

FINAL REPORT



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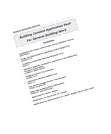
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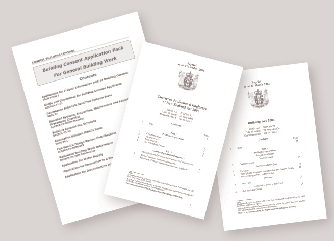
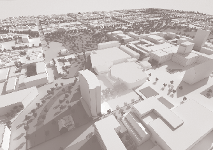
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**VOLUME 7**

ROLES AND RESPONSIBILITIES



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A. Safety assessment personnel at work in the Christchurch Central Business District after the 22 February 2011 earthquake (source: Applied Technology Council)

B. Barricades erected on Colombo Street after the 4 September 2010 earthquake

C. The Building Act 2004, the Chartered Professional Engineers of New Zealand Act 2002 and a building consent application pack

D. Context for the new Square, the civic heart of central Christchurch (source: Central City

Development Unit/Canterbury Earthquake Recovery Authority)

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**Section 1: Introduction**

The Royal Commission’s Terms of Reference require us to consider “the adequacy of the current legal and best-practice requirements for the design, construction and maintenance of buildings in central business districts in New Zealand to address the known risk of earthquakes”.

The Terms of Reference specifically provide that, in doing so, we must investigate, among other things, the legal and best-practice requirements for the assessment of buildings after earthquakes and of any remedial work carried out on them. In section 2 of this Volume, the Royal Commission explores the legal and best-practice requirements underpinning the building safety evaluation process following a severe earthquake. The Canterbury earthquakes have provided a very stern test of the existing legal requirements and perceived best-practice in assessing buildings after earthquakes. We consider the lessons able to be learned from these events. This builds on observations already made in Volume 4, where we discussed the approach taken in Christchurch after the September and Boxing Day earthquakes to assess individual buildings that failed in the February earthquake. Our observations also discuss how buildings should be managed after the transition from civil defence to normal building control arrangements.

Among the recommendations that we make are recommendations relating to the manner in which buildings are evaluated after significant earthquakes, the development of evaluation guidelines, and training for building safety evaluators. Other recommendations cover the placarding system used in the rapid assessment process; we favour in principle changing from green to white the placards currently used to indicate that a building has been inspected without significant damage being observed. We also make recommendations about the kinds of evaluations to which buildings should be subjected to before their long-term reoccupation after a significant earthquake.

The Terms of Reference also require the Royal Commission to consider “the roles of central and local government, the building and construction industry and other elements of the private sector in developing and enforcing legal and best-practice requirements”.

Through the course of our Inquiry we identified systemic issues relating to the regulatory framework for buildings. These issues include misunderstandings of the framework, a complex and confusing suite of regulatory documents, and quality assurance issues. There was also a fundamental issue raised by some submitters about a lack of “leadership” in the regulatory field. Section 3 of this Volume briefly describes the key elements of the current building control framework. We then discuss and make recommendations to address these issues. (Volume 4 of this Report discusses and makes recommendations about the legal and best-practice requirements for buildings that should be treated by law as earthquake-prone. That subject is not revisited in this Volume.)

Recommendations in section 3 include various proposals to enhance quality assurance. Examples are a proposed requirement for provision of a Structural Design Features Report with the building consent applications for all commercial and residential buildings of three or more storeys (provided, in the case of residential buildings, the building will contain three or more household units) as well as for proposed buildings in importance levels 3–5 as defined in the relevant Standard.1 The structural design features report would then be used to assess whether the building is complex. Complex structures would require certification by a recognised structural engineer, a qualification that we address in section 4. We also make recommendations in section 3 that are designed to enhance the leadership of the sector, by providing for the position within the Ministry of Business, Innovation and Employment (MBIE) of Chief Structural Engineer, with a leadership role in relation to complex buildings; and for the development by MBIE, in consultation with interested groups, of a policy and regulatory work programme. This programme would identify the priorities for the development, review and

update of compliance documents and Standards. The development and implementation of the Programme would be the responsibility of the Chief Structural Engineer. We also recommend that Standards referenced in the Building Code should be available online, free of charge.

The Royal Commission also examined current arrangements for the education and training of structural and geotechnical engineers in New Zealand, the competence standard used by the Institution of Professional Engineers New Zealand (IPENZ) to register engineers, and the occupational regulations and ethical rules that apply to the engineering profession. Section 4 of this Volume reports our consideration of these matters. We compare New Zealand practice with that of other countries, and describe how the training of engineers here conforms with international best-practice.

We were confirmed in our decision to inquire into these matters as a result of evidence that we heard in relation to the failure in the February earthquake of individual buildings considered as part of the representative sample of buildings, including the CTV building. While the failure of the CTV building had tragic consequences and can in large part be attributed to the inadequacy of its design, we discuss other cases as well where the designers of the buildings had evidently failed to recognise fundamental aspects of structural behaviour. A closely linked concern relates to the ability of the regulatory system to pick up defective designs in the processing of building consents for complex structures. In the case of the CTV hearing, there was evidence from experienced structural engineers that it would not have been reasonable for the Christchurch City Council (CCC) checking engineer to have identified some design defects. It is against the background of the discussion in section 4 that we recommend that legislation should provide for Recognised Structural Engineers to be involved in the design or peer review of complex structures. Such engineers would be Chartered Professional Engineers but with special competence in the field of structural engineering, and who would be well experienced in the design of complex structures. We propose that a set of qualifications and competencies for Recognised Structural Engineers be developed by MBIE in consultation with the Chartered Professional Engineers Council, IPENZ and others.

In section 5 of this Volume we examine local

government management of earthquake risk. The Terms of Reference for the Royal Commission require us to consider whether or not the legal and best-practice requirements for building design, construction and maintenance adequately manage risks of building

failure caused by earthquakes. The Terms of Reference refer explicitly to the role of local government in developing and enforcing legal and best-practice requirements. One way of minimising the failure of buildings in future earthquakes is to ensure that new development occurs on land that is suitable for development, having regard to its susceptibility to liquefaction, lateral spreading or significant softening of soils in earthquakes, and the ability to provide suitably robust foundations for new buildings. In Volume 1 we dealt with issues such as subsurface soils investigation, ground improvement techniques and issues of foundation design. However, we also thought it appropriate to consider how the local authorities in the Canterbury region had dealt with the issue of earthquake risk in exercising their Resource Management Act powers, and we commissioned Mr Gerard Willis of Enfocus Limited to examine the way that the planning documents of both the Canterbury Regional Council (CRC) and the CCC deal with earthquake risk. The Enfocus report considered the steps the CRC and the CCC have taken under the Resource Management Act 1991 to avoid and mitigate the effects of natural hazards, one of which is earthquakes. We have taken that report into account as well as submissions on it.

Drawing on the experience in the Canterbury region, we recommend that sections 6 and 7 of the Resource Management Act 1991 be amended to ensure that regional and district plans are prepared in a way that acknowledges the potential effects of earthquakes and liquefaction, and to ensure that such risks are considered in the processing of resource and subdivision consents.

**References**

1. See Table 3.2 in AS/NZS 1170.0:2002. *Structural* Design *Actions Part 0: General Principles ,* Standards Australia/ Standards New Zealand.

**Section 2:**

**Building management after earthquakes**

**2.1 Introduction**

Of the 185 people who lost their lives in the earthquake on 22 February 2011, 175 people died as a result of building failures. The Royal Commission has investigated all of the buildings and structures that failed causing these deaths. We have considered the failures of the Canterbury Television (CTV) building, and the Pyne Gould Corporation (PGC) building, where respectively 115 people and 18 people died. We have also inquired into the failures of other individual buildings or structures that resulted in the deaths of 42 people. In all but one of these individual buildings, the deaths were caused when older, unreinforced masonry buildings or brick or block structures failed.

The Royal Commission has received evidence that describes the manner in which these buildings were assessed after the 4 September 2010 earthquake and the process for assigning placards to buildings.

This section considers the framework and assumptions that underpin the management of buildings after an earthquake, both during and after a state of emergency. We briefly outline New Zealand’s civil defence and emergency management framework and give an overview of the building safety evaluation process used to assess buildings after an earthquake. In section 2.4, we discuss who should be responsible for the development and maintenance of this process. We consider whether or not the process needs a specific legislative mandate, and what its objectives and scope should be. The Royal Commission heard evidence

that the objectives of the building safety evaluation process are not well understood by the public and some building safety evaluators. Skilled evaluators

are needed to successfully carry out a building safety evaluation operation, so we consider the methods, frameworks and assumptions evaluators use when

they assess buildings. We particularly focus on whether the use of damage-based assessments is appropriate and if evaluators need to change the way in which they account for aftershocks. This section also explores options to ensure that New Zealand has sufficient numbers of skilled evaluators. The Royal Commission considered it important to look at whether or not the current system is the right approach or model. Having

done so, we consider that the current approach is appropriate and in accordance with international best- practice. However, we recommend making changes to improve the delivery of the current system. We have not found a viable alternative.

Section 2.5 records the results of our investigation into the delivery of the building safety evaluation operations after the Canterbury earthquakes. In section 2.6, we discuss the issues that arose when the responsibility for the building safety evaluation process transitioned from civil defence to normal building management arrangements. The Royal Commission considers that these issues negatively impacted on the building safety evaluation operation after the Canterbury earthquakes, especially the management of buildings that may be suitable for reoccupation but still in need of repair. We review options for a transition mechanism and make recommendations for change.

This section must be read in the context of earlier Volumes of our Report. We note that some of the problems that arose with the delivery of the building safety evaluation process and its transition to normal building management arrangements demonstrate issues with the normal management of buildings: for example, the legislative barriers delaying the repair or demolition of damaged buildings. We discuss and make recommendations about particular issues raised in this section in Volume 4 of the Report. The recommendations we make in this section regarding the management of unreinforced masonry buildings after earthquakes should also be read in the context of our discussion about these buildings in Volume 4.

The Royal Commission considers that, overall,

New Zealand was very well served by the engineers, building control officials, and other civil defence workers who participated in the building safety evaluation operations in Canterbury, most of whom were volunteers who worked to ensure the safety of the wider Christchurch community in very difficult circumstances. Some of the volunteers gave valuable evidence to the Royal Commission to assist our understanding of where improvements can be made. New Zealand owes them a debt of gratitude.

2.1.1 Background

At 4:35am on 4 September 2010, a 7.1 magnitude earthquake occurred with an epicentre 40km west of Christchurch, on a previously unknown fault beneath the Canterbury Plains. This earthquake damaged Christchurch’s older brick and masonry buildings, historic stone buildings and Canterbury homesteads. It seriously affected the city’s eastern suburbs and Kaiapoi, both of which experienced liquefaction and lateral spreading. Broken water and sewer pipes caused flooding. A state of local emergency was declared.

The magnitude 4.7 aftershock on 26 December 2010, which we will refer to as the Boxing Day aftershock, occurred at 10:30am. It had an epicentre located 1.8km north-west of Christ Church Cathedral. Although its effects were localised, this aftershock caused further damage to buildings in the Central Business District (CBD). No state of emergency was declared.

On 22 February 2011, at 12:51pm, what is now known as the Port Hills Fault ruptured. The fault ruptured on a northeast-southwest orientated fault at a shallow depth, reaching to within one kilometre of the surface. This earthquake had a magnitude of 6.2. Its epicentre was located 6km south-east of Christchurch’s CBD. Although this earthquake was of a lesser magnitude than the September earthquake, it was the most destructive of the Canterbury earthquakes because its resulting ground motions were extremely high. Many buildings damaged in the September earthquake were brought down and many heritage buildings sustained major damage. Many modern buildings experienced higher structural failure and a number of modern buildings were damaged beyond repair. Christchurch experienced widespread liquefaction. One hundred and eighty-five people died from the injuries they received in this earthquake. A national state of emergency was declared. Failures that resulted in loss of life are reported in Volumes 2, 4 and 6.

A magnitude 6.0 aftershock occurred on 13 June 2011 at 2.20pm. Its epicentre was located near Sumner. This aftershock caused further widespread damage in Christchurch and Lyttelton. Once again, Christchurch experienced widespread liquefaction and there were rock falls from cliffs in the Port Hills suburbs.

There is a detailed discussion of the Canterbury earthquake sequence and the seismicity of Christchurch and the wider Canterbury region in Volume 1 of this Report.

2.1.2 The scope of this section of the Report and the Royal Commission’s approach

This volume of the Report considers lessons learned from the building safety evaluation operations carried out after the earthquake events that occurred between September 2010 and June 2011.

The Royal Commission received several reports on the building safety evaluation operations. A report from the Ministry of Civil Defence and Emergency Management1 sets out the key principles and the underlying approach behind New Zealand’s civil defence and emergency management framework. The Ministry of Civil Defence and Emergency Management was in the process of preparing an independent review of the civil defence and emergency management operations after the September earthquake when it was overtaken by events following the February earthquake. A draft of this report2 was made available to the Royal Commission. In addition, we commissioned a review of the building safety evaluation operations after the Canterbury earthquakes by the New Zealand Society for Earthquake Engineering3 (NZSEE). This report was prepared by Mr David Brunsdon of the Kestrel Group. Further, Christchurch City Council4 (CCC) provided the Royal Commission with a report on the building safety evaluation operation in the Christchurch CBD after the September earthquake. At our request, CCC also released a draft report focusing on the processes used after the state of emergency, by Ms Esther Griffiths (now Ms Newman) and Mr Dene McNulty5. This report was not finalised and was not formally “received” by the CCC. In the discussion that follows, we refer to these documents as “the reports” received by the Royal Commission.

We have also had regard to the draft report by the Applied Technology Council (ATC)6 on the building safety evaluation operation after the February earthquake, prepared by Mr Ronald Gallagher, Mr Jim Barnes and Mr Bret Lizundia. ATC developed the Californian building safety evaluation process on which New Zealand’s is based. The authors of its draft report on the Christchurch operation in February 2011 are experts in these processes. Mr Bret Lizundia gave evidence to the Royal Commission as our international peer reviewer on this topic.

On 4 November 2011, the Royal Commission called for submissions on the subject of building assessments after earthquakes; submissions closed on 17 February 2012. We received seven submissions. On 21 June 2011, the Royal Commission called for submissions on our *Discussion Paper*: *Building Management After Earthquakes*. We received 12 submissions on the discussion paper. Appendix 3 of Volume 5 lists these submitters.

2.2.1 National civil defence arrangements

New Zealand’s civil defence and emergency management framework is set out in the Civil Defence and Emergency Management Act 2002. Figure 1 sets out the key elements of this system.

The Royal Commission held a hearing on managing buildings after earthquakes on 3–4 September 2012. A list of the witnesses who gave evidence at this

**Local**

**Plans**

**Local**

**Plans**

**Local**

**Plans**

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hearing can be found in Appendix 3 of Volume 5. The Royal Commission has also held hearings on the CTV building, the PGC building, and the failure of many individual buildings causing death. Evidence from these hearings, discussed in Volumes 2, 4 and 6 of this Report, informs the discussion, conclusions and recommendations we set out in this section.

To provide context for our discussion, we give below an overview of New Zealand’s civil defence and emergency management framework.

**2.2 New Zealand’s civil defence and emergency management framework**

The intent of the civil defence and emergency management framework is to deal with the consequences of a disaster by:

• *reducing* the risk associated with the disaster;

• building *readiness* to respond to the disaster;

• *responding* to the disaster; and

• setting up *recovery* processes that reduce the impacts of future disasters.

**16 CDEM Group Plans National CDEM Plan/Guide National CDEM Strategy**

**CDEM Act 2002**

**Figure 1: Key elements of New Zealand’s civil defence and emergency management framework (source: adapted from the Ministry of Civil Defence and Emergency Management, 2011)**

The Civil Defence and Emergency Act 2002 requires the development of a National Civil Defence and Emergency Management Strategy7 and a National Civil Defence and Emergency Management Plan8. The National Civil Defence and Emergency Management Plan is set out in an Order in Council (the National Civil Defence Emergency Management Plan Order 2005) and is supported by a Guide9. These documents identify community goals, set out how to respond to a national emergency and describe how to support the local management of emergencies.

The Minister of Civil Defence can declare a national state of emergency in all or part of the country. The Minister and/or local authorities can declare local emergencies. A state of emergency can last up to seven days, although it can be extended indefinitely in seven day increments. Declaring a state of emergency allows civil defence authorities to exercise a wide range of statutory powers.

2.2.2 Local civil defence arrangements

New Zealand’s civil defence framework is constructed from elements put in place at the local level. Section 12 of the Civil Defence and Emergency Management Act 2002 requires local authorities to establish Civil Defence and Emergency Management Groups for each region of New Zealand. Each Group is required to develop a Civil Defence and Emergency Management Plan. These Groups are a core element in New Zealand’s civil defence and emergency management framework. New Zealand has 16 Civil Defence and Emergency Management Groups. The Canterbury Group is made up of 10 local authorities.

Territorial authorities are the first to respond to emergencies in their own areas. They are expected to take the lead in responding to a disaster such as earthquake. Regional and national civil defence and emergency management both activate to support the territorial authority managing the response to the disaster. Regional or national civil defence and emergency management may also take over if the territorial authority is significantly impacted and/or overwhelmed.

Each local authority must plan and provide for civil defence and emergency management within its district. A fundamental principle in New Zealand’s civil defence framework is the idea that the amount of detail that a local authority puts in its emergency management plans should reflect the level of risk a particular disaster poses to the buildings in the district. The emergency management plans for larger cities and areas of higher seismicity should therefore be more detailed and specific.

2.2.3 The civil defence response to the

Canterbury earthquakes

Within an hour of the earthquake at 4:35am on

4 September 2010, the CCC, Waimakariri District Council and Selwyn District Council each declared a local state of emergency for their area. They each established their own Emergency Operations Centre run by a Local Controller. The Canterbury Civil Defence and Emergency Management Group also set up an Emergency Coordinating Centre at the Environment Canterbury premises in Christchurch. The Local Controllers were in charge of their district’s response to the earthquake, including their building safety evaluation operation. All three local states of emergency ended at midday on 16 September 2010.

The earthquake on 22 February 2011 occurred at

12.51pm. CCC declared a local state of emergency at

2.45pm. The immediate response was led by CCC staff, who established an Emergency Operations Centre in the Christchurch Art Gallery, as the primary emergency operations centre in the main council building was inaccessible. At 10.30am on the following day, the Minister for Civil Defence declared a national state of emergency. At this point, the local state of emergency ceased to have effect and the National Controller became responsible for the response to the earthquake. The state of national emergency was extended 10 times before being terminated on 30 April 2011.

In its report to the Royal Commission, CCC4 refers

to uncertainty about whether to declare a local state of emergency after the Boxing Day aftershock. In the end, it established an Emergency Operations Centre, but did not declare a local state of emergency. The Council considered the damage observed in the city did not meet the requirements for declaring a state of emergency set out in the Civil Defence and Emergency Management Act 2002. We discuss these requirements in section 2.4.2.1 of this Volume.

The NZSEE3 records that the scale of the rapid assessment operation carried out after the September earthquake was large by international standards. The civil defence and emergency management response to the February earthquake was on a scale unprecedented in New Zealand. ATC6 states that:

The extent of liquefaction, the extensive damage to mid-rise and high-rise buildings, and the challenges posed in the evaluation, repair, and recovery process were unprecedented.

**2.3 The building safety evaluation process**

Guidelines issued by the NZSEE10 envisage that each territorial authority will develop and implement its own building safety evaluation process. In accordance with international best-practice, New Zealand’s building safety evaluation framework uses local reconnaissance teams to assess the damage to buildings caused by a disaster. These teams indicate the results of this assessment by placing colour-coded placards on individual buildings.

2.3.1 Guidelines for the building safety evaluation process

Works Consultancy Services (formerly part of the Ministry of Works) released New Zealand’s first guidelines for a building safety evaluation process in 1991.

In 1998, the NZSEE released guidelines for territorial authorities, *Building Safety Evaluation During a State of Emergency: Guidelines for Territorial Authorities*10, which we refer to as the NZSEE Guidelines. Section 6.2.1 of Volume 4 discusses the different NZSEE documents for assessing buildings before and after earthquakes: this discussion is summarised in Appendix 1 of this Volume.

The response to the earthquake in Gisborne in December 2007 was the first time a building safety evaluation operation based on this type of approach was implemented in New Zealand. In 2009, the former Department of Building and Housing endorsed the current version of the NZSEE Guidelines.

