2023 Te Hiranga Rū QuakeCoRE Annual Meeting Posters

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Agarwal, S., Hashemi, A., Quenneville, P. 23

Seismic behaviour factors for rocking Cross-Laminated Timber walls with friction devices

Rocking Cross-Laminated Timber (CLT) walls has emerged as a prominent lateral load-resisting system (LLRS) for mass timber structures. These rocking walls allow for the realisation of more robust and taller mass timber structures. Different design and modelling techniques for rocking CLT walls as LLRS have been published in recent research, including self-centring hold-downs. However, due to the lack of comprehensive full-scale test data, uncertainties surrounding these methodologies, modelling techniques, and performance hinder the adoption of rocking CLT walls by design engineers.

To address these uncertainties, published standards provide guidelines on the range of seismic behaviour factors such as the structural ductility factor μ, inelastic spectrum scaling factor kμ, structural performance factor Sp, and overstrength factors Ω. Previous research on deriving these factors mainly focuses on post-tensioned elements with separate dampers on single CLT walls.

This poster presents the results of seismic behaviour factors of select archetype buildings with single, friction-coupled wall-wall and friction coupled wall–column LLRS. The LLRS is evaluated using incremental dynamic analysis for MCE and beyond MCE-level earthquakes to account for the impact of appropriate uncertainties related to record-to-record variation, design methods, test data, and numerical modelling. To ensure the system's robustness in line with current standards, the collapse probability was limited to 10%.

Ge, Y., **Aigwi, E.,** Nwadike, A. **67**

Assessing the Flood Vulnerability of New Zealand's Earthquake-Prone Heritage Buildings Due to Climate Change Patterns

The impact of climate change on earthquake-prone heritage buildings, particularly those in flood-prone areas, is a significant concern. In addressing this issue, the United Nations Sustainable Development Goals 11 and 13 highlight the importance of vulnerability assessment as the initial step. To this end, this research aims to evaluate the flood vulnerability of earthquake-prone heritage buildings in New Zealand due to climate change patterns. The research has three objectives: (i) to determine the location of Auckland's earthquake-prone heritage buildings, (ii) to evaluate the flood vulnerability index of these buildings using an index-based approach, and (iii) to provide recommendations to stakeholders on appropriate measures to safeguard earthquake-prone heritage buildings from the impacts of climate change-related flooding in New Zealand.

An index-based vulnerability approach was adopted to assess ten mapped earthquake-prone heritage buildings in Auckland, randomly selected from New Zealand's earthquake-prone

building register. The results revealed the different flood vulnerability levels of the selected buildings based on their "Exposure", "Susceptibility", and "Resilience" to flooding.
This study's findings are significant for New Zealand's National Climate Change Adaptation Plan. Also, relevant stakeholders can be guided on how to accurately quantify and grade the flood vulnerability levels of Auckland's earthquake-prone heritage buildings, considering the increasing impact of climate change. Additionally, the vulnerability indicators analysed in this study can serve as a model for future flood vulnerability assessments of earthquake-prone heritage buildings in other flood-prone cities in New Zealand and globally.

Alger, B., Thomas, K., Kaiser, L. **56**

Papa Wiri: Te Ao Māori Disaster Risk Reduction through Participatory Design and Co-Design of Educational tools

Most current Disaster Risk Reduction (DRR) education programmes to build community resilience are designed for Pākehā use and engagement with little connection to Te Ao Māori. There is an opportunity to weave Māori narratives and education pedagogies to create bi-cultural and engaging DRR education resources, community solutions based on diverse knowledge, to empower all to reduce disaster impacts. Currently there is little, true, co-designed research with Māori in the DRR space. This research aims to trial and improve the current journey with Māori partners and present learnings to the wider research community.
This research, co-led by Māori Educational Advisors, uses a qualitative kaupapa Māori research approach to explore Te Ao Māori perspectives around DRR and inform co-designed indigenous innovation of Māori-cantered educational tools for kura and wider communities. An iterative process with research partners and users will shape the research design and wairua journey.

Anderson, M., Logan, T., Brunner, L. 75

Functional Isolation: The compounding burden amidst cascading infrastructure network failures and disrupted supply chains

Escalating climate change impacts and increasing vulnerability to natural hazards have highlighted the significance of addressing the risks of indirect impacts, specifically isolation, in promoting community resilience, emergency preparedness, and climate change adaptation. While prior research has made advancements in understanding and identifying isolation caused by road outages and destination closures, an important aspect has been overlooked: the additional burden placed on communities due to cascading failures in infrastructure networks and disrupted supply chains. This study aims to fill this research gap by evaluating the effects of functional isolation resulting from a natural hazard event on transportation, electricity, wastewater, potable water systems, and building infrastructure. Through a cascading failures analysis in the electricity, wastewater, and potable water networks, the study aims to uncover the impact on available utilities within amenities. Additionally, an assessment of the operational supply chain will be conducted to identify functioning sites. The study will further analyse residents' access to functional amenities to determine changes in community access, the number of impacted residents, the distributional justice of impacts, and the contribution to functional isolation. By investigating these aspects, the study expects to demonstrate the compounding burden imposed on communities and the subsequent modifications in distributional justice. Furthermore, it aims to identify previously overlooked amenity locations that are ill-equipped to cope with natural hazard events due to limitations in traditional approaches. This research holds significant importance as accurate identification of impacted populations and infrastructures is crucial for equitable climate adaptation and emergency preparedness. It enables the targeted allocation of resources and support to the most vulnerable communities, addressing concerns of social and environmental justice. By

tailoring interventions to specific needs, disparities and maladaptation can be reduced, while strategic investments in critical systems can enhance their resilience and ability to maintain essential services during disruptive events.

Andige, N. 39

How might green and blue infrastructure planning considerations inform the re-design of public open spaces for DRR?

Green and blue infrastructure (GBI) is widely acknowledged for its ability to mitigate the effects of natural disasters. Using Te Whanganui-a-Tara Wellington, this research first examines the respective levels of risk the city faces from seismic hazards and then investigates the potential of using public open spaces in disaster recovery and resilience. Using ArcGIS Pro mapping software, this study compares the vulnerability of the city's public open spaces to seismic related risks and then identifies key DRR spaces such as community centres, civil defence centres, and Maraes in the city. This study includes an examination of secondary sources to better understand the social phenomena caused by disasters and to investigate the cultural significance of disaster recovery. The second phase of the research looks at how landscape architecture is used to transform Wellington City's selected available public open spaces after a seismic event into multifunctional spaces that can serve as short-term shelter, temporary housing, a central base of operations, and a safe recovery lane to get to the safe open spaces after an event of seismic hazard in Wellington City. The first stage of the design concept of both re-design of public open spaces and disaster recovery lane uses the idea of the land mass splitting apart during an earthquake and how we use technically and logically land split by Voronoi methodology. From there, seismic forms and shapes have been investigated to redesign open spaces.

Apriani, I. 24

Medium Density Housing (MDH) – Preliminary Study to Develop Low-damage Solution for Low-rise Residential Building

In recent years, strong demand for residential buildings has increased the multi-unit home construction in New Zealand and triggered the Government to boost Medium Density Housing or MDH (1-4 attached houses or 3-6 story apartments) in the largest urban area. The lesson learned from Canterbury Earthquake in 2010/2011 that caused a big disruption from the downtime due to significant damage has led the building design to shift from life safety to functional recovery. Therefore, despite the simple design and construction method of low-rise apartment buildings, seismic performance improvement must be addressed. The growing need to reduce post-earthquake damage has led to the development of Low damage solutions in recent years that can improve the lateral resisting structure to limit the damage in the future earthquake. This solution can be achieved by limiting the drift and ductility of conventional systems or adding new innovative systems or devices. For low-rise buildings, seismic improvement is expected without compromising the cost-efficiency of the construction. This study aims to investigate the trend of low-rise apartment building construction in New Zealand and other countries to identify the low-damage technologies that are applicable and effective for this type of building. The study will identify and classify the development of low-rise apartment building typology in New Zealand and some other countries and then investigate the current performance of the building. Following that, some low-damage solutions will be added to the study to identify the most effective solution for low-rise apartment buildings. The study will also compare the cost-effective and future downtime after the earthquake between low-damage solutions and the conventional design of the low-rise building.

Azul, K., Orense, R., Wotherspoon, L. 1

Assembling Liquefaction-related Data for the Development of Hybrid Liquefaction Prediction Model

A hybrid liquefaction prediction model combining geospatial and subsurface geotechnical data is being developed. In developing the model, exploration of possible surficial liquefaction manifestation (SLM) predictors (independent variables) and collation of said predictors along with the SLM observations (dependent variable) is required. The study discusses various methodologies explored to represent subsurface data to describe the SLM probability and the various aspects of liquefaction resistance they are expected to represent. Alternative representations of loading and saturation to describe SLM probability were also explored. By binning the data, the relationship between the SLM predictors and the SLM probability was analyzed to ensure it follows physical expectations based on the current understanding of the liquefaction phenomenon. This process was extended to do a preliminary check for the assumption of linearity in logistic regression. Exploration and initial analysis showed certain SLM predictors to be viable candidates for developing the hybrid model. However, a key factor to their viability is how they were defined (ex., definition of a water body for computing site's distance to water bodies, etc.). It was found that while many SLM predictors' correlation with SLM probability makes physical sense, most do not satisfy the linearity assumption. Future tasks include refining the SLM predictor definitions where applicable, transforming them to satisfy the linearity assumption, and using the assembled data in model development through logistic regression. The last part includes more formal ways of testing the SLM predictors' significance and appropriateness in the chosen regression method.

Bae, S., Ridden, J., Schill, C., Paterson, J., Bradley, B., Lee, R. 2

Cybershake NZ 2023 updates: New Zealand simulation-based probabilistic seismic hazard analysis

This poster highlights progress on the probabilistic seismic hazard analysis (PSHA) in New Zealand using 'Cybershake NZ,' a physics-based ground motion simulation. Initiated in 2017, Cybershake NZ initially focused on 478 shallow crustal faults listed in the 2010 National Seismic Hazard Model, covering the entire country with a 0.4km grid spacing. To achieve higher resolution, intensive computation was required. Since 2021, the coverage of this study expanded incrementally using a 0.1km grid spacing and this update completes the South Island section of the project, incorporating 45 faults out of the total 189 shallow crustal faults in the region. It involved 1,098 finite fault simulations and computed seismic hazard results using a spatially-variable grid of 25,948 stations. The simulation methodology, a NZ-specific modification of the Graves and Pitarka (2010, 2015) hybrid broadband ground motion simulation with a transition frequency of 1 Hz, remained consistent with previous runs in other parts of the South Island. The study employed the NZVM v2.06 3D velocity model, incorporating 31 distinct sedimentary basins in New Zealand, and a Vs30-based local site response model. Rupture generation utilized a Monte Carlo scheme, sampling variability in seismic source parameters such as hypocentre location, slip distribution, and magnitude for each realization. The number of realizations varied with source magnitude, and the 3D velocity model dynamically combined with perturbation data.

With the South Island now fully covered, a simulation-based hazard map can be created and compared to conventional empirical analysis. The project's extensive data necessitated efficient data management and curation, leading to the development of software tools and a data sharing platform.

Finally, we outline future opportunities for advancing this computational platform over the next 12-24 months. Particularly, the release of the 2022 NZ National Seismic Hazard Model,

including new seismic source modelling, presents an opportunity for integration into this platform.

Bora, S., Bradley, B., Manea, E., Gerstenberger, M., Lee, R., Stafford, P., Atkinson, G., Kaiser, A., DiCaprio, C., Van Dissen, R. 3

Hazard Sensitivities Associated with Ground-Motion Characterization Modelling for the New Zealand National Seismic Hazard Model Revision 2022

This study summarizes hazard sensitivities associated with the updated ground-motion characterization modelling (GMCM) scheme adopted in the recent revision of New Zealand National Seismic Hazard Model (NZ NSHM 2022). In terms of impact on ground-motion hazard, the current GMCM scheme (GMCM 2022) results in an overall, at times significant, increase in calculated mean hazard with respect to NZ NSHM 2010. With regard to relative impact, the update in GMCM accounts for the dominant change in high hazard regions while in low hazard regions update in source characterization model dominate. Within GMCM 2022, the change in shallow crustal ground-motion models (GMMs) dominates the effect on calculated hazard while change in subduction interface GMMs has a compounding effect for east coast of North Island and south-west of South Island. Impact of the two NZ specific adjustments to some of the published GMMs is also discussed. The back-arc attenuation adjustment accounts for an 20-30 % reduction in calculated hazard for PGA in north west of North Island while aleatory uncertainty adjustment accounts for 10-20 % reduction in high hazard regions such as along the east coast of North Island and in the lower west of South Island.

Mayer, B., Boston, M., Chang-Richards, A. 59

Using tertiary building performance to define post-disaster functionality timeframes for community recovery and resilience

Building damage from earthquakes can have significant consequences for communities, leading to direct and indirect losses. These losses include casualties and repair costs, reduced productivity and well-being. Current building codes prioritize life safety by aiming to prevent deaths, but lack provisions for repairability and functionality, resulting in potentially long recovery times.

There has been growing interest in enhancing post-earthquake building functionality, which refers to a building's ability to serve its intended purpose. Beyond life safety, additional functionality states have been defined, including re-occupancy (safe shelter), functional recovery (basic service provision), and full functionality (restoration to pre-earthquake conditions). Several frameworks and design methodologies have been developed in the United States to understand the requirements for achieving these higher functionality states. However, these frameworks predominantly focus on structural and non-structural component damage, with limited consideration for external impacts (e.g., neighbouring buildings) and social factors (e.g., pre-event planning and occupancy policies). Furthermore, their applicability outside the United States and on a broader scale remains uncertain.

In response to the disruptions caused by the Canterbury earthquake sequence in 2010/2011, New Zealand government organizations have expressed a desire to move beyond existing life safety codes and increase the country's resilience. The requirements for achieving higher functionality states within a New Zealand context remains an active research area.

This poster proposes developing a framework for post-earthquake building functionality tailored explicitly to New Zealand. Tertiary education institutions in New Zealand are selected as a case study due to their functional similarities to other community buildings such as libraries, offices, cafes, and auditoriums. The research objectives include learning from institutions affected by the Canterbury earthquake sequence, understanding the needs of institutions nationwide, and investigating the framework's applicability to other types of

buildings. The poster presents these objectives and details on required resources, timelines, risks, and ethical considerations.

Buck, N., Hogan, L., Stephens, M. 60

A Comparative Study of New Zealand and Japanese Concrete Moment Frames Designed for Low Seismic Regions

This research compares the seismic performance of RC moment frame buildings designed according to seismic design philosophies from New Zealand and Japan. A four-storey case study building located in Auckland was designed using New Zealand material properties, but with scaled seismic demands and design requirements based on the New Zealand and Japanese standards. A suite of 78 ground motions, representing various magnitudes of expected seismic hazards in Auckland, was employed to compare the seismic performance of the two buildings. Results from the case-study indicate different design methodologies do not drastically influence the relative seismic performance of moment frames in low seismic regions. However, it is important to note that in this study the design of the moment frame was controlled by gravity loading and minimum detailing requirements based on the New Zealand specifications and a 0.5% elastic drift limit following the Japanese standard. Designing to Japanese requirements result in moment frames with larger section sizes, but lower reinforcement ratios and smaller beam-to-column strength ratios compared to frames designed to New Zealand specifications. Under moderate earthquake intensities, the New Zealand frame had larger peak inter-storey drifts with increasingly larger differences compared to the Japanese frame despite not much difference in peak floor accelerations. Ongoing work is focused on additional case study buildings located in higher seismic regions.

