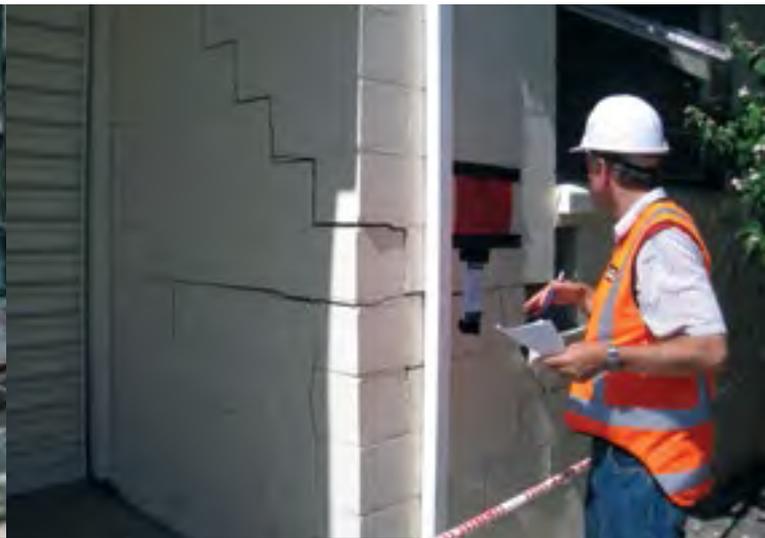




Responses to the Canterbury Earthquakes Royal Commission recommendations

FINAL REPORT

FEBRUARY 2017





**MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT**
HĪKINA WHAKATUTUKI

ABOUT THIS REPORT

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Foreword from the Minister

The earthquakes that struck the Canterbury region in 2010-2011 was one of the most significant tragedies New Zealand has experienced as a nation. The 22 February 2011 earthquake resulted in 185 people losing their lives and many more injured.

The Canterbury earthquakes changed public perceptions and highlighted the vulnerability of our buildings to seismic activity and the fatal consequences if these building fail. Since that terrible time in our history, Seddon and in particular the Kaikoura earthquake in November 2016 have further heightened awareness of our need to improve New Zealand's management of earthquake risks.



The Government recognised the need to understand why such significant loss of life occurred in Christchurch in 2011 and initiated the Canterbury Earthquake Royal Commission of Inquiry (the Royal Commission) to report the causes of building failure as a result of the earthquakes. The Royal Commission presented its findings by way of recommendations in 2012. These recommendations then became a multi-year body of work led by MBIE, but with many other contributing agencies.

This report sets out the actions the government has taken to improve the building and construction sector. These include:

- New laws for managing earthquake prone buildings
- Immediate changes to processes and the creation of cross agency actions
- Improving occupational regulations for building and construction sector professions
- Revising standards and creating or updating guidance for design new buildings

While significant progress has been made to improve our buildings following the events in Canterbury, we cannot afford to be complacent about earthquakes and the devastation they can cause our communities. The changes made today will improve their safety so fewer families will face the loss of a loved one, and cities and towns will remain resilient into the future.

A handwritten signature in blue ink, appearing to read 'Nick Smith', written in a cursive style.

Hon Dr Nick Smith
Minister for Building and Construction

Acknowledgements

MBIE would like to acknowledge and pay tribute to:

- the victims of the earthquakes and their families
- the many practitioners and people from Canterbury who assisted with this work programme.

MBIE would also like to acknowledge the continuing contributions and support of the following organisations:

Building Research Association of New Zealand (BRANZ)
Building Officials Institute of New Zealand (BOINZ)
Canterbury Earthquake Recovery Authority (CERA)
Cement and Concrete Association of New Zealand (CCANZ)
Christchurch City Council
Earthquake Commission (EQC)
Engineering Advisory Group (EAG)
GNS Science (Geological and Nuclear Sciences)
Heavy Engineering Research Association (HERA)
Institution of Professional Engineers New Zealand (IPENZ)
Land Information New Zealand (LINZ)
Local Government New Zealand (LGNZ)
Ministry of Civil Defence & Emergency Management (MCDEM)
Ministry for the Environment (MfE)
Ministry for Culture and Heritage (MCH)
National Institute of Water and Atmospheric Research (NIWA)
Natural Hazards Research Platform
New Zealand Construction Industry Council (NZCIC)
New Zealand Geotechnical Society (NZGS)
New Zealand Institute of Architects (NZIA)
New Zealand Registered Architects Board
New Zealand Society for Earthquake Engineering (NZSEE)
New Zealand Transport Agency (NZTA)
Quake Centre
QuakeCoRE
Selwyn District Council
Standards New Zealand
Steel Construction New Zealand (SCNZ)
Structural Engineering Society New Zealand (SESOC)
The Treasury
University of Auckland
University of Canterbury
Waimakariri District Council

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Section 1: Overview

New Zealand is a seismically active country, with many people sensing earthquake shaking several times each year. However the Canterbury earthquake sequence, with five major destructive shocks between September 2010 and December 2011 and thousands of smaller shakes, is unprecedented in recent times. The shallow depth and proximity to the major urban area of Christchurch city made it the most destructive earthquake sequence since the 1931 Napier earthquake.

Supporting the Canterbury rebuild and addressing the lessons and recommendations drawn from the Canterbury Earthquakes Royal Commission (the Royal Commission) inquiry have been a focus for government agencies and many other organisations during these past six years. There is a collective responsibility to those who have experienced loss, which is to learn, effect change and make improvements for the benefit of all New Zealand communities.

Instigating a multi-year work programme within MBIE, with many streams of ongoing work, recognises the importance and long-term benefits that this work will bring to New Zealand.

The improvements, research and collaboration outlined in this introduction highlight just part of the large body of work that has been led, facilitated and supported by MBIE and other government agencies.

The detailed technical responses in Section 2 of this report provide a more in-depth explanation about all of the Royal Commission recommendations and the responses to them, which agency is leading the work and an outline of ongoing actions initiated by the recommendation.

The Royal Commission's 189 recommendations cover a wide range of issues, from the very specific, to broad improvements across the building and construction sector. MBIE has worked through all of the recommendations recognising this opportunity to improve the overall building system for the benefit of all New Zealanders. It is important to have a building and construction sector that uses all the skills of trained experts and highly skilled practitioners, with a regulatory system that is fit-for-purpose, and that is supported by relevant legislation. It is with that interpretation and purpose that work began upon the recommendations accepted by Cabinet in 2012.

The Royal Commission collated detailed evidence of building performance, commissioned extensive analysis of these observations and recommended significant changes that aim to:

- provide overall system improvements
- reduce risk from existing buildings
- improve new building design, and
- improve response capability following earthquakes

Before the 22 February 2011 earthquake, New Zealand had not experienced significant modern-day building collapses from earthquakes. New Zealand buildings are designed to a performance-based building code. Building design methods are only truly tested when a significant event such as the Canterbury earthquake sequence occurs. Therefore, it is necessary for us to learn as much about how buildings performed and make changes to reduce the risks from future events.

The Royal Commission recommendations are now the basis for a multi-year work programme in MBIE. 177 recommendations are overseen by MBIE, in collaboration with all parts of the building and construction sector, in particular the engineering profession. Other agencies with lead responsibilities for recommendations are:

- Ministry for the Environment (3)
- Ministry of Civil Defence and Emergency Management (1)
- Treasury (1)
- Land Information New Zealand (1)
- Ministry for the Environment/Ministry for Culture and Heritage (1 shared)
- Institution of Professional Engineers New Zealand (IPENZ)(4)
- GNS Science (1)

MBIE is reporting on all the recommendations.

Canterbury Earthquakes Royal Commission

The Royal Commission, and the contributing Department of Building and Housing investigation, recognised the importance of reviewing the performance of buildings in the Christchurch central business district (CBD) during the earthquakes. It considered the adequacy of current legal and best-practice requirements for building design, construction and maintenance. Public hearings were held during 2011 and 2012, covering:

- seismicity
- soils and the seismic design of buildings
- the performance of CBD buildings
- low-damage building technologies
- earthquake-prone buildings
- building management after earthquakes
- roles and responsibilities within the current regulatory framework.

The Royal Commission's Final Report was published as seven volumes containing 189 recommendations.

- Volume 1: Seismicity, soils, and the seismic design of buildings focused on improving seismicity knowledge and building foundations.
- Volume 2: Performance of Christchurch CBD buildings focused on a number of buildings that included Pyne Gould Corporation, Hotel Grand Chancellor, and Forsyth Barr.
- Volume 3: Low-damage building technologies focused on how low-damage building technologies can achieve better building resilience.
- Volume 4: Earthquake-prone buildings focused on existing earthquake-prone buildings.
- Volume 5: Christchurch, the city, and approach to this inquiry focused on Christchurch's history and the impact of the earthquakes; also the methodology used by the Royal Commission. Note: There were no recommendations in Volume 5.
- Volume 6: Canterbury Television building (CTV) focused on the history of the CTV from design and construction to the building failure in the 22 February earthquake.
- Volume 7: Roles and responsibilities focused on legal and best-practice requirements for building design to address known earthquake risks.

This report outlines what has been achieved to date and long term changes initiated in response to the Royal Commission recommendations. Section 2 of this report provides detailed responses to the 189 Royal Commission recommendations, grouped together into aligned issues.

It shows the work within MBIE, with other government agencies and with technical societies, to make:

- immediate changes to processes and create cross-agency actions
- legislative changes to the Building Act (which governs the sector)
- a comprehensive difference in the long-term to the whole building sector.

Several large pieces of work have therefore been launched to improve the overall system and other important issues are being worked on in tandem.

Research activity extends across the Canterbury response work programme to effectively address the Royal Commission's recommendations. Reference is made to research in many parts of this report. MBIE has sought research partners from within New Zealand and internationally to find the appropriate facilities and personnel to build the body of knowledge that MBIE uses to lead the building and construction sector.

Significant changes have been made

Significant changes that aim to reduce the likelihood of loss of life in future New Zealand earthquakes include:

- new legislation with amendments to the Building Act for earthquake-prone buildings, the National Civil Defence Emergency Management Plan, and the Civil Defence Emergency Management Amendment Act 2016.
- training of assessors and producing field guides for building management in an emergency
- strengthened registration and re-registration processes and a new code of ethical conduct for Chartered Professional Engineers
- improved monitoring capability of the sector
- changes to design standards
- new guidance for engineers and other building designers
- improved opportunities for collaboration and for technical and sector input into policy development
- enhanced support for research and improved research capability
- improved international linkages providing opportunities to learn from building performance during earthquakes elsewhere and to other approaches for improving the resilience of the built environment.

After the recommendations from the Royal Commission were accepted, the three priorities for policy and legislative change were identified by Cabinet as:

- occupational regulation of engineers in building and construction
- earthquake prone buildings and
- building management after an emergency

Occupational Regulation

Following the report of the Royal Commission, the Government decided to look at the occupations in the building sector to see whether the way they are regulated is fit for purpose.

In 2014, MBIE reviewed the occupational regulation of professional engineers. The review found that:

- the regulatory system for engineers did not ensure that commercial and multi-unit and multi-storey residential buildings were designed by people with the right knowledge, skills and competency levels
- engineers were not always held to account when their engineering designs are sub-standard
- the regulatory system was based on self-regulation without sufficient checks and balances.

A consultation document was then released regarding this review.

In 2015, the Minister for Building and Housing asked MBIE to broaden the review to include the six major occupational groups that work

within the building and construction sector to ensure the regulation of occupations within the sector is fit-for-purpose. The six occupational groups included within this widened scope are:

- professional engineers and engineering associates
- architects
- plumbers
- gasfitters and drainlayers
- electrical workers
- licenced building practitioners.

MBIE continues to work on this important regulatory change, as well as a suite of changes designed to facilitate a wider culture change within the engineering sector. This includes working with IPENZ, who reviewed the Chartered Professional Engineers and IPENZ code of ethical conduct to specifically consider an engineer's obligation to report a building or structure considered to present a risk to health and safety to people or to the environment. The new code was published in July 2016. Education around the change has included interpretive guidance, workshops and professional development opportunities for engineers.

Earthquake Prone Buildings

The Building (Earthquake-prone Buildings) Amendment Act 2016 establishes a more effective and consistent framework for identifying, prioritising and remediating earthquake-prone buildings across New Zealand. It aims to better target those districts, buildings and parts of buildings that pose the greatest risk, and to provide improved information for territorial authorities (local councils), building owners, engineers and the public.

A new category within the Act has been created to improve public safety by requiring the strengthening of hazardous elements of unreinforced masonry buildings and providing a higher level of protection from falling hazards such as chimneys, parapets and ornaments.

The new Act categorises New Zealand into three seismic risk areas (high, medium, and low) with varying timeframes for identification and remediation of building in these areas.

Within the Building (Earthquake-prone Buildings) Act, an Earthquake-prone Building methodology will specify the tools and methods for identifying potentially earthquake prone buildings, and provide a method for assessing the seismic capacity of the building. Education, hospital and buildings on strategic routes, as well as emergency service facilities are all prioritised. A register of earthquake prone buildings will make this information available to the public.

Public safety, including minimising future fatalities, is a priority in developing policy for earthquake-strengthening buildings. A challenge is to balance costs of strengthening or demolishing, while retaining as much of our built heritage as possible.

The technical guidance and supporting regulations needed for the new system are currently being developed. The Act and new system are scheduled to commence in July 2017.

Building Management after an emergency

In 2014 the government announced a new system for managing buildings after an emergency. This system provides stronger guidance with revised forms and access placards, and a training programme for assessors. A key change is the shift away from the 'traffic light' system of red, yellow and green placards to indicate the condition of the building. Instead, red, yellow and white colours will be used. Green was assumed by the public to mean the building had no issues. In reality, it meant that, on visual inspection, the building could be used but should have further detailed evaluation. The new white placard will indicate that the building is suitable for occupancy but it does not necessarily mean it is safe. The placards have been rewritten in plain English.

Field guides have been published to assist assessors undertaking the rapid building usability assessment immediately following an emergency. These include processes for placing, changing and removing placards. More than 400 engineers, building officials and architects have been trained in the system. Further guidance is in development to assist territorial authorities to be prepared for managing buildings in the event of an emergency.

The government released a discussion document in 2015 seeking to address gaps, omissions and barriers in current legislation for managing buildings after an emergency that were highlighted during the Canterbury earthquakes. These included:

- the lack of clear legislative mandate for the system for managing buildings after a state of emergency
- the lack of smooth transition between civil defence and emergency management powers and normal, business-as-usual powers under the Building Act 2004
- insufficient powers in the Building Act 2004 for managing buildings damaged in an emergency.

Submissions have been considered and it is likely that new legislation will be introduced into Parliament shortly.

Collaboration

Responding to the earthquakes highlighted the importance of collaboration; this has been recognised in the Royal Commission's recommendations across many professional branches of the building and construction sector. Sustained collaboration is central to making changes to the whole construction system and is key to many of the legislative changes, guidance development, and new ways of working that have resulted from the recommendations. MBIE has worked across the various disciplines within the sector and is entering into agreements facilitating collaboration now and into the future.

The collaboration that was strengthened during the response to assist with recovery has been formalised, starting with the establishment of the Engineering Advisory Group. A number of strategies put in place continue constructive dialogue between groups and professions. This has resulted in meaningful changes in the way MBIE and professional

Geotechnical database and geotechnical research

bodies operate and communicate.

The geotechnical database provides for sharing of professional geotechnical data on geotechnical investigations (such as bore holes, cone penetration tests, piezometers and ground water monitoring). It is an online tool that allows all geotechnical engineers to upload information they have collected about sites, and access information uploaded by others.

This is an extremely valuable dataset that commands international interest. The database enables data to be captured once and be used many times over. It now contains more than 70,000 records that have on average been downloaded 20 times over. It is changing the way New Zealand geotechnical consultants operate, with them now competing on service and data interpretation instead of holding onto data for competitive advantage. The database now incorporates all regions in New Zealand. It was established by the Canterbury Earthquake Recovery Authority (CERA) with strong support from the Earthquake Commission (EQC) and MBIE, and is being jointly funded by MBIE and EQC.

National and international research has been conducted to look at better methods for predicting the effects of liquefaction, its consequences on lateral spreading and the subsequent effect on building foundations in Canterbury. This research includes improving understanding of the performance of shallow and deep pile foundations during earthquakes. The additional knowledge from this research will be progressively incorporated into standards and building design guidance.

Changes at MBIE

MBIE has made internal changes recommended by the Royal Commission.

These include:

- signed agreements with the three technical societies (Structural Engineering Society New Zealand, New Zealand for Earthquake Engineering and New Zealand Geotechnical Society) to work in partnership on technical projects to support the Chief Engineer. The societies also participate in the Engineering Design Reference Group to provide early input into the development of public policy.
- a formal role for the Engineering Advisory Group, providing advice to the Chief Engineer on MBIE's technical work programme, trends, quality issues and research needed.
- increased capability to support the Chief Engineer, including the establishment of the roles of Engineering, Design & Science Manager, Deputy Chief Engineer and additional structural and geotechnical engineering positions.
- creation of Sector Trends and Innovation Group which works closely with Building Control Authorities (mainly territorial authorities) to monitor trends and identify risks in the building sector.

Seismicity and Structural engineering

There has been a significant increase in funding for collaborative research to better understand both the demands buildings are likely

research

to be subject to during earthquakes (i.e. New Zealand seismic hazards), and the capacity buildings have to resist seismic shaking. New understanding can then be reflected in improved building design requirements in codes and standards.

An MBIE Chair in Earthquake Engineering has been appointed at the University of Auckland to assist technical public policy development and provide closer collaboration between researchers and designers within New Zealand and internationally.

A number of collaborative efforts are underway to better define research objectives, coordinate, and align domestic and international funding:

- The Universities of Canterbury and Auckland have made considerable investment in new large-scale experimental facilities and significant testing programmes addressing the Royal Commission recommendations are underway. MBIE, EQC, QuakeCoRE, Natural Hazards Research Platform, Resilience to Natures Challenges National Science Challenge, and the University of Canterbury Quake Centre are all facilitating this effort.
- To leverage international research, a number of collaborative initiatives have occurred with North American, Japanese, Chinese, Chilean and European practitioners and researchers. This has included holding a number of workshops to share design practices, research outcomes, and plan common testing programmes.

This, combined with other ongoing research being undertaken around the world, will improve the design of new buildings both in New Zealand and internationally.

Built Environment Leaders Forum

In September 2015 MBIE, EQC and the Building Research Association of New Zealand (BRANZ) brought together public and private sector leading decision makers to a two-day Built Environment Leaders Forum. Actions identified during the forum included:

- creating a strong national joint public and private leadership
- a community engagement programme to build understanding of risks
- improving the resilience of critical infrastructure
- better understanding of interdependencies and community expectations for levels of service
- developing better tools and incentives to increase building resilience.

The recommendations from this forum are now informing a number of strategies including the Wellington and Christchurch Resilience City initiatives and the Canterbury Earthquake Recovery Learning and Legacy Programme.

Architect Engineer collaboration

IPENZ, the New Zealand Institute of Architects, the New Zealand Registered Architects Board and MBIE, have worked with university schools of architecture and engineering to encourage development of

collaborative design methods within their curriculum. An ArchEng workshop is now run annually that brings together students from across New Zealand to work on design projects to foster collaboration. This will strengthen and expand the generations of architects and engineers with the experience necessary to work together effectively.

Reducing risk from existing buildings

As well as the Building (Earthquake-prone Buildings) Amendment Act, significant work has been undertaken related to the recommendations seeking to reduce the risk from existing buildings.

It is generally recognised that assessing the capacity of an existing building to resist an earthquake is more technically challenging than designing new buildings. The Canterbury earthquakes and other more recent earthquakes such as the Seddon/Cook Strait earthquakes have increased the demand for building assessments. Providing building owners with consistent assessments has been a challenge to the profession.

The Canterbury earthquakes mean we also now have considerably improved understanding of how buildings perform. Therefore, significant work is being done to improve assessment procedures and to upskill professionals making assessments. Changes to technical guides, technical standards and communicating risk in assessing buildings have been targeted by MBIE and technical societies with support from EQC and Local Government New Zealand. This includes ongoing training and professional development of structural engineers. Legislation has been updated to ensure that the earthquake risk posed by existing buildings is reduced. The Building (Earthquake-prone Buildings) Amendment Act 2016 contributes significantly to the Royal Commission recommendations in this area. Together with the changes to legislation, a training programme of seminars for engineers on initial seismic assessment was run in 2013 and seminars on unreinforced masonry were delivered in 2015. A further extensive training programme on the new procedures has been developed to improve the consistency and quality of assessments.

The new assessment procedures and guidance are addressed in the updated 'Seismic Assessment of Existing Buildings – Technical Guidelines for Engineering Assessments'. This is a reference book for engineers assessing the earthquake performance of buildings. It is being extensively reviewed, updated and expanded by MBIE, New Zealand Society for Earthquake Engineering, the Structural Engineering Society of New Zealand, the New Zealand Geotechnical Society, EQC, and Local Government New Zealand. The practice methods prescribed in the updated guidelines will become technical practice requirement for building assessment via citation in the Earthquake-prone Building methodology under the Building (Earthquake-prone Buildings) Amendment Act 2016.

Improving new building design

Recommendations from the Royal Commission on geotechnical land information, foundation design, ground improvement, improving building design standards and low-damage building technologies all contribute to MBIE's work programme to improve the overall design of new buildings. These improvements are all based on new knowledge and research.

The findings from ground improvement trials carried out by the Earthquake Commission (EQC) in collaboration with MBIE have been incorporated into MBIE's guidance; 'Repairing and rebuilding houses affected by the Canterbury Earthquakes'. MBIE has partnered with the New Zealand Geotechnical Society (NZGS) to develop earthquake geotechnical engineering design guidelines. The guidelines are being progressively published. They address the geotechnical recommendations of the Royal Commission. A training programme for geotechnical engineers to support the new guidelines, a partnership between MBIE, NZGS and IPENZ, has started with on-line resources and training seminars. It aims to lift the general standard of geotechnical engineering practice in New Zealand.

