Study Report SR463 [2021]

Managing earthquake-prone council buildings: Balancing life safety risks and community costs

Michael Nuth, Charlotte Brown, Dave Brunsdon, John Hopkins, Emma Hudson-Doyle and Richard Ball

BRANZ
LEAD Institute of Law, Emergencies & Disasters
kestrel group
JOINT CENTRE FOR DISASTER RESEARCH
Resilient ORGANISATIONS

Funded from the Building Research Levy

1222 Moonshine Rd, RD1, Porirua 5381
Private Bag 50 908, Porirua 5240
New Zealand
branz.nz

© BRANZ 2021
ISSN: 1179-6197

Cover photo courtesy of Whakatāne District Council.

Acknowledgements

- This project has been enabled through BRANZ Research Levy funding. We are grateful for this ongoing support.
- The authors wish to thank Cameron Eade (Research Associate at the LEAD Institute for Law, Emergencies and Disasters, University of Canterbury Law School) for his assistance in developing the legal elements of this report.
- We would also like to sincerely thank the territorial authority representatives that have contributed their valuable time and insights to this project.

Managing earthquake-prone council buildings: Balancing life safety risks and community costs

BRANZ Study Report SR463

Authors

Michael Nuth, Charlotte Brown, Dave Brunsdon, John Hopkins, Emma Hudson-Doyle and Richard Ball

Reference

Nuth, M., Brown, C., Brunsdon, D., Hopkins, J., Hudson-Doyle, E. & Ball, R. (2021). *Managing earthquake-prone council buildings: Balancing life safety risks and community costs*. BRANZ Study Report SR463. Judgeford, New Zealand: BRANZ Ltd.

Abstract

The focus on seismic risk following the 2010–2011 Christchurch and 2016 Kaikōura earthquakes has seen the rapid closure of a number of council buildings throughout the country. The introduction of the Building (Earthquake-prone Buildings) Amendment Act in 2016 (the 2016 Act) has reinforced perceptions of risk through the legal requirement for certain buildings to have seismic assessments undertaken. The 2016 Act's requirements led to a focus on percentage of the new building standard (%NBS) ratings, with buildings rating less than 34%NBS often being determined by the territorial authority to be earthquake prone, with defined timeframes for remediation. A common misconception in some sectors is that, if a building is rated as less than 34%NBS and/or declared earthquake prone, the building is dangerous and should be closed immediately. This is often reinforced by a common belief amongst territorial authorities that the Health and Safety at Work Act 2015 (HSWA) creates significant legal exposure for senior staff responsible for council buildings that have been judged to be seismically vulnerable. The decision to close council-owned buildings has evidently led to long periods when facilities and services housed in those buildings are not available to local communities, resulting in some notable socio-economic impacts.

There appears to be inconsistency in how territorial authorities, acting as public building owners, are approaching this challenge, with some councils rapidly closing buildings (in some cases, prior to buildings rated less than 34%NBS being categorised as earthquake prone) and others keeping buildings with low seismic ratings open. This paper explores:

- the legal obligations on territorial authorities around earthquake-prone buildings
- the background to the engineering risk associated with earthquake-prone buildings
- the theory of risk management and making decisions under uncertainty
- the processes territorial authorities currently use to make decisions around the closure of buildings categorised as earthquake prone.

The intent of this report is to ensure that the legal classification of earthquake-prone buildings is not being misinterpreted by territorial authorities (in their role as building owners) as representing an immediate safety concern requiring urgent suspension of building occupancy. Correspondingly, this report forms the basis for a decision-making framework designed to help territorial authorities navigate their obligations around seismic safety and community wellbeing in a way that is more consistent with the timeframes for remediation set in the earthquake-prone buildings provisions of the Building Act and is not inconsistent with the requirements of the HSWA.

Keywords

Earthquake prone, council buildings, community impact, risk management, public policy, health and safety.

Contents

Figures

Tables

Executive summary

Context

The decision of some territorial authorities to immediately cease occupancy of buildings that they own which are found to have a seismic rating less than 34% of the new building standard (NBS) has led to long periods where facilities and services housed in those buildings have become unavailable to local communities. In some cases, this has resulted in notable socio-economic impacts.

To date, few territorial authorities have adopted formal policies relating to occupancy of earthquake-prone council buildings. It is unclear how territorial authorities as building owners approach these closure decisions, how seismic assessments are interpreted, how life safety risk is evaluated and whether socio-economic impacts of closure are considered at all. This lack of transparency and consistency around council-owned assets leaves policy decisions open to challenge and could lead to adverse effects on our communities.

This research, undertaken during the period April 2020 to April 2021, aimed to better understand how territorial authorities currently make occupancy decisions related to earthquake-prone buildings and how they could do this better. In doing so, we combined legal, engineering, risk management and behavioural theory to co-design a decision process aimed at supporting territorial authorities to make robust building occupancy decisions.

The Building Act and the concept of earthquake-prone buildings

Seismic resilience is addressed in New Zealand as part of a three-part legal framework. This comprises the Building Act 2004 (the primary legislation), the Building Code (a deemed regulation) and a number of regulations enacted under the (now revoked) Building Regulations Act 1992. In practice, the Building Code provides the minimum standards required for new building construction alongside a number of other regulations introduced to deal with specific issues, including seismic resilience.

Of particular relevance here are amendments to the earthquake-prone buildings provisions of the Building Act introduced as a consequence of the Canterbury 2010–2011 earthquake sequence and the Royal Commission that followed it. The Building (Earthquake-prone Buildings) Amendment Act 2016 created a more nationally focused and consistent system through new mechanisms such as the earthquake-prone building methodology, the requirement for engineers to use the national seismic assessment guidelines and the establishment of a national earthquake-prone buildings register.

Owners of buildings designated as earthquake prone are subject to legal obligations around remediation. In particular, they must be strengthened to bring their seismic rating above 34%NBS within a specified timeframe or be demolished, depending on their seismic hazard zone. However, of particular note to this research, the Building Act does not preclude continued occupancy of earthquake-prone buildings.

The Health and Safety at Work Act

The Health and Safety at Work Act 2015 (HSWA) is a general act that applies to all legal individuals (public and private) and does not specifically apply to seismically vulnerable buildings. It nevertheless has potentially significant implications for owners of such buildings and employers who operate businesses within them (as well as employees and users). The overall legislative position is laid out clearly in section 37 of the HSWA, which defines the key concept of a person conducting a business or undertaking (PCBU).

The duty of a PCBU set out in section 36 of the HSWA is broad and requires both the PCBU itself, and responsible individuals within it, to protect the health and safety of workers, protect the health and safety of other people and provide a work environment that is without risks to health and safety. "Such a duty only needs to be undertaken to the extent that it is "reasonably practicable", defined in section 22 in relation to five key criteria of which the *likelihood* of the hazard or risk is a key determination.

Enforcement of the HSWA largely falls to WorkSafe New Zealand. WorkSafe has developed non-binding policy guidelines regarding earthquake-related health and safety risks that state WorkSafe will not enforce building safety to a higher standard than the Building Act 2004. However, this does not mean that the owner of such a building is not liable under the HSWA. WorkSafe has no role interpreting the HSWA itself, and such decisions lie in the hands of a court.

The responsibilities of a building owner under the HSWA and that of the Building Act need to be considered separately. Regardless of whether or not a building is designated as being earthquake prone, PCBUs have a responsibility to eliminate or minimise seismic risks "so far as is reasonably practicable" under the HSWA. How the likelihood of a sufficiently damaging earthquake plays into what is "reasonably practicable" is unclear. It is yet to be tested in a court of law and, due to the contextual nature of the issue, may never be specifically defined.

The Local Government Act

The Local Government Act 2002 (LGA) provides both statutory authority and limits to territorial authority decision making, the purpose of which is defined in section 10 as "to enable democratic local decision-making and action by, and on behalf of, communities, as well as promoting the social, economic, environmental, and cultural well-being of present and future communities".

Section 14 sets out various general principles that territorial authorities must follow when performing their function, primarily related to democratic values, transparency and community engagement, which could have relevance to decisions around community assets. In particular, territorial authorities must take the interests of both current and future communities into account when making decisions and take into account factors such as the economic and cultural wellbeing of the communities they represent.

If a territorial authority determines through relevant evidence and assessment that a building they own or occupy poses too great a risk to safety to remain open, the legal framework requires that they must also consider the economic and cultural impacts of such a closure and, potentially, mitigate the impacts.

A decision to close a council-owned building without any consideration of the impacts or other possible options would thus appear open to challenge.

Method

To understand how territorial authorities translate engineering advice and community impacts into public policy decisions about earthquake-prone council buildings, a series of recorded interviews were conducted with eight staff representing five territorial authorities across New Zealand. To ensure our research obtained a range of perspectives, interviewees represented both the property owner and regulatory arms of councils and were from territorial authorities of varying sizes and located within different seismic zones.

Each interview involved providing participants with three hypothetical scenarios about council buildings categorised as earthquake prone. The scenarios and the associated questions were designed to enable interviewees to talk through their respective decision-making processes, in particular, who makes decisions, what the key decision drivers are and how seismic risk information is assessed alongside other risk information.

Based on interview findings and expertise within our research team, the authors developed a 'strawman' decision-making framework reflecting a possible best-practice approach to seismic risk management in council buildings that also considers community impacts. This framework was tested and refined through two online workshops with representatives from nine territorial authorities in late 2020. During the workshops, the framework was presented and feedback on its potential utility obtained. This instigated a process of refinement leading to the creation of the decision framework introduced in this paper.

Empirical findings

Across each territorial authority involved in the study, there appeared to be little internal discussion around risk tolerance. Much of the decision making of these territorial authorities appears to rest on the potential *consequence* of an earthquake event rather than its *likelihood*. None of the territorial authorities we interviewed explicitly considered and assessed the life safety risk against the socio-economic impacts on the community of closing a building.

This is a significant finding because it suggests that the likely short-term community impacts of immediate building closure are overshadowed by concerns about the potential scale of seismic risk that occurs over a vast geological timeframe.

Without a robust process that seeks to balance risk consequence and likelihood, this approach may result in territorial authorities inadvertently and adversely impacting their communities. This points to a need for a clearer process that enables territorial authorities to balance hazard likelihood more deftly with the direct consequences of suspending building occupancy.

Decision framework

A core output of this research is a co-designed decision process that will support territorial authorities as building owners to understand and more confidently balance the potential effects of building damage should an earthquake occur against the impacts that follow directly from a decision to close a building. The five steps in the decision framework are shown in Figure 1, which is a high-level summary of the full decision framework detailed in Appendix D. The steps largely align with the ISO 31000 risk management process, stepping users through the risk identification, assessment and treatment phases of risk management.

The framework enables the actual risk exposure to be explored in more detail. Factors such as the numbers of people occupying the building and the average periods of time they are present are evaluated, along with the likely period of time before the building is strengthened. This is because risk is a function of time: the longer we are exposed to a risk, the more chance we have of the event occurring. Critically, the framework also prompts users to consider the consequences of immediate building closure, such as the ability to deliver services by other means, impact on vulnerable communities, impact on neighbouring buildings, and impact on staff. Step five in the process combines both the life safety exposure and the consequences of closure. This step is critical to ensure that territorial authorities are balancing both their roles as PCBU under HSWA and their duties under the Local Government Act.

The framework sets out the information needed and process for decision makers to make robust and considered decisions. The framework is set out in a way that allows territorial authorities to adjust the parameters to match their own risk management processes and risk tolerance.

Step 1. Structural assessment
Obtain a (preferably) peer-reviewed detailed seismic assessment that clearly identifies the specific structural vulnerability, mode of failure and area of building affected.

Step 2. Life safety exposure evaluation
Determine life safety exposure through review of number and frequency of affected building users and likely length of time until strengthening can commence.

Step 3. Ability to temporarily mitigate risk
Identify any measures that can be temporarily put in place to reduce life safety risk (such as propping, fencing, removal of parapets).

Step 4. Consequences of immediate building closure
Determine likely immediate consequences of closing a building. This includes impacts on staff, building users and neighbouring business and community.

Step 5. Overall occupancy assessment
Evaluate the risk through consideration of both life safety risk and consequences of closure and make decision on continued occupancy.

Figure 1. Steps in earthquake-prone council building decision framework.

Summary

Our research shows that territorial authorities as building owners are obligated to consider both life safety and the community impact of closure of earthquake-prone council buildings. However, a key finding of this report is that the likelihood of a building's failure in an earthquake appears to be significantly outweighed by concern amongst PCBUs about the direct legal consequences to them if such a failure was to occur. This is significant because *likelihood* of a hazard or risk is an important consideration in determining whether an intervention is required by a PCBU under the HSWA. This appears to indicate that the decision making of territorial authorities in relation to continued occupancy is not necesarily based on a balanced evaluation of the components of risk and is unduly influenced by consequence.

Our research also highlights the gap between common perception of %NBS as a measure of how buildings are expected to seismically behave and what this measure is realistically able to signify. Fundamental to this understanding is that there are multiple variables that influence how buildings perform (including the different characteristics of earthquakes themselves) and that a low %NBS rating doesn't represent a prediction of how the building will perform in any given earthquake. Given this uncertainty, relying on %NBS alone to inform occupancy decisions is insufficient even if preserving life safety was the only objective. However, territorial authorities must consider the community impacts of their decisions as well, and decisions to suspend occupancy of council buildings can have direct and immediate socio-economic consequences. It is therefore important that territorial authorities undertake a comprehensive and systematic risk evaluation before such impactful decisions are made.

To help territorial authorities take a considered approach to decisions about seismically vulnerable council buildings, this research has developed a decision-making framework that steps territorial authorities through a specific risk assessment process. This process considers all aspects relating to life safety exposure and then balances this against the socio-economic impacts of building closure. Our intention is for this framework to become a resource for territorial authorities to more confidently and robustly make decisions around the continued occupancy of earthquake-prone buildings.

The challenge of managing earthquake-prone buildings extends beyond territorial authorities as owners and occupiers of public buildings. The process and theory behind the framework presented here will be applicable to all building ownership/tenant situations.

1. Introduction

1.1 Closure of earthquake-prone council buildings

The 2010–2011 Christchurch and 2016 Kaikōura earthquakes have heightened awareness of New Zealand's vulnerability to seismic hazards. The introduction of the Building (Earthquake-prone Buildings) Amendment Act in 2016 (the 2016 Act) and the focus on seismic assessment ratings generally, has seen the closure of several council buildings throughout the country. The 2016 Act's requirements are primarily based upon how a building performs as a percentage of the new building standard (NBS).[1] Buildings rating less than 34%NBS are generally declared by the relevant territorial authority to be earthquake prone and subject to defined timeframes for remediation (7.5–35 years). A common belief is that, if a building is rated as less than 34%NBS or declared earthquake prone, the building is dangerous to life and should be closed immediately (Hare, 2019).

This approach has led to long periods where facilities and services housed in those buildings become unavailable to local communities, resulting in some notable socio-economic impacts. For example, closure of the Southland Museum affected 41 jobs (Harding, 2019). Closure of Naenae Olympic Pool in Lower Hutt created a sense of uncertainty in the community and led to the closure of some local businesses (Hatton, 2019). The closure of the Wellington Central Library due to structural concerns with the library's floor seating had a significant community impact, including on Wellington's homeless population (Desmarais & Chumko, 2019). Such examples demonstrate that the wellbeing of communities is often interwoven with the bricks and mortar of council assets.[2] Decisions by territorial authorities to pre-emptively close council buildings while determinations about their operational future are still being made can therefore cause disruption to community life.

Public safety has been cited by some territorial authorities as a reason for the pre-emptive closure of buildings deemed seismically prone, irrespective of whether the risk is based on a theoretically possible event within a geological timeframe (i.e. hundreds to thousands of years). On one hand, this appears to be due to emphasis being placed on the consequence component of the seismic risk (including the potential legal consequences associated with fatality or injury) such that the potential consequences may influence decisions more than the very low probability of occurrence also present in the risk equation. Auckland Council presented this rationale following its decision to close Ponsonby Library in December 2019 after a seismic assessment found that the building was earthquake prone (NZ Herald, 2019).[3] Nelson City Council applied similar caution in its decision to pre-emptively close Stoke Memorial Hall (a multi-purpose

[1] %NBS describes the rating given to a building as a whole expressed as a percentage of new building standard achieved, based on an assessment of the expected seismic performance of an existing building relative to the minimum that would apply under the Building Code (Schedule 1 to the Building Regulations 1992) to a new building on the same site with respect to life safety. See https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/methodology-identify-earthquake-prone-buildings/introduction/.

[2] Public buildings and the services that they contain can also contribute to the social connectedness necessary for building social and community resilience to future disasters (Kwok, Doyle, Becker, Johnston & Paton, 2016).

[3] Although the Auckland region is categorised as a low-risk seismic zone, Auckland Council deemed that, in light of the strong incentives of the Health and Safety at Work Act 2015 for officers under the Act to eliminate or control risks and hazards, it was best to eliminate the risk.

venue available for community hire) and the Refinery ArtSpace building (which holds community events and exhibitions) in March 2020 following earthquake safety concerns (Bohny, 2020).[4] Other examples are available from elsewhere in the country and may reflect a widely held view among territorial authorities that the severity and potential liability associated with seismic risk outweighs its probability of occurrence when making policy decisions about the continued operation of council services. As discussed in section 2, there are clear legal reasons for this perception.

Although territorial authorities may simply be applying caution in such cases, anecdotal evidence suggests that council decisions to promptly close council buildings upon receipt of an engineer's seismic assessment of <34%NBS have resulted in negative outcomes for some communities in the short term. This raises questions about the extent to which community impacts are (or should be) considered when territorial authorities opt to restrict building occupancy or to close earthquake-prone council buildings entirely while long-term asset management decisions are being made.

Here lies the central issue addressed by this study. At a surface level, there appears to be inconsistency between how councils, acting as building owners, are evaluating life safety risk alongside wider community impacts, with some councils opting to swiftly close council buildings assessed as <34%NBS (even prior to earthquake-prone decisions being made) and others keeping buildings with low seismic ratings open. Although the 2016 Act provides timeline parameters around when an earthquake-prone building should be remediated, it does not dictate that earthquake-prone council buildings be immediately closed while the future of such buildings is being deliberated by territorial authorities.

Further, while some territorial authorities presently have or are developing policies to guide occupancy decisions about council buildings rated <34%NBS,[5] others appear to lack such a framework and their decisions appear to be more ad hoc. In addition, %NBS can be a poor indicator of a building's actual seismic performance and may not reflect the real risk of building failure (Hare, 2019). For territorial authorities that largely base decisions about council building closure on %NBS alone, the lack of a systematic decision-making framework that recognises the limitations of %NBS and accounts for a variety of risks beyond just those associated with seismicity potentially leaves their public policy decisions open to challenge. It also brings into question whether the potential social and economic impacts of building closure are being neglected by some territorial authorities during their risk analysis.

1.2 The social and economic value of council buildings

Modern thinking about the built environment has moved away from viewing buildings as simply being the end point of a production system towards reconceptualising the built environment as being in dialectic with human and natural forces, which it both influences and is influenced by in turn (Shrubsole, 2018). Corresponding with this line of thinking, analysis of the built environment cannot be divorced from analysis of how buildings both influence and are shaped by human society (Moffatt & Kohler, 2008). Because of the complexity inherent within the built ecosystem, a systems perspective

---

[4] Although Nelson City Council has acknowledged that the buildings do not present an immediate danger to the public, it nevertheless explained that it was not prepared to accept the risk that the buildings present if an earthquake should occur.
[5] For example, Palmerston North City Council – see https://www.pncc.govt.nz/media/3132384/earthquake-prone-buildings-policy-2019.pdf

maintains that the formulation and application of regulations, standards and construction processes that ignore the dynamic relationships between buildings and people risks negative consequences (Shrubsole, 2018).

This perspective is supported by literature on building conservation, which promotes the idea that buildings provide more than just shelter – they offer a sense of constancy in people's social and material surroundings. This is seen to offer individuals a sense of 'ontological security' whereby a feeling of history, permanence and orientation is provided by the familiarity of physical cues. Some researchers maintain that this explains why some people seek to conserve buildings, as the loss of familiar features within the built environment can lead to a sense of displacement (Grenville, 2007).

Literature on the social value given to the built environment also discusses the role that buildings play in enabling social connectivity, promoting physical activity and supporting local economies (Mulgan, Potts & Audsley, 2006). This is evident upon viewing the role that council facilities such as libraries and pools often play in supporting community activities and for drawing a customer base for local businesses. Council buildings can therefore provide a public good that extends beyond their physical form and monetary value. Accordingly, decisions around the management and mitigation of seismic risk in council-owned buildings are part of a broader and more complex risk landscape.

1.3 Understanding the components of risk

The systematic evaluation of risk requires the considered evaluation of both likelihood and consequence.

Putting the annual probability of a major earthquake occurring in context is one of the challenges in communicating earthquake risk to owners. Prior to the Canterbury earthquakes, annual probabilities of 1 in 100 or less were considered by building owners and occupiers as sufficiently low as to act as a deterrent for taking positive mitigation action, irrespective of the vulnerability. However, following the 22 February 2011 earthquake, the dominant personal perspective became one of conditionality – i.e. given that "another major earthquake may well occur in the foreseeable future, I don't want to have a collapse or loss situation occur" (Brunsdon et al., 2013). This is an understandable perspective for those who have experienced the Canterbury earthquakes and one that appears to have influenced council-owned building occupancy decision making across New Zealand.

As defined by the international standard for risk management ISO 31000, risk is the effect of uncertainty on objectives. Importantly, the standard acknowledges the need to address the potential for both negative and positive effects of policy decisions. The process of assessing and managing risks of any form therefore requires careful account to be taken of the context of the risk in order to establish appropriate objectives and criteria. ISO 31000 provides a framework to ensure that a robust and comprehensive assessment of the risks and potential treatment options are undertaken before critical risk management decisions are made, such as closure of council buildings.

1.4 Research aim and objectives

While risk is a subjective concept, strong risk literacy and structured processes for interpreting risk information are important for robust risk assessment. Without a robust risk assessment process, some territorial authorities may be inadvertently and adversely impacting their communities when forming decisions on council buildings.

Therefore, the aim of this project is to utilise ISO 31000 to develop a comprehensive risk identification and decision-making framework that supports territorial authorities to navigate occupancy decisions about earthquake-prone council buildings. The intent is that territorial authorities will be able to use the framework to make decisions that account for a variety of impacts beyond those solely associated with seismicity and physical vulnerability. It is also intended that this decision framework will help territorial authorities form a clear rationale for the management of earthquake-prone council buildings that can be communicated to the public.

To achieve this aim, the study is guided by the following objectives:

- Investigate the key drivers leading territorial authorities to decisions about earthquake-prone council building use.
- Understand how earthquake-prone engineering risk information is interpreted, evaluated and acted upon by territorial authorities.
- Identify and develop tools, resources and processes to help territorial authorities to confidently and transparently make earthquake-prone building decisions.

1.5 Methodology

1.5.1 Data collection

Interviews

As the project is focused on how territorial authorities translate engineering advice into public policy decisions about earthquake-prone council buildings, empirical data was obtained via a purely qualitative approach.

A series of recorded interviews were conducted with eight staff representing five territorial authorities across New Zealand to understand their internal processes for identifying and managing seismic risk and community impacts. To ensure our research obtained a range of perspectives, interviewees typically represented either the property owner or regulatory arms of councils and were recruited from territorial authorities with varying degrees of internal resourcing and located within different seismic zones. Interviewees were typically people who provided advice on whether to continue occupying buildings assessed as less than 34%NBS or those who acted upon that advice.

Each interview involved providing participants with three hypothetical scenarios and a range of questions about occupancy of earthquake-prone council buildings,[6] which were designed to enable interviewees to talk through their respective decision-making processes. The same scenarios were presented to each territorial authority to enable the research team to compare different approaches to the same problem. The questions developed for each scenario were designed to help the team evaluate:

- how seismic risk information is assessed alongside other risk information in relation to liability, reputation, legislative responsibility, insurance, social impact and public sentiment
- what information councils require for their decisions
- how the provision of risk information could be improved to assist in the formation of potentially high-risk asset management decisions.

---

[6] See Appendix A for a description of the three scenarios. These were presented to interviewees to reflect upon 1 week prior to the interview.