Chandrakumar, C., Prasanna, R., Holden, C., Stephens, M., Punchihewa, A., Tan, M. 85

Extended Warning Window: A P-wave based Community-Engaged Earthquake Early Warning System

This study aims to extend the warning window of an experimental community-engaged Earthquake Early Warning System (EEWS) implemented in the Wellington region. A community-engaged EEWS refers to a network that engages the community in deploying and operating the early warning system; in this case, members of the public host sensors in their homes for the network. Led by the CRISiSLab team at the Joint Centre for Disaster Research, Massey University, this project utilises low-cost Micro Electromechanical Systems (MEMS)-based sensors for earthquake detection. The system employs the PLUM (Propagation of Local Undamped Motion) algorithm and uses decentralised processing at the node level. The PLUM algorithm has proven highly efficient in providing up to 10 seconds of warning time, even for moderate to strong shaking. However, the algorithm is currently limited to a maximum warning time of 10 seconds within a 30-kilometre radius, as it relies solely on S-waves for earthquake ground motion detection. To overcome this constraint, this study proposes to enhance the system's performance by incorporating a P-wave detection algorithm into the existing PLUM algorithm. Since P-waves are the initial seismic waves generated by an earthquake, the integration of a P-wave detection algorithm could significantly increase the warning time. This poster presents ongoing research progress, focusing on identifying a suitable P-wave detection algorithm for the community-engaged EEWS. It also outlines the ongoing work of establishing an algorithmic correlation between P and S-waves to improve the prediction accuracy of ground shaking.

Chaneva, J., Kluger, M., Moon, V., Lowe, D., Orense, R. 4

Particle crushing in pumiceous sands and silts during cyclic triaxial loading

Pumiceous particles have a distinct vesicular nature as well as a complex surface texture that makes them potentially vulnerable to crushing under cyclic loading. Pumiceous sand mixtures have received more scientific attention than pumiceous silts in this regard. Researchers have found the undrained cyclic behaviour of pumiceous sands to be significantly different than of that of hard-grained sands, because of the particle crushing process that occurs during cyclic testing and/or sample reconstitution. The liquefaction resistance of pumiceous sands is also considered to be higher, as a result of the pore-water pressure distribution that occurs during particle crushing. Methods based on field tests, such as CPT and SPT, are also considered unsuitable for these types of sands. The undrained behaviour of pumiceous silt was only studied once. The material (with 51% fines content and 48% pumice content) did not crush during sample reconstitution and undrained cyclic testing, which was attributed to the silty particles acting as cushions between the coarse sandy pumice particles. The thresholds of fines content and pumice content, at which pumiceous soil mixtures start to behave more closely as hard-grained soils, are yet to be unravelled and remain relevant for engineers and scientists. This paper analyses the particle crushing after sample reconstitution and undrained cyclic triaxial testing of five pumiceous natural soil mixtures from Northern New Zealand, having fines and pumice contents ranging between 18% and 80% and 30% and 60%, respectively. The results analyse the extent of particle crushing of the different soil mixtures and discusses potential influence of the fines content and/or the pumice content on the particle crushing.

Campbell, A. 40

Community Resilient Landscapes: examining blue green networks as a catalyst for social resilience

Rapid urbanisation presents cities with a myriad of challenges, especially related to climate change, disaster risk, and social fragmentation. Establishing a planned network of natural and semi-natural areas 'blue green' infrastructure (BGI) to deliver a range of ecosystem services is an adaptive and resilience building planning response to these pressures. BGI distinguishes itself from other climate mitigation urban features through its stormwater regulating potential and as a place where community interactions build social networks, community bonds, and sense of belonging that foster social resilience.

Additional BGI to support growth and enhance resilience in the central city, Pōneke Wellington is needed. In addition, identifying more accessible alternatives to the Town Belt portion of the city would contribute to this social resilience. In order to develop BGI to enhance social resilience, BGI must be safe, accessible, and equitably distributed, while also appealing to people's perceptions and preferences.

To support the development of BGI in the central city, this research aims to generate insights that contribute to inclusive BGI that foster social resilience particularly for vulnerable populations who are often disproportionately excluded. To attain this objective, a conceptual framework was developed to characterise and measure social resilience in the context of BGI. This framework will provide a foundation for assessing peoples' perceptions and practices in two multifunctional BGI spaces, Aro Park and Matairangi Mount Victoria, to understand their relationship with social capital as a proxy for social resilience. A spatial assessment of the distribution and accessibility of existing and potential BGI spaces within the central city will help identify deficiencies within BGI provisions and uncover demographic groups that face inequitable access to existing services.

Findings from this research will inform effective city planning strategies for expanding BGI to support social resilience.

Chey, M., Jang, S., Mehta, V. 5

Comprehensive Seismic Damage Assessment in Gyeongju City: Integrating Local Seismic Environment with ERGO-EQ Platform

This study addresses the need for comprehensive seismic disaster mitigation research beyond individual structure-based studies, particularly in the aftermath of the Gyeongju Earthquake (2016, MW = 5.4) and the Pohang Earthquake (2017, MW = 5.4) in South Korea. The objective is to derive realistic estimates of seismic damage of nearly 60,000 building structures in Gyeongju city by incorporating the local seismic environment using the earthquake disaster assessment platform, ERGO-EQ. This platform, developed by the MAE Center and NCSA, offers numerous benefits in evaluating individual structural damage and conducting multi-hazard disaster assessments. The open data inventory from the Korean National Spatial Information Portal was utilized, and the Q-GIS platform was also employed for accurate ground classification and transformation of geological age. Some developed built-in fragility curves in ERGO-EQ were used to determine the final structural mean damages in the city. The results revealed that relatively greater moderate-level damages in lightweight steel frames and unreinforced masonry structures, while timber structures exhibited lower damages than expected. Finally, this study demonstrates the effective integration of the local seismic environment and spatial infrastructure information using the seismic disaster assessment platform, which approximates real seismic events.

Church, C., Orchiston, C., Saunders, W. 41

A new direction: Opportunities for national direction on natural hazard management during RMA reform

New Zealand is exposed to a variety of geological and meteorological hazards due to it being located on the active plate boundary of the Pacific and Australian plates, and a stretch of ocean subject to intense weather such as ex-tropical cyclones from the equator. Due to both historic land-use decisions and increasing urbanisation and development, many New Zealand communities are located in areas that are exposed to natural hazards. Recognising the vulnerability of New Zealand's communities and the importance of land-use planning in mitigating natural hazard risk, the Resource Management Act 1991 (RMA) classifies "the management of significant risks from natural hazards" as a matter of national importance. This classification is of high legal standing and means that natural hazards (where relevant) must be considered during the planning and consenting process. However, the decentralised nature of New Zealand's local authorities has led to inconsistent planning outcomes across the country. Previous research has found that further guidance is required from central government, who, in turn can provide national direction for local authorities, through documents such as National Policy Statements; to set a national direction and encourage consistent decision making and planning outcomes. With the RMA slated to be replaced by the Natural and Built Environments Act, Strategic Planning Act, and the Climate Change Adaptation Act, this research will explore how national direction can be used to mitigate natural hazard risk and how central government can create 'good guidance' for this new resource management system. Data will be collected through the use of qualitative methods such as policy review, interviews and workshops which will be used to examine relevant legislation and current national guidance documents, pinpoint how these documents work in practice and formulate a path forward for the use of national direction in New Zealand's emerging planning systems.

Clausing, S. 42

Parenting and Family Rights in the Midst of Earthquakes

This project is concerned with the impact of earthquakes and other natural disasters on family relationships as well as individual vulnerability within a family and their legal protection in three comparable jurisdictions in the Pacific region (Aotearoa, the French Territories of New Caledonia and French Polynesia, and two U.S. States California and Hawaii). This project will examine how the law and policies (and the institutional arrangements) influence the caregiving responsibility of parents during and in the aftermath of earthquakes and other natural disasters in these jurisdictions.

"Parenting rights" is a complex area of law to compare, as aspects of these rights are regulated and reflected inter alia in laws relating to employment relationships, the welfare state, the education system, family relationships, and human rights. To capture the complexity of parenting and family rights, the analysis will be underpinned by gender and child rights perspectives.

Taking a comparative legal approach, the project aims to identify lessons learned from the three jurisdictions with a view to improving seismic resilience for families. The conclusion will look at legal mechanisms that can help share better responses to enhance parents' and children's well-being, support gender equality, and provide positive outcomes for children and carers in earthquake situations.

Collins, T. 43

Identifying and Navigating Roadcones on the long road to the establishment of the Canterbury Earthquake Insurance Tribunal

The establishment of an independent and accessible disputes resolution tribunal in Christchurch was welcomed by homeowners embroiled in insurance claim disputes as a result of the Canterbury earthquake sequence (CES). While valuable for those still engaged in disputes and successful in terms of settlement rates, the length of time, nearly eight years, it took to establish the Christchurch Earthquakes Insurance Tribunal after the initial quake was too late for most.

The prompt settlement of insurance claims and the resolution of disputes has an impact on community resilience to a disaster. Therefore, what lessons can be learnt from the delays in and impediments to establishing suitable dispute resolution systems in Canterbury to inform the development of efficient and effective dispute resolution processes for future disasters?

We have mapped out a detailed timeline of the events that followed the CES that highlight the many and major roadblocks to insurance claim resolution. We are using this timeline to review the roles that advisory services, the court system and other agencies played. The aim is to identify potential ways to overcome the types of issues that slow progress in post-disaster dispute resolution.

Cui, A., Tan, M., Prasanna, R. 86

CRISiSLab: Advancing Resilience through Innovative Technology for Disaster Management

CRISiSLab, at the Joint Centre for Disaster Research, Massey University, is a dynamic multidisciplinary research hub dedicated to advancing technological solutions for managing disasters through independent and collaborative research, capability development, and community engagement. Our research themes encompass a wide range of critical areas, including earthquake early warning systems (EEWs), artificial intelligence (AI), communication technologies, citizen science and crowdsourcing, and sensor design and development. Our mission is to harness cutting-edge technologies to understand hazards better, enhance warning systems, and strengthen crisis management practices, ultimately fostering more

resilient and prepared communities. Our approach is committed to knowledge exchange as we actively engage with stakeholders, policymakers, and local communities through webinars and workshops, ensuring the practical application and real-world impact of our work and research findings. We also provide support and mentorship to PhD students with a technological focus on disaster research. Furthermore, we extend our engagement beyond academia through the CRISiSLab Challenge and CRISiSLab Internship, which encourages school students to explore STEM (Science, Technology, Engineering, and Mathematics) solutions with hands-on experience in real-life scenarios. Additionally, we share teaching resources on natural hazards through our website. This poster showcases and highlights the diverse and impactful work carried out by CRISiSLab, addressing the challenges posed by hazards and emergencies while shaping effective technological strategies for disaster management in Aotearoa New Zealand and worldwide.

Daglish, J., Stahl, T., Wotherspoon, L., Howell, A., Bloom, C. 6

Fault Displacement hazard in a New Zealand context and implications this has towards the road network exposure

Surface fault displacements can impact critical infrastructure like roads, and road network performance is crucial to post-event response and societal function in seismically active countries like New Zealand. Displacements in historical earthquakes can be used to identify parts of the transportation system exposed to different levels of fault displacement hazard. This project uses displacement data from the 1987 Edgecumbe, 2010 Darfield, and 2016 Kaikōura earthquakes as well as rupture scenarios from the National Seismic Hazard Model for New Zealand, to conduct a national-scale, empirical fault displacement hazard exposure analysis. This analysis includes (i) the creation of distributed displacement curves that show how off-fault displacement varies across different faulting regimes, styles of displacement, and surface geology; (ii) the creation of displacement contour maps around faults in the NZ community fault model; and (iii) a site-specific exposure analysis for areas of high importance where the road network intersects with major active faults. The rupture of an intersecting fault would likely lead to extensive damage to the road and could further induce detrimental social and economic impacts on isolated communities that heavily rely on the accessibility the road provides.

Daysh, I. 7

How effective was sluicing as a rockfall remediation method following the 2016 Kaikōura earthquake?

Coseismic landslides during the 2016 Kaikōura earthquake significantly affected road and rail infrastructure resulting in the isolation of communities. Urgent remediation was required to restore this nationally strategic transport link. In the initial response, large-scale helicopter sluicing was used to remove loose debris from earthquake-damaged slopes. Heli-sluicing is a novel and uncommon approach to landslide mitigation globally, but was used extensively post-earthquake, with up to 220 million litres of seawater dropped on more than 40 coastal landslides. Despite its widespread use in the earthquake response, little has been published on the approach, effectiveness, and cost-benefit of heli-sluicing coseismic landslides. In particular, comparing the effect of natural rainfall on post-earthquake source zones with targeted sluicing operations. The Kaikōura earthquake presented a unique case study to test these questions, as a series of ex-tropical cyclones passed over the area damaged by the fault rupture in the years following the event.

These research questions will be investigated using a combination of helicopter flight path data, time-series rockfall data, and the NIWA HIRDS database. Using the results of this investigation, the aim will be to identify if sluicing accelerates slope recovery to the point of

acceptably reduced rockfall hazard. If this is found then these results may be used to inform decisions around installing and maintaining permanent passive rockfall mitigation on slopes that have already been actively mitigated with sluicing. Consequently, the cost of many of these permanent rockfall protection structures on sluiced slopes, with their associated installation and maintenance costs, may be shown to exceed their benefits as the hazard they were installed to protect against was meaningfully reduced through sluicing operations.
Whether the initial cost of heli-sluicing is sufficient to offset the reduced duration of maintenance costs remains contentious, with this study presenting the first quantitative test of heli-sluicing performance post-earthquake.

de la Torre, C., Bradley, B., Lee, R., Tiwari, A., Wotherspoon, L., Ridden, J., Kaiser, A. 8

Residual-Based Non-Ergodic Site-Response Adjustments to Empirical Ground-Motion Models to Account for Basin Effects in Wellington, New Zealand

Analysis of prediction residuals from the empirical ground motion models (GMMs) used in the 2022 New Zealand National Seismic Hazard Model (NZ NSHM) update indicates a general underprediction of ground motions at intermediate to long periods in Wellington, the capital city of New Zealand. The Central Business District (CBD) of Wellington is built over a sedimentary basin, which has been observed to significantly amplify ground motions in the period range of 0.5 to 2 seconds. As part of the NSHM, the performance of these models was rigorously assessed, revealing that the models generally do not fully capture the amplification produced by basin effects in the Wellington region. The objectives of this study are to: 1) quantify this underprediction, 2) thoroughly understand the spatial distribution of these residuals and the basin/site conditions that cause them, and 3) develop non-ergodic adjustment factors to the GMMs to account for region-specific basin effects on the scale of small basins and valleys. The period at which maximum underprediction occurs at these sedimentary basin and valley sites was found to correlate well with site period (Tsite). Four different adjustment factors were considered: two of which require site-specific ground-motion observations and two that are sub-region-specific and can be applied to other sites within the region at which ground motions have not been observed. The site-specific adjustments were found to reduce the site-to-site variability φS2S to essentially zero, which is consistent with previous studies on single-station aleatory variability. For the region-specific adjustments, a reduction in the regional φS2S is observed when the shape of the regional adjustment factor is shifted for each site such that the peak amplitude of the adjustment factor occurs at Tsite. This suggests that improvements can be made to regionalized GMMs by incorporating site period into the site-response prediction for sedimentary basin sites.

Dicaprio, C., Chamberlain, B., Chamberlain, C., Gerstenberger, M. 9

Exploring the 2022 Aotearoa New Zealand NSHM with Kororā, a Public Webapp

Free and easy access to the results of the 2022 revision of the New Zealand National Seismic Hazard Model -- Te Tauira Matapae Pūmate Rū i Aotearoa (NZ NSHM 2022) is an important facet of the programme. Seismic hazard scientists, engineers, risk modelers, social scientists, and the general public all have an interest in viewing, downloading, and exploring the NZ NSHM 2022. To make access to the model ubiquitous and simple, we have developed a webapp, nicknamed Kororā. Kororā provides hazard curves, uniform hazard spectra (UHS), maps, and disaggregations. These tools are interactive and provide all of the same hazard results that are available to the research team.
Koroā not only provides hazard curves and UHS, but tools to understand the sources that contribute to the seismic hazard. Disaggregations for distance, magnitude, tectonic region type, and epsilon are available at a number of locations and spectral periods. The NZ NSHM 2022 uses an inversion fault model (IFM) to forecast earthquakes above M 6.8 on known

faults. Kororā's rupture tool lets users explore the IFM of all branches of the logic tree. Ruptures in the model can be filtered by rate, magnitude, location, or specific faults. Users can obtain magnitude frequency distributions, rates, and geometry of the ruptures.
We continue to solicit feedback to improve and add features to make the NZ NSHM 2022 more useful to the seismic hazard user community.

