

GUIDANCE

Repairing and rebuilding houses affected by the Canterbury earthquakes.



A TECHNICAL GUIDANCE

B TECHNICAL INFORMATION

C TECHNICAL CATEGORY 3

D SUBDIVISIONS



Ministry of Business,
Innovation & Employment

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This document's status

This document is issued as guidance under section 175 of the Building Act 2004. The Department of Building and Housing became part of the Ministry of Business, Innovation and Employment (MBIE) on 1 July 2012. The former Department of Building and Housing is referred to in this document as 'the Ministry'. While the Ministry has taken care in preparing this document, it is only a guide and, if used, does not relieve any person of the obligation to consider any matter to which that information relates, according to the circumstances of the particular case. The document will be updated from time to time and the latest version is available from the Ministry's website at www.dbh.govt.nz.

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Scope of update

This is the third edition of the guidance for repairing and rebuilding houses following the Canterbury earthquake sequence and supersedes the guidance documents published in December 2010, November 2011, April 2012 and September 2012. This update is provided in a new loose-leaf format to allow the guidance to be updated on a regular basis. It now incorporates all parts of the residential foundation guidance in one volume:

- **Part A** – Technical Guidance
- **Part B** – Technical Information
- **Part C** – Guidance for assessing, repairing and rebuilding foundations in TC3
- **Part D** – Guidelines for the investigation and assessment of subdivisions in the Canterbury region

The guidance is presented in a new format, with associated editorial adjustments, particularly in relation to Part C which was previously issued as a separate volume.

There are also updates to some technical provisions, although the guidance has not been subject to a comprehensive review.

Where changes to the document have been made, these are identified as updates and deletions via margin notes within the document.

Foreword

This document, issued by the Ministry, provides technical guidance for repairing and rebuilding houses in the Canterbury region following the Canterbury earthquake sequence. Publication of this document is a part of the Government's support for long-term recovery in Canterbury. It gives robust and well-balanced engineering solutions that will reduce the risk of injury to people and damage to homes in future earthquakes.

The technical guidance has been developed in response to the Canterbury earthquake of 4 September 2010 (sometimes referred to as the Darfield earthquake). Since the 2010 guidance was published, there have been numerous aftershocks, large and small, including the disastrous 22 February 2011 aftershock, known as the Lyttelton aftershock. This document incorporates information gained from each significant aftershock and extensive scientific and geotechnical investigation into the impacts of the Canterbury earthquake sequence. In particular it draws on learnings about the effects of liquefaction. The scale of liquefaction in the Canterbury earthquake sequence, and the impact on residential dwellings, highlighted the importance of ensuring there are appropriate foundations on land that may be subject to liquefaction in major events.

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Properties in the Canterbury Green Zone have been assigned (on an area-wide basis) one of three technical categories for foundation investigation and design guidance (TC1, TC2 and TC3). These categories describe, on an area-wide basis, how the land might perform in future large earthquakes and the foundations that are considered appropriate to reduce the risk of injury and damage. The technical categories were developed to guide consent authorities, engineers, builders and insurance companies on the level of site investigation required and, based on the site investigation results, the most appropriate foundation systems for a particular site. The technical categories were the result of intensive research and analysis based on a mix of historical and post-earthquake data, discussions with geotechnical consultants and research groups, and a degree of engineering judgement. The technical categories are based on an area-wide analysis of observed damage and known geological conditions.

Without the technical categories and the Ministry's guidance, every site where foundation repairs are required in the Green Zone would require further geotechnical investigation and site-specific foundation design. The technical categories ensure valuable engineering resource is directed where it is needed most (TC3 areas, for example) and will enable homeowners to commence repairs with greater certainty.

The volume of repair and reconstruction activity is placing challenges on the insurance assessment, engineering design, construction and consenting capacity available in New Zealand. The reconstruction has and will continue to put pressure on New Zealand's engineering resources, both structural and geotechnical. Given the numerous aftershocks, insurers and reinsurers need confidence that the rebuilding work is robust, will reduce the risk of damage in future large events and does not involve unnecessary expense. There is also pressure on councils to process large volumes of consent applications. This has the potential to result in delays to homeowners and slow the re-establishment of the most affected communities.

