Interim Health New Zealand

Health Infrastructure Unit

Understanding and Improving the Seismic Resilience of Hospital Buildings

SUMMARY REPORT

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Document Information

Prepared by:

Kestrel Group Ltd
Building Engineering and Emergency Management Consultants
Level 6, 117 Lambton Quay, Wellington
www.kestrel.co.nz

Dave Brunsdon CNZM
DistFEngNZ, CPEng
Director
db@kestrel.co.nz

Mike Stannard
DistFEngNZ
Consultant

Reviewed By:

Health Infrastructure Unit (HIU)

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Understanding and Improving the Seismic Resilience of Hospital Buildings

This overview report summarises the key findings, observations and recommendations from the Technical Report prepared by Kestrel Group for the Health Infrastructure Unit.

Background

An initial review of a sample of seismic assessments of key hospital buildings commissioned by various District Health Boards (DHBs) was undertaken for the Ministry of Health by Kestrel Group in 2019, and provided an input to the Ministry's June 2020 *Current State Assessment* report. That initial review of DHB seismic assessments highlighted the age and lack of consistency of some of the assessments, and that they typically covered only the primary structural elements. A further observation was that the critical aspect that affects the ability of hospital buildings to enable the delivery of acute services following an earthquake had not been assessed – namely, the adequacy of the seismic restraint of non-structural elements such as ceilings, partition walls, building services, pipe runs and heavy specialist medical equipment.

Kestrel Group was commissioned by the Ministry of Health's Health Infrastructure Unit (HIU) in March 2021 to build upon this previous work. This work included summarising the key seismic information the HIU currently holds on hospital buildings, and developing a framework for categorising the seismic risk of existing hospital buildings and enabling the prioritisation of mitigation work.

In addition, the HIU requested guidance to be developed on other aspects such as the interpretation of Importance Levels, approaches to evaluating non-structural elements and the components of seismic information that should be included in business cases, and recommendations for developing technical guidance for new and existing hospital buildings.

Overview of the Technical Report

The Technical Report provides analysis, commentary and proposed guidance in three main areas:

Understanding the Current Seismic Risk Profile

A general background to the technical and regulatory aspects of seismic assessments is provided, along with an outline of what is currently known and not known in relation to the seismic risk profile and status of public hospital buildings across New Zealand.

Addressing Areas of Inconsistency and Uncertainty

A framework for more consistent presentation of seismic information in investment business cases is provided, along with guidance on how to interpret and apply Importance Level categorisations for hospital buildings. A triage-based approach for evaluating the seismic vulnerability of non-structural components to tackle this significant information gap is also proposed.

A Structure for Consistent Management of Seismic Risk in Hospital Buildings

A framework for both categorising and prioritising the treatment of seismic risk is proposed. This is further supported with recommendations for a *Seismic Policy* and a *Seismic Risk Management Strategy* for hospital buildings. The need for national technical guidance for the design of new and assessment existing hospital buildings is highlighted, and a suggested process for preparing this guidance is outlined.

The report presents 23 recommendations to enable a comprehensive and systematic approach to *understanding and improving the seismic resilience of hospital buildings*.

Key Findings and Observations

Hospital buildings, particularly those with clinical and associated functions, are extremely complex facilities with multiple points of vulnerability to earthquake shaking. There are many challenges in understanding the nature and extent of the vulnerabilities, and in summarising and conveying them.

The following points summarise the technical report's key findings and observations, and proposed solutions.

Understanding the Current Seismic Risk Profile

1. A significant number of hospital buildings have not yet had seismic assessments undertaken or reported on

The majority (63%) of public hospital buildings throughout New Zealand have had seismic assessments commissioned by the respective District Health Boards reported to the Ministry. However, more than a third of all hospital buildings have yet to have an assessment reported on to the Ministry, including 40 buildings currently categorised as Importance Level 4.

