

FINAL REPORT



H.2



**VOLUME 5**

SUMMARY AND RECOMMENDATIONS IN VOLUMES 5-7

CHRISTCHURCH, THE CITY AND APPROACH TO THIS INQUIRY



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A. A bird’s eye view of Banks Peninsula and the Canterbury Plains (source: Alexander Turnbull Library) B. Manchester Street, looking towards the Avon River, circa 1868 (source: Christchurch City Libraries)

C. An aerial photo of Christchurch central city taken in October 2012 after many of the buildings had

been demolished (source: Canterbury Earthquake Recovery Authority)

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**Contents**

**Letter of Transmittal**

**Introduction**

**Section 1: Summary and recommendations – Volumes 5–7**

Volume 5: Christchurch, the City and approach to this Inquiry

Volume 6: CTV Building

Volume 7: Roles and responsibilities

**Section 2: Christchurch, the City**

2.1 Introduction

-

2.2 Ma-ori Settlement in Otautahi (Christchurch)

2.3 European settlement

2.4 Christchurch’s built environment

2.5 Christchurch before the earthquakes

2.6 Economic activity of the region and city

2.7 Impact of the earthquakes

**Section 3: Methodology**

3.1 Establishment of the Canterbury Earthquakes Royal Commission

3.2 Terms of Reference

3.3 The Royal Commission’s approach to the issues

3.4 Records management

3.5 Communications

3.6 Bereaved families, injured and tenants

3.7 Reporting requirements

**Appendix 1: Terms of Reference**

**Appendix 2: Expert advisors**

**Appendix 3: Submitters and witnesses**

**Appendix 4: Hearings Schedule**

**Appendix 5: Glossary of terms**

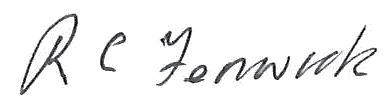
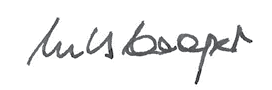
**Letter of Transmittal**

To His Excellency, Lieutenant General The Right Honourable Sir Jerry Mateparae GNZM, QSO Governor-General of New Zealand

Your Excellency

Pursuant to the Orders in Council dated 11 April 2011, 7 February 2012 and 23 October 2012 appointing us to be a Royal Commission of Inquiry into Building Failure caused by the Canterbury Earthquakes and to provide a Final Report not later than 30 November 2012, with a first part delivered by 29 June 2012 and a second part delivered on10 October 2012, we now humbly submit the third and final part of our Final Report for Your Excellency’s consideration.

We have the honour to be

Your Excellency’s most obedient servants **Hon Justice Mark Cooper (Chairperson) Sir Ronald Carter**

**Adjunct Associate Professor Richard Fenwick**

Dated at Wellington this 29th day of November 2012.

**Introduction**

Volumes 5, 6 and 7 of this Report complete the reporting of the findings and recommendations of our Inquiry into building failures caused by the Canterbury earthquakes. These Volumes must be read in the context of the earlier volumes of our Report: Volumes 1–4. Those Volumes include a detailed discussion of the nature of the Canterbury earthquakes and the earthquake risk that must be taken into account by building designers in New Zealand (see section 2 of Volume 1); and the findings of the study of the representative sample of buildings, including all those buildings whose failure caused death (see Volumes 2 and 4) except for the CTV building, which is reported in Volume 6.

They also include our recommendations about matters to consider:

• when designing new buildings (see section 4 of

Volume 1, and Volumes 2 and 3);

• when assessing existing buildings; and

• when dealing with those buildings that are considered to be earthquake-prone or potentially earthquake-prone (see Volume 4).

This is the third, and final, part of our Final Report. The first part (Volumes 1–3) was delivered in June 2012; the second part (Volume 4) was delivered in October 2012. The Terms of Reference for our Inquiry are set out again, for ease of reference, in Appendix 1 of this Volume. The matters dealt with in Volumes 5, 6 and 7 relate to the:

• Inquiry into specified buildings, namely the

Canterbury Television (or CTV) building (Volume 6);

• Inquiry into the adequacy of legal and best-practice requirements for the design, construction, and maintenance of buildings in central business

districts in New Zealand to address the known risk

of earthquakes and, in particular–

– the legal and best-practice requirements for the assessment of, and for remedial work carried out on, buildings after any earthquake (section 2 of Volume 7); and

– the roles of central government, local government, the building and construction industry and other elements of the private sector in developing and enforcing legal and best-practice requirements (sections 3, 4 and 5 of Volume 7).

Volume 5 sets out our approach to the Inquiry as

a whole and includes a brief description of the city of Christchurch and the impact of the Canterbury earthquakes.

One of the most significant and tragic consequences of the 22 February 2011 earthquake was the rapid and total collapse of the CTV building, which is the subject of Volume 6. We extend our sympathy to all those who lost a family member or friend in the collapse of that building and acknowledge their grief. We have endeavoured in our Inquiry to be thorough and to find the reasons why this building suffered such a catastrophic collapse. We hope that the investigation we have carried out, and the findings we have made, will provide some of the answers people have sought. In Volume 6 we have set out the facts, and our analyses of the building’s design, construction, assessment following the September earthquake,   
and collapse.

Volume 7 addresses matters relating to the systems and skills we have in New Zealand to ensure that buildings are well-designed and well-built, and that following an event such as an earthquake, damage to buildings can be assessed and appropriate actions taken. Section 2 of Volume 7 addresses the latter subject in some detail: we have reviewed the building safety evaluations that occurred after the September and Boxing Day 2010 earthquakes, and the subsequent processes, and conclude that the system and skills we have are adequate but that there is a significant gap in respect of those buildings whose rapid assessment resulted in a “green placard”. In sections 3 and 4 of Volume 7 we have discussed, and made recommendations for changes to, the regulatory requirements for what we have called “complex structures”. For these buildings, we have recommended a new requirement, that their design be certified by Recognised Structural Engineers, intended to be structural engineers highly experienced in the design of complex structures. This, in our view, will achieve an increased level of quality assurance in the design of such structures. We have also made recommendations that are intended to strengthen the leadership role of the Ministry of Business, Innovation and Employment. These include the development by the Ministry of a policy and regulatory work programme, in consultation with various parties. We have also concluded that the various documents that support compliance with the Building Code need to be reviewed and updated regularly, and have made recommendations for this to occur.

Other subjects we address in Volume 7 include the training and education of civil engineers and the organisation of the civil engineering profession. Among the recommendations that we make are a proposal that there should be an ethical obligation to advise the relevant territorial authority and the Institution of Professional Engineers New Zealand about structural weaknesses that have been discovered in buildings.

An issue at the margin of our Inquiry is the subject of subdivision and land use. We considered how various relevant resource management powers had been exercised by the Canterbury Regional Council (CRC) and Christchurch City Council (CCC), since one way of minimising the risk of building failure in the future is to ensure that land development rules take into account the effects that earthquakes might have on the land. Recognising the inherent uncertainties in dealing with issues of earthquake risk, we nevertheless conclude that the Resource Management Act 1991 should more explicitly acknowledge the potential effects of earthquakes and liquefaction, and we make recommendations accordingly.

**Section 1:**

**Summary and recommendations – Volumes 5–7**

In these last three Volumes of our Report, we make a number of recommendations for changes to the legislation, policies and practices for the prevention or minimisation of the failure of buildings in earthquakes, on the legal and best- practice requirements for the management of buildings after earthquakes and for the design of new buildings. The numbering of the recommendations we make continues sequentially from the recommendations made in Volumes 1 to 4 of   
our Report

**Volume 5: Christchurch, the City and approach to this Inquiry**

Section 2 of Volume 5 provides a brief history of the city of Christchurch, its buildings and its economy. It also describes the impact the Canterbury earthquakes have had on the city and its population.

In section 3 of this Volume we have set out our approach to this Inquiry, including communications

with the families of those who lost their lives in building failures in the 22 February 2011 earthquake, the public hearings we conducted and the other ways in which we gathered information, investigated matters and received submissions. We have also described the way in which we managed the thousands of documents we received in the course of our Inquiry, and the reporting structure we have followed.

**Volume 6: CTV building**

The CTV building, designed and constructed in the

mid-1980s, collapsed during the earthquake that struck Christchurch at 12:51pm on 22 February 2011. The collapse resulted in the death of 115 people and others suffered serious injuries.

Our Terms of Reference directed us to inquire into:

• whether the building as originally designed and constructed, and as altered and maintained, complied with legal and best practice requirements;

• whether the building was identified as earthquake- prone or was subject to any measures to make it less susceptible to earthquake-risk before

4 September 2010;

• the nature of the land associated with the building;

• the nature and effectiveness of assessments and

remedial work after the earthquakes on

4 September and 26 December 2010;

• why the building failed on 22 February 2011;

• why the failure caused extensive injury and death;

• why it differed from other buildings in the extent to

which it failed; and

• whether any particular features of the building

contributed to the failure.

The Terms of Reference precluded any inquiry into questions of liability. However, this did not prevent consideration of errors or failings in design, permitting, construction, inspection or any other matter that might explain why the CTV building failed and why the failure caused such extensive injury and death.

In Volume 6 we have set out our findings on these matters. The collapse of the CTV building caused much more injury and death than any of the other building failures on 22 February 2011. Even though it was designed under relatively recent building codes, its failure was severe and resulted in the floor slabs collapsing on top of one another, leaving most of those inside the building with no chance of survival.

We do not summarise our conclusions here. Readers wanting to see a summary of those findings are directed to section 9 of Volume 6, where we set out the principal conclusions we have reached. That section was also written with a view to it being translated into the languages spoken by many of the bereaved. Unusually for a New Zealand tragedy, many of those who died were foreign nationals. Resources have not permitted the full report to be translated. However, section 9 of Volume 6 has been translated into Japanese, simplified Chinese, Thai and Korean.

The engineering design of the building was deficient

in a number of respects. While there were elements of the applicable codes that were confusing, a building permit should not have been issued for the building as designed. There were also inadequacies in the construction of the building. The post-earthquake inspections of the CTV building also illustrated areas in which building assessment processes could be improved. As noted above, a summary of all our findings in respect of the CTV building is set out in section 9 of Volume 6 of this Report.

We mention here matters that are the subject of specific recommendations arising from our inquiry into the CTV building.

The CCC issued a number of permits and consents (including resource consents) for work on the CTV building between the time of its original construction and the September earthquake. In most cases, the approved work would have had no impact on the structural performance of the building in an earthquake. A penetration was cut in the floor of level 2 for installation of an internal staircase during a fit-out in 2000. We are satisfied that the penetration would not have affected the seismic performance of the building. However, in our view particular care should be takento ensure that damage to critical reinforcing does not occur when buildings are altered.

**Recommendation**

We recommend that:

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.

Following the earthquake, Urban Search and Rescue engineers working on the CTV site, Mr Graham Frost, Dr Robert Heywood and Mr John Trowsdale, took extensive photographs and labelled building elements. Their public-spirited initiative created an excellent record of the state of the building and individual elements following collapse. There was no formal system whereby this information was collected and the Royal Commission commends these engineers for their very thorough documentation and assessment of the collapse debris.

Overall, we consider that the evidence provided an adequate basis to make findings about the state of

the building after its collapse and to draw conclusions about possible collapse scenarios. However, implementation of practice guidelines for forensic engineering is warranted to ensure that high quality forensic work is guaranteed for future investigations.

**Recommendation**

We recommend that:

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.

It is important to identify other buildings in New Zealand that have characteristics that might lead to their

collapse in a major earthquake, so that appropriate steps can be taken to reduce the potential hazard posed by these structures.

**Recommendation**

We recommend that:

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.

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 that they have adequate ductility to sustain the maximum inter-storey drifts that may be induced in a major earthquake.

In sections 8 and 9 of Volume 2 and section 6.2.5 of Volume 4 of our report we discuss other issues related to the assessment of the potential seismic performance of existing buildings.

**Volume 7: Roles and responsibilities**

Section 2: Building management after earthquakes

This section considers the management of buildings after an earthquake, both during and after a state of emergency. We briefly outline New Zealand’s civil defence and emergency management framework

and give an overview of the building safety evaluation process used to assess buildings after an earthquake.

We consider 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. We appreciate the valuable evidence many of these volunteers gave the Royal Commission to assist us to make recommendations for improvements to the management of buildings after earthquakes.

The Royal Commission considers that life safety should be the main objective for managing buildings after earthquakes. We consider that current legislation provides for New Zealand’s building safety evaluation process, but we recognise that proposals to introduce new emergency management provisions into the Building Act 2004 may address some of the problems that occurred when the process transitioned from

civil defence to normal building control arrangements controlled by territorial authorities.

**Recommendations**

We recommend that:

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

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

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

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

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

New Zealand’s building safety evaluation

process;

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

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

115. The Ministry of Business, Innovation and Employment should continue working with the Ministry of Civil Defence and Emergency Management on the detail of the above proposals.

As well as considering the process of building safety evaluation, we have discussed and made recommendations about the way in which engineers evaluate buildings when carrying out rapid assessments and detailed engineering evaluations after earthquakes. We also make recommendations about the way that building safety evaluators should be identified and trained.

**Recommendations**

We recommend that:

**How evaluators assess buildings after earthquakes**

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

for aftershocks.

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

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

• the direction of the main shock and any

likely aftershocks; and

• how soil, ground conditions and any other relevant factors may affect the intensity of the ground motions in an aftershock.

**Mobilising a sufficient number of skilled building safety evaluators**

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

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

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

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

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

state of emergency.

**Guidelines for building safety evaluators**

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.

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

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

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

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

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

**Training for building safety evaluators**

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

130. Such training should cover:

• what the building safety evaluation

process is and how it works; and

• how to identify and assess the damage

evaluators observe in buildings after an earthquake.

131. This training programme should be

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

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

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

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

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

who have attended the compulsory training.

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

**Indicating that evaluators have the right skills**

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

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

Despite some problems, we consider that, overall, the building safety evaluation operations after the Canterbury earthquakes were well delivered. We recommend that a number of changes are made to improve the delivery of New Zealand’s building safety evaluation process, which follows current international best-practice.

**Recommendations**

We recommend that:

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

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

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

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

**Recommendations related to the placards**

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

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.

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.

**Communication and information management**

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

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

147. Information management systems should be developed as part of planning for

New Zealand’s building safety evaluation process.

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

149. A clear system for identifying individual buildings should be developed and included in the

plans for a building safety evaluation process.

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

The Royal Commission heard evidence that there were significant issues in the transition of responsibility for the building safety evaluation process from civil defence to normal building management arrangements governed by territorial authorities. We discuss and make recommendations about the need for transition mechanisms and about the way in which territorial authorities should manage buildings after earthquakes. We consider that all buildings should be assessed further after the rapid assessment phase of the building safety evaluation operation. This assessment should be based on the nature of the event, the type of structure and the level of damage observed. The Royal Commission has heard evidence regarding the barriers faced by some building owners motivated to address the damage to their building after the September earthquake. We consider that some of these barriers are indicative of issues with the management of earthquake-prone buildings and we make recommendations about these specific issues in Volume 4 of our Report.

**Recommendations**

We recommend that:

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

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

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

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

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

• in the case of structural steel

buildings, were designed to NZS

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

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

67% ULS or greater (we discuss the term “ULS” in section 6.2.4 of Volume 4);

ii) Group 2: buildings designed between

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

iii) Group 3: buildings designed before

1976, but not included in Group 1; and

iv) Group 4: unreinforced masonry buildings;

c buildings used for residential purposes that are three or less storeys in height should be excluded from Groups 2 and 3. In the case of those buildings, a pragmatic approach needs to be taken to assessment and occupancy, which balances the need

for shelter with safety considerations. Other commercial and residential buildings

should not be occupied unless approved for occupancy in accordance with the process outlined below;

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

e where the rapid assessment process had identified the need for further evaluation of a building in one of these defined Groups, the building should not be occupied

until the Civil Defence Controller or the territorial authority (as appropriate) has approved the occupancy of the building after the following assessments:

i) for Group 1 buildings:

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

• where significant structural damage was seen, a Plans-Based Assessment for lower levels of structural damage and

a Detailed Engineering Evaluation for

higher levels of structural damage;

ii) for Group 2 buildings:

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

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

iii) for Group 3 buildings:

• for all levels of damage, a Detailed

Engineering Evaluation;

iv) for Group 4 buildings:

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

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

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

g the Ministry of Business, Innovation and

Employment should further develop

the Plans-Based Assessment concept, in consultation with the New Zealand Society for Earthquake Engineering and the Structural Engineering Society New Zealand, and set out the Plans-Based Assessment in published guidelines.

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

6.2.5 of Volume 4, and section 6.3.8 of

Volume 6 of this Report.

153. Any Plans-Based Assessment and Detailed

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

154. The Plans-Based Assessment and Detailed

Engineering Evaluation should confirm that all known falling hazards and other vulnerabilities have been assessed and secured or removed.

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

**Cordon management**

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

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

the public space or building they surround is made safe.

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

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

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

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.

**Transition mechanism**

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

Section 3: Roles and responsibilities

Through the course of our Inquiry, we identified some systemic issues relating to the regulatory framework for buildings, such as misunderstanding of the framework, a complex and confusing suite of regulatory documents, and quality assurance issues. These issues relate to the design and construction of complex, new buildings.

Quality assurance is vital in the structural design of complex buildings. Quality assurance occurs at a number of levels throughout the design and construction of such buildings. The currently large number of building consent authorities results in inconsistent application requirements and consent decisions around the country, and varying levels of capability within these authorities.

The experience and skill of structural engineers designing such structures also may vary, with reliance placed on the building consent authority to provide a check.

This poses risks for the quality of our buildings. We have concluded that the design of complex buildings

(as defined in section 3.3.8.2 of Volume 7 of this Report)

requires a higher level of competence. We consider the appropriate regulatory procedure to ensure this occurs is through the preparation and submission of

a Structural Design Features Report at the start of the building consent authority’s assessment of a building consent application. The building consent authority would, on the basis of this report and criteria to be developed, determine if the structure is a complex one. If it is determined to be a complex structure, a “Recognised Structural Engineer” would be required to certify the structural integrity of the design. The building consent authority would then determine whether it has the staff with the appropriate competency to process the consent application in-house (and whether any additional peer review certified by a Recognised Structural Engineer is required), or whether it needs to refer the application to another building consent authority that has the staff with the appropriate competency to process the application. If the structure is determined to be not complex, the engineer who provided the Structural Design Features Report would certify the structural integrity of the building’s design. These recommendations would give further assurance of building quality and reduce reliance on the building consent authority.

