When prevention is better than cure – the case for more resilient buildings

Key points

Exposure to earthquakes highlighted – New Zealand has recently experienced a period of significant seismic activity. This has highlighted the impacts on New Zealanders of the direct costs of property damage and the indirect costs from social distress and economic disruption in addition to the tragic loss of life.

Kiwis want more than life safety – Recently completed social research asked how New Zealanders want buildings to perform during and after an earthquake. It found:

- Life safety is non-negotiable
- Kiwis want more than life safety. In particular, social and economic recovery are important objectives
- Speed of recovery is a particular priority for some building types, including marae, community centres and homes – that are currently not a priority.

Kiwis want to shelter in place in their homes – With the growth in working from home, increasingly people will want more than just to shelter in place.

Building performance linked to wellbeing – A framework has now been developed to map these social expectations on to building performance. It maps key dimensions of building performance – life safety, loss of function as well as protection from property damage – onto social, economic and environmental outcomes.

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

Gaps in the current code – Using the framework, we found Kiwis' expectations for life safety is largely catered for within the current code settings but there was a gap of one order of magnitude on other dimensions of building performance. Kiwis want a significantly increased focus on reducing loss of function and protecting property by delaying the onset of damage and reducing its consequences overall.

It is now feasible to design buildings for improved resilience limiting damage and loss of function without necessarily adding to the cost.

Tool to close the gap – The framework is a powerful tool that can be used to guide the changes in required seismic standards, codes and design practices in New Zealand. The project did not set out to prescribe precisely what needs to change.

Not just the code – Improvements in resilience can be achieved by a range of design practices, building industry changes and land-use practices, in addition to the seismic provisions in the building code.

Prevention better than cure? – The big policy question this raises is whether prevention is better than cure on the basis that a fence at the top of the cliff is better than an ambulance at the bottom.

Size of the prize – Improved seismic performance and resilience of buildings could generate a range of valuable benefits over time. A large US research study suggests the direct gains from reduced property loss from improving resilience to earthquakes are matched by equally significant reductions in indirect costs of social distress and economic disruption. As the cost premia for improved earthquake resilience were found to be low, and there were significant direct and indirect gains, the benefits from mitigation exceeded the costs many times over.

Cost effective – Our research suggests that there are highly cost-effective interventions that would improve new building resilience in New Zealand. The cost premium is likely to be low, and the interventions are highly targeted at the source of the problem, with limited adverse side effects. Increasing the resilience of buildings provides a clear case of where prevention is better than cure.

Key messages

- Research shows Kiwis want much more than life safety from their buildings in earthquake events.
- Investigations reveal a significant shortfall between these societal expectations and what the seismic elements of the code deliver.
- Increasing the resilience of new buildings – by raising the threshold for onset of damage and loss of function - would speed up social and economic recovery while retaining the focus on life safety.
- The framework developed by the project provides a tool that makes this possible.
- Designing more resilient buildings without necessarily adding costs is entirely feasible using simpler more regular structures on solid ground.

Revisiting seismic building settings

Reform is required. There are several imperatives for change in the seismic building performance regime:

- A period of unprecedented seismic activity in New Zealand has highlighted shortcomings in the seismic settings of our building code regime
- Engineering knowledge in designing for earthquakes has advanced significantly since current building code settings were originally developed in the 1970s
- New Zealand's urban landscape has changed profoundly since then with multi-storey development and infill housing.

New Zealand's Building Code development has not kept up. It is possible now to design buildings to reduce damage and limit loss of function that was not feasible when the current seismic code settings were first developed. Seismic thresholds for damage are relatively low, exposing New Zealanders (NZers) to considerable economic and social disruption after earthquakes.

Filling gaps in our understanding

Understanding expectations of building seismic performance. The Canterbury Earthquakes Royal Commission recommended that the treatment of seismic risk be reviewed to ensure the regime is aligned with societal expectations of building performance during earthquakes.

This required work to better understand the aspects of building seismic performance that Kiwis most value.

