Evaluating and Communicating Seismic Risk for Low Rating Buildings

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ABSTRACT

There are many challenges for owners and occupiers of buildings where seismic assessments produce ratings of less than 34%NBS, including addressing questions about whether they should continue to occupy the building.

MBIE's 2022 Seismic Risk Guidance provides a clear point of reference with statements such as *in most cases, vacating a building should be a last resort means of mitigating life safety risk for buildings occupants*. Nevertheless, some owners and occupiers with buildings ratings less than 34%NBS still wish to have a specific evaluation of the seismic risk to inform their decision on continuing to occupy the building. This will often be sought in the context of their responsibilities under the Health and Safety at Work Act. Seismic risk evaluations of this nature go beyond the scope of typical engineering assessments, including consideration of how a structure might perform at different levels of earthquake shaking.

This paper outlines the approaches that have been applied to a range of buildings based on the information and framework in the MBIE seismic risk guidance and the 2021 BRANZ decision framework for council-owned buildings, and how the outcomes are communicated to users of the buildings. These approaches have been developed and applied for diverse organisations such as government agencies with national portfolios, councils with prominent public buildings and community-based groups such as church parishes. The reactions of both the organisations and the users of the buildings to the seismic risk evaluations are outlined, along with observations on the key risk communication success factors.

1 INTRODUCTION

Many seismic assessments have been undertaken over the past two decades for various reasons - regulatory (earthquake-prone) purposes, post-earthquake status evaluation and for owners and occupiers to understand the seismic risk profile of their premises for purposes such as health and safety, property transactions, financing and/or insurance.

The intent of the earthquake prone buildings provisions in the Building Act is to address low rating buildings within statutory time frames, and for the buildings to continue to be used and occupied during those time frames, unless found to be dangerous or insanitary for reasons other than earthquake. However the failure of some buildings in the Canterbury and Kaikoura earthquakes inevitably raises concerns of building owners and tenants when they learn that their building has received a low rating (whether or not the building is determined by the territorial authority to be earthquake-prone). An additional cause of concern stems from the provisions of the Health and Safety at Work Act, which places emphasis on eliminating risk where it is reasonably practicable to do so.

These factors have led to a significant number of buildings being vacated upon owners and/or tenants learning of low seismic ratings. Almost without exception, these decisions are based on seismic risk considerations alone, without due analysis of the impacts of vacating the building on individuals and the community.

In 2021, a research study for BRANZ highlighted the implications of decisions to close earthquake prone buildings owned by local councils that did not take into account the other (non-earthquake) risks to communities (Nuth et al 2021). This study developed a decision framework that assisted building owners systematically evaluate all relevant factors and options (BRANZ 2021; Brown et al 2022).

In 2022 MBIE with input from the Joint Committee on Seismic Assessment of Existing Buildings prepared a document *Seismic Risk Guidance for Buildings* which expanded on the BRANZ framework to cover buildings more generally, and outline key messages and considerations (MBIE 2022).

This paper outlines the approaches that have been applied by the author to a range of buildings based on the information and frameworks in the MBIE seismic risk guidance and the 2021 BRANZ decision framework for council-owned buildings, and how the outcomes are communicated to users of the buildings. These approaches have been developed and applied for diverse organisations such as government agencies with national portfolios, councils with prominent public buildings and community-based groups such as church parishes. The reactions of both the organisations and the users of the buildings to the seismic risk evaluations are outlined, along with observations on the key risk communication success factors. Observations are also made about the challenges at the interface between the Health and Safety at Work Act and the earthquake prone buildings provisions of the Building Act, and how the processes associated with seismic risk evaluations provide pointers as to how some aspects of seismic assessments can be enhanced.

2 THE CONTEXT FOR DECISION-MAKING FOR LOW RATING BUILDINGS

2.1 The limitations of seismic assessments

Seismic assessments identify and provide information around the seismic vulnerabilities of buildings that give rise to their low ratings. Some of these vulnerabilities are local in nature (for example cladding panels that affect those outside or entering/ leaving the building). However the overall building rating as a single parameter doesn't clearly distinguish these vulnerabilities from those that affect primary structure. Other structural elements have low ratings that result from non-compliance with detailing requirements of current design standards (for example steel connections in buildings of lightweight and low-rise construction), and do not correspond to failure modes observed in major earthquake events, either in New Zealand or overseas.

