New Zealand Society for Earthquake Engineering

Report to the Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes

Building Safety Evaluation Following the Canterbury Earthquakes

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1. Introduction

1.1 Background

The *Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes* is covering matters relating to the assessment of buildings undertaken following the initial earthquake and subsequent aftershocks.

Post-disaster building safety evaluation procedures have been developed by the New Zealand Society for Earthquake Engineering over the past two decades, based initially on the procedures of the United States Applied Technology Council. Formalisation occurred recently with support from the Department of Building and Housing and the Ministry of Civil Defence and Emergency Management.

The Canterbury Earthquakes Royal Commission has requested the New Zealand Society for Earthquake Engineering (NZSEE) to provide a report covering two of the subjects to be addressed under its Terms of Reference, namely the issues of:

(a) the effectiveness of the assessment of buildings following the Canterbury Earthquakes on 4 September and 26 December 2010; and

(b) the legal and best practice requirements for the assessment of buildings after any earthquake, having regard to the lessons learned from the Canterbury Earthquakes.

These issues are set out in paragraphs (c) and (d)(v) of the Commission's Terms of Reference which further states –

> "The Terms of Reference for the Canterbury Earthquakes Royal Commission define the term Canterbury Earthquakes, by reference to the events of 4 September, 26 December and 22 February. However, if there are relevant lessons to be learned about the above matters as a result of the aftershocks of 13 June, commentary on them is to be included in the report.
>
> The report is also to benchmark New Zealand's approach to the assessment of buildings after earthquakes with international practices. "

This report was prepared for the NZSEE by Dave Brunsdon of Kestrel Group, who led the Society's Working Group which produced the current version (August 2009) of the building safety evaluation guidelines. These guidelines were used as the basis for the building safety evaluation operations following the 4 September 2010 and 22 February 2011 earthquakes.

The report has been reviewed by and had input from several people involved with the building safety evaluation operations following these events.

1.2 Scope of This Report

This report addresses the requirements of the Canterbury Earthquakes Royal Commission brief to NZSEE.

The history of the development of the post-disaster building safety evaluation arrangements that were in place at the time of the 4 September 2010 earthquake, and their relationship in terms of best practice with procedures in other countries is outlined in Section 2.

The implementation of those arrangements following the 4 September 2010 earthquake is described in Section 3, along with the issues arising. Observations are also provided on the building safety evaluation activities that followed the 26 December 2010, 22 February 2011 and 13 June 2011 aftershocks.

There are a number of elements of the building safety evaluation operations that are not covered in detail in this report, as they lie outside the direct areas of interest to the Royal Commission. These include aspects such as information management and mapping, and the national mobilisation of engineers and building control officials.

A discussion on future best practice in post-earthquake building assessments for New Zealand is provided in Section 4, noting that a more comprehensive review is underway at the time of preparing this report.

Summary observations are presented in the final section of this report.

2. Legal and Best Practice Requirements for the Assessment of Buildings Following Earthquakes

2.1 Overview of Building Safety Evaluation Objectives

In general, a post-disaster building safety evaluation process is comprised of three phases:

- Overall damage survey
- Rapid building assessments
- Detailed engineering evaluations

The *overall damage survey* is typically carried out as part of the immediate response by emergency services personnel and local authority staff. *Rapid building assessments* are generally undertaken by small teams comprising volunteering engineers and other building professionals working with local authority building officials. *Detailed engineering evaluations* are generally carried out by structural and geotechnical engineers specifically engaged by building owners.

The objectives of a *rapid building assessment process* are to:

- confirm where damage to buildings is concentrated to assist response and recovery decision making;
- indicate whether physical action is to be taken to enable, restrict or prevent access to individual buildings; and
- commence the process of systematically gathering data on damaged buildings that will facilitate the planning and monitoring of longer term recovery actions and re-occupation

The focus of the rapid building safety evaluation process is on *immediate public safety*, not the provision of an engineering assessment service to building owners. It is an initial triaging process, akin to initial medical assessments at the scene of a large emergency or in a hospital emergency department. Buildings that have sustained visible and significant structural damage are marked as not being suitable for re-occupancy. Other buildings that do not show signs of visible damage or movement may be suitable for occupancy, but they require further attention subsequently from building owners and their engineers when resources become available.

Rapid building assessments are just that – undertaken quickly in the face of potentially large numbers of buildings to be appraised within an affected area. Rapid assessments of only the exterior are expected to take of the order of 10 to 20 minutes while rapid assessments involving exterior and interior inspections can take anywhere from one to four hours, depending on the size of the building. These assessments are almost always undertaken without recourse to structural drawings.

Detailed engineering evaluations involve accessing all available information, detailed interior inspections and performing specific calculations where required. They can take anywhere from one day to a week or more, depending on the size of the building and the type of damage.

2.2 Development of Building Safety Evaluation Procedures Internationally

Following the 1971 San Fernando earthquake in California, the Structural Engineers Association of California began working with the California Governor's Office of Emergency Services to develop a process for the assessment of the safety of buildings and structures following earthquakes. A plan to enable government to use private engineering resources during an emergency was produced in 1978.

In 1987, the United States Applied Technology Council (ATC) was contracted by state and federal government agencies to prepare procedures for the post-earthquake safety evaluation of buildings. The ATC-20 procedures[1] were published in 1989, three weeks prior to the Loma Prieta, San Francisco earthquake, where they were first implemented. They have been used in other significant US earthquakes. They were updated in 1995 via an addendum (ATC-20-2[2]). A companion field manual was also produced and there is now a second edition (ATC-20-1[3]).

Written specifically for volunteer structural engineers and building inspectors, the ATC procedures address both the rapid and the detailed evaluation procedures for evaluating earthquake-damaged buildings and posting them as INSPECTED (apparently safe, green placard), LIMITED ENTRY (yellow placard), or UNSAFE (red placard).

In 2004, the Applied Technology Council published guidelines for post-windstorm and post-flood building safety evaluations (ATC-45[4]).

The common objective of these evaluation procedures is to determine whether damaged or potentially damaged buildings are likely to be safe for use, or if entry should be restricted or prohibited. These objectives are common to building safety evaluation procedures developed in other countries of high seismicity.

The ATC procedures were also applied following the 1989, Newcastle, Australia earthquake under the guidance of New Zealand engineers. This followed the first-hand experience gained by NZSEE post-earthquake reconnaissance team members who were in San Francisco at the time of the September 1989 Loma Prieta earthquake[5].

The potential scope of application of rapid building safety evaluation procedures beyond earthquake response was highlighted in New York following the collapse of the World Trade Center towers. A variation of this system was used by engineers working for New York City to quickly triage the buildings surrounding the World Trade Center site to identify those that could or should not be re-occupied.

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[1] ATC-20 *Procedures for Post-earthquake Safety Evaluation of Buildings,* Applied Technology Council, California, 1989

[2] ATC-20-2 *Addendum to the ATC-20 Post-earthquake Building Safety Evaluation Procedures,* Applied Technology Council, California, 1995

[3] ATC-20-1 *Field Manual: Post-earthquake Safety Evaluation of Buildings, Second Edition,* Applied Technology Council, California, 2005

[4] ATC-45 *Field Manual: Safety Evaluation of Buildings After Wind Storms and Floods* Applied Technology Council, California, 2004

[5] Shephard R B et al *The Loma Prieta, California, Earthquake of October 17, 1989: Report of the NZNSEE Reconnaissance Team* Bulletin of the New Zealand National Society for Earthquake Engineering, Vol. 23, No. 1, March 1990 pp1-78

An important feature of the Californian arrangements is the formal structuring of the State of California *Safety Assessment Program*. This programme is administered by the California Emergency Management Agency. The Safety Assessment Program provides professional resources to local governments to help with the safety evaluation of buildings and infrastructure after a disaster. The goal of the Safety Assessment Program (SAP) is to enable these safety assessments to be performed as quickly as possible[6].

SAP provides two types of resources: *SAP Evaluators*, who work in the field performing safety evaluations, and *SAP Co-ordinators*, who are local government lead personnel that co-ordinate the field activities. It is expected that each local authority has a designated and trained Building Safety Evaluation leader for preparation and response purposes.

The California Emergency Management Agency is supported in their management of SAP by a Steering Committee with representatives from the professional groups involved (engineers, architects and building officials). A comprehensive database of more than 6,000 trained professional SAP Evaluators is maintained, with official photo identity/ authorisation cards being issued to those who are trained and registered. These cards have a validity period of five years, renewable following attendance at a re-certification course or via an online refresher course.

One of the following credentials is required in order for a person to be registered on the state-wide *SAP Evaluator* database[7]:

- Professionally registered civil, structural, or geotechnical engineers (from any state);
- Professionally licensed architects (from any state);
- Professionally registered geologists or engineering geologists;
- Certified building inspectors or officials; or
- Certified public works inspectors

Liability protection is available for those responding to disasters in the State of California. Private sector engineers, architects, and building inspectors who are California residents are registered by the California Emergency Management Agency as *Disaster Service Workers* in accordance with the *California Emergency Services Act.* This liability protection applies when the California Emergency Management Agency officially deploys volunteers into the field.

2.3 Development of Building Safety Evaluation Procedures in New Zealand

Initial Versions

Following the involvement of NZ engineers and civil defence personnel in the Loma Prieta earthquake response in 1989, the Ministry of Civil Defence commissioned Works Consultancy Services to produce post-earthquake safety evaluation procedures for New Zealand. The procedures were produced in June 1990[8], and were adapted for the New Zealand situation from ATC-20.

[6] See http://www.calema.ca.gov/Recovery/Pages/Safety-Assessment.aspx
[7] California Emergency Management Agency *Safety Assessment Program Evaluator Manual,* April 2011
[8] Works Consultancy Services Ltd, *Procedures for Post-Earthquake Safety Evaluation of Buildings,* NZ Ministry of Civil Defence, 1990

One of the adaptations included a fourth (Orange) placard to provide for a gradation of levels of risk between buildings that were clearly dangerous (Red) and considered suitable for occupancy (Green). The Orange placard, in addition to the Yellow placard, was considered useful in facilitating a more rapid occupancy of moderately damaged structures.

An NZSEE Study Group was set up in March 1995 to provide guidelines for the emergency response of both territorial authorities and NZSEE's own members in the event of a damaging earthquake. NZSEE is the professional society with members having technical expertise and an interest in promoting earthquake preparedness, and which has had the full support of government agencies such as the Earthquake Commission (EQC) and the (then) Ministry of Civil Defence.

In 1996 the NZSEE Study Group produced a draft document *Post-earthquake Building Safety Evaluation Procedures*[9]. Sub-titled *Preparedness Checklist and Response Plan for Territorial Authorities,* the primary aim of the document was to provide territorial authorities with the framework for their response plans so that safety evaluations of damaged buildings can be activated efficiently and effectively following a major earthquake (or any other disaster which affects buildings).

A final copy of the document was sent to each territorial authority in New Zealand in 1998. There was however only limited take up of the recommended arrangements by councils in the following years. This appeared to be largely due to the lack of a legislative mandate, and consequently there being no national agency with the designated responsibility to actively encourage (if not require) specific preparedness action by individual councils.

Other factors contributing to the lack of adoption of the 1998 NZSEE procedures were the reduction in council-employed structural engineers during the 1990s (the most likely champions of having arrangements of this nature put in place), and limited connection between building and civil defence units in some councils.

2009 Update

In 2004 a comprehensive update of the 1998 procedures document was initiated by NZSEE. In addition to the limited uptake of the 1998 procedures by territorial authorities, two other factors encouraged the revision. Firstly, the Civil Defence Emergency Management Act and the Building Act were completely revised and came into force in 2002 and 2004 respectively. These acts were seen to provide a legal basis for building evaluation procedures, although neither provided a specific legislative mandate. Secondly, in 2002 the Auckland City Council had purchased and customised the ATC-20 training package based on the US three-placard regime. Being at variance to the four-placard basis of the NZSEE 1998 Guidelines, this was seen to potentially cause difficulties in New Zealand for both national operational planning and the development of training arrangements.

One of the challenges that arose in developing the New Zealand procedures related to the liability of engineers and other building professionals undertaking the rapid building safety assessments. The emergency context and assessment process is quite a departure from usual engineering practice, and not one that engineers are familiar with or extensively trained in. Accordingly, engineering consultancies required an effective waiver of liability to be put in place, particularly given that most

[9] *Post-earthquake Building Safety Evaluation Procedures – Preparedness Checklist and Response Plan for Territorial Authorities* NZSEE, 1998

engineers and other professionals would be volunteering their services on a "best endeavours" basis. After considerable discussion, led by NZSEE and including the Ministry of Civil Defence & Emergency Management (MCDEM), the Institution of Professional Engineers New Zealand (IPENZ), the Association of Consulting Engineers New Zealand (ACENZ), Local Government New Zealand (LGNZ), and Risk Pool (Civic Assurance, the predominant insurer of local authorities), it was determined that the most effective management of liability would be afforded by s110 of the Civil Defence Emergency Management Act 2002. This provides protection from liability for persons carrying out functions or duties in a state of emergency under the direction of the Controller (except for gross negligence).