Since 2004, the NZSEE Guidelines have been in a constant state of revision. In 2008, the former Department of Building and Housing established a reference group to participate in the NZSEE’s review. This reference group is made up of representatives from the NZSEE, other engineering technical societies, government agencies, and several local authorities. The CCC is a member of this reference group. The NZSEE published revised Guidelines in 2009, with the endorsement of the former Department of Building and Housing.

International best-practice suggests that such guidelines incorporate the lessons learnt from major earthquakes and the reference group decided to take into account the earthquakes in Padang, Indonesia and L’Aquila, Italy in 2009. In July 2010, members of the reference group were asked to review a new version of the Guidelines, but this revised version had not been officially adopted when the September earthquake occurred. The Ministry of Civil Defence and Emergency Management and the Ministry of Business, Innovation and Employment are revising the NZSEE Guidelines to incorporate the lessons learnt from the Canterbury earthquakes.

**2.3.1.1 International best-practice**

New Zealand looked to international best-practice

when developing its building safety evaluation process. The NZSEE Guidelines draw heavily on California’s building safety evaluation process, as set out in the ATC-20 documents11. A common system of evaluation facilitates cooperation between trained persons from countries that experience earthquakes. New Zealand was supported by overseas specialists during the Canterbury earthquake sequence.

Although detailed engineering evaluations (DEEs) are conceptually part of the building safety evaluation process, many countries focus on developing and maintaining the rapid assessment phase of the process; this is the focus of the NZSEE Guidelines.

We now describe the building safety evaluation process.

2.3.2 Overview of the building safety evaluation process

As summarised in Table 1, the NZSEE Guidelines10 set out the three phases of New Zealand’s building safety evaluation process:

• the Overall Damage Survey;

• rapid assessments; and

• DEEs.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Purpose** | **Timing\*** | **Initiated by** | **Task** | **Conducted by** | **Comment** |
| **Overall Damage Survey** | Within hours after event | Civil Defence staff, emergency service action plans, territorial authority action plans | Assess aggregate damage and identify affected areas | Emergency services, territorial authority staff, Civil Defence volunteers | No entry of premises, no formal records, emphasis on extent of damage, areas of high impact, identifying areas of priority for rapid assessment, estimating manpower and skill base  needs etc |
| **Level 1**  **Rapid Assessment** (Figure 2) | During a period of a state of emergency declared  under the Civil Defence Emergency Management Act | Controller; Building Safety Evaluation Leader | Asertain level of structural damage to individual buildings and note other hazards; assess building safety and decide appropriate level of occupancy; recommend security  and shoring requirements | Structural and civil engineers, architects and other personnel from the building industry  volunteer status | Formal system, typically based on exterior inspection only; placards posted on buildings, central record maintained, note made of sites needing further inspections, unsafe areas cordoned off |
| **Level 2**  **Rapid Assessment** (Figure 3) | Structural engineers, building services and geotechnical engineers  volunteer status | Formal system based on inspection of interior and exterior of the building plus reference to available drawings. Calculations not envisaged. May result in revised placards posted on buildings, central record updated, unsafe areas cordoned off, urgent work recommendations  Typically for priority inspection of critical facilities (for situations where facilities operators do not have contracted engineers), or where further information that raises concerns is received |
| **Detailed Engineering Evaluation and Remedial Work** | Typically longer-term, but may be immediate for critical structures | Building owners, insurance companies, Territorial Authorities | Ascertain extent of structural damage, establish losses for insurance purposes, and recommend remedial work  to restore functionality  and compliance with Building Code | Engineers, architects and loss adjusters  contractual agreement | Meets insurance and restoration requirements under the Building Act 2004  These evaluations are likely to involve review of construction documentation, and the preparation of detailed engineering reports |
|  |  |  |  |  |  |

**Table 1: Summary of building safety evaluation inspection categories (source: NZSEE Guidelines, 2009)**

Note: All timings are indicative estimates only

**2.3.2.1 The Overall Damage Survey**

The Overall Damage Survey is the first step in the building safety evaluation process. This survey is carried out by civil defence workers within hours of the disaster occurring. It is a quick stocktake of the extent of the damage caused by the disaster. Decision makers are likely to use the Overall Damage Survey when deciding whether or not to declare a state of emergency. It is also used to indicate what locations the rapid assessment teams should focus on.

An initial purpose of the Overall Damage Survey is to identify the need for urban search and rescue operations. The rapid assessment phase of the building safety evaluation operation typically takes place after the urban search and rescue efforts are complete. ATC has expressed the view that carrying out the Overall Damage Survey in a step-by-step way, as occurred on the first day after the February earthquake, was very efficient and effective.

**2.3.2.2 Rapid assessments**

Carrying out rapid assessments is the next step in the building safety evaluation process. The rapid assessment phase is made up of two assessments:

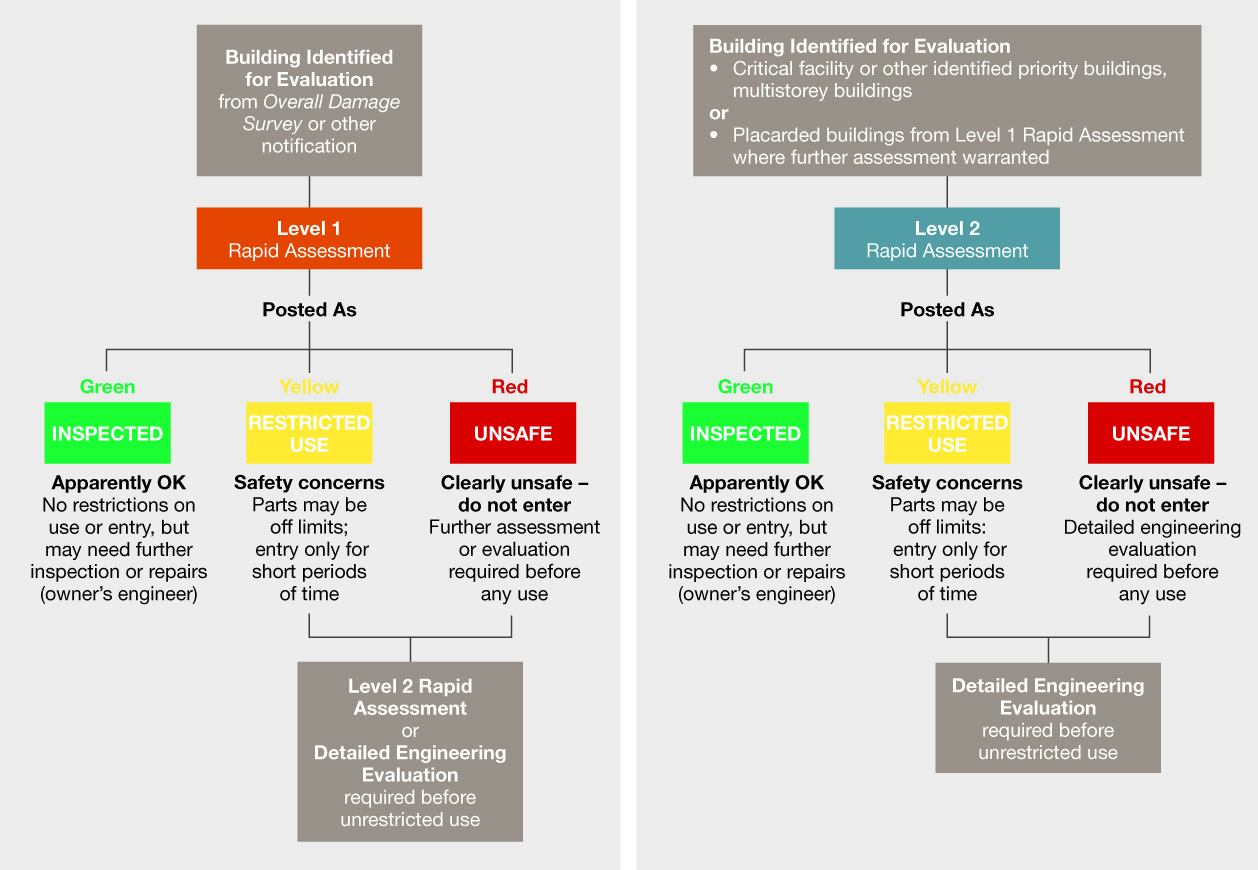
• the Level 1 Rapid Assessment; and

• the Level 2 Rapid Assessment.

Level 1 Rapid Assessments are typically carried out by building control officials from territorial authorities, volunteer structural and civil engineers, or other suitably qualified people including architects. Level 1 Rapid Assessments are typically a 10–20 minute inspection of the structural damage visible from the outside of the building. Level 1 Rapid Assessments are normally carried out on buildings up to four storeys.

Level 2 Rapid Assessments should be carried out by structural, geotechnical or territorial authority engineers. They are usually carried out on larger, more complex buildings, but will include critical facilities such as hospitals. They are also carried out on buildings that have had a Level 1 Rapid Assessment that has resulted in a recommendation that evaluators carry out a Level 2 assessment. The Level 2 Rapid Assessment is a more detailed visual assessment lasting from one to four hours, examining both the interior and exterior of the building.

Level 1 and Level 2 Rapid Assessments are summarised in the following flow charts.



**Figure 2: Level 1 Rapid Assessment**

**(source: NZSEE Guidelines, 2009)**

**Figure 3: Level 2 Rapid Assessment**

**(source: NZSEE Guidelines, 2009)**

Both Level 1 and Level 2 Rapid Assessments are intended to give a short-term indication of the condition of a building. Rapid assessments give an early indication of whether the building is an immediate danger to the people using it, or to the public in the vicinity. In this phase of the building safety evaluation process, evaluators place red, yellow or green placards on buildings to indicate their status following assessment. They may limit entry to buildings and recommend the erection of cordons to restrict access to the area around the building.

**2.3.2.3 Detailed Engineering Evaluations**

The third step in the building safety evaluation process is to undertake a DEE. This is carried out by structural and/or geotechnical engineers as appropriate. DEEs involve accessing and considering all of the information available on the building, carrying out thorough exterior and interior inspections and performing calculations if required. They can take from one day to one week or more. Building owners are expected to take responsibility for obtaining a DEE by engaging their own engineers, and ensuring the safety of the public and occupants. This evaluation is not, normally, undertaken by local authorities.

**2.3.2.4 Sequences of the building safety evaluation process**

During a local or national state of emergency, the Overall Damage Survey and the rapid assessments should be carried out under the authority of a civil defence Controller. Because DEEs take longer to complete, they are more likely to be carried out after a state of emergency has ended, and the relevant Civil Defence and Emergency Management Act 2002 powers are no longer applicable.

2.3.3 Overview of the building safety evaluation operations after the Canterbury earthquakes

The reports received by the Royal Commission describe how the CCC and the Waimakariri and Selwyn District Councils each implemented their own building safety evaluation operation after the September earthquake. These operations were broadly based on the NZSEE Guidelines. Each territorial authority carried out a rapid assessment operation, which then transitioned from civil defence to normal building management arrangements. CCC’s building safety evaluation process also included Project East, a rapid assessment operation that assessed residential buildings in Christchurch’s eastern suburbs.

**2.3.3.1 The rapid assessment teams**

CCC’s rapid assessment teams were a mix of building control officials and engineers. These rapid assessment teams were typically made up of a minimum of three people:

• a council building control officer or civil defence

response team member;

• a structural engineer; and

• an Urban Search and Rescue technician.

Level 2 Rapid Assessment teams had one more building control officer and/or engineer join these teams. These teams were expected to include at least one engineer.

**2.3.3.2 Managing the building safety evaluation operation**

CCC’s civil defence Building Evaluation Manager organised building control officials and volunteers into informal teams to carry out the Overall Damage Survey as they arrived at the Emergency Operations Centre from 5:30am on 4 September 2010. Over the course of the day, civil defence workers at the Emergency Operations Centre gradually pieced together an overview of the level of damage caused by the earthquake.

**2.3.3.2.1 Completing Level 1 Rapid Assessments**

The reports we received note that CCC sent out 29 rapid assessment teams to carry out rapid assessments on the morning of 5 September. Level 1 Rapid Assessments were carried out by 23 of the 29 rapid assessment teams. These teams were assigned to one of 25 CBD grids. The grids were planned out by CCC staff, workers from the former Department of Building and Housing, and the Urban Search and Rescue Engineering Team Leader. When the rapid assessment teams were sent out on the morning of 5 September, six teams were assigned to immediately carry out Level 2 Rapid Assessments on critical facilities and buildings that the Overall Damage Survey had identified as needing more detailed assessment than Level 1. The CCC had completed most of the Level 1 Rapid Assessments by the evening of 5 September. This was a remarkable effort.

**2.3.3.2.2 Completing Level 2 Rapid Assessments**

The Level 2 Rapid Assessments of Christchurch’s CBD buildings began on the morning of 6 September. The CCC developed a process that established which of the Level 1 assessed buildings would receive a Level 2 Rapid Assessment. It also developed a process for prioritising when these buildings would be assessed.

As a general rule, green placard buildings that were recommended for further assessment were prioritised above red and yellow placard buildings. This was because red and yellow placard buildings had already been vacated as they were regarded as potentially dangerous. The CCC had completed some, but not all, of the proposed Level 2 Rapid Assessments by the end of the state of emergency on 16 September. The CCC then re-evaluated the buildings that had been assessed during the state of emergency when the building safety evaluation process transitioned to normal building management arrangements.

**2.3.3.3 The building safety evaluation operations in later earthquakes and aftershocks**

After the Boxing Day aftershock, the CCC decided on

27 December not to declare a state of emergency. The CCC categorised buildings as either red or green, and placed notices issued under section 124 of the Building Act 2004 instead of affixing placards. The Boxing Day aftershock did not cause significant damage in Waimakariri or Selwyn districts.

The building safety evaluation operation carried out

in Christchurch after the February earthquake differed from that used after the September earthquake because of the search and rescue operation. The immediate response to the February earthquake focused on locating and rescuing trapped people. Christchurch’s CBD was locked down while Urban Search and Rescue operations were in progress. Reports to the Royal Commission from the NZSEE3 and the CCC4 describe how civil defence workers planned the rapid assessment process on 23 and 24 February before sending out teams on 25 February. CCC building control officials led this planning, supported by engineers who had taken leadership roles after the September earthquake. This group incorporated some of the lessons learned in the response to the September earthquake in their plans. Between 22 and 25 February, the CCC carried out rapid assessments on suburban commercial buildings and other premises suitable for welfare centres; this rapid assessment operation was known as Operation Shop. The CCC then began Operation Suburb, which assessed residential buildings. After an initial check, Waimakariri and Selwyn District Councils decided not to carry out large-scale building safety evaluation operations after the February earthquake because the buildings in these areas did not suffer significant damage.

Following the 13 June 2011 aftershock, the Canterbury

Earthquake Recovery Authority (CERA) sent out

12 engineers to carry out rapid assessments in

Christchurch’s CBD Red Zone. The Red Zone at

this time covered about 24 blocks. These engineers identified buildings that were now dangerous, or more dangerous, due to the aftershock. No damage was recorded in Waimakariri or Selwyn.

**2.4 The development and maintenance of the building safety evaluation process**

The Royal Commission has identified matters that may lead to improvement of the building safety evaluation process. This section discusses the objectives for the management of buildings after earthquakes and whether there is a need to establish a legislative mandate for the building safety evaluation process. We discuss who should be responsible for developing and maintaining this process, and the methods, frameworks and assumptions engineers use when carrying out assessments. We also consider how New Zealand mobilises skilled building safety evaluators, what their numbers should be and barriers to developing a sufficient core of skilled evaluators.

International approaches to building safety evaluations are not subject to international benchmarking or codification. Nevertheless, the NZSEE3 has identified several key indicators of good planning for a building safety evaluation process. These indicators include:

• setting out an appropriate legal mandate for

the process;

• identifying a central government focal point to

which the process belongs;

• making sure that territorial authorities plan

appropriately before the event;

• siting the plans and procedures for the building evaluation process after a disaster within the civil defence and emergency management operation;

• establishing the criteria and process for the

reoccupation of buildings;

• developing information management systems to record information, produce maps, and transfer the information collected into the wider territorial authority information management systems; and

• planning how to mobilise trained people at a

national and local level.

2.4.1 Objectives of building management after earthquakes

The Royal Commission has heard evidence that the objectives of the building safety evaluation process are not well understood by the public and building safety evaluators.

The rapid assessment operation is designed to identify the visible structural damage to buildings after an earthquake or other disaster and to prioritise how to treat these buildings based on the severity of the damage to them. Buildings are assessed for damage to ensure that they do not pose an immediate threat to the safety of the people using them. Clarity is required regarding the purpose of the building safety evaluation process in comparison with the subsequent need to manage buildings after a disaster. Getting the city moving again and deciding when and under what conditions reoccupation of a building may occur are not part of the rapid assessment process.

Ensuring public safety following a disaster is the main objective of the building safety evaluation process. The management of buildings after earthquakes must deal with the competing objectives of public safety and the economic imperative of reactivating the commercial life of the city. The New Zealand Historic Places Trust notes that the unnecessary loss of heritage due to poorly-informed, rushed decision making has been observed in other countries after earthquakes and other disasters. It suggests ensuring the immediate safety of the public by carrying out make-safe works, or shoring and erecting cordons around the damaged building, and then taking the time to consider all the factors that affect the decision to repair or demolish the building. In its submission, the New Zealand Society for Risk Management states that adopting one objective to the exclusion of others is overly simplistic and does not reflect reality. It favours setting objectives for each stage of the building safety evaluation process, from the initial response through to the recovery phase.

The Royal Commission confirms that life safety should be the one, overarching objective for the management of buildings after earthquakes. However, we also consider it appropriate to have different secondary objectives at different times. In the short-term, the Royal Commission considers that life safety should be the objective that is most emphasised in the rapid assessment phase of the building safety evaluation process. As the civil defence and emergency

management response moves into recovery, it may be appropriate to consider other objectives such as the reoccupation of damaged buildings and recovery of the community and local businesses. However, we consider it important that these objectives remain secondary to the main objective of life safety.

**Recommendation**

We recommend that:

111. Life safety should be the overarching objective of building management after earthquakes as communities both respond to and recover from the disaster.

**2.4.1.1 Scope of the building safety evaluation process**

An important issue is whether the building safety evaluation process should only be used after earthquakes, or whether it can be used after other disasters. The NZSEE Guidelines indicate that the process is broadly applicable to any disaster that may cause large numbers of buildings to be severely damaged. Likely causes are earthquakes, floods, slips, landslides, coastal hazards, wind and volcanic activity.

In practice the building safety evaluation process is primarily a structural assessment focused on earthquake damage. The Royal Commission has received evidence that the rapid assessments after the February earthquake did not adequately cover geotechnical matters. Structural engineers did not understand why the geotechnical team had assessed the building as dangerous, and the placard did not say it was assessed for geotechnical reasons. This meant that evaluators had to revisit and replace placards at some dangerous sites.

The Ministry of Business, Innovation and Employment supports using the building safety evaluation process for other disasters. If it can be used after a range of disasters, particularly floods, it becomes more cost effective to develop and maintain this process; 70 per cent of emergency declarations since 1963 have been flood-related. The Royal Commission accepts that the building safety evaluation process should be applied to a range of disasters.

**Recommendation**

We recommend that:

112. The building safety evaluation process should be used following a range of disasters.

New Zealand’s building safety evaluation framework does not have a specific legislative mandate in either the Civil Defence and Emergency Management Act 2002 or the Building Act 2004. However, the general provisions contained within the Civil Defence and Emergency Management Act 2002 allow Controllers to authorise a rapid assessment operation. We now explore whether the current legislative arrangements are sufficient.

2.4.2 Legislative mandate and responsibility for the building safety evaluation framework

The NZSEE3 contends that setting out an appropriate legal mandate for a building safety evaluation process that authorises its implementation in a range of circumstances is a feature of international best- practice. The placing, maintaining and removing of

the placards should also have a clearly defined legal basis. Establishing a legal mandate for the process should involve specifying the lead agency responsible for it. The NZSEE states that establishing a central government focal point responsible for the building safety evaluation process is a feature of international best-practice. The central government agency would also guide the preparation of territorial authority plans, and develop and maintain core elements of the building safety evaluation process, together with common tools such as training materials. Having a central government focal point would give the building safety evaluation process a formal structure and provide resources to support territorial authority plans. Territorial authority plans are another feature of international best-practice for building safety evaluation processes.

