Low Damage Seismic Design

VOLUME 1: BENEFITS, OPTIONS AND GETTING STARTED

DECEMBER 2024

RESOURCE

Te Kāwanatanga o Aotearoa
New Zealand Government

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

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Purpose

The purpose of this document is to introduce the concept of Low Damage Seismic Design (LDSD).

The guide outlines the philosophy of LDSD, explores the benefits and opportunities of adopting this approach for new building projects and explains the limitations of seismic performance of buildings designed to the New Zealand Building Code (the Building Code).

The guide is designed to help building owners and developers, and their tenants, decide if LDSD is the right approach for them and provide advice on how to embark on an LDSD project.

This document is Volume One of a three-volume LDSD Guidance Series:

- **Low Damage Seismic Design: Benefits, Options and Getting Started (Volume One).**
- Low Damage Seismic Design: Performance Framework (Volume Two).
- Low Damage Seismic Design: Technical Guidance (Volume Three).

Table 1 following provides a summary of the purpose and target audience for each of these documents.

The Low Damage Seismic Design: Performance Framework (Volume Two) and the Low Damage Seismic Design: Technical Guidance (Volume Three) are scheduled to be completed in 2025.

This document is intended to help you understand LDSD and can be used to initiate a conversation with an engineer or architect about choosing an LDSD approach.

Table 1. LDSD Guidance Series

Low Damage Seismic Design Resource Series			
Title	**Low Damage Seismic Design: Benefits, options and getting started** (Volume One)	**Low Damage Seismic Design: Performance framework** (Volume Two)	**Low Damage Seismic Design: Technical guidance** (Volume Three)
Purpose	A guide designed to introduce the philosophy and benefits of Low Damage Seismic Design (LDSD). It contains an explanation of key concepts and terms involved with LDSD and outlines the value of an LDSD approach to building design for building developers and owners. It also provides advice on how to start an LDSD project.	Defines the recommended performance framework for LDSD projects and how LDSD projects fit within the New Zealand building regulatory system. The performance framework defines the LDSD outcome objectives and related performance goals corresponding to life safety, asset protection, and improved functionality.	Provides detailed LDSD design criteria and related project requirements, which can be used by design teams, contractors, and facilities management for LDSD projects.
Target audience	Commercial and multi storey residential building owners, developers. Pull out guides for commercial building tenants and apartment owners and tenants.	Building owners, developers, tenants, project managers and design consultants.	Project managers, design consultants, contractors, and facilities management.
When might you use this document?	In the concept phase of a building design project or when considering purchasing or leasing a building, in which limiting future earthquake damage and enabling faster recovery is of interest.	Throughout the design stages of a building project.	Throughout the design, construction, and operational life cycle of a building.
Key words	Low damage, building functionality, seismic design.	Outcome objectives, performance goals, physical states, Building Code, compliance pathways.	Reflected brief, design criteria, building component design, construction documents, construction monitoring, building maintenance.
Date published	2024	Expected 2025	Expected 2025

Executive Summary

Ensuring buildings are well designed against seismic hazard is essential for building resilience in Aotearoa New Zealand. The New Zealand Building Code sets minimum seismic performance requirements to minimise the life safety risk posed by buildings in earthquakes. While minimum seismic design standards are crucial, they may not fully mitigate the potential for extensive damage and operational disruption to buildings following an earthquake. Even buildings designed to minimum seismic design standards could still experience substantial damage, be unusable for extended periods or face challenges that make repair uneconomical.

Low Damage Seismic Design (LDSD) is a design philosophy that goes beyond minimum regulatory compliance and enhances the seismic resilience of buildings. This approach to building design provides greater confidence in a building's performance, including the ability to continue using the building after an earthquake.

There are various LDSD options available for building owners and developers, ranging from lower- to higher-tech solutions. Design approaches can be tailored to meet the specific needs, values, budget, and timelines of building owners and developers. By consulting with design professionals, including engineers and architects, building owners and developers can utilise the full potential of LDSD to enhance the seismic resilience of their buildings.

The benefits of using an LDSD approach in a building project are numerous, and include:

- reducing the potential of extensive building damage in an earthquake
- minimising uncertainty and the time a building may be unusable
- reducing the financial losses associated with building damage and disruption to operations following an earthquake
- providing sustainability benefits through reduced repairs, or avoiding demolition of a building, after an earthquake
- attracting and retaining tenant organisations.

Organisations that would most benefit from an LDSD approach include those:

- that are unable to easily relocate to another building
- that provide essential community services
- that undertake time-critical operations in their organisation and/or are heavily dependent on their building for these operations
- with a longer-term interest in their property
- interested in the environmental sustainability of their building.

An LDSD approach is ultimately about future-proofing buildings, protecting investments and safeguarding the resilience of communities against the unpredictable nature of earthquakes. It is a shift towards greater resilience, sustainability, and peace of mind of building owners, developers and building tenants in the face of seismic uncertainty.

Who is this guide for?

This guide is specifically targeted at those directly involved in commercial and multi-storey residential building projects, including building owners and developers.

The guide will be most useful to those who are seeking to undertake a new building project and want to ensure their building has a high degree of resilience.

Design professionals involved in new building projects may also find this guide a useful resource to discuss LDSD with their clients.

While this guidance is not specifically targeted at building tenants, it is acknowledged that tenants and users of buildings have a strong interest in the resilience of the buildings. Appendices One and Two provide short pull-out guides to help commercial building tenants and residential apartment owners and tenants understand the benefits of occupying buildings designed to LDSD principles. These guides may be a useful resource for developers and owners when working with potential tenants.

What is in this document?

- **Section 1** discusses the expected performance of buildings built to minimum seismic design standards.
- **Section 2** introduces the philosophy of LDSD, including what it is, what it aims to achieve and the range of outcomes it can achieve.
- **Section 3** provides advice for determining whether LDSD would be beneficial your building project, including benefits/opportunities and how to understand your tolerance to seismic risk.
- **Section 4** sets out a process for identifying your LDSD needs and priorities.
- **Section 5** describes how to assemble a design team for a LDSD approach, including professionals to include and when to include them.
- **Section 6** provides an overview of what is involved in the LDSD process.

1. Why build beyond minimum seismic design standards?

Current minimum seismic design standards primarily focus on protecting lives, not business or investments.

The Building Code provides minimum seismic performance requirements for how buildings should perform in earthquakes.

For most buildings, minimum seismic design standards prioritise life safety protection rather than damage reduction. However, at very low levels of shaking, typical buildings should not experience damage that would prevent them from being used as originally intended without repair.

The Building Code does not address all factors influencing the time it takes to reoccupy the building and the financial losses incurred.

During the 2010-2011 Canterbury earthquakes, the vast majority of buildings designed since the introduction of modern seismic design provisions in mid 1970s performed as expected and preserved life safety. However, because of extensive damage, many buildings were unusable and eventually demolished. This had significant economic and social consequences for building owners, tenants, users, and the community.