In a number of these cases it is apparent that these seismic vulnerabilities would only materialise under relatively strong earthquake shaking. These cases are clearly different to firstly, the buildings that are the focus of the earthquake prone buildings provisions based around 'moderate' earthquake shaking (ie. the 'worst of the worst' buildings), and secondly from the larger, heavier buildings with the potential to perform poorly in significant ground shaking and whose failure would endanger a large number of people.

This distinction is however typically not provided within seismic assessments, leaving owners and occupiers struggling to understand the significance of the low ratings and the nature of the risk it represents.

2.2 Risk Context

When considering the continued occupation of buildings with low seismic ratings, there are effectively two different sets of risks being compared:

1. The potential for injury or harm from structural failure in the event that a sufficiently large earthquake occurs; and
2. The disruption to the services delivered in the building and associated impacts on the wider community from direct closure.

Both sets of risks have consequences, with the first potentially resulting in injury and the loss of life. The second risk can involve loss of employment to those who work in the building, loss of community access to recreational and cultural facilities and inefficiently delivered community services with associated cost penalties. However the first sets of risks typically have a low likelihood, whereas the consequence of the second risk occurs immediately after the decision is made to vacate a building.

It is apparent that much of the decision-making around the continued occupancy of earthquake prone and low rating buildings has been based on the potential consequence of an earthquake on the building, rather than its likelihood. This is understandable in the light of the collapses of the multi-storey CTV and PGC buildings in the February 2011 Christchurch earthquake, along with the failures of many unreinforced masonry facades. In combination with the subsequent introduction of the Health and Safety at Work Act, this has brought the desirability of eliminating (avoiding) the risk into sharper focus.

This also highlights the need to more carefully understand what a low seismic rating actually means in terms of risk.

2.3 The Health and Safety at Work Act

The Health and Safety legislation was extensively updated in 2015 following concerns about how workplace safety was being managed. One of the principal drivers was the 2010 Pike River mining disaster, along with the poor safety record of some other industry sectors. The loss of life in the February 2011 Christchurch earthquake was also a consideration in the revision of the legislation. The Health and Safety at Work Act (HSWA) imposes duties and obligations on organisations to provide a safe working environment, and this includes the buildings in which work is carried out in (HSWA, 2015).

Accordingly, when thinking about occupancy of seismically vulnerable buildings, HSWA requirements must also be considered by those with responsibilities as Person Conducting a Business or Undertaking (PCBU). It should be noted that owners and tenants both have PCBU responsibilities for a given building.

The HSWA does not have specific provisions that relate to seismically vulnerable buildings. However, in its June 2018 policy guidance, WorkSafe indicates that if building owners and tenants are meeting the Building Act 2004 requirements, they will not enforce to a higher standard under HSWA (Worksafe 2018). This indicates that occupants might remain in the building while remediation is taking place within the time frames set out in the Building (Earthquake-prone Buildings) Amendment Act 2016, provided that PCBUs are keeping abreast of new or emerging information that is relevant to the building's performance in an earthquake.

HSWA requires that building owners and employers must protect the health and safety of workers as far as is reasonably practicable. The meaning of *reasonably practicable* outlined in Section 22 provides the following series of considerations:

(a) the likelihood of the hazard or the risk concerned occurring; and

(b) the degree of harm that might result from the hazard or risk; and

(c) what the person concerned knows, or ought reasonably to know, about—

(i) the hazard or risk; and

(ii) ways of eliminating or minimising the risk; and

(d) the availability and suitability of ways to eliminate or minimise the risk; and

(e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Viewed collectively, these considerations provide a balanced consideration for evaluating 'reasonable practicality'. However the key issue in relation to seismic vulnerability lies in how the first aspect of *likelihood* is regarded. As noted earlier, the common perception is that earthquakes causing the collapse of buildings and loss of life do occur reasonably frequently.

Research by Hatton et al (2021) has identified the key role that HSWA has in reducing disaster risk in New Zealand, and in motivating organisations to reduce health and safety risks of their employees and customers during an earthquake.

It is nevertheless apparent that there is a lack of alignment between the Health and Safety at Work Act and the Building Act. This stems from the focus in HSWA on eliminating risks once identified, and the lack of guidance on how the low likelihood of an earthquake large enough to cause life safety risks should be viewed against the likelihood of everyday workplace risks occurring, and the direct risks associated with the decanting or closure of a building.