The objective of these exercises was to prompt key stakeholders within each participant territorial authority to explain their decision-making rationale. This included understanding key decision drivers. The interviews allowed us to investigate how engineering information is communicated to decision makers and assessed alongside other risk information (such as social and economic impacts) and how the provision of information may be improved to better assist territorial authorities to make complex asset management decisions.

Online workshops

Interviews with local government stakeholders allowed the research team to understand the varied approaches to territorial authorities' building occupancy decision processes. This enabled us to develop a strawman decision-making framework reflecting a possible best-practice approach to seismic risk management in council buildings that also considers community impacts. Upon completion of the interviews and analysis of the data, the research team consulted with a selection of nine territorial authorities on the strawman model during two online workshops held in early November 2020.[7] During the workshops, the logic underlying the strawman model was presented, and feedback on the model's potential utility was obtained. This instigated a process of ongoing refinement, ultimately leading to the creation of the risk management framework presented in full in Appendix D.

1.5.2 Ethics

Because of the political sensitivity associated with the management of earthquake-prone council buildings, a decision was made to anonymise all empirical data. The reason for this decision was to protect territorial authorities from uninvited media or public attention.

1.6 Report content overview

Regulation of council buildings

A review of the literature details the complexity associated with making risk-based decisions about council buildings and commences in section 2 with a look at legislation that regulates how seismic risk is managed. This section begins by examining the legal framework around seismic resilience in New Zealand as provided in the Building Act, particularly the amendments introduced in the 2016 Act around earthquake-prone buildings. We then turn to the interactions between the Building Act and the Health and Safety at Work Act 2015. These Acts apply to territorial authorities in their capacity as building owners (or users). As public entities, territorial authorities are also subject to the legal framework that applies to all council decisions in New Zealand as well as the statutory framework provided by the Local Government Act 2002 and associated legislation. These elements are discussed in turn.

Understanding engineering risk

This legislative review is followed in section 3 by an overview of how the engineering profession evaluates seismic risk. This includes an investigation of why %NBS does not necessarily represent an absolute assessment of risk and why a rating of less than 34%NBS does not necessarily mean that a building poses an imminent threat to life safety. By highlighting the disparity between common technical language to describe

---

[7] See Appendix B for a full description of the workshop method and questions asked of participants.

seismic risk and the variability in how buildings categorised as earthquake prone seismically perform, section 3 prompts questions asking whether a more nuanced approach to defining tolerable levels of life safety risk can be adopted.

Risk management processes

This discussion leads to the introduction of the practice of risk management and the science of decision making in section 4. Here, the international risk management standard ISO 31000 is outlined with consideration of how it may apply within the context of earthquake-prone council buildings. This is complemented with a look at how behavioural science can inform decisions about earthquake-prone buildings in a way that recognises the individual, social and cultural contexts that influence how risks and impacts are perceived, evaluated and publicly communicated.

Case studies

Sections 1–4 provide background for an empirical analysis of local government decision making across five case studies in section 5. Using information obtained via a series of interviews with local government officials, section 5 includes an analysis of decision-making processes of territorial authorities across New Zealand related to the occupancy of seismically vulnerable council buildings. This segment of the study also presents an analysis of common decision drivers within local government such as concerns about liability and life safety that appear to commonly underlie many local government decisions about occupancy of council buildings categorised as earthquake prone or assessed as <34%NBS.

Through these case studies, we further investigate how engineering information is typically communicated to decision makers and assessed alongside other risk information during the formation of public policy.

Decision framework

The report continues in section 6 by coupling key findings from section 5 with facets of ISO 31000 to outline a potential best-practice approach to risk management in the context of earthquake-prone council buildings in New Zealand. This section presents an overview of the framework and its underlying logic, which was designed with input from the local government sector (the full version of which is presented in Appendix D). The objective of the framework is to provide an adaptable process for territorial authorities to account for a variety of risks associated with occupancy decisions of council buildings deemed earthquake prone or assessed as less than 34%NBS.

Conclusion

Section 7 concludes the report by reflecting on the aims and objectives of this study and summarising our proposition that ISO 31000 provides a standard on which territorial authorities can make consistent policy decisions about council buildings that encompass a broad range of risks.

2. Regulation of council buildings

2.1 Introduction

The legal framework that applies in cases of seismic risk and public safety is complex, particularly in a jurisdiction such as New Zealand where there is no clear delineation between public and private law. Constrained by the requirements of their public law responsibilities to ensure legal, transparent and reasoned decision making, local governments must also incorporate the private responsibilities of building owners (and employers) towards their employees and the wider public. Such dualism makes for confusion and, like all attempts to sit on the fence, often very uncomfortable compromises.

2.2 The Building Act, the concept of earthquake prone and council buildings

Seismic resilience is addressed in New Zealand as part of a three-part legal framework. This comprises the Building Act 2004 (the primary legislation), the Building Code (a deemed regulation) and a number of regulations enacted under the (now revoked) Building Regulations Act 1992.[8] In practice, the Building Code provides the minimum standards required for building construction alongside a number of other regulations introduced to deal with specific issues, including seismic resilience, such as the Building (Specified Systems, Change the Use, and Earthquake-prone Buildings) Regulations 2005.

Complementing the statutory framework, a number of standards, methodologies and guidelines provide additional detail on Building Code and regulatory provisions. Most of these, despite their names, have legal force through specific reference to them in regulations (including the Building Code) or the Building Act itself. Thus, to understand the exact requirements for seismic building requirements in New Zealand requires an understanding of a number of legal requirements, not all of which are complementary.

Of particular relevance here are amendments introduced into the Building Act relating to seismic risk as a consequence of the Canterbury 2010–2011 earthquake sequence and the Royal Commission that followed it. The risk posed by existing buildings through the identification and regulation of earthquake-prone buildings was first introduced in the Building Act 1991 and subsequently amended and extended in the 2004 revision of the Building Act. The 2016 Act created a more nationally focused and consistent system through new mechanisms such as the earthquake-prone building methodology,[9] the requirement for engineers to use the seismic assessment guidelines (MBIE, EQC, NZSEE, SESOC & NZGS, 2017) and the establishment of a national earthquake-prone buildings register.

The concept of an earthquake-prone building is a legal term rather than a normative indicator of the seismic safety of a building. The label is attached to buildings that fail specific tests laid out in the Building Act and associated regulations. Once a building is placed in this category, legal duties then apply to its owners.

---

[8] Confusingly, the Building Code is legislatively part of the 1992 Building Regulations (Schedule 1). The rest of the 1992 Building Regulations have been revoked.

[9] https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/methodology-identify-earthquake-prone-buildings/

The broad framework for the concept is laid out in the Building Act under section 133 but many structures are exempt. Significant exclusions include residential buildings (unless of two or more storeys and three or more residential units) and farm buildings. Subject to these exclusions, the definition of an earthquake-prone building is:

> A building or a part of a building is earthquake prone if, having regard to the condition of the building or part and to the ground on which the building is built, and because of the construction of the building or part,—
>
> (a) the building or part will have its ultimate capacity exceeded in a moderate earthquake; and
>
> (b) if the building or part were to collapse, the collapse would be likely to cause—
>
> (i) injury or death to persons in or near the building or on any other property; or
>
> (ii) damage to any other property.
>
> (2) Whether a building or a part of a building is earthquake prone is determined by the territorial authority in whose district the building is situated: see section 133AK.
>
> (3) For the purpose of subsection (1)(a), ultimate capacity and moderate earthquake have the meanings given to them by regulations.

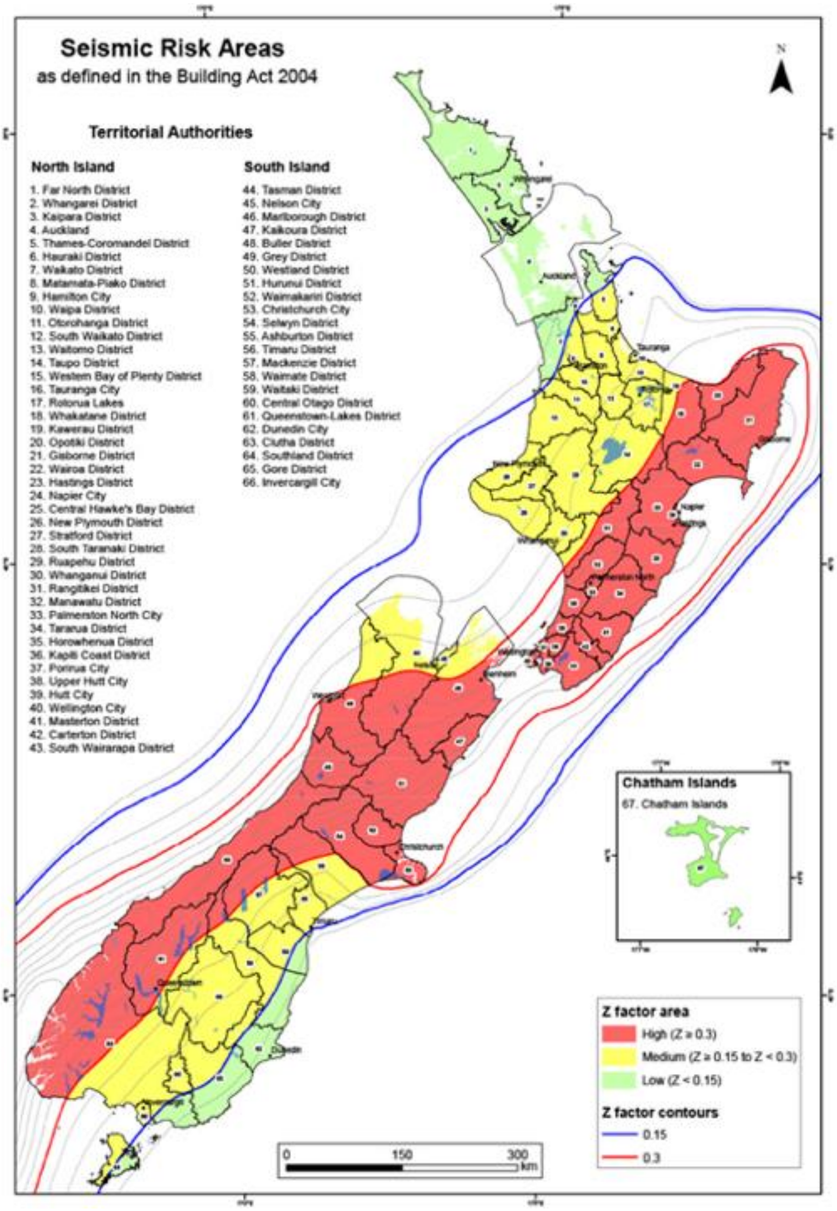
The key elements of the legal definition (beyond the definition of building) are therefore "ultimate capacity" and "moderate earthquake". These two terms are defined in regulation 7 of the Building (Specified Systems, Change the Use, and Earthquake-prone Buildings) Amendment Regulations 2017:

- "Ultimate capacity" is a widely used engineering term referring to the limit beyond which a building element could fail. However, the earthquake-prone building regulations defines this specifically as "the probable capacity to withstand earthquake actions and maintain gravity load support assessed by reference to the building as a whole and its individual elements or parts".
- "Moderate earthquake" is defined in the regulations as "an earthquake that would generate shaking at the site of the building that is of the same duration as, but that is one-third as strong as, the earthquake shaking … that would be used to design a new building at that site if it were designed on 1 July 2017". This is a somewhat misleading definition as earthquakes of one-third of the magnitude do not occur for the same duration. However, the difference is academic as, in practice, engineers do not take into account the duration of an earthquake when conducting assessments under the engineering assessment guidelines. Instead, consideration is given to whether an earthquake would create shaking at the building site that is one-third as strong as the shaking that would be used to design a building at the site.

The seismicity component of the level of shaking that is required to make this assessment is represented by the Z factor. This value varies according to defined regions and represents the peak ground acceleration expected in a particular area. It is defined in section 3.1.4 of NZS 1170.5:2004 *Structural design actions – Part 5:*

Earthquake actions – New Zealand. These definitions reflect historical seismicity and the distance of areas from active fault lines.[10]

Figure 2 shows the areas of New Zealand that have been determined to have a low, medium and high seismic risk,[11] which is based on the area's Z factor.



Copyright © Standards New Zealand. Reproduced under licence.[12]

Figure 2. Seismic risk areas (MBIE, 2018).

[10] http://www.seismicresilience.org.nz/topics/seismic-science-and-site-influences/faults/earthquake-risk-zones/

[11] Given that risk is the combination of likelihood and consequence, this term is more correctly 'hazard'.

[12] Copyright in NZS 1170.5:2004 is owned by the Crown and administered by the New Zealand Standards Executive. Reproduced with permission from Standards New Zealand, on behalf of New Zealand Standards Executive, under copyright licence LN001424.

Other components that contribute to the level of ground shaking include the applicable importance level (AS/NZS 1170.0:2002 *Structural design actions – Part 0: General principles* section 3.3) and the subsoil classification factor (NZS 1170.5:2004 section 3.1.3).

Therefore, to meet the first criterion of an earthquake-prone building in the Building Act, a building must be assessed as failing a test comprising three elements – its ultimate capacity will be exceeded during an earthquake of one-third of the strength that an equivalent new building constructed on the site concerned would be designed to withstand.[13]

These tests are to be applied as if they had occurred on 1 July 2017. Thus, any higher standards introduced into the legal framework for new buildings will not be reflected in the threshold for a building to be earthquake prone. The apparent regulatory issues associated with having the 2018 update of the concrete buildings section[14] formally incorporated in the engineering assessment guidelines for earthquake-prone building purposes suggests that improvements in understandings around vulnerability may also not be reflected in assessments.

This collection of assessments is usually shortened to defining an earthquake-prone building under the legislation as "buildings under 34%NBS". However, this shorthand version perhaps obscures the fact that the definition is purely legal and only used to define whether an owner must act to resolve seismic issues with a building and, if so, the timeframes that apply for doing so. It does not necessarily define that a building will fail in an earthquake. These issues and their implications are explored further below. However, before we get to this stage, it is important to briefly sketch out the practicalities and consequences of a seismic assessment.

2.3 Assessment and remediation of earthquake-prone buildings

Determination of an earthquake-prone building is essentially a four-step process:[15]

1. Territorial authorities identify buildings that are potentially earthquake prone.
2. Building owners are given 12 months to obtain seismic assessments to validate or disprove this. Owners must follow MBIE's earthquake-prone building methodology.
3. Territorial authorities use this information to determine whether a building is earthquake prone or not.
4. Owners of earthquake-prone building must then remediate the risk by retrofit or demolition (within required timeframes).

For step 1, the key point to note is that not all buildings are equally likely to be assessed as earthquake prone. Instead, only those buildings that are deemed as potentially being earthquake prone are subject to a compulsory assessment. The profiles that determine those buildings that must be assessed are provided in the

[13] For a building to acquire the legal definition of earthquake prone, injury or death to persons in or near the building or on any other property or damage to other property is considered likely to result from a collapse of the building or part. This test is applied by a territorial authority as part of determining a building to be earthquake prone.
[14] https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/what-you-need-to-know-section-c5-concrete-buildings-proposed-revision/
[15] https://www.building.govt.nz/managing-buildings/managing-earthquake-prone-buildings/how-the-system-works/

earthquake-prone building methodology and vary depending upon the seismic risk of the area (as defined in the legal framework, see below), the age and the type of building.

In all areas, unreinforced masonry buildings and pre-1976 buildings of three storeys (or with a height of 12 metres or above) must be assessed. In high and medium seismic risk areas, all buildings constructed prior to 1935 must also be assessed, other than those of timber construction. Territorial authorities are required to identify such potentially earthquake-prone buildings within certain timeframes that broadly reflect the seismic risk in the area. In areas of high seismic risk ($Z > 0.3$), the timeframe for identification is 5 years (2.5 years for priority buildings), rising to 10 years (5 years for priority buildings) in areas of medium risk ($Z = 0.15– 0.3$) and 15 years for areas of low seismic risk ($Z < 0.15$). Section 133 of the Building Act states that the only exception to this is if the territorial authority "has reason to suspect that a building or a part of a building in its district may be earthquake prone". In these cases, such buildings "may" be classified as potentially earthquake prone. Priority buildings include certain hospital, emergency and education buildings as well as buildings that could cause harm on major pedestrian or vehicle routes or thoroughfares.

Owners of buildings that have been profiled using the above categories are required to commission an engineering assessment using the earthquake-prone building methodology (discussed below). If this determines that the building falls below 34%NBS and the territorial authority then establishes that the building collapse or element failure could injure a number of people in or near it or cause damage to other property, it will be classified as earthquake prone. Such buildings will be subject to the legal regime for remediation and be placed on the national earthquake-prone building register[16] along with an approximate %NBS earthquake rating. Earthquake-prone building notices must also be displayed on those buildings. These notices contain the building's earthquake rating (where available) and the deadline for remediation. As at March 2021, there were 3,643 buildings identified on this register.

Such buildings are also subject to obligations around remediation. In particular, they must be strengthened to bring their NBS rating above 34% within a specified timeframe. These timeframes depend upon where the building is situated. Using the same zones as discussed above, buildings in areas of high seismic risk must be remediated within 16 years (7.5 years for a priority building), 25 years (12.5 years for a priority building) in medium seismic risk areas and 35 years for any building in a low seismic risk area. In limited circumstances, building owners can apply for an exemption from the requirement to carry out strengthening work or an extension of time to complete the seismic work.

A building owner who discovers through an independent assessment that their building would fall under the earthquake-prone definition does not have legal obligations to inform the territorial authority or remediate under the Building Act. However, it would appear that this does not apply to buildings in council ownership. Should a territorial authority have information that one of its buildings is potentially earthquake prone, it would seem required to undertake the formal earthquake-prone assessment. Christchurch City Council, for example, has listed a number of earthquake-prone buildings on the national register that, due to their age, would not have fallen within the categories recognised as a potentially earthquake-prone building under the

[16] https://epbr.building.govt.nz/

methodology. Nevertheless, once recognised as such, the formal legal requirements apply.

This process is further confused by the fact that MBIE's earthquake-prone methodology cites the engineering assessment guidelines (known as the Red Book).[17] This, however, does not necessarily reflect current science in the field as the decision on whether to incorporate new engineering research into the regulatory framework is a policy one. One can see this in the current situation around earthquake-prone building methodologies in New Zealand. The current science around concrete buildings, as recognised by Engineering New Zealand, is reflected in the proposed revision to chapter 5 (the Yellow Chapter) of the Red Book (MBIE, NZSEE, SESOC, NZGS & EQC, 2018). However, the current methodology to be applied for earthquake-prone building assessment remains the Red Book. The differences between these two methodologies can be significant for some 1980s era buildings, a number of which could fall below 34% if assessed using the new technical proposal to revise the Yellow Chapter.

This further emphasises the point that the term "earthquake prone" is a legal definition, not a normative one. As it stands, it is possible that buildings that fall under the 34%NBS level specified under the Building Act's legal framework will not be subject to the requirements of the 2016 Act. The question then arises as to whether the owners of such buildings are under any obligations to remedy them or manage them in any way outside of the requirements laid out for buildings formally recognised as earthquake prone. In addition, do the owners of buildings that are above 33%NBS but have some structural deficiency that could make them vulnerable to an earthquake have any responsibility to mitigate or prevent this eventuality? The answer to this question is possibly, but not through, the Building Act itself. For public agencies, such decisions could be restrained by the public law requirements laid out in the sections below, but there are further issues to consider that apply to all building owners, the most important of which is the HSWA.

2.4 The Health and Safety at Work Act

The Health and Safety at Work Act 2015 (HSWA) is the primary piece of legislation governing workplace safety in New Zealand. Health and safety regulations are particularly important in a New Zealand context as the existence of the ACC scheme and the consequent ban on actions for personal injury removes most liability for personal harm under private law. Unlike in most jurisdictions where personal safety is regulated by a combination of private risk (suing for fault, negligence and so on) and public regulation, in New Zealand, the onus falls entirely upon the state. In essence, the HSWA (and related legislation) and the agencies that police it are the only check on unsafe behaviour relating to personal injury in New Zealand.

The HSWA was introduced in 2015 as a direct result of failures in the previous regime, which had allowed high-risk activities with no practical legal consequence across a number of sectors. This was cruelly exposed in the 2010 Pike River Mine disaster, which cost 29 lives. As such, the HSWA is a general act that applies to all legal individuals (public and private) and does not specifically apply to earthquake-vulnerable buildings. It nevertheless has potentially significant implications for owners of such buildings and employers who operate businesses within them (as well as employees and users). The key concept within the act is that of the person conducting

[17] https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/seismic-assessment-existing-buildings/

a business or undertaking (PCBU). The overall legislative position as regards the responsibilities of these persons and organisation is laid out in section 37 of the HSWA:

> A PCBU who manages or controls a workplace must ensure, so far as is reasonably practicable, that the workplace, the means of entering and exiting the workplace, and anything arising from the workplace are without risks to the health and safety of any person.

It is important to note that the definition of a PCBU can include building owners even if they do not occupy the building, as the leasing of premises is in itself a business. Therefore, a single building may have more than one PCBU liable for the activities within it, depending upon the nature of the specific relationship between the owner/landlord and tenant. At the very least, a landlord will owe a duty to their tenants, while the employer who leases a building will owe a duty to their employees.

The duty set out in section 36 of the HSWA is broad and requires PCBUs and "officers"[18] within a PCBU to protect the health and safety of workers, protect the health and safety of other people and provide a work environment that is without risks to health and safety. Such a duty is not open-ended, and mitigation need only be undertaken to the extent that it is "reasonably practicable", defined in section 22 as something to be decided by taking into account five key criteria: the *likelihood* and the degree of harm that might result from the hazard or risk, what the PCBU knows about the hazard or risk, ways of eliminating or minimising the risk plus the availability and cost of those actions. How the likelihood of a sufficiently damaging earthquake plays into what is "reasonably practicable" is unclear. It is yet to be tested in a court of law and, due to the contextual nature of the issue, may never be specifically defined.

Should a responsible officer within a PCBU be convicted for failing to comply with their duty, the consequences are personal and serious. At the most egregious end of the scale, they include a term of imprisonment not exceeding 5 years and/or a fine not exceeding $600,000 for "reckless" actions that were "without reasonable excuse" and a "risk to an individual of death or serious injury or serious illness" (HWSA, s 47). Lesser penalties apply for failing to comply with a duty that exposes an individual to risk of death, serious injury or serious illness ($300,000) or a failure to comply with a duty alone, which can lead to a maximum fine of $100,000 (HWSA, s 49).[19] There are two key points to recognise here. First, the PCBU or responsible officer can be personally liable (PCBUs can also be liable as an organisation) and, second, such a liability can arise irrespective of whether an incident has actually occurred.

Enforcement of the HSWA largely falls to WorkSafe, the government agency responsible for workplace health and safety in New Zealand.[20] Although there is some consideration of existing regulatory schemes under section 35 of the legislation,[21] there

[18] An "officer" is defined under the HSWA as "any other person occupying a position in relation to the business or undertaking that allows the person to exercise significant influence over the management of the business or undertaking (for example, a chief executive)". (HSWA s18(b)).
[19] The penalties rise to a maximum of $1.5 million and $3 million respectively for PCBUs and other entities.
[20] The HSWA does recognise other designated regulators but not in the field of earthquake-prone buildings.
[21] "[A] person or court may have regard to the requirements imposed under any other enactment (whether or not those requirements have a purpose of ensuring health and safety) that apply in the circumstances and that affect, or may affect, the health and safety of any person."

is little evidence that, when the HSWA was introduced, there was much consideration of earthquake-prone buildings. Nevertheless, the existence of section 35 does provide authority for consideration of the Building Act in assessing the relevant duties of a PCBU under the HSWA. However, the weak language of section 35, particularly the fact that it only recognises that other enactments "may" be considered, makes it unlikely that reference to the Building Act could effectively reduce the duty of PCBUs and officers under the HSWA in relation to building safety.

Nevertheless, WorkSafe has developed policy guidelines regarding earthquake-related health and safety risks[22] to outline its approach to the relationship between the Building Act and the HSWA. These guidelines are not binding, but they set out WorkSafe's intended approach to enforcement of the HSWA in this area. The guidelines state that WorkSafe will not enforce building safety to a higher standard than the Building Act. In other words, if a PCBU owns or occupies an earthquake-prone building and they are complying with the earthquake-prone building framework, WorkSafe has a policy not to enforce standards beyond those required by the Building Act.

