18 February 2022

Mr Andrew Boyd
Executive Services Director
Hawke's Bay District Health Board
Private Bag 9014
Hastings 4156

Independent Seismic Risk Advice on the Acute Services Buildings at Hawke's Bay Hospital

Dear Andrew

This report reviews and summarises the report recently prepared by WSP on the current seismic status of the acute services buildings at the Hawke's Bay Fallen Soldiers' Memorial Hospital, and provides additional risk commentary and recommendations.

1. Introduction

We have been engaged by the Hawke's Bay District Heath Board to provide independent risk advice in relation to the current seismic status of the acute services buildings at the Hawke's Bay Fallen Soldiers' Memorial Hospital in Hastings. This advice draws upon information contained in the 11 February 2022 WSP 'current state' report, in addition to our knowledge of the buildings from work undertaken over the past six months.

We are also currently engaged by the Ministry of Health to provide seismic risk advice generally, and to prepare a report on the current state of seismic resilience across hospital buildings in New Zealand.

The writer has an extensive background in both the technical and regulatory aspects of the seismic assessment of existing buildings. He has had an oversight and co-ordination role in the development of the previous and current national seismic assessment guidelines, and is a technical adviser to MBIE and various territorial authorities on earthquake prone building matters.

2. Context and Drivers for the WSP Report on the Acute Services Buildings

The context and drivers for the WSP 'current state' report on the acute services buildings can be summarised as follows:

1. Hawke's Bay DHB has had extensive seismic assessments of its buildings carried out over the past decade, primarily by WSP (formerly Opus).
2. These assessments have focused on buildings at the individual structure level, as assessments are required to do. One of the key areas of focus for this WSP study was to consider how the set of buildings are likely to perform collectively.
3. There have been changes to assessment methods in recent years, and increases to seismicity are in prospect. Accordingly, there is a need to consider the impacts on the current seismic assessments and the seismic risk profile, and to draw these findings together to better inform campus master planning.
4. The implementation of strengthening works to date and recent planning for the strengthening of Radiology has led to the realisation that strengthening buildings while they are in-service is highly challenging for users of the buildings, and adds considerably to buildability challenges.
5. Hawke's Bay DHB is about to embark upon site-wide master planning to establish the future configuration of the hospital to address clinical and operational requirements, and to meet the needs of the community. Everything points to the need for the Board to continue to use the acute services buildings for up to ten years before redevelopment of the campus is planned and completed.

Given these technical developments and considerations, there is a need to have a clearer picture of the current seismic risk profile of these buildings – individually and collectively. This needs to be considered through the two lenses of *life safety* and *post-earthquake functionality*, which involves going beyond the basic information provided by %NBS ratings from seismic assessments.

3. The Changing Environment of Seismic Assessments

3.1 Regulatory and Technical Changes

Changes to the earthquake-prone buildings provisions of the Building Act were introduced in 2017, along with a major revision of the national technical guidance for seismic assessments. Some of the most relevant changes include the requirement to include *Secondary Structural and Non-Structural Elements* in assessments and to consider more carefully where buildings are interconnected.

The Canterbury and Kaikoura earthquakes also raised concerns about more modern forms of construction, most notably precast concrete floor systems (focusing on multi-storey buildings) and wall panel connections in buildings with precast concrete wall panels that are poorly connected into steel roof framing (typically one and two storey buildings).

The seismic assessments undertaken over the past decade by WSP and others however represent the 'assessments of record', and there is not considered to be any need for them to be revisited for regulatory purposes.

3.2 Changes to Seismicity

Most of the assessments undertaken over the past decade have been based on the 2012 GNS site-specific study for the hospital campus. That study was comprehensive, and a valid basis for use in the subsequent assessments, including those that were supplied to Hastings District Council for earthquake-prone buildings purposes. However the new understanding of off-shore faults means that the 2012 GNS study understates the seismicity at the site, and is no longer suitable for use for either assessments or strengthening design.

A project to update the National Seismic Hazard Model is currently being led by GNS Science for MBIE, and a new model is scheduled to be released later this year. This information is likely to be incorporated into the Building Code in 2023. Changed understanding of the underlying faults (including extensive research on the Hikurangi trench) is leading to increased seismicity parameters for central New Zealand and the east coast of the North Island.

The main impact of these changes is likely to be on new building designs. The earthquake prone buildings legislation currently requires that assessments of existing buildings are to be based on the seismic factors in the current earthquake design standard NZS1170.5 as at July 2017.

