16th World Conference on Earthquake, 16WCEE 2017

Santiago Chile, January 9th to 13th 2017

Paper N° 1078

Registration Code: S-B1463084170

THE CONTINUED RESPONSE OF THE NEW ZEALAND GOVERNMENT TO THE CANTERBURY EARTHQUAKES

D. McGuigan[(1)], M. Stannard[(2)], L. Bellamy[(3)], J. Gardiner[(4)]

[(1)] *Deputy Chief Engineer, Ministry of Business, Innovation & Employment, dave.mcguigan@mbie.govt.nz*
[(2)] *Chief Engineer, Ministry of Business, Innovation & Employment, mike.stannard@mbie.govt.nz*
[(3)] *Ada Rutherford Professor of Architectural Engineering, University of Canterbury, larry.bellamy@canterbury.ac.nz*
[(4)] *Manager Determinations & Assurance, Ministry of Business, Innovation & Employment, john.gardiner@mbie.govt.nz*

Abstract

The Canterbury earthquakes of 2010 and 2011 caused significant damage and disruption to the city of Christchurch, New Zealand. A Royal Commission was established to report on the causes of building failure as a result of the earthquakes as well as look at the legal and best-practice requirements for buildings in New Zealand Central Business Districts. The Royal Commission made 189 recommendations on a variety of matters including managing damaged buildings after an earthquake, the adequacy of building codes and standards, and the processes of seismic assessments of existing buildings to determine their earthquake vulnerability. In response the Ministry of Business, Innovation and Employment, the agency responsible for administering building regulation in New Zealand, established a work programme to assist with the Canterbury rebuild and to implement the lessons learned throughout New Zealand. The five primary work streams in the programme are:

- Facilitating the Canterbury Rebuild
- Structural Performance and Design Standards
- Geotechnical and structural guidance
- Existing Building Resilience
- Post Disaster Building Management

This paper provides more detail on each of the work streams. There has been significant collaboration between the New Zealand Government and the research community, technical societies, and engineering consultants, both within New Zealand and internationally, to deliver the programme and improve the resilience of the New Zealand built environment. This has presented major challenges for an extremely busy industry in the aftermath of the Canterbury earthquakes. The paper identifies the items of work that have been completed and the work that is still in progress at the time of writing.

Keywords: Canterbury Earthquake; Structural Design Standards; Post-Disaster Building Management; Building Resilience

1. Introduction

The devastating Christchurch earthquake on 22 February 2011 resulted in the loss of 185 lives, led to the Central Business District of Christchurch being inaccessible for over three years, and the eventual demolition of nearly 1600 buildings in the central city. This earthquake was part of the Canterbury earthquake sequence that commenced in September 2010. The New Zealand Government was required to provide leadership to the building design and construction sector to support the rebuild activity and review the wider implications for New Zealand.

A Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes made 189 recommendations in their final report [1]. The Building System Performance branch within the central New Zealand government agency of the Ministry of Business, Innovation & Employment (MBIE) was the primary agency tasked with responding to recommendations made by the Royal Commission. A work programme with five main work streams was developed:

- Facilitating the Canterbury Rebuild
- Structural Performance and Design Standards
- Geotechnical Earthquake Engineering Guidance
- Existing Building Resilience
- Post Disaster Building Management

MBIE reviewed its own technical capability and additional geotechnical and structural engineering staff have been appointed so it could more effectively respond to the issues generated by the earthquakes. The government has been strongly supported by technical societies and specialist advisors through the formation of an Engineering Advisory Group comprising technical specialists.

This paper provides more specific detail on each of the work programmes and also looks into other initiatives the MBIE has taken to improve the built environment.

2. Facilitating the Canterbury Rebuild

2.1 Developing Guidance

Approximately 167,500 residential dwellings were damaged because of the 2010 and 2011 Canterbury earthquakes. The subsequent residential repair and rebuild of damaged homes is one of the largest residential building projects in the history of New Zealand. This significant volume of repair and reconstruction activity challenged the insurance assessment, engineering design, construction, and consenting capacity in New Zealand. To address this challenge, MBIE, in collaboration with external technical experts, developed guidance to assist with the repair and rebuild of houses in the Canterbury region [2]. Overseas experiences of recovery from major earthquakes has shown that confusion, delays, and additional design costs can occur if designers, insurers, and local authorities have different perspectives and therefore this guidance document encourages a consistent approach.

