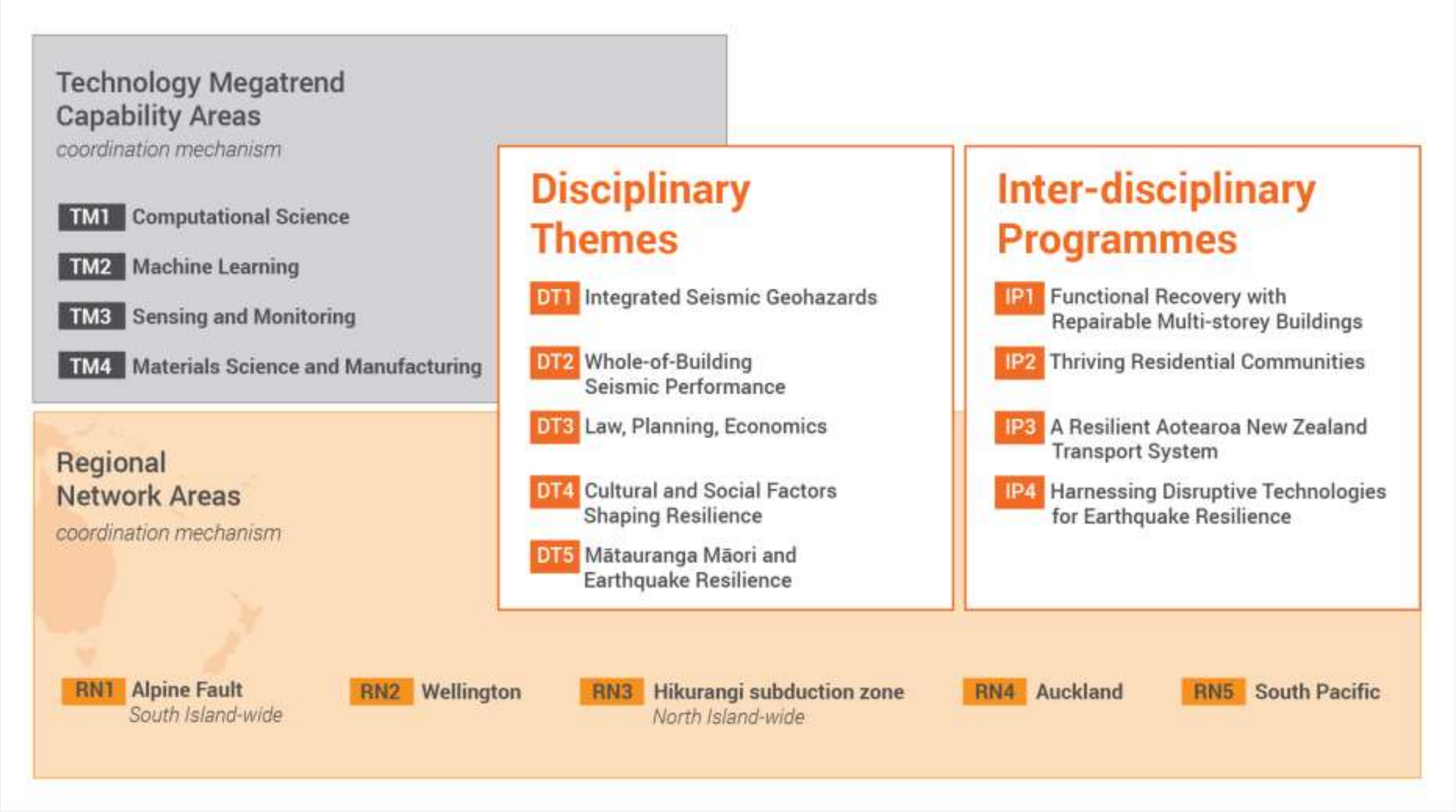
QuakeCoRE Research Accomplishments
Wellington Earthquake Resilience Collaboratory 2023

David Johnston
on behalf of the QuakeCoRE community

30 November 2023

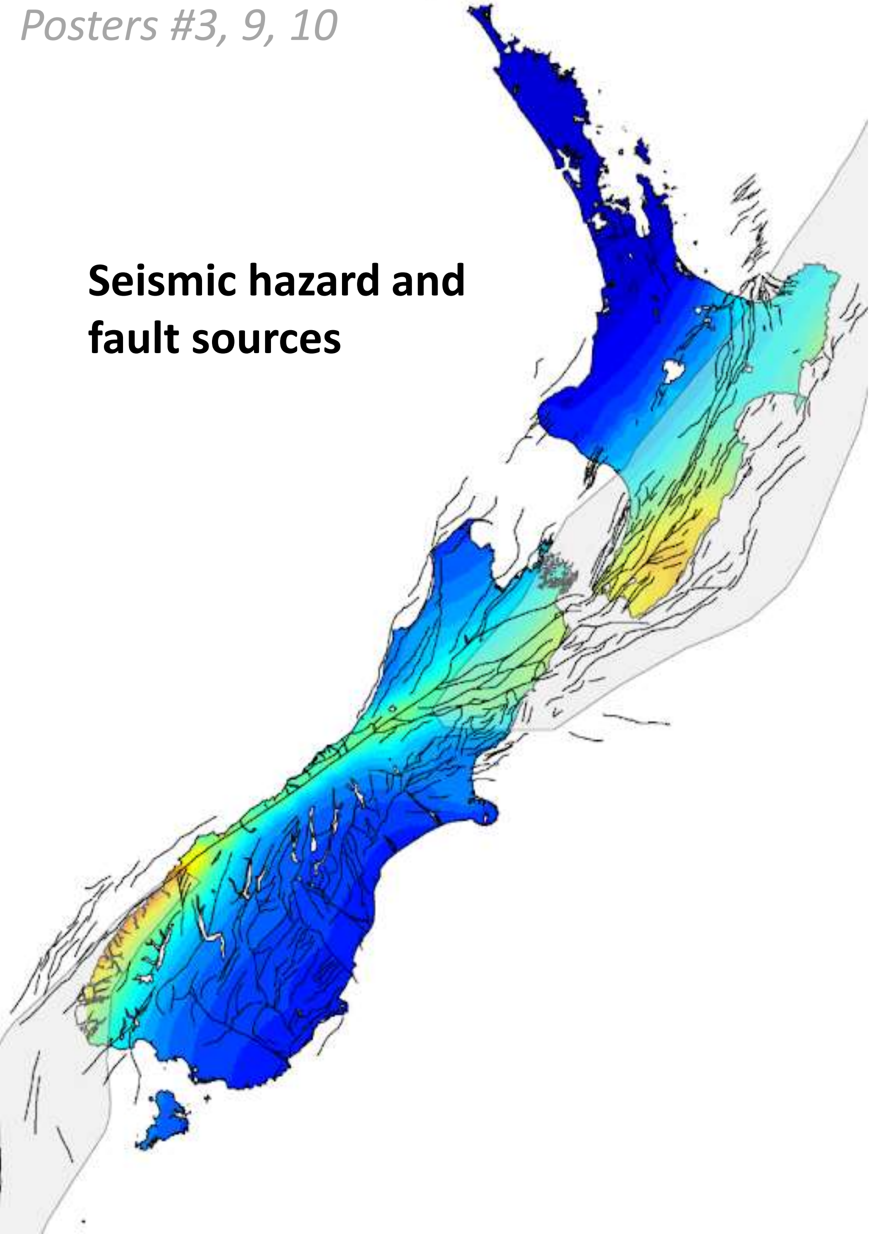
Research Programme



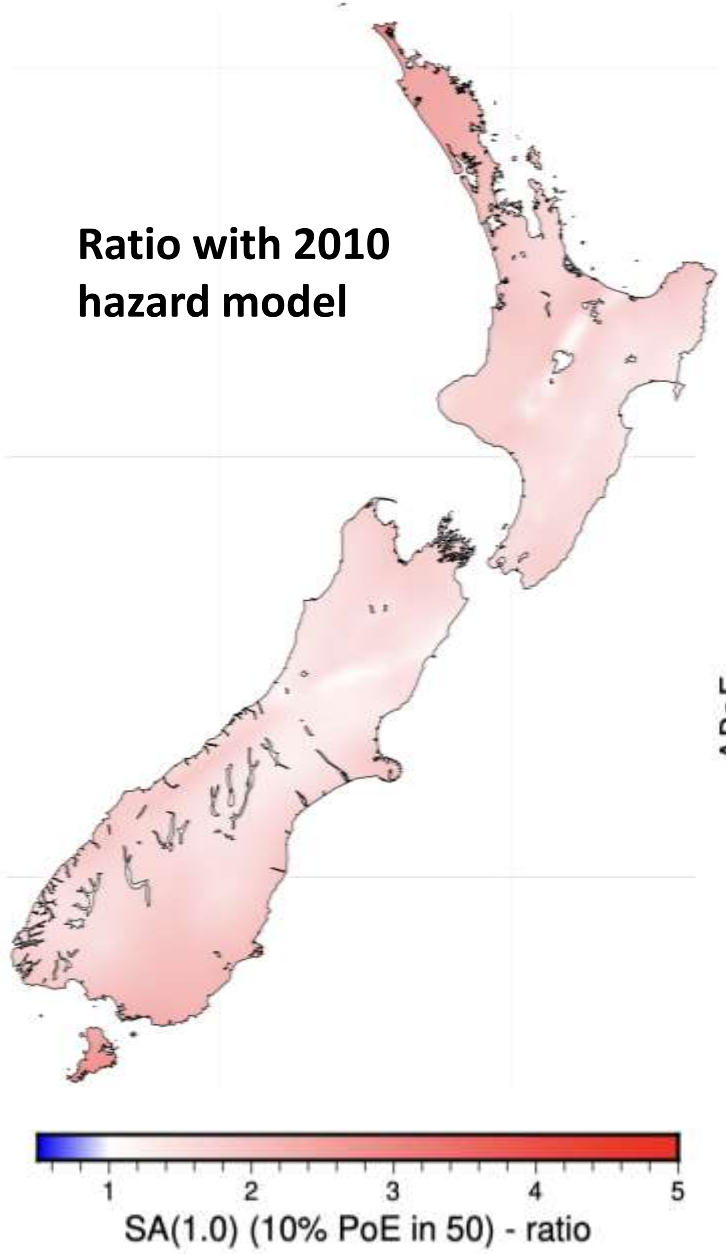
2022 Aotearoa NZ National Seismic Hazard Model