Overseas experience of recovery from major events has shown that confusion, delays and additional design costs can occur if designers, insurers and councils have different perspectives. The Ministry's guidance encourages consistency of approach. It identifies areas where costly investigations and design for properties are unnecessary and recommends site-specific investigations for certain properties, where significant land damage from liquefaction may be possible in future large events. It provides solutions and construction methods that will meet the requirements of the Building Act and Building Code while avoiding 'over-design'.

It also includes useful information on retaining walls for hillside properties, chimney repairs and repairs to wall and roof frame connections, steel and pole frames and masonry walls. This provides guidance for the many dwellings that have suffered minor damage to the superstructure, such as damaged chimneys and superficial cracking to cladding or linings.

Following the methods or solutions proposed in the document is not mandatory. Different and improved details and methods may well be developed as the recovery proceeds. Earthquakes and their effects are complex. Investigations into the full picture of how residential structures responded to liquefaction effects are ongoing.

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The Natural Hazards Research Platform

Sections

Introduction

Part A: Technical guidance

Part B: Technical information

Part C: Assessing, repairing and rebuilding foundations in TC3

Part D: Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region

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Glossary of terms

List of acronyms

1. Introduction

1.1 Background

1.1.1 Damage from the Canterbury earthquake sequence

The Darfield earthquake of 4 September 2010 was an internationally significant event that focused attention on damage to residential properties from liquefaction and lateral spreading. The 22 February 2011 Lyttelton aftershock caused further liquefaction that affected houses across a far wider area of Christchurch, and caused extensive rockfall and some landsliding on the Port Hills. Significant shaking damage was also observed in the hill suburbs.

Other significant aftershocks, most notably on 13 June 2011 and 23 December 2011, again caused liquefaction in the low-lying areas worst affected in the 4 September 2010 and 22 February 2011 events, and further shaking damage to hillside properties.

As at the end of 17 September 2012, approximately 460,000 insurance claims relating to 120,000 properties had been submitted to the Earthquake Commission (EQC). Of these properties, approximately 30,000 are likely to have experienced land damage as a result of the Canterbury earthquake sequence (ground deformation resulting from the effects of liquefaction, landslip and rockfall), ranging from very minor to very severe. The effects of liquefaction included differential and overall vertical settlement and lateral spreading, with the latter being the most damaging to buildings and infrastructure.

The majority of the dwelling damage claims not affected by land damage relate to minor damage such as damaged chimneys and superficial cracking to cladding/wall linings.

In many cases, damage will have increased following the subsequent major aftershocks.

1.1.2 Residential land zones

On 23 June 2011, the Government and the Canterbury Earthquake Recovery Authority (CERA) announced four residential land zones:

- **Green** – repair/rebuild process can begin
- **Red** – land repair would be prolonged and uneconomic
- **Orange** – ‘hold zone’, further assessment required; to be rezoned Red or Green depending on further investigation
- **White** – ‘un-zoned’, parts of the Port Hills and CBD; still being mapped.

Subsequent announcements have resolved the status of properties that were initially designated within the Orange and White Zones, see www.cera.govt.nz

Guidance provided in this document focuses primarily on the Green Zone on the flat¹ and to a lesser extent the Port Hills areas affected by landslip, rockfall and shaking damage.

(1) The term ‘on the flat’ is used to distinguish the areas affected by liquefaction from the Port Hills area

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This document has been prepared in conjunction with work undertaken by Tonkin & Taylor Ltd for the Government, in order to coordinate the analysis and mapping of land and residential building damage.

1.2 Objectives

The principal objective of this document is to provide building repair and reconstruction solutions and options that:

1. are appropriate to the level of land and building damage experienced
2. take account of the likely future performance of the ground
3. meet Building Act and Building Code requirements
4. are acceptable to insurers and property owners.

Increasing the resilience of residential dwellings is also an underlying objective.