New social research on Kiwis' expectations. The New Zealand Society for Earthquake Engineering, with funding from the Earthquake Commission, commissioned the Resilient Buildings Project. The project was designed to inform the review of seismic risk settings in the current Building Design Standards (currently under way) and to underpin the development of future New Zealand design practices, building codes, and guidance documents.

To achieve this, the Resilient Buildings Project has:

- researched Kiwis' expectations for the seismic performance of buildings
- evaluated the gap between those expectations and current code provisions
- developed a series of schema that relate Kiwi user expectations into the seismic performance expected of buildings.[1]

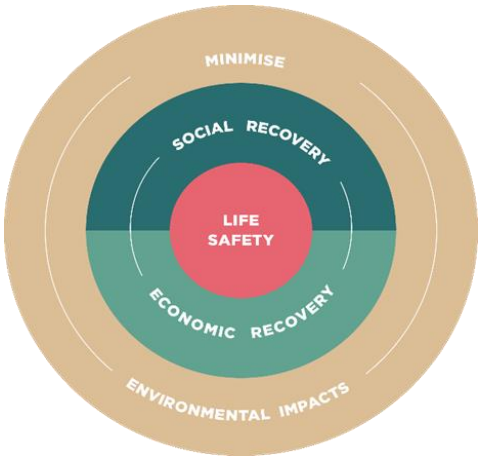
[1] For more details see The Resilient Buildings Project – Stage 3 Final Report: https://www.eqc.govt.nz/resilience-and-research/research/search-all-research-reports/the-resilient-buildings-project-stage-3

What do Kiwis want?[2]

Life safety is non-negotiable. The project started by researching how Kiwis expect buildings to perform during and after an earthquake. The key finding was that, while life safety is non-negotiable (as provided in the current building code), people want more out of their buildings. There is a desire for buildings to be resilient enough to reduce social disruption and distress and speed economic recovery after an earthquake. This reflects the reality that the impacts of earthquakes extend beyond the boundaries of affected properties to include the wider lives of the occupants and the communities they live in.

Different building types become important as recovery proceeds. Speed of recovery is a particularly important for some building types – dwellings, marae, community centres and aged care facilities – that currently are not a priority in the code. Details on findings from the societal expectations research can be found in the previous policy brief.[3]

Figure 1 Life safety comes first



Mind the gap

Assessing the gap. The project assessed the current regulatory approaches to building seismic risk management against societal expectations.

Current code meets expectations for safety. The research indicated that current New Zealand requirements for design and construction of buildings broadly align with societal expectations about avoidance of injuries and deaths. Safety is considered non-negotiable and desirable at all levels of shaking.

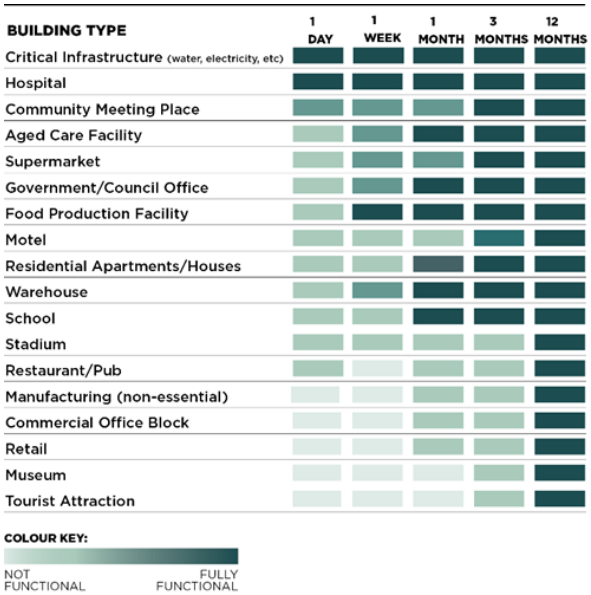
Kiwis want more than life safety. The research found a significant gap between societal expectations for protection of property and amenity and function and the requirements of the current regime. Kiwis' preferences dramatically exceed what the current code provides for both for protection of property and restoration of function following a significant earthquake.