Further, building design standards in Aotearoa New Zealand are periodically updated, as knowledge about engineering and seismic risk improves. This means that older buildings may be more vulnerable in significant earthquakes than those built more recently.

"There's a shift in the industry to go beyond Building Code minimum and actually start to think about the performance of buildings post-event; so we don't treat them as a crash helmet that survives the earthquake to protect people inside, but that you throw away afterwards."

Bruce Curtain
Head of Architecture, WSP

Structural Building Elements

The primary focus of minimum seismic design standards is to protect against the collapse of a building's structural system. The structural system of a building comprises the elements that support the weight of the building, its fit-out and the people who use it and withstands the force of an earthquake.

In a significant earthquake, a structure may remain standing and allow safe evacuation but, unless specifically designed to reduce damage, it may be irreparable.

Non-Structural Building Elements

Minimum seismic design standards often require lower levels of seismic resilience for non-structural building elements.

Non-structural elements are fixed to a building and needed for the building's use, for example, partition walls, ceiling systems and elevators.

While the structure of a building often accounts for approximately 20-30 per cent of the cost of a building, non-structural elements can account for at least 70-80 per cent of the building cost.

Previous earthquakes in Aotearoa New Zealand, and around the world, show the most common and significant sources of building damage are typically from non-structural elements and building contents. These factors are often the largest contributor to total financial losses from building damage. In addition to the direct cost of reinstating non-structural elements, disruptive and prolonged repairs can have a significant impact on business operations.

Non-structural elements that can be damaged during an earthquake shaking include:

- facades, including windows, doors, and awnings
- partition walls
- ceiling systems
- floor coverings (eg tiles)
- electrical systems and lighting
- mechanical systems such as elevators and heating and cooling (HVAC)
- plumbing
- communications infrastructure, such as phone lines and internet cables.

Because minimum seismic design standards prioritise life safety over building damage and disruption, many of these elements may be irreparable after moderate shaking unless specifically protected from damage.

Building contents

Minimum seismic design standards do not require building contents to be braced within a building.

Building contents are things inside a building that are movable including items that are brought into a building by tenants or other occupiers. Examples include furniture, computer equipment, machinery, scientific apparatus, data and files, hazardous substances, and stock or inventory. In addition to the replacement cost of damaged contents, delay in replacement of stock can interrupt business operations.

Interior damage in this Christchurch building after the 4 September 2010 Darfield earthquake. This demonstrates the extensive damage to the non-structural elements and length of time it might take to restore non-structural elements of a building to a usable condition.

Some buildings are required to be operational immediately after an earthquake, such as emergency operations centres, hospital operating theatres, and critical infrastructures. These are classified as Importance Level (IL) 4 buildings, and are designed to both preserve life safety and prevent significant damage.

Most buildings in Aotearoa New Zealand are Importance Level 2 and 3, where minimum seismic design standards mainly require a design that mitigates life safety risks.

2. Low Damage Seismic Design approaches

An LDSD approach enables you to limit and control earthquake damage, based on your desired seismic performance.

It is not realistic to make a building "earthquake proof". However, LDSD is an approach to building design which aims to limit earthquake damage up to certain levels of shaking to minimise repairs and help return your buildings to function sooner after an earthquake. This approach to building design can provide building developers, owners, tenants, and users with greater confidence when facing the expected impacts and disruption to their building and/or organisation after an earthquake.

There is always a degree of uncertainty when it comes to how a building will perform in an earthquake. LDSD provides improved confidence in the level of damage a building may sustain.

When designing a new building, an LDSD approach is both complementary to and fundamentally different from a design approach where buildings are built to minimum seismic design standards (a conventional approach). A conventional approach to seismic design follows a series of prescriptive requirements that, based on decades of experience, are deemed by regulators to limit life safety risk.

In contrast, an LDSD approach is based around design decisions that aim to limit and control expected earthquake damage to a building, reflecting the specific needs of the building owner and/or tenants. While LDSD represents a departure from conventional seismic design approach, it can achieve a design that both limits expected earthquake damage, as well as limiting the life safety risk as required by minimum seismic design standards.

Table 2 provides a high-level comparison of a conventional approach and LDSD approach.

Table 2: High-level comparison of conventional and LDSD-based approaches

Type of impact and loss	Conventional approach	LDSD based approach
Safety	Low probability of loss of life or major injuries in a significant earthquake. An LDSD approach may offer some limited additional safety benefits by controlling damage, although standard safety requirements from the Building Code are generally considered adequate.	
Damage (structural elements)	Damage may occur at (or below) the level of shaking directly considered in the design of the building.	Evaluates and controls the likely extent of damage to the building structure.
Damage (non-structural elements)	Some elements are required to be designed to remain in position. Other elements and contents are not regulated.	Evaluates and controls the likely extent of damage to non-structural elements and some contents.
Building Functionality[1]	Provides for continued functionality of the building only at very low levels of shaking, except for facilities with post-disaster functions (eg hospitals).	Provides for a likely faster return to building functionality by limiting damage at higher levels of shaking.

There are a variety of LDSD approaches that can be used to meet your desired goals. These range from lower-tech to higher-tech solutions.

Reducing building damage does not have to require expensive technology. Better and more reliable building performance can be achieved through simple measures such as:

- simple/regular structural layouts
- limiting how much a building moves during an earthquake (displacement), and/or
- smart site selection.

Higher levels of damage control can be achieved through use of low damage technologies such as base isolation and/or viscous dampers.[2]

LDSD approaches sit on a continuum of performance that goes beyond minimum seismic design standards. LDSD can be categorised as Level 1, Level 2, and Level 3 (Figure 1).

Level 1 LDSD buildings incorporate some design features that help to minimise damage in addition to complying with minimum seismic design standards.