The NZSEE3 reports that since the introduction of their Guidelines in 1998, the uptake has been low. It attributes the low uptake to the lack of specific

legislative mandate for the process. Territorial authorities have no legislative or regulatory obligations to use the NZSEE Guidelines and the latter cannot be enforced.

In addition, currently it is not clear who is responsible

for developing New Zealand’s building safety evaluation framework or any associated guidelines. Since Works Consultancy Services developed New Zealand’s

first building safety evaluation guidelines in 1991, responsibility for any guidelines has been shared informally between government agencies and the NZSEE. The NZSEE essentially took responsibility for developing New Zealand’s building safety evaluation process in 1998, when it released its Guidelines. However, in 2008 the former Department of Building and Housing also took up a supporting role when it established the reference group to participate in the NZSEE’s review. Both the Ministry of Business, Innovation and Employment and the Ministry of Civil Defence and Emergency Management now have a role in the current review of the NZSEE Guidelines.

The reports received by the Royal Commission support the view that current legislation already provides for

a building safety evaluation process. The NZSEE3

maintains that the Civil Defence and Emergency Management Act 2002 provides a legal basis for the building safety evaluation process despite not

containing a specific legislative mandate. Under the Civil Defence and Emergency Management Act 2002, Controllers can:

• issue and control the use of signs (section 18(2)(c));

• carry out inspections (section 92);

• evacuate people and exclude them from any

premises or places (section 86); and

• prohibit or restrict access to public roads and places to prevent or limit the extent of the emergency (section 88).

In addition, a Civil Defence and Emergency Management Group may require the securing or otherwise making safe of dangerous structures under section 85(1)(a)(iii) of the Civil Defence and Emergency Management Act 2002.

The Royal Commission considers that collectively these provisions authorise a rapid assessment operation

such as those carried out after the September and February earthquakes during the state of emergency. For these reasons, the Royal Commission does not

consider that there is a need to make further provisions for the building safety evaluation process in legislation.

The Ministry of Business, Innovation and Employment has indicated that it wishes to take on responsibility for developing and maintaining New Zealand’s building safety evaluation process. It proposes that new emergency risk management provisions be incorporated into the Building Act 2004. The new provisions would establish a mandate for carrying

out a building safety evaluation operation within a new emergency management building system. They

would set out the authority and process for placing, changing and removing placards; they would also establish an appropriate penalty regime for carrying out these activities without authority. This new emergency management building system would be applicable to a range of disasters, not just earthquakes.

Although the new emergency management building system would be mandated under the Building Act

2004, the response to the disaster as a whole would remain coordinated through the Civil Defence and Emergency Management Act 2002. This means the building safety evaluation system would be designed at a national level, with territorial authorities planning its execution. To support the development and execution of the new emergency management building system, the Ministry of Business, Innovation and Employment would take on a role within New Zealand’s national civil defence and emergency planning arrangements. The Ministry of Civil Defence and Emergency Management and CERA both support these proposals.

The Royal Commission has concluded that the Civil Defence and Emergency Management Act 2002 provides for New Zealand’s building safety evaluation process. However, in principle, we endorse the Ministry of Business, Innovation and Employment’s proposal that it assume responsibility for the building safety evaluation process and we support the incorporation

of new provisions in the Building Act 2004 that would establish an emergency building management system. This is because this proposal may address some of

the problems that occurred when the building safety evaluation process transitioned from civil defence to the building control arrangements governed by territorial authorities. We note that these proposals would also specifically mandate New Zealand’s building safety evaluation process. Issues with the transition from civil defence to normal building management arrangements and the options for addressing these issues are discussed in section 2.6 of this Volume. The Royal Commission favours undertaking more policy work on the merit and detail of these proposals to ensure that they are robust, flexible, efficient and effective.

**2.4.2.1 Building safety evaluation operations are confined to a state of emergency**

A rapid assessment operation is usually only carried out when a state of emergency is declared. Civil defence and emergency management Controllers can only exercise the wide-ranging powers that allow them to authorise a building safety evaluation

operation during a state of emergency. In practice, this means that a rapid assessment operation that results

in placards being placed on a building cannot take place outside of a state of emergency. We discuss the problems this caused throughout this section.

To address these problems, several submitters suggest that territorial authorities should be able to carry out a building safety evaluation operation and place placards outside of a state of emergency; they suggest placing emergency management provisions that provide for this in the Building Act 2004.

Sections 4 and 68 of the Civil Defence and Emergency

Management Act 2002 set out the criteria that civil defence and emergency management use when deciding whether or not to declare a state of emergency. Section 4 of the Act states that an:

emergency means a situation that—

(a) is the result of any happening, whether natural or otherwise, including, without limitation,

any explosion, earthquake, eruption, tsunami, land movement, flood, storm, tornado,

cyclone, serious fire, leakage or spillage of any dangerous gas or substance, technological failure, infestation, plague, epidemic, failure

of or disruption to an emergency service or a lifeline utility, or actual or imminent attack or warlike act; and

(b) causes or may cause loss of life or injury or illness or distress or in any way endangers the safety of the public or property in New Zealand or any part of New Zealand; and

(c) cannot be dealt with by emergency services, or otherwise requires a significant and co- ordinated response under this Act[.]

Section 68(1) of the Act states that an authorised person:

…may declare that a state of local emergency exists in the area for which the person is appointed if at

any time it appears to the person that an emergency has occurred or may occur within the area.

The Royal Commission considers that a building safety evaluation operation should only be triggered by a state of emergency. This is because the wide-ranging powers Controllers have under the Civil Defence and

Emergency Management Act 2002 significantly reduce the rights of property owners. The civil defence and emergency management framework recognises that this is appropriate when the safety and well-being of the public is compromised after a disaster. However (leaving aside issues that arise during the transition from the state of emergency to the normal legislative framework), removing the rights of property owners outside of a state of emergency is not appropriate.

We consider that if the impact of the event warrants carrying out a building safety evaluation operation, then it is likely to be significant enough to warrant a declaration. For these reasons, the Royal Commission does not believe that there is a problem with the existing civil defence and emergency management framework or its empowering legislation that needs to be specifically addressed: it is the local authority’s

decision whether or not to declare a state of emergency.

**Recommendations**

We recommend that:

113. Legislation should provide that a building safety evaluation operation should only be commenced during a state of emergency.

114. The Ministry of Business, Innovation and Employment should progress its proposals to incorporate new emergency risk management provisions into the Building Act 2004 to:

• make the Ministry of Business, Innovation and Employment responsible for the development and maintenance of

New Zealand’s building safety evaluation

process;

• make territorial authorities responsible for delivering a building safety evaluation operation; and

• give the Ministry of Business, Innovation and Employment a formal role within national civil defence and emergency planning arrangements.

115. The Ministry of Business, Innovation and

Employment should continue working with

the Ministry of Civil Defence and Emergency Management on the detail of the above proposals.

2.4.3 How evaluators assess buildings in rapid assessments and detailed engineering evaluations after earthquakes

As well as considering the process of building safety evaluation, the Royal Commission considered the way in which engineers evaluate buildings when carrying out rapid assessments and DEEs after earthquakes. Consideration of the methods, frameworks and assumptions used by engineers is important because different skill sets are needed to assess the damage to

different types of buildings and structures. The Royal Commission has heard evidence about assumptions made as a result of inspections and about when engineers should be expected to:

• examine the interior of the structure;

• consult plans and drawings;

• carry out calculations;

• pull linings off the walls, floors and ceilings to check

the structural elements underneath;

• use invasive methods such as boring holes and

taking samples to test; and

• move from a damage-based assessment to one that

indicates the building’s (residual) seismic capacity.

**2.4.3.1 Damage-based assessments**

Most countries with comparable building safety evaluation systems first assess the visible damage that an earthquake or other disaster has done to the building. The purpose of a damage-based assessment is to identify those buildings that are obviously unsafe and therefore at risk of collapse in an aftershock. Rapid assessments are clearly damage-based assessments based on visible damage. DEEs tend to begin as

damage-based assessments.

Most countries also assess the danger from the non- structural parts of a building; for example, parapets that could fall on passers-by in an aftershock. The building safety evaluation processes in some countries look at the danger a building might pose to its neighbours. Several countries also consider whether other hazards like broken utility lines, asbestos or chemicals are present. Some researchers suggest that evaluators

use particular models and methods when carrying out damage-based assessments: for example, several propose grading a building and giving it a number depending on the intensity of the damage described.

From October 2010, damage-based assessments in Christchurch were carried out by evaluating visible evidence as to whether the earthquake resistance capacity of the building was no worse than it was before the September earthquake. This is the approach engineers in Japan take when they assess the capacity of the building to withstand aftershocks through assessment of observed damage and calculation of residual seismic resistance. Future aftershocks were assumed to be events with an order of magnitude one less than the damaging event. Some local authorities

in California also allow building owners to restore their building back to the condition the building was in before the earthquake if the observed damage is not considered substantial.

**2.4.3.2 Seismic capacity assessment**

Calvi et al.12 discuss how seismic vulnerability assessment methodologies have developed over the past 30 years, including how to assess the residual capacity of buildings after an earthquake. In Turkey, the rapid assessment of reinforced concrete buildings after recent earthquakes there has led to some researchers proposing building safety evaluation methods that define the lateral load resistance systems using mathematical modelling. The researchers Calvi et al. suggest in their paper that these methods could help civil defence workers’ decision making, such as prioritising which buildings need a more detailed engineering assessment, and determining when to

allow people to reoccupy a building after an earthquake. However, Calvi et al. also believe that the potential for the use of such methods in large-scale seismic risk models is limited because evaluators still need to consider buildings individually, for repair and reoccupation.

**2.4.3.3 Seismic capacity assessments within a damage-based assessment**

Instead of replacing the damage-based assessment, the building evaluation systems in Greece, California and Japan all recommend assessing the (residual) seismic capacity of buildings damaged in an earthquake within a damage-based approach. This

is because it is not generally easy to fully identify the residual capacity a building has to withstand

of wall or floor linings if structural elements have yielded or lost their structural capacity. We accept that is so.

In such cases wall linings, floor coverings and ceiling tiles should be removed to enable examination of the damage. There are some cases where damage may not be apparent before the collapse condition is reached. The PGC and the CTV buildings are examples of this situation, where there was no significant damage evident prior to collapse, but because the structures of these buildings did not possess resilience through ductile detailing they subsequently failed in a brittle manner.

In assessing the percentage of ULS (we prefer to refer to the ULS (ultimate limit state) rather than to NBS (new building standard) for the reasons explained in

section 6.2.4 of Volume 4), it is essential to consider the

capacity of the building to sustain gravity loads under seismic shaking. The strength of the building is only part of the consideration that is needed: it is essential to consider also the deformation capacity and the

rate at which strength will degrade with additional seismic shaking.

In their evidence to the Royal Commission, Mr David Brunsdon and Mr John Hare illustrated the significance of strength degradation with reference to Figure 4.

ok to occupy

**B**

% NBS

aftershocks quantitatively from quick inspections.

Engineers would primarily carry out a damage-based assessment, but include some calculations and other analyses of a building’s (residual) seismic capacity.

In practice, most methodologies follow a stepped process, where an engineer would carry out a range of qualitative and quantitative assessments set on

a continuum. The simple, inexpensive qualitative

Building

33

**A**

Building

not acceptable

Loss of lateral strength

Time

assessments are at one end of this continuum; more complex calculations and invasive investigative methods (like boring holes into walls) are at the other. A rapid assessment would be the first qualitative step, to locate potential fall hazards and identify buildings

in urgent need of further attention from the point of view of public safety. This should be followed by more detailed engineering assessments appropriate to the circumstances. We discuss the nature and content of such assessments in section 2.6.2.2.1 of this Volume. Engineers move from qualitative to quantitative methods, and from simpler to more complex analyses, depending on the damage they observe at each step. Evidence to the Royal Commission indicates that there is usually visible evidence of cracking or displacement

**Figure 4: Building status and reoccupation (source: adapted from evidence to the Royal Commission by D. Brunsdon, September 2012)**

The notional building B in the figure may initially have

a strength in excess of 33 per cent of NBS, but due to damage occurring at non-ductile zones its strength can degrade in aftershocks of significantly smaller intensity than the original ground motion. Such a building may lose its strength in a non-ductile manner due to a

critical structural weakness or weaknesses, without any apparent damage in an initial earthquake. The Royal Commission saw examples of such non-ductile behaviour in the failure of the PGC and CTV buildings (see the discussions in section 2.8.2.2. of Volume 2 and Volume 6) and the non-ductile failure of a number of other structural elements discussed in Volume 2.

The notional building A in Figure 4 may have a low lateral strength, which may be below 33 per cent of the strength of a new building but, due to ductile behaviour of the potential plastic regions and the lack of damage in other locations, it will continue to perform in a safe manner in aftershocks.

Identifying a critical structural weakness that limits the displacement capacity of the structure is more important than determining the lateral strength. This aspect needs to be considered in determining the percentage ULS.

**2.4.3.4 Accounting for aftershocks**

The Royal Commission has heard evidence that the rapid assessments in the building safety evaluation process in New Zealand are based upon an assumption that a building should be able to withstand an aftershock of one magnitude less than the main shock

if it has not been significantly damaged in the main shock. Building safety evaluation best-practice does not plan for the situation seen in Christchurch, where increased ground accelerations from a near aftershock damaged buildings more than the main shock, even though its magnitude was one order less. This was an unforeseen circumstance.

The view that a building should withstand an aftershock of one magnitude less than the main shock developed after researchers in several countries studied the performance of buildings after earthquakes. The

Federal Emergency Management Agency (FEMA)13 in

the United States undertook the seminal research on this topic; this major research project examined how buildings performed in aftershocks. Researchers found that if the structural elements in a building had been damaged, but did not suffer strength degradation, then the building generally had the same capacity as it did before the earthquake. FEMA recognises that this may seem counterintuitive, stating that:

… it is natural to assume that [a building] is worse off than if the damage had not occurred. It seems likely that the maximum displacement in the future, larger earthquake would be greater than if it had not been damaged. Extensive nonlinear time-history analyses performed for the project indicated otherwise for many structures. This was particularly true in cases in which significant strength degradation did not occur during the prior, smaller earthquake. Careful examination of the results revealed that maximum displacements in time histories of relatively large earthquakes tended to occur after loss of stiffness and strength would have taken place even in an undamaged structure. In other words, the damage that occurs in a prior, smaller event would have occurred early in the subsequent, larger event anyway.

In section 2 of Volume 1 of this Report, we discuss the characteristics of the Canterbury earthquakes. It is clear that the February earthquake had much greater ground accelerations that the main September event though

the aftershock was of a lesser magnitude. As we noted in section 2.7.1.8 of Volume 1, the comparatively high magnitude of the aftershocks in the Canterbury earthquakes sequence is not the norm. The epicentre of the February event was much closer to the Christchurch CBD than that of the September earthquake, and more shallow, and this greatly increased the intensity of the shaking in Christchurch’s CBD. Consequently, we do

not consider that the theoretical underpinning of the building safety evaluation process should be abandoned as a result of the Canterbury earthquakes sequence.

The Royal Commission nevertheless considers that building safety evaluators must look at other factors when considering how a building might perform in an aftershock. Where the earthquake is generated on a distant fault, aftershocks may generally be expected to be of shorter duration and lower intensity than the main shock. Where the fault is close to the city, there

is a greater likelihood of subsequent aftershocks being closer to the city than the initial earthquake. Such

an event may result in a greater intensity of shaking and the possibility of the directions of the major components of shaking being different from those of

the initial earthquake. The result may be to cause major damage to buildings not severely damaged in the initial earthquake. Where the earthquake was on a local fault, a greater level of care in the assessment is required

with more conservative judgements being made due

to the possibility of aftershocks with a greater intensity and with different principal directions of shaking.

**Recommendations**

We recommend that:

116. The Ministry of Business, Innovation and Employment, the Ministry of Civil Defence and Emergency Management, GNS Science, the New Zealand Society for Earthquake Engineering and other engineering technical groups should research how and when building safety evaluators should account for aftershocks.

117. The building safety evaluation process should set out the factors evaluators need to take into account when considering how a building will respond in an aftershock, including:

• how close the main shock was to an urban centre that could be affected by an aftershock;

• the direction of the main shock and any

likely aftershocks; and

• how soil, ground conditions and any other

relevant factors may affect the intensity of the ground motions in an aftershock.

2.4.4 Mobilising a sufficient number of skilled building safety evaluators

The ability to carry out an effective building safety evaluation operation depends on the number of skilled evaluators available. For this reason, effective plans

for the mobilisation of trained professionals at national and local levels, and for events of different magnitudes, are important.

**2.4.4.1 Model based on volunteers**

New Zealand’s building safety evaluation framework relies on volunteers. The process was developed by the NZSEE, a volunteer organisation. We have heard evidence that CCC building control officials and other council staff are required to support the civil defence

and emergency management response to a disaster as part of their job description. However, other evaluators such as engineers, architects, and members of the construction industry are generally volunteers.

In New Zealand, professional bodies like the Institution for Professional Engineers New Zealand (IPENZ)

and the Building Officials Institute of New Zealand encourage their members to assist after a disaster.

IPENZ led the mobilisation of volunteer engineers from the rest of the country after the September and February earthquakes; some engineers also volunteered of their own accord. Local Government New Zealand mobilised workers from other territorial authorities to support local council staff.

**2.4.4.2 Availability of building safety evaluators after the Canterbury earthquakes**

Approximately 250 volunteers carried out rapid assessments in Christchurch during the state of emergency declared after the September earthquake. About 75 of these volunteers were engineers who worked in the rapid assessment teams alongside

24 Urban Search and Rescue engineers. Urban Search and Rescue engineers were able to join the rapid assessment teams and carry out other tasks to support the local civil defence response because there were

no casualties and they did not need to carry out a

rescue operation.

After the February earthquake, civil defence planners identified the need for up to 100 engineers and a further 50 building control officials to make up the

rapid assessment teams going into Christchurch’s CBD. Approximately 350 engineers were involved in the rapid assessments carried out during the national state of emergency.

**2.4.4.3 Constraints caused by the number of building safety evaluators available after the Canterbury earthquakes**

After the September earthquake, the number of available engineers limited the number of rapid assessment teams carrying out evaluations in Christchurch’s CBD to 29. The limited number of available engineers particularly affected Waimakariri District Council, which used its own building control officials to carry out rapid assessments until structural engineers and people with more technical expertise became available on 7 September.

There were significant issues with the availability of people to carry out building safety evaluations after the Boxing Day aftershock. Because the aftershock occurred in the holiday season, many local engineers and CCC staff were on holiday and had left the

city. Further problems with mobilising the volunteer engineers arose when the CCC did not declare a state of emergency. This is because there are difficulties with utilising volunteer engineers outside of a state

of emergency declared under the Civil Defence and Emergency Management Act 2002. We discuss these issues further in section 2.4.5.1 of this Volume.

The number of available building control officials also constrained the rapid assessment operation after the February earthquake. Not every rapid assessment team had a warranted officer to support placing the placards because Operation Suburb, an extensive evaluation of suburban residences, reduced the number of building control officials available. At its peak, Operation Suburb deployed up to 1,000 building control officials, welfare representatives and Earthquake Commission staff

each day. This reduced the number of building control officials available for the rapid assessment operation in Christchurch’s CBD. The CCC therefore decided to give temporary warrants to the building safety evaluation team leaders, who were almost exclusively Chartered

Professional Engineers.

number of buildings than a larger group of engineers with less training or experience. CERA contends

that this group should be supplemented by a pool of evaluators for larger-scale events.

The NZSEE3 also favours using a tiered model. It suggests developing three groups of trained evaluators:

• a small group of experts;

• a larger group of trained building safety evaluators;

and

• the largest group of potential evaluators who have

received basic training.

This model is illustrated below.

The response to the February earthquake incorporated some of the lessons learnt about staffing issues after the September earthquake. The reports received by

the Royal Commission note that the building safety evaluation management team was better resourced than its September equivalent. They suggest that this, along with a formal roster to keep staff alert, allowed the building safety evaluation management team to

support a wider range of activities conducted in parallel.