The new seismicity values in the updated National Seismic Hazard Model are likely to be greater again than the NZS1170.5 values, but using NZS1170.5 values at the present point in time is considered an appropriate point of reference for the assessment of existing buildings.

3.3 Importance Levels

There is a lack of clarity nationally about which hospital functions warrant Importance Level 4 (IL4) categorisation. There is currently no clear definition of how 'medical emergency' and 'surgical facilities' are intended to be interpreted in the context of 'special post-disaster functions' that defines the scope of IL4 categorisation.

Part of the current work being undertaken by Kestrel Group for the Ministry of Health involves elaborating upon the current basic definitions across the range of services or functions delivered in the hospital context.

The headline building categories currently proposed in our draft report for the Ministry as IL4 are summarised below, and were incorporated in the brief for the WSP report:

- **Key Clinical Operational Areas** (including operating theatres, Emergency Department and Intensive Care Units)
- **Critical Clinical Support Functions** (including radiology, laboratories and some inpatient wards)

- **Other Specialist Functions or Services** (possibly including maternity and neonatal, forensic mental health)
- **Infrastructure and Supplies** (facilities providing services used in the above functions)

As part of taking account of the physical interconnection of buildings, it should be noted that if any special post-disaster function is housed within a section of a building, then the overall building is required to be categorised as IL4.

4. Additional Background to Seismic Risk and Vulnerability

4.1 *%NBS* Ratings and Life Safety

The principal outcome from a seismic assessment is a rating in the form of the % of New Building Standard (NBS). These ratings are essentially a risk comparator, and relate the subject building to an equivalent new building. They are not a predictor of expected performance in a particular earthquake, as every earthquake is different in terms of frequency of shaking.

Accordingly, *%NBS* ratings don't represent a specific assessment of safety. A building with a low seismic rating (less than 34%NBS, for example) is not necessarily in any imminent risk of failure in an earthquake. This is particularly the case when the higher return periods (lower likelihoods) associated with the higher importance levels are used (eg. 2,500 years for IL4). The low rating primarily signals that action should be taken to address the seismic vulnerabilities that engineers have identified.

The intended outcomes of a low *%NBS* rating can be summarised as:

- To signal heightened risk in the event of earthquake occurrence;
- To convey the need for mitigation work to be undertaken, and sooner rather than later; and
- If the building is determined to be earthquake prone, to link this with defined statutory timeframes

For buildings with seismic ratings less than 34%NBS, the risks identified typically do not correspond to the building being regarded as dangerous. It is important to note that the low %NBS ratings reflect the presence of structural shortcomings and a lack of resilience in these systems, not the levels of shaking at which they might fail.

Furthermore, in their 2018 position statement[1], Worksafe advise:

> *If a building is found to be earthquake prone, this doesn't necessarily mean that it shouldn't be occupied. The Building Act provides a period of several years for strengthening or demolition work to be undertaken. While the risk to people in or around an earthquake-prone building is greater than an equivalent new building, this doesn't typically require short-term action.*

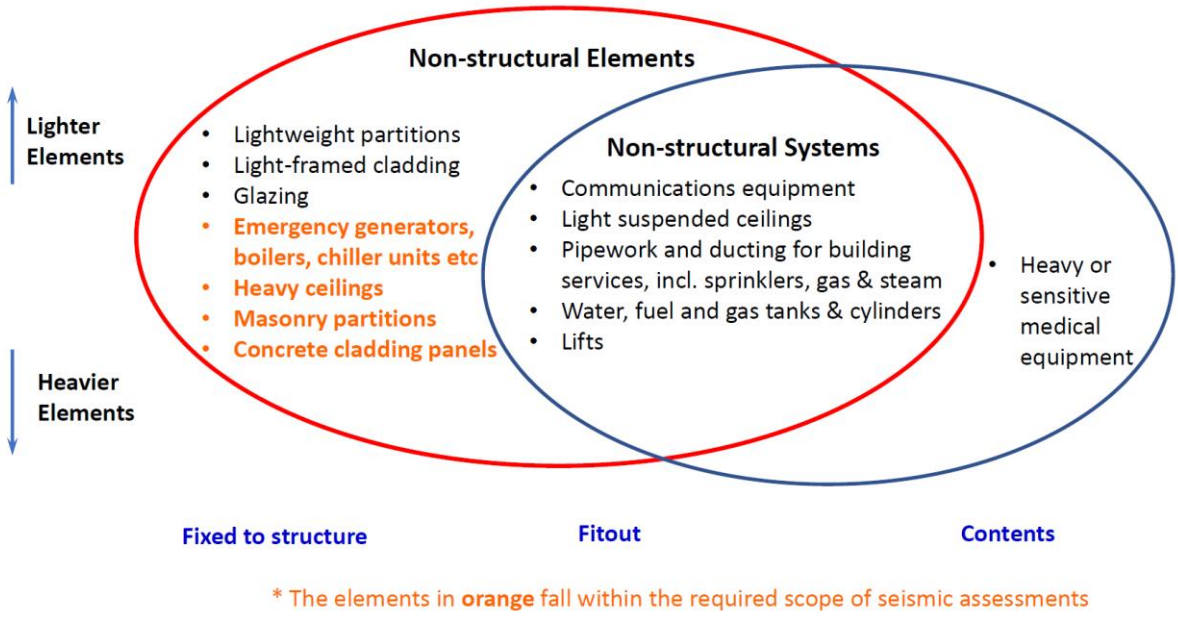
[1] Worksafe Information for PCBUs and Building Owners May 2018: *Dealing with earthquake-related health and safety risks*