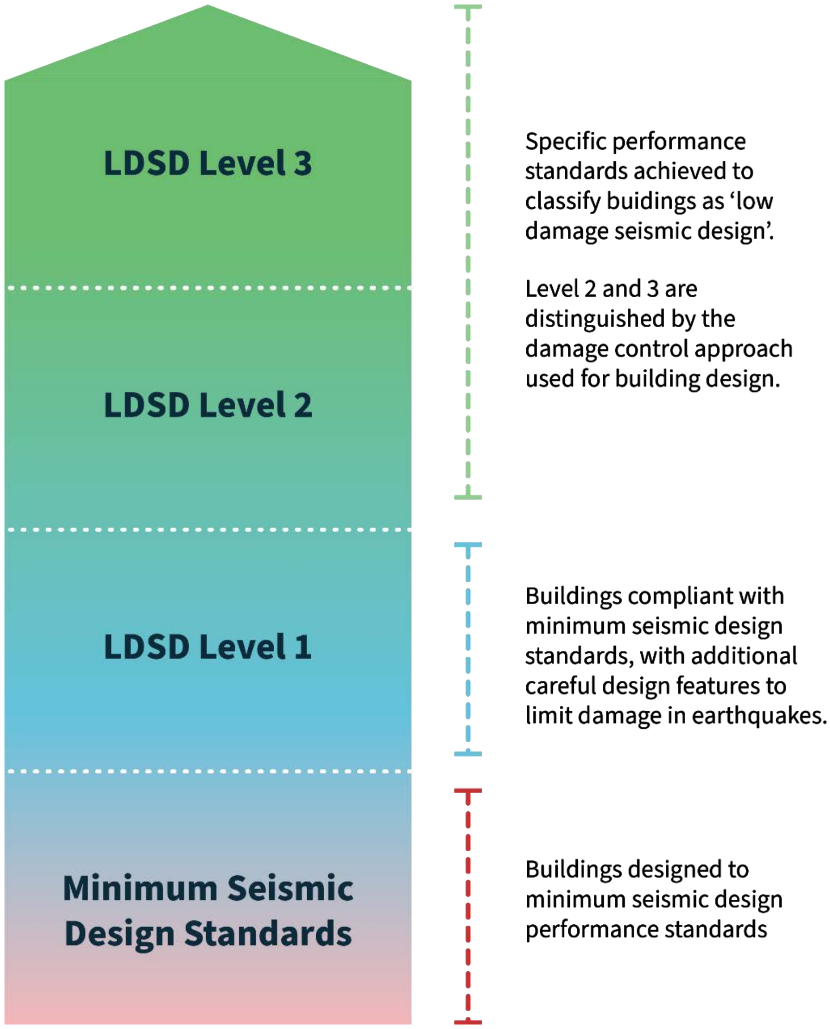
Level 2 and 3 LDSD buildings are designed to meet specific performance requirements, with Level 3 providing the highest level of expected performance. The key difference between Level 2 and Level 3 is that

[1] External influences can also impact the functionality of your building following an earthquake. However, appropriate site selection for your building can help to mitigate the impact of some of these factors. See Section 4.
[2] See Canterbury Earthquakes Royal Commission. *Volume 3 Low-Damage Building Technologies* (2012). https://canterbury.royalcommission.govt.nz/vwluResources/FinalReportVol3Print/$file/Final_Report_Volume_3_Web.pdf.

buildings designed to LDSD Level 3 aim to limit damage in larger and rarer earthquakes, with a correspondingly much reduced average economic loss in each year resulting from all possible earthquakes.

Buildings designed to be LDSD Level 1 are a middle ground between complying with minimum seismic design standards but having the enhanced damage control features[3].

Figure 1: LDSD performance level



There is no one size fits all approach to LDSD. Design options should be developed based on the performance you need from your building. Your design team can help you understand your needs and find an option that is best for you.

A %NBS (New Building Standard) rating is not a useful measure to describe the performance of a LDSD building. %NBS is used to assess the expected performance an existing building compared to a new building on the same site. Its primary purpose is to identify those buildings most at risk of collapse in an earthquake, and where this is likely to cause injury or death. %NBS is used by the earthquake-prone building system to identify buildings and require them to be strengthened or demolished over time. However, %NBS is often used by building owners or users to assess the seismic risk of other buildings. Separate descriptions are required for the expected building performance in relation to minimum regulatory requirements and for the impact of damage and disruption to a LDSD building.

[3] More detailed information on these performance levels is provided in the companion document: Low Damage Seismic Design: Performance Framework (Volume Two – in preparation).

Figure 2: Extent of damage from different design approaches (adapted from FEMA P-58-7)

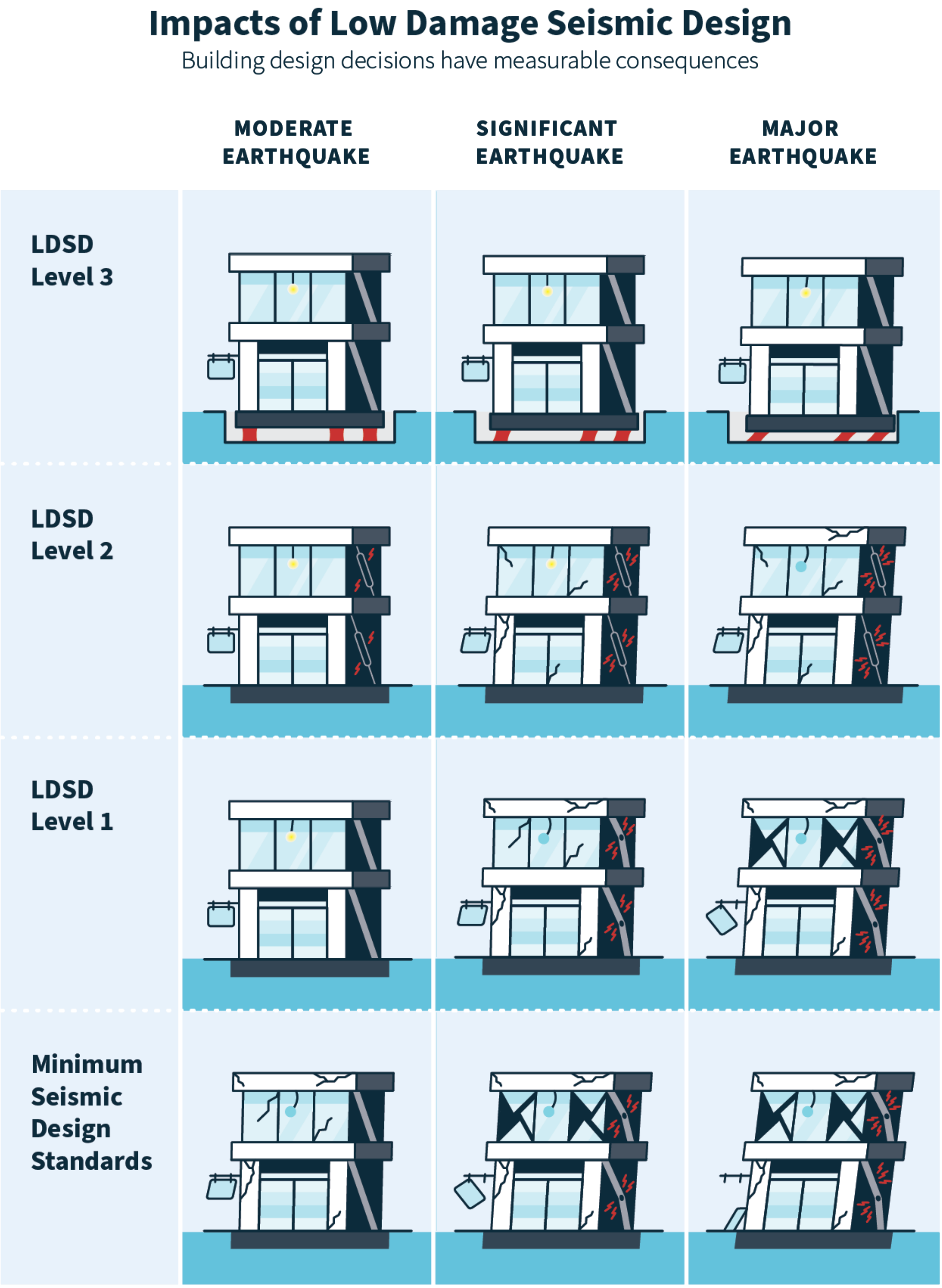


Figure 2 illustrates the extent of damage that can be expected for different building design approaches, from a basic compliant design with additional features to the highest level of LDSD and for different levels of earthquake shaking.