This solution however led to the restriction that the rapid building safety evaluation process can only fully apply during a formally declared state of local or national emergency.

Obtaining endorsement from a relevant national agency was an additional important aspect of developing effective national building evaluation procedures. As building safety is a key function of the building regulatory system, the Department of Building and Housing (DBH) as the responsible agency was actively encouraged to be the lead government agency for this work and to assist with the subsequent implementation by territorial authorities.

In 2008 DBH endorsed the development of the Guidelines, and established a national reference group with representatives of NZSEE, MCDEM, IPENZ, and territorial authority building officials (senior building control managers of Auckland, Christchurch and Wellington city councils, and New Plymouth and Gisborne district councils). The reference group provided input into the finalisation of the update.

The updated NZSEE Guidelines[10] were released in August 2009[11]. The key features of the rapid building safety evaluation process from this document are summarised in Appendix A.

There are two levels of rapid assessment – Level 1 and Level 2. Level 1 is an assessment of the structural damage based on a quick observation of the exterior only. In situations of size or complexity of buildings, or when there is particular uncertainty around its Level 1 classification (placard), Level 2 assessments are undertaken. These involve brief internal inspections, which in turn require appropriate access to the building.

Different information collection forms are provided for each level of rapid assessment, as more information is gathered for the Level 2 assessment. The placards are however the same.

It should be noted that the 2009 NZSEE Guidelines have a stated focus on the *rapid assessment* component of the overall building safety evaluation process. No specific guidance is provided on detailed engineering evaluation, as this was outside the scope of the document. Pending the establishment of a project to develop NZ-oriented detailed engineering evaluation guidelines, it was generally envisaged that US technical documents would be used.

[10] *Building Safety Evaluation During a State of Emergency: Guidelines for Territorial Authorities, NZSEE August 2009 (available from* http://www.dbh.govt.nz/bofficials-building-safety-evaluation *)*

[11] Announced in Parliament 20 August 2009 by the Minister of Civil Defence - http://www.beehive.govt.nz/release/traffic-light-system-disaster-damaged-buildings *accessed 19 July 2011*.

Training

At the time of the September 2010 Darfield earthquake, only a limited number of NZ engineers had undertaken training in building safety evaluation.

Pilot training courses based on the NZSEE Guidelines were prepared in 2009 with funding provided by Dunedin and Christchurch city councils. Two training modules (*Process Management* and *Building Safety Evaluation Procedures*) were delivered to Dunedin, Christchurch and Wellington city council building control officials and engineers in 2009, and Hastings District Council and Waitakere City Council building control officials in 2010. In addition, all 24 NZ Urban Search and Rescue (USAR) engineers were trained in June 2010.

A wider rollout of training sessions through NZSEE and IPENZ was planned for late 2010.

2.4 New Zealand Experiences with Rapid Building Safety Evaluations

Gisborne Earthquake

The 20th December 2007 Gisborne earthquake was the first implementation of a rapid building safety evaluation process in New Zealand. The key elements of the NZSEE draft Guidelines were implemented during that response, which provided useful experience that assisted in the refinement of the Guidelines prior to the August 2009 release.

While being aware of the 1998 NZSEE document, Gisborne District Council did not have specific arrangements in place, nor a capability for delivery, being a small council. The arrival of the writer on the morning after the earthquake as a member of the NZ USAR Task Force, deployed in case of rescue needs, enabled a base building evaluation operation to be launched for Gisborne District Council. The CBD was assessed by early afternoon on the 21st, with 23 Red (Unsafe) placards and 11 Yellow (Restricted Entry) placards posted.

The experience of Gisborne District Council subsequent to the lifting of the state of emergency highlighted that the Building Act did not make any provision for a range of post-earthquake matters. The provisions of s121 of the Building Act relating to the assessment of dangerous buildings excludes earthquake, thereby creating difficulties when seeking to transform building placards from the rapid building safety evaluation process into the 'business as usual' building regulatory regime. Given that Red and Yellow placards provided prima facie evidence of the building being 'dangerous' (actually or potentially), *Dangerous Building Notices* were issued by Gisborne District Council under s124 of the Building Act to Red and Yellow placarded premises prior to the lifting of the state of emergency late on Saturday 22nd December. The limited numbers of buildings compromised by this event made this achievement possible.

Gisborne District Council faced many issues in the months following the December 2007 earthquake around the levels of earthquake strength that structural repairs should meet, having due regard to the Council's Earthquake-Prone Buildings Policy. Interactions with the insurance industry, on the levels of strengthening that their policies would cover, created additional complexity (albeit on a much smaller scale than subsequently experienced by Christchurch City Council).

Padang Earthquake

On 30 September 2009, a magnitude 7.5 earthquake struck offshore from Padang, Indonesia, killing more than 1,100 people. The United Nations Development Programme (UNDP), acting on behalf of the Government of Indonesia, requested New Zealand to provide up to ten engineers for rapid structural assessments of the earthquake-affected buildings in and around the city. A ten-member team of volunteer engineers was deployed by NZSEE with funding from the NZ Aid Programme, DBH and EQC for a two-week period to assist Indonesian local and provincial agencies with rapid structural assessments of earthquake-affected buildings in and around Padang[12].

In order to add value to the early three-category rapid assessments that were already being undertaken by local engineers in Padang, the NZ team developed the concept of six *Usability Categories* – two corresponding to each of the three Red, Yellow and Green base levels (refer Table 2.1). These categories assisted in conveying to the various agencies and building owners and managers additional status information and required actions, beyond the three primary categories.

Table 2.1: Level 2 Usability Categories Developed by the NZ Engineering Team in Padang

Placard Category	Usability Category (Safety Focus)
Green	G1 – Occupiable, no immediate further investigation required
	G2 – Occupiable, repairs required
Yellow	Y1 – No entry to parts until affected sections repaired or demolished
	Y2 – Short-term entry only
Red	R1 – Significant damage – repairs/ strengthening possible
	R2 – Significant damage – demolition likely

A database spreadsheet which recorded the key information from the field assessment forms for each building inspected was developed by the team in the field. Upon returning to New Zealand, the database was developed further into a form considered suitable for use by New Zealand local authorities.

The ATC-20 based NZ Level 2 Rapid Assessment Forms were also enhanced with the addition of the six Usability Categories developed for the Padang deployment.

In addition to the recommended enhancements from the NZSEE Padang team, the 6th April 2009 L'Aquila, Italy, earthquake had highlighted aspects of the Italian (and wider European) building safety evaluation practice that differed from the US approach. One particular aspect was the category '*unusable building for external risk only*' [13]– that is, the situation where a building, damaged or not, is unsafe due to the threat posed by damaged adjacent buildings.

[12] Brunsdon, Bothara et al *Building Safety Evaluation Following the 30 September 2009 Padang Earthquake, Indonesia* NZSEE Bulletin June 2010
[13] Progettazione Sismica *L'Aquila, April 6th 2009*, 3:32am Special Issue 03, 2009

Accordingly, the DBH/NZSEE Reference Group elected to incorporate both the enhancements resulting from the Padang team's experiences and the above point from European practice in a further update of the NZ Building Safety Evaluation Guidelines.

A revised draft of the guidelines was prepared in July 2010 including updated forms, and circulated to the DBH Reference Group. A draft Field Guide had also been prepared, along with an induction module for 'on the day' operational briefing purposes. These drafts had not been officially reviewed and signed off by the time of the 4 September earthquake.

Table 2.2: Level 2 Usability Categories in the July 2010 Update of the NZSEE Guidelines (unpublished)

Placard Category	Usability Category (Safety Focus)
Green	G1 – Occupiable, no immediate further investigation required
	G2 – Occupiable, repairs required
Yellow	Y1 – No entry to parts until affected sections repaired or demolished
	Y2 – Short-term entry only
Red	R1 – Significant damage – repairs/ strengthening possible
	R2 – Significant damage – demolition likely
	R3 - At risk from adjacent premises or from ground failure

2.5 Benchmarking New Zealand's Approach with International Practice

Building Safety Evaluation approaches are not subject to any formal international benchmarking. In addition to the process not being codified in any technical way, its implementation depends on key local and national jurisdictional aspects such as legislative mandate and emergency management arrangements.

In formulating the 2009 NZSEE Guidelines, a conscious effort had been made to maintain alignment with the US (ATC-20) arrangements. This was both for general consistency with this established methodology and the recognition that, should a major earthquake occur in New Zealand, overseas engineers with training and experience with the ATC-20 approach may arrive to assist with building-safety evaluation operations.

The principal areas of difference between the New Zealand and United States practices prior to the 4 September earthquake were:

1. Limiting the placarding operation in New Zealand to only being carried out in a declared emergency situation
    - This was due to the lack of an appropriate liability indemnity under which volunteering building professionals could operate.

2. Not having a register of trained and 'pre-warranted' engineers prepared to undertake rapid building safety evaluation activities
    - The lack of a legal mandate, and hence inability to resource an effective organisational structure and management process, meant that a systematic approach had not been developed.

3. Differences in nomenclature and practice around the stages of rapid building safety evaluation
    - ATC-20 call their stages 'Rapid' and 'Detailed', whereas in 2009 New Zealand adopted 'Level 1 Rapid' and 'Level 2 Rapid' to avoid the implication that the second stage of rapid evaluation was in any way 'detailed'.

2.6 New Zealand and Canterbury Arrangements in Place on 4 September

The 2009 NZSEE Building Safety Evaluation Guidelines were in place at the time of the 4 September earthquake. The Christchurch City, Waimakariri District and Selwyn District councils had taken various steps to implement these guidelines.

Christchurch City Council had organised training sessions for its building control officials and staff engineers in June 2009. Selwyn District Council also have a programme for civil defence training of building control staff, although this had not included building safety evaluation in accordance with the 2009 NZSEE Guidelines.

These national and local arrangements focused on the immediate building safety assessment processes. Consideration had not been given to the development of building regulatory arrangements to enable large numbers of placards issued under the rapid evaluation phase to be transitioned back to normal building control mechanisms.

Similarly, the associated technical procedures for undertaking post-earthquake Detailed Engineering Evaluation had not yet been given specific attention. It had been broadly envisaged that engineers would have access to sufficient guidance using NZ engineering documents and knowledge, as well as drawing upon established international documentation such as available via the US Federal Emergency Management Agency[14].

[14] Federal Emergency Management Agency *FEMA 306 Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings*, 1998

3. Implementation of Building Safety Evaluation Following the Canterbury Earthquakes

3.1 4 September 2010 Earthquake

3.1.1 Christchurch City Council

The implementation of the building safety evaluation operation by Christchurch City Council and the processes adopted following the lifting of the state of emergency are described in a separate report to the Canterbury Earthquakes Royal Commission[15].

During the state of emergency

The Christchurch City Council Emergency Operations Centre was established continuously from 0530 hours on Saturday 4th of September through to 1200 hours on Friday 17 September. The declaration was lifted at 1200 hours on Thursday 16 September.

The *Overall Damage Survey* and initial impact assessment was undertaken by emergency services and Christchurch City Council personnel.

The Council's Building Safety Evaluation Manager arrived at their new Civic Offices on Hereford Street at approximately 5.30am. Staff from the Council's Building Inspections team and engineers volunteering their services had also started arriving at the Civic Offices (and at the Art Gallery when operations moved there). Initial observations from the staff included appraisals of key facilities such as Princess Margaret Hospital, and where contractors were clearing rubble and setting up barriers.

The building inspectors and engineers were arranged into informal teams to begin general damage assessments in the Central Business District (CBD) and along the city's main arterial routes (Colombo Street, Papanui Road, Riccarton Road, Ferry Road and Lincoln Road).

The information gathered from these initial assessments was transferred to whiteboards in the Emergency Operations Centre, and an overview of the level of damage caused by the earthquake was gradually pieced together. A media release at 6.00am on 5th September 2010 stated that more than 500 buildings in the city had been found to be damaged; and more than 90 of those buildings were in the central city area.