To highlight the importance that people with sufficient knowledge, experience and competency are involved and are indeed integral to the design process, MBIE published two Practice Advisories¹ to explain the importance of collaboration in the design process.

Additional Practice Advisories have been released that emphasise the importance of:

- appropriate geotechnical investigation
- adequate attention being paid to the fixing and supervision of non-structural building items, eg ceilings, partitions and building services
- the need for professional engineering attention in the design of secondary structural elements such as stairs.

Separate work is underway by the Structural Engineering Society of New Zealand to promote the use of a Design Features Report to accompany design documents. The Design Features Report is a key document that includes explanations of key design assumptions, highlighting the critical aspects that need to be checked during construction.

New Zealand structural design is, in the main, covered by New Zealand Standards. MBIE is focusing on updating 40 to 60 New Zealand Standards that are important for supporting Building Code compliance.

Low-Damage Building Technologies

Low-damage building technologies are proven to help buildings perform well in earthquakes and suffer as little damage as possible. The use of existing technologies such as base isolation (as used in the Christchurch Women's Hospital which suffered little damage in the

¹ A Practice Advisory is guidance information issued in accordance with section 175 of the Building Act 2004

February 2011 earthquake) was identified by the Royal Commission as an area that could be better promoted.

MBIE is supporting the development of specific low-damage building technology guidance for the building industry, starting with base isolation. Other industry-led guidance documents, incorporating findings from recent research, have been published or are being developed for other low damage building technologies. This includes rocking steel-braced frames and buckling restrained braces like those being used with increasing frequency in the rebuild of Christchurch.

Research

Research is vital to the ongoing improvement in new building design. MBIE has initiated, collaborated with, and funded a suite of projects to look at a wide range of issues with a focus on better building design. The Universities and Crown Research Institutes are continuing to better understand New Zealand's seismic hazard. The Natural Hazards Research Platform is funded by MBIE, and hosted by GNS Science. It has awarded a four-year programme to researchers at the Universities of Canterbury and Auckland to research advancements in engineering guidelines and standards. MBIE is funding significant research through the University of Canterbury QuakeCentre into the behaviour of concrete walls to resist seismic loading and their interaction with floor diaphragms and other building elements. These research programmes are being further augmented by research funded by QuakeCoRE on low-damage and repairable structural systems. These findings, along with others as a result of international collaboration, will be reflected in revisions to standards and guidelines to improve new building design.

Improving response capability following an earthquake

The way that buildings damaged in the earthquakes were assessed, by whom, the placard system and cordons, as well as who gets the information about a building's status has been reviewed and updated with several immediate changes made by MBIE.

In accordance with Royal Commission recommendations, MBIE has developed and instigated a three tier system for training and ongoing management for rapid building assessment² along with a register of trained assessors that can be called upon across New Zealand:

- A Tier one leadership group of highly-skilled building assessors will provide management to the tier two certified group.
- Tier two is a core group of 400 rapid building assessors around New Zealand have been trained, certified and issued with identity cards. These assessors include senior engineers, architects and senior building control officers, who can be called on in an emergency.

² The *rapid building assessment* process was called the *building safety evaluation* process when the recommendations were written in 2012

- MBIE is working to identify and train a wider Tier three group to support the trained assessors. They will receive basic training and be mobilised in very large events. MBIE is also producing a guidance document for Local Authorities, 'Building Management in an Emergency' to standardise systems and responses across New Zealand.

Field guides for rapid building assessment after floods and earthquakes were published in 2014. The field guides contain specific guidance on when and how to enter damaged buildings that is based on Urban Search and Rescue processes.

During the immediate response to the earthquake, the rapid assessments focused on damage identification rather than the actual capacity of the buildings to withstand further tremors. Therefore the Detailed Engineering Evaluation (DEE) process was developed by the Engineering Advisory Group brought together by MBIE for use after the Canterbury earthquakes. It is now intended that the DEE will become the Detailed Damage Evaluation (DDE) procedure.

An important element to enhance the DDE procedure is to develop a better understanding of the residual capacity of buildings that have been exposed to earthquake shaking. MBIE, with the technical societies, the New Zealand Universities and international collaborators are undertaking research in this area. The DDE guidance will sit alongside the suite of documents and processes being compiled by MBIE in collaboration with relevant technical societies. These include: the rapid building assessment field guides, the three tier training and registration of rapid building assessors, and the framework (under the current system) for managing buildings after flooding or earthquakes.

Conclusion

The multi-year work programme begun by MBIE in 2012 in response to the Royal Commission recommendations is multi-layered, with some work completed, while other work, in particular research and collaboration, will be sustained and contribute to the development of better standards and guidance in the future. MBIE, with the support of other government agencies, technical societies, universities and international collaborators is committed to driving consistent improvement in the building and construction industry.

The Royal Commission introduced its recommendations by noting there was justified confidence in earthquake risk assessments and building design within New Zealand and that only incremental improvements were required. This approach has guided MBIE as it collaborates with the many participants in the sector to undertake fundamental and lasting change to the construction and building sector.

The Canterbury experience has provided a much greater national awareness of resilience. While the social and economic consequences have been significant and tragic, it has presented an opportunity and a responsibility to learn from the earthquake sequence; to improve processes responding to emergencies, to improve our understanding

of building and land performance in rare events, and to review the structure of the building sector. By setting up the Royal Commission and instructing MBIE, (then the Department of Building and Housing) to investigate specific building failures in mid-2011, the New Zealand Government provided this opportunity. Indeed, it strongly signalled our responsibility to those who have experienced loss to make sure lessons are learned and improvements made to decision making processes and in the way buildings are designed and constructed. Many of the developments are a step-change in how building regulation will monitor and improve building performance in the future, through a combination of better informed, skilled and collaborative design teams.

This section of the report has outlined the responses to the three Cabinet priorities for policy and legislative change and associated improvements to design and construction practice, the second section of this report summarises the responses to the individual Royal Commission recommendations.

Section 2: Detailed responses

The Canterbury Earthquakes Royal Commission (the Royal Commission) made 189 recommendations for specific improvements to the building and construction sector. Section 1 provided an overview of the sector changes that MBIE and other government agencies implemented in response to the recommendations. Section 2 provides detailed responses to each of the recommendations.

The safety of people in and around a building relies heavily on the structural integrity of the building, which in turn depends on its design and construction. Most of the recommendations address improving the design and construction process. The process relies on a number of professional groups working collaboratively to deliver the functional and aesthetic requirements desired by the building owner.

This introduction provides an overview of:

- how buildings, building work and the people in the occupational groups are regulated
- how professional engineers develop the knowledge, skills and experience required to design buildings
- how the standards and guidance documents that they rely upon are developed
- the key actions and documents that resulted from the recommendations.

The responses in this report are presented in groups of closely related recommendations. The recommendation groups have been assembled into four high-level interrelated themes:

- Overall system improvements (Section 2.1)
- Reducing risk from existing buildings (Section 2.2)
- Improving new building design (Section 2.3)
- Improving response capability following earthquakes (Section 2.4)

The recommendation numbers used in this report are the same as those in the Royal Commission's final report. However, they have been reordered and grouped to avoid repetition of the details as far as is practical. A sequential list of recommendations at the end of the report provides an index to the responses to specific recommendations.

In responding to the Royal Commission recommendations, MBIE acknowledges and is grateful for the on-going support, efforts and initiatives from many organisations, firms and individuals. This includes other government departments, Crown Research Institutes, EQC, the universities of Auckland and Canterbury, the Christchurch City, Selwyn District and Waimakariri District Councils, the Engineering Advisory Group, and the technical and professional societies.

Regulation of buildings and building work

Many of the recommendations require changes to the challenging and complex regulation of buildings and building work. MBIE is responsible for the regulations and co-regulates the buildings and building work with territorial authorities (building consent authorities). The primary source of

this regulation is the Building Act 2004 and its associated Building Code.

The Building Code defines performance requirements for buildings and provides methods that can be used to verify that a building will meet those requirements. Many of the methods refer to national standards that designers can use to verify that a building complies with the Building Code.

Occupational regulation

The damage observed in some complex buildings following the Christchurch earthquakes highlighted the need for the professionals contributing to the design process to have a higher level of competence and involvement than is required for buildings that are more straightforward. These building sector occupations are also regulated by MBIE.

Development of knowledge, skills and experience

Another effective method of enhancing building performance is to improve the standards referenced within the Building Code system, which have regulatory force. Technical guidance provides methods that are difficult to standardise, such as new or developing techniques, and may not be adopted by all designers.

Design methods within standards and guidance are improved incrementally. Their first publication introduces conservative provisions to improve building designs as quickly as possible. The provisions are updated once building behaviour is better understood and the methods have been tested by designers.

Most of these incremental improvements require research. It often takes a long time to both procure funding and carry out the research, because most engineering research requires expensive and extensive physical testing in a laboratory. The technical societies publish research results in technical articles and hold seminars and conferences to inform the engineering community.

The improvement process requires management, both to identify what needs improving and to provide quality control for the improvements. Standards are managed by Standards New Zealand with oversight from specially convened committees. Guidance is managed by MBIE with oversight from the Engineering Advisory Group that was formed to advise MBIE following the 4 September 2010 earthquake. Both oversight teams have representatives from the research, consulting, and government sectors who also represent their respective institutions, companies, departments, and technical societies.

The knowledge and skills required to use the standards and guidance are taught at university level. This is followed by a period where the skills are extended and consolidated within a consulting company until the graduate gains the experience required to be a Chartered Professional Engineer. IPENZ is responsible for setting the competence standards and assessing the candidates. IPENZ also operates a professional accreditation programme through which university degrees are assessed against an internationally benchmarked standard.

Actions

The Royal Commission introduced its recommendations by noting there was justified confidence in earthquake risk assessments and building design within New Zealand and that only incremental improvements were required. MBIE, as steward of the building regulatory system, needed to consider the roles of all of the participants in the sector as it collaborated with them to produce sector change.

In 2012, MBIE began a multi-year work programme to implement the recommendations. This programme has been supported by other government agencies, the technical societies, universities and international collaborators. The programme is ongoing and will be adapted to drive continuing improvement to the regulatory system, the buildings that it produces, and the existing building stock.

Outcomes

Many of the recommendations required legislation changes, which were developed following public consultation. To date, this includes:

- > Building Amendment Act 2012
- > Building Amendment Act 2013
- > National Civil Defence Emergency Management Plan Order 2015
- > Civil Defence Emergency Management Amendment Act 2016
- > Building (Earthquake-prone Buildings) Amendment Act 2016

Complex buildings rely on the regulation, development and resourcing of design professionals. IPENZ addressed this by:

- > strengthening Chartered Professional Engineer registration and re-registration processes
- > publishing a revised code of ethical conduct for Chartered Professional Engineers and IPENZ members in July 2016

MBIE has implemented a number of changes to improve its regulatory role as a result of these recommendations. These include

- > establishing an Engineering and Design Reference Group to contribute to public policy development
- > preparing policy principles and criteria for ongoing development of the Building Code and the cited standards
- > formalised role of the Engineering Advisory Group within MBIE
- > establishing Engineering Design & Science Manager, Deputy Chief Engineer, and structural and geotechnical engineering roles within MBIE
- > signing partnership agreements with technical societies
- > supporting conferences and work by the technical societies
- > supporting learning from earthquakes team reconnaissance visits
- > supporting data gathering following emergency international workshops
- > contributing to the Canterbury Technical Forum and other technical events

MBIE has established a new position to provide leadership for the research community and sponsored research activities:

- > appointed an MBIE Chair in Earthquake Engineering
- > funded new research initiatives
- > sponsored international workshops to identify research needs
- > strengthened international research collaboration

GNS Science, the University of Canterbury, and the National Institute of Water and Atmospheric Research have ongoing research programmes:

- > research programmes identifying the location and behaviour of active faults

MBIE, in partnership with EQC, also took responsibility for the geotechnical investigation repository developed by the Canterbury Earthquake Recovery Authority and seeded with a substantial quantity of data supplied by EQC:

- > established New Zealand Geotechnical Database in 2016

Timeline

Responses to the recommendations produced a significant body of technical literature. The events, actions, requirements, and documentation produced as a result the recommendations are shown on the following two pages.

Timeline



Canterbury Earthquakes Royal Commission

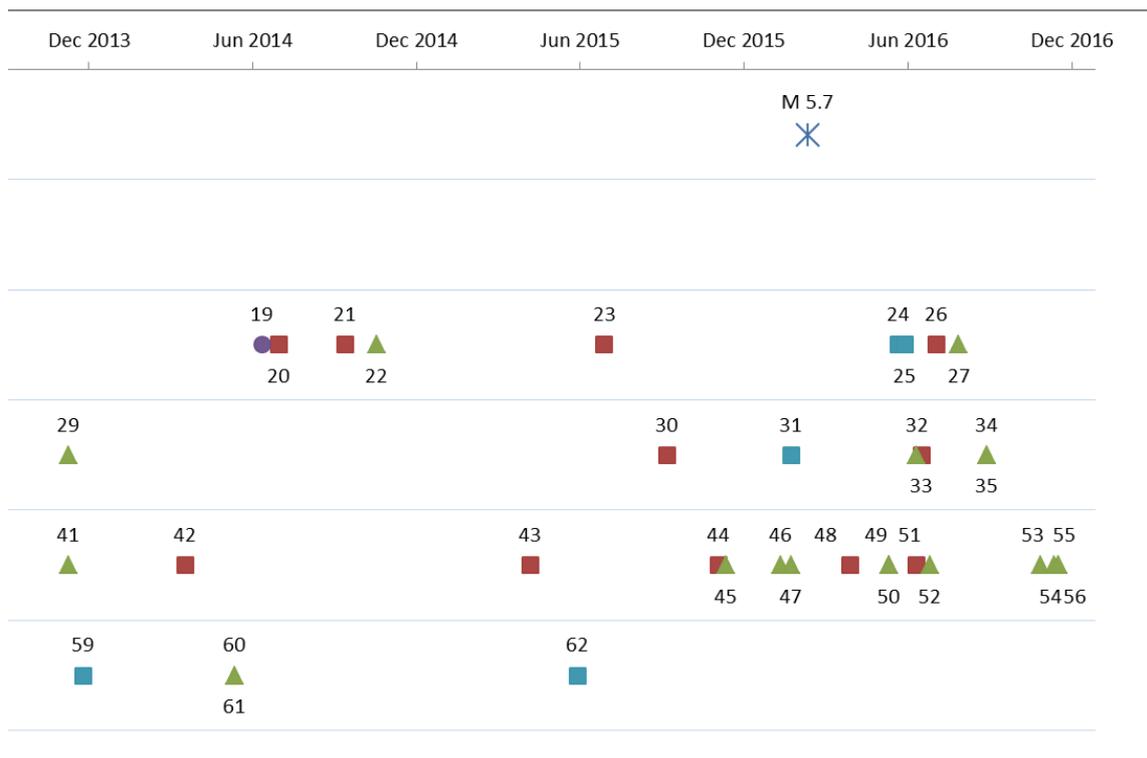
- 1 ● Appointment of Royal Commission chair
- 2 ● Appointment of other commissioners
- 3 ■ First meeting of commissioners
- 4 ■ Submissions for expressions of interest closed
- 5 ▲ First technical report released
- 6 ■ Hearings opened
- 7 ▲ New reporting dates released
- 8 ▲ Delivered first part of final report to Governor-General
- 9 ■ Final hearings
- 10 ▲ Delivered second part of final report
- 11 ▲ Completed delivery of final report

2.1 Overall system improvements

- 12 ■ Chartered Professional Engineers of New Zealand Amendment Rules 2011
- 13 ■ Building Amendment Act 2012
- 14 ■ 2012 ArchEng workshop
- 15 ■ formalised role of Engineering Advisory Group within MBIE
- 16 ■ additional MBIE technical capability
- 17 ● established Engineering and Design Reference Group
- 18 ■ 2013 ArchEng workshop
- 19 ● appointed MBIE Chair in Earthquake Engineering
- 20 ■ 2014 ArchEng workshop
- 21 ■ partnership agreements signed with SESOC, NZGS & NZSEE
- 22 ▲ guidelines: Improving Collaboration between Architects and Engineers
- 23 ■ 2015 ArchEng workshop
- 24 ■ Chartered Professional Engineers of New Zealand Rules (No 2) 2002 Amendment Rules 2016
- 25 ■ IPENZ Code of Ethical Conduct
- 26 ■ 2016 ArchEng workshop
- 27 ▲ MBIE Regulatory Management Strategy 2016-2017

2.2 Reducing risk from existing buildings

- 28 ▲ proposals to improve the New Zealand earthquake-prone buildings system
- 29 ▲ CCANZ Information Bulletin (IB No. 95)
- 30 ■ Built Environment Leaders Forum 2015
- 31 ■ Building (Earthquake-prone Buildings) Amendment Act 2016
- 32 ▲ draft document: The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments
- 33 ■ briefings on the new earthquake prone buildings regime
- 34 ▲ discussion document: Proposals for Regulations under the Building (Earthquake-prone Buildings) Amendment Act 2016
- 35 ▲ discussion document: Proposals for a methodology to identify earthquake-prone buildings



2.3 Improving new building design

- 36 ▲ Repairing and rebuilding houses affected by the Canterbury earthquakes
- 37 ■ 9th Pacific Conference on Earthquake Engineering
- 38 ▲ Practice Advisory 13: Egress stairs – earthquake checks needed for some
- 39 ■ 2012 NZSEE technical conference
- 40 ■ 2013 NZSEE technical conference
- 41 ▲ HERA design guide P4100 - Seismic design of eccentrically braced frames
- 42 ■ 2014 NZSEE technical conference
- 43 ■ 2015 NZSEE technical conference
- 44 ■ 10th Pacific Conference on Earthquake Engineering
- 45 ▲ Module 5A: Specification of ground improvement for residential properties in the Canterbury region
- 46 ▲ Practice Advisory 15: Improving collaboration in building design
- 47 ▲ Practice Advisory 16: Quality assurance in design and construction
- 48 ■ 2016 NZSEE technical conference
- 49 ▲ Module 1: Overview of the earthquake geotechnical engineering practice guidelines
- 50 ▲ Module 3: Identification, assessment and mitigation of liquefaction hazards
- 51 ■ International collaboration on reinforced concrete building performance
- 52 ▲ Practice Advisory 17: Well-planned ground investigations can save costs
- 53 ▲ Module 2: Geotechnical Investigations for earthquake engineering
- 54 ▲ Module 4: Earthquake resistant foundation design
- 55 ▲ Practice Advisory 19: Improving earthquake performance of non-structural elements
- 56 ▲ Practice Advisory 20: Improving earthquake performance of secondary structural elements

2.4 Improving response capability following earthquakes

- 57 ▲ AS/NZS 4819:2011 - Rural and urban addressing
- 58 ■ Civil Defence Emergency Management Amendment Act 2012
- 59 ■ Building Amendment Act 2013
- 60 ▲ Field guide: Rapid post disaster building usability assessment - earthquakes
- 61 ▲ Field guide: Rapid post disaster building usability assessment - flooding
- 62 ■ National Civil Defence Emergency Management Plan Order 2015

Section 2.1: Overall system improvements

Overview

The safety of people in and around a building relies heavily on the structural integrity of the building during and after an earthquake. Even though the level of shaking during the earthquakes was much greater than buildings were designed for, particularly during the 22 February 2011 earthquake, much of the general public had not anticipated the widespread damage that occurred. Besides the tragic collapses caused by inadequate design, even many relatively modern buildings were damaged to the extent of having to be demolished.

The Royal Commission heard considerable detailed evidence about specific building collapses. The poor performance of those and other buildings was often attributed to them having more complex shapes, element arrangements or foundation conditions than other buildings.

A building's structural integrity depends on its design and construction, which is a complex process involving a number of distinct professional groups working collaboratively to deliver the aesthetic and functional requirements desired by the building owner.

The Royal Commission heard little evidence of the poor construction practices that are often observed following significant overseas earthquakes, so most recommendations address changes to the design process.

Improving the design process

The poor seismic performance of some complex buildings highlights the need for the professionals contributing to the design process to have a higher level of competence and involvement than is required for more straightforward buildings. However, the recommendations that the Royal Commission made from the lessons of those failures did not require major changes to the system.

The Royal Commission recommended changes because they found:

- Engineers were not always held to account when their designs for complex buildings are sub-standard.
- There is a lack of clarity defining the roles and responsibilities of building and construction sector participants for establishing design criteria, to the point that the policy is sometimes only defined within New Zealand Standards.
- Lack of collaboration and central leadership within the sector has resulted in less than optimal outcomes for the design of some complex buildings.
- The design of complex buildings and buildings with complex foundation conditions require higher structural and geotechnical engineering competence.
- The building consent authority (BCA) process was not able to identify and manage the additional risks associated with the design and alteration of complex buildings.

Response

Actions taken

MBIE consulted with the construction sector to identify the most critical aspects of the design and construction of large, complex commercial buildings. It found that the construction of these buildings relies heavily on the skills and experience of qualified professionals and the sophisticated quality assurance and risk management systems that they use to meet their contractual obligations. The Chartered Professional Engineer/IPENZ framework holds engineers to account for breaches of competence, poor quality of work and negligence but engineers are able to practice outside the framework.

This reliance on professionals makes their regulation, development and resourcing the most important methods of improving the design and construction of these more complex buildings.

MBIE is responsible for the occupational regulation of engineers. The Institution of Professional Engineers New Zealand (IPENZ) is the Registration Authority for Chartered Professional Engineers.

IPENZ have made two key changes:

- > strengthened Chartered Professional Engineer registration and re-registration process
- > published revised code of ethical conduct for Chartered Professional Engineers and IPENZ members in July 2016.

MBIE reviewed the occupational regulation of Chartered Professional Engineers in 2014. In 2015, the scope of this work was extended to cover the major occupational groups within the construction sector.