3. Establishing whether Low Damage Seismic Design is right for you

LDSD approaches work well for some buildings but are not suitable for all.

Establishing whether to use LDSD for your building should reflect what really matters to you. LDSD has many benefits, including reduced losses following an earthquake, environmental sustainability, improving the seismic resilience of your community, and making your property more appealing to tenants. The extent to which you and/or your organisation may benefit from reduced damage will depend on what your building is to be used for.

"Victoria University of Wellington has incorporated Low Damage Seismic Design (LDSD) into its design guidelines for over a decade, and reflects our commitment to safety and resilience. This approach has been incorporated into several new buildings including Alan MacDiarmid, Te Toki a Rata and Living Pā and ensure they withstand earthquakes with minimal damage, reduced repair costs and downtime post an event. As an Owner, the University benefits from enhanced asset protection and long-term operational continuity and aligns with our values around sustainability and community well-being. As an earlier adopter, this strategy has positioned us a leader in innovative and responsible design practices."

Patrick Homan
Associate Director-Asset Management
Te Herenga Waka - Victoria University of Wellington

3.1 Benefits and opportunities of Low Damage Seismic Design

By limiting building damage, adopting an LDSD philosophy for your building design can create several (direct and indirect) benefits and opportunities. Figure 3 illustrates how some of these benefits increase with higher LDSD levels.

Increased certainty

There is a lot of uncertainty about the nature of earthquakes and how buildings will respond to them. LDSD can provide you with greater certainty about how your building will perform in any given earthquake. This can help with planning for emergencies, business continuity, and financial management. This is particularly important for organisations that have time-critical operations and/or strongly depend on their building to operate.

Increased property value

LDSD has the potential to increase the capital value of your building and financial return from rent. The degree of increase will depend on the property market at the time. However, even if the market is not valuing the investment, being an LDSD building will still be a differentiating feature that will appeal to some tenants.

Reduced losses and insurability

LDSD buildings have clear financial benefits, especially over the lifetime of a building. These include avoiding costly repairs and minimising the time until you can reoccupy a building following an earthquake. In this sense, LDSD can act as a form of self-insurance, by reducing the risk that the building will be unusable and require expensive repairs or replacement after an earthquake.

Aotearoa New Zealand's insurance market is marked by high premiums and coverage limitations. By investing in a more resilient LDSD building, you may improve your ability to secure ongoing insurance coverage and better position yourself to navigate future changes in the market.

"The Low Damage Seismic Design (LDSD) philosophy provides clear targets for improved seismic performance of future building designs. Great Work. We do need to move away from the current life safety only approach as insurers certainly have lost confidence in it. Insurers would like to see the LDSD Philosophy go a stage further to provide certainty of cost-effective building repairability."

John Lucas
Insurance Manager
Insurance Council of New Zealand

Greater sustainability benefits

Since LDSD buildings are designed to reduce damage, demolition is less likely, and you will reduce the extent of repairs your building requires following an earthquake. This may have environmental benefits, including reduced carbon emissions and waste production.

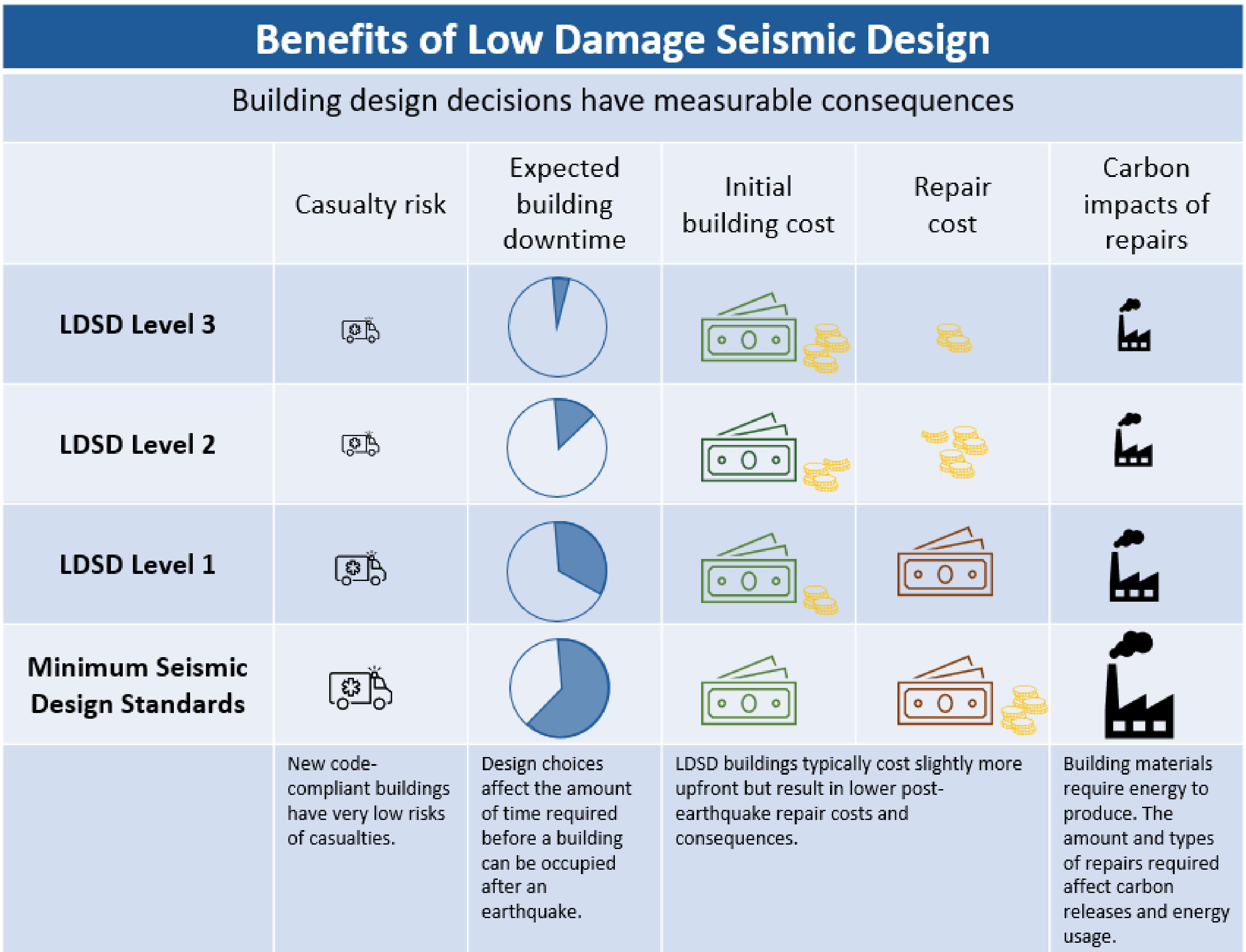
Supporting community resilience

Collectively, individual buildings contribute to the overall functionality of communities. Having more buildings designed with LDSD means less damage and disruption after an earthquake. By choosing LDSD for your building project you are helping to improve the resilience of your community to earthquakes.