Kiwis want to raise the seismic performance of a wider range of building types. The research also found a gap between the relatively narrow range of types of buildings prioritised by the current importance level (IL) rating system and the types of buildings that Kiwis expect should be covered. Speed of recovery is a particular priority for some building types such as dwellings, marae, aged care facilities and community centres and was not limited to essential facilities like hospital and emergency management centres, which are currently covered in our building system.

2 More details on the societal expectations research can be found on https://www.resorgs.org.nz/our-projects/risk-and-resilience-decision-making/nzsee-reilient-buildings-project/

[3] www.nzsee.org.nz/db/PUBS/Policy_Brief_Resilient_Buildings_FINAL110422.pdf

Figure 2 Recovery priorities by building type



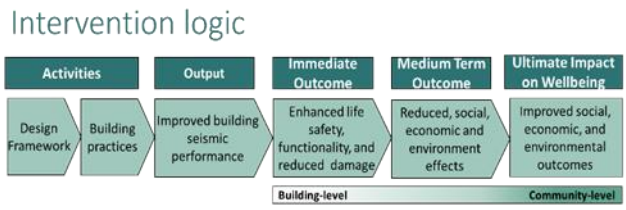
Kiwis want to shelter in place in their homes. Kiwis want more than life safety from residential dwellings. Shelter in place is a key performance objective for residential construction. NZ has a history of building resilient homes with single storey timber frame construction dominating the housing stock. Barring adverse factors like land subsidence or not being tied onto the piles correctly, this type of construction helped people to shelter in place after a significant earthquake. NZers increasingly are moving into multi-unit residential dwellings and homes with more 'adventurous' designs. The shelter in place objective needs to be factored into how these buildings are designed and constructed.

Working from home. Looking into the future, with the growth in working from home post COVID, for many people the home is going to be a place of work for many months following a significant earthquake event. Increasingly people will want more than just to shelter in place.

Closing the gap

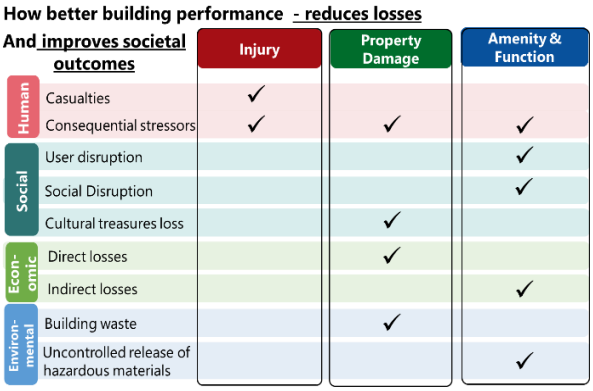
Building performance maps neatly on societal outcomes. The research developed a framework to translate the social expectations into building performance outcomes.

Figure 3 Logic linking activities to outcomes



The framework shows how the key dimensions of building performance – protection from injury, protection of amenity and function and protection of property – are systematically linked to wider social, economic and environmental outcomes.

Figure 4 Dimensions of building performance



This provides a clear robust intervention logic that can be used to link how proposals to improve particular dimensions of building performance contribute to wider outcomes and overall wellbeing.

Useful tool for code writers and designers. The framework has been developed as a comprehensive and flexible tool to be interpreted by building designers as well as writers of codes, standards and guidelines. The framework provides a mechanism so designers can systematically target those aspects important to people. The framework is outcome-focused to allow flexibility of design approaches to meet the objectives consistent with the performance-based design approach of the New Zealand building code. This also enables articulation of seismic building performance objectives above code minima where desired.

A tool not a rule. The framework is not intended to be prescriptive. It is agnostic about what level of building performance is required and how that may be achieved. Rather it provides a tool that can be used to guide the development of the changes required to seismic standards, codes and practices in New Zealand.

Tailoring performance to the type of building. The research also provides a way to categorise building types and identify why some building types and usages are more important to people. The categorisation system links building use to desired dimensions of building performance and the framework tool.

Using all the keys on the piano. Improvements in resilience can be achieved through a range of design practice, building industry and land-use measures and are not limited to the changes to the building design standards.

Prevention or cure?

When is early intervention justified? The more general policy question that this research raises is whether prevention is better than cure for new buildings. This is consistent with the old saying that a fence at the top of the cliff is better than an ambulance at the bottom. While it may seem intuitively obvious, on closer inspection, the conditions justifying early intervention are quite restrictive.