**2.4.4.4 Options for mobilising a sufficient number of building safety evaluators**

**Drawn from Senior Building Officials**

**and structural Chartered Professional Engineers**

**Drawn from**

**National resource capable of leading a Building Safety**

**Evaluation operation**

The main questions are whether volunteer evaluators should be paid or unpaid, and how many evaluators New Zealand needs to carry out rapid assessments after a disaster.

The Royal Commission has heard evidence that the mobilisation of volunteers after the Canterbury earthquakes was timely and well-organised. For this reason, we consider the current arrangements are appropriate, provided matters of liability are resolved.

The Ministry of Business, Innovation and Employment and CERA suggest establishing a core team of trained, registered and warranted building safety evaluators. This team of building safety evaluators would be a national resource that could be called in by the Chief Executive of the Ministry of Business, Innovation and Employment to carry out building safety evaluation operations. The Ministry would decide when and where to deploy this team in conjunction with the civil defence and emergency management Controller after a state

of emergency had been declared. CERA supports this concept. It has observed that a relatively small group of experienced, well-trained engineers could be more effective in completing rapid assessments over a

**All Building Officials**

**and**

**Structural Engineers and**

**Civil Engineers**

**Figure 5: Building evaluation resource**

**(source: NZSEE, 2011)**

Currently, the Urban Search and Rescue engineers and other engineers who have developed expertise by assisting in the response to overseas disaster events, form the smallest group. The middle group would be drawn from senior building officials and chartered structural engineers who wish to become building safety evaluators. The largest group is made up of potential building safety evaluators drawn from all

building officials, structural engineers and civil engineers.

The building safety evaluators who assessed buildings after the Canterbury earthquakes comprised a small group of experts and volunteers drawn from all building officials, structural engineers and civil engineers. The

middle group of senior building officials and structural Chartered Professional Engineers who could be called on to supplement the small group of building safety

evaluation experts did not exist when engineers

mobilised to respond to the Canterbury earthquakes.

The Urban Search and Rescue engineers and the engineers who have significant expertise gained from their participation in the response to overseas disaster events could become the Ministry of Business, Innovation and Employment’s core team. The middle group would supplement this group of experts in larger building safety evaluation operations. The largest group is made up of the potential building safety evaluators who would only be brought in for very large operations.

The Royal Commission considers that establishing a core team of building safety evaluators supplemented by two larger pools of potential evaluators is conceptually sound. It recognises that, notwithstanding the experience of Christchurch, earthquakes in New Zealand will

not generally significantly impact on major urban centres. The Ministry of Business, Innovation and Employment’s core team of building safety evaluators should be sufficient to respond to a smaller centre, such as Gisborne. The middle group could be called in to assist this core team when an event occurs in a

larger provincial centre. If a territorial authority needs to carry out a large-scale, urban building safety evaluation operation, it could call upon all three groups of potential evaluators. We discuss the training needs of the middle group of building safety evaluators in section 2.4.5.2.4

of this Volume.

**Recommendations**

We recommend that:

118. The Ministry of Business, Innovation and Employment should progress their proposal to establish a core team of building safety evaluators that the Ministry could call on.

119. The Ministry of Business, Innovation and Employment should carefully consider the merits and detail of any proposals about the size of this group of building safety evaluators.

120. The ability to supplement this team with more evaluators who have received basic training should be maintained.

2.4.5 Barriers to obtaining skilled building safety evaluators

**2.4.5.1 The liability waiver for building safety evaluators**

The reports received by the Royal Commission record that when the NZSEE Guidelines10 were reviewed from 2004 to 2009, engineering consultancies made it clear that they would not volunteer their workers for a building safety evaluation operation without a waiver of liability. They wanted a waiver to recognise that engineers would be volunteering on a “best endeavours” basis in an emergency situation: engineers would normally evaluate buildings more thoroughly.

To find a way forward, the NZSEE convened a large group made up of government, industry and technical engineering societies to discuss the liability issues. This group concluded that section 110 of the Civil Defence and Emergency Management Act 2002 was the best way to manage engineers’ concerns about liability

for building safety evaluations. Section 110 gives civil defence workers protection from liability for damages or loss during a state of emergency, unless they acted in bad faith or were grossly negligent. It states:

110 Protection from liability

(1) Except as provided in sections 107 to 109, there is no cause of action against the Crown, or a Civil Defence Emergency Management Group,

or an officer or employee or member of any of them, or against any other person, to recover damages for any loss or damage that is due directly or indirectly to a state of emergency.

(2) Subsection (1) applies whether the loss or damage is caused by any person taking any action or failing to take any action, so long as the act or omission occurred in the exercise or performance of his or her functions, duties, or powers under this Act.

(3) No person is exempted from liability under subsection (1) for any act or omission to act that constitutes bad faith or gross negligence on the part of that person.

This liability waiver was carried through into the recovery phase after the February earthquake. Section 83 of the Canterbury Earthquakes Recovery Act 2011 sets out a comparable liability waiver:

83 Protection from liability

(1) Except as otherwise provided in this Act, no action lies against the Crown, or an officer or employee or Minister of the Crown, or against any other person,—

(a) to recover any damages or other amount for any loss, damage, or adverse effect that is due directly or indirectly to any action taken under this Act; or

(b) to require any work to be carried out or other action to be taken in order to remedy or mitigate any loss, damage, or adverse effect that results directly or indirectly from any action taken under this Act.

(2) No person who takes any action under this Act is liable under the Resource Management Act

1991 for any fine, costs, or expenses in respect of that action, except as otherwise provided in this Act.

(3) Subsection (1) applies whether the loss, damage, or adverse effect is caused by any person taking any action or failing to take any action, so long as the act or omission occurred in the exercise or performance, or intended exercise or intended performance, of his or her functions, duties, or powers under this Act.

(4) No person is exempted from liability under subsection (1) for any act or omission to act that constitutes bad faith or gross negligence on the part of that person.

Submitters suggest that providing a liability waiver for building safety evaluations is necessary and desirable because it recognises that these evaluations are carried out in special circumstances. Turner’s14 analysis of the building safety evaluation processes in several countries indicates that evaluators have liability

to address any concerns about liability for work done under special circumstances, such as after a disaster. If engineers are not given a liability waiver when they volunteer as building safety evaluators, they may carry out more thorough assessments, or alternatively, not

provide their services. In either case, the recovery from the disaster is likely to be delayed. It was made clear to the Royal Commission by some of those who suffered personal loss that they held those involved in the assessments responsible. Taking these considerations into account, the Royal Commission considers it is both prudent and reasonable to provide a liability waiver for building safety evaluators.

It is important to consider whether a building safety evaluation operation can continue outside of a state of emergency because civil defence and emergency management best-practice is to move from response to recovery as soon as possible. A large-scale rapid assessment operation may not be complete before a state of emergency ends. The Ministry of Business, Innovation and Employment suggests aligning the liability waiver with the building safety evaluation

process rather than whether or not a state of emergency is declared. This would allow territorial authorities

and other decision makers to carry out building safety evaluation operations in a range of circumstances.

It may also remove the need for a mechanism that transitions the process from civil defence to normal building control arrangements governed by territorial authorities: we discuss this transition in section 2.6 of this Volume. The Royal Commission therefore considers that the liability waiver for building safety evaluators should be associated with the process itself, not when

it takes place.

**Recommendations**

protection in California and Japan; evaluators in Italy

and the European Union do not have liability protection.

The unwillingness of some engineers to carry out building safety evaluations after the Boxing Day aftershock without the protection of a liability waiver clearly illustrates that having a waiver incentivises individual behaviour. The reports received by the Royal Commission describe how some engineers withdrew as evaluators when the CCC decided not to declare a

state of emergency. Griffiths and McNulty5 contend that

this is because the CCC’s contracting management system could not resolve their concerns about potential liability outside of a state of emergency. This suggests that the standard contracting arrangements used by human resourcing departments may not be sufficient

We recommend that:

121. Legislation should continue to provide for a waiver of liability for building safety evaluators carrying out rapid assessments.

122. The liability waiver for building safety evaluators should be aligned with the building safety evaluation process instead of being restricted to an operation carried out in a

state of emergency.

**2.4.5.2 The skills of building safety evaluators**

In addition to constraints caused by the availability of engineers, the skill sets and abilities of the evaluators may also affect the efficiency and effectiveness of

a building safety evaluation operation. International literature on building safety evaluations indicates that the quality of assessments produced by evaluators can be inconsistent. The Royal Commission has heard evidence that the quality of both the DEEs and rapid assessments in Christchurch varied. We have also heard evidence that geotechnical engineers

had to reassess properties in the Port Hills that were incorrectly given a green placard by structural engineers who did not identify the fall hazards from the surrounding cliff faces. Some submitters stated that, overall, they thought that the poorer-quality rapid assessments tended to be too conservative. International literature on building safety evaluations also suggests that rapid assessments tend to be conservative. However, the Royal Commission has found that this was not the case with evaluations

of unreinforced masonry buildings. In section 4 of Volume 4 we discuss the individual buildings that caused the deaths of 42 people when they failed in the February earthquake. These buildings were nearly all unreinforced masonry or brick or block structures.

We note several examples where engineers carried out less cautious assessments, such as those on

7 Riccarton Road.

**2.4.5.2.1 The skill sets engineers require**

International literature indicates that many engineers may not be skilled enough to carry out good quality evaluations of buildings damaged in an earthquake. The NZSEE15 recommendations on how to assess whether a building is potentially earthquake-prone also express concerns about the ability of engineers to assess existing buildings before an earthquake.

This is because the processes used to assess the structural performance of a building in an earthquake are different from those an engineer would use when designing a building. In addition, Saito and Thakur16 note it can be particularly difficult to assess moderate damage to a building; it is easier to identify when

a building is severely damaged or hardly damaged at all. Engineers assessing a building’s structural performance in an earthquake need to assess the way in which individual structural elements affect the overall response of the building. This requires considerable judgement by the engineer, who needs a thorough

understanding of the underlying theory and its empirical justifications to adequately identify and assess the observed condition of the building. For this reason, the

NZSEE15 recommends that only Chartered Professional Engineers with experience in earthquake engineering determine whether a building is potentially earthquake- prone. The Royal Commission has heard evidence that the number of engineers with this experience before the September earthquake was small.

**2.4.5.2.2 Guidance on carrying out DEEs after earthquakes**

The Royal Commission has received evidence that engineers carrying out DEEs for building owners were expected to use their own knowledge and refer to guidance documents produced in New Zealand and the United States if necessary. We note advice that some of these overseas guidance documents are not

directly applicable to New Zealand. Engineers were not

familiar with what needed to be included in a DEE after an earthquake. Some engineers effectively repeated a Level 2 Rapid Assessment: they did not seek out plans, identify any critical structural weaknesses or adequately determine the structural load paths in the building. Owners confused them with a DEE because they were provided by a Chartered Professional Engineer.

After looking at how engineers carried out DEEs in

Christchurch following the Canterbury earthquakes,

the Ministry of Business, Innovation and Employment17 began developing guidelines for engineers to use when carrying out DEEs after earthquakes. We consider that these DEE guidelines should be finalised as soon as possible to assist building owners and other decision makers in the rebuild of Christchurch.

**Recommendation**

We recommend that:

123.The Ministry of Business, Innovation and Employment should work with the New Zealand Society for Earthquake Engineering, the Structural Engineering Society New Zealand and others with appropriate experience and expertise to finalise guidelines for Detailed Engineering Evaluations as soon as possible.

**2.4.5.2.3 Guidance for entering dangerous buildings after earthquakes**

In section 4.16.4.2 of Volume 4, we discuss the circumstances in which workers entered the damaged Durham Street Methodist Church and lost their lives in the February earthquake. We highlight the lack of clear guidelines for engineers and others in assessing the risk of entering what was essentially a dangerous building.

The Royal Commission has heard evidence that building safety evaluators checking buildings in the CBD Red Zone in Christchurch were nearly caught in them during the second June 2011 aftershock. In

addition, engineers carrying out detailed engineering evaluations in red or yellow placard buildings may need to enter them to assess the building. Urban Search

and Rescue engineers receive training on assessing

the risks to themselves and their team when entering a building. For this reason, they accompanied the rapid assessment teams working in Christchurch’s CBD

after the February earthquake, to make sure that these teams were carrying out their work in a safe way.

The Royal Commission considers that guidelines should be developed to assist building safety evaluators to assess when and how to enter a damaged building. These guidelines should be based on the Urban Search and Rescue training. We consider that they should be attached to the guidelines for carrying out DEEs after earthquakes that the Ministry of Business, Innovation and Employment are currently developing.

**Recommendations**

We recommend that:

124.Guidelines should be developed that assist building safety evaluators to assess when and how to enter a damaged building.

125. These guidelines should be based on the Urban Search and Rescue training on when and how to assess entry to a damaged building.

126. These guidelines should be attached to the guidelines the Ministry of Business, Innovation and Employment is developing on the way in which engineers should carry out Detailed Engineering Evaluations after earthquakes.

**2.4.5.2.4 Training for building safety evaluators**

The lack of specific training for building safety evaluators and the wider engineering community contributed to the variable quality and inconsistencies in both rapid assessments and DEEs after the earthquakes, which were reported to the Royal Commission. Many of the Urban Search and Rescue engineers who carried out rapid assessments after the September earthquake were familiar with the building

safety evaluation process: they had supported overseas

operations and had received pilot NZSEE training in 2010. However, few of the volunteer engineers had received direct training on this process, or had

previously used the NZSEE Guidelines. This meant that a consistent brief for these engineers on the building safety evaluation process was desirable before they carried out rapid assessments.

From 5 September 2010, members of the rapid assessment teams received a briefing of about 30 minutes on the NZSEE Guidelines and the process they were

to follow. However, because of when they arrived and were deployed, not everyone received this briefing. New Zealand has yet to develop a field manual for building safety evaluators to take out with them.

This does not mean that these engineers received no support in carrying out building safety evaluations. The Royal Commission has heard evidence that

building safety evaluators would hold informal debriefs with each other at the end of the day. Participants commented on how valuable these conversations were, because more experienced evaluators shared their knowledge about how and why they assessed damaged buildings the way they did.

The NZSEE has been developing a training programme for building safety evaluators for some time. In 2005

and 2006, the NZSEE developed drafts of the following:

• an Information Sheet,

• Training Modules;

• Induction materials; and

• a Field Guide.

However, work on these drafts stalled in 2007. By 2009, work on the development of a field guide had progressed. Pilot training modules had also been developed to accompany the revised version of the NZSEE Guidelines10. These pilot training modules focus on managing the building safety evaluation process, with participants split into groups to work through case studies where they assess damaged buildings. This training was delivered to building control officials and

local council engineers. Only six territorial authorities, including the CCC, had received this training in 2009 and 2010. Most of the CCC engineers and building control officials carrying out building safety evaluations after the September earthquake had undergone

this training.

Like the pilot training materials, the NZSEE Guidelines focus on how to plan for and manage a building safety evaluation operation. The guidelines in countries with similar building safety evaluation processes tell engineers

and other evaluators what methods, frameworks and assumptions they should use. Their building safety evaluation guidelines typically describe the characteristics and the damage that evaluators are likely to observe in different types of buildings. These countries usually develop specific training programmes to supplement their guidelines.

In section 2.4.5.2.1 of this Volume, we discuss the need for engineers to have specialised training and experience in order to successfully evaluate the performance of an existing building in an earthquake. For these reasons, the Royal Commission considers New Zealand’s building safety evaluation process should include guidelines for evaluators about what methods, approaches and assumptions they should use when assessing the damage to a building. Although this will make the guidelines considerably larger, we consider that these guidelines should be incorporated into the main guidance documents, instead of being published separately. This will ensure that they reach all building safety evaluators.

The Royal Commission has heard evidence that building safety evaluators would have found it useful to have a field manual summarising the damage to look for in particular building types. We consider that the draft NZSEE field guide should be finalised and provided to all building safety evaluators.

**Recommendations**

We recommend that:

127. New Zealand’s building safety evaluation guidelines should incorporate detailed guidance to engineers about the way they should assess the damage to particular building types.

128. The field guide for building safety evaluators should be finalised.

Submitters discussed how much training engineers need before becoming a building safety evaluator, and who should provide this training. The NZSEE3 contends that not all building safety evaluators need the same level of training to successfully carry out rapid assessments. Using the model set out in Figure 5, Figure 6 illustrates the level of training each group of evaluators needs.



**Figure 6: Building evaluation resource and training capability objectives (source: NZSEE, 2011)**

The training for each of these groups is what is needed to maintain their ability to carry out rapid assessments of buildings after earthquakes. Each group would receive a different level of training. The smallest group is the most highly trained, attending presentations on the management of disasters and participating in visits to disaster scenes overseas. This group of experts would assist with training those in the middle group of structural Chartered Professional Engineers and senior building officials who are building safety evaluators

in the methods, frameworks and assumptions they should use when they carry out rapid assessments. The middle group would maintain their preparedness through this advanced training, which would be supplemented by refresher courses. They would keep up to date with lessons from disaster events, and the

structural engineers who wish to become building safety evaluators could undertake optional training as part of their preparation to become a Chartered Professional Engineer. The largest group of building safety evaluators would develop a basic awareness of the building safety evaluation process through engineering conferences

and seminars, such as the “Learning from Earthquakes”

seminars given by the Urban Search and Rescue

engineers returning from overseas events.

The Royal Commission considers that New Zealand’s building safety evaluation process and guidelines should be supplemented by a training programme. This training should explain what the building safety evaluation process is, and show evaluators how to

assess the significance of damage to different types of buildings and structures. We consider that the Ministry of Business, Innovation and Employment should be responsible for developing and delivering this training programme. The assessment of damage observed in

a building after an earthquake requires engineering judgement, and this judgement is usually garnered through experience. Developing and delivering training helps engineers to acquire the skills needed to carry out a building safety evaluation process because it provides a forum where engineers can learn from

their more experienced peers. We consider that New Zealand should develop training for engineers on how to assess damaged buildings based on the NZSEE model illustrated in Figure 6. As well as identifying

and assessing the damage to buildings caused by earthquakes, training on the building safety evaluation process could cover how to assess buildings damaged by other disasters.

**Recommendations**

We recommend that:

129. The building safety evaluation process should incorporate a training programme for all building safety evaluators.

130. Such training should cover:

• what the building safety evaluation

process is and how it works; and

• how to identify and assess the damage evaluators observe in buildings after an earthquake.

131. This training programme should be

developed using the New Zealand Society for Earthquake Engineering’s building evaluation resource and training capability objectives framework, in which building safety evaluators are split into three different groups and each group receives a different level of training.

**2.4.5.3 Indicating that the pool of building safety evaluators has the right skills**

Several submitters favour developing a way to indicate that building safety evaluators have the right skills and experience. They contend that when building safety evaluation managers know what skills and experience their volunteers have, they are better able to decide where to send them. Some submitters proposed a training and warranting system for building safety evaluators similar to the system used in California. Several discuss whether or not building safety evaluators need to be chartered professionals. Some submitters suggest that the pool of available evaluators should be assigned to assess different types of structures based on their particular skills and experience.

**2.4.5.3.1 A registration and warranting scheme for building safety evaluators**

In contrast to New Zealand, volunteers in California must be formally registered and warranted as building safety evaluators (with the California Safety Assessment Program). Their registration as evaluators must be renewed every five years and they must attend training to keep it current. The Ministry of Business, Innovation and Employment suggests that the proposed core team of building safety evaluators should be registered

and warranted.

The Royal Commission has received evidence that

the mobilisation of engineers and other building safety evaluators after the Canterbury earthquakes was fast, efficient and largely effective. However, the reports

we received recognise that pre-planning for how to mobilise volunteer evaluators was poor. We understand that the efforts of IPENZ and Local Government

New Zealand in mobilising volunteer engineers and building control officials from other councils were largely responsible for the successful mobilisation. There is no reason to assume that such efforts would not be repeated after another major disaster. Consequently, we do not consider it necessary to register and warrant building safety evaluators to assist mobilisation.

However, it is important that these evaluators keep their skills current. The Royal Commission therefore considers that the training should be compulsory for the core team of building safety evaluators that forms a national resource capable of leading a building safety evaluation operation. We also consider that this training should be compulsory for those Chartered

Professional Engineers, structural engineers and senior building officials who wish to be able to carry out rapid assessments. These building safety evaluators should

regularly attend compulsory refresher courses to keep their training up to date. The Royal Commission does not consider that it is necessary for the largest group of building safety evaluators, drawn from all building officials, structural engineers and civil engineers, to attend compulsory training as they will rarely be called upon to assist after a disaster. Only trained evaluators should participate in a building safety evaluation operation, unless the circumstances of a particular disaster make this impractical and the largest pool

of potential evaluators is mobilised. Should the need to call upon the largest group of potential evaluators arise, we consider that, wherever practicable, these evaluators should carry out rapid assessments under the supervision of those evaluators who have attended

the compulsory training and therefore possess a greater level of preparedness.