However, it is important to note at this point that, although this might bind WorkSafe's regulatory role to some extent (through the principle of legitimate expectation), WorkSafe can deviate from this policy statement if the circumstances warrant it. Thus, the policy statement does not mean that the owner of a building that complies with the earthquake-prone requirements of the Building Act is not liable under the HSWA. In addition, WorkSafe's role in interpreting the HSWA relates only to its own enforcement actions, and definitive decisions around the relationship between the Building Act and the HSWA will lie in the hands of a court. In the aftermath of a seismic event leading to building failure, for example, prosecutions under the HSWA could still be possible, notwithstanding the earthquake-prone status of the buildings concerned and WorkSafe's published guidelines. These could eventuate from WorkSafe itself, other Crown prosecution agencies or legal individuals (including companies).

In addition, WorkSafe's guidelines also note that PCBUs must be aware of potential earthquake risks and that they must consider any new information that might be relevant to the performance of their building in an earthquake. For example, the guidelines recommend that a PCBU obtain relevant professional advice, such as an engineer's assessment, if they are concerned about the building's earthquake structural integrity. This appears to indicate that, even if a building has not been identified as earthquake prone, the PCBU may be liable if they fail to minimise the risk of the building collapsing (or causing injury) in an earthquake if they were privy to the potential risk of this occurring or had concerns about the building's structural integrity. In addition, there is also the possibility that an owner of a building who is aware that the building is less than 34%NBS may have some responsibility to address this weakness under the HSWA, whether or not the building has gone through the process that would render it subject to the earthquake-prone requirements of the Building Act.

The responsibilities of a building owner under the Building Act and the HSWA thus need to be considered separately. A building with a 33%NBS rating determined by the territorial authority as being earthquake-prone will be subject to the seismic work requirements of the Building Act. However, this does not alter the responsibility of the individual to eliminate or minimise seismic risks "so far as is reasonably practicable"

[22] https://www.worksafe.govt.nz/laws-and-regulations/operational-policy-framework/operational-policies/dealing-with-earthquake-related/

under the HSWA. Notwithstanding WorkSafe's policy guidelines, this may require a building owner to take additional steps to avoid prosecution after a seismic event. Equally, a building that is found to be less than 34%NBS (or is recognised as having seismic vulnerabilities) but not determined by the territorial authority to be earthquake prone and thus not subject to the requirements of the Building Act may require some action on the part of the owners under the HSWA to ensure that the seismic risk is minimised or eliminated.

Although the responsibilities of the HSWA apply to the PCBU as a whole, section 18 of the HSWA makes it clear that the specific liability can lie with those individuals within the PCBU "occupying a position in relation to the business or undertaking that allows the person to exercise significant influence over the management of the business or undertaking (for example, a chief executive)". Thus, although these are council buildings, it is the view of the authors that decisions around their safety are not "public" decisions. Liability under the HSWA applies to the responsible officer within the PCBU as an individual (in the case of a territorial authority, likely to be the chief executive) and the territorial authority acting in its private corporate capacity, not to the council as a public body.[23]

2.5 Local government decision making

Although a decision taken by a territorial authority under the HSWA may not be a public decision, elements of these decisions will have a public context. Most local government decisions must comply with the general principles of public law under which a number of key tests must be met, each of which can be infused with the principles of te Tiriti o Waitangi. These can be summarised as:

- Who made the decision? Did they have the legal authority?
- How was the decision taken? Were the correct procedures followed?
- Why was the decision taken? Were the correct reasons used for the decision?
- What was the decision? Was the decision itself in breach of wider legal principles?

First, the decision must be taken by the person (or group) that is statutorily tasked with the role. In the context of local government, this principle is particularly important as New Zealand territorial authorities are entirely creatures of statute, having no powers outside those provided to them in legislation. In terms of building safety, it is crucial that the person or persons who make the decisions are authorised to make them. For example, depending upon the nature and significance of the decision, the correct authority may be the council itself or the chief executive.

Second, a local government decision maker must follow correct procedure in making any decisions. This can be outlined in the statute, any relevant regulations (or deemed regulations) and accepted practice.[24] The decision maker must also ensure that there was no appearance of bias and that individuals affected have had the chance to comment (the right to a hearing). In relation to the closure of a council building, this may require consultation with users or other relevant parties, but only if the decision

[23] In cases where the council is landlord, such responsibility may be shared between the building owner and, depending upon the nature of the leasing arrangements, the tenant. Equally, the council may have some responsibilities under the HSWA when it is the tenant. In all cases, the relevant officer(s) of the PCBU are personally liability under the HSWA.

[24] If this creates a "legitimate expectation" – such an expectation can also be created by Treaty principles.

being taken is held to be a public one (rather than a decision taken by the territorial authority in its private capacity).

Finally, in making the decision itself, the decision maker must utilise their power for the purposes outlined (not an ulterior motive), take into account all relevant factors (outlined in any legal requirements that structure the discretion and potentially those that need to be taken into account more generally) and ignore all irrelevant factors.

Once a decision is taken, there is then a final test to be met. It must comply with the substantive principles of the New Zealand constitution (in practice, this primarily equates to compliance with the New Zealand Bill of Rights Act 1990 and Treaty principles) and be "reasonable". This latter principle is somewhat controversial, and courts are reluctant to intervene unless the decision is egregious.

2.6 The Local Government Act

The Local Government Act 2002 (LGA) provides the statutory authority and limits territorial authority decision making, the purpose of which is defined in section 10 as "to enable democratic local decision-making and action by, and on behalf of, communities, as well as promoting the social, economic, environmental, and cultural well-being of present and future communities". Before a repeal in 2019, the LGA specifically required territorial authorities to "have regard" to "the avoidance or mitigation of natural hazards" in performing their duties. Although this is no longer the case, under section 101B, territorial authorities must still adopt an infrastructure strategy, "identifying and managing risks relating to natural hazards and by making appropriate financial provision for those risks". In addition to roads, footpaths, water, sewerage and stormwater supply, the LGA is clear that infrastructure strategies can include community facilities at the councils' discretion. However, in practice, territorial authorities' infrastructure strategies seldom include vertical infrastructure.

Section 14 sets out various general principles that territorial authorities must follow when performing their function, primarily related to democratic values, transparency and community engagement, which could have relevance to decisions around community assets. In particular, territorial authorities must take the interests of both current and future communities into account when making decisions. Such interests would need to include the seismic resilience of such assets (at least partially covered in the infrastructure strategy discussed above) but also, potentially, the community impacts of closing such assets.

Territorial authorities must also take into account other factors in their decision-making process, including the economic and cultural wellbeing of the communities they represent.[25] The management of risk in council buildings must therefore be made in the context of economic and cultural interests. If a territorial authority determines through relevant evidence and assessment that a council building poses too great a risk to safety to remain open, the legal framework requires that they must also consider the economic and cultural impacts of such a closure and, potentially, mitigate the impacts.

In sections 77–79, territorial authorities are also mandated to consider views and perspectives of persons likely to be impacted by the decision and the need to consider and balance all available options when agreeing on a decision. A decision to close a

[25] Section 4 of the LGA makes it clear that such considerations must also take into account Treaty of Waitangi commitments and wider reference to Māori interests.

council-owned building without any consideration of the impacts or other possible options would thus appear open to challenge. The question then arises as to the relationship between these requirements, the recognition of earthquake-prone buildings under the Building Act and responsibilities under the HSWA.

2.7 Conclusion

This section has provided a brief sketch of the legal framework surrounding council buildings, public safety and earthquake risk in New Zealand. It has shown that, when making decisions about council buildings categorised as earthquake prone (or rating less than 34%NBS), territorial authorities are obligated to consider both life safety and community impact. This creates a difficult tension because it compels territorial authorities to balance their legal requirement to manage health and safety risk as far as reasonably practical with their broader requirement to preserve the social, cultural, economic and environmental wellbeing of present and future communities. Policy decisions must take into account the views of users. However, territorial authorities also have a responsibility (as PCBUs) to ensure the safety of their staff and users of facilities under the HSWA. This responsibility is clear and could lead to personal liability. When a decision to close a facility is taken by a senior manager of a territorial authority, it would appear that the only public law aspects that could apply would be around the continuation of the services provided or, potentially, whether the risks or impacts associated with the closure could be addressed in an alternative way.

What should the relevant decision maker(s) within a PCBU do when they discover that a building poses a seismic risk? The matter is complicated by the fact that the earthquake-prone delineation used by the Building Act is itself confusing. The designation "earthquake prone" is a legal definition. However, other buildings (of more recent construction, for example) that pose equivalent risks will not fall under the earthquake-prone definitions. The owner of a building would therefore be unwise to rely upon the earthquake-prone definition as a means of assessing the risk that a building poses and the liability that they may thus have under the HSWA. However, as the liability falls to the individual under the HSWA, the decision on how to address an earthquake-prone building (or a non-earthquake-prone building rating either above or below 34%NBS that has a potential risk) also lies with that individual. There is no requirement to close an earthquake-prone building, for example, but the decision on whether to do so appears to lie with the chief executive (or delegate).

The WorkSafe guidelines, although attempting to create clarity, in fact complicate matters. They provide an assurance that PCBUs (and individual council officers) will not be liable under the HSWA for an earthquake-prone building as long as they are complying with the requirements of the Building Act. However, they also state that PCBUs must be aware of potential seismic risks and consider any information relevant to the building's performance in an earthquake to comply with the HSWA. The result is a situation where the definition of a building as earthquake prone is only one aspect that a PCBU must take into account when considering seismic risk.

3. Understanding engineering risk

3.1 Introduction

The previous sections have demonstrated that the Building Act sets out a legal definition of an earthquake-prone building that does not necessarily map directly to risk. So, what is the actual life safety risk? For territorial authorities to adequately balance seismic risk and community impact and to suitably comply with regulatory responsibilities, a broad understanding of engineering risk is useful. In this section, %NBS is explored in more detail, including the underlying elements that contribute to life safety risks for a given building.

3.2 Seismic design

Buildings are designed to withstand different-sized earthquakes based on their function, likely occupancy and design life. In addition to the seismicity as represented by the Z factor and site ground conditions, the seismic strength required for a new building is determined based on its importance level (IL) classification and the design life of the building. Under AS/NZS 1170.0:2002, importance levels are defined based on a combination of building function and occupancy. IL4 buildings are those that are required post-disaster (such as emergency and surgical facilities, fire, police and utilities). IL3 buildings are those that house large numbers of people (such as stadiums, large schools and airport terminals). Most buildings are IL2.[26]

Buildings with a higher IL or longer anticipated design life are designed to withstand larger earthquakes that correspond to a longer return period (an average or estimated time between events). Most buildings in New Zealand are designed with a 50-year design life. IL2 buildings with a 50-year life, for example, are designed to withstand a 1 in 500-year event, whereas an IL4 building with a 50-year design life is designed for a 1 in 2500-year event. These earthquake loadings relate to a probability of exceedance during the life of the building of 10% for IL2, 5% for IL3 and 2% for IL4. These design levels are referred to as the ultimate limit state event. At this point, the building is designed to allow for safe evacuation but may no longer be habitable or repairable. Importantly, overall building collapse should only occur at a much higher level of ground shaking.

As described in earlier sections, the strength of existing buildings is often represented via %NBS ratings (percentage of new building standard). While %NBS may appear at face value a straightforward concept to describe how well a building will perform in an earthquake, the complexities of seismic events and the nuances of structural design mean that the link between %NBS and building performance is not always direct. How an earthquake affects a building depends on many factors. They include the earthquake itself (duration, amplitude, period of shaking), local and geotechnical features (soil conditions, presence of liquefiable materials, ground slope, water table), the characteristics of specific buildings (regularity of the structure both in plan and throughout its height) and how these factors interact. Short sharp earthquakes will have the most significant impact on stiff, low-rise buildings. Long rolling earthquakes will impact high-rise buildings most significantly. Accordingly, %NBS does not predict seismic performance from one earthquake to the next (Hare, 2019).

[26] IL1 are low-risk structures such as fences and farm buildings, and IL5 are buildings that could cause catastophic risk such as dams.

There are two stages to seismic assessment prescribed by MBIE et al. (2017) – initial seismic assessment (ISA) and detailed seismic assessment (DSA). The ISA provides a broad indication of the likely level of seismic performance of a building. In some cases, an ISA will be followed by a DSA, which provides a more-comprehensive assessment than an ISA. These assessments can range from an exterior inspection (ISA only) to a complex structural analysis depending on the complexity of the building and level of detailed understanding required (see Figure 3). All assessments require a level of engineering judgement. The assessment guidelines explicitly recognise that "[%NBS] assessments of the same building by two or more experienced engineers may differ – sometimes significantly" (MBIE et al., 2017: pA9-1). However, the guide notes that experienced engineers should be able to find consensus around critical issues that will affect seismic behaviour, even if the exact %NBS figure differs. Of critical importance is the specific mode of failure that will likely govern whether there is risk to life.

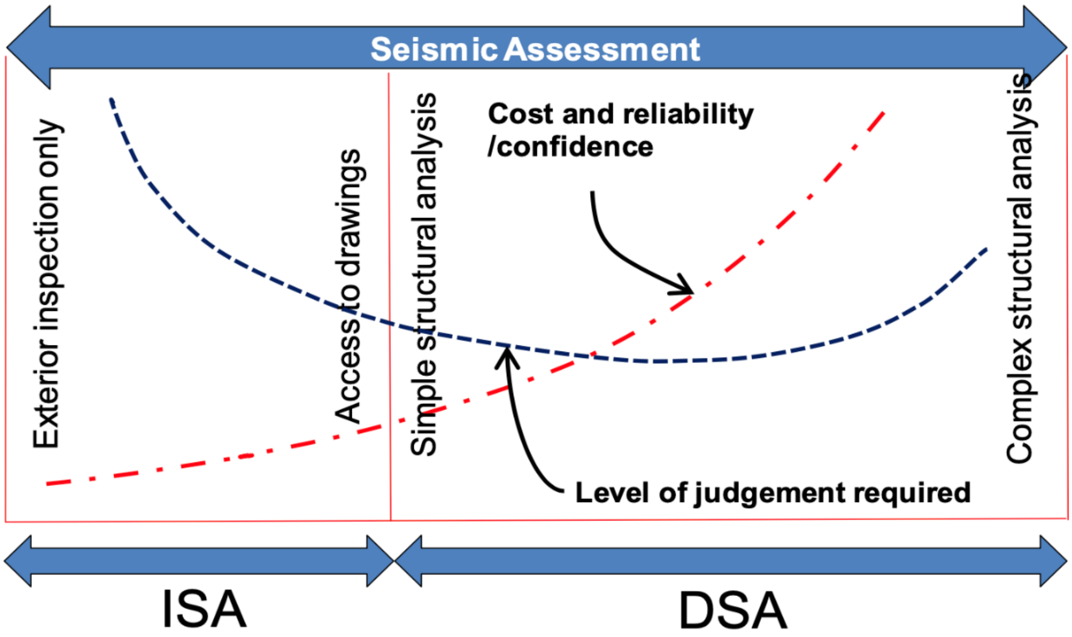


Figure 3. Seismic assessment continuum (MBIE et al., 2017, p. A7-6).

With the advent of the 2016 Act, a common misconception has emerged that a building assessed as earthquake prone or less than 34%NBS is dangerous. It is important to note that "earthquake prone" is specifically excluded from the scope of dangerous buildings unless damaged directly by an earthquake such that an aftershock could give rise to a life safety hazard. Under the Building Act, dangerous buildings are those that are considered to pose an imminent threat to people in or around the building due to imposed loading or forces from weather events – for example, as a result of deterioration or damage. The process for managing these buildings is set out in section 121 of the Building Act.

Figure 4 conveys the spectrum of buildings that are fully compliant through to buildings that are dangerous in terms of the Building Act. As well as conveying that earthquake-prone buildings are not necessarily dangerous, this also highlights that some buildings that are not defined as earthquake prone also have imperfections that present risks to occupants. For example, precast flooring systems in some mid to late 20th century buildings may perform satisfactorily in a moderate earthquake but they have the potential to cause significant damage in larger earthquakes (Engineering New Zealand, 2018).

Figure 4. Categories of building performance (Engineering New Zealand, 2018, reproduced with permission).

As discussed above, there is a heterogeneity in how individual buildings respond to the variety of earthquakes possible, making an overall unique assessment challenging. Accordingly, a %NBS rating does not represent an absolute assessment of risk or safety. Moreover, a rating of less than 34%NBS does not mean that a building poses an imminent risk, nor is that building expected to collapse in moderate levels of earthquake shaking. The aim of the %NBS metric is to provide a relative assessment of seismic risk. It is not a predictor of building collapse nor building performance. Unfortunately, it appears that this nuance is often not understood by the public, media and even decision makers.

3.3 Life safety risk

Understanding the risk of building damage during an earthquake is only part of the risk equation. The potential exposure of people to building damage in the event of an earthquake is the main determinant in life safety risk.

The MBIE and others have produced some qualitative life safety risk estimates against %NBS rating (Table 1).

Table 1. Estimated life safety risk of buildings based on %NBS (MBIE et al., 2017).

Percentage of new building standard (%NBS)	Alpha rating	Approximate risk relative to a new building	Life-safety risk description
>100	A+	Less than or comparable to	Low risk
80–100	A	1–2 times greater	Low risk
67–79	B	2–5 times greater	Low to medium risk
34–66	C	5–10 times greater	Medium risk
20 to 33	D	10–25 times greater	High risk
<20	E	25 times greater	Very high risk

Generally, this shows that life safety risk exponentially increases as %NBS decreases. It is unclear how these ratings were arrived at. The ranges in the table presumably indicate the uncertainties and complexities described above – including the variability in earthquakes, complexities in the Building Code, different importance levels of buildings and the range of occupancy types. To put these relative risk ratings into context, new IL2 buildings are designed to have an annual average individual life safety risk for earthquakes at around 10^{-6}.

One factor that contributes to life safety risk that is not explicitly integrated in current assessments of life safety is occupancy. The IL ratings single out large buildings for higher design requirements (IL3 buildings), but they focus on peak occupancy. The average occupancy of a building, including how many people use the building and the frequency and duration they occupy it, is not considered. However, this impacts the actual life safety risk because it represents the average exposure of people to the hazard. There is thus a higher life safety risk where a building is more frequently occupied by a greater number of people and, conversely, a lower life safety risk where a building is either occupied by a smaller number of people or for a shorter period of time (or a combination of both).

The 2016 Act focuses on building performance rather than occupancy. The 34%NBS threshold is constant regardless of the IL rating (and corresponding occupancy rates). Therefore, the life safety risk (to an individual in a given earthquake) is lower for higher IL buildings. This makes it unclear what the acceptable level of life safety risk is.

Some authors have questioned whether the life safety risk can reasonably be expected to be the same for both new and existing buildings. Enright (2015) suggests that an appropriate level of life safety risk for existing buildings in New Zealand is 10^{-5}. The difference between that and the acceptable standard for new buildings (10^{-6}) is accounted for by the principle of ALARP (as low as reasonably practicable), recognising the cost and practicalities of retrofitting old building stock.

Current observations indicate that there is no common view as to what risk is acceptable for seismic safety of existing buildings. This is partly due to a lack of understanding of the intricacies of seismic design (Hare, 2019). Murphy and Gardoni (2007) stress the importance of society setting risk acceptability and tolerability limits. However, how this can and should be achieved is an ongoing challenge[27] as the engineering community contemplates a move toward risk-based performance building codes (Meacham & van Straalen, 2018). Further, the public appetite for seismic and other natural hazard risks is highly variable, being influenced by the duration since and impact of recent earthquake events (nationally and internationally). This in turn influences decision making at the individual, council and broader political level.

3.4 Conclusion

Following an outline of New Zealand's legislative framework for managing seismic risk in council buildings presented in section 2, this section detailed variance between a common understanding of %NBS as a measure of how buildings are expected to seismically behave and what this measure is realistically able to signify. Section 2 detailed that the term "earthquake prone" denotes a legal definition rather than mirroring an objective risk state. This section further demonstrated disparity between common language used to represent seismic risk and actual risk to life by outlining that the threshold that prompts territorial authorities to categorise buildings as earthquake prone (<34%NBS) can be a poor indicator of a building's seismic behaviour. Fundamental to this understanding is that there are multiple variables that influence how buildings perform and therefore no uniformity in how buildings categorised as

[27] There is work under way through both QuakeCoRE and NZSEE to explore societal expectations of building performance during earthquakes.

<34%NBS will behave during a seismic event. There is also potential for inconsistency in how professional engineers might assess a particular building's %NBS rating.

As discussed, a building's seismic performance only presents part of the risk equation when considering life safety. Equally influential is the degree of risk exposure. This is reflected in the extent of building occupancy. However, as outlined, IL ratings within the Building Act focus on peak occupancy and not the more accurate determinant of life safety risk – a building's actual occupancy, including average occupancy and frequency of use. This may prompt conservatism or potentially risk taking when territorial authorities (or any owners) consider occupancy of an earthquake-prone building. This begs the question whether a more nuanced approach to defining tolerable levels of life safety risk can be adopted and, if so, how this might address the vulnerability that PCBUs may feel owing to their potential liability under the HSWA.

4. Risk management processes

4.1 Introduction

Risk management decisions, such as responses to earthquake-prone building reports, are not made in isolation. They sit within the context of wider risk management and decision-making processes. The previous sections highlighted the trade-off between seismic impacts that are potentially life-threatening but very unlikely against more immediate and certain social and economic impacts of building closures. The associated key legal and engineering considerations have also been summarised.

This section adds two perspectives on the decision-making process itself. First, the international standard for risk management ISO 31000 is outlined alongside the key considerations that are required to establish a robust risk management and decision process for the earthquake-prone building context.

This is followed by insights from the behavioural literature on risk communication and decision making. The behavioural literature outlines the decision-making steps in a similar manner to the ISO 31000 but emphasises the individual, social and cultural contexts that influence how the risks and impacts are perceived, evaluated and communicated – or even considered at all.

4.2 ISO 31000 risk management standard

As noted in section 1.3, ISO 31000 identifies two key components in risk: likelihood and consequence. The likelihood is the chance that something will happen, and the consequence is the outcome of an event. Overall risk is a combination of both likelihood and consequence. Subsequently, risk can be reduced by either altering the likelihood or the consequence. In the case of risk from earthquake-prone buildings, it is the consequence that we can influence the most.

In the case of a decision to close an earthquake-prone building (or a building assessed as less than 34%NBS), decisionmakers are effectively comparing two sets of risks:

1. The potential for injury or harm in an earthquake-prone building in the event of an earthquake.
2. The known and definite disruption to council services and the wider impact on the community from closure of the building.

Both risks contain consequences – risk 1 has the potential catastrophic consequence of loss of life, and risk 2 has socio-economic impacts to a community – but the likelihood associated with each risk is very different – risk 1 has a very low likelihood while risk 2 is certain. The trade-off between the two is not straightforward and will differ depending on the life safety risk of the building and the immediate consequences of closing the building. To effectively assess and compare these risks, a robust process needs to be followed.

The ISO 31000 risk management process is shown in Figure 5. It is provided here as the international benchmark of a standardised process for systematically managing risk. For decisions around occupation of earthquake-prone buildings to be transparent (as required under the various legislative responsibilities discussed in section 2), territorial authorities need to follow a robust risk management process such as the one set out in ISO 31000.