Evans, R. 44

More than just a civil defence hub: Ngāi Tahu involvement in the Canterbury Earthquake Recovery - a model

In a disaster, marae (Māori meeting houses) are often used as part of the Civil Defence emergency response network. However, iwi (tribes) and hapū (subtribes) have had little role in the governance or management of disaster recovery. This changed after the Canterbury Earthquake Sequence, where a role for Ngāi Tahu (the principal South Island tribe) was specifically recognised in the Christchurch recovery through a formal process created by the Canterbury Earthquake Recovery Act 2011. This successful initiative provided Ngāi Tahu with a voice in the development of central Christchurch "anchor" projects. As a consequence, there is more Ngāi Tahu presence in the city than previously. Despite the success of this model, it was not replicated following the 2016 Kaikōura Earthquake. This poster explores the Canterbury model in more detail and suggests that, despite the failure to adopt the model in the wake of the Kaikōura event, it provides the basis of future iwi and hapū involvement in the governance of disaster recovery.

Fatourehchishabestari, A., Filippova, O., Rehm, M. 45

Post-Earthquake Reconstruction of Christchurch City Center- Housing Challenges

Throughout its history, Christchurch city center has consistently prioritized residential activity before and after the earthquake. However, the destructive impact of the earthquake complicated the city's objective, leading to significant doubts and delays in the post-earthquake reconstruction of the city center. Despite the city's efforts and introduction of the Christchurch Central housing program (Project 8011), the city center's current demographic makeup falls short of expectations.
To review the housing challenges in the Christchurch City Center, we analyze the factors contributing to the challenges for current and future permanent residency. We first explore the statutory context and urban development strategies related to residential activity in the city center. The second part of the study presents an analysis of the city center's current household structure and demographic configuration, residential development pattern, and housing ownership status.
Our review identifies that the current purchasers' motivation for buying property in this area primarily revolves around investment potential rather than establishing permanent residency. The early results of the review reinforce this; the prevalence of unoccupied or non-residentially utilized properties where short-term online rental platforms such as Airbnb are popular. While Airbnb offers advantages such as financial support for the hosts and cultural interaction, its adverse impacts on community structure, housing affordability, and gentrification cannot be overlooked. Additionally, our findings indicate a prevalence of terrace houses and two-bedroom units within the city center, rendering it more attractive to the rental market while potentially diminishing its attractiveness for families with children.
In the forthcoming stages of this research, we will examine how these phenomena impact the dynamics and resilience of neighborhoods in the city center, particularly in response to potential disruptions. We aim to formulate strategies that promote sustainable housing development, community cohesion, and affordability while mitigating the negative impacts of the investment market and short-term accommodations.

Faulkner, H. 46

Governing Disasters in Aotearoa New Zealand: An Auckland Volcanic Field Case Study

A volcanic field located within a densely populated urban area (like the Auckland Volcanic Field) creates the possibility of a high-impact, low-probability event with ongoing, long-term impacts as well as the cascading and potentially multi-hazard events.

An important (but often overlooked) aspect of disaster risk management is the legal framework in which it operates. In New Zealand, legal frameworks for disasters tend to be based on a response focussed, all-hazard model. Recovery is then managed by bespoke frameworks introduced in the aftermath of an event (e.g. the Canterbury Earthquake Recovery Act 2011). By creating recovery policies and legal frameworks post-event, these frameworks often fail to consider the requirements of long-term recovery, the potential of cascading hazards and ongoing hazards such as climate change.

In an urban context, having recovery frameworks drafted in advance is even more important, given the level of considerations required in urban disaster response. In the aftermath of the Christchurch earthquake sequence, for example, short-term focused recovery policies were created post-event which led to communities being rebuilt on land that is vulnerable to future events including climate change. These policies created future risk rather than building resilience. Forward thinking legal recovery frameworks will be even more important for Auckland, where a greater population may be displaced in an area where land is at a premium. This project looks at the role of legal frameworks in managing large scale urban disasters, using the AVF as a case. It advocates, on the basis of New Zealand and overseas examples, that the recovery frameworks need to be established in advance not only in volcanic hazard events but in large scale urban disasters generally. These frameworks also need to acknowledge the additional challenges which urban disasters pose and the impact that these decisions can have on mitigating or creating future disasters.

Ferner, H., Abeling, S., Beaven, S., Brown, C., Brunsdon, D., Cowan, H., Dunn, C., Elwood, K., Gill, D., Hare, J., Jury, R. 61

Resilient Buildings Project: Relating Societal Expectations to Performance Objectives for Buildings - the Earthquake Performance Outcome Framework

The Resilient Buildings Project was initiated as part of a broad New Zealand technical response to a Canterbury Earthquakes Royal Commission recommendation, that the treatment of seismic risk be reviewed to ensure that arrangements for incorporating relevant knowledge of seismic hazard and risk over time are harmonised with reasonable societal expectations of building performance during earthquakes.

The project first sought to better understand through qualitative research those aspects of building seismic performance that New Zealanders most value, then use the findings to identify and describe tolerable impacts and develop a framework that enables the performance expectations to inform objectives for the design of new buildings and the supporting codes and technical standards.

In this poster we present the tolerable impacts inferred from the findings on societal expectations reported previously to the QuakeCoRE community. We introduce a framework developed to relate societal expectations to performance objectives for buildings showing how the treatment of seismic risk in design for life safety, economic and social outcomes can reasonably anticipate and describe performance objectives.

Formichetti, G., Loporcaro, G., Pampanin, S. 62

Multi-performance parametric framework to enhance the design process and implementation of low-damage timber buildings

In order to face the increasing challenges resulting from climate change and catastrophic events, the built environment has to deal with multi-performance requirements. The well-recognised dependency between seismic performance and environmental footprint calls for advanced technological solutions together with integrated (multi-)decision-making approaches, able to handle multiple and sometimes conflicting domains in building design.
Combining sustainability with high seismic performance, the use of the timber low-damage post-tensioned structural system, also known as Pres-Lam, represents a viable strategy to design more resilient buildings. The components modularity enables also the proper adaptive capacity to meet changes in user demands over time. Nevertheless, to address the multiple potentials of this technology and to guide decision-makers towards the optimal solution, an integrated building design methodology is needed. Such an approach inherently leads to Multi-Objective Optimization (MOO) problems due to the conflictual nature of the goals involved.
This study proposes a parametric framework for the multi-performance optimization and evaluation of adaptive Pres-Lam buildings, through a comprehensive model within the Rhino-Grasshopper platform. The MOO is carried out through the evolutionary algorithm inside the Octopus component for Grasshopper. The aim is to reduce embodied and operational carbon emissions, while ensuring the proper seismic capacity of the post-tensioned timber frames and the maximum flexibility of the internal space. The effective seismic performance of the selected Pareto optimal solutions is then assessed through a probabilistic approach.

Gerstenberger, M., Bora, S., Bradley, B., DiCaprio, C., Kaiser, A., Nicol, A., Stirling, M., Thingbaijam, K., Van Dissen, R., and the NSHM Team. 10

The 2022 Aotearoa New Zealand NSHM

The 2022 Aotearoa New Zealand Seismic Hazard model is a significant revision in all model components. Changes to the seismicity rate model (SRM) include a focus on removing strict segmentation from ruptures on known faults. This allows for modelling of more realistic ruptures including uncertainty in both magnitude and length of possible ruptures. Additionally, more low-probability high-impact ruptures were included than were possible in the past. Specific low-seismicity region models were used that allow for the greater variability in occurrence rates that are observed in similar regions around the world. Finally, the SRM targets a 100-year forecast and models the variability in the occurrence rate that is greater than has been included in the past.
The Ground Motion Characterisation Model (GMCM) includes the use of multiple ground models (GMMs) for each tectonic type and includes internationally developed models (e.g., NGA). A new ground motion database has been compiled for assessment of the international models and for the development of two NZ backbone GMMs. The GMCM is a significant departure from past NSHMs and produces noticeably different ground shaking forecasts, both in median spectral values (and shape) and epistemic uncertainty. The large number of models used allow for the hazard results to include a large range of uncertainty in what the true hazard is.
Overall, the hazard forecast is increased in almost all parts of New Zealand compared to the 2010 model. On average the increase is about 50%, but this can vary significantly for any location or shaking frequency. Importantly, the revision estimates shaking for Vs30 rather than NZ Site Class, and this makes comparison to previous models challenging; there is no clear mapping between them. Finally, the range of increases are from roughly no change to more than doubling of the hazard.

Harvey, J., Robinson, T. 11

Modelling coseismic landslide impacts on infrastructure systems in Wellington

A rupture of the Wellington Fault is widely considered to be the greatest seismic risk to NZ. A MW7.5 earthquake has been posited on the Wellington-Hutt Valley segment of the fault, with an estimated probability of 10-15% occurrence in the next century and potential shaking intensities exceeding MM10 in Wellington's city centre. Despite coseismic landslides having occurred in previous large earthquakes in this region, the hazard posed in this scenario has yet to be assessed.

This study models coseismic landsliding susceptibility for a MW7.5 Wellington Fault rupture, estimating plausible runout pathways of potential landslides. Further, this research assesses the extent of infrastructure situated within predicted runout pathways, to ascertain potential impacts of coseismic landsliding in this urban environment.

This research uses a statistical landslide model, applying fuzzy logic within GIS to assess the relationship between ground motion and conditioning factors to determine landslide susceptibility. Outputs of susceptibility modelling have been used to estimate runout areas, using viewsheds and reach angles as a proxy, allowing for identification of infrastructure exposed to landslide hazards in this scenario.

Areas of high susceptibility were identified across the Wellington Region, with plausible estimates of slope failure between 3 and 138km2. Transport infrastructure situated in high susceptibility areas has a total length of ~40km, with high exposure predicted for critical routes such as the connection between Wellington City and the Hutt Valley along SH2. Significant infrastructure is located within potential runout pathways of coseismic landslides, presenting a substantial threat to populations within the high-density urban environment of Wellington City.

The significance of landslides resulting from earthquakes is clear throughout historic seismic events both globally and in Aotearoa-NZ. The fuzzy logic model applied in this research signifies that Wellington City may not be exempt from these impacts, with widespread susceptibility across the Wellington Region.

Holman, B. 47

Earthquakes, Emergency Responses Targeted at Business Recovery and Gender

How do earthquakes and business relate to gender?

Paid employment provides women with the opportunity to improve their socio-economic status which is typically jeopardised when a natural disaster strikes. Women are disproportionately at risk of loss of employment and financial strain.

Following the Canterbury Earthquake, total employment rates declined by 9%, and women bore the brunt of the vast majority of job losses.

Research by the Ministry for Women showed that despite their willingness and availability to work in the rebuild, women were not included in the construction labour force.

What we need?

An enabling regulatory environment that prioritises prosperity through gender equality needs to be set for businesses to operate following an earthquake. This requires a top down approach in the form of Government regulation and policies, and a bottom up approach by communities and businesses ("quasi-regulatory community initiatives") like collaboration and time banks.

What we want to learn?

Using the Canterbury and Kaikōura Earthquakes as case studies, how can emergency response legislation and policies, and quasi-regulatory community initiatives targeted at business recovery promote gender equality for employees following a natural disaster?

How can emergency response legislation and policies, and quasi-regulatory community initiatives support socio-economic status through paid employment?

What lessons can the Government learn from quasi-regulatory community initiatives to foster a gender-sensitive approach in its response to keep women in employment?
The aim
Provide recommendations to improve resilience and mitigate the negative impact future disasters have on women.

Horsfall, S., Brown, C., Kilvington, M., Horn, C. 68

Let's talk about risk: engaging communities in natural hazard and climate change conversations

Engaging with communities about climate and natural hazard risks is a challenge for local authorities. However, it is critical to sound risk management decision making - to ensure decisions meet community needs and expectations and to make the most of limited resources. Local government agencies are at the frontline of work to prepare existing and future communities for an increased frequency and severity of natural hazard events, through their land-use planning as well as resilience and disaster preparedness. Increasingly local and regional councils are having conversations with communities to manage and reduce exposure to risk. These critical conversations ensure limited resources are allocated based on real needs and preferences of communities. However, the unique demands of these conversation, fears about public response, and limited guidance on engagement approaches are barriers to effective engagement. Local government agencies need support to engage their communities so that they can confidently ascertain the community-wide view on risk that underpins their mandate to act. Communities also need access to the information on changing risk that affects their lives and livelihoods so they themselves can act.
During our 2022/23 Toka Tū Ake EQC- funded project we have identified several overarching challenges that make community engagement processes for natural hazard and climate risk challenging. To help practitioners understand and address these challenges, we have developed a framework for practitioners to use prior to starting their engagement. The framework helps users to establish strong contextual positioning and understanding of how these challenges will shape their engagement.

Inal Kaynar, C., Isaacs, N., Brown, A., Noy, I. 69

An Investigation of the Influence of the Reuse of Heritage Buildings on the Resilience of New Zealand Small Town Centres

Adaptive reuse transforms an obsolete building to give it a new useful life. For heritage buildings, it also means restoring the building to contemporary standards while conserving heritage and creating functional spaces. The literature review revealed four important themes for adaptive reuse in small towns: population loss, seismic risk, heritage conservation and environmental sustainability. These were evaluated within the UNESCO Sustainable Development Goals (SDG). Population loss relates to SDG 8 "Decent work & economic growth" and SDG 11 "Sustainable cities and communities." Population loss in small towns is a global issue due in part to the industrialization of farming. In provincial New Zealand this has created an abundance of unoccupied heritage buildings. Seismic risk also has a strong relation with SDG 11. This is especially important for New Zealand since most of the unoccupied heritage buildings are earthquake-prone, meaning the town might not be able to function after an earthquake. Heritage conservation also relates to SDG 11 as well as to the missing "cultural" SDG suggested by the International Council on Monuments and Sites (ICOMOS). The Christchurch earthquake sequence showed the devastating impact on heritage and historic buildings, as well as the loss of community memory. Environmental sustainability fits within SDG 12 "Responsible consumption & production." My research will now undertake a number of case studies in Whanganui which has many earthquake-prone URM heritage buildings in its

town centre. This will help develop an understanding of how to better design effective adaptive reuse in order to create resilient small town centres for the future while retaining the links to the past.

Jaramillo-Velez, A., Tan, M., Prasanna, R., McColl, S., Stewart, C., de Vilder, S. 51

Earthquake-triggered rockfalls from coastal cliffs: can citizen science play a role?

Assessing the risk to people in rocky coastal environments from natural hazards remains a challenge for coastal hazard management. In tectonically active regions, earthquake shaking is one of several processes that can trigger the collapse of coastal cliffs. The contribution of earthquakes to cliff collapse and retreat, relative to other non-seismic triggers, is hard to evaluate due to the challenges of establishing high temporal resolution monitoring in remote coastal cliff locations needed to measure episodic processes and link triggers to cliff activity.

This study aims to assess the contribution of earthquakes to the generation of mass movements, particularly rock falls, on coastal cliffs in two study areas: Cape Kidnappers and North Taranaki. The assessment will be conducted through citizen science initiatives and using data from the GeoNet Data Centre. These study sites were selected to able to compare two soft-rock coastal cliff settings with differing physiographical conditions and community groups/visitor types.

Citizen science methodologies will be employed to gather images, videos, and event reports of rock falls observed by locals or visitors. Reports of new activity will be compared with earthquake activity recorded by the GeoNet seismograph network, along with climate data, to examine the effects of seismic activity and other climate variables on rockfall at the two study case's locations.