2. A number of key hospital buildings have low seismic ratings for life safety in rare earthquakes

Of those buildings that have been assessed, a number have been found to have low %NBS ratings. Of all hospital buildings for which assessments have been reported, 103 (13%) currently rate less than 34%NBS. For Importance Level 4 buildings, 31 (16%) are currently rated less than 34%NBS. It is unclear how many of the buildings rating less than 34%NBS have been determined by territorial authorities to be earthquake prone.

Also of concern is that shortcomings in relatively modern public hospital buildings (ie. constructed since 2000) are continuing to emerge from new seismic assessments. These are buildings that until recently had been thought to represent a low seismic risk, but learnings from the Canterbury and Kaikōura earthquakes have highlighted areas of vulnerability in aspects of modern construction.

3. There is considerable variation in the reliability of seismic information currently held on key hospital buildings

A number of seismic assessments obtained by DHBs are somewhat dated, preceding the amendment to the earthquake prone buildings provisions of the Building Act and the associated update of the national assessment guidance that took effect in 2017. The key impacts of these changes relate to the need to include heavy non-structural elements within assessments, and for buildings that are structurally interconnected to have a single overall rating.

Some assessments are only qualitative Initial Seismic Assessments (ISA), rather than quantitative Detailed Seismic Assessments (DSA). *Reliability categories* are therefore proposed to enable a more transparent understanding of the usefulness of the seismic ratings for life safety obtained by the DHBs, as per the following table.

Reliability Category	Reliability Expectation	Assessment Type and Date
REL1	High reliability	From post-July 2017 DSA
REL2	Reasonable reliability for primary structure	From post-July 2017 ISA/pre-July 2017 DSA
REL3	Limited reliability	From pre-July 2017 ISA
REL4	Low reliability	From pre-2011 IEP
NI	None	No information

Significant investment decisions on existing buildings should be based on reliable and detailed seismic information.

4. *The post-earthquake functioning of hospital buildings is highly dependent on the performance of non-structural elements*

A key area of operational vulnerability of existing hospital facilities during and following earthquakes relates to non-structural components such as ceiling systems, fire sprinkler pipes, pipe runs for medical gases and steam, and specialist medical equipment. Even for buildings with relatively recent seismic ratings that do take heavy non-structural elements into account, there is typically no information about the status of other non-structural systems and medical equipment. Where these elements are not adequately restrained or separated, damage in earthquakes can be considerable, with associated impacts on functionality in addition to life safety concerns.

The lack of information on the seismic vulnerability of non-structural systems limits the understanding of the level of resilience of hospital buildings and site-wide infrastructure, and the likelihood of their being able to function following a significant earthquake. However, the likelihood of having key facilities such as operating theatres rendered unusable due to damage to non-structural elements in earthquakes appears quite high for many hospital buildings.

Addressing Areas of Inconsistency and Uncertainty

5. *More consistent use of seismic information is needed in investment business cases for hospital redevelopments*

A review of recent investment business cases has highlighted inconsistent and incomplete use of seismic information. This information should:

- Be based on a seismic assessment that reflects current national assessment guidance;
- Include the expected response of all elements that could adversely affect the ability of the building or buildings to operate;
- Include the potential impacts of and to adjacent and adjoining buildings; and
- Include the potential disruption to hospital services.

A framework for more consistent use of seismic information in business cases is proposed.

6. There is a need for a greater appreciation of the impact of seismic strengthening on clinical services

The biggest challenge in planning and undertaking seismic strengthening work in existing operational buildings is the impact on clinical services, as it typically involves highly intrusive activities.

Hospitals that have had buildability reviews of strengthening proposals undertaken by contractors usually identify greater operational impacts and challenges (and hence time and cost impact) than envisaged by the project teams. This raises fundamental questions around the practicality and viability of seismic strengthening for buildings housing acute services.

The operational impacts of seismic strengthening (and also demolition) need to be more consistently evaluated as part of master planning and business case development.

7. Clarity is required around the Importance Level categorisations that apply to the different functional uses of hospital buildings

There has also been a lack of consistency in the way that importance level classifications have been applied to hospital buildings for both assessment and design purposes across the DHB network. A clarification of those hospital buildings that warrant classification as Importance Level 4 structures to address this information void is proposed.