Gerstenberger et al.
Posters #3, 9, 10

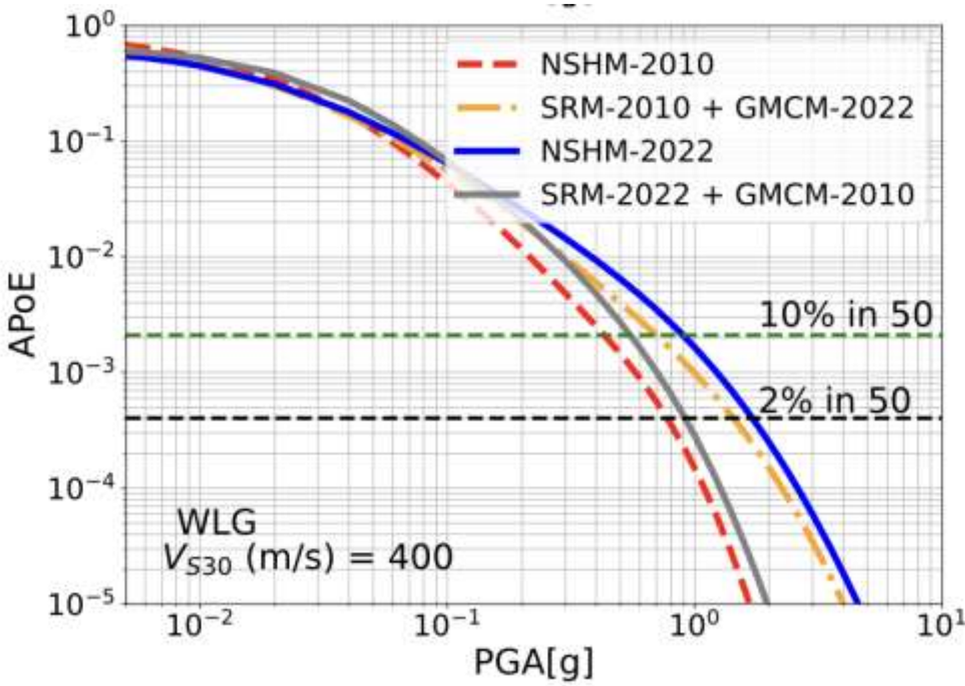
Seismic hazard and fault sources



Ratio with 2010 hazard model



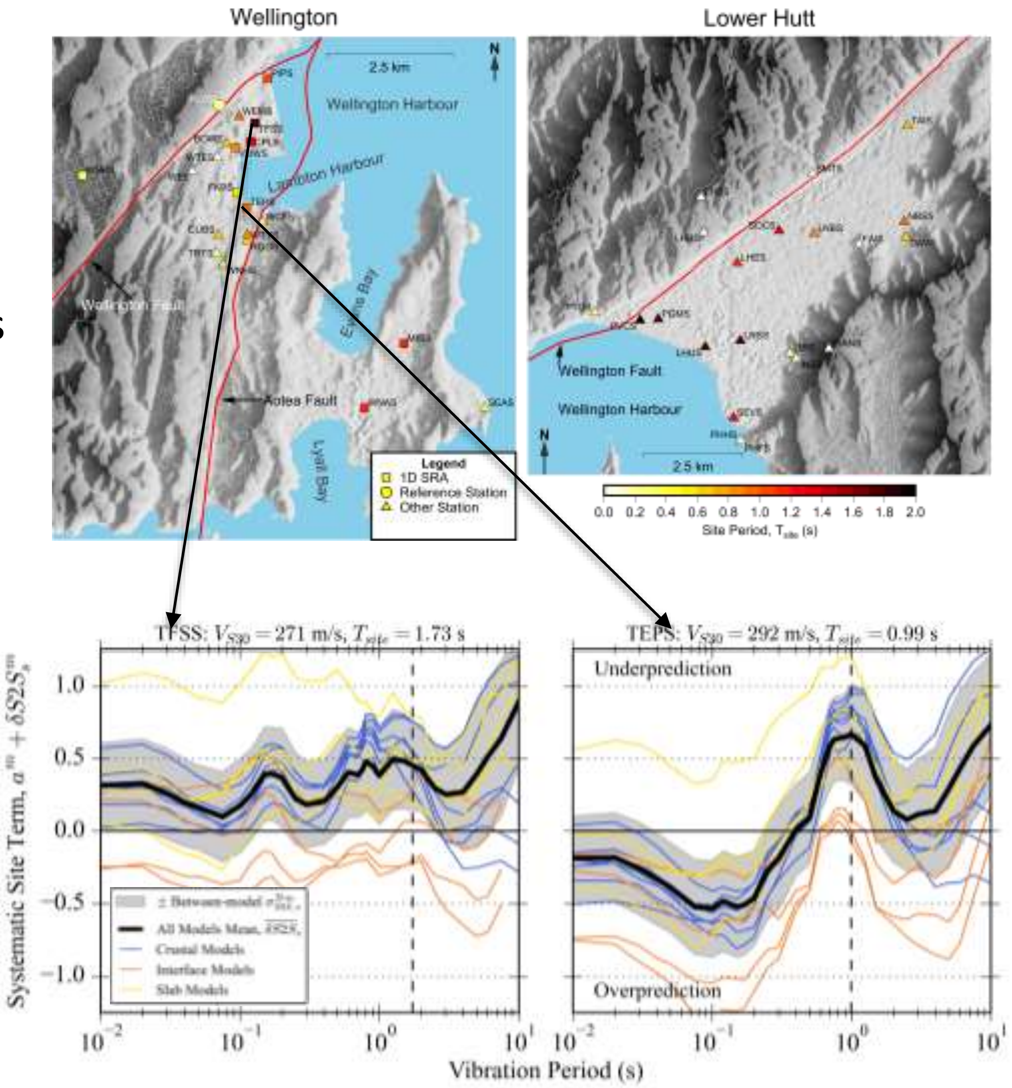
Hazard curves illustrating source vs. ground motion sensitivity



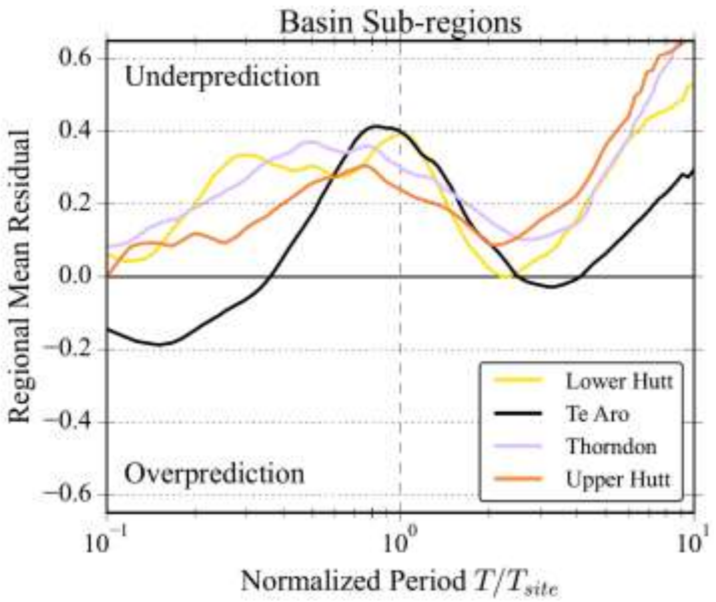
Site-Response Adjustments to Account for Basin Effects in Wellington

de la Torre et al.
Poster #08

- Prediction residuals for sites in Wellington and Lower Hutt
- 4 basin and 3 valley sub-regions



- Ground motion models from 2022 NZ NSHM
- Model-to-model variability
- Underprediction at site period for basins and valleys



- Similar shape for basin regions (and valley regions)
- Centred around T_{site}
- Max underprediction: factor of ~1.5
- Option for regional adjustment

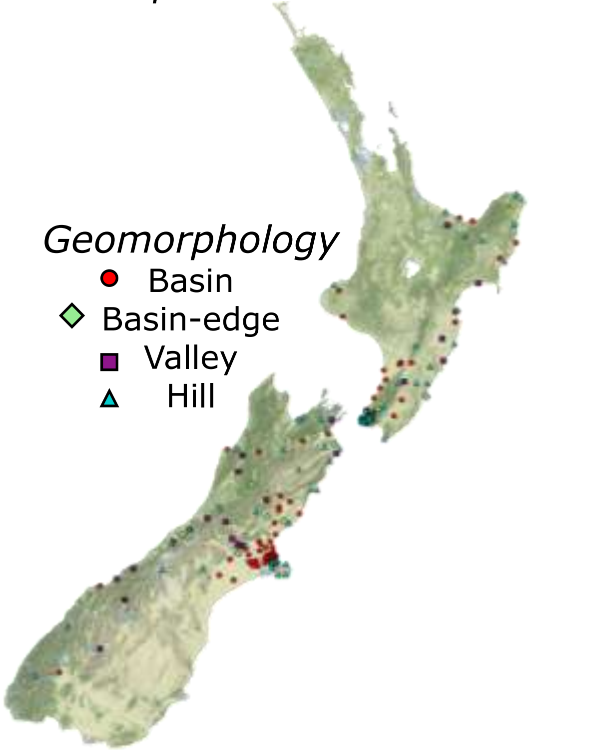
Site effect residual analysis of physics-based ground motion simulations