3.2 Cost impacts

As every building is unique, it is not possible to compare the costs of a project that uses LDSD with a project that does not. Sometimes, investing early on in LDSD can save costs in the construction phase. Other times, decisions to invest in greater seismic resilience can result in a more expensive building project. The costs will depend on the LDSD level that is selected for a building.

Figure 3. Benefits of LDSD building design (adapted from FEMA P-58-7)



3.3 Understanding your vulnerability to disruption

When establishing whether an LDSD approach is right for you, it is important to understand the impact of both property loss and business disruption, to you and/or your future tenants, resulting from a damaged building.

LDSD may be an attractive option if you have a heightened vulnerability to damage and resulting property loss and business disruption.

An LDSD approach is most relevant when you want to have confidence that your building will sustain minimal damage and you or your tenants will be able to quickly reoccupy the building in the event of a significant earthquake.

Table 3 is designed to help you determine if LDSD might be appropriate for you and/or your future tenants.

Table 3: Criteria that indicate heightened vulnerability to disruption

LDSD might be right for you if one or more of the following statements apply to your building:	
Property Loss	❑ Tenants will have stock/plant/contents/fit-out that is difficult to replace and/or move. ❑ Your insurance (or your building occupiers' insurance) may not suitably cover potential damage and/or losses. ❑ You or your tenants want to protect yourself against future changes (reductions in cover) in the insurance market.
Business Disruption	❑ The building is a significant financial investment for you and/or you intend to maintain a long-term interest in the building. ❑ Tenants' business operations are heavily place-based and dependent on being able to occupy the building. ❑ You, or your tenants, will need to reoccupy the building quickly after an earthquake. ❑ The building will have significant symbolic, cultural, or brand importance. ❑ The building will have a post-disaster support function in the weeks and months following a significant earthquake (e.eg public assembly space or insurance assessors). ❑ Tenants will use the building to provide essential goods and/or services to the community, including vulnerable users (eg supermarket, pharmacy). ❑ The building will provide a strong social function/connection space for the community (eg community meeting spaces).
Hazard Exposure	❑ The building will be located in an area with high earthquake hazard.

4. Determining your Low Damage Seismic Design needs and priorities

Identifying what you need from your building, and what the business priorities of the intended tenants are, is essential for determining what LDSD approach to take.

Once you have established that LDSD is right for you, you need to think about what you or your future tenants' needs and priorities are. There are several factors to consider: what level of performance is required from the building, what building tenants need to operate and how the building will be managed.

Answering these questions will assist you and your design team to decide the LDSD objectives. For instance, prioritising the protecting of building contents will require a different approach compared to prioritising minimising damage and repair costs to the building itself.

It is important to do this early in the LDSD process, to ensure that the design is shaped around the specific needs for both yourself and/or your building's current and future tenants.

Identifying your LDSD needs and priorities is the first step in the iterative process of determining your LDSD performance goals

LDSD performance goals specify the outcomes you want at different levels (and different likelihoods) of earthquake shaking.

The LDSD Performance Framework outlined in Volume 2 provides a reference point for selecting the level of LDSD required for your circumstances.

The hierarchy of the LDSD performance framework comprises the following elements:

Outcome objectives – overall objectives corresponding to the building performance aspects of life safety, protection of other property, damage control (asset protection) and functionality (operability).

Performance goals – maximum expected levels of building damage and anticipated functional states corresponding to different levels of ground shaking.

Physical states – qualitative description of expected damage to main structural and non-structural elements corresponding to the performance goals and different levels of ground shaking.

LDSD performance goals are expressed in terms of the reduction in the expected (average) annual loss for each of the LDSD categories introduced in Figure 1.

An **LDSD project brief sheet** is provided at the end of this section. The questions and considerations should help you determine your specific needs and priorities, which you can then work with your design team on how best achieve them. You can also work through the project brief with your design team.

Once the **LDSD project brief** is provided to your design team, they will be able to commence concept design. To ensure the concept design meets the needs and priorities of you or future tenants, the design team will seek to work with you to define the project's LDSD performance goals. This is then documented in a **reflected brief** or **design features report** that summarises the agreed performance goals the building design aims to achieve. This will be updated as design stages progress.

It is important to consider site conditions and property location when setting LDSD performance goals.

The nature of a building site and the resilience of the built environment around the site will impact how feasible your LDSD design goals are. Poor site conditions could make achieving desired performance levels unaffordable or could mean that it is not possible to achieve desired performance goals.

Good site selection is also critical for helping to achieve your LDSD objectives.

Good ground conditions will make controlling damage in the building much easier. It is also important to consider any external factors that might impact the ability of your building to function after an earthquake. This includes risk from neighbouring buildings and disruption to critical infrastructure services.

Refer to the box below for additional information, including potential mitigations, related to external factors when determining your performance goals.

Key external factors to consider when determining your LDSD performance goals:

- **Disruption to critical infrastructure**. Earthquakes can cause significant and prolonged disruption to critical infrastructure services, such as power, water, communications, and internet. The impact of critical infrastructure disruption is an important consideration in site selection and when setting LDSD performance goals, particularly where ongoing continued building functionality is desired. While decisions on providing critical infrastructure emergency backup facilities sits outside the design of the building and its elements, you may want to consider if there is anything you can do to reduce the impact of potential infrastructure disruption (eg install a generator).

- **Damage to neighbouring/surrounding buildings**. Buildings located near or directly adjacent to your building may suffer extensive damage in an earthquake. This could impact the ability for you or future tenants to access or utilise the building, even if it has sustained little to no damage. Consult your design team on the potential risks from neighbouring buildings and the viable mitigations.

- **Labour and/or material shortages affecting repair times**. Repairs depend on the availability of professionals, contractors, and materials to complete the work. These can all be constrained in a post-disaster environment. When setting performance goals or estimating the likely time for building reoccupation, consider these potential delays. It is important to check that business continuity arrangements for you or your future tenants can accommodate some delay in reoccupying your building. For instance, to help facilitate timely repair, you may want to consider having priority service supplier arrangements in advance.

Some factors listed above can be mitigated through appropriate site selection and design choices for your building. However, the resilience of the building stock, and critical infrastructure, is ultimately a long-term effort. As more building owners and infrastructure providers invest in resilience, the potential disruption of these external factors will reduce. Advocating for, and being an early adopter of LDSD, can help improve this community-wide resilience.

