Technical Guidelines for the Seismic and Structural Design of Hospital Buildings

Overview

Health Engineering Advisory Group

Chile-NZ Seismic Design of Hospitals Workshop - July 2024

Te Kāwanatanga o Aotearoa
New Zealand Government

Health New Zealand
Te Whatu Ora

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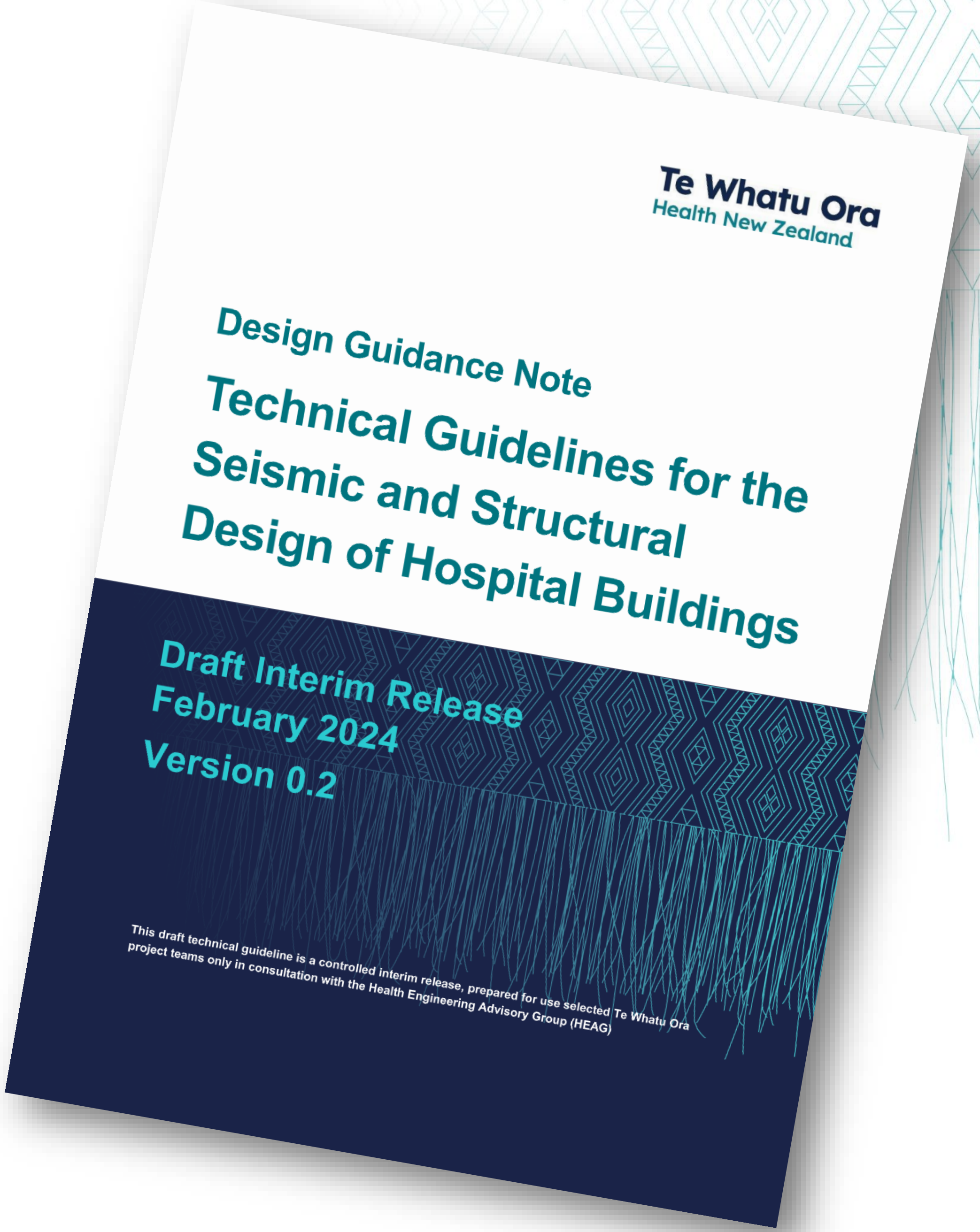