3 SEISMIC RISK EVALUATION TOOLS

3.1 BRANZ Decision Framework

The BRANZ decision framework was developed in 2021 to guide decision making for low rating council-owned buildings. The principles and approach were acknowledged as being applicable to buildings generally, irrespective of ownership.

The focus of this decision framework is to enable both dimensions of risk outlined in the previous section to be taken into account, with a focus on evaluating the impacts of closure. Figure 1 provides an overview of the key steps, which are covered in more detail elsewhere (Brown et al 2022).

Step 1 involves having a good understanding of the findings of the seismic assessment. The framework emphasises that the starting point for the risk evaluation is an appropriately reviewed seismic assessment. This sends the signal that the subsequent decision needs to follow a measured process, emphasising that the nature of the risk is not one that requires immediate or urgent decision-making. With reference to the observations in Section 2.1 on the limitations of seismic assessments, this step can involve clarifying with the assessing engineer key aspects such as the *mode of failure and consequence statement* as required by MBIE's EPB methodology (MBIE 2017) and Part A of the seismic assessment guidelines (MBIE et al 2017).

Input information to the framework process includes:

- Step 2 - Exposure of people to the building risk
    - The maximum number of people in the building at any one time;
    - The average number of people in the building;
    - The average user time in the building (duration of use);
    - The average user time in the building (person-hours per week);

- Exposure of people outside the building
- The period of exposure – ie. the likely period of time until strengthening is undertaken

- Step 3 – Consideration of relevant interim risk mitigation measures
- Step 4 - Consequence of building closure
  - Ability to deliver service by other means
  - Impact on vulnerable communities (homeless, disabled, high needs, children, elderly)
  - Impact on neighbouring business
  - Impact on staff