Increasing resilience however involves a range of possibilities. For houses on land that has the potential for future liquefaction, achieving optimum resilience would involve remediating the ground to remove or reduce this potential. While this approach may be preferable for new subdivisions where the cost per property can be minimised, it may not be practical for individual developed sites. In addition, it is not necessarily within the scope of insurance cover or regulatory requirements for a given level of damage.

The guidance provided in this document aims for a consistent approach to repair and rebuilding that minimises the individual investigation and design effort required for each property. It takes a prudent approach that is mindful of costs and risks, providing solutions and construction methods that aim to meet the requirements of the Building Act and Building Code. It also looks to satisfy the relevant insurance requirements without giving rise to 'betterment concerns'. Independent costing advice indicates a strong positive benefit to cost in following the proposals in the document.

Owners may choose to specify additional measures to achieve greater levels of resilience, noting that this is likely to be outside the scope of insurance contracts and would also require specialist geotechnical engineering advice.

1.3 Regulatory context

All work undertaken to repair damage is 'building work' and needs to comply with Building Code requirements, whether or not a building consent is required.

After repair work that requires a building consent is carried out, a building needs to comply, as nearly as is reasonably practicable, with the provisions of the Building Code that relate to means of escape from fire and access and facilities for persons with disabilities. It must also continue to comply with the other provisions of the Building Code to at least the same extent as before the repair work.

However, the requirement for access and facilities for people with disabilities does not apply to private houses, while special fire safety requirements for houses are essentially limited to the installation of domestic smoke alarms. **Note:** If the house is not fully detached there may be other requirements. This means the requirements can generally be satisfied by installing smoke alarms and by demonstrating that the overall performance of the house for structural safety, weathertightness, sanitary, etc, is no worse than before the application for building consent (ie, before the repair work).

Repairs being undertaken, therefore, do not require the building to be fully upgraded to comply with the performance requirements of the Building Code. Only the **scope of work being undertaken** needs to comply with Building Code Requirements.

In undertaking repairs and rebuilding, particular attention needs to be paid to health and safety requirements. The Health and Safety in Employment Act 1992, the Hazardous Substances and New Organisms Act 1996, and the various regulations made under these Acts need to be complied with. The MBIE fact sheet “Lifting Earthquake-Affected Buildings in Christchurch” provides appropriate guidance on lifting existing buildings to enable foundations to be repaired or rebuilt (refer www.dol.govt.nz/quake/lifting-earthquake-affected-buildings-christchurch.pdf). Where repairs are undertaken and there is a possibility of asbestos being present in the building the MBIE fact sheet “Disaster Recovery – Asbestos Management” should be consulted for guidance (refer to www.dol.govt.nz/quake/asbestos-management.pdf).

This document is issued as guidance under section 175 of the Building Act 2004, so the methods and solutions presented here are not mandatory. This guidance has been endorsed by the Christchurch City, Waimakariri, and Selwyn District Councils which if followed will result in consents being issued.

For more details on insurance and regulatory requirements, refer to section 8.2 and Appendix C1.

1.4 Scope

1.4.1 Audience

This guidance is intended for the engineering design, construction and insurance sectors, building consent authorities, PMO’s and their professional advisors and contractors.

1.4.2 Canterbury focus

The options and recommendations in this document are specific to residential properties directly affected by the Canterbury earthquake sequence. The information on reducing the effects of liquefaction on residential properties should not necessarily be taken as a best practice guide for addressing liquefaction in other parts of Canterbury or New Zealand.

National best practice guidance for the design of residential dwellings to take account of potential liquefaction will be prepared in due course, and will draw on information in this document.

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1.4.3 Technical scope

The document focuses principally on one- and two-storey timber-framed dwellings, which are the dominant form of construction in the affected area (ie, houses built to NZS 3604 or its predecessor Standard).

There are, however, other forms of construction and materials for which other design approaches and documentation apply (for example, non-specific design standards such as NZS 4229 for reinforced concrete masonry). Assessment and repair specifications for these types of buildings will require case-by-case consideration, although the guidance provided on assessment, repair and reconstruction of foundations and floors may apply.