Te Whatu Ora
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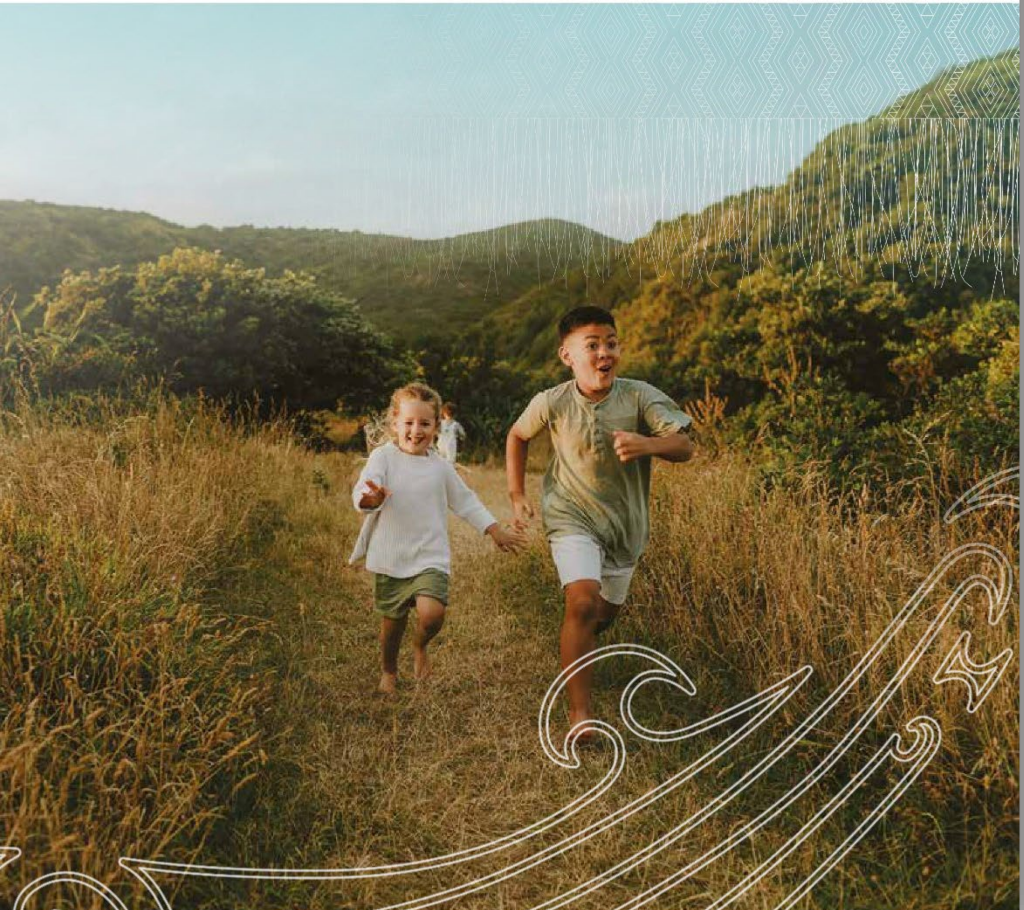
Te Pae Tata | Interim New Zealand Health Plan

2022



Te Whatu Ora
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New Zealand Health Facility Design Guidance Note