It is important to realise that the focus of importance levels is primarily on deriving the structural parameters for individual buildings. They do not in themselves inform the wider need and requirement for campus-wide resilience, including in relation to infrastructure.

8. A systematic approach to evaluating the seismic vulnerability of non-structural elements is required

There is a vast array of non-structural elements in hospitals, and the failure of any one of these has the potential to render a building and its associated services unusable following a significant earthquake. Observations from recent earthquakes in New Zealand and overseas has highlighted that certain heavier components such as emergency generators, elevators (lifts), suspended ceilings, water storage tanks and bulk oxygen tanks are more prone to damage or failure.

We propose that a higher level review of non-structural components be used, based on a qualitative evaluation that avoids using a compliance approach to gather 'big picture' information as rapidly and efficiently as possible. This triage-based approach suggests non-structural elements be evaluated under each of the three areas of ***Element restraint***, ***Element movement capacity*** and ***Internal capability of specialised equipment***, with vulnerability categorised in relation to the likelihood of *functionality* of the building to be affected under levels of earthquake shaking consistent with the design of new IL4 buildings.

A Structure for Consistent Management of Seismic Risk in Hospital Buildings

9. A risk categorisation of hospital buildings to reflect known levels of vulnerability and resilience is proposed

A framework for categorising individual hospital buildings into five risk categories that indicate the likelihood of post-earthquake building functionality is proposed. These risk categories are derived from the key inputs of *life safety* (%NBS) ratings and *building functionality* ratings, with the corresponding qualitative levels of building resilience indicated in the following table.

Risk Category	Overall Resilience
RC1	High Resilience
RC2	Resilient
RC3	Some Vulnerability
RC4	Vulnerable
RC5	Highly Vulnerable
Not Established	Not Known

A further cycle of refreshing the assessment information currently held by DHBs is necessary before these categories can be initially populated and reported on, and then monitored. It should be emphasised that the effectiveness of these categories is quite limited in the absence of information on non-structural components.

The proposed risk categories referred to above can be used as a basis for prioritising the concurrent activities of seismic mitigation and obtaining further information where little exists.

10. *Prioritising the mitigation of seismic risk across New Zealand hospitals should take into account the wider consequences for the community of key buildings not being functional*

From a building perspective, it is suggested that initial priority be given to Importance Level 4 buildings in Risk Categories RC4 and RC5, with emphasis on hospitals in high seismic hazard areas as defined in the Building Act.

However, an additional component of risk that should be taken into account when prioritising mitigation work involves the consequences for the affected community of the potential poor performance of hospital buildings and associated infrastructure. The scope and sequencing of mitigation work should be based on comprehensive site Master Planning informed by a vulnerability assessment of site-wide infrastructure (including external network vulnerabilities), with reference to the relevant local, regional and national health emergency plans.

This can also extend to regional analysis in situations where there is more than one hospital in a region. Consideration should then be given to comparing the building vulnerabilities and populations affected between different regions. This may lead to different national mitigation priorities than those based purely on seismic hazard and risk aspects.

11. *Prioritising the mitigation of seismic risk across New Zealand hospitals needs to take account of current information gaps*

Progress needs to be made to mitigate seismic risk for hospital buildings that pose significant risks to life safety and continued functionality. There is nevertheless a need to balance getting physical risk reduction underway with the need for more information in some areas, given the significant knowledge gaps highlighted above. It is considered that both the physical mitigation of risk and the gathering of additional seismic information can be progressed in parallel.

12. *A Seismic Policy is required to outline the expectations and requirements for hospital buildings, supported by a Seismic Risk Management Strategy to establish the basis and priorities for managing buildings with identified seismic vulnerabilities*

Currently, each DHB makes decisions in relation to managing seismic risk that respond to aspects such as their own situation, professional advice and the availability of operational and capital funding.