MBIE has actively collaborated with the Structural Engineering Society New Zealand, the New Zealand Geotechnical Society and the New Zealand Society for Earthquake Engineering (the technical societies) when developing policies and plans for regulatory work. Members of the technical societies are also collaborating more effectively in the design process.

MBIE has:

- > established an Engineering and Design Reference Group to contribute to public policy development
- > signed partnership agreements with technical societies
- > supported conferences and work by the technical societies
- > prepared policy principles and criteria for development of the Building Code and the cited standards.

MBIE now has a strengthened presence in the building sector. It has made significant contributions to the guidance required to inform and improve practice in the sector as well as to the regulatory environment:

- > formalised role of the Engineering Advisory Group within MBIE
- > established Engineering Design & Science Manager, Deputy Chief Engineer, and structural and geotechnical engineering roles within MBIE.

MBIE has also collaborated with the University of Auckland, the University of Canterbury and other research institutions such as GNS Science to fund and oversee the research required to develop guidance. It has also established a new position to provide leadership for the research community:

- > appointed an MBIE Chair in Earthquake Engineering
- > sponsored international workshops to identify research needs

> strengthened international research collaboration.

The universities, IPENZ and the technical societies are working to improve engineering capability and skills, particularly for the design of complex commercial buildings and buildings with complex foundation conditions.

A new risk-based consenting process was developed and incorporated into the 2012 amendment to the Building Act 2004. Once in force, this process will begin with designers agreeing on an appropriate risk profile and a quality assurance system with the building consenting authority. The risk that the building work will not comply with the Building Code is assessed along with the consequences of that non-compliance.

> enacted the Building Amendment Act 2012.

Improving occupational regulation

Engineers were not always held to account when their designs for complex buildings are sub-standard.

Recommendation 64	In designing a building, the overall structure, including the ancillary structures, should be considered by a person with an understanding of how that building is likely to behave in an earthquake.
Recommendation 182	The Ministry of Business, Innovation and Employment should develop prescribed qualifications and competencies for “Recognised Structural Engineers” in consultation with the Chartered Professional Engineers Council, the Institution of Professional Engineers New Zealand, the Structural Engineering Society New Zealand and the New Zealand Society for Earthquake Engineering. These prescribed qualifications and competencies should be a more specific prescription of the qualifications and competencies of the role, and require more extensive design experience of the type required for the design of complex structures than that required for a Chartered Professional Engineer. These should be included in an appropriate regulation.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

In 2014, MBIE reviewed the occupational regulation of professional engineers and found that:

- the system does not provide assurance that commercial and multi-unit and multi-storey residential buildings are designed by people with the right knowledge, skills, and competence levels
- engineers are not always held to account when their engineering designs are sub-standard
- the regulatory system is based on self-regulation with insufficient checks and balances to ensure the interests of the public are served.

There is no regulatory requirement for engineers undertaking complex design to be Chartered Professional Engineers. The Chartered Professional Engineer/IPENZ framework holds engineers to account for breaches of competence, poor quality of work and negligence but engineers are able to practise outside this framework.

MBIE released a consultation document in late 2014 that included proposals to reform the way professional engineers are regulated. These proposals included:

- requiring the structural integrity of complex buildings to be certified by a Chartered Professional Engineer registered in an appropriate practice field
- establishing a new independent occupation body that is responsible for reviewing and approving the rules and standards for Chartered Professional Engineers
- improving the complaints and disciplinary system so that it is easier for a professional engineer to be held to account and disciplined.
- separating the management of serious complaints from the membership organisation (IPENZ).

In 2015, the Minister for Building and Housing extended the review to six major occupational groups that work within the building sector. The review aims to ensure that occupational regulation for the sector is fit-for-purpose

and delivers safe, good quality buildings at minimum cost. The occupational groups are:

- professional engineers and engineering associates
- architects
- plumbers
- gasfitters and drainlayers
- electrical workers
- all licensed building practitioner trades.

MBIE considered introducing Recognised Structural Engineer as a second competency level within the Chartered Professional Engineer credential. This was not supported by Structural Engineering Society New Zealand members and others who preferred to strengthen the registration criteria for Chartered Professional Engineers (which includes education, training, and experience).

> strengthened Chartered Professional Engineer registration criteria

Ongoing actions

The review of all six major occupational groups is underway. The review aims to:

- ensure that people who work in the sector are competent by improving the way that registration and licensing services are organised
- lift the skill levels across the whole sector
- ensure that people are held to account by establishing a single model for complaints and discipline across the six occupations, in which every complaint is dealt with in the right way.

It is anticipated that there will be public consultation proposing reforms to the way these occupations are regulated in early 2017. Any necessary legislative changes may be introduced to Parliament in 2017.

Performance indicators are being developed for the Chartered Professional Engineer registration criteria.

Improving occupational regulation (continued)

Recommendation 183	<p>The Institution of Professional Engineers New Zealand should provide clarification of its codes of ethics, in respect of the following matters:</p> <ol style="list-style-type: none"> the test for taking action should be well understood by engineers – i.e. ensuring public health and safety; each clause in the codes of ethics stands alone and no one clause can override another. In the case of a perceived conflict between two or more clauses, the question as to which clause should carry most weight in the circumstances presented should be a carefully considered matter of judgement; and reporting obligations of engineers when a structure has been identified that presents a risk to health and safety. There should be clarity as to the point at which an obligation of a reviewing engineer to report is extinguished, and where the accountability for addressing the matter and rectifying any weaknesses rests.
Recommendation 184	<p>Part 3, clause 6 of the Institution of Professional Engineers New Zealand Code of Ethics and Rule 48 of the Chartered Professional Engineers Rules of New Zealand (No 2) 2002 should be amended to provide for an obligation to advise the relevant territorial authority and the Institution of Professional Engineers New Zealand in circumstances where a structural weakness has been discovered that gives rise to a risk to health and safety.</p>
Recommendation 178	<p>The Institution of Professional Engineers New Zealand (as the Registration Authority) should publish on the Chartered Professional Engineer register information about a Chartered Professional Engineer’s area of practice and any other information that may further inform consumers of engineering services of the competence of individual engineers, under section 18(1)(d) of the Chartered Professional Engineers of New Zealand Act 2002.</p>
Lead Organisation	<p>Institution of Professional Engineers New Zealand (IPENZ)</p>

Response

Actions taken

IPENZ reviewed both the IPENZ code of ethics and the Chartered Professional Engineers code of ethical conduct contained within the *Chartered Professional Engineers of New Zealand Rules (No 2) 2002*.

A new code of ethical conduct for IPENZ members and Chartered Professional Engineers was released on 1 July 2016. The new code:

- has identical ethical obligations for IPENZ members and Chartered Professional Engineers
- makes the ethical values more easily understood
- addresses the recommendations of the Royal Commission

The new code of ethical conduct:

- adds a new requirement that an engineer reports, to a relevant regulatory body, any engineering matter that has, or could have, adverse consequences – being significant harm to the health and safety of people, or significant damage to the environment
- adds a new requirement for an engineer to keep their relevant knowledge and skills up to date

- adds a new requirement that an engineer report significant breaches of the code by other engineers

The new code removes the requirement for an engineer to inform another engineer before reviewing and providing comment on that engineer's work. Although no longer considered an ethical obligation, this practice is still encouraged as a professional courtesy.

IPENZ members and Chartered Professional Engineers were informed of their new obligations and responsibilities prior to the release of the new code. In addition an interpretive practice note was issued and ongoing professional development opportunities on ethics are being offered.

- > published Chartered Professional Engineers of New Zealand Rules (No2) 2002 Amendment Rules 2016

The Chartered Professional Engineers of New Zealand Act 2002 defines the purpose of the CPEng register as providing the public with the names of Chartered Professional Engineers (and their status and relevant registration history) and any other information the registration authority deems necessary and desirable. The register enables members of the public to identify Chartered Professional Engineers and to select a suitable one.

The Registration Authority now includes practice fields (such as geotechnical, fire, and structural) in the CPEng register, and the register can be searched by practice field.

- > included practice fields on the CPEng register
- > added facility for consumers to search by practice field

The Registration Authority decided not to include the engineer's qualifications, previous work experience and practice areas as they may mislead members of the public who are assessing an engineer's competency.

Ongoing actions

IPENZ plans ongoing professional development focused on ethics and professionalism.

The Registration Authority is considering whether to add information about the practice field by developing classes of registration or prescribed areas of practice relating to safety-critical work. Classes of registration for structural and geotechnical engineers may be an outcome of the IPENZ/MBIE project to define bodies of knowledge for structural and geotechnical engineering (see page 33).

IPENZ is also working to review the broad professionalism competencies expected to be demonstrated by Chartered Professional Engineers and IPENZ members.

Clearly defining roles and responsibilities

There is a lack of clarity defining the roles and responsibilities of building and construction sector participants for establishing design criteria, to the point that the policy is sometimes only defined within New Zealand Standards.

Recommendation 173	The Ministry of Business, Innovation and Employment should develop, lead and fund a Policy and Regulatory Work Programme in consultation with the Institution of Professional Engineers New Zealand, the New Zealand Construction Industry Council, Standards New Zealand, the Building Research Association of New Zealand, the New Zealand Geotechnical Society, the New Zealand Society for Earthquake Engineering and the Structural Engineering Society New Zealand.
Recommendation 174	The Policy and Regulatory Work Programme should identify the priorities for the development, review and update of compliance documents and Standards, and define the status of compliance documents and guidance material. Work relating to Standards prioritised for update as part of the Policy and Regulatory Work Programme should be funded as part of the work programme.
Recommendation 177	A communications plan should be developed by the Ministry of Business, Innovation and Employment to communicate the Policy and Regulatory Work Programme and ensure information is effective, and targeted for different participants in the sector. There should be clarity about the status of information provided to the sector; for example, whether it is a compliance document, Standard or guidance.
Recommendation 176	The Policy and Regulatory Work Programme should be the responsibility of the Chief Structural Engineer.
Recommendation 170	The Chief Structural Engineer should have the statutory power to collect consent applications for complex structures (as part of the Policy and Regulatory Work Programme in Recommendations 173 and 174 below) for the purpose of analysing trends, identifying issues and risks, and sharing knowledge with the building and construction sector.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

Under the State Sector Act 1988, MBIE has regulatory stewardship responsibility for the legislation it administers so that it is and will remain 'fit for purpose'. MBIE's Regulatory Management Strategy 2016/2017 was published in August 2016 to address how it is undertaking this responsibility. The building regulatory system is one of the most challenging and complex MBIE has responsibility for. Under the Building Act, MBIE regulates buildings and building work and Councils fulfil the operational role of a building consent authority. MBIE is also regulating other occupations in the building sector. The system has had to cope with major adverse events over the past decade in the form of leaky buildings and the Canterbury earthquakes. MBIE is now shifting focus to ensuring the system is coherent and adaptable for the longer term.

> published MBIE Regulatory Management Strategy 2016-2017

An internal regulatory system assessment of the building sector has been carried out and a regulatory charter is being developed with the sector to clarify roles and responsibilities. The stewardship role has also involved

developing an intelligence function within MBIE to ensure it has the necessary understanding, information and intelligence on the performance of the system to ensure MBIE and the other participants in the system are making progress on the priority areas.

> established Sector Trends and Innovation group

MBIE established an Engineering and Design Reference Group to provide early input into the public policy development process. The group has representatives from IPENZ, the New Zealand Institute of Architects, the Structural Engineering Society New Zealand, the New Zealand Society for Earthquake Engineering, the New Zealand Geotechnical Society, the Society for Fire Protection Engineers, and the New Zealand Society of Engineering Deans.

> established Engineering and Design Reference Group

The policy and regulatory work programme is ongoing. MBIE has worked with the sector to consider priorities for revising the New Zealand building standards catalogue. The 40 to 60 standards most important for supporting the Building Code system have been identified. A development programme is being finalised.

> identified the most important New Zealand Standards to support the Building Code

The executive function of Standards New Zealand is now part of MBIE. MBIE has focused on strengthening the New Zealand Standards that support the New Zealand Building Code and accreditation system. MBIE is also investing more in the most important supporting standards and has increased the development budgets for those standards from less than one percent of the building levy revenue to about eight percent.

> increased investment levels for the review and update of important standards

MBIE decided the General Manager for the Building Systems Performance Branch should continue to have responsibility for the policy and regulatory work programme, because it involves many non-technical aspects. The Chief Engineer reports to this general manager.

The Chief Executive of MBIE has a general monitoring role under section 169 of the Building Act 2004. This requires territorial authorities to provide MBIE with information about their functions, duties and powers. One of the MBIE regulatory management priorities emphasises improving the operation of the regulatory system by improving how risk is managed in the sector.

Ongoing actions

MBIE will continue to monitor sector performance, identify trends and publish an annual four-year Statement of Intent that includes the Building and Housing policy and regulatory work.

MBIE will continue to communicate its overall Building Code development intentions to the sector through its website, CodeWords (an online newsletter for building practitioners) and email notification of changes to the Building Code, related standards and resources. The structure of the Building Code system is also being reviewed to provide greater clarity of the different supporting documents.

MBIE will communicate the long-term standards investment programme to provide funding for the most important standards required to support the Building Code, with appropriate revision cycles for those standards.

MBIE is working with territorial authorities to establish how other information could be shared in a useful and efficient manner.

Better collaboration and strong technical leadership

Lack of collaboration and central leadership within the sector has resulted in less than optimal outcomes for the design of some complex buildings.

Recommendation 163	A structural Chartered Professional Engineer should be engaged at the same time as the architect for the design of a complex building.
Recommendation 185	The Institution of Professional Engineers New Zealand, the New Zealand Institute of Architects, and the New Zealand Registered Architects Board, supported by the Ministry of Business, Innovation and Employment, should work together to ensure greater collaboration and information sharing between architects and structural engineers.
Recommendation 70	To prevent or limit the amount of secondary damage, engineers and architects should collaborate to minimise the potential distortion applied to non-structural elements. Particular attention must be paid to prevent the failure of non-structural elements blocking egress routes.
Recommendation 53	There should be greater cooperation and dialogue between geotechnical and structural engineers.
Recommendation 169	The role of Chief Engineer should be renamed Chief Structural Engineer to reflect a greater focus on the structure of complex buildings and should be further strengthened and supported with additional capability.
Recommendation 171	The Engineering Advisory Group should continue as an ongoing function to provide expert advice to the Chief Structural Engineer.
Recommendation 172	The Ministry of Business, Innovation and Employment should consult with learned societies, such as the New Zealand Society for Earthquake Engineering, the New Zealand Geotechnical Society and the Structural Engineering Society New Zealand, about the ongoing membership of the Engineering Advisory Group. The membership of the Group should always include senior practising structural engineers.
Recommendation 175	Standards referenced in the Building Code should be available online, free of charge.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE considered renaming the Chief Engineer role to Chief Structural Engineer. However, building work includes other disciplines such as fire, geotechnical and building services, so it was decided the role should remain as Chief Engineer.

Capability has been increased to support the Chief Engineer. This includes establishment of new roles and positions.

> established and filled Engineering Design & Science Manager, Deputy Chief Engineer, and structural and geotechnical engineering roles

The Engineering Advisory Group continues its formal role within MBIE to support the Chief Engineer. Leading structural and geotechnical engineers and researchers participate under the leadership of the Chief Engineer. They meet regularly to provide direction on the MBIE technical work programme, provide advice on trends, quality issues, and research needs. They also review projects and their outputs. The Engineering Advisory Group

membership is continually reviewed to ensure that the people with the most appropriate skills are involved.

- > formalised role of the Engineering Advisory Group within MBIE

MBIE now works in closer collaboration with the three technical societies— Structural Engineering Society New Zealand (SESOC), New Zealand Society for Earthquake Engineering (NZSEE) and New Zealand Geotechnical Society (NZGS). Agreements have been signed with each society to work in partnership on various technical projects to support the Chief Engineer.

- > signed MBIE partnership agreements with SESOC, NZSEE, and NZGS

The three societies, along with the Institute of Architects and IPENZ, also participate in the Engineering and Design Reference Group, established to provide early input into the public policy development process.

- > established Engineering and Design Reference Group

MBIE provided support for the Institution of Professional Engineers, the New Zealand Institute of Architects, and the New Zealand Registered Architects Board to establish a working group to respond to these recommendations in 2013. The architect-engineer working group also included representatives from SESOC and NZSEE.

The working group published a paper and a practice note for architects and engineers in 2014, *Improving Collaboration Between Architects and Engineers*. The document details the need for collaboration and how it can be achieved at various stages in the building design process.

- > sent paper and practice note to all registered architects and engineers in 2014

The working group engaged with university schools of architecture and engineering to encourage development of collaborative design methods in their curricula.

The University of Canterbury has now established a Chair in Architectural Engineering to encourage greater collaboration between architects and engineers.

An ArchEng Workshop programme was started in 2011 by the Cement & Concrete Association of New Zealand. This annual workshop for senior architecture and engineering students from universities throughout New Zealand fosters collaboration by working together on design projects. The 2015 workshop was expanded to include the timber and steel sectors. This will provide a new cohort of architects and engineers with experience collaborating on design projects. In 2016 the ArchEng workshop was run as the ArchEngBuild workshop and included student representatives from architecture, engineering and construction.

- > hold annual ArchEng workshops for senior architecture and engineering students

A Practice Advisory was written by MBIE in 2016 to emphasise that design professionals such as architects and structural engineers need to collaborate early in the design process. A second Practice Advisory addressed the importance of maintaining egress.

- > issued Practice Advisory 15: Improving collaboration in building design

- > issued Practice Advisory 13: Egress stairs

The New Zealand Society for Earthquake Engineering held more than fifty meetings of the Canterbury Technical Forum at the University of Canterbury between 2010 and 2016. The forum promoted better collaboration between the members of that society, the New Zealand Geotechnical Society, the

Structural Engineering Society New Zealand, and the Canterbury Structural Group. Representatives of the local government, civil defence and emergency management, and international communities also attended these meetings. These meetings allowed the engineering community to share technical information gathered during and after the Canterbury Earthquakes and informed the response and recovery process. The meetings provided valuable feedback on the MBIE guidance documents being developed by the Engineering Advisory Group in response to the earthquakes.

> held more than fifty meetings of the Canterbury Technical Forum.

Standards referenced in the Building Code are a critical part of the performance based regulatory system and need to be accessible to all those involved in designing and constructing buildings. The Royal Commission heard that their purchase price is a barrier to their accessibility and use. While the referenced standards were already available for purchase or subscription online, it is unlikely that all standards can be free of charge because overseas and joint standards have copyright fees that need to be paid.

Ongoing actions

MBIE will continue to work with the engineering and architecture professional institutions and licensing authorities, and with university schools of engineering and architecture, to promote collaborative design practice methods in education and professional development programmes.

MBIE is developing a digital search tool to assist in locating resources referenced by the Building Code. This will make it easier for people to search for and identify the standards they require to demonstrate Building Code compliance. The digital search tool is scheduled for release in 2017.

It is intended that the collaborative-partnership model between MBIE and the sector will continue. This enables highly experienced technical experts to work with MBIE to provide best practice guidance to the sector. Agreements with universities and technical societies are renewed annually so that work programmes can be adjusted to suit current needs.

Engineering education and training

The design of complex buildings and buildings with complex foundation conditions require higher structural and geotechnical engineering competence.

Recommendation 180	The universities of Auckland and Canterbury should pursue ways of increasing the structural and geotechnical knowledge of civil engineers entering the profession.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

Undergraduate civil engineering degrees in New Zealand are regularly reviewed by the Institution of Professional Engineers (IPENZ) to ensure they meet the educational requirements of the engineering profession and of the Washington Accord (an international professional engineering qualification recognition agreement). There is general agreement that the content of these degrees is appropriate and effective. Additional knowledge and skills required by Chartered Professional Engineers (CPEngs) in the structural and geotechnical disciplines are best gained through a combination of post-degree training, education, mentoring and work experience.

> decided current post-degree training, education, mentoring, and work experience meet the current requirements of the engineering profession

IPENZ, MBIE, the Structural Engineering Society New Zealand, and the New Zealand Geotechnical Society have been developing a body of knowledge and skills for structural engineers, and another for geotechnical engineers. These outline the knowledge and skills that are expected of Chartered Professional Engineers in these disciplines. These bodies of knowledge and skills will help guide the development of postgraduate qualifications and improve the consistency of CPEng competency assessments.

Ongoing actions

The development of both structural and geotechnical engineering bodies of knowledge are ongoing projects.

Engineering education and training (continued)

Recommendation 179	There should be ongoing provision of post-graduate continuing education for engineers through the provision of block courses, mentoring within engineering firms and courses suitable for those who are working.
Lead Organisation	Institution of Professional Engineers New Zealand (IPENZ)

Response

Actions taken

The universities of Auckland and Canterbury have been collaborating with the engineering profession and MBIE to investigate the development of new postgraduate qualifications in structural and geotechnical engineering practice, to improve the knowledge and skills of at-work engineers.

The Institution of Professional Engineers (IPENZ) develops and delivers a range of continuing professional development courses for engineers. From 1 October 2015 to 30 September 2016, 211 courses were delivered in 15 locations to a total of 2708 engineers. There are also four online courses.

> delivered 211 continuing professional development courses to 2,708 engineers

The range of topics is wide and covers technical engineering aspects, legal aspects and business skills. IPENZ's Technical Groups deliver more in-depth technical presentations for their members.

Through their Professional Development Partner programme, IPENZ recognises and partners with organisations that help their engineers engage with the wider engineering profession, maintain professional values, and obtain support to develop and maintain competencies. IPENZ currently has 45 established Professional Development Partner companies with high interest from others wishing to participate in the programme.

Ongoing actions

The development of the postgraduate qualifications in both structural and geotechnical engineering are ongoing projects.

IPENZ is expanding its continuing professional development course portfolio as needs are identified, and is developing pre-recorded webinars.

IPENZ will continue to recruit Professional Development Partners to ensure more engineering organisations provide professional development for their engineering staff.

Through its Engineering Practice Advisory Committee (EPAC) activity IPENZ develops and issues engineering practice advice to its members. Two relevant areas of activity are the development of a practice note on 'Construction Monitoring' and a review of the existing practice note on 'Peer Review'.