In section 2.4.2 of this Volume, we suggest that building safety evaluation operations should be delivered by territorial authorities. Consequently, we consider it particularly important that territorial authority staff with civil defence and emergency management responsibilities attend the compulsory training. This should be considered part of the job training for this group.

Because the training for the core team that forms a national resource capable of leading a building safety evaluation operation and the building safety evaluators who actively maintain their preparedness would be compulsory, the Ministry of Business, Innovation and Employment would be able to keep a list of people who have attended the training. The Ministry of Business, Innovation and Employment should make this list available to territorial authorities’ civil defence and emergency management planners.

**2.4.5.3.2 Should building safety evaluators be**

**Chartered Professional Engineers?**

Some submitters suggest that using non-chartered professional engineers could lead to poorer quality rapid assessments because these engineers are typically less experienced than their chartered peers.

Turner14 outlines who can be building safety evaluators in California, Greece and Japan. Engineers registering as building safety evaluators in California must be the equivalent of a Chartered Professional Engineer. Civil engineers in Greece carrying out evaluations should have four to five years’ experience. Building safety evaluators in Japan must be trained and registered first or second class authorised architects; the legislation

governing the authorisation to architects applies to both architects and building engineers. In Japan, architects receive substantial training in structural engineering.

After the February earthquake, only Chartered Professional Engineers were allowed to join the building safety evaluation teams working in the CBD Red Zone. Because of their greater experience, civil defence management believed that they would be better able

to assess the damage to a building, and therefore the risk to their team and ultimately the wider public, from ongoing aftershocks.

However, allowing only Chartered Professional Engineers to become building safety evaluators would significantly reduce the pool of people available to carry out rapid assessments. Further, volunteer building control

officials, architects and members of the construction industry can be valued members of a rapid assessment team. In addition, the Ministry of Business, Employment and Innovation contends that while only Chartered Professional Engineers should carry out DEEs after earthquakes, suitably trained building control officials could produce rapid assessments of consistent

quality. We accept that this is so, and consider that all building safety evaluators do not need to be Chartered Professional Engineers.

**2.4.5.3.3 The assignment of specific tasks to evaluators with specific qualifications and experience**

Another way of indicating that building safety evaluators have the right skills and experience is to organise for different groups of evaluators to assess particular

types of buildings and structures depending on their qualifications, training, and/or experience.

The 199818 version of the NZSEE Guidelines took this approach. So do the Californian building

safety evaluation guidelines11 on which the NZSEE

Guidelines are based. These documents suggest that building control officials, architects and members

of the construction industry carry out Level 1 Rapid Assessments. The engineering resource is reserved for Level 2 Rapid Assessments. This is because Level 2

Rapid Assessments are more thorough and therefore take more time (note, however, that Level 2 Rapid Assessments are still only a basic evaluation of the condition of the building).

The New Zealand Historic Places Trust expands on this idea. It proposes developing a core group of specialist heritage building safety evaluators because considerable experience is needed to assess the damage to heritage buildings, particularly unreinforced masonry buildings.

After the February earthquake, civil defence and emergency management introduced targeted building safety evaluation teams to assess sections of the

city or issues important to the community. As well as evaluating suburban commercial buildings in Operation Shop and residential properties in Operation Suburb, specialist evaluators assessed shopping malls (so that the public could access food and other necessities), critical buildings (including those six or more storeys high), the CBD, when and where cordons were needed, and what buildings needed immediate demolition.

ATC6 suggests that this approach may have some

advantages over the block-by-block method usually used internationally: civil defence and emergency management in Christchurch were able to move more rapidly to open up entire segments of the community. California19 has therefore added this concept to

the operational plans used by the state agency that supports local authority delivery of the building safety evaluation process.

Based on how efficient and effective the building safety evaluation operations were overall after the Canterbury earthquakes, the Royal Commission does not believe that it is necessary to formalise who should carry

out what assessments based on the qualifications, skills and experience of the evaluator. As Operations Shop and Suburb proved, it is possible to informally manage a building safety evaluation operation this way if necessary. Nevertheless, we consider that non-

chartered professional engineers and more experienced evaluators drawn from building control officials, architects and other suitably qualified people should primarily carry out Level 1 Rapid Assessments. Where possible, only Chartered Professional Engineers should carry out Level 2 Rapid Assessments.

**Recommendations**

We recommend that:

132. The core group of building safety evaluators who are a national resource capable of

leading a building safety evaluation operation, and those Chartered Professional Engineers, structural engineers and senior building officials who wish to be building safety evaluators, should be required to attend compulsory training.

133. Only trained building safety evaluators should be authorised to participate in a building safety evaluation operation unless the circumstances of a particular disaster make this impractical.

134. If the scale of the emergency requires the mobilisation of the largest group of potential building safety evaluators, who have not received the compulsory training, these evaluators should work, wherever practicable, under the supervision of those evaluators

who have attended the compulsory training.

135. Territorial authority staff with civil defence and emergency management responsibilities should be required to attend the compulsory building safety evaluator training as part of their job training.

136. The Ministry of Business, Innovation and Employment should keep a list of the people who complete the compulsory training for building safety evaluators and should make this list available to all territorial authorities.

137. Where available, only Chartered Professional Engineers should carry out Level 2 Rapid Assessments.

2.4.6 Building safety evaluation models

The Royal Commission considered it important to look at whether or not the current system is the right

approach or model. Researchers are developing

technology-based building safety evaluation models. We also looked at building safety evaluation models based on building type, private contracting and

the Indicator Building system that developed in

Christchurch after the September earthquake.

**Option 1: Technology-based building safety evaluation models**

International literature on building safety evaluations suggests that cities adopt technology-based building safety evaluation models as the main building safety evaluation process. If adopted widely, these methods could develop into a building safety evaluation process that is fully automated. Researchers contend that this will result in better quality rapid assessments because raw data of each building’s performance will be available, and these models reduce the number of evaluators needed for a building safety evaluation operation.

Vidal et al.20 identifies several technology-based building safety evaluation models. Scenario modelling involves looking at the characteristics of the buildings

in an area and modelling what would happen in various disasters before a potential event. Aerial surveying (increasingly carried out using high-resolution satellite

imagery), laser scanning and damage mapping determine the extent of the damage caused by the earthquake by comparing photographs, laser images or information from sensors with baseline images or data. These sensors are placed throughout locations

and/or in individual buildings. Some of these tools were used in Christchurch after the Canterbury earthquakes. A number of buildings were assessed using laser scanning. GNS Science also used laser scanning to monitor movement in the cliff face in the Port Hills. Building safety evaluators used remote reconnaissance by a small unmanned aerial vehicle with a camera mounted on it and a New Zealand Army robot to assess the damage to the Cathedral of the Blessed Sacrament in Barbadoes Street.

Generally, these methods tend to be less accurate when applied to a single building. Consequently, these building safety evaluation models tend to work better

in places where there has been extensive building collapse; aerial surveying and damage mapping

have been used in Haiti, China and Turkey. In addition, technology-based building safety evaluation approaches rely on high-quality digital information about the area or individual buildings being available before and after a disaster. Although territorial authorities in New Zealand may have semi-automated building record systems, the Royal Commission has received evidence that territorial authorities may struggle to provide this information in a format that building safety evaluators can use.

**Option 2: Status quo – local reconnaissance teams**

New Zealand’s building safety evaluation framework uses local reconnaissance teams to assess the damage a disaster causes to an area’s buildings. In section 2.3.2 of this Volume, we describe how it is characterised by teams placing colour-coded placards on buildings after assessing the damage to them. This approach was first developed in Europe in the early 1980s. It is used by

the United States, Japan, Indonesia, Greece, Italy, the

wider European Union, Colombia and Mexico.

**Option 3: Privately contracted building safety evaluators**

Rather than implementing a building safety evaluation operation managed by public agencies, New Zealand could encourage or require building owners to contract their own engineers to check their buildings after a disaster. San Francisco developed a building safety evaluation model based on this concept; this is the voluntary Building Occupancy Resumption Program (BORP).

There are precedents for developing a model based on using privately contracted building safety evaluators

in New Zealand. Lifeline utilities typically contract engineering consultancies to carry out a baseline evaluation of the utility and then check it after a disaster; Telecom has contracted Opus to do so, for example. The Royal Commission has heard evidence that building owners also contacted engineers and asked them to check their buildings immediately after the September earthquake. However, if this system is adopted building owners and engineers may need to renegotiate the assessment contract every time the building is sold or engineers move on. The Royal Commission therefore considers that it would not be feasible to rely solely

on privately-contracted building safety evaluators. However, we encourage owners to be aware of the likely seismic performance of their buildings.

**Option 4: Evaluating buildings based on their building type**

Building safety evaluation literature and some submitters suggest determining what placard to assign to a building based on its building type, particularly its age and construction. This approach involves identifying the key structural weaknesses associated with each particular building type and the key damage patterns it is likely to experience in an earthquake. This idea would require certain processes to be followed in relation to particular kinds of buildings without regard to the extent to which they had been damaged by the earthquake. We do not favour this approach as it would unnecessarily restrict access to undamaged buildings.

**2.4.6.1.1 Conclusions**

The Royal Commission considers that improvements should be made to our current process instead of looking for an entirely different model. This is because New Zealand follows current international best-practice and we have not found any viable alternative. Although some of the semi-automated systems have merit, it may be some time before they can be adopted in a systematic way throughout the country due to the limitations of the current technology and the base information.

On the other hand, the Royal Commission considers that the management of buildings after earthquakes should incorporate separate procedures and assessments for different kinds of buildings. This issue is discussed in section 2.6.2 of this Volume.

**2.4.6.2 The Indicator Building system**

According to the reports we received, the Indicator Building system was first used after the September earthquake. After the February earthquake, this model was expanded and formalised. The Indicator Building system is designed to assess the effects of aftershocks on buildings. The relevant authority identifies examples of different types of buildings whose structural elements were damaged in the main shock, but are not close

to collapse: these are the Indicator Buildings. It then monitors the new damage that an aftershock causes to see if it falls within expected limits. If the Indicator Buildings are sufficiently damaged, or the damage

observed in them is greater than expected, the authority may decide to carry out a building safety evaluation operation in respect of the class of building that the indicator building represents.



**Figure 7: An Indicator Building in Christchurch after the February earthquake (source: draft ATC Reconnaissance Team report, 2012)**

The NZSEE3 states that this model proved invaluable for determining how to use the resources available to carry out building safety evaluations in Christchurch’s CBD after significant aftershocks. CERA has also communicated to the Royal Commission that the model has been an effective tool in their management of buildings after aftershocks. In January 2012, California19 amended the operational plans used by the state agency that supports local authority delivery of the building safety evaluation process to incorporate New Zealand’s Indicator Building system. This is because the Indicator Building system provides a rational decision making tool for civil defence and emergency management and territorial authority staff.

We consider that the Indicator Building system is particularly useful when an area is experiencing an earthquake swarm or a prolonged aftershock sequence. For this reason, the Royal Commission considers that the Indicator Building system should be incorporated into New Zealand’s building safety evaluation process.

**Recommendation**

We recommend that:

138. The Indicator Building model should be incorporated into New Zealand’s building safety evaluation process.

**2.5 Delivery of the building safety evaluation process**

The Royal Commission has heard evidence that planning for a building safety evaluation process (prior to the September earthquake) in Canterbury had only just begun when the earthquake occurred. However, as our international expert, Mr Bret Lizundia, pointed out

in his evidence to the Royal Commission, New Zealand overcame this lack of planning with considerable efficiency and innovation. He discussed how impressed California’s ATC were with New Zealand’s quick mobilisation of extra help and resource, and the way procedures were developed, and that volunteers

came forward and carried out the necessary tasks efficiently. ATC6 expresses the view that “officials did an outstanding job” at improvising on an urgent basis after the February earthquake. Mr Lizundia particularly notes the creative use of shipping containers for propping

and as barricades, how well temporary utilities were organised and that portable sanitary facilities were provided that allowed people to shelter in place.

The Royal Commission therefore considers that despite some problems, overall, the building safety evaluation operations after the Canterbury earthquakes were well delivered: for example, the NZSEE3 reports that most of the rapid assessments of 1236 commercial buildings and 6686 residential buildings were completed during the first week following the September earthquake. In our Report, we make recommendations about how to improve the building safety evaluation process. The Royal Commission considers that relevant plans should be flexible and adaptable, rather than prescriptive rules that must be followed. Because they will be applied in an emergency, they need to be flexible enough to allow innovative responses to unusual situations.

We now discuss the more significant issues we have identified with the delivery of the building safety evaluation operations after the Canterbury earthquakes.

2.5.1 Processes developed at the time

The NZSEE Guidelines10 suggest that territorial authorities need to plan the building safety evaluation process before the event. This is also international best- practice; building safety evaluation literature stresses

pre-planning the implementation of a building safety

evaluation process.

It is not clear how much CCC, Waimakariri District Council and Selwyn District Council had pre-planned for carrying out a building safety evaluation operation before September 2010. All three territorial authorities had taken steps to implement the NZSEE Guidelines

by this time. On the morning of 4 September, the Urban

Search and Rescue Engineering Team Leader and a civil defence and emergency management consultant worked with the CCC to plan and set up the building safety evaluation process used after 5 September. The Urban Search and Rescue Engineering Team Leader suggested using draft revised Guidelines, developed in 2010, to take advantage of the improvements introduced from the lessons learnt in the Indonesian and Italian earthquakes in 2009.

Time is needed to explain these new arrangements to people. Even though CCC staff had recently received training on the 2009 version of the NZSEE Guidelines, they would have been unfamiliar with the draft 2010 revision.

The NZSEE3 contends that many territorial authorities believe that they can pick up the NZSEE Guidelines on the day and use them to run their building safety evaluation process. We consider it important that

local authorities should plan for the process in advance. This should occur as part of their civil defence responsibilities. This requirement should be set in legislation.

**Recommendations**

We recommend that:

139. The Ministry of Business, Innovation and Employment should provide guidance to territorial authorities to support their plans to carry out a building safety evaluation process.

140. Territorial authorities should be required to plan their building safety evaluation process as part of their civil defence and emergency management plans.

2.5.2 Development of multiple processes

After the September earthquake, parallel building safety evaluation processes developed as engineers engaged by owners carried out evaluations of varying detail alongside the official operations. Privately contracted engineers are not required to undertake the same process as official building safety evaluators. There is no legal requirement to follow the NZSEE Guidelines. The Royal Commission has heard evidence that these engineers carried out the equivalent of Level 1 and Level 2 Rapid Assessments, DEEs, or assessments that fell between one or other of these categories. Some building owners and engineers changed the official placard placed on the building, or posted their own placards on the basis of these evaluations. We consider the processes used

to change the placards in section 2.5.3.2 and discuss the development of multiple placard systems further in section 2.5.3.1 of this Volume.

Building owners and their engineers are not legally required to share the information in these evaluations with their local authority and there was no system

in place to integrate them into the building’s record. However, these reports sometimes contained information that would have triggered a change in a building’s status. For these reasons, CCC introduced procedures to consider the reports on red and yellow placard buildings generated by a building owner’s engineer.

Some submitters suggest formalising the parallel building safety evaluation process that developed after the Canterbury earthquakes and integrating it with the official process. Other submitters note the confusion the parallel building safety evaluation process caused

and question whether it can be successfully integrated.

The Royal Commission supports building owners, their property managers and tenants taking the initiative

to check out the condition of their building after an earthquake or other disaster. Nevertheless, we consider that there should be one rapid assessment process

that is managed and implemented by officials with a clear mandate and authority. Building owners should understand the need for DEEs of their building and should engage their own engineers to carry out this service. They should also be required to give a copy of this evaluation to the relevant authority. This would eliminate much of the confusion that arose after the Canterbury earthquakes and ensure that authorities have access to all of the information that could affect the status of a building.

**Recommendation**

We recommend that:

141. Only official building safety evaluators should be authorised to place, change or remove placards, and to carry out rapid assessments for this purpose.

2.5.3 Issues with the placards

We have reproduced the placards used after the September earthquake in Appendix 2 of this Volume. The reports we received, international literature on building safety evaluations and submitters agree that the public, and some building safety evaluators, do not understand the meaning of the placards; in the same way, some do not understand the objectives

of building management after earthquakes. These sources contend that the wording and the colour of the placards is unclear and confusing. A failure to understand the wording and meaning of the placards is an issue because the placard is often the main

way that tenants or the wider public know whether a building can be entered and used. In particular, green placards are frequently interpreted as meaning that the building is “safe” and needs no further inspection.

The development of placard systems in addition to the official process contributed to this confusion. Issues also arose when the status of the building and the placard on the building needed to be changed.

The Royal Commission, in the progression from red, to yellow, to green, notes that the placards become more wordy and less understandable. We consider the following sections of the green placard to be less clear than is desirable:

This building has received a brief inspection only. While no apparent structural or other safety hazards have been found, a more comprehensive inspection of the exterior and interior may reveal safety hazards…

Owners are encouraged to obtain a detailed structural engineering assessment of the building as soon as possible. Report any unsafe conditions to the Territorial Authority. Subsequent events causing damage may change this assessment.

Re-inspection may be required. Secondary damage (partition, windows, fittings and furnishings) may be hazardous. Electrical and mechanical equipment, gas connections, water supplies and sanitary facilities have not been inspected.

Put simply this means:

• there has been a quick visual inspection of your

building;

• no obvious structural problems were found after

a quick look over your building;

• this does not mean that it is not damaged;

• this does not mean that it is completely safe;

• you need to organise for someone to look at it

more thoroughly;

• if aftershocks cause more damage, the placard

on your building may need to be changed;

• tell the council if you find anything that could

be dangerous; and

• the role owners have in regard to the future safety

of occupants and the public is important.

The Royal Commission considers that the wording of

the placard should be changed to a plain English format along these lines. This would be easier to read and understand in an emergency situation, when people are stressed. The messages on the placards could be more clearly emphasised, so that people notice its text as

well as its colour.

**Recommendation**

We recommend that:

142. The placards placed as a result of the building safety evaluation process should be rewritten in a plain English format.

New Zealand’s building safety evaluation process uses red, yellow and green colour-coded placards to indicate the status of the building; this type of system is known as the “traffic light model”. Examples of where it is

used include project planning, risk management and prioritising medical treatment in emergency situations.

Part of the appeal of the traffic light model is that the general public is likely to have a basic understanding of the meaning of the colours. However, this can also become a disadvantage. People associate red with “stop”, yellow with “caution” and green with “no issues”, or “go”. The green placard’s colour may reinforce the commonly

held view that the building is “safe” and does not need to be checked further. The CCC, the NZSEE,

Mr David Brunsdon and Galloway and Hare21 propose

changing the colour of the green placard to white.

They contend that people are less likely to think that no further action is needed if the placard is not green.

In principle, the Royal Commission favours changing the colour of the green placard to white. However, we have heard evidence that changing the colour of the green placard to white could make New Zealand’s building safety evaluation process less compatible with other countries’ systems. The traffic light system is international best-practice and this change could result in confusion when evaluators assist in New Zealand

or our evaluators help overseas. For these reasons, the Royal Commission considers that any decision to change the colour of the placards should be made after consulting with the wider international building safety evaluation community.

**Recommendation**

We recommend that:

143. In principle, the colour of the green placard should be changed to white. The Ministry of Business, Innovation and Employment should consult with the international building safety evaluation community about the merits and detail of the change before deciding whether or not to do this.

**2.5.3.1 Multiple placard systems**

Some engineers engaged by building owners developed and used their own building safety evaluation forms

and placards during and after the state of emergency. Typically, these were adapted from the templates in the NZSEE Guidelines, or the ones used by the CCC and/or in the civil defence response. This led to the

growth of multiple placard systems after the Canterbury earthquakes. As Figure 8 illustrates, by late November

2010, a building could stickered with:

• the (red/yellow/green) rapid assessments placards

placed under a civil defence warrant;

• the placards developed by engineers engaged by building owners, placed during and/or after the state of emergency;

• the red section 124 Building Act notice placed by their territorial authority after the state of emergency;

• a variety of general engineering assessment notices;

and/or

• notices placed by lifeline utility operators.