Police and New Zealand Fire Service (NZFS) personnel also contributed information into the overall damage survey, as did members of the Christchurch-based NZ USAR Task Force as part of establishing if there were people trapped and requiring rescue. An early decision was made to deploy the other USAR Task Forces from Palmerston North and Auckland to provide additional support to the affected councils and communities. Most members from these teams arrived in Christchurch by nightfall on the day of the earthquake, with others arriving overnight.

[15] Christchurch City Council *Report into Building Safety Evaluation Processes in the Central Business District Following the 4 September 2010 Earthquake*

In addition to the Rescue Technician capability, the USAR Task Forces included six contracted structural and geotechnical engineers, with access to an additional eighteen trained support rescue engineers. Six contracted and seven USAR support engineers responded on 4 September, with five of these working with the USAR Task Forces throughout the following fortnight.

Given that there were no structural collapse rescues to be undertaken, the USAR resources were applied to a variety of tasks, including assisting Christchurch City Council with the building safety evaluation process.

The writer, operating as the USAR Engineering Team Leader, was able to assist Christchurch City Council to plan and set up a co-ordinated *Rapid Building Safety Assessment* process for commencement on the morning of Sunday 5th, with assistance from MCDEM, DBH and IPENZ. This involved members of the NZSEE Padang team and Kestrel Group colleagues working with key Christchurch City Council personnel to establish information management structures and systems, and the basis for a systematic rapid assessment of all properties within the 'four avenues'.

An early decision was made to recommend use of the June 2010 updated but unpublished version of the NZSEE Building Safety Evaluation Guidelines version in order to take advantage of the enhanced features, noting that the underlying base arrangements and core aspects such as placard wording were unchanged from the August 2009 version. The usability categories from Table 2.2 were used for Level 2 assessments.

Assessment teams were organised to comprise structural and/or geotechnical engineers and Christchurch City Council building control personnel (or Council's Response Team members). Council personnel were warranted to place the placards on buildings, following agreement by the teams. NZ USAR Rescue Technicians were also added in due to their availability, and this enabled teams of a minimum of three persons to be created. The number of teams deployed into the CBD was limited to 29 by the availability of engineers. 23 of these teams were tasked with Level 1 (exterior) assessments, and allocated to identified blocks of the CBD. The remaining teams were tasked with Level 2 assessments of buildings already identified as requiring a more detailed assessment, and with interior access available. These five-person teams were assigned two engineers and two Council personnel along with a USAR Rescue Technician.

Due to the limited number of engineers available on the Sunday (Day Two), some teams were sent out with engineers who had not yet attained Chartered Professional Engineer status. Chartered Professional Engineer (CPEng) is a statutory title under the Chartered Professional Engineers Act of New Zealand 2002, and provides a quality mark that attests to the current competence of a professional engineer in New Zealand[16]. The requirement to use Chartered Professional Engineers as leaders of assessment teams had not previously been specified, but the experience and knowledge represented by engineers of this status is clearly required for this role.

IPENZ played a major role in mobilising structural and civil engineers from around New Zealand, starting on the day of the earthquake and extending through the declared emergency period. A total of 94 professional engineers were involved as volunteers in the rapid building evaluation process during the state of emergency period.

[16] IPENZ *Chartered Professional Engineer Overview* http://www.ipenz.org.nz/ipenz/finding/cpeng/

While the majority of the Christchurch City Council building officials deployed as part of the assessment teams had received training via the June 2009 pilot course, few of the engineers deployed as part of these initial field teams had previously received training in rapid building safety evaluation (apart from the USAR engineers).

A half-hour induction session was provided by the writer for all inspection team members on the morning of 5 September, and re-run on subsequent days for other building officials and engineers arriving from other parts of New Zealand. The induction modules had been developed for the DBH/ NZSEE Working Group in June 2010.

The initial sweep of rapid evaluations of the CBD was largely completed by the end of Sunday September 5th. Teams were then deployed to undertake rapid assessments of the principal arterial routes with building frontages (Riccarton Rd, Papanui Rd, Ferry Rd and Colombo St through Sydenham).

The data management operation, to enter all the data from the field forms and plot maps, etc., was also underway. This was a major undertaking which involved a large team of Christchurch City Council personnel. The generic database developed by the NZSEE Padang team was used in this operation[17].

The focus within the CBD moved to providing quality assurance to the initial assessments. This took the form of Level 2 assessments where considered necessary and where access within the buildings became available, and working with the Police, NZFS and the city's streetworks contractors as the extent of the cordon around the CBD was actively reduced, prior to re-admission of members of the public. This involved using the most experienced USAR engineers and others with operational experience from the 2009 Padang deployment to check the appropriateness of the placards on buildings along streets that were next to be re-opened, and to advise on the placement of barricades to protect life-safety by restricting access.

Members of Christchurch City Council's Building Evaluation Team developed a basis for prioritising Level 2 assessments for buildings that had received Level 1 assessments. This approach is summarised as[18]:

> *As a first step, all buildings in the CBD and along arterial routes in the following categories were identified:*
>
> - *All buildings which had received a red or yellow placard in the Level 1 assessment.*
> - *All green placarded buildings with 4 or more levels.*
> - *All green placarded buildings with high occupancy levels.*
> - *All green placarded buildings where the Level 1 rapid assessment form recommended that a Level 2 assessment be carried out.*
>
> *These buildings were then allocated to one of the following categories of priority:*
>
> - *VH = very high*
> - *MH = medium high*

[17] Christchurch City Council *Report into Building Safety Evaluation Processes in the Central Business District Following the 4 September 2010 Earthquake* – Appendix 6
[18] Ibid – page 14

- *M = medium*
- *L = low*

Buildings with yellow placards were generally allocated to the M category and buildings with red placards were generally allocated to the L category. The reasoning was that the features rendering these buildings unsafe had already been identified as requiring action.

As a general rule, the green placarded buildings that had been identified for a Level 2 assessment in the first step were allocated to either the VH or MH category. Green Placarded buildings were allocated to the VH category if there was some urgency due to the building being critical to the reduction of the CBD cordon or if the building was important for another reason (for example, it was to be used for welfare purposes, or for other critical purposes. Other green placarded buildings were allocated to the MH category.

However, factors particular to certain buildings may have resulted in a different category of priority being allocated.

Difficulties in gaining access to buildings inevitably hampered the progress of Level 2 assessments, and led to the need to repeat some Level 1 assessments.

A building evaluation process was launched on Wednesday 8th for the badly affected residential areas in eastern Christchurch. Called *Project East*, this major operation involved a large number of building officials who led the overall process, with relatively minor inputs being required from engineers. This was appropriate given the level of knowledge of building control officials of domestic construction. Initially the placards used were the same as for the CBD, but these were modified to reflect concerns around health risks from sewage contamination of liquefaction material and the lack of toilet facilities. Additional field forms were created, titled *Christchurch Eq RAPID Health Hazard Assessment Form – Level 1*, and which covered aspects such as water supply, sewer damage, interior silt contamination and whether or not the building was secure. This information covered the EQC criteria of "safe, sanitary, and secure" for supporting continued residential occupation.

On Friday 10th, an extraordinary meeting of the full Christchurch City Council adopted a revised Earthquake Prone Buildings policy[19]. A key feature of the modification of this policy was the alignment with the NZSEE[20] recommendation that earthquake-prone buildings be strengthened as nearly as is reasonably practicable to 67% of current Building Code requirements. This provision in the Christchurch City Council Earthquake Prone Buildings Policy represents a target level of strengthening rather than an absolute requirement, noting also that under the Building Act, territorial authorities can only legally require that the building owner ensures that the building is no longer earthquake prone (i.e. greater than 33% of current code). This policy also included the provision that applications for a building consent for repairs to earthquake-damaged buildings should include structural strengthening work (2.3.6).

The numbers of placards posted in each category and for commercial and residential areas during the state of emergency period are summarised in Table 3.1.

[19] Christchurch City Council *Earthquake-Prone, Dangerous and Insanitary Buildings Policy* September 2010
[20] New Zealand Society for Earthquake Engineering *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes* June 2006

Table 3.1: Placards Posted by Christchurch City Council Teams by 14 September 2010

	Commercial		Residential	
Green	873	71%	5,498	82%
Yellow	275	22%	937	14%
Red	88	7%	251	4%
Totals	*1,236*		*6,686*	

Issues arising

Some of the issues arising from the building safety evaluation operation during the state of emergency included:

1. Difficulty in communicating the meaning of the placards to the public

   The material on the building safety evaluation process available from NZSEE did not include summary information suitable for public information communication purposes.

   The building safety evaluation team in the Emergency Operations Centre worked with Christchurch City Council public information management personnel to develop information suitable for issuing as part of CDEM media releases. Early communications conveyed appropriate messages in relation to Green placards[21] (including *'It is the building owner's or occupier's responsibility to get further independent advice regarding the safety of any building if necessary'* on 8 September), but faced with the volume of and focus on Yellow and Red placarded buildings, this emphasis was not maintained.

2. Inconsistent skillsets, knowledge and confidence of field team members

   Some of the teams were sent out on 5 September with engineers who were not Chartered Professional Engineers, due to the limited number of engineers available at this early stage.

   Also, not all those in the inspection teams on subsequent days received induction, due to their arriving into Christchurch after the daily induction sessions were delivered and being deployed before the next day's briefing/induction.

   This led to differences in the quality and consistency of placarding and information recording between teams. Some notably conservative results were observed (for example, broken glazing resulting in a Red placard, with no structural damage in evidence); in other situations some significant structural damage observable from the outside was missed.

3. Lack of integration of owner-appointed engineers with the Council-led process

   Independently, but running parallel to the Territorial Authority and Civil Defence response, local consulting engineers were engaged directly by building owners, property managers and tenants seeking independent assurance as to the safety of their buildings prior to re-opening for business. The majority of buildings in the

[21] Christchurch City Council *Report into Building Safety Evaluation Processes in the Central Business District Following the 4 September 2010 Earthquake* – page 19

CBD and suburban centres are managed by a core group of property management companies.

The level of detail of the consultant's assessments was in some cases greater than the Level 2 Rapid Assessment, although it was noted that the Level 2 assessment forms did provide a common starting point for consultants to prepare initial reports for their building owner clients.

However, not all of the consulting engineers had been through the Council's induction, and so none of their assessments were part of the council-led process. For this reason, Christchurch City Council only made the forms available for the consultants to submit information on, and posted the placards subsequently themselves.

This also led to the situation where some engineers and facilities managers developed their own similar-looking placards, resulting in several different types of placards being posted.

The inefficiency of this was picked up at the start of the 22 February operation, where consultants were warranted and trained, and encouraged to do the more detailed Level 2 assessment of their client's buildings (see 3.3) and provide the information to Council.

4. A clear approach to managing the changing of placards was not established in the early stages.

   There was considerable pressure for some of the originally-posted placards to be changed, usually from owners or tenants who saw no reason why they could not re-occupy their premises.

   Various suggestions were made to address this gap in the rapid building safety evaluation process[22]. For example, if a building already had a Level 2 placard, the placard type should not be permitted to be changed without contacting the original engineer to discuss the reasons why a change in placard was justified. Provided such formalities of exchanging information were followed, often the greater knowledge of the buildings from a more detailed assessment by the owner's engineer could be brought to bear.

5. The register of building placards was not publically available

   In some instances building owners were not notified of their building's status. It is understood that on some occasions the status of buildings was changed in the Council system following re-inspection without revised placards being placed on the building by the building assessment teams.

   There are potentially significant contractual issues associated with the occupancy status of a building. Commercial leases and residential tenancy agreements generally have termination clauses if a building is not occupiable beyond a given period, a situation which would generally be triggered by a Yellow or Red placard.

   Having the official status of building placards available in both list and mapped formats would answer many questions from building owners and tenants.

[22] Hare H J and Galloway BD *Building Evaluation Processes Following the Darfield Earthquake,* Proc Pacific Conference on Earthquake Engineering, Auckland, April 2011

Arrangements following the lifting of the state of emergency

The 2009 NZSEE Guidelines contemplate that Building Act 2004 (s124) dangerous building notices will replace the rapid assessment placards prior to the state of emergency ceasing, because the rapid assessment placards do not have any effect once the state of emergency is lifted. However, given the large number of buildings involved, there was insufficient time for the Council to carry out this replacement exercise before the state of emergency came to an end on 16th September 2010.