Tiwari et al.
Poster #19

Objective: Nationwide investigation of *strong systematic site effects* to determine the attributes influencing these effects for advancing ground motion simulations

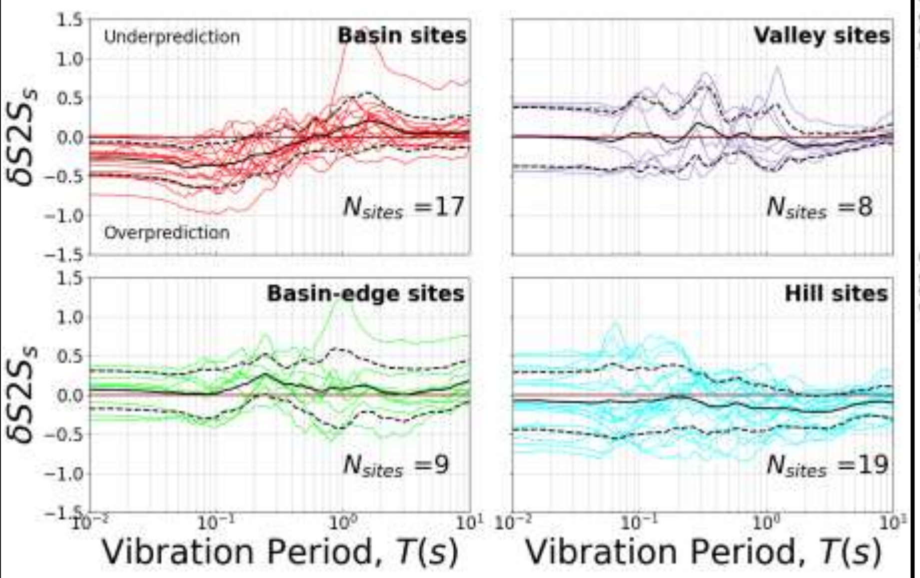
Approaches: Geomorphology, V_{S30}, T_0, $Z_{1.0}$, topo parameters etc. ⟷ Understanding of systematic site effects ⟷ Clustering of site-to-site residuals

Geomorphic classification of sites

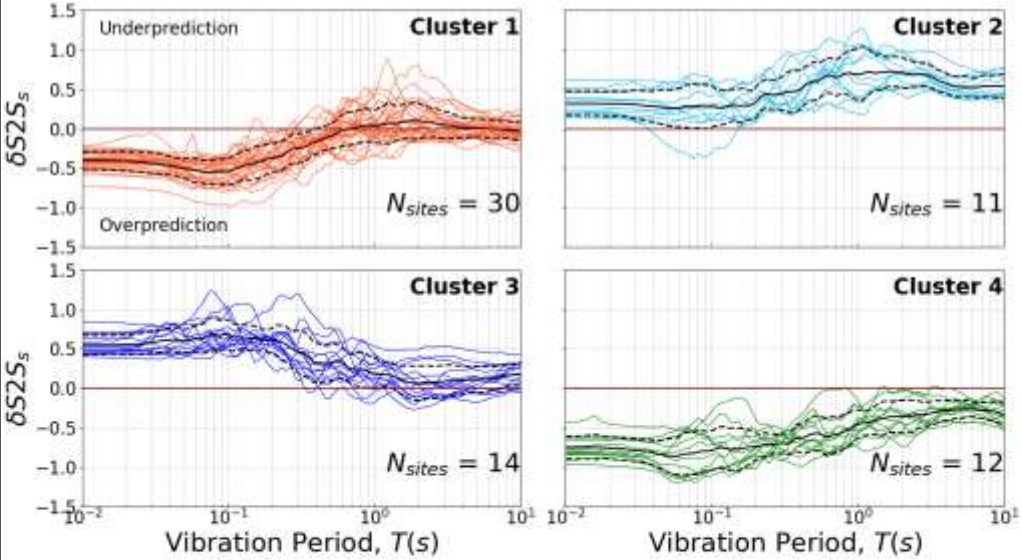


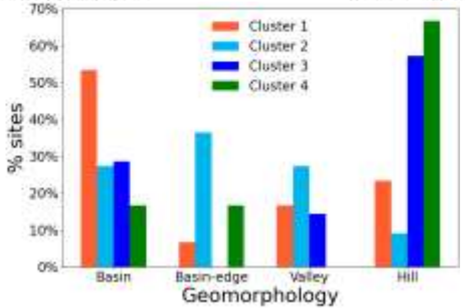
Trends with geomorphology

Wellington region



Trends with clustering





Liquefaction Hazard of Wellington Reclamations

Dhakal et al.

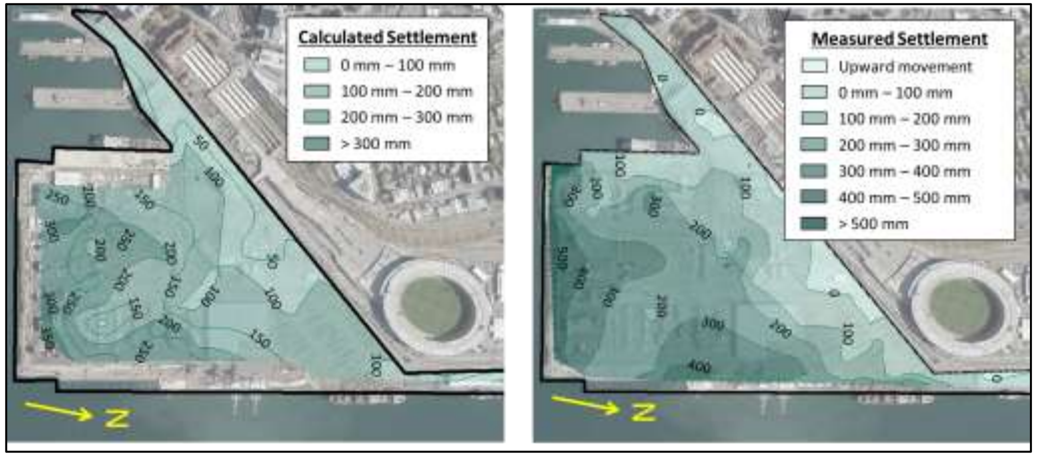
1. Soil and site characterization using CPT (2016-2021) ✓

→ Port and waterfront areas

2. Simplified liquefaction evaluations (2016-2022) ✓

→ Predictions VS Observed EQ damage

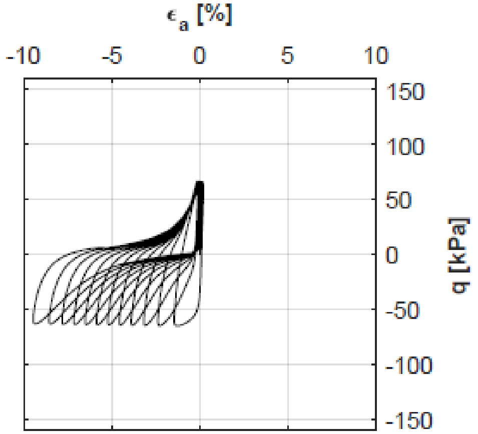
→ Scenario-based assessment



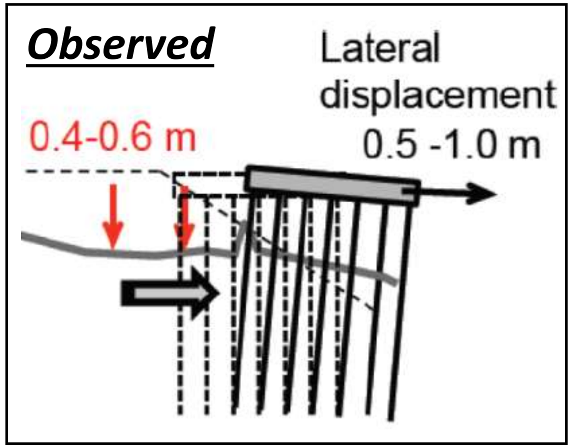
3. "Undisturbed" soil sampling & laboratory testing (2021-2023)

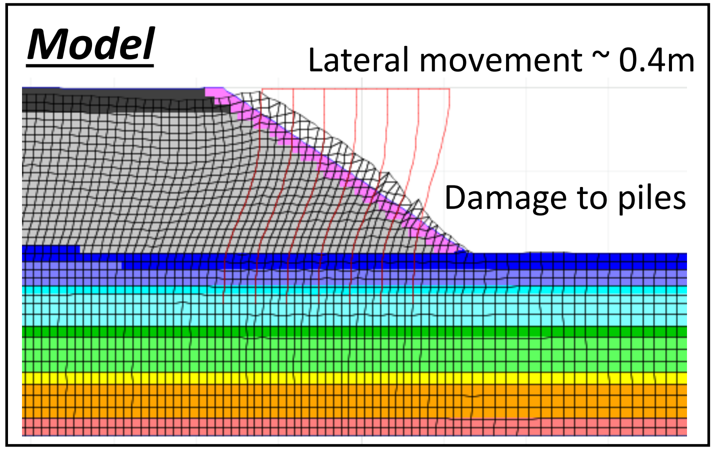
→ Compare against CPT characterization

→ Inform numerical analyses



4. Advanced dynamic numerical analyses (2021-in progress)





IMPACT OF COSEISMIC LANDSLIDES ON INFRASTRUCTURE SYSTEMS IN WELLINGTON

Harvey et al., Poster #11

KEY FINDINGS:

- High susceptibility (90th percentile) across all five districts in a M_W 7.5 Wellington Fault Rupture Scenario
- Plausible estimates of slope failure over an area between 3 and $138km^2$
- ~1500 buildings situated within 90th percentile of values, with ~1000 of these situated in Wellington City
- Areas susceptible to slope failure across key transport routes, including the connection between Wellington City and the Hutt Valley on SH 2