**Recommendations**

We recommend that:

162.Building consent applications for:

• 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

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.

163. A structural Chartered Professional Engineer should be engaged at the same time as the architect for the design of a complex building.

164. After consideration of the Structural Design Features Report, the building consent authority should decide whether or not the structure should be regarded as complex.

165. 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.

166. If the structure is determined to be not complex, the engineer who provided the Structural Design Features Report should certify the structural integrity of the building’s design.

167. If the structure is determined to be complex, a Recognised Structural Engineer should be required to certify the structural integrity of the design.

168. On receipt of the building consent application, the building consent authority should decide:

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.

We have also reviewed the leadership structures within the building sector, as they relate to the matters we are concerned with, and consider that the role of Chief 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.

We discuss the role of Standards in New Zealand’s “performance-based” regulatory system and note that the suite of Standards supporting the Building Code plays a vital role in ensuring our buildings are designed well and built well. We have concluded that these Standards should be regularly reviewed and updated.

**Recommendations**

Engineer within the Ministry of Business, Innovation and Employment should be strengthened and supported

with additional capability.

**Recommendations**

We recommend that:

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.

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.

171. The Engineering Advisory Group should continue as an ongoing function to provide expert advice to the Chief Structural Engineer.

We recommend that:

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.

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.

175. Standards referenced in the Building Code should be available online, free of charge.

176. The Policy and Regulatory Work Programme should be the responsibility of the Chief Structural Engineer.

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.

Section 4: Training and education of civil engineers and organisation of the civil engineering profession

In this section of our Report, we have reviewed the training and education of civil engineers and the organisation of the civil engineering profession.

International agreements underpin the nature and content of engineering education in New Zealand.

The Royal Commission has heard nothing that suggests there should be a change in the structure of the

Bachelor of Engineering degree. Rather, key matters for further consideration are in post-degree training and continuing education through provision of tailored block courses for those who are working, and mentoring within engineering firms.

Life safety is and should remain the paramount objective in the design and construction of buildings to resist earthquake motions. This is best achieved by having highly experienced people performing

the highest risk activities. In this regard, the Royal Commission has heard proposals and views from interested parties as to the merits, issues and risks of implementing a two-tier certification system that would raise the level of training and experience required of

a structural engineer who certifies engineering design plans for complex structures. We consider there is merit in this concept and recommend the creation of the role of ”Recognised Structural Engineer” for these purposes (see also section 3 of Volume 7 of this Report).

We have also reviewed the competence requirements against which engineers are assessed for registration as a Chartered Professional Engineer (CPEng).

We recommend the introduction of an additional competence measure against which every structural engineer must be assessed – “a good knowledge of the fundamental requirements of structural design and of the fundamental behaviour of structural elements subjected to seismic actions”.

**Recommendations**

We recommend that:

178. 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.

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.

180. The universities of Auckland and Canterbury should pursue ways of increasing the structural and geotechnical knowledge of civil engineers entering the profession.

181. 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.

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.

Members of the Institution of Professional Engineers New Zealand (IPENZ) are required to act in accordance with the IPENZ Code of Ethics, and Chartered Professional Engineers (CPEng) are bound to a Code

of Ethical Conduct. Both codes are identical in the obligations they impose on the registered engineers. The key matters of interest to the Royal Commission have been the clauses governing the requirement not to misrepresent competence (IPENZ clause 4 and CPEng rule 46) and the obligations to report buildings

and structures that place the public’s health and safety at risk (IPENZ clause 11 and CPEng rule 53). We consider that reviewing structural engineers should have a clearly expressed ethical duty to disclose the existence of a critical structural weakness, in a process which protects them from any liability where they have acted in good faith.

**Recommendation**

We recommend that:

183. The Institution of Professional Engineers New Zealand should provide clarification of its codes of ethics, in respect of the following matters:

a the test for taking action should be well understood by engineers – i.e. ensuring public health and safety;

b 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

c 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.

184. 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.

A particular feature of the engineering profession is the existence of learned societies dedicated to particular fields of engineering practice. Membership

of the individual societies largely consists of engineers practising within the society’s particular field, although many engineers are multi-disciplinary and are therefore members of more than one society.

These learned societies include the Structural Engineering Society New Zealand (SESOC), New Zealand Society for Earthquake Engineering (NZSEE), New Zealand Concrete Society (NZCS), New Zealand Geotechnical Society (NZGS), New Zealand Timber Design Society Incorporated, Cement and Concrete Association of New Zealand (CCANZ), the Heavy Engineering Research Association (HERA) and others.

The work undertaken by the societies’ members includes both contributing to formal processes

for reviewing and updating New Zealand Building Standards, and issuing guidance on best-practice for the profession and industry, some of which is paid work but much of which is not. Society members also

contribute technical papers for conference proceedings

and provide guidance on best-practice to industry. Processes in which guidance is given are informal, and do not pass through the scrutiny of a regulatory review process: the best-practice advice is not formalised as legal requirements, and therefore may or may not be utilised or taken into account by practitioners.

There are risks in the informal component of this approach. These include whether the necessary expertise will remain available on a voluntary basis

to enable the process to continue over time, and the absence of an objective process that tests the content and assesses the consequences of the

best-practice guidance by formal regulatory review. Assessment of consequences would include

examining the costs of the best-practice standards and requirements to determine value in the context of the risks being managed. In addition, without any formal recognition, the adoption of the recommended best- practices is difficult to monitor and cannot be enforced. This makes it unlikely that they will be consistently applied by practitioners.

As discussed above, we consider that the Ministry of Business, Innovation and Employment (MBIE) should develop a policy and regulatory work programme to identify priorities and clarify roles. In doing this work, MBIE should consult with the engineering profession’s learned societies as to where best-practice guidance

is required, and the appropriate process for achieving it, including the need to codify any parts of the advice into regulations or Standards, and whether the issues should be led by the regulator, or left to the societies.

The professional and learned societies play an

important role in facilitating information sharing, debate, and problem resolution across the various disciplines within the engineering profession. Of particular interest to the Royal Commission is the need for collaboration between structural and geotechnical engineers. The societies also endeavour at times to bring engineers together with other intersecting professions within

the construction industry (for example, constructors, manufacturers and architects).

The Royal Commission considers there is a reasonable level of constructive engagement between the different branches of engineering. However, there is scope for more constructive, and early, collaboration between architects and engineers.

**Recommendation**

We recommend that:

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.

Section 5: Canterbury Regional Council and Christchurch City Council – management of earthquake risk

As part of our Inquiry into the Canterbury earthquakes, we considered it would be inappropriate to ignore entirely the fact there has been unnecessary damage and costs sustained as a result of the development

of land subject to a risk of liquefaction without duly considering that risk. Apart from anything else, an understanding of how that has been possible under the existing regulatory system might enable better outcomes in the future.

As a result of our Inquiry into these matters, we conclude that there should be better provision for the acknowledgment of earthquake and liquefaction risk in the various planning instruments that are made under the Resource Management Act 1991. One way of minimising the failure of buildings in the future is to ensure that the land on which they are developed is suitable for the purpose. Having said that, we need to emphasise that it is not possible to predict with any

certainty when an earthquake will occur and, in reality, the public and private investment in the country’s cities is such that it is not realistic to redirect development from the existing central business districts. However, when zoning for new development areas is in contemplation, we consider that it would be appropriate for the risks of liquefaction and lateral spreading to be taken into account.

**Recommendations**

We recommend that:

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.

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.

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.

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.

**Section 2: Christchurch, the City**

**2.1 Introduction**

In preparing this section of our Report, the Royal Commission consulted a variety of sources. For the early history of Christchurch, we turned to *Te Ara*1, the online encyclopaedia of New Zealand, Michael King’s2 *Illustrated Penguin History of New Zealand*

and John Wilson’s3 contextual history of Christchurch

City. Wilson provided information about Christchurch’s built heritage, as did Professor Geoffrey Rice. Professor Rice provided the Royal Commission with draft material and we also consulted his publication *Changing Christchurch: An Illustrated History*4. For modern Christchurch, and the impact of the February

earthquake upon the city and the Canterbury region, we consulted the December 2011 Briefing to the Incoming Minister for Canterbury Earthquake Recovery5 by the Canterbury Earthquake Recovery Authority (CERA)

and their *Greater Christchurch Recovery Update*6. We

also consulted the Christchurch City Council’s7 (CCC) draft Central City Plan. The Stronger Christchurch Infrastructure Team’s8 website describes the impact

of the Canterbury earthquakes on Christchurch’s infrastructure. Christchurch Psychology’s website provided valuable information about the impact that the February earthquake has had on Cantabrians, particularly those who lost loved ones.

**2.2 Ma-ori Settlement in - tautahi**

**O**

**(Christchurch)**

Canterbury was first settled by Ma-ori 600–700 years ago. Archaeological sites at Redcliffs and on the shores of the estuary, especially near the mouth of the Avon River, have provided evidence that Ma-ori lived in the Christ Christchurch area in the earliest years of Ma-ori occupation of New Zealand

The predominant iwi in Christchurch is Nga- i Tahu, the main iwi of the South Island. Originally from the East Coast of the North Island, the Nga- i Tahu people migrated south to Wellington, and then to the South Island. As they moved south they fought several

battles with two tribes already living in the South Island, Nga- ti Ma- moe and Waitaha, and today’s iwi members

are linked to these earlier peoples.

.Figure 1 shows the Canterbury landscape, which is characterised by its flat plain, Banks Peninsula, and the distant relief of the Southern Alps in the west.

The Christchurch area had plentiful resources for Ma-ori including eel and other freshwater species in the rivers, flounder and other fish and shellfish in the estuary, and birds in the forests on the Port Hills and the plains. To ensure easy access to food, the early Ma-ori lived mainly by the wetlands near the coast, and around Te Waihora (Lake Ellesmere) and Wairewa (Lake Forsyth). Artefacts have also been found inland at camps for expeditions

to gather moa, weka, eels and rats. Horomaka (Banks Peninsula) was important because it combined the resources of forest and sea. By 1800, as many as 5000

Ma-ori may have lived in central Canterbury, most of whom were at Kaiapoi and Banks Peninsula.

There were smaller pa- and seasonal ka-inga on the swampy area of plains now occupied by Christchurch. The most notable of these was located at

Pu-taringamotu (in the area we now know as Riccarton)

and Papanui. Both ka-inga were on higher, drier, forested land surrounded by tussock grassland and swamp. Tautahi, the Nga- i Tahu chief whose name forms part

of - tautahi, the Ma-ori name for Christchurch, had a pa- located near the position of the Barbadoes Street bridge. There were also urupa- on the corner of

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Manchester and Kilmore Streets, and on the corner of

Cambridge Terrace and Hereford Street.

The biggest pa- site was located at Kaiapoi. This was

Nga- i Tahu’s largest and most important pa-: it may have housed 1000 people at its peak. It was a centre of trade in pounamu from the West Coast. In the early 1830s, the Kaiapoi pa- was sacked by the North Island Nga- ti Toa chief, Te Rauparaha, but overall his raids were unsuccessful and Nga- i Tahu kept their ownership of Canterbury.

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**Figure 1: Bird’s eye view of Banks Peninsula and the Canterbury Plains (source: Alexander Turnbull Library)**

**2.3 European settlement**

The first Europeans who settled the Canterbury Plains established themselves at Banks Peninsula as they felt the land there was more viable than the swampland on the plains. In the 1830s, shore whaling stations were established with small settlements in the southern bays of Banks Peninsula. Organised settlement began when French (and some German) settlers founded Akaroa in August 1840. By this time, approximately 80 Europeans were living at Banks Peninsula.

In 1840, whalers based at Oashore established a farm

at Pu- taringamotu (Riccarton) but abandoned the venture after 18 months. Brothers John and William Deans established a farm on the same site in 1843. They remained the only permanent European residents on

the Canterbury plains until the Canterbury Association immigrants arrived in 1850.

With the support of prominent Anglican clergy,

John Robert Godley and Edward Gibbon Wakefield formed the Canterbury Association in 1848 to develop an Anglican settlement in Canterbury. Over a decade earlier, Wakefield had established the New Zealand

Company, a private business venture, to settle

New Zealand using a planned colonisation scheme. In 1848, they sent Captain Joseph Thomas, an experienced New Zealand Company surveyor, to select the site of the new Canterbury venture.

2.3.1 The site chosen for the settlement

Captain Thomas initially planned to establish the main Canterbury settlement at Port Cooper, which is

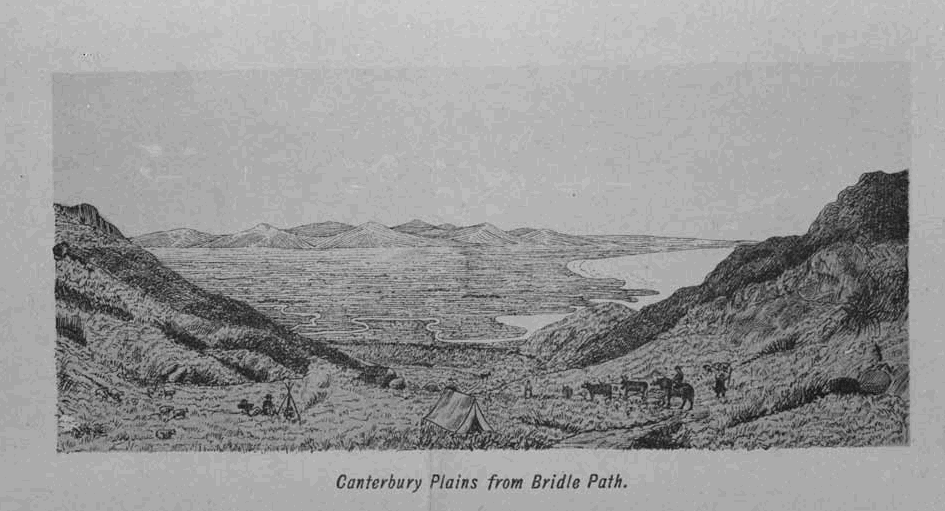
now known as Lyttelton. After realising the amount of

reclamation needed at the Lyttelton site to produce the necessary flat land for the Canterbury Association’s plans, Captain Thomas moved the main town to

the proposed satellite settlement on the plains. This settlement became Christchurch.

The site had previously been rejected by New Zealand Company agents (who went on to establish the Nelson settlement) and the Scottish Free Church (who founded Dunedin). They noted, as did Captain Thomas when

he originally chose the Lyttelton site, the extensive swamps, the lack of timber, and the difficult access between the only suitable port site on Banks Peninsula and the plains.



**Figure 2: Sketch of the Canterbury Plains from the Bridle Path, Port Hills, circa 1850 (source: Christchurch City Libraries)**

2.3.2 The land Christchurch is built on

In section 4 of Volume 1, we describe the soils found in Canterbury. As Figure 2 illustrates, the Canterbury plains consist of a 300–500m thick layer of alluvial gravel formed from ice age glaciers and rivers. Wilson3 suggests that by 1850 the plains were characterised by a mosaic of lobes of shingle and other deposits from the Waimakariri River. Swamplands and waterways lay to the south-east of the shingle lobes. The Heathcote and Avon Rivers created an estuary where they drained into the sea from the swamplands. There were also belts of sandhills parallel to the coast. Even though

the settlement was sited on higher, drier land further up the Heathcote and Avon Rivers, it was still built on fluvial deposits and loose soil in older river beds. Traces of Christchurch’s former topography can be seen in

the creases in North Hagley Park and the sandhills in

Linwood.

The site for the Canterbury settlement was also characterised by poor drainage, high groundwater levels and flooding (although the European settlers did not appreciate the extent to which it was a flood plain for the Waimakariri River until major floods in

1868). Early maps of Christchurch show the extensive network of streams and surface water associated with the spring-fed Avon River, which bisected the original settlement. The water table in Christchurch’s Central Business District (CBD) sits at a depth of 1–1.5 metres, increasing to 5 metres west of the CBD. There are also aquifers in the top 25 metres of the ground. Cathedral Square is only 4.7 metres above the high water mark

for spring tides, although western parts of the city are about 15 metres above that mark. This combination

of a high water table, aquifers and loose alluvial soil composition makes Christchurch prone to liquefaction during severe earthquakes. Liquefaction occurred

in Amuri (North Canterbury) after an earthquake in

1888 and in Kaiapoi as a result of the 1901 Cheviot earthquake. The attempt to address the issues presented by Christchurch’s swampy ground did not begin until the Drainage Board was formed in 1875–76.

2.3.3 The development of Christchurch

Captain Thomas founded the port town of Lyttelton, laid out the plains town of Christchurch, and began a

road over the Port Hills before the first settlers arrived.

Between 1850 and 1853, 3,549 settlers arrived, most of whom originated from southern England.

Of these, 400 were land purchasers, and the rest were mostly labourers and servants. Christchurch was the settlement that came the closest to realising Wakefield’s vision of transplanting a cross-section of class-based British society into a farming community with a strong urban hub.

As set out in Figure 3, the central city and early suburbs were laid out in a regular grid pattern on a north-south orientation, straddling the Avon River. Christchurch’s CBD now covers Captain Thomas’ original settlement. The banks of the Avon were gazetted as public

reserves, forming a green corridor through the built-up area, and Cathedral Square (actually a cross shape), Cranmer Square and Latimer Square (both of which

are rectangular) were set aside as public spaces. In addition, Hagley Park and the Government Domain were reserved from private development. These green spaces, along with fenced and well planted gardens offering protection from the wind, led to the city becoming known as the “Garden City” from the beginning of the twentieth century.