Through this project, a better understanding of earthquake-induced landslides on coastal cliffs will be gained, providing valuable input for improving future models of coastal cliff retreat. Furthermore, the study will evaluate the applicability of alternative data sources, such as citizen reports, for monitoring mass movements and identifying their various causes.

Involving community groups and visitors in the science process may help to empower these members of the public to become more informed about the environmental hazards they are exposed to in these locations, thus contributing to risk reduction.

Jeong, S., Kwak, D., Hwang, E. 12

Real-time correction of ground motion amplification for a rapid seismic intensity reporting system

The Korea Meteorological Administration currently provides near real-time earthquake information based on estimated magnitude. However, the use of magnitude-based warning messages has led to confusion among the public, as they often misunderstand that a high-magnitude earthquake does not necessarily indicate strong shaking. To address this issue, it is necessary to provide earthquake information and issue localized warnings based on seismic intensity, which directly measures the strength of ground shaking.

Many earthquake early warning or rapid report systems employ an automatic algorithm to determine the magnitude and hypocenter. The expected intensity is then estimated using empirical ground motion models. However, this two-step process introduces significant uncertainty in the estimated intensity.

This research aims to develop and implement an algorithm that directly estimates the intensity scale from real-time streaming of ground motion records, without relying on information about the magnitude or hypocenter. The proposed real-time algorithm will also account for site amplification effects, as many seismic stations in South Korea are installed inside boreholes. Past earthquake records will be used to validate the proposed algorithm, and the real-time performance will be investigated by operating a trial system.

Tapuke, K., Kaiser, L., Johnston, D., Becker, J., McCombe, G. 52

Enhancing earthquake and tsunami preparedness and response in Kura Kaupapa Māori/Schools in Te Tairāwhiti and Waiāriki, Aotearoa New Zealand

Aotearoa New Zealand is exposed to numerous potentially damaging impacts from various hazard events. The east coast of the North Island, one of the most active seismic regions in New Zealand, faces significant earthquake and tsunami risk. Given the variety of hazards the regions face, how risks are managed within schools needs to be considered. This research aims to understand the challenges and opportunities for enhancing earthquake and tsunami preparedness and response in Te Tairāwhiti/Waiāriki Kura Kaupapa Māori/ Kura ā-Iwi (Total Immersion Māori years 1-13)/ mainstream schools (English & bilingual, immersion unit(s) years 1-13). Seven schools were visited from Gisborne to Torere in September 2022. Information was collected from a hui with school staff. Topics included tsunami zones, evacuation practice, resources for teachers, planning at home, school response plans, stakeholder involvement, and capability development. There are two dominant languages in the East Coast region, Te Reo o Te Tairāwhiti and English. Formalities and prestige are conducted in Te Reo o Te Tairāwhiti. Te Reo o Te Tairāwhiti and tikanga (protocols) o Te Tairāwhiti go in unison. The uniqueness of the Te Tairāwhiti language and protocols promote action and a stronger response to an event. A forward work programme was discussed, with the co-development of plan, maps and signage, care packs, and other community-based activities.

Khadka, A., Costello, S., Ranjitkar, P. 76

A literature review of post-disaster road network performance assessment and management

Background: Modern societies' economic and social well-being depends heavily on the efficient and reliable operation of road networks. As natural disasters have a significant implication for the proper functioning of road networks, it is imperative for researchers to understand existing practices in investigating post-disaster road network performance.

Objectives: This study aims to review the literature on post-disaster performance assessment and management of road networks to understand current practices, trends, and gaps to guide future research directions.

Methods: A search was performed in Scopus and Google Scholar databases using the terms describing concepts, including transport mode (e.g., road network), event (e.g., disaster), and network performance dimension (e.g., resilience). Research articles published from 2010 to March 2022 in peer-reviewed journals in the English language are included in the review.

Results: A total of 2,067 articles were identified. Of those articles, 84 were included in the review based on the inclusion criteria. Evaluation methods used in the literature can be broadly classified as topological, data-driven, simulation, and analytical methods. Notably, the analytical methods are popular due to their ability to address uncertainties in the disaster impact on the road network and its recovery processes using probabilistic modelling approaches. Only limited research works were identified related to user perspectives (i.e., adaptation in travel decision-making) and emerging transport technologies (e.g., autonomous vehicles).

Conclusions: Despite the rapid advancement of autonomous vehicle (AV) technologies and the expanding fleet of vehicles with various levels of automation, most past research has mainly concentrated on conventional vehicles to analyze road network performance. It is important to consider the driving patterns and behaviour of AVs when examining post-disaster performance and recovery of road networks. Simulation-based methods can be useful to account for the complex behaviours and interactions of AVs in the absence of AV-related data.

Assadi, S., Hashemi, A., Quenneville, P. 25

Upcoming Large Scale Experimental Test of A Two-Storey Rocking Timber Wall Structure With Innovative Low-Damage Floor Connections

Preparations for a large-scale test of a two-storey rocking timber wall structure with innovative low-damage floor connections are underway at the University of Auckland. The engineered timber structure is comprised of CLT rocking walls, CLT floors, CLT columns and CLT beams. The overall dimension of the structure is 6 meters high with a footprint of 3.75m by 6m. This poster demonstrates why this test is being carried out. It provides an overview of what it will look like and presents a brief description of the test describing how it will be conducted. A key feature of this test is the use of innovative low-damage floor connections which will be highlighted. Additionally, it is shown what the objectives of this study are, what the major parameters are that will be assessed. There is an emphasis on providing a resilient structure that meets the low-damage design criteria as well as providing self-centring amongst others.

Kieu, M., Senanayake, G. 53

Perception, Experience and Resilience to Risks: A global analysis

This study presents an intricate, data-driven, and causal exploration of individual resilience to threats and disasters on a global scale, tapping into the wealth of information from the Lloyd's Register Foundation World Risk Poll. We unveil four new innovative indices - Risk Perception, Experience, Impact, and Resilience - that provide a panoramic and comprehensive comparison of individuals' concerns, exposures, and levels of preparedness across various geographical landscapes.

Our study not only examines general global trends but also delves into country-specific analyses, with a particular focus on New Zealand. This in-depth comparison uncovers how New Zealand's individual resilience landscape aligns or diverges from global trends, offering valuable insights for both local and international policy development. By contextualizing New Zealand's experience within the broader global landscape, we are able to ascertain shared patterns and unique divergences, contributing to a more nuanced understanding of resilience and its multifaceted drivers.

At the core of our investigation is a rigorous causal discovery and inference analysis, an approach that affords a clearer understanding of the complex interplay of factors shaping resilience on a global scale. This examination illuminates the pivotal role of individual experiences and perceptions in determining resilience and suggests that strategies for resilience-building must be as diverse and multifaceted as the experiences and perceptions they aim to influence.

Our findings indicate a complex web of factors, from socioeconomic status to geographical location, contributing to individual and collective resilience. This complexity underscores the importance of tailored resilience-building strategies that consider a wide array of influences.

Kuncar, F., Bradley, B., de la Torre, C., Rodriguez-Marek, A., Zhu, C., Lee, R. 13

Frequency-domain methods to account for shallow site effects in hybrid broadband ground-motion simulations

One of the current challenges in hybrid broadband ground-motion simulations is refining the modelling of shallow site effects. Three aspects hinder the explicit modelling of these effects in regional-scale simulations: the minimum shear-wave velocity considered is usually too high; the grid spacing adopted is typically too coarse; and a linear viscoelastic constitutive model is generally adopted. Two approaches can be used to adjust the simulated ground-motion time series to account for shallow site effects: (a) a frequency-domain adjustment based on the

application of a site correction factor, and (b) a time-domain adjustment based on 1D, 2D, or 3D nonlinear site-response analysis. This study elaborates on approach (a) and presents four methods that can be used to develop the site correction factor: Method 1 utilizes the site-response component of a ground-motion model; Method 2 is similar to Method 1 but includes a host-to-target Vs-profile adjustment to the reference condition; Method 3 combines the square-root-impedance method for the linear component with the nonlinear part of Method 1; and Method 4 is similar to Method 3 but utilizes the theoretical transfer function from 1D site-response analysis for the linear component. These methods are applied to a site in Christchurch, using two levels of ground-motion intensity. This case study is used to compare the methods and to illustrate some of the challenges involved in the modelling of site effects in hybrid broadband ground-motion simulations.

Kuwabara, R., Hogan, L., Elwood, K., Opabola, E. 63

Residual Capacity of Steel Reinforcement

Following the Christchurch earthquake in 2011, a significant number of multi-storey buildings were demolished in Christchurch CBD due to the absence of appropriate guidelines and knowledge to assess the residual capacity and repairability of earthquake-damaged buildings. This experience indicates that it is necessary to develop a methodology to assess the residual capacity and repairability of buildings. To assess the building residual capacity and repairability, it is important to ensure that sufficient residual capacity remains in steel reinforcements to withstand future earthquakes.

In this study, the low-cycle fatigue capacity and strain-ageing effect of steel reinforcement were investigated by an experimental program. Reinforcing bars were tested under uniaxial monotonic and cyclic loading until failure. In addition to undamaged bars, earthquake-damaged bars extracted from a large-scale test building tested at E-Defense facility in Japan in 2020 were also tested. The test results showed that reinforcing bars had sufficient fatigue capacity, and the impact of fatigue damage on strain capacity was insignificant. However, it was found that strain-ageing effect has a certain influence on yield strength, tensile strength, ultimate strain and fatigue capacity. While yield strength and tensile strength were increased, ultimate strain capacity was degraded depending on strain demand before ageing. Moreover, it was shown that strain-ageing effect affected the fatigue capacity. After strain-aged, the fatigue capacity of reinforcement was compromised depending on strain demand and fatigue damage before ageing.

Not only did this study examine the capacity of steel reinforcement, but it also investigated probable cyclic and strain demand to be imposed during an earthquake using an analytical approach and experimental data. By comparing cyclic/strain demand to fatigue capacity, it was found that steel reinforcement has sufficient fatigue capacity. This result implies that low-cycle fatigue failure is not a significant concern unless an excessive local strain is imposed by bar buckling.

Kwon, Y. 87

CrowdQuake: Earthquake Early Warning using IoT and Deep Learning

In recent years, a low-cost micro-electro-mechanical systems (MEMS) acceleration sensor has been widely used for earthquake early warning (EEW). In our work, we introduce a networked earthquake detection system, CrowdQuake which can deal with acceleration data sent from 8,000 IoT sensors and detect an earthquake in a few seconds using deep-learning-based algorithms. For two years of operation, CrowdQuake detected a series of earthquakes and collected various earthquake and non-earthquake data. Based on the successful operation of CrowdQuake, in this poster, we discuss how it could be constructed across the whole country by addressing the following challenges: (1) sensor deployments for a highly dense network; (2)

earthquake detection performance using a deep learning model, and (3) high-performance and scalable system design for big data processing.

Lal, R., Hashemi, A., Quenneville, P. 26

A Novel Inter-Story Isolation System for Cross-Laminated Timber (CLT) Platform Construction- Concept Development and Preliminary Evaluation

In New Zealand, platform-type construction is becoming a well-known technique for engineers and developers in multi-story mass timber buildings. Platform-type construction offers numerous advantages, such as fast erection, high rigidity, and enhanced aesthetic features. In a platform-type construction, stories are formed by stacking the floors on top of the load-bearing wall, creating a platform for the level above. Recent research findings have shown that cross-laminated (CLT) platform buildings constructed with conventional connections, such as wall-to-floor hold-down brackets and shear connectors with nails and screws, are inadequate for structures with large open-plan floors utilizing wall panels with low aspect ratios. Such connections are prone to high shear demand due to sliding and can experience significant damage under design-level earthquakes. Thus, conventional connections in the current platform-style construction are vulnerable to aftershocks and do not satisfy the damage avoidance criteria of seismic design. This research presents a novel low-damage concept (RFIS) for mass timber platform systems using resilient connections to replace conventional connections. A numerical model with a Resilient Floor Isolation System (RFIS) for a platform type structure was developed in ETABS, and the seismic performance of the isolated structure was evaluated using static pushover and non-linear dynamic time history analyses. The preliminary results showed that inter-story isolation systems significantly reduced the seismic demands on the mass timber building, thus leading to improved seismic response. Moreover, the system displayed good energy dissipation capability while exhibiting self-centering behaviour.

L'Hermitte, C., Trent, N., Qin, Y. 77

Capturing the full complexity of post-disaster freight disruptions in New Zealand: an application of the Theory of Constraints

Natural hazards cause multifaceted freight issues and an intricate sequence of interconnected disruptions and constraints. To investigate this complexity, quantitative modelling is commonly used in the literature. This research takes a different approach and investigates the value of qualitative research and of the Theory of Constraints to capture the full complexity inherent in a post-disaster freight system. The Theory of Constraints is widely used in business to thoroughly analyse operational and management systems and, ultimately, improve the performance of a system relative to its goal. In this research, a diagnostic tool prescribed by the Theory of Constraints and called Current Reality Tree is used. This tool opens a system's black box by uncovering the underlying mechanisms affecting performance and supporting a fine-grained understanding of its multiple components and how they interact with each other. Data was collected through 20 semi-structured interviews with transport and logistics experts in the New Zealand (NZ) fresh fruit and vegetables sector. From the data, we identified 30 post-disaster constraints affecting transport functionality, 40 cause-and-effect relationships between these constraints, 4 ultimate impacts on freight performance, and 8 root causes triggering the causal relationships. The root causes are opportunities for increasing the resilience of the NZ freight system. By combining all these components in a single diagram, our Current Reality Tree captures the intricate reality of transport disruptions in NZ. It depicts the web of interdependent constraints that are embedded in a post-disaster freight system and that span across operations, strategy, and policy.

Ultimately, this research presents a model that is not constrained by the quantitative representation of variables. It tells the story of why fresh fruit and vegetables are not available where and when needed in the aftermath of a natural hazard in NZ. In doing so, this research provides concrete insights for practitioners and policymakers.

Li, L., Chang-Richards, A., Boston, M., Elwood, K. 64

Analysis of quantitative methods for assessing functional recovery in post-earthquake

While modern building design codes ensure buildings achieve the life safety performance objective, a 'better than code' building design, namely functional recovery, is needed. As evidenced by the Canterbury earthquakes and the Kaikōura earthquake, continued building functionality in post-earthquake with acceptable recovery times considered is important for community resilience. This research focuses on a critical analysis of quantitative functional recovery assessments. A number of functional recovery quantification methods are compared with their advantages and disadvantages discussed. It is suggested that future research could focus on measuring functional recovery probabilistically, capturing pervasive uncertainties towards different functionality levels with more advanced algorithms, such as neural network theory.

Lin, S., Moratalla, J., Uma, S., Lukovic, B. 27

Developing and Implementing Vulnerability Functions for Multi-Storey Residential Buildings in New Zealand

This poster details the development of a ground motion-damage database for multi-storey buildings (3-storey or above) in New Zealand using EQC's claim information from the 2010-2011 Canterbury and 2016 Kaikōura Earthquakes. The database is used to derive vulnerability functions for multi-storey residential buildings in New Zealand.

Based on the availability of building damage samples, vulnerability functions for i) post-1976, 3-storey and above; ii) post-1976, 3-storey only; and iii) post-1976, 4-storey and above were developed. Peak Ground Acceleration (PGA) is the shaking intensity used to derive all 3 sets of vulnerability functions. In addition, spectral acceleration (Sa) at 0.3s for 3-storey buildings and spectral acceleration (Sa) at 1s for buildings with 4-storey or above are also proposed to reflect their structural period effect.

Buildings subjected to liquefaction damage deserved separate attention. In our damage database, a substantial proportion of 3-storey buildings recorded liquefaction damage and hence two sets of vulnerability functions, namely shaking only and shaking and liquefication combined were able to be derived. Only a small number of buildings with 4-storey and above showed damage from liquefaction hence only combined functions were developed.

A 2-step approach is proposed in this report. Step 1 is to determine the likelihood of a building being undamaged or demolished or to sustain damage that is repairable. For this step, we use fragility functions representing probabilities of exceeding certain discrete damage state. Step 2 is to calculate damage ratio expressed as a ratio of repair cost to replacement cost for the building corresponding to the damage sustained. For this step, we use vulnerability functions relating damage ratios to hazard intensity that are derived from the present study.