Low Damage Seismic Design Project Brief Sheet

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Natural Hazards Commission
Toka Tū Ake

Building use

- What is the primary use?
- Is there a secondary use?
- How many occupants use the building in normal operation, and does this change at peak times?
- Will the building have some post-disaster function (eg emergency assembly or residential 'shelter in place')?
- Is the way the building is used likely to change in the future?

Building location

- Are you committed to a site, or could you select an alternative?
- Do you understand how your site will perform?
- Have you conducted any land assessments?
- Do you need to protect against other hazards (eg tsunami, flood, landslide)?
- Are there risks from neighbouring buildings or would the building be affected by potential disruption to critical infrastructure following an earthquake?

Safety & wellbeing

- Generally, code-based safety requirements are considered sufficient. The following questions explore whether there are any unique safety requirements for your situation.
- Will vulnerable or high needs persons use your building? If so, what are their requirements in an emergency?
- Are there any hazardous substances that may pose a risk in an earthquake?
- How important is it to show occupants they are safe?
- Will having a building with enhanced safety be attractive to future users (eg prospective tenants and employees)?
- How safety-conscious are your directors?

Business continuity

- Are some operations more critical than others?
- How long could you cope with reduced or no operations?
- What are the minimum requirements to keep critical business going?
- Can your operations be moved and/or replicated to another location if you cannot access your building?
- Do you need disaster response processes to support people and evaluate/ respond to risks?

Building management

- How will the building be managed (eg is there a facilities manager, or body corporate)?
- Will it be possible to inform maintenance personnel about the ongoing LDSD requirements?
- Will it be possible to establish a process for ensuring that building additions and alterations adhere to the LDSD requirements?
- Will it be possible to establish clear post-event protocols for inspection, reporting, and repair after an earthquake?

Building priorities

- When would you like to be able to reoccupy the building after an earthquake?
- Should the entire building be protected, or just more critical areas?
- How quickly should full function be restored?
- Is your priority to protect the building or the contents?
- Do you want to spend more upfront to make savings in running costs?

Building contents

- Are there particularly hazardous and/or valuable contents in the building?
- How vulnerable are these contents to damage?
- What is the associated risk?
- What containment measures need to be taken to reduce risk?

Commercial considerations

- What are the costs of downtime and response?
- What are the costs of repair / replacement?
- Is there a significant business partner and should they have input?
- Do you know if you can get insurance for the completed building?
- Could you self-insure if you cannot get or do not have cover?

Design & leadership

- Do you have a commitment to the environment and reducing your impact?
- Are you seeking to push boundaries in resilience or other areas?
- Is architectural style and flair important to your project?
- Is it important for your brand that you project stability and continuity?

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5. Selecting and working with a knowledgeable Low Damage Seismic Design team

Selecting a skilled and efficient team is essential for LDSD project success.

Everyone involved in an LDSD project needs to understand the LDSD performance goals and be able to work together to achieve them. Investing in the services of professionals well-versed in or open to LDSD approaches at the outset of a project can save money in the long-term.

It is important to involve key people during the establishment phases for LDSD projects. This may mean early engagement of structural and geotechnical engineers along with an architect. Mechanical, electrical, and fire engineers and early contractor involvement (including suppliers of seismic technology devices) may also be required.

If the project involves high-tech solutions, specialist subtrades may also be required early in the design process.

The professionals likely to be involved in your LDSD design team are listed in Appendix 3.

Regular communication and collaboration between all team members is key for achieving your project goals.

Successful design teams generally talk early and often during the design process – both amongst each other and with representatives of yourself or future tenants. Frequent communication helps the design team understand each other's role and how various LDSD choices can affect building performance.

It is important to have detailed and well-coordinated construction documents and strong quality assurance procedures on site. This will ensure the main contractor and subcontractors understand the LDSD requirements, and that the building is constructed according to these requirements.

Questions for prospective design team members

Start a discussion about LDSD by asking the following questions to potential members of the design team:

- What is your experience with LDSD projects?
- What LDSD approaches do you think would work well for this project (eg structural systems, layouts)?
- What non-structural components of our building do you think will be most vulnerable in an earthquake, and what can be done to protect them?

"Close teamwork is essential to achieving successful LDSD outcomes. It's all about making sure everyone one on the design team is on the same page, from start to finish. This includes making sure the whole team has a clear and shared understanding of the challenges, methods, and goals of each project, so that the right standards can be met."

Jasper van der Lingen
Fellow
New Zealand Institute of Architects

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6. Following the Low Damage Seismic Design process

Determining your design goals and the design approach to achieve these goals is an iterative process.

An LDSD project requires an integrated design approach. Essential to this process is that, early on, you and the design team clearly define the earthquake damage levels that are acceptable to you or your future tenants, based on the initial project brief. Options for these levels are framed in terms of the outcome objectives and performance goals referred to in Section 4.

In the concept design stage, an LDSD approach helps you pick the most appropriate solution to achieve your agreed performance objectives.

The decisions made early, during the concept design phase, can have a big impact on the building damage that can be expected in a significant earthquake. Important early decisions for new building designs include selecting the structural system and layout for the building. For example, simple, regular building layouts generally perform significantly better than more complex, irregular structures. This can be sufficient to achieve LDSD Level 1.

Decisions about structural elements must be made alongside the consideration of other building elements that support the ongoing operation of a building. This includes non-structural elements, building services, fire protection systems and mechanical plant.

Making good construction-related decisions early can help to ensure the design and construction of your building achieves your project goals. For example, this might include early contractor involvement. A good record of documents should be maintained throughout the entire process, including a record of the LDSD project brief, responsibilities, decisions, and how these are implemented right through to post-construction. Good construction monitoring practices should be observed throughout construction.

Once construction has completed, you need to actively maintain the LDSD qualities of your building throughout its lifetime.

Good facilities management practices that incorporate seismic resilience are important for maintaining an LDSD building. By communicating underlying seismic performance goals and establishing good maintenance practices, you can preserve the benefits of your assets.

Having plans for building repairs immediately following an earthquake is an essential component of managing an LDSD building.

Being able to swiftly inspect and repair any critical damage following an earthquake, to restore building functionality sooner, is key to an LDSD approach. Pre-arranged service agreements with consultants for building inspection, and priority arrangements with contractors to complete repairs, will enable you or future tenants to enjoy the full benefits of an LDSD building.