As European settlement on Banks Peninsula was more established when Christchurch was founded in 1850, Lyttelton was the principal Canterbury settlement

until the 1860s. From 1855, small satellite settlements developed in Sumner, New Brighton, Linwood, Richmond, Papanui and Upper Riccarton. Julius Vogel’s assisted immigration schemes spurred the rapid

growth of the city in the 1870s, when the suburbs

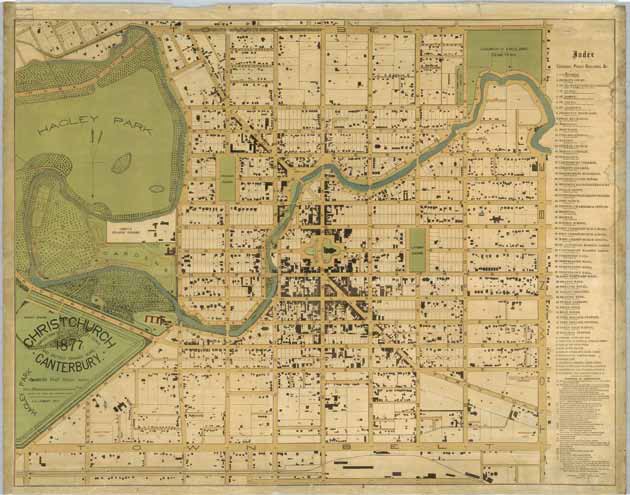
of Addington, Spreydon and St Albans became well established. In the late nineteenth and early twentieth century, Christchurch expanded into the foothills of the Port Hills at Cashmere. Further suburban development occurred over the course of the next century.

**2.4 Christchurch’s built environment**

Like other European settlements in New Zealand, the first residential and commercial buildings in Christchurch were constructed from wood. Victorian New Zealanders soon replaced their wooden public and commercial buildings with structures comprised of more permanent materials (see Figure 4). In 1864,

the first stone church was constructed in Christchurch. This building, the Durham Street Methodist Church, completely collapsed in the February earthquake, tragically killing three people. Rice4 contends that the rebuilding of earlier wooden churches in stone during the early 1870s was a sign of Christchurch’s increasing maturity and prosperity: more substantial masonry buildings were perceived as indicating greater wealth and status. In addition, as European settlers moved down the South Island they found few large forest stands to log for building materials; this encouraged stone and masonry construction. As the city prospered, at the turn of the century, most (but not all) of the remaining older wooden buildings were replaced by

larger, masonry commercial buildings.



**Figure 3: A map of Christchurch central city dated 1877 (source: Alexander Turnbull Library)**



**Figure 4: Manchester Street, looking towards the Avon River, circa 1868 (source: Christchurch City Libraries)**

European immigrants to New Zealand looked to

re-create in the new, unfamiliar environment the familiar landscapes and built environment they had left behind. Consequently, they built their new homes and public and commercial buildings in the architectural styles popular in Victorian and Edwardian Europe. Early buildings in Christchurch were constructed in the

neo-Gothic style popular in England for most of the nineteenth century. Christchurch’s commercial buildings in the late nineteenth century echoed the Gothic theme with variations on Venetian Gothic and Renaissance styles.

By the beginning of the twenty-first century, Christchurch architecture was distinctive in combining Victorian and Edwardian architecture with Modern and Post-modern innovation. Although Christchurch has relatively few Art Deco buildings, Cecil Wood produced several buildings that combined Modernist features with Stripped Classicism (a simplified Classical style). From the 1960s to the early 1990s, older commercial buildings were replaced with large, modern high-

rise office blocks and hotels. In this period, Sir Miles Warren and Peter Beaven were the most well-known proponents of the form of Modernism that became known as the Christchurch Style of architecture. The Christchurch Style combined the structural expression and clear exposure of construction materials that characterised Brutalism, and the Scandinavian and Japanese commitment to straightforward design.

**2.5 Christchurch before the earthquakes** Christchurch is the largest city in the South Island. Christchurch City includes Akaroa and Banks Peninsula, but does not include adjacent satellite centres such as Kaiapoi, Prebbleton, Rolleston, Lincoln or Tai Tapu. It is the market town and transport hub for the Canterbury plains, the largest area of relatively flat farmland in

New Zealand. Canterbury comprises 9.3 per cent of

New Zealand’s land area, at 25,252 sq km. According to the 2006 Census, its inhabitants make up 11.4 per cent of the country’s total population. Canterbury’s regional population was around 522,000, of which two thirds lived in Christchurch.

In the 2006 Census, Christchurch City was

New Zealand’s second largest population district after Auckland. The city is home to 9.1 per cent of

New Zealand’s total population. Modern Christchurch, the urbanised area within a radius of 30 km of

Cathedral Square (excluding Banks Peninsula), contains approximately 370,000 people. The city comprises

a third of the South Island’s population, and about

70 per cent of the Canterbury population. Before the Canterbury earthquakes, Christchurch’s population had increased by 7.5 per cent between 2001 and 2006 in response to a growing regional economy.

**Figure 5: Christchurch and the Canterbury Plains, August 2011**



**2.6 Economic activity of the region and city**

In the nineteenth century, Christchurch’s early development was driven by the city’s physical growth and rapidly increasing production from the farms developing in north- and mid-Canterbury. Canterbury farmers contributed to the New Zealand economy

by producing large amounts of wool, wheat and (from the

1880s) frozen meat for export. In addition to farm- related industries, Christchurch developed a strong manufacturing sector. At the turn of the nineteenth and twentieth centuries, brands originated in Christchurch that became household names throughout Australasia, including Aulsebrooks biscuits, Edmond’s baking powder, Sanitarium health foods, Kaiapoi woollen goods, and even cough remedies such as Bonnington’s Irish Moss.

The reliance on supporting the farming industry, both in manufacturing and handling farm produce, has given Christchurch an industrial history that differs somewhat from that of other New Zealand industrial centres. Although the economy diversified in the twentieth century, the structure of industry in Christchurch changed little until the deregulation of New Zealand’s economy in the mid-1980s and 1990s. The Canterbury regional economy is driven largely by agriculture, manufacturing and tourism. Christchurch City contributes around 8 per cent of the national Gross Domestic Product (GDP)

from economic activities.

**2.7 Impact of the earthquakes**

The scale of the damage in the September earthquake resulted in the declaration of a local state of emergency. A national state of emergency was declared after the February earthquake, due to the size of this event and its impact on Christchurch.

During the February earthquake, 185 people tragically lost their lives and many more were injured. Those who lost their lives as a result of the February earthquake came from all corners of the world, including New Zealand, Australia, Japan, China,

the Philippines, Thailand, Great Britain, Korea, Turkey, Ireland, Malaysia, Taiwan, United States of America, Israel and Canada. Of those who died in the earthquake, 77 were foreign nationals. Much of the loss of life was due to the catastrophic collapse of

two multi-storey office buildings: the CTV and PGC buildings where 115 and 18 people died respectively. Other building failures caused the deaths of a further

42 people. Other deaths attributable to the earthquake arose from causes not related to building failures. They included those attributable to rock falls.

A significant number of people were also injured to varying degrees in the earthquakes and immediately afterwards. By 27 January 2012, the Accident Compensation Corporation, which provides personal injury insurance cover for all New Zealand residents and visitors to

New Zealand, had accepted 12,984 earthquake-related claims. Soft tissue injuries, such as bruising, strains and sprains, accounted for the majority (over 9,500) of these claims. The next most common category of injury was lacerations and puncture wounds (around 1,500 claims), followed by fractures and dislocations (770 claims).

Six people had limbs amputated.



**Figure 6: The eastern suburbs suffered repeatedly from liquefaction. This aerial photo shows a street in Bexley after the June 2011 aftershock (source: Fairfax Media/ The Press)**



**Figure 7: Collapsing rocks in the suburb of Sumner caused houses to fall down the cliff. A row of shipping containers was installed to protect the busy road below from danger (source: Flickr/newtown graffiti)**

In the larger earthquakes that occurred in Canterbury there was extensive liquefaction, particularly in the eastern suburbs near the sea (Figure 6 shows the liquefaction in the eastern suburb of Bexley). Hill suburbs experienced cliff collapse and rock fall, as Figure 7 illustrates. In the Port Hills, especially Lyttelton, moving land, collapsed cliffs, and rockfall caused

severe damage to retaining walls. Damage to the land under the CBD is described in section 2 of Volume 1.

Christchurch citizens were affected by widespread damage and interruptions to infrastructure including roads, fresh water, waste water systems, storm water systems, electricity and telecommunications networks. Rebuilding the city’s damaged street-level civic infrastructure to the same level of infrastructure service that existed before the earthquakes is likely to cost around $2 billion dollars and will take several years

to complete.

Figure 8 shows the road damage caused by the Canterbury earthquakes. An estimated 1,021 kilometres of road need to be rebuilt due to earthquake damage. This is 52 per cent of Christchurch’s urban sealed

roads. There will be major renewal projects to rebuild these roads and in some cases the road will need full reconstruction.

The earthquakes damaged 51 kilometres of water supply mains, excluding those yet to be properly assessed because they are under roads. However the damage was far less than it might have been a few years ago because a proactive programme was already underway to strengthen the fresh water pipe network. Huntsbury reservoir, the city’s biggest, was seriously damaged, placing significant pressure on the water supply. Pump station buildings are operating but will need to be repaired properly in the future.



**Figure 8: Road damage caused by the earthquakes**

**(source: Michael Campbell)**

Because of a higher proportion of old materials used in waste water pipes than in fresh water pipes, around 528 kilometres, or about 31 per cent, of the sewer system was damaged and 100 sewer pumping stations were identified as needing to be repaired or rebuilt. For health reasons, restrictions on recreational use of the waterways around Christchurch were imposed because of the effects of the damage. The main causes of ocean and waterway contamination were leakage of waste water and the temporary pumping of waste water into waterways as

an emergency diversion after severe aftershocks.

The earthquakes badly damaged the Christchurch waste water treatment plant and its oxidation ponds, although it continued to operate at a reduced capacity. As a temporary measure, for a short period, the effluent that was pumped into the ocean was not treated to the usual safe level.

Fortunately, the earthquakes left the storm water system largely in a functional state. There was still some damage, but the system is catching most storm

water and most breaks have been temporarily repaired. At the time of writing, about one fifth of the storm

water system had been properly assessed for damage; however CCC advises that the system is performing acceptably with only moderate impact from the damaged parts.

Some of the stopbanks by the Avon River settled and cracked so that a spring tide could flood the land. Contaminated tidal water came onto roads through broken drainage pipes. Banks and pipes

failed because the ground moved toward the river and settled in a lower position than it had been. All of the stopbanks by the Avon River were at least weakened by the shaking. They need to remain raised, firm,

and uncracked to function effectively. The city needs another four kilometres of stopbanks along the Avon River because the surrounding land is lower than before the earthquakes.

The city’s electricity distribution networks were severely affected by the earthquakes. Earth movement stretched some underground power cables up to a metre in the February earthquake and caused more faults than would usually be seen in a decade. The June 2011 aftershocks caused further cable damage.

Only four of 314 substations were severely damaged in the February earthquake, including the Pages Road substation, which sank two metres into the ground. The good performance of the substations was largely due to an extensive seismic strengthening programme started in the 1990s by the network’s owner, Orion New Zealand Limited. Without this work, the impact of the earthquakes would likely have been significantly worse. Telecommunications were also damaged and temporarily overloaded during the earthquakes.

Many educational facilities were damaged. Consequently, some schools were temporarily closed and the students shared premises with other schools until they were repaired. In the long term, schools may be permanently closed, merged, or relocated because of damage or falling rolls due to migration.

At the time of writing, the Earthquake Commission (EQC) had received 459,325 claims for damage to residential buildings, personal property (contents) and land in the Canterbury earthquakes. The red placards affixed to unsafe residential homes in Operation Suburb, the rapid assessment operation CCC carried out after the February earthquake, meant they could not be occupied. By the end of September 2012, CERA had red zoned

7,859 residential properties as unsuitable for long-term reoccupation and therefore likely to be demolished.



**Figure 9: An aerial photo of Christchurch central city, October 2012, taken after many of the buildings had been demolished (source: Canterbury Earthquake Recovery Authority)**



**Figure 10: In October 2011 a temporary shopping precinct was set up to attract people back into the city.**

**The Re: START project, located in Cashel Street, makes use of shipping containers to house a variety of businesses**

**(source: Paul Roper-Gee)**

Because of the danger posed by damaged buildings, parts of the CBD were cordoned off after both the September and February earthquakes. After the February earthquake, the CBD Red Zone covered a significant area of the city (as Figure 9 indicates). More than 3,000 of the 5,000 businesses in the CBD were displaced, many migrating to the suburbs. There has been a general shift of activities, such as retailing, away from the damaged CBD and eastern and riverside suburbs to the south and south-west. Retailers

also moved into temporary premises (for example, the shipping container mall in Figure 10) in Cashel Mall and elsewhere. More than 1,200 Christchurch CBD buildings require full or partial demolition or deconstruction, including heritage buildings. As the

demolitions are completed the cordon is progressively reduced, enabling further access to the central city.

2.7.1 The economic impact of the earthquakes

Estimates of net departures from the region vary, but are generally reported10 at between eight and ten thousand in the year to June 2011. It has been suggested that net departures continued at a slower rate in the second half of 2011, and in the last few months there have been more arrivals than departures, due possibly to the inflow of workers to assist with the rebuild.

Population loss has a flow-on impact to a number of economic indicators, as discussed further below.

Economic commentators note the difficulties inherent in isolating the effects of the earthquakes from other economic developments. In addition, data often lags well behind an actual event. It is noted that New Zealand had, at the time of the September earthquake, made a modest recovery from recession, and was looking at a positive medium-term outlook.

The Reserve Bank of New Zealand (RBNZ) has characterised the Canterbury economy as having been “reasonably resilient to the impact of the earthquakes” and stated that the New Zealand economy “appears to have been little affected”. In particular, the RBNZ noted in September 2012 that exports and manufacturing activity have held up well and that the agricultural sector was largely unaffected. It noted that:

…disruption to industrial production, goods exports and activity was relatively short lived as the region’s manufacturing hub escaped significant damage.

But Christchurch is the tourist gateway to the South Island; accommodation capacity has been greatly reduced and tourist numbers have fallen considerably.

In its 2011 Fiscal Strategy Report, the Treasury estimated that the impact of the February earthquake would be a reduction in GDP growth for 2011 of

around 1.5 per cent from what it would have otherwise been. It noted that the impact would be offset as the reconstruction commences, resulting in higher growth from 2012.

**2.7.1.1 Capital costs**

These costs are largely related to the repair and rebuild of commercial buildings, infrastructure and residential housing.

Damage to buildings can be defined in a number of ways, but we adopt the RBNZ definition as the cost of rebuilding and repairing in 2011 dollars. Building damage resulting from the earthquakes is estimated at around $20 billion. This equates to approximately

10 per cent of annual GDP. The RBNZ estimates

$13 billion for dwellings (estimates are that 150,000 homes, around 75 per cent of Christchurch’s housing stock, have sustained some damage, and 20 per cent have sustained damage exceeding $100,000 in value),

$4 billion for commercial buildings and $3 billion for infrastructure. In comparison, the Japanese earthquake and tsunami caused damage equal to 3–4 per cent

of GDP.

**2.7.1.2 Funding the rebuild**

The Treasury and the RBNZ note that much of the damage is covered by private insurance and EQC,

and reinsured through overseas insurance companies. This will help to fund rebuilding, and lead to a large boost to economic growth from reconstruction activity.

Central and local government are also contributing

to the costs of repairing and replacing infrastructure. Residents of Canterbury will bear some of the cost through increased rates – an average 7.8 per cent for

2012/13 over 2011/12, of which approximately 3.7 per cent is to fund earthquake-related costs (e.g. repair of

10 major community facilities) and replace lost revenue.

Since the earthquakes, there has been limited new insurance cover available for earthquakes in Canterbury. Some owners of earthquake-prone buildings and infrastructure can no longer obtain insurance cover in Canterbury or elsewhere in New Zealand. Reinsurance premiums have increased substantially, some more

than doubling.

**2.7.1.3 Economic impact**

As stability has returned in Canterbury with the reduction of aftershocks and a clearer plan for

the future, the economy is settling as the region’s population gets back to business as usual. Nevertheless there continues to be disruption to business through, for example, the red-zoned CBD being unavailable to businesses, the city’s roading being subject to major repair and a lack of facilities catering to tourists at present. There remains, at present, a drag on the region’s economy. We now discuss the major impacts on business profitability.

Retail sales are estimated to currently be around

10 per cent behind the rest of the country, probably as a result of the loss of premises in the CBD and the decline in population. Retail trade has increased by around 7.7 per cent in nominal terms nationwide since September 2010, but only by 1.3 per cent in Christchurch.

The Treasury indicates that employment in the

Canterbury region was 8 per cent lower in the year

to September 2011 over the previous corresponding period. The New Zealand Institute of Economic Research reported that to September 2011, there had been around 27,000 job losses and the RBNZ noted that the decline in employment has been mostly in

the retail, accommodation and food services sectors with the loss of some 12,000 jobs between June 2010 and June 2012. However, Westpac Bank notes that the unemployment rate in the region has remained

low because of strong demand in certain industries and for particular occupations. Between June 2010 and June 2012, there has been an increase in jobs in the construction sector of an estimated 6,000. There is evidence that it is now becoming difficult to recruit labour for skilled jobs in Canterbury because of the miss-match of the skills of those who lost jobs after the earthquakes and the skills needed for the rebuild.

Business profitability has been impacted by earthquake damage to capital items (e.g. machinery) and buildings that reduced the production capacity of businesses, damage to roads and other infrastructure that has impeded their ability to carry out their operations,

and changes in demand for goods and services from a reduced number of clients (e.g. tourists). Some businesses benefitted from increased clientele, especially where they were located outside the worst affected areas.

The housing market initially turned down with uncertainty over repairs and ability to get insurance, but signs of

it rising in Canterbury while being flat nationwide were being seen by November 2011. The reduction in population appears to have been exceeded by the reduction in the housing stock, which has put upward pressure on prices. New property rental

agreements have seen rents increased by 18 per cent in Christchurch since the end of 2010 compared

with a seven per cent increase nationwide, with higher rentals being achieved in the south-western suburbs.