Key features of the guidance include:

- Assigning foundation technical categories to assist with determining the site investigation requirements and the most appropriate foundation systems for a site.
- Providing guidance criteria to assist with decision making around whether to repair or rebuild.
- Providing design solutions and construction methods that meet the requirements of the Building Code.

To support the release of the guidance and ensure it is being understood by its target audience, MBIE has provided training sessions on specific topics, facilitated feedback sessions with key stakeholders, and developed a suite of answers to common questions or issues raised in the application of the guidance.

Guidance has also been developed for the assessment, repair, and rebuild of earthquake-affected industrial buildings in Canterbury [3] to address the specific nature and use of these buildings.

2.2 Monitoring the Quality of the Canterbury Rebuild

The significant volume of residential repair and rebuild as outlined in the previous section was a major challenge to the consenting, design and construction fields and concerns were raised by the media, advocacy groups, and individual homeowners about the quality of the repair work. This led MBIE in 2014 to undertake a review of the quality of structural residential repair work being done. MBIE conducted a physical survey of 101 homes that focussed on houses with completed structural repair work that was exempt from a Building Consent. The homes were randomly selected from information provided by four agencies that were involved in the delivery of home repair programmes and homeowners were invited to voluntarily participate in the survey. The survey found [4] that there were a significant number of homes with non-compliant or deficient repairs. Recommendations were made to address the repair quality issues identified.

In early 2016, MBIE followed up with the agencies that participated in the survey to ensure steps had been taken to address the quality issues and was generally pleased with the actions that the agencies have taken to improve their quality processes.

3. Reviewing the Structural Provisions of the Building Code and Structural Design Standards

3.1 Review of Building Code Structural Provisions and development of Guidance

The Canterbury earthquakes provided many lessons on how buildings performed including the need to clarify structural performance requirements. A review of the New Zealand Building Code Structural Provisions [5] has sought to clarify the performance requirements and to what extent the likely physical conditions need to be considered. Significant changes to the B1-Structure code clause were considered including the introduction of a risk-informed performance matrix containing a series of Tolerable Impact Level Statements (TILS). The TILS specify structural performance outcomes depending on the severity of the natural disaster (earthquake, wind, and snow) for buildings with different importance levels and design lives. MBIE's Engineering Advisory Group considered it premature to incorporate TILS in the B1-Structure code clause primarily due to concerns relating to complexity, liability and lack of verification of TILS. It was considered more appropriate to include them in a guidance document to the B1-Structure code clause. This guidance document is intended to give structural engineers a better understanding of the objectives and performance criteria of the B1-Structure code clause. The guidance is also expected to provide standards writers with clear and consistent definitions of what is required for building structures to meet the structural provisions of the Building Code.

At the time of writing, the guidance document is being developed and it is intended to go out for building sector consultation in the second half of 2016.

3.2 Increased Building Resilience

An important question raised by the Canterbury earthquakes was whether the structural performance requirements in the Building Code met societal expectations. While the life-safety objectives of the Building Code were generally met by modern buildings, the significant damage and disruption to Christchurch led to calls for improved building performance to reduce the likelihood of similar disruptions in future, similar magnitude earthquakes. In late 2015, MBIE commissioned research to analyse whether there are economic justifications for raising the structural performance requirements in the code. At the time of writing, this research is still in progress.

3.3 Review of Structural Design Standards

The Royal Commission highlighted a number of concerns with the primary structural design standards that contributed to undesirable building performance. The initial focus was to make amendments to the Earthquake Actions Standard (NZS1170.5) and the Concrete Structures Standard (NZS3101) to address these concerns. MBIE commissioned Standards New Zealand to manage the amendments to these standards. The amendment to NZS1170.5 was published in September 2016 and the amendment to NZS3101 is expected to be published in early 2017. These amendments are to be followed by a more comprehensive review process of the primary structural design standards that will incorporate the findings of both local and international research that are relevant to these standards.

