BUILDING
PERFORMANCE

Seismic Risk Guidance for Buildings

GUIDANCE

Using seismic assessments in occupancy decision-making

MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Te Kāwanatanga o Aotearoa
New Zealand Government

Ministry of Business, Innovation and Employment (MBIE)
Hīkina Whakatutuki – Lifting to make successful

MBIE develops and delivers policy, services, advice and regulation to support economic growth and the prosperity and wellbeing of New Zealanders.

The Seismic Risk Guidance for Buildings document is produced by the Building System Performance branch.

This document is issued as guidance under section 175 of the Building Act 2004.

While MBIE has taken care in preparing the document it should not be relied upon as establishing compliance with all relevant clauses of the Building Act or Building Code in all cases that may arise. This document may be updated from time to time and the latest version is available from MBIE's website at www.building.govt.nz

Information, examples and answers to your questions about the topics covered here can be found on our website: www.building.govt.nz or by calling us free on 0800 24 22 43.

First published July 2022

ISSN 978-1-99-104122-7

DISCLAIMER

This document is a guide only. It should not be used as a substitute for legislation or legal advice. The Ministry of Business, Innovation and Employment is not responsible for the results of any actions taken on the basis of information in this document, or for any errors or omissions.

Contents

1. Purpose

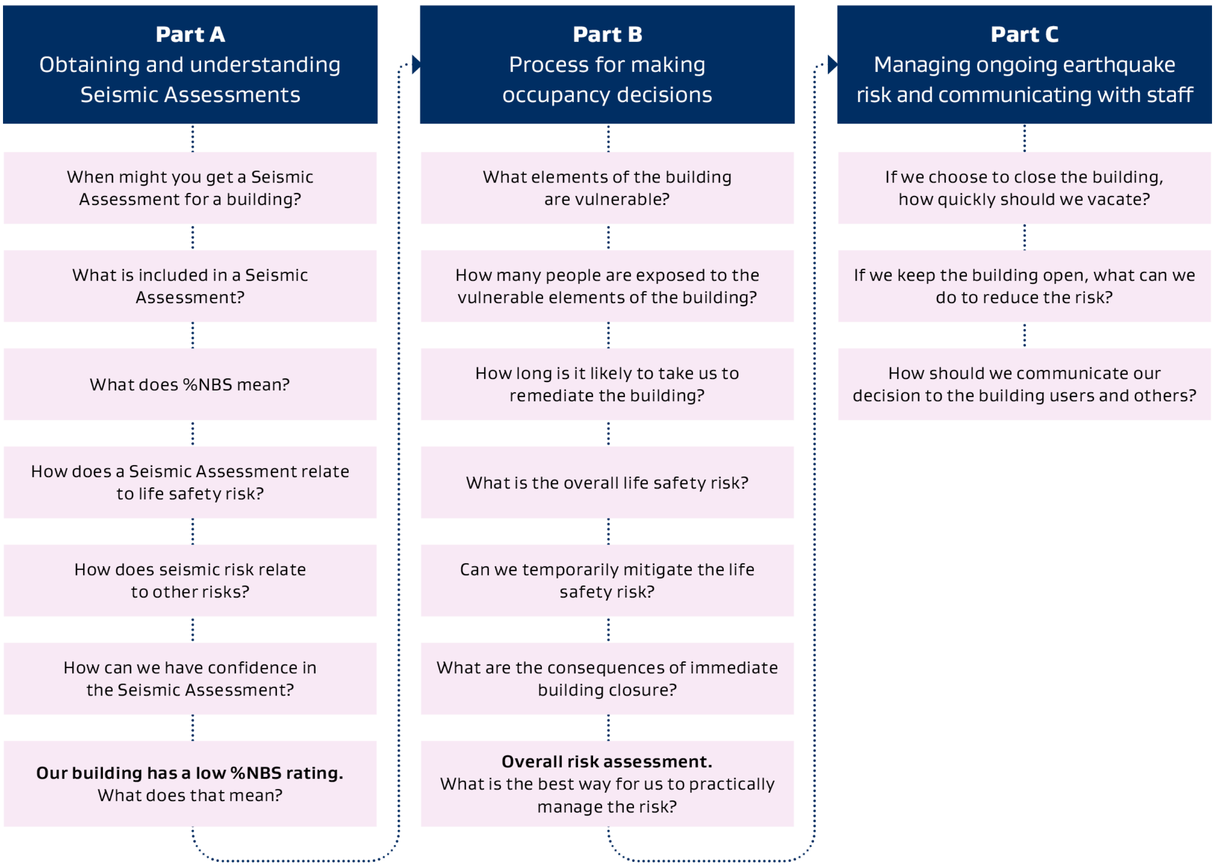
The purpose of this document is to help building users, tenants and owners understand seismic assessments of their buildings and make risk-informed decisions about continued occupancy of these buildings when they have a low seismic rating. It also provides the tools and language for engineers and their clients to discuss seismic assessments and what these mean for building performance in an earthquake.

What is in this document?

The document is in three parts.

- Part A provides background material on when to obtain and how to interpret a seismic assessment, including the limitations of the New Building Standard (%NBS) metric.
- Part B describes a process for building owners and tenants to go through when making decisions on occupancy of seismically vulnerable buildings.
- Part C provides guidance on how to manage ongoing earthquake risk and communicate this information with staff and other stakeholders.

Figure 1 Document overview



There are over 4200 buildings that have already been identified as earthquake-prone and many thousands more that have been or will be identified as seismically vulnerable. While these buildings do not meet the standards we require of modern buildings, they are not imminently dangerous and most continue to be occupied. Closing all these buildings would have a significant impact on the wellbeing of our communities and businesses. Seismic resilience is something we need to address over a period of years, so that we look after our communities today, while we work to reduce the impact of future earthquakes.

Key messages

- 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.
- In most cases, seismically vulnerable buildings can be occupied while you plan, fund and then undertake seismic remediation work.
- There is no legal requirement to close a building based solely on a low %NBS rating.
- The purpose of seismic assessments is to inform building owners and users about their building vulnerabilities, encourage strengthening of vulnerable buildings and lead to the improvement of our building stock over a reasonable time period.
- Understanding the relative vulnerability of different building elements, and potential consequences of failure of these elements, is always more important than the overall %NBS rating for a building.
- Occupancy decisions should be made only after all relevant information about the building has been obtained and the engineering assessment has been independently reviewed and finalised.
- If you are concerned about ongoing occupancy, you should consider the likelihood of an earthquake, the potential consequences of an earthquake and the temporary mitigation measures you can put in place to reduce risk.
- Compared to most business-as-usual risks, earthquakes are low probability. The potential consequences will depend on the seismic vulnerabilities of different building elements, the potential exposure of people to these vulnerabilities and the ability to temporarily mitigate the risk. You should also compare this risk against the consequences of immediate closure of the building.
- You cannot eliminate seismic risk. Even if a building is vacated, staff and building users will be exposed to seismic risk in their homes and other buildings.
- While planning seismic remediation work, you can mitigate risk to staff and other building users through emergency planning and training as well as restraining plant, services and contents within the building.
- It is best to communicate openly and honestly with building occupants about the information you have, what you don't know, your decision process, and measures you are taking to manage risk.

Acknowledgements

This guidance has been prepared by the Building Performance team at MBIE, with specialist support from a technical working group of industry professionals.

