POLICY BRIEF FOR NZSEE PROJECT ON RESILIENT BUILDINGS

How do Kiwis want buildings to perform during and after an earthquake?

Key points

New Zealand has gone through a period of unprecedented losses from seismic activity, which has highlighted shortcomings in the seismic settings of our building regime.

Engineering knowledge in designing for earthquakes has advanced significantly since the current approach to building design was developed in the 1970s.

New Zealand's urban landscape has also changed profoundly with more multi-storey development, in-fill housing etc.

New Zealand's Building Code has not kept up with these developments. New Zealand's seismic thresholds for damage are relatively low, meaning Kiwis are exposed to considerable economic and social disruption after earthquakes.

A recent review commissioned by MBIE from the Seismic Risk Working Group raised fundamental issues about Building Code's seismic regime objectives and who makes the value tradeoffs required.

New social science research responded to this challenge by asking Kiwis what is important to them. The key findings include:

1. Safety is non-negotiable
2. Kiwis want more than life safety. In particular, social and economic recovery are important objectives
3. Speed of recovery is a particular priority for some building types – marae, community centres, and homes – that currently are not a priority
4. Appetite for risk and expectations of buildings seismic performance varies significantly amongst Kiwis.

The challenge of modernising the regulatory regime required to make buildings resilient to earthquakes

New Zealand has experienced a period of unprecedented losses from seismic activity. These include the 2010-11 Canterbury earthquake sequence, the 2013 Cook Strait-Marlborough earthquakes and the 2016 Kaikoura earthquake. In the case of the Canterbury earthquake sequence, several thousand homes and several hundred Christchurch commercial buildings were judged uneconomic to repair, despite having met performance objectives for life safety.

New data and lessons are emerging. Several lessons can be drawn from studies that have revealed how complex the patterns of earthquake shaking can be and how buildings and the ground performs in response. New seismic modelling, updating estimated earthquake exposure, will be released shortly.

New Zealand has changed. New Zealand's urban landscape has changed profoundly since the seismic provisions of the Building Code were introduced. There is more multi-storey development, in-fill housing and mixed-use, and much higher inner-city populations who rely on networked services.

And seismic engineering has advanced. Engineering knowledge in designing for earthquakes has also advanced significantly since the current code settings were originally developed. Technical advances over the last 50 years mean that engineers can now design for damage limitation as well as life safety, something that was not an imperative when the current technical settings of the Code were first introduced.

We have much to learn from other leading jurisdictions. Some other countries, such as Japan and Chile, have responded to damaging earthquakes by tackling seismic resilience through performance objectives in the Building Codes and design practices that go beyond life safety to include broader social and economic resilience outcomes.

New Zealand's Building Code has not kept up with developments. New Zealand's seismic thresholds for damage are relatively low and have only been reviewed in a piecemeal way. Our current approach to building design was originally developed in the 1970s, and the technical aspects of the seismic Code settings have not been significantly revised since then. We now face the challenge of how seismic design should respond to the latest estimates of earthquake exposure from the National Seismic Hazard Model.

A recent review highlighted opportunities to learn from developments and recent experiences. The Seismic Risk Working Group's (SRWG) late 2020 report[1] has shown up gaps and inconsistencies in the building seismic performance regime and raises important questions on how objectives and priorities are set.

There are fundamental issues about regime objectives and who makes the value tradeoffs required. The SRWG's report raised several important technical issues but also highlighted fundamental questions including:

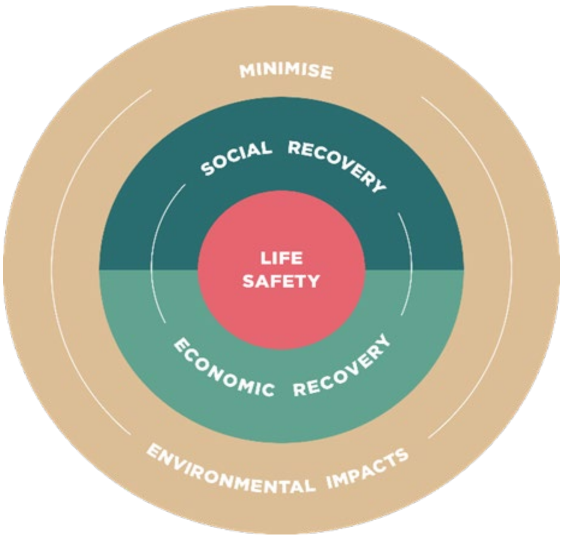
1. The Building Code focuses on life safety, but should that be extended to consider recovery of functions in buildings after an earthquake?
2. Should key terms like low probability, amenity values be clearly defined and clarified in guidance?
3. How should gaps in the current regime be addressed, including should the design of future buildings consider the impacts relating to adjacent buildings and how to mitigate legacy issues for existing buildings such as precast concrete flooring systems and their supports?
4. Who decides what is prioritised and how should these priorities be expressed in a design sense? (Currently, technical standards committees make critical value judgements about importance levels of different types of buildings – by privileging schools but not marae or aged care homes, for example).