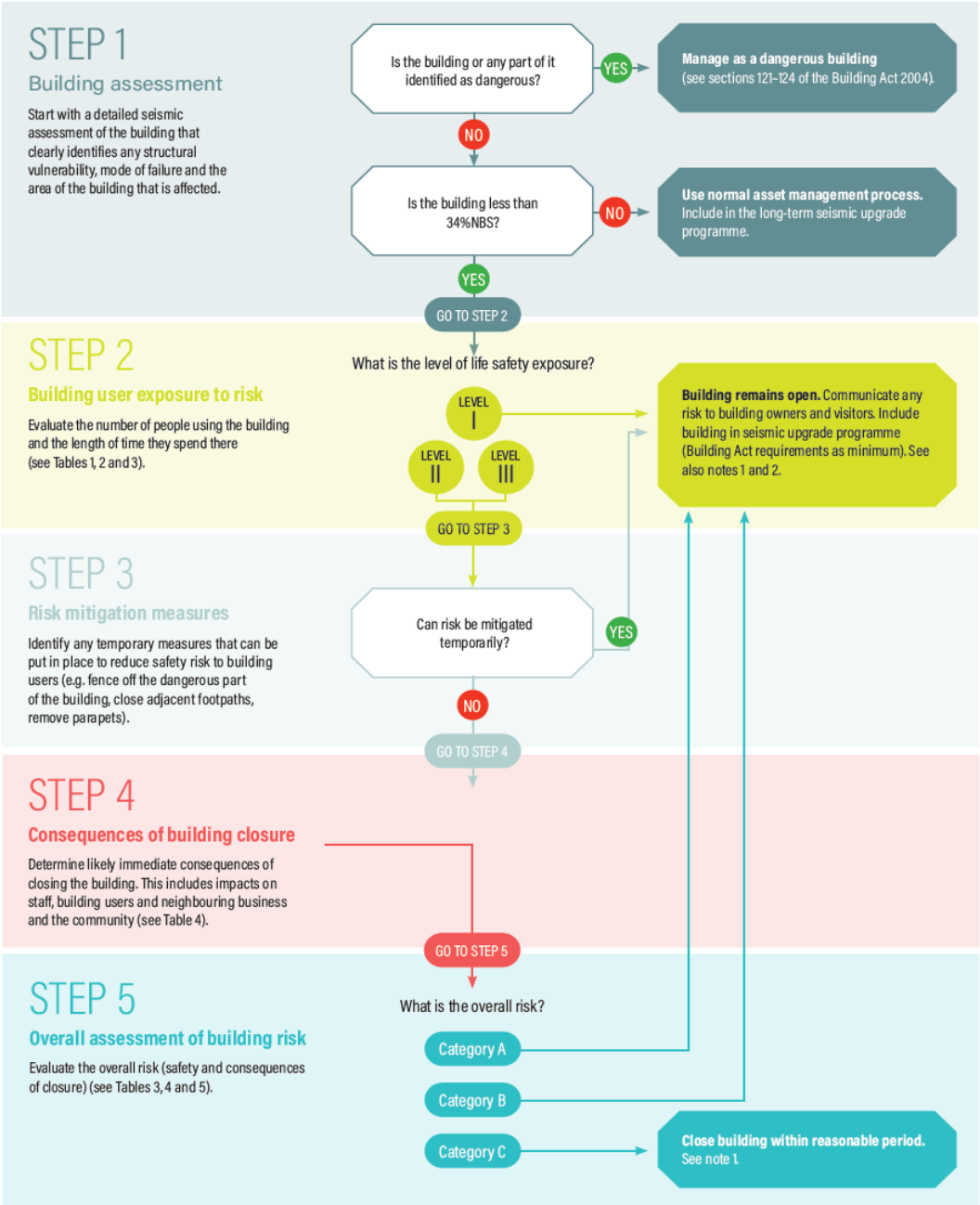

Figure 1: Overview of the BRANZ Decision Framework process (BRANZ 2021)

3.2 MBIE's Seismic Risk Guidance for Buildings

The document *Seismic Risk Guidance for Buildings* was released by MBIE in July 2022 with the primary aim of assisting those interpreting and making ongoing occupancy decisions on buildings based on the outcome of a seismic assessment (MBIE 2022). This guidance built upon the material in the BRANZ Decision Framework and broadened the application to the users, tenants, owners and their engineers of any low rating building. Tools and language are provided for engineers and their clients to discuss seismic assessments and to enable owners and tenants to make risk-informed decisions.

The document contains a number of key messages aimed at putting the risk posed by low rating buildings into context, including:

- *In general, a low %NBS rating is no need for alarm or immediate action. The life safety risk is still very low*, and
- *In most cases, vacating a building should be a last resort means of mitigating life safety risk for building occupants*

The guidance also provides key messages to help people in their understanding of what %NBS as a metric does (and more importantly) doesn't mean. An important part of the overall risk communication process involves de-mystifying perceptions around '%NBS' and low seismic ratings for less technical audiences. These messages include:

- *The aim of the %NBS metric is to provide a relative assessment of seismic risk. It is not a predictor of building failure in any particular earthquake.*
- *While a low %NBS rating does indicate a heightened life safety risk in the event that an earthquake occurs, it does not mean that the building is imminently dangerous.*

An additional key message around low %NBS ratings is that they reflect the presence of structural shortcomings and a lack of resilience in structural systems, not the levels of shaking at which buildings overall might fail.

The guidance also notes that for Importance Level 3 and 4 buildings it is more appropriate to make occupancy decisions based on NBS ratings corresponding to 1 in 500 year events (ie. IL2).

The MBIE Seismic Risk Guidance is regarded by industry as a valuable point of reference, and is recognised as providing a moderating influence on decisions in relation to low-rating buildings.

4 APPLICATION OF THE TOOLS IN PRACTICE

Seismic risk evaluations for occupancy decision purposes have been undertaken by the author for a number of government agencies, city and district councils and other organisations over the past five years.

All of these risk evaluations have had the same fundamental driver – *Is it appropriate to continue to occupy this building that has a seismic rating of less than 34%NBS?* However they each have a different organisational context, and associated set of risk perspectives and tolerances, which are typically anchored back to PCBU responsibilities and accountabilities. Also, in terms of the consequence of closure, there are different aspects and scales of the community affected (eg. a community hall vs an acute services hospital building).

Some risk evaluation reports are reviewed by governance levels within organisations – for example elected council or school board trustees, and appointed board members. Accordingly, while the basis for the risk evaluations is the same, the level of detail requested in some areas can differ. The use of less technical language and 'earthquake jargon' is however a common necessity. This in itself highlights the additional treatment required beyond standard seismic assessment reports.

The material in the BRANZ Decision Framework and MBIE's Seismic Risk Guidance as outlined in the previous section are used as the basis for all seismic risk evaluations undertaken by the author, which are qualitative in nature. Additional elements have been developed in order to enhance communication of the earthquake risk, as summarised in the following sub-sections.