We would like to acknowledge and thank those who have contributed to the development of this guidance.

2. MBIE's Role

MBIE is the over-arching regulator of Aotearoa New Zealand's building system providing policy and technical advice on New Zealand's building system, rules and standards, and implementing building legislation and regulations to meet New Zealand's current and future needs.

Our role is to work with stakeholders to deliver fit-for-purpose, performance-based building regulation that protects public safety and property and helps lift the sector's performance. We work with a range of people across the building sector to ensure they understand their roles and responsibilities. We do this by providing clear and effective guidelines, information, and education.

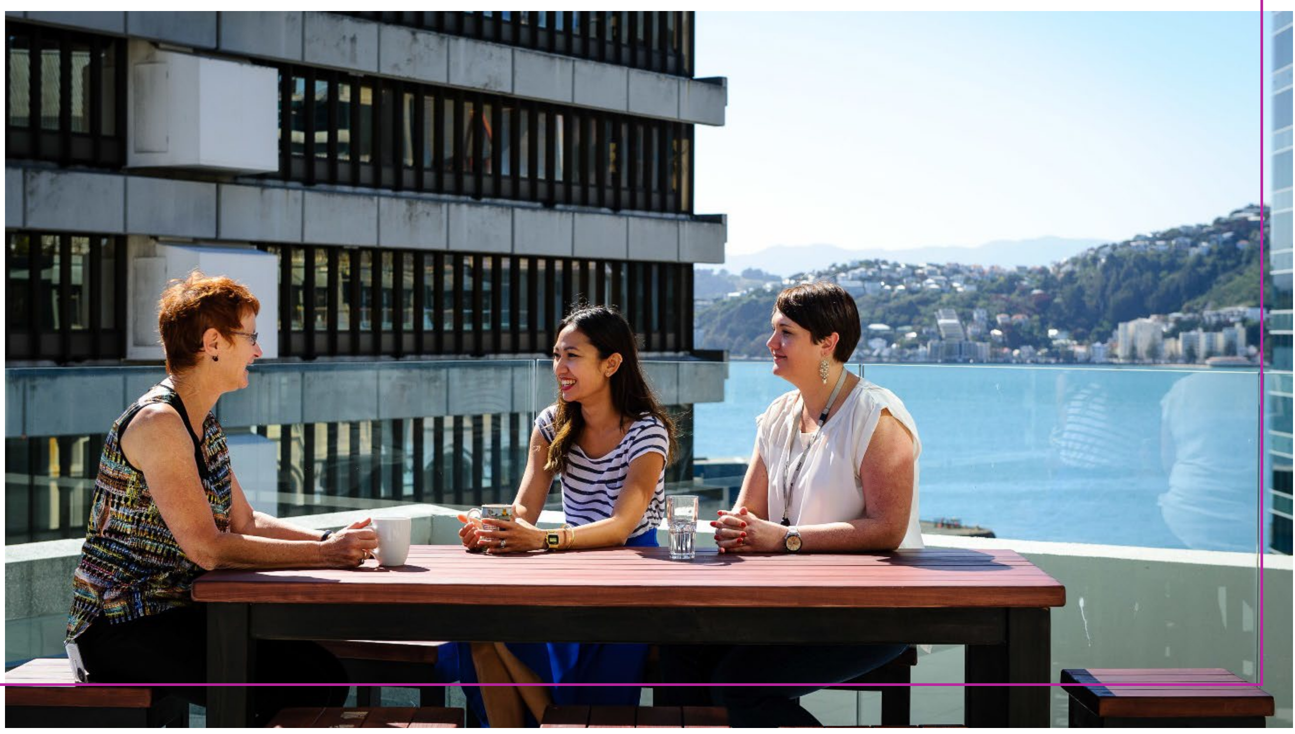
We have a range of statutory responsibilities in relation to the building system and administer Aotearoa New Zealand's building legislation. We also work with other regulators whose legislation has an impact on the building sector.

Our work includes:

- educating and informing people on building compliance
- monitoring and evaluating the overall performance of New Zealand's building system
- reviewing and updating building policy, laws and regulations
- occupational regulation (for example, Licensed Building Practitioners)
- oversight of the Building Code and setting and developing standards
- earthquake building-related guidance
- supporting investigations into building or product failures
- determinations and product assurance.

Who is this guidance for?

This document is for users, tenants, owners and their engineers. It addresses all building types, from office blocks to post-disaster critical facilities. In particular, it is for those interpreting and making ongoing occupancy decisions on buildings based on the outcome of a seismic assessment.



3. Part A: Obtaining and understanding seismic assessments

Background

Engineering design standards and our understanding of earthquakes have advanced over time, in particular as a result of learnings from the 2011 Christchurch and 2016 Kaikōura earthquakes. Consequently, many older buildings do not meet the standards required of new buildings.

The purpose of seismic assessments is to inform building owners and users about vulnerabilities in their buildings, encourage strengthening of vulnerable buildings and improve Aotearoa New Zealand's building stock over time. When the outcome of a seismic assessment is a low New Building Standard (%NBS) rating, this should be a trigger for planning, funding and implementing a seismic upgrade, addressing the identified vulnerabilities and mitigating risk. Section 3.6 explains %NBS ratings.

Most of the New Zealand Building Code focuses on the safety of building users. While some existing buildings are identified through a seismic assessment as seismically vulnerable, the risk to life is still relatively low for most buildings given the low likelihood of a significant earthquake occurring in a given location in the immediate future. While a low rating does indicate a heightened life safety risk in the event that a significant earthquake occurs, it does not mean that the building is imminently dangerous. In most cases, occupancy can be continued while mitigation work is planned and designed, and in some cases even while works are being carried out. Many building owners and tenants continue to occupy buildings with identified seismic vulnerabilities, as they work towards remediating the vulnerabilities identified.

3.1 Obtaining a seismic assessment for a building

As a building owner you will need to obtain a seismic assessment of your building if:

- the building has been identified by a territorial authority as being potentially earthquake-prone under the national earthquake-prone building programme, as per requirements in the Building (Earthquake-prone Buildings) Amendment Act 2016 (see Managing earthquake-prone buildings); or
- In certain circumstances where there is a change of use or a planned redevelopment (triggered by Sections 112, 115, or 133AT in the Building Act).

As a building owner or tenant, you may seek a seismic assessment of your building if:

- you are purchasing a property, or taking on a long-term lease;[1]
- you need to understand the current seismic risk profile of a building (for example as part of a risk evaluation exercise, or building portfolio planning); or
- insurers and other stakeholders request updated seismic assessments.

Aotearoa New Zealand has been through a time of significant change since the 2011 Christchurch and 2016 Kaikōura earthquakes. Knowledge gained from recent earthquakes has led to the introduction of new assessment guidance and has prompted more re-evaluation of seismic assessments. Generally, the seismic assessment of your building will not change unless there have been significant technical changes in how engineers assess the behaviour of buildings.

[1] This is so you can make informed decisions on the purchase or lease of a building. For a lease agreement this could include planning for seismic strengthening requirements before, during, or after a cycle of occupation.

If you are unsure whether you need to update your seismic assessment, talk to a suitably experienced Chartered Professional Engineer. They will let you know if there have been any changes that might affect the seismic assessment of your building. To find a Chartered Professional Engineer in your area, visit the Engineering New Zealand Te Ao Rangahau website https://www.engineeringnz.org/public-tools/find-engineer/.