MBIE's Building System Performance and Standards New Zealand held a workshop with key players in the structural engineering sector in May 2016 to determine the future direction of the primary structural design standards including:

- Structural Design Actions (AS/NZS1170:2002 & NZS1170.5:2004)
- Concrete Structures (NZS3101:2006)
- Structural Steel (NZS3404:1997)
- Timber Structures (NZS3603:1993)

The objectives of the workshop were to:

- streamline future revisions of these standards
- encourage greater consistency of presentation and approach in these standards
- ensure the standards address the overarching objectives of the B1-Structure clause of the Building Code

It is also important to note that one of the main directives from the Minister of Building and Housing is to significantly increase the investment in standards for the building industry in the coming years to improve the future performance of the sector.

4. Developing Geotechnical Earthquake Engineering Guidance

MBIE, in collaboration with the New Zealand Geotechnical Society, is developing geotechnical guidance to improve the understanding of likely ground performance under seismic action. This has included a suite of Earthquake Geotechnical Engineering modules that provide guidelines for practising geotechnical engineers. Specific guidance for ground improvement for residential properties in the Canterbury region was issued in November 2015. The overview module was issued in March 2016 [6]. The main objective of the guidelines is to promote a consistent approach to engineering practice in New Zealand and improve the earthquake performance of the built environment. The other modules in development, at the time of writing, will provide guidance on the following topics:

- geotechnical investigation for earthquake engineering
- liquefaction assessment
- foundation and retaining wall design
- ground improvement methods and specification
- slope stability
- rockfall protection structures

Another significant development is the establishment of a New Zealand-wide geotechnical database, building on the successful Canterbury Geotechnical database that was developed to assist with the greater

Canterbury rebuild. It provides a platform for geotechnical professionals to store and readily access the results of all geotechnical investigations in the wider area when considering new building work. This enables a much greater understanding of subsurface conditions allowing building projects to be much better informed as to the likely behaviour of ground under seismic actions. Buildings can then be more economically designed appropriate to ground conditions. It supports the government philosophy of maximising the use of data, upload once and download multiple times. The New Zealand database is run via a voluntary "terms of use" whereby registered users are able to download factual information for use on a project but in return must upload new geotechnical factual information generated for these same projects. Liability on the use of the geotechnical data by data providers is waivered by those who download information by way of the database "terms of use".

5. Existing Building Resilience - Improving the System for Managing Earthquake Risk Buildings

5.1 Developing new Earthquake-prone Building legislation

The Canterbury earthquake sequence highlighted the vulnerability of some of New Zealand's existing building stock and the government wished to minimise this risk for future generations. While legislation already existed under the Building Act 2004 to identify and address buildings considered to possess an unacceptable risk in an earthquake (defined in legislation as an earthquake-prone building), it was left to local authorities to develop their own policies and this often led to inconsistent approaches across New Zealand.

The emphasis was therefore to develop a consistent national framework to identify and subsequently address buildings assessed as earthquake-prone.

The Building (Earthquake-prone Buildings) Amendment Bill was introduced in 2013 and was passed by Parliament in May 2016. Key features of the bill include:

- Avoiding a 'one-size' fits all approach and instead focussing on the geographic areas, buildings, and parts of buildings that pose the greatest risk
- Prioritising the identification and strengthening of educational and emergency services buildings
- Incentivising building owners to strengthen buildings in a timely manner

Regulations and a methodology to support the new legislation are currently being developed and are expected to come into effect in 2017.

5.2 Improving assessment guidance for structural engineers

The key to the successful implementation of new processes to identify and strengthen earthquake-prone buildings is improved guidance for structural engineers undertaking assessments of existing buildings. The Canterbury earthquakes led to a significant increase in the number of buildings being assessed across New Zealand to determine their likely performance in earthquakes. The current variability in building assessments, highlighted when the same building assessed by different structural engineers resulted in significantly different assessment outcomes, is an issue.

To address this issue, and provide a document that would satisfy the requirements of the new earthquake-prone legislation, MBIE in collaboration with technical societies initiated a complete review of the 2006 NZSEE guidance document [7].

The revised guidelines were prepared by structural engineering practitioners and academics specialising in the seismic assessment of buildings. The document has three sections:

- Part A – Issues and Objectives
- Part B – Initial Seismic Assessment
- Part C – Detailed Seismic Assessment

Part D has been proposed to provide guidance on seismic improvement methods for existing buildings.

The detailed seismic assessment section places more emphasis on understanding the deformation of a building in order to obtain a more appropriate rating, rather than assigning a building rating on the strength of the weakest element or member.

The new guidelines will also provide templates to ensure consistent assessment reporting and this will support reviews when there are different assessments results for the same building.