2.7.2 The cultural impact of the earthquakes Before the earthquakes, Christchurch had one of New Zealand’s best-preserved heritage townscapes.

New Zealand is internationally recognised for the quality

of its Victorian and Edwardian architecture. The preference of its early settlers for neo-Gothic

architecture in its churches and public buildings gave Christchurch a distinctive character, and prompted visitors to comment on its “Englishness”. Christchurch had the only intact surviving set of government buildings from the period of provincial government

in New Zealand (1852-76), and the interior of Benjamin Mountfort’s great debating chamber was widely recognised as the finest neo-Gothic interior outside England. Christ Church Cathedral was the city’s centrepiece since 1881, a rare example of Sir Gilbert Scott’s work outside England. The 1906 Cathedral of the Blessed Sacrament in Barbadoes Street (Figure 11) was one of the finest classical buildings in New Zealand. Christchurch Arts Centre (Figure 12), the former buildings of Canterbury University College before the university’s move to its suburban campus at Ilam, together with the nearby Canterbury Museum, formed

a neo-Gothic precinct unique in New Zealand.



**Figure 11: The Cathedral of the Blessed Sacrament, also known as the Catholic Basilica, after the Canterbury earthquakes**



**Figure 12: The neo-Gothic-style Christchurch Arts Centre (source: Roger Wong)**

Of these buildings, only the Canterbury Museum has emerged from the February earthquake without significant damage. Much of Christchurch’s heritage townscape was destroyed in the Canterbury earthquakes. Many adjacent Victorian and Edwardian buildings act as one structure in an earthquake. In the February earthquake, whole streetscapes were lost when the façades of an entire block of interconnected buildings rotated outwards onto the street. This was particularly noticeable in Colombo Street, where two buses were trapped under fallen façades, tragically resulting in loss of life in one of them.

While they did not collapse as substantially as Christchurch’s older unreinforced masonry buildings, the February earthquake damaged many of Christchurch’s Modernist buildings beyond repair. Notable demolitions include Beaven’s Southland Building Society building, his central city Holiday Inn, and Warren’s Crowne Plaza building (Figure 13). The Christchurch Town Hall also sustained major damage and, at the time of writing, has an uncertain future.



**Figure 13: The Crowne Plaza Hotel, formerly the Park Royal Hotel, was damaged by the earthquakes and demolished in 2012 (source: Gudrun Gisella)**

Since the February earthquake, and the closure of the

CBD, many businesses have shifted to the west of

the city. Colombo Street south of Moorhouse Avenue, Sydenham, Addington, Riccarton and the light industrial area surrounding Christchurch airport have all grown since 2011. New residential subdivisions are also emerging in Christchurch’s satellite towns.

**2.7.2.1 Impact of the Canterbury earthquakes on individuals and the community**

The Canterbury earthquakes have changed the people of Christchurch. The psychological impact of the earthquakes has been complicated by the many aftershocks since the first earthquake on 4 September

2010. The continuous aftershocks have kept people in a prolonged state of hypervigilance and exposed them to recurrent acute stress. This unpredictable and uncontrollable stress has affected some people physically and emotionally. Some relationships that

were already under stress before the earthquakes have been unable to survive under the constant stress.

Post-traumatic stress can arise following a traumatic event that threatens people’s safety. It is characterised by symptoms of re-experiencing the original trauma(s) through flashbacks or nightmares, avoidance of stimuli

associated with the trauma, and increased arousal such as difficulty in falling or staying asleep, anger,

and hypervigilance. While most Cantabrians would not be classified as having post-traumatic stress disorder, many are experiencing or have experienced varying degrees of post-traumatic stress symptoms. For some people this now manifests as a “startle response” or feeling “jumpy” when they hear or feel a bus go past their house, or a hypervigilance regarding their personal safety or that of their family members. Post-traumatic stress disorder develops when these symptoms do

not lift and people remain stuck in a state of psychological shock.

Many Christchurch people have experienced an enormous sense of loss including the loss of work

and businesses, homes and the lives they had before. Those who were seriously injured in the earthquakes have experienced the loss of their former selves, independence and autonomy. The sense of loss is, of course, most profound for those who lost a loved one in the February earthquake.

For some people, the earthquakes have been a chance to reassess and re-evaluate their lives to determine what is really important. As time goes on, some people who have lived through the earthquakes are able to

feel that new opportunities have emerged from it all, opening up possibilities that were not there before. People have displayed extraordinary innovation, adapting to the new situation by creating exciting new projects. People and communities banded together

and offered support to each other following each major earthquake, developing stronger relationships with others in their community as a result of a collective understanding because of a collective experience.

For many people, it appears that living through this disaster has given them a greater appreciation of life in general and a sense of what is really important

to them. Many Cantabrians now have a reduced attachment to material things and a new appreciation for what is truly important in life. For many, the earthquakes have given them a chance to stop and reconsider their priorities; to focus on what they still have despite all that has been lost.

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10. For example, the Reserve Bank of New Zealand and Westpac Bank discuss net departures from the

Canterbury region.

**Section 3: Methodology**

**3.1 Establishment of the Canterbury**

**Earthquakes Royal Commission**

The Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes was formally constituted on 11 April 2011. Its appointment was notified in the *New Zealand Gazette* on 14 April. A sitting High Court judge, Justice Mark Cooper, was appointed to be the chairperson of the Commission.

A month later two other Commissioners, eminent engineers Sir Ron Carter and Professor Richard Fenwick, were appointed and the Terms of Reference were finalised. The Commissioners met for the first time in Christchurch on 4 May 2011.

Later that month, in consultation with Justice Cooper, the Solicitor-General appointed Mr Stephen Mills QC and Mr Mark Zarifeh as counsel assisting the

Royal Commission. At the request of some bereaved families for government-funded legal representation, a third counsel, Mr Marcus Elliott, was appointed in August 2011. Mr Elliott was appointed as counsel assisting the Commission, but with a particular focus

on representing the interests of bereaved families and those who were injured.

Executive Director Ms Justine Gilliland was appointed at the end of April. A Royal Commission office

was established in Christchurch staffed with a project manager, an administration and information management team, legal analysts, policy analysts, a senior communications advisor, a family and community liaison officer, a structural engineer and hearings staff.

**3.2 Terms of Reference**

The full Terms of Reference are included in Appendix 1. The following is an overview of their requirements and discusses matters which emerged and required

specific attention.

The Royal Commission’s Terms of Reference were wide ranging and required the Royal Commission to investigate two major areas:

1. Buildings in the Christchurch central business district (CBD), an area bounded by the four avenues (Fitzgerald, Deans, Moorhouse and Bealey) and Harper Avenue. While the Commission’s principal focus was on the effects of the Canterbury earthquakes, the Royal Commission was also required to consider the wider implications of

these events for the rest of the country. In considering the effects in the Christchurch CBD, the Royal Commission was required to look specifically at what factors led some buildings to fail severely, why the failure of buildings caused extensive injury and death, and why buildings differed in the extent to which they failed and caused injury or death.

That meant looking at, among other things, the characteristics of buildings that may have led to failure (for example, age, location, and whether buildings conformed to earthquake risk best- practice). The Royal Commission was required to include the Canterbury Television (CTV) building, the Pyne Gould Corporation (PGC) building,

the Forsyth Barr building and the Hotel Grand Chancellor building, but was otherwise left to decide which buildings it should investigate.

2. The adequacy of current legal and best-practice requirements for the design, construction and maintenance of buildings in central business districts in New Zealand.

The Terms of Reference required the Royal Commission to make both interim and final recommendations upon or for—

(a) any measures necessary or desirable to prevent or minimise the failure of buildings in New Zealand due to earthquakes likely to occur during the lifetime of those buildings; and

(b) the cost of those measures; and

(c) the adequacy of legal and best-practice requirements for building design, construction, and maintenance insofar as those requirements apply to managing risks of building failure caused by earthquakes:

The Terms of Reference also contained specific exclusions. The Royal Commission was not permitted to inquire into, determine, or report in an interim or final way upon:

(a) whether any questions of liability arise; and

(b) matters for which the Minister for Canterbury Earthquake Recovery, the Canterbury Earthquake Recovery Authority, or both are responsible, such as design, planning, or options for rebuilding in the Christchurch City CBD; and

(c) the role and response of any person acting under the Civil Defence Emergency Management Act

2002, or providing any emergency or recovery services or other response, after the 22 February

2011 aftershock.

The interpretation of exclusion (c) was tested on

6 March 2012 when Justice Cooper publicly heard an application from counsel for bereaved family member Mr Srecko (Alec) Cvetanov. Mr Cvetanov’s wife Dr Tamara Cvetanova survived the collapse of the CTV building but died before she could be rescued.

Mr Cvetanov requested that the Royal Commission investigate the search and rescue response. The application was opposed by counsel assisting the Royal Commission on the basis that the Commission did not have jurisdiction to address this issue.

Justice Cooper delivered a reserved decision finding that the Royal Commission did not have jurisdiction to investigate. The Coroner’s office subsequently confirmed it would investigate the deaths in the

CTV building in the hours following the collapse.

The failure of five buildings outside the CBD claimed the lives of six people, as noted in section 4.1 of Volume 4. Although the Terms of Reference did not require the Royal Commission to inquire into the failure of these suburban buildings, it decided to do so,

relying on its power to examine matters it considered to be sufficiently linked to its principal inquiries. These buildings were commercial premises in Riccarton

Road in Riccarton, Coleridge Street in Sydenham and Worcester Street in Linwood and a residential property in Bishop Street, St Albans (see Figure 2 in section 4 of Volume 4).

3.2.1 Issues arising under the Terms of

Reference

Early in our Inquiry, the Royal Commission identified

six principal issues that were to be considered. A Notice of Issues was published on the Royal Commission website in June. The issues were:

• **Seismicity**. The Terms of Reference required

the Royal Commission to understand the nature and severity of the Canterbury earthquakes, the susceptibility of land to liquefaction as a result

of earthquakes, and the nature and extent of earthquake risk that should be provided for in the construction and maintenance of buildings, both in Christchurch and throughout New Zealand.

Key: Commission activities Non-Commission activities

**4 September 2010**

7.1Mw earthquake

strikes Christchurch and the surrounding region

at 4:35am. Three local councils declare local states of emergency

**26 December**

“Boxing Day” sequence of aftershocks, beginning at

10:30am with

a M 4.7 shake

w

**23 February**

The Minister for Civil

Defence declares a national state of emergency

**14 March**

Government agrees

to establish the Royal Commission to inquire into the Canterbury Earthquakes chaired by Justice Mark Cooper

**30 April**

The state of national emergency ends

**2010 2011**

**16 September**

The local states of emergency end

**22 February**

6.2Mw aftershock strikes at 12:51pm

**11 April**

The Royal Commission is established



**36**

• **Consideration of a representative sample of buildings** in the Christchurch CBD. The content of the representative sample was to be determined having regard to the obligations to consider why some buildings failed severely, why the failure of some caused extensive injury and death, why buildings differed in the extent to which they failed and why some did not fail. Under this issue, the Royal Commission also investigated the subsurface

conditions in the CBD, particular features of buildings that contributed to failures, the extent of compliance of the buildings with relevant building controls, and the inspection and remediation processes followed after the September and December 2010 and February 2011 earthquakes and aftershocks.

• **Legal and best-practice requirements** for the design, construction and maintenance of buildings, including those that were or should be considered as earthquake-prone. This included the existing

and desirable form of legislative provision for

the inspection of buildings and remedial actions following earthquakes. The Royal Commission also considered the respective roles of central and local government, the building and construction industry and the significant inputs of volunteers (in the drafting and amendment of relevant New Zealand standards) in developing and enforcing legal and best-practice requirements.

• **Change of New Zealand design standards/codes of practice** over time and appropriate future controls for new and existing buildings

• **Development of technical expertise** in the design and construction of earthquake-resistant buildings.

• **Future measures** for existing and new buildings.

**3.3 The Royal Commission’s approach to the issues**

Commissions of Inquiry are often conducted by inviting submissions from interested parties and considering what they might be prepared to tell the Commission, supplemented where appropriate by questioning from counsel assisting, with findings based on evidence from one or more hearings.

The Royal Commission decided that, because of the breadth of the investigation required by the Terms

of Reference, this approach alone would not be adequate. It would risk some relevant issues being covered incompletely, or even not at all. There would be a risk also that the Royal Commission would not be presented with differing opinions on some important

issues, because in the absence of clear disputes arising plainly or by necessary implication from the Terms of Reference itself, persons having rival opinions might

not be aware of what others were saying to the

Royal Commission.

Accordingly the Royal Commission developed and implemented its own approach to the investigation of the principal issues, which had the elements discussed below.

**4 May**

The Commissioners meet for the

first time in

Christchurch

**2 July**

Expressions

of interest open

**14 July**

Potential representative building sample list is published

**22 July**

Expressions of interest close

**24 August**

Mr Marcus Elliott is appointed as counsel assisting with a focus on bereaved families and injured

**2012**

**13 June**

**15 July**

**9 August**

**30 September**

6.0M

w

aftershock

A delegation of

First technical

The results of the DBH

at 2:20pm

bereaved families and officials from China visits

report published

technical investigation into

the PGC, Forsyth Barr and Hotel Grand Chancellor buildings are received



**37**

3.3.1 Expressions of interest

Section 4A of the Commissions of Inquiry Act 1908 sets out which persons (including organisations) are entitled to be heard by the Royal Commission:

Persons are entitled to be heard if they are parties to

the inquiry, or satisfy the Commission that they have an interest in the inquiry apart from any interest in common with the public. Persons who satisfy the Commission that any evidence given before it may adversely affect their interests must be given an opportunity during the inquiry to be heard in respect of the matter to which

the evidence relates. Every person entitled, or given an opportunity, to be heard may appear in person or be represented by a lawyer or agent.

In addition to identifying affected and interested parties, the Royal Commission concluded there would be other people and organisations who might wish to participate in the Inquiry, for example, because they had been

or may have been affected in some relevant way by the Canterbury earthquake sequence or might have information of relevance to the Inquiry.

To identify these people and organisations, and what part of the Inquiry they wanted to contribute to and in what manner, on 2 July 2011 the Royal Commission called for public expressions of interest in relation to each of the identified principal issues. Public notices were placed in four major metropolitan papers: the *New Zealand Herald, Dominion Post, The Press* and *Otago Daily Times*. In addition, notices were placed

in the following regional daily newspapers:

*Northern Advocate, Bay of Plenty Times, Waikato Times, Gisborne Herald, Wanganui Chronicle, Taranaki Daily News, Manawatu Standard, Hawke’s Bay Today,*

*Nelson Mail, Timaru Herald, Southland Times*, *Greymouth Star, Marlborough Express* and *Hokitika Guardian*. People or organisations were requested to register with the Royal Commission and indicate if they wished to meet with the Royal Commission, provide a written submission, participate in public hearings or communicate information to the Royal Commission.

The Royal Commission received 80 expressions of interest by the 22 July 2011 deadline. They were from people who were trapped in buildings as a result of the February 2011 earthquake, building owners and tenants, persons with professional knowledge about matters arising in the Inquiry, learned societies, the Auckland Council, the Christchurch and Wellington City Councils, Local Government New Zealand and the former Department of Building and Housing (DBH) (now the Ministry of Business, Innovation and Employment or MBIE). Other individuals and organisations came forward with information as the Inquiry progressed. Some organisations that did not respond were contacted by the Commission if it was thought that their views may be of value.

The Royal Commission also advised persons bereaved in the February earthquake that they would be regarded as affected parties, and advised of the progress of the Commission’s work (unless they preferred not to be) without the need for them to lodge expressions of interest.

3.3.2 Expert advice

On the principal issues the Royal Commission commissioned advice in the form of reports from people and organisations within New Zealand who

had appropriate expertise. The Royal Commission also adopted a policy that advice received would generally

Commission activities Non-Commission activities

**10 October**

The Royal Commission delivers Interim Report to the Governor-General

**17 October**

Public hearings commence

**7 February**

The Terms of Reference are modified to

enable a later final reporting date

(by 12 November)

**21 February**

Delegations of bereaved families and officials from

Japan and China visit

Christchurch and the

Royal Commission

**2012**

**12 October**

**23 December**

**9 February**

**6 March**

The Government

5.8M

aftershock

The results of the

Justice Cooper rules on

releases the

w

Interim Report

strikes at 1:58pm

DBH technical investigation into the CTV building are received

the jurisdiction of the Commission in response to an application

from Mr Srecko

(Alec) Cvetanov



**38**

be peer reviewed by eminent overseas experts. The expert advisers and peer reviewers contracted by the Royal Commission are listed in Appendix 3 of this Volume, in Appendix 2 of Volume 1 and Appendix 3 of Volume 4 of the Report. The reports were published on the

Royal Commission’s website. Details of the reports can also be found in the relevant Volumes of this Report dealing with the subject matter covered in the reports.

3.3.3 Consultation

The Commission sought submissions from those who had lodged expressions of interest and from a wide variety of other parties the Royal Commission identified as having relevant contributions, including local government, educational institutes and engineers.

**3.3.3.1 Technical reports**

The Royal Commission sought submissions on each of the expert reports. The submissions received were analysed and published on the Royal Commission’s website.

**3.3.3.2 Memorandum about issues raised**

The Royal Commission sought input from Structural Engineering Society New Zealand (SESOC) and other engineers on a memorandum about issues identified in two expert reports – “Stairs and Access Ramps between Floors in Multi-storey Buildings”, by Professor Desmond Bull and “Preliminary Observations from the Christchurch Earthquakes” by John Hare. This process is discussed

in more detail in section 3.4 of the Royal Commission’s

Interim Report, delivered in October.

**3.3.3.3 Draft SESOC practice note**

The Royal Commission also published a draft SESOC practice note “Design of Conventional Structural Systems Following Canterbury Earthquakes”, called for submissions on it and then held a technical workshop to discuss the issues raised. This input was considered when formulating the findings and recommendations reached in Volume 2.