> The understanding of the performance of concrete buildings in earthquakes has evolved rapidly in the last decade. The Seismic Assessment Guidelines (Red Book) were released in July 2017 to support the Building (Earthquake-prone Buildings) Amendment Act 2016 and is the regulatory method required when assessing a building under this piece of legislation. A seismic assessment gained prior to 2017 may still be of value to identify potential vulnerabilities, but frequently these do not include assessment of some critical components such as precast floors. In 2018, the chapter of the Seismic Assessment Guidelines on concrete buildings (Section C5) was updated to reflect lessons from the Kaikōura Earthquake and recent research. This update has become known as the "Yellow Chapter". The Yellow Chapter is considered the most up to date guidance available in Aotearoa New Zealand and should be used for seismic assessments informing continued occupancy decisions. Engineers must continue to use the July 2017 version of the Seismic Assessment Guidelines (Red Book) to identify earthquake-prone buildings under the Building Act 2004. For further information on the Red and Yellow chapter assessments please refer to What you need to know: Section C5 'Concrete Buildings' proposed revision and https://www.engineeringnz.org/news-insights/mbie-releases-yellow-chapter-findings/.

3.2 What a seismic assessment includes

There are two forms of seismic assessments in Aotearoa New Zealand:

- Initial Seismic Assessment (ISA) - An ISA is a simplified procedure to estimate the likely seismic rating of a building.
- Detailed Seismic Assessment (DSA) - A DSA is a detailed, modelled, assessment of the likely seismic behaviour of a building. Given their complexity, it can be appropriate for a DSA to be independently reviewed by another engineer. When doing a DSA, engineers will assess the vulnerability of any and all critical elements in the building (such as columns, floors, parapets, heavy exterior cladding) that could present a significant life safety hazard during an earthquake. Each of the elements gets a score expressed in terms of percentage of New Building Standard (%NBS) achieved.

What does the law say?

The Building (Earthquake-prone Buildings) Amendment Act 2016 (the Act) contains the requirement for territorial authorities to identify buildings or parts of buildings that are potentially earthquake-prone and to request engineering assessments for them from building owners. There are two main purposes, to:

- identify buildings that pose a higher seismic risk and disclose this to building users and the public; and
- require the seismic strengthening of the lowest performing buildings over a period of time.

The Act includes statutory timelines for remediating earthquake-prone buildings (from 7.5 to 35 years) and does not preclude continuing to use and occupy them in the meantime.

A building may be identified as a 'dangerous' building (Building Act 2004, section 121). This means that the building poses immediate danger to the people in or around the building in the ordinary course of events and action to protect people must be taken immediately. An earthquake-prone or seismically vulnerable building is not considered a dangerous building as an earthquake is not an ordinary event and is specifically excluded from the definition of a dangerous building in the Act.

When thinking about occupancy of seismically vulnerable buildings, the Health and Safety at Work Act 2015 (HSWA) must also be considered. Building owners and employers must protect the health and safety of workers as far as is reasonably practicable. The consideration of reasonably practicable (HSWA, section 22) includes a balanced consideration of five factors: the likelihood of the hazard, the degree of harm that might result, knowledge of the risk, ability to eliminate or minimise the risk, and (after all other matters have been considered) the cost of mitigation relative to the risk.

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. This allows for the possibility 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.

‘New Building Standard’ refers to the minimum life safety requirements for a new building set out in clause B1 of the New Zealand Building Code. The lowest score (ie worst performing element) will determine the overall earthquake rating (%NBS) for the building. The element governing the earthquake rating for the building is referred to as the “Critical Structural Weakness”. All buildings have a Critical Structural Weakness.

Another term sometimes found in a seismic assessment is “Severe Structural Weakness”. This denotes a specific vulnerability which is difficult for engineers to quantify and has the potential to cause extensive life-threatening consequences.

Seismic assessments should describe elements from the building’s primary structure, which provides the overall stability to the building (for example, foundations, columns and beams), and relevant secondary structural and non-structural elements (for example stairs and heavy external cladding panels).

For key primary and secondary elements, alongside a %NBS score, there should be a description of their anticipated response and vulnerability to different degrees of earthquake shaking and where <34%NBS, a brief description of the consequences of their failure.

Understanding the relative vulnerability of different building elements, and potential consequences of failure, is always more important than the overall %NBS rating for a building. For example, vulnerabilities in the primary structure may have significantly different consequences of failure than vulnerabilities in a secondary structural element. Your engineer can help you understand the vulnerabilities and potential consequences. This is particularly important when making mitigation and occupancy decisions.

3.3 What %NBS means

%NBS is an index used to characterise the expected seismic response of a building to earthquake shaking. It helps identify buildings that represent a higher seismic risk than a similar new building, built to current Building Code standards.

There are many variables for seismic assessment and there can be uncertainty in estimating the relative life safety risk for a particular building. Among other factors, this uncertainty comes from the random nature of earthquakes, the complex response of buildings to earthquake shaking particularly at the point of structural failure, the variability in construction quality, and the lack of accurate records of buildings’ construction. The uncertainty arising from these factors mean that %NBS should be viewed as indicative of the engineer’s confidence in the expected seismic performance of the building rather than an exact prediction.

The purpose of the %NBS metric is to provide a relative assessment of seismic risk. It is not a predictor of building failure, nor is it an assessment of safety in a particular earthquake. Given the range of variables associated with earthquakes outlined above, no person can make categorical statements about safety, just relative degrees of risk.

The %NBS metric was specifically developed to support the implementation of the earthquake-prone building legislation. This legislation seeks to quantify the seismic performance of buildings in relation to an equivalent new building, and a simple metric was needed to classify buildings. %NBS building ratings were not intended to be used to support building occupancy decisions.

There are many variables that ultimately determine how a building responds to a particular earthquake including the earthquake itself, local geological and geotechnical features, the characteristics of that specific building and how all of these factors interact. For example, short sharp earthquakes will have the most significant impact on stiff, low-rise buildings. Long rolling earthquakes will impact high-rise buildings most significantly.

3.4 How a seismic assessment relates to life safety risk

When thinking about life safety risk[2] to building users, %NBS and the specific seismic *vulnerabilities* identified in a seismic assessment are only part of the equation. The *likelihood* of an earthquake occurring, and the potential *exposure* of people are also important.

Risk is a combination of *likelihood* and *consequence*. In this case *likelihood* is the potential for a damaging earthquake to occur. Large earthquakes are rare events.

The potential *consequences* are a combination of the building *vulnerabilities* identified in the seismic assessment and the potential *exposure* of people to *vulnerable* parts of the building. The level of exposure can depend on how many and how frequently people use or are near a vulnerable building element. Exposure over time is also important; that is, how long are people going to use the building before it is remediated? The less time people are exposed, the lower the overall risk.

%NBS ratings for buildings include broad parameters that reflect likelihood (ie seismicity of the region) and peak exposure for high occupancy buildings. But when decisions are being made around continued occupancy, closer consideration of the specific risk components is warranted.

> Life safety risks are often quantified in terms of the annual fatality risk for an individual. New buildings are designed with a 1 in 1,000,000 annual fatality risk due to earthquakes.
>
> An earthquake-prone building (<34%NBS) is estimated at 1 in 40,000-100,000 annual fatality risk. Flying in an aeroplane has an estimated fatality risk of approximately 1 in 700,000 and driving a car in New Zealand is estimated to carry a fatality risk of 1 in 20,000.