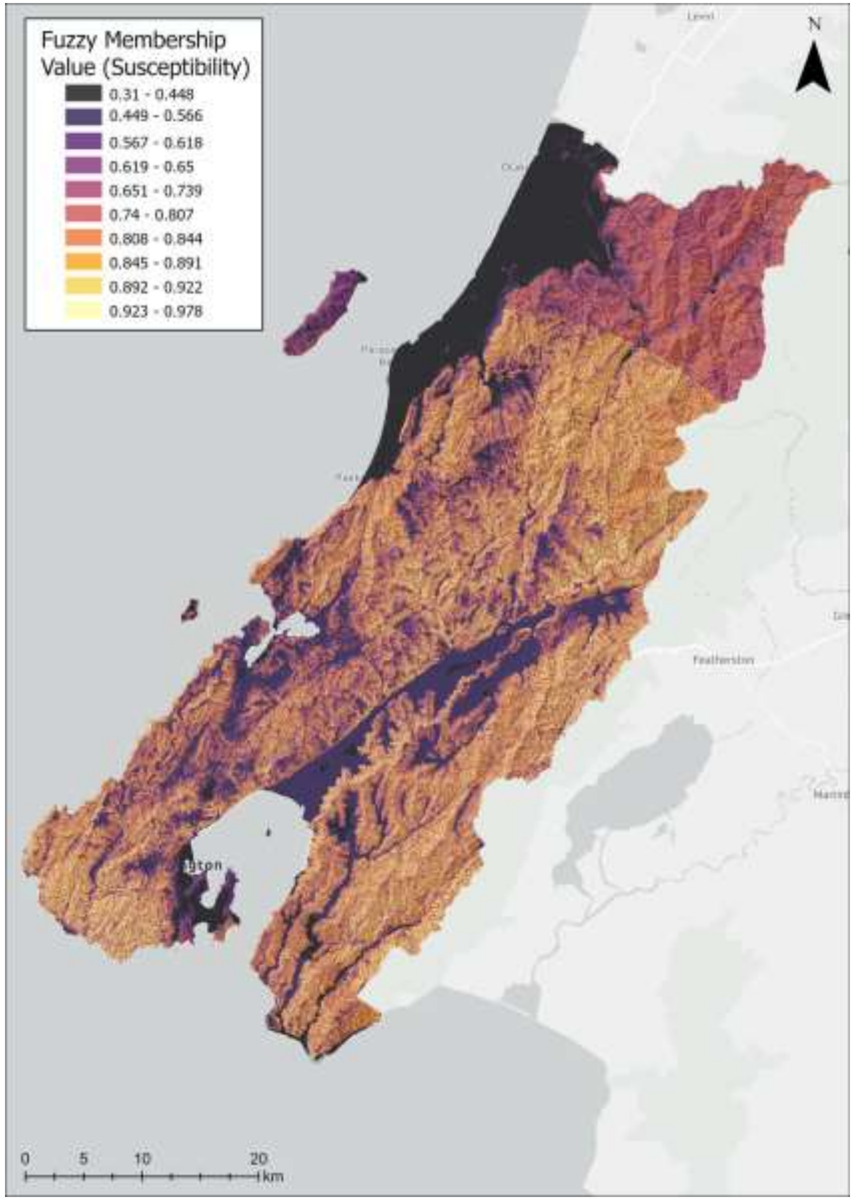


Figure 1. Coseismic landslide susceptibility of research area, as determined by fuzzy membership.

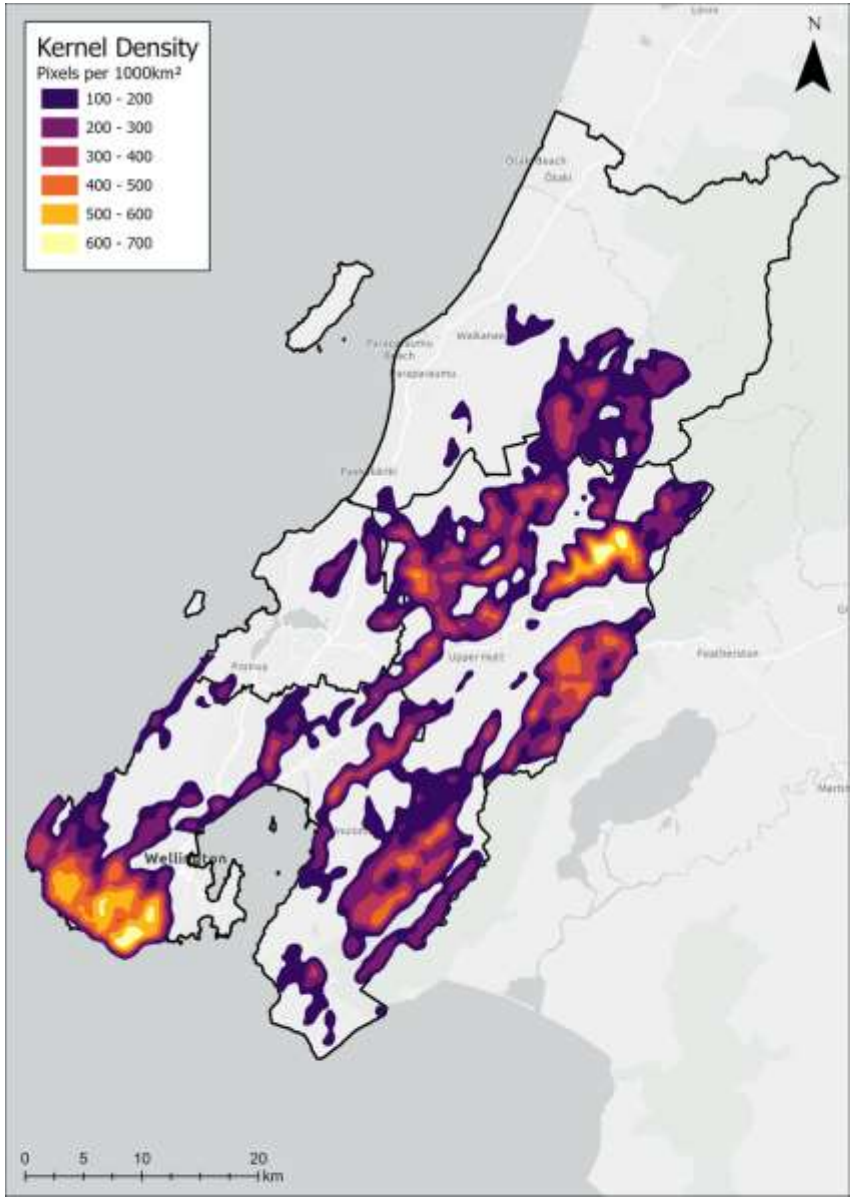
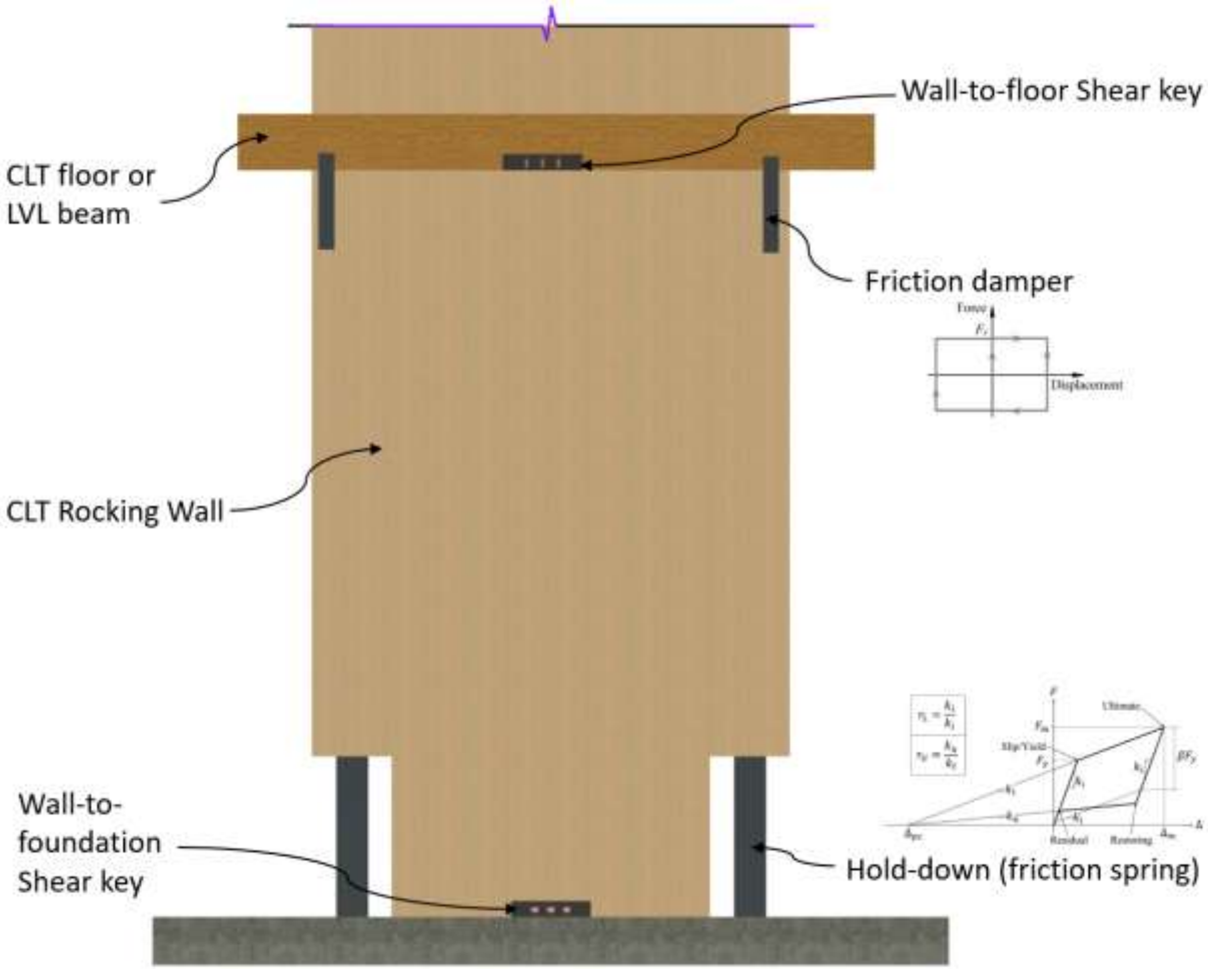