IPENZ has identified, as one of its strategic initiatives, the need to develop and promote an active and effective mentoring programme, to encourage its members to participate in mentoring activities and provide support for them.

Identifying and managing complex buildings

The building consent authority (BCA) process was not able to identify and manage the additional risks associated with the design and alteration of complex buildings.

Recommendation 162	<p>Building consent applications for:</p> <ul style="list-style-type: none"> • buildings in importance levels 3, 4 and 5 in Table 3.2 of AS/NZS 1170.0:2002; • commercial buildings comprising three or more storeys; and • residential buildings comprising three or more storeys with three or more household units <p>should be accompanied by a Structural Design Features Report, which describes the key elements of the design, including the foundations and gravity and lateral load resisting elements.</p>
Recommendation 164	<p>After consideration of the Structural Design Features Report, the building consent authority should decide whether or not the structure should be regarded as complex.</p>
Recommendation 165	<p>The Ministry of Business, Innovation and Employment should develop criteria to be applied in determining whether a structure is complex, in consultation with the Structural Engineering Society New Zealand, the New Zealand Society for Earthquake Engineering, the New Zealand Geotechnical Society and other relevant groups, including building consent authorities. When developed, the criteria should be given regulatory force.</p>
Recommendation 166	<p>If the structure is determined to not be complex, the engineer who provided the Structural Design Features Report should certify the structural integrity of the building's design.</p>
Recommendation 167	<p>If the structure is determined to be complex, a Recognised Structural Engineer should be required to certify the structural integrity of the design.</p>
Recommendation 168	<p>On receipt of the building consent application, the building consent authority should decide:</p> <ol style="list-style-type: none"> a. whether it has the staff with the appropriate competency (qualifications and experience) to process the application in-house (including any decision as to whether the structure is complex and whether any additional peer review certified by a Recognised Structural Engineer should be required); or b. whether it needs to refer the application to another building consent authority that has the staff with the appropriate competency (qualifications and experience) to process the application
Recommendation 181	<p>Legislation should provide for Recognised Structural Engineers to be responsible for the certification of the design of complex buildings as described in Recommendations 162–168.</p>
Lead Organisation	<p>Ministry of Business, Innovation & Employment</p>

Response

Actions taken

The new risk-based consenting process was developed and included in the 2012 amendment to the Building Act 2004. Once this is in force and building work is consented, the building consent authority will only be responsible for ensuring that the quality assurance system has been followed.

> enacted the Building Amendment Act 2012

Past experience has demonstrated that a controlled introduction is required for a change as significant as risk-based consenting. Parts of the process are being piloted in Christchurch to learn about them and develop guidance for the use and introduction of risk-based consenting elsewhere.

> piloted parts of the new risk-based consenting process in Christchurch

MBIE considered introducing Recognised Structural Engineer as a second competency level within the Chartered Professional Engineer credential. This was not supported by Structural Engineering Society New Zealand members and others who preferred to strengthen the registration criteria for Chartered Professional Engineers (which includes education, training, and experience).

> strengthened Chartered Professional Engineer registration criteria

Ongoing actions

Experience with the pilot consenting process in Christchurch will inform the content of the regulations, including the criteria used to develop risk profiles and the nature of the quality assurance system. A second pilot is planned for Hamilton.

MBIE is reviewing the BCA accreditation process and has developed a BCA Competency Framework which can be used to assess BCA staff for different categories of buildings. A mandatory framework is expected to be introduced later in 2017.

Work on the proposed commercial consenting process regulations, the wider review of occupational regulation, and the BCA accreditation review, are closely linked. Further work on developing regulations on commercial consenting under the Building Amendment Act 2012 will commence after the wider occupational regulation review and liability framework is completed.

Section 2.2: Reducing risk from existing buildings

Overview

The Building Act 2004 (the Act) requires territorial authorities to have policies in place that set out how they will perform their roles and responsibilities to address earthquake-prone buildings in their area. These provisions have not been implemented consistently across New Zealand as territorial authorities have had the option to take an active or a passive approach. Inconsistent enforcement of these policies, combined with unacceptably long timeframes for identifying and then strengthening or demolishing earthquake-prone buildings, likely contributed to avoidable injuries and deaths during the 22 February 2011 earthquake.

The Royal Commission recommended a rigorous national system to manage earthquake-prone buildings by addressing the underlying issues that included:

- Earthquake-prone buildings need timely identification and action because people often don't understand, or underestimate, the risks associated with low-probability, high-consequence events and may overlook the likelihood of harm to people in and around buildings during a future earthquake.
- The performance of some building types and building elements during the Canterbury earthquake highlighted the need to incorporate new knowledge into the technical assessment procedures used to assess existing buildings. An important part of updating technical assessment procedures is also ensuring that those people required to use them have appropriate training and experience.
- In many cases, the building industry and the public don't fully understand or appreciate the risk that some buildings pose in earthquakes, the likelihood of an earthquake and what a seismic assessment and its rating mean for a building.
- Timeframes for strengthening earthquake-prone buildings are inconsistent across territorial authorities. Many have passive policies that only require strengthening work to be completed at the same time as other alterations. As a result, very little strengthening work has been carried out in some areas.
- Public safety needs to be improved by strengthening the hazardous elements of earthquake-prone buildings throughout New Zealand, and particularly in unreinforced masonry buildings to provide a higher level of protection from falling hazards such as chimneys, parapets, and ornaments.
- Alterations to some buildings were found to compromise the seismic capacity of the structure or some of the individual building elements in the Canterbury earthquakes.

The Building (Earthquake-prone Buildings) Amendment Act 2016 (the Amendment Act) was enacted in May 2016. When it comes into force, it will

provide a nationally consistent framework to identify and address the risks posed by earthquake-prone buildings. The objective of the new system is to better protect people from harm in an earthquake by identifying and either strengthening or demolishing earthquake-prone buildings within an appropriate timeframe, with consideration for the costs of the work, and the impact on our built heritage.

> passed Building (Earthquake-prone Buildings) Amendment Act 2016

The new system will include several key components, including regulations and a new methodology that sets the requirements for identifying earthquake-prone buildings (the EPB methodology). Additional guidance to support implementation is also being developed. These will all be published when the Act comes into force, which is currently scheduled for July 2017.

Before the Act comes into force, proposals for the new regulations and the methodology to support the new system are being publicly consulted on.

The proposals for regulations include:

- a clear definition of the term ‘ultimate capacity’, to clarify the level of building performance required to help determine whether or not a building is earthquake-prone
- the categories of earthquake ratings for earthquake-prone buildings
- the form of notice that owners of earthquake-prone buildings will be required to display
- the criteria for substantial alterations for other purposes that will require seismic work to be carried out at the same time
- the criteria that buildings must meet to be considered for exemption from the requirement to undertake strengthening work.

The discussion document containing these proposals for regulations was released in September 2016 and a public consultation process closes in February 2017.

> published discussion document: *Proposals for Regulations under the Building (Earthquake-prone Buildings) Amendment Act 2016*

The proposals for the EPB methodology broadly include:

- how potentially earthquake-prone buildings will be identified by territorial authorities
- how engineering assessments of potentially earthquake-prone buildings will be carried out
- how territorial authorities are to determine whether or not a potentially earthquake-prone building is earthquake-prone and, if it is, its earthquake rating.

A discussion document containing the proposals for the EPB methodology was released in September 2016, at the same time as the proposed regulations. Its public consultation process also closes in February 2017.

> published discussion document: *Proposals for a methodology to identify earthquake-prone buildings*

An essential part of identifying and managing earthquake-prone buildings is the use of engineering assessments. *The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments* (the Engineering Assessment Guidelines) provide the technical framework and methods for engineers to use when assessing buildings. The EPB methodology that forms part of the consultation includes proposals requiring the use of the Engineering Assessment Guidelines when assessing buildings under the new earthquake-prone buildings provisions.

A draft version of the Engineering Assessment Guidelines was published in June 2016. A more advanced draft was released during the consultation period. This will be revised to incorporate technical feedback from the engineering profession and released formally when the Amendment Act comes into force.

> published draft document: *The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments*

MBIE will be assisting territorial authorities, building owners and engineers through the transition to the new system. This will include developing additional guidance and a training programme in various locations nationwide.

Requiring buildings to be assessed

Earthquake-prone buildings need timely identification and action because people often don't understand, or underestimate, the risks associated with low-probability, high-consequence events and may overlook the likelihood of harm to people in and around buildings during a future earthquake.

Recommendation 82	The Building Act 2004 should be amended to require and authorise territorial authorities to ensure completed assessments of all unreinforced masonry buildings within their districts within two years from enactment of the Amendment, and of all other potentially earthquake-prone buildings within five years from enactment.
Recommendation 91	The Building Act 2004 should be amended to make it clear that sections 122 and 124 of the Act apply to parts of a building. <i>Note: Section 122: Meaning of earthquake-prone building</i> <i>Note: Section 124: Dangerous, affected, earthquake-prone, or insanitary buildings: powers of territorial authority</i>
Recommendation 93	The proposed amendments to sections 124 and 125 of the Building Act 2004 in the Building Amendment Bill (No. 4) should be enacted. <i>Note: Section 125: Requirements for notice requiring building work or restricting entry</i>
Recommendation 101	Territorial authorities should be required to maintain and publish a schedule of earthquake-prone buildings in their districts.
Recommendation 95	Legislation should provide for: <ul style="list-style-type: none"> a. a duty to disclose information that a building is in a dangerous or potentially dangerous condition to the relevant territorial authority and any affected neighbouring occupier; b. the above duty to be applied to statutory bodies, engineers and other professional persons who have become aware of the information; c. a similar duty on building owners in respect of their own tenants and neighbouring occupiers; and d. the protection of those carrying out these duties in good faith from civil or other liability or allegations of professional misconduct.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The Building (Earthquake-prone Buildings) Amendment Act 2016 (the Amendment Act):

- provides central leadership and direction for managing earthquake-prone buildings
- provides enforcement powers for territorial authorities
- revises the definition of an earthquake-prone building and clarifies that this applies to parts of buildings
- categorises New Zealand into three seismic risk areas (high, medium and low) with corresponding timeframes within which earthquake-prone buildings must be identified and remediated (strengthened or demolished) in these areas
- provides nationally consistent timeframes for owners of potentially earthquake-prone buildings to obtain engineering assessments

- provides for a new methodology (the EPB methodology) that will set out requirements for identifying potentially earthquake-prone buildings, engineering assessments, determining whether or not a building is earthquake-prone and, if it is, assigning its earthquake rating
- prioritises certain earthquake-prone buildings in high and medium seismic risk areas, including education buildings, emergency service facilities, certain hospitals and buildings on strategic routes, as well as highly vulnerable elements of unreinforced masonry buildings that could fall on busy thoroughfares
- introduces a rating system for earthquake-prone buildings, required to be displayed on earthquake-prone building notices and the national earthquake-prone building register
- requires owners of earthquake-prone buildings to display earthquake-prone building notices
- provides for a publicly accessible national register of earthquake-prone buildings
- excludes certain buildings from the system where applying the provisions would be impractical or excessive or both, such as farm buildings, stand-alone retaining walls, fences, some monuments, bridges and tunnels. Most residential buildings will continue to be excluded, as under the current system
- encourages earlier remediation through a requirement to strengthen earthquake-prone buildings when substantial alterations are planned
- provides for an opt-in extension of time of up to 10 years to remediate certain heritage buildings
- enables owners of certain earthquake-prone buildings to apply to their territorial authority for an exemption from strengthening requirements where the consequences are considered very low.

> passed *Building (Earthquake-prone Buildings) Amendment Act 2016*

In relation to Recommendation 95, professional engineers who are either Chartered Professional Engineers or members of the Institution of Professional Engineers New Zealand (IPENZ) are now required to report engineering matters that could have adverse consequences under the revised *Code of Ethical Conduct* that came into effect 1 July 2016.

> published a revised *code of ethical conduct* for Chartered Professional Engineers and IPENZ members

Ongoing actions

Proposals for regulations and a methodology to identify earthquake-prone buildings under the Amendment Act are now being publicly consulted on. The new system is currently scheduled to come into force in July 2017.

Additional training is planned and guidance is under development to support territorial authorities, building owners and engineers in implementing the requirements of the new system.

Requiring buildings to be assessed (continued)

Recommendation 94	Section 32(4) of the Earthquake Commission Act 1993 should be amended to allow for disclosure of information that may affect personal safety. A suggested wording is set out in section 4.25.4.3 of this Volume. <i>Note: the Volume referred to in the previous sentence is Volume 4 of the Royal Commission Final Report.</i>
Lead Organisation	The Treasury

Response

Actions taken	The Earthquake Commission has implemented protocols and procedures to notify territorial authorities if staff or contractors become aware of a serious safety hazard in the course of their work for the Commission. <ul style="list-style-type: none">> implemented protocols and procedures for notifying territorial authorities about serious safety hazards
Ongoing actions	The government is conducting a legislative review of the Earthquake Commission Act 1993.

Seismic Assessment of Existing Buildings

The performance of some building types and building elements during the Canterbury earthquake highlighted the need to incorporate new knowledge into the technical assessment procedures used to assess existing buildings. An important part of updating technical assessment procedures is also ensuring that those people required to use them have appropriate training and experience.

Recommendation 72

The Ministry of Business, Innovation and Employment should work with territorial authorities, building owners, the New Zealand Society of Earthquake Engineering and other interested parties to develop a grading system for existing buildings that is able to be understood by the general public and adequately describes the seismic performance of a building.

Recommendation 73

The Ministry of Business, Innovation and Employment should review the New Zealand Society of Earthquake Engineering Recommendations entitled *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes* and, in conjunction with engineering practitioners, establish appropriate practice standards or methods for evaluating existing buildings. These practice standards or methods should have regulatory standing, and be monitored by the Ministry of Business, Innovation and Employment for consistency of application.

Recommendation 109

In the assessment of buildings for their potential seismic performance:

- the individual structural elements should be examined to see if they have capacity to resist seismic and gravity load actions in an acceptably ductile manner;
- relatively simple methods of analysis such as the equivalent static method and/or pushover analyses may be used to identify load paths through the structure and the individual structural elements for first mode type actions. The significance of local load paths associated with higher mode actions should be considered. These actions are important for the stability of parts and portions of structures and for the connection of floors to the lateral force resisting elements;
- the load path assessment should be carried out to identify the load paths through the different structural elements and zones where strains may be concentrated, or where a load path depends on non-ductile material characteristics, such as the tensile strength of concrete or a fillet weld where the weld is the weak element;
- while the initial lateral strength of a building may be acceptable, critical non-ductile weak links in load paths may result in rapid degradation in strength during an earthquake. It is essential to identify these characteristics and allow for this degradation in assessing potential seismic performance. The ability of a building to deform in a ductile mode and sustain its lateral strength is more important than its initial lateral strength; and
- sophisticated analyses such as inelastic time history analyses may be carried out to further assess potential seismic performance. However, in interpreting the results of such an analysis, it is essential to allow for the approximations inherent in the analytical models of members and interactions between structural members, such as elongation, that are not analytically modelled.

Recommendation 60

Training or guidance should be provided so that structural engineers are aware of the following issues when assessing existing buildings:

- a. In a number of reinforced concrete buildings designed using Standards published prior to 1995, the columns that were provided primarily to support gravity loading had inadequate confinement reinforcement to enable them to sustain the inter-storey drifts associated with the ultimate limit state. There are a number of reasons for this:
 - first, it was not until 1995 that a requirement was introduced for all columns to have confinement reinforcement;
 - second, design inter-storey drifts calculated using Standards in use prior to 1995 gave smaller inter-storey drifts than the corresponding values found using current Standards. The difference arises from the use of stiffer section properties, the lack of a requirement for drifts associated with P-delta actions to be included, and the practice of taking the design inter-storey drift as 50 per cent of the peak value (${}^2/S_M$) while the ductility was calculated on the basis of (${}^4/S_M$).
- b. There are a number of structural weaknesses in existing buildings due to aspects of design not being adequately considered in earlier design Standards. The report by MacRae et al identifies many of these aspects.
- c. In assessing the potential seismic performance, particular attention should be paid to ensuring that seismic gaps for isolating stairs or separating buildings, or parts of buildings, have been kept clear.

Recommendation 74

Structural engineers assessing non-URM buildings should be familiar with the practical assessment considerations discussed in section 6.2.5 of this Volume. Those considerations should also be referred to in the practice standards or methods developed in accordance with Recommendation 73.

Recommendation 110

Arising from our study of the CTV building, it is important that the following, in particular, should be examined:

- the beam-column joint details and the connection of beams to structural walls;
- the connection between floors acting as diaphragms and lateral force resisting elements; and
- the level of confinement of columns to ensure they have adequate ductility to sustain the maximum inter-storey drifts that may be induced in a major earthquake.

Recommendation 80

The detailed assessment of unreinforced masonry buildings that are earthquake-prone should take into account the potential need to:

- a. ensure adequate connection between all structural elements of the building so that it responds as a cohesive unit;
- b. increase the in-plane shear strength of masonry walls; or
- c. introduce high-level interventions (such as the insertion of steel and/or reinforced concrete frames) to supplement or take over the seismic resisting role from the original unreinforced masonry structure.

Such buildings should be strengthened in accordance with the findings of that detailed assessment.

Recommendation 106	Territorial authorities and subject matter experts should share information and research on the assessment of, and seismic retrofit techniques for, different building types.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

Engineering assessments are an essential part of the system for identifying and managing earthquake-prone buildings.

The technical assessment guidelines document used by engineers, *Assessment and Improvement of Structural Performance of Buildings in Earthquakes*, has been superseded.

An updated document, *The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments* (the Engineering Assessment Guidelines), is being written and progressively released to the sector. This expanded document includes new knowledge and research in earthquake engineering assessment methods. It also provides a reporting framework for the presentation of assessments.

The new Engineering Assessment Guidelines document provides engineers with the framework and technical methods to use when undertaking engineering assessments of existing buildings. This will enable engineers to use the most current assessment methods and increase the consistency of their assessments.

The updated document has been a collaborative effort by the New Zealand Society for Earthquake Engineering (NZSEE), Structural Engineering Society New Zealand (SESOC), the New Zealand Geotechnical Society (NZGS), the Ministry of Business, Innovation and Employment (MBIE) and the Earthquake Commission (EQC).

The Building (Earthquake-prone Buildings) Amendment Act 2016 (the Amendment Act) was enacted in May 2016. Under the Amendment Act, proposals for a new methodology to identify earthquake-prone buildings (the EPB methodology) are currently under public consultation. To enhance the consistency of assessments, it is proposed that the new EPB methodology will require the Engineering Assessment Guidelines to be used when assessing buildings.

The Engineering Assessment Guidelines were released as a draft version in June 2016, with sections on analysis methods, geotechnical considerations, and specific considerations for buildings made from various materials. The document has three parts:

- Part A: Assessment Objectives and Principles
- Part B: Initial Seismic Assessment
- Part C: Detailed Seismic Assessment.

Training was delivered for engineers on Part B in 2014, and on some of Part C in 2015, using the new knowledge and research available at the time.

Ongoing actions

Feedback on the Engineering Assessment Guidelines from the engineering profession is currently being collated and will be incorporated, as appropriate, in any further revisions. A second draft was issued during the consultation period on the proposals for regulations and the EPB methodology under the Amendment Act. The final document will be published when the Amendment Act comes into force, which is currently scheduled for July 2017.

A further training programme has been developed for engineers, and training seminars will be run in various regional locations covering the key sections of the Engineering Assessment Guidelines.

Communicating earthquake risks

In many cases, the building industry and the public don't fully understand or appreciate the risk that some buildings pose in earthquakes, the likelihood of an earthquake and what a seismic assessment and its rating mean for a building.

Recommendation 76	The Ministry of Business, Innovation and Employment should clearly describe to territorial authorities and the public the difference between the expected behaviour of an existing building prior to collapse, and the behaviour of a building that complies with the current Building Code.
Recommendation 102	The Ministry of Business, Innovation and Employment should review the best ways to make information about the risk buildings pose in earthquakes available to the public and should undertake appropriate educational activities to develop public understanding about such buildings.
Recommendation 103	The engineering and scientific communities should do more to communicate to the public the risk buildings pose in earthquakes, what an assessment of building strength means, and the likelihood of an earthquake.
Recommendation 104	Industry participants, such as insurers, valuers, and property managers, should ensure that they are aware of earthquake risks and the requirements for earthquake-prone buildings in undertaking their roles, and in their advice to building owners.
Recommendation 105	The Ministry of Business, Innovation and Employment should support industry participants' awareness of earthquake risks and the requirements for earthquake-prone buildings through provision of information and education.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

Technical professionals have increased their communication with the public to explain the earthquake risks of existing buildings. Media coverage, the main form of communication to the public about earthquakes, has increased since the Canterbury earthquake and now commonly encourages discussions on earthquake-related matters from a wider range of people.

An example of public engagement was a consultation document and series of public meetings in 2013.

> held consultation on *Building Seismic Performance: Proposals to Improve the New Zealand Earthquake-prone Building System*

This public engagement significantly influenced the content of the Building (Earthquake-prone Buildings) Amendment Act 2016.

> passed *Building (Earthquake-prone Buildings) Amendment Act 2016*

MBIE presented an overview of the new system in June 2016, outlining the key changes and the structure and components of the new system, including some of the proposals for identifying and managing earthquake-prone buildings.

> held briefings on the new earthquake-prone buildings regime

Public consultation on proposals for regulations and a methodology to identify earthquake-prone buildings (the EPB methodology) under the Amendment Act is underway.

- > released discussion document: *Proposals for Regulations under the Building (Earthquake-prone Buildings) Amendment Act 2016*
- > released discussion document: *Proposals for a methodology to identify earthquake-prone buildings*

MBIE, BRANZ, and EQC held a Built Environment Leaders Forum in September 2015. This brought together public and private sector decision makers, including property owner and insurer representatives, to reflect on the lessons from the Canterbury earthquakes and to develop recommendations for actions to achieve a more resilient built environment for New Zealand. The forum included discussions on the new earthquake-prone buildings regime, particularly for private sector building owners.