6. Post-Disaster Building Management

6.1 Building Usability Assessments

The Royal Commission highlighted a number of issues around the processes for assessing and placarding buildings in the immediate aftermath of earthquakes, typically performed by structural engineers. Also, the objectives of the building assessment process were not always well understood by the public.

The Royal Commission made a number of recommendations for building management operations following emergencies. This included developing guidance for assessors and local authorities who manage operations, defining roles, providing appropriate training to enable consistent assessments, amending placarding practice, and providing enabling legislation for initiating building management operations in emergencies.

Field guides for assessors have been produced drawing on ACT20 material. Other guidance to assist Local Authorities prepare for managing building assessment processes in the event of earthquakes or flooding is being developed and is intended to be released by the end of 2016.

To ensure there is a national group of building assessors, MBIE has provided training to building professionals, predominantly structural engineers and building officials, throughout 2015 to support a three-tier structure of building assessors:

- Tier 1: a small group of highly-skilled building assessors to provide leadership for the wider group of building assessors (in development).
- Tier 2: a core group of 400 building assessors around New Zealand to be called upon in an emergency.
- Tier 3: a larger group that will receive basic training and can provide support for the building assessors (in development).

Ongoing work in this area includes incorporating building emergency management powers into the Building Act 2004. A consultation document was issued by MBIE in 2014 [8] and it is intended that any amendments will be introduced in 2016.

6.2 Guidelines for Building Failure Investigations

As a result of the 22 February 2011 Christchurch earthquake, MBIE's predecessor agency, the Department of Building and Housing, undertook a number of building failure investigations. It was recognised that comprehensive guidelines and legal powers were necessary for undertaking these investigations. MBIE engaged external consultants to develop guidelines, which will be used to provide guidance on what to do in circumstances when sites need to be preserved for formal forensic examination.

7. Other Initiatives

7.1 Review of the occupational regulation of engineers

To address concerns about the perceived lack of accountability of engineers after of the Canterbury earthquakes, MBIE issued a consultation document in September 2014 [9] that proposed a review of the occupational regulation of engineers in New Zealand.

Four key proposals were provided in the document:

- Emphasising the need for buildings to be designed by people with the right knowledge, skills, and competence.
- Developing a robust system to hold engineers to account when they perform sub-standard work.
- Promoting greater rigour in the assessment of chartered professional engineers.
- Improving the checks and balances in the system to regulate engineers.

The responses received generally supported the objectives of the review, in particular a desire to improve the quality of new graduates and engineering practitioners. Most submissions accepted that some change was needed to the regulatory system, especially to disciplinary processes.

The strongest message from the submissions received to the consultation document [10] was that changes to occupational regulation alone will not deliver all the objectives. Respondents identified that the proposed reforms needed to occur in conjunction with changes to the engineering profession and the building system to improve:

- General engineering practice
- Processes within the building regulatory system
- Construction processes for engineering works including linking responsibility for design with site monitoring and oversight of building construction

The review was broadened to incorporate other key occupational groups within the building sector including architects, electricians, plumbers, and builders to ensure that these groups have the right knowledge, skills, and competencies and that they will be held to account if their work is sub-standard. A consultation document seeking sector feedback is expected to be issued in the second half 2016.

7.2 Low-Damage Building Systems Guidance

The Royal Commission recommended that MBIE, in collaboration with researchers and technical societies, should continue research and develop guidance to promote the use of low-damage building systems. The use of these systems in new buildings became more prevalent after the Canterbury earthquakes. Low-damage systems frequently used include base isolation, buckling restrained braces, and viscous damping. Concerns were expressed by practitioners that some systems were unproven and the basis for calling them low-damage technologies may be arbitrary.

MBIE, in collaboration with technical societies, has initiated a project to provide more definitive guidance, including establishing performance objectives and criteria, for these new technologies so that both building owners and practitioners have an improved understanding of what they should expect when considering a low-damage system. It is expected that this guidance, intended to be completed by the end of 2016, will provide the structure for a suite of guidance documents for more detailed technical requirements for specific low-damage systems.

The most mature and proven low-damage system is considered to be base isolation and a separate project, supported by MBIE, is underway to develop specific guidelines for this system. This project is also intended to be completed by the end of 2016.