4.1 Indicative levels of earthquake shaking and associated likelihoods

As indicated earlier, one of the 'missing pieces of the seismic assessment puzzle' is conveying a sense of the relative earthquake intensities that are likely to give rise to 'failure' of the element identified in the assessments, and of the overall structure.

In order to convey a broad sense of how large (rare) an earthquake is likely to be required to cause the life safety risk, the indicative earthquake shaking intensities and likelihoods listed in Table 1 can be used.

Table 1: Indicative earthquake shaking intensities and likelihoods

Intensity	Frequency	Indicative Return Period
Moderate	Infrequent	100 years
Significant	Less frequent	500 years
Major	Rare	1,000 years
Severe	Very Rare	2,500 years

The use of the term 'moderate' in this context is meant in the common or general sense of the word and not a specific correlation to the legal moderate earthquake used in the definition of earthquake prone buildings in the Building Act.

When indicating how structures are likely to perform under these different levels of shaking, qualitative risk descriptors can be used. An example of this is:

> *The nature of this vulnerability is such that structural failure is **unlikely** in either moderate, more frequent earthquakes. However under significant, less frequent earthquake shaking, failure of sections of the building is **more likely** to occur.*

Forming and expressing a view in this way involves looking beyond the calculated level of loading at which the ultimate capacity of individual elements is exceeded when measured against current standards, and careful consideration of the likely modes of failures.

4.2 Visual representation of risk

MBIE's seismic risk guidance contains figures which convey the components of risk in a two-axis format (Figures 3 and 5, MBIE 2022). These figures use colour shading to convey risk aspects in a non-specific way. Figure 5 in particular reinforces the key message that it is only a small proportion of buildings rating less than 34%NBS for which decanting is warranted.

These figures have been adapted into a risk matrix format to enable more specific reference in seismic risk evaluations, as shown in Figures 2 and 3 following. Figure 2 provides a means of relating the level of life safety risk to the degree of exposure of people to the building vulnerabilities and the time before remediation.

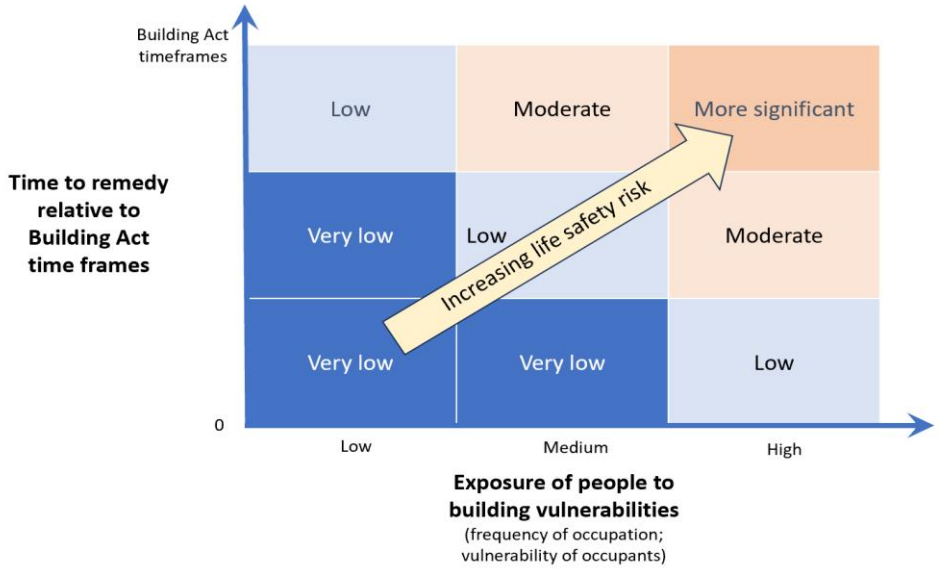

Figure 2 Evaluating Life Safety Risk (adapted from Figure 3, MBIE 2022)

Figure 3 then evaluates the life safety risk obtained from Figure 2 against the consequence (risk) of direct closure.

