Societal Expectations for Functional Recovery of Primary and Secondary School Buildings

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ABSTRACT

In the ongoing investigation of functional recovery requirements, the spectrum of functional requirements for different facility types is necessary to ensure that buildings are designed, constructed, and maintained to meet society's expectations. Schools are essential to communities, providing education and shelter to children. Education facilities that remain functional enable the community to recover quickly as parents can return to work or focus on rebuilding. However, functional recovery levels and expectations for schools could be better defined. Using interview responses, this pilot study, focusing on Hamilton, New Zealand, has constructed a five-level functionality continuum for school buildings addressing the societal expectations of community members, including parents, teachers, principals, civil defence, and the Ministry of Education. The five levels of functionality include life safety, re-occupancy, partial functionality, mostly functional, and fully functional. Each level has been defined in terms of available teaching and community expectations, acceptable damage and infrastructure requirements, and expectations for achievable timelines.

1 SOCIETAL EXPECTATIONS OF SCHOOL BUILDINGS

Schools are central to communities and, after a disaster, essential to the recovery of the surrounding community. At times considered the centre or heart of a community (Bagley and Hillyard, 2011; Bingler et al., 2003), schools influence community well-being (Autti and Hyry-Beihammer, 2014) and play an essential role in disaster recovery (Mutch, 2018). However, school facilities are vulnerable to structural and non-structural earthquake damage. Worldwide, damage or collapse of school buildings has caused education disruptions for school children. Examples from earthquakes alone include the 2005 earthquake in Turkey, where 102 school buildings collapsed and an additional 1503 were damaged (Akbaba-Altun, 2005); the 2008 Wenchuan, China, earthquake where many school buildings collapsed, killing at least 10,000 students (GADRRRES, 2015; Zhang and Jin, 2008; Zhao et al., 2009); the 1.5 million students affected by damaged schools after the 2010 Chile earthquakes (GADRRRES, 2015); and the 7000 schools were significantly damaged during the 2015 Nepal Earthquake (NPC, 2015). Closer to home, the 2010 and 2011 Christchurch earthquakes temporarily closed school buildings until full damage assessments could be completed (Mutch, 2018). These examples highlight how critical it is to strengthen school buildings to preserve access to education and enhance community well-being.

Additionally, the role schools play in post-disaster recovery varies. This study explores the societal expectations of school buildings following an earthquake, exploring the expected structural performance, the role of schools in community recovery, and a return to teaching.

1.1 The contrast between expectations and engineering practice

Current building standards focus on protecting life and falls short of preserving building function following major or significant earthquakes. Nevertheless, the public's perception of building performance assumes a higher level of performance (Porter, 2021). Surveys in the USA indicate that communities expect structures to be occupiable or functional following a design-level earthquake (Porter, 2018). Studies done following the Kaikoura earthquake indicate a similar sentiment in New Zealand, with people stating that buildings should be operable and repairable after major earthquakes (Payne et al., 2021). Beyond individual buildings, society also expects community societal well-being to be preserved (Brown et al., 2022). As schools are critical to communities as locations of support (Mutch, 2018), these facilities should be constructed to maintain function.

Considering the functionality of buildings cannot be limited to the performance of the physical structure. Current work on functional recovery indicates the importance of connecting physical building damage to organisational and system performance (Boston, 2017; Cook et al., 2022; Jacques et al., 2014). Particularly for schools, researchers have found that school functionality requires staff, access, utilities, and a supporting supply chain in addition to the physical teaching space (Enderami et al., 2022; Hassan et al., 2020).

In 2020, the New Zealand Ministry of Education published a comprehensive guideline of performance requirements for school buildings following different levels of shaking. The guideline incorporates many of the previously mentioned functionality requirements including the structural, non-structural, and external service functionality for SLS1, SLS2, and ULS levels of shaking are provide as illustrated in Table 1 Ministry of Education Expectations for School Building Performance, created from Designing Schools in New Zealand: Structural and Geotechnical Requirements (Ministry of Education, 2020). This guideline also defines repairability requirements for school buildings that are in line with keeping students in class and limiting damage to what can be safely repaired during standard maintenance (SLS1) or during school holidays (SLS2). In additional to these building performance requirements, which focus on the physical building and connecting services, it is also necessary to consider the use of the school building and the ability to continue to provide teaching and learning activities to students.