The Canterbury Earthquake (Building Act) Order 2010[23] sought to address the limitations recognised in the Building Act with regard to post-earthquake situations. Clause 8 of the Building Act Order in Council recognised Red and Yellow placards as notices issued under s124(1)(b) and (d)(as modified by clause 9 of the Order) respectively of the Building Act. Clause 7 extended the Building Act definition of dangerous buildings by the addition of the following three clauses to s121(1):

> *(1) A building is deemed dangerous for the purpose of this Act if, -*
>
> *(c) there is a risk that the building could collapse or otherwise cause injury or death to any person in the building as a result of an earthquake that generates shaking that is less than a moderate earthquake; or*
>
> *(d) there is a risk that other property could collapse or otherwise cause injury or death to any person in the building; or*
>
> *(e) a territorial authority has not been able to undertake an inspection to determine whether-*
>
> *(i) the building is dangerous under paragraph (a); and*
>
> *(ii) the territorial authority or the chief executive, as the case may be, is required to exercise powers under section 124 or 129 as modified by this order*

The inclusion of the *moderate earthquake* definition created a cross-connection with s122 of the Building Act and the related regulations that define a moderate earthquake. This meant that clauses 1 (c) and (d) above were widely interpreted as meaning that all buildings deemed as 'dangerous buildings' under s121 as a result of the 4 September earthquake were also 'earthquake-prone' buildings. 'Dangerous buildings' in terms of the Building Act relate to a direct threat of injury or death to persons in the building (or adjacent properties), whereas 'earthquake prone buildings' provisions have due regard to the annual probability of a moderate earthquake occurring in a given location, with the objective of setting agreed timeframes for addressing the risk. These timeframes are determined by individual territorial authorities, and extend to many years - typically ranging from 15 to 30 years – reflecting the economic implications of major strengthening programmes on individual building owners and urban centres as a whole.

The above clauses therefore created a situation of uncertainty for engineers and Christchurch City Council. Engineers could not sign-off on their building consent documentation for specific earthquake repairs (e.g. replacement of a parapet or wall) unless they had confirmed that the building as a whole was no longer earthquake-prone. This linkage between dangerous building repairs (short-term actions) and resolving earthquake prone building issues (medium-term actions) created via the Order in Council led to problems between owners and their insurers, and slowed the

[23] Canterbury Earthquake (Building Act) Order
http://www.legislation.co.nz/regulation/public/2010/0315/14.0/versions.aspx

early stages of the evaluation and repair process. The certification form agreed to in October[24] included the requirement that buildings in this situation would be strengthened within three years of the earthquake.

Re-occupancy was thereafter permitted for Yellow and Red placarded buildings once the short-term 'dangerous' situation was addressed through either consented work or certified statements by Chartered Professional Engineers in the agreed format.

The occupancy of Green-placarded buildings was able to continue, as there is no requirement under section 124 of the Building Act to prevent occupancy without engineering investigation or verification statement. The Building Act Order in Council also did not address Green placards, which essentially have no meaning once the state of emergency is lifted. The Christchurch City Council certification form (developed for the Building Evaluation Transition team, see below) also stated '*no action required – notice may be removed or stay at discretion of owner*' for these buildings.

The Building Act Order in Council also did not transfer the exclusion of residential buildings from the requirements for earthquake prone buildings. Under the Building Act, residential buildings are exempt from the earthquake prone building provisions unless they comprise two or more storeys and contain three or more residential units. The Order in Council meant that for the first time houses were included in the context of earthquake prone buildings, introducing a further degree of complexity.

Clearly, the philosophies of 'dangerous' and 'earthquake prone' need careful alignment in a post-earthquake situation, particularly around the issue of building re-occupancy. It is also observed that the long time-frames associated with addressing earthquake prone buildings should be subject to review.

The issues raised by the Order in Council are discussed further in Section 4.4 in relation to recovery processes following the 22 February earthquake.

Christchurch City Council established a Building Evaluation Transition (BET) team on 20 September 2010 to manage the transition from building evaluation carried out under the CDEM Act to that operating under the Building Act 2004. The objectives of this team included carrying out follow-up inspections of unstable structures and the extent of the cordons, maintaining records of post-earthquake damage status, and co-ordinating supervised access into cordoned areas. The team comprised Council building officials, engineers and administrators, and operated until the end of November 2010.

A total of 580 buildings in the CBD and on the principal arterial routes were re-inspected by the BET team between the 5th and 20th of October. In addition to a handover manual containing procedures for identifying dangerous buildings, and procedures for accepting engineer's reports from building owners, updated files on all Yellow and Red placarded buildings were provided to the Council's Enforcement team for the issuing of s124(1) (c) dangerous building notices under the Building Act. As at 29 October 2010, 131 s124 notices were issued as a result of evaluations by the BET team[25].

[24] Christchurch City Council *Report into Building Safety Evaluation Processes in the Central Business District Following the 4 September 2010 Earthquake* – Appendix 22
[25] Sisirc Consulting Ltd and McNulty Engineering Management Ltd *Building Evaluation Transition Team – Processes Used and Lessons Learnt Following the Darfield Earthquake of 4 September 2010*

The BET team developed a process for updating/revising the placard status of buildings, which involved both reports from Chartered Professional Engineers and peer reviews of those reports by the BET team. This process required extensive debate with and between the Canterbury Structural Group (the umbrella group for structural engineers in Canterbury) and the Council's legal advisor, resulting in the certification form referred to on the previous page.

A Christchurch City Council debrief of the experiences and lessons learned from the 4 September response and recovery was held on 20 December 2010. This debrief had a broad scope which encompassed all of the activities of the Emergency Operations Centre, with some coverage of building safety evaluation operations.

3.1.2 Waimakariri District Council

During the state of emergency

On the day of the earthquake, two inspectors travelled through commercial areas of Rangiora and Kaiapoi, taping off hazards, making initial assessments and placing placards on obviously unsound buildings. When a structural engineer became available later in the day, some of the worst affected buildings were revisited.

On the second day (Sunday 5th), Waimakariri District Council had approximately 16 building officials checking mainly commercial and public buildings, working from the 2009 NZSEE Guideline document. These were generally external (Level 1) inspections only, with more of a focus on damage assessment than habitability.

Assistance from other engineers (who were paired up with an inspector) and building control officials from other parts of the country became available on Monday 6th. The focus shifted to housing, starting with areas where council had become aware of significant damage. Much of this work was undertaken by building control officials working in pairs.

A team comprised of senior inspectors and an engineer looked at large public buildings that were likely to be needed for accommodating large numbers of people evacuated from damaged housing - schools, halls with commercial kitchens, and other halls. This was followed by the first thorough assessment of essential government support offices such as Work and Income, Housing NZ, etc, and then retirement villages and rest homes. These inspections were Level 2 rapid assessments (i.e. with interior access).

From Tuesday 7th (Day 4) onwards, the main body of inspection concentrated on housing and facilities in Kaiapoi and beach suburbs. Teams with more technical expertise were sent to large or complex buildings on request. Some larger industries that were able to continue operating were checked to allay worker's concerns, noting that these had already been checked by owner-engaged engineers. Teams also started on early childcare centres with a view that it would assist parents if their children were being cared for in Green-placarded buildings.

Issues arising

In the initial haste to place placards, some teams did not fill in the 2009 NZSEE Guideline evaluation forms. This was quickly recognised as a lost opportunity to collect information that would have been very useful in later stages of recovery planning.

Inspectors carrying out residential inspections commented several times that the 2009 NZSEE Guideline placards and assessment forms were set up for commercial properties, and that a revised version should be created that was more applicable to housing. The early placarding of residential structures tended to use Red-placards where significant damage was observed in part of the building, rather than using the flexibility of the Yellow to retain occupancy but with dangerous sections taped off or otherwise indicated as 'no go'. The Yellow placard needs amendment to more clearly indicate where occupation can be allowed in designated areas, and that no occupation is permitted in restricted areas.

There was a very strong expectation (and, in many cases, a need) by home owners to have their house checked and placarded, possibly to get their own judgements confirmed or put into perspective.

While local industry (larger facilities) generally organised their own building assessments, commercial property owners (smaller buildings) generally waited for the council inspection.

Consideration was given as to whether the status of reticulated services (water and sewer) should have been included in the building assessments. There was, however, recognition that the respective asset management teams had macro information (i.e. what streets were not being serviced), which was more relevant at that time than knowing the state at each house.

A number of other practical implementation suggestions were identified by Waimakariri District personnel, including greater emphasis on the hazards posed by partially damaged old brick chimneys.

Arrangements following the lifting of the state of emergency

The Canterbury Earthquake (Building Act) Order 2010 applied to Waimakariri District Council as for Christchurch City and Selwyn District councils.

All commercial and public buildings with Yellow and Red placards were issued a dangerous building notice/notice to fix. Red-placarded buildings (commercial and residential) were issued this notice at the time the state of emergency was lifted in the district. The owners of Yellow-placarded buildings were subsequently sent a *damaged building* letter pursuant to the Order in Council, noting that some repairs were required before the building would be fit for its intended use, and that this may include in some cases substantial rebuilding or replacement. The notices were open ended (i.e. with no date specified to comply by), as enforcement action was not anticipated.

Where dwellings were damaged but still safe and sanitary, and owners/occupants wished to continue to occupy or circumstances make it necessary to occupy, no restriction was placed on their use.

3.1.3 Selwyn District Council

During the state of emergency

Selwyn District Council building control personnel followed the 2009 NZSEE Guideline document, including using the forms and placards.

Inspection teams comprising building control officials and local engineers were deployed in pairs in response to requests for building safety assessments. Each pair had a cellphone and handheld radiotelephone, noting that all of their inspectors have kits in their vehicles with basic equipment, including a copy of the 2009 NZSEE Guideline and its forms and placards, as well as warning tape, etc.

All information from the evaluation forms was entered into Council's computer system. Selwyn has developed a programme specifically for disaster events which provides a continuous record of information on any property that is easily searchable.

A total of 805 assessments were undertaken by 15 October 2010.

Arrangements following the lifting of the state of emergency

Due to the nature of building stock in Selwyn and the low number of Red-placarded buildings, it was decided not to replace Red placards with dangerous building notices under the Building Act. Instead, Selwyn District Council monitored buildings, and where necessary, approached owners directly to require remedial works to be undertaken.

3.2 26 December 2010 Aftershocks

A series of aftershocks occurred on 26 December 2010, including a shallow earthquake of Magnitude 5.1 at 10.30am. This was located within 5km of the centre of Christchurch, and strong shaking was felt across the CBD and other parts of the city. Further damage from that of September was evident to a number of buildings in the city, with unreinforced masonry buildings being the most obviously affected. There were large numbers of the general public in the central city for holiday shopping, at the early stages of a major retail shopping day, and again it was very fortunate that no casualties resulted from falling masonry or glazing.

There was no significant building damage in the Waimakariri and Selwyn districts.

The response of Christchurch City Council was affected by a number of its core emergency staff being out of the area given the holiday season. There was uncertainty as to whether or not a state of emergency should be declared, and whether a systematic building safety evaluation operation was to be launched. It was considered by senior Council managers and the rostered Local Controller that emergency services were responding adequately to the event, that the extent of the damage was limited to a small area, and there was little damage or disruption to services in the residential areas. Accordingly, it was determined that the situation did not require a declaration of a state of local emergency[26].

[26] Christchurch City Council *Report into Building Safety Evaluation Processes in the Central Business District Following the 4 September 2010 Earthquake* – Page 32

However in the absence of a declaration, there appeared to be a lack of clarity around Council's responsibilities, liabilities, and authorities, resulting in less effective co-ordination with the emergency services, and lifeline utilities. Also, there was limited engineering input in the early stages into understanding both the scope and nature of damage, and the implications for buildings where damage may not be apparent, such as in office buildings closed for the holiday period.

Under current arrangements, an emergency declaration is required to enable building safety evaluation placards to be posted and enforced. In addition, without the liability cover that a declaration affords, the few engineers locally available were understandably reluctant to become involved. It is also understood that no Christchurch City Council engineers were available. However, other engineering resources were being readied in Wellington following this aftershock, in case they were required to support a full building safety evaluation operation.

A form of rapid building safety evaluation, broadly based on the draft 2010 NZSEE Guidelines, was undertaken between 26th and 28th December, and some placards were posted. Towards the end of the 26th of December, three assessment processes were in place within the four avenues; targeted evaluations of buildings identified as damaged, rapid assessments based on a grid system, and Police-led cordon assessments with an engineer. A modified form based on the NZSEE Guideline Level 1 rapid assessment form was developed for use the following day.

A decision was made on the morning of the 27th that the placard system would not be used and that dangerous building notices would be used under s124 of the Building Act. The deployment of NZ USAR resources, targeted engineering assessment teams (which included some engineers contracted by Christchurch City Council), and police cordon teams continued through until the end of that day. Council and some emergency services resources continued with dangerous buildings assessments and posting in subsequent days.

