MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA

Functional Recovery: Technical, Economic and Societal Factors for Maintaining and Restoring Function of Multi-storey Buildings

Ministry of Education

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New Zealand Government

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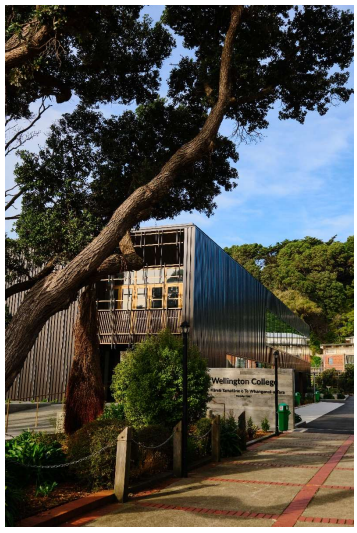
Growing demand for multistorey (3+) schools



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A school is a central part of its community and has an important role to play in the aftermath of an event.

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Recent experience: Canterbury Earthquakes

Changing expectations

- "*September 3, 2010. The last day… the biggest concerns on parents' minds being whether sandwiches would be eaten or homework handed in on time. …**The safety of schools, and indeed all buildings, has now gained a higher priority in everyone's mind**.*" Stuff, 16 July 2011

Use of schools immediately post-earthquake

- "*Hundreds of displaced people flocked to the Burnside High School evacuation centre last night to take shelter.*" NZ Herald, 23 February 2011
- "*at least six schools would be used as water distribution centres. Water tankers would be sent to them today for people to collect water from…Steps were also under way to get food supplies in.* NZ Herald, 23 February 2011

Return to 'normal'

- Two weeks after the February 22 earthquake, people in Christchurch are getting back to a new sort of normal. **Children are going back to school**, elective surgery restarted yesterday, washing machines are running again in most of the city and businesses are reopening." Stuff, 8 March 2011
- Re-opening of Linwood College after works to repair earthquake damage - "*It's **part of going forward in the recovery and rebuild***." Stuff, 28 July 2011

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Recent experience & changes to typical school buildings

- The Canterbury earthquakes provided an opportunity to rethink how the Ministry should specify school building performance and whether a more targeted approach could be achieved.
  - Better aligns with societal expectations
  - Results in more cost-effective designs
  - Improved building resilience/more sustainable building portfolio

- **Previous approach**: All new school buildings designed as Importance Level 3 structures
  - Targeted life-safety performance in extreme events but did not necessarily preclude significant damage at lower levels of shaking that may render the building unusable.
  - Resulted in more expensive buildings, but without assurance of good performance at all levels of shaking.

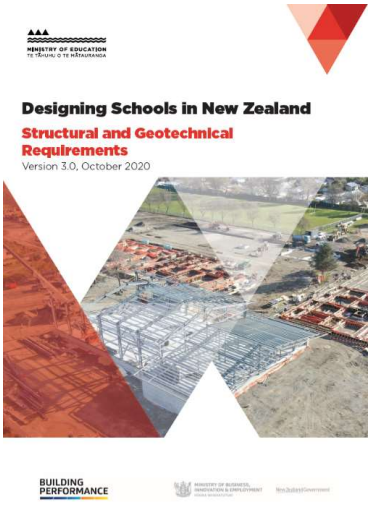
New Approach: Structural and Geotechnical Requirements (SGR)

Purpose: Sets out the structural and geotechnical requirements for designing and assessing school buildings

Audience: Structural and Geotechnical engineers and lead designers

Version: v3.0 October 2020

(V1.0 released in 2015)