7.3 Seismic Performance of Non-structural elements

The Canterbury earthquakes and subsequent earthquakes in other regions of New Zealand highlighted concerns about the performance of non-structural elements. In some cases, the poor performance of non-structural elements caused buildings to be unusable for significant periods of time.

An MBIE project is looking at the design, construction, and consenting aspects related to the non-structural elements in buildings. A steering group has been formed to provide advice, direction, and industry

support for the project. Research has been commissioned to look at the risks and economic considerations associated with the failure of non-structural elements.

Future project work is expected to include revising the relevant design standards, developing guidance, and providing a training and education programme to upskill the building sector on requirements relating to non-structural elements.

7.4 Built Environment Leaders Forum

In September 2015, MBIE, in conjunction with the Earthquake Commission and the Building Research Association of New Zealand, convened a Built Environment Leaders Forum. This Forum brought together public and private sector leaders to identify actions needed to improve the management of risks from natural hazards to the built environment. The Forum was an opportunity to reflect on the lessons learned from Canterbury and to develop an action plan to achieve a more resilient built environment in New Zealand.

Actions identified to achieve greater resilience include:

- Creating strong national leadership, both public and private sector working together
- Creating a community engagement programme to build understanding of risks
- Improving the resilience of critical infrastructure, better understand interdependencies and community expectations for levels of service
- Developing a better understanding of incentives and tools to increase building resilience

It is intended that further Built Environment Leaders Forums will be held to review progress against the identified actions and consider future directions to improve the resilience of the New Zealand built environment.

8. Conclusions

This paper has demonstrated how MBIE has continued to play a significant role in supporting the building design and construction sector in New Zealand in response to the issues raised by the Canterbury earthquakes. This has included reviewing and increasing its own technical capability and developing a comprehensive work programme to respond to the recommendations made by the Royal Commission.

MBIE, in collaboration with external experts, has focussed on the development of guidance for a range of subjects to provide consistent application of engineering analysis and methods. These include:

- Repair and rebuild guidance for Canterbury
- Earthquake geotechnical engineering guidance
- Seismic assessments of existing buildings
- Investigations into building failures
- Building usability assessments after a natural disaster
- Low-damage design systems

MBIE, in collaboration with other agencies and technical societies, continues to review the challenges to improve the built environment. Implementation of new earthquake-prone legislation is intended to improve or remove the majority of buildings that pose an unacceptable risk in an earthquake.

It is expected that MBIE will significantly increase its investment in standards for the building industry to improve the performance of the sector.

Finally, MBIE recognises that it needs to continue working with the engineering profession to monitor engineering practice, as well as the processes within the building regulatory system, to ensure buildings are designed and built by people with the right skills and competence.

9. Acknowledgements

The authors would like to primarily acknowledge the support of the following New Zealand engineering technical societies for their assistance and collaboration with the work programme:

- New Zealand Society for Earthquake Engineering
- New Zealand Structural Engineering Society
- New Zealand Geotechnical Society

10. References

[1] Canterbury Earthquakes Royal Commission, *Final Report*, November 2012

[2] Ministry of Business, Innovation & Employment: *Guidance: Repairing and rebuilding houses affected by the Canterbury earthquakes*, 2012.

[3] Ministry of Business, Innovation & Employment: *Guidance: Assessment. Repair and rebuild of earthquake-affected industrial buildings in Canterbury*, 2014.

[4] Ministry of Business, Innovation & Employment: *Earthquake Repairs to Canterbury Homes: Home Inspection Survey Report*, August 2015.

[5] Lawrance G. M., Hopkins D. C., Cheong D. P. H., Stannard M.C.: *Review of the Building Code Structural Provisions*, NZSEE Conference, 2014.

[6] Ministry of Business, Innovation & Employment: *Earthquake geotechnical engineering practice, Module 1: Overview of the Guidelines*, March 2016

[7] New Zealand Society for Earthquake Engineering: *Assessment and improvement of the structural performance of buildings in earthquakes*, 2006.

[8] Ministry of Business, Innovation & Employment: *Building Act Emergency Management Proposals*, August 2015.

[9] Ministry of Business, Innovation & Employment*: Proposals to change the occupational regulation of engineers in New Zealand*: Proposals Document, September 2014

[10] Ministry of Business, Innovation & Employment: *Proposals to change the occupational regulation of engineers in New Zealand: Summary of Submissions*, January 2015