Prior to Christmas, 148 s124 notices were issued in the CBD. A further 177 Building Act s124 notices were issued for buildings in the Christchurch CBD as a result of damage caused by the Boxing Day aftershock.

Christchurch City Council commissioned a plan from a Chartered Professional Engineer to restore pedestrian access to Cashel Mall. This plan was peer reviewed by another Chartered Professional Engineer and then, following sign off from Council, Cashel Mall re-opened to pedestrians on 29th December 2010, with unsafe buildings cordoned off.

In the absence of a declaration and structured building safety evaluation operation, and because many building owners were actively working with engineers following the September event, there was a general expectation that building owners should take responsibility for sourcing engineering assessments of their properties.

A media release by Christchurch City Council at 9.30pm on 26th December 2010 stated:

> *"The work being carried out today in the Central City by Civil Defence building assessors, assisted by the New Zealand Fire Service, is an initial check of the extent of damage, with the aim of protecting public safety on footpaths and roads adjacent to damaged buildings.*
>
> *It is the responsibility of building owners, working with their insurers, to have their buildings structurally assessed by engineers. Any*

> *remediation work necessary will be carried out by the building owner and their insurer".*

A further media release issued by the Council on 27th December emphasised the need for owners to bring in their structural engineers to assess the buildings and to ensure safety measures are in place. There was, however, concern by some involved in the response to this aftershock that, due to many owners and engineers being out of town for the holiday period, affected CBD buildings may not all have received timely inspection.

3.3 22 February 2011 Aftershock

The Magnitude 6.3 earthquake that occurred at 12.51pm on Tuesday 22nd February 2011 was located 10km southeast of the centre of Christchurch with a focal depth of 5km. It caused a number of commercial buildings to collapse in Christchurch City, plus extensive landsliding and rockfall around the populated areas of the Port Hills.

A total of 181 lives were lost in this event, including 40 in relation to unreinforced masonry buildings.

This section of the report comments briefly on the building safety evaluation arrangements that were implemented, and issues arising that may inform future best practice. It is noted that Christchurch City Council are preparing a separate report for the Canterbury Earthquakes Royal Commission on building evaluation matters arising from their response to this event.

Response

A state of local emergency was declared by the Mayor of Christchurch City at 1445 hours on the 22nd of February. A state of national emergency for the area of Christchurch City was declared by the Minister of Civil Defence at 1030 hours on Wednesday 23rd February for the area of Christchurch City. The immediate response focus was on locating and rescuing trapped persons.

There was no significant building damage in the Waimakariri and Selwyn districts, and, after an initial check, neither council initiated large-scale building evaluation operations.

The Christchurch City building safety evaluation and placarding operation was planned on Wednesday 23rd and Thursday 24th, with field inspections in the CBD commencing on Friday 25th. This planning work was led by Council building control officials supported by engineers who had been closely involved in the leadership group in the 4 September operation. Other volunteer engineers from outside the Canterbury region were swiftly mobilised by IPENZ.

With the benefit of two days lead time, and the experience from September, a more carefully planned operation was able to be launched. As the whole CBD was locked down while USAR operations were underway, there was not the same urgency to commence rapid building safety evaluation operations as there was in September. However due to the significantly heightened risk within the CBD, only experienced Chartered Professional Engineers were used for assessments within the Red Zone.

An important aspect of the operation was the early inclusion and warranting of consulting engineers that had been working on buildings following September and had a detailed understanding of the likely response of the buildings to major

aftershocks, as well as other privately engaged engineers acting for clients to assess commercial buildings newly damaged.

As part of the overall building safety evaluation process, specific plans were established and implemented for the evaluation of:

- the Central Business District within the four avenues;
- key shops and other community services that could provide critical services and goods including pharmacies, supermarkets, medical centres, hardware stores, and libraries; and
- arterial routes into and out of the central city to facilitate safer travel.

In addition to the above, a limited pool of specialist engineers was provided to two building control operations. These two operations covered the extensive evaluation of suburban residential dwellings (*Operation Suburb*, deploying up to 1,000 building control officials, welfare representatives and EQC personnel per day) and suburban commercial buildings (*Operation Shop*). A team of engineers that could respond rapidly to urgent incoming requests for building inspections was also established, and included geotechnical engineers as well as structural engineers.

The building safety evaluation operations were a major undertaking within the emergency period in and of themselves, with a planned need for up to 100 engineers and a further 50 building control officials acting in a safety and warranted officer role. The management team was better resourced following this earthquake than during September's event, including both technical and managerial engineering personnel and administrative and welfare support. This improved resourcing plus the implementation of a formal roster allowed the team to support a wider range of activities conducted in parallel, with capacity to resource field operations being the limiting element.

The linkages with and systems developed between the team and IPENZ through the September earthquake state of emergency period were refined. IPENZ again sourced and facilitated a supply of large numbers of appropriately experienced engineers throughout this period. A total of 352 professional engineers were involved in the rapid building evaluation process during the state of emergency period. The Building Officials Institute of New Zealand (BOINZ) also played a corresponding important role in mobilising building control officials.

The number of building control officials available for the CBD was reduced by the major suburban residential dwelling inspection programme *Operation Suburb*, and this meant a warranted officer was not available for every building safety evaluation team to support placement of the building placards. Christchurch City Council decided to expand the available warranted officer pool by temporarily warranting the building safety evaluation team leaders. These people were, almost exclusively, Chartered Professional Engineers.

The Indicator Building procedure that had its genesis after the September earthquake was expanded and formalised. This procedure involves identifying a set of buildings to specifically check following significant aftershocks to gauge the extent of further damage (if any). This provides a rational decision making tool to determine whether to continue with the building assessment programme as planned, or revisit or re-start building safety evaluations. This proved invaluable in safe and efficient use of resources for re-assessing particularly the CBD building stock after each of the significant aftershocks. It also encouraged the management team to increase the rigour of the welfare checking process of deployed teams.

Other examples of the process learnings from the September 2010 response that were incorporated into the February 2011 operation included:

- The management of large volumes of assessments (up from 9,300 over 21 days in September 2010 to 130,000 over a corresponding period in February 2011) would not have been possible without the experience and process improvement from September
- A simple risk assessment process was developed for an even more rapid review of an already placarded building condition rather than undertaking a further Level 1 assessment
- The database used in February was further developed by Christchurch City Council to better enter building assessment data directly into their own property system, to ensure effective searching and mapping of the data. The data inputting, management, and mapping outputs were resourced by Council.

Issues arising

Many of the issues and gaps that appeared during the rapid building safety evaluation process in September were addressed in the February operation. Some of the issues arising from the building safety evaluation operation during the February response included:

1. Inconsistent assessment approaches by teams

   Some of the teams evaluating buildings were conservative in their approach. While in general this is more desirable than being non-conservative, buildings that were unnecessarily placarded Red required substantial further input to have this replaced by a more appropriate Yellow or Green placard.

2. Continued lack of clarity on placard meaning for the public

   The statements and messages about the meanings of the respective placards issued via media releases and other spokespeople provided a range of interpretations.

3. Green or Yellow placards were not posted by the residential building evaluation operation

   The focus of Operation Suburb in the eastern suburbs was on identifying those houses which could not be occupied. A decision was therefore made for many areas to only use the Red placard where it was required on residential dwellings. A black and white leaflet was used to inform the residents that their building was safe to enter unless they had a red placard on their house, but there may still be hazards associated with the building. This situation was also described in media communications.

   Although generally not posted, Yellow and Green assessments were made and entered into the Council database. Where parts of buildings were damaged but the house still occupiable, efforts were made to isolate those parts with emergency tape. It is, however, understood that some buildings with unsafe elements or rooms, such as partially collapsed chimneys, unstable walls, or failed floors were not necessarily identified, leading to the situation where some residents were left considering their houses “safe” when specific areas should have been identified as off-limits. Conversely, some dwellings received Red placards when parts were safe to occupy (i.e. should have Yellow placards).

4. Lack of co-ordination of geotechnical and structural evaluation of buildings in the Port Hills area

   Teams were initially undertaking rapid building safety evaluations in the Port Hills area from a geotechnical hazard perspective. This resulted in a large number of houses being assigned Red placards due to the threat of further landslip or rockfall.

   Many of these houses were otherwise in an adequate structural condition. It is, however, understood that some subsequent rapid building safety evaluation teams with a structural focus were not made aware of the geotechnical risk, and replaced some Red placards with the black and white 'occupiable' notice.

   There are clearly co-ordination challenges with respect to rapid building safety evaluation in areas of unstable land that require additional operational planning effort in terms of briefing teams, etc.

   The provision of space on the Red placard to briefly state the prime reason for the 'unsafe' assessment could also have mitigated this situation.

The national state of emergency was lifted on 30 April 2011. The Canterbury Earthquake Recovery Act 2011[27] came into effect on 18 April 2011, including provisions that extended the life of the posted placards for twelve weeks following the commencement of the Act. In the lead up to the expiry of this period, Canterbury Earthquake Recovery Authority (CERA) Engineers used the provisions of the Canterbury Earthquake Recovery Act to post notices on buildings that had Red or Yellow "Civil Defence" placards. While this activity is understood to be outside the time frame of interest to the Canterbury Earthquakes Royal Commission, it is noted here for reference and any follow up.

3.4 13 June 2011 Aftershocks

At 1.00pm on Monday 13th of June there was an aftershock of magnitude 5.5, located 10km southeast of the centre of Christchurch with a focal depth of 11km. This aftershock was strong enough to cause further damage in parts of the CBD and eastern suburbs.

This was followed by a further aftershock of magnitude 6.3 at 2.20pm. This was centred at essentially the same location and depth as the earlier aftershock.

Some significant further damage was caused on the eastern side of the Christchurch CBD, most notably to buildings within the Red Zone cordon. Liquefaction occurred again in a number of areas both east and west of the CBD, along with corresponding further damage to residential dwellings. Further landsliding and rockfall occurred around the Port Hills.

There was no further damage of note recorded in the Selwyn and Waimakariri districts.

It was fortunate that a number of contractors working in the Christchurch CBD had withdrawn from the buildings they were in as a result of the earlier 1pm aftershock. Several of those buildings suffered further partial collapse. Some had however

[27] Canterbury Earthquake Recovery Act 2011 http://www.pco.parliament.govt.nz/reprints/

resumed work in dangerous buildings by the time of the larger aftershock that followed, and were extremely lucky to not be injured or killed.

CERA engineering personnel were also out checking on indicator buildings in the southeast part of the Red Zone following the 1pm aftershock, and were very nearly caught up in falling facades.

The CBD Red Zone of approximately 24 blocks was reviewed on 14th June by twelve engineers that were already working for CERA and DBH. The focus of this review was to identify buildings that (i) were clearly more dangerous than before, or (ii) were now dangerous as a result of the aftershocks. From this, buildings that needed making safe or priority demolition were identified, and barricading was extended in the meantime.

4. Discussion on Future Best Practice in Post-Earthquake Building Assessments for New Zealand

The objective of this section is to highlight areas where current practice needs to be improved, and where possible give indications of what best practice should cover or include. It is acknowledged that several post-earthquake reviews and development of building evaluation procedures are ongoing, and that their outcomes will inform the Canterbury Earthquakes Royal Commission inquiry in addition to this report.

This section proposes key best practice components for rapid building evaluation, and corresponding indicators. Additional comment is then provided on some of the key issues that have arisen at the time of writing from the experience of the three councils following the Canterbury earthquake sequence between 4th September 2010 and 13th June 2011. These relate to best practice covering legislative context, structures and systems, and resources and training. The fundamental issue around the criteria and process for building re-occupancy is examined, as is the process for the detailed engineering evaluation of placarded buildings.

The objective of the rapid phase of a building safety evaluation process must be re-emphasised at this point – namely the initial management of damaged buildings and building re-occupancy to address life safety during the response phase. Territorial Authorities have the responsibility of co-ordinating building inspections during the response phase of an emergency to provide for public safety. If territorial authorities are significantly impacted and/or overwhelmed, then Civil Defence Emergency Management arrangements under the Act, together with the associated strategies and plans (at local and national levels), are there to support or in a worst case, co-ordinate and manage. People need to be kept from entering or using dangerous buildings, or be informed of access restrictions at such times.

Building owners however have the ultimate responsibility to have their buildings checked after a damaging event (actual or potential damage), to ensure that their premises are not dangerous.

4.1 Building Evaluation Development Following the Canterbury Earthquakes

MCDEM and the Department of Building and Housing (DBH), supported by NZSEE, have commenced development of revised and augmented building evaluation arrangements, based on the experience gained from the arrangements applied for the Canterbury earthquakes.