DGN V2.0: NZ Health Facility Design

Released September 2022

Masterplanning Guidance for Health New Zealand | Te Whatu Ora Health Facilities

AusHFG

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Health New Zealand

Design Guidance Note: Fire engineering design for New Zealand public hospitals

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Design Guidance Note

Technical Guidelines for the Seismic and Structural Design of Hospital Buildings

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Te Whatu Ora
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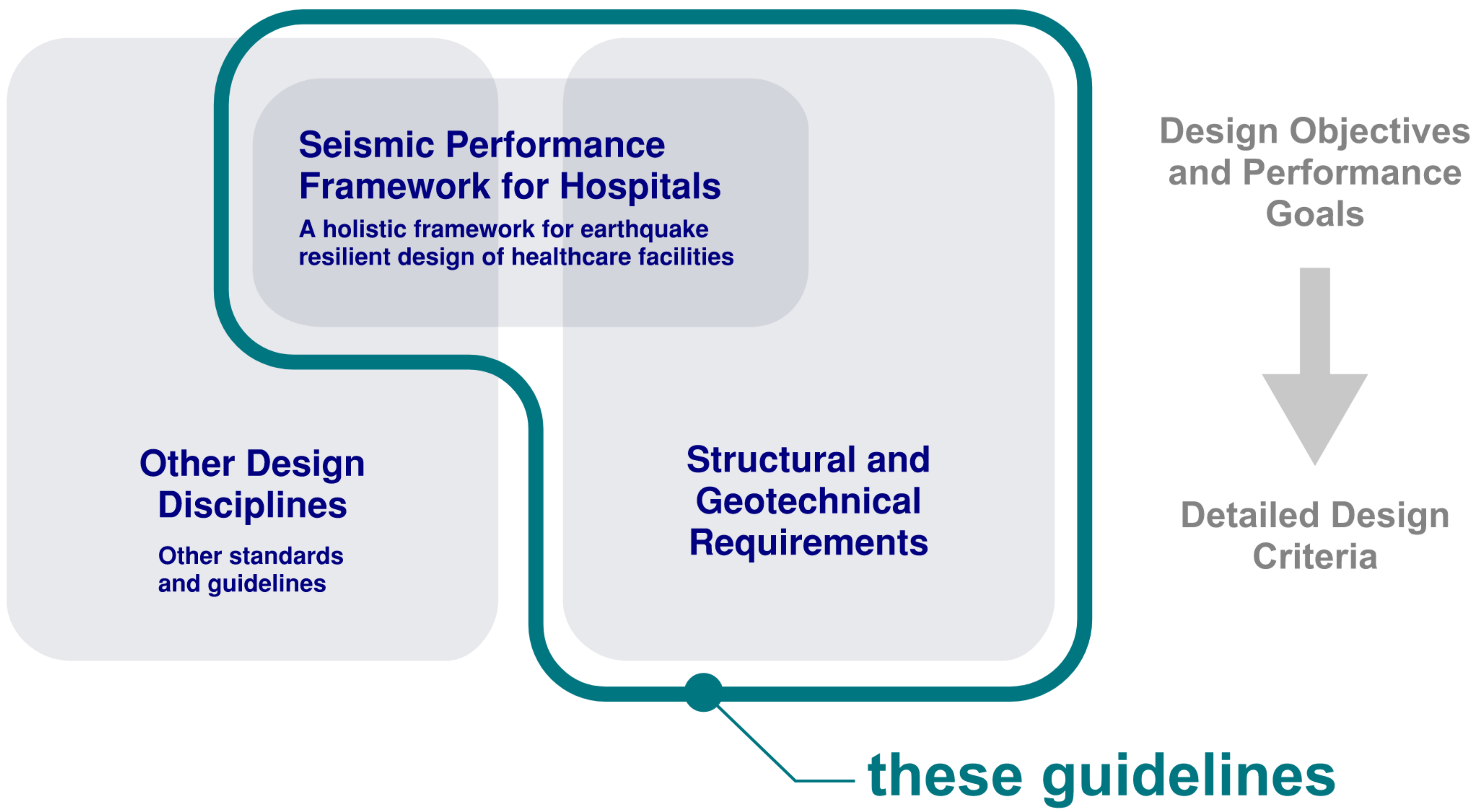
Design Guidance Note

Technical Guidelines for the Design of Building Services in Hospitals

In Preparation


Seismic Performance Framework for Hospitals
A holistic framework for earthquake resilient design of healthcare facilities
Other Design Disciplines
Other standards and guidelines
Structural and Geotechnical Requirements
Design Objectives and Performance Goals
Detailed Design Criteria
these guidelines

Te Whatu Ora
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Design Guidance Note

Technical Guidelines for the Seismic and Structural Design of Hospital Buildings

June 2024

Version 0.4 DRAFT for Health NZ Internal Review

This draft technical guideline is a controlled interim release, prepared for use selected Te Whatu Ora project teams only in consultation with the Health Engineering Advisory Group (HEAG)

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CHILLED WATER FLOW


KLS martin
MAQUET
AMBU BAG
CICO SCALPEL BOUGIE
T-PIECE

A1.7 Masterplanning and Site Context

A1.7.1 General

Te Whatu Ora's *Masterplanning Guidance for Public Hospital Facilities* is the key reference document for masterplanning in public healthcare contexts. This Section A1.7 contains additional information relevant to the processes described in that document—with specific additional detail relevant to seismic performance, and structural and geotechnical matters. This includes:

- Geotechnical considerations which are important for site selection, and for developing robust business cases that reduce cost uncertainty.
- Alterations and refurbishments to existing buildings (including making design provision for future structural additions, risks and benefits).
- Seismic resilience of hospital campuses
  - Seismic policy considerations for existing buildings.
  - Managing physical risks from adjacent buildings.
  - Site wide dependencies on utilities and engineering systems (in the context of structural and geotechnical performance).

A1.7.2 Geotechnical Considerations and Site Selection

Prior to embarking on site planning, and then the various building design phases, it is vital that the site and its environs are adequately characterised. This is to identify key site constraints and opportunities that influence planning and design decisions, and to enable an intelligent, holistic approach to the planning of health facilities. Siting can have considerable impacts on cost and performance of hospital buildings and infrastructure.

This geotechnical investigation and assessment must be carried out well in advance of any other design-related activities (including architectural planning). As discussed in Section A3.4, even at site acquisition or master planning stage Te Whatu Ora expects geotechnical reporting to provide comprehensive and technically justified advice on all geotechnical aspects of the site, including design data (even if preliminary) for likely feasible foundation types, as well as any advice that might influence the siting of facilities (including on and off site hazards that could compromise access to a facility in the event of an emergency).