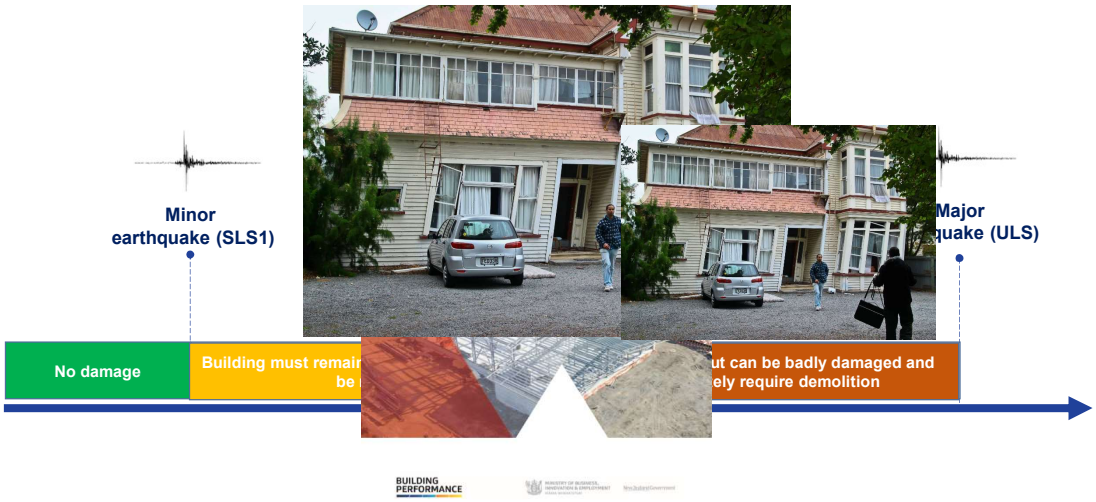


New Approach: School Performance Requirements

- Specific performance criteria that are different to normal construction:
  - School buildings are required to remain usable after significant earthquake shaking (SLS2)
  - Damaged is allowed BUT repairs must able to be carried out within reasonable timeframes
    (e.g. school holiday periods: 2 – 8 weeks)
  - No impact on safety or access and egress
- Extends to non-structural elements (such as the cladding, ceilings, partition walls, and building services)

➢ Applies to all large or heavy school budlings, not just multistorey buildings

New Approach: The key difference in school building design



New Approach: School Performance Requirements
Significant earthquake shaking (SLS2)

The Ministry has requirements that **go beyond** the Building Code requirements :

- Any reduction in capacity of the structure should not compromise its ability to undergo a subsequent major (ULS) event with acceptable performance
- The non-structural elements of the building must, in the main, remain intact and attached to the structure, with no impact on safety or access and egress
- Building and site services that are essential to the continued use of the building either must remain functional, or are designed in such a way to be reinstated or otherwise re-provisioned in an acceptable manner
- The building may suffer *tolerable damage*, which is defined as when the building may continue to be used for its intended purpose, but with some reduced amenity

Implementation
Importance Levels and Return Periods

Similar approach to the design of civil defence buildings (IL4)

Description	Importance Level	School Building Use[1]	Return Periods		
			SLS1	SLS2	ULS
Low risk associated with human life, or economic, social or environmental consequences	IL1	Small ancillary buildings that are not usually occupied (e.g. isolated garages) and <30m².	n/a	n/a	100 years
Medium risk associated with human life, or economic, social or environmental consequences	IL2	Larger ancillary buildings (e.g. Boiler Houses and standalone administration offices)	25 years	n/a	500 years
		Buildings of lightweight construction, with less than 250 occupants[1] in a block [3]	25 years	100[4] years For secondary structural and non-structural elements only[5]	500 years
		All buildings of heavy construction, with less than 250 occupants[1] in block[3]	25 years	100[4] years	500 years
High risk associated with human life, or economic, social or environmental consequences	IL3	Buildings of lightweight construction, with 250 or more occupants[1] (IL3)	25 years	250[4] years For secondary structural and non-structural elements only[5]	1000 years
		All buildings of heavy construction[6], with 250 or more occupants[1]	25 years	250[4] years	1000 years
		Assembly halls, gymnasiums, performance arts buildings etc. where occupants may congregate	25 years	250[4] years	1000 years

Table 5.1, p 24

Normal structures

Implementation

Qualitative primary structural performance requirements

Table A1: Performance requirements for structural elements.

Element/System		Good Gr
3. Superstructure in buildings without specifically designed re-levelling capab		
3.1 Primary lateral and gravity load resisting structure	SLS1	No significant displacement or combined effects of long-term within acceptable limits.
	SLS2	No significant displacement or combined effects of long-term within acceptable limits.
	ULS	All elements shall be within ro limits implied by the NZBC.
3.2 Secondary structure	SLS1	No significant displacement or combined effects of long-term within acceptable limits.
	SLS2	No significant displacement or combined effects of long-term within acceptable limits.
	ULS	All elements shall be within rotation and displacement limits implied by the NZBC.