The development is being undertaken in two parts. The first part involves a consolidation of the key operational aspects of the process to augment the 2009 NZSEE Guidelines and to document areas previously not covered by either the 2009 NZSEE Guidelines or ATC-20 material.

The second part will require implementing more fundamental changes, a number of which are indicated later in this section. The changes required will be informed by the findings of the Royal Commission, and any subsequent developments relating to the management of dangerous buildings during and subsequent to an emergency.

It is proposed to produce an interim revised guideline that, if required, may be applied nationally before the second part is completed.

The first step already undertaken was a workshop of key participants who had been involved in the process management and field inspections during the Canterbury earthquakes. The workshop was held in Christchurch on 27 June 2011 and included members of a United States investigation team from ATC who were in Christchurch to learn from New Zealand's experiences with the building safety evaluation process.

4.2 Components of Building Evaluation Best Practice

The suggested key components of best practice for the establishment and management of an effective building evaluation operation are summarised below, and explored further in subsequent sections.

1. **Appropriate legal mandate**
2. **Central government agency providing a focal point, guidance and support for preparedness activities**
3. **Criteria and process for building re-occupancy established**
4. **Local authorities appropriately prepared to set up and manage a building evaluation operation**
5. **Appropriate numbers of trained and warranted building professionals**
6. **Effective mobilisation arrangements for warranted building professionals (locally and nationally)**

These components are expanded upon in Table 4.1, along with additional indicators.

The components and indicators are considered broadly relevant to any country or set of jurisdictions. They are also applicable to any hazard or cause that may have given rise to large numbers of impaired buildings and structures, not just earthquake. A robust building safety evaluation framework needs to be consequence-based rather than hazard-based, noting that aspects of the skillsets and processes may differ depending on the causative event.

Additional comments and observations on key issues in relation to New Zealand are provided in the following sub-sections.

It is emphasised that these components of best practice all require specific preparation prior to an event – that is, activities to be undertaken during the 'Readiness' phase, to use civil defence emergency management terminology.

Table 4.1: Components and Indicators for Best Practice in Building Evaluation

Component	Indicator	Comments (NZ Focus)
1. Appropriate legal mandate	1.1 Authorisation and mechanics for implementation in a range of emergency situations (both during and outside of states of emergency)	These and other considerations suggest that the Building Act is the appropriate legislation to build upon
	1.2 Clear legal status of posting, maintaining, and removing placards and/ or notices	
	1.3 Aligned with building control arrangements to enable effective transfer back to normal building safety arrangements	
2. Central government agency providing a focal point, guidance and support for preparedness activities	2.1 Structure and resources to: • provide leadership and support to local authorities (for both planning generally and during a building safety evaluation operation) • Enable the development and maintenance of core components and common tools, including training and warranting arrangements	The Department of Building and Housing has the mandate to be the central government focal point
	2.2 Actively supporting international linkages to ensure best practice is developed and maintained	Linkages with United States agencies, including FEMA, the California Emergency Management Agency, ATC, and with other relevant international agencies
3. Criteria and process for building re-occupancy established	3.1 Criteria for building re-occupancy following a disaster event established (national level)	The Department of Building and Housing has the mandate to provide the central government national lead
	3.2 Clear process for further engineering assessment following placarding prior to long-term building re-occupancy	Defined process for the detailed engineering evaluation of placarded buildings (structural, geotechnical and/ or environmental) Relationship with Earthquake Prone Buildings policy and Dangerous Buildings approaches clarified

Component	Indicator	Comments (NZ Focus)
4. Local authorities appropriately prepared to set up and manage a building safety evaluation operation	4.1 Plans and procedures for the building safety evaluation operation that tie in with other aspects of the local authority's civil defence emergency management operations	Including key roles designated (with alternates) and all relevant pre-prepared material. The arrangements to be maintained and exercised
	4.2 Primary and alternate venues for co-ordinating building safety evaluation operations that have been structurally verified	Operational venues meet Importance Level 4 structural performance requirements
	4.3 Appropriate information management systems linked into customer information systems to enable recording of building evaluation field information, production of maps and transferral into normal council systems	Territorial Authorities are encouraged to provide for management of building evaluation information in their 'business as usual' information management systems that allows at times of need for the surge capacity that can be expected
	4.4 Effective ongoing engagement between building control officials and professional engineers	A national activity that IPENZ, BOINZ, DBH, and MCDEM can advance
5. Appropriate numbers of trained and warranted building professionals	5.1 Broad capability targets established (regionally and nationally)	
	5.2 Agreed national agency(s) tasked with: • developing and delivering appropriate training • maintaining a registration and warranting system, linked to operational deployment • working towards the agreed capability targets	A national activity that IPENZ, BOINZ, DBH, and MCDEM need to progress collectively
	5.3 Appropriate capability maintained in each region	Linked in with CDEM Group (regional) and local arrangements
	5.4 Pool of national resources that can be drawn upon to assist in major operational responses	Linked with other related response functions such as NZ USAR
6. Effective mobilisation arrangements for warranted building professionals (locally and nationally)	6.1 Local trained and warranted building professionals understanding their roles, responsibilities, and mobilisation arrangements	
	6.2 Mechanisms in place to swiftly mobilise building professionals from other regions	Using agencies such as IPENZ and BOINZ in support of the lead central government agency

4.3 Legislative Mandate and Context

The building safety evaluation process needs to be mandated in legislation.

While it is an operation undertaken in an emergency or disaster situation, it fundamentally relates to building safety, and involves agencies, sectors and individuals that have a day-to-day role maintaining building safety standards.

Moreover, as the experiences of the Canterbury earthquakes have demonstrated, a key issue with the building safety evaluation process is the transition back to normal building control arrangements.

Therefore, it would seem appropriate for building safety evaluation to be a function defined in and carried out under the Building Act. There are a number of building control matters in relation to post-earthquake activities and actions that need addressing as an amendment to the Building Act, and this would fit within such an amendment.

It was noted earlier that one of the reasons why rapid building safety evaluation is currently framed up within the context of a state of emergency was the default provision of liability protection via s110 of the Civil Defence and Emergency Management Act. It is considered that an equivalent form of protection for individuals undertaking this task could readily be addressed within the Building Act. This could be linked to and given effect via a prior registration and warranty system along the lines established in California, linked to the currency of training.

4.4 Criteria and Process for Building Re-occupancy

Placards and 'Safe'

The 'Rapid' component of the Building Safety Evaluation process with the associated placards as output is intended only to give a short-term indication, focusing on those buildings where there is visible evidence that access should be *prevented* (Red placard) or *restricted* (Yellow).

The meaning of 'Safe' in relation to buildings in a post-disaster situation clearly needs further consideration. To verify the safety of a building in terms of the usual concepts of the Building Code and Building Act requires a measured and generally quite detailed assessment.

The Green placards do not say that a building is 'safe' – merely that '*While no apparent structural or other safety hazards have been found, a more comprehensive inspection of the exterior and interior may reveal safety hazards*'. The Green placards go on to state '*Owners are encouraged to obtain a detailed structural engineering assessment of the building as soon as possible*'.

Essentially, an 'Inspected' placard only means that the building can be *used*. The responsibility for confirming building *safety* lies with the owner.

It is understandable that the general public can interpret Green as equating to safe, by applying the traffic light analogy. However, driving through an intersection on a green light still leads to the risk of being hit by a 'red-light runner'.

The US Applied Technology Council team that visited NZ in June also noted that it is a common misunderstanding in the US that the *Inspected* or Green posting means that the building is 'safe'.

The writer has previously suggested that the Green placard should in fact be white, in order to de-couple the general public interpretation that '*Green = Go*', with no further action required.

There is a growing body of opinion that saying something is "safe" is inappropriate. It has been said that saying something is safe means that it is risk-free. But given uncertainties, nothing is risk-free, so nothing should be called safe.

This leads to the view that the whole process should be renamed 'Building Evaluation' (i.e. taking out the word 'safety') or 'Dangerous Building Evaluation' (to better align with the language of the Building Act).

Process for the Detailed Engineering Evaluation of placarded buildings

As noted in Section 2.1, it is envisaged that Detailed Engineering Evaluations would be undertaken by Chartered Professional Engineers engaged by building owners, across all placarded buildings.

The 2009 NZSEE Guidelines do not define a specific process for further engineering assessment following placarding prior to long-term building re-occupancy, either technically or in relation to regulatory processes.

The Detailed Engineering Evaluation guidelines as developed by the Engineering Advisory Group following the 22 February earthquake[28] provide a clearer focus of what structural and geotechnical engineers should look at to establish the presence of 'critical structural weaknesses' that would make a building vulnerable to a major aftershock or future earthquake. A considered review of the drawings (where available and accessible) followed by inspection and appropriate levels of calculation is required. The Detailed Engineering Evaluation guidelines give clear pointers as to what potential critical structural weaknesses should be investigated, and how to assess their seriousness. While some information of this nature was available to practitioners prior to September 2010, much of it was in overseas literature and not in a form suitable for direct application in a New Zealand post-earthquake environment.

It is therefore important that the various elements of the Detailed Engineering Evaluation procedures be completed to sit alongside the Rapid Building Evaluation guidelines.

Building Re-occupancy

The larger the number of buildings affected in a major earthquake, the harder it is for territorial authorities to manage a controlled process within reasonable time frames. There is also the associated increase in the number of buildings with less visible structural damage from the mainshock that could be vulnerable to further damage, and possibly collapse, following significant aftershocks.

[28] Engineering Advisory Group and Department of Building and Housing *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury – Part 2 Evaluation Procedure*

It is however apparent that, even if priority was given to applying a detailed engineering evaluation process to Green-placarded buildings (which are of course the majority of buildings, with reference to Table 3.1) prior to any re-occupancy, it would take a considerable period of time to undertake a systematic detailed engineering evaluation on a city-wide basis following a major earthquake. Had this approach been taken following the 4th September earthquake, the majority of the placarded areas (CBD and arterial routes) would not have been occupiable for many months. As observed earlier, there are many financial and other tenancy implications for businesses of delayed access, quite apart from the wider economic impacts.

Nevertheless, public safety considerations indicate that criteria should be developed to require certain categories of buildings to be subject to a Detailed Engineering Evaluation prior to any re-occupancy. Principal criteria should involve aspects such as the function of the building (Importance Level), number of occupants (size of building), and whether the building has previously been identified as being at risk (buildings identified as being actually or potentially earthquake-prone).

Size and location of aftershocks

One of the key uncertainties that surround a post-earthquake building safety evaluation operation is the size of aftershocks to plan for - both from the perspective of field personnel undertaking the operation (immediate aftershocks) and for building re-occupancy.

The rule of thumb used in training and preparation (for both building evaluation and Urban Search and Rescue) is to expect aftershocks of up to one magnitude less that the mainshock at any stage in the weeks and months following. The general expectation is that buildings that have experienced a major earthquake without significant visible structural damage or signs of movement will typically withstand an aftershock of one magnitude less than the mainshock. This expectation has come from many years of observing major urban earthquakes, including twenty-five years of NZSEE earthquake reconnaissance, and is aligned with the perspective of the US Geological Survey.

In strictly magnitude terms, the 22 February 2011 aftershock is not inconsistent with this expectation. However it is the different location of the aftershocks from the mainshock, their proximities to the city and the very high intensity of shaking that has generated the major damage that followed.

The potential migration of location, and indeed increase in shaking intensity, is not something that is taken account of internationally in the planning of rescue, building safety evaluation or recovery activities generally[29]. That an aftershock should cause extensive further damage and collapse with significant loss of life and injury than the main event is internationally unprecedented.

Relationship with earthquake-prone buildings policies

Another important aspect of establishing a clearer re-occupancy and recovery process is greater alignment between the treatment of earthquake-prone building policies and post-earthquake operational arrangements at both local and national levels.

[29] ATC TechBrief 2 *Earthquake Aftershocks – Entering Damaged Buildings*, Applied Technology Council, California, 1999

The level of damage resulting from the February earthquake across a wider range of construction types has increased the difficulty in separating 'dangerous' from 'earthquake prone'.

Quite apart from technical and legal debates, there is an understandable perception that people are unwilling to occupy buildings that have been identified as earthquake-prone (i.e. less than 33% of current code, including the increase in seismic hazard factor), even if it is showing no signs of being 'dangerous'. This perception represents a marked shift from the prevailing attitudes following the 4 September 2010 earthquake, and highlights the different reactions to moderate and major earthquake events that need to be taken into consideration.

Clarity is also needed to assist mutual understandings between insurers, owners, occupiers, and the territorial authorities in order to reduce unnecessary delays in resolving repair and rebuilding matters.