To create a systematic risk management basis for implementing this work, the development of a *Seismic Policy* (seismic performance objectives and expectations) and a *Seismic Risk Management Strategy* (implementation approach and priorities) that is integrated with asset management and infrastructure risk management approaches is recommended. Site-specific Seismic Risk Management Plans (akin to the current Asbestos Risk Management Plans) could then follow, providing the key linkage with site-wide infrastructure.

An important component of the seismic policy is the process and risk basis for evaluating the continued occupancy of buildings that rate less than 34%NBS. It is noted that for IL4 buildings, these ratings are based on a 2,500 year return period earthquake – a very rare event.

13. *Seismic performance objectives and expectations for new and strengthened hospital buildings need clearer definition*

New IL4 buildings are specifically designed to achieve both *life safety* and *building functionality* objectives. Although the life safety objectives for new IL4 buildings in rare earthquakes are clear, the corresponding objectives for the arguably more important *building functionality* in major (500 year return period) earthquakes are much less clearly defined, particularly for hospital buildings delivering acute medical services.

The objective of a building being usable following a 500 year return period earthquake doesn't correspond to a 'no damage' requirement, but the reality is damage or disruption to even small elements of many hospital facilities can be sufficient to make the building unusable.

The corresponding objectives, expectations and requirements for existing IL4 buildings are also not defined. The logical starting point is to establish these for new buildings.

14. *There is a need for national technical guidance for both the strengthening of existing and the design of new hospital facilities*

There is currently no specific guidance in New Zealand for design practitioners on how to achieve the building functionality objective for IL4 buildings for either new or existing hospital buildings where they are upgraded.

National technical guidance for both the strengthening of existing and the design of new hospital facilities (across all importance levels) is therefore required to reflect the objectives, expectations and requirements for hospital buildings as noted above. The general scope and form of the Ministry of Education's technical requirements document provides a useful reference framework for the corresponding guidance for hospital buildings.

15. Hospital emergency plans should more clearly define the post-earthquake decision-making process relating to alternative facilities

Given the observation that there is a high likelihood of having key facilities rendered unusable due to damage to non-structural elements in earthquakes, hospital emergency plans must clearly outline the post-earthquake decision-making and implementation process. This should include nominated alternative facilities with reasonable degrees of resilience and appropriate backup infrastructure.

A decision to continue to deliver services in a damaged building or evacuate to an alternative facility is a significant one that needs to take into account a number of clinical and functional considerations and compromises.

16. Specific Priority Response Agreements need to be formalised with engineers to ensure effective post-earthquake responses

Greater emphasis should be placed on the technical aspects of earthquake response in hospitals and across the health sector network. As part of hospital emergency planning, it is essential that specific arrangements are in place with engineering consultants to respond to any earthquake event as required. The specific response expectations and mechanisms need to be clearly mapped out, including outline inspection plans and the nature of initial reporting. The response arrangements for the engineers should be integrated within hospital emergency plans, with associated annual 'readiness' activities to ensure that the arrangements are up to date.

The option of having seismic instrumentation installed in key hospital buildings should also be considered. This could reduce the time taken by engineers to evaluate the response of the structure to significant earthquake shaking, hence hastening re-occupancy decisions.

Summary and Recommendations

In summary, this report aims to create a framework and language that enables a clearer and more consistent understanding of the seismic vulnerability of public hospital buildings in New Zealand.

Much of this report focuses on buildings as individual structures, with the associated regulatory linkages. However, it is fundamental that a campus-wide approach to both buildings and infrastructure is adopted. Part of this involves understanding the difference between *meeting minimum building regulatory requirements* and *achieving appropriate levels of resilience across a hospital campus* (extending to regional and national levels, where necessary) to ensure the delivery of medical services to the community following major adverse events.

In many cases, currently low rating hospital buildings will need to continue to be used for some years until replacement facilities can be constructed. In most situations this is likely to be acceptable from a life safety risk perspective, provided that clear timelines and expectations are established, documented and managed. Buildings with potentially brittle failure mechanisms affecting the primary structure should however receive specific consideration. The expectation that a number of hospital buildings may not be usable immediately following a major earthquake requires a stronger focus on alternative facility identification and post-earthquake decision-making in hospital emergency plans.