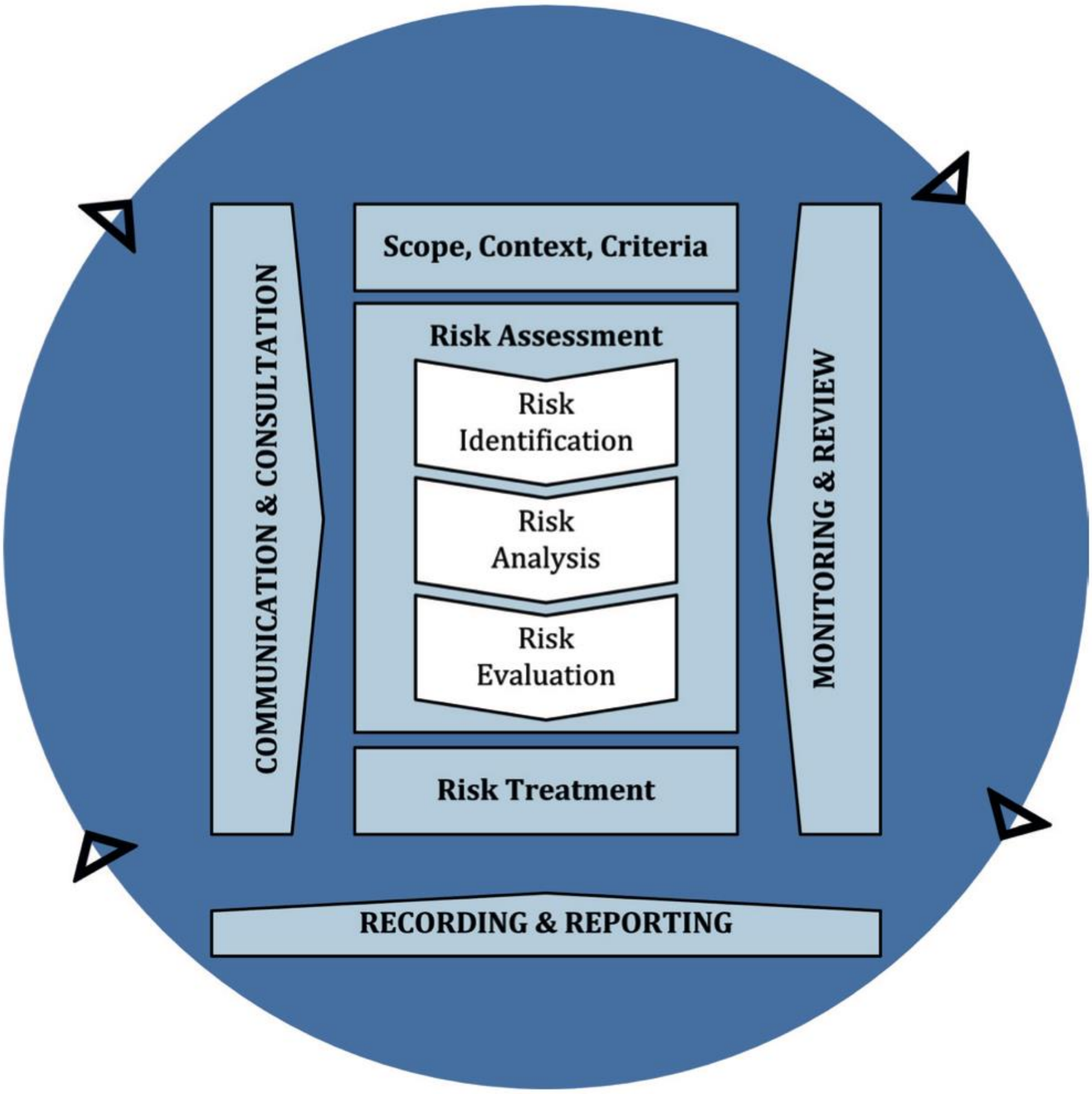


Figure 5. ISO 31000 risk management process.

As Figure 5 demonstrates, risk management is an iterative process. The primary risk management process in the centre of the diagram (context – risk assessment and risk treatment) is supported by the ongoing processes of communication and consultation, monitoring and review, and recording and reporting.

Table 2 applies the key elements of the ISO 31000 risk management framework to identify the components necessary for a robust decision process around occupancy of council-owned earthquake-prone buildings (or those assessed as less than 34%NBS).

Scope, context and criteria is arguably the most important step in a risk management process. This is where decision makers clearly identify their risk management objectives. In the case of earthquake-prone building occupancy, this includes understanding the legal context and requirements, knowing who is (legally) responsible for making the decision and establishing clear criteria for making a decision – what objectives are you trying to achieve?. The risk management criteria or objectives will likely go beyond meeting basic legal requirements and will reflect an organisation's mission and values and will ideally map to existing risk management processes. This first step sets the scene for the rest of the process.

Table 2. Risk management process considerations related to occupancy of council-owned earthquakeprone buildings.

Risk management step	Focus/key elements	Earthquake-prone building specific considerations
1 Scope, context and criteria	Defining the external and internal parameters to be taken into account when managing risk and setting the scope and risk criteria for the risk management policy.	Relevant legislation – objectives (disclosure and mitigation) and associated time periods. Correct people delegated to make the decision – reflecting PCBU and local government responsibilities. Criteria based on organisational objectives, including risk tolerance/existing risk management frameworks. Consideration of risk to whom?
2 Risk assessment	**2.1 Risk identification** The process of finding, recognising and describing risks.	Specific structural vulnerability and area affected (preferably) peer reviewed by chartered professional engineer.
		Implications and costs of not continuing to occupy the building, including options to deliver services through alternative means.
		Other risks that may be relevant such as presence of asbestos or other hazardous substances that may increase life safety risk in the event of earthquake.
	2.2 Risk analysis The process of comprehending the nature of risk and to determine the level of risk.	Likelihood of the earthquake occurring and structural failure endangering life (not just likelihood of the earthquake).
		Exposure of people/occupancy characteristics – types and numbers of people, frequency and duration of occupancy, time before seismic strengthening may occur.
		Consequences of closure – impact on service delivery and building users including vulnerable users and staff, impact on neighbouring businesses.
	2.3 Risk evaluation The process of comparing the results of risk analysis with risk criteria to determine tolerability.	May involve wider engineering review and review of broader social, cultural, environmental and economic impacts. Consider short-term risk treatment options (such as removal or isolation of parapets). Consider change of building use to reduce life safety risk (such as number of users).
3 Treatment of the risk	Avoiding the risk.	Move out and/or fence off affected walkways.
	Removing the risk source.	Strengthen/demolish.
	Changing the consequences.	Short-term mitigation – change use of building (fewer users), emergency plans, staff training.
	Retaining the risk.	By informed decision and notification to all building users (as per MBIE guidelines) until the building is ready to strengthen.

Risk management step	Focus/key elements	Earthquake-prone building specific considerations
4 Communication and consultation	Assisting relevant stakeholders in understanding and, where applicable, ownership of risk.	Ongoing and iterative – should commence early with all building users and stakeholders.
5 Monitoring and review	Ensuring quality and effectiveness of process and outcomes.	Ongoing to ensure use of building (number or types of users) and building condition does not change so there is an intolerable level of risk.
6 Recording and reporting	Communicating information, activities and outcomes to relevant parties.	Reporting as required under MBIE processes.

The **risk assessment** process is a combination of identifying, analysing and evaluating the risk. The scope of this assessment will be defined by step 1. However, in general, it will involve gathering and evaluating information on:

- the seismic rating of a building (%NBS)
- likely mode of failure and the associated risk to life (inside and outside of the building)
- building occupancy (peak, average and frequency of use)
- implications of building closure and options for alternative delivery of services
- other risks that might pose a hazard during an earthquake
- potential temporary mitigation measures.

The main focus of the exercise is to understand the likelihood that people will be injured if the building is damaged in an earthquake and the consequences of closing a building in the short term.

Step 3 is where **risk treatment** is determined – in this case, the primary decision is whether to close the building but may also include use of temporary mitigation measures such as fencing off areas. The type of risk treatment will depend on the life safety risk associated with the building and the consequences of closing the building in the short term. Risk treatment should also consider risk management approaches such as developing emergency plans and training staff.

Step 4, **communication and consultation**, is a critical element in the risk management process that will ensure that often controversial decisions to close council buildings (or continue using earthquake-prone buildings) are received well by the community, building users and staff.

Step 5, **monitoring and review**, is an important process that ensures the desired outcomes of the risk management process are achieved and that the risk management options are changed if the risk changes – for example, through deterioration of the building or through a change of building use (increased occupancy).

Step 6, **recording and reporting**, is necessary to ensure all affected parties are aware of the risk and risk treatment activities. In the case of earthquake-prone council buildings, reporting is also a legislative responsibility.

The aim of the ISO 31000 risk management framework is to ensure that a robust and comprehensive assessment of the risks and potential treatment options is undertaken before critical risk management decisions, such as closure of council buildings, are made.

4.3 The behavioural science approach to decision making

Behavioural science views an individual's decisions and actions as a process. While the steps described in ISO 31000 are reasonably linear and logical, there are a number of human influences that impact perceptions, decisions, actions and ultimately the outcomes of risk management processes. This section emphasises that human behaviours and decisions are not rational evaluations of facts but are heavily influenced by a complex array of individual and social influences that impact in ways that are sometimes surprising and can make the resulting choices appear irrational (Eiser et al., 2012).

4.3.1 The rational choice model of decision making

The behavioural approach to decision making sits in contrast to the rational choice approach, initially developed in classical economics (Eiser et al., 2012). The rational choice approach assumes decision makers compare the costs and benefits of available options, take account of probabilities and make a logical choice based solely on the expected values of the options (Kahneman & Tversky, 1979). It implies decision makers will make optimal decisions based on their preferences and the information available to them.

In the rational choice model, a poor, apparently illogical or irrational decision is either the result of an information deficit or the misinterpretation of the relevant information (Tversky & Kahneman, 1981). Thus, the solution is to provide better information or enhance decision makers' understanding of how to interpret it.

This approach has been subject to both theoretical and empirical critique, including in the context of natural hazards (Eiser et al., 2012; Stewart, Ickert & Lacassin, 2018). As outlined below, the behavioural approach highlights a wider range of influences on decision making, which appears relevant in the earthquake-prone building context.

4.3.2 The behavioural approach

Like all territorial authority decisions about earthquake-prone buildings, the behavioural decision-making process usually starts with the recognition of a problem (a gap between the desired situation and the perceived current or future state). This is followed by an exploration and evaluation of options, a decision being made, implementation of the decision and a post-decision evaluation. According to behavioural science, these stages are all influenced by factors such as the individual's preferences, past experiences, skills, knowledge, sources of information, how it is presented and perceived, trust in the source, perceived social norms and the level of desire to conform to them and so on (Eiser et al., 2012).

Social influences

When territorial authorities make decisions about council buildings deemed earthquake prone (or rating less than 34%NBS), there are often multiple individuals and decision points involved. The risk communication dialogue between parties as well as the decisions themselves are all subject to the above human influences and sources of potential bias (Crawford, Saunders, Doyle, Leonard & Johnston, 2019). The individuals may include external professional advisors (engineers, lawyers), council officers managing buildings or providing services from the building, directly affected parties (staff, visitors, tenants, neighbours) and senior council executives or elected councillors making decisions. It may include communication through traditional and social media with the wider public and those impacted through implementing the decision. All the individuals involved will have varying roles, experience, knowledge, attitudes and beliefs, resulting in varying levels of understanding and information needs (Becker, Johnston & Paton, 2015; Becker et al., 2019). This means communications may need to be tailored to these particular needs (Doyle, Johnston, Smith & Paton, 2019).

People's values, group identity and perceived norms can also have a stronger influence on their risk judgements than the information communicated (Kahan et al., 2012). Solberg, Rossetto and Joffe (2010) provide an overview of the seismic hazard adjustment literature from a social psychology perspective, covering aspects such as risk perception, social norms and attitudes towards seismic adjustment attributes. Social norms (socially defined rules of behaviour) can have a substantial effect on both attitudes and behaviour The extent to which these impact on risk adjustment behaviours is dependent on the existence of norms, their visibility and the extent of social connection.

Social influences extend into organisational cultures and professional backgrounds. For example, Demeritt et al. (2007) found meteorologists preferred to issue precautionary warnings even at low likelihoods or with high uncertainty to reduce chances of unwarned floods, while flood forecasters preferred to decrease the chance of false alarms because of their impact on future public response.

Trust consistently comes through as a key determinant of risk perceptions (Khan, Mishra, Lin & Doyle, 2017; Solberg et al., 2010; Wachinger, Renn, Begg & Kuhlicke, 2013) for both the public and official decision makers. A high degree of trust increases the likelihood that information will be believed and acted upon. The converse is true when there is a low degree of trust.

Stewart et al. (2018) suggest that trust is arguably more important than technical understanding because people use trust as a cognitive shortcut when faced with complexity. This thus reduces their need to make rational evaluations directly (Wachinger et al., 2013).

Trust is a complex social phenomenon with multiple dimensions (Kasperson, Golding & Tuler, 1992). It can include trust in both the communicator of technical information and in the information itself. The literature on trust suggests the actions taken by a council when presented with an earthquake-prone building risk assessment will be highly dependent upon their trust in the information, usually built on previous experience with the individual or organisation undertaking the assessment.

Individual factors

A decision maker's risk numeracy and cognitive limitations are also factors. For example, risk numeracy can affect an individual's recognition of risk (Frewer, 2004; Sturgis & Allum, 2004; Ziman, 1991), although as reviewed by Doyle et al. (2020), this does not always translate into better decisions due to other individual and social influences. Regardless of risk numeracy, Simon (1955, 1992) found people to be "rationally bounded", whereby they rarely analyse all the relevant information even if it is readily available. Instead, decisions are made on limited information or simplifying heuristics, a process described as "satisficing". In addition, Eppler and Mengis (2004) identify that providing too much information may overwhelm the decision maker, influencing the situational awareness needed for effective decisions.

The context and framing of the decision determine not only what is regarded as relevant to the decision but the way risk information is presented and perceived. For example, presenting the choice as avoiding a potential loss rather than receiving a potential gain is more likely to be accepted, even when the outcomes are identical. Kahneman and Tversky (1979) illustrated this in an epidemic response example where two intervention options with the same expected outcomes are presented using a different reference point, thereby framing the decision as a loss or gain. The preferred choices were highly skewed towards avoiding losses. McClure, White and Sibley (2009) found for natural hazards that a negative framing of outcomes (such as focusing on what will happen if preparations are not taken) increases willingness to prepare more than positive framing. Other framing examples relating to technical risk communication are available in Doyle, McClure, Johnston and Paton (2014), Kahan et al. (2012), McClure et al. (2009) and Vinnell, McClure and Milfont (2017). Without an appreciation of these various framing effects, risk communication can result in a greater degree of support for or against a statement than intended.

In this complex decision-making environment, the key message from behavioural science is that facts are only one part of the decision-making equation and what people regard as rational decision making can play a surprisingly small part (Eiser et al., 2012). Solberg et al. (2010) conclude that it is difficult to judge whether material (actual) risk has a consistent effect on risk perceptions. It is therefore not surprising that decisions around occupation of earthquake-prone council buildings appear to vary significantly between councils.

4.4 Conclusion

The risk management process set out in ISO 31000 is aimed at promoting robust and consistent assessment of risks. The principles in ISO 31000 provide a good backdrop for the development of a decision framework related to occupancy of earthquake-prone buildings. However, the literature from behavioural science illustrates that, despite our best efforts, decision makers have a tendency to be irrational in their decision making, informed by bias, experience, values, risk numeracy, trust and other personal factors.

Behavioural science provides a clear explanation for the varied approaches taken by territorial authorities towards occupancy of earthquake-prone buildings (discussed further in the section 5). It also supports the hypothesis that current decision making is skewed toward avoiding losses and seeking to avoid the least-certain outcomes – potential injury during an earthquake.

Moving forward in the development of our framework to help decision makers, the principles in ISO 31000 and behavioural science contain a few clear lessons. A comprehensive, transparent and cohesive decision process will provide the transparency and robustness required under territorial authorities' legislative responsibilities. It will also help to simplify the decision process to avoid overwhelming the decision maker while also ensuring decisions consider all the relevant information, avoiding the potential for a later overruling of the decision. A robust framework based on best practice, which avoids yo-yoing between decisions, may also help facilitate trust in territorial authorities' decision-making processes as well as the outcomes of decisions.

In section 5, we take a more detailed look at how territorial authorities are currently making decisions around occupation of earthquake-prone buildings – how decisions are made, what informs decisions, who makes decisions and how these decisions are perceived.

5. Case studies: interviews with five territorial authorities

5.1 Introduction

The preceding sections provide context to an empirical analysis of how territorial authorities make decisions about the immediate future of council buildings categorised as earthquake prone.

Thus far, we have established that the body of law guiding local government decisions about earthquake-prone buildings is complex and primarily involves three different forms of legislation, each with different objectives. This body of legislation outlines different sets of legal obligations, which, when taken together, may elicit uncertainty amongst territorial authorities about how to balance the laws' diverse intents.

Looking deeper into how engineers assess and communicate seismic risk, we have also established that there may at times be disparity between conventional language used to represent seismic risk and a building's actual risk to life safety. This is because the method used to assess and communicate seismic risk (%NBS) is sometimes too crude to account for all variables that influence a building's seismic behaviour and corresponding life safety risk.

This invites investigation into how territorial authorities currently respond to such uncertainty when making impactful decisions about council buildings. It also presents an opportunity to find strengths within territorial authorities' divergent approaches that could help inform a universal best practice.

To understand the key drivers influencing territorial authorities when making public policy decisions about earthquake-prone buildings, the authors undertook a series of anonymised interviews with five territorial authorities across New Zealand (Table 3).[28]

Table 3. Interview summary.

Council ID	Council size	Seismic hazard zone	Interviewees
1	Large	Low	Two separate interviews: • Manager parks and community services and head of seismic risk team • Chief engineer
2	Large	High	Combined interview with two council representatives: • Regulatory manager • Asset manager
3	Mid-sized	High	• Building services manager (responsible for both council and non-council owned buildings)
4	Mid-sized	Medium	Combined interview with two council representatives: • Environment and planning group manager • Manager planning and building regulatory side
5	Mid-sized	High	• Property manager

[28] The authors apporached several small councils to participate, but of those that responded to the request, all were too busy.

5.2 Policies

Of the five councils interviewed, only three had formal policies related to council-owned earthquake-prone buildings. Of these:

- one had been ratified by council (Council 2) and is a policy for occupation of all buildings (not just those assessed as earthquake prone)
- one was in the process of being adopted by its executive leadership team (Council 1)
- one had a policy dating back to 2006 (revised in 2012) (Council 3).

Council 4 did not have a policy, and Council 5 had an established practice but no formal policy.

Each of the policies have been translated by the authors into decision flowcharts (refer Appendix C). A flowchart was also developed for Council 5.

Generally, it appeared that the policies for managing earthquake-prone buildings emerged from each council's property management arm in conjunction with their building regulation team (depending on the size of the council). Both Council 1 and 3 noted that a policy enabled them to remove the risk of immediate perception responses to building assessments and to create a consistent platform for balanced decision making across the building portfolio. It was also noted that this approach made decisions more easily defendable. That said, Council 1 also noted that their policy was not designed to be applied rigidly but instead was designed to set bounds for decision making.

Council 2 commented that establishing a robust governance-led property-owner policy, administered by operational staff and communicated well to stakeholders, was essential for effectively managing council-owned building risk.

5.3 Driver for building management decisions

The primary driver behind earthquake-prone building decisions for all five councils was staff and public safety. However, legal obligations such as the HSWA and 2016 Act were also a factor.

Council 1's property arm developed its seismic policy based on an interpretation of legislation. The council's chief engineer was tasked by the executive to work through how to address the issue of safe occupancy in the development of the earthquake-prone building policy. Ultimately, the driver is to understand the risk posed to staff and communities by having earthquake-prone buildings available for use – finding a balance between health and safety risk and geological timescales of earthquakes. Each of the two Council 1 interviewees stressed that safety was at the heart of their policy. While HSWA obligations were part of this, they were not the primary driver.

Council 3's policy was driven primarily by health and safety obligations under the HSWA. The interviewee stressed the importance of following the law:

> Need to be black and white based on law so it is defensible … I have a job to do, it is all about life safety.

Council 4 indicated that, while health and safety and obligations under the HSWA are important, in terms of legal obligations, they would follow the guidance contained in the Building Act and would only consider closing buildings if there was an immediate threat to safety – that is, if it was a dangerous building.

Council 5 indicated that they considered the HSWA and the Building Act. However, representatives from this council explained that foremost in their mind was the safety of building occupants, including staff and the public.

Across each case study, there appeared to be little internal discussion around risk tolerance – in particular, the contrast in health and safety risks for day-to-day activities and health and safety risks from low-probability events such as earthquakes. Much of the decision making of these councils accordingly appears to rest on the potential consequence of an earthquake event rather than its likelihood. Council 1 and 2 indicated they had done some work to try and educate their respective executive leadership teams on this issue but explained that it remained a work in progress. As a Council 1 interviewee noted:

> We know it is impossible to keep everyone safe, but then health and safety says we have to keep everyone safe.

However, some interviewees noted that the pragmatic approach taken to keep things open until strengthened inherently considered likelihood.

5.4 Delegated decision makers

For all councils, there was a clear and conscious delineation between building safety and building function or role in the community. Property or building managers tended to make the decision about the building before consulting with the corresponding service manager. Council 1 established a cross-functional seismic risk team to review building assessment information and make decisions on buildings. This includes the chief engineer, community facilities and services – a broad range of expertise. The interviewee also noted that the group has a diversity of perceptions around risk, which helps to achieve a balanced decision. There is a regular process – typically one or two buildings to deal with each meeting. For smaller councils interviewed, the building manager will typically take a recommendation to the asset manager/service manager.

Relatedly, three out of five council decision processes did not require sign-off from elected officials (the council) or from local community boards but rather were approved by senior managers/executive leadership team. This demonstrates that governance and management are generally kept separate with respect to earthquake-prone buildings. Council 1 noted that they believed that accountability is fundamentally held by its asset manager as PCBU. It was explained that elected officials (councillors) have accepted this and, to date, have not pushed back on any decision. Rather than make decisions about managing seismic risk, it was made clear that an elected official's role within Council 1 is to answer the question what do we do now? Community boards for Council 1 would be asked to endorse decisions relating to services within their jurisdiction.

Conversely, Council 4 indicated they would take a decision about a potential building closure to elected officials because it was felt it was a public interest rather than a decision that could be made by the executive leadership team.

For Council 5, elected members would be involved to confirm a decision made by the chief executive on recommendation from the property manager.

Tenants and other stakeholders were also generally communicated with after a decision about building safety had been made.

Council 1 indicated that health and safety officials are typically not involved in the decision-making process but are included if it was determined that the seismic issue is likely to impact council staff and the broader public.

5.5 Closure decisions

Four of the five councils indicated they would make a building closure decision based on %NBS. However, only one council had a rigid policy of building closure at a certain %NBS (Council 3 – closure of buildings at <34%NBS).

Councils 1 and 5 also considered %NBS in determining building closure. However, both also have a different policy response for buildings where critical elements could fail catastrophically during a moderate earthquake (approximately <15%NBS). Council 1 stressed the importance of applying judgement, even for engineers, and the need to not be too rigid.

Council 5's closure process was the only one to (explicitly) consider the ease of retrofit in the consideration of continued occupancy. Representatives from Council 5 noted that buildings were only closed if a short-term strengthening option was not available.

Council 2 originally had a policy that was black and white: closure at <34%NBS. However, they soon realised they needed a policy that gave engineers an opportunity to look at behaviour and performance that looked beyond %NBS. Since then, Council 2 has taken a different approach and worked with engineers to develop a policy that went beyond the Building Act and %NBS to one that considered life safety risk caused by catastrophic failure of a structure. Specifically, their policy now revolves around the potential for brittle catastrophic risk under any earthquake loading. This encapsulates buildings that are not covered under the 2016 Act, such as those identified in MBIE's Yellow Chapter.

Many of the councils we spoke to indicated the importance of conversing with engineers to understand a building's behaviour and to understand the judgement behind the assessment made. This included requiring engineers to be more explicit about what a critical structural weakness means and giving engineers a broad scope to look at risk holistically (risk to services, nearby roadways, risk from other buildings).

Some councils also required a built-in peer-review process so that, when a report was received, it would be reliable.

Language around engineering assessment and building safety came up with several interviewees. Council 2 noted they decided not to use terminology describing buildings as "safe" and preferred to use terms such as "fit to occupy". Safe means zero risk, but they were conscious that a risk-free environment was impossible to achieve.

Most councils who participated in an interview decided to wrap an ISA and DSA together so that a decision could be based on the outcome of a DSA. They found ISAs to be too vague – they indicated a potential problem but there was not enough information to understand the risk. One council noted that receiving recommendations for strengthening in a DSA was unhelpful as it set expectations around what might be done without considering the wider longer-term issues related to asset management.

5.6 Inclusion of other considerations

The majority of respondents indicated that decisions to close buildings were purely based on perceptions of life safety risk. Generally, this was driven by concerns about the potential consequences of building failure rather than any explicit or measured consideration of likelihood of failure. Impact on services was a secondary concern. Generally, council services were considered resilient, and interviewees felt accustomed to services being disrupted during normal maintenance and other cycles.