In evaluating the risk posed by a hazard to a building structure and its occupants, the aspects of both *Likelihood* and *Consequence* need to be taken into account.

4.2 Post-earthquake Building Usability

For hospital buildings with key operational functions, %NBS ratings only tell part of the seismic vulnerability story. The ability to continue to function following a 500 year return period earthquake is a requirement for new IL4 buildings, and is arguably as important as life safety in a 2,500 year event.

This can be governed more by the adequacy of the restraint of non-structural elements and allowance for movement of service pipes between buildings than the behaviour of the primary structural elements, particularly for low-rise buildings. Non-structural elements include heavy overhead elements (ceiling systems; light fittings), plant or specialist operating equipment, water tanks, lifts, ceiling systems and light; sprinkler and service pipe runs, as represented in the diagram below.



Only those elements shown in orange are covered in seismic assessments, and were only required to be included from July 2017. Earlier seismic assessments typically did not include coverage of these elements. The other elements are typically not included within the scope of seismic assessments.

5. WSP Report on the Current Seismic Risk Status

5.1 The Brief

As part of the Ministry of Health's support for master planning, a brief was prepared in August 2021 by Kestrel Group for WSP to prepare a report which summarises the current state with respect to seismic risk across the acute services buildings.

The key requirements of this report were to:

- Draw together the findings from previous seismic assessments
- Indicate the likely %NBS ratings if based on NZS1170.5 seismicity and the current draft Ministry of Health proposal on Importance Level interpretations
- Clarify the physical interfaces between the key buildings
- Highlight any structural and non-structural elements with particular vulnerabilities
- Make recommendations for any priority mitigation work in the context of the buildings being used until replacement facilities are in place

While the WSP report focused on the acute services buildings clustered around Radiology as indicated in the following figure, they also provided relevant commentary in relation to other IL4 buildings across the campus.

5.2 Key WSP Findings

The key findings from the WSP report dated 11 February 2022 are summarised below under the above headings of the brief.

Updated indicative ratings

The following tables summarise both the ratings from the current assessments and the indicative adjusted ratings for firstly, the acute services buildings and secondly, the other IL4 buildings on the campus.

(1) Acute services buildings

Building	Current Rating (All IL4)	Indicative Adjusted Rating (NZS1170.5; IL4)
HA37 Theatre Block	15%NBS	50%NBS
HA27 Radiology	35%NBS	**30%NBS**
HA27a Radiology Extension	34%NBS	**25%NBS**
HA25 Emergency Department	45%NBS	45%NBS
HA30 ICU	40%NBS	**25%NBS**
HA26 Laboratory	65%NBS	45%NBS
HA26a Laboratory Extension	70%NBS	50%NBS
HA28 SCBU	40%NBS	**30%NBS**

(2) Other IL4 buildings

Building	Current Rating (Various IL3 and IL4)	Indicative Adjusted Rating (NZS1170.5; IL4)
HA23 Physiotherapy	40%NBS	**30%NBS**
HA29 Ward Block B	67%NBS	67%NBS
HA29a Ata Rangi	34%NBS	34%NBS
HA29b Waioha	85%NBS	85%NBS
HA31 Ward Block AB	67%NBS	67%NBS
HA32 Ward Block A	67%NBS	67%NBS
HA32a Paediatrics	85%NBS	60%NBS
HA12 Chiller Plant	100%NBS	100%NBS
HA13 Former Boiler House	100%NBS	100%NBS
HA11 Dangerous Goods	76%NBS	100%NBS
HA15 Helicopter Service	100%NBS	67%NBS

In summary, all of the indicative ratings for the acute services buildings fall short of the preferred 67%NBS(IL4) level. Four are indicated as falling below 34%NBS (IL4) as shown in bold in the tables: HA27 Radiology and HA27a Radiology Extension, HA30 ICU, and HA28 SCBU. Of the other IL4 buildings, HA23 Physiotherapy would also fall below 34%NBS using NZS1170.5 seismicity.