1.2 Schools' role in community recovery

In addition to a school's role as an educational facility, schools are often locations of support for communities. This can extend to acting as civil defence centres, communication hubs, or emergency shelters. Schools in some regions, such as Japan, are commonly designated as emergency or evacuation shelters (Kawasaki et al., 2022; Wang, 2016). The use of schools as shelters is controversial. Community members commonly see schools as places of safety as they are generally built to higher building standards and are visible and familiar structures (Tsioulou et al., 2021). On the contrary, use as a shelter, especially for an extended period of time, disrupts education and employment (Tsioulou et al., 2021; Wang, 2016). Schools in Christchurch were temporarily used as emergency shelters after the 2010 and 2011 earthquakes (Mutch, 2018).

Outside their potential role as emergency shelters, schools positively influence community recovery. Schools are centres of community support (Mutch, 2018). Restoration of educational offerings allows students to return to school and caregivers to work, enabling the community to recover from the disaster and regain a sense of normality (Baytiyeh, 2018; Peek, 2006). Further, schools can promote a psychological sense of safety in the broader community by providing individual students, teachers, and others with a safe learning environment (Hobfoll et al., 2007).

Table 1 Ministry of Education Expectations for School Building Performance, created from Designing Schools in New Zealand: Structural and Geotechnical Requirements (Ministry of Education, 2020)

Shaking Level	Expected frequency	Structure	Non-structural	Utilities and Services	Building Code	Repairable
Minor Shaking (SLS1)	Several times	No significant reduction	Intact & attached	-Mechanical, electrical and hydraulic: Fully operation -Functional reticulation connections	Meets B1.3.2 (MBIE, 2021)	Readily Repairable: Immediate or with standard maintenance
Significant Shaking (SLS2)	More than once	Not compromised for larger ULS earthquake	Mostly intact, no loss of egress or safety	-Mechanical, electrical and hydraulic, essential services fully functional or can be reinstated -Functional reticulation connections or can be connected to alternative service	Beyond code	-Tolerable damage: Does not affect safety or access. -Repairs completed during school holidays
Major Shaking (ULS)	At least once			Repairable connections to reticulation	Life Safety B1.2.1 (MBIE, 2021)	Repairable if foundation intact

1.3 Determining Levels of Functionality

The above ideas lead to the formation of the main research questions: How does society view a school's role in earthquake recovery? And what are the expected functionality levels for schools? To answer these questions, views from a range of individuals need to be consulted to truly understand community expectations.

This paper summarises the findings of a small pilot study conducted in Hamilton, New Zealand, on determining societal expectations of primary and secondary school buildings to define levels of functionality to improve community resilience. Interviews were conducted to determine how schools fit into the post-earthquake recovery process and to identify the requirements of these structures throughout the disaster recovery cycle. Community members were asked what they wanted the recovery process to look like and the associated timeframes with different recovery actions. Participants considered the building structure and the functional requirements of the school. The study was approved by the University of Waikato HECS Human Ethics Committee, reference number HREC(HECS)2022#30.

2 HAMILTON PILOT STUDY

The pilot study was conducted in Hamilton, New Zealand. While Hamilton has a relatively low seismic risk compared to other parts of New Zealand, seismic safety and functional recovery are still topical due to epistemic and aleatoric uncertainty of the actual seismicity in the Waikato Region following the discovery of fault lines running through the area (Moon et al., 2016) and the potential for moderate to strong shaking following an earthquake on the Kerepehi fault (Dempsey et al., 2021).

2.1 Interview Participants

Interviews were conducted with thirteen individuals. The study participants came from a convenience sampling method. Convenience sampling is a non-probability form of sampling (Stratton, 2021). Participants were recruited by invitation and word of mouth. However, an effort was made to get a representative sample that covered parents, teachers, school administrators, civil defence, and the Ministry of Education. Parents were interviewed based on their direct connection to schools through their children. They provided an external view of community expectations for school buildings outside of an educational setting. Teachers and principals provide the viewpoints of those directly involved in the day-to-day teaching and running of schools. Parents, teachers, and principals were also selected to represent viewpoints of public schools and Māori schools. This input provides essential information on school needs and recovery expectations following an earthquake. As Civil Defence provides a significant role in disaster management and relief, interview participants provided insights into the role school buildings are expected to play in community-wide recovery efforts. The Ministry of Education provided a government perspective on technical requirements and school building performance.

Interviews were conducted either in person, over the phone, or on zoom depending on the availability and preference of the participant.

2.2 Interview Questions and Analysis

Interview questions were developed around answering the research questions. Questions varied slightly based on the participant's relationship with schools. Some questions included:

- What purpose do you want school buildings to be used for straight after a natural disaster?
- What timeframe do you expect before teaching can commence?
- What do you want the recovery process to look like?
- What relationship do you envision between the community and school?