- > held Built Environment Leaders Forum in 2015

The key outputs from the Forum are contributing to the following strategy processes—

- the Wellington and Christchurch City Resilience Strategies (Rockefeller 100 Resilient Cities Programme)
- the Department of Prime Minister and Cabinet’s Canterbury Learning and Legacy Programme
- the Ministry of Civil Defence and Emergency Management’s National Disaster Resilience Strategy.

Ongoing actions

The components that make up the new system under the Amendment Act, including the regulations and the EPB methodology, are under consultation. Additional supporting guidance and regulations needed for the new Earthquake-prone Buildings system are being developed. Submissions will be considered and, as appropriate, incorporated into the final system, scheduled to come into force in July 2017.

Guidance, education, and training will be provided for different audiences, such as engineers and territorial authorities, as the new system is developed and implemented. It is important that these groups understand their roles in the new system, and are adequately resourced and trained to undertake these roles, as well as being able to answer questions from the public and building owners.

When it comes into force, the Amendment Act will require owners of earthquake-prone buildings to display the earthquake-prone building notice of their building’s earthquake rating. This disclosure of information will provide information about the risk of specific buildings and allow prospective building users to make informed decisions about building use. Proposals for the earthquake ratings system and the form of notices are being publicly consulted on.

Earthquake-prone buildings will also be listed on a public register being developed by MBIE.

Recommendations from the Built Environment Leaders Forum 2015 are being progressively implemented through strategic initiatives across New Zealand.

Requiring earthquake-prone buildings to be strengthened or demolished

Timeframes for strengthening earthquake-prone buildings are inconsistent across territorial authorities. Many have passive policies that only require strengthening work to be completed at the same time as other alterations. As a result, very little strengthening work has been carried out in some areas.

Recommendation 96	Legislation should ensure that all portions of a structure are included in the requirement to strengthen buildings to achieve the minimum level required by the legislation by the due date. In drafting the legislation, consideration should be given to providing for a fair process in which all owners of a building divided into separate titles may be required to strengthen the building at the same time.
Recommendation 85	The legislation should provide for the enforcement of the upgrading requirements by territorial authorities, with demolition (at owner's cost) being the consequence of failure to comply.
Recommendation 83	The legislation should be further amended to require unreinforced masonry buildings to be strengthened to 34% ULS within seven years from enactment of the Amendment and, in the case of all other buildings that are earthquake-prone, within 15 years of enactment.
Recommendation 84	The legislation should be further amended to require that, in the case of unreinforced masonry buildings, the out-of-plane resistance of chimneys, parapets, ornaments and external walls to lateral forces shall be strengthened to be equal to or greater than 50% ULS within seven years of enactment.
Recommendation 86	The legislation should allow territorial authorities to adopt and enforce a policy that requires a shortened timeframe for some or all buildings in the district to achieve the minimum standard required by the legislation, after following the special consultative procedures in the Local Government Act 2002.
Recommendation 81	Recommendations 75 to 80 should be undertaken within the same timeframes as recommended in Recommendations 82 to 86 for unreinforced masonry buildings
Recommendation 87	The legislation should allow territorial authorities to adopt and enforce a policy that requires a higher standard than the minimum ULS required by the legislation for some or all buildings in the district, after following the special consultative procedures in the Local Government Act 2002.
Recommendation 88	The legislation should allow territorial authorities to adopt and enforce a policy that requires a higher standard of strengthening for buildings of high importance or high occupancy, where public funding is to be contributed to the strengthening of the building or where the hazard to public safety is such that a higher standard is justified, after following the special consultative procedures in the Local Government Act 2002.
Recommendation 89	Guidance should be provided by the Ministry of Business, Innovation and Employment to territorial authorities on the factors to be considered in setting discretionary policies under the amended legislation. These factors should include the nature of a community's building stock, economic impact, numbers of passers-by for some buildings, levels of occupancy, and potential impact on key infrastructure in a time of disaster (e.g. fallen masonry blocking key access roads).

Recommendation 90	The legislation should exempt buildings that are very seldom used and are so located that their failure in an earthquake is most unlikely to cause loss of life, or serious injury to passers-by.
Recommendation 98	Section 112(1) of the Building Act 2004 should be amended to enable building consent authorities to issue building consents for strengthening works without requiring compliance with section 112(1)(a)(ii). The existing provision would continue to apply to building consents for other purposes.
Recommendation 99	The Building Act 2004 should be amended to authorise territorial authorities to adopt and enforce policies to address hazardous elements in or on residential buildings (such as URM chimneys), within a specified completion timeframe consistent with that applied to non-URM earthquake-prone buildings in their district.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The Royal Commission identified a need to set timeframe requirements for strengthening and better guidance on the level of strengthening required, so that the economic and social needs of communities can be balanced with the risk to life posed by earthquake-prone buildings.

The Building (Earthquake-prone Buildings) Amendment Act 2016 (the Amendment Act):

- provides central leadership and direction for managing earthquake-prone buildings
- provides enforcement powers for territorial authorities
- revises the definition of an earthquake-prone building and clarifies that this applied to parts of buildings
- categorises New Zealand into three seismic risk areas (high, medium, and low) with corresponding timeframes within which earthquake-prone buildings must be identified and remediated (strengthened or demolished) in these areas
- provides nationally consistent timeframes for owners of potentially earthquake-prone buildings to obtain engineering assessments
- provides for a new methodology (the EPB methodology) that will set out requirements for identifying potentially earthquake-prone buildings, engineering assessments, determining whether or not a building is earthquake-prone, and if it is, assigning its earthquake rating
- prioritises certain earthquake-prone buildings in high and medium seismic risk areas, including education buildings, emergency service facilities, certain hospitals and buildings on strategic routes, as well as highly vulnerable elements of unreinforced masonry buildings that could fall on busy thoroughfares
- introduces a rating system for earthquake-prone buildings, required to be displayed on earthquake-prone building notices and the national earthquake-prone building register
- requires owners of earthquake-prone buildings to display earthquake-prone building notices
- provides for a publicly accessible national register of earthquake-prone buildings
- excludes certain buildings from the system where applying the provisions would be impractical or excessive or both, such as farm

buildings, stand-alone retaining walls, fences, some monuments, bridges and tunnels. Most residential buildings will continue to be excluded, as under the current system

- encourages earlier remediation through a requirement to strengthen earthquake-prone buildings when substantial alterations are planned
- provides for an opt-in extension of time of up to 10 years to remediate certain heritage buildings
- enables owners of certain earthquake-prone buildings to apply to their TA for an exemption from strengthening requirements where the consequences are considered very low.

> passed *Building (Earthquake-prone Buildings) Amendment Act 2016*

Consultation on proposals for regulations and a methodology to identify earthquake-prone buildings (the EPB methodology) under the Amendment Act is underway.

> released discussion document: *Proposals for Regulations under the Building (Earthquake-prone Buildings) Amendment Act 2016*

> released discussion document: *Proposals for a methodology to identify earthquake-prone buildings*

The government consulted the public on whether all residential buildings should be included before the Amendment Act was introduced into Parliament. After reviewing submissions, the government decided most residential buildings should be managed via guidance, information, and education rather than by regulatory change.

Ongoing actions

The Amendment Act is currently scheduled to come into force in July 2017. Additional training is planned and guidance is under development to support territorial authorities, building owners, and engineers in implementing the requirements of the new system.

Reducing hazard within earthquake-prone buildings

Public safety needs to be improved by strengthening the hazardous elements of earthquake-prone buildings throughout New Zealand, and particularly in unreinforced masonry buildings to provide a higher level of protection from falling hazards such as chimneys, parapets, and ornaments.

Recommendation 61	Where mesh has been used to transfer diaphragm forces that are critical for the stability of a building in a major earthquake, retrofit should be undertaken to ensure there is adequate ductility to sustain the load path.
Recommendation 71	Free-standing masonry walls of unknown structural strength should be adequately restrained or demolished.
Recommendation 75	Further research should be carried out into the suitability of assuming 15 per cent damping, and a structural ductility factor of 2 and an S_p factor of 0.7, in assessing unreinforced masonry elements.
Recommendation 77	For unreinforced masonry buildings, falling hazards such as chimneys, parapets and ornaments should be made secure or removed.
Recommendation 78	The design actions for the elements and connections to be strengthened should be based on the provisions in NZS 1170.5:2004: Section 8 – <i>Requirements for Parts and Components</i> .
Recommendation 79	The external walls of all unreinforced masonry buildings should be supported by retrofit, including in areas of low seismicity.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The methods for assessing the building elements specified in these recommendations in existing buildings are now included in the fully updated technical guidance for engineers, *The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments* (the Engineering Assessment Guidelines), which was released as a draft in June 2016.

Research relating to Recommendation 75 has been carried out at the University of Auckland, and the results have been incorporated into section C8 (unreinforced masonry) of the Engineering Assessment Guidelines:

- > published draft document *The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments*

If a part of a building is to be found earthquake-prone, the Building (Earthquake-prone Buildings) Amendment Act 2016 requires these parts to be strengthened or removed so that the part and the building as a whole is no longer earthquake-prone:

- > passed *Building (Earthquake-prone Buildings) Amendment Act 2016*

Recommendation 78 resulted in an amendment to NZS 1170.5, which informs the design of some elements and connections in new buildings.

- > issued amendment to NZS 1170.5

Ongoing actions

Feedback on the Engineering Assessment Guidelines from the engineering profession is currently being collated and will be incorporated, as appropriate, in any further revisions. A second draft was issued during the consultation period on the proposals for regulations and the EPB methodology under the Amendment Act. The final document will be published when the Amendment Act comes into force, which is currently scheduled for July 2017.

Guidance on retrofit solutions is being developed to reduce the risk identified by the assessment process.

Avoiding increased risk during building alterations

Alterations to some buildings were found to compromise the seismic capacity of the structure or some of the individual building elements in the Canterbury earthquakes.

Recommendation 107	Where holes are required to be drilled in concrete, critical reinforcing should be avoided. If it cannot be avoided, then specific mention should be made on the drawings and specifications of the process to be followed if steel is encountered, and inspection by the engineer at this critical stage should be required.
Recommendation 97	Territorial authorities should be authorised and required to ensure the acceptable strength of remaining walls, particularly end walls, when issuing building consents for the removal of adjoining walls.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

In 2013, the Cement and Concrete Association NZ (CCANZ) published an Information Bulletin (IB No. 95) with guidance for concrete cutters on drilling, cutting, or forming holes in suspended concrete floor slabs. The bulletin emphasises that drilling in the wrong place or through reinforcing steel can seriously affect the strength of the structural element, the fire rating, and the acoustic and durability performance of a floor. The bulletin also encourages contractors to seek specialist structural engineering advice before cutting beams, columns and walls.

> published CCANZ Information Bulletin (IB No. 95)

Six CCANZ concrete construction seminars, supported by MBIE, were held throughout New Zealand between 2014 and 2016. These emphasised the need for contractors to seek specialist structural engineering advice before cutting.

> held concrete construction seminar series

Building consent authorities, prior to issuing building consents on proposals to remove or alter walls, will check that the overall performance and strength of the building is not worse than it was prior to their removal, in accordance with section 112 (Alterations to existing buildings) of the Building Act 2004 (the Act). This action is in response to Recommendation 97.

Ongoing actions

The concrete construction seminar series delivered nationally to concrete contractors two or three times each year will continue.

Work is underway to determine how section 112 of the Act is applied across the various building consent authorities. If inconsistent interpretations are identified, it is likely that additional guidance will be developed for designers, owners, and building consent authorities to illustrate how removing walls will compromise the code compliance of the remaining walls and therefore the building.

Section 2.3: Improving new building design

Overview

The building design profession has always sought to learn from failure in order to minimise the possibility the same conditions will lead to another failure. Buildings are almost always unique, so there is no simple production line process to test their performance and either fix or remove sub-standard products before they are put into service. Only the design process can be improved.

Societal expectations for the structure supporting a building are defined by the New Zealand Building Code. This provides objectives of safeguarding people from injury and protecting other property from physical damage caused by structural failure. Unfortunately, structural performance can only be assessed when a building is exposed to the extreme conditions it is designed to survive. These conditions are infrequent and building failures are rare, so there are few opportunities to learn from failures and improve the design process.

The design process for a new building is complex, with a number of professional groups working collaboratively to deliver the building owner's functional and aesthetic requirements. It is more complex for multi-storey buildings and even more complex when the site, its function, or the aesthetic requirements require the structure to be asymmetric or irregular.

The Building Code performance requirements are expected to be fulfilled when the building is designed using methods set out in a suite of structural design actions standards and the material standard for the specific type of construction. The most important standards for the seismic design of larger building structures are:

- Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004)
- Concrete structures (NZS 3101.1&2:2006)
- Steel structures (NZS 3404 Parts 1&2:1997)

The design of the foundations for a building requires knowledge of the sub-soils and geology beneath the proposed building and its surroundings. Different ground conditions will markedly influence the way the building will perform during an earthquake. While the geotechnical investigation process is well established, the Canterbury earthquakes illustrated that more investigation guidance and a better understanding of subsurface conditions are needed for each particular site to improve building design.

Moreover, with the variable nature of soils, there is a clear need for better guidance on the selection of appropriate foundation systems and their design.

The design methods for new buildings are based on the concept of 'capacity design', which permits controlled building damage in extreme events but does not lead to collapse. With some notable and tragic exceptions, most modern buildings performed as anticipated in the Canterbury earthquakes.

However, there was extensive damage observed in many structural and non-structural systems, which has been attributed to many factors.

The Royal Commission's recommendations particularly addressed the design of complex buildings, including:

- Inappropriate assumptions or judgements were sometimes made during the complex design process required to engineer the buildings' structural system.
- Poor design and/or construction practices led to significant damage within secondary and non-structural elements such as stairs, ceilings, and building services (air conditioning, plumbing, and lighting).

They addressed unexpected forms of damage observed in reinforced concrete buildings, including:

- Some reinforced concrete buildings had structural parts that did not perform as expected, and some damage was different from that predicted by laboratory testing. There is an inadequate understanding of the complex nature of regularity, torsion, ratcheting, and diaphragms that need further research and better guidance for designers.
- Some buildings with reinforced concrete walls had unexpected failure modes, demonstrating a need for additional research and guidance for designers.
- Many reinforced concrete elements elongate during an earthquake, and have a significant effect on other structural elements, which is not fully accounted for in building design.
- Some of the construction details used for reinforced concrete elements need minor changes to improve their performance during earthquakes.

They addressed issues with geotechnical investigations and liquefaction, including:

- Inadequate geotechnical investigations at some building sites and inadequate understanding of the geology resulted in poor foundation performance and subsequent damage to the building.
- There was limited appreciation of the impacts of widespread liquefaction. Land-use planning decisions have not always taken into account liquefaction hazards. Foundations were not always appropriately designed to take into account liquefaction vulnerability, resulting in variable building performance.

They addressed issues with the design of foundations, including:

- Unanticipated building settlement and structural damage occurred at serviceability limit state (SLS) loading because some designers had a poor understanding of how soil types and foundations respond to earthquakes.
- Prior to the Canterbury earthquakes, geotechnical professionals had limited New Zealand-specific guidance on ground improvement methods that could be used to mitigate liquefaction risk.
- There is a lack of understanding of how shallow foundations perform and improved design criteria are needed.
- There is a lack of understanding of how deep foundations perform and improved design criteria are needed.

And, they addressed factors that influence more than just the design and performance of an individual building including:

- There is inherent uncertainty in the prediction of the location, magnitude, and timing of the earthquakes. Ongoing investment into the locations of faults and anticipated ground motions will benefit the design of foundations and buildings.
- Promising, low-damage building technologies were seldom used due to limited development and guidance for building owners, designers, building consent authorities, and the public.

The most effective method of improving building performance is to improve the design standards and guidance. This often requires research to understand what influences the performance and develop amendments. Once published, journal articles, seminars, and conferences are used to explain the significance of the amendments and how they should be applied in practice. This process requires a considerable amount of work and collaboration across sectors.

With the lack of existing standards for foundation design, MBIE and the New Zealand Geotechnical Society (NZGS) are developing a series of earthquake geotechnical engineering guidelines. These explain current practice in earthquake geotechnical engineering, seek to improve engineering practice and improve the seismic performance of buildings and infrastructure. They are being published in a series of modules. *Module 1 Overview, Module 2 Geotechnical Investigations, Module 3 Liquefaction, Module 4 Foundation design and Module 5a Specifications for Ground Improvement* have been published. Others are being developed.

The Canterbury Geotechnical Database (CGD) successfully increased access to geotechnical data during the rebuild in Canterbury, and in 2016 was extended into a national database for geotechnical site investigation information for engineers and territorial authorities.

Building design assumptions

Inappropriate assumptions or judgements were sometimes made during the complex design process required to engineer the buildings' structural system.

Note: The standard referred to in recommendation 38 below is Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004)

Recommendation 54	Designers should define load paths to ensure that the details have sufficient strength and ductility to enable them to perform as required.
Recommendation 55	Structural engineers should assess the validity of basic assumptions made in their analyses.
Recommendation 38	Explanation should be added to the commentary to the Standard to explain: <ul style="list-style-type: none">• the difference between design inter-storey, and peak inter-storey drifts; and• the influence of ductile behaviour on the shape profile of a multi-storey building
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE published Practice Advisory 16 to encourage designers to test and verify assumptions made during the design process. It also encourages designers to confirm that load paths are complete, to avoid complex or unreliable load paths.

> published *Practice Advisory 16: Quality assurance in design and construction*

MBIE has published Practice Advisory 15 to explain the importance of collaboration and communication during the design process.

> published *Practice Advisory 15: Improving collaboration in building design*

An amendment clarifying the difference between design inter-storey and peak inter-storey drifts was proposed for the commentary of the standard Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004). However, the implications of the proposed amendment needed wider agreement so was not included in the 2016 revision.

An amendment to the commentary for NZS 1170.5:2004 provides additional explanation about how ductile deformations influence the inter-storey drift and the most extreme deflected shape profile that a multi-storey building could have during an earthquake.

> added additional explanation of shape profiles to NZS 1170.5:2004 commentary

Ongoing actions

The Structural Engineering Society New Zealand is promoting the use of Design Features Reports. These reports provide a summary of the important assumptions within the building design documents that they are intended to accompany. The reports include explanations of load paths. (Note: MBIE has published guidance on the use of Certificates of Work, Producer Statements, and Design Features Reports related to residential construction.)

The Building Act 2004 requires MBIE to monitor sector performance and identify trends. It will continue to do this by working with specialised sector bodies such as the Institution of Professional Engineers New Zealand, New Zealand Institute of Architects, and the New Zealand Construction Industry Council and make changes as necessary to provide a 'fit for purpose system'.

Building design assumptions (continued)

Note: The standard referred to in the recommendation below is the Steel structures Standard (NZS 3404 Parts 1&2:1997)

Recommendation 52	The Standard should be amended to require a level of redundancy to be built into structures where eccentrically braced frames are used to provide seismic resistance.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The New Zealand Heavy Engineering Research Association (HERA) design guidance used for the seismic design of steel structures (first published in 1995) was revised. The new HERA design guide published in 2013 provides updated guidance and seismic design procedures for eccentrically braced frames (EBFs). This includes provisions to build redundancy into buildings with these frames, which require all columns in the structure to be detailed so they can provide alternative load paths.

> published HERA design guide *P4001 - Seismic design of eccentrically braced frames*

MBIE held a scoping meeting with the NZS 3404 committee members in 2013, during which it was decided to improve redundancy by requiring columns to have sufficient strength and stiffness, and to provide alternative load paths.

A design standard for composite steel and reinforced concrete structures is under public consultation. This includes provisions for seismic design of composite structures, including those with EBFs.

> consultation on AS/NZS 2327 Composite structures

Ongoing actions

MBIE is scheduled to commission Standards New Zealand to amend NZS 3404.

Design and construction of secondary and non-structural elements

Poor design and/or construction practices led to significant damage within secondary and non-structural elements such as stairs, ceilings, and building services (air conditioning, plumbing, and lighting).

Note: The standard referred to in recommendation 39 below is Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004)

Recommendation 39	The Standard should be amended to require that the supports of stairs and access ramps be designed to be capable of sustaining 1.5 times the peak inter-storey drift associated with the ultimate limit state, together with an appropriate allowance for construction tolerance and any potential elongation effects.
Recommendation 62	Critical elements such as stairs, ramps and egress routes from buildings should be designed to sustain the peak for inter-storey drifts equal to 1.5 times the inter-storey drift in the ultimate limit state. In calculating this inter-storey drift, appropriate allowance should be made for elongation in plastic hinges or rocking joints with an appropriate allowance for construction tolerance. NZS 1170.5:2004 and the relevant materials Standards should be modified to provide for this requirement.
Recommendation 63	The principles of protecting life beyond ultimate limit state design should be applied to all elements of a building that may be a risk to life if they fail in an earthquake.
Recommendation 65	Building elements considered to pose a life-safety issue if they fail should only be installed by a suitably qualified and experienced person, or under the supervision of such a person. The Department of Building and Housing should give consideration to the necessary regulatory framework for this.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

With designers needing a better understanding of the restraint, separation, and movement of these elements during an earthquake, MBIE issued a Practice Advisory in 2011. This recommends that designers increase the clearance and seating for stairs so they can sustain twice the potential inter-storey displacement that is calculated in accordance with NZS 1170.5:2004. This includes increased movement clearances and seating provisions for stair landings to reduce the possibility of stairs collapsing.

> published *Practice Advisory 13: Egress stairs*

Two further Practice Advisories were published to promote best practice when designing secondary and non-structural elements.

> published *Practice Advisory 19: Improving earthquake performance of non-structural elements*

> published *Practice Advisory 20: Improving earthquake performance of secondary structural elements*

MBIE has established a working group with industry representatives from design, research, construction, insurance, and Council sectors, and property owners, to review the design, installation, and consenting practices of non-structural elements to achieve improved performance in earthquakes.