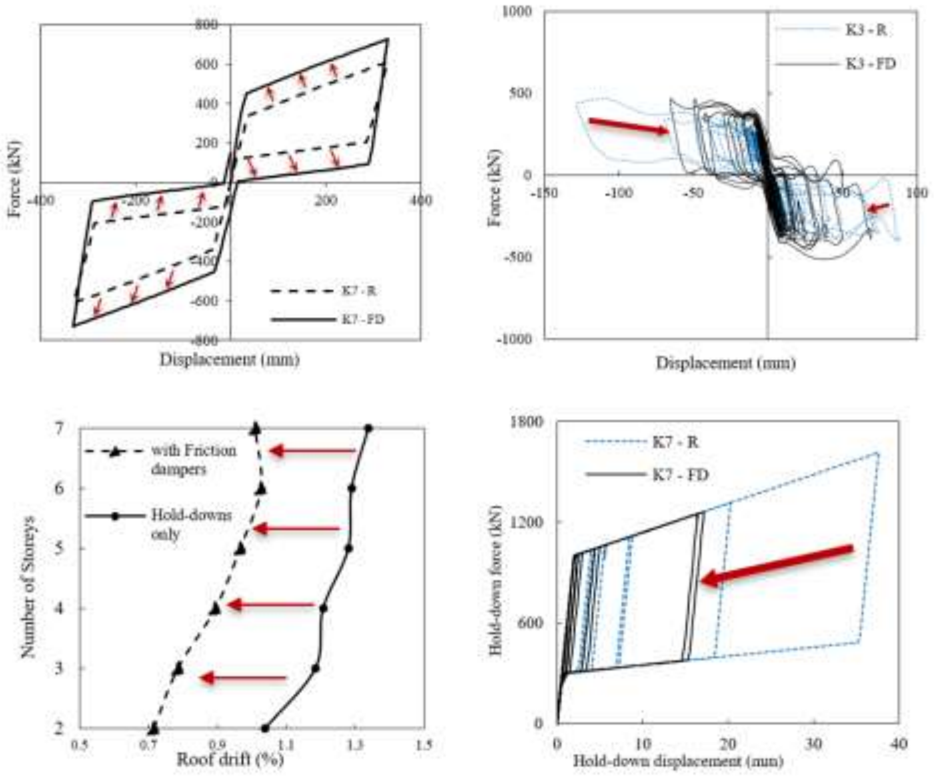
Figure 2. Kernel density map of 90th percentile of susceptibility values, that is > 0.933.

QuakeCoRE UC UNIVERSITY OF CANTERBURY New Zealand Geotechnical Society

Low Damage Wall To Floor Connections For Seismic Resilient Timber Structures

Assadi et al.
Poster #25



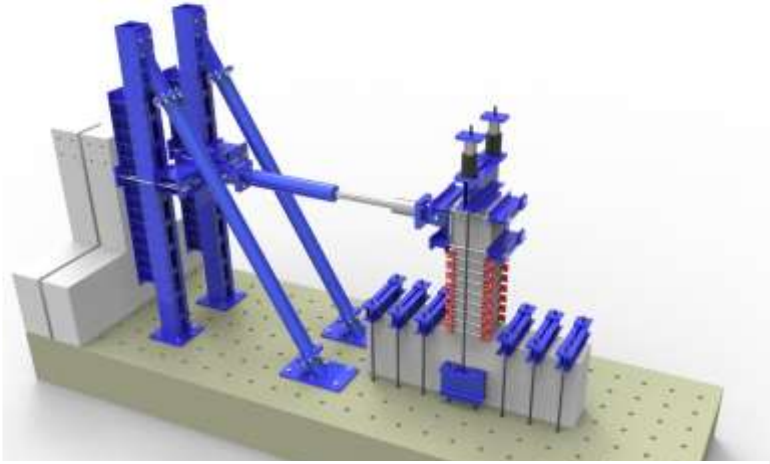


Results:
- ➢ Complete self-centring
- ➢ Substantial mitigation of structural drift demands
- ➢ Significant reduced wall hold-downs demands
- ➢ No yielding or damage to any of the joints or structural parts
- ➢ Repeatable and pinching free flag-shaped force deformation behavior (hysteresis)
- ➢ High damping ratio system (energy dissipation) 20%~25%
- ➢ highly cost-effective and competitive timber structure and construction
- ➢ Immediate occupancy

Retrofit and repair of RC columns with post-tensioned clamps

Rincon et al.
Poster #32

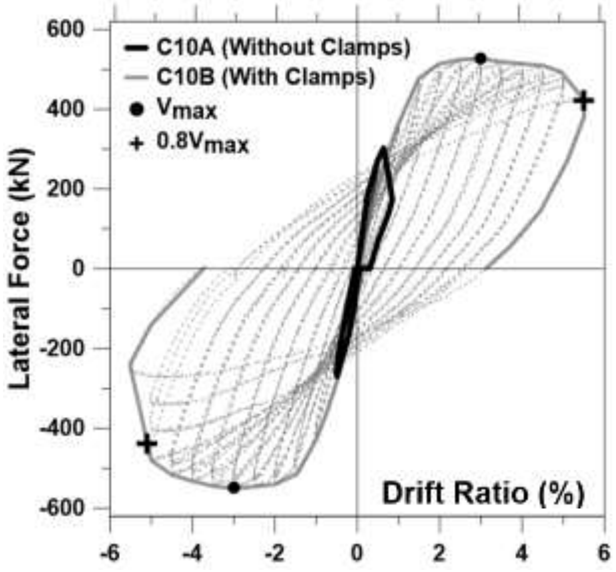
Damage after 2023 Turkey EQs



Experimental Programme on full-scale RC columns

Proposed P.T. Clamps for retrofit and repair

How to retrofit and/or repair RC columns in large building inventories or in developing countries ?

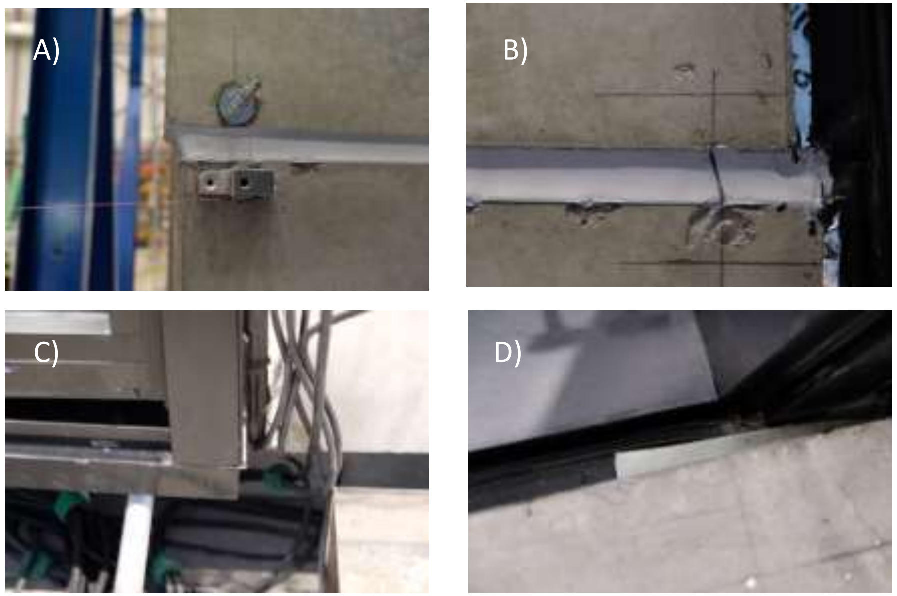


Increase in Lateral-load Resistance

Increase in Drift Capacity

Non-Structural Element (NSE) Interaction Testing

Photos from the experimental setup just before the testing.



Displacements and damage observed at 2.5% drift: A) Rotation at the corner of the panels B) Dispalcement in the Sealant C) Uplift of the internal glazing frame D) Damage to the Gasket of the External Glazing Frame.

- Testing of interaction between Precast Rocking Panels and Seismic Frame Glazing
- Experimental Rig tested up to ± 2.5% Interstorey Drift
- No oberved damage to the precast panels, which was expected
- Minor damage to the sealant was observed at the interestion between the stacked panels and the Glazing Frame
- Damage to the Glazing system was limited only to the external frame, glass and internal frame unaffected
- Data processing still in progress

A Socio-Legal Analysis of Seismic Building Regulation in Aotearoa New Zealand

Hopkins

The Project

A Socio-Legal examination of the EPB Elements of the Building Act and their operation.

Project Findings

The EPB Sections of the Building Act apply to buildings based not upon life safety but age and ownership.

The project argued that this outcome is not obvious due to inappropriate use of secondary legislation and deemed regulations (particularly the EPB methodology) .

Project Intended Impact:

Increased awareness of the impact of the EPB elements of the Building Act and potential reform of the legal framework.

Hopkins W.J., "Safe as Houses? The Limits of Seismic Building Regulation in Aotearoa New Zealand" NZLR, 2023, (Forthcoming)

LEAD Institute of Law, Emergencies & Disasters
QuakeCoRE NZ Centre for Earthquake Resilience
UC LAW Te Kura Ture

Post-Disaster Dispute Resolution

The Canterbury Earthquake Insurance Tribunal the ‘fors’ and the ‘flaws’

2010 → **2011**

Ongoing seismic activity

Mapping of a timeline for post CES dispute resolution – to establishment of CEIT

2012 →

High Court List established

Little progress on reinstatements – discontent and mistrust grow.