Recommendations to enable a comprehensive and systematic approach to ***understanding and improving the seismic resilience of hospital buildings*** are grouped under seven key themes in the following table. The majority of these recommendations require adoption and implementation by Health New Zealand (Health NZ). Preparatory work can however be undertaken in several areas prior to the formation of Health NZ.

Theme		Recommendation
1. Update seismic information to address gaps and reliability issues	1.1	Update the status of current DHB seismic assessment information held by the HIU, with emphasis on clarifying the date and type of seismic assessments
	1.2	Review the seismic assessment information currently held to enable the reliability of the information to be taken into account
	1.3	The interpretation of the Importance Level definitions outlined in this report should be adopted by Health New Zealand to ensure that seismic ratings are based on the appropriate Importance Levels
	1.4	Provide tools such as briefing and report summary templates to support DHBs in obtaining additional seismic information
	1.5	Establish a process and programme for obtaining additional seismic information, giving priority to those IL4 buildings that have not had any seismic assessments to date
	1.6	Develop a plan and approach to obtain information on the seismic status of non-structural elements, giving priority to acute services buildings with high seismic ratings for primary structure
2. Prepare technical guidelines for designing new and assessing existing hospital buildings for Health New Zealand	2.1	Establish a specialist engineering panel (eg. the Health Engineering Strategy Group) to prepare technical guidelines for designing new and assessing existing hospital buildings
	2.2	Establish seismic performance objectives for new and strengthened hospital buildings, covering both *life safety* and *building functionality*
	2.3	Confirm the scope and key elements of the technical guidance for practitioners required to support the *Seismic Policy* and *Seismic Risk Management Strategy*
	2.4	Develop a process for evaluating the seismic vulnerability of site-wide infrastructure that interfaces with both the building-based non-structural element evaluation processes and with external service providers
	2.5	Prepare a briefing template for consulting engineering practices undertaking seismic strengthening designs, and a template for summarising the strengthening scope and outcomes at the various stages of design

3. Establish a framework to enable the systematic categorisation of seismic vulnerabilities and identification of information gaps	3.1	Adopt the proposed risk categorisation to identify priority categories of hospital buildings for seismic upgrade or replacement, and where additional seismic information is required
	3.2	Extend the proposed risk categorisation to reflect overall hospital campus-wide seismic vulnerability
4. Develop a Seismic Policy and Seismic Risk Management Strategy for Health New Zealand	4.1	Develop a *Seismic Policy* to outline the expectations and requirements for new and strengthened hospital buildings and for managing buildings with identified seismic vulnerabilities
	4.2	Develop a *Seismic Risk Management Strategy* to implement the recommendations from this report in accordance with the requirements of the Seismic Policy
5. Actively progress seismic risk mitigation	5.1	Establish a seismic risk mitigation programme that utilises the seismic priority categories identified in this report and reflects overall campus-wide seismic vulnerability (including infrastructure) and the consequences for the community of key hospital buildings not being able to function following earthquakes
	5.2	Prepare guidance for how natural hazards and other risks should be addressed in hospital site-wide Master Planning
	5.3	Adopt the checklist proposed for seismic information to be included in business cases for the upgrades of existing hospital buildings
6. Ensure that hospital emergency plans provide greater emphasis and clarity around early post-earthquake decision-making	6.1	Update hospital emergency plans to provide greater clarity on early stage post-earthquake decision-making for key acute services functions
	6.2	Ensure that nominated alternative facilities have a reasonable level of seismic resilience and appropriate emergency backup infrastructure
7. Establish specific arrangements with engineers for post-earthquake response at each main hospital	7.1	Ensure that post-earthquake response arrangements for engineers are incorporated within hospital emergency plans
	7.2	Develop a common template for Priority Response Agreements with engineers for post-earthquake response
	7.3	Consider installing seismic instrumentation to key acute services buildings to provide information to support responding engineers and facilities managers with re-occupancy decisions

Kestrel Group
www.kestrel.co.nz