2020 Te Hiranga Rū QuakeCoRE Annual Meeting Poster List

8th – 10th December, 2020 – Rutherford Hotel, Whakatū Nelson, New Zealand

Aigwi, E., Filippova, O., Sullivan-Taylor, B.   21

Public perception of heritage buildings in Invercargill's city centre

This study examined the public perception of heritage buildings in the city centre of Invercargill, New Zealand. An online survey was used to gain information from the public, and address policy-related issues regarding the demolition of a significant number of heritage buildings in Invercargill's city centre.

From over 600 respondents who completed the online survey, the perception of Invercargill's public regarding their city centre heritage buildings include: (i) 477 of the respondents were ICC ratepayers, of which about 69% of them were Invercargill residential ratepayers; (ii) the younger age groups participated the most compared to the older age groups, with a marginal gender balance of about 47% females and 48% males; (iii) a high proportion (77.2%) of the public agree that they should have their say on what happens with heritage buildings in the city centre in terms of potential alterations or demolition, and disagree (34.7%) that all heritage buildings in Invercargill's city centre should be demolished and replaced with modern structures. Also, the open-ended responses from the online survey identified a higher perception of the public (mostly in the 25-44 age group) regarding demolishing all the historical buildings in Invercargill's city centre and replacing them with modern structures (51%).

These discoveries are expected to provide strong arguments that will guide policy regulators in Invercargill on the public's preferences regarding the heritage buildings in the city centre. Although expert opinions from the local Council still play a central role in deciding which category of heritage buildings will be retained, information about the public's inclinations regarding such decisions would be useful in complementing those expert judgements.

Alger, B., Midwood-Murray, A., Midwood-Murray, B., Kaiser, L., Lake-Hammond, A., Boersen, K.   95

Te Hiranga Rū QuakeCoRE Quake Centre Outreach Programmes

This poster covers the Outreach Programmes created by Te Hiranga Rū QuakeCoRE along with Quake Centre. The Outreach Programmes cover a multitude of projects and audiences with the goal of creating a more resilient Aotearoa New Zealand.

Allen, N., Wilson, T., Kennedy, B., Scott, A., Stewart, C.   54

Multi-Volcanic Hazard Impact assessment for Residential Buildings in the Auckland Volcanic Field, New Zealand

Volcanic eruptions are complex events which commonly produce multiple hazards, which can occur simultaneously or one after another. Research has been conducted on volcanic hazards but the impact of interacting volcanic hazards, which could potentially cause greater damage than any single hazard, has only recently been explored. Single hazard impact assessments, while useful, do not fully describe the impacts experienced by assets during a volcanic eruption and do not consider potential interactions between multiple hazards.

This study outlines a conceptual framework for multi-volcanic hazard impact assessments to buildings and highlights data, considerations and assumptions which are required for the assessment. The aim of the conceptual framework is to incorporate hazard interactions into volcanic impact assessments in order to form a greater understanding of volcanic impacts and how impacts evolve through time. The framework is developed using current information on multiple and single volcanic hazard impact assessments and is designed to be built upon as more knowledge of hazard interactions becomes available. This study then applies the conceptual framework to multi-hazard eruption scenarios previously developed for the Auckland Volcanic Field, New Zealand.

The study also comprises empirical experimentation conducted to strengthen the conceptual framework by assessing the interaction of tephra fall and volcanic ballistic projectile impacts. The intent is to establish the fragility and habitability of New Zealand building systems during multi-volcanic hazards and to use this information to inform council and emergency responders of areas and buildings likely to survive an eruption and also to inform the improvement of residential building resilience for the future.

Avendano-Uribe, B., Milke, M., Beaven, S., Hughes, M.   55

The use of Participatory Modelling to integrate social and infrastructure resilience-building.

The Sendai Framework for Disaster Risk Reduction 2015-2030 adopted by the United Nations argues the need for planning resilience: 1) Improving physical infrastructure assets or physical systems, and 2) Improving social resilience or the social capital needed to effectively respond to a future disaster. However, disaster experts, planning managers, and policymakers made decisions assuming independence between social and physical systems. There is a need to understand the challenge to integrate both social and physical assets, their interactions, and non-linear complexity to make informed decisions.

For example, to prepare for faster recovery after the next earthquake, what would you prioritise for investment today?

(a) Building stronger classrooms, or (b) training teachers to be able to motivate children to study effectively in post-earthquake settings, or (c) some of both.

The difficulty in making this type of decision highlights the constant tensions between social and infrastructure resilience. The example demonstrates how the level of analysis needs to be at the larger socio-technical system.