In summary, further consideration needs to be given to the concept of 'interim occupancy' for a Green-placarded building or the accessible part of a Yellow-placarded building. This is a matter for international, as well as national, clarity and consistency.

Target time frames for addressing damaged and undamaged earthquake-prone buildings should also be considered further, having due regard to the scale of the event.

Current work defining the process and procedures for the detailed engineering evaluation (structural and geotechnical) of placarded and other damaged buildings should be progressed to the point where they can be applied to any location in NZ.

4.5 Structures and Systems

In addition to having a clear national mandate via legislation, the post-disaster building evaluation process needs to have effective national and local structures and systems in place.

The key aspects of this are summarised under components 2 and 4 in Table 4.1.

It remains a concern that, despite the 2009 NZSEE Guidelines stating very clearly that territorial building control managers should prepare their own emergency plan and procedures for building safety evaluation, it appears that many thought that the Guideline document itself provided sufficient information from which to run an operation.

It is a fundamental principle of emergency management planning that territorial authorities should have a level of detail in their response arrangements and preparedness that reflects the level of risk presented by the building stock in their city or district. In this context, level of risk covers the age, construction type, size, and numbers of buildings in addition to the level of seismic hazard. Put simply, larger cities (which by their very nature have older and taller buildings) should have specific arrangements in place, with those centres in areas of higher seismicity having more detailed plans.

It is clear that common guidance needs to be provided to assist territorial authorities to put in place effective arrangements that are consistent with those of other authorities. This should probably be in the form of a sample set of standard operating procedures which are prepared as a national guideline for local adaptation and adoption, with subsequent submission to the appropriate government agency. The current provisions for local earthquake-prone buildings policies in the Building Act and supporting information provided by the Department of Building and Housing with the support of NZSEE represents an analogous model. The Act requires each territorial authority to develop and formally adopt policies to address dangerous, earthquake-prone and insanitary buildings, with reviews at not greater than five-yearly intervals. This requirement was supported by DBH producing a generic guideline for territorial authorities of what such a policy should contain, and an example format.

More thought also needs to be given as to how the building safety evaluation activity should be co-ordinated regionally across territorial authorities when issues relating to resource allocation and prioritisation are involved. From an operational perspective, this should be carried out by the regional CDEM Emergency Management Group Emergency Co-ordination Centre. The role of Building Consent Authorities, where they are regionally based, also needs to be aligned with CDEM Group operational arrangements.

4.6 Resources and Training

The limited number of trained evaluators (engineers and building control officials) in New Zealand sits in marked contrast to the significant number of currently trained and registered evaluators in California (refer Section 2.2). On a population-adjusted basis, it can be inferred that New Zealand needs more than 600 trained and registered evaluators with Chartered Professional Engineer status.

One of the features of this capability objective is having a national resource capable and ready to either lead or support a building safety evaluation operation.

In formulating the pilot training modules in 2009, NZSEE proposed recommended capability objectives that should be worked towards. These are represented in Figure 4.1.

The development of an appropriate capacity and capability for building safety evaluation involves two key elements, namely:

- the development and maintenance of materials and arrangements for training; and
- the mechanisms for registering the status of those who have undergone training as part of their professional development.

Both elements require appropriate resourcing. Registration mechanisms should link directly to deployment arrangements.

It is considered that many aspects of the current Californian arrangements as outlined in Section 2.2 represent a good model for New Zealand to consider further.

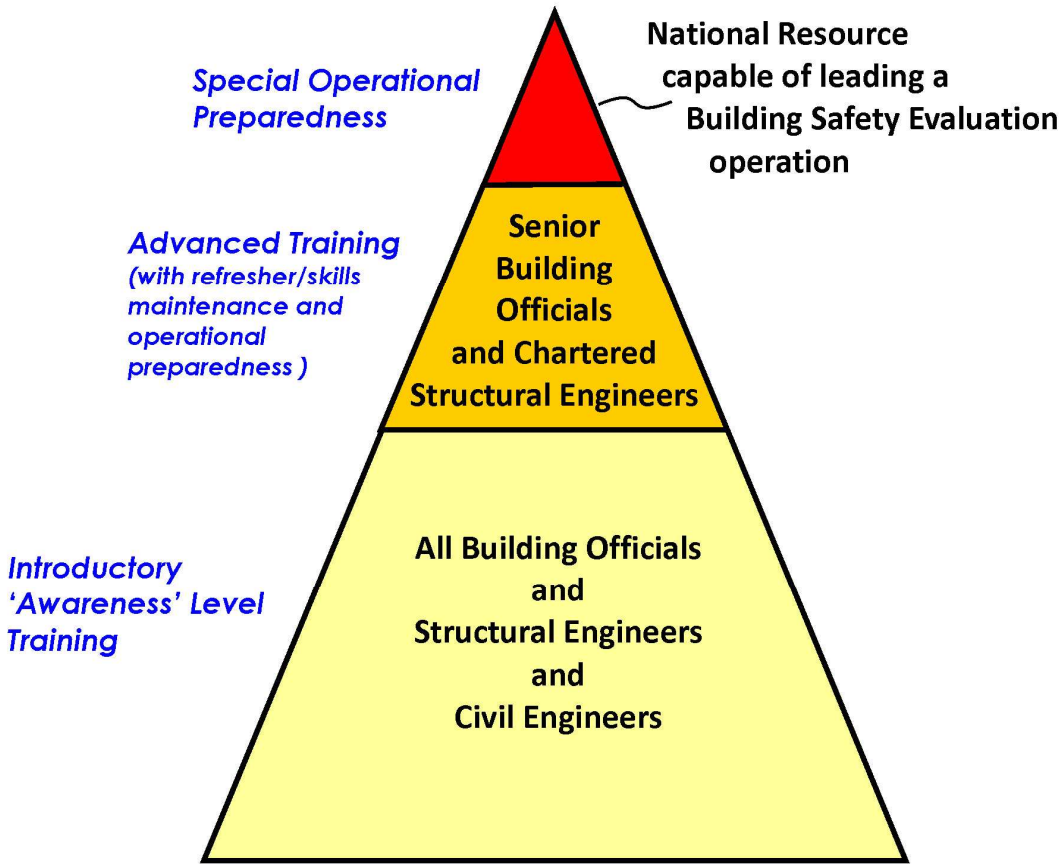


Figure 4.1: Building Evaluation Resource and Training Capability Objectives

4.7 Other Issues for Consideration and Development

Scope of Post-Disaster building evaluation

As noted previously, the 2009 NZSEE Guidelines have a wider scope than just earthquake. They are intended to cover any disaster scenario where there is extensive damage to buildings and infrastructure over a large area.

Rapid Building Evaluation was carried out in Hawke's Bay following the severe flooding that occurred in late April 2011. Placards were posted on buildings (primarily houses) to prevent or restrict access due to the effects of flooding, slope instability, and sewerage. One territorial authority declared a state of local emergency and then used the provisions of the 2009 NZSEE Guidelines to triage the impacted buildings. A neighbouring territorial authority did not declare a state of local emergency, but used the provisions of s124 of the Building Act.

Further development of post-disaster building evaluation arrangements and systems should ensure that this wide scope of application is maintained.

Consistent public information on placards

The experiences from the large-scale rapid building safety evaluation operations following the 4 September 2010 and 22 February 2011 earthquakes have highlighted the challenges in communicating the meanings of the different placards to building owners and other members of the public.

A central element is the different interpretations of the words ‘safe’ and ‘occupiable’, particularly with respect to Green placards, and the actions that owners need to undertake.

Subsequent reviews and revisions of the placard need to have the principles of public communication uppermost, including clarity, consistency, and simplicity, in addition to conveying the legal context and status of the placards. The associated public information summary sheets should be developed in conjunction with the placard wording.

5. Summary Observations

The Scope and Focus of Post-Disaster Building Evaluations

1. The core focus of building evaluation operations immediately following an emergency affecting large numbers of buildings is undertaking a rapid assessment of their structural condition.
2. The principal output from a rapid assessment is the posting of a placard which indicates whether access to premises should be *allowed*, *restricted* or *prevented*. These placards are only intended to have a short life-span.
3. Rapid building evaluation operations are based on a triage approach, with a more detailed evaluation of all premises in areas of general damage remaining the responsibility of the owners. In extreme events this responsibility falls to the Civil Defence Emergency Management Controller.
4. A key component of a building evaluation system is having all arrangements in place, including readiness, planned response and planned transition from the triage state to normal building control arrangements that deal with dangerous buildings.

New Zealand Systems and Arrangements in Place Prior to September 2010

5. New Zealand building safety evaluation arrangements are based on Californian practice, with some further development reflecting European practice and the experience of the NZ Engineering Team in Indonesia in 2009.
6. NZSEE members and Civil Defence officials were first exposed to the Californian approach in 1989 following the Loma Prieta earthquake in San Francisco, and had further experience in leading its implementation following the December 1989 Newcastle, Australia earthquake. NZSEE members and others have put considerable effort over the following two decades into encouraging the development of suitable arrangements for New Zealand.
7. However, it was only in 2009 that national procedures were able to be published with the support of the Department of Building and Housing as the central government agency with responsibility for building safety generally.
8. Moreover, these procedures are still not mandated through any legislation. There is also only very limited central government resource allocation to support territorial authority implementation via standard information, training, capability recording and monitoring, etc.
9. As a consequence, post-disaster building evaluation arrangements have not been set up by territorial authorities with consistency or depth of systems, and training has only been delivered to relatively few territorial authorities.
10. While a number of building control officials had received training in building evaluation prior to September 2010, only a limited number of engineers had been trained.

11. In order to provide liability cover for professional engineers and others undertaking post-disaster building evaluations, this work was framed to be undertaken under the CDEM Act, at the direction of the CDEM Controller during a state of emergency.
12. Shortcomings in the Building Act with respect to post-earthquake processes, most notably around dangerous buildings provisions, had been identified following the December 2007 Gisborne earthquake.
13. The building safety evaluation arrangements in place prior to the 4 September 2010 earthquake provided a functional rapid building safety evaluation capability. The arrangements for transitioning back from a declared emergency involving large numbers of buildings to normal building control arrangements had not been considered in any depth.

Implementation of Building Safety Evaluation Operations Following the 4 September Darfield Earthquake

14. Building Safety Evaluation operations were implemented by Christchurch City, Waimakariri District and Selwyn District councils following the 4 September earthquake. These used different approaches that broadly followed the 2009 NZSEE Guidelines, and made use of available resources.
15. The Christchurch City Council rapid building safety evaluation operation was of significant size, and drew upon a range of local and national resources and agencies. A total of 1,236 commercial and 6,686 residential buildings received placards during the state of emergency period in September, most during the first week.
16. The scale of this operation was large by international standards, and the management and breadth of coverage of the operation represented a considerable achievement by Christchurch City and the range of support agencies involved.
17. There were however some shortcomings in the implementation of the procedures for Christchurch City Council, including:
    - Some teams deployed in the CBD contained engineers with insufficient general experience (i.e. non-Chartered Professional Engineers);
    - Lack of integration of owner-appointed engineers and property managers with the Council-led process for commercial buildings;
    - A clear approach to managing the changing of placards had not been established;
    - The different requirements of residential properties (scope and method of assessment) had not been fully anticipated;

    The first three of these points were addressed in the corresponding operation that followed the 22 February aftershock.

18. Waimakariri and Selwyn district councils initially used their own resources plus available local engineers and consultants and the 2009 Building Safety Evaluation Guidelines.

Actions Subsequent to the Lifting of the State of Emergency

19. In the absence of any post-earthquake provisions in the Building Act, actions in relation to building evaluation and access following the lifting of the initial state of emergency on 17 September were taken under provisions written under urgency into the Canterbury Earthquake (Building Act) Order 2010.
20. By introducing elements of earthquake-prone building definitions (i.e. the definition of a *moderate earthquake*) as part of an extension to the definition of dangerous and insanitary, the September 2010 Order in Council implied that all earthquake-prone buildings are dangerous (even if undamaged), and vice versa. This added uncertainty to the legal status of occupancy, thereby creating confusion for building owners, engineers and Building Consent Authorities.
21. In the absence of any legislative provisions in either the Building Act or the Building Act Order in Council, the three territorial authorities were only able to encourage the owners of Green-placarded buildings to have detailed engineering evaluations undertaken, rather than require them.
22. In the absence of specific technical guidance for detailed engineering evaluations, engineers were left to apply their own knowledge in adapting and applying NZ and international documents and standards for assessing buildings actually or potentially affected by the Darfield Earthquake.

