Preliminary Reflections from the New Zealand Learning from Earthquakes Delegation

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1. INTRODUCTION

Initial reports after the Myanmar Earthquake on the 28th of March have indicated that while the seismic demands in Bangkok (nearly 1000 km away) were relatively small, many high-rise building structures have sustained non-structural damage, while several also sustained structural damage [1]. Many high-rise buildings in Bangkok are apartment, office and hotel buildings. Though the Thai Building Code considered Bangkok as low seismicity region, the damage to these buildings was unexpected considering the large distance of Bangkok from the epicentre.

To gain a detailed understanding of the impacts of the earthquake, a New Zealand team was deployed to Bangkok in June 2025. This extended abstract summarises the activities carried out by the New Zealand team, preliminary observations and key insights from several meetings with key stakeholders.

The takeaways from this reconnaissance will not only provide valuable insights for New Zealand, but also this trip aimed to start bringing together the Thai and NZ societies for earthquake engineering.

2. TEAM MEMBERS AND OBJETIVES

The delegation aimed to support knowledge-sharing and contribute to a broader understanding of disaster resilience. The primary goals of the reconnaissance were, but not limited, to:

- Assess the dynamic characteristics of soft soils underneath Bangkok. Broadband seismometers were used to assess the fundamental period of vibration of the soft soil over rock (i.e., site period). This work was led by Andrew Stolte, a Senior Lecturer at the University of Auckland. His research centred on the improvement of site characterisation, blending geophysical and geotechnical methods. He has characterised sites and sedimentary basins around Aotearoa New Zealand and contributed to the 2022 NSHM Update.

- Using systematic surveys, the functional recovery of buildings following the event was explored. This work was led by Catalina Miranda, a Lecturer at the Joint Centre for Disaster Research, Massey University. She works at the intersection of engineering and social science. The conducted surveys aimed to gather insights from property managers about the functionality and recovery timelines of various building components (e.g., elevators, lighting, water supply, HVAC systems, windows, façades, etc.). The aim was to understand how damage to these elements affects the building's ability to return to full functionality.

- Document examples of both structural and non-structural damage in the built environment. This work was carried out by Jitendra Bhatta, Andrew Baird, Lucas Hogan, Jitendra Bothara, and Chungwook Sim. Their combination of research and practice aimed to understand how different construction types and details responded to shaking, by documenting damage to non-structural elements (e.g., ceilings, facades, and building services)

3. ACTIVITIES

Guided by local academics and practitioner engineers, the New Zealand team visited 10 buildings in central Bangkok and met with academics from the Asian Institute of Technology, Kasetsart University, the King Mongkut's University of Technology Thonburi, and Thammasat University.

In general, building visits involved a conversation with property managers to understand the context and experienced damage to the building, followed by a walkthrough to observe any visible damage or repairs. Systematic visual inspections were carried out to document earthquake damage to both structural and non-structural elements. All observed damage was photographically recorded. The assessment also included well-performing buildings to identify effective seismic-resistant design features and construction practices that contributed to their resilience. When possible, functional surveys were also carried out.

4. PRELIMINARY INSIGHTS AND TAKEAWAYS

Bangkok is underlain by a deep sedimentary basin predominantly filled with soft clay. The long-period amplification of ground shaking by deep, soft soils is well understood and has been observed in numerous events, including the 1985 M_w 8.0 Mexico City Earthquake. Thus, an important aspect of (geotechnical) earthquake engineering is the characterisation of soil stiffness (e.g., shear wave velocity (V_S)) and depth of the sedimentary basin. Tuladhar et al, [2] used the mHVSR method [3, 4] to estimate the fundamental period of vibration of the soil sites at 150 sites in Bangkok. Later, Poovarodom et al, [5] used microtremor measurements at 36 sites in Bangkok to profile shear wave velocity, evaluate V_{S30}, estimate predominant period, and create a microzonation map of the Bangkok metropolitan area. However, these previous studies were limited by their instrumentation and could not resolve mHVSR peaks at periods longer than approximately 5 s.

As a part of the NZ learning from earthquakes teams' efforts to document 10 case history buildings, the foundation-level and uppermost story of the buildings were temporarily instrumented using portable broadband seismometer stations, consisting of a Nanometrics Pegasus Digitizer and a Nanometrics Trillium Compact Horizon 120s Sensor. This equipment has a flat response to velocity between a period of 120s and a frequency of 200 Hz (0.005s), enabling the measurement of the deep sedimentary basin response and the long-period response of tall buildings in Bangkok. The data was processed using hvsrpy [6] an open-source Python package. An example of the mHVSR spectra from mictrotremor measurements in the basement of one case history building are shown in Figure *1*, with a median T0 estimate of 7.2 s

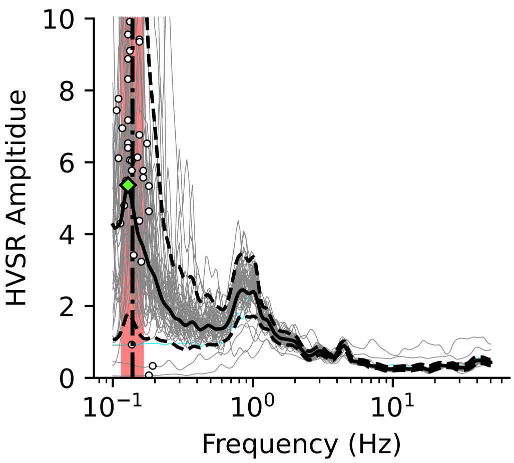

Figure 1 mHVSR spectra of microtremor recordings at foundation level. The solid black and dashed black lines indicate the mean and +/- standard deviation bounds of the mHVSR spectra. The green square indicates the median T0 estimate, the red shaded area indicates +/-1 lognormal standard deviation.