The guidance provides standard methods and solutions for the assessment, repair and rebuilding of foundation and floor elements. The guidance focuses primarily on solutions for Green Zone land on the flat. Advice on assessing the effects of land movement on houses and retaining walls on the Port Hills is also included, along with limited general information on repairs as in most cases specific advice will be required.

For superstructure damage resulting from strong ground shaking, standard repair methods can be used in most cases. Some guidance is included in this document, particularly for chimneys, plasterboard linings and unreinforced masonry.

Even though future liquefaction may occur within the Green Zone, and there remains uncertainty about the extent and severity of future ground deformations, this is expected to be manageable by appropriate design.

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The 22 February 2011 aftershock brought a greater understanding of damage to houses from liquefaction, particularly about the extent of ground damage that is likely to result in excessive settlement of the house. This has led to land on the flat being assigned into three foundation technical categories based on the expected future liquefaction performance:

- **TC1:** Liquefaction damage is unlikely in future large earthquakes. Standard residential foundation assessment and construction is appropriate.
- **TC2:** Liquefaction damage is possible in future large earthquakes. Standard enhanced foundation repair and rebuild options in accordance with MBIE guidance are suitable to mitigate against this possibility.
- **TC3:** Liquefaction damage is possible in future large earthquakes. Individual engineering assessment is required to select the appropriate foundation repair or rebuild option.

Parts A and B of the guidance concentrate on areas where the overall settlement in a future earthquake is not expected to be excessive (ie, TC1 and TC2).

Houses on land in TC3, where overall house settlement may be significant in a future earthquake, will generally require deep geotechnical investigation and site-specific engineering design for new foundations. Options including deep piles founded to a good bearing layer will be required. Other innovative and economic foundation system solutions, including ground treatment options, have also been trialled. Further guidance on assessment and solutions in TC3 is included in Part C: Assessing, repairing and rebuilding foundations in Technical Category 3.

To mitigate the effects of liquefaction, as a guiding **principle it is preferable to build using light materials rather than heavy materials**. This particularly applies in properties categorised as TC2 or TC3 or in uncategorised areas where liquefaction is possible. Light construction (roof, walls and floors) significantly reduces the imposed loads on the subsoils and therefore the potential for liquefaction-induced settlement. For example, lightweight construction imposes as little as 30% of the imposed weight around the perimeter compared to a heavy roof, masonry cladding and concrete slab dwelling.

This document does however provide foundation solutions that may enable other forms and weights of building elements to be used.

Table 1.1 summarises the future land performance criteria and the corresponding repair and reconstruction approaches for each technical category.

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Table 1.1: Summary table of technical categories, land criteria and repair and rebuild approaches.

Foundation technical category	Land criteria	Where new foundations are required (including floor slab) ¹	Where foundations are to be repaired only (including floor slab)	Superstructure repairs only (no foundation damage)
TC1	Liquefaction is unlikely in future large earthquakes	Use foundations provided in NZS 3604 Timber Framed Buildings, as modified by B1/AS1 which requires ductile reinforcing in slabs (refer to the Ministry's information sheet at www.dbh.govt.nz/seismicity-info)	Refer to section 4	Refer to section 7
TC2	Liquefaction damage is possible in future large earthquakes	New houses with light- or medium-weight cladding, light-weight roofing with suspended timber floors and foundations in accordance with NZS 3604 ² or Replace foundation with enhanced slab Options 1 to 5 as provided in section 5		
TC3	Liquefaction damage is possible in future large earthquakes	Specific geotechnical investigations and engineering design required For foundation options where TC3 performance is confirmed see Part C	Refer to Part C	

(1) Solutions provided are minimum recommendations. Homeowners can always choose more robust options, noting the need to discuss this with the insurer.

(2) Refer to Glossary.

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Individual house owners may wish to go beyond the solutions suggested in this document and specify a higher level of foundation performance or resilience. This document provides information on the relevant engineering principles and parameters for an enhanced foundation and floor system. This information should assist engineers undertaking specific structural and geotechnical engineering design, and inform discussions with insurers as to whether the proposed solution falls within the scope of the insurance policy.