2.3 Limitations of Study

The study size and location were limited due to the timeframe for conducting this research. As a pilot study, this research aimed at identifying standard requirements for school buildings within a single city. Only a few people were interviewed and selected using convenience sampling methods. The results may not reflect the general population, but they reflect the opinions of those involved in the study (Stratton, 2021). This initial study should be expanded to more participants representative of the community in question.

3 FINDINGS ON SOCIETAL EXPECTATIONS

3.1 Functionality Levels

Functionality levels were determined from interview data. These levels were matched to existing definitions in published literature where possible. Five levels of functional recovery were determined from the interviews. Each level had a defined timeframe and definition of the available activities, as illustrated in Figure 1. These are life safety, re-occupancy, partially functional, mostly functional, and fully functional. Each level has different requirements for available utilities, space, and teaching availability, Table 1.

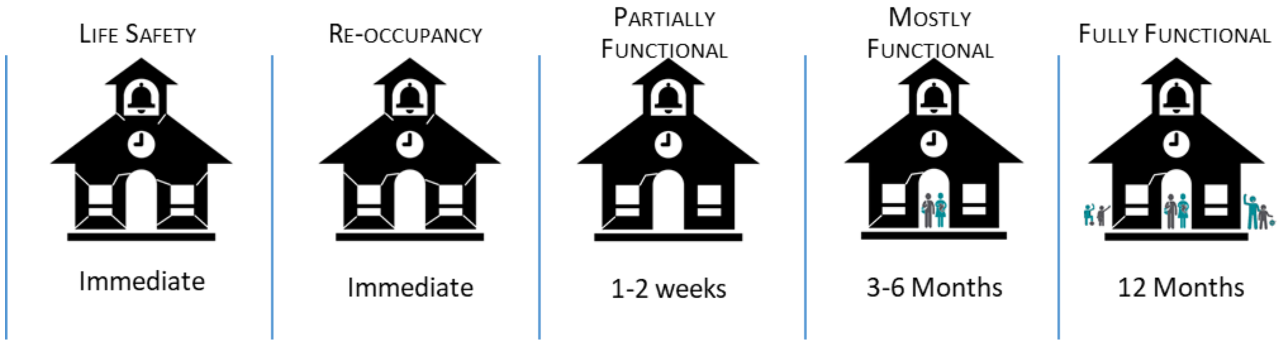

Figure 1 Timeframes and expected activities for five defined levels of functionality

3.1.1 Life Safety

This is the first and most important level of functionality for a school building and the minimum requirement to meet building standards. From the literature, life safety refers to the avoidance of mass casualty events, protection of vulnerable persons, ensuring safety at mass gathering points, preserving high-value skills and resources, providing support for immediate response activities, and maintaining a perception of safety (Almufti and Willford, 2013; Brown et al., 2022). To meet this requirement, school buildings are expected to remain standing after an earthquake, and all individuals can safely evacuate immediately after the event.

3.1.2 Re-occupancy

Re-occupancy was the second level of functionality identified by the interviews and the literature. Re-occupancy is when a building is safe enough to be used for shelter (Almufti and Willford, 2013) but cannot be used for normal operations (Molina Hutt et al., 2022). During re-occupancy, the school buildings are safe to re-enter for cleaning, repairs, and to be used as an emergency refuge. Schools are expected to immediately meet re-occupancy requirements, especially in the instance where communities will require buildings for displaced people, help and assistance, and emergency response.

3.1.3 Partially Functional

Levels of functional recovery are not commonly used in the literature. Building function, the ability to be used for its basic intended function, is usually used to cover all levels of building functionality (Cook et al., 2022). When used, levels are specific to building types (Boston, 2017; Enderami et al., 2022). From the interviews, partially functional was defined as when most of the buildings on a school campus are safely functional, but some areas of the school need further inspection or repair. Due to ongoing construction or safety concerns on parts of the school campus, teaching should resume in online or remote formats. This should occur within one to two weeks of the disaster.

3.1.4 Mostly Functional

At this stage, all teaching areas have been assessed and are safe for in-person classroom instruction. Teachers have all of the resources required to teach effectively and students are able to return to school. School administrators, senior leaders, and other staff members can access office spaces. Not all buildings, such as halls or gyms, are suitable for limited extra-curricular activities and school boarding. It is expected that this is achieved within three to six months.

3.1.5 Fully Functional

All the buildings have been restored to pre-event levels at the fully functional level, with no further repairs required (Almufti and Willford, 2013; Cook et al., 2022). Extra-curricular activities and boarding can resume in conjunction with in-person teaching.