Limitations, such as inherent small building sample sizes, uncertainties of liquefication being present and demolition being required is discussed, and recommendations for future improvement are summarised.

Wang, K., Mourot, P., Vorster, C., Ahn, H., Liu, Y., Ye, X., Nair, N., McDonald, G. 88

Enhancing resilience - interdisciplinary machine learning research in QuakeCoRE

The wide spread of embedded and sensing technologies offers the ability to collect large quantities of invaluable in-situ data, but at the same time also brings forth the challenges of managing and processing data to retrieve useful information. Therefore, data-driven machine learning (ML) technologies offers great opportunities to automatically process and retrieve information that assists specific applications. Numerous innovative interdisciplinary applications, such as in healthcare, automation, renewable energy, are enabled by data-driven machine learning techniques. To this end, the Artificial Intelligence (AI) and Machine Learning (ML) megatrend is established to explore the potential of AI & ML technologies in bringing resilience to the related fields of QuakeCoRE. In this poster, we will share some of the ongoing resilience applications in QuakeCoRE presented in the Megatrend workshop and panel discussion, including but not limited to building, environmental, and human resilience, together with the future challenges to broaden the use and application of ML technologies.

Loghman, V., Bradley, B., Lee, R., Schill, C., Chandramohan, R., McGann, C. 14

Comparison of seismic performance assessment using observed or simulated ground motions in seismic hazard analysis and ground motion selection

This paper illustrates the process of using recorded and simulated ground motions in seismic performance assessment. It presents three different approaches to utilise recorded and simulated ground motions to calculate risk metrics and compares and contrasts the obtained results and addresses the probable causes of differences.

The considered approaches utilise empirical ground motion models or simulated ground motions from NZ CyberShake for hazard analysis. In the first and second approaches, as-recorded and simulated ground motions from a large database are selected where empirical ground motion models are used for hazard analysis. Whereas, in the third approach, site-specific simulated ground motions are selected using the NZ CyberShake hazard model. The impact of these alternative approaches on seismic risk are examined via the response of a 12-storey structure (located in the Canterbury region, NZ) subjected to 20 ground motions selected for seven intensity levels using the generalized conditional intensity measure (GCIM) approach (Bradley2010, 2012). Structural responses are mainly quantified via peak floor acceleration and peak inter-storey drift ratio through multiple-stripe analysis. The risk is compared and contrasted in terms of demand hazard and collapse risk for the considered approaches.

The results show the similarity of demand hazard when simulated or observed ground motions are selected and scaled to a seismic hazard using empirical ground motion models (i.e., that spectrally consistent recorded and simulated ground motions produce similar seismic responses). In contrast, differences are observed when using an entirely simulation approach. This study, therefore, helps to highlight the present opportunities and drawbacks of using simulated ground motions in the seismic risk assessment context.

Luo, Z., MacRae, G. 65

Revolutionizing Post-Earthquake Inspections and Repairs: The Efficacy and Cost-Effectiveness of Using Structural Access Panels (SAPs) in Buildings

Access panels may be placed in buildings so that structural damage can be quickly inspected and possibly repaired without damaging building non-skeletal elements (NSEs) after earthquakes. Such access panels are readily available, and can be placed near the dissipative elements of building structures for inspection. This paper describes the concept of structural access panel (SAP) and the benefit from analysis considering inspection cost and downtime.

When damage inspections are required after the peak ground acceleration is greater than SLS level, the SAP can be beneficial for structural inspection when structural damage occurs at lower shaking levels than the levels causing building irreparability, or major NSE damage. A 6-storey 3-bay eccentrically braced frame structure using different levels of earthquake intensity shaking is conducted and simulated by nonlinear time history analysis, to evaluate the changes in structural inspection costs in buildings with and without SAPs. It is shown that the probability of the SAP being beneficial decreases as the shaking intensity increases, Additionally, SAPs are more beneficial in buildings with low-damage NSEs. The total savings resulting from use of SAP, considering damage and downtime, is up to 15 times the initial cost of SAP. It reveals that SAPs may be a cost-effective post-earthquake structural inspection scheme significantly accelerating and simplifying the post-earthquake structural inspection process.

Mabin, S. 78

Rockfall risk and lifelines mitigation performance following the 2016 Kaikōura earthquake

On the 14th November 2016 an Mw 7.8 earthquake struck North Canterbury, New Zealand. Landslides and embankment failures during the event made State Highway 1 (SH1) and Main North Line (MNL) impassable both north and south of the township of Kaikōura, cutting off residents and tourists, and disrupting the main transport route from Christchurch to Wellington. Landslides and debris flows caused over 200 sites on SH1 and 950 on the MNL to be damaged. Rapid restoration of these lifelines was critical and a variety of mitigation options were used to safely re-open SH1 and MNL as soon as possible. These mitigation methods require ongoing maintenance and monitoring to ensure they are working as designed and continue to meet cost-benefit threshold, particularly as rockfall rates decline post-earthquake. This study examines the rockfall rates since the earthquake and the effectiveness of each mitigation method. A simple cost benefit analysis is conducted to determine whether ongoing maintenance provides value-for-money.

Time series rockfall data is used to examine rockfall rates throughout the study area pre- and post-instalment to determine the relative performance of each method at preventing rockfall reaching SH1 and MNL over time. Risk analysis is undertaken for each mitigation method along the transport network along with a simple cost benefit analysis based on initial costs and expected maintenance costs. Time series rockfall data is analysed to determine the changing rockfall rates in order to understand when the landscape has recovered to pre-earthquake rates.

Magill, C., Hales, S. 70

Respiratory health impacts of natural hazard events in Aotearoa

Understanding the public health impacts of natural hazard events informs risk modelling and allows mitigation actions to be investigated. International literature shows new respiratory illness and exacerbation of existing respiratory disease is associated with hazards including earthquakes, volcanic gas and ash, tsunami, bushfire, convective storms, tropical cyclones, and floods. These respiratory health impacts have been attributed to confined conditions in emergency shelters, aspiration of contaminated water, reduced access to medical assistance and medication, damage to housing and infrastructure, stress and increased levels of smoking, mobilised pollen and dust, and air pollution from debris, smoke, and volcanic ash.

We will describe findings of an exploratory epidemiological study carried out to establish if statistical relationships can be observed between respiratory hospitalisation and non-accident emergency department visits, and natural hazard events in Aotearoa. We will present a detailed descriptive analysis for four well-defined hazard events: Canterbury earthquake

sequence (beginning 4 September 2010), Ruapehu volcanic eruption (1995-1996), Edgecombe flooding (April 2017) and North Island thunderstorms (December 2017). We will then show results from a cluster analysis that utilised a catalogue of natural hazard events occurring in Aotearoa since 1993 and Ministry of Health data for the same period. We present findings by Region and hazard type, and describe where effects are modified by age, gender, ethnicity and indicators of deprivation.

Mason, D., Brabhaharan, P., Fenton, C. 15

Lessons from the 2016 Kaikōura earthquake for the resilience of earthworks

The Kaikōura earthquake caused widespread damage to transport infrastructure across the northeast part of the South Island. Landslides and embankment failures caused the most damage and disruption, closing the Main North Line railway for 10 months and State Highway 1 for over a year. The extent of ground damage and the duration of outage of this nationally important corridor reinforce the need to improve earthquake design practices for slopes and enhance our understanding of hazard management of existing infrastructure. A multi-year research programme funded by MBIE into the performance of earthworks and the impacts of landslides on infrastructure in the Kaikōura earthquake has recently been completed. Findings from this research are presented in this poster.

The principal landslide types that caused the most disruption to the transport infrastructure were shallow-seated rock avalanches in highly fractured greywacke bedrock and deep-seated structurally-controlled slides in greywacke and Tertiary sedimentary rocks. These landslides produced the longest outage time for earthmoving to clear debris and then implementation of engineered risk mitigation measures. Extensive damage to earth fill embankments was caused by the strong ground shaking, which resulted in difficult access for the initial emergency response and often required lengthy outage for repair of the failed sections. Progressive thickening of the fills for road realignment without engineering design, a lack of geogrid reinforcement or subsoil drainage measures, and inclusion of unsuitable soils within the fill materials are all contributing factors to the poor performance of these slopes. The damage caused by cut and fill slope failures and landslides on high hillslopes in the Kaikōura earthquake highlights the need to incorporate the key mechanisms driving slope failure, the response of slopes to strong ground shaking and the consequences of failure into a resilience-based framework for slope design, which are lacking from commonly-used design approaches.

McDonald, N. 79

Mitigating FMCG transport bottlenecks following an extended Cook Strait ferry outage in New Zealand

Fast Moving Consumer Goods (FMCGs) are essential to society and the economy, relying on critical transport infrastructure and resources to facilitate their movement. Such dependence is especially true for New Zealand (NZ), which relies on ferry services linking the North and South Islands and providing an extension of road and rail lines. The experience of several recent natural events, including earthquakes, floods, and cyclones, raises concern that a major event could result in an extended Cook Strait ferry outage, severely compromising transport operations and causing bottlenecks and cascading effects throughout the freight system. Potential bottlenecks include a shortage of resources, such as containers, personnel, trucks, and coastal vessels, exacerbating the initial disruption.

This research will address the following question: How can freight bottlenecks be mitigated following an extended Cook Strait ferry outage in NZ? To address this question, the research aims to:

1) Identify the post-disaster constraints in NZ's FMCG transport system,

2) Establish and visualise the cause-and-effect relationships between these constraints,

3) Identify possible solutions to mitigate FMCG transport disruptions and support timely deliveries.

To achieve these objectives, qualitative data will be collected through semi-structured interviews with various transport and FMCG sector participants. Quantitative data, such as transit times and carrying capacity, will then be collected to quantify the bottlenecks. The collected data will be analysed by applying a set of problem-solving tools called the Theory of Constraints Thinking Process. These tools will help make sense of the mechanisms underlying major freight disruptions by establishing the cause-and-effect relationships between the multiple constraints affecting freight operations, uncovering root causes, and identifying potential solutions to ensure the continuity of freight operations. The findings from this research will improve the understanding of the resources and capacity needed to keep FMCGs moving following a major disruptive event, leading to more informed decision-making.

McEwan, E., Stahl, T., Howell, A., Langridge, R., Wilson, M. 16

Examining coseismic river response to surface-rupturing fault displacement

Displacements on surface-rupturing faults are capable of generating rapid and unexpected coseismic river response (CRR). Such events can generate spatially extensive and temporally prolonged flooding, endangering surrounding populations and infrastructure. In this study we use various flood hazard models and case study meta-analysis to define CRR susceptibility for New Zealand. Globally, 50+ case studies of this phenomenon have been documented. Our meta-analysis provides crucial information on the factors governing styles of CRR, allowing four main classes of CRR to be identified, with the most severe of these being a fault-rupture induced river avulsion, wherein a river permanently shifts into a new course. An example of this occurred during the 2016 Kaikōura earthquake, where ~7 m of vertical and ~4 m of lateral offset upon the Papatea Fault generated a partial avulsion within the braided Waiau Toa | Clarence River. A hydrodynamic model compiled and calibrated with pre–and-post-event imagery, lidar, and river data reproduced the salient characteristics of the avulsion, suggesting that FIRA events can be modelled ahead of time. Based on additional scenario models, we derived an 'F-Index' that provides a preliminary measure of the relative likelihood of a CRR occurring at any river-fault intersection. Application of the F-Index across New Zealand reveals areas where the fault and river properties combine to create varying levels of relative CRR hazard. Combining this quantitative approach with qualitative observations compiled from historical case studies provides a path towards a regional-scale susceptibility model of CRR. Site specific hydrodynamic flood modelling can then be applied to high-risk areas, allowing coseismic flood hazards to be prepared for, and mitigated ahead of time.

Miranda, C., Brown, C., Becker, J., Hudson-Doyle, E. **48**

Seismic risk communication with commercial building tenants

Large commercial building tenants have a significant influence over property developers and landlords in Aotearoa New Zealand, who respond to tenant preferences to ensure they are able to lease and make a return on their property investment(s). This includes preferences for the seismic performance of buildings. Tenants' desires for seismic performance can be reflected in lease requirements for seismic building performance or willingness to occupy buildings. However, there is currently little research on how tenants receive and interpret seismic risk information and how this information is used to make building occupancy decisions. To ensure the seismic performance of buildings matches the needs of organisations that tenant commercial buildings, it is important to understand how seismic risk information is interpreted by these tenant organisations, as provided by the engineering community, property managers, building owners, and other key communicators of seismic risk information. Through a series of interviews with tenants, property managers, building owners,

and engineers who have experience communicating seismic risk information with tenants, this BRANZ/MBIE-funded research will examine (1) how large commercial building tenants across Aotearoa New Zealand understand and interpret seismic risk information about their buildings, and (2) how this translates into tenant requirements for the seismic performance of buildings they occupy, and decisions to vacate or continue occupying these buildings. To conclude, best-practice communication approaches will be developed and tested to support tenant organisations in making well-informed decisions about the seismic risk of the buildings they occupy.

Mostafa, M., Henry, R., Elwood, K. 28

Seismic Performance of Precast Prestressed Hollow-core Floors and Residual Capacity of Web-cracked Floor Units

Precast floors are the dominant flooring system in New Zealand's multi-story building stock, where hollow-core floors are the most ubiquitous flooring system. Following the 2016 Kaikōura Earthquake, hollow-core floor units were observed to sustain critical damage that is expected to have significantly impaired the performance of these floors.

This poster presents some of the recent seismic damage observations to hollow-core floor units incorporating current design and detailing requirements from a case study building and proposes links between the observed response and specific design concerns.

The observed damage suggests that hollow-core flooring systems incorporating current support design and detailing requirements may not satisfy the targeted performance of the New Zealand concrete design provisions to consider deformation compatibility between precast flooring systems and the supporting structural system if the units were seated within the plastic hinge region.

Furthermore, preliminary results from twelve full-scale tests investigating the post-cracking residual load-carrying capacity of hollow-core units are presented. The results indicate that the support seating length significantly affects the post-cracking residual shear capacity of hollow-core units. The findings from the experimental campaign suggest that hollow-core floor units that sustained damage in their unreinforced webs during an earthquake may not have sufficient residual gravity load capacity to ensure life safety during or after an earthquake.

Mowll, R., Becker, J., Wotherspoon, L., Stewart, C., Johnston, D. 71

Infrastructure planning emergency levels of service for the Wellington Region

There are known vulnerabilities in the various lifeline utilities networks in the Wellington Region. These are across the energy, telecommunications, transport (and therefore also food delivery) and water sectors. The vulnerabilities have been documented in documents such as the Wellington Lifelines Group (WeLG) (2012), and in subsequent WeLG documents. While these documents outline anticipated outages, these should be also be considered alongside any emergency plans that the lifeline utilities or CDEM have to mitigate against outages. Such plans could have a target output, or 'planning emergency level of service' (PELOS). If community needs of delivery of utility services requirements (or infrastructure emergency levels of service) can be defined, the gap between recommendations and PELOS can then be defined at 'suburb level'. The identification of any gaps will then aid the lifeline utilities and CDEM to refine emergency planning for the affected suburbs. Similarly, this information would be useful to the communities themselves, setting understandings of delivery and allowing detailed local planning to take place. Finally, it will be useful for the lifeline utilities in assessing future investments in upgrades to infrastructure.

Nkrumah, S., Filippova, O., Ying, F. 66

User-focused Post-Earthquake Functional Recovery of Commercial Buildings in New Zealand

The office market keeps evolving and presently, there is remote and hybrid working model that is reshaping how corporate institutions operate. Despite the strong demand for high-quality office buildings in major city centres (Bayleys, 2023), the lease arrangements are becoming shorter indicating changes in tenant preferences of workspaces (Re-leased, 2023).