Preliminary mHVSR analysis indicates site period ranges from 4.5 to 7.6 seconds across the ten case history sites. However, further analysis is needed to determine if the deep foundation of the buildings obscures the longer period peaks at a few of the sites.

Additionally, mHVSR analysis was used to estimate the fundamental period of the buildings from the ambient vibration recordings on the highest floors. An mHVSR spectra from the example site is shown in Figure 2. The estimated period is 2.8 s for the 25-storey building.

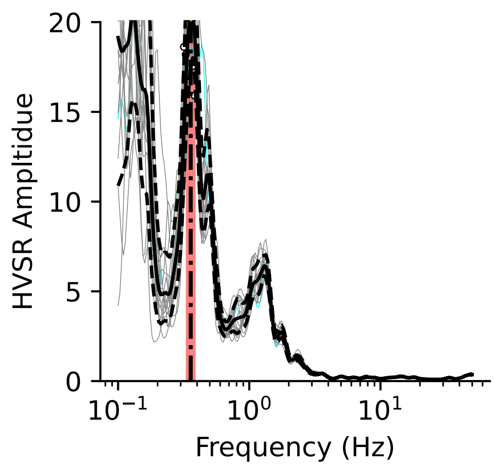

Figure 2 mHVSR spectra of microtremor recordings on the 25th floor. The solid black and dashed black lines indicate the mean and +/- standard deviation bounds of the mHVSR spectra.

The next steps in this aspect of our work are to evaluate ambient vibration transfer functions for each building, draw comparisons to empirical estimates of building period, and compare site period estimates to available deep sedimentary basin site characterization data.

A distinctive aspect of this research was the use of a survey to assess functional recovery. Originally developed by the National Institute of Standards and Technology (NIST), the survey was adapted and translated into Thai for use in Bangkok. To begin data collection, researchers needed ethics approval—a process that typically takes months or even years, especially when involving participants who may have experienced trauma from an earthquake.

To streamline this process, the research team chose to interview property managers in their professional capacity, rather than directly affected individuals. This approach helped reduce ethical concerns. In addition, the questions were technical in nature, and the interviews took place approximately 2.5 months after the earthquake, by which time Bangkok had largely recovered. As a result, the study was deemed low-risk and received ethics approval through a peer review process (Low-Risk Ethics Notification Number: 4000030705).

The systematic survey was used to collect data on building functionality, damage to various elements, and associated recovery times. Questions included levels of observed damage, time to recovery to the current state, reasons for losing functionality, specific questions on different elements (i.e., electric, water supply, sewer, stairs, lifts, architectural components, etc.), recovery times of those specific elements, reasons for failure, and repair and impending factors.

At the time of the visit, most buildings had returned to full functionality. One building exhibited a staged recovery process, with different levels becoming operational based on user needs.

Structural damage was generally limited in the case study buildings visited. Two buildings had significant damage to walls, which experienced axial failures. It was noted that older buildings (from the 1990's) generally had larger section sizes (basement walls of 400 mm) compared to newer buildings (walls of 200-250 mm). These newer buildings also tended to have more slender footprints, driven by architectural site constraints. The two buildings with wall damage were both constructed in the last 5 years. With respect to non-structural damage to partitions, walls, and ceilings generally did not affect the overall functionality of the buildings. However, whether a building was used often depended on occupants' perceptions of safety.

The most significant factor impacting functionality was elevator damage. On average, 24% of lifts in a given building were damaged following the earthquake, with full recovery taking approximately 40 days; however a few elevators were still no functional when the team visited Bangkok (see Table 1). While elevator damage limited building use, relocation due to damage to lifts occurred in only one documented case. Water supply was also affected; however, recovery times were on average 1-2 days.

The most prevalent damage occurred in infill walls, ceiling systems, and architectural finishes, with recurring failure patterns observed at component interfaces and mid-height building levels (typically between 8th to 20th storey). Additional damage was also observed at uppermost floors, where amplified accelerations led to cracking, dislodgement of tiles, and displacement of unsecured contents.

5. NEXT STEPS

Currently, the team is in the process of analysing the collected data. Comparisons will be made across multiple datasets including site period, building period, location and extent of non-structural damage, and wall density to building period. These comparisons will enable patterns to be identified and help justify potential policy changes to promote better functional recovery. Results will be presented in conference proceedings, journal publications, and reports.

Table 1 Damage to lifts and water supply

	Total number of elevators	**Damaged lifts**	**Days to full recovery**	**% of damaged elevators**	**Days to full recovery of water supply**
Building 1	41	13	77	31.7	0.17
Building 2	13	9	77	69.2	0.17
Building 3	33	5	45	15.2	0.00
Building 4	10	0	-	0.0	3.00
Building 5	12	1	5	8.3	3.00
Building 6	7	1	7	14.3	0.17
Building 7	5	1	60	20.0	2.00
Building 8	21	7	10	33.3	0.00
Average			**40.1**	**24.0**	**1.1**

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