Impacts beyond service provision (impact on vulnerable populations, nearby businesses, tenants) were also not routinely considered by interviewees or their policies. Life safety risk was seen as the key determinant, not service continuity. Council 5, in fact, noted that they had vacated an earthquake-prone building, and this had had a significant negative impact on nearby buildings.

Interviewees also indicated there would be no difference in their assessment between a building that housed primarily members of the public or staff, despite the plan by many to train staff in earthquake procedures for those remaining in earthquake-prone buildings.

Asbestos was also not considered in the immediate closure decision, with some larger councils indicating there was a separate programme managing this.

Reputational risks were also not routinely considered. One interviewee noted that there are potential reputational risks that derive from both building closure and from keeping an earthquake-prone council building open to use should the building collapse.

The presence of heritage features seldom appeared to impact these councils' initial occupancy decision. However, all respondents indicated that heritage preservation would impact longer-term management decisions because retrofitting buildings with heritage status was likely to be expensive and possibly take longer to raise funds to carry out retrofit.

It appeared not many interviewees had considered the use of an earthquake-prone building as a civil defence hub.[29] However, in general, it did not seem to impact their decision unless there was no alternative nearby.

5.7 Move-out activities

If a decision to vacate a building was made, the time given for occupants to move out varied between councils significantly. Council 2 would require immediate action. They would then run a managed process to allow staff and tenants to retrieve essential contents. Council 2 has developed a streamlined process for building evacuation. This includes a communications strategy outlining the required actions for tenants, staff, media, the executive team, councillors and the mayor. Communications are generally carried out in line with the decision being made. Council 1 learned early that they needed to make the final seismic report available at the same time as notification to ensure decision-making transparency.

Council 1 allows 20 days for a building to be closed, giving time for the organisation of replacement services.

[29] One interviewee noted that civil defence hubs are slowly being merged out, so this might have impacted responses.

5.8 Risk mitigation activities

If a building is deemed earthquake prone but it remains open, each council has a range of strategies to communicate, manage and mitigate risk to building users. These initiatives show that councils are thinking beyond risk reduction by building closure/retrofit but also other ways to mitigate life safety risk. These include:

- talking to unions
- involving health and safety representatives of council
- erecting signage (Building Act requirement)
- talking with tenants
- talking with staff
- training staff: drop, cover, hold; how to get out of building; health and safety procedures and practices
- isolation of dangerous part of building (chimney, stairwell)
- tie back parapets and façades.
- leased premises – pulling out of the lease
- closing adjacent footpath
- fencing
- making DSAs available for business continuity planning and also to portfolio for rapid building assessments so they know about structure behaviour and other risks like asbestos.

5.9 Public perception

The councils we spoke to indicated that the public are generally accepting of the ongoing occupation of earthquake-prone building.

Council 2 have an example of a playcentre that was an earthquake-prone building. The council openly communicated with the playcentre about the risks, and they became the biggest advocates of the decision to reopen.

Council 5 noted that it had several council meetings to explain its rationale regarding why it opted to keep some earthquake-prone buildings open. Interestingly, they noted that these meetings resulted in little public pushback, but they noted that they only keep buildings open when they have a plan to strengthen.

5.10 Conclusion

Interviews with territorial authorities identified clear variance in how policy decisions about buildings categorised as earthquake prone are made. This variance is reflected in different processes for rationalising risk-based decisions, who has ultimate decision-making authority and whether there is a documented policy guiding decisions to begin with. Differences in approach also extended to the degree to which territorial authorities tolerate potential life safety risk.

Despite these differences, there was also commonality across our sample in some of the key drivers influencing territorial authorities' decisions. This was especially clear with territorial authorities' concern about protecting the health and safety of council staff and the broader public. In some cases, the HSWA was cited as a key reason for this concern. However, it was also clear that this concern was, for some, intrinsic and values driven.

Although concerns about life safety pervaded many responses, a key observation during the interviews was that there was little discussion about risk likelihood. Indeed, most interviewees indicated that their respective councils mainly focused on the potential consequences of a building's seismic failure and less on the likelihood of seismic failure. Correspondingly, while interviewees were generally cognisant of the community impacts of precautionary building closure as a means of risk management, these concerns were given much less weight than the potential consequences of a seismic event.

This is a significant finding in the context of this study because it suggests that the likely community impacts of pre-emptive building closure are overshadowed by concerns about the potential scale of a hypothetical risk and/or the risk of liability in the event of a council building's seismic failure. In other words, the likelihood and immediacy of an event (the socio-economic impacts of a building closure on a community) is outweighed by the theoretical possibility of a catastrophe over an extended geological timeframe. However, without a defined tolerance threshold for seismic risk, weighting risk-based decisions in this way itself risks causing socio-economic harm. This points to a clear need for a standardised process that assists territorial authorities to balance risk consequence more deftly with risk likelihood and the possible side-effects of public policy decisions.

6. Decision framework

A core output of this research project is a co-designed decision process that will support territorial authorities to make robust and defendable building occupancy decisions. The aim of the framework is to help councils as building owners understand and more confidently balance the potential effects of building damage should an earthquake occur against the impacts that follow directly from a decision to suspend building occupancy. The five steps in the decision framework are shown in Figure 6. The steps largely align with the ISO 31000 risk management process, stepping users through the risk identification, assessment and treatment phases of risk management. The framework sets out the information needed and process for decision makers to make considered decisions. The framework is also set out in a way that allows territorial authorities to adjust the parameters to match their own risk management processes and risk tolerance.

In this section, we qualitatively describe each step of the assessment process as well as the rationale behind each step. This presents the logic of the decision framework, with the full framework documented in Appendix D.

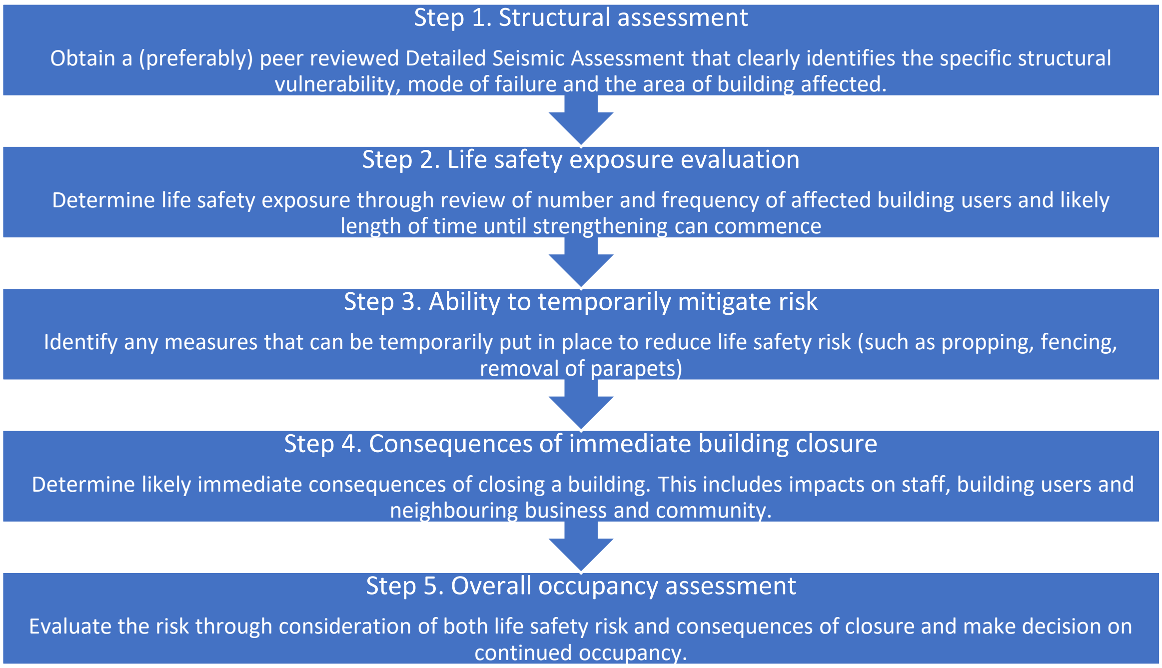


Figure 6. Steps in earthquake-prone council building decision framework.

6.1 Step 1. Structural assessment

Step 1 of the framework describes the process of engaging a qualified engineer to assess the building. Although this step sounds simple, our interviewees noted a number of challenges in this step around quality and interpretation of engineering assessments, and the framework provides some guidance on this.

Decisions to change the occupancy of buildings should be based on sound engineering advice and a clear understanding of the likely behaviour of the building under a range of earthquake actions. Usually this requires a DSA from an experienced chartered professional engineer who has not only assessed the %NBS rating but is confident they understand the likely vulnerability, mode of failure and physical consequences of failure. The assessment should include any adjoining structures that might affect building safety (such as shared structural roof or wall elements). For any buildings rating less than 34%NBS, the DSA should be critically reviewed internally or externally (through a panel or via a peer review) to ensure confidence in the technical advice provided and that life safety risks are identified and managed appropriately.

Given the very low probability of a significant earthquake occurring in the short term and the potential immediate adverse consequences for the community of closing a building, it is important that decisions to change occupancy are made on a peer-reviewed DSA rather than upon the receipt of only an ISA or draft DSA. Draft assessments should be appropriately reviewed, along with an equally considered review of the impacts of closure. This process can take a period of weeks or months. The only exception to this is if an ISA has indicated a critical and urgent deficiency that must be addressed immediately, which would result in the building being identified as a dangerous building under the Building Act. It is important to note that "earthquake" is specifically excluded from the scope of dangerous buildings unless damaged directly by an earthquake such that an aftershock could give rise to a life safety hazard.

We recommend all buildings with structural vulnerabilities that could lead to a brittle or sudden collapse in larger earthquakes be subject to a review of continued occupancy, regardless of their %NBS rating. They may not be designated earthquake prone under the Building Act, but they may pose a significant enough risk to pose a liability under the HSWA.

6.2 Step 2. Life safety exposure

In step 2, users of the framework are guided through a series of tables to ascertain the likely life safety exposure of a particular building. To fulfil obligations as a PCBU under the HSWA, the life safety exposure of earthquake-prone buildings must be considered. This includes consideration of the failure mechanism and part of building affected (step 1), how many people use that part of the building and how frequently they use the building. It also includes exposure to those outside the building. This helps decision makers understand the likelihood that someone will be in the building at the time of an earthquake.

Territorial authorities also need to consider the length of time it will take to design and fund the remediation of an earthquake-prone building and people will therefore be using the building while it is earthquake-prone. This is because risk is a function of time – the longer we are exposed to a risk, the more chance we have of the event occurring. In the case of seismic performance of buildings, this risk is exacerbated by the natural deterioration of buildings over time contributing to lower seismic performance and the increasing stress in earthquake fault systems over time.

Building Act earthquake-prone building provisions since 1991 have always recognised that it is impractical and impossible to mitigate all seismic risk immediately. The 2016 amendments define statutory timeframes that give building owners between 7.5 years (for priority buildings in high seismic hazard zones) and 35 years (for non-priority buildings in low seismic hazard zones). The decision framework provides some added nuance to the MBIE timeframes and encourages territorial authorities to think about the time it will take to design and fund seismic remediation projects and compare that against the life safety exposure to occupants.

Figure 7 illustrates how the risk of occupying an earthquake-prone building increases over time. Total life safety risk is a combination of the life safety exposure at any time and the duration people are exposed to the risk (the area under the graph). You could have a building that has high life safety exposure, but if you can remediate it quickly, the building occupants are only exposed for a short period and the overall risk to occupants is reduced. Conversely, if you have a building with low life safety exposure, you could leave it occupied for a longer period and have the same overall life safety exposure risk.

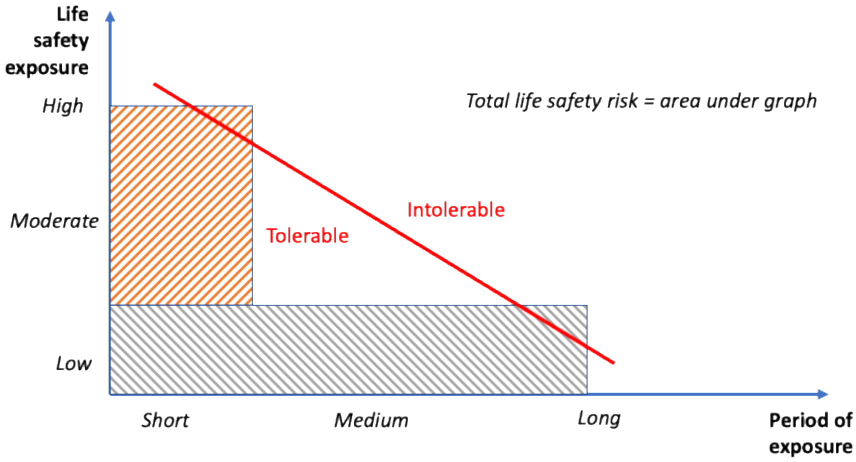


Figure 7. Total life safety risk is a combination of life safety exposure at any time and the duration people are exposed to the risk.

If the building poses a high life safety risk, territorial authorities need to either work to reduce that risk more quickly, mitigate the risk (step 3) or have a sound reason for keeping the building open (step 4). Conversely, if the risk is low, territorial authorities can take more time to remediate the risk. Buildings that pose a higher life safety risk and remain occupied should be prioritised for remediation.

What constitutes a short, medium or long period of exposure will depend on the territorial authority. The territorial authority may take into account factors such as the seismic hazard zone, geological fault history or localised earthquake probabilities or aftershock forecasts.

6.3 Step 3. Ability to temporarily mitigate risk

In step 3, territorial authorities are encouraged to consider ways to temporarily mitigate life safety risk, particularly in cases where there may be a long time before earthquake strengthening can occur. Any measure that can reduce life safety risk should be considered including physical works to remove or secure high-risk building elements (parapet ties or props, chimneys) and closing parts of the building or moving some services to reduce building occupancy.

6.4 Step 4. Consequences of immediate building closure

Step 4 is an evaluation of the consequences of closing a building while seismic strengthening or other alternative plans are made for the building. Under section 14 of the LGA, territorial authorities must take into account the interests of both current and future communities when making decisions. This includes the seismic resilience of assets as well as the economic, social and cultural impacts of closing such assets. Specifically, the framework suggests territorial authorities evaluate the ability to deliver services by other means, impact on vulnerable communities, impact on neighbouring buildings and impact on staff. During this assessment, we suggest reviewing options for alternative service delivery. This includes ability to move services to another location or to deliver them by alternative means (such as online).

6.5 Step 5. Overall occupant assessment

The final step is to combine and evaluate both the life safety exposure and the consequences of closure. This step is critical to ensure that territorial authorities are balancing both their roles as a PCBU under the HSWA and their duties under the LGA. In the framework, users give buildings a rating of A, B or C based on the combination of life safety exposure and consequences of closure. The aim of this step is to minimise significant disruption to communities from closure of high-importance buildings and also minimise unnecessary exposure of occupants to life safety risk in a low-importance building.

Before a final decision is made, the framework prompts users to do a sense check on the final decision. The decision framework is designed to ensure all relevant information is considered in a logical and robust way. However, there will always be situations where the complexity of the building or community will mean that the process does not derive the best solution. The framework should be used as a starting point and a basis for gathering and considering all relevant information.

In particular, there may be other factors that influence a closure decision including building condition (extent of any deterioration not specifically addressed in the engineering assessment), the presence of other hazards in the building (hazardous substances or asbestos) or geological hazards adjacent to the building (unstable ground) that might create an additional life safety and human health risk during an earthquake.

Also, the demographics of the people using the building could also be considered. Are they young, elderly, physically impaired or vulnerable in any way? Does this vunerability put them in an unacceptably risky situation – for example, users are unable to safely exit a damaged building following an earthquake?

The framework also provides guidance around mitigating the risk to occupants while they occupy an earthquake-prone building including erecting signage, isolating any dangerous building elements, creating and practising emergency plans and training staff.

For any closure decision, the framework suggests a reasonable time period is allowed to vacate the premises and relocate services unless there is imminent danger to building users. This is to help mitigate and reduce the impact on the health and wellbeing of building service users.

7. Conclusion

7.1 Research aims and objectives

Our research shows that territorial authorities are faced with a range of complex and potentially conflicting obligations when making decisions about council buildings assessed as <34%NBS or earthquake prone. Of the various factors territorial authorities must take into account, the legal obligations of the PCBU under the HSWA to ensure health and safety risk is minimised or eliminated are significant and appear to prompt conservatism in territorial authority decisions. To some extent, this is understandable given that liability under the HSWA is attached to the PCBU and may involve a substantial fine or, in exceptional circumstances, imprisonment.

However, a PCBU's duty to mitigate seismic risk need only be taken to the extent that it is "reasonably practicable". According to the HSWA, determining what is reasonably practicable requires taking into account and weighing up five key criteria: the *likelihood* and the degree of harm that might result from the hazard or risk, what the PCBU knows about the hazard or risk, ways of eliminating or minimising the risk plus the availability and cost of those actions. The majority of our research participants were quick to focus on the consequences of a building failure when considering occupancy decisions, and there was little to no consideration of the low likelihood of a sufficiently damaging earthquake occuring within a council building's functional lifetime. This is consistent with behavioural science literature, demonstrating that territorial authorities' decision making is skewed towards avoiding potential losses associated with a seismic event, however unlikely they may be.

The report has also shown that territorial authorities' obligation towards community wellbeing extends towards people who may be negatively affected by their policy decisions. This is made clear within sections 10 and 14 of the LGA, which require that local government decision making promotes the social, economic, environmental and cultural wellbeing of present and future communities. While this principle appears to be regularly applied by territorial authorities to horizontal infrastructure, it appears to be seldom applied to vertical assets (such as council-owned pools, libraries etc.). However, there is no clear reason why this principle should not be applied consistently across both asset types (including community assets). Accordingly, these provisions within the LGA suggest that the management of seismic risk in council buildings should be made with consideration of broader social and cultural interests (via the mechanism of territorial authorities' respective infrastructure strategies).

Although there has been a significant movement across New Zealand to ensure the safety of council buildings, there is a notable difference in how territorial authorities are interpreting seismic risk information and contextualising this information within broader socio-economic settings. Recognising this, the aim of this project was to co-develop a decision framework with local government stakeholders that allows for a degree of consistency in how life safety and community impacts are evaluated and translated into policy. We also identified that an additional benefit of such a framework would be that it would help territorial authorities to demonstrate a transparent and robust decision-making logic to the broader public that fulfils their diverse set of statutory obligations.

7.2 Applying the international standard for risk management to earthquake-prone buildings

A key point made in the report is that %NBS and “earthquake prone” are measures that do not necessarily map directly to risk. As outlined in section 4, there is variability in how buildings deemed seismically vulnerable may otherwise behave. However, by comparison, the consequences of suspending building occupancy are reasonably certain. Nevertheless, “public safety” is frequently cited by territorial authorities as a key reason for pre-emptive building closure. It is evident that this is due to the emphasis being placed on the consequence aspect of the seismic risk (life safety risks to building users as well as the legal risks to PCBUs in the event of building failure) over the likelihood of a seismic event occuring within a vast geological timespan. This begs the question how community impact can be systematically considered within a risk-based decision framework.

Applying the international standard for risk management ISO 31000, the framework developed during the course of this research steps territorial authorities through a robust and thorough risk assessment process that looks beyond %NBS to consider all aspects relating to life safety exposure and then balances this against the socio-economic impacts of building closure. ISO 31000 has been presented as a logical basis for the framework because it provides a globally recognised benchmark for risk management best practice. Recognising that risk associated with earthquake-prone buildings involves interplay between the potential impact and temporal probability of a seismic event, coupled with the immediate impact of building closure, ISO 31000 also provides a mechanism for territorial authorities to evaluate different risk types in a way that acknowledges that decisions to mitigate seismic risk are part of a more-complex risk landscape.

7.3 Final word

Because risk management typically involves a degree of subjective judgement, the decision framework has not been designed as a prescriptive guide. Rather, it has been framed as a suggested pathway for respective territorial authorities to make their own risk-based decisions that are consistent with a diverse body of legislation. Accordingly, the framework has been designed to afford territorial authorities the flexibility to determine their own risk tolerances. How territorial authorities wish to assess the risks associated with earthquake-prone buildings is up to them. The framework that we have co-created alongside local government stakeholders simply provides a standardised process to make such judgements.

While this report has focused on local government decision making pertaining to earthquake-prone buildings, the challenge of managing earthquake-prone buildings extends beyond territorial authorities as building owners. There is the potential for future research to apply the process and theory developed here to other building ownership situations.

References

Becker, J. S., Johnston, D. M. & Paton, D. (2015). *Communication of risk: A community resilience perspective*. GNS Science Report 2015/66. Lower Hutt, New Zealand: GNS Science.

Becker, J. S., Potter, S. H., McBride, S. K., Wein, A., Doyle, E. E. H. & Paton, D. (2019). When the earth doesn't stop shaking: How experiences over time influenced information needs, communication, and interpretation of aftershock information during the Canterbury Earthquake Sequence, New Zealand. *International Journal of Disaster Risk Reduction*, *34*, 397–411. https://doi.org/10.1016/j.ijdrr.2018.12.009

Bohny, S. (2020, 6 March). Two earthquake-prone buildings in Nelson to close. Retrieved from https://www.stuff.co.nz/nelson-mail/120028318/two-earthquakeprone-buildings-in-nelson-to-close

Brunsdon, D., Hare, J., Stannard, M., Berryman, K., Beattie, G. & Traylen, N. (2013). The impact of the Canterbury earthquake sequence on the earthquake engineering profession in New Zealand. *Bulletin of the New Zealand Society for Earthquake Engineering*, *46*(1), 56–67.

Crawford, M. H., Saunders, W. S. A., Doyle, E. E. H., Leonard, G. S. & Johnston, D. M. (2019). The low-likelihood challenge: Risk perception and the use of risk modelling for destructive tsunami policy development in New Zealand local government. *Australasian Journal of Disaster and Trauma Studies*, *23*(1), 3–20.

Demeritt, D., Cloke, H., Pappenberger, F., Thielen, J., Bartholmes, J. & Ramos, M.-H. (2007). Ensemble predictions and perceptions of risk, uncertainty, and error in flood forecasting. *Environmental Hazards*, *7*(2), 115–127. https://doi.org/10.1016/j.envhaz.2007.05.001

Desmarais. F. & Chumko, A. (2019, 19 March). Wellington Central Library to close indefinitely due to earthquake concerns. Retrieved from https://www.stuff.co.nz/dominion-post/news/111397052/wellington-city-library-to-close-after-advice-received-from-engineers

Doyle, E. E. H., Johnston, D. M., Smith, R. & Paton, D. (2019). Communicating model uncertainty for natural hazards: A qualitative systematic thematic review. International Journal of Disaster Risk Reduction, *33*, 449–476. https://doi.org/10.1016/j.ijdrr.2018.10.023

Doyle, E. E. H., McClure, J., Johnston, D. M. & Paton, D. (2014). Communicating likelihoods and probabilities in forecasts of volcanic eruptions. *Journal of Volcanology and Geothermal Research*, *272*, 1–15. https://doi.org/10.1016/j.jvolgeores.2013.12.006

Doyle, E. E. H., McClure, J., Potter, S. H., Lindell, M. K., Becker, J. S., Fraser, S. A. & Johnston, D. M. (2020). Interpretations of aftershock advice and probabilities after the 2013 Cook Strait earthquakes, Aotearoa New Zealand. *International Journal of Disaster Risk Reduction*, 49, 101653. https://doi.org/10.1016/j.ijdrr.2020.101653

Eiser, J. R., Bostrom, A., Burton, I., Johnston, D. M., McClure, J., Paton, D., van der Pligt, J. & White, M.P. (2012). Risk interpretation and action: A conceptual framework for responses to natural hazards. *International Journal of Disaster Risk Reduction*, *1*, 5–16. https://doi.org/10.1016/j.ijdrr.2012.05.002

Engineering New Zealand. (2018). *Engineering a better New Zealand*. Wellington, New Zealand: Engineering New Zealand. https://d2rjvl4n5h2b61.cloudfront.net/media/documents/EngineeringBetterNZ_FINAL_web.pdf

Enright P. A. (2015). Is there a tolerable level of risk from natural hazards in New Zealand? *Georisk Assessment and Management of Risk for Engineered Systems and Geohazards*, *9*(1), 1–8.