SLS1	No significant displacement or offset. Settlement under combined effects of long-term and short-term loading within acceptable limits.
SLS2	Some residual displacement or offset is acceptable, within stated repair threshold limits. Should maintain capacity to resist additional displacement from a full ULS level event. May trigger need for limited repair in areas of greatest displacement.
ULS	All elements shall be within rotation and displacement limits implied by the NZBC.
SLS1	No significant displacement or offset. Settlement under combined effects of long-term and short-term loading within acceptable limits.
SLS2	Some residual displacement or offset is acceptable, within stated repair threshold limits. Should maintain capacity to resist additional displacement from a full ULS level event. May trigger need for limited repair in areas of greatest displacement.
ULS	All elements shall be within rotation and displacement limits implied by the NZBC.

Implementation

Qualitative secondary and non-structural performance requirements

Table A2: Performance requirements for non-structural elements.

Building System	Level of Damage Expected SLS1	SLS2	ULS	Comments
1. Building envelope				
1.1. Roofing	N	O	X1	
1.2. Flashings	N	O	X1	
1.3. Glazing	N	O	X1	
1.4. Exterior cladding systems	N	O	X1	
2. Floors and stairs				
2.1. General floors	N	O	X1	
2.2. Corridors	N	O	X1	
2.3. General access stairs	N	O	X1	
2.4. Stairs required to be used for emergency egress	N	O	X2	
2.5. Secondary access stairs	N/O	R	X1	
3. Partitions				
3.1. Partitions not required as smoke barriers	N/O	R	X1	
3.2. Partitions required as part of the fire and smoke control system	N	O	X2	Refer also to section 12 of this Table
4. Ceilings				
4.1. Lightweight ceiling systems, the failure of which will not cause failure of other systems	N	R	X1	Design in accordance with Parts section in NZS1170.5. Note weight limitation applies to entire system. Assess as P.3/P.7 to NZS1170.5 Table 8.1
4.2. Heavy (acoustic or other) ceilings (>0.25kPa)	N	R	X1	Assess as P.2/P.6 to NZS1170.5 Table 8.1
4.3. Any ceiling systems, the failure of which may compromise other systems	No less than the affected systems			Assess as P.2/P.5 to NZS1170.5 Table 8.1

4. Ceilings			
4.1. Lightweight ceiling systems, the failure of which will not cause failure of other systems	N	R	X1

Key to Table A2:

N = No Damage

e

re replacement.

X1 = Element may be severely damaged, requiring replacement but must retain structural integrity

X2 = As per X1 but must continue to hold hazardous contents, or continue to support emergency service function.

Implementation
SLS2 Quantitative Requirements

Primary structural elements designed to limit SLS2 displacements to the lesser of:

- The repairability limits provided in Table 9.1; or
- The limits determined by deformation compatibility of non-structural elements

Material/System	Element	SLS2 Repairability limit
Concrete or structural steel	Ductile moment frame (μ≥3)	0.8% (1 in 125)
	Non-ductile moment frame (μ≤1.25)	0.42% (1 in 240)
	Ductile shear wall	0.4% (1 in 250)
	Non-ductile shear wall	0.2% (1 in 500)
Structural steel	Ductile moment frame	0.8% (1 in 125)
	Ductile braced frame(1)	0.8% (1 in 125)
	Limited ductile or non-ductile braced frame	0.2% (1 in 500)
Structural timber	Frame systems	0.8% (1 in 125)
	Braced frame systems	0.2% (1 in 500)
Wall systems	Timber or metal stud framed wall systems	0.5% (1 in 200)
	Concrete block wall	0.3% (1 in 333)

Table 9.1:

Guidance on repairability drift limits for primary structural elements.

Further information

- SGR available for download:

  Earthquake Resilience webpage (education.govt.nz)
- Two-page summary sheet
- Development of additional templates:
  - Design Features Report
  - Briefing document for secondary elements (design of ceilings, partition walls)
  - Responsibility matrix
- Training of engineers and designers

QuakeCore Programme

What does functional recovery mean to the Ministry of Education?

Function recovery in a school context is ensuring school buildings are usable after a significant earthquake. Damaged is allowed BUT repairs must able to be carried out within reasonable timeframes such as during school holiday periods, and there must be no impact on safety or access and egress.

What does success of the QuakeCore programme look like to the Ministry of Education

Functional recovery is well understood by all designers and building owners and is incorporated into general building design, not only by those wanting improved resilience for their own buildings. Recognition that functional recovery is much wider than individual building performance.

It will be useful promoting functional recovery through freely available and easy to read literature or examples which easily communicate the beneficial aspects of designing for some form of functional recovery.

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kia **rangatira** ai, kia **mana taurite** ai ōna **huanga**

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