Research findings – what do Kiwis think is important? How do Kiwis want buildings to perform during and after an earthquake?

New social science research aimed to fill gaps in our understanding. Despite the advances in engineering science and design, our Building Code and standards remain primarily focused on life safety. A 2021 research project focused on understanding societal tolerance for the impact of earthquakes on new buildings in New Zealand. The New Zealand Society for Earthquake Engineering (NZSEE), using funding from EQC, commissioned research that asked Kiwis what they thought about the seismic performance of buildings generally, importance of different types of buildings, and how seismic risk compares with other building design priorities. The research for the report '*Societal expectations for seismic performance of buildings'* was conducted by Resilient Organisations and included 32 interviews and 6 geographic focus groups.[2]

The research focused on how Kiwis' performance expectations for buildings changed based on building use and location, the variation in risk tolerance, and the importance of seismic risk. What came through confirmed the importance of factors beyond life safety set out in Figure 1.

Figure 1 Life safety comes first



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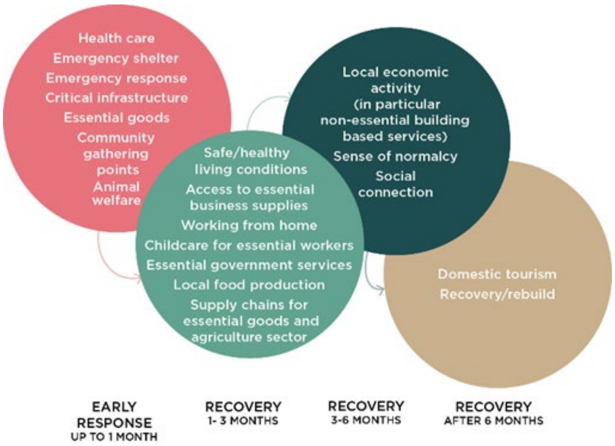
[1] https://fl-nzgs-media.s3.amazonaws.com/uploads/2020/11/Seismic-Risk-and-Building-Regulation-in-NZ-For-Release.pdf

[2] https://www.nzsee.org.nz/db/PUBS/RBP_SocietalExpectationsReport-FINAL-for-Release.pdf
NZSEE (2022) Societal expectations for seismic performance of buildings. All the graphics in this brief are drawn from this report.

Safety is non-negotiable. Safety was confirmed as the most important overall performance objective. Safety here includes sheltering in place during and after an earthquake and ensuring people and places that support life (hospitals, emergency responders etc.) can function.

Kiwis want more than life safety. The findings demonstrate a growing need and expectation that the built environment should provide recovery of functions to support social and economic objectives following an earthquake; this is consistent with findings from US studies discussed on page 13 of the research report.

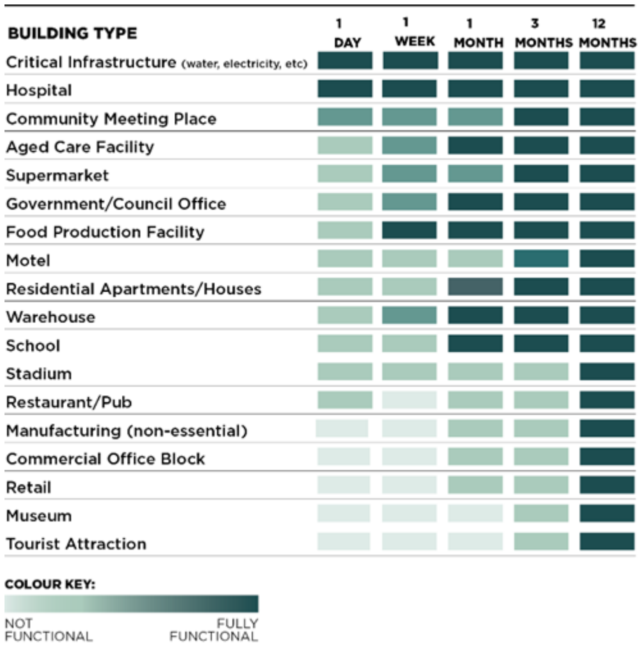
Figure 2 Priorities shift as recovery progresses



The speed of recovery desired varies by the type of building. Figure 2 shows the different stages of post-earthquake recovery and how new priorities become important as the recovery from the earthquake proceeds. The research focused on the speed at which certain types of building functions shown in Figure 3 should return following a major earthquake:

- The initial priority in the first 30 days following a major earthquake is providing services that support life – including emergency response services and healthcare and goods and services to meet basic needs (shelter, food, water, electricity). Access to alternative facilities such as marae, community centres, and schools was also important.
- After a month, once individuals' basic survival needs are met, the focus shifts to access to services, including government services such as welfare support, healthy living conditions, access to childcare services to enable people to work and business such as building suppliers.
- After three months during the recovery phase, economic activity and employment are the priority.
- After six months, the built environment needs to support the ongoing recovery and rebuild process (e.g. motels to house rebuild workers, community spaces and social networks such as places of worship to support individuals).