A site zonation plan should be provided that identifies any areas of a site that are more, or less, suitable for the siting of buildings or other facilities, as well as identifying any particular geotechnical hazards that might influence the design of buildings or infrastructure.

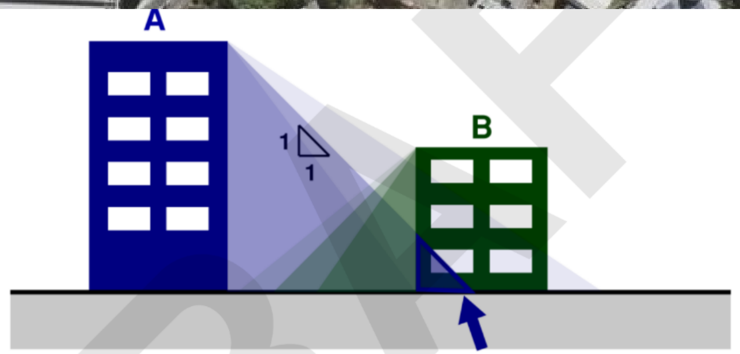


Figure 3: Definition of an adjacent building for earthquake risk assessment (using a 1:1 height ratio as a starting point). Building A poses a risk to building B, as it could present a hazard if it were significantly damaged or if it collapsed in an earthquake. Refer to text and footnote on the height ratio (which can be reviewed).

C5 Design of Lightweight and Low-rise Hospital Infrastructure

C5.1 Scope

This section applies to low-rise hospital buildings of all Importance Levels and *Service Categories*. This content intends reference to one or two storey facilities (excluding small appendages or rooftop plant platforms and enclosures). However, the scope includes all situations where lightweight construction techniques are proposed as part of the primary structural system supporting floors and the building enclosure. This includes:

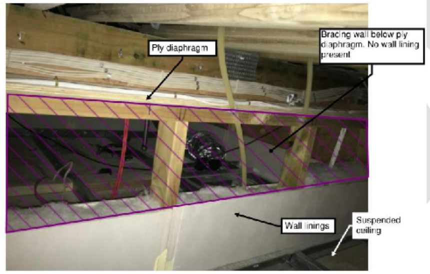
- Construction types typically used in one to two storey residential construction (light timber framing, light-gauge steel framing or reinforced masonry).
- 'Light industrial/commercial' typologies, typically using mixtures of:
  - Steel (structural steelwork or light gauge steel) or timber portal frames,
  - Wall or roof plane cross bracing,
  - Concrete or masonry wall panels (self-supporting or partly supported by steel framing or other lightweight structure),
  - Panel shear walls using plywood or other panel products, and/or panel roof and floor diaphragms.
  - Can include areas of heavy suspended floors or plant platforms.

This section does not apply to non-structural partitions (refer Section C4.5).

Figure 12: Example of an IL2 Oral Health Centre (dental clinic) generally using NZS 3604 and B2/AS1 (left); and a single storey IL4 Acute Facility, constructed in a mixture of timber framing and structural steelwork (right).

C5.4 Examples

Table 12: Some common examples of poorer practice and recommended improvements

ID	Photograph	Comments	Recommendation
1.	  	Load path discontinuity: Bracing wall specified—not fixed off to top plate (and not engaging boundary joist and roof diaphragm), and in case of lower image, not perimeter fixed. High damage risk and potential ultimate strength risk. Did not sufficiently recognise that the difference in roof makeup and suspended ceiling detailing (compared with typical NZS 3604 application) would create ambiguity to the builder.	Specifically document bracing wall details in context (i.e. including the load path to the roof diaphragm and other intersecting elements). Reduce reliance on numerous opportunistically placed bracing elements (which create many opportunities for similar deficiencies). Specify appropriate construction monitoring. However, recognise that most construction monitoring is risk-based, and reliance can be minimised by good design (Design for Construction Execution).

B2 Seismic Performance Requirements

The seismic performance framework sets the minimum seismic performance standards required by Te Whatu Ora for public hospital buildings—which will also meet, as a minimum, New Zealand Building Code requirements.

