Earthquake Stories: Experiences of building performance in earthquakes to inform future standards

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ABSTRACT

The performance of the built environment during earthquakes plays an important role in reducing risk and enhancing the resilience of New Zealand's urban centres. Although engineering codes and building standards regulate building performance and seek to ensure the safety of occupants, it is during major earthquakes that building performance is put to the test.

The 2010-2011 Canterbury earthquake sequence (including the M7.2 Darfield and M6.3 Christchurch events) and the M7.8 Kaikōura earthquake in 2016 highlighted that many buildings performed well in a seismic event. Other buildings did not meet expectations with regard to structural performance. In support of the New Zealand Society for Earthquake Engineering (NZSEE) Resilient Buildings project, this research documents the recent earthquake experience of building owners, tenants and other stakeholders.

The aim of this ongoing research is to undertake interviews and collect stories from people who had direct experience of building performance in the Canterbury or Kaikōura earthquakes, either personally or from involvement in managing buildings. The stories will help identify societal expectations of building performance in the context of recent earthquake experience in New Zealand. The findings will enhance future building performance by informing the refinement of engineering codes and standards through experience-based insight. Initial thematic data is presented in this paper from 16 interviews, which highlight extremely varied perspectives of risk, that that new buildings perform beyond a minimum requirement of life-safety, that buildings should repairable, and that an overall goal is to ensure urban centres are functional.

1 INTRODUCTION

1.1 Background

The performance of the built environment during earthquakes plays an important role in reducing risk and enhancing the resilience of New Zealand's urban centres (Powell et al., 2015; Thomas et al., 2014). Although engineering codes and building standards regulate building performance and seek to ensure the safety of occupants, it is during significant earthquakes that building performance is put fully to the test (Taig et al., 2015; Porter, 2014). The 2010-2011 Canterbury earthquake sequence, which includes the September 2010 Darfield earthquake (M_w7.2) and February 2011 Christchurch earthquake (M_w 6.3), and the 2016 Kaikōura earthquake (M_w7.8) were major seismic events that highlighted the impacts of earthquakes on both buildings and their inhabitants . Although many buildings performed well during these earthquakes, a number of buildings experienced damage leading to disruptions to the lives of occupants.

The collapse of engineered buildings in Christchurch, such as the Canterbury Television (CTV) and Pyne Gould Corporation (PGC) buildings caused significant loss of life. In addition, damage to a large proportion of the city's building stock and complexities with insurance-related rebuilds, resulted in prolonged disruption to business and the city is still in the process of recovery more than 10 years after the initial earthquake. These prolonged effects have intensified inequalities and other social stressors (Canterbury DHB, 2020; Potter et al., 2015) and underpinned significant macro-scale (with significant losses to infrastructure impacting the national level) and localised impacts (e.g. small businesses failing or relocating; economic impacts, etc., (Parker and Steenkamp, 2012)). In the Kaikōura earthquake example, it is widely recognised that had the same level of ground shaking occurred during the day rather than just after midnight, there could have been many casualties, especially in Central Wellington. The earthquake caused significant structural damage to many buildings and major disruptions to the population (Stevenson et al., 2017; Fleisher, 2019). Had the earthquake been closer in proximity to Wellington, damage could have been catastrophic.

This research seeks to develop a more nuanced understanding of how people expect buildings to perform during earthquakes in support of the New Zealand Society for Earthquake Engineering (NZSEE) Resilient Building's Project. The project will document the recent earthquake experience of building owners, tenants and other stakeholders by investigating two research objectives, as follows. Objective One seeks to collect stories and impressions from a diverse range of people who had direct experience of building performance in the Canterbury or Kaikōura earthquakes, either personally or from involvement in managing buildings. Objective Two seeks to understand how these lived experiences help to identify societal expectations of building performance in the context of recent earthquake experience in New Zealand. It is intended that the findings will inform the refinement of engineering codes and standards through experience-based insight.

1.2 Theoretical underpinnings

This research draws from the behavioural science literature for disasters to help understand peoples' perspectives about building performance, and how this might link with a desire to improve how buildings perform through methods such as codes and standards. It is often considered that if someone perceives a high risk of an earthquake then they will automatically want to reduce that risk (McClure et al., 2015) whether it be through personal preparedness actions, or through wider community or societal actions (such as codes and standards). This is not the case, however, as while risk perception is important, there are also a range of other factors that influence decision-making processes (Eiser et al., 2012; Johnston et al., 2013). These include attitudes and beliefs (e.g. a fatalistic view that nothing can be done to prevent a poor outcome in an earthquake; belief about whether an action will be effective in reducing risk or not); past experience (sometimes resulting in optimism or normalisation biases, which can reduce someone's desire to take action); social factors (e.g. interactions with others in solving problems, norms, trust in agencies); and resource factors (e.g. cost) (Spittal et al., 2005, 2008; Becker et al., 2012; Johnston et al., 2013; Paton and McClure, 2013; McClure et al 2015; 2016; Vinnell et al., 2019). The interactions between such factors are important to understand, as these drive peoples' expectations about building performance (which can evolve over time), and their appetite for addressing any risk posed by performance. They also drive the type of solution that may be sought. In this case they can shape the nature of codes and standards that may be used to address earthquake risk. Consequently, it is from the perspective of behavioural science that we are conducting the following study.