Figure 3 Recovery priorities by type of building.



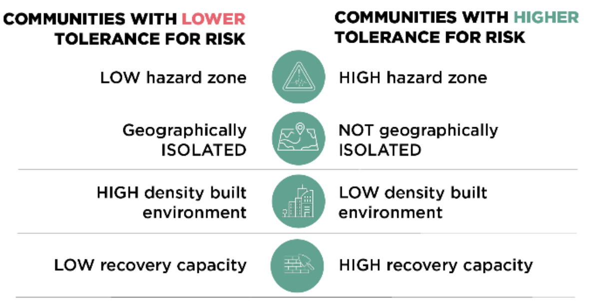
Appetite for risk varies amongst Kiwis. A consistent finding in overseas research was the heterogeneity of people's risk tolerance, and Kiwis are no different. Geographic context influences risk tolerance. Communities facing low seismic hazard risk, geographic isolation, and high density of the built environment are more risk-averse shown in Figure 4.

Access to resources. Communities that have access to resources (physical, financial, and human) are more accepting of seismic risk. Communities with fewer resources, under stress or facing significant social inequity issues, are less risk-taking.

Rural/urban contrasts. Recovery priorities are different for different communities. For example, rural communities place higher importance on buildings that support agri-business.

Tolerance for minor to moderate damage but not permanent dislocation. Regular minor damage is acceptable to research respondents. Minor to moderate damage (every 10–20 years, respectively) is acceptable if it doesn't disrupt building tenants. However, there is less tolerance for long term impacts. A strong theme that emerged was intolerance to impacts that created permanent dislocation of a community. While not assessed directly, with recent seismic activity, overall tolerance for risk appears likely to have declined.

Figure 4 Differences in communities' risk tolerance



How important is seismic performance? The research also focused on relative priorities by comparing seismic with other non-seismic building design priorities (shown in Appendix A). While life safety during an earthquake came through as the top priority, other design issues also featured.

Accessibility came through strongly, particularly the need to facilitate access to disabled and low mobility users. Good access is important for the daily wellbeing of users but also supports safe and efficient evacuation during a fire, earthquake, or another hazard event.

Environmental sustainability has been growing in importance in recent years. Sustainability ranked relatively highly along with similar importance to air quality. Reducing building damage from earthquakes adds to building longevity and reduces environmental impact including reducing the use of carbon.

The importance of cost differed significantly between participants. Those with strong commercial interests tend to rate cost considerations more highly if they factor in return on investment on short time frames. However, those with a building user perspective are much less likely to rate capital or whole of life cost as important. The structural component is just part (20–33%) of total building cost and a small fraction of the annualised value of the services the building delivers. Exploring willingness to pay further is an important area for future research.

The architectural value of buildings scored quite low in terms of importance. However, effective architectural design is a key component of a building's performance increasing durability, functionality, and longevity.

Multiple overlapping objectives. Overall, these results reinforce that the strongest imperative for seismic resilience remains life safety. Pursuing other objectives like economic and social recovery and environmental sustainability are likely to be complementary reinforcing objectives.

Next steps

Research begets more research. The research discussed here provides systematic evidence on what is important to Kiwis about how buildings perform during and after an earthquake. Conducting research inevitably identifies the opportunity for more research. For example, social norms are pliable, and respondents' recent experience of COVID clearly influenced the results. Similarly, one gap is the research did not explore the cost implications of improved building resilience.

Better focused questions. But these caveats aside, it is important not to let the perfect get in the way of the good. Data and research data doesn't tell you what to do. But it does highlight key questions to ask and enables better-informed decision-making. One key question emerging from the research will be how to respond to the diversity in risk tolerance and seismic performance expectations amongst Kiwis in the future design of building standards?

Find the gap. More work is needed to determine how we should effectively incorporate societal expectations into New Zealand Building Code, standards, and engineering practice. This includes understanding the gap between societal expectations and what our current building and engineering practices, standards, and regulations deliver. Future research needs to undertake this gap analysis between the Code and societal expectations and undertake an intervention analysis to assess which policy levers and other tools to use.