**3.3.3.4 Discussion papers**

To seek further information and comment, prior to some of the public hearings, discussion papers were published and written submissions were sought

from invited parties. The discussion papers refined the issues, canvassed options to address identified problems, and outlined the main areas of common view or debate in order to ensure that the hearings were as focused and effective as possible. Submitters were asked to consider the extent of the identified issues in practice, provide evidence and analysis underpinning the issues/problems, and to describe the pros and cons of options to address the problems.

Three discussion papers were published on the topics of:

• building management after earthquakes;

• training and organisation of the engineering

profession; and

• roles and responsibilities.

The submissions received helped refine the issues and draw out options for addressing them ahead of the hearings.

**15 April**

Technical workshop about draft SESOC practice note held

**29 June**

The Royal Commission delivers Volumes

1–3 of its Final

Report to the

Governor-General

**25 July**

Officials from Toyama city in Japan attend

the CTV building hearing

**12 September**

Public hearings finish

**23 October**

The Terms of Reference are modified to

enable a later final reporting date

(by 30 November)

**21 June**

“Training and organisation of the engineering profession” and “Building management after earthquakes” discussion papers are published

**11 July**

“Roles and Responsibilities” discussion paper is published

**23 August**

The Government releases Volumes

1–3 of the Final

Report

**10 October**

The Royal Commission delivers Volume 4 of its Final Report to the Governor- General

**29 November**

Part three of the Final Report is delivered to the Governor-General. The Commission of Inquiry is complete



**39**



**Figure 14: Children of St. Teresa’s school sing at opening of Royal Commission hearings on 17 October 2012 (source: *The Press*/Fairfax Media)**

3.3.4 Department of Building and Housing technical investigation

The Terms of Reference envisaged that the Royal Commission would receive and take into account the results of a separate technical investigation conducted by the former Department of Building and Housing

into the failure of the CTV, PGC, Forsyth Barr and Hotel Grand Chancellor buildings. Early in its Inquiry, the Royal Commission decided that the results of the

DBH investigations would be peer reviewed by eminent

Californian structural engineer Mr William T. Holmes, be contestable, and the subject of individual hearings in our Inquiry process. In order for the results of the DBH investigation to be properly contestable in the Royal Commission’s own Inquiry, the results needed to be available to affected and interested parties prior to the hearings.

When the DBH technical investigation was established, it was expected that the results would be available

by 31 July 2011. However, that proved to be overly optimistic. The DBH consultants’ and expert panel’s reports about three of the four specified buildings were made available on 30 September 2011. The results

of the investigation into the CTV building were not available until 9 February 2012.

It was therefore not possible to schedule hearings on

the four specified buildings in the order that might have been ideal and the Royal Commission decided to defer scheduling hearings in respect of some issues relevant to the Inquiry, which logically had to be addressed after the hearings on the failure of these four buildings.

These issues included the management of buildings after earthquakes, the training and organisation of the engineering profession and the roles and responsibilities of those in the building and construction sector.

3.3.5 Public hearings

Public hearings were conducted on an issue-by-issue basis. They began on 17 October 2011 with a simple opening ceremony that included singing and kapa haka by St Teresa’s School children and a blessing/karakia

by Reverend Gray of Nga- i Tahu and Father Antoine Thomas of St Teresa’s Parish. Justice Cooper welcomed a large contingent of bereaved family members and acknowledged their loss with the words: “Welcome to this Inquiry in which we will find out the reasons why people died in the tragic earthquake of

22 February. We begin by acknowledging the families of those who died and your suffering. We express our deepest sympathy to you.” The acknowledgment was translated into the other seven languages spoken by those who died. Mr Elliott then read out the names of all those who died due to building failures. This was followed by two minutes of silence. At the start of each

hearing about a building that caused loss of life, Justice Cooper acknowledged those who died in that particular building and their families and the injured.

The hearing about seismicity and New Zealand’s seismic landscape began in the afternoon of 17

October (see Volume 1). The following week a one- day hearing was held about the soil conditions in Christchurch (see Volume 1).



**Figure 15: A hearing underway at St Teresa’s church hall in Christchurch**

In November, the Royal Commission commenced

a hearing about policies for earthquake-prone building types, including unreinforced masonry buildings

(see Volume 4) and the failure of the PGC building

(see Volume 2).

The PGC hearing ran into December and the 2011 hearing programme concluded with the first of 19, usually one-day, hearings about other building failures that had caused loss of life (see Volume 4). The CTV building (see Volume 6) was the subject of a later, separate hearing.

After the Christmas break the hearings programme resumed in January 2012 with a two-day hearing about the Hotel Grand Chancellor building (see Volume 2), followed by more hearings about other buildings whose failure caused loss of life. These hearings continued

into March, interrupted by a two-day hearing about the Forsyth Barr building (see Volume 2). In March a hearing about new building technologies (see Volume 3) was also held followed by the final hearings about other buildings whose failure caused loss of life.

The hearings programme was then adjourned for three months to enable the Commission to meet the date

set to deliver the first part of the Final Report and to continue the investigation and preparation for the hearing into the failure of the CTV building. The CTV hearing began on 25 June and it was by far the longest hearing, taking 32 days including closing submissions (see Volume 6). The final three hearings were held in September 2012. They canvassed systemic issues regarding the engineering profession, building management after earthquakes, and roles and responsibilities (see Volume 7).

Because many public buildings and convention centres, were closed due to earthquake damage, the hearings were held at St Teresa’s Hall in Riccarton. Carpet, furniture, computers, internet, microphones and heating were installed to equip it as a hearing venue and

Canterbury Arts and Heritage Trust artist Mr Wayne Seyb provided the finishing touches by kindly agreeing to display his paintings of earthquake-damaged Christchurch buildings in the hall.

To facilitate open communication, people who wished to give evidence and/or make submissions were required to provide them in electronic form in advance of the hearings. In the interests of fairness, evidence and other information the Royal Commission had received about the CTV building and other buildings whose failure caused loss of life was made available on a confidential basis to affected and interested parties prior to the hearing, via a secure online document



**Figure 16: Canterbury artist Wayne Seyb with one of his works at the hearings venue**

access system. Evidence was published for the general public on the Royal Commission’s website once it had been presented in evidence at a hearing.

In total, the Royal Commission held hearings for

82 days, hearing evidence and submissions in person and via video link from other places in New Zealand and overseas. Witnesses included technical experts, eye witnesses, injured people, engineers, building inspectors, property owners, property managers, local and central government

officials and others. The technical experts in many cases participated in expert discussion panels.

Offsite Ministry of Justice transcribers produced 10,877 pages of official transcripts, which were published on the Royal Commission’s website. A summary setting

out the Royal Commission’s hearing topics and the dates of the hearings is in Appendix 4 of this Volume.

3.3.6 Representative sample

The requirement that the Royal Commission analyse a representative sample of buildings required a different approach to other issues addressed in the Inquiry.

A full description of the approach to the representative sample of buildings is explained in section 1 of Volume 2. In summary, a ‘long list’ of buildings of potential interest was created. Information and existing reports were then sought about these buildings from a range of people

and organisations, and technical reports were commissioned. The long list was eventually reduced to

15 buildings, which were fully assessed.

The studied buildings are expected to be of interest to structural engineers in New Zealand and internationally, to improve knowledge of building performance in earthquakes now and in the future. Reports and other information about the studied buildings are available

on the Royal Commission’s website for a limited time and are discussed in Volume 2. Once they are no longer available on the website they will be available from Archives New Zealand.

**3.4 Records management**

By its very nature the Inquiry generated vast quantities of information. More than 6,000 documents were logged in the Royal Commission’s Inquiry database including reports, photos, emails and letters, statements, drawings, presentations, invoices, articles, video clips, forms, work files, microfiche scans, handwritten notes and sketches, minutes, interviews, lists and schedules. All records were logged and assigned an ID number according to their content, and meta-data was added for search purposes.

As part of the study of the representative sample of buildings, building records for approximately 200 buildings were obtained from the Christchurch City Council or viewed on their system and assessed for relevance. Documentation was also sourced from building owners and engineers for many of these buildings. The availability of records varied widely. A very large amount of documentation was available about some buildings.

For example, the Royal Commission received over

20,000 pages of documentation about the CCC civic offices in Hereford Street. After assessment, relevant documents were tracked in a separate buildings database.

A third database was established to record next of kin details and contact the Royal Commission had with bereaved families. As many family members as wished to be were on the Royal Commission’s communications database to receive information. The list expanded from

216 to 350 as people took the opportunity to be kept informed of the Royal Commission’s work.

At the end of the Inquiry originals of all documentation and evidence acquired in the course of the Inquiry

are being transferred to Archives New Zealand for archiving. Some of the material is also being harvested by the University of Canterbury CEISMIC Canterbury Earthquake Digital Archive and published on the earthquake-related research material website <http://www.ceismic.org.nz/>to ensure people have easy access to it in perpetuity.

**3.5 Communications**

Due to the scale of damage to the Christchurch CBD and subsequent loss of life, the Royal Commission anticipated high levels of public interest in the

Inquiry from around New Zealand and the world. The Commission also wished to conduct a transparent and accessible Inquiry, and was mindful of the significant number of persons from overseas who lost close family members and friends in the February earthquake.

In conjunction with the Department of Internal Affairs, the Royal Commission’s website [http://canterbury.](http://canterbury/) royalcommission.govt.nz/ was developed as the major communications channel because of its ability to make information available to anyone in the world at any time. At the time of writing in October 2012, the website had been visited more than 137,000 times since October

2011 and more than half a million pages of content had been viewed.

Early on in the Inquiry the Commission decided to web-enable the Inquiry database to simplify and speed up the document publishing process. More than 1200 of the Inquiry database records were web-

published, including reports, photos, emails and letters, statements, drawings and presentations. During the hearings, evidence was published within minutes

of being presented, giving people timely access to information. At the time of writing, the document library had been viewed more than 50,000 times and a wide range of material had been viewed and downloaded. The reports prepared for the Department of Building and Housing on the CTV building collapse were among the most frequently accessed documents published by the Commission.

To cater for people who were interested in the hearings but could not attend personally, the Royal Commission live streamed the proceedings on the internet. Three high definition webcams were installed to record the Commissioners, counsel and witness stand. The footage was mixed in real time and web-cast on the Commission’s website with information about who

was speaking at the time. The Commission’s hearings were the biggest and longest live stream broadcast undertaken in New Zealand to date with more than

500 hours streamed and nearly two terabytes of data downloaded by viewers. The majority of the traffic was from New Zealand but there was also interest from

the US, Australia and Japan. The first day of the CTV building hearing on 25 June 2012 saw the highest usage of the Commission’s website with almost 5,000 people visiting the site, mostly to watch the live feed of the morning session.

To overcome international time differences and make the hearings accessible at any time, the Royal Commission also recorded the entire live stream, edited it into approximately 15 minute videos and published the videos on the Commission’s website. The videos were published throughout each hearing day in the website video library with website links to the appropriate

hearing timetable, evidence presented by each witness and related reports. Each video was also linked to the appropriate written transcript once it was available.

A search tool enabled website users to search for

videos by date, topic, building and witness. In total, 1866 videos were published and linked to 1200 documents. At the time of writing people from 132 countries had viewed the videos 73,588 times. The videos have also been watched more than 2000 times since the hearings

finished. The Department of Internal Affairs will continue to manage the Royal Commission website now the Inquiry is over. It is likely eventually to be archived by Archives New Zealand.

The Royal Commission recognised that the news media would also play an important role in keeping the public informed about its work. Regular media statements

were issued to keep the media informed of the Inquiry progress and interviews were granted with the

Royal Commission as required. Prior to the hearings, the media were requested to register with the Royal Commission and invited to attend two background media briefings. Such was the level of interest from the Japanese media that a Japanese-only media conference was held in February 2012. There was only room for one television camera operator and press photographer in the actual hearing room. The Royal Commission thanks TVNZ, Mediaworks and

*The Press* for providing their footage and photographs to other media throughout the hearings. Reporters worked from a portable media centre provided

outside the hearings venue. Media who could not attend the hearings personally also watched via the live stream from around New Zealand and the world. The Royal Commission believes there has never been a more accessible Royal Commission process.



**Figure 17: Volunteers translate Justice Cooper’s condolences to bereaved families at the opening of the hearings**

**3.6 Bereaved families, injured and tenants**

From the time it was established, the Royal Commission endeavoured to assure bereaved, seriously injured people and other surviving occupants of failed buildings that there would be a thorough inquiry, and that they would be kept informed if they wished to be. People’s needs differ greatly when grieving. Accordingly, the Royal Commission’s approach was to ask people

what they needed rather than making assumptions, and to provide information to them before it was released publicly.

The Commission communicated directly with all bereaved families, including overseas families, throughout the Inquiry. Contact began early in the Inquiry when Justice Cooper wrote to all known family members and invited them to meet with him individually or in a group. Many families took up this offer over a period of several months. They included families from Japan and China. Efforts were also made to contact injured people and building tenants although this was more difficult because of a lack of a centralised list.

The Ministry of Foreign Affairs and Trade arranged a briefing for foreign missions and kept them informed at key points during the Inquiry, particularly about the release of reports.

Ms Kate Collins was appointed as the Royal Commission’s Family and Community Liaison Officer. Her role was to act as the first point of contact with the Royal Commission for bereaved families, injured people and survivors of failed buildings that the Royal Commission was investigating. She sent regular

email updates to all bereaved families to keep them informed of Inquiry progress. Face-to-face briefings were organised prior to and during the PGC and CTV hearings including meetings with visiting overseas bereaved families. The Royal Commission particularly acknowledges the assistance of Chinese volunteer

Mr Cai Qunliang (Liam) and Ms Susan Urakami of the Toyama College of Foreign Languages in Japan

in organising these meetings and providing language support. Teleconferences were held for those living outside Christchurch.

Chinese and Japanese bereaved families specifically requested language support to enable them to follow our investigation into the failure of the CTV building where 28 Japanese and 23 Chinese language students died. The Commission responded by translating key documents and communications into Chinese and Japanese as resources allowed, and made these

available via the online document access system.

The Royal Commission acknowledges the support of embassies that helped their citizens gain access to the system. At the request of next of kin, section 9

of Volume 6, which summarises the Commission’s conclusions about the causes of the CTV building collapse, is also translated into Simplified Chinese, Japanese, Thai and Korean documents that are published separately.

Ms Collins attended all hearings about buildings that caused loss of life and was available to liaise between families, injured people, tenants, survivors and Mr Elliott. She organised on-site counselling support as needed.

A memorial board was available at the Royal Commission’s hearings venue, where families and community members could place photos, mementos and messages acknowledging the deceased and their friends and families. The children of St Teresa’s School decorated this space and wrote messages of support.



**Figure 18: Memorial board at Royal Commission hearings venue**

Ms Collins’ role also included arranging practical support for families, for example, referrals to psychotherapists and counsellors and advocating on behalf of those applying for grants to help raise children after the loss of a partner. She also organised facilitated support groups for bereaved families, and then handed these over to the Red Cross to provide ongoing assistance beyond the life of the Royal Commission.

To provide continuity, Ms Collins also attended events organised by other organisations such as Coronial Services and the former DBH.

As noted earlier, families of those who died, the injured and tenants were given the status of affected parties for the hearings related to buildings that caused their death or injury. This conferred certain rights, including the

right to access evidence, on a confidential basis, prior to the hearings. In this way they had the opportunity to be prepared for the evidence that would be presented at the hearing and be well informed. It is thought that this enabled them to engage more effectively in the hearing process. The status of affected party also gave them the right to be represented by counsel at the relevant hearing and to suggest to counsel assisting additional documents or witnesses that ought to be called. As affected parties, families were also invited to contribute to a closing submission for the CTV hearing presented by Mr Elliott on behalf of bereaved families and those who were injured.

Mr Elliott kept bereaved families and the injured informed of details of the investigation at group briefings and, upon request, individually. Bereaved families

and injured were invited to have input into Mr Elliott’s questioning of witnesses. He often prefaced his questioning with “the bereaved families would like to know…” Almost without exception bereaved families, tenants and the injured chose not to engage their own counsel. One CTV bereaved family member exercised her right to make a closing statement.

The Royal Commission wished to acknowledge in this Final Report, all those who lost their lives due to building failure. Biographical information was sought from bereaved family members and short biographies on those who died, based on the information received, were published in the following Volumes of the Final Report:

• Volume 2 section 2: PGC building fatalities;

• Volume 4 section 4.3: Individual unreinforced

masonry buildings that caused fatalities; and

• Volume 6 Introduction: CTV building fatalities.

The Royal Commission is grateful to all the families for generously sharing their memories and also wishes to acknowledge the Japanese and Chinese embassies

for language support and *The Press* for providing additional information.

**3.7 Reporting requirements**

It was necessary for the Royal Commission to run parallel work streams in order to prepare its Reports progressively as various aspects of the Inquiry were completed.

3.7.1 Interim Report

It was important that the reasons for the severity of the damage to buildings were understood as soon as possible to facilitate new building work in Christchurch. The Terms of Reference accordingly specified that

an Interim Report was to be provided by 11 October

2011. As the Inquiry was then only part-way through, and there had been no opportunity to hear and test evidence on any issues, the Interim Report consisted largely of preliminary views.

The Interim Report, which was delivered to the Governor-General in Wellington on 10 October 2011, nevertheless contained 15 recommendations covering seismicity, geotechnical considerations, the general performance of unreinforced masonry buildings, design practice and new building technologies. It focused on measures that the Royal Commission recommended should be implemented in Christchurch as it rebuilt following the earthquakes, but also dealt with matters that required early attention in New Zealand as a

whole. The Report was released by the Government on 12 October 2011.

3.7.2 Final Report

The Terms of Reference required the Royal Commission to deliver a Final Report by 11 April 2012. Delays in receiving the results of DBH’s technical investigation

into the four named buildings soon made it plain that the Royal Commission was not going to be able to achieve this deadline.

In February 2012 the Governor-General agreed to an extension to the reporting date. To enable decisions about the central city rebuild to be made as soon as possible, it was agreed that the Final Report would be delivered in stages. Part one, to be delivered by

29 June 2012, would contain recommendations to inform early decision-making about the Christchurch CBD’s recovery from the Canterbury earthquakes.