Figure 4. Illustration of the LDSD Process

Project establishment	**Determine if LDSD is right for you**	→ Consider what seismic performance you want and need from your building. → Determine your post-earthquake recovery needs.
	Get the right people on board	→ Select a qualified design team for LDSD. → Maintain close communication with your design team throughout the LDSD process.
	Select an appropriate building site	→ Seek expert advice about the condition of the site you wish to purchase (if relevant) or build upon (if pre-existing). → Consider the surrounding built environment and ground condition.
	Develop an initial LDSD project brief with the design team	→ Discuss desired outcomes with design team, including damage, time to reoccupancy, and expected post-earthquake functionality.
Concept design	**Develop a concept building design**	→ Consider performance of both structural and non-structural elements. → Ensure risks from neighbouring environment and appropriate site selection are considered.
Preliminary design	**Review reflected LDSD brief from design team**	→ Check the expected building performance outcomes align within your goals. → Seek clarification on anything that is not clear.
Detailed design	**Create a developed/ detailed design**	→ Ensure all design team members are aware of desired performance objectives. → Maintain good communication and collaboration across the design team.
Procurement	**Engage qualified contractors**	→ Select suitably qualified contractors and subcontractors. → Ensure contractors understand the project brief. *Note that some LDSD projects will benefit from early contractor involvement (ECI).*
Construction design, administration, and observation	**Construct the building**	→ Ensure clear and well-coordinated construction documentation. → Maintain good construction monitoring practices.
Post-completion	**Maintain building and earthquake preparedness**	→ Establish good building maintenance practices. → Implement and maintain measures to enable timely building inspection and repair processes following an earthquake.

Iterative process with the design and construction team.

Clear communication and active engagement are key to ensure everyone is aligned on project goals.

Figure 4 illustrates a high-level overview of the LDSD process. The process is embedded in the key stages of construction projects as set out in the NZCIC Guidelines.

7. Resources

FEMA (2018). FEMA P 58 Report Volumes". https://femap58.atcouncil.org/reports.

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8. Glossary

Building Code	Secondary legislation and sits directly below the Building Act 2004. It specifies the minimum requirements for buildings to achieve in Aotearoa New Zealand. For the purposes of this guide, the Building Code refers to the minimum *seismic performance and functional requirements* that buildings are required to be constructed to.
Design team	A team of skilled professionals who are essential for designing and achieving an LDSD building. See Appendix 3: LDSD design team professionals for the professionals likely to be part of the design team for an LDSD building project.
Low Damage Seismic Design (LDSD)	A building philosophy where buildings are designed to minimise damage in an earthquake and enable more rapid return to use of a building following an earthquake.
LDSD Levels	Used to describe categories of building which meet specific Low Damage Seismic Design requirements as detailed in the Low Damage Seismic Design: Performance Framework (Volume 2).
LDSD Level 1	LDSD Level 1 buildings incorporate some design features that help to minimise damage in addition to complying with minimum seismic design standards. LDSD Level 1 building are designed with lesser performance standards than LDSD Level 2 and 3 buildings.
LDSD Level 2	LDSD Level 2 buildings are designed to have a high level of seismic performance.
LDSD Level 3	LDSD Level 3 buildings are designed to have a very high level of seismic performance.
Earthquake shaking levels	Qualitative descriptors used to broadly characterise different levels of earthquake shaking.
Moderate earthquake	An earthquake where damage is possible and can be expected on a more frequent basis than a significant or major earthquake. In this document, the term 'moderate earthquake' is not associated with the same term used within the Building Act 2004.
Significant earthquake	An earthquake that is more severe than a moderate earthquake and can be expected on a more frequent than a major earthquake but less frequent than a moderate earthquake.
Major earthquake	An earthquake that is more severe than a significant earthquake and can be expected on a less frequent basis than a moderate or significant earthquake.
Minimum seismic design standards	A series of design rules that set out a minimum design standard within the building code system that buildings are required to be constructed to.
New building	A building that is designed and constructed to at least the minimum performance requirements within the Building Code.

New building	A building that is designed and constructed to at least the minimum performance requirements within the Building Code.
Non-structural element	Elements within a building that are not part of the primary or secondary structure but are needed for the building to function. Examples include ducts, pipes, suspended ceilings, and partition walls.
Primary structural system	The main structural system of a building. This includes all building elements that are necessary to keep the structure standing. Examples include beams, columns, floors, structural walls and foundations.
Reoccupation time	The expected period to re-occupy a building after an earthquake.
Risk tolerance	The level and frequency of loss (ie damage, disruption) that an individual or organisation is willing to accept.
Secondary structural system	Structural elements in a building that are not part of the primary structural system, but nevertheless are still needed to keep parts of a building standing. Examples include stairs, precast concrete panels, canopies, and curtain wall framing systems.
Seismic performance	The expected response of a building or structure during a given earthquake.
Seismic risk	The potential for harm, loss, and/or disruption as a result of an earthquake. It is a measure of both the likelihood of damage occurring and the corresponding consequences.

MBIE Seismic Risk Series			
Title	*This document*	*Related MBIE seismic risk documents*	
	Low Damage Seismic Design: Benefits, options and getting started	**Seismic Risk Guidance: Making building occupancy decisions**	**Seismic Risk Resource for Commercial Building Tenants**
Purpose	To introduce the philosophy and benefits of Low Damage Seismic Design (LDSD), explain the key terms involved and what the value of an LDSD approach to building design means for developers, owners, and tenants.	To help building users, tenants and owners interpret and make ongoing occupancy decisions based on the outcome of a seismic building assessment, and to provide tools and language for engineers and their clients to discuss seismic assessments.	To guide commercial building tenants on how to understand their seismic risk tolerance and inform decisions about the required seismic performance of the buildings they occupy or are considering leasing, based on the work their organisation does.
Target audience	Commercial and multi storey residential building owners, developers	Residential and commercial building users, owners, tenants Engineers	Commercial building tenants
When might you use this document?	When you are in the concept phase of a building design project in which limiting future earthquake damage and enabling faster recovery is of interest.	When you are deciding whether to continue occupying a seismically vulnerable building.	When you want to know whether the expected seismic performance of the building you occupy, or intend to occupy, is right for your business operations.
Key words	*Low damage, building functionality, seismic design*	*Seismic assessment, building occupancy, %NBS rating*	*Risk tolerance, lease requirements, organisational risk*
Date published	2024	2022	2024

WHAT IS LOW DAMAGE SEISMIC DESIGN?

Low Damage Seismic Design (LDSD) is a building design philosophy that aims to limit earthquake damage up to certain levels of shaking. LDSD buildings are designed to reduce the repairs needed and help a building return to functionality sooner after an earthquake. This approach to building design also provides tenants and other users with a better understanding of the expected impacts and disruption to their building and/or organisation following a significant earthquake.

There is always a degree of uncertainty when it comes to how a building will perform in an earthquake. LDSD provides improved confidence in the damage a building is likely to sustain.

WHAT ARE THE BENEFITS OF LEASING AN LDSD BUILDING?

Reduced costs following an earthquake

LDSD can provide financial benefits over the lifetime of a lease, including saved fit out replacement costs and business downtime costs following an earthquake.

LDSD can serve as a form of self-insurance, by reducing the potential for losses after an earthquake. This can help mitigate risks from the fast-changing insurance market in Aotearoa New Zealand, including rising premium costs and limits on what insurers are willing to cover.

Greater security for your organisation

LDSD can provide increased certainty around the level of damage that can be expected to your building following a significant earthquake. As a result, LDSD can be an effective means of supporting business continuity.