2 METHOD

Researching how people expect buildings to perform during major earthquakes offers insights toward enhancing technical engineering standards and building codes in beneficial ways, and also offers a lens into informing technical knowledge in rich and nuanced ways. Consequently, this study seeks to interview a varied range of participants who had first-hand experiences of building performance during the Darfield, Christchurch or Kaikōura earthquakes. These experiences have likely influenced their perspectives on risk and how they or their organisation is approaching structural improvements to buildings. Their experiences will also frame their perspectives on risk reduction measures such as engineering codes and standards.

A leadership group was formed to frame and conduct this research. The leadership group includes a range of people with experience across the engineering field, as well as social researchers who have examined wider resilience issues associated with New Zealand's recent seismic events. The leadership group for this research identified an initial group of 26 interview participants. A snowball sampling method has subsequently broadened this initial list, where interview participants have recommended further people to contact to elicit experience-based information.

There were two requirements/limitations placed on participant eligibility, including as follows:

- That they had experienced the Canterbury or Kaikōura earthquakes and/or dealt with buildings that were impacted by the earthquakes
- That the participants experience related to an engineered building (i.e. multistory or engineered commercial or residential buildings, not single-storey residential dwellings).

In addition, the types of people interviewed, or to be interviewed, have included – building owners, large portfolio holders (both government and private sector), apartment owners and tenants, and commercial tenants (corporate and small business holders).

The research process remains a work in progress. To date, 16 key informant interviews have been undertaken with participants based in Wellington, Auckland and Dunedin. A round of 12 key informant interviews will also be undertaken in the first quarter of 2021 with participants based mainly in Christchurch and the wider Canterbury region. Each interview follows a set of semi-structured questions and investigates the categories of information outlined below:

- Participants' background and direct earthquake experience.
- Understanding of building standards/codes.
- Earthquake risk perception.

- Expectations of building performance.
- Expectations of functionality and repair.
- Development and improvement of codes and standards.

Each interview is limited to one hour, and data from interviews is recorded and transcribed, and analysed using qualitative thematic analysis (Rubin & Rubin 2011).

Interviews are an effective form of qualitative data collection, and a qualitative research approach is excellent for extracting details about perspectives (such as expectations of building performance) and processes (Rubin & Rubin, 2011; Gubrium & Holstein, 2003). The information is not intended to be generalisable across populations; for this purpose, a quantitative survey approach would be used. However, interviews are useful in extracting the nuances of opinion that we wish to learn about. Limitations of conducting interviews may be that people could be reluctant to offer certain types of information in their conversations, however, we attempt to address this issue by offering anonymity. Additionally, depending on the people interviewed, there is potential for bias, which again we seek to address by interviewing a range of people from different perspectives.

Each interview is a very different undertaking, with each participant bringing a diverse background of experience and different ways of rationalising an earthquake event (e.g. pragmatic through to emotional responses) to the conversation. For a number of participants, their experience of a major earthquake, and the subsequent challenges in the aftermath of the event, remained traumatic and emotional. However, the genuine interest of the researchers to hear their lived experiences, and to improve building codes and clarify some of the challenging institutional arrangements associated with engineering performance, generally assisted with achieveing rapport and a rich dialogue with interviewees.

It is noted that the nature of the project leadership team has meant the inclusion of many people who have experience and are highly skilled with building management processes and engineering standards. In the later phases of the research we intend to diversify this set of informants to include more variation of expertise and experience. In addition to the interviews currently underway, a survey is being developed to broaden the cross section of participant experience and insights on expectations of building performance.

This research has followed Massey University Human Ethics processes (low risk notification number: 4000023412).

3 EMERGING THEMES AND INITIAL FINDINGS

At the time of writing 16 out of 28 planned interviews had been conducted. The following sections provide the authors' preliminary impressions from the interviews completed to date and are intended to provide a broad overview of emerging themes and initial findings. The interviews are in the process of being transcribed and detailed analysis will be undertaken after all the interviews are complete. The insights from key informant interviews will also be supported by the broader findings elicited by the survey.