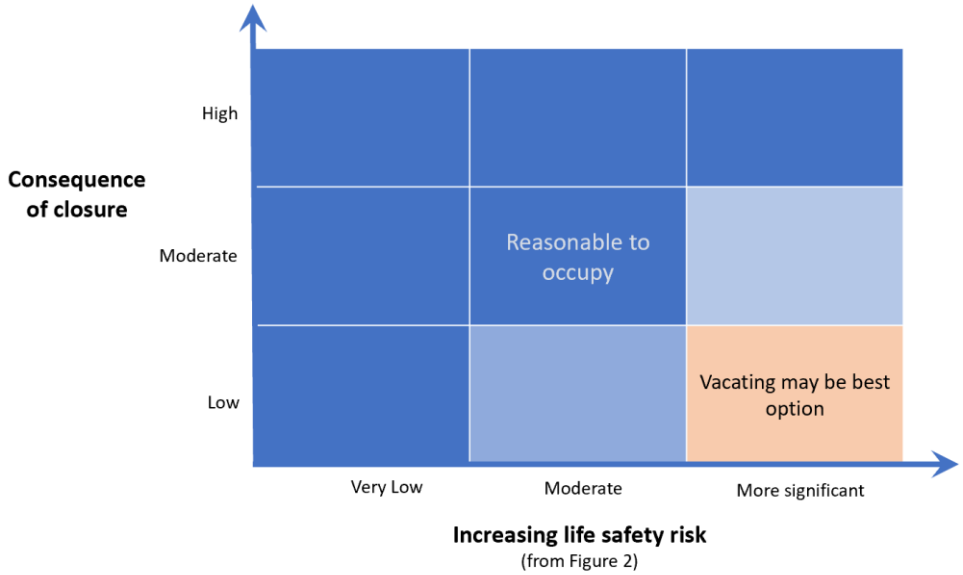

Figure 3 Overall Risk Assessment (adapted from Figure 5, MBIE 2022)

5 CASE STUDIES

Some key points and outcomes from a sample of recent evaluations of different types of buildings with ratings less than 34%NBS for continued occupancy risk are summarised below.

Car parking building

- A multi-storey council-owned car parking building constructed in the 1980s with precast concrete floors and had been closed upon receipt of an earthquake prone building notice. There was a desire to re-open the building for public use.
- The risk exposure for people in car parking buildings involves only short periods of time that people are in the building, in contrast to an office or residential building.

- The risk evaluation supported re-opening of the building, but only after mitigation of the floor system which had specific vulnerabilities.

Cathedral

- A parish cathedral with a tall bell tower constructed from reinforced concrete in the late 1950s had received a low seismic rating due to a range of structural vulnerabilities.
- The building was open but with restricted occupancy, and no use of the bell tower was permitted.
- The risk evaluation highlighted that the structure was unlikely to fail in moderate, more frequent earthquakes, and that the number and duration of large assemblies of people were short in relation to the likelihood of a major earthquake occurring.
- With respect to closure, there were concerns that prolonged closure and displacement would threaten the viability of the facility given the amount of time needed to plan and fund the required strengthening.
- The evaluation supported continued occupancy, and also enabled restrictions on use and areas of access to be lifted.

Civic Library

- A district council library with the main section constructed from reinforced concrete wall framing and a steel truss roof in the 1950s had received a draft low rating assessment.
- The risk evaluation was undertaken in parallel with the peer review and finalisation of the detailed seismic assessment.
- The nature of the seismic vulnerabilities and regular configuration of the building indicated that notwithstanding the low rating, structural failure causing a significant life safety hazard was unlikely to occur under moderate levels of earthquake shaking.
- The evaluation supported continued occupancy, and was used to brief affected staff ahead of the posting of the earthquake prone building notice.

6 OBSERVATIONS AND CURRENT NEEDS

Seismic risk evaluations form part of the process of explaining and communicating seismic assessments that result in low ratings. A key aspect of this is breaking down engineering and risk terminology into simpler terms for lay persons. This initial step in the risk communication process is fundamental to conveying the findings of seismic assessments in order to avoid being unduly alarmist, without denying the potential for large earthquakes to occur at any time. An associated step is de-mystifying %NBS ratings, as noted earlier.

Occupancy seismic risk evaluations are typically undertaken as a separate exercise to seismic assessments, butb sometimes in parallel with the finalisation of assessments. The process involves discussing the assessment with the assessing engineer, and also often the peer review engineer. There are advantages associated with having a different engineer undertaking the risk evaluation to the assessing engineer – having a fresh pair of eyes for the seismic risk evaluation provides a perceived independent perspective. The risk evaluation is also a separate exercise to any technical review which will have been undertaken against the seismic assessment guidelines without necessarily referring to wider seismic performance and risk considerations.