**Figure 8: Multiple placards on the same building**

**(source: the Applied Technology Council)**

The large, red “Danger” notice in Figure 8 is an example of an assessment notice developed by building owners, their engineers, or other groups. Figure 8 also illustrates the problems that arose because the placards were not printed onto colourfast materials that faded over time.

It became particularly difficult to tell the difference between a green and yellow placard as both faded to a pale yellow colour.

Placing several different placards on a building made

it difficult for building owners, tenants and the general public to know what the status of the building was.

The Royal Commission considers that only the relevant authorities should place, change or remove placards.

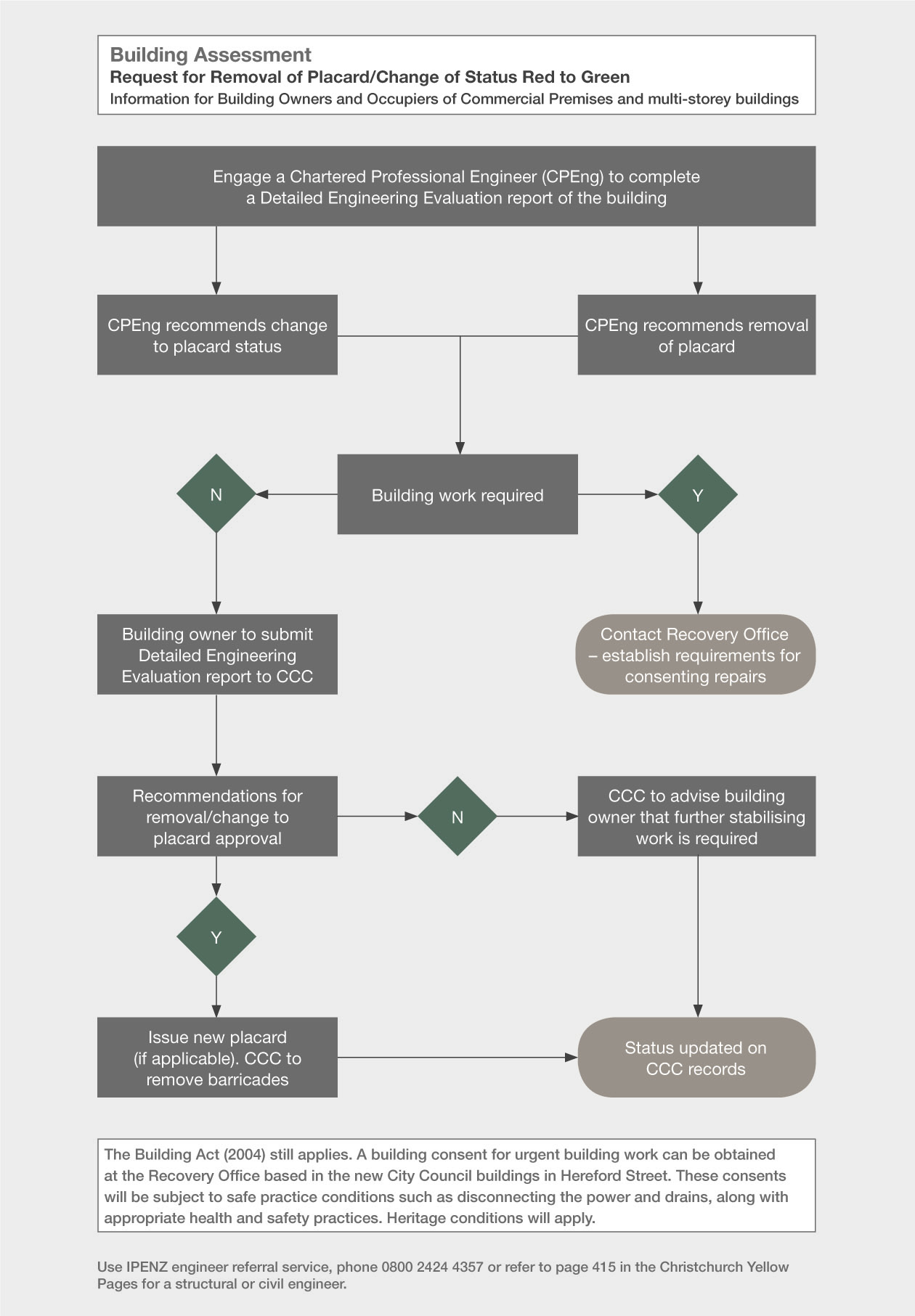
**2.5.3.2 Changing the placards**

The Royal Commission has heard evidence that building owners found the processes for changing a building’s placard unclear. During the state of emergency after the September earthquake, some engineers engaged by building owners filled in the official Level 2 Rapid Assessment forms, which they obtained from the Emergency Operations Centre. Others provided their completed report to the Centre. In both cases, civil defence and emergency management would arrange

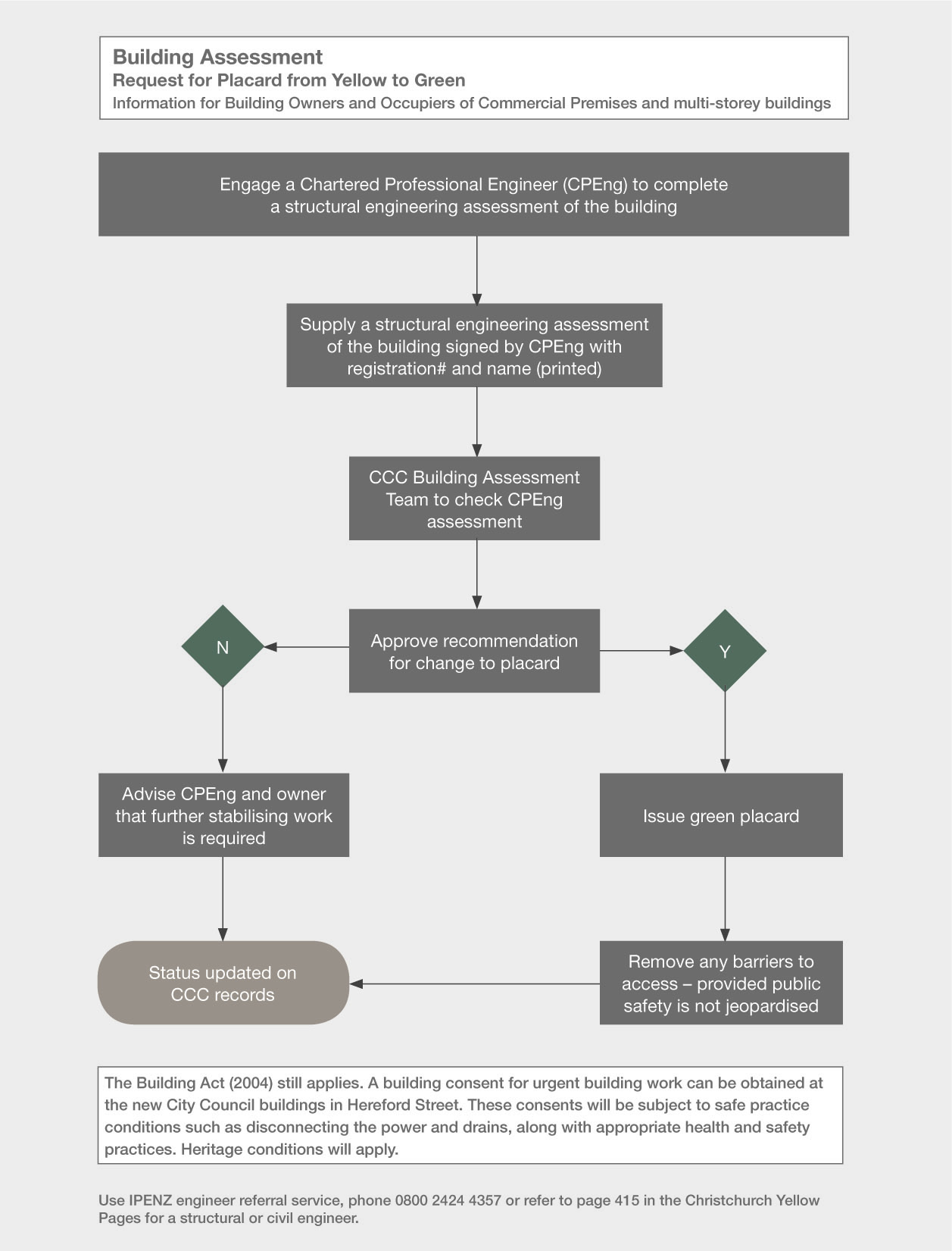
for a placard to be placed on the building. The reports received by the Royal Commission contend that some building owners and their engineers did not realise that their evaluation would not automatically result in a change of placard. As well as placing multiple placards on buildings, some building owners or their engineers would remove placards without authorisation in both the response and recovery phases.

After the transition from civil defence to normal building management arrangements, the CCC developed processes to be followed before changing a red or yellow placard to a green placard.

These processes are set out in Figures 9 and 10.



**Figure 9: Process for changing a placard from red to green after the state of emergency in 2010 (source: CCC, 2011)**



**Figure 10: Process for changing a placard from yellow to green after the state of emergency in 2010 (source: CCC, 2011)**

Initially, the CCC requested that building owners submit a DEE completed by a Chartered Professional Engineer. We have heard evidence that the level of detail in these

reports varied. Griffiths and McNulty5 contend that, as

a result, the CCC effectively became peer reviewers for

DEEs after earthquakes.

**2.5.3.2.1 The CPEng Certification Form**

To clarify and facilitate change procedures, the CCC introduced a new certification form that Chartered Professional Engineers submitted to request a change of placard. This form, reproduced in Appendix 3 of this Volume, is known as the CPEng Certification Form.

This form assured the CCC that the building was safe for occupancy and posed no further hazard to people or property, before the status of a red or yellow placard

could be changed. It specifically recognised the danger falling hazards posed to public safety and the potential danger from damage to adjacent buildings, with the engineer stating that these dangers had been addressed. CCC staff discussed when and how to change a building’s status with the certifying engineer if they needed to consider additional factors like removing cordons.

The CPEng Certification Form contemplated that a building was suitable for reoccupation if the structural integrity, and performance of the building had been restored “to at least the condition that existed prior to the earthquake of 4 September 2010”. This meant that the building did not have to be made stronger than it had been prior to the September earthquake, before reoccupation could occur. Consequently, if a damaged building was earthquake-prone before the September earthquake, then it could be reoccupied even though it was still earthquake-prone after repair. The statement assumes that people were happy to take on the same risk associated with the building as they had prior

to the earthquake. We discuss issues of risk and understanding in section 7.8 of Volume 4.

Submitters suggest developing procedures setting out when and how to change the status of a building and its placard. The Royal Commission also considers that formal procedures for changing the status of a building and its placards should be developed as part of the building safety evaluation process.

**Recommendation**

We recommend that:

144. Formal procedures should be developed that set out when and how the status of a building could be changed. The placard on a building should only be changed if the formal procedures are followed.

2.5.4 Communication tools

Civil defence and territorial authorities used a variety of communications tools to let the public know:

• what the building safety evaluation process was;

• what the placards meant;

• the responsibilities of building owners; and

• how to deal with their damaged buildings.

These tools included a mix of print, electronic media and public meetings. In addition to using flyers and posters, the CCC also set up a web-based newsletter. People had to register to receive this newsletter,

which reduced its reach. Despite this, the media, building owners, engineers and the public did not fully understand what the building safety evaluation process was or the meaning of its placards.

The Royal Commission considers that the Ministry of Business, Innovation and Employment should be the lead agency responsible for any public communications about how to manage buildings after earthquakes

and other disasters. It should be responsible for this during and after the state of emergency. The Ministry of Business, Innovation and Employment should develop communications material before it is needed and release this information as soon as possible after the

disaster. This material should include information about:

• the extent of the risk posed by the damage the

disaster has caused;

• the implications of aftershocks; and

• the roles and responsibilities of building owners.

The Royal Commission also considers that GNS Science should develop protocols and plans to ensure that it

is ready to advise the Ministry of Business, Innovation and Employment, other government agencies, local authorities and the wider public after an earthquake.

**Recommendations**

We recommend that:

145. The Ministry of Business, Innovation and Employment should be responsible for developing and releasing public communication materials about building management after earthquakes and other disasters during and after the state of emergency.

146. GNS Science should develop protocols and plans to ensure that it is ready to advise

the Ministry of Business, Innovation and Employment, other government agencies, local authorities and the wider public after an earthquake.

2.5.5 Information sharing

As well as problems with how authorities communicated with the public, the Royal Commission has heard evidence of communication problems between people and organisations after the Canterbury earthquakes. People and organisations failed to share information about the damage to a building with others who needed to be involved in decisions about its use, repair or demolition. When discussing information sharing within a civil defence context, Doyle and Johnston23 contend that effective teams under high pressure commonly

adopt a communication style characterised by expecting people to tell them the information they need to know, rather than team members specifically asking for it.

The Royal Commission has heard evidence that after the Canterbury earthquakes, networking was a key tool in obtaining and disseminating information about the damage to a building and its status. This was particularly important for green placard buildings,

as territorial authorities had no way of finding out information about these buildings after the state of emergency ended.

Several submitters have suggested that mechanisms that allow different people and organisations to share information more easily should be developed. The Royal Commission discusses and makes recommendations about information sharing in section 7.5.3 of Volume 4.

2.5.6 Information management

Civil defence and emergency management literature suggests that access to good quality information is a key component of making initial assessments of the situation and informing ongoing decision making. The NZSEE3 recommends developing a database to receive and record information gathered in rapid assessments.

The information management system used after the September earthquake, based on an Excel spreadsheet, was developed by the Urban Search and Rescue Engineering Team Leader, CCC and a civil defence and emergency management consultant on 4 September. This spreadsheet became the

basis of the information management system that

developed when the building safety evaluation process transitioned to the CCC.

Griffiths and McNulty5 describe how this information management system designed for the building safety evaluation process did not interface well with CCC’s own systems. The Royal Commission has heard evidence that there were other problems with how information on damaged buildings was gathered and managed after the September earthquake. Inefficient information recording meant that civil defence management, territorial authority staff and building owners had problems knowing the status of a building at a given point in time. Middleton and Westlake2 contend that sometimes the only way to find out if

the status of a particular building had changed was to carry out a visual check. In addition, sometimes official records would note a change to the building’s status, but a new placard was not placed on the building.

Several submitters propose using information technology tools to collect and analyse data on damaged buildings. They suggest integrating a variety of tools, such as portable personal computers (e.g., tablets and notebooks), GPS and cellular telephones. Shibayama and Hisada24 found that their electronic information management system, which was based on these tools, was more efficient than using conventional paper-based information gathering methods. This is despite practical issues with obtaining good quality digital maps and using portable personal computers; technological advances should address these issues.

The Royal Commission has heard evidence that engineers and building owners were not able to access records as they were held in the CCC’s earthquake- damaged building. Consequently, several submitters suggest digitising building records and storing

them offsite. Like technology-based building safety evaluation approaches, electronically-based information

management systems need to interface with existing electronic records to work effectively. This may not be possible, even in first world countries. Although

some territorial authorities in New Zealand have certain building control records on microfiche or in digitised formats, not all records are kept electronically and stored offsite. This means that it may not be possible to directly download or access existing building records, even if the technology to do so was available.

Nevertheless, the Royal Commission considers that digitising building control records and storing them offsite is good business continuity planning and should be encouraged. We have heard evidence that the

CCC is encouraging other territorial authorities to do so based on their experiences after the Canterbury earthquakes and that the Ministry of Business, Innovation and Employment proposes establishing

a national database of building records with several access points. The Royal Commission understands that this goal may not be achieved for some time because of the cost to territorial authorities to digitise their records. However, we consider that the Ministry of Business, Innovation and Employment and territorial authorities should progress their plans to achieve this.

**Recommendations**

We recommend that:

147. Information management systems should be developed as part of planning for New Zealand’s building safety evaluation process.

148. The Ministry of Business, Innovation and Employment should work with territorial authorities and other relevant agencies to develop a way for territorial authority building records to be electronically recorded and stored off-site.

**2.5.6.1 Identifying buildings**

The Royal Commission has also heard evidence of the problems that arose because records for each building appear to have been kept according to its postal address. If a building has several entry points and/or multiple tenancies, then the territorial authority may have alternative addresses for the same structure. Alternatively, territorial authorities could have decided to identify a particular building by one particular address, even though different people and organisations may

use several addresses. These addresses may not be

the same as the postal address or the street address for the building and/or tenancy. The Royal Commission has heard evidence that this led to issues with identifying buildings.

Some submitters suggested looking at establishing a national unique address system. Middleton and Westlake2 note that the United States is exploring how to develop a unique address system based on mapping coordinates.

Territorial authorities are responsible for allocating road names and numbering in New Zealand. When they name a road, they are required to advise Land Information New Zealand, which keeps an official national record of all properties in New Zealand.

Land Information New Zealand has recently introduced several initiatives to improve how people access property information via addresses. In 2011, it began work on a Spatial Data Infrastructure project that pulls together geospatial data; this project incorporates information on identifying individual properties. It has also introduced a new section on “Property Addressing” on its website. These webpages provide information on why addressing properties properly is important, who is responsible for allocating road names and numbering in New Zealand, addressing standards and address data. In addition, Land Information New Zealand now allows public access to the Authoritative Streets and Places database. This database provides:

• up-to-date nationwide listings of street names and

place names that may potentially be used as part of an address, referenced against the territorial authorities and their electorates;

• nearby place names to provide locational context;

and

• historical records of former names (since late 1992).

The Royal Commission considers that a clear system for identifying individual buildings should be developed and included in the plans for a building safety evaluation process. This needs to be set out in the general training about the building safety evaluation process, the induction evaluators receive before they are assigned to a rapid assessment team, and the assessment forms, so that evaluators know immediately how they are to indicate which building they are assessing. Clear instructions will avoid some of the inconsistent information recording seen in Christchurch. The Royal Commission considers that Land Information New Zealand should continue to develop consistent national addressing protocols, working with territorial authorities, and make this information available to the general public.

**Recommendations**

We recommend that:

149. A clear system for identifying individual buildings should be developed and included in the plans for a building safety evaluation process.

150. Land Information New Zealand should continue to work on initiatives that develop consistent national addressing protocols and make this information available to the general public.

**2.6 Transition from the civil defence response to the recovery phase governed by territorial authorities**

The reports received by the Royal Commission indicate that there were significant issues in the transition of responsibility for the building safety evaluation process from civil defence to normal building management arrangements governed by territorial authorities after the Canterbury earthquakes. We have heard evidence from Mr Bret Lizundia that this is an issue that United States engineers have not encountered before: he considered that it negatively impacted on the building safety evaluation operation after the Canterbury earthquakes. This is also the Royal Commission’s view.

This section considers the need for a transition mechanism, the NZSEE Guidelines recommendation, and the mechanism used after the Canterbury earthquakes. We examine how territorial authorities should manage buildings after earthquakes, the roles and responsibilities different decision makers have in this, and the management of cordons. We also consider the barriers building owners faced when they sought to repair or demolish their damaged buildings.

2.6.1 The need for a transition mechanism

The initial building safety evaluation operation takes place during a state of emergency under civil defence

and emergency management arrangements. The

placards placed on buildings in the rapid assessment phase of this operation only have legal status during a state of emergency. To be able to manage necessary building work after the state of emergency ends, there needs to be a transition mechanism.

**2.6.1.1 The transition mechanism recommended in the NZSEE Guidelines**

The NZSEE Guidelines10 recommend placing a notice issued by the territorial authority under section 124 of the Building Act 2004 before the end of the state of emergency. Section 124 states:

124 Powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings

(1) If a territorial authority is satisfied that a building is dangerous, earthquake prone, or insanitary, the territorial authority may—

(a) put up a hoarding or fence to prevent

people from approaching the building nearer than is safe:

(b) attach in a prominent place on, or adjacent to, the building a notice that warns people not to approach the building:

(c) give written notice required work to be carried out on the building, within a time stated in the notice (which must not be less than 10 days after the notice is given under section 125, to—

(i) reduce or remove the danger; or

(ii) prevent the building from remaining insanitary.

(2) This section does not limit the powers of a territorial authority under the Part.