3.5 Having confidence in the latest seismic assessment for a building

There are two types of seismic assessments you can get: an initial seismic assessment (ISA) or a detailed seismic assessment (DSA). Any decision to change the occupancy of the building should be based on a sound and complete understanding of the building and its potential vulnerabilities. Generally, an ISA does not provide enough detail to make a decision about occupancy of a building.

A DSA used to inform continued occupancy decisions should be based on the latest assessment guidelines available (eg 2018 update of section C5 of the Seismic Assessment Guidelines, the "Yellow Chapter", for a concrete building). The latest guidelines will provide the most up to date knowledge on the potential vulnerabilities in the building.

A comprehensive DSA will include:

- %NBS rating for the building
- %NBS scores for critical building elements, description of vulnerabilities and identification of the critical structural weakness
- the physical consequences of any potential failure
- identification of the portion(s) of the building that is affected
- consideration of any adjoining structures that might affect the response of the building in an earthquake such as shared structural roof or wall elements
- consideration of building condition, presence of other hazards (eg hazardous substances), or geological hazards in proximity to the building (eg unstable ground) that might affect the performance of the building and/or pose additional risks to building users.

A DSA should be carried out by an experienced chartered professional engineer. Seismic assessments are typically more challenging than new building design, so need to be carried out by structural and geotechnical engineers experienced in the field.

An independent review of a DSA is useful, especially for bigger, more complex buildings or where there are significant consequences related to the rating. %NBS is a very blunt measure of likely building performance in an

[2] "Earthquake ratings are based primarily on life safety considerations rather than damage to the building or its contents unless this might lead to damage to adjacent property – Part A, Section A3, Technical Guidelines for Engineering Assessments"

earthquake and it is important that your engineer talks through the nature of the building vulnerabilities. This includes highlighting any uncertainty in the assessment, and the potential consequences of failure for vulnerable building elements.

Occupancy decisions should not be made until you have received an independently reviewed seismic assessment and had time to discuss and work through Part B of this document with your engineer and other key stakeholders. Receipt of a seismic assessment does not change the seismic vulnerability of your building. You should take time to carefully review and understand the DSA so that you can decide how best to manage the risk without creating unintentional harm.

A building closure decision can be difficult to reverse, so take time to make sure you are confident in the information you have received and decision process you have followed.

Making occupancy decisions on importance level (IL) three and four buildings

Some buildings are built to withstand larger earthquakes than others. A building is given an importance level (1-5) based on occupancy, its post-disaster function and potential environmental consequences of failure. Buildings with higher importance levels are designed to withstand larger, less frequent earthquakes. Most buildings are importance level 2 (IL2). For all buildings, regardless of importance level, short-term occupancy decisions should focus on life safety risk in the near term: that is considering earthquakes that are more frequent and hence smaller. Therefore, it is more appropriate for occupancy decisions for IL3 and IL4 buildings to be based on the design earthquake for an IL2 building, that is a 1 in 500-year event. Further consideration of risk in high occupancy buildings is factored into the decision guidance in Part B.

3.6 Understanding what a low %NBS rating means

If a building is calculated as less than 34%NBS using the Red Book assessment guidelines, it may be classified as 'Earthquake-prone' under the Building (Earthquake-prone buildings) Amendment Act 2016. This means the building is more likely to sustain damage following a moderate earthquake and, in the event of an earthquake, there is a higher risk to users than there is in a new building. Over time, the law requires this risk for earthquake-prone buildings to be reduced.

If your building is greater than 34% but less than 100%NBS, this also indicates your building poses a somewhat higher risk to users than a new building does. There is no requirement for you to do anything under the Building Act, but over time you may want to improve the building's seismic resilience.

In general, a low %NBS rating is no need for alarm or immediate action. The life safety risk is still very low.

At the time of the 2016 Kaikōura earthquake, there were over 700 earthquake-prone buildings in Wellington. Due to the nature of that earthquake, very few of these buildings received damage, much less failed. Most were occupied at the time, and many of those that have not yet been strengthened continue to be occupied.

Further references

MBIE online learning modules on earthquake-prone buildings: Building Performance: All courses.

4. Part B: Process for making occupancy decisions

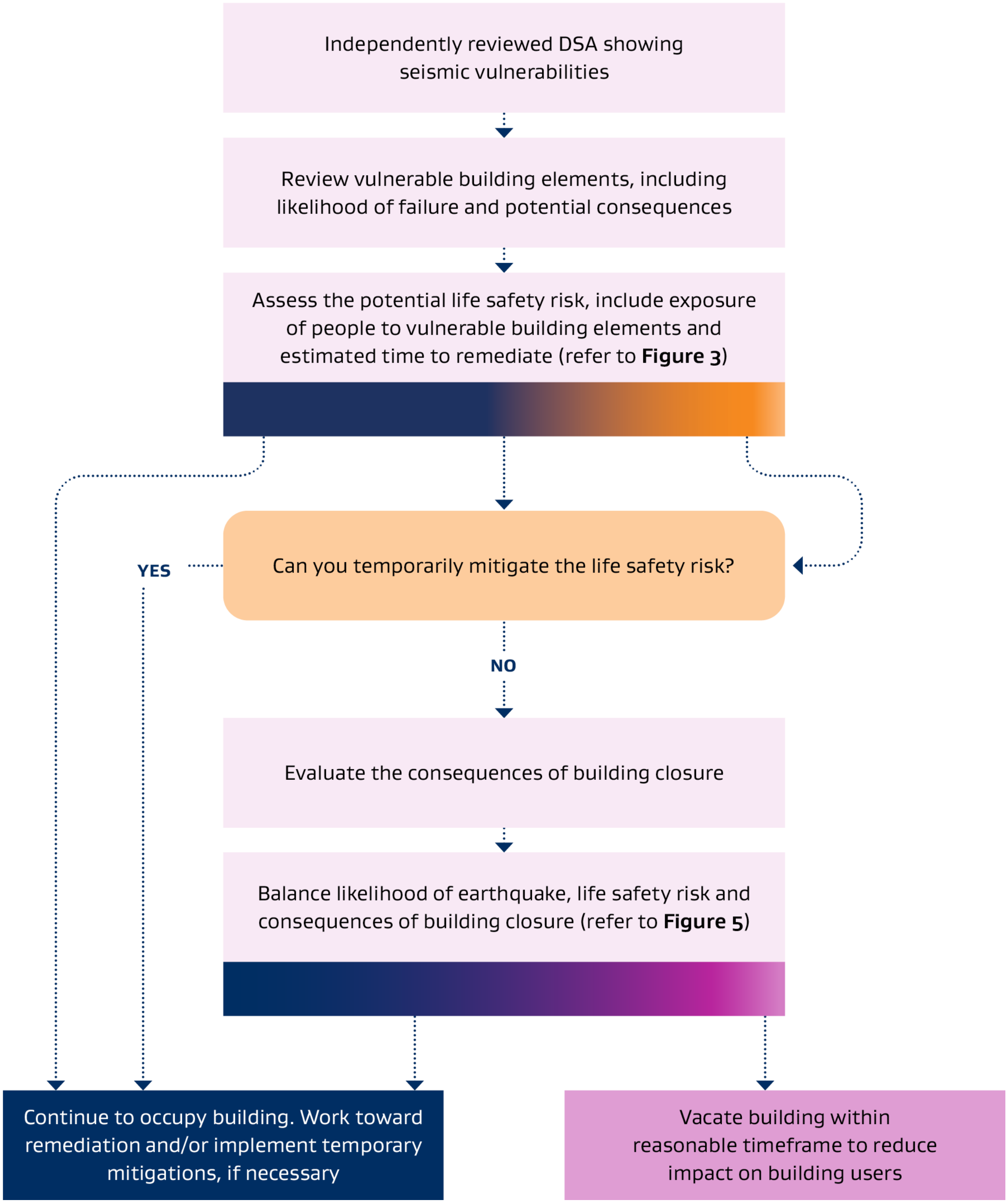
Occupation of seismically vulnerable buildings can be an emotive topic and the fear of injury or death, moral obligation toward safety of building users and/or personal liability can weigh heavily on the shoulders of decision-makers.