It is however desirable that these risk evaluations are undertaken by highly experienced earthquake engineers. Considerable risk judgements are involved in order to provide appropriate interpretation of the seismic assessment and commentary. The final stage of delivering a seismic risk evaluation also usually

involves presenting the findings to management and those working in the buildings, and the ability to draw upon a range of experience in presenting the information effectively and answering questions is a key part of building a sense of trust with the people most affected by the assessment outcome, and associated decisions.

A key connecting point between seismic assessments and risk evaluations is the *mode of failure and consequence statement* required to be included in the Assessment Summary Table by the EPB Methodology (MBIE 2017) and Part A of the Guidelines (MBIE et al 2017). It is observed that these statements are often given only cursory treatment by engineers. Having the assessing engineer look more closely at the mode of failure has however in some cases led to a review and increase of the rating as the likely response of the structure overall (including dependable secondary load paths) is more fully taken into account.

The risk evaluations recommend annual monitoring of all the information in the evaluation to see if any aspect of the risk has changed. An important aspect of this is monitoring future intentions in relation to likely time frames for addressing the identified vulnerabilities of the building, and that planning to address them is continuing. As well as meeting one of the aspects highlighted in the Worksafe Position Statement about keeping on top of new information, this provides all parties with a defensible position in the case that a major earthquake causing injuries or loss of life occurs prior to mitigation being implemented.

Occupancy risk evaluations can take time to develop, as they require a number of inputs from the owner and occupiers. The time to develop a comprehensive understanding of the nature of the risk should always offset the perceived need to quickly disclose seismic assessment outcomes as part of the duty of the PCBU to disclose risk to users of a building. Once the risk evaluation is completed, the results of the assessment do need to be actively communicated to building users. It is important to note that these risk evaluations do not state that the buildings are 'safe', but acknowledge the potential for low probability high impact earthquakes to occur.

Achieving a better alignment of HSWA and the EPB provisions of the Building Act remains an area of need in order to further reduce unnecessary decanting of buildings with low seismic ratings. From a practical risk management perspective, this simply requires guidance on how likelihood should be applied in the context of high impact low probability natural hazard events. While this doesn't seem like a significant exercise, it remains one that the respective regulators have not yet grappled with. This is fundamentally an exercise in understanding risk tolerance, the spectrum of risk and associated communication. The risk tolerability framework recently released by Toka Tū Ake EQC (Toka Tū Ake EQC 2023) provides a useful point of reference for moving towards this alignment.

7 SUMMARY

The process of explaining and communicating seismic assessments that result in low ratings continues to be a challenge for structural and geotechnical engineers. The impacts of the collapse of some buildings and loss of life in the Christchurch earthquake and poor performance of relatively modern multi-storey buildings in Wellington in the Kaikoura earthquake continue to be felt across New Zealand, and along with health and safety responsibilities, generates concern from some people that own or occupy buildings with low seismic ratings. Unfortunately the general perception is firstly, that the consequence of failure is the overriding risk consideration, and secondly that earthquakes causing the collapse of buildings and loss of life do occur reasonably frequently.

This is compounded by the lack of clarity as to how the Health and Safety at Work Act and the Building Act are intended to interface. This stems from the focus in HSWA on eliminating risks once identified, and the lack of guidance on how the low likelihood of an earthquake large enough to cause life safety risks should be viewed against the likelihood of everyday workplace risks occurring, and the direct risks associated with the decanting or closure of a building. This is in contrast to the earthquake prone provisions of the Building Act

which envisage people continuing to occupy buildings determined to be earthquake prone until the expiry of the statutory time frames.

Qualitative occupancy seismic risk evaluations based on the BRANZ and MBIE frameworks are proving to be a valuable tool in assisting owners and occupiers of low rating buildings in understanding the various risk components, including the consequence of closure. They have provided individuals and organisations with objective information relevant to their decision-making, and enabled the users of the buildings to be more comfortable in continuing to occupy low rating buildings, without declaring them to be 'safe'. An important part of this process is considering interim mitigation measures where necessary to address a significant vulnerability.

These evaluations also provide a pointer to how seismic assessments could usefully provide more information about how a building is likely to perform at different levels of earthquake shaking. This involves looking beyond the calculated level of loading at which the ultimate capacity of individual elements and the primary structure is exceeded when measured against current standards, and reflecting on how the building overall is likely to perform.

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