It consisted of three Volumes, which were delivered

to the Governor-General in Auckland on the due date. The Volumes were:

• Volume 1: Summary and recommendations in Volumes 1–3: Seismicity, soils and the seismic design of buildings (112 pages);

• Volume 2: The performance of Christchurch CBD

buildings (236 pages); and

• Volume 3: Low-damage building technologies

(39 pages).

Part one contained 70 conclusions and recommendations based on the Royal Commission’s consideration of the performance of the representative sample of Christchurch central business district buildings, as well as the Commission’s analysis of many of the technical expert reports it had received and insights gained through the public hearings held

to date. It also set out the Commission’s findings on the PGC building. It was released by the Government on 23 August 2012.

The modified Terms of Reference required the remainder of the Final Report to be delivered on or before 12 November 2012. Part two of the Final Report was delivered to the Governor-General in Wellington

on 10 October 2012. It consisted of:

• Volume 4: Earthquake-prone Buildings (240 pages).

It contained reports on the individual buildings whose failure caused death (excluding PGC and CTV). Part two contained a further 35 recommendations as well as conclusions about unreinforced masonry and other earthquake-prone buildings. At the time of writing, it was yet to be released by the Government.

When the Terms of Reference were modified, planning for the CTV hearings was still in its preliminary stages. At this time it was thought the hearing would take a few weeks and that the 12 November deadline would be achievable. However the eventual length of the hearing meant a short second extension was required to enable the Commission to deliver a quality report. In October the Governor-General agreed to extend the reporting date to 30 November 2012.

The remainder of the Final Report consists of this

Volume and two others. These three Volumes are:

• Volume 5: Summary and recommendations in Volumes 5–7, Christchurch, the City and approach to this Inquiry;

• Volume 6: CTV building; and

• Volume 7: Roles and responsibilities.

**Appendix 1:**

**Terms of Reference**

Royal Commission of Inquiry into Building Failure caused by Canterbury Earthquakes

Elizabeth the Second, by the Grace of God Queen of New Zealand and her Other Realms and Territories, Head of the Commonwealth, Defender of the Faith:

To The Honourable MARK LESLIE SMITH COOPER, of Auckland, Judge of the High Court of New Zealand; Sir RONALD POWELL CARTER, KNZM, of Auckland, Engineer and Strategic Advisor; and

RICHARD COLLINGWOOD FENWICK, of Christchurch, Associate Professor of Civil Engineering: GREETING:

**Recitals**

WHEREAS the Canterbury region, including Christchurch City, suffered an earthquake on 4 September 2010 and numerous aftershocks, for example—

(a) the 26 December 2010 (or Boxing Day) aftershock; and

(b) the 22 February 2011 aftershock:

WHEREAS approximately 180 people died of injuries suffered in the 22 February 2011 aftershock, with most of those deaths caused by injuries suffered wholly or partly because of the failure of certain buildings in the Christchurch City central business district (CBD), namely the following 2 buildings:

(a) the Canterbury Television (or CTV) Building; and

(b) the Pyne Gould Corporation (or PGC) Building:

WHEREAS other buildings in the Christchurch City CBD, or in suburban commercial or residential areas in the

Canterbury region, failed in the Canterbury earthquakes, causing injury and death:

WHEREAS a number of buildings in the Christchurch City CBD have been identified as unsafe to enter following the 22 February 2011 aftershock, and accordingly have been identified with a red card to prevent persons from entering them:

WHEREAS the Department of Building and Housing has begun to investigate the causes of the failure of 4 buildings in the Christchurch City CBD (the 4 specified buildings), namely the 2 buildings specified above, and the following

2 other buildings:

(a) the Forsyth Barr Building; and

(b) the Hotel Grand Chancellor Building:

WHEREAS it is desirable to inquire into the building failures in the Christchurch City CBD, to establish— (a) why the 4 specified buildings failed severely; and

(b) why the failure of those buildings caused such extensive injury and death; and

(c) why certain buildings failed severely while others failed less severely or there was no readily perceptible failure:

WHEREAS the results of the inquiry should be available to inform decision-making on rebuilding and repair work in the Christchurch City CBD and other areas of the Canterbury region:

**Appointment and order of reference**

KNOW YE that We, reposing trust and confidence in your integrity, knowledge, and ability, do, by this Our Commission, nominate, constitute, and appoint you, The Honourable MARK LESLIE SMITH COOPER, Sir RONALD POWELL CARTER, and RICHARD COLLINGWOOD FENWICK, to be a Commission to inquire into and report (making any interim or final recommendations that you think fit) upon (having regard, in the case of paragraphs (a) to (c), to the nature and severity of the Canterbury earthquakes)—

**Inquiry into sample of buildings and 4 specified buildings**

(a) in relation to a reasonably representative sample of buildings in the Christchurch City CBD, including the 4 specified buildings as well as buildings that did not fail or did not fail severely in the Canterbury earthquakes—

(i) why some buildings failed severely; and

(ii) why the failure of some buildings caused extensive injury and death; and

(iii) why buildings differed in the extent to which—

(A) they failed as a result of the Canterbury earthquakes; and

(B) their failure caused injury and death; and

(iv) the nature of the land associated with the buildings inquired into under this paragraph and how it was affected by the Canterbury earthquakes; and

(v) whether there were particular features of a building (or a pattern of features) that contributed to whether a building failed, including (but not limited to) factors such as—

(A) the age of the building; and

(B) the location of the building; and

(C) the design, construction, and maintenance of the building; and

(D) the design and availability of safety features such as escape routes; and

(b) in relation to all of the buildings inquired into under paragraph (a), or a selection of them that you consider appropriate but including the 4 specified buildings,—

(i) whether those buildings (as originally designed and constructed and, if applicable, as altered and maintained)

complied with earthquake-risk and other legal and best-practice requirements (if any) that were current— (A) when those buildings were designed and constructed; and

(B) on or before 4 September 2010; and

(ii) whether, on or before 4 September 2010, those buildings had been identified as “earthquake-prone” or were the subject of required or voluntary measures (for example, alterations or strengthening) to make the buildings less susceptible to earthquake risk, and the compliance or standards they had achieved; and

(c) in relation to the buildings inquired into under paragraph (b), the nature and effectiveness of any assessment of them, and of any remedial work carried out on them, after the 4 September 2010 earthquake, or after the

26 December 2010 (or Boxing Day) aftershock, but before the 22 February 2011 aftershock; and

**Inquiry into legal and best-practice requirements**

(d) the adequacy of the current legal and best-practice requirements for the design, construction, and maintenance of buildings in central business districts in New Zealand to address the known risk of earthquakes and, in particular—

(i) the extent to which the knowledge and measurement of seismic events have been used in setting legal and best-practice requirements for earthquake-risk management in respect of building design, construction, and maintenance; and

(ii) the legal requirements for buildings that are “earthquake-prone” under section 122 of the Building Act 2004 and associated regulations, including—

(A) the buildings that are, and those that should be, treated by the law as “earthquake-prone”; and

(B) the extent to which existing buildings are, and should be, required by law to meet requirements for the design, construction, and maintenance of new buildings; and

(C) the enforcement of legal requirements; and

(iii) the requirements for existing buildings that are not, as a matter of law, “earthquake-prone”, and do not meet current legal and best-practice requirements for the design, construction, and maintenance of new buildings, including whether, to what extent, and over what period they should be required to meet those requirements; and

(iv) the roles of central government, local government, the building and construction industry, and other elements of the private sector in developing and enforcing legal and best-practice requirements; and

(v) the legal and best-practice requirements for the assessment of, and for remedial work carried out on, buildings after any earthquake, having regard to lessons from the Canterbury earthquakes; and

(vi) how the matters specified in subparagraphs (i) to (v) compare with any similar matters in other countries; and

**Other incidental matters arising**

(e) any other matters arising out of, or relating to, the foregoing that come to the Commission’s notice in the course of its inquiries and that it considers it should investigate:

**Matters upon or for which recommendations required**

And, without limiting the order of reference set out above, We declare and direct that this Our Commission also requires you to make both interim and final recommendations upon or for—

(a) any measures necessary or desirable to prevent or minimise the failure of buildings in New Zealand due to earthquakes likely to occur during the lifetime of those buildings; and

(b) the cost of those measures; and

(c) the adequacy of legal and best-practice requirements for building design, construction, and maintenance insofar as those requirements apply to managing risks of building failure caused by earthquakes:

**Exclusions from inquiry and scope of recommendations**

But, We declare that you are not, under this Our Commission, to inquire into, determine, or report in an interim or final way upon the following matters (but paragraph (b) does not limit the generality of your order of reference, or of your required recommendations):

(a) whether any questions of liability arise; and

(b) matters for which the Minister for Canterbury Earthquake Recovery, the Canterbury Earthquake Recovery Authority, or both are responsible, such as design, planning, or options for rebuilding in the Christchurch City CBD; and

(c) the role and response of any person acting under the Civil Defence Emergency Management Act 2002, or providing any emergency or recovery services or other response, after the 22 February 2011 aftershock:

**Definitions**

And, We declare that, in this Our Commission, unless the context otherwise requires,—

best-practice requirements

includes any New Zealand, overseas country’s, or international standards that are not legal requirements

Canterbury earthquakes

means any earthquakes or aftershocks in the Canterbury region—

(a) on or after 4 September 2010; and

(b) before or on 22 February 2011

Christchurch City CBD

means the area bounded by the following:

(a) the 4 avenues (Bealey Avenue, Fitzgerald Avenue, Moorhouse Avenue, and Deans Avenue); and

(b) Harper Avenue

failure

in relation to a building, includes the following, regardless of their nature or level of severity:

(a) the collapse of the building; and

(b) damage to the building; and

(c) other failure of the building

legal requirements

includes requirements of an enactment (for example, the building code):

**Appointment of chairperson**

And We appoint you, The Honourable MARK LESLIE SMITH COOPER, to be the chairperson of the Commission:

**Power to adjourn**

And for better enabling you to carry this Our Commission into effect, you are authorised and empowered, subject

to the provisions of this Our Commission, to make and conduct any inquiry or investigation under this Our Commission in the manner and at any time and place that you think expedient, with power to adjourn from time to time and from place to place as you think fit, and so that this Our Commission will continue in force and that inquiry may at any time and place be resumed although not regularly adjourned from time to time or from place to place:

**Information and views, relevant expertise, and research**

And you are directed, in carrying this Our Commission into effect, to consider whether to do, and to do if you think fit, the following:

(a) adopt procedures that facilitate the provision of information or views related to any of the matters referred to in the order of reference above; and

(b) use relevant expertise, including consultancy services and secretarial services; and

(c) conduct, where appropriate, your own research; and

(d) determine the sequence of your inquiry, having regard to the availability of the outcome of the investigation by the

Department of Building and Housing and other essential information, and the need to produce an interim report:

**General provisions**

And, without limiting any of your other powers to hear proceedings in private or to exclude any person from any of your proceedings, you are empowered to exclude any person from any hearing, including a hearing at which evidence is being taken, if you think it proper to do so:

And you are strictly charged and directed that you may not at any time publish or otherwise disclose, except to His Excellency the Governor-General of New Zealand in pursuance of this Our Commission or by His Excellency’s direction, the contents or purport of any interim or final report so made or to be made by you:

And it is declared that the powers conferred by this Our Commission are exercisable despite the absence at any time of any 1 member appointed by this Our Commission, so long as the Chairperson, or a member deputed by the Chairperson to act in the place of the Chairperson, and at least 1 other member, are present and concur in the exercise of the powers:

**Interim and final reporting dates**

And, using all due diligence, you are required to report to His Excellency the Governor-General of New Zealand in writing under your hands as follows:

(a) not later than 11 October 2011, an interim report, with interim recommendations that inform early decision-making on rebuilding and repair work that forms part of the recovery from the Canterbury earthquakes; and

(b) not later than 11 April 2012, a final report:

And, lastly, it is declared that these presents are issued under the authority of the Letters Patent of Her Majesty Queen Elizabeth the Second constituting the office of Governor-General of New Zealand, dated 28 October 1983\*, and under the authority of and subject to the provisions of the Commissions of Inquiry Act 1908, and with the advice and consent of the Executive Council of New Zealand.

In witness whereof We have caused this Our Commission to be issued and the Seal of New Zealand to be hereunto affixed at Wellington this 11th day of April 2011.

Witness Our Trusty and Well-beloved The Right Honourable Sir Anand Satyanand, Chancellor and Principal Knight Grand Companion of Our New Zealand Order of Merit, Principal Companion of Our Service Order, Governor-General and Commander-in-Chief in and over Our Realm of New Zealand.

ANAND SATYANAND, Governor-General. By His Excellency’s Command—

JOHN KEY, Prime Minister. Approved in Council—

REBECCA KITTERIDGE, Clerk of the Executive Council.

*\*SR 1983/225*

**Modifications to Reporting Requirements and Powers of Royal Commission of Inquiry into Building Failure Caused by Canterbury Earthquakes**

Elizabeth the Second, by the Grace of God Queen of New Zealand and her Other Realms and Territories, Head of the Commonwealth, Defender of the Faith:

To The Honourable MARK LESLIE SMITH COOPER, of Auckland, Judge of the High Court of New Zealand;

Sir RONALD POWELL CARTER, KNZM, of Auckland, Engineer and Strategic Adviser; and RICHARD COLLINGWOOD FENWICK, of Christchurch, Associate Professor of Civil Engineering:

GREETING:

WHEREAS by Our Warrant, dated 11 April 2011, issued under the authority of the Letters Patent of Her Majesty Queen Elizabeth the Second constituting the office of Governor-General of New Zealand, dated 28 October 1983, and under the authority of and subject to the provisions of the Commissions of Inquiry Act 1908, and with the advice and consent of the Executive Council of New Zealand, we nominated, constituted, and appointed you, the said The Honourable MARK LESLIE SMITH COOPER, Sir RONALD POWELL CARTER, KNZM, and RICHARD COLLINGWOOD FENWICK,

to be a Commission to inquire into and report (making any interim or final recommendations that you think fit) upon certain matters relating to building failure caused by the Canterbury earthquakes:

AND WHEREAS by Our said Warrant you are required to report finally to His Excellency the Governor-General of

New Zealand not later than 11 April 2012:

AND WHEREAS it is expedient that the time and other requirements for reporting under Our said Warrant should be modified as hereinafter provided:

NOW, THEREFORE, We do by these presents require you to report and make final recommendations (required and otherwise) on the matters in Our said Warrant as follows:

(a) not later than 29 June 2012, on matters that would inform early decision-making on rebuilding and repair work that forms part of the recovery from the Canterbury earthquakes;

and

(b) at any time before 12 November 2012 on any other matter, if you are able to do so; and

(c) not later than 12 November 2012, on all matters on which you have not otherwise reported:

AND WHEREAS it is expedient that the powers conferred by Our said Warrant be modified, We do by these presents declare that the powers are exercisable by the Chairperson, or a member deputed by the Chairperson to act in the place of the Chairperson, despite the absence of 1 or 2 of the persons appointed to be members of the Commission, so long as at least 1 other member concurs in the exercise of the powers:

AND it is declared that nothing in these presents affects any act or thing done or decision made by the Commission or any of its members, in the exercise of its powers, before the making of these presents:

And We do hereby confirm Our Warrant dated 11 April 2011 and the Commission constituted by that Warrant, except as modified by these presents:

And, lastly, it is declared that these presents are issued under the authority of the Letters Patent of Her Majesty Queen Elizabeth the Second constituting the office of Governor-General of New Zealand, dated 28 October 1983, and under the authority of and subject to the provisions of the Commissions of Inquiry Act 1908, and with the advice and consent of the Executive Council of New Zealand.

In Witness whereof We have caused these presents to be issued and the Seal of New Zealand to be hereunto affixed at Wellington this 7th day of February 2012.

Witness Our Trusty and Well-beloved Lieutenant General The Right Honourable Sir Jerry Mateparae, Chancellor

and Principal Knight Grand Companion of Our New Zealand Order of Merit, Principal Companion of Our Service Order, Governor-General and Commander-in-Chief in and over Our Realm of New Zealand.

[L.S.]

LT GEN SIR JERRY MATEPARAE, Governor-General

By His Excellency’s Command- JOHN KEY, Prime Minister. Approved in Council-

REBECCA KITTERIDGE, Clerk of the Executive Council.

**Further Extension of Time Within Which Royal Commission of Inquiry into Building**

**Failure Caused by Canterbury Earthquakes May Report**

Elizabeth the Second, by the Grace of God Queen of New Zealand and her Other Realms and Territories, Head of the

Commonwealth, Defender of the Faith:

To The Honourable MARK LESLIE SMITH COOPER, of Auckland, Judge of the High Court of New Zealand;

Sir RONALD POWELL CARTER, KNZM, of Auckland, Engineer and Strategic Adviser; and RICHARD COLLINGWOOD FENWICK, of Christchurch, Associate Professor of Civil Engineering:

GREETING:

WHEREAS by Our Warrant, dated 11 April 20111, issued under the authority of the Letters Patent of Her Majesty Queen Elizabeth the Second constituting the office of Governor-General of New Zealand, dated 28 October 19832, and under the authority of and subject to the provisions of the Commissions of Inquiry Act 1908, and with the advice and consent of the Executive Council of New Zealand, we nominated, constituted, and appointed you, the said The Honourable MARK LESLIE SMITH COOPER; Sir RONALD POWELL CARTER, KNZM, and RICHARD COLLINGWOOD FENWICK, to be a Commission to inquire into and report (making any interim or final recommendations that you think fit) upon certain matters relating to building failure caused by the Canterbury earthquakes:

AND WHEREAS by Our said Warrant you were required to report finally to His Excellency the Governor-General of

New Zealand not later than 11 April 2012:

AND WHEREAS by Our Warrant, dated 7 February 20123, the time within which you were so required to report finally was extended to 12 November 2012:

AND WHEREAS it is expedient that the time and other requirements for reporting under Our said Warrant should be extended as hereinafter provided:

NOW, THEREFORE, We do by these presents extend, until the end of 30 November 2012, the time within which you are required to report finally on all matters on which you have not otherwise reported:

And We do hereby confirm Our Warrant dated 11 April 2011 and the Commission constituted by that Warrant, save as modified by these presents:

And, lastly, it is declared that these presents are issued under the authority of the Letters Patent of Her Majesty Queen Elizabeth the Second constituting the office of Governor-General of New Zealand, dated 28 October 1983, and under the authority of and subject to the provisions of the Commissions of Inquiry Act 1908, and with the advice and consent of the Executive Council of New Zealand.