Table 2 Requirements for functionality levels

Functionality Level	**Utilities**	**Space**	**Teaching**
Life Safe	None	Safe to exit	
Re-occupancy	Power Water Sanitary	-Safe for cleaning and repairs -Available as a community shelter	
Partially	Re-occupancy + Internet Communication Heating	-Teaching Resources -Teaching spaces are weatherproof -Some areas are unsafe or need repairs	Online only
Mostly	Partially +	-All resources available to teachers -Teaching spaces are safe	In-person teaching
Fully	Partially +	-All facilities safe and functional, including gyms and recreational spaces	Resume extra-curricular activities

3.2 Schools as a place of refuge

Schools are an essential asset in community recovery, either as a place of refuge or maintaining the primary purpose as an educational centre. Community members had various opinions on the purpose of schools after an earthquake. Most participants agreed that schools should be available as a shelter, refuge, or emergency response centre. However, the Ministry of Education, civil defence and school principals stated that while schools should be available to support the community, they should not be the primary choice for emergency refuge as this would prevent students from returning to class. Community halls were recommended as an alternative shelter. Post-disaster, schools should focus on returning to their primary purpose as educational facilities. Students returning to school is necessary for communities to meet recovery goals (Baytiyeh, 2019; Mutch, 2018).

A common expectation was that schools should be available to support the community. This could be by providing accommodation, a base of operations for civil defence, focal points for families to gather, organisational points for rescues, or placing notices regarding the disaster. Communication centres and information points were the most common expectations for schools after a disaster, particularly important was the ability to preserve communication with parents.

Those associated with Māori schools expressed a greater need for schools to be available to look after Māori communities. One interviewee stated that the school space should be utilised as a place where the "community can be fed, slept, watered, and clothed." However, once the community has moved into the recovery phase of a disaster, these schools should also move to restore teaching activities.

3.3 Return to teaching

All participants agreed that a quick return to teaching is essential. Different school resources were identified by parents, teachers, and principals. Parents felt that schools could resume some level of functionality once the buildings were safe to enter and had adequate water, power, heating, and sanitary facilities. Teachers and principals expanded these requirements to include having resources for effective teaching, safe learning and teaching spaces for students, and spaces for administrators and school leadership. Assembly halls and gymnasiums were not considered important for the initial return to teaching.

Teaching activities are preferred to be conducted in person as this allows caregivers to return to work. However, online classes can be utilised to resume teaching quickly after a disaster if the school campus remains unsafe. Recent experience with Covid-19 has changed how schools and teachers view fully functional schools. Based on the interview of one teacher, high decile schools can be determined as fully functional if teachers can conduct learning activities fully online. Students are not required to be able to come on-site for these schools to be considered functional, as students are likely able to learn online successfully. The opposite is true for low decile schools, where full functionality would not occur until all students are able to return to campus.

Schools used as a refuge will expect a further delay in preparing the school for teaching. Teachers stated that returning to in-person teaching would require equipment (i.e. desks and chairs), academic records, worksheets, and computers.

In addition to resuming teaching activities, some participants stated the importance of learning from the disaster. This was sometimes viewed to be more important than students returning to the classroom. Students should be involved in the recovery and exposed to disaster management.

Full functionality of schools is expected to take some time following a major earthquake. A school is considered fully functional when it has no loss of amenities and can be utilised in the same manner as it was before the earthquake. This includes restoring outdoor recreational areas, resuming extra-curricular activities, and providing after-school care. Teachers were less likely to view extra-curricular activities and after-school care as essential activities. However, parents and principals expressed that these are important or expected requirements for the school to be fully functional.

4 CONCLUSIONS

This paper summarises the findings of a pilot study examining societal expectations for schools following an earthquake. Through interviews, five levels of functionality were identified for school buildings. These ranged from life safety to fully functional. Teaching expectations at different levels of functionality varied, with limited teaching expected while the school was partially functional. A resumption of all school-related activities is expected for a full functionality recovery, which should occur within 12 months of a significant earthquake. The use of schools as an emergency shelter is accepted, but it should not be a primary solution for communities as educational continuity is more important. A return to in-person teaching is best for providing learning opportunities to all students and should be done as quickly as possible. Schools can provide support to communities as an avenue for communication.

The results from the community study add to the performance objectives set by the Ministry of Education by providing further insights to the functional needs of the building to continue to provide learning activities or serve as an aide in community recovery. Combining the performance objectives with the functionality goals will help refine the connections between the performance of the physical structure and connecting utilities with the building use and human organisation requirements. This step is critical to ensuring continuity of educational services and increased community resilience.

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