Outcome Objective

The mission—the overall success criteria following a big earthquake

Performance Goals for buildings

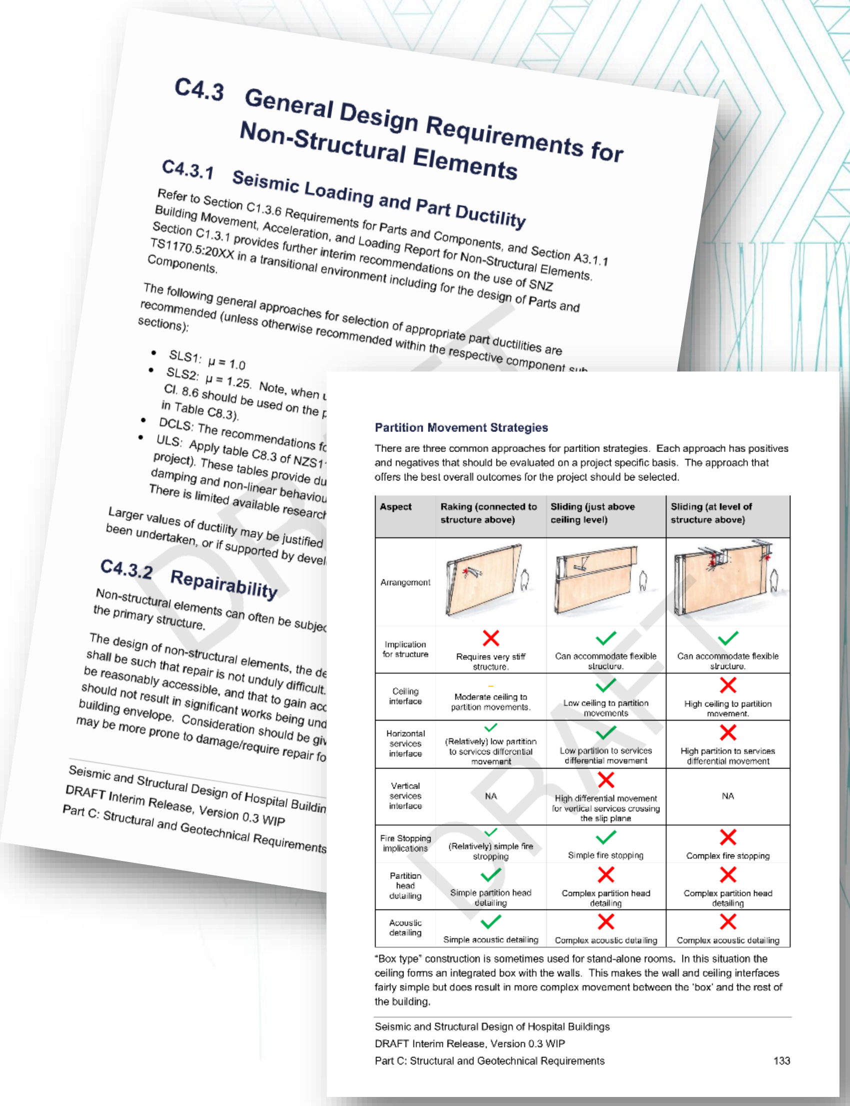
Translates the clinical and user needs into the performance requirements for hospital buildings

Physical States

Descriptions of the maximum tolerable levels of damage that would allow the performance goals to be met

Engineering Design Criteria

Structural response parameters that correspond to the physical states/ damage thresholds



C4.3 General Design Requirements for Non-Structural Elements

C4.3.1 Seismic Loading and Part Ductility

Refer to Section C1.3.6 Requirements for Parts and Components, and Section A3.1.1 Building Movement, Acceleration, and Loading Report for Non-Structural Elements. Section C1.3.1 provides further interim recommendations on the use of SNZ TS1170.5:20XX in a transitional environment including for the design of Parts and Components.

C4.3.2 Repairability

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Part C: Structural and Geotechnical Requirements

Partition Movement Strategies

There are three common approaches for partition strategies. Each approach has positives and negatives that should be evaluated on a project specific basis. The approach that offers the best overall outcomes for the project should be selected.

Aspect	Raking (connected to structure above)	Sliding (just above ceiling level)	Sliding (at level of structure above)
Arrangement			
Implication for structure	✗ Requires very stiff structure.	✓ Can accommodate flexible structure.	✓ Can accommodate flexible structure.
Ceiling interface	– Moderate ceiling to partition movements.	✓ Low ceiling to partition movements	✗ High ceiling to partition movement.
Horizontal services interface	✓ (Relatively) low partition to services differential movement	✓ Low partition to services differential movement	✗ High partition to services differential movement
Vertical services interface	NA	✗ High differential movement for vertical services crossing the slip plane	NA
Fire Stopping implications	✓ (Relatively) simple fire stropping	✓ Simple fire stopping	✗ Complex fire stopping
Partition head detailing	✓ Simple partition head detailing	✗ Complex partition head detailing	✗ Complex partition head detailing
Acoustic detailing	✓ Simple acoustic detailing	✗ Complex acoustic detailing	✗ Complex acoustic detailing

"Box type" construction is sometimes used for stand-alone rooms. In this situation the ceiling forms an integrated box with the walls. This makes the wall and ceiling interfaces fairly simple but does result in more complex movement between the 'box' and the rest of the building.