HA34 AAU has been confirmed as IL3, but the rating changes slightly from 37%NBS to 33%NBS.

Building Interfaces

Most of the acute services buildings are seismically separated, but the separation is relatively nominal. As a consequence, in a major earthquake the buildings are likely to impact against each other during significant earthquake shaking.

While this is a different response to that assumed in the WSP seismic assessments which were based on each building being its own separate structure, their further work as part of this project has concluded that the individual ratings are essentially unchanged.

However the services and ceilings crossing the junctions in the corridors beneath the building interface are likely to be significantly damaged in a 500 year return period earthquake, thereby affecting post-earthquake functionality.

Non-structural Elements

WSP have been progressively undertaking evaluations of the restraints and movement allowance of non-structural elements prior to this project. They have drawn together their findings in the format recommended in the brief, with the key findings as follows:

- Most of the services and fluid piping runs have some form of restraint
- Fire sprinkler heads on droppers penetrating down through ceiling tiles without allowance for movement are an issue – this can lead to sprinkler head damage which in turn leads to post-earthquake flooding
- Computer racks/ cabinets in the IT Hubs sit on floating floors apparently without restraints

Potential Levels of Damage in 500 Year Earthquake Shaking

The key points from WSP's expectations of the foreseeable levels of damage in a 500 year return period earthquake can be summarised as follows:

- Significant damage to many columns in Radiology and the Laboratory block (eg. cracking and spalling of concrete)
- Uncertainty of the structural performance of HA34 AAU foundations due to the potential for liquefaction
- Buckling of the roof trusses over HA27a Radiology Extension and possible collapse, affecting plant room functionality. Functionality of the plant room to ICU also affected

- Damage possible adjacent to seismic gaps around the Laboratory block
- Loss of ceiling tiles over extended areas
- Broken windows and some loss of masonry cladding in older blocks

5.3 WSP Recommendations

WSP have provided nine recommendations to reduce the currently identified risks and to investigate certain aspects further.

Six recommendations relate to specific investigation and mitigation, and these are:

- Investigate the seismic restraint of the water tanks in HA32 Block AB, and undertake mitigation work if found necessary
- Strengthen the steelwork connections in the roof structure associated with the elevated plantroom of HA30 ICU
- Creation of separation between the main stair HA26 Laboratory and the primary structure
- Assess and improve the seismic restraint of the IT Q Hub in HA23
- Investigate the fixings of the brick and stone cladding to the facades of HA29 and HA32 (Ward Blocks A & B), and mitigate if found necessary
- Progress the design and implementation of the ground and foundation strengthening to HA34 AAU

Three general recommendations cover the following aspects:

- Detailed Seismic Assessments to provide additional clarity on seismic ratings of Emergency Department Entry, HA29a Ata Rangi and HA32a Paediatrics
- Development of a service-by-service upgrade of the main piped networks from source to where they enter each acute services building, particularly around junctions and seismic joints between buildings
- Geotechnical investigation of identified sub-surface silt layers to better inform master planning

6. Analysis of Current Risk State

6.1 Kestrel Perspective

Based on the findings of the WSP current state report and our knowledge of the buildings, our view on the acute services buildings with respect to both life safety and post-earthquake functionality is summarised as follows:

1. The acute services buildings were not designed for the level of seismic loading that today's equivalent buildings would be (including to a 2,500 year return period), nor detailed as well. This results in the low and mid-range seismic ratings indicated.
2. The buildings are however low rise (one and two storeys) with a highly regular structural layout and configuration. They do not contain the types of structural vulnerabilities that have caused buildings to fail in previous major New Zealand earthquakes.
3. The buildings also contain few heavy non-structural elements that can give rise to significant life safety hazards.
4. The aspects giving rise to low ratings in some of the buildings would typically require the occurrence of a significant earthquake to generate the failure modes identified. The likelihood of an earthquake of this magnitude occurring over the next decade while new acute services buildings are being developed is therefore considered low.
5. Accordingly, the continued use of the buildings over the next ten years is considered appropriate from a life safety perspective. This is also consistent with the current earthquake prone buildings legislation which provides a period of up to 7.5 years for the strengthening or demolition of these building if (hypothetically) they were determined to be earthquake-prone.
6. The buildings were however not originally designed to limit damage in major earthquakes (500 year return period). The recent work by WSP as drawn together in this study has established that these buildings are unlikely to be all usable following earthquakes of this size. There is however a reasonable expectation that most would be functional in more frequent smaller earthquakes.
7. Specific attention should therefore be given to planning for alternative facilities for key functions and the associated response arrangements in the event that one or more of the buildings housing these functions are rendered unusable.