(3) A persons commits an offence if the person fails to comply with a notice under subsection (1)(c).

(4) A person who commits an offence under this section is liable to a fine not exceeding

$200,000.

In this context, a section 124 notice requires the building owner to reduce or remove the danger the building poses to its occupants or the wider public. Reducing

or removing the danger associated with a building can include removing the part of the building that is dangerous, securing or repairing the building, or demolition. An example of a section 124 notice used after the Canterbury earthquakes is attached as Appendix 4 of Volume 7.

**2.6.1.2 The transition after the Canterbury earthquakes**

It is unclear what pre-planning had been done to manage the transition of the building safety evaluation process from civil defence to normal building management arrangements after the September earthquake. CCC4 contends, and we accept, that

the large number of buildings damaged after the September earthquake meant that it was not possible to place section 124 notices on all red or yellow placard buildings before the state of emergency

ended: the large number of damaged buildings meant that the workload of its Enforcement Team was

much greater than the approximately 65 complaints a year about buildings alleged to be dangerous that

it usually processes. The CCC developed its policies and procedures about how to treat red and yellow placard buildings after the state of emergency ended. In 2008, Brunsdon25 noted that it would be difficult to issue section 124 notices before the end of a state of emergency in a building safety evaluation operation larger than Gisborne’s.

The Canterbury Earthquakes (Building Act) Order 2010, which extended the status of the red and yellow placards for a further 60 days, was intended to respond to this difficulty. Clause 8 deemed them to be section

124 notices. It provided that:

(2) A red card is deemed to be a notice issued under section 124(1)(b) of the Act that warns people not to approach the building.

(3) A yellow card is deemed to be a notice issued under section 124(1)(d) of the Act as modified by clause 9.

(4) Any restrictions on use that are described on a yellow card are deemed to be requirements of a notice issued under section 124(1)(d) of the Act as modified by clause 9.

Note that Clause 9 inserts paragraph (d) into section

124(1) of the Building Act 2004.

As well as extending the status of the red and yellow placards for 60 days, Clause 9 also required that building owners take action within five days of receiving written notice (or having a notice placed on their building) setting out the need to reduce or remove the danger their building posed. Normally under section 124 building owners have no less than 10 days before they must take action.

Extending the status of the red and yellow placards

gave the CCC time to develop the procedures it needed to transition the building safety evaluation process into its building control arrangements. The CCC established the Building Evaluation Transition team and the Building Recovery Office to manage this process.

The Building Evaluation Transition team operated from

20 September 2010 to the end of November 2010. This team audited the placards of approximately 580 commercial properties in October 2010 to maintain an accurate schedule of building safety evaluations. It developed a process for incorporating the reports generated by engineers engaged by building owners

and for changing the status of placards on a building.

The team also carried out inspections of dangerous or unstable buildings, maintained cordons and arranged for section 124 notices to be placed on buildings.

CCC established the Building Recovery Office on

13 September 2010. The Building Recovery Office was the main point of contact for building and home owners. It responded to queries about the building evaluation process, answering questions about the meaning of

the placards, what the Building Act notices meant,

and what building owners needed to do to change the status of their building. As the main point of contact

for building owners, the Building Recovery Office was where owners registered the need for demolition work, major repairs or rebuilds, obtained property records, and obtained any consents needed to proceed.

From 28 November 2010, a new Building Recovery Office was established that combined the functions of the old Building Recovery Office with those of

the Building Evaluation Transition team. The new Building Recovery Office was responsible for the case management of all remaining dangerous buildings, both in the CBD and other areas. It also responded to customer service requests about dangerous buildings.

Most building owners had until the end of January 2011 to address the danger associated with their buildings, unless they were particularly dangerous or impeded traffic flow or public access. Evidence the Royal Commission has heard indicates that work to follow

up on the status of these buildings was ongoing when the February earthquake struck. Owners’ actions were compromised while they waited for insurance company decisions before committing to costly make-safe or demolition decisions. This issue and other barriers to the repair or demolition of buildings damaged in the Canterbury earthquakes are discussed in section 2.6.4 of this Volume.

2.6.2 Managing buildings after an earthquake

The need for a transition mechanism is part of a larger issue with the management of buildings after earthquakes. After a significant earthquake or other disaster, it is necessary to prioritise how to treat buildings based on the severity of the damage to them. However, there is also a need to consider all buildings that may have been damaged, even if the damage appears minor. Even if a building has a green

placard, it may be appropriate to assess it further. This is important because the rapid assessments are only designed to indicate the condition of the building as

an interim measure until a more detailed evaluation

can be arranged by the owner. Rapid assessments are

not thorough. They are appropriate for a basic sifting method, but a brief assessment of the damage to a building is unlikely to identify the capacity it has left to withstand damage from further aftershocks or its suitability for long-term reoccupation.

Because the process is designed to prioritise which damaged buildings to focus on, buildings fall out of the system as soon as a green placard is applied. Green placard buildings were not considered further during the rapid assessment phase unless their Level 1 Rapid Assessment form noted the need for a Level 2 Rapid Assessment. Because the Canterbury Earthquakes (Building Act) Order 2010 only dealt with the status

of red and yellow placard buildings, green placards had no status after the state of emergency ended. The Royal Commission has heard evidence that after the September earthquake civil defence workers

and building control officials did not have a formal mechanism for the further assessment of a building that was able to be used, but remained in need of repair.

**2.6.2.1 Need for further engineering evaluations**

The NZSEE Guidelines10 make it clear that New Zealand’s rapid assessment process is not designed to provide an engineering assessment service for building owners and insurers. This is because the result of rapid assessments are inevitably indicative

only. Building owners and other decision makers need better information to decide what short-term repairs

are needed, when to carry these out, and the long-term future of the building. For these reasons, the NZSEE Guidelines envisage that DEEs will be carried out on all buildings after the state of emergency. These Guidelines state that building owners are responsible for organising DEEs for their buildings. Building owners remain responsible for the safety of their buildings.

We have heard evidence that many building owners did not act on the green placard’s recommendation to obtain “a detailed structural engineering assessment” of their building. It is not known how many owners

did authorise engineers to carry out full evaluations of their buildings. Middleton and Westlake2 suggest that territorial authorities were able to require DEEs from owners after the September earthquake. However, the CCC4 states that it could not legally require building owners to order a DEE of their building. The Royal Commission agrees with this view.

The Royal Commission considers that building owners have the primary responsibility to ensure that buildings are safe to occupy and owners should therefore carry out the appropriate engineering assessments after

the rapid assessment phase of the building safety evaluation process.

Submitters discussed whether or not to require DEEs after earthquakes, particularly before allowing the

short- or long-term reoccupation of the building. There was some debate among submitters about what level of assessment should be required before people are allowed to reoccupy buildings after a disaster.

They discussed what the appropriate triggers for the short-term reoccupation and for the long-term reoccupation should be.

The Royal Commission has received evidence that establishes that a full engineering evaluation, using the methods and approaches engineers employ

in normal circumstances, is both costly and time- consuming. There would be very significant economic and social impacts if completion of such evaluations was required before allowing reoccupation, and the Royal Commission considers that would be both undesirable and unrealistic.

However, we consider that in many cases a rapid assessment will not be sufficient for reoccupation without a further evaluation of the building, because it is a short, coarse inspection. The NZSEE Guidelines also take this view. In particular, we consider that the Level 1

Rapid Assessment is not sufficient to ensure the safety of the building’s occupants or the wider public. By contrast, a DEE would confirm that the building is safe for long-term reoccupation. Under section 51 of the Canterbury Earthquake Recovery Authority Act 2011, CERA can compel building owners to obtain a DEE of their building before its reoccupation and provide this information to CERA.

In practice, CERA recognised that some buildings only had minor damage after the Canterbury earthquakes and it might not be appropriate to restrict their reoccupation while their owners arranged for a full

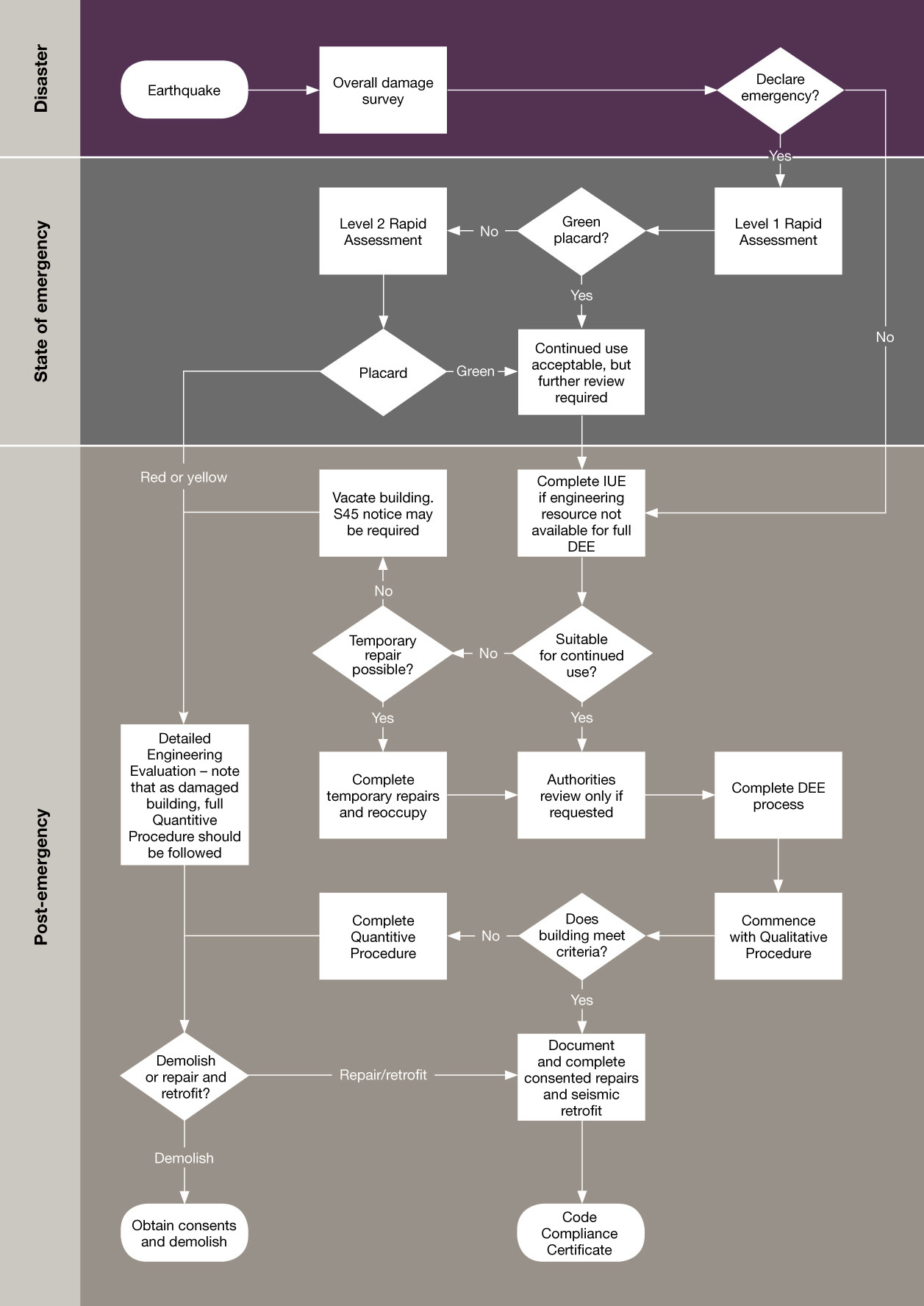
DEE. CERA developed a process to determine whether a building can be occupied before a full engineering evaluation is carried out on it; this process is called the Interim Use Evaluation (IUE). Japan’s Post-Earthquake Damage Evaluation and Rehabilitation guidelines are an international example of a process that is specifically designed to determine how a building can be used temporarily after repair but before full, long-term

earthquake strengthening.

In their evidence to the Royal Commission, Mr John Hare and Mr David Brunsdon discussed the IUE. It involves examining the structural drawings to identify the locations of critical structural weaknesses and potential plastic zones. Having established these locations, the building is examined with the appropriate wall and

floor linings and ceiling tiles removed to enable the

critical zones to be inspected and the level of damage assessed. If the damage is seen in other locations the drawings and foundations should be further assessed until a satisfactory explanation is obtained for the observed damage. If the level of damage is acceptable, the building contains no critical structural weaknesses and is judged to have an acceptable level of ductility and redundancy, the building may be opened to the public for interim use. Figure 11 demonstrates how this process works in practice:



**Figure 11: Simplified building safety evaluation and use decision making framework (source: adapted from email from**

**John Hare to the Royal Commission, 1 September 201226)**

We note that in June 2012, the former Department of Building and Housing27 released guidance on how to carry out an IUE.

**2.6.2.2 The Royal Commission’s proposals**

As has been seen, the Terms of Reference require us to examine the legal and best-practice requirements for the assessment of buildings after any earthquake, having regard to lessons from the Canterbury

earthquakes. As a result of considering the performance of buildings in the Canterbury earthquakes, the Royal Commission has identified a number of factors that engineers need to consider when deciding how best to facilitate the return of a city to an operational state after an earthquake.

**2.6.2.2.1 Practical assessment considerations**

We have already dealt with practical considerations that need to be taken into account in the assessment of individual buildings. We set out several factors that engineers need to note when assessing buildings that are not constructed from unreinforced masonry in section 6.2.5 of Volume 4. Examples of these factors include:

• allowing for the effect of flexural cracking on the

stiffness of structural members;

• allowing for accidental torsion;

• considering how the inter-storey drifts should

be calculated;

• ensuring that there are valid load paths for seismic forces and gravity loads through the building and through details such as beam-column joints; and

• the attachment of floors to lateral force resisting

elements.

Volume 2 and section 6.3.8 of Volume 6 of this Report address the vulnerabilities of different building types we observed from buildings in Christchurch (including the CTV building). These should also be taken into account. The Royal Commission considers that there is a lack

of adequate guidance given in New Zealand Standards on the design forces required to tie floors on to lateral force resisting elements. This aspect of the design is

of concern where the primary source of lateral force resistance is provided by structural walls or braced frames located on the perimeter of the building. In such cases, we propose that, where practicable, structural drawings should be examined to check that the floors are adequately tied into the lateral force resisting elements. This check should be made in the case of all buildings to which this consideration is applicable.

The Royal Commission considers that these matters should be incorporated into the Ministry of Business, Innovation and Employment’s draft guidelines17 on carrying out detailed engineering evaluations after earthquakes.

We note that in the following sections we outline the concept of a “Plans-Based Assessment” (PBA), and its role in the assessment of buildings after a major earthquake. We observe here that the PBA concept could also be adapted for use in the assessment of buildings prior to an earthquake.

**2.6.2.2.2 The post-earthquake assessment system**

The focus of this section of the Report is mainly on the overall system that should be adopted following the occurrence of a major earthquake that has resulted

in the declaration of a state of emergency. Following a significant earthquake, international best-practice is to carry out an Overall Damage Survey to identify

areas where appreciable damage has occurred so that appropriate steps can be taken to direct assistance to locations where help may be required to free people trapped in buildings and provide assistance to those that have been injured. A decision on whether to declare a state of emergency is one outcome from

this survey.

This step should be followed by the rapid assessment of individual buildings to locate potential fall hazards and identify buildings that are in urgent need of further attention from the point of view of public safety. Subsequent steps should be based on a number of considerations which include the extent of the damage, the characteristics of the earthquake, the likely intensity of subsequent aftershocks (as advised by GNS Science), the manpower available for the assessment of buildings and the mix of building types and ages in the city.

The system that we are proposing envisages that in the area in which the state of emergency applies all buildings should be assessed prior to reoccupation. That process would commence with Level 1 and 2

Rapid Assessments. Where the rapid assessment process has identified the need for further evaluation of an individual building, the reoccupation of the building would then depend on assessments that vary according to the building’s structural type and the nature of the earthquake event. Assessments after the

rapid assessments would include a PBA or, at the most thorough level, a DEE. The concept of a PBA is similar to that of the IUE discussed above.

We envisage that a PBA would involve examining the structural drawings to identify the locations of plastic zones and other locations where high strain may be induced. In addition it would involve identifying critical structural weaknesses, including assessing the level

of ductile detailing in columns, beams, beam-column joints, structural walls, braced frames (concentric and eccentric) and the way in which the floors are tied into the lateral force resisting elements. Ideally in a PBA these locations in the building should be examined to identify the extent of the damage. This would require the removal of areas of ceilings and wall and floor linings to allow the level of damage to be assessed. Where damage is located in other parts of the building, the drawings and foundations should be re-examined until the damage can be satisfactorily explained.

The objective of the PBA is to identify whether the building has any critical structural weaknesses that could result in sudden and/or non-ductile behaviour, such as occurred in the CTV and PGC buildings. Any calculations involved in a PBA are envisaged as being approximate in nature and sufficient to determine the order of strength or ductility of a detail or structural element. We address below the situations in which

the PBA would be carried out. We recommend that the Ministry of Business, Innovation and Employment further develop the PBA concept, in consultation

with the NZSEE and the Structural Engineering

Society New Zealand.

The following discussion also refers to a DEE, which should include the calculation of the percentage of ULS of the damaged structure. The concept of the DEE is discussed in sections 2.3.2.3 and 2.4.5.2.2 of this Volume.

Where the initial earthquake is generated by a distant fault, aftershocks may be expected to be of shorter duration and lower intensity than the main shock. Where the fault is close to the city there is the possibility of subsequent aftershocks being closer to the city than the initial earthquake. In such an event the ground shaking may be more intense than the initial earthquake and there is also the possibility that the directions of the major components of shaking will be different from those of the initial earthquake. Both of

these factors can potentially cause damage to buildings not significantly damaged in the initial earthquake.

We therefore propose that a more conservative approach is taken to the assessment of buildings when the rupture causing the earthquake is on a local fault line rather than on a distant fault line. The Royal Commission considers that if significant structural damage has been observed in a significant proportion

of the multi-storey buildings, then all buildings of three or more storeys (provided in the case of residential buildings that they contain three or more household units) should be subjected to a DEE in the months following a major earthquake.

**2.6.2.2.3 Categorisation of buildings**

To allow for the changes that have occurred in design practice over the years, we propose that buildings are divided into four groups, namely:

**Group 1**: non-unreinforced masonry buildings that do not have a known critical structural weakness, and either:

• in the case of concrete buildings, were designed to NZS 3101:199528 or later editions of that Standard; and

• in the case of structural steel buildings, were designed to NZS 3404:199229 (informed by the Heavy Engineering Research Association

guidelines30 published in 1994) or later editions of

that Standard;

or have been subject to an evaluation that has shown that the building has 67% ULS or greater (we discuss the term “ULS” in section 6.2.4 of Volume 4);

**Group 2**: buildings designed between 1976 and the mid-1990s, but not included in Group 1;

**Group 3**: buildings designed before 1976, but not included in Group 1; and

**Group 4**: unreinforced masonry buildings.

The extent of post-earthquake assessment of a building in each group should depend on the extent of the damage it has sustained, having regard to the

assessment considerations that we have addressed in section 2.6.2.1.1 above.

Buildings used for residential purposes that are three or less storeys in height should be excluded from Groups 2 and 3. In the case of those buildings, a pragmatic approach needs to be taken to assessment and occupancy, which balances the need for shelter with safety considerations. In our view other commercial and residential buildings should not be occupied until that is approved in the process outlined below.

The assessment process should also reflect the characteristics of the earthquakes, the proximity of the fault and the nature of the soils in the affected area.

We are not able to be precise about these matters in advance. The discussion that follows reflects the understandings that we have developed as a result

of our consideration of the performance of buildings in the Canterbury earthquakes, which had the characteristics we set out in Volume 1 of our Report. It must be understood that the assessment process following future earthquakes will inevitably need to be adapted to the circumstances that then apply.

However, we consider that the assessment process and decisions about occupancy should be informed by an understanding of the characteristics of the earthquake and the potential for aftershocks. The civil defence Controller (and the territorial authority after the state of emergency has come to an end) should be responsible for obtaining authoritative advice about those matters, and making the information available so that those involved in the assessment process are aware of it.

**2.6.2.2.4 Other considerations**

The Royal Commission considers that the civil defence

Controller and the Ministry of Business, Innovation

and Employment (as the agency that deploys the core team of building safety evaluators) should decide the timeframe in which building owners should obtain a PBA and a DEE considering the circumstances and extent of the disaster.