Eppler, M. J. & Mengis, J. (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines, *The Information Society*, *20*(5), 325–344. https://doi.org/10.1080/01972240490507974

Frewer, L. (2004). The public and effective risk communication. *Toxicology Letters*, *149*(1–3), 391–397. https://doi.org/10.1016/j.toxlet.2003.12.049

Grenville, J. (2007). Conservation as psychology: Ontological security and the built environment. *International Journal of Heritage Studies*, *13*(6), 447–461.

Harding, E. (2019, 13 March). *Southland museum options to be considered one year on from closure*. Retrieved from https://www.stuff.co.nz/national/111205112/southland-museum-options-to-be-considered-one-year-on-from-closure

Hare, J. (2019). A different way of thinking about seismic risks: a call for debate. *Bulletin of the New Zealand Society for Earthquake Engineering*, *52(*3), 141–149. https://doi.org/10.5459/bnzsee.52.3.141-149

Hatton, E. (2019, 1 May). *Lower Hutt business struggles after local pool closes*. Retrieved from https://www.rnz.co.nz/news/national/388164/lower-hutt-business-struggles-after-local-pool-closes

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D. & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change, 2*, 732–735. https://doi.org/10.1038/nclimate1547

Kahneman, D. & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

Kasperson, R. E., Golding, D. & Tuler, S. (1992). Social distrust as a factor in siting hazardous facilities and communicating risks. *Journal of Social Issues*, *48*(4), 161–187.

Khan, S., Mishra, J. L., Lin, K. E. & Doyle, E. E. H. (2017). Rethinking communication in risk interpretation and action. *Natural Hazards*, *88*, 1709–1726. https://doi.org/10.1007/s11069-017-2942-z

Kwok, A. H., Doyle, E. E. H., Becker, J., Johnston, D. & Paton, D. (2016). What is 'social resilience'? Perspectives of disaster researchers, emergency manager practitioners, and policymakers in New Zealand. *International Journal of Disaster Risk Reduction*, *19*, 197–211. http://dx.doi.org/10.1016/j.ijdrr.2016.08.013

Meacham, B. J. & van Straalen, I. J. (2018). A socio-technical system framework for risk-informed performance-based building regulation. *Building Research & Information*, *46*(4), 444–462.

McClure, J., White, J. & Sibley, C. G. (2009). Framing effects on preparation intentions: distinguishing actions and outcomes. *Disaster Prevention and Management*, *18*(2), 187–199. https://doi.org/10.1108/09653560910953252

MBIE, NZSEE, SESOC, NZGS & EQC. (2017). *The seismic assessment of existing buildings: Technical guidelines for engineering assessments. Part A – Assessment objectives and principles*. Wellington, New Zealand: Ministry of Business, Innovation and Employment. https://www.building.govt.nz/assets/Uploads/building-code-compliance/b-stability/b1-structure/seismic-assessment/a-assessment-objectives-principles.pdf

MBIE, NZSEE, SESOC, NZGS & EQC. (2018). *Concrete Buildings C5: Technical proposal to revise the engineering assessment guidelines*. Retrieved from http://www.eq-assess.org.nz/wp-content/uploads/2018/11/c5-concrete-buildings.pdf

MBIE (2018). *How the system for managing earthquake-prone buildings works*. Retrieved from https://www.building.govt.nz/managing-buildings/managing-earthquake-prone-buildings/how-the-system-works/

Moffatt, S. & Kohler, N. (2008). Conceptualizing the built environment as a social–ecological system. *Building Research & Information*, *36*(3), 248–268.

Mulgan, G., Potts, G. & Audsley, J. (2006). *Mapping value in the built urban environment*. London, UK: The Young Foundation. https://youngfoundation.org/wp-content/uploads/2013/06/mapping-value.pdf

Murphy, C. & Gardoni, P. (2007). Determining public policy and resource allocation priorities for mitigating natural hazards: A capabilities-based approach. *Science and Engineering Ethics, 13*(4), 489–504.

NZ Herald. (2019, 19 December). Earthquake risk: Auckland's oldest suburban library to close indefinitely. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12295472

Shrubsole, C. (2018). Systems thinking in the built environment: Seeing the bigger picture, understanding the detail. *Indoor and Built Environment*, *27*(4), 439–441.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics*, *69*(1), 99–118.

Simon, H. A. (1992). What is an "explanation" of behavior? *Psychological Science*, *3*(3), 150–161.

Solberg, C., Rossetto, T. & Joffe, H. (2010). The social psychology of seismic hazard adjustment: Re-evaluating the international literature. *Natural Hazards and Earth System Sciences, 10*, 1663–1677. https://doi.org/10.5194/nhess-10-1663-2010

Stewart, I. S., Ickert, J. & Lacassin, R. (2018). Communicating seismic risk: The geoethical challenges of a people-centred, participatory approach. *Annals of Geophysics*, *60*. https://doi.org/10.4401/ag-7593

Sturgis, P. & Allum, N. (2004). Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science*, *13*(1), 55–74. https://doi.org/10.1177/0963662504042690

The International Standard for Risk Management (2021). ISO31000. http://www.iso.org

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

Tversky, A. &, Kahneman D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*(4481), 453–458.

Vinnell, L. J., McClure, J. & Milfont, T. L. (2017). Do framing messages increase support for earthquake legislation? Disaster Prevention and Management, *26*(1), 28–40. https://doi.org/10.1108/DPM-06-2016-0127

Wachinger, G., Renn, O., Begg, C. & Kuhlicke, C. (2013). The risk perception paradox – implications for governance and communication of natural hazards. *Risk Analysis*, *33*(6), 1049–1065. https://doi.org/10.1111/j.1539-6924.2012.01942.x

Ziman, J. (1991). Public understanding of science. *Science, Technology and Human Values*, *16*(1), 99–105. https://doi.org/10.1177/016224399101600106

Appendix A: Interview methodology: earthquake-prone building occupancy decision scenarios

Aim of scenarios

The aim of these hypothetical scenarios is to understand how territorial authorities form decisions about earthquake-prone council buildings under a range of conditions. The scenarios have been formed to gauge how territorial authorities balance different types of risk when considering the future of council-owned buildings assessed as being under 34%NBS.

By participating in this exercise, you will help us to understand how territorial authorities evaluate risk when forming strategies to manage earthquake-prone council buildings. You will also help us to identify the most influential factors behind local authorities' decisions in relation to continued occupancy (e.g. council safety, cost, social impact etc).

In broad terms we are seeking to understand:

- what decisions need to be made
- the timing or sequence of decisions
- who would make or be involved in decision making
- the key factors that you see as relevant to those decisions.

Scenario 1 – Central city library

Consulting engineers commissioned by the Council have just provided a draft detailed seismic assessment report rating the Council-owned library in the central city as 30%NBS. The library is located among privately-owned buildings of varying ages and construction types, some of which have Council-issued Earthquake Prone Building notices. It is likely access to the library would be affected by damage to some of these following a major seismic event.

The two-storey library was built in 1970 and the seismic resisting system consists of slender concrete frames, cast together with in situ concrete floors. An asbestos survey has identified asbestos in the library's walls and ceilings. It is non-friable and of no risk to tenants or to the public currently but would pose a minor risk should the structure be damaged in an earthquake and adds time and cost to strengthening work.

The library is used by a wide cross section of the community for education and social gatherings. It is open 8am to 8pm daily and has an average of 80 members of the public onsite at any time, with a maximum of 200. There are also an additional 10-15 library staff onsite at any time. There are three smaller libraries available in suburbs, each 5-10km from the city centre.

A commercial tenant operates a café in the library, employing 10 staff, of whom 4-6 are on site at any given time. The café is highly popular with local people. The closure of the library would also necessitate cancelling the commercial tenant's contract.

The library acts as an economic anchor for this part of the CBD with nearby businesses relying heavily on the foot traffic the library generates. Closure would have a significant economic impact on the area with the likely result of some businesses closing, with a potential cascading impact on other businesses in the area.

The Council's consulting engineers consider the library building's principal critical structural weakness to be the lack of shear strength in the columns, which could give rise to collapse of part or all of the upper level under significant earthquake shaking.

Scenario 2 – Council office building

This scenario involves the same building (and the exact same seismic assessment) as detailed in Scenario 1. However, in this scenario, the building is used as a council office building rather than as a council library.

One of the main offices for the council has been given a seismic rating of 30%NBS. This council office building houses 80-100 council-employed staff during normal business hours. Council activities in the building include the executive, accounts, engineering, building consents and customer service.

Approximately 60% of council staff in the building could work from home temporarily. 40% would need alternative accommodation including some services that are customer facing.

Scenario 3 – Memorial hall in isolated community

A memorial hall in an isolated community has been given a seismic rating of 30%NBS. The hall can accommodate up to 80 people but is generally only used once or twice a week for smaller gatherings. It is also used as a Civil Defence welfare centre.

The building is a Category 2 Heritage Building. The building and adjacent war memorial were built in the late 1940s.

The building was built from cast in-situ columns and walls, with timber roof trusses. The low rating is due to inadequate connections between the trusses and concrete walls, and the lack of bracing in the roof structure.

Appendix B: Workshop methodology

Earthquake prone council building decision process – strawman for discussion

Preamble

The following is a strawman of a proposed risk-based decision process to help local authorities make initial occupancy decisions for council-owned earthquake-prone buildings.

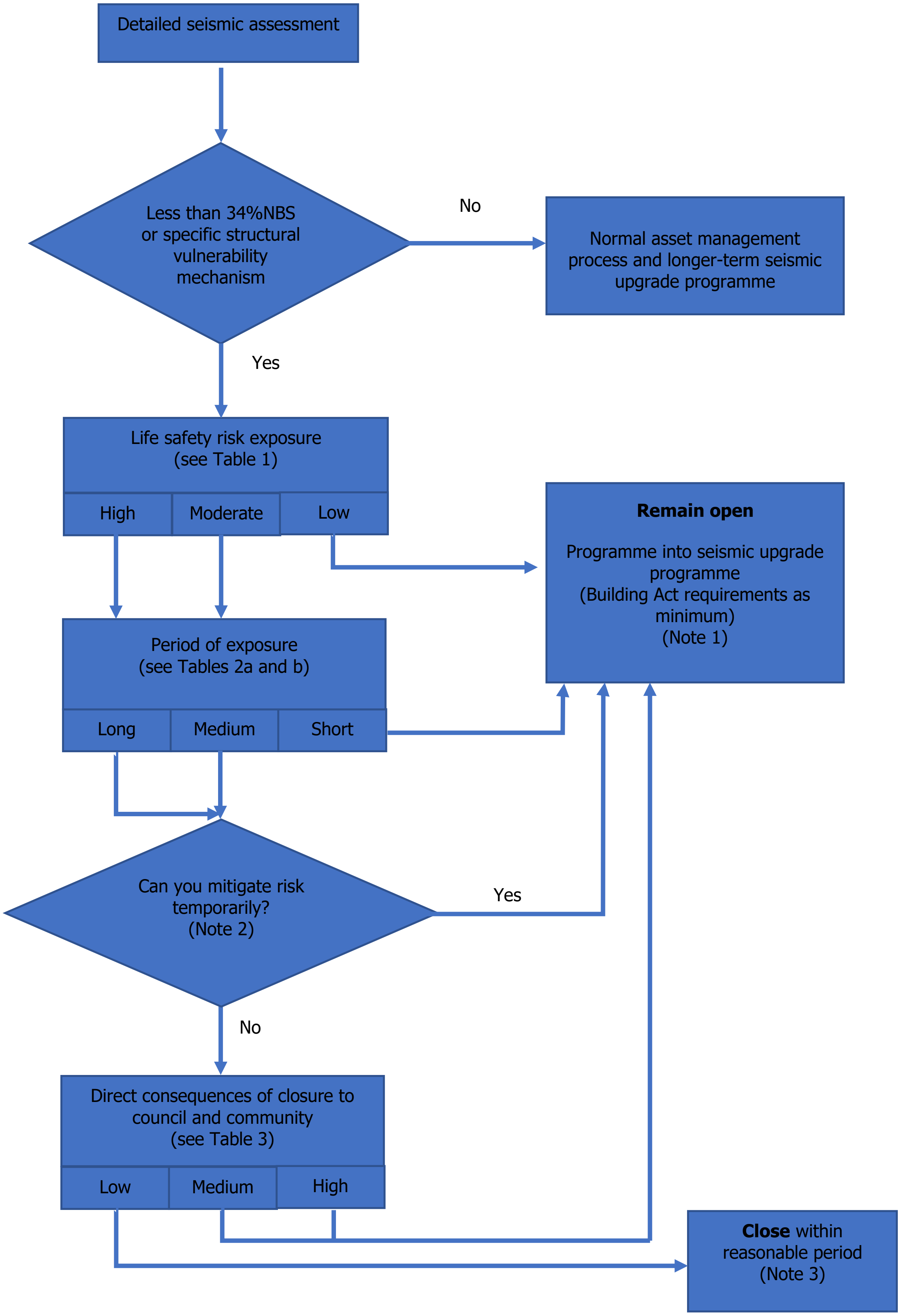
The aim of the decision process is to provide confidence to Council Executives and Elected Members that they are 1) meeting their legislative obligations, and 2) appropriately (morally, ethically and legally) managing public safety risk while also minimising disruption to important community services.

The framework has been developed through the review and distillation of a range of decision processes currently used by Territorial Authorities; in addition to drawing on the experience from within the research team.

The framework is designed to reflect and balance all of council's legislative responsibilities including:

- The Health and Safety at Work Act 2015
- The Building (Earthquake-prone Buildings) Amendment Act 2016
- The Local Government Act 2002

The overall process follows the following 5 key steps:


Detailed seismic assessment
Less than 34%NBS or specific structural vulnerability mechanism
No
Normal asset management process and longer-term seismic upgrade programme
Yes
Life safety risk exposure (see Table 1)
High
Moderate
Low
Remain open
Programme into seismic upgrade programme (Building Act requirements as minimum) (Note 1)
Period of exposure (see Tables 2a and b)
Long
Medium
Short
Can you mitigate risk temporarily? (Note 2)
Yes
No
Direct consequences of closure to council and community (see Table 3)
Low
Medium
High
Close within reasonable period (Note 3)

Note 1: Before making a final decision – do a sense check. Does this feel right? Consider any other hazards like hazardous substances or asbestos in the building that create an additional life safety risk during an earthquake. Once your decision is made, talk with staff/occupants, erect signage, isolate any dangerous elements if possible, emergency plans, train staff.

Note 2: Temporary mitigation measures include: isolation of dangerous part of building (e.g. chimney), tie back parapets and facades, close adjacent footpath.

Note 3: Before making a final decision – do a sense check. Does this feel right? Once your decision is made, talk with staff/occupants, isolate building from public, erect signage.

Table 1. Life safety risk exposure.

Note that the numerical values below are for illustrative purposes. Councils could decide these values based on their own risk appetite and risk management processes.

Select risk exposure category (A,B,C) where highest score occurs

	High	Moderate	Low
Max number of people in building at any time	>100	10-100	<10
Average number of people in building at any one time	>50	5-50	<5
Frequency of use (man-hours per week)	>2000	50-2000	<50
Duration of use (average user time in building)	Over eight hours a day	2-8 hours a day	<2 hours

Table 2a – Period of exposure for HIGH life safety risk exposure

Note that the category durations below are for illustrative purposes. Councils could decide these values based on their own risk appetite and risk management processes.

	Long	Medium	Short
Likely period until strengthening commenced	>3 years	1-3 years	<1 year

The period of exposure will likely depend on the complexity of the seismic retrofit, challenges around relocating services/finding alternative delivery mechanisms for service, and the availability of funding.

Table 2b. Period of exposure for MODERATE life safety risk exposure.

Note that the category durations below are for illustrative purposes. Councils could decide these values based on their own risk appetite and risk management processes.

	Long	Medium	Short
Likely period until strengthening commenced	>5 years	3-5 years	<3 years

The period of exposure will likely depend on the complexity of the seismic retrofit, challenges around relocating services/finding alternative delivery mechanisms for service, and the availability of funding.

Table 3. Direct consequences of closure (to organisation and community).

Note that the category descriptions below are for illustrative purposes. Councils could decide these values based on their own risk appetite and risk management processes.

Select category (High, Medium, Low) where highest score occurs

	High	Medium	Low
Ability to deliver services by other means (include consideration of buildings as civil defence hubs, for non-earthquake emergencies)	Service cannot be delivered through alternative means	Service can be partially delivered outside of the building	Service easily delivered through other means
Impact on vulnerable communities (homeless, disabled, high needs)	Vulnerable community significantly impacted as they cannot be easily catered for	Vulnerable community impacted but services/amenities can be found nearby	Limited or no vulnerable community use the building/services
Impact on neighbouring businesses	Neighbouring businesses significantly impacted by direct loss of customers	Neighbouring business affected by reduced foot traffic	Limited or no impact on neighbouring businesses
Impact on staff	Significant numbers of staff affected by closure	Some staff notably impacted by building closure	Few or no staff impacted

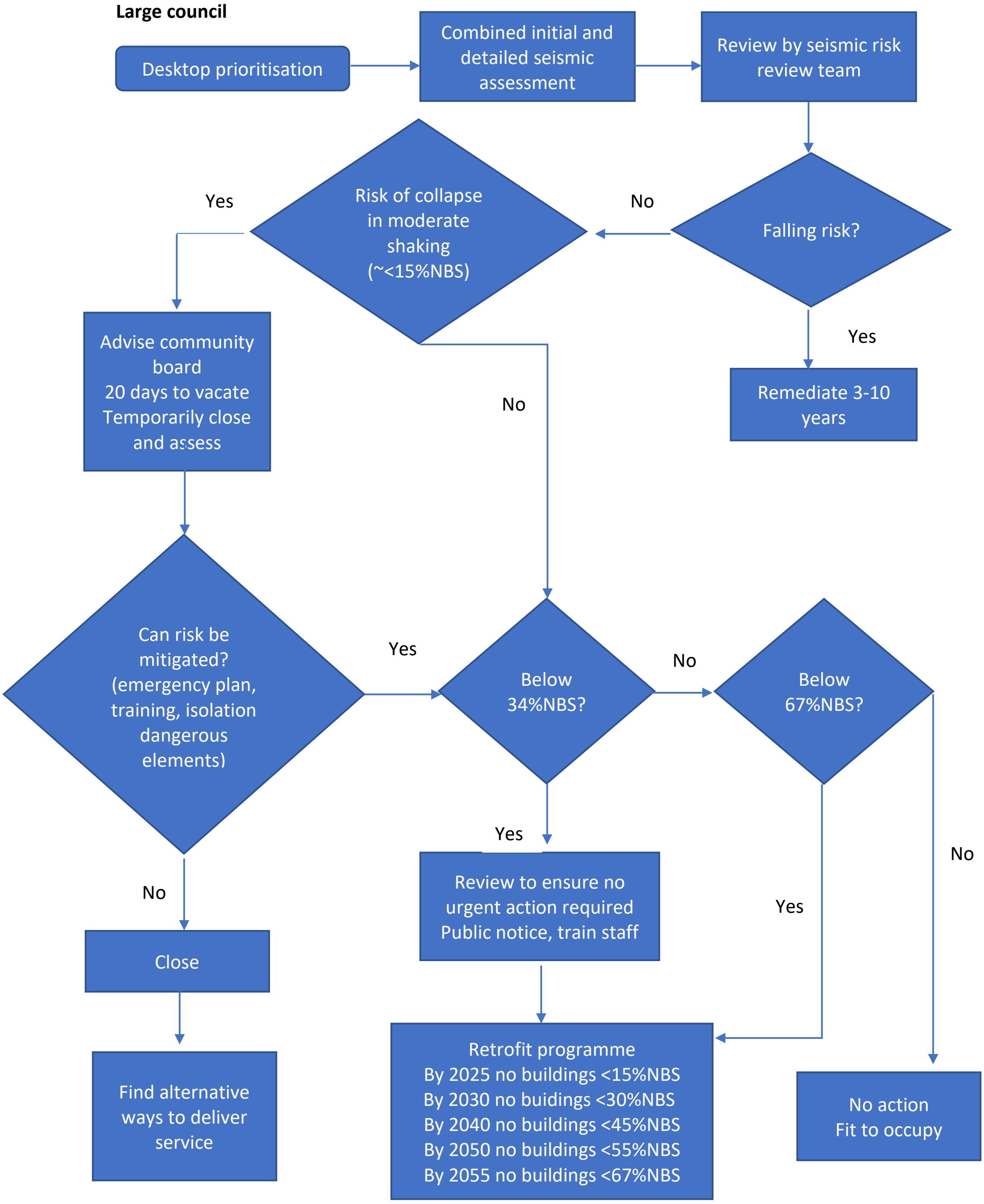
Discussion questions

1. Does the overall process seem sound?
   a. First: decision point around structural assessment (34%NBS or specific structural vulnerability)
   b. Second and third: evaluation of life safety risk exposure (including duration)
   c. Fourth: decision point around mitigation of risks
   d. Fifth: evaluation of wider impacts of building closure
2. We have started at detailed seismic assessment stage – are you comfortable with this?
3. We have not delineated between life safety risk to public and staff – is that suitable?
4. Is further guidance needed around mitigation of risk (and to what level risk should be mitigated to allow a building to remain open?)

We have added some placeholder values/descriptions in the life safety exposure and closure consequences tables. Is it useful to define these or let councils decide the values based on their own risk management processes and risk tolerance.