International practice is also being considered. Non-structural issues were one focus of the June 2016 US-Japan-NZ *Workshop on Improvement of Structural Engineering and Resiliency*. Issues and solutions proposed in this workshop will be reflected in the review.

Substantial amendments have been made for the requirements for parts and components within the standard Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004).

> amended requirements for parts and components within NZS 1170.5

Ongoing actions

NZS 1170.5 will continue to be amended to align it with future research findings as required.

The MBIE non-structural elements review is likely to result in changes to design, consenting, and installation practices for incorporating non-structural elements into buildings.

Need for additional research on the seismic performance of concrete structures

Some reinforced concrete buildings had structural parts that did not perform as expected, and some damage was different from that predicted by laboratory testing. There is an inadequate understanding of the complex nature of regularity, torsion, ratcheting, and diaphragms that need further research and better guidance for designers.

Recommendation 35	The requirements for regularity in buildings, and for torsion due to the distance between the centre of mass and the centres of stiffness and strength, should be revised to recognise the implications of these parameters on observed behaviour.
Recommendation 36	Design actions for floors acting as diaphragms need to be more clearly identified in the Standard. This includes actions that arise from: <ul style="list-style-type: none"> • the weight of the floor and its associated gravity loading and the acceleration of the floor; • shear transfer between the lateral-force-resisting elements; • self-strain forces induced by elongation and bending of beams; and • local forces induced by structural elements such as T-shaped walls that have differing strengths for displacement in the forward and backward directions.
Recommendation 40	A comprehensive study of the existing literature on the influence of the rate of loading on seismic performance of reinforced concrete structures should be undertaken to address the inconsistencies in the published opinions, and to make appropriate recommendations for design.
Recommendation 41	Research into the influence of the sequence of loading cycles on yield penetration of reinforcement into beam-column joints and the development zones of reinforcement is desirable.
Recommendation 45	Research should be carried out into stiffness degradation due to yielding in the structure and elongation of the plastic hinges, as this could be of considerable value in establishing acceptable design criteria.
Recommendation 56	Appropriate allowance should be made for ratcheting where this action may occur.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE commissioned a literature review on the effects of the rate of loading for reinforced concrete structures in earthquakes, which identified that there were diverse opinions and concluded that additional research was required in order to make design recommendations. MBIE established a working group to identify a framework suitable for the assessment of residual capacity of earthquake damaged concrete buildings. The group is also considering the influence of strain rate effects.

MBIE identified a need for additional research leadership and established the MBIE Chair in Earthquake Engineering in the Department of Civil and Environmental Engineering at the University of Auckland in 2014 (jointly funded by MBIE and the university).

> established the MBIE Chair in Earthquake Engineering

Research to resolve design issues for engineers has been a focus for MBIE's Engineering Advisory Group and has informed the development of research programmes.

The Natural Hazards Research Platform managed by GNS Science has been funding research on the seismic performance of reinforced concrete and steel structures. In 2016, the Natural Hazards Research Platform awarded a four-year contract for research on advancements in engineering guidelines and standards to researchers at the universities of Canterbury and Auckland. This programme includes reinforced concrete and will support revisions to the Concrete Structures Standard (NZS 3101:2006).

A Centre of Research Excellence for earthquake resilience research (QuakeCoRE) was established in January 2015 (funded for five years by the Tertiary Education Commission). With seven partners from across New Zealand, including the universities of Canterbury and Auckland and GNS Science, QuakeCoRE seeks to transform the earthquake resilience of communities and societies through innovative world-class research, human capability development, and national and international collaborations.

The research is organised into Technology Platforms and Flagship programmes. QuakeCoRE Flagship programmes address six areas of multi-disciplinary research, interconnected to understand and improve how our communities recover and thrive after major earthquakes. QuakeCoRE Technology Platforms are advancing the underpinning infrastructure needed for our research, from lab and field experimentation to complex community datasets and high-performance computing.

Translation of research outputs into policy and practice is achieved through:

- active participation with stakeholders and end users in research programmes
- education of next-generation leaders in earthquake resilience.

A broad range of research projects are underway, including determining the residual capacity of earthquake-damaged building elements, such as structural walls.

> established QuakeCoRE

New Zealand researchers and practitioners also participated in a joint US-Japan-NZ *Workshop on the Improvement of Structural Engineering and Resiliency* in June 2016. The primary focus for New Zealand was to understand international approaches to assessing the residual capacity of repaired earthquake-damaged buildings. Other benefits of participation included more knowledge on best practices for non-structural components. Collaboration is ongoing.

> international collaboration on reinforced concrete building performance

Amendments have been made to the standard Structural design actions – Part 5: Earthquake actions – New Zealand (NZS 1170.5:2004) that are expected to:

- improve the torsional stability of ductile buildings
- avoid ratcheting within ductile buildings. This amendment also requires lateral forces and element strengths to be balanced and eccentric gravity loadings to be minimised
- improve the design of diaphragms and connections between vertical primary lateral-load-resisting elements and floor diaphragms.

> issued amendment to NZS 1170.5

Ongoing actions

The New Zealand research programmes include:

- investigating the rate and sequence of loading
- reinforcing ratios and their influence on cracking
- effects of seismic loads on strain hardening of steel (including in plastic hinges).

QuakeCoRE is negotiating access to unique experimental facilities not available in New Zealand. These are needed to address recommendations relating to system level issues rather than performance of individual elements. These facilities include Tongji University's (Shanghai) large-scale testing facility with multiple shake tables, and Swinburne University's (Melbourne) testing facility that can reproduce earthquakes' complex biaxial loading on structural systems, including concrete walls.

The participants in the 'Virtual International Institute for Performance Assessment of Wall Systems' are developing an overarching research programme to improve the seismic performance of concrete wall buildings.

Results from the Natural Hazards Research Platform four-year contract for research on advancements in engineering guidelines and standards will inform future revisions to New Zealand Standards and guidelines.

The New Zealand Concrete Structures Standard NZS 3101 is under review. Research results are being incorporated. It is scheduled for publication in 2017.

NZS 1170.5 and the other standards will be amended to align them with future research findings as appropriate.

Reinforced concrete structural walls

Some buildings with reinforced concrete walls had unexpected failure modes, demonstrating a need for additional research and guidance for designers.

Note: The standard referred to in the recommendations below is the Concrete structures Standard (NZS 3101.1&2:2006)

Recommendation 42	Changes should be made to the Standard to ensure that yielding of reinforcement can extend beyond the immediate vicinity of a single primary crack, and that further research be carried out to refine design requirements related to crack control in structural walls.
Recommendation 43	<p>The Standard should be modified to include requirements related to confinement of ductile walls.</p> <p>For the ductile detailing length of ductile walls, transverse reinforcement shall be provided over the full length of the wall as follows:</p> <ul style="list-style-type: none"> • confinement of boundary regions shall be provided in accordance with NZS 3101:2006, clause 11.4.6, modified to provide confinement over the full length of the compression zone; and • transverse reinforcement in the central portion of the wall shall satisfy the anti-buckling requirements of NZS 3101:2006, clause 11.4.6.3. <p>We note that earlier this year the Structural Engineering Society New Zealand Inc. (SESOC) published a draft recommendation to this effect.</p>
Recommendation 44	<p>As a short-term measure, where there is a ductile detailing length in the wall and the axial load ratio, $N/A_g f'_c$, equals or exceeds a value of 0.10, the ratio of the clear height between locations where the wall is laterally restrained to the wall thickness should not exceed the smaller of 10, or the value given by clause 11.4.2 in the Standard.</p> <p>Research should also be carried out to establish more rational expressions for limiting the ratio of clear height to thickness, allowing for both the loading and the imposed deformations on walls.</p>
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

After the 22 February 2011 earthquake, MBIE carried out technical investigations into the behaviour of some reinforced concrete Christchurch central business district buildings, including reviewing the effects of the concrete detailing.

MBIE has proposed Amendment 3 to the Concrete Structures Standard (NZS 3101:2006). It includes:

- specific reinforcement detailing requirements for structural walls
- revised requirements for the confinement of ductile walls.

> proposed amendment to NZS 3101:2006

MBIE convened a series of workshops with researchers and practitioners to help define the research questions and prioritise research activity. It then commissioned the University of Canterbury Quake Centre to manage five substantial research projects on reinforced concrete walls and diaphragms to address these recommendations.

The three-year research projects, being carried out jointly by the University of Canterbury and the University of Auckland, are:

- global and local buckling of reinforced concrete walls
- ductile wall detailing
- lightly reinforced concrete walls
- bi-directional response and performance of rectangular shear walls
- in-plane demands and performance of diaphragms.

> funded MBIE concrete building research, managed by the University of Canterbury Quake Centre

The United States National Science Foundation established the 'Virtual International Institute for Performance Assessment of Wall Systems'. MBIE helped facilitate its establishment and has funded New Zealand participation. This is an ongoing collaborative network for international researchers and practitioners to identify research needs for the seismic performance of concrete buildings that are common to US, Japan, Chile, and Europe, and to coordinate testing programmes.

Three international workshops have been held to date and task groups have responsibility for a database of testing results, wall modelling, and biaxial loading. This international collaboration enhances the value of the MBIE investment in the concrete building projects managed by the University of Canterbury Quake Centre.

This collaboration is being enhanced by support from the Japan Society for the Promotion of Science and the Royal Society of New Zealand, with the first joint workshop held in New Zealand in September 2016. A joint publication of research results from this workshop is planned to be published in the Bulletin of the New Zealand Society for Earthquake Engineering.

Ongoing actions

Amendment 3 to NZS 3101 is intended to be published in 2017.

Elongation

Many reinforced concrete elements elongate during an earthquake, and have a significant effect on other structural elements, which is not fully accounted for in building design.

Note: The standard referred to in the recommendations below is the Concrete structures Standard (NZS 3101.1&2:2006)

Recommendation 46	Guidance should be given in the Standard on the expected magnitude of elongation that occurs with different magnitudes of material strain and structural designers should be required to account for this deformation in their designs.
Recommendation 47	Structural designers develop a greater awareness of the interactions between elements due to elongation so that allowance for adverse effects can be mitigated in the design; and guidance on these matters should be given in the commentary to the Standard.
Recommendation 48	The Standard should be revised to provide guidance on elongation of plastic hinges in beams. This should include: <ul style="list-style-type: none">• the width and location of cracks that may be induced in floor slabs at the junction of the floor and supporting beams and the disruption that these cracks may cause to membrane forces that transfer seismic forces to the lateral-force-resisting elements; and• details of reinforcement required to ensure that the bars do not fail in tension at the cracks.
Recommendation 49	In the Commentary to the Standard attention should be drawn to the significant axial compression force that may be induced in beams by the restraint of floor slabs.
Recommendation 57	Structural engineers should be aware that current widely used methods of analysis do not predict elongation associated with flexural cracking and the formation of plastic hinges.
Recommendation 58	In designing details, compatibility in deformations is maintained between individual structural components.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE has proposed Amendment 3 to the Concrete Structures Standard (NZS 3101:2006). It includes:

- provisions on how to estimate elongation and how this should be incorporated in building design
- a requirement that allowance is made for the effects of deformation arising from elongation, including methods on how to calculate the magnitude of elongation
- provisions and details to prevent the potential separation of columns and beams from floor slabs and compromising the structural integrity of a building.

> proposed amendment to NZS 3101:2006

Ongoing actions

Amendment 3 to NZS 3101 is intended to be published in 2017.

More research will be required to improve the elongation provisions.

Detailing structural concrete elements

Some of the construction details used for reinforced concrete elements need minor changes to improve their performance during earthquakes.

Note: The standard referred to in the recommendations below is the Concrete structures Standard (NZS 3101.1&2:2006)

Recommendation 50	Low-friction bearing strips should be used to support double-Tee precast units to isolate the precast units and the supporting structure from friction forces.
Recommendation 51	Where clause 8.7.2.8 in the Standard permits the use of stirrups in the form of overlapping U-shaped bars, the proportion of these bars lapped in cover concrete should not exceed 0.5.
Recommendation 59	Structural engineers should be aware of the relevance of the tensile strength of concrete and how it can influence structural behaviour.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

Proposed amendments to NZS 3101:2006 include requirements that:

- all precast flooring units be supported on low-friction bearing strips to reduce friction effects
- at least half of the stirrups need to be anchored conventionally in the core concrete by standard 135 degree hooks. This permits fewer than half of the stirrups to be straight lap splices
- the effects of the tensile strength of concrete need to be considered.

> proposed amendment to NZS 3101:2006

Ongoing actions

Amendment 3 to NZS 3101 is intended to be published in 2017.

Geotechnical considerations

Geotechnical site investigations

Inadequate geotechnical investigations at some building sites and inadequate understanding of the geology resulted in poor foundation performance and subsequent damage to the building.

Recommendation 3	A thorough and detailed geotechnical investigation of each building site, leading to development of a full site model, should be recognised as a key requirement for achieving good foundation performance.
Recommendation 4	There should be greater focus on geotechnical investigations to reduce the risk of unsatisfactory foundation performance. The Department of Building and Housing should lead the development of guidelines to ensure a more uniform standard for future investigations and as an aid to engineers and owners.
Recommendation 7	Greater use should be made of in situ testing of soil properties by the cone penetrometer test (CPT), standard penetration test (SPT) or other appropriate methods.
Recommendation 5	Geotechnical site reports and foundation design details should be kept on each property file by the territorial authority and made available for neighbouring site assessments by geotechnical engineers.
Recommendation 6	The Christchurch City Council should develop and maintain a publicly available database of information about the subsurface conditions in the Christchurch CBD, building on the information provided in the Tonkin and Taylor report. Other territorial authorities should consider developing and maintaining similar databases of their own.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE has focused on providing information to increase awareness of the effectiveness of geotechnical site investigations, and to increase industry understanding about best practice geotechnical site investigations.

Module 2 of the guidelines for earthquake geotechnical engineering practice, developed by MBIE and the New Zealand Geotechnical Society (NZGS), addresses the importance of developing a site geotechnical model, key issues, planning, and the advantages and disadvantages of various techniques available for subsurface exploration.

> published *Module 2: Geotechnical investigation for earthquake engineering*

MBIE published Practice Advisory 17 for building professionals who are not geotechnical specialists, which explains the benefits of matching the investment in a geotechnical site investigation to the level of project risk associated with unforeseen conditions or poor performance and site knowledge.

> issued *Practice Advisory 17: Well-planned ground investigations can save costs*

The Canterbury Geotechnical Database (CGD) was developed by the Canterbury Earthquake Recovery Authority (CERA) for registered users to store and retrieve site investigation data and view maps and other

geotechnical information. The CGD database was transferred to MBIE with support from EQC when CERA was disestablished in 2016.

> established Canterbury Geotechnical Database in 2012

It was expanded into the New Zealand Geotechnical Database (NZGD) by MBIE, to provide a national database. It includes Auckland site investigation data from the Watercare database. The NZGD is available for all registered users, which includes building consent authorities.

> established New Zealand Geotechnical Database

A geotechnical engineering education programme, a partnership between MBIE, NZGS, and the Institution of Professional Engineers New Zealand, has commenced. It includes on-line resources and training seminars as modules are progressively published.

> created Geotechnical Engineering Education Programme

IPENZ and NZGS have developed a Professional Engineering Geologist register to identify engineering geology professionals competent to undertake geotechnical site investigation work that informs geotechnical engineering design.

> developed Professional Engineering Geologist register

Auckland City, MBIE, New Zealand Transport Agency and industry partners have developed a geotechnical site investigation specification to provide a more consistent approach to geotechnical site investigations across the building industry.

> developed geotechnical investigation specification

Ongoing actions

The training programme for New Zealand geotechnical engineers and other building professionals will continue to be rolled out as modules are finalised and training needs are identified.

MBIE will continue to develop the NZGD to simplify the collection and sharing of geotechnical information. It will also promote the addition of geotechnical data by public and private sectors, and provide links to other relevant databases (such as natural hazards and building data) managed by other agencies.

Registered users of the NZGD (professionals who can interpret the data) will be able to use the resource and add to it as additional investigations are carried out. The greater the density of data, the better the understanding of New Zealand sub-surface conditions. Increased understanding of ground performance during earthquakes will enable improved building design.

Liquefaction

There was limited appreciation of the impacts of widespread liquefaction. Land-use planning decisions have not always taken into account liquefaction hazards. Foundations were not always appropriately designed to take into account liquefaction vulnerability, resulting in variable building performance.

Recommendation 8	The Department of Building and Housing should work with the New Zealand Geotechnical Society to update the existing guidelines for assessing liquefaction hazard to include new information and draw on experience from the Christchurch earthquakes.
Recommendation 186	Sections 6 and 7 of the Resource Management Act 1991 should be amended to ensure that regional and district plans (including the zoning of new areas for urban development) are prepared on a basis that acknowledges the potential effects of earthquakes and liquefaction, and to ensure that those risks are considered in the processing of resource and subdivision consents under the Act.
Recommendation 187	Regional councils and territorial authorities should ensure that they are adequately informed about the seismicity of their regions and districts. Since seismicity should be considered and understood at a regional level, regional councils should take a lead role in this respect, and provide policy guidance as to where and how liquefaction risk ought to be avoided or mitigated. In Auckland, the Auckland Council should perform these functions.
Recommendation 188	Applicants for resource and subdivision consents should be required to undertake such geotechnical investigations as may be appropriate to identify the potential for liquefaction risk, lateral spreading or other soil conditions that may contribute to building failure in a significant earthquake. Where appropriate, resource and subdivision consents should be subject to conditions requiring land improvement to mitigate these risks.
Recommendation 189	The Ministry for the Environment should give consideration to the development of guidance for regional councils and territorial authorities in relation to the matters referred to in Recommendations 186–188.
Lead Organisations	Ministry of Business, Innovation & Employment (8) Ministry for the Environment (186 – 189)

Response

Actions taken

MBIE partnered with the New Zealand Geotechnical Society (NZGS) to develop a number of modules that provide guidelines for earthquake geotechnical engineering design.

> developed earthquake geotechnical engineering design guidelines

Module 3 on liquefaction has been updated and published to reflect the new insights and understanding of liquefaction arising from the Canterbury earthquakes and the latest international research.

> published *Module 3: Identification, assessment, and mitigation of liquefaction hazards*

A training programme to upskill New Zealand geotechnical engineers has been delivered by MBIE, in partnership with industry, for module 3.

MBIE developed Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region in 2012 as Part D of the guidance *Repairing and rebuilding houses affected by the Canterbury earthquakes*. The MBIE residential guidance provisions informed the

development of Christchurch City's district planning rules around liquefaction management and the required levels of geotechnical investigation.

> published *Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region*.

The Ministry for the Environment (MfE) and MBIE are jointly preparing national guidance for the development of land vulnerable to liquefaction that includes planning, geotechnical site investigations, and ground improvement

techniques. This has been piloted in some locations and will be released for stakeholder comment in 2017.

Ongoing actions

Research is being conducted on liquefaction of silty soils by a number of organisations, including the universities of Canterbury and Auckland, sometimes partnered with overseas institutions. The research results will be used to update guidance on geotechnical site investigations.

MBIE and the MfE will finalise and promote the use of the national guidance for assessing the liquefaction hazard and development of land vulnerable to liquefaction.

The *Resource Legislation Amendment Bill* currently before Parliament aims to better manage risks from natural hazards in New Zealand by including "the management of significant risks from natural hazards" as a new matter of national importance in section 6 of the *Resource Management Act*. The amendment also proposes changes to section 106 to require risks from all natural hazards to be considered before granting subdivision consents. The broad reference to 'natural hazards' ensures that every low likelihood natural hazard that would have high consequences is considered in the decision rather than limiting it to liquefaction following an earthquake.

The geotechnical education programme will continue.

Building foundations

Foundation design

Unanticipated building settlement and structural damage occurred at serviceability limit state (SLS) loading because some designers had a poor understanding of how soil types and foundations respond to earthquakes.

Note: The SLS loading is the design limit at which a building is expected to be able to be used as originally intended after an earthquake, without needing significant repair.

Recommendation 10	Where liquefaction or significant softening may occur at a site for the SLS earthquake, buildings should be founded on well-engineered deep piles or on shallow foundations after well-engineered ground improvement is carried out.
Recommendation 11	Conservative assumptions should be made for soil parameters when assessing settlements for the SLS.
Recommendation 12	Foundation deformations should be assessed for the ULS load cases and overstrength actions, not just foundation strength (capacity). Deformations should not add unduly to the ductility demand of the structure or prevent the intended structural response.
Recommendation 13	Guidelines for acceptable levels of foundation deformation for the ULS and overstrength load cases should be developed. The Department of Building and Housing should lead this process.
Recommendation 9	Further research should be conducted into the performance of building foundations in the Christchurch CBD, including subsurface investigations as necessary, to better inform future practice.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

In December 2010, MBIE published design solutions for residential foundations that address some of these recommendations.

- > published *Repairing and rebuilding houses affected by the Canterbury earthquakes*

These design solutions were revised and extended as the behaviour of these foundations during the Canterbury earthquakes was better understood and the industry implemented and improved the solutions.

MBIE and NZGS have published *Module 4: Earthquake resistant foundation design*, which provides direction on foundation solutions and soil parameter assumptions that should be used in foundation designs on soils vulnerable to liquefaction, including the appropriate level of conservatism. It addresses many of the Royal Commission recommendations.

- > published *Module 4 Earthquake resistant foundation design*

Ongoing actions

A training programme to upskill New Zealand geotechnical engineers on the contents of Module 4 will be delivered by MBIE, in partnership with industry. Collaborative national and international research is being conducted to improve methods for predicting the effects of liquefaction, its consequences on lateral spreading, and the subsequent effect on building foundations. These projects are funded either separately and/or jointly by MBIE,

Earthquake Commission, QuakeCoRE, Natural Hazard Research Platform, the Resilience to Nature's Challenges National Science Challenge, the United States National Science Foundation, other international research funding agencies, and the private sector.

The research will be progressively incorporated into standards and building design guidance.