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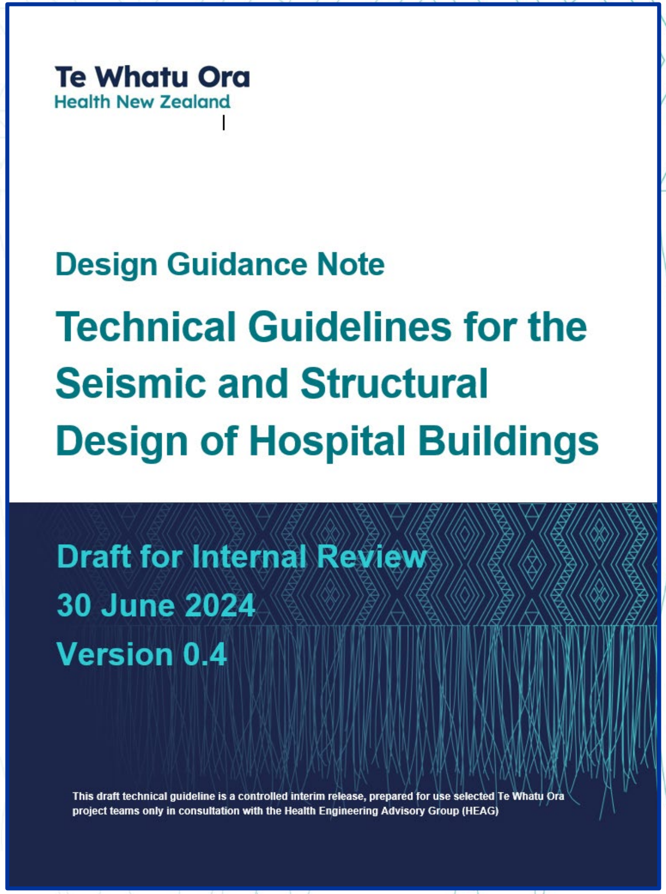
Part C: Structural and Geotechnical Requirements 133

Te Whatu Ora Guidelines - Functionality

Focus on 'Continuing to Function after a major earthquake' for acute services and other hospital buildings.

- Building Categorization
- Functional Recovery
- Outcome objectives
- Physical states
- Examples of key NSE design requirements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Building Categorisation

Acute Services	Other Inpatient Facilities	Other Services - Medical	Other Services - Support
IL4	IL3+	IL2+	IL2

Building Categorisation (Examples)

Acute Services	Other Inpatient Facilities	Other Services - Medical	Other Services - Support
IL4	IL3+	IL2+	IL2
Emergency Facilities (Emergency Departments, Operating Theatres, ICU)	**General wards**	**Outpatients' clinics**	**Offices, kitchens, laundries etc**
Post disaster support functions (Radiology, Pathology Labs, Sterilisation etc)	**Secure residential facilities**	**Non-emergency departments** (gastroenterology, respiratory, dental etc)	
Specialist Functions (Maternity, Burns, Paediatrics etc)		**Elective surgery**	

Building Categorisation (Examples)

Acute Services	Other Inpatient Facilities	Other Services - Medical	Other Services - Support
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High Functionality Requirement

Outcome Objectives

- Life Safety
  - Protection against loss of life or significant injuries
- Functional Continuity
  - The ability to continue to provide the services for which the building is intended
  - Limiting the reduction in function
  - Clearer understanding of the time to return to full functionality
- Asset Protection
  - Limiting the levels of damage expected