In Witness whereof We have caused these presents to be issued and the Seal of New Zealand to be hereunto affixed at Wellington this 23rd day of October 2012.

Witness Our Trusty and Well-beloved Lieutenant General The Right Honourable Sir Jerry Mateparae, Chancellor and Principal Knight Grant Companion of Our New Zealand Order of Merit, Principal Companion of Our Service Order, Governor-General and Commander-in-Chief in and over Our Realm of New Zealand.

[L.S.]

Lt Gen Sir JERRY MATEPARAE, Governor-General. By His Excellency’s Command—

Rt Hon JOHN KEY, Prime Minister. Approved in Council—

REBECCA KITTERIDGE, Clerk of the Executive Council.

1 *New Zealand Gazette*, 14 April 2011, No 51, page 1201

2 SR 1983/225

3 *New Zealand Gazette*, 9 February 2012, No. 14, page 345

**Appendix 2: Expert advisors**

Dr Christopher Allington, Managing Director, Holmes Solutions LP, Christchurch

David Brunsdon, Kestrel Group, Wellington

Athol Carr, Professor Emeritus, Department of Civil and Natural Resources Engineering, University of Canterbury

Dr Barry Davidson, Director, Compusoft Engineering Limited, Civil, Structural and Mechanical Engineers, Auckland

Dr Andrew Dickson, Technical Director, Civil Structures Section, Beca Infrastructure Limited, Auckland

Graeme Frost, Chief Engineer, Fletcher Construction Company, Auckland

John Henry, Associate, Eliot Sinclair and Partners Limited, Christchurch

Dr Robert Heywood, Principal, Heywood Engineering Solutions Pty Ltd, Queensland

Dr Clark Hyland, Director, Hyland Consultants Limited Institution of Professional Engineers New Zealand (IPENZ) Dr Murray Jacobs, Consulting Engineer, Auckland

Dr James Mackechnie, Adjunct Senior Fellow, Department of Civil and Natural Resources Engineering, University of Canterbury

New Zealand Society for Earthquake Engineering (NZSEE)

Nigel Priestley, Emeritus Professor, University of California at San Diego and Emeritus Co-director of the ROSE School

Gerard Willis, Enfocus Limited, Auckland

**International peer reviewers/experts**

William T. Holmes, Principal, Rutherford and Chekene, Consulting Engineers, San Francisco

Bret Lizundia, Principal, Rutherford and Chekene, Consulting Engineers, San Francisco

**Appendix 3:**

**Submitters and witnesses**

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| **Submissions received: Local government management of earthquake risk** | |
| **Person or organisation** | **Paper** |
| Christchurch City Council | *Response by the Christchurch City Council to Enfocus report “Management of Earthquake Risk by Canterbury Regional Council and Christchurch City Council”* |
| Environment Canterbury | *Environment Canterbury’s response to the*  *Royal Commissions report on the Management of Earthquake Risk by Canterbury Regional Council and Christchurch City Council* |
| Malcolm Flain | *Submission* |
| Ministry of Business, Innovation and Employment (including submissions by the former Department of Building and Housing) | *Department of Building and Housing submission to the Royal Commission for the Canterbury Earthquakes on the management of earthquake risk by Canterbury Regional Council and Christchurch City Council* |
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| **Submissions received: Building management after earthquakes** | |
| **Person or organisation** | **Paper** |
| Brian Andersen | *Submission by email on 13 December 2011 regarding Street Address Records and Confusion in Emergency Response* |
| Auckland Council | *Discussion Paper: Building Management After*  *Earthquakes* |
| Christchurch City Council | *Submissions on the process and authority for building assessment after earthquakes (stickering/placarding) (Issue 3(e)) and related issues* |
| *Submissions on the Discussion Paper: Building*  *Management after Earthquakes* |
| Bronwyn Dewar | *Submission by email on 15 December 2011 regarding*  *Confusion of status of buildings safe to occupy* |
| Dunning Thornton | *Submission to the Canterbury Earthquakes Royal Commission: Building Management after Earthquakes* |
| Malcolm Flain | *Further submission from Malcolm Flain* |
| Nigel Harwood | *The Placarding of Buildings and Barricade Location*  *(The Perspective of a Volunteer Chartered Engineer)* |
| Institution of Professional Engineers New Zealand | *Discussion Paper: Building Management After Earthquakes: Submission to Canterbury Earthquakes Royal Commission* |
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| **Submissions received: Building management after earthquakes** | |
| **Person or organisation** | **Paper** |
| Dr Marion Irwin | *Dr Marion Irwin Canterbury Earthquakes*  *Royal Commission Submission* |
| Guy Marriage | *Submission to: Canterbury Earthquakes*  *Royal Commission* |
| Ministry of Business, Innovation and Employment (including submissions by the former Department of Building and Housing) | *Department of Building and Housing submission to the Royal Commission for the Canterbury Earthquakes on Building Assessments after Earthquakes* |
| *Ministry of Business, Innovation and Employment Submission on the Discussion Paper: Building Management after Earthquakes* |
| Ministry of Civil Defence and Emergency Management | *Ministry of Civil Defence and Emergency Management Submission on the Canterbury Earthquakes Royal Commission Discussion Paper: Building Management after Earthquakes* |
| New Zealand Historic Places Trust | *Submission of New Zealand Historic Places Trust*  *Pouhere Taonga to Canterbury Earthquakes*  *Royal Commission discussion papers* |
| New Zealand Society for Earthquake Engineering | *Building Management After Earthquakes: Submission to the Canterbury Earthquakes Royal Commission* |
| New Zealand Society for Risk Management | *Evidence to the Canterbury Earthquakes Royal Commission: Submission by the New Zealand Society for Risk Management in Respect of the Discussion Paper: Building Management after Earthquakes* |
| Structural Engineering Society New Zealand | *Building Management after Earthquakes: Submission to the Canterbury Earthquakes Royal Commission* |

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| **Submissions received: Education and training of engineers and organisation of the profession** | |
| **Person or organisation** | **Paper** |
| Paul Baker | *Education of Engineers* |
| Beca | *Submission Concerning Training and Professional*  *Development of Graduate Structural Engineers* |
| Derek Bradley | *Submission by letter on 31 January 2012 regarding The Training of Engineers and Organisation of the Engineering Profession* |
| David Brunsdon | *Integrating Professional Engineering within Emergency*  *Management Planning and Response in New Zealand* |
| Cement and Concrete Association of New Zealand | *Submission to the Canterbury Earthquakes*  *Royal Commission on Discussion Paper: Training and Education of Engineers and Organisation of the Engineering Profession* |
| Chartered Professional Engineers Council | *Submission to the Canterbury Earthquakes*  *Royal Commission* |
| Department of Geological Sciences, University of Canterbury | *Education of Structural and Geotechnical Engineers at the University of Canterbury* |
| *The Education of Engineers; Submission to the*  *Royal Commission: Response to the Discussion Paper: Training and education of engineers and organisation of the engineering profession* |
| Matt Furness | *Submission – Training and Education of Engineers and Organisation of the Engineering Profession* |
| Institution of Professional Engineers New Zealand and the Association of Consulting Engineers New Zealand (joint submission) | *Discussion Paper: Training and Education of Engineers and Organisation of the Engineering Profession: Submission to Canterbury Earthquakes*  *Royal Commission* |
| C. Lund & Son Ltd | *Submission to the Canterbury Earthquakes*  *Royal Commission: Education and Training in the*  *Construction Industry* |
| *Submission by letter on 23 July 2012 in response to the Discussion Paper; Training and Education of Engineers and Organisation of the Engineering Profession* |
| Guy Marriage | *Submission to: Canterbury Earthquakes*  *Royal Commission* |
| Ministry of Business, Innovation and Employment (including the former Department of Building and Housing) | *Department of Building and Housing submission to the Royal Commission on the training of engineers and the organisation of the profession* |
| *Ministry of Business, Innovation and Employment Submission on the Discussion Paper: Training and Education of Engineers and Organisation of the Engineering Profession* |

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| **Submissions received: Education and training of engineers and organisation of the profession** | |
| **Person or organisation** | **Paper** |
| Peter Morgan | *Submission to the Canterbury Earthquakes*  *Royal Commission, on the role of professional societies in the engineering sector* |
| New Zealand Concrete Society | *Submission by the New Zealand Concrete Society to the*  *Canterbury Earthquakes Royal Commission* |
| New Zealand Historic Places Trust | *Submission of the New Zealand Historic Places Trust*  *Pouhere Taonga to the Canterbury Earthquakes*  *Royal Commission discussion papers* |
| Carl O’Grady | *Report to the Canterbury Earthquakes Royal*  *Commission. July 2012. Discussion paper: training and education of engineers and organisation of the engineering profession* |
| Opus International Consultants | *Submission Re: Discussion Paper on Training and Education of Engineers and Organisation of the Engineering Profession* |
| John Scarry | *A Submission to the Canterbury Earthquakes*  *Royal Commission: Training and Education of Engineers and Organisation of the Engineering Profession* |
| Structural Engineering Society New Zealand | *Training and education of engineers and organisation of the engineering profession: Submission to Canterbury Earthquakes Royal Commission* |

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| **Submissions received: Roles and responsibilities** | |
| **Person or organisation** | **Paper** |
| The Architectural Centre Incorporated | *Architectural Centre submission on The Canterbury Earthquakes Royal Commission Discussion Paper: Roles and Responsibilities* |
| Building Officials Institute of New Zealand | *Submission to Canterbury Earthquake Royal Commission*  *Aug 2012* |
| Brian Carter | *Roles and Responsibilities* |
| Cement and Concrete Association of New Zealand | *Submission to the Canterbury Earthquakes Royal Commission on Discussion Paper: Roles and Responsibilities* |
| Claire Chambers | *A Submission to the Canterbury Earthquakes Royal Commission: Roles and responsibilities – An Architect’s Perspective* |
| Christchurch City Council | *Submission on the Discussion Paper: Roles and*  *Responsibilities* |

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| **Submissions received: Roles and responsibilities** | |
| **Person or organisation** | **Paper** |
| Environment Canterbury | *Submission by letter on 12 August 2012 regarding the Discussion Paper: Roles and Responsibilities* |
| Ian Fraser | *Submission by email on 13 August 2012 regarding the*  *Discussion paper: Roles and Responsibilities July 2012* |
| Hamilton District Council | *Submission to the Commission’s Discussion Paper on*  *Roles and Responsibilities* |
| Dr David Hopkins | *Roles and Responsibilities: Submission by*  *Dr David C Hopkins, Consulting Engineer, Wellington* |
| Institution of Professional Engineers New Zealand and the Association of Consulting Engineers New Zealand (joint submission) | *Discussion Paper: Roles and Responsibilities: Submission to the Canterbury Earthquakes Royal Commission* |
| International Accreditation New Zealand | *Submission by email on 14 August 2012* |
| Local Government New Zealand | *Submission to the Canterbury Earthquakes*  *Royal Commission In the matter of Discussion Paper: Roles and Responsibilities* |
| Guy Marriage | *Submission to Canterbury Earthquakes*  *Royal Commission* |
| Ministry of Business, Innovation and Employment | *The Ministry of Business, Innovation and Employment Submission on Discussion Paper: Roles and Responsibilities* |
| New Plymouth District Council | *Submission by email on 10 August 2012* |
| New Zealand Concrete Society | *Submission by the New Zealand Concrete Society to the Canterbury Earthquakes Royal Commission* |
| New Zealand Construction Industry Council | *CERC Discussion Paper: Roles & Responsibilities in the Building & Construction Industry* |
| New Zealand Geotechnical Society | *Canterbury Earthquakes Royal Commission: NZGS Submission on Discussion Paper: Roles and Responsibilities* |
| New Zealand Institute of Building Surveyors | *Roles and Responsibilities in the Building and*  *Construction Industry* |
| Queenstown Lakes District Council | *Queenstown Lakes District Council Submission to Canterbury Earthquake Royal Commission Aug 2012: Topic: Roles and Responsibilities in New Zealand’s building controls and regulatory system* |
| John Scarry | *Submission to the Canterbury Earthquakes*  *Royal Commission: Roles and Responsibilities* |
| Standards Council | *Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes: Standards Council – Submission on Discussion Paper:*  *Roles and Responsibilities* |

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| **Submissions received: Roles and responsibilities** | |
| **Person or organisation** | **Paper** |
| Structural Engineering Society New Zealand | *Roles and Responsibilities: Submission to Canterbury*  *Earthquakes Royal Commission* |
| Stuart Thomson | *Submission by letter on 6 August 2012* |
| Waikato Building Consent Group | *Submission to: Canterbury Earthquakes Royal Commission On: Discussion Paper: Roles and Responsibilities* |
| Waimakariri District Council | *Submission to the Canterbury Earthquake Royal Commission on its Discussion Paper: Roles and Responsibilities* |
| Wellington City Council | *Wellington City Council submission on the Royal Commission ‘Discussion Paper: Roles and Responsibilities’* |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Margaret Aydon | Building occupant (Level 4) 26 June 2012 | |
| Andrew Ayers | Urban Search and Rescue | Written statement |
| David Bainbridge | Witness to the damage after the  September earthquake | 26 June 2012 |
| Geoffrey Banks | Director, Structex Harvard | 16 August 2012,  17 August 2012 |
| Neil Blair | Former Director, Prime West  Corporation | Written statement |
| Dr Brendan Bradley | Lecturer, Department of Civil and Natural Resources Engineering, University of Canterbury | 24 July 2012,  25 July 2012,  26 July 2012,  15 August 2012 |
| Derek Bradley | Senior Engineer, Compusoft 25 July 2012, Engineering 26 July 2012,  13 August 2012,  14 August 2012 | |
| Marie-Claire Brehaut | Witness to the damage after the  September earthquake | 26 June 2012 |
| Michael Brooks | Formerly of Williams Construction | 8 August 2012 |
| Peter Brown | Witness to the damage after the  September earthquake | 26 June 2012 |
| Graeme Calvert | Former Senior Building Support  Officer, Christchurch City Council | 28 June 2012 |
| Elizabeth Cammock | Building occupant (Level 6) | 25 June 2012 |
| Bruce Campbell | Witness to the collapse of the  CTV building | 26 June 2012 |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Athol Carr | Emeritus Professor, Department 25 July 2012, of Civil and Natural Resources 26 July 2012  Engineering, University of Canterbury | |
| David Coatsworth | Senior Associate, Structural  Engineers, CPG New Zealand | 4 July 2012 |
| Michael Collins | Loss Adjustor, Cunningham Lindsey | Written statement |
| Barry Davidson | Director, Compusoft Engineering | 25 July 2012,  26 July 2012,  13 August 2012,  14 August 2012 |
| Dr Andrew Dickson | Technical Director, Auckland Civil Written statement  Structures, Beca | |
| William Dray | Civil Engineer, Engineering Services Written statement  Team, Christchurch City Council | |
| John Drew | Director, EGT Holdings Limited and Company Director, New Regent Medical Centre | 2 July 2012 |
| Alan Edge | Witness to the collapse of the  CTV building | 26 June 2012 |
| Shane Fairmaid | Project Manager, Ruby Views | 15 August 2012 |
| David Falloon | Falloon & Wilson Limited | 25 July 2012 |
| David Flewellen | Former Building Inspector, Christchurch City Council | 28 June 2012 |
| Leonard Fortune | Witness to the collapse of the  CTV building | 26 June 2012 |
| Graeme Frost | Urban Search and Rescue | 27 June 2012 |
| Robert Gaimster | Chief Executive Officer, Cement and Concrete Association of New Zealand | 15 August 2012 |
| Stephen Gill  Ronald Godkin | Witness to the collapse of the 26 June 2012  CTV building  Building occupant (Level 4) 25 June 2012 | |
| Stephen Grenfell | Witness to the collapse of the CTV  building | 26 June 2012 |
| Euan Gutteridge | Witness to the collapse of the CTV  building | 26 June 2012 |
| Douglas Haavik | Consulting Engineer, Costa Mesa, California | 15 August 2012 |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| David Harding | Harding Consulting Engineers 30 July 2012, Limited 31 July 2012,  7 August 2012,  14 August 2012,  15 August 2012 | |
| John Hare | Director, Holmes Consulting Group | 15 August 2012 |
| Malcolm Harris | Witness to the damage after the  September earthquake | 26 June 2012 |
| Thomas Hawker | Witness to the collapse of the  CTV building | 26 June 2012 |
| John Henry | Associate, Eliot Sinclair and 1 August 2012, Partners Limited 2 August 2012,  13 August 2012,  14 August 2012 | |
| Dr Robert Heywood | Queensland Taskforce 1 Urban 27 June 2012  Search and Rescue | |
| Peter Higgins | Southern Regional Manager, Concrete Techniques Limited | 2 July 2012 |
| Marie Holland | Former Building Inspector, Christchurch City Council | 2 July 2012 |
| William T. Holmes | Principal, Rutherford & Chekene, Consulting Engineers, San Francisco | 10 July 2012 |
| Terry Horn | Estimator, Kingston Building | 6 August 2012 |
| Lionel Hunter | Director, Madras Equities Limited | Written statement |
| David Hutt | Team Leader, Building Consents, Christchurch City Council (seconded to the Canterbury Earthquakes  Royal Commission) | Written statement |
| Dr Clark Hyland | Director, Hyland Fatigue and 5 July 2012, Earthquake Engineering (author 9 July 2012, of the Department of Building and 10 July 2012, Housing’s technical investigation into 25 July 2012, the collapse of the CTV building) 26 July 2012,  13 August 2012,  14 August 2012,  15 August 2012 | |
| Russell Ibbotson | Retired chartered accountant 17 August 2012 | |
| Maryanne Jackson | Receptionist, Canterbury Television | Written statement |
| Dr Murray Jacobs | Director, Murray Jacobs Limited | 9 August 2012,  13 August 2012 |
| Richard Johnson | Former Chairman, Canterbury  Regional Council | Written statement |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Geoffrey Jones | Manager, Materials Testing Written statement  Laboratory, Opus International  Consultants | |
| William Jones | Foreman for the CTV building | 8 August 2012 |
| Robert Jury | Manager, Wellington Structural, Beca 10 July 2012, (member of the former Department of 25 July 2012, Building and Housing’s Expert Panel) 26 July 2012 | |
| Brian Kehoe | Associate Principal, Wiss, Janney, Elstner Associates, Illinois | 4 July 2012,  5 July 2012 |
| Stephen Kissell | Service Technician, Otis Elevator  Company Limited | 2 July 2012 |
| Nilgun Kulpe | Building occupant (Level 6) | 25 June 2012 |
| Douglas Latham  Phillippa Lee | Structural Engineer, Alan Reay 26 July 2012, Consultants Limited 13 August 2012,  14 August 2012  Building occupant (Level 5) 25 June 2012 | |
| Stephen McCarthy | Environmental Policy and Approvals  Manager, Christchurch City Council | 3 July 2012,  6 August 2012,  7 August 2012 |
| Dr James MacKechnie | Adjunct Senior Fellow, Department of Civil and Natural Resources Engineering, University of Canterbury | 15 August 2012 |
| John Mander | Zachry Professor of Design  and Construction Integration 1, Department of Civil Engineering, Texas A&M University | 23 July 2012,  24 July 2012,  25 July 2012,  26 July 2012,  15 August 2012,  16 August 2012 |
| Kendyll Mitchell | Building occupant (Level 6) | 25 June 2012 |
| Murray Mitchell | Senior Structural Engineer, Opus  International Consultants | Written statement |
| Daniel Morris | Formerly of Knock Out Concrete 5 July 2012  Cutters | |
| Peter Nichols | Retired structural engineer | 6 August 2012 |
| Robert Officer | General Manager, AML Limited | Written statement |
| Dr Arthur O’Leary | Retired structural engineer | 9 August 2012,  13 August 2012,  14 August 2012 |
| John O’Loughlin | O’Loughlin Taylor Spence Limited Written statement | |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Leo O’Loughlin | Building Consent Officer, 7 August 2012, Christchurch City Council 14 August 2012 | |
| Leonard Pagan | Quantity Surveyor, Rawlinsons  Limited | 3 July 2012 |
| Nigel Priestley | Emeritus Professor, University of California at San Diego and Emeritus Co-director of the ROSE School | 11 July 2012,  12 July 2012 |
| Dr Alan Reay | Alan Reay Consultants Limited | 12 July 2012,  16 July 2012,  31 July 2012,  1 August 2012,  7 August 2012,  15 August 2012,  17 August 2012 |
| Phillip Reynish | Managing Director, Reynish 2 July 2012  Decorators Limited | |
| Trevor Robertson | Senior Principal, Sinclair Knight Merz 16 August 2012 | |
| Matthew Ross | Witness to the collapse of the  CTV building | 27 June 2012 |
| Anthony Scott | Retired quantity surveyor | 8 August 2012 |
| Robin Shepherd | Emeritus Professor, Civil and Environmental Engineering, University of California, Irvine | 16 July 2012,  25 July 2012,  26 July 2012 |
| Gerald Shirtcliff | Former construction manager for the  CTV building | 8 August 2012 |
| Russell Simson | Building Consent Officer, Christchurch City Council | 28 June 2012 |
| Timothy Sinclair | Principal, Tonkin & Taylor | 25 July 2012 |
| Ashley Smith | Director, Structure Smith Limited 5 July 2012, (author of Department of Building 9 July 2012, and Housing’s technical investigation 10 July 2012, into the collapse of the CTV building) 25 July 2012,  26 July 2012,  9 August 2012,  13 August 2012,  14 August 2012 | |
| Graeme Smith | Concrete Protection and Repair Limited | 2 July 2012 |
| Paul Smith | Director, Alan Reay Consultants  Limited | 6 August 2012 |
| Judith Smitheram | Administrator, Relationships Aotearoa | Written statement |