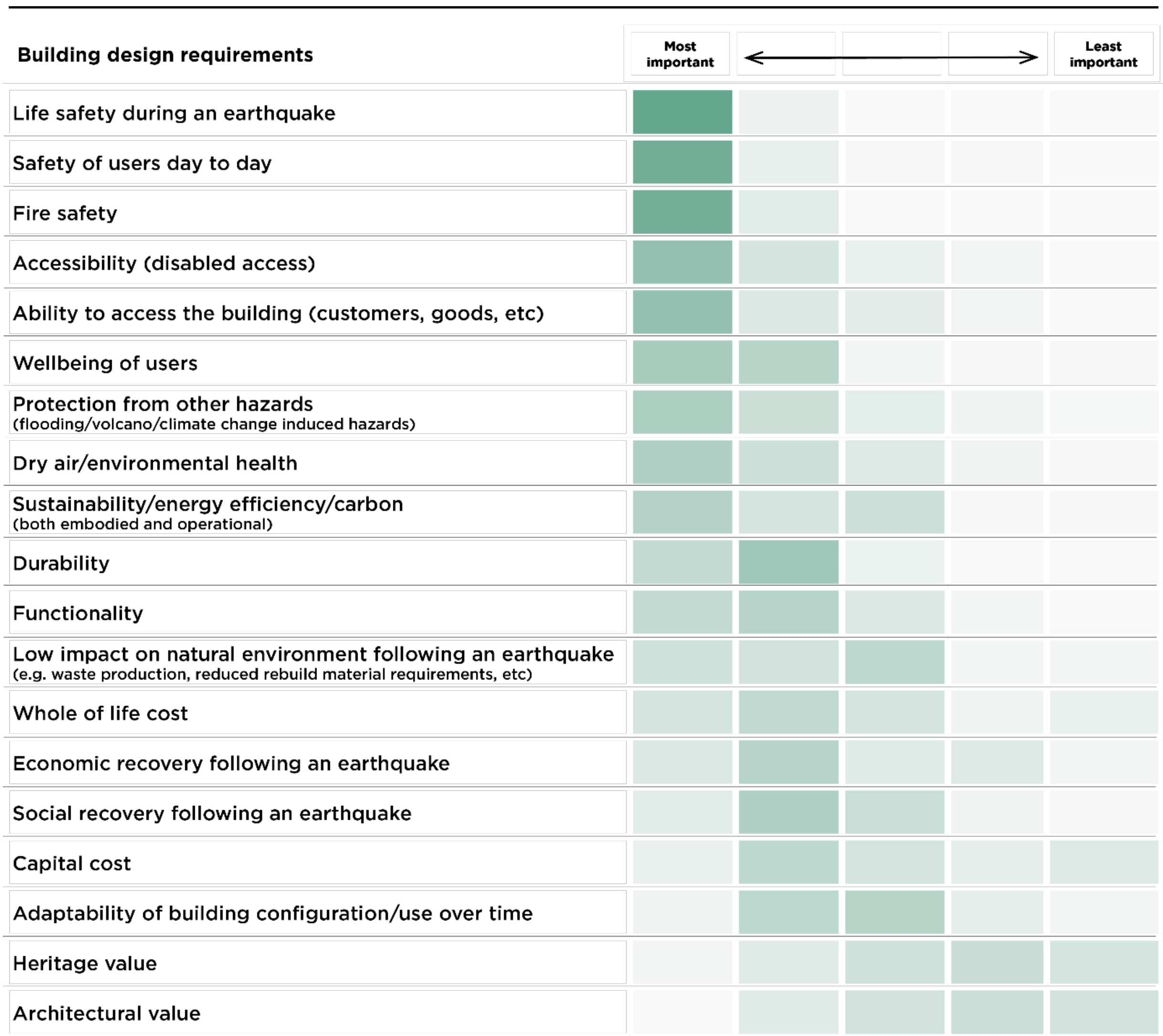
Conclusion – the choices ahead

New Zealand's recent experience with a series of earthquakes has highlighted the need for reform. Since the existing approach to seismic design was first adopted, engineering practices have improved markedly. In addition, there have been changes in both risk tolerance and the urban environment, and we face a new imperative for sustainable building practices. New Zealand's seismic thresholds for damage are relatively low; meaning Kiwis are exposed to considerable economic and social disruption after earthquakes.

New insights from the National Seismic Hazard Model have updated our understanding of earthquake exposure and, when these are released shortly, will provide an increased imperative for change.

New Zealand is coming to a fork in the road, and the research discussed here provides the opportunity to learn the way forward. Or, like the Bourbons after Napoleon, we can be destined to learn nothing and forget nothing by clinging to the approach of the existing outdated regulatory regime.

Appendix A – Kiwis' ranking building design requirements



This paper was written by Derek Gill at NZIER, 24 March 2022 based on research commissioned by the New Zealand Society for Earthquake Engineering and undertaken by Resilient Organisations with funding from Earthquake Commission (EQC). For further information on the NZSEE project please contact Helen Ferner, helenmferner@gmail.com.