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Key Focus

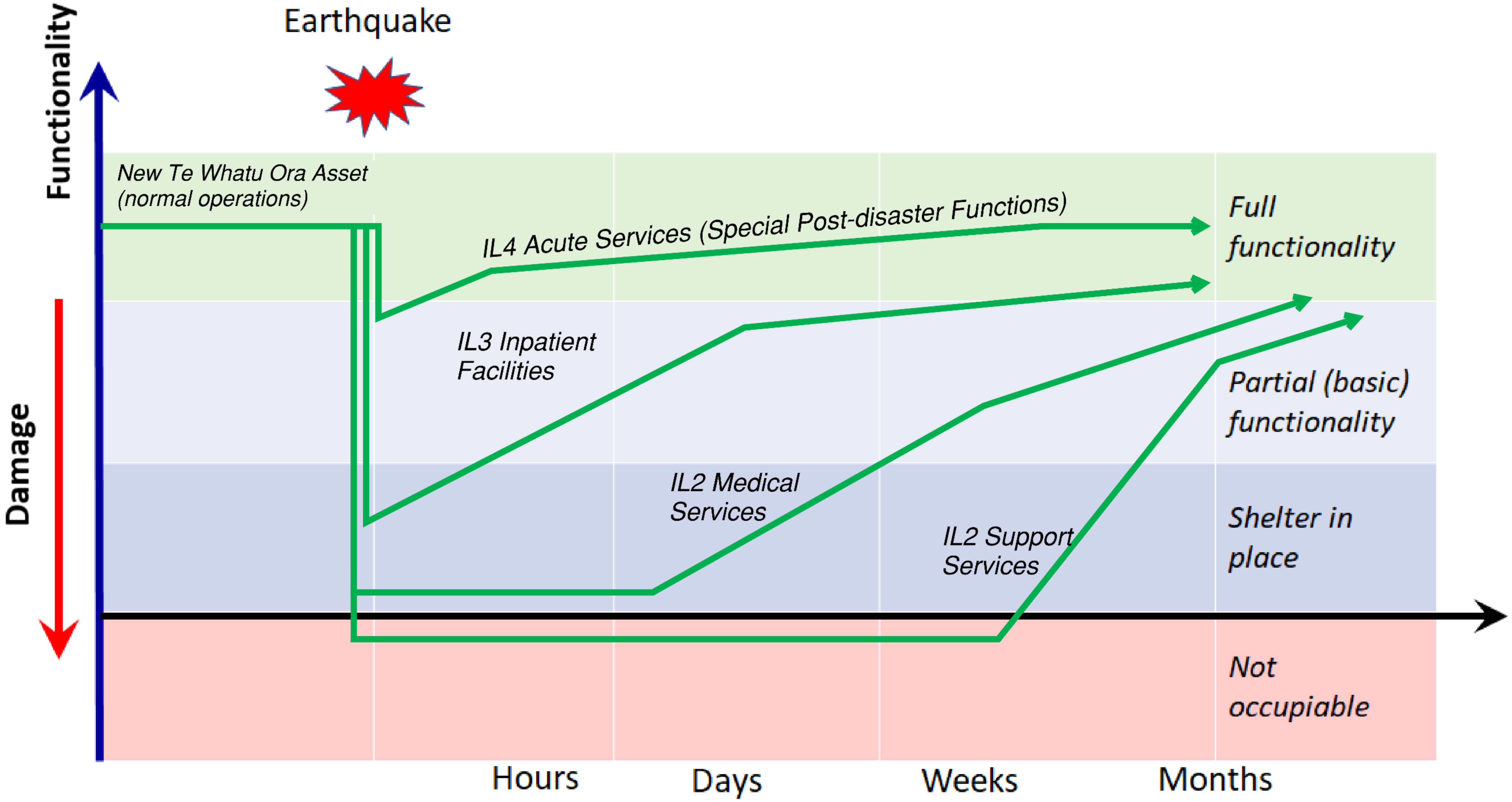

Figure 8: Tolerable reductions in functionality for Te Whatu Ora assets, and timeframes to full recovery, indicated in graphical form for different asset types (health service categories).

Summary of Outcome Objectives

Table 3: Summary of outcome objectives following a significant earthquake

Objectives	Acute Services	Other Inpatient Facilities	Other Services - Medical	Other Services - Support
	Importance Level 4	**Importance Level 3**	**Importance Level 2**	
Life Safety	Low probability of loss of life or significant injury—including to those with a high dependence on medical assistance (care or equipment) for life support.	Low probability of loss of life or significant injury.	Low probability of loss of life or significant injury	Low probability of loss of life or significant injury.
Functional Continuity	No requirement to evacuate. Basic functionality and life support continuously maintained. Full functionality[1] returned within hours.	Very unlikely to require emergency evacuation (for structural safety reasons). Basic/partial functionality restored within minutes to hours. Full functionality within weeks.	Very unlikely to require emergency evacuation (for structural safety reasons). Basic/partial[2] functionality restored within days to weeks. Full functionality within weeks to months.	Evacuation tolerable (including where resulting from a higher threshold of caution[3]). High likelihood of a return to basic functionality within weeks to months (or days to weeks for residences).