Ground improvement

Prior to the Canterbury earthquakes, geotechnical professionals had limited New Zealand-specific guidance on ground improvement methods that could be used to mitigate liquefaction risk.

Recommendation 24	The Department of Building and Housing should consider the desirability of preparing national guidelines specifying design procedures for ground improvement, to provide more uniformity in approach and outcomes.
Recommendation 22	Ground improvement, where used, should be considered as part of the foundation system of a building and reliability factors included in the design procedures.
Recommendation 23	Ground-improvement techniques used as part of the foundation system for a multi-storey building should have a proven performance in earthquake case studies.
Recommendation 21	The performance of ground improvement in Christchurch should be the subject of further research to better understand the reasons for observed variability in performance.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE and the New Zealand Geotechnical Society (NZGS) are developing a number of modules that provide guidelines for earthquake geotechnical engineering design. The general module, *Module 5: Ground improvement*, is under development and Module 5A has been published.

> published *Module 5A: Specification of ground improvement for residential properties in the Canterbury region*

MBIE has undertaken research field trials and has also collaborated with the Earthquake Commission (EQC) and international experts to carry out further ground improvement research in Christchurch. MBIE is supporting further injected resin ground improvement trials being undertaken by industry in Christchurch.

> field trials of ground improvements in Christchurch

The results of the ground improvement trials were used to inform the MBIE residential guidance. A new section was added to the guidance in 2012, which provides guidance and design solutions for various forms of ground improvement beneath residential buildings. That section was substantially revised in 2015, based on the performance observed during the EQC-led foundation trials. The research will also be used to inform *Module 5 Ground Improvement*.

> updated *Repairing and rebuilding houses affected by the Canterbury earthquakes*

Ongoing actions

Module 5: Ground improvement is to be published with a training programme for geotechnical practitioners.

Research results will be included in updated guidance.

Shallow foundation design

There is a lack of understanding of how shallow foundations perform and improved design criteria are needed.

Recommendation 18	The Department of Building and Housing should lead the development of detailed guidelines to address the design and use of shallow foundations.
Recommendation 19	The Department of Building and Housing should lead the development of more detailed guidance for designers regarding acceptable foundation deformations for the ultimate limit state (ULS).
Recommendation 20	Shallow foundations should be designed to resist the maximum design base shear of the building, so as to prevent sliding. Strength- reduction factors should be used.
Recommendation 16	For shallow foundations, soil yielding should be avoided under lateral loading by applying appropriate strength-reduction factors.
Recommendation 14	The concessional strength-reduction factors in B1/VM4 for load cases involving earthquake load combinations and overstrength actions ($\phi_g = 0.8-0.9$) should be reassessed.
Recommendation 15	The strength-reduction factors in B1/VM4 should be revised to reflect international best practice including considerations of risk and reliability.
Related to	Recommendations 10, 11, 12, and 13
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE developed guidelines on the design of residential foundations, which includes designing shallow foundations.

> published *Repairing and rebuilding houses affected by the Canterbury earthquakes*

The MBIE-NZGS *Module 4: Earthquake resistant foundation design* has been published for industry comment. It provides guidance on design of shallow foundations.

> published *Module 4 Earthquake resistant foundation design*

Ongoing actions

MBIE will review Verification Method 4 within Clause B1 – Structure of the Building Code to align it with these modules as they are published. MBIE is also developing guidance to assist interpreting and understanding Clause B1 – Structure of the Building Code, as recommended by a review of the Building Code.

A training programme to upskill New Zealand geotechnical engineers and other building professionals will be delivered for Module 4 by MBIE in partnership with industry.

Deep foundation design

There is a lack of understanding of how deep foundations perform and improved design criteria are needed.

Recommendation 25	Detailed guidelines for deep foundation design should be prepared to assist engineers and to provide more uniformity in practice. The Department of Building and Housing should lead this process.
Recommendation 26	Because driven piles have significant advantages over other pile types for reducing settlements in earthquake-resistant design, building consent authorities should allow driven piles to be used in urban settings where practical.
Recommendation 27	Where there is a risk of significant liquefaction, deep piles should be designed to accommodate an appropriate level of lateral movement of the surface crust even when they are far from any watercourse.
Recommendation 28	Base friction should not be included as a mechanism for lateral load transfer between the ground and the building when it is supported on deep piles.
Recommendation 29	If reliance is to be placed on passive resistance of downstand beams and other vertical building faces, a realistic appraisal of the relative stiffness of the load-displacement response of the passive resistance compared to the pile resistance should be made.
Recommendation 30	For buildings on deep piles, it is not essential that the calculated lateral capacity of the foundations should exceed the design base shear at the ULS, provided that the piles have sufficient flexibility and ductility to accommodate the resulting yield displacement and kinematic displacements.
Recommendation 17	For deep pile foundations, soil yielding should be permitted under lateral loading, provided that the piles have sufficient flexibility and ductility to accommodate the resulting displacements. In such cases, strength-reduction factors need not be applied.
Recommendation 31	There are major problems in the use of inclined piles where significant ground lateral movements may occur. Where the use of inclined piles is considered, the kinematic effects that may generate very large axial loads that could overload the pile and damage other parts of the structure connected to the pile should be considered.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE developed guidelines on the design of house foundations, which includes the use of deep piles:

- > published *Repairing and rebuilding houses affected by the Canterbury earthquakes*

The MBIE-NZGS *Module 4: Earthquake resistant foundation design* has been published for industry comment. It provides guidance on design of deep foundations. This includes guidance on how to design piles to accommodate lateral movements and liquefaction effects.

- > published *Module 4 Earthquake resistant foundation design*

Ongoing actions

A training programme to upskill New Zealand geotechnical engineers and other building professionals will be delivered for Module 4 by MBIE in partnership with industry.

Earthquake ground motion

There is inherent uncertainty in the prediction of the location, magnitude, and timing of the earthquakes. Ongoing investment into the locations of faults and anticipated ground motions will benefit the design of foundations and buildings.

Recommendation 1	Research continues into the location of active faults near Christchurch and other population centres in New Zealand, to build as complete a picture as possible for cities and major towns.
Recommendation 2	The provisions of the Earthquake Actions Standard, NZS 1170.5, relating to vertical accelerations be reviewed. (See also recommendations 33 and 34 below.)
Recommendation 32	The response spectral shape factor, $C(T)$, for deep alluvial soils under Christchurch, should be revised. The likely change in spectral shape with earthquakes on more distant faults also needs to be considered.
Recommendation 33	The shape of response spectra for vertical ground motion should be revised.
Recommendation 34	The implications of vertical ground motion for seismic design actions should be considered and locations identified where high vertical accelerations may be expected in earthquakes.
Recommendation 37	A more rational theoretical basis should be developed for 'magnitude weighting', which is used in the development of the design response spectra for structures.
Lead Organisation	Ministry of Business, Innovation & Employment and GNS Science

Response

Actions taken

GNS Science, the University of Canterbury, and National Institute of Water and Atmospheric Research have ongoing research programmes that aim to identify the location and behaviour of active faults. For example, a multidisciplinary pilot study commissioned by the Natural Hazards Research Platform is currently identifying active faults close to Dunedin that cannot be analysed using standard techniques.

GNS Science also has been awarded substantial funding in the MBIE 2016 Endeavour Round to diagnose the peril of the Hikurangi subduction zone, New Zealand's largest plate boundary fault.

A number of government-funded collaboration and networking initiatives have been established to support the research and distribute findings to other stakeholders such as territorial authorities, communities, businesses, iwi, and government agencies. These initiatives include:

- the Resilience to Natures Challenges – National Science Challenge
- the Natural Hazards Research Platform
- QuakeCoRE
- other international research initiatives.

> established collaboration and networking initiatives to support research

Amendments have been made to the New Zealand standard for Structural design actions – Earthquake actions (NZS 1170.5:2004) that:

- improve the spectral shape factor used to characterise the effects of horizontal ground motion at sites with 'deep' soft sub-soils

- provide spectral shape factors for sites with sub-soil depths that are between 'shallow' and 'deep'
- improve the spectral shape factor used to characterise the effects of vertical ground motion.

> issued amendments to NZS 1170.5:2004

International seismicity experts are reviewing the GNS Science New Zealand Seismic Hazard model that provides the basis for design actions included in NZS 1170.5. The review is to provide direction for the hazard model's future development and governance.

> initiated review of New Zealand Seismic Hazard Model

Ongoing actions

The new knowledge about the location and behaviour of active faults will be used to improve the understanding of seismic hazards throughout New Zealand. That understanding will be used to progressively improve building design methods.

Other research that will improve NZS 1170.5:2004 further includes:

- improving the hazard estimates by replacing the outdated earthquake ground-motion prediction equations
- reducing the artificial dominance small magnitude earthquakes have in hazard estimates, which is currently achieved using magnitude weighting
- estimating spectral shape factors using a conditional approach
- improving how the spectral shape factors include the influences of vertical ground motion, local ground conditions and earthquakes generated by more distant faults
- improving understanding of how vertical accelerations influence the performance of buildings.

Recommendations from the review of the New Zealand Seismic Hazard Model will be considered by MBIE, GNS Science and other interested parties, and implemented as appropriate.

Low-damage building technologies

Promising, low-damage building technologies were seldom used due to limited development and guidance for building owners, designers, building consent authorities, and the public.

Recommendation 66	Research should continue into the development of low-damage technologies.
Recommendation 67	The Department of Building and Housing should work with researchers, engineering design specialists and industry product providers to ensure evidence-based information is easily available to designers and building consent authorities to enable low-damage technologies to proceed more readily through the building consent process as alternative solutions.
Recommendation 68	The Department of Building and Housing should work with researchers, engineering design specialists and industry product providers to progress, over time, the more developed low-damage technologies through to citation in the Building Code as acceptable solutions or verification methods. This may involve further development of existing cited Standards for materials, devices and methods of analysis.
Recommendation 69	The Department of Building and Housing should foster greater communication and knowledge of the development of these low-damage technologies among building owners, designers, building consent authorities, and the public.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE is working with the technical societies (the Structural Engineering Society New Zealand, New Zealand Society for Earthquake Engineering, and the New Zealand Geotechnical Society) to develop guidance on low-damage building technologies (LDBT) for building owners and other building industry participants, to increase awareness and understanding, and to promote the use of proven LDBT such as base isolation.

More detailed guidance on base isolation is being developed by the New Zealand Society for Earthquake Engineering, with support from the Earthquake Commission and MBIE. This guidance is expected to produce buildings that exceed the requirements of Building Code Clause B1 – Structure and should readily proceed through the building consent process.

Industry-led guidance documents have been published or are being developed using findings from recent research, including:

- guidance on controlled rocking steel-braced frames
- guidance on buckling-restrained braces
- research on buckling-restrained brace systems.

> published industry-led guidance

The University of Auckland was awarded funding in the MBIE 2016 Endeavour Round to study seismic building damage-avoidance technology using a novel resilient slip friction joint. QuakeCoRE is funding further research on various low damage systems.

> funded building damage avoidance research

Ongoing actions

The LDBT guidance documents being developed by MBIE and NZSEE are intended to be published in 2017.

QuakeCoRE is conducting research into LDBT, including the residual capacity of repaired reinforced concrete walls, design modifications that aim to reduce their future damage, and monitoring the dynamic characteristics of post-tensioned multi-storey timber buildings.

Research will continue in the field of LDBT and associated guidance will be published and updated as more information becomes available.

MBIE will support future training and education in LDBT so that the building industry is kept up-to-date with developments.

In the future, MBIE intends to work with researchers, engineering design specialists, and industry product providers to develop documentation that can be cited in the Building Code to promote the use of proven LDBT.

Section 2.4: Improving response capability following earthquakes

Overview

The first procedures and guidelines for making on-the-spot evaluations and decisions about the continued use and occupancy of earthquake damaged buildings were published by the Applied Technology Council just two weeks before the 1989 Loma Prieta, California earthquake.

The procedures and guidelines have incrementally improved since then, initially based on experience using them after the Loma Prieta earthquake. They provided a reasonably comprehensive system for managing buildings in the aftermath of an earthquake. Works Consultancy Services adapted them for New Zealand use in 1991 and the New Zealand Society for Earthquake Engineering (NZSEE) updated them in 1998. They were used after the 20 December 2007 Gisborne earthquake and updated to address lessons from that experience.

The revised NZSEE procedures and guidelines were used in Indonesia, after the 30 September 2009 Padang earthquake. This use demonstrated that, although the assessment guidelines could be universally applied, the entire process needs to be well integrated into local practice and government regulations.

The Royal Commission reported “that, overall, New Zealand was very well served by the engineers, building control officials and others who volunteered in the building safety evaluation process carried out after the Canterbury earthquakes.”

However, the Royal Commission recommended further improvements because:

- The building management and assessment system needs to be included within the legislation governing both emergency management and buildings.
- The management of rapid building assessments needed better guidance, particularly regarding the roles and responsibilities, procedures and support systems.
- Insufficient information on aftershocks, when and how to enter and assess damaged buildings were provided and guidelines needed to be developed on assessing the usability of damaged buildings.
- The procedures for Detailed Damage Evaluation that were developed during the Canterbury earthquakes had some aspects that need improvement.
- There was confusion about the risks posed by damaged buildings and how that risk should be conveyed using placards.
- It was unclear who had the responsibility and authority for setting up, maintaining, and removing cordons and barricades around buildings.
- There were insufficient powers to cordon, repair or demolish buildings posing a public safety risk that have been damaged by earthquake.
- The building assessment and management system relied heavily on untrained volunteers for its design, mobilisation and delivery.

The responsibilities for managing buildings during the response and recovery

phases of an emergency were not clearly defined in either the Civil Defence Emergency Management Act 2002 or the Building Act 2004. Both frameworks needed amending to provide an orderly transition of the various roles and responsibilities between the Ministry of Civil Defence & Emergency Management (MCDEM), MBIE and the territorial authorities.

In 2015, the National Civil Defence Emergency Management Plan was revised to include new provisions for managing buildings during an emergency, which requires “co-ordinated readiness, response, and recovery arrangements [to be] in place that involve building owners, territorial authorities, [Civil Defence Emergency Management] Groups, agencies, and building professionals”

> signed *National Civil Defence Emergency Management Plan Order 2015*

The Civil Defence Emergency Management Amendment Act 2016 provides a strengthened framework for recovery and a new role of Recovery Manager. The general focus of this role is carrying out recovery activities after an emergency or, where no emergency has been declared, where short term powers are needed to manage the impacts of an emergency.

> enact *Civil Defence Emergency Management Amendment Act 2016*

Many of the changes to procedures and guidelines were addressed within a revised system for managing buildings following natural disasters such as earthquake or flooding that was published by MBIE in 2014. This provides improved systems and processes, stronger guidance, and better preparation for managing buildings after emergencies.

> revised the post-emergency building assessment system

The updated system has two parts, one with explanations for building owners and managers and a second with access field guides for assessing buildings, forms and placards that are aimed at territorial authorities and their agents.

To date, approximately 400 engineers and building consent officers have been trained in its use.

> published field guides and tools for post-disaster usability assessments of buildings

MBIE is finalising a guidance document that is to assist territorial authorities to be prepared to set up and manage the rapid building assessment process in the event of an emergency. This supports the new operational framework introduced in 2014.

In 2015, MBIE published a consultation document proposing significant changes to the Building Act 2004. The proposed changes would provide continued management of unstable buildings once the broad powers of the Civil Defence Emergency Management Act 2002 finish at the end of an emergency. Specifically, they are intended to:

- minimise injury or death caused by buildings after an emergency
- provide a more orderly transition from an emergency where the scale of building damage and building risks is significant
- manage unsafe buildings in situations when resources may be strained and there may be significant risk of subsequent extraordinary events
- minimise disruption to the users of buildings posing danger, and to nearby properties
- provide greater clarity to the process of managing unusable buildings after an emergency ends.

The consultation document sought feedback on:

- the decision to use the emergency powers when no state of emergency exists

- the assessment of buildings
- placing red, yellow, or white placards on buildings
- restricting access
- the power to alter or demolish buildings without requiring a building or resource consent.

The proposals include clear appeal rights, give particular regard to heritage, and prescribe how the powers transition to the territorial authority after an emergency event.

There were 35 submissions on the proposed changes, many of which discussed specific difficulties in implementing the proposal. These included concerns that new powers in the proposal significantly impact on people's property rights and on heritage. It was recommended that occupied residential buildings and marae should, as a special case, have reduced unilateral access while they are assessed.

These issues are now being considered and addressed by MBIE. It is intended that new legislation will be introduced into Parliament in 2017 to amend the Building Act 2004.

Post-emergency building assessment process

The building management and assessment system needs to be included within the legislation governing both emergency management and buildings.

Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012.

Recommendation 161	The building safety evaluation and wider building management after earthquakes (and other disasters) framework should be developed and provided for in legislation.
Recommendation 111	Life safety should be the overarching objective of building management after earthquakes as communities both respond to and recover from the disaster.
Recommendation 151	<p>After an earthquake that has given rise to the declaration of a state of emergency, buildings should be assessed in accordance with the following process:</p> <ol style="list-style-type: none">a. all buildings should be subject to a rapid assessment process;b. for the purposes of subsequent steps, buildings should be placed in the following categories:<ol style="list-style-type: none">i) Group 1: non-unreinforced masonry buildings that do not have a known critical structural weakness, and either,<ul style="list-style-type: none">• in the case of concrete buildings, were designed to NZS 3101:1995 or later editions of that Standard;• in the case of structural steel buildings, were designed to NZS 3404:1992 (informed by the Heavy Engineering Research Association guidelines published in 1994) or later editions of that Standard; or have been subject to an evaluation that has shown that the building has 67% ULS or greater (we discuss the term “ULS” in section 6.2.4 of Volume 4);ii) Group 2: buildings designed between 1976 and the mid-1990s, but not included in Group 1;iii) Group 3: buildings designed before 1976, but not included in Group 1; andiv) Group 4: unreinforced masonry buildings;c. buildings used for residential purposes that are three or less storeys in height should be excluded from Groups 2 and 3. In the case of those buildings, a pragmatic approach needs to be taken to assessment and occupancy, which balances the need for shelter with safety considerations. Other commercial and residential buildings should not be occupied unless approved for occupancy in accordance with the process outlined below;d. legislation should require territorial authorities to classify buildings in their districts in accordance with the preceding Recommendation within the timeframes established under Recommendation 82 in Volume 4 of our Report (Recommendation 82 requires the assessment of earthquake-prone and potentially earthquake-prone buildings);e. where the rapid assessment process had identified the need for further evaluation of a building in one of these defined Groups, the building should not be occupied until the Civil Defence Controller or the territorial authority (as appropriate) has approved the occupancy of the building;

	<ul style="list-style-type: none"> i) for Group 1 buildings: <ul style="list-style-type: none"> • where no significant structural damage was seen, a Level 2 Rapid Assessment; • where significant structural damage was seen, a Plans-Based Assessment for lower levels of structural damage and a Detailed Engineering Evaluation for higher levels of structural damage; ii) for Group 2 buildings: <ul style="list-style-type: none"> • where no significant structural damage was seen, a Plans-Based Assessment; • where significant structural damage was seen, a Detailed Engineering Evaluation; iii) for Group 3 buildings: <ul style="list-style-type: none"> • for all levels of damage, a Detailed Engineering Evaluation; iv) for Group 4 buildings: <ul style="list-style-type: none"> • where no significant structural damage was seen and the building has been retrofitted to 67% ULS or greater, a Plans-Based Assessment; • where significant structural damage is apparent and where the building has not been retrofitted to 67% ULS or greater, a Detailed Engineering Evaluation; <p>f. arranging for the Plans-Based Assessments and Detailed Engineering Evaluations should be the responsibility of the owner of the buildings concerned; and</p> <p>g. the Ministry of Business, Innovation and Employment should further develop the Plans-Based Assessment concept, in consultation with the New Zealand Society for Earthquake Engineering and the Structural Engineering Society New Zealand, and set out the Plans-Based Assessment in published guidelines.</p>
Recommendation 137	Where available, only Chartered Professional Engineers should carry out Level 2 Rapid Assessments.
Recommendation 112	The building safety evaluation process should be used following a range of disasters.
Recommendation 114	<p>The Ministry of Business, Innovation and Employment should progress its proposals to incorporate new emergency risk management provisions into the Building Act 2004 to:</p> <ul style="list-style-type: none"> • make the Ministry of Business, Innovation and Employment responsible for the development and maintenance of New Zealand’s building safety evaluation process; • make territorial authorities responsible for delivering a building safety evaluation operation; and • give the Ministry of Business, Innovation and Employment a formal role within national civil defence and emergency planning arrangements.
Recommendation 113	Legislation should provide that a building safety evaluation operation should only be commenced during a state of emergency.
Recommendation 115	The Ministry of Business, Innovation and Employment should continue working with the Ministry of Civil Defence & Emergency Management on the detail of the above proposals.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The building management section of the National Civil Defence Emergency Management Plan 2005 has been revised and has life safety as the first objective for every stage of the response and recovery. That is followed by objectives to minimise damage to and loss of property, to restore building functions as soon as possible and to minimise losses or disruption of lifeline utility services that are in or near any building.

> signed *National Civil Defence Emergency Management Plan Order 2015*

The updated post-emergency building assessment system published in 2014 uses two levels of rapid assessment and a detailed evaluation:

- **Level 1 rapid building assessment:** An external visual inspection to determine if a building poses a risk and attaching a placard showing if use of the building is restricted or not. Cordons may be set up if the building is considered unsafe.
- **Level 2 rapid building assessment:** External and internal inspections of complex buildings, such as:
 - all multi-storey buildings regardless of use
 - any critical facilities, such as hospitals
 - any buildings identified as needing further inspection in Level 1 assessments.

A Level 2 assessment supersedes the earlier Level 1 assessment and a new placard may be placed. It may recommend urgent work to secure unsafe buildings and set up cordons around them.

Where available, a team led by a Chartered Professional Engineer should carry out a Level 2 assessment.