Also, prime-grade office buildings have modern facilities and are designed to meet the current building codes and standards such as New Building Standard (NBS) rating. Therefore, building users expect a minimum level of damage following major earthquakes. This research seeks to investigate the expectations of building users regarding essential building services to ensure continuous use of workspaces after a major earthquake event.

Significantly, there is a human connection to buildings whilst buildings are salient partners of users in pursuing work, rest, and pleasure (Kemp & Baker, 2007). Besides, there is an interrelationship between users and buildings/office workspace. Furthermore, the functionality of a building, in terms of meeting expectations, is interrelated with the building users and the office workspace (Allen, 2005). The preceding underscores the concept of building function system.

The building function system has both social components (building users) and technical components (building/office workspace). Thus, socio-technical system (STS) theories have been adapted to describe the building function system which is analysed from micro and macro levels. Whilst the micro level describes the functionality from an internal perspective, the macro level considers external factors that can influence the building function system such as culture. The variables in the building function system are essential in understanding users' expectations.

O'Kane, A. 29

What controls earthquake-induced building damage and what implications do they have for magnitude estimates of historical earthquakes?

In the present day, there is a pressing societal need to understand the relative influence of earthquake magnitude, epicentral distance, and subsurface geology in controlling destructive ground shaking generated by earthquakes. Correctly assessing the magnitudes of past events from the historical record in relation to the distribution of building damage is essential for understanding the accumulated elastic strain on major fault systems. My poster presents how these topics were addressed by running a series of seismic-wavefield models, both with and without a foreland basin present, and independently varying the magnitude and location of a thrust-faulting earthquake within the adjacent deformation belt. Modelling the earthquake ground motions and using global fragility curves for generic building types allows for the relationship between the earthquake parameters, geological characteristics, and building damage to be investigated, as the modelling can account for important wave-propagation effects through geological structures such as basins, which empirical ground motion relations cannot. I will present how these results reveal the trade-off between the proximity of the fault rupture to a foreland basin and the magnitude of the earthquake, with increases in distance from the range front of ≃50 km being equivalent to a reduction of earthquake magnitude by 1–2 moment magnitude units, in terms of the resulting ground motions. Using established Peak Ground Velocity (PGV)-intensity-magnitude relationships, the source and structural characteristics that can contribute to the over- or under-estimation of historical earthquake magnitudes based on building damage reports have been quantified. Our research demonstrates that whether a foreland basin has been correctly accounted for in the analysis can affect the estimates of historical earthquake magnitudes by up to ≃0.5 magnitude units,

which is important for obtaining more accurate estimates of the slip deficits on fault systems and calculating the potential hazard in active seismic zones.

Pascua, C., Henry, R., Toma, C., Clifton, C. 30

Seismic performance of recently-constructed concrete wall-steel frame hybrid buildings

This PhD research examines the seismic performance of an emerging building type in New Zealand that combines concrete walls and steel frames. Despite their growing popularity, the seismic performance of this building type has not been extensively investigated. Current design standards are compartmentalised into materials and do not explicitly address the design of buildings with mixed-material structural systems. There is little research on concrete wall-to-steel beam connections, and existing studies conducted overseas do not apply to the New Zealand context due to differences in design. Given the knowledge gaps, this emerging trend of hybrid buildings must be investigated to ensure that they will behave as intended by design. This research aims to identify and address potential vulnerabilities with the current design practice before this building trend becomes more prevalent.

A review of 50 recently-constructed concrete wall-steel frame hybrid buildings in Christchurch and Auckland was conducted to understand the current state of practice. Based on findings from the building review, an experimental programme was undertaken on concrete wall-steel beam connections to understand their seismic performance. Four full-scale specimens were designed based on current practice and then subjected to actions simulating seismic demands. All specimens experienced non-ductile failure characterised by concrete breakout of the anchorage into the wall, thus highlighting the vulnerability of the connections and a need for a more reliable design procedure. Finally, the seismic performance of concrete wall-steel frame buildings will be quantified through numerical modelling of a case study building. A 2D building model on OpenSeesPy will be used to understand the effects of connection capacities on the building behaviour. Ultimately, the outcomes of this study will be used to develop recommendations for design practices and detailing of concrete wall-steel beam connections, which can be used to update New Zealand design guidelines.

Penney, C., Howell, A., McLennan, T., Nicol, A., Fry, B. 17

Investigating the occurrence of Kaikōura-like ruptures in a multi-fault, multi-cycle earthquake simulator

The 2016 Kaikōura earthquake produced surface ruptures on over 18 faults, and likely involved slip at depth on an even greater number. These faults also spanned multiple tectonic domains, which had previously been assumed to contribute separately to the overall accommodation of Pacific-Australia plate motions. The earthquake therefore raised a number of questions, with important implications for seismic hazard: what proportion of earthquakes involve multiple faults? How frequently do such "multifault" earthquakes occur? And what are the controls on which faults are able to co-rupture? The historical, particularly the instrumental record, contains too few events to answer these questions meaningfully, and the uncertainties associated with paleoseismic data make the conclusive identification of multifault earthquakes challenging. We therefore use a new method to create the 3D model of the fault network in central Aotearoa New Zealand which allows us to control fault intersections at depth. We use this 3D fault network as a basis for creating a catalogue of synthetic earthquakes using a physics-based earthquake simulator, RSQsim. We then investigate the occurrence of Kaikōura-like earthquakes in this synthetic earthquake catalogue. We find that the definition of "Kaikōura-like", and even "multifault", has a significant effect on the proportion of earthquakes with these properties. We also find that the subduction interface may play a key role in controlling which faults are able to co-rupture in a single earthquake.

Prasanna, R., Adikari, K., Holden, C., Punchihewa, A., Stephens, M., Drummond, P., Ravishan, D., Chandrakumar, C. 89

Feasibility of LPWAN (Low Power Wide Area Network) based communication solutions for earthquake early warning (EEW) and building/infrastructure monitoring systems

This research project proposes exploring the feasibility of using LPWAN (Low Power Wide Area Network) embedded communication technologies like LoRa (Long Range) as an alternative to overcome the limited or no access to the Internet during a large earthquake scenario in the context of Aotearoa New Zealand. In the past few years, the investigators of this research have been successfully exploring the use of micro-electromechanical systems (MEMS) based sensor networks for earthquake early warning, building instrumentation and infrastructure monitoring solutions. Currently, these systems rely heavily on having connectivity to the Internet for sensor communication. Observing these systems' performance and related literature on similar systems operating in other parts of the world clearly indicates their vulnerability when operating with limited or no Internet connectivity. These identified limitations justify the need of exploring the feasibility of using LPWAN technologies as an alternative solution for sensor communication. The successful achievement of the aim and objectives of the proposed research will contribute to extending the ongoing research, product development and capability development of the listed project investigators, collaborators and students. Further, the findings of this research will contribute to the design and development of more reliable and sustainable earthquake early warning and building/infrastructure monitoring solutions.

Prattley, L., Beaven, S., Wilson, T., Williams, J., Leonard, G. 72

Tsunami Evacuation Behaviour: a review of survey findings across Aotearoa New Zealand

Approximately 70% of Aotearoa New Zealand's population reside in coastal areas, and almost 10% live within tsunami evacuation zones. Tsunamis are a low frequency, high impact hazard, with the potential to cause widespread damage and loss of life. Evacuation from exposed areas is the only effective emergency response to imminent tsunami hazard. A recent international review has indicated that most tsunami research has focused on particular aspects within the evacuation process, finding that more research is required to understand behaviours across the wider evacuation process, from initial warnings to the return home.

Aotearoa New Zealand was used as a case study to address this gap in international literature. A survey was used to gather data from seventeen east coast communities concerning decision-making and behaviours when three earthquakes occurred on the 5th March 2021 near the North Island and generated separate tsunami warnings and evacuation operations involving thousands of people. The data was analysed across the sequence of decisions involved in the wider evacuation journey, making it possible to identify some of the factors influencing higher risk decisions and behaviours. These findings were compared with other twenty-first century Aotearoa New Zealand studies to identify high level key findings and trends.

Findings of particular concern involve reported post-event behaviours and decisions that indicate that if either the 5th March 2021 or 2016 Kaikōura earthquake and tsunami sequence had produced large damaging tsunamis, a significant proportion of respondents would have remained exposed at the time of tsunami arrival due to a failure to promptly evacuate exposed coastal areas. In addition to low reported rates of evacuation, the data indicates that three additional factors appear to have contributed to this sustained exposure: an overreliance on official warnings, high-use of private vehicles, and a failure to recognize and act on the need to evacuate immediately.

Price, L., Stock, K. 90

A Web Application to Map Disaster Impacts from Social Media Posts

Social media allows users to connect and share information, news, and content with a large network. Following a natural disaster, people use social media to share information relevant to recent disasters, often faster than official channels. This information is extremely valuable for emergency responders to plan and implement relief operations. While web mapping applications and satellite images are commonly used to visualize disaster impacts, they either lack specific information about individual impacts or require manual intervention. Unlike previous work, we are developing an application to map fine-grained, individual impacts that are automatically extracted from tweets, along with an accurate and informative open-source mapping interface. This accurate mapping of disasters will provide first responders with important information that they would not have had otherwise, or there would have been a significant delay in receiving the information. This poster displays the development of this web mapping application that displays accurate disaster impact details from social media posts.

Rahayani, R., Nair, N. 91

AHP Analysis for Disaster Hazard Mapping to Optimize Solar and Wind Farm Site Selection

Constructing solar and wind power plants is a significant long-term investment that requires intensive consideration. The objective is to generate optimal power while minimizing investment and operational expenses, all while ensuring minimal environmental impact. Thus, identifying the most optimal location becomes crucial. Unfortunately, countries prone to natural disasters, including floods, landslides, earthquakes, bushfires, and storms, consistently experience damage and power loss. This study aims to explore the Analytical Hierarchy Process algorithm, which incorporates input from stakeholders and planners, to establish a comprehensive disaster mapping criteria's. By identifying and prioritizing crucial parameters, we can effectively mitigate the impact of natural hazards on solar and power generation and make informed decisions for sustainable and resilient energy infrastructure.

Ramhormozian, S., Yan, Z., Clifton, C., Quenneville, P., MacRae, G., Dhakal, R., Xiang, P., Jia, L. 31

Three-storey Configurable Steel Framed Building Incorporating Friction Based Energy Dissipaters

A 9 m high, full-scale three-storey configurable steel frame composite floor building incorporating friction-based connections is being tested using two linked bi-directional shake tables at the International joint research Laboratory of Earthquake Engineering (ILEE) facilities, Shanghai, China. This RObust BUilding SysTem (ROBUST) project includes the testing of 9 different structural configurations. To have a better understanding of the system as well as effects of other structural and non-structural elements in a complete system level, experimental testing at component level were conducted prior to the shake table testing. A total of 3 concepts were tested namely, the optimised sliding hinge joint (OSHJ), the brace to gusset plate connection using symmetric friction connection (SFC) with Belleville Springs (BeSs) and the column base strong axis aligned asymmetric friction connection with BeSs. A summary of the component test results for the above-mentioned connections are reported as well as some preliminary results from the shake table testing.

Ravishan, D., Prasanna, R., Hudson-Doyle, E. 92

Unleashing the Potential: AI at the Edge of Distributed EEW Network

The field of Earthquake Early Warning (EEW) has witnessed a vast variety of research, highlighting its significance in mitigating the impact of seismic events. Traditionally earthquake detection approaches used for EEW have been dominated by maths or physics-based algorithms. In recent times we have seen the rise of a new generation of earthquake detection algorithms driven by Artificial Intelligence (AI). However, most of the AI-based EEW research focuses on the centralised processing of earthquake data ignoring extracting the capability and capacity of the sensor nodes to the fullest. More recently, domains which are not related to EEW have started showing promising results using AI at the edge (Edge AI). Such successes promote exploring the possibilities of harnessing the capability of AI models at the sensor nodes for more efficient, cost-effective, and widespread deployment of EEW systems.

At the Joint Centre for Disaster Research, the CRISISLab research team has been exploring the capability and capacity of decentralised edge-based technologies, and in the process successfully implemented an EEW system comprised of a mesh network of sensors driven by earthquake detection at the edge. Extending this work we intend to explore possibilities for EEW supported by Edge AI. Through leveraging the existing mesh network architecture, the CRISISLab team has created an ideal environment to explore the execution of AI-based detection algorithms at the sensor nodes.

Delving into this unexplored area of research, our research team expect to unlock the power of AI-based algorithms operating at the sensor nodes and contribute to the field of EEW knowledge base focusing on enhancing detection accuracy and warning duration. Therefore the stage is set to embark on a journey to investigate the feasibility of deploying AI models at the sensor nodes of an EEW system driven by the decentralised approach for processing earthquake data and earthquake detection.

Rincon Gil, J., Pujol, S. 32

Repair of RC Concrete Columns with Post-tensioned Clamps

Older reinforced concrete (RC) buildings, which were designed before the implementation of seismic design standards, pose a significant risk to life and property in earthquake-prone regions. These buildings often have RC columns that lack transverse reinforcement and adequate confinement. The damage observed in previous earthquakes has revealed the vulnerability of those columns and highlighted the need for reliable and easily applicable alternatives, especially in developing countries. A new repair technique is proposed, which involves the use of post-tensioned external clamps fastened around the column. The clamps are easy to design and implement and do not require specialized workmanship. They are well-suited for the rapid repair of RC columns after strong ground motion. To assess the effectiveness of this repair technique, experimental testing was conducted on four full-scale RC column specimens. The specimens were initially subjected to damage in the form of flexural and shear cracks, and then repaired by adding post-tensioned clamps. The experimental results have shown the potential of the proposed technique in restoring the shear strength and drift capacity of damaged RC columns.

Roundill, M. 73

The Role of Housing in Tertiary Students' Ability to Prepare for Earthquakes

Many students live in mouldy, damp, and uninsulated houses, which are more susceptible to damage following a disaster, like an earthquake. The volatile housing market and the dire renting situation continues to perpetuate poor housing conditions for students studying at tertiary institutions who are renters. This housing situation needs to be considered alongside

other determinants of health, like financial and employment which can leave some students vulnerable and at risk of harm. Consequently, in disaster management literature, students are highlighted as being unable to prepare for an earthquake due to strict regulations governing renting, housing insecurity, a lack of financial resources, information or knowledge about disaster preparation, and little understanding of the risks associated with not being prepared. Yet despite this obvious social vulnerability, students are often positioned as healthy and self-sufficient, and not categorised as an at-risk group within disaster management, leaving them to defend for themselves in the event of a disaster. Therefore, it is imperative to increase the ability of students to be prepared for earthquakes and improve their likelihood of surviving and thriving within the residential housing environment.

My research aims to understand the role in which this substandard housing impacts tertiary student's earthquake preparedness; firstly, by identifying the number of tertiary students that are prepared and the quality of their housing through a quantitative survey, followed by qualitative interviews with tertiary students on what barriers they experience to prepare within their homes, and how this might differ across those who rent, own their home or live with their whanau. Finally, a qualitative study will be conducted with landlords to identify what barriers they may experience preventing them from ensuring their rental properties are healthy and safe during an earthquake.

Rowe, C. 54

Preparing for Impact: How is science communication helping us prepare for the next Alpine Fault Rupture?

On a global scale, New Zealand is one of the countries most at risk from disasters and many New Zealanders have living memories of disasters that have had devastating impacts. Yet reported levels of New Zealanders' preparedness remains relatively low. Building resilience is identified as one the key priorities in the National Disaster Resilience Strategy and there are many programmes and initiatives that have and are being carried out with the aim of improving community resilience –AF8 [Alpine Fault Magnitude 8] being one.

Since its formation in 2016, AF8 has carried out numerous engagement initiatives with Civil Defence and Emergency Management (CDEM) stakeholders and the public to communicate the likelihood and potential impact of a magnitude 8+ earthquake. However, there has been no evaluation of the impact this engagement has had on enhancing awareness and preparedness. This is not uncommon in the field of risk reduction communication or indeed science communication as a broader field, where evaluation studies are relatively limited in both quantity and scope.