6.2 Greater Emphasis on Alternative Facilities in Emergency Response Plans

All key operational facilities need a specifically designated alternative facility or arrangements. While this principle applies irrespective of whether a building is near-new and purpose designed or an older structure, it is clearly more important to have specific alternative arrangements in place for older, lower rating buildings.

We have reviewed the Hawke's Bay DHB Major Incident Plan, Evacuation Plan and Business Continuity Plan documents, and consider that more specificity is required across the plans in relation to alternative facilities for post-earthquake situations. This includes the critical decision-making around whether or not to evacuate buildings found to be damaged – a significant decision in itself - and how to quickly set up alternate facilities for key functions.

A key input into this decision-making process is quick information on levels of damage from engineers who are familiar with the buildings. We have also reviewed the 'Post-earthquake Building Assessment Response Plan' outlining how the DHB and WSP will co-ordinate and undertake rapid post-earthquake structural assessments of the buildings as priority tasks. This is a comprehensive document that in our view represents best practice across New Zealand hospitals. However better integration of the arrangements in this document into the overall response processes will enhance the overall earthquake response.

It is noted that the designation of alternative operational facilities requires the corresponding provision of infrastructure. A key consideration here is emergency power, which may involve a wider coverage than is currently the case.

7. Summary and Recommendations

7.1 Current Seismic State of Acute Services Buildings

The assessments undertaken over the past decade by WSP and others were comprehensive and met statutory requirements, and have led to appropriately prioritised strengthening work. The seismicity used was appropriate, based on the 2012 site-specific study by GNS. As noted earlier, we consider these assessments to represent the 'assessments of record', and there should not be any need for them to be revisited for regulatory purposes. Hastings District Council have been briefed on this work, and concur with the view that the increased new seismicity values will not lead to buildings being found to be earthquake prone.

Understanding the nature of seismic ratings using newer seismicity is however part of *being on top of new and emerging information,* as noted in the 2018 Worksafe Position Statement. This also suggests that the seismicity to come from the new National Seismic Hazard Model may warrant a further adjustment of the indicative ratings for risk purposes, once that information has been incorporated into the Building Code later in 2023.

Notwithstanding the indicative adjusted ratings for the Radiology and Extension, ICU, SCBU, Physiotherapy and AAU buildings falling below 34%NBS, we believe that collapse of any of these buildings is highly unlikely (in either 500 or 2,500 year levels of ground shaking). The buildings are generally low-rise, of regular layout and are well-detailed for their time. They also contain relatively few heavy non-structural elements that can give rise to life safety hazards. It is therefore considered that continued occupancy of these buildings is appropriate during the period when the planning and construction of new acute services buildings is undertaken.

The low ratings and identified weaknesses point more to the expectation of structural and non-structural damage in 500 year shaking. Emergency response planning for the buildings with low ratings should therefore be based on the expectation that individual buildings are unlikely to be usable following a major earthquake.

7.2 Recommended Actions

We support the WSP recommendations to reduce the most likely risks – ie. addressing the things that would cause problems in more frequent earthquakes, and give rise to life safety risks in larger earthquakes.

Within the WSP recommendations, there should be an initial focus on the things that impact on the ability to continue to use the buildings following earthquakes – ie. the seismic restraint of the water tanks on HA32 Block AB and the seismic restraint of the IT Q Hub in HA23, plus the junctions of the main piped networks at each acute services building.

As noted in the previous section, there should be a focus on having alternative facilities clearly identified within the respective Health Emergency Plans, along with a clear decision-making pathway for evacuating acute services buildings if necessary following a major earthquake and the process for setting up alternative facilities.

Various groups should be briefed on the key findings from the WSP report. This includes staff at the hospital, as part of Hawke's Bay DHB's responsibilities as PCBU.

We trust the information and independent advice provided in this report is of assistance to the Hawke's Bay District Health Board. Please contact the writer if you have any questions in relation to this report.

Yours sincerely

Dave Brunsdon
Chartered Professional Engineer

Director

Kestrel Group Ltd