For example, in the case of medicine, there are relatively few conditions where primary prevention is the best treatment. For most conditions, we wait for the onset of symptoms in particular patients before commencing treatment. The health experience suggests early invention through primary prevention is more effective where:

- it is highly effective relative to costs
- there is very effective targeting to the population that needs it
- there is a low rate of unintended harm
- there is a moral imperative to prevent the harm.

Is early intervention justified to improve buildings' response to earthquakes? Applying these criteria to making buildings more resilient to earthquakes is instructive.

Major benefits. A major US study quantified significant benefits from greater resilience. These include both direct benefits from reducing casualties and property damage as well as indirect benefits from increased speed of recovery. Recent New Zealand experience suggests significant potential to benefit from reducing property damage, loss of function and avoiding the costs from social distress and economic disruption.

Relatively minor costs. The same US study[4] found that the cost premia for increasing the seismic resilience of new buildings was low, averaging 1% of construction costs. The review of existing evidence for New Zealand suggests that similar results applied here. For example, commercial office construction costs in Auckland in 2019 were approximately 10% greater than Wellington despite the design seismic load demand at that time being one-third as high. More generally, simple regular buildings are more resilient than larger more complicated ones. The best way to achieve resilience at no or minimal costs is to avoid fragile designs and focus on simple regular building designs.

Well targeted. Making buildings more resilient is a highly targeted intervention. Improving building performance for each of the key dimensions in the framework – casualties, damage and loss of function – effectively targets the problem at source. Moreover there is little, if any, unintended harm.

[4] Multi-Hazard Mitigation Council (2019) Natural Hazard Mitigation Saves (p. 369–370) National Institute of Building Sciences www.nibs.org/files/pdfs/NIBS_MMC_MitigationSaves_2019.pdf

Moral imperative. There is an old but true saying that a successful engineer is one who is never mentioned. Building more resilient buildings – like hiring engineers and plumbers – is a grudge purchase unwanted until an adverse event occurs. For decision makers like ministers or building developers, the problem of the unseen counterfactual is particularly acute as the harm avoided is never experienced so decision makers face the upfront costs of introducing change without receiving credit for the benefits from the harms and costs avoided down the track. However the size of the prize – the potential to avoid the direct property loss and associated social distress and economic disruption – creates a moral imperative to intervene early in the building development phase. The research provides a tool useful for decision makers – both public code setters and private building developers – to design resilient buildings better aligned with social expectations.

The case for more resilient buildings

New Zealand has experienced a period of unprecedented losses from seismic activity. New Zealand's recent experience with a series of earthquakes has highlighted the need for reform. Recent earthquakes highlight how the costs extend well beyond damage to property and casualties to include economic disruption and significant impacts on mental health and social wellbeing.

The urban environment has changed. Since the existing approach to seismic design standards was first adopted, engineering knowledge has improved markedly. New Zealand's seismic thresholds for damage are relatively low and coverage of loss of function is very limited, which means NZers have been exposed to considerable economic and social disruption after earthquakes.

This is not what Kiwis want. The research found a major gap between Kiwis' expectations for significant protection of property and amenity and function and the requirements of the current regime.

Closing the gap. The research discussed here has not developed recommendations for specific performance settings to address this gap. This is a task for others, and work is under way reviewing the building code's seismic provisions. The project has focused on providing the framework and tools required to learn the way forward.

There is a case for improving buildings' response to earthquakes. The research suggests that there is a prima facie case to reduce the costs and harm of earthquakes in New Zealand so a focus on determining cost-effective interventions logically will follow.

There are opportunities not just for code setters but also for building designers to improve seismic resilience of buildings. Constructing more resilient buildings is a clear case of when prevention is better than cure.

Want to know more. For further information on the Resilient Building Project, please contact Helen Ferner, helenmferner@gmail.com. This paper was written by Derek Gill, Research Associate at VUW and NZIER, in February 2024, drawing on the project undertaken by the New Zealand Society for Earthquake Engineering with funding from the Earthquake Commission.