Identification of obstacles and **impediments** to the resolution of insurance claims

2013 →

RAS established

Slow progress with claims

Residents needed advice! Decisive action needed! Issues included: Red/land zoning, policy entitlements, geotech, lack of resources and lack of collaboration between agencies including national and local govt

2018 →

GCCRS established

Stalled claims
New issues arose such as failed/ inadequate repairs

Utilising experts effectively - critical to resolution

2019 on

CEIT established

CEIT – established 8 years after CES!
How could early barriers to resolution of claims/ disputes and reinstatement of homes have been overcome???

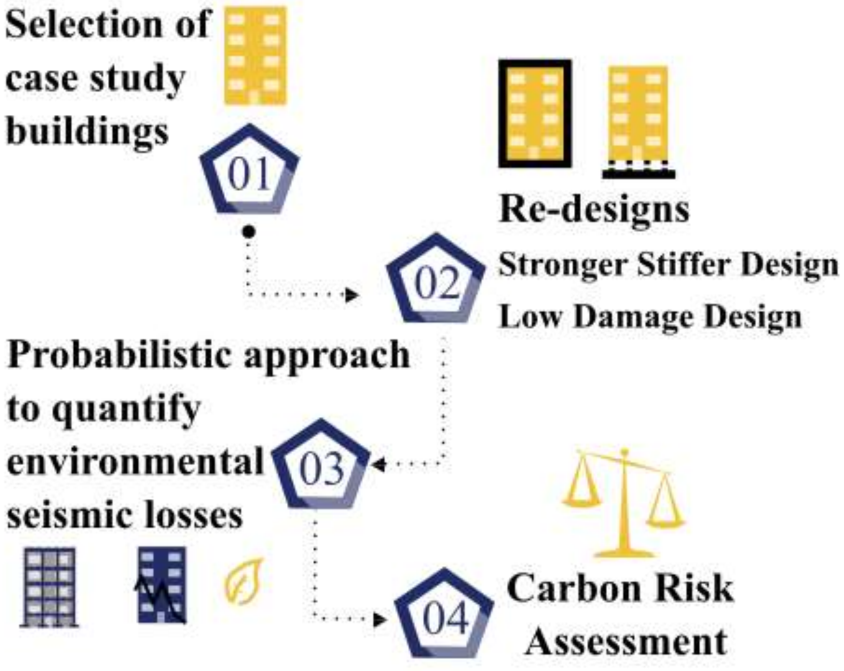
Building the Carbon Case for Resilient Design

Gonzalez *et al.*

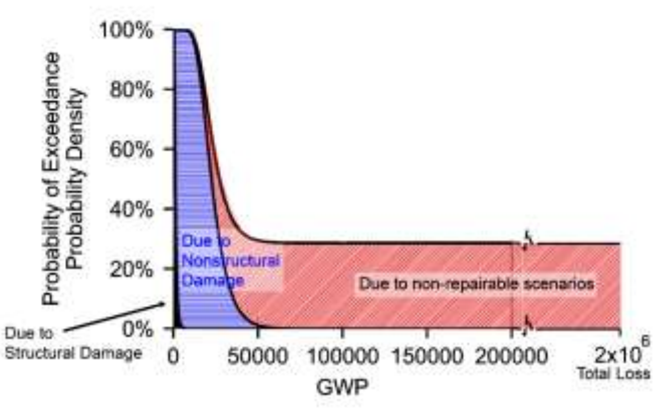
Goals and Scope of Study

This research aims to provide valuable insight into the **carbon cost of designing** seismically resilient buildings in New Zealand.

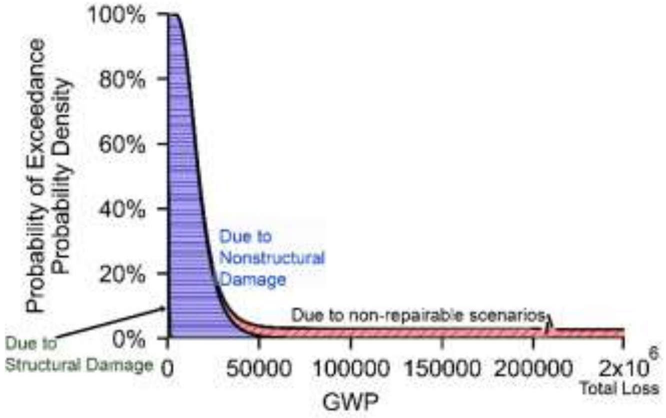
Methodology



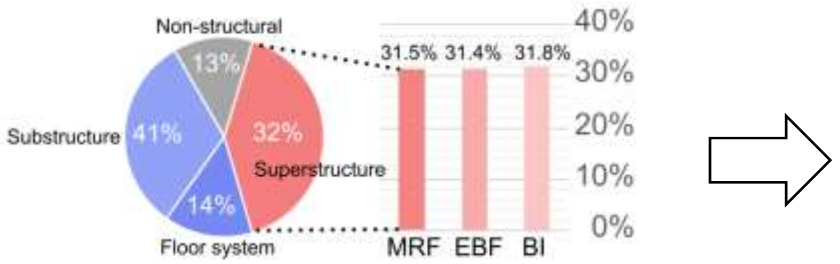
Results



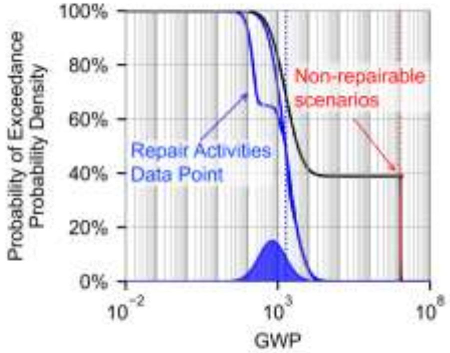
Code-Minimum Building



Stronger-stiffer Building



Initial Embodied Carbon across building designs
-MRF Moment Resistant Frame (Code Minimum)
-EBF Eccentrical Braced Frame (Stronger-Stiffer)
-BI Base Isolated building (Low Damage design)



MCE earthquake response

Post-disaster building functionality: A systematic review

Mayer et al.
Poster #59

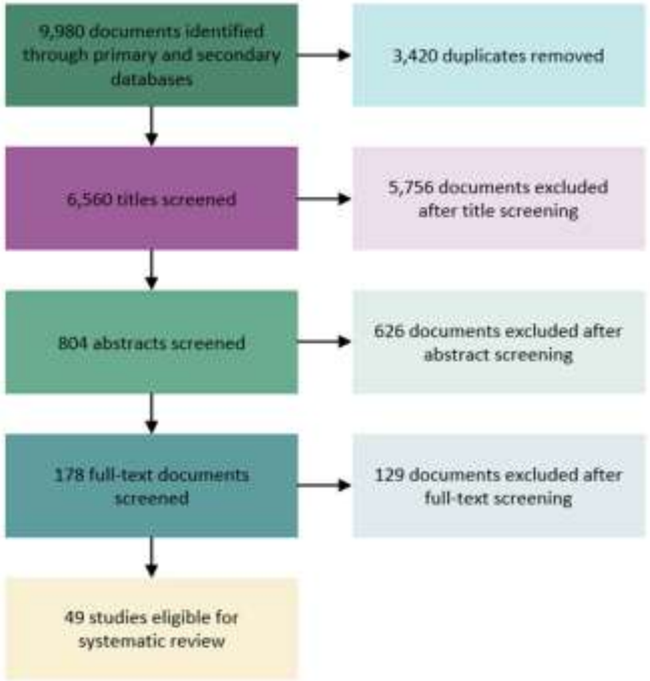


Fig. 1 Systematic Review of Functionality and Occupancy

Fig. 2 Systematic Review Results classifying components of building functionality

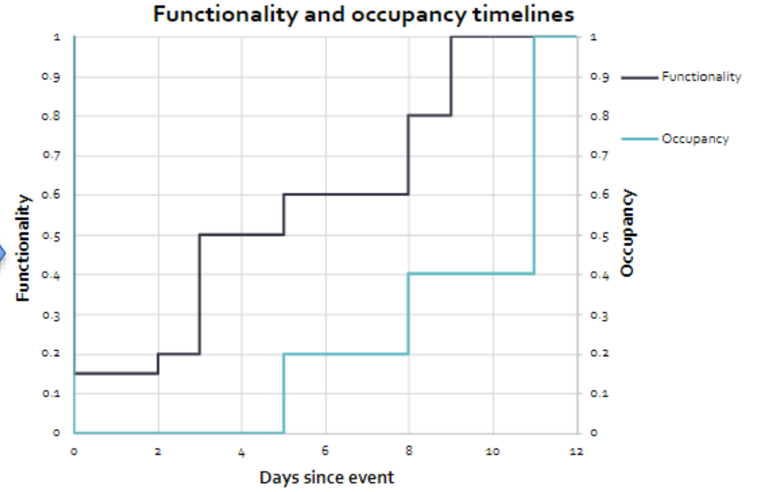


Fig. 3 Planned work to combine functionality and occupancy

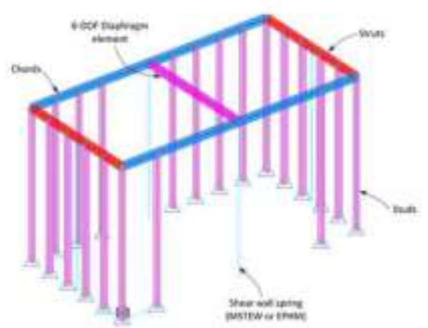
Planned results

- ***Learn from past post-earthquake experiences of NZ tertiary education facilities***
- ***Develop a framework for post-earthquake building functionality and occupancy***