The following section provides a set of questions that you, as a building owner or tenant, can ask yourself and your engineer as you make occupancy decisions for a seismically vulnerable building. The questions will help you to interpret the seismic assessment, understand what this means in terms of life safety risk, assess the consequences of building closure and ensure your decision is a balanced assessment of risk. This structured approach to decision making will also help you to communicate your decision with key building stakeholders, including staff, tenants, and other building users. The decision process is summarised in Figure 2.

If you follow the process outlined in this section, you will have the information you need to document and justify your decision. In most cases, seismically vulnerable buildings can justifiably be occupied while mitigation actions are planned and designed.

Making a decision about continuing to occupy an earthquake-prone building can be thought of as a comparison of two different risks. The risk of an earthquake has potential consequences for injury and loss of life but has a low likelihood of occurring. The risk of building closure has arguably lesser consequences on building users, staff and operations but the consequences are almost certain to occur if the building is closed. Closing a building does not mean that earthquake risk for building users has been eliminated. Many building users will face earthquake risks in their homes or other buildings they are displaced to. There are risks in all decisions and you need to consider the benefits and consequences of all decisions and who is bearing them.

Figure 2 Occupancy decision process



Key

Third box: The transition of colour from blue (left) to orange (right) represents an increasing life safety risk.

Sixth box: The transition of colour from blue (left) to purple (right) represents an increasing balance of life safety risk vs consequence of closure.

4.1 Identify which elements of a building are vulnerable

Focus your occupancy decision on the vulnerabilities of all critical building elements and the consequences associated with potential failure of each element. In particular, understand which elements of the building any low %NBS scores apply to and evaluate the vulnerability of each of those elements to failure. Also consider the likelihood of an earthquake which could trigger failure of those building elements.

Remember that failure of structural elements that support other parts of the building, such as a column or a wall, are likely to have greater consequences than failure of elements that only support their own load, such as heavy cladding panels. Your engineer can help you think through these differences.

Vulnerability to precast (particularly hollow-core) floors can be concerning. Generally, however, this presents a lower life safety risk than vulnerability in a column, as the floor only supports its own weight. In many cases, the precast floors in the corners of a building are the most vulnerable and avoiding these areas can be a good way to reduce risk while mitigations are being planned. Ask your engineer to identify the regions in your building with the most vulnerable precast floors.

4.2 Understand how many people are exposed to the vulnerable elements of a building

Consider how many people might be exposed to the vulnerable building elements on a daily basis. This includes consideration of:

- peak and average number of users in the affected area;
- how long people spend in the affected part of the building at any one time (for example, are people passing through or do they spend eight hours a day there?); and
- mobility requirements of the building users (are they young, elderly, disabled, likely to have difficulty with mobility or vulnerable in any other way that might impact their ability to evacuate after an event?).

The more people that are exposed to a vulnerable building element, and the more time they spend in or around the element, the higher the exposure risk.

4.3 Evaluate how long it may take to remediate a building

Consider how long building users might be occupying the building before it is strengthened.

The period will likely depend on:

- the complexity of the seismic retrofit
- the length of time it will take to design and consent the remediation works
- challenges around relocating operations or finding alternative delivery mechanisms
- whether the works can be carried out in a (part) occupied building
- the availability of funding to carry out works, and
- the statutory timelines for earthquake-prone building remediation.

Consider this in the light of how likely it is that a damaging earthquake will occur during this time.

Small mitigation or localised measures can be put in place in a matter of weeks to months, while more general strengthening will take months to several years (refer to mitigations below). Non-structural elements are typically easiest to remediate, followed by secondary structural elements, with the primary structure and foundations being most difficult.

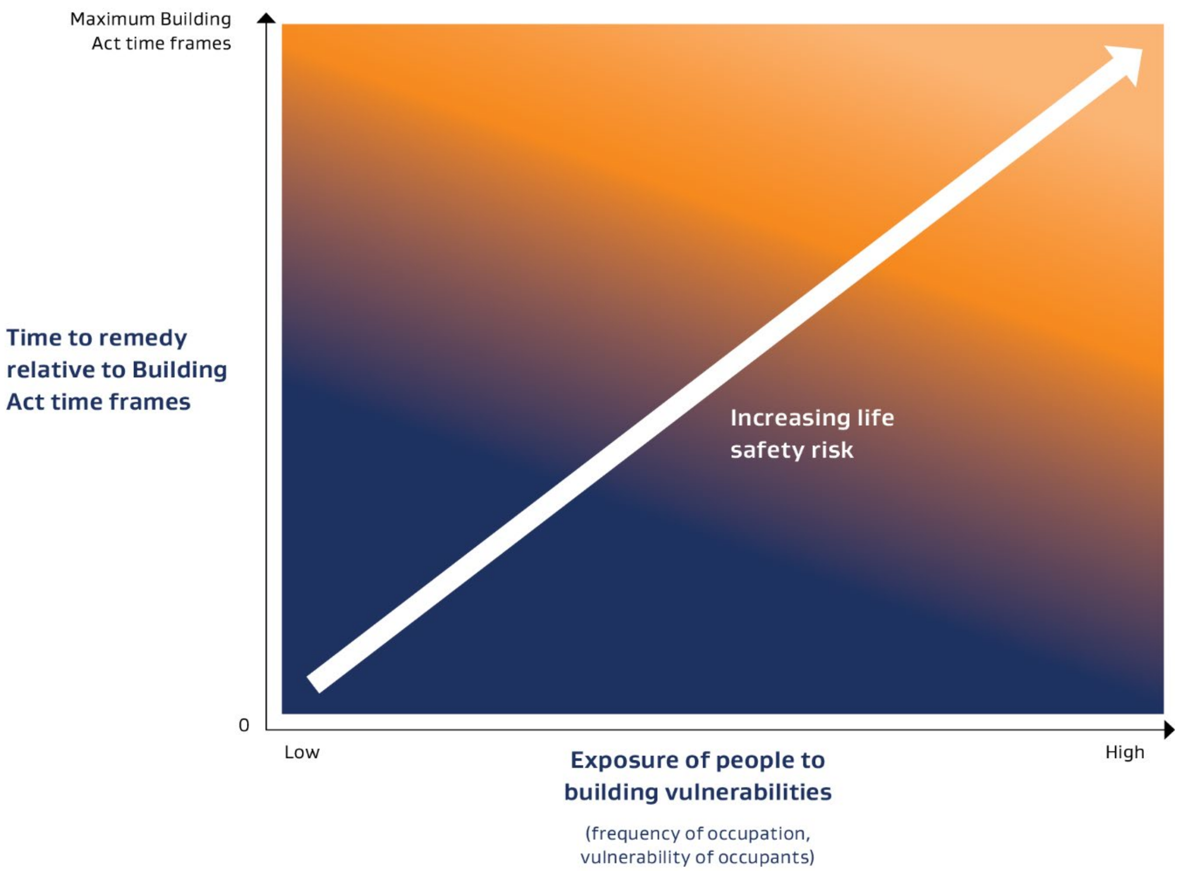
4.4 Identify the overall life safety risk