Contribute to community resilience

More LDSD buildings will help to reduce overall earthquake risk within communities. By seeking an LDSD building to lease, you are contributing to the wider resilience of Aotearoa New Zealand to earthquakes, benefiting both you and your customers.

Greater sustainability benefits

Reduced damage to the building fit out will reduce the amount of repairs following an earthquake. This will have environmental benefits, including reduced carbon emissions and waste production.

IS LOW DAMAGE SEISMIC DESIGN RIGHT FOR ME?

As a tenant of a commercial building, it might be worthwhile considering an LDSD building if:

- you are actively searching for a new premise to lease
- you are in the process of reviewing your current lease, or
- you have decided to reflect on your current arrangements, for example after receiving new seismic risk information about your building.

The following table provides a series of factors to help you decide whether leasing an LDSD building is right for you. These primarily relate to the importance, or criticality, of your building to operating your business. You should consider leasing an LDSD building if one or more of the following statements apply:

Property Loss

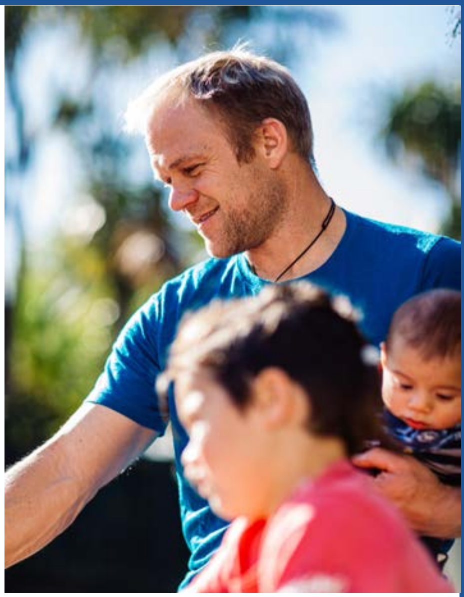
- ○ Your organisation has plant or fit-out that is difficult to replace and/or move.
- ○ Your building contains hazardous materials.
- ○ Your insurance is not suitable to cover property damage/loss.

Business Disruption

- ○ Your business operations are heavily place-based and/or dependent on being able to occupy your building.
- ○ There is a high time criticality for reoccupying your building after an earthquake to continue operations.
- ○ Your premises are critical to your organisation's brand.
- ○ Your organisation is not readily able to operate elsewhere and/or staff are unable to work elsewhere (ie from home).
- ○ Your organisation supports a post-disaster function (eg. public assembly space or insurance assessors).
- ○ Your organisation provides essential goods and/or services to the community, including vulnerable users (eg supermarket, legal aid).
- ○ Your organisation provides a strong social function / connection space for the community (eg community meeting spaces).

Appendix 2: LDSD for multi-storey residential building apartment owners and tenants

WHAT IS LOW DAMAGE SEISMIC DESIGN?



Low Damage Seismic Design (LDSD) is a building design philosophy that aims to limit earthquake damage up to certain levels of shaking. LDSD buildings are designed to reduce the repairs needed and help a building return to functionality sooner after an earthquake. This approach to building design also provides tenants and other users with a better understanding of the expected impacts and disruption to their building and/or organisation following a significant earthquake.

There is always a degree of uncertainty when it comes to how a building will perform in an earthquake. LDSD provides improved confidence in the damage a building is likely to sustain.

WHAT ARE THE BENEFITS OF LEASING AN LDSD BUILDING?

Reduced costs following an earthquake

For apartment owners, LDSD can provide financial benefits over the lifetime of ownership including reducing cosmetic repairs required following an earthquake.

LDSD can serve as a form of self-insurance, by reducing the potential for losses after an earthquake. This can help mitigate risks from the fast-changing insurance market in Aotearoa New Zealand, including rising premium costs and limits on what insurers are willing to cover.

Reduced stress

Following an earthquake, dealing with insurance and disruption during repairs or having to relocate temporarily or permanently can be very stressful. By reducing the damage, LDSD can reduce the potential for housing-related stress following an earthquake.

Greater sustainability benefits

Since LDSD buildings are designed to reduce damage, you will reduce the amount of repairs your building requires following an earthquake. This will have environmental benefits, including reduced carbon emissions and waste production.

IS LOW DAMAGE SEISMIC DESIGN RIGHT FOR ME?

It might be worthwhile considering an LDSD building if you are actively searching for a new apartment to buy or rent.

You should consider buying or renting an apartment in an LDSD building if one or more of the following statements apply:

Property Loss

- (For apartment owners) You want to reduce potential losses following an earthquake.
- (For apartment owners) Your insurance is not, or may not be, suitable to cover future property damage / loss.

Business Disruption

- You have specific housing needs (eg accessibility needs).
- You would find it difficult to relocate after an earthquake.
- You might need (or want) to be able to work from home following an earthquake.
- You want to reduce the potential of having to move out permanently or temporarily to allow for repairs.

Appendix 3: LDSD design team professionals

Architects	They plan the building configuration (ie footprint, shape, number of stories), select materials such as exterior cladding, ceilings, interior walls, escape routes, location of critical plant, and other architectural elements. Each of these decisions can affect the seismic performance of the building. Architects also play a critical role in coordinating interaction among other design consultants.
Electrical engineers	They plan and implement power supply to mission-critical IT infrastructure, security, heating, ventilation, and air conditioning (HVAC), and lighting systems, as well as back-up power.
Fire engineers	They establish performance requirements for fire protection systems. Fire protection engineers design active fire protection systems, including sprinkler systems that might be needed to fight post-earthquake fires but could flood the building if damaged by the shaking.
Geotechnical engineers	They will assess (or if there are multiple options, compare) suitable sites for LDSD construction. This includes ground conditions and the exposure of a site to other hazards, such as liquefaction and landslides.
Interior architects or interior designers	They often select elements like suspended or feature ceilings, decorative wall hangings, large furniture, and storage systems, which can be hazardous if not properly secured.
Mechanical engineers	They design and oversee the proper installation of equipment, piping, and essential systems such as HVAC. These systems can be very vulnerable to earthquake shaking, depending on design.
Project managers	They are responsible for making sure that project goals are meet, quality is assured, and budgets are met. You can engage specialist project managers or in some cases an engineer or architect can fill this role.
Plumbing specialists	They design a building's water systems. Design and installation decisions impact leaks or breaks in earthquakes that can lead to flooding and loss of use of the entire building after an earthquake.
Quantity surveyors	They determine how design decisions are likely to impact construction costs. This can be an important contribution to the LDSD process, ensuring that performance goals are met within the budget available.
Seismic restraint specialists	They design and coordinate how non-structural elements of your building should be restrained.
Structural engineers	They select and design the structural system. This is critical both to minimising structural damage and building movement that can damage architectural, mechanical, and electrical components. Structural engineers typically lead the LDSD process. They may also specify seismic technology to control building damage.

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