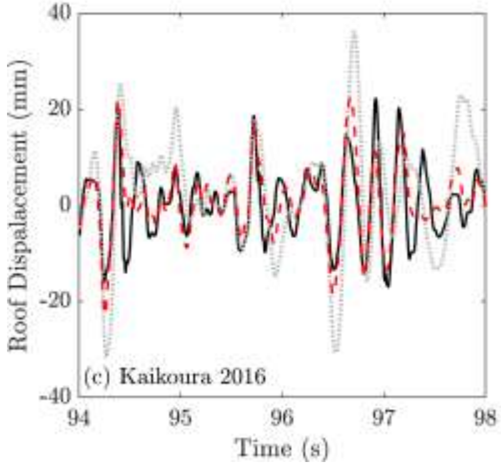
Conference Publication: Mayer, B., Boston, M., Chang-Richards, A. (2023) Post-disaster building functionality: Preliminary findings of a systematic review. NZSEE Annual Technical Conference. Auckland, NZ. April 2023

Advanced testing, modelling and assessment of New Zealand housing

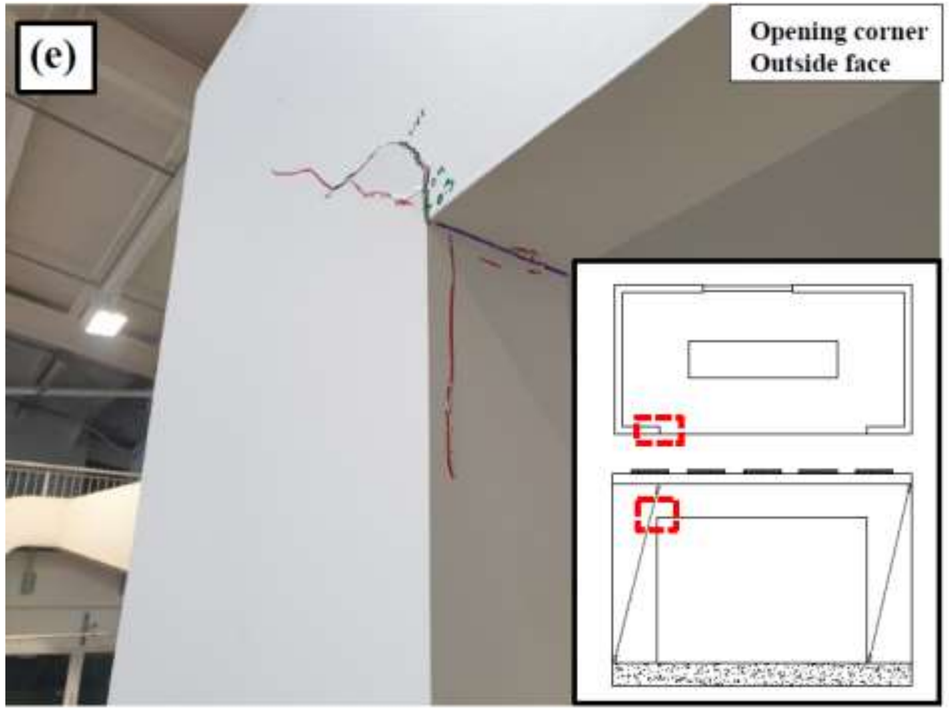
Francis et al.

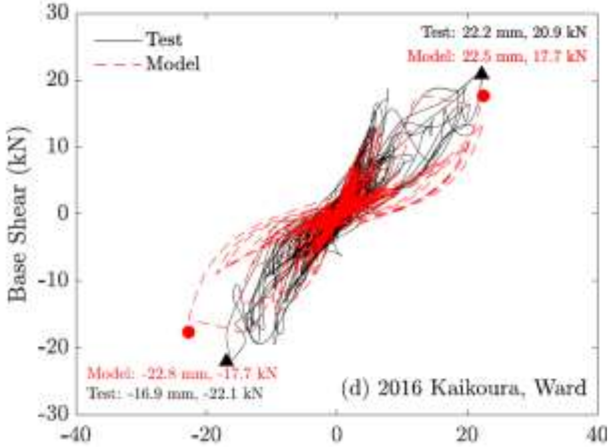


Shake-table testing results used to verify advanced numerical modelling and assessment approach to aid vulnerability assessment of NZ housing (timber-framed walls with plasterboard panels).



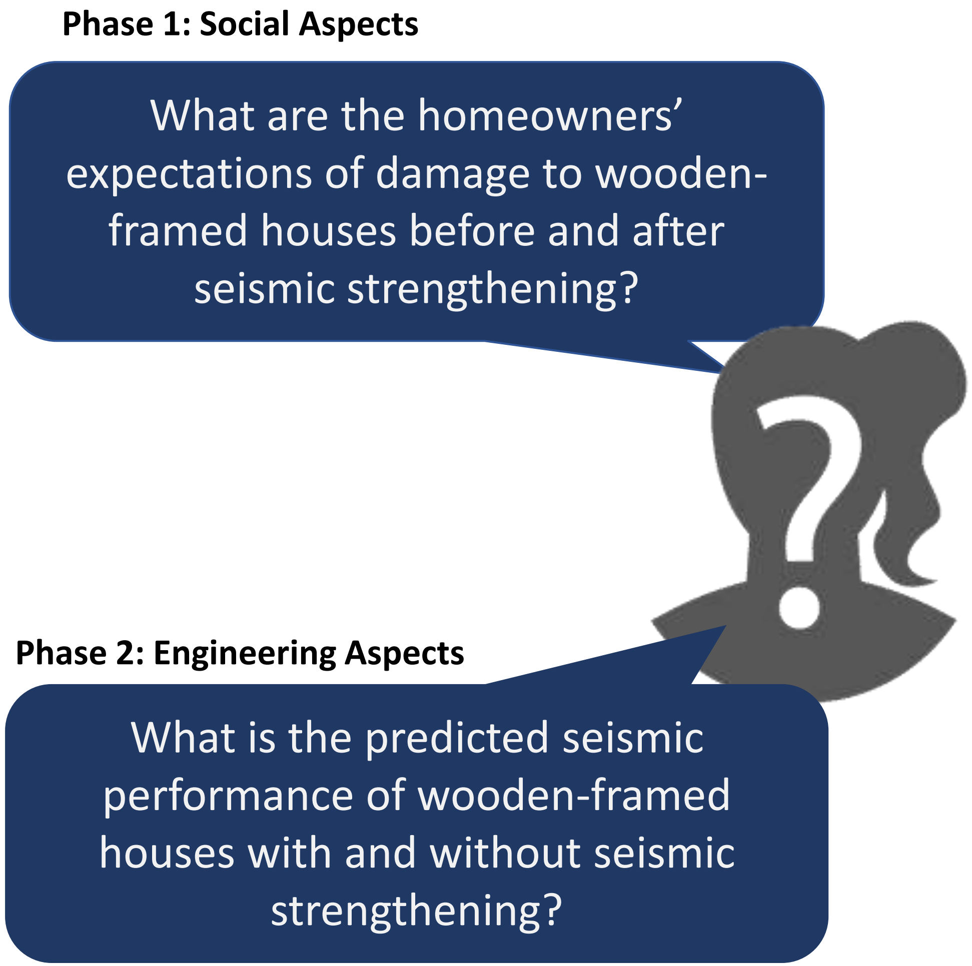
Published in ASCE Journal of Structural Engineering





Expectations and performance of wooden framed houses, Wellington, NZ

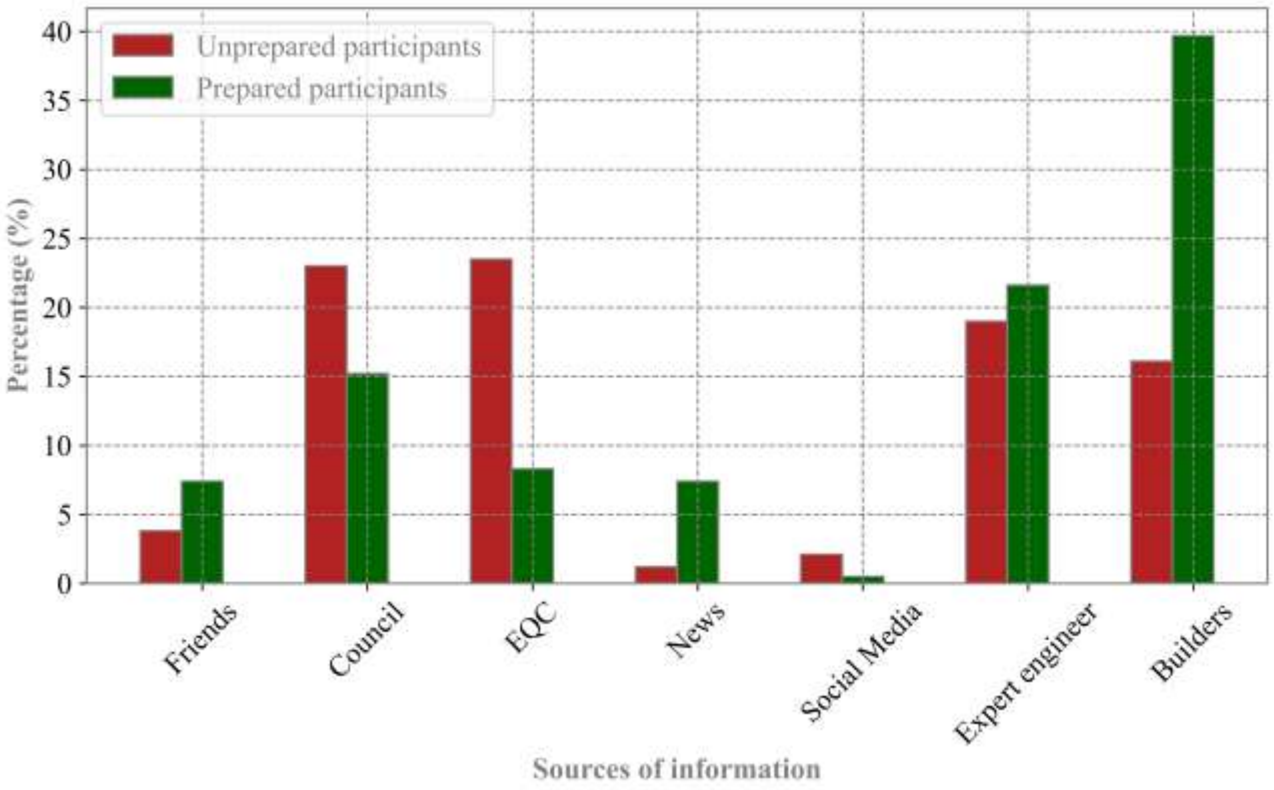
Miranda et al.