This research positions Local Government CDEM groups as the enabler of community resilience, through their community-based work across the 4Rs. The role of AF8 in providing underpinning science evidence, and as a collaborative network, is used to assess the tangible impacts and outcomes of AF8 risk communication efforts, in informing decision-making and supporting community awareness and preparedness for a future Alpine Fault earthquake disaster. A range of qualitative research methods will be employed, including key informant interviews, content analysis and surveys.

The research seeks to provide a framework for evaluating the likely efficacy of future science communication activities in the area of risk reduction, specifically focused on providing practitioners working in this field with practical strategies to increase the effectiveness of communication efforts and build greater community resilience.

Salimian, M., del Rey Castillo, E., Hogan, L., Stephens, M. 33

Experimental study on FRP ties used in precast diaphragm strengthening subjected to incompatible support beam rotation and parallel beam elongation

Precast floors were used profusely in the construction industry in New Zealand. However, these floors were not designed originally to fulfil a diaphragm role during an earthquake or are damaged and weak when transferring inertial loads to the lateral load-resisting elements. Strengthening the diaphragm with FRP ties is a preferred solution compared to other traditional methods to address these shortcomings. An additional issue is that precast diaphragms, especially hollow core units, suffer from deformation incompatibility between the floor and the support beams. Not only can these large and localised deformations damage the diaphragm connections, but also may lead to strain concentration on the FRP ties resulting in premature FRP rupture. A prevalent incompatible deformation can occur when the column drift rotates the support beam of the units, generating a large discontinuity crack at the interface of the support beam and the unit interface. Such deformation can be combined with beam elongation from the parallel beams' plastic hinges and exacerbate the deformation demand on the FRP ties.

This research studies the behaviour of FRP ties subjected to the support beam rotation and parallel beam elongation deformations, and the influential parameters on their performance. A well-established test setup was designed to accomplish these goals. Ten large-scale specimens are built and tested to replicate the support beam and the hollow core unit interaction during an earthquake. Different parameters will be investigated, including the FRP tie's width and thickness, end and middle anchor configuration, loading protocol, and the seating angle effect.

Sarwary, S. 49

Institutional structures, social capital and community disaster resilience: can legislative and governance arrangements facilitate community influence on disaster recovery decision making?

My research is concerned with the extent to which the legal frameworks (both laws and policies) required community engagement in disaster recovery decision-making before and during the Canterbury Earthquake Sequence. It consists of two phases. Firstly, I carry out a review of the legal frameworks in place before and during the Canterbury Earthquake Sequence (CES) to identify provisions and mechanisms for community engagement. The second phase consists of qualitative research conducted with three groups of population (community groups that existed before the CES, pop up organisations and community facing government officials) who were involved in recovery decision-making over this time, as part of community groups, or because they were in community facing roles in local or central government agencies. For this poster, as part of the first phase, I focus on the specific provisions in the DRM legal framework before the Canterbury Earthquake Sequence and during the bespoke recovery framework to see if they enabled the public to influence higher level recovery decision-making and access resources for their recovery.

Saunders, W. 50

A national risk tolerance assessment methodology

Risk tolerance is our willingness to bear a risk. Understanding risk tolerance helps us decide how to manage the potential impacts of a hazard on the things we value (such as our health, environment, economy, and buildings and infrastructure). To manage risks effectively and appropriately, we must assess our risk tolerance. While Aotearoa New Zealand has well-established approaches for hazard risk management, we lack a nationally agreed approach

for assessing and reviewing our risk tolerance. Furthermore, there is no framework (regulatory or otherwise) to understand what is tolerable, intolerable, or acceptable, and there is no consistent, agreed terminology to support this. This often leads to ambiguity in who manages risk and inconsistency in what risks are significant, as well as inconsistent approaches to risk across regions and organisations. This is a critical gap that this methodology seeks to address. This methodology integrates a risk tolerance assessment into our current hazard risk management approaches, i.e., at the evaluation stage of the risk assessment process (typically based on ISO 31000:2018). This can be adapted for any hazard risk or policy framework. The methodology provides consistency while being adaptable to suit varying contexts and timeframes, including for decision-makers across local, regional, and central government levels, and within the private sector. This will enable more robust, transparent, and documented risk-based decision-making. The methodology is aimed at central, regional, and local government agencies who manage natural hazard risks. It was developed following an extensive literature review by Toka Tū Ake EQC titled 'Natural Hazards Risk Tolerance Discussion Paper'.

Scadden, M. 57

Understanding cascading climate change risks for Māori communities

Māori communities in Aotearoa New Zealand experience disproportionate vulnerabilities from climate change risks. This paper posits that the long-lasting impacts of colonisation have increased vulnerability, therefore impacting the resilience of Māori communities and exacerbated risks from climate change. Tangata whenua face increased risks to their cultural practices, identities, connections to land, access to sites of significance, and loss of economic opportunities, among other difficulties. I am at the beginning of my research, working with an interdisciplinary team to explore the risks of climate change and where to focus adaptation for communities. I will be considering the cascading risks from the natural and built domains outlined in the National Climate Change Risk Assessment onto the social and cultural aspects of Māori communities, a space which currently has many gaps in knowledge. This requires engaging with tangata whenua, as well as local Council members. The progress and outcomes of my research are to be entirely shaped by Māori. Therefore, location specific approaches will be emphasised according to the tikanga and kawa of each hapu. Ethical considerations of engagement include navigating mistrust over previous exploitation of people and resources, and the possibility of over-stepping boundaries. I consider it necessary to engage with the past in field sites, particularly with the history of colonisation in Aotearoa New Zealand, as it has shaped how climate change is experienced and therefore the adaptive capacity of Māori communities.

Scheele, F., Wilson, T., Becker, J., Horspool, N., Campbell, M. 74

Simulating household impacts for an Alpine Fault earthquake

The Alpine Fault is a major source of seismic hazard for the South Island of New Zealand, with ruptures typically producing earthquakes of around Mw 8.0. Ground shaking and associated effects will be felt across multiple regions, resulting in a range of societal impacts across diverse communities including towns, cities and rural areas. Households within affected communities will be required to make decisions on adaptive actions to respond to impacts such as building damage, utility outage and transport disruption. Some households will choose or be required to relocate, whereas others will shelter in place.

This study simulates household decision-making through the response and early recovery stages of the earthquake event, accounting for changing circumstances over time. Models of building damage, infrastructure outage, evacuation and cordons are combined to represent the physical environment. A synthetic population model of households contains many

attributes which influence the decision-making process. Household decision-making is achieved via Belief-Desire-Intention architecture. Model outputs include relief requirements for sheltering in place, accommodation demand, and population movement of displaced residents. The simulation accounts for microscale effects at the individual household level as well as aggregated and wide-scale effects allowing for examination of tipping-points for the functioning of communities.

Schill, C., Bradley, B., Dempsey, D. 18

Post-Event Ground Motion Estimation Using Physics-Based Simulations

Following an earthquake, there is a need for accurate ground motion (GM) estimation at uninstrumented sites for forensic analysis of collapsed or damaged structures. Existing methods use observations at nearby sites, in addition to empirical models, to estimate the GM intensity measures (IMs) or the acceleration time series at the site of interest. However, these methods only produce accurate results when a sufficient number of observation sites within the immediate proximity of the site of interest is available, due to the limitations of the underlying empirical models. Physics-based GM simulations, on the other hand, have the potential to provide more accurate and precise GM estimations compared to empirical models, due to the explicit modeling of the underlying physics. This study investigates the use of physics-based GM simulations for site-specific post-event GM estimation. To constrain the uncertainty in the source parameters of the event, a Monte Carlo approach is taken where 100 simulation realisations of the event are generated. The available observations are then used to estimate the posterior distribution of the realisations for the site of interest. Multiple methods are investigated and developed to estimate the posterior distribution, ranging from existing probabilistic methods to machine learning- and heuristic-based methods. This study uses the Canterbury region due to the number of significant events and the high density of recording stations, however, the developed methods are applicable in general.

Shariati, A., L'Hermitte, C., Trent, N. 80

Prepositioning of relief items: A study of the factors influencing emergency management decisions

Major disasters strike with little or no warning, causing massive infrastructure damage, casualties, and isolated communities. In such circumstances, the swift and effective distribution of relief items to the affected communities is crucial. The prepositioning of emergency supplies, defined as the storage of relief items and equipment in strategic locations nearby disaster-prone areas, has been recognised as an effective practice to ensure the timely distribution of relief items. However, prepositioning decisions are complex, involving conflicting objectives related to the costs and benefits of this practice, uncertainties, as well as various contextual factors (e.g. urban vs rural). Furthermore, the existing literature primarily focuses on quantitative research, neglecting the qualitative foundation required for developing practical and applicable prepositioning models.

This research proposes a holistic qualitative-quantitative framework for prepositioning decision-making on the basis of a value-focused thinking approach and the multi-attribute utility theory. The study comprises three phases, including a literature review, qualitative research through interviews with practitioners in New Zealand, and quantitative research involving the development and application of a multi-objective location-allocation model. The model will be applied to two case studies in New Zealand: an urban area (the Hutt Valley) and a rural area (Wairarapa). Two types of storage methods (permanent warehouses and alternative storage methods such as shipping containers) will be considered as different prepositioning strategies.

Through interactions with practitioners, the study aims to develop an applicable mathematical model for prepositioning and to evaluate the influence of contextual factors and storage methods on prepositioning decisions. This research is expected to support decision makers in emergency management in finding the best prepositioning strategy, achieving a balance between the costs and benefits associated with prepositioning, and ultimately contributing to the management of major disasters.

Siddiqui, U. 34

Enhancing City Resilience: A Local Council's Approach in Managing Risk from Earthquake-Prone Buildings

With an established EPB Policy since 2006, the Wellington City Council WCC has been a frontrunner in EPB management, preceding the 2017 national policy. WCC adopts a people-centric approach to address the legislative change's impact on EPB owners. A recent city-wide survey by the council assessed progress, challenges, and barriers faced by building owners in meeting EPB notice deadlines. WCC offers support options such as rates remission, consent fee rebates, and the Heritage Regeneration and Resilience fund. The Council's Resilient Buildings team provides strategic advice to ensure informed decision-making for EPB owners. WCC is the first council in the country to handle EPBs with expired notice deadlines and a policy development is underway focusing on swift strengthening while ensuring public safety. Collaboration among the councils, academia, industry, and partner agencies is recognized as vital for extending funding and technical support to EPB owners in complex seismic risk reduction efforts.

Stahel, K. 55

QuakeBox Similes: Change and persistence in similes in post-earthquake narratives

This study is a longitudinal analysis of change and persistence in the use of similes in a corpus of retold disaster narratives recorded seven years apart in the University of Canterbury's QuakeBox project. Previous work on figurative language in disaster narratives has mainly focused on media or political discourse and how the concepts used to frame a disaster influence public opinion and behaviour. Studies of figurative language in personal narratives often concentrate on individual experiences of trauma, illness, or adversity. Studying similes in the retold narratives of people who experienced a major earthquake contributes to knowledge of how figurative language helps people to describe and process natural disasters. Studying narrative accounts of traumatic events can be beneficial for evaluating and understanding the impact of these events on individuals and their communities, and for expanding our knowledge of the processes of recovery and the development of resilience. The similes identified in the corpus belong to two broad groups: 'mediated/unreal' sources such as MOVIE/TV and WARZONE and 'sensory/embodied' sources such as ROLLERCOASTER and TRAMPOLINE. The overall frequency of simile use, dominant source themes, and target and source mappings are found to be persistent over time at the cohort, but not individual, level.

Stucki, E., Trent, N., L'Hermitte, C. 81

Exploring logistics behaviour in Aotearoa New Zealand for better disaster impact modelling using vehicle telemetry data

Freight transport affects all New Zealanders every day. In New Zealand, over 92% of the tonnage of freight is transported by trucks, with the total amount of freight transported increasing each year. However, the road network is exposed to a range of natural hazards, including earthquakes and extreme weather. When the road network is disrupted, the efficiency of freight transport is deteriorated, affecting the economy and quality of life.

Transport models are often used to understand the impact of disruptions on road transport, with agent-based transport models becoming the model of choice. In order for these models to be accurate, understanding the behaviour of the logistics agents is essential. However, the current understanding of logistics behaviour is deficient. Therefore, this research will study the underlying behaviour of logistics agents to better inform freight transport models. The analysis will cover logistics behaviour under both business-as-usual and post-disaster circumstances.
Commercial vehicle telemetry data will be the primary source of data in this study. Telemetry data is ideal because of the comprehensive nature of the data as well as the accuracy and individualisation that are available. This research will analyse the data using a spatio-temporal analysis.
This research will result in an understanding of logistics behaviour, specifically, when and where trucks move, what patterns emerge, and how these patterns change over time. The insights from this research will enable more accurate agent-based transport models. These models, in turn, could be used to improve New Zealand supply chains, creating a more efficient and resilient system.

Syed, Y., Uma, S. 82

Using decision support system as an infrastructure network planning and visualisation tool for natural hazard risk assessment

Natural hazards cause significant disruption in terms of damage to buildings and distributed infrastructure networks. Understanding the extent of disruption and quantification of the resulting consequences is important to assist various stakeholders' decision-making processes to complete their tasks successfully. Stakeholders therefore need a robust decision-making framework that can integrate the different models, experts' knowledge, and problem-solving tools into a single intelligent decision support system (DSS). In this poster, we present a "Knowledge-centered DSS through some case studies to demonstrate its use as a network planning and visualisation tool. Stakeholders including infrastructure network providers and other emergency management organizations can test a variety of 'what-if' recovery scenarios. This would allow them to examine various post-disaster recovery options for disruptive infrastructure networks.

Tan, M., Vinnell, L., Valentin, A., Prasanna, R., Becker, J. 93

Understanding technology adoption of an earthquake early warning system through a continuance intention model

This study delves into the theoretical aspects of technology adoption, focusing on the Android Earthquake Alert (AEA) system in New Zealand, analysed through a continuance intention model. The research aims to investigate the model's implications by investigating the public's perceptions and attitudes towards the AEA system, specifically emphasising continuance intention and its influencing factors. Utilising Structural Equation Modelling, this study uses data collected from the public after alerts were sent out during two separate earthquake events. The results reveal partial support for the continuance model, emphasising the significance of perceived usefulness and perceived trust in driving continuance intention. By investigating the theoretical underpinnings of the continuance intention model and interpreting the findings in the context of the AEA system, this research contributes to a deeper understanding of technology adoption. The implications of these results hold promise for advancing EEW technologies and refining technology adoption strategies, ensuring their sustained relevance and impact. The poster presentation will elaborate on the theoretical framework and show the importance of perceived usefulness and perceived trust in shaping continuance intention for the AEA system. The poster also discusses the potential implications

for EEW system design and implementation, fostering a more resilient and user-centred approach to earthquake early warning efforts.

Till, H., Stephens, M., Toma, C. 35

Tsunami Loading on Buildings

Tsunamis have among the lowest frequencies of natural disasters, but when they occur are among the most devastating. There has been significant research done on tsunami loading in the recent past to better understand the devastation of the 2011 Tohoku tsunami and improve the response to future disasters. Expected tsunami loading has been included in guidance documents from MBIE and ASCE based on reconnaissance following tsunamis as well as physical and numerical modelling. The current investigation continues this work with physical testing of models with variation in opening ratios, opening locations, structural orientations, and the incorporation of flexibility. Models were tested under tsunami conditions ranging from small bores of approximately half a story in depth up to those exceeding three stories in depth. Forces and moments acting on the structure were recorded for all three axes, local pressures were recorded on walls and floor diaphragms, and roof displacements were recorded for the testing of flexible models. While openings and orientations have been previously investigated, the introduction of flexibility to the structural model allows for an approximation of structural performance under tsunami loading conditions. Further work following the conclusion of testing will include numerical fluids and structural modelling with sequential earthquake and tsunami loading analyses.

