there large amounts of liquefaction ejecta during the earthquake events? › Was there extensive ground cracking of the site? › Are there large ground undulations as a result of the earthquake events? › Has the dwelling settled relative to the surrounding land?
Type A, B, or C foundations	**Type A** Timber-framed suspended timber floor structures supported only on piles. **Type B** Timber-framed suspended timber floor structures with perimeter concrete foundation. **Type C** Timber-framed dwelling on concrete floor (slab-on-grade). For more information, refer to section 2.
Uniform settlement of a portion of the building	This term is used to describe the displacement of superstructure loads laterally through the foundation in a manner that limits differential movement (settlement). 

Term/Acronym	Definition
Unit	A single residential occupancy within a larger building complex.
Unit repair threshold	Threshold of repair where up to 50% of the concrete slab, 50% of the perimeter foundation beam, and/or 50% of the piles can be replaced within an individual unit within a multi-unit building without separate foundation rebuild criteria being imposed.
URM	Unreinforced concrete block or brick masonry wall.
Vertical ownership	Different owners on each level of a building, ie, apartment style ownership.