3.1 Earthquake risk perception

Earthquake risk perception varied greatly among participants, with some interviewees saying that they hardly ever thought about earthquake risk, through to other interviewees who emphasised that they thought about earthquake risk several times a day. Those that often thought about earthquake risk spoke about their level of preparedness including supplies stored in their house or vehicles. Of note is that when questioned about earthquake risk and earthquake risk perception in the context of buildings, most interviewees referred to Percent New Building Standard (%NBS) as part of their understanding.

Participants agreed that buildings should be safe (i.e. they were not willing to take on risk to people), but levels of acceptance of earthquake risk in terms of building damage and downtime were diverse. Some participants believed that no form of risk was acceptable, and others were very accepting of earthquake risk stating that earthquake risk was inevitable when living in a city in a seismically active country. In general, people with higher levels of knowledge about earthquakes and building performance tended to be more accepting of risk. Additionally, people with contingency plans for businesses were also more willing to accept earthquake risk to commercial buildings, and interviewees frequently cited the ability to work from home during COVID-19 lockdowns.

3.2 Expectations of building performance

When asked about expectations of building performance, all participants agreed that buildings should be operable following small frequent earthquakes and that buildings should not lose structural integrity or endanger occupants of the public rare severe earthquakes. Most participants expressed that they felt that 'life-safety' should be a minimum requirement and expressed a desire that new building perform beyond the minimum requirement, with consideration given to repairability and enhanced engineering standards that enable buildings to withstand larger earthquakes and be re-occupied rapidly.

Some participants spoke about the quality of design and construction, stating that catastrophic engineering failures such as the one experienced in the Christchurch CTV building are unacceptable. Additionally, substandard construction that affects building performance is also unacceptable. One participant spoke about a personal experience with a contractor that installed inferior materials to save on costs (e.g. concrete mixed with a reduced amount of cement and steel from overseas that was not certified by the Australasian Certification Authority for Reinforcing and Structural Steels). Had this interviewee not had engineering knowledge, this substandard practice would have likely gone unnoticed and the building would not have met the intended seismic design strength. Consequently, several interviewees suggested that contractors have some kind of required accreditation and continued education, as is mandatory for engineers to practice. In general, these participants expressed a desire for reliable and consistent quality assurance measures taken prior to and during construction phase.

3.3 Expectations of functionality and repair

All participants felt that new buildings should be repairable following a strong (MM 6-7+) earthquake near Wellington or Christchurch. The timeframe for repair varied based on the participants, but generally participants felt that buildings should be occupiable within the short term (0-3 days) and fully repaired in the medium term (1-3 months), with consideration given to the availability of trades.

Another expectation beyond singular building performance was that cities should be functional following a strong earthquake. Participants expressed that 'red-zones' established for long periods of time were unacceptable. Many accepted that older buildings or heritage buildings would be damaged, but believed that there should be enough functional buildings within a city that businesses can continue to operate with only minor interruptions.

3.4 Development and improvement of codes and standards

The level of understanding of building codes and standards in relation to earthquakes varied greatly among interview participants, with some interviewees expressing a high level of understanding and others claiming that they have limited or no knowledge on the subject. Additionally, feelings about updates to the building code were mixed. Some participants expressed the desire to continually update the building code as new engineering knowledge became available. Other participants expressed dislike for the 'drip fed' changes to codes and standards that have been updated following the Canterbury earthquakes and the Kaikoura earthquake. However, after further probing, this dislike generally stemmed from the repercussions of upgrading levels that are based on %NBS ratings and was not necessarily related to new buildings.

Another notable theme of discussion that arose from questions related to building codes and standards was that many interviewees expressed a desire to understand how updating codes and standards would affect insurance and reinsurance rates when asked about the personal impacts of building codes and standards. When asked whether expectations of building performance could vary for buildings located in a large city (e.g. Wellington) versus a rural town, interviewees generally agreed. Reasons for agreement were generally attributed to rural buildings presenting less risk both in terms of population and cost. However, questions were raised over the difficulties of implementing different systems of building standards for rural and urban centres, and consequently, the potential difficulties of delineation between urban and rural, as the national population continues to increase in both urban and rural locations.

4 FUTURE DIRECTIONS

As discussed previously, the findings presented here are initial themes that have emerged from data analysis of 16 interviews. Further interviews and analyses will contribute to a more comprehensive understanding of peoples' diverse perspectives on building performance. We plan to publish this research in a peer-reviewed report, and use this information in future workshops, where it can contribute towards our understanding of building performance through experiential insight and influence the refinement of building codes and engineering standards in New Zealand.

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