- We cannot rely on direct experience of earthquakes to motivate seismic strengthening.
- **All participants expected lower levels of damage** than what is covered by current seismic codes (i.e. life safety).
- Numerical models validated the **positive effects** of sub-floor strengthening on slope timber houses; however, their effectiveness is affected by different geometric parameters.
- Analysis showed that the reduction of damage after strengthening meets the philosophy behind the building codes – life safety; however, **damage will still** occur, which will **not satisfy** owners' expectations of building performance who have voluntarily undertaken building strengthening.

Understanding the influences of builders on building a resilient community

Miranda et al.



A project that looks at how **builders interpret seismic risk** information and how this translates into activities related to **earthquake strengthening**.

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

JOINT CENTRE FOR DISASTER RESEARCH

Toka Tū Ake EQC

Resilient Infrastructure: Planning Emergency Levels of Service (PELOS)

Mowll et al.
Poster #71

- Wellington-based study
- Aimed at understanding how to develop emergency levels of service
- Framework devised, which can be adapted locally/internationally
- Investigation into mapping tools that can help visualise PELOS
- Being considered in new Emergency Management Bill in NZ.

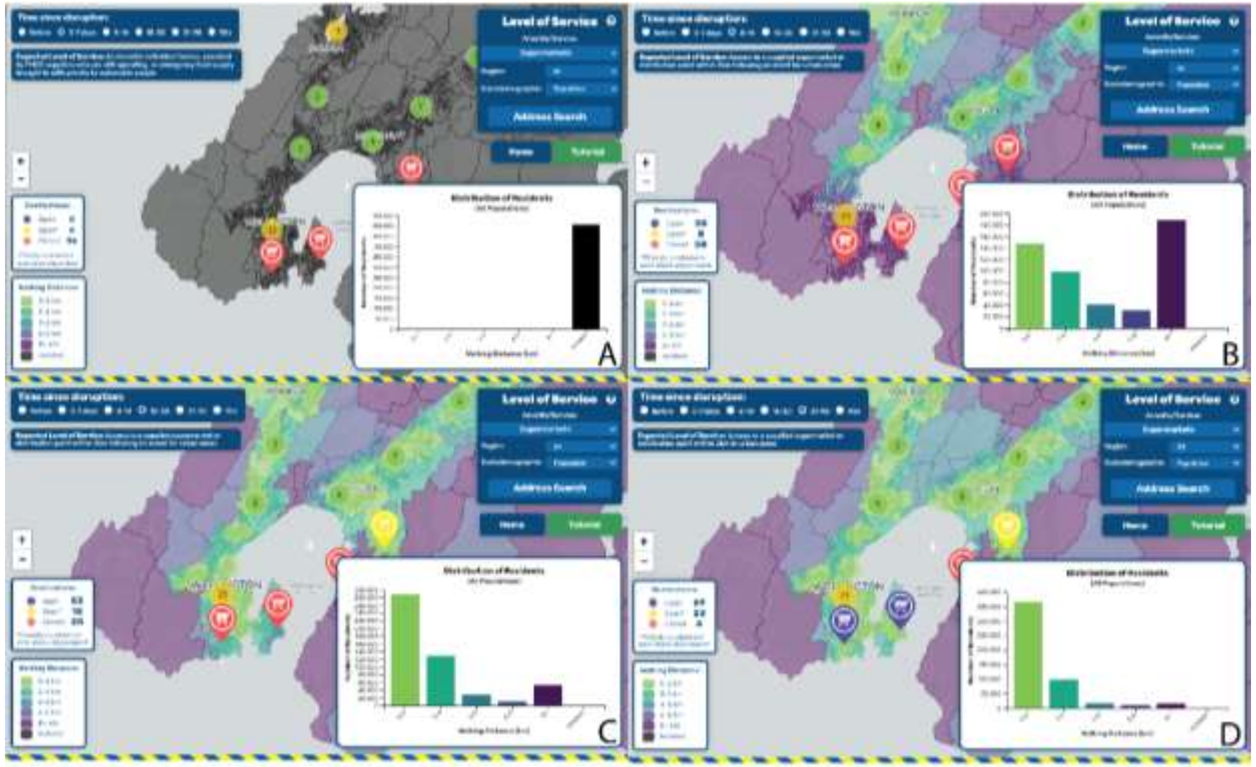


Figure 1: Accessibility to food sources over time. The mapping tool shows how access to supermarkets changes over four time periods post-event: 0-7 days, 7-14 days, 15-30 days, and 31-90 days.

P-wave-based S-wave intensity estimation with PLUM to extend the warning window for EEW

Chandrakumar et al.
Poster #85

Stage 1: Selection of P-wave Detection Algorithm

•Our project commenced with a thorough selection process to identify an optimal P-wave detection algorithm. This choice is crucial as it accurately identifies P-wave arrivals within seismic waveforms. [1][2]

•We assessed multiple algorithms, considering their performance metrics and capacity to handle diverse seismic data. This comprehensive evaluation guarantees the reliability of our subsequent analysis. [3][4]

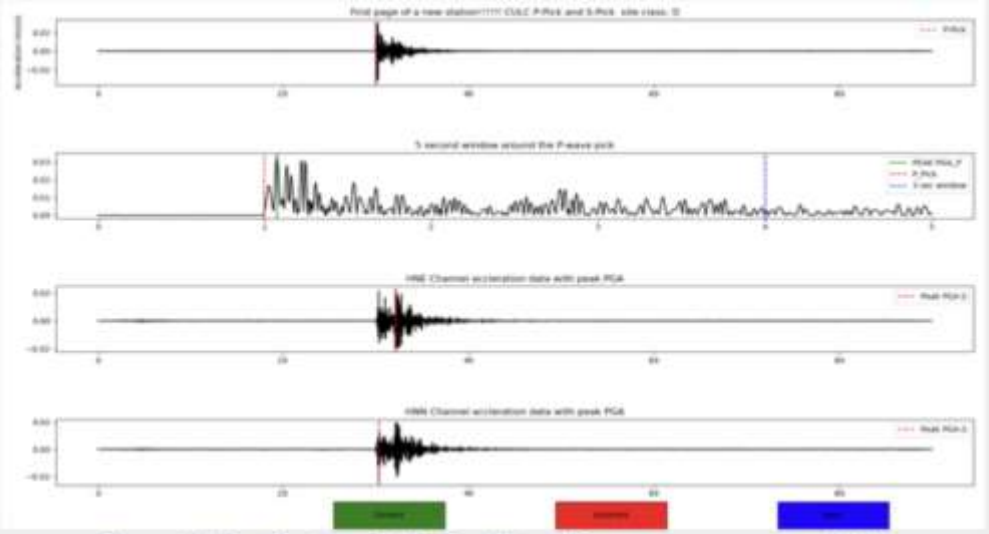


Figure 1: Our Custom-Built Tool P and S-wave parameter picking

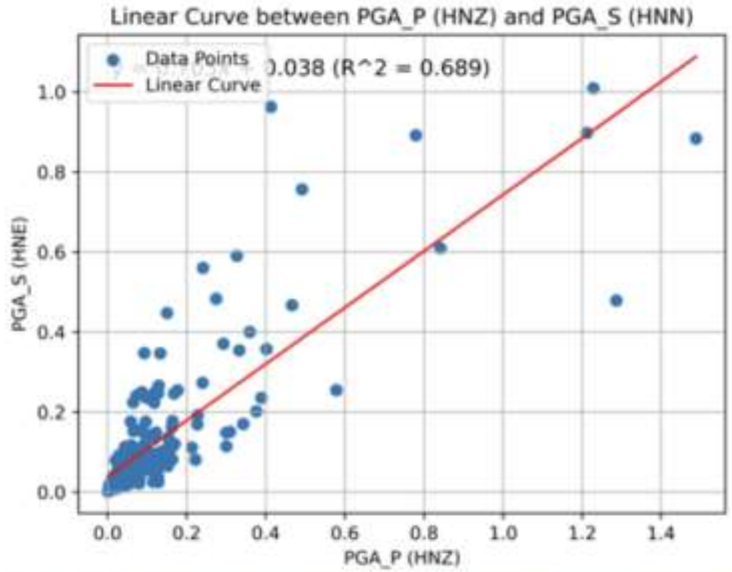


Figure 2: An empirical relationship built between the Peak Ground Acceleration of P and S-waves

Stage 2: Building a relationship between P and S-wave's intensity

•**Data Source Selection:** Our study is centred on CUSP stations in Canterbury (2015-2022) with labelled P-wave picks, ensuring robust data quality.

•**Waveform Collection:** From the selected stations, we acquired 3085 waveforms, forming a substantial dataset for analysis.

•**P-wave and S-wave Parameters:** Extracted key parameters within three seconds of P-wave arrivals and during the S-wave using a tool (Figure 1) developed by the research team.

Relationship Building: Our ongoing work involves correlating the extracted parameters, and building an empirical relationship between P-wave and S-wave intensities (e.g., Figure 2).[5]

QuakeCoRE Research Accomplishments
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David Johnston
on behalf of the QuakeCoRE community

30 November 2023