Given the problems with information sharing, which we discuss in section 2.5.5 of this Volume, we consider that building owners should be required to provide a copy of any PBA and DEE obtained to the territorial authority.

In section 7.4.2 of Volume 4, we recommend that the Building Act 2004 should be amended to

require and authorise territorial authorities to ensure completed assessments of all unreinforced masonry buildings within their district within two years from the enactment of the Amendment, and of all other potentially earthquake-prone buildings within five years of enactment. We note that this would require each territorial authority to develop a database

listing all of the earthquake-prone buildings in its district. We consider that the information gained and recorded in that exercise should be supplemented

by information classifying buildings of three or more storeys into the groups that we have discussed

above. The database thereby produced, which can be prepared in anticipation of a future earthquake, could be used to guide the assessment process that would be appropriate after the rapid assessment operation following a major earthquake.

**2.6.2.2.5 Occupation**

As with the assessment process, the decisions made about the occupation of buildings following a significant earthquake should reflect the nature of the buildings,

the characteristics of the earthquake, the proximity of the fault and the nature of the soils in the affected area. The following proposals reflect the experience of the Canterbury earthquakes.

The September earthquake produced shaking in Christchurch of a level comparable to the design level for the ultimate limit state. However, the duration of strong ground shaking was on the low side of what might be expected in other parts of the country.

The February earthquake produced shaking with an intensity that was unusually high and such an event is rare. In our opinion, the experience gained from the September earthquake gives a better guide to what is required for the assessment of buildings for

reoccupation after an earthquake for other locations in New Zealand. Where the geological situation is such that an aftershock may occur on a fault line closer to

or within the CBD, as occurred in Christchurch with

the February earthquake, additional precautions should be taken.

The Royal Commission considers that, following Level 1 and Level 2 Rapid Assessments, occupation should be based on the outcome of the assessment process set out below:

a) For Group 1 buildings:

• where no significant structural damage was

seen, a Level 2 Rapid assessment;

• where significant structural damage was seen, a

PBA for a lower levels of structural damage and a DEE for higher levels of structural damage.

b) For Group 2 buildings:

• where no significant structural damage was

seen, a PBA;

• where significant structural damage was seen,

a DEE.

c) For Group 3 buildings:

• for all levels of damage, a DEE.

d) For Group 4 buildings:

• where no significant structural damage was

seen and the building has been retrofitted to

67% ULS or greater, a PBA;

• where significant structural damage is apparent and where the building has not been retrofitted to 67% ULS or greater, a DEE.

Where the earthquake is located on a fault that is close to the city or where there is a possibility of an aftershock or new earthquake closer to the CBD, a higher level of assessment should be made.

Decisions about the occupancy of buildings should be made once the appropriate level of assessment has been carried out, and forwarded to the Civil Defence Controller (while the state emergency continues) and

to the territorial authority when it is completed, for their approval.

**Recommendations**

We recommend that:

151. After an earthquake that has given rise to the declaration of a state of emergency, buildings should be assessed in accordance with the following process:

a all buildings should be subject to a rapid assessment process;

b for the purposes of subsequent steps, buildings should be placed in the following categories:

i) Group 1: non-unreinforced masonry buildings that do not have a known critical structural weakness, and either,

• in the case of concrete buildings, were designed to NZS 3101:1995 or later editions of that Standard;

• in the case of structural steel

buildings, were designed to NZS

3404:1992 (informed by the Heavy Engineering Research Association guidelines published in 1994) or later editions of that Standard;

or have been subject to an evaluation that has shown that the building has

67% ULS or greater (we discuss the

term “ULS” in section 6.2.4 of Volume 4);

ii) Group 2: buildings designed between

1976 and the mid-1990s, but not included in Group 1;

iii) Group 3: buildings designed before

1976, but not included in Group 1; and

iv) Group 4: unreinforced masonry buildings;

c buildings used for residential purposes that are three or less storeys in height should be excluded from Groups 2 and 3. In the case

of those buildings, a pragmatic approach needs to be taken to assessment and occupancy, which balances the need for shelter with safety considerations. Other commercial and residential buildings should not be occupied unless approved for occupancy in accordance with the process outlined below;

d legislation should require territorial authorities to classify buildings in their districts in accordance with the preceding Recommendation within the timeframes established under Recommendation 82 in Volume 4 of our Report (Recommendation 82 requires the assessment of earthquake-prone and potentially earthquake-prone buildings);

e where the rapid assessment process had identified the need for further evaluation of a building in one of these defined Groups, the building should not be occupied until the Civil Defence Controller or the territorial authority (as appropriate) has approved

the occupancy of the building after the following assessments:

i) for Group 1 buildings:

• where no significant structural damage was seen, a Level 2 Rapid Assessment;

• where significant structural damage was seen, a Plans-Based Assessment for lower levels of structural damage and a Detailed Engineering Evaluation for higher levels of structural damage;

ii) for Group 2 buildings:

• where no significant structural damage was seen, a Plans-Based Assessment;

• where significant structural damage was seen, a Detailed Engineering Evaluation;

iii) for Group 3 buildings:

• for all levels of damage, a Detailed

Engineering Evaluation;

iv) for Group 4 buildings:

• where no significant structural damage was seen and the building has been retrofitted to 67% ULS or greater, a Plans-Based Assessment;

• where significant structural damage is apparent and where the building has not been retrofitted to 67% ULS or greater, a Detailed Engineering Evaluation;

f arranging for the Plans-Based Assessments and Detailed Engineering Evaluations should be the responsibility of the owner of the buildings concerned; and

g the Ministry of Business, Innovation and Employment should further develop the Plans-Based Assessment concept, in consultation with the New Zealand Society for Earthquake Engineering and the Structural Engineering Society

New Zealand, and set out the Plans-Based

Assessment in published guidelines.

152. Plans-Based Assessments and Detailed Engineering Evaluations should include checking the vulnerabilities observed after the Canterbury earthquakes that the Royal Commission describes in Volume 2, section

6.2.5 of Volume 4, and section 6.3.8 of

Volume 6 of this Report.

153. Any Plans-Based Assessment and Detailed

Engineering Evaluation of a building after an earthquake should begin with a careful examination of the building’s plans.

154. The Plans-Based Assessment and Detailed Engineering Evaluation should confirm that all known falling hazards and other vulnerabilities have been assessed and secured or removed.

155. A copy of the Plans-Based Assessment and the Detailed Engineering Evaluation should be given to the relevant authorities.

2.6.3 Confusion of roles and responsibilities

The NZSEE4 suggests that pre-prepared building

evaluation plans should describe the roles

and responsibilities of key personnel responsible

for delivering the building safety evaluation process.

A number of units within CCC worked on building recovery activities after the September earthquake. For this to be successful, these units had to work together in an integrated way. Griffiths and McNulty5 suggest that the Building Recovery Office and the Building Transition Evaluation Team did not work together in a coordinated way, resulting in some information sharing problems, owners being told incorrect information about their buildings, and a

number of inaccurate or contradictory messages being released to the media and wider public.

The Royal Commission has heard evidence that an engineer engaged to evaluate a building became a point of contact for many of the people who had an interest in the building; often, this was not something that was clearly articulated or clearly required of the engineer. Property managers were another group

who took on a similar role. These groups could be encouraged to take up a coordinating role after an earthquake or other disaster. We have also heard evidence that engineers found it difficult when they had to consider how their advice about the building could affect the safety of the wider public, a role that they took on for the good of society, while contracted and liable, however, only to the building owner.

In addition, the Royal Commission has heard evidence that the responsibilities of building owners were not clear following the Canterbury earthquakes. Ultimately, building owners are responsible for confirming that

their building is safe after a disaster. We have heard

evidence that there were issues with the way the responsibility for a damaged building transferred from the CCC to building owners. Normally building owners are responsible for emergency repairs on a building and any barricades erected while this work is ongoing.

However, after the September earthquake civil defence emergency management and territorial authorities organised for assessments of buildings and the setting up of cordons.

Some building owners waited for civil defence or council workers to evaluate their buildings, assuming that these authorities would inform them if any problems existed. Griffiths and McNulty also describe how the Building Evaluation Transition team carried out activities that were normally the responsibility of the

building owner: for example, clearing rubble from major arterial routes and designing propping to enable the cordons around a building to be removed.

**2.6.3.1.1 Cordon management**

The Royal Commission has heard evidence that it was not clear who was responsible for setting up and maintaining cordons after the state of

emergency ended. Mr Stephen McCarthy of the CCC told us that normal building practice is for building owners to organise safety fencing around their properties if they are carrying out works on them. Building owners must gain permission from their territorial authority to do so, but the owners or their contractors erect and manage these barricades until the work on the site is complete. During the state of emergency in September 2010, civil defence

workers set up a cordon around Christchurch’s CBD. Civil defence workers then set up cordons around particular buildings or areas as they slowly reopened access to the wider CBD.

After the state of emergency ended, the CCC decided when and where cordons were to be placed, moved or dismantled. However, evidence the Royal Commission has heard indicates that building owners may have been expected to take over some responsibility

for maintaining the cordons around their buildings, especially when they were carrying out repairs to the building but using council barricades and cordons. When and how this change over was to occur was not clear to the CCC or to building owners.

We have also heard evidence that indicates that cordons were not wide enough to ensure public safety in the February earthquake. We consider that public pressure to keep access to streets and businesses open may have contributed to this. There is clearly a

need to balance such considerations with public safety, which nevertheless should be the main consideration. Best-practice indicates that cordons should be set to allow for a fall zone of one and a half times the height

of the building. The Royal Commission saw examples of cordons having been set up around an individual building that failed causing death with a fall zone considerably less than this.

We received evidence from Mr Peter Smith, who analysed the failure of each individual building causing death, that even if the cordon was set up to protect the public from a particular fall hazard, such as a parapet, when parapets fell in the February earthquake they often took a considerable part of the exterior wall with them. Sometimes, this meant that the cordon was

inadequate and the building collapsed across the street.

The Royal Commission considers that territorial authorities should be responsible for placing, moving and removing cordons. Territorial authorities should

take over the responsibility for maintaining any cordons set up during the response phase after the transition

to normal building management arrangements. This is because territorial authorities are responsible for ensuring that people are safe in public areas, including, of course, streets and footpaths. We recognise that

this may place a burden on territorial authorities when building owners take time to make a decision about the repair or demolition of their damaged building.

The Royal Commission therefore considers that territorial authorities should be able to recover the costs of maintaining any cordons set up due to the damage to a particular building from the building owners after a reasonable period, which we would assess as three months.

The Royal Commission considers that the wider roles and responsibilities of statutory authorities, other decision makers and building owners should be set in the plans for the building safety evaluation process. These plans should set out their roles and responsibilities during the response and recovery phases. We consider that such plans should keep a

degree of flexibility, so that people and organisations are aware of their responsibilities but can respond to the disaster as appropriate within the circumstances and scale of the event.

**Recommendations**

We recommend that:

156. Civil defence and emergency management should be responsible for setting up and maintaining cordons during the state of emergency.

157. Territorial authorities should be responsible for maintaining any cordons that are in place at the end of the state of emergency until

the public space or building they surround is made safe.

158. Territorial authorities should be able to recover the costs of maintaining any necessary cordons from the building owner after three months.

159. The roles and responsibilities of decision makers should be described in the building safety evaluation process. The roles and responsibilities should allow for flexibility of operation according to the circumstances and scale of the event.

2.6.4 Barriers to action

The Royal Commission has heard evidence that some building owners were motivated to address the damage to their building after the September earthquake, but were not able to carry out work on their buildings because of problems finding a contractor, insurance issues, or legislative barriers.

**2.6.4.1 Meeting the requirements of insurers**

We have heard evidence that problems settling their insurance claims caused delays for building owners attempting to repair their buildings after the September earthquake. These issues caused the reluctance of some owners to act in response to a section 124

notice on their building. Griffiths and McNulty5 note

that owners had little control over the time it would

take to repair the buildings while still in negotiation with their insurers. The NZSEE4 suggests that the level of insurance claims insurers are willing to meet makes

the decision about the level of repair and strengthening territorial authorities require for a building after an earthquake more complex. Brunsdon25 notes that issues about what work insurance policies covered also arose after the 2007 Gisborne earthquake. There is little that can be done to address these issues, since they involve rights that are under individual contracts of insurance.

**2.6.4.2 Legislative barriers**

Rotimi31 contends that the Civil Defence and Emergency Management Act 2002, the Resource Management Act 1991 and the Building Act 2004, and their regulatory guidelines in particular, are a barrier to coordinated and unhindered recovery from a disaster. He also highlights the lack of cross linking between these statutes, and expresses the opinion that statutory powers to coordinate recovery efforts are inadequate.

Building consents for repairs to buildings damaged in the September earthquake would normally trigger requirements to ensure access to the building for people with disabilities and for escape from fire.

The Royal Commission discusses and makes recommendations about this issue in section 7.5.5 of Volume 4.

The Royal Commission has heard evidence that section

124 notices issued under the Canterbury Earthquake (Building Act) Order 2010 did not override the need for a resource consent under the Resource Management Act 1991 (for example, to repair or demolish a heritage building). The timeframes for processing these

consents were sometimes long. The Royal Commission

discusses and makes recommendations about this issue in the case of buildings that could cause injury or death in section 7.7 of Volume 4.

The Canterbury Earthquake (Resource Management

Act) Order 2010 let territorial authorities act immediately to fix a building without resource consent if they did

the work themselves, by modifying section 129 of the Building Act 2004. In section 7.5.2.2 of Volume 4 we discuss how the CCC was reluctant to exercise this power. We discuss and make recommendations there for the conferral of a general legislative power to enable territorial authorities to take action where a building requires immediate demolition or repair as a result

of an earthquake.

**2.6.4.2.1 Buildings that act as one structure in an earthquake**

The Royal Commission has heard evidence that problems can arise when buildings are divided into separate properties with different addresses separated by party walls, but nevertheless act as a single structure in an earthquake. The former Austral Buildings in Colombo Street, shown in Figure 12, are an example

of such a structure.



**Figure 12: Former Austral Buildings, 603, 605–613 Colombo Street before the February earthquake**

Figure 12 shows how this structure can be one, large unreinforced masonry building that takes up most

of a block. The party walls that divide each part of the building, while thicker and more substantial than other internal walls, are not built to be an external wall. Structurally, each property acts as a part of one

building in an earthquake. As we saw in Christchurch, this often resulted in the façades of the entire row of separate properties collapsing onto the street. Figure 13 shows how first floor façades of the Austral Buildings, acting as one large façade, collapsed outward onto

the Number 702 Red Bus and pedestrians, tragically causing death.



**Figure 13: Former Austral Buildings, 603, 605–613 Colombo Street after the February earthquake**

For this reason, such buildings should be assessed as one structure by building safety evaluators. Although the intent was that the whole of one structure be inspected and treated as one, and the placards

placed on each tenancy or property accordingly, we have heard evidence of instances when that did not occur. Having separate properties that act as one structure also caused problems when attempting to repair the building, because each property was treated individually by engineers, building owners, territorial authorities and other decision makers. To address

this issue, section 52 of the Canterbury Earthquakes Recovery Act 2011 allows CERA to direct the owners of two or more adjacent buildings to act together for

their mutual benefit. CERA32 advise that it has not implemented this provision because a reluctant owner is unlikely to see the action as being to their benefit. The owners of a row of properties in New Regent

Street voluntarily acted together to repair and preserve their building.

The Royal Commission considers that it is important that these buildings are assessed as one structure by building safety evaluators. In section 7.5.4 of Volume 4, we discuss and make recommendations about the need for general legislative provision to ensure that all portions of such structures are able to be strengthened contemporaneously.

**Recommendation**

We recommend that:

160. The building safety evaluation process should direct evaluators to assess properties that

act as one structure in an earthquake as one structure, rather than as separate buildings.

2.6.5 Options for a transition mechanism Submitters propose developing formal transition mechanisms that set out the process and procedures

to be used when shifting the building safety evaluation

process from civil defence to the building management arrangements governed by territorial authorities. The Ministry of Business, Innovation and Employment

and the Ministry of Civil Defence and Emergency Management contend that the new emergency risk management provisions proposed for the Building Act

2004 would ensure a seamless transition from response to recovery after a disaster.

Figure 14 describes the Ministry of Business, Innovation and Employment’s proposed new emergency risk management provisions for the Building Act 2004.

**State of emergency begins – ends**

**CDEM Act**

Emergency capability (trigger, powers, capacity)

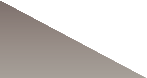
**Building Act**

**Pre-event building management**

**Response Transition to recovery**

**Building management in rebuild**

**Figure 14: Proposal for Building Act 2004 emergency building evaluation arrangements integrated with normal building management arrangements (source: submission from the Ministry of Civil Defence and Emergency Management)**



In contrast to the current legislative arrangements, the new provisions propose to build in a gradual shift from building management after earthquakes and other disasters to normal building management

arrangements. Under these proposals, the responsibility

for the building safety evaluation process and wider

building management after earthquakes does not shift from the civil defence and emergency management framework into the building regulatory framework. Consequently, it is theoretically possible to manage

the process end to end within the territorial authority’s building management arrangements.

The Ministry of Civil Defence and Emergency Management discusses how placing emergency management provisions in the Building Act 2004

is consistent with New Zealand’s civil defence and emergency management framework. It33 encourages “clusters” of agencies to facilitate routine coordination

of readiness planning on a daily, standard arrangements basis; these clusters may also be activated to carry out response and recovery activities. In its submission to

the Royal Commission, it contends that each cluster or agency continuing to work through its primary mandate as far as practicable is a key principle that underpins New Zealand’s civil defence and emergency management framework. Figure 15 demonstrates how national civil defence and emergency management plans are informed by and integrated with other

legislative and planning frameworks.

**Local risk reduction**

e.g. local RMA plans, river management, infrastructure design, Business Continuity Planning and LTCCPs

**CDEM Group plans and local arrangements**

CDEM Groups, local authorities

**Government agency operational plans**

Health, MAF, Police, MetService etc

**Non-govt agency operational plans**

Lifeline utility, voluntary welfare, SPCA, etc

**Links between operational plans**

**Central government policies for risk reduction**

e.g. Building Code, GeoNet, hazard research, sustainable land

management, flood risk management

**The Guide to the National CDEM Plan**

**National CDEM Plan**

**National CDEM Strategy**

**Other national strategies and legislation**

e.g. RMA

**Civil Defence**

**Emergency Management Act 2002**

**Figure 15: Linkage between national, regional and local operational plans and arrangements (source: *Guide to the***

***National Civil Defence and Emergency Management Plan*, 2009)**

The civil defence Controller is still in charge during a state of emergency. For example, after the February earthquake the Ministry of Social Development led the response of the welfare cluster under the authority of the civil defence Controller.

Developing a standard Order in Council that transitions the management of buildings from civil defence to normal building control arrangements could also address the problems with the legal status of the placards at

the end of a state of emergency. Drafting a standard Order in Council in advance would allow the detail of any proposed changes to legislation, such as those contained in the Canterbury Earthquake (Building Act) Orders 2010 and 2011, to be carefully considered. Nevertheless, the Royal Commission considers that it would be difficult to guarantee many years in advance of an event that all of the relevant issues had in fact been covered. In addition, a standard Order in Council would still need to be authorised by a special legislative procedure.

The Royal Commission considers that the Ministry of Business, Innovation and Employment’s proposal to introduce emergency risk management provisions into the Building Act 2004 has merit. The transition fully into standard processes will be less abrupt and is likely to be better planned than under the current legislative arrangements. We consider that there could be several advantages to this proposal once its details are further explored. For example, does this proposal establish a cluster, led by the Ministry of Business, Innovation and Employment, that deals specifically with building management after earthquakes and other disasters? Given that the clusters are encouraged to make their own arrangements within New Zealand’s civil defence and emergency management framework, the Royal Commission considers that this could be one way to ensure that central and local government take up a formal role in developing building safety evaluation processes.

Regardless of where these mechanisms are placed, or what format they take, submitters clearly believe that

it is important to develop these transition mechanisms before they are needed. We agree, and consider that the building safety evaluation process and wider building management after earthquakes (and other disasters) framework should be developed and provided for in legislation.

**Recommendation**

We recommend that:

161. The building safety evaluation and wider building management after earthquakes (and other disasters) framework should be developed and provided for in legislation.

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