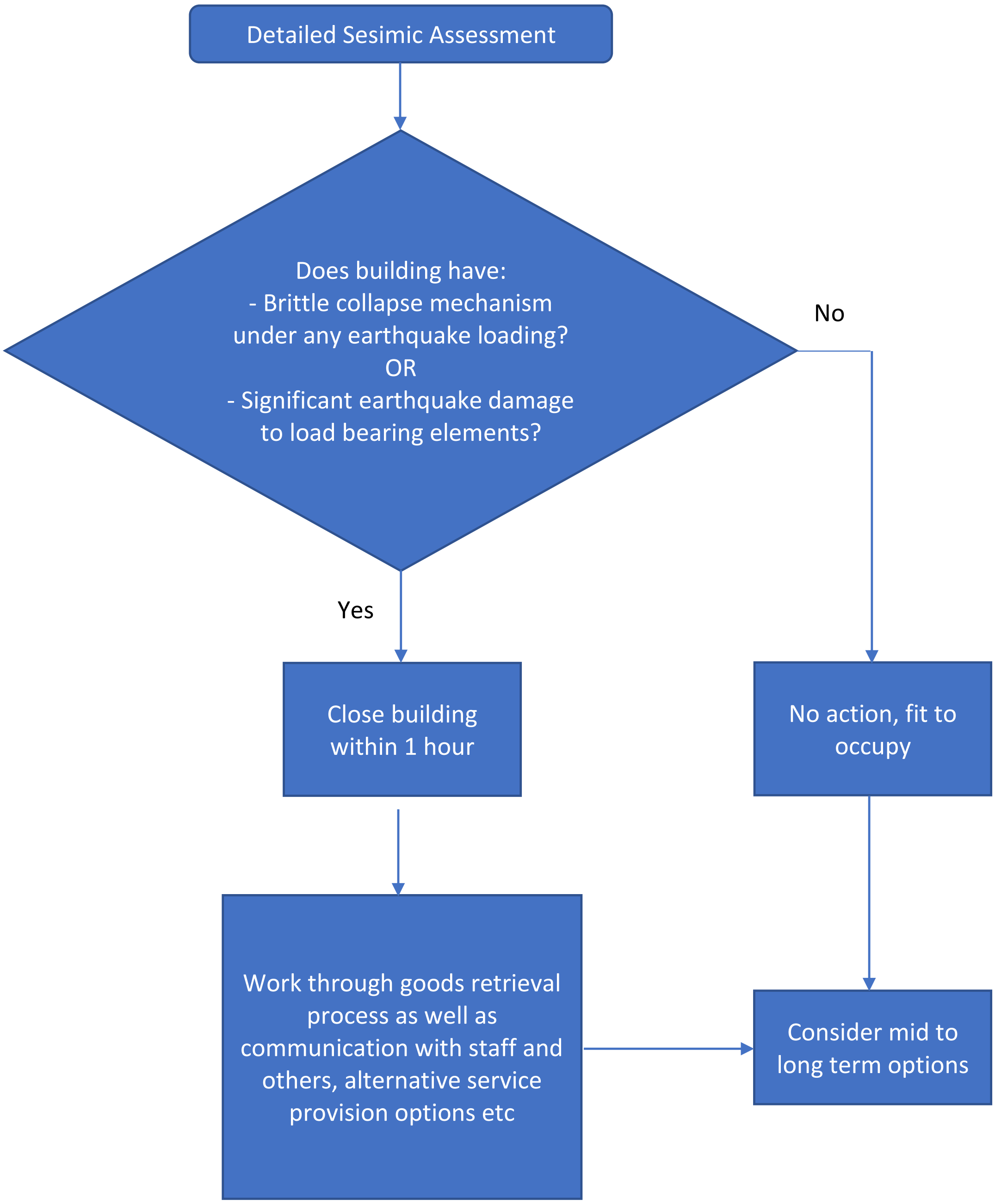
Appendix C: Case study process flowcharts

Case 1
Low seismic hazard zone
Large council



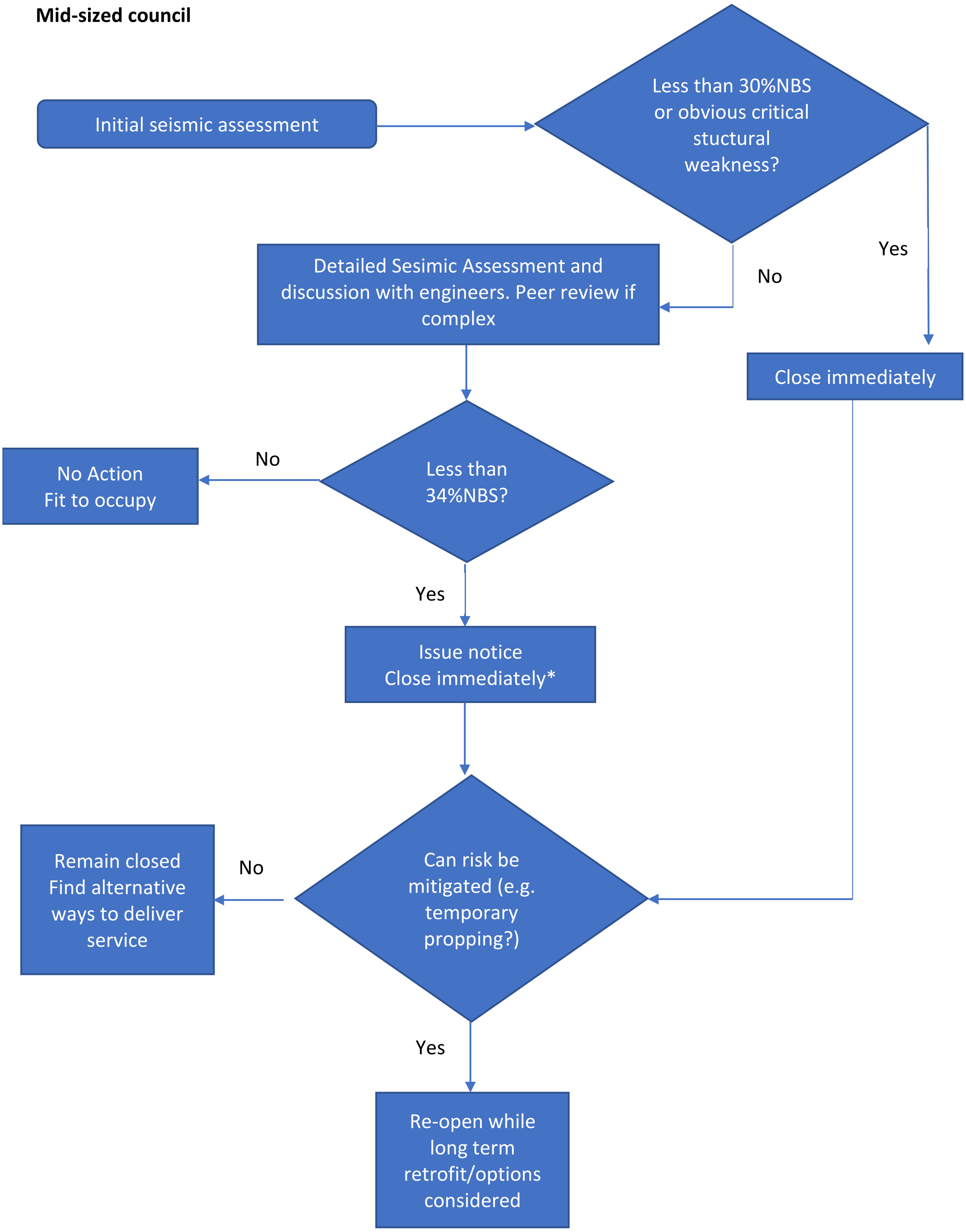
* Approval by: seismic risk review team recommendation to Executive.

Case 2
High seismic hazard zone
Large council – policy for building occupancy not just EQPB



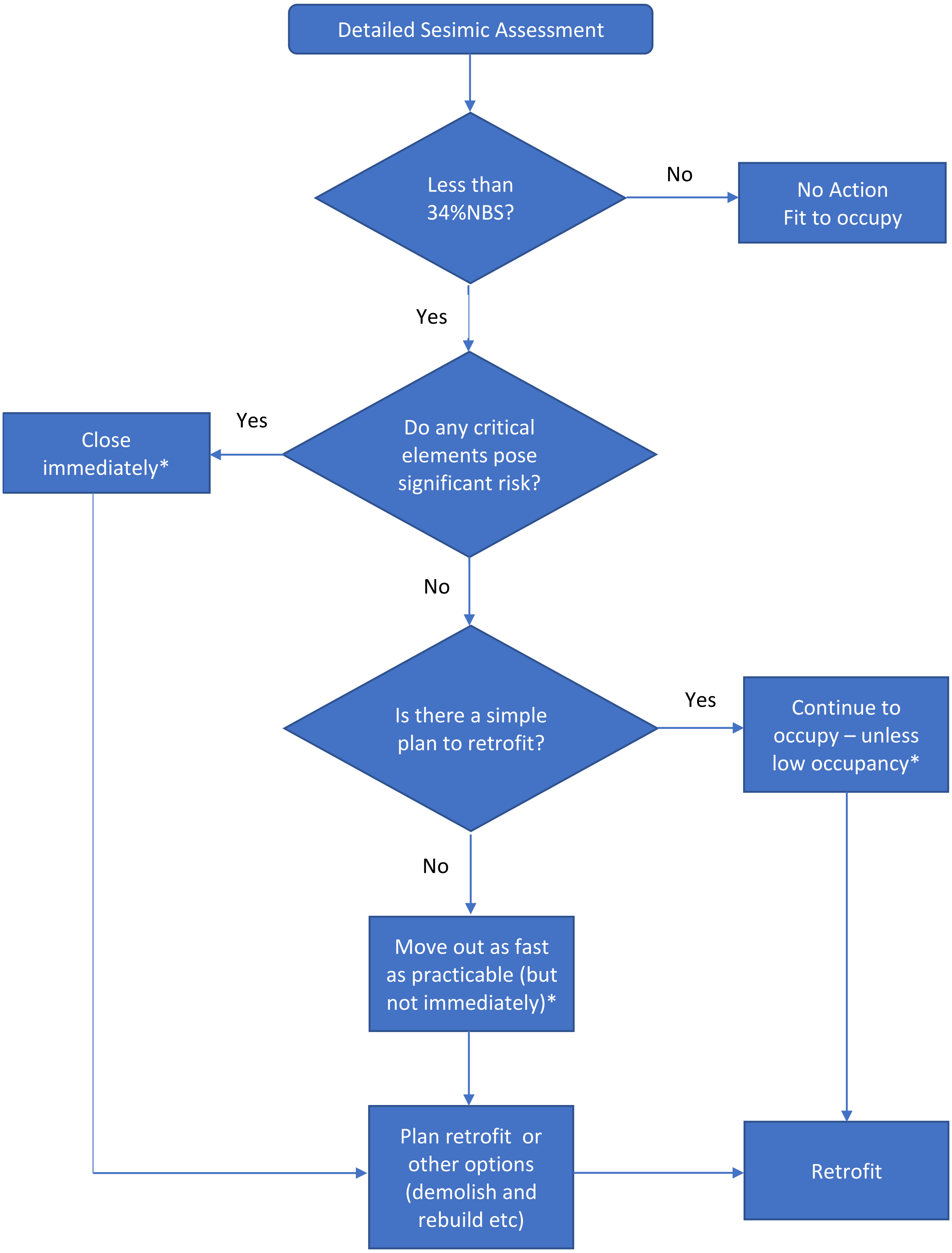
* Approval by: property manager recommendation to General Manager once final DSA approved (but generally aware of what final DSA will be and are ready to act immediately)

Case 3
Medium seismic zone
Mid-sized council



* Approval by: Building services manager in consultation with asset manager

Council 5
High seismic hazard zone
Mid-sized council



* Approval by: property manager recommendation to Chief Executive and activity manager and then Council Resolution

Appendix D: Earthquake-prone council building decision framework

This appendix provides the full decision framework produced by this study. A more succinct version called *Managing earthquake-prone council buildings – a decision framework* has been published for use by territorial authorities and can be downloaded for free from www.branz.co.nz/shop/catalogue/earthquake-prone-buildings_994/.

Overview

This document provides a framework to help territorial authorities make occupancy decisions for buildings that they own and are either earthquake prone or have a seismic rating of less than 34% of the new building standard (NBS).

The aim of the framework is to provide confidence to council officers, chief executives and elected members on how to meet their legislative obligations (including those specified within the Health and Safety at Work Act 2015) while also minimising disruption to council activities and community services.

The focus of the framework is to help councils as building owners understand and balance the potential effects of building damage should an earthquake occur against the impacts that follow directly from a decision to close a building. The framework is not intended for use in post-earthquake building occupancy decision making.

The framework was developed through BRANZ Research Levy funding and based on contributions from several territorial authority building owners and building control representatives across New Zealand.

Context

Vacating buildings identified as earthquake prone (or rating less than 34%NBS) can have significant impacts on users, surrounding businesses and the wider community. These include not just the financial impacts but immediate social impacts that can affect individual and community health and wellbeing. Recent BRANZ research identified a diverse range of practices and processes currently being used to manage risks associated with council-owned earthquake-prone buildings. In a number of cases, decisions to vacate buildings appear to have been solely focused on the prospect of harm to life in the event that a damaging earthquake occurs and territorial authorities' associated liability under health and safety legislation, without taking into account the likelihood of such an earthquake occurring.

The Building Act 2004, as the underpinning regulatory framework for buildings, does not require buildings to be closed following the decision that they are earthquake prone. The amendments to the earthquake-prone buildings provisions in the Building (Earthquake-prone Buildings) Amendment Act 2016 allow for periods of between 7.5 and 35 years for such buildings to be strengthened or demolished and no longer occupied. These statutory periods reflect seismic hazard, usage and risk to the public in adjacent areas. It is important to note that "earthquake prone" is specifically excluded from the scope of dangerous buildings unless damaged directly by an earthquake such that an aftershock could give rise to an immediate life safety hazard. Under the Building Act, dangerous buildings are those considered to pose an imminent threat to people in or around the building due to imposed loading or forces from weather events – for example, as a result of deterioration or damage. The process for managing these buildings is set out in section 121 of the Building Act.

Councils manage many potential risks to staff and the public in their daily operations. For very infrequent but high-consequence events such as a major earthquake, the hazard literature and anecdotal evidence suggest there is a tendency to overestimate the likelihood of occurrence and emphasise the consequences of the event. In the case of earthquake-prone buildings, relatively certain economic and social impacts of vacating a building are typically given less weight than the very low probability of seismic-related harm that may occur prior to mitigation and strengthening actions being completed. The framework seeks to address this issue, providing a legally defendable approach that is consistent with the other risks that councils face.

What is risk?

Risk is a combination of both the likelihood of an event occuring (uncertainty) and the consequences of the event (effect on objectives). Risk increases if either or both consequence and likelihood increase. When making decisions about earthquake-prone buildings, decision makers are effectively comparing two sets of risks:

1. The potential for injury or harm in an earthquake-prone building in the event of an earthquake.
2. The known and definite disruption to council services and wider impact on community from closure of the building.

Both risks contain consequences:

- Risk 1 has potential catastrophic consequences of loss of life.
- Risk 2 has socio-economic impacts to a community.

However, the likelihood of the risks are very different:

- Risk 1 has a very low likelihood within a specified time period.
- Risk 2 is certain within the same time period.

The trade-off between the two decisions is not straightforward and will differ depending on the life safety risk of the building and the consequences of closing the building in the short term. To effectively and robustly assess and compare these risks, a robust process needs to be followed and decision objectives need to be clearly articulated.

The decision framework is designed to reflect and balance all of councils' legislative responsibilities, in particular:

- the Health and Safety at Work Act 2015
- the Building (Earthquake-prone Buildings) Amendment Act 2016
- the Local Government Act 2002.

In presenting this framework, we draw attention to two caveats. First, the framework is intended for the management of *council-owned* buildings. It is not meant to guide a council's regulatory functions relating to earthquake-prone buildings. Second, it is intended as a framework that reflects current best practice. It is a process to help decision makers work through all relevant considerations relating to occupation of earthquake-prone buildings. Councils need to ensure the process and thresholds included reflect their own levels of risk tolerance and that the final decision is taken by the responsible decision maker. While this framework is aimed at councils, its logic and process could be applied to occupation decisions about any earthquake-prone building.

Disclaimer

This document is general in nature and is only a suggested framework for territorial authorities to make their own decisions about the management of council buildings categorised as earthquake prone. This document does not constitute advice of any nature, must not be relied on as advice and must not be seen as a prescriptive guide. Without limiting the foregoing, in all cases, territorial authorities are responsible for their own decisions and should seek independent advice (including legal and other expert advice) regarding the legality of their respective policy positions.

Further, BRANZ does not accept any responsibility or liability for any direct, indirect, incidental, consequential, special, exemplary or punitive damage or for any loss of profit, income or any intangible losses or any claims, costs, expenses or damages, whether in contract, tort (including negligence), equity or otherwise, arising directly or indirectly from or connected with your use of this document or your reliance on information contained in this document.

Decision framework

The overall decision process has five key steps, which reflect the different risk components and considerations, as summarised below:

Step 1. Structural assessment
Obtain a (preferably) peer-reviewed detailed seismic assessment that clearly identifies the specific structural vulnerability, mode of failure and area of building affected.

↓

Step 2. Life safety exposure evaluation
Determine life safety exposure through review of the number and frequency of affected building users and likely length of time until strengthening can commence.

↓

Step 3. Ability to temporarily mitigate risk
Identify any measures that can be temporariy put in place to reduce life safety risk (such as propping, fencing, removal of parapets).

↓

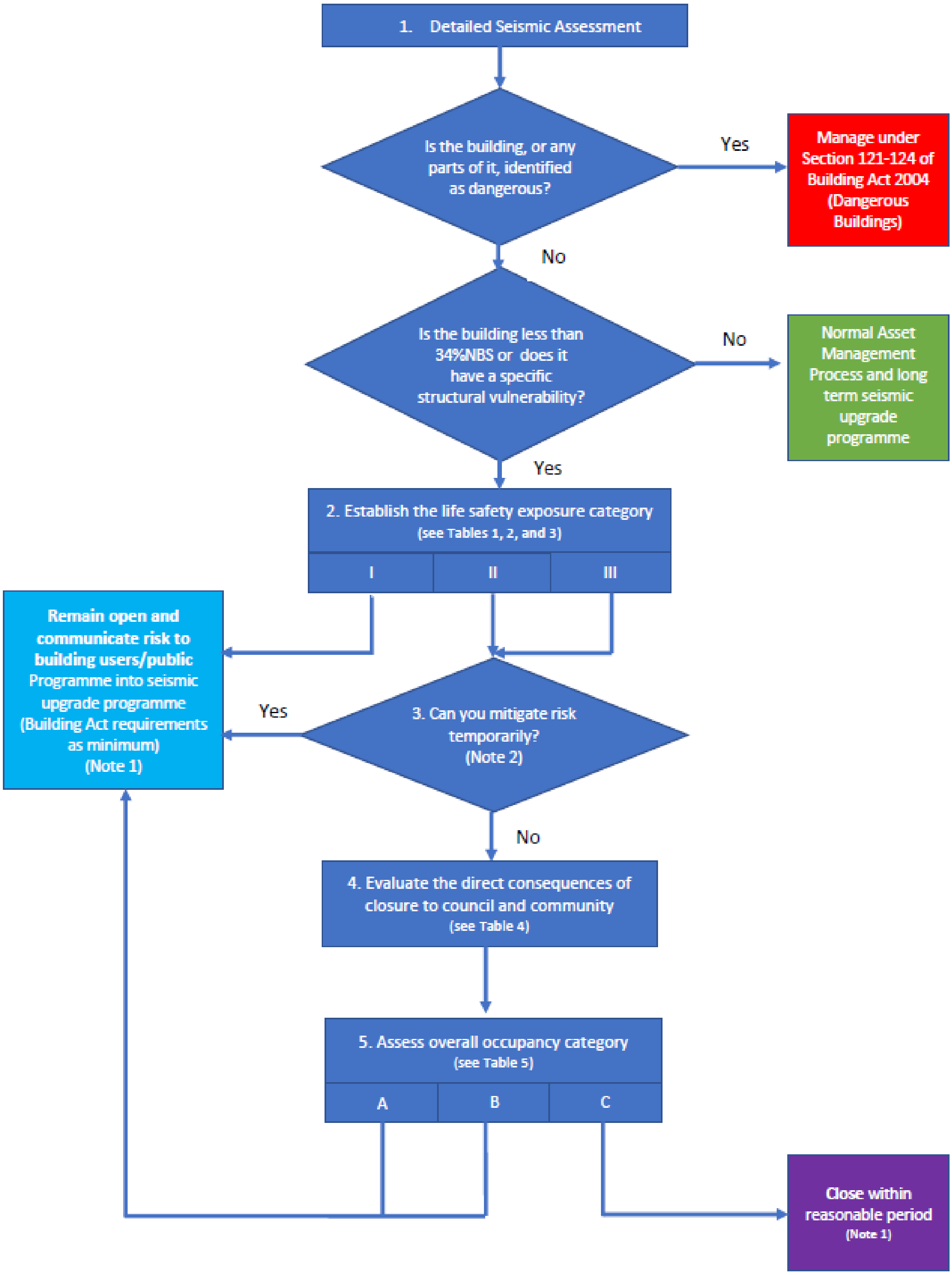
Step 4. Consequences of building closure
Determine likely immediate consequences of closing a building. This includes impacts on staff, building users and neighbouring business and community.

↓

Step 5. Overall occupancy assessment
Evaluate the risk through consideration of both life safety risk and consequences of closure and make decision on continued occupancy.

The flowchart below works though these steps and is the core of this framework. Supporting information and risk-based criteria are provided in Tables 1–5 to enable the life safety exposure, ability to mitigate the risk and the consequences of the building closure to be systematically evaluated and categorised. Additional background information is provided for each step in the subsequent commentary section.

Earthquake-prone council building decision framework



Note 1: Before making a final decision, do a sense check. Ask is this a reasonable and justifiable decision? Consider any other hazards (hazardous substances, asbestos in the building or geological hazards adjacent to the building such as unstable ground) that might create an additional life safety and human health risk during an earthquake. Also consider the demographics of the people using the building. Are they elderly, physically impaired or vulnerable in any way? Does this change the risk to life?

If the final decision is to occupy the building, talk with staff/occupants, erect signage, isolate any dangerous elements if possible, create emergency plans, train staff. Ensure the risk is adequately communicated.

Ensure that the retrofit or demolition is complete or the building demolished within the statutory timeframes set out by MBIE.

Note 2: Temporary mitigation measures include isolating dangerous parts of building (such as chimneys), move services/occupants away from dangerous parts of the building, tie back parapets and façades, close adjacent footpath.

Table 1. Life safety risk exposure.

Use Table 1 to identify the degree of life safety exposure in the event of an earthquake occurring. Make the assessment relative to the failure mechanism and part of building affected. Select the life safety risk exposure category (high, moderate, low) where the highest score occurs, then go to Table 2.

Note that the numerical values below have been defined for illustrative purposes. Councils may wish to adopt different values based on their own risk perceptions and risk management processes.

	Life safety risk exposure category		
	High	**Moderate**	**Low**
Maximum number of people in building at any time	>100	10–100	<10
Average number of people in building at any one time	>50	5–50	<5
Average user time in building (duration of use)	Over 8 hours a day	2–8 hours a day	<2 hours
Average weekly usage (person-hours per week)	>2,000	50–2000	<50
Exposure to people outside the building	Risk of collapse onto adjacent high-use footpath (>100 people per hour); risk of collapse onto neighbouring structure	Risk of collapse onto adjacent moderate-use footpath (5–100 people per hour)	Risk to low-use footpath (<5 people per hour)

Table 2. Period of exposure.

Use Table 2 to identify how long occupants will be exposed to life safety risk. The period of exposure will likely depend on complexity of the seismic retrofit, challenges around relocating services/finding alternative delivery mechanisms for services and the availability of funding. Select the period of exposure category (long, medium, short) based on the seismic hazard zone the building is in, then go to Table 3.

Note that the category durations below have been defined for illustrative purposes. Councils may wish to adopt different values based on their own risk tolerance and risk management processes. This may be influenced by the seismic hazard zone, geological fault history, localised earthquake probabilities or aftershock forecasts.

	Seismic hazard zone	Period of exposure category		
		Long	**Medium**	**Short**
Likely period until strengthening commenced	High	>3 years	1–3 years	<1 year
	Medium	>6 years	2–6 years	<2 years
	Low	>9 years	3–9 years	<3 years

Table 3. Total life safety exposure.

Use Table 3 to calculate the total life safety exposure by combining the results from Table 1 and 2. Select total life safety exposure category (I, II, III) and return to flowchart step 3.

Note that the categories I, II, III below have been defined for illustrative purposes. Councils may wish to adopt different values based on their own risk tolerance and risk management processes.

	Period of exposure (Table 2)		
Life safety exposure (Table 1)	**Short**	**Medium**	**Long**
Low	I	I	II
Moderate	I	II	III
High	II	III	III

Table 4. Direct consequences of closure (to organisation and community).

Use Table 4 to evaluate the consequences of closing a building prior to seismic remediation works starting. Select the consequence of closure category (high, moderate, low) where the highest score occurs. Then go to step 5/Table 5.

Note that the category descriptions below have been defined for illustrative purposes. Councils may use different criteria that better reflect their risk management processes as well as any other strategic outcomes the council is aspiring to.

	Consequence of closure category		
	High	**Moderate**	**Low**
Ability to deliver services by other means	Service cannot be delivered through alternative means	Service can be partially delivered outside of the building	Service easily delivered through other means
Impact on vulnerable communities (homeless, disabled, high needs, children, elderly)	Vulnerable community significantly impacted as they cannot be easily catered for	Vulnerable community impacted but services/amenities can be found nearby	Limited or no vulnerable community use the building/services
Impact on neighbouring businesses	Neighbouring businesses significantly impacted by direct loss of customers	Neighbouring business affected by reduced foot traffic	Limited or no impact on neighbouring businesses
Impact on staff	Significant numbers of staff affected by closure	Some staff notably impacted by building closure	Few or no staff impacted

Table 5. Overall occupancy assessment.

Use Table 5 to determine the overall occupancy assessment for the building. Combine the results from Table 3 and 4. Select occupancy category (A, B, C) and return to flowchart to determine final decision.

Note that the categories of A, B and C have been defined for illustrative purposes. Councils could alter these values based on their own risk appetite and risk management processes.

	Consequences of closure (Table 4)		
Total life safety exposure (Table 3)	**High**	**Moderate**	**Low**
II	A	B	B
III	B	B	C

Commentary

Who should be involved in decision making?

Given a potential consequence of building failure is personal injury, decisions around occupation of earthquake-prone buildings are a health and safety issue. As a result, these decisions are the responsibility of the chief executive or their delegate acting on behalf of a person conducting a business or undertaking (PCBU) under the Health and Safety at Work Act 2015 (HSWA).