Once you understand the exposure of people to the vulnerable building elements, the duration people will be exposed to the increased risk, and the likelihood of a damaging earthquake occurring during that time, you can determine the overall life safety risk. It is useful to think of the time people will be exposed to the risk relative to the times set out in the Building (Earthquake-prone Buildings) Amendment Act 2016, as these times account for the Seismic Risk Area a building is in and hence the likelihood of an earthquake occurring in the region. If you are planning to remediate within or significantly faster than the times set out in the Act, you are significantly reducing the risk to building users.

Figure 3 illustrates one way to evaluate the level of life safety risk for your building, based on the exposure of people to the seismic vulnerabilities in the building and the expected time to remediate. Figure 3 shows how life safety risk increases with higher exposure of people and longer periods before the risk is remediated. How you evaluate the life safety risk, and what is considered low or high 'exposure of people' will depend on your organisation's own risk tolerance.

For example, an office building has a seismic assessment that identifies a seismic vulnerability that could affect the building's primary structure. If the building has a peak occupancy of 200 people that spend eight hours per day, this is a fairly high exposure for building occupants. Assuming it will take 12 years to plan and carry out remediation work and the building is in a high hazard zone, 12 years from now is close to the maximum remediation time set out in the Building (Earthquake-prone buildings) Amendment Act 2016. Using Figure 3, a high exposure and long time to remediate (relative to Building Act timeframes) means the life safety risk is relatively high, although does not present an immediate danger. This risk can be reduced through temporary mitigation measures and needs to be considered alongside the potential impacts of building closure (see next steps).

Figure 3 Evaluating life safety risk



4.5 Identify whether you can temporarily mitigate the life safety risk

If only part of the building is at risk, you can look at options to reduce or avoid use of these vulnerable parts of the building. If this is not an easy option, then talk to engineers about potential physical risk mitigation measures including their cost and impact on building element vulnerability.

Temporary mitigation measures include:

- closing parts of the building where structural failure could occur in more frequent earthquakes
- removing, propping or tying back the high-risk features of the building such as chimneys, parapets, or heavy cladding
- cordoning areas where exterior secondary structural elements may fall
- moving affected services to reduce building occupancy, or
- limiting access to higher risk areas of the building.

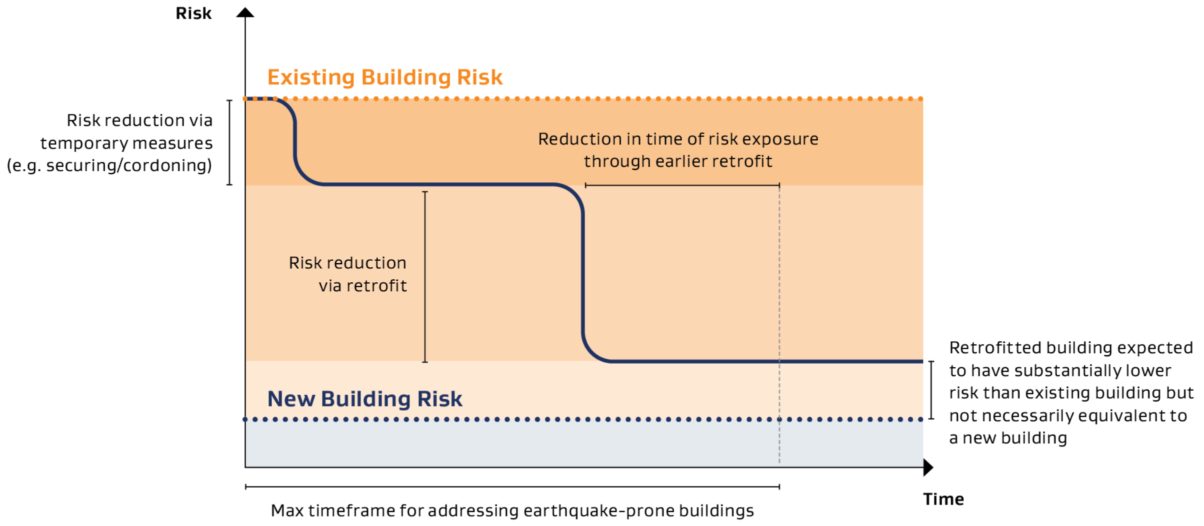
There are also a number of permanent mitigation measures that could be implemented over time:

- bracing, strengthening and addressing hazards in stairwells and exits
- bracing services and restraint or replacement of heavy ceilings, or
- staged/incremental strengthening.

Many of these items can be addressed while people continue to occupy the building. Ask your engineer how effective the proposed measures are at reducing the risk to the building users. Each mitigation measure undertaken will reduce the risk. The earlier mitigation measures are taken, the lower the overall risk for building occupants.

In the office building example, temporary mitigation could involve moving people away from the higher risk areas and allowing flexible working from home arrangements.

Figure 4 Impact of seismic risk mitigation



4.6 Understand the consequences of immediate building closure

Consider the immediate impact of closing the building. In many cases the certain consequences of closure outweighs the uncertain consequences of an earthquake (which is unlikely to occur prior to remediation).

Consider the impact on:

- Building / business services: can you continue doing your business without use of the building? Do you have ways to deliver services through other means (eg online) or in another location?
- Customers or building users: will building closure adversely impact customers who rely on your service? Do you have vulnerable customers/users and will they be able to meet their needs elsewhere?
- Tenants: will tenants and their customers be adversely affected?
- Staff: will building closure cause unreasonable inconvenience or stress to staff? Will this have an impact on staff wellbeing? For example, could building closure lead to job losses or unsuitable working conditions elsewhere (including seismic risk)?
- Neighbouring businesses/community: will closure of the building have impacts to neighbouring buildings and/or surrounding community? Is this impact material to you and your business?

How you measure each of the impacts will depend on your organisation's own risk tolerance and organisational priorities. For example, some organisations will place high importance on supporting their community, while others may have vulnerable customers that are a high priority. If you have a risk management framework or set of strategic objectives, this could be a useful frame for measuring building closure consequences against. In the office building example, the closure consequences could be considered moderate due to ability to work from home, but we should account for increased potential for staff isolation.

Where possible, talk through the potential impacts of closure with building users. Many decision-makers fear staff reaction when considering ongoing occupancy of a seismically vulnerable building. Talking with staff can help you understand the likely consequences of closure on building users. Discussing issues with staff before a decision is made can help build confidence in the decision process.

4.7 Complete an overall risk assessment: identify the best way to practically manage the risk

You should assess the potential for life safety risk in the event of an earthquake and the immediate consequences of closure. Figure 5 below is an example of how you can balance the life safety risk (from Figure 3) and the consequences of closure, to evaluate whether or not you should vacate your building. As Figure 5 shows, the overall risk assessment (and associated occupancy decision) indicates that building closure decisions are more likely in situations where the life safety risk is higher and there are fewer consequences of closure.