Tiwari, A., de la Torre, C., Bradley, B., Lee, R. 19

Investigating systematic site effects and within-site variability in New Zealand: A comprehensive residual analysis of empirical- and physics-based GMMs

This study examines systematic site effects and within-site variability from prediction residuals of empirical- and physics- based ground-motion models (GMMs) using a dataset of >2900 MW 3.5-8.0 earthquakes recorded in New Zealand (NZ). A significant amount of total uncertainty in ground-motion modelling comes from within-event residuals highlighting the need for a comprehensive study of the site and path characteristics that contribute to these site effects. A diverse range of sedimentary basins and sites in distinct geomorphic categories are considered in this paper with the primary objective of improving physics-based simulations in New Zealand. Advancing ground-motion predictability through physics-based GMMs is a continually iterative process and requires addressing fundamental questions like: Is there salient physics which has been overlooked? Which geographic regions have predictions that significantly deviate from observations and why? Which sites exhibit systematic prediction residuals and how can the attributes influencing them be identified? Which predictor variables show dependence with the site-to-site residuals?

This study examines these questions by classifying ~400 NZ sites using Nweke et al. (2022) geomorphic categories. Using these categories and data-driven approaches, this study explores the geospatial variation of site residuals. A multitude of intensity measures are used against multiple predictor variables to obtain a high-dimensional assessment of physics-based simulations. Trends in the site-to-site residuals for each geomorphic category indicate apparent differences between the four categories, with residuals for valley sites illustrating a clear dependence with the inferred fundamental site period. Computed residuals from both empirical- and physics-based GMMs provided insight into the role of site-specific attributes vs. the different prediction methods, assisting to understand the primary factors influencing these residuals. Results also indicate that incorporating site-specific characterization data into ground-motion modelling and utilizing more refined basin models can improve predictions at sites with significant site/basin amplification.

Uma, S., Moratalla, J. **83**

A framework to estimate damage and potential blockages for road network under cascading hazards with propagation of uncertainties

Road networks are widespread systems featuring multiple types of assets/components. The components are vulnerable to damaging earthquakes and the resulting cascading hazards, severely compromising the functionality. Understanding the nature of cascading hazards (direct and indirect) and the damage that could be suffered by the road network assets is fundamental for assessing likely impact in terms of loss of access to various sites. Restoring access is vital for emergency response activities and for restoration of other infrastructure systems.

Prediction of damage for defined areas within a road network include large uncertainties, especially when including the effect of cascading hazards. Modelling and accounting for uncertainties from different sources is important to provide confidence to stakeholders for resilience planning and decision making.

To achieve this objective, we propose a comprehensive framework to model hazards and likely damage to road assets. Due to the uncertain nature of hazard events and response/performance of road network components, a probabilistic framework is proposed to predict damage probabilities by systematically considering the effects of: (i) multi-hazards that are cascading; and (ii) damage of various components of the network. The framework allows to track the uncertainty in the hazard modelling to the fragility of the road assets through a Monte Carlo simulation that creates thousands of damage realizations.

The approach proposed is suitable for modelling scenario earthquake and its cascading hazards. Road assets are assessed for (i) direct damage due to earthquake shaking and cascading hazards including liquefaction, lateral spreading or earthquake induced landslides; and (ii) indirect damage from debris due to collapse of buildings adjacent to roads. Results generated from a case study on Napier city road network for damage realisations will be presented. The proposed method can be extended to determine (i) probabilities of inaccessibility for various sites; and (ii) probabilities of recovery time with uncertainties quantified.

Vercoe, H., Fa`aui, T., Wotherspoon, L. 58

Adaptation of Marae Infrastructure for Natural Hazards Resilience

The precarious exposure of marae to natural hazards and climate change poses a significant threat to the cultural identity and well-being of Māori communities across Aotearoa New Zealand. Marae geographical positioning presents a considerable natural hazard risk, amplified by climate change impacts. Despite their pivotal role in recent hazard events, a large number of marae lack the necessary resources, support, and infrastructure to adequately prepare for and respond to these events, underpinning the research need.

This research focusses on evaluating the vulnerability and resilience of marae infrastructure in the face of natural hazards and climate change across Aotearoa New Zealand. Adhering to the tenets of kaupapa Māori theory, the research employs a mixed methods approach to ensure a holistic understanding and perspective. A core element of the research ensures that engineering solutions address the specific issues present for marae, bringing together engineering and Māori knowledge bases. The inquiry collaboratively engages with whānau, hapū and iwi, recognising their unique knowledge and experience whilst affirming that the research provides practical utility to those most impacted. The investigation will transpire across varying degrees of granularity: (1) at the expansive, regional iwi level and (2) at the localised, marae-specific, hapū level to provide an in-depth understanding of risks and impacts on marae infrastructure. The explored infrastructure includes three waters, roading, telecommunications and energy networks. Correspondingly, the considered hazards span

seismic, geotechnical, hydrological and meteorological phenomena. Within the research timeframe, engagement will be sought from 5-10 marae.
The development of marae-specific recommendations aims to prioritise adaptation and mitigation efforts, ensuring that resources are allocated effectively to assist marae in resilience-building endeavours. The outcomes of this research will contribute to the national dialogue, policy formation and co-creation of solutions with marae to enhance their resilience and preparedness for natural hazard occurrence and impending climate change.

Vincent, K., Crawford-Flett, K., Wotherspoon, L. 20

Identifying internal instability type with soil microstructure

Dams form a critical part of New Zealand's infrastructure, contributing to the supply and management of water. The majority of dams within New Zealand are constructed of earth. Under static conditions seepage occurs as expected, where water percolates through the pores of the soil to the downstream side of the dam. Internal instability, the movement of small soil particles through a matrix of larger particles under seepage, is over-represented as the cause of failure for earth dams where the cause is known. Internal instability can lead to changes in soil gradation, porosity and strength, increasing uncertainties around the expected performance of embankment dams under earthquake loading.
The influence of soil microstructure on internal instability manifestation has been conceptually understood in numerous experimental and numerical investigations. By identifying the soil microstructure type, the probable type of internal instability can be identified; suffusion, suffosion, or heave/fluidisation. Understanding instability type can assist with identifying failure modes for structures susceptible to internal instability.
Recent experimental studies have conceptualised microstructural types related to internal instability for gap-graded soils. These include clast-supported, where the coarse fraction dominates the load-bearing behaviour; matrix-supported, the fine fraction dominates load-bearing behaviour; and transitional. Suffusion and suffosion internal instability types are thought to be characterised by clast-supported and matrix-supported microstructures, respectively.
This poster reviews experimental and theoretical work completed in the fields of soil microstructure and internal instability and demonstrates links between these. Based on this review, a method is proposed for identifying soil microstructure based on finer content and void ratio for gap-graded soils. This method can complement established methods used in practice for assessing internal instability susceptibility by identifying probable modes.

Wallace, T. 21

Understanding Operational Vulnerabilities & Systemic Risk in Integrated Stopbank-Dam Catchments

Floods are New Zealand's most frequent and damaging natural hazards, with over 100 flood-prone communities. Stopbanks and dams are one of the primary strategies employed within New Zealand to ensure people and infrastructure are out of harm's way.
However, a non-integrated approach has contributed to inconsistencies between regions in the construction, maintenance, and management of these structures. Despite the importance of stopbanks and dams, these differences have led to varying levels of resilience which may not be proportional to the relative importance of the structures.
This PhD research aims to investigate several operational factors related to flood management within four stopbank-dam catchments. In this process, a framework will be developed so that the techniques may be adapted and applied to other catchments and systems. By determining these factors' effects and impacts, recommendations will be made to improve resilience in our flood-prone communities.

Within this research, stopbank breaching is being considered by modeling breaching in areas where water surfaces exceed a threshold depth as currently, stopbank breaching is often limited to worse-case or historical scenarios. Preliminary results showed that including stopbank breaching in one catchment led to an average increase in inundated area by 48.2%, and a tripling in the potentially exposed area. This highlights the importance of accounting for the breaching in flood simulations and the potential risk associated with these structures. Further investigation is recommended to consider how mitigation strategies might be implemented to reduce this risk and improve safety in our communities.

Wang, Q., Henry, R. 36

Effect of Dynamic Loading Rates on the Seismic Response of Lightly Reinforced Concrete Walls

The revised minimum vertical reinforcement requirements for lightly reinforced concrete walls in NZS 3101:2006 Amendment 3 are sufficient to ensure the formation of a well-distributed plastic hinge under quasi-static cyclic loading. However, the performance of such walls subjected to earthquake-induced dynamic loading rates was uncertain. An experimental program was conducted on 15 reinforced concrete (RC) prisms representing the end zones of three RC walls with different minimum vertical reinforcement contents to help fill this research need. The prism tests verified that dynamic loading rates had a limited effect on the crack pattern but led to increased strengths and deformation capacity. The prism test results were then used in conjunction with wall test data to develop a finite element model to simulate the response of flexure-dominant lightly reinforced concrete walls. The first numerical analysis showed that the crack pattern of rectangular RC walls containing end zones equivalent to the test prisms was primarily a function of vertical reinforcement content and shear span ratio; loading rate was not a significant factor. Dynamic loading rates led to modest strength increases and more pronounced increases in the wall deformation capacity. For a more comprehensive investigation, a parametric study was conducted on 33 I-shaped RC walls with various flange-to-web length ratios and vertical reinforcement contents. The modelling results consistently showed that loading rate had a limited impact on cracking behaviour; the deformation capacity followed this trend. Instead, walls with increased flange-to-web length ratios had increased overstrength and decreased deformation capacities. Furthermore, increased concrete strength resulted in reduced cracking and drift capacity. However, the detrimental effect of higher concrete strength was mitigated by an increased steel strain hardening ratio. The results of this research confirmed that load rate effects did not cause any major concerns, and there is no need to revise design standards.

Wight, J. 84

Improving Urban Food Supply Chain Resilience using DES of Local Supply Chains

Following a disaster, local supply chains are essential to food resilience. Strengthening these supply chains requires the ability to evaluate alternative interventions. However, we must improve our ability to compare different interventions to enable local supply chains to deliver sufficient food to retail stores after a disaster. A Discrete-Event Simulation (DES) will be developed and used to address this. This model will explore different local supply chain interventions that strengthen local food distribution following a disaster. The quantitative output provides decisions makers with the ability to understand better the risks, resources, uncertainty, and trade-offs of the different intervention options.

Ye, X. **94**

Hierarchical Federated Learning With Social Context Clustering-Based Participant Selection for Resilient Internet of Things Applications

In light of the rapid advancements in embedded and communication technologies, the Internet of Things (IoT) has become a reality. IoT sensor networks are now capable of persistently monitoring various physical conditions and environmental factors, gathering vast amounts of data in the process. However, these geographically distributed systems present a unique challenge to existing machine learning strategies to accurately analyzing and interpreting the gathered data. This challenge is critical for ensuring remote sensing resilience and reliability, as inaccurate or imprecise data can lead to false interpretation and compromised system functionality. Distributed machine learning paradigms, such as federated learning, offer potential solutions for these challenges, providing a means for privacy-preserving knowledge sharing without the need to transmit raw data. Yet, federated learning can be susceptible to harmful participants who may share low-quality data, further compromising sensor reliability and overall model quality. Therefore, the selection of reliable and high-quality participants is critical to enhance the resilience and dependability of IoT sensor networks. In this article, we propose a unique clustering-based approach that harnesses context data for participant selection, designed to enhance both the resilience of IoT sensor networks. We will establish different edge participant groups and perform group-specific federated learning. The models from various edge groups will then be aggregated, enhancing the robustness of the global model and, by extension, the robustness of the overall sensor network. Experimental results underscore the efficacy of our proposed approach. Through strategic participant selection, our clustering-based hierarchical federated learning model demonstrates improved results in diverse IoT applications. This validation highlights the potential of our proposed method to improve not only federated learning performance and efficiency but also to significantly enhance the resilience of IoT sensor networks.

Yu, T., Enrique, D 37

Seismic strengthening of floor diaphragms with carbon fibre materials（CFRP）— FEM modelling

An important application of Fibre reinforcement polymer (FRP) is as a strengthening material in the seismic retrofit of existing reinforced concrete diaphragms. The location, flexibility and deformation levels of the ties have a significant influence on the response of the diaphragm and of the global building, but studying these aspects experimentally is expensive and time-consuming – if possible at all. This study will provide new insight into the finite-element (FE) analysis of a series of FRP-strengthened RC diaphragm specimens (with or without FRP anchors) to address the issue of incompatible deformation and global stiffness in externally bonded FRP systems. The performance of the numerical model will be demonstrated through comparisons of its predictions with relative experiment results. The FE model is expected to have good predictive properties when applied to a wider range of structural elements and the whole building.

Zhang, J., del Rey Castillo, E. 38

Optimizing the Design of EB-FRP for Tension Strengthening: Exploring the Impact of Diverse FRP Sheets and Anchor Configurations

Fiber-reinforced polymer (FRP) composites hold promise for enhancing the performance and service life of concrete structures. This study focuses on optimizing the design of externally bonded fiber-reinforced polymer (EB-FRP) systems for tension strengthening, with a specific emphasis on varied FRP sheets and fibre anchor configurations. While small-scale FRP

(thickness less than 1 mm and bond length no more than 250 mm) -strengthened concrete structures have been extensively studied, limited research exists on large-sized FRP systems. The single-lap shear tests were used to investigate the debonding capacity of large-sized EB-FRP systems, to explore the influence of thicker and longer FRP sheets, along with diverse configurations and alignments of fiber anchors. The findings highlight the importance of accurately predicting debonding force and reveal that thicker, stiffer and longer FRP ties generally exhibit higher bond strength and increased post-debonding deformation capacity. The limitations in current design codes and emphasize the need for reassessment were identified. This study provides practical guidance to engineers and designers, enabling them to optimize calculation of debond capacity for large-sized EB-FRP systems.

Zhu, C., Bradley, B., Bora, S. 22

Spectral Decomposition of Ground Motions in New Zealand using the Generalized Inversion Technique

In this study, we perform spectral decomposition of the Fourier amplitude spectra (FAS) of ground motions in the New Zealand Ground-Motion Database (GMDB v3.0) compiled during the National Seismic Hazard Model (NSHM) 2022 update project. We apply a non-parametric generalized inversion technique (GIT) to isolate source, path, and site effects from 20, 813 ground motions from 1200 crustal events recorded by 693 sensors at 439 unique locations. Each channel is treated as an independent "site". Using the high-quality observational dataset of nonparametric site responses, attenuation, and source spectra in the Fourier domain, we address questions regarding the classification and prediction of site effects, geometric spreading and Q attenuation, as well as source scaling in a NZ context.

We found that the current NZS1170.5 soil classification scheme has a rather limited capability in discerning different amplification curves; and shear-wave velocity VS30 is the best single parameter in describing linear site effects, followed by site period T0. In addition, we found a very mild earthquake magnitude-dependence of stress parameter Δσ (assuming a Brune-type circular rupture model) for crustal events and a slight increase in Δσ with focal depth. Δσ exhibits a statistically significant spatial clustering, which can potentially be utilized to improve ground-motion predictions at high frequencies.

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Intelligent and Data-driven Infrastructure Inspection and Management

Rapidly capturing and quantifying the extent and severity of damage on bridges could help engineers accurately understand the bridge's serviceability and safety, and make corresponding repair and retrofit plans. Among all bridge inspection methods, visual inspection is the most common technique; however, it is often a manual, risky and labour-intensive undertaking that might involve the use of, for example, cameras to record data and bridge inspection vehicles to access hard-to-access areas. Moreover, such an approach may disrupt the traffic and pose safety concerns to the inspectors. It might not be suitable for emergency bridge inspection in the aftermath of a major earthquake or other disasters, which requires complete rapid screening of all critical bridges in the disaster area within hours or several days to support further search and rescue. In recent years, Unmanned Aerial Vehicles (UAVs) have been growingly used for bridge inspection, which is a safe, efficient and accessible method. This poster will introduce recent and ongoing research efforts to develop a rapid, fully-automated and data-driven method for bridge inspection and management through combining the use of UAVs, 3D photogrammetric reconstruction, Building Information Modelling (BIM), Artificial Intelligence (AI) and Virtual Reality (VR).