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| **Witnesses who appeared at the hearing for the Canterbury Television building**  **(25 June–16 August 2012; 5–7 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Penelope Spencer | Witness to the collapse of the 26 June 2012  CTV building | |
| Wayne Strachan | Former draughtsman at Alan Reay  Consultants Limited | 6 August 2012 |
| Tony Stuart | Structural Engineer, Compusoft  Engineering | 25 July 2012,  26 July 2012 |
| Richard Sullivan | Principal, RD Sullivan & Associates | Written statement |
| Patricia Tapper | Widow of Graeme Tapper, the Christchurch City Council structural checking engineer who reviewed the structural aspects of the building permit for the CTV building | 2 August 2012 |
| Simon Thomas | Administrator, Steelbro Limited | Written statement |
| John Trowsdale | Support Engineer, Urban Search Written statement and Rescue | |
| Arthur Tyndall | Witness to the collapse of the 26 June 2012  CTV building | |
| Chris Urmson | Structural Engineer, Alan Reay  Consultants Limited | Written statement |
| Pieter Van den Berg | Managing Director, Standstill and  Seymour Builders Limited | 2 July 2012 |
| Peter Van der Zee | Building Consent Officer, Christchurch City Council | 28 June 2012 |
| Jo-Ann Vivian | National Practice Manager, 2 July 2012  Relationships Aotearoa | |
| Peter Wilding | National Manager, Fire Investigation and Arson Reduction, New Zealand Fire Service | 17 August 2012 |
| Alun Wilkie | Director, Wilkie Bruce Registered  Architects Limited | 30 July 2012,  15 August 2012 |
| Grant Wilkinson | Managing Director, Ruamoko 16 August 2012  Solutions Limited | |
| Michael Williams | Witness to the collapse of the CTV 26 June 2012  building | |

On 7 September 2012, Marwa Alkaisi, a bereaved family member, addressed the Royal Commission at the close of the hearing for the Canterbury Television building.

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| **Witnesses who appeared at the hearing for building management after earthquakes (3–4 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| David Brunsdon | Director, Kestrel Group 3 September 2012,  4 September 2012 | |
| Ken Gledhill | GNS Science | 3 September 2012 |
| John Hamilton | Director, Ministry of Civil Defence and Emergency Management | 4 September 2012 |
| John Hare | Structural Engineering Society  New Zealand | 4 September 2012 |
| Bret Lizundia | Principal, Rutherford & Chekene, 3 September 2012  Consulting Engineers, San Francisco | |
| Stephen McCarthy | Environmental Policy and Approvals 4 September 2012  Manager, Christchurch City Council | |
| Peter Mitchell | General Manager, Regulation and 4 September 2012  Democracy Services, Christchurch  City Council | |
| Esther Newman | Sisirc Consulting Limited | 4 September 2012 |
| Tony Sewell | National President, Property Council of New Zealand | 4 September 2012 |
| Peter Smith | New Zealand Society for Earthquake  Engineering | 4 September 2012 |
| Mike Stannard | Chief Engineer, Building and Housing Group, Ministry of Business, Innovation and Employment | 4 September 2012 |
| Richard Toner | Chief Building Officer, Wellington  City Council | 4 September 2012 |
| Peter Wood | Emergency Management Advisor, Hazard Risk Management and Analysis, Ministry of Civil Defence and Emergency Management | 4 September 2012 |

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| **Witnesses who appeared at the hearing for the education and training of engineers and organisation of the profession (10 September 2012)** | |
| **Person** | **Organisation** |
| Derek Bradley | Senior Engineer, Compusoft Engineering |
| Andrew Buchanan | Professor of Timber Design, Department of Civil and  Natural Resources Engineering, University of Canterbury |
| Win Clark | The Executive Officer, New Zealand Society for  Earthquake Engineering |
| Dr Andrew Cleland | Chief Executive, Institution of Professional Engineers  New Zealand |
| John Gardiner | Manager, Determinations, Building and Housing Group, Ministry of Business, Innovation and Employment |
| Stuart George | Structural Engineering Society New Zealand |
| Joanne McGregor | C. Lund & Son Ltd |
| Peter Millar | Business Development Manager, New Zealand and  Australia, Tonkin & Taylor |
| Dr David Prentice | Chief Executive and Managing Director, Opus  International Consultants |
| David Sheppard | President, New Zealand Institute of Architects |
| Mark Spencer | General Manager, Building Structures, New Zealand, Beca |

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| **Witnesses who appeared at the hearing for roles and responsibilities (11–12 September 2012)** | | |
| **Person** | **Organisation** | **Hearing** |
| Derek Bradley | Senior Engineer, Compusoft 12 September 2012  Engineering | |
| Pieter Burghout | Chief Executive, New Zealand  Construction Industry Council | 11 September 2012,  12 September 2012 |
| Debbie Chin | Chief Executive, Standards  New Zealand | 11 September 2012,  12 September 2012 |
| Dr Nicki Crauford | Deputy Chief Executive, Institution of Professional Engineers  New Zealand | 11 September 2012,  12 September 2012 |
| Geoff Hallam | Programme Manager, Inspection Bodies Accreditation, International Accreditation New Zealand | 12 September 2012 |
| Nicholas Hill | Chief Executive, Building Officials  Institute of New Zealand | 12 September 2012 |
| David Kelly | Director, Canterbury Rebuild and 11 September 2012, Recovery, Building and Housing 12 September 2012  Group, Ministry of Business, Innovation and Employment | |
| Peter Laurenson | Manager, Building, Lakes  Environmental (Queenstown Lakes  District Council) | 12 September 2012 |
| John Lumsden | Chair, Standards Council | 11 September 2012,  12 September 2012 |
| Dr Peter Mumford | Director, Economic Development Group, Ministry of Business, Innovation and Employment | 11 September 2012,  12 September 2012 |
| Simon Pickford | Manager, Customer and Regulatory Services, New Plymouth District Council | 12 September 2012 |
| John Scarry | Structural engineer | 11 September 2012 |
| Frances Sullivan | Senior Policy Analyst, Local  Government New Zealand | 12 September 2012 |
| Adam Thornton | Structural Engineering Society 12 September 2012  New Zealand and Institution of  Professional Engineers New Zealand | |

**Appendix 4: Hearings Schedule**

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| **Date Topic** | |
| 17–20 October 2011 | Seismicity |
| 25 October 2011 | Soils and ground conditions |
| 7–15 October 2011 | Unreinforced masonry (URM) buildings and earthquake-prone policies |
| 28 November – 6 December 2011 | Pyne Gould Corporation building |
| 12 December 2011 | 593 Colombo Street |
| 13 December 2011 | 90 Coleridge Street |
| 14 December 2011 | 7 Riccarton Road |
| 15 December 2011 | 391/391A Worcester Street |
| 17–18 January 2012 | Hotel Grand Chancellor |
| 23 January 2012 | 116 Lichfield Street |
| 24 January 2012 | 89/89A, 91 and 93 Cashel Street |
| 25 January 2012 | 194 Hereford Street |
| 26 January 2012 | 200–204 Manchester Street |
| 30 January 2012 | 32 Cathedral Square |
| 31 January 2012 | 308 Durham Street |
| 1 February 2012 | 603 Colombo Street |
| 2 February 2012 | 605–613 Colombo Street |
| 13 February 2012 | 595 and 595A Colombo Street |
| 14 February 2012 | 601/601A Colombo Street |
| 15 February 2012  16 February 2012 | 194 Gloucester Street and 246 High Street  382 Colombo Street |
| 23–24 February 2012 | Forsyth Barr building |
| 27 February 2012 | 43 Lichfield Street |
| 28 February 2012 | 265–271 Manchester Street |
| 29 February 2012 | 753–759 Colombo Street |
| 1 March 2012 | 738 Colombo Street |
| 12–14 March 2012 | New building technologies |
| 15 March 2012 | 738 Colombo Street (continued) and Hotel Grand Chancellor (continued) |
| 25 June – 9 August 2012 | Canterbury Television building |
| 3–4 September 2012 | Building management after earthquakes |

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| **Date Topic** | |
| 5–7 September 2012 | Canterbury Television building closing submissions |
| 10 September 2012 | Education and training of engineers and organisation of the engineering profession |
| 11–12 September 2012 | Roles and responsibilities |

**Appendix 5: Glossary of terms**

A further glossary of terms is contained in Appendix 4 of Volume 1 and Appendix 5 of Volume 4 of our Report.

Arterial route An important route in a system of roads, railway lines or rivers.

Axial force The compression or tension force acting along the longitudinal axis of a structural member.

If the load on a column is applied through the centre of gravity of its cross-section, it may be called an axial load.

Building Warrant of Fitness

Column hoop reinforcement

A building warrant of fitness (BWoF) is a statement confirming that the systems specified in the compliance schedule for their building have been maintained and checked in accordance with the compliance schedule for the previous 12 months, and that they perform as required.

In concrete columns and piles, a hoop is a circular ring of reinforcement that is placed around the longitudinal reinforcement.

Compression force The application of compression force to an object causes it to be subjected to compression. Coupled wall A coupled wall is formed when two or more cantilever walls are joined by coupling beams at

each storey which can transfer shear forces between the walls.

Damping In structural engineering, damping can be defined as the inherent property of a material and a structure that dissipates energy. The higher the damping of a system, the quicker the vibrations will cease when it is in a displaced position from its rest position.

Deflection Displacement of a structural element under a load.

Dowel action The dowel action is the shear force resisted by the reinforcing bars across a crack. Geospatial data Geospatial information is information describing the location and names of features beneath,

on or above the earth’s surface. At its simplest this can mean the basic topographical information found on a map, but also includes different location-related datasets combined into complex layers that show information such as land use and population density.

Gross Domestic

Product (GDP)

The total value of goods produced and services provided in a country during one year.

Hypervigilance A symptom of post-traumatic stress that refers to the experience of being constantly tense and “on guard”. A person experiencing this symptom will be motivated to maintain an increased awareness of their surrounding environment, sometimes even frequently scanning the environment to identify potential sources of threat.

Inter-storey drift The relative displacement of two adjacent floors in a building.

Iwi The Ma-ori term for an extended kinship group, tribe, nation, people, nationality, race. Often refers to a large group of people descended from a common ancestor.

K/SM factor A term used to multiply an analysed inter-storey drift obtained from an elastic analysis to give the design drift.

Ka-inga The Ma-ori term for a village, or habitation.

Lateral load resistance system

A structural member such as a wall, or group of members such as a moment resisting frame, that provide lateral force resistance in a building.

Moa Large extinct flightless birds of several subspecies resembling an emu, formerly found in New Zealand.

Modern and Modernist architecture

A style of architecture that aims to depart significantly from classical and traditional forms, styles and values. It is generally characterised by simplification of form and creation of ornament from the structure and theme of the building.

Neo-Gothic architecture A style of art and architecture that originated in the nineteenth century, characterised by the revival of medieval Gothic forms. In architecture, it is manifested in pointed arches, vaulted ceilings and mock fortifications.

Orthogonal walls Walls that are at right angles to each other.

Pa- The Ma-ori term for a fortified village, fort, stockade, screen, blockade, or city. Party wall A partition erected between two tenancies in a building.

Pad footing A pad footing is a type of foundation. Pad foundations are used to support individual or multiple columns, spreading the load to the ground below.

Poisson’s ratio The ratio of the lateral strain to the axial strain in a member when it is subjected to axial load.

Post-modern architecture

A late-twentieth century style of art and architecture that represents a departure from modernism and is characterised by the self-conscious use of earlier styles and conventions and a mixing of different architectural styles.

Pounamu Greenstone, nephrite jade from New Zealand.

Probative value A term used mainly within the legal profession that describes having a quality or function of proving or demonstrating something. Affording proof or evidence.

Qualitative analysis When using this analytic method, data is collected in textual form on the basis of observation. It is not converted into numerical form. This analysis also involves a certain degree of deductive reasoning.

Quantitative analysis This analytic method usually involves collecting and converting data into numerical form so that calculations can be made and conclusions drawn.

Radial force A force that is exerted perpendicular to the centre line, or axis, of an object.

Renaissance Revival architecture

Satellite settlement, centre or town

The style of architecture that originated in the nineteenth century that is based on the architecture of sixteenth century Renaissance Italy and France, with additional elements borrowed from classical Greek and Roman architecture. Sometimes called Neo-Renaissance, and may include buildings that others classify as Italianate or French Baroque.

A community or town dependent on a nearby larger town.

Seating A support ledge for the end of a beam.

Seismic capacity The ability of a building or other structure to withstand earthquake actions. Shoring Shores or props used to support or hold up a structure.

Soffit The underside of a part of a structural component, such as an arch, beam, stair, slab, etc.

Stirrups A type of steel reinforcement in concrete beams formed by closed loops of steel bars placed at regular intervals along a beam.

Strip footings A strip footing is a type of foundation that distributes loads from columns or walls to the foundation soils.

Stripped Classicism architecture

An architectural style that took the typical features and motifs of Classicism but pared them back so that decoration was reduced, but an imposing structure remained. It was

an authoritarian style adopted by a number of state organisations, including the American

Postal Service and the government of Nazi Germany.

Tension force The application of tension force to an object causes it be subjected to tensile stress. Tie forces A force that ties two structural components together.

Tilt-slab construction Tilt-up, tilt-slab or tilt-wall is a type of building and construction technique using concrete elements such as walls or columns that are formed horizontally and later “tilted” into the final

position in the structure.

Transverse reinforcement

Reinforcement at right angles to the principal axis of a structural member.

Trimmer beam A timber or metal beam (joist) in a floor or roof structure attached to truncated joists in order to create an opening around a stairwell, skylight, chimney, and the like.

Urupa- The Ma-ori term for a burial ground, cemetery, or graveyard.

Venetian Gothic architecture

A style of architecture that combines the lancet arches of the Gothic period with Byzantine and Arabic influences.

Weka A New Zealand woodhen, *Gallirallus australis*. A brown-feathered bird streaked with black, with a short bill and heavily built legs and feet, able to run fast but flightless.