For example, take the office building example used earlier. Figure 3 indicated a relatively high life safety risk. The closure consequences (above) are considered moderate. Combining these on Figure 5 shows that maintaining occupancy might be the most reasonable decision.

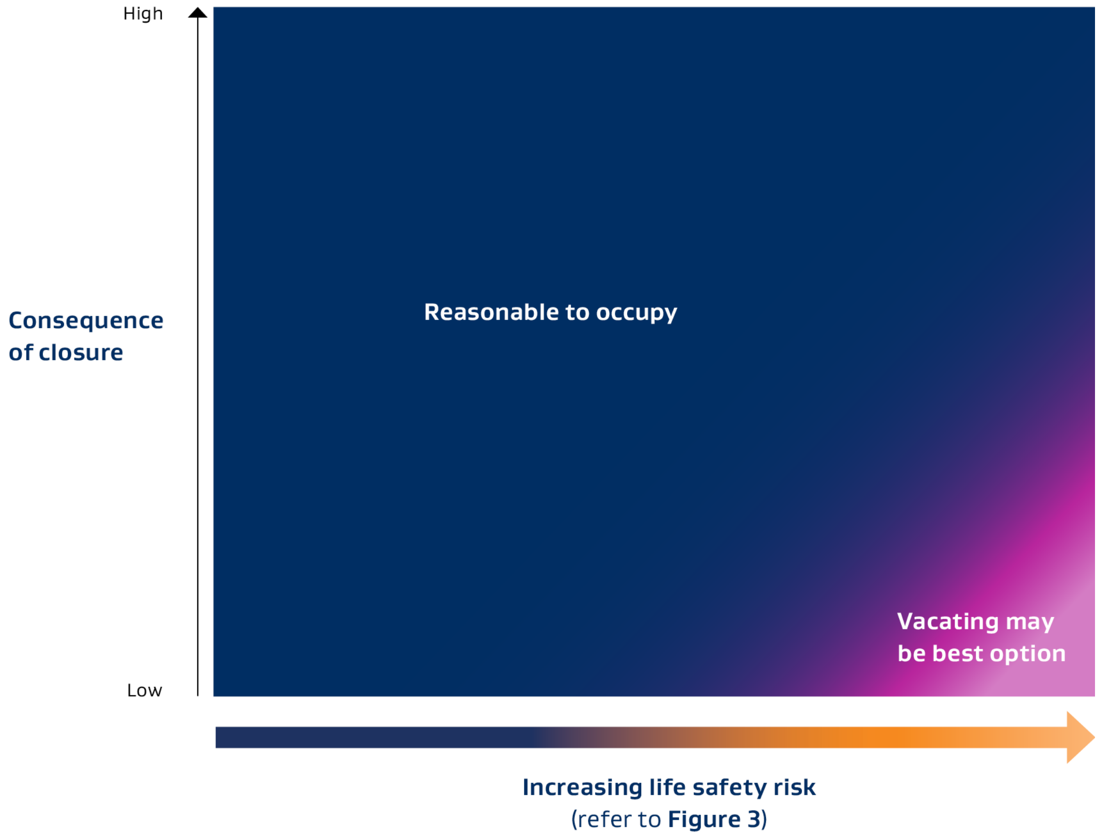
As with the life safety assessment and closure consequence evaluation, the overall risk assessment and balance of life safety risk and consequence will depend on your organisation's risk tolerance. Where you have an existing risk assessment framework, make sure your decision is consistent with the management of other risks within your organisation.

Finally do a sensibility check on the decision. You may need to consider factors beyond what is described above, including other factors that might heighten safety risks during an earthquake (eg building condition and presence of other hazards such as hazardous substances in the building, or geological hazards in proximity to the building (unstable ground)).

In most cases, vacating a building should be a last resort means of mitigating life safety risk for buildings occupants. However, it is important to note that this does not eliminate the risk for building occupants. Life-safety risk from earthquakes will still be present for staff working from home or in an alternate location.

As schematically shown in Figure 5, vacating a building should generally only be considered where the consequences of closure are low and the life safety risk is very high. Such a building will typically have one or more severe structural weaknesses, and a range of vulnerabilities which suggest a propagating failure from one vulnerability to another (progressive collapse) is possible in strong ground shaking. Alternatively, a building with very low consequences of closure, for example a low use building where closure will not notably affect staff or service delivery, could be justified based on fewer, less severe vulnerabilities.

Figure 5 Overall risk assessment



Further references

For more information on making occupancy decisions, and how to document these decisions, BRANZ have developed some guidance specifically on management of earthquake-prone council-owned buildings: https://www.branz.co.nz/shop/catalogue/earthquake-prone-buildings_994/

5. Part C: Managing ongoing earthquake risk and communicating with staff

5.1 Determining how quickly to vacate a building if the decision is made to close a building

If you determine that the seismic risk is unacceptable, allow reasonable time to vacate the building. Unless there is immediate danger to building users from issues other than earthquake, allow time for occupants to make alternative arrangements for service delivery/business operations to reduce the impact on building users. A low %NBS rating does not in itself signify an imminent risk to users and occupants and it is reasonable to take a measured approach to vacating a building. There is no legal requirement to close a building based solely on a low %NBS rating.

5.2 Ways to reduce risk when a building remains open

As outlined in Part B, there are a number of ways to temporarily and permanently mitigate the risk posed by the building itself, including limiting access to particularly vulnerable parts of the building, and carrying out physical remediation works.

Alongside these physical mitigation measures, there are a number of actions that can be taken to mitigate both life safety risk and disruption to operations in more frequent earthquakes. This includes but is not limited to:

- having an emergency plan,
- staff education (eg drop, cover, hold),
- removing hazardous substances or other risks,
- restraining plant, services and non-structural elements, and
- creating a business continuity plan, including identifying alternative ways to deliver services and having back-ups for critical infrastructure services.

In addition, actively working toward seismic retrofit or strengthening is a key mitigation activity.

5.3 Communicating a decision to building users and others

Often communicating a decision to continue occupation of a seismically vulnerable building is more daunting than the decision itself. The best approach is to be open and honest with building occupants. Key messages should include:

- the information you have received,
- what you know and what you don't know,
- the decision process you have gone through (including factors considered),
- the decision you have made, and
- the measures you are taking to manage risk in the short and longer term.

Some staff or building users might be anxious about working in a building with identified seismic vulnerabilities. Use the information here to help staff and building users to understand the risk and put it into context. Other ways to help staff understand the issues include:

- providing a simple publicly visible, one-page summary of the key items from the engineer's report;
- organising a session for staff where the building's engineer can provide a summary of their assessment and answer any questions that they may have;
- getting staff involved in making their own workplace as safe as it can be, for example securing of non-structural items such as bookcases, unsecured equipment; and/or
- providing choice and flexibility in how staff use the building, including working from home options (where possible).