Summary of Outcome Objectives

Table 3: Summary of outcome objectives following a significant earthquake

Objectives	Acute Services	Other Inpatient Facilities	Other Services - Medical	Other Services - Support
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Physical States(examples)

Building Element	Sub-component	Expected Physical States/ Requirements (SLS2 or DCLS unless noted otherwise)			
		Acute Services (IL4)	Other Inpatient Facilities (IL3)	Other Services – Medical (IL2)	Other Services – Support (IL2)
	Structural Members	Minor damage or plasticity to structural members. No significant reduction in capacity, and tolerable residual drift. Practical and economic to repair for return to normal operations. For concrete members this could include minor cracking and isolated spalling of cover concrete—able to be reinstated by practical extents of epoxy injection or mortar repair and not requiring reinforcing replacement. For structural steel elements, minor permanent distortion but no buckling of plate elements.			Similar (t.b.c.)
Exterior cladding	Façade, general	Enclosure overall should retain water shedding ability. Some reduction in air seal tolerable. Minimal damage to façade panels, no cracked glass. Localized tearing to sealant joints and minor dislocation or damage to flashings. Readily repairable.			Enclosure overall should retain water shedding ability. Modest and localized damage to façade

Physical States(examples)

Building Element	Sub-component	Expected Physical States/ Requirements (SLS2 or DCLS unless noted otherwise)			
		Acute Services (IL4)	Other Inpatient Facilities (IL3)	Other Services – Medical (IL2)	Other Services – Support (IL2)
	Medical gases	Reticulated supply to function continuously.	Reticulated supply to return to function or alternative supply provided within minutes or hours. Services required to support preservation of life to have redundancy to allow them to retain basic function.	Preference for IL3 level of performance where practical.	Generally not applicable.
		ULS Requirement: Oxygen and medical air to remain available (even if on backup supply) to enable evacuation.		Generally not applicable.	
		ULS Requirement: Containment [1, p.Error! Bookmark not defined.] to be maintained at ULS in all areas within the building envelope to avoid direct life safety hazard and fire risk.			Generally not applicable.
	HVAC	Supply of systems directly required for post disaster operations or clinical isolation to function continuously. Remaining systems to return to full	Systems providing pressure differential for clinical isolation continuous basic function (measured pressure differential may be compromised but air flow direction should be maintained). Remaining systems to return progressively through basic function to full function over the course of days or weeks. (generally prioritising ventilation		No specific requirements.

Detailed Design Requirements (Examples)

Design Criteria for Elements Requiring Liquid Containment

The performance requirements for many elements include a requirement to maintain liquid containment due to that disruption that loss of containment can cause.

For design purposes, this shall generally be taken as:

- Where liquid containing systems are considered to behave in a nominally ductile manner, limiting system ductility demands to μ=1.25 is considered appropriate. Where systems are known to be ductile, higher ductility limits should not be adopted unless specific testing is available showing that these higher ductilities can be achieved whilst still maintaining liquid containment.
  - This is considered applicable to most modern plastic and metal piping systems.
- Where liquid containing systems are considered to be at risk of brittle behaviour, limiting system ductility demands to μ=1.0 is considered appropriate. Ideally brittle systems would not be used on hospital buildings.
  - This is considered applicable to (for example) water tanks that are not designed for seismic actions.

Detailed Design Requirements (Examples)

Table 11: Descriptions of physical damage states due to in-plane deformation for traditional plasterboard partitions subject to imposed interstorey drift

Limit State and Wall Type	Required Physical State	Recommended Drift Limit	Commentary on the damage state at the recommended drift limit
(Reference only)	**Significant Damage**	1.0%	Severe cracking, crushing or out of plane buckling of the gypsum wallboards such that replacement of the wallboards becomes necessary. (FEMA P-58/BD-3.9.32 damage state 2). Deemed unacceptable for hospitals at SLS2.
General partitions. SLS2/DCLS limit	**Damage localized, easily repairable and not impacting basic function.** Localised means not all walls should require repair, with most of the damage located around non-standard or stiff wall intersections or areas which are less practical to design for movement tolerance (i.e., the exception rather than the rule). Easily repairable means mainly limited to cracking in plaster and paint along panel edges, isolated pull through or popping of fasteners. Repair should be predominantly sealant and/or plaster and paint. Repair may require some refixing in a handful of areas, but sheet replacement should not be required.	0.50%	Screw pop-out, cracking of wall board, warping or cracking of tape, slight crushing of wall panel at corners. (FEMA P-58/BD-3.9.32 damage state 1). Aligned to Ministry of Education and LDSD recommendations.
Plasterboard fire separations. SLS2/DCLS limit	**Damage limited to that which can maintain reasonably adequate passive fire resistance.** This means that the level of assurance in the performance of fire safety systems can be reduced compared with newly installed compliant/tested systems. However, there should be reasonable confidence in the expected performance of safety systems to provide	0.50%	Screw pop-out, cracking of wall board, warping, or cracking of tape, slight crushing of wall panel at corners (FEMA P-58/BD-3.9.32 damage state 1). Aligned to median demand data from FEMA P-58/BD-3.9.32.