However, as well as being a PCBU, territorial authorities have a dual role under section 10 of the Local Government Act (LGA) "to enable democratic local decision-making and action by, and on behalf of, communities, as well as promoting the social, economic, environmental, and cultural well-being of present and future communities". Territorial authorities must consider the impact of any decisions that affect the community beyond health and safety. This responsibility lies with the council as a whole (including the elected members). Consequently, territorial authorities should establish a decision and delegation process that allows PCBUs to manage their HSWA obligations and consider the impacts of such decisions upon local communities.

While this decision process is designed to provide a consistent structure to increase the objectivity and robustness of the decision process, the final decision will require a level of judgement. As a result, it is beneficial for decisions relating to occupation of earthquake-prone buildings to be made with input from a diverse group from across an organisation. Although the final decision may lie with one individual, this 'portfolio approach' ensures that a variety of perspectives and interests are represented.

Step 1. Structural assessment

Carrying out structural assessments on potentially earthquake-prone buildings is required under the Building (Earthquake-prone Buildings Amendment) Act 2016. Buildings that are potentially earthquake prone are those within the profile categories defined in MBIE's earthquake-prone building methodology[30] or where the territorial authority has other reasons to believe the building may be earthquake prone.

However, like many other building owners, most councils have had or are planning seismic assessments to be undertaken on their buildings, whether or not they fall within these profile categories. These assessments can be either an initial seismic assessment (ISA) or detailed seismic assessment (DSA).

[30] Unreinforced masonry buildings, buildings of 3 or more storeys constructed prior to 1976, buildings of 1–2 storeys constructed prior to 1935 (excluding timber-framed buildings) – https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/methodology-identify-earthquake-prone-buildings/.

Decisions to change the occupancy of buildings should be based on sound engineering advice and a clear understanding of the likely behaviour of the building under a range of earthquake actions. Usually this requires a DSA from an experienced chartered professional engineer who has not only assessed the %NBS rating but has critically reviewed the building and is confident they understand the likely vulnerability, mode of failure and physical consequences of failure. The assessment should include any adjoining structures that might affect building safety (such as shared structural roof or wall elements). For any buildings rating less than 34%NBS, the DSA should be critically reviewed internally or externally (through a panel or via a peer review) to ensure confidence in the technical advice provided and that life safety risks are identified and managed appropriately.

All buildings with specific structural vulnerabilities should also be subject to a review of continued occupancy, regardless of their %NBS rating. Some buildings that rate above 34%NBS may have vulnerabilities that could lead to a brittle or sudden collapse in larger earthquakes. Examples of such vulnerabilities may include buildings with precast concrete floor systems with inadequate seating or poorly restrained concrete wall panels.

Given the very low probability of a significant earthquake occurring in the short term and the potential immediate adverse consequences for the community of closing a building, it is important that decisions to change occupancy are made on a reviewed DSA rather than upon the receipt of only an ISA or draft DSA. Draft assessments should be appropriately reviewed, along with an equally considered review of the impacts of closure. This process can take a period of weeks or months. There are two primary exceptions to this rule.

- If the ISA has indicated a critical and urgent deficiency that must be addressed immediately – for example, the building would be classed as a dangerous building under section 121 of the Building Act or is an unreinforced masonry building.
- If the building is importance level 1 or consequences of closure are negligible, an ISA may be sufficient.

Information needed for step 1:

- Detailed seismic assessment from engineer (including any review that may be needed to confirm building assessment).
- Clear indication in the assessment on the expected mode of failure and physical consequences of failure.

Step 2. Life safety exposure

To fulfil obligations as a PCBU under the HSWA, the life safety exposure of earthquake-prone buildings must be considered. To understand the life safety exposure of a particular building, we need to consider not only the behaviour of the building but how many people may be affected by building failure. This includes consideration of the failure mechanism, the part of the building affected, how many people use that part of the building and how long they are in the building. Table 1 is designed for users to assign a likely life safety exposure at the time of an earthquake.

When considering a decision to occupy an earthquake prone building, territorial authorities should also consider the length of time it will take to design and fund the remediation of an earthquake-prone building (Table 2). Risk is a function of time – the longer we are exposed to a risk, the more chance we have of it occurring. In the case of seismic performance of buildings, this risk is exacerbated by the natural deterioration of buildings over time, contributing to lower seismic performance. The chance of an earthquake also increases over time as stress accumulates in seismic fault systems over time. This means that, while we don't need to immediately close earthquake-prone buildings, the risk we bear from occupying earthquake-prone buildings will increase over time.

The MBIE seismic retrofit timeframes acknowledge this point and give building owners between 7.5 years (for priority buildings in high seismic hazard zones) and 35 years (for non-priority buildings in low seismic hazard zones).[31] MBIE recognises it is impractical and impossible to mitigate all seismic risk immediately and so has defined reasonable timelines in which to remediate buildings. Table 2 provides some added nuance to the MBIE timeframes and encourages users of this framework to think about the time it will take to design and fund seismic remediation projects – short, medium or long – with timeframes assigned relative to the seismic hazard zone the building is in. Users may also want to consider factors such as the seismic hazard zone, geological fault history, localised earthquake probabilities or aftershock forecasts when setting timeframes in Table 2.

The total life safety exposure (Table 3) is a combination of the life safety exposure (Table 1) and the period of exposure (Table 2).

If the building poses a high life safety risk (category III in Table 3), territorial authorities need to either work to reduce that risk more quickly, mitigate the risk (see step 3) or have a sound reason for keeping the building open (see step 4). Conversely, if the risk is low, territorial authorities can take more time to remediate the risk. Buildings that pose a higher life safety risk and remain occupied, should be prioritised for remediation.

Information needed for step 2:

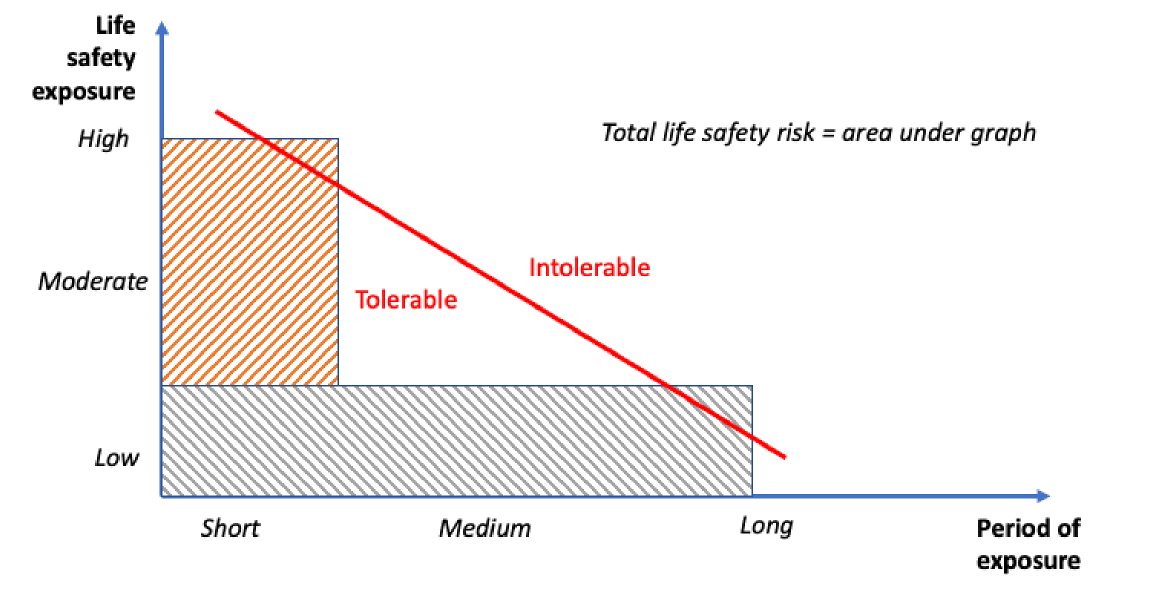
- Building usage information: estimates of the average number of users, average time spent in building and peak number of occupants.
- Estimated time to complete earthquake retrofit. This will include consideration of time for the retrofit design and accessing funding, any consent requirements, construction time and time to arrange and manage relocation of services/ alternative delivery mechanisms for services.

Risk increases over time

The figure below illustrates how the risk of occupying an earthquake-prone building increases over time. The total risk is a product of the total time the risk is present and the size of the risk (the area under the graph). You could have a building that has high life safety exposure, but if you can remediate it quickly, the building occupants are only exposed for a short period and the overall risk to occupants is reduced. Conversely if you have a building with low life safety exposure, you could leave it occupied for a longer period and have the same overall life safety risk.

Note that each council will have different risk tolerance, and this will change what combination of life safety risk exposure and period of exposure is tolerable.

[31] https://www.building.govt.nz/managing-buildings/managing-earthquake-prone-buildings/how-the-system-works/



Step 3. Ability to temporarily mitigate risk

If there is likely to be considerable time before earthquake strengthening can occur, temporary mitigation measures should be considered. Any measure that can reduce life safety risk should be considered including physical works to remove or secure high-risk building elements (parapet ties or props, removal of chimneys) and closing parts of the building/moving some services to reduce building occupancy.

It is important to clearly understand how effective the proposed measures are at reducing life safety risk – what is the revised %NBS or risk to life?

Information needed for step 3:

- Discussion with building managers and occupants on ways to change services to avoid dangerous building elements.
- Options from engineers on potential temporary risk mitigation measures (cost and effectiveness at mitigating the life safety risk).

Step 4. Consequences of immediate building closure

With a clear understanding of the life safety exposure and subsequent health and safety implications, step 4 is to consider the consequences of closing a building while seismic strengthening or other alternative plans are made for the building. Under section 14 of the LGA, territorial authorities must take into account the interests of both current and future communities when making decisions. This should include the seismic resilience of assets as well as the economic, social and cultural impacts of closing such assets.

The aim of this step is to understand the impact of interim building closure on staff, the public, neighbouring businesses and wider community. During this assessment, we suggest reviewing options for alternative service delivery. This includes the ability to move services to another location or to deliver them by alternative means (such as online). It also includes consideration of all uses of a building, such as a civil defence community hub, which may be needed for non-earthquake emergencies while it is closed and waiting a seismic upgrade.

Information needed for step 4:

- Alternative service delivery options.
- Social impact assessment of building closure – staff, building users and neighbourhood.

Step 5. Overall occupant assessment

The final step is to balance the life safety exposure and the consequences of closure. This step is critical to ensure that territorial authorities are balancing both their roles as a PCBU under the HSWA and their duties under the LGA. In Table 5, a rating of A, B or C is given to a building based on the combination of life safety exposure and consequences of closure. The aim of this step is to minimise significant disruption to communities from closure of high-importance buildings and also minimise unnecessary exposure of occupants to life safety risk in a low-importance building.

This framework provides indicative occupancy categories of A, B, C (with C being buildings that should close following designation as earthquake prone or rating less than 34%NBS). It is important that any territorial authority using this framework checks these ratings against their own risk tolerance.

Normal asset management process and seismic upgrade programme

This decision framework has focused on the initial closure decision, not the prioritisation of the seismic upgrade programme. We recommend using the concepts in this decision framework to help prioritise retrofits, including the life safety risk (after temporary mitigation is in place) and disruption to community – for example, by prioritising buildings that have high life safety risk and whose closure would give rise to significant community disruption. Whether a building is considered a priority building under the Building Act will also be important to consider.

As a minimum, earthquake-prone buildings will need to be retrofitted, or demolished, within the statutory timeframes set out in the Building Act.

Seismic risk area*	Owners of earthquake-prone buildings must carry out seismic work within (time from issue of earthquake-prone building notice)	
	Priority	**Other**
High	7.5 years	15 years
Medium	12.5 years	25 years
Low	N/A	35 years

**As defined in NZS1170.5:2004.*

This decision framework has also focused on buildings that are less than 34%NBS and are likely to be determined to be earthquake prone under the Building Act. However, territorial authorities may also want to set in place a programme to improve buildings that are above 34%NBS but below 100%NBS. To do this, territorial authorities as building owners will need to determine an acceptable level of seismic performance for a given building. We suggest that, instead of setting a blanket %NBS strengthening level (such as all buildings will be >67%NBS), buildings that have more people in them and that are more important for the community are strengthened to a higher level than those that have low occupancy and importance. This will be a more effective use of limited public resources than strengthening everything to the same level. We suggest using the concepts of life safety risk and disruption to community in this decision framework to help think about the desired level of strengthening for different buildings.

Final decision (note 1)

We recommend always doing a sense check on the final decision. The decision taken by a council must be "reasonable", and it is important that the decision maker makes a final assessment as to whether the conclusion reached is justifiable from their standpoint. This decision framework is designed to ensure all relevant information is considered in a logical and robust way. However, there will always be situations where the complexity of the building or community will mean that the process does not derive the best solution. This process should be used as a starting point.

In particular, there may be other factors that might influence a closure decision including building condition (the extent of any deterioration not specifically adressed in the engineering assessment), the presence of other hazards (hazardous substances or asbestos in the building) or geological hazards adjacent to the building (unstable ground) that might create an additional life safety and human health risk during an earthquake. Ask: Does this pose an unacceptable risk during an earthquake? How can this risk be mitigated? Mitigation options could include removal of the hazardous substances and having personal protective equipment available for building users (and training so that building users know when and how to use it). Closure of building may also be deemed the best solution in some cases.

The demographics of the people using the building should also be considered. Are they young, elderly, physically impaired or vulnerable in any way? Does this vunerability put them in an unacceptably risky situation – for example, users are unable to safely exit a damaged building following an earthquake? Is there a potential alternative, safer location for vulnerable persons to access key services? Alternatively, are building occupants essential for emergency response?

As the final part of making a decision to keep an earthquake-prone building open (until remediation work starts), it is best practice to talk about the risks with staff and other regular users/occupants of the building and to implement strategies to manage and clearly communicate earthquake risk including erecting signage, isolating any dangerous building elements, creating and practising emergency plans and training staff.

It is also important to manage council understanding of why a building has been kept open, given the common misunderstanding about what %NBS means. There is the potential for people to view a building remaining open as a failure of duty and a risk to the public. If the reasons behind this decision are not adequately communicated, it could significantly affect trust in the responsible authority. Have a clear communication plan established for situations recognised as being potentially contentious. This could include sharing the decision-making process and judgement in a transparent manner (via a council website such that queries can be directed there, through community meetings if the scale demands that attention or via other public information channels).

Any uncertainties in risk assessment and judgement should be carefully communicated. Be clear about what the territorial authority knows and doesn't know. To manage public perceptions of that uncertainty, communicate what is causing that uncertainty, what is being done to reduce it and when more information is expected to be available. Focusing on communicating the information that is relevant to council decision making will reduce the potential for overwhelming the public with too much information. For large-scale high-impact decisions, this may require some focus groups or community feedback to identify what the public questions and concerns are and the information needed to satisfy their decisions.

For any closure decision, we suggest a reasonable time period is allowed to vacate the premises and relocate services unless there is imminent danger to building users. This is to help mitigate and reduce the impact on the health and wellbeing of building service users.

Information needed for note 1:

- Information on demographics of building users.
- Information on hazardous substances inside or adjacent to the building.
- Information on geological hazards adjacent to the building.

Example use of decision framework

Scenario 1 – Council office building, medium seismic hazard zone

One of the main offices for the council has been given a seismic rating of 30%NBS. This 2-storey council office building houses 120 council-employed staff during normal business hours. Council activities in the building include the executive, accounts, engineering, building consents and public-facing customer service. There is also a tenant who runs a café.

Approximately 60% of council staff in the building could work from home temporarily. 40% would need alternative accommodation including the services that are customer facing. There are a number of businesses nearby that benefit from the foot traffic brought by the council offices.

The council's consulting engineers consider the council office building's principal critical structural weakness to be the lack of shear strength in the columns, which could give rise to collapse of part or all of the upper level under significant earthquake shaking, posing a life safety risk to a large number of building users. This is likely to be a complex retrofit, which may take up to 4 years to plan and finance. Engineers have indicated there are no feasible temporary mitigation options for the building.

Decision steps

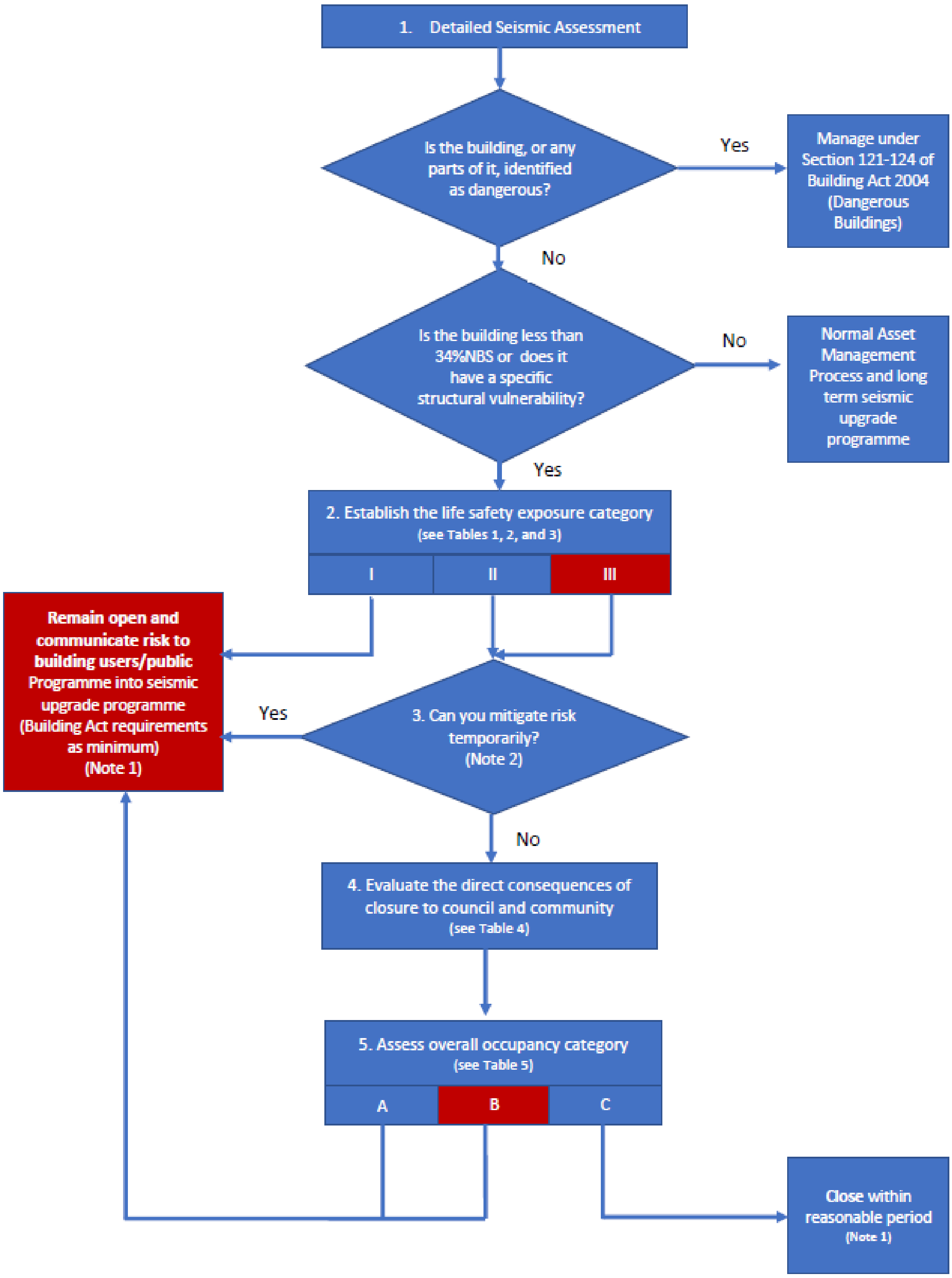
Step 1: The DSA indicates the building is less than 34%NBS or is earthquake prone. Continue to step 2.

Step 2: The life safety risk exposure is high, given it scores high in every category in Table 1. Table 2 indicates that a 4-year wait until retrofit commences is a medium period of exposure, given the building is in a medium seismic hazard zone. A combination of a high life safety exposure and medium period of exposure in Table 3 gives a total life exposure rating of III. Continue to step 3.

Step 3: The nature of the structural weakness and layout of the building means there is no way to mitigate the risk. Continue to step 4.

Step 4: The likely disruption of closure of the office building is moderate overall. It scores moderate for ability to deliver services by alternative means (because of the ability of staff to work at home) and moderate for impact on staff and tenants and neighbouring businesses. It scores low for impact on vulnerable people. The moderate score is because there was a moderate rating in at least one row.

Step 5: The overall occupancy category is B, given the combination of category III life safety exposure and moderate consequences of closure (Table 5). This therefore suggests that the building should remain open until planned seismic retrofit works go ahead (within the MBIE timeline). In the meantime, a sign is erected, emergency plans including evacuation procedures are updated, staff are trained and risk is clearly communicated to building users and the public.



To further demonstrate the framework, below are five more scenarios to demonstrate the decision framework. The evaluation for all scenarios is summarised in Table 6.

Scenario 2 – Memorial hall in rural community

A memorial hall in an isolated community has been given a seismic rating of 30%NBS. The hall can accommodate up to 80 people but is generally only used once or twice a week for smaller gatherings. It is also used as a civil defence welfare centre. The building was built from cast in situ columns and walls, with timber roof trusses. The low rating is due to inadequate connections between the trusses and concrete walls and the lack of bracing in the roof structure. It will take some time to obtain funding for repair of the building.

Scenario 3 – Memorial hall in urban community, high seismic hazard zone

As for scenario 2 but in an urban centre, the seismic retrofit is more straightforward and funding is readily available.

Scenario 4 – Carpark building, medium seismic hazard zone

A carpark building in a town centre has been given a seismic rating of 25%NBS. The council's consulting engineers consider the building's principal critical structural weakness to be the wall elements, which could fail in a major earthquake, posing a life safety risk to those inside. It will likely take 5 years to design, fund and coordinate retrofit of the carpark.

On any given day during the week, approximately 200 people use the building but typically for only 15–20 minutes (parking their car and then returning to it). There are no alternative parking facilities. If closed, users would have to use already busy on-street parking or use public transport. Closure of the building will impact local businesses as shoppers elect to shop elsewhere.

Scenario 5 – Library, low seismic hazard zone

A suburban library that can have in excess of 100 users at any one time has been given a seismic rating of 25%NBS. The council's consulting engineers consider the building's principal critical structural weakness could give rise to collapse of part or all of the upper level under significant earthquake shaking, posing a life safety risk to a large number of building users.

This unreinforced masonry building also has parapets that pose a hazard to pedestrians. They can be easily and quickly removed. The building requires retrofit work to tie the unsecured masonry. The retrofit is likely to take some time due to funding constraints and the heritage listing on the building. The closest library is 10 km away. Some library services are available online, but there is not an obvious alternative to provide a community meeting space nearby.

Scenario 6 – Suburban council service centre, high seismic hazard zone

A suburban council service centre that has an average of 25 occupants at any one time has been given a seismic rating of 30%NBS. The council's consulting engineers indicate the building could suffer a partial collapse during a moderate earthquake, affecting the building foyer. The service centre services can be easily delivered from portacoms on site in addition to online services. This heritage listed building will take some time to fix due to funding constraints and design complexities.

Table 6. Scenario evaluations to demonstrate decision framework

Scenario	Description	Hazard zone	Life safety risk exposure (step 2)			Consequence of closure category (step 4/Table 4)	Overall occupancy category (step 5/Table 5)	Decision outcome	Comments
			Table 1	Table 2	Table 3				
1	Council office building	Medium	High	Medium	III	Moderate	B	Remain open	Fictional case
2	Memorial hall in rural community	High	Moderate	Long	III	Moderate	B	Remain open	Actual case where council decided to no longer use building as a civil defence centre
3	Memorial hall in urban community	High	Moderate	Short	II	High	A	Remain open	Actual case
4	Carpark building	Medium	Moderate	Medium	II	Moderate	B	Remain open	Adapted case
5	Library	Low	High	Long	III	Moderate	B	Remain open	In the immediate term, the parapets are removed and fences are erected to isolate the affected area
6	Suburban council service centre (heritage listed)	High	Moderate	Long	III	Low	C	Close within reasonable period	Fictional case where services can be easily relocated with limited impact on building users