The 26 December, 2010 Aftershock

23. Significant problems were encountered by Christchurch City Council following the 26 December aftershock as they attempted to undertake building evaluations without a state of emergency being in place.
24. The lack of urgency in undertaking detailed engineering evaluations of buildings affected by this earthquake is likely to have resulted from the absence of a systematic approach to the rapid evaluation process.

Best Practice Systems and Arrangements Required for New Zealand

25. Best-practice systems and arrangements required for New Zealand will be influenced by the findings and recommendations of the Canterbury Earthquakes Royal Commission of Inquiry.
26. The Ministry of Civil Defence and Emergency Management and the Department of Building and Housing, supported by NZSEE, have commenced further development of the building safety evaluation arrangements from those in place at the time of the 4 September 2010 earthquake.
27. This report proposes that the following key components of best practice should underpin and frame the preparation for and management of an effective Building Evaluation operation:
    1. Appropriate legal mandate
    2. Central government agency providing a focal point, guidance and support for preparedness activities
    3. Criteria and process for building re-occupancy established
    4. Local authorities appropriately prepared to set up and manage a building evaluation operation

5. Appropriate numbers of trained and warranted building professionals
6. Effective mobilisation arrangements for warranted building professionals (locally and nationally)

28. The legal mandate should be provided through the Building Act, as building evaluation is primarily a building control function. This would ensure effective alignment between the process during a state of emergency and normal regulatory processes for dangerous, earthquake-prone, or insanitary buildings under the Building Act. Moreover, the Department of Building and Housing has the mandate to be the central government focal point for post-disaster building-related activities.
29. Further consideration needs to be given to the concept of 'interim occupancy' and associated criteria for application to Green-placarded buildings and the accessible parts of a Yellow-placarded building. This is a matter for international clarity and consistency, as well as in New Zealand.
30. There is a need for preparation of information management and communication systems pre-event to cope with the huge demands in response phase, including aftershocks. These systems should be aligned with business-as-usual building control systems in order to be able to manage information effectively during the recovery phase.
31. The development of national arrangements must include the enhancement and delivery of appropriate training, and the maintenance of a registration and warranting system that is linked to operational arrangements.
32. Further development of post-disaster building evaluation arrangements and systems should ensure applicability to any disaster scenario where there is extensive damage to buildings and infrastructure over a large area.
33. The Green-placard needs to give clearer advice to owners as to what 'usable' means, and the steps they should follow. The Yellow-placard currently focuses on short-term entry, and doesn't adequately deal with part of a building that is accessible. The wording on all placards will need reviewing in conjunction with revisions to legislation and regulations.
34. Revisions of the placards need to provide clarity of communication to public, in addition to conveying the legal context and status of the placards. Pre-event public information material should be developed in conjunction with the placard wording.
35. Consideration needs to be given to the differences between rapid building evaluation operations in commercial and residential areas, and whether the same placards and forms can continue to be used.
36. Target time frames for addressing damaged and undamaged earthquake-prone buildings should also be considered further, having due regard to the different scales of disaster events.
37. Current work defining the process and procedures for the detailed engineering evaluation (structural and geotechnical) of placarded and other damaged buildings should be further developed to the point where they can be applied to any location in New Zealand.
38. Engineering evaluations of buildings throughout New Zealand for earthquake-prone building investigations or other purposes need to focus more sharply on identifying critical structural weaknesses, and addressing them.

Glossary of Key Terms and Acronyms

Term or Acronym	Description
ACENZ	Association of Consulting Engineers New Zealand
ATC	Applied Technology Council (United States)
BET Team	Building Evaluation Transition Team (Christchurch City Council)
BOINZ	Building Officials Institute of New Zealand
CBD	Central Business District
CDEM	Civil Defence Emergency Management
CERA	Canterbury Earthquake Recovery Authority
Chartered Professional Engineer (CPEng)	A statutory title under the Chartered Professional Engineers Act of New Zealand 2002, and provides a quality mark that attests to the current competence of a professional engineer in New Zealand
DBH	Department of Building and Housing
Earthquake Prone Building	A building likely to cause injury to people or damage to other property in a moderate earthquake (excludes residential buildings unless two or more storeys and three or more household units).
EQC	Earthquake Commission
FEMA	United States Federal Emergency Management Agency
IPENZ	Institution of Professional Engineers New Zealand
MCDEM	Ministry of Civil Defence and Emergency Management
Moderate earthquake	Defined in the Building Regulations as an earthquake causing shaking equivalent to one-third that would be used for the design of a new building at the same site
NZFS	New Zealand Fire Service
NZSEE	New Zealand Society for Earthquake Engineering
Placard	The Green, Yellow and Red notices issued for buildings during the rapid building assessment process carried out during the state of emergency
SAP	Safety Assessment Program (California)
USAR	Urban Search and Rescue
2009 NZSEE Guidelines	The August 2009 NZSEE document *Building Safety Evaluation During a State of Emergency – Guidelines for Territorial Authorities*

Appendix A
Key Features of NZ Rapid Building Safety Evaluation Procedures

Legal and Operating Basis

- The process is not mandated under either the Building Act or the Civil Defence Emergency Management Act
- The process is based on the 2009 guideline document published by NZSEE
- It is undertaken during a state of emergency under the direction of the Civil Defence Emergency Management Controller (thereby providing liability cover for those parties involved)
- It is expected that territorial authority building control managers will lead the process, including appropriate preparations
- Resourcing is provided by volunteering engineers and other building professional working alongside building control officials. Many of these resource groups are from out of the affected region

Building Safety Evaluation Inspection Categories

- There are four inspection categories:
    - Overall damage survey
    - Level 1 Rapid Assessment
    - Level 2 Rapid Assessment
    - Detailed Engineering Evaluation and Remedial Work

- Level 1 Rapid Assessments are an assessment of the current building structural damage by external observation only. These assessments should be carried out by teams comprising building control officers, structural and civil engineers, architects, and other suitably experienced building professionals during the emergency response phase.
    - The expected time for a Level 1 Rapid Assessment is 10 to 20 minutes per building
    - The general scope of applicability of a Level 1 Rapid Assessment is for buildings of up to 3 or 4 storeys in height

- Level 2 Rapid Assessments should be undertaken for substantial buildings and for buildings identified in the Level 1 Rapid Assessment as requiring further rapid assessment for clarification. The Level 2 Rapid Assessment involves interior and exterior observations and should be performed by structural, building services and geotechnical engineers (as appropriate) during the emergency response phase.
    - The expected time for a Level 2 Rapid Assessment is from 1 hour to 4 hours per building depending on the size and complexity

Placard Types

Insert Council Crest & Contact phone number

INSPECTED

NO RESTRICTION ON USE OR OCCUPANCY

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.

☐ Exterior Only

☐ Exterior and Interior

Facility/ Tenancy Name and Address

_____

_____

Please ensure the owners are advised of this notification. 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 (partitions, windows, fittings and furnishings) may be hazardous. Electrical and mechanical equipment, gas connections, water supplies and sanitary facilities have not been inspected.

This facility was inspected pursuant to the Civil Defence Emergency Management Act 2002

Inspector ID:

_____

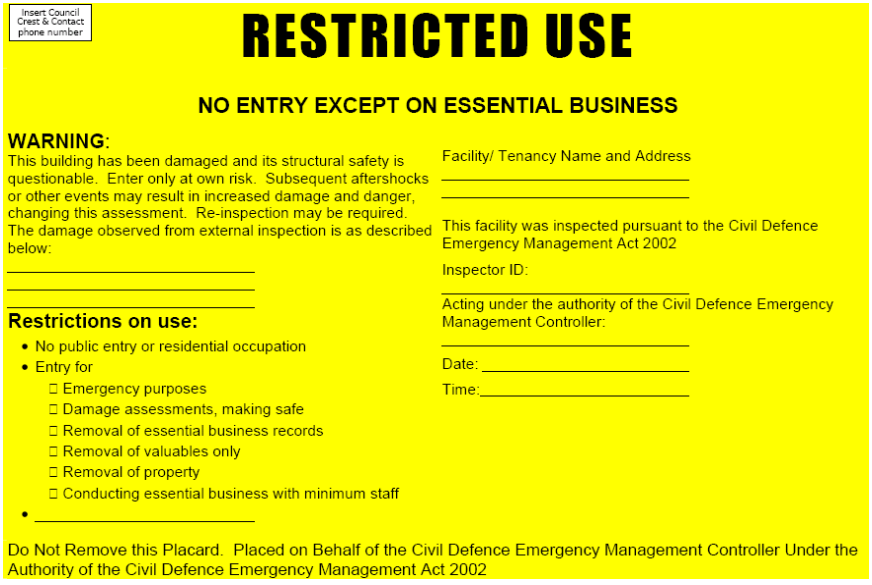
Acting under the authority of the Civil Defence Emergency Management Controller:

_____

Date: _____

Time:_____

Do Not Remove this Placard. Placed on Behalf of the Civil Defence Emergency Management Controller Under the Authority of the Civil Defence Emergency Management Act 2002



Insert Council Crest & Contact phone number

RESTRICTED USE

NO ENTRY EXCEPT ON ESSENTIAL BUSINESS

WARNING:

This building has been damaged and its structural safety is questionable. Enter only at own risk. Subsequent aftershocks or other events may result in increased damage and danger, changing this assessment. Re-inspection may be required. The damage observed from external inspection is as described below:

_____

_____

_____

Restrictions on use:

- No public entry or residential occupation
- Entry for
  - ☐ Emergency purposes
  - ☐ Damage assessments, making safe
  - ☐ Removal of essential business records
  - ☐ Removal of valuables only
  - ☐ Removal of property
  - ☐ Conducting essential business with minimum staff
- _____

Facility/ Tenancy Name and Address

_____

_____

This facility was inspected pursuant to the Civil Defence Emergency Management Act 2002

Inspector ID:

_____

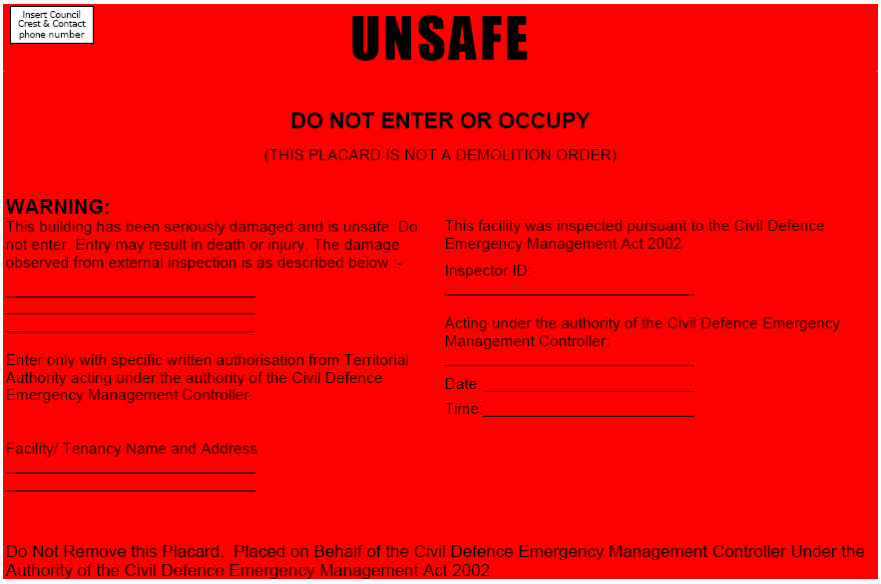
Acting under the authority of the Civil Defence Emergency Management Controller:

_____

Date: _____

Time:_____

Do Not Remove this Placard. Placed on Behalf of the Civil Defence Emergency Management Controller Under the Authority of the Civil Defence Emergency Management Act 2002



Insert Council Crest & Contact phone number

UNSAFE

DO NOT ENTER OR OCCUPY

(THIS PLACARD IS NOT A DEMOLITION ORDER)

WARNING:

This building has been seriously damaged and is unsafe. Do not enter. Entry may result in death or injury. The damage observed from external inspection is as described below :-

_____

_____

_____

Enter only with specific written authorisation from Territorial Authority acting under the authority of the Civil Defence Emergency Management Controller.

Facility/ Tenancy Name and Address

_____

_____

This facility was inspected pursuant to the Civil Defence Emergency Management Act 2002

Inspector ID:

_____

Acting under the authority of the Civil Defence Emergency Management Controller:

_____

Date: _____

Time:_____

Do Not Remove this Placard. Placed on Behalf of the Civil Defence Emergency Management Controller Under the Authority of the Civil Defence Emergency Management Act 2002