Further references

- Earthquake preparedness checklist:

  https://www.resorgs.org.nz/wp-content/uploads/2021/04/Resilient_Organisations_EQ_Preparedness_Checklist.pdf

- Emergency preparedness:

  https://www.business.govt.nz/risks-and-operations/planning-for-the-unexpected-bcp/emergency-planning-for-businesses/

- Stacking shelves

  https://www.worksafe.govt.nz/topic-and-industry/building-and-construction/building-restraint

- Fix-fasten don't forget

  https://www.eqc.govt.nz/assets/Documents/EQC0047-QuakeSafeHome_2020_SP_1.pdf

- Incremental seismic rehabilitation of office buildings

  https://www.fema.gov/pdf/plan/prevent/rms/397/fema397.pdf

- Drop, cover, hold
  https://www.civildefence.govt.nz/assets/Uploads/public-education/tsunami-public-education/drop-cover-hold-fact-sheet.pdf

6. Examples of risk inputs to continued occupancy decisions

This table outlines some examples of temporary mitigation measures for buildings with low seismic ratings that could support ongoing occupancy of the building ahead of permanent seismic strengthening for long term risk reduction.

These examples are provided for illustrative purposes only – every building and occupancy circumstance is different, and specific risk evaluation is required. This can be undertaken using the information and tools in the earlier sections of this document.

As indicated in Part C: Communications, both the hazards and the mitigations put in place are usefully communicated at the main entrances to buildings so that occupants and the public can be informed about the risk. In all cases, refreshing emergency plans for the building is encouraged.

Building	Building vulnerabilities[1]	Exposure[2]	Possible Temporary Mitigation[3]
Large multi-storey office building CBD	Precast floors *30%NBS*.	High: Peak occupancy of 200 people, most users spend 8 hours per day inside.	Where possible high density / occupied desking moved away from higher risk areas in building corners.
Small/medium two-storey office building in provincial centre	Precast upper level cladding connections and associated roof restraint 25*%NBS* – panels likely to fall outward.	Medium: Peak occupancy of 40 people, most users spend 8 hours per day inside.	Locally restrain panel above main entry.
Small town single storey office building in old retail premises	Part of Un-reinforced Masonry façade could fall outward 15%NBS, primary lateral bracing 20*%NBS*	Low: Peak occupancy of 4 people, mostly 1-2 users.	Evacuation plan using rear entry. Desks moved to areas with higher lateral strength towards rear of premises.
Single storey warehouse in provincial centre	External precast panels with poor connections to primary structure 15*%NBS*.	Low: Peak occupancy 6 people, individuals regularly moving in and out of and around building.	Potential fall zones inside and out used for heavy storage (forklift only access) or transport corridors. Forklift has roll cage.
Large industrial park warehouse	Roof bracing 35*%NBS*. Hollowcore floor in two-storey office 30*%NBS*	Medium: Peak occupancy 20 people, individuals regularly moving in and out of building. Office use more static.	Office occupants prioritised to occupy the upper level of warehouse.

Community Hall	Unreinforced masonry building. Falling masonry presents danger to those entering and exiting building and around perimeter <15%*NBS*	Low-Medium: Low occupancy during week, larger community events during weekend. Many users with mobility issues.	Weekend crowd events moved outside away from building façade when practical. Seating located in area of least risk. Fall hazard canopy over accessible entry/exit.
3-storey "row"-style townhouses in suburban centre	Irregular light timber framed bracing walls along the "row" 30%*NBS*	Medium: Generally 2+ people per apartment throughout day and night	Users develop emergency plan. Tenants plan jointly for future retrofit plan in statutory timeframes.
Multi-storey apartment building in CBD previously converted from 60's office building	Primary lateral capacity 40%*NBS*	Medium: Generally 2-3 people per apartment throughout the day	None. Body corporate creates sinking fund for future strengthening.
Small town two storey unreinforced masonry building ground floor retail first floor residential	URM façade could fall outward <15%NBS, primary lateral bracing <15%*NBS*	Low: Peak occupancy of 6 people, mostly 2-3 occupants either downstairs or upstairs	Evacuation plan with alternative exits to rear and into adjacent building. Develop an incremental retrofit plan starting with restraining parapets, followed by restraining façade.
Single storey suburban medical centre	Shallow foundations on liquefiable soils 45%*NBS*. Masonry chimney and nearby features 25%*NBS*	High: Heavily occupied 12hour/day 6 days per week.	Masonry features removed when practical. Temporary securing of masonry considered if near areas of high public occupation.
3 storey aged care facility	Reinforced concrete block bracing walls 45%*NBS* ground floor, 65%*NBS* upper floors.	High: Generally fully occupied 24/7	Securing of heavy moveable contents. Develop emergency plan.
Single storey public facility such as community library	Primary structure >67%*NBS*, however heavy plaster ceiling tiles present over large area and ceiling grid <34%*NBS*.	Medium: Peak occupancy 20-30 people, most occupants in the building for up to 1 hour.	Remove ceiling tiles, or limit access to area where heavy tiles present.

1: See Part B 4.1
2: See Part B 4.2
3: See Part B 4.5

7. Glossary

%NBS	An index used to characterise the expected seismic response of a building to earthquake shaking. It identifies buildings that represent a higher seismic risk than a similar new building, built to the minimum life safety requirements of the Building Code (or New Building Standard).
%NBS rating	Rating given to a building based on an assessment of the vulnerability of key building elements. The lowest *%NBS* score for any one building element represents the *%NBS* rating for the building.
%NBS score	Score given to each critical building element, denoting how vulnerable that building element is to earthquake shaking.
Consequence	The impact of failure of one or more critical building elements. This also covers the impact of building closure.
Critical building element	Key part of a building (eg columns, floors, parapets, heavy exterior cladding, foundations) that could present a significant life safety hazard during an earthquake.
Critical structural weakness	The building element governing the seismic rating for the building (the element with the lowest %NBS score).
Dangerous building	Legal term to define a building that poses an immediate danger to people in or around the building in the ordinary course of events (Building Act, section 121). A building cannot be classified as *Dangerous* due to earthquake risk.
Earthquake-prone building	Legal term to define buildings that rate less than 34%NBS and are designated as "Earthquake-prone" by a Territorial Authority under the Building (Earthquake-prone Buildings) Amendment Act 2016. Earthquake-prone buildings must be remediated or demolished within a period of 7.5 to 35 years depending on their use and location in Aotearoa New Zealand
Exposure	The number of people that might be affected by failure of a structural vulnerability and the duration they are subjected to the risk.
Importance level	Designation of building used in the Building Code based on consequence of failure and impact on human life, the environment, economic cost and other risk factors in relation to its use. The higher the importance level, the higher the design requirements. Most buildings (residential, commercial and industrial) are importance level 2. importance level 3 indicates buildings with large occupancy and importance level 4 buildings are those essential to post-disaster recovery. Importance level 1 buildings are generally not occupied by people.
Likelihood	The potential for an event (such as an earthquake) to occur.
Non-structural element	Elements within a building that are not part of the primary or secondary structure but are required for the building to function. Examples include ducting, piping, suspended ceilings, internal partitions.
Primary structure	All building elements in a building that are necessary to keep the structure standing. Examples include beams, columns, floors, structural walls, foundations.
Secondary structure	Heavy elements of the building that are not part the primary structure but are required to transfer loads to the primary structure. Examples include precast panels, stairs, and parapets.

Seismic risk area	Geographically defined area, indicating a particular level of earthquake hazard (low, medium or high) as defined in the section 133AD of the Building Act 2004.
Severe structural weakness	Specific building element vulnerability(s) which is difficult for engineers to quantify and are more likely to cause extensive life-threatening consequences.
Vulnerability	The susceptibility of a building element to failure due to earthquake shaking.