- **Detailed damage evaluation:** performed by qualified Chartered Professional Engineers that:
 - use plans-based assessments
 - identify specific risks and vulnerabilities
 - consider the consequences of future earthquakes of similar magnitude
 - consider engineering options to mitigate the risks.

> updated *post-emergency building assessment system*

Two field guides were published in 2014 that provide guidelines for rapid building usability assessment after earthquake and flooding disasters.

> published Field Guide: *Rapid Post Disaster building usability assessment – earthquakes*

> published Field Guide: *Rapid Post Disaster building usability assessment – flooding*

The Ministry of Civil Defence & Emergency Management considered it desirable to perform building assessments at times other than during an emergency.

The public consultation on the 2015 discussion document proposing changes to the Building Act 2004 specifically sought feedback on the viability of:

- the Royal Commission's recommended steps for the rapid assessment process

- whether there are situations that building emergency management powers should be made available when no emergency has been declared
- new powers to manage the actual or likely life-safety risks posed by buildings assessed as damaged during a rapid building assessment operation.

Transition periods were recently introduced by the Civil Defence Emergency Management Amendment Act 2016.

Ongoing actions

The Government has decided to introduce a new system of managing buildings during an emergency and transition periods. It is intended that new legislation will be introduced into Parliament in 2017 to amend the Building Act 2004.

Managing building assessments

The management of rapid building assessments needed better guidance, particularly regarding the roles and responsibilities, procedures and support systems.

Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012.

Recommendation 139	The Ministry of Business, Innovation and Employment should provide guidance to territorial authorities to support their plans to carry out a building safety evaluation process.
Recommendation 159	The roles and responsibilities of decision makers should be described in the building safety evaluation process. The roles and responsibilities should allow for flexibility of operation according to the circumstances and scale of the event.
Recommendation 138	The Indicator Building model should be incorporated into New Zealand's building safety evaluation process.
Recommendation 140	Territorial authorities should be required to plan their building safety evaluation process as part of their civil defence and emergency management plans.
Recommendation 160	The building safety evaluation process should direct evaluators to assess properties that act as one structure in an earthquake as one structure, rather than as separate buildings.
Recommendation 147	Information management systems should be developed as part of planning for New Zealand's building safety evaluation process.
Recommendation 148	The Ministry of Business, Innovation and Employment should work with territorial authorities and other relevant agencies to develop a way for territorial authority building records to be electronically recorded and stored off-site.
Recommendation 149	A clear system for identifying individual buildings should be developed and included in the plans for a building safety evaluation process.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The updated *post-emergency building assessment* system provides improvements that:

- have been used to establish a more disciplined and consistent approach to assessment
- are scalable to cope with the range of the most likely situations
- are well-linked to those required for the *National Civil Defence Emergency Management Plan Order 2015*.

An indicator building procedure was developed during the Canterbury earthquakes to guide the rapid assessment programme after a significant aftershock. This procedure identifies a set of buildings that are re-assessed following the aftershock to record the extent of any further damage. The extent of new damage provides a rational basis for a decision on whether to continue with the planned building assessment programme or to revisit or restart building assessments.

As an example of Canterbury developments influencing international best practice for managing buildings after earthquakes, the indicator building procedure was incorporated in the United States Applied Technology Council document ATC-20 in 2012.

> incorporated the indicator building procedure into *Procedures for post-earthquake safety evaluation of buildings (ATC-20) & Addendum*

The 2015 consultation document proposed changes to the Building Act 2004 to define the roles and responsibilities for building assessments after an emergency.

Ongoing actions

MBIE is writing new guidance documents explaining how territorial authorities should manage buildings following emergencies. The objectives are to:

- assist territorial authorities to have appropriate plans in place for managing building assessment processes following emergency
- clearly define the roles and responsibilities of all decision makers during and after the emergency
- uniquely identify individual buildings and portions of buildings
- facilitate the use of reliable, accessible, and standardised information systems and other infrastructure required to support the management of buildings
- use the indicator procedure to guide reassessment of buildings following aftershocks
- have rapid building assessment reports entered into a building register

MBIE will also develop training material for territorial authorities and their assessors.

MBIE is developing an electronic data capture system in collaboration with territorial authorities for recording rapid building assessments.

The Government has decided to introduce a new system of managing buildings during an emergency and transition periods. . It is intended that new bills will be introduced into Parliament in 2017 to amend the Building Act 2004.

Managing building assessments (continued)

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

Response

Actions taken

LINZ has included this recommendation as an objective within its National Address Data Improvement project.

LINZ contributed to an update of the 2003 edition of the Australian/New Zealand Standard for rural and urban addressing, which included simplifying the addressing for complex sites and introduced a new method for addressing within multi-level buildings.

> published *AS/NZS 4819:2011 – Rural and Urban Addressing*

In 2013, LINZ analysed the difficulties that earthquake response organisations experienced when working with address and property information and has been working with the Christchurch City Council and the Selwyn and Waimakariri District Councils to resolve long standing problems, and ensure that future addresses meet the Rural and Urban Addressing Standard (AS/NZS 4819:2011).

Christchurch City Council is now supplying addresses to LINZ through a web-based process that is quicker and more consistent. Selwyn and Waimakariri District Councils are now providing regular address updates and proactively working with LINZ to resolve addressing issues.

> changed process: Christchurch City Council to supply addresses using a web-based process

> changed process: Selwyn and Waimakariri District Councils provide regular updates to LINZ

Ongoing actions

The findings of the 2013 analysis are being used in other LINZ projects to improve how the national address dataset is managed and shared. This will standardise the way territorial authorities describe address data and protocols for sharing it. LINZ is also reviewing the system changes required to create more effective addresses.

LINZ will continue work to make it easier for organisations to adopt and use AS/NZS 4819:2011, and to create ways for addresses to be more reliably linked to information about property, buildings, and people.

Field guide for rapid building assessment

Insufficient information on aftershocks, when and how to enter and assess damaged buildings were provided and guidelines needed to be developed on assessing the usability of damaged buildings. *Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012. Detailed Damage Evaluations were called Detailed Engineering Evaluations.*

Recommendation 116	The Ministry of Business, Innovation and Employment, the Ministry of Civil Defence & Emergency Management, GNS Science, the New Zealand Society for Earthquake Engineering and other engineering technical groups should research how and when building safety evaluators should account for aftershocks.
Recommendation 117	The building safety evaluation process should set out the factors evaluators need to take into account when considering how a building will respond in an aftershock, including: <ul style="list-style-type: none"> • how close the main shock was to an urban centre that could be affected by an aftershock; • the direction of the main shock and any likely aftershocks; and • how soil, ground conditions and any other relevant factors may affect the intensity of the ground motions in an aftershock.
Recommendation 124	Guidelines should be developed that assist building safety evaluators to assess when and how to enter a damaged building.
Recommendation 125	These guidelines should be based on the Urban Search and Rescue training on when and how to assess entry to a damaged building.
Recommendation 126	These guidelines should be attached to the guidelines the Ministry of Business, Innovation and Employment is developing on the way in which engineers should carry out Detailed Engineering Evaluations after earthquakes.
Recommendation 127	New Zealand's building safety evaluation guidelines should incorporate detailed guidance to engineers about the way they should assess the damage to particular building types.
Recommendation 128	The field guide for building safety evaluators should be finalised.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The field guides developed to accompany the 2014 post-emergency building assessment system incorporate guidance for:

- how assessors should consider aftershocks
- assessing risk when entering damaged buildings
- assessing damage in common types of New Zealand buildings.

> published Field Guide: *Rapid Post Disaster building usability assessment – earthquakes*

Ongoing actions

MBIE is developing a third field guide for geotechnical assessment. It will periodically review the three field guides to incorporate improvements identified when they are used during future emergencies.

Guidance for Detailed Damage Evaluations

The procedures for Detailed Damage Evaluation that were developed during the Canterbury earthquakes had some aspects that need improvement.

Note: Detailed Damage Evaluations were called Detailed Engineering Evaluations when these recommendations were written in 2012.

Recommendation 123	The Ministry of Business, Innovation and Employment should work with the New Zealand Society for Earthquake Engineering, the Structural Engineering Society New Zealand and others with appropriate experience and expertise to finalise guidelines for Detailed Engineering Evaluations as soon as possible.
Recommendation 152	Plans-Based Assessments and Detailed Engineering Evaluations should include checking the vulnerabilities observed after the Canterbury earthquakes that the Royal Commission describes in Volume 2, section 6.2.5 of Volume 4, and section 6.3.8 of Volume 6 of this Report.
Recommendation 153	Any Plans-Based Assessment and Detailed Engineering Evaluation of a building after an earthquake should begin with a careful examination of the building's plans.
Recommendation 154	The Plans-Based Assessment and Detailed Engineering Evaluation should confirm that all known falling hazards and other vulnerabilities have been assessed and secured or removed.
Recommendation 155	A copy of the Plans-Based Assessment and the Detailed Engineering Evaluation should be given to the relevant authorities.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The original Detailed Engineering Evaluation (DEE) procedure was developed by MBIE's Engineering Advisory Group and published by the Structural Engineering Society New Zealand (SESOC) in 2012. This will evolve into the Detailed Damage Evaluation (DDE) procedure which, as recommended for a plans-based assessment, includes evaluation of the structural drawings for a building.

Ongoing actions

SESOC, the New Zealand Society for Earthquake Engineering, and MBIE are continuing to develop the DDE guidelines to incorporate Royal Commission recommendations and feedback from engineers who have used them since their publication. The residual capacity of buildings damaged during earthquake shaking is being investigated by MBIE, with support from NZSEE. This is being undertaken with collaboration from Japan to consider their system. Results will be incorporated into the DDE procedure.

The MBIE guidelines for DDE will be periodically updated as the ongoing research results are published.

Communicating risk and hazard

There was confusion about the risks posed by damaged buildings and how that risk should be conveyed using placards.

Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012.

Recommendation 142	The placards placed as a result of the building safety evaluation process should be rewritten in a plain English format.
Recommendation 143	In principle, the colour of the green placard should be changed to white. The Ministry of Business, Innovation and Employment should consult with the international building safety evaluation community about the merits and detail of the change before deciding whether or not to do this.
Recommendation 141	Only official building safety evaluators should be authorised to place, change or remove placards, and to carry out rapid assessments for this purpose.
Recommendation 144	Formal procedures should be developed that set out when and how the status of a building could be changed. The placard on a building should only be changed if the formal procedures are followed.
Recommendation 145	The Ministry of Business, Innovation and Employment should be responsible for developing and releasing public communication materials about building management after earthquakes and other disasters during and after the state of emergency.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The local and international building assessment communities were consulted on changing the green placard to a white placard to indicate that there is low risk rather than no risk perceived by the community when it was green.

The 2014 system for managing buildings following earthquake and flooding emergencies included:

- placards that were rewritten in plain English
- white placards to indicate low risk
- explanations about the assessment and placarding process for building owners and managers.

> included placarding provisions within the revised 2014 system for managing buildings following earthquake and flooding emergencies

> revised placard colours and content included in field guides for assessing buildings after a natural disaster

The 2015 consultation document proposed changes to the Building Act 2004 to address how and when a placard can be updated or removed once the emergency is no longer in force.

Ongoing actions

Once the emergency management amendment to the Building Act 2004 has been enacted, MBIE will develop communication materials for a territorial authority to use during an emergency and transition periods.

Communicating risk and hazard (continued)

Recommendation 146	GNS Science should develop protocols and plans to ensure that it is ready to advise the Ministry of Business, Innovation and Employment, other government agencies, local authorities and the wider public after an earthquake.
Lead Organisation	GNS Science

Response

Actions taken

A Memorandum of Understanding between GNS Science and the Ministry of Civil Defence & Emergency Management (MCDEM) was updated to include processes for GNS Science to interact with and provide information and advice to MCDEM, MBIE, and the wider government system.

- > improved communication between GNS Science, its key stakeholders, and the public (tested during the 2013 Cook Strait earthquakes, the 2014 Eketahuna earthquake and the 2016 Kaikoura earthquake)

The GeoNet project team has developed a protocol for rapid publication of possible future scenarios following significant earthquakes and other natural disasters, such as volcanoes and tsunami risks.

- > developed a protocol for rapid publication of the possible future scenarios following significant events

In addition, GNS Science has:

- introduced, and continues to improve, methods of providing information to key stakeholders and the public such as GeoNet Quake (230,000+ active users)
- enhanced education using media and social media campaigns, including development of a support community for GNS Science (the 'GeoNet Community')
- started to use social media after events to provide public information on both what has happened and what may happen next
- increased the use of science liaison officers to provide expert advice to government officials and ministers
- participated in national exercises including Exercise Tangaroa in August and September 2016.

Ongoing actions

GNS Science is:

- continuing to develop scalable 'whole of GNS Science' event response procedures based on the Coordinated Incident Management System (this is the across-agency emergency response management system)
- developing a periodic publication of earthquake probabilities for all of New Zealand, expanding on the current publication of earthquake probabilities following significant earthquakes
- working with MBIE to develop protocols for providing critical data and information to key stakeholders.

Cordons and barricades

It was unclear who had the responsibility and authority for setting up, maintaining, and removing cordons and barricades around buildings.

Recommendation 156	Civil defence and emergency management should be responsible for setting up and maintaining cordons during the state of emergency.
Recommendation 157	Territorial authorities should be responsible for maintaining any cordons that are in place at the end of the state of emergency until the public space or building they surround is made safe.
Recommendation 158	Territorial authorities should be able to recover the costs of maintaining any necessary cordons from the building owner after three months.
Lead Organisations	Ministry of Civil Defence & Emergency Management (156) Ministry of Business, Innovation & Employment (157 & 158)

Response

Actions taken

In 2015, the Director of the Ministry of Civil Defence & Emergency Management published a guideline for planning the implementation of movement control during an emergency.

- > published guideline for *Emergency Movement Control, Director's Guideline for CDEM Groups, and other agencies with responsibilities for movement control in an emergency [DGL 18/15]*

The Civil Defence Emergency Management Amendment Act 2016 provides powers for territorial authorities to manage damaged buildings during transition periods.

- > enacted the Civil Defence Emergency Management Amendment Act 2016
- > The 2015 discussion document on proposed changes to the Building Act 2004 included arrangements for restricting access to buildings, including cordons and barricades and the recovery of related costs if cordons are still required after three months. included cordon and barricade management in proposed changes to the Building Act 2004

Ongoing actions

Once the emergency management amendment to the Building Act 2004 has been enacted, MBIE will develop communication materials on cordoning and barricades for a territorial authority to use during an emergency and transition periods.

Restoring public safety around dangerous buildings

There were insufficient powers to cordon, repair or demolish buildings posing a public safety risk that have been damaged by earthquake.

Recommendation 92	<p>The Building Act 2004 should be amended to empower territorial authorities to take action where a building is not deemed dangerous under section 121 or earthquake-prone under section 122, but requires immediate repair or demolition due to damage caused by an event such as an earthquake.</p> <p><i>Note: Section 121 excludes earthquakes.</i></p> <p><i>Note: Section 122 has a statutory process that may delay the danger being addressed.</i></p>
Recommendation 100	<p>Legislation should provide that, where a building is in a state that makes demolition or protective works necessary to protect persons from injury or death, no consent is required, regardless of whether the building is protected by a district plan, or registered or otherwise protected under the Historic Places Act 1993.</p> <p><i>Note: The Historic Places Act 1993 was repealed on 20 May 2014 by section 105 of the Heritage New Zealand Pouhere Taonga Act 2014.</i></p>
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The *Civil Defence Emergency Management Amendment Act 2016* provides provisions for managing the safety of people in and near a building during transition periods, which includes carrying out stabilisation work and demolitions.

> enacted *Civil Defence Emergency Management Amendment Act 2016*

The 2015 discussion document on proposed changes to the Building Act 2004 addressed how public safety should be restored when a building is severely damaged during an event such as an earthquake. This includes providing for the appropriate management of significant heritage buildings.

> included proposed changes to manage life safety risk in the *Building Act 2004*

Ongoing actions

The Government decided on a new system for managing buildings after an emergency in November 2016. It is intended that new legislation will be introduced into Parliament in 2017 to amend the Building Act 2004.

Mobilising rapid building assessors

The building assessment and management system relied heavily on untrained volunteers for its design, mobilisation and delivery.

Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012.

Recommendation 118	The Ministry of Business, Innovation and Employment should progress their proposal to establish a core team of building safety evaluators that the Ministry could call on.
Recommendation 119	The Ministry of Business, Innovation and Employment should carefully consider the merits and detail of any proposals about the size of this group of building safety evaluators.
Recommendation 120	The ability to supplement this team with more evaluators who have received basic training should be maintained.
Recommendation 133	Only trained building safety evaluators should be authorised to participate in a building safety evaluation operation unless the circumstances of a particular disaster make this impractical.
Recommendation 134	If the scale of the emergency requires the mobilisation of the largest group of potential building safety evaluators, who have not received the compulsory training, these evaluators should work, wherever practicable, under the supervision of those evaluators who have attended the compulsory training.
Recommendation 136	The Ministry of Business, Innovation and Employment should keep a list of the people who complete the compulsory training for building safety evaluators and should make this list available to all territorial authorities.
Recommendation 121	Legislation should continue to provide for a waiver of liability for building safety evaluators carrying out rapid assessments.
Recommendation 122	The liability waiver for building safety evaluators should be aligned with the building safety evaluation process instead of being restricted to an operation carried out in a state of emergency.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The revised post-emergency building assessment system published in 2014 addressed these recommendations using three tiers of post-disaster building usability assessors:

- Tier 1 – a small group of highly-skilled building assessors who provide leadership for the other two tiers of rapid building assessors
- Tier 2 – a core group of 400 trained rapid building assessors who reside throughout New Zealand and can be quickly mobilised in an emergency
- Tier 3 – a larger group who will support rapid building assessors when there are very large events. They receive basic training and work under supervision after they are mobilised.

MBIE has established the small Tier 1 group of building assessors. This group will also assist with training and development of any required guidance.

> established the Tier 1 small group of highly-skilled building assessors

In 2015, MBIE trained the core group of 400 Tier 2 rapid building assessors, who are mostly building control officers and Chartered Professional Engineers from across New Zealand, in the revised building management following emergency system.

> trained 400 rapid building assessors

MBIE created a national deployment register with the 400 Tier 2 rapid building assessors.

> established the national register of trained rapid building assessors

New provisions are provided in the Civil Defence Emergency Management Amendment Act 2016 protecting building assessors from liability during transition periods.

Ongoing actions

MBIE is developing guidance for training and mobilising the Tier 3 group, who provide support for Tier 2 assessors. It is intended that this group will be identified and trained in 2016. A register will be established for this group.

The Government has decided to introduce a new system for managing buildings after an emergency event. It is intended that new legislation will be introduced into Parliament in 2017 to amend the Building Act 2004.

Training building assessors

The volunteers carrying out building assessments had a mix of knowledge, skills, and experience, which resulted in inconsistent assessments.

Note: The rapid building assessment process was called the building safety evaluation process when these recommendations were written in 2012.

Recommendation 129	The building safety evaluation process should incorporate a training programme for all building safety evaluators.
Recommendation 130	Such training should cover: <ul style="list-style-type: none">• what the building safety evaluation process is and how it works; and• how to identify and assess the damage evaluators observe in buildings after an earthquake
Recommendation 131	This training programme should be developed using the New Zealand Society for Earthquake Engineering's building evaluation resource and training capability objectives framework, in which building safety evaluators are split into three different groups and each group receives a different level of training.
Recommendation 132	The core group of building safety evaluators who are a national resource capable of leading a building safety evaluation operation, and those Chartered Professional Engineers, structural engineers and senior building officials who wish to be building safety evaluators, should be required to attend compulsory training.
Recommendation 135	Territorial authority staff with civil defence and emergency management responsibilities should be required to attend the compulsory building safety evaluator training as part of their job training.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

The revised post-emergency building assessment system published in 2014 requires three tiers of assessors who are trained to use the building usability assessment field guides.

MBIE determined the appropriate levels of training to be delivered to the three tiers of assessors. This training is based on the New Zealand Society for Earthquake Engineering (NZSEE) *Building evaluation resource and training capability objectives framework*.

The Tier 2 training has been developed and a core group of 400 people have been trained, certified, given ID cards. A list of Tier 2 assessors is included on the national deployment register held by MBIE.

> trained and registered 400 Tier 2 rapid building assessors

Ongoing actions

Tier 1 training (for the managers of the building assessment process) will be incorporated into council civil defence and emergency management exercises in 2017.

MBIE is developing guidance and associated Tier 3 training for a group to support the Tier 2 rapid building assessors. The Tier 3 group will receive basic training and be mobilised after very large events. All cities and districts will be targeted for Tier 3 training.

Refresher training needs to be ongoing so that rapid building assessors are aware of any changes to best practice and can be mobilised and operational. MBIE plans to provide annual contact and five-yearly refresher training to maintain the 400 assessors' registration.

Forensic investigations following building collapse

There were no guidelines for forensic structural investigation of the collapsed Canterbury Television and Pyne Gould Corporation buildings.

Recommendation 108	The Ministry of Business, Innovation and Employment should consider developing guidelines for structural failure investigations, including circumstances in which sites should be preserved for formal forensic examination.
Lead Organisation	Ministry of Business, Innovation & Employment

Response

Actions taken

MBIE commissioned guidelines for undertaking forensic investigations into building failure, drawing on international best practice and the experience from investigations carried out by MBIE in Christchurch, and in Invercargill following the Southland Stadium collapse. The guidelines were completed in 2015 and will be used by MBIE in the event of having to undertake major forensic investigations into building failure.

> produced *Guidance for the Investigations into Building Failure*

Under the National Civil Defence Emergency Management Plan Order 2015, MBIE is to “lead the securing and management of compromised building sites for forensic investigations” during an emergency.

Ongoing actions

The MBIE policy development programme includes consideration for providing more specific investigation powers following building failure or where there is a building related risk to life safety. Issues to be addressed in the policy development process include protecting the site and materials to allow the investigation to be carried out, and powers to obtain any relevant design or construction information.

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