This research aims to develop participatory methodologies to bring stakeholders together to collaboratively analyse and evaluate those interconnections. The four goals are to:

(1) Develop a conceptual model and validate with stakeholders,

(2) Develop materials and details for workshops on Participatory Modelling,

(3) Conduct trials and refine approach while also considering the added value of gamification

(4) Consider the potential for the approach to be applied to other socio-technical systems

The resulting modelling methodology will have the potential to improve disaster risk governance and disaster resilience planning and practice, in New Zealand and internationally, by empowering multiple stakeholders through the use of collaborative learning, and by increasing the efficacy and legitimacy of resilience-building decision making.

Bae, S., Huang, J., Bae, S., Bradley, B., Polak, V.   **91**

Web Interfaces for Earthquake and Ground Motion Simulation Visualisation

This poster presents two recently deployed web interfaces for data visualisation associated with New Zealand earthquakes, consequent ground motions, and geotechnical conditions.

Simulation Atlas (http://atlas.seistech.nz) provides a map-based visualisation of the historically-observed and potential future earthquakes on major known faults in New Zealand and key information about them, such as tectonic type, anticipated magnitude of a potential rupture, and probability in 50 years. For selected faults (100 at present), it provides the 3D animation of the potential ground motion produced by GMSimViz, an in-house-developed automation tool that converts the ground motion simulation output into a 3D animation.

NZ Vs30 model viewer (https://vs30.seistech.nz) allows users to visualise and query Vs30 estimates for Geology, Terrain and combined models for a specified location as well as geology and terrain categories. This gives an improved visibility about how a Vs30 is chosen making it easy to verify the value intuitively and also identify areas for improving such models for regional applications.

Barnhill, D., Wilson, T., Hughes, M., Beaven, S., Schoenfeld, M., Chandratilake, S., Jack, H.   **56**

Informing tsunami evacuation modelling by evacuation dynamics from Christchurch and Banks Peninsula during the 2016 Kaikōura earthquake

Recent tsunami events have highlighted the importance of effective tsunami risk management strategies (including land-use planning, structural and natural mitigation, warning systems, education and evacuation planning). However, the rarity of tsunami means that empirical data concerning reactions to tsunami warnings and evacuation behaviour is rare when compared to findings for evacuations from other hazards. More knowledge is required to document the full evacuation process, including responses to warnings, pre-evacuation actions, evacuation dynamics, and the return home. Tsunami evacuation modelling has the potential to inform evidence-based tsunami risk planning and response. However, to date, tsunami evacuation models have largely focused on the timings of evacuations, rather than behaviours of those evacuating.

In this research, survey data was gathered from coastal communities in Banks Peninsula and Christchurch, New Zealand, relating to behaviours and actions during the November 14th 2016 Kaikōura earthquake tsunami. Survey questions asked about immediate actions following the

earthquake shaking, reactions to tsunami warnings, pre-evacuation actions, evacuation dynamics and details on congestion. This data was analysed to characterise trends and identify factors that influenced evacuation actions and behaviour, and was further used to develop a realistic evacuation model prototype to evaluate the capacity of the roading network in Banks Peninsula during a tsunami evacuation. The evacuation model incorporated tsunami risk management strategies that have been implemented by local authorities, and exposure and vulnerability data, alongside the empirical data collected from the survey. This research enhances knowledge of tsunami evacuation behaviour and reactions to tsunami warnings, and can be used to refine evacuation planning to ensure that people can evacuate efficiently, thereby reducing their tsunami exposure and personal risk.

Bhanu, V., Chandramohan, R., Sullivan, T.　　　　　　　　　　　　　　　　　　　　　37

Earthquakes: Are we ready for a LONG one?

Recent studies have demonstrated the effect of earthquake ground motion duration on structural collapse capacity. They have also proposed methods to explicitly account for this effect of duration in structural design and assessment procedures via an adjustment to the design ground motion intensity. The objective of this study is to explore an alternative method to account for the effect of duration by adjusting the permissible peak deformations instead. This study investigates the effect of ground motion duration on the dynamic deformation capacity of modern-ductile reinforced concrete and steel framed structures. To this end, a method is proposed to evaluate the structural dynamic deformation capacity, associated with collapse, through incremental dynamic analysis. The proposed method is then utilised to investigate the correlation between dynamic deformation capacity and ground motion duration. Preliminary results indicate a reduction in the dynamic deformation capacity of the analysed structures under the increased cyclic demands imposed by long duration ground motions. These results will be assimilated to propose a modification to the peak deformation acceptance criteria employed by seismic design and assessment procedures to explicitly account for the effect of duration.

Bolomope, M., Filippova, O.　　　　　　　　　　　　　　　　　　　　　　　　　22

The relationship between building lifecycle of commercial properties and seismic adaptation in Wellington CBD

Earthquake fatality is a function of building vulnerability. Several studies that have investigated seismic disruptions have revealed that the severity of earthquakes is influenced by vulnerable buildings, especially unreinforced masonry (URM) structures. Also referred to as earthquake-prone buildings (EPB), most vulnerable buildings have been identified to be multi-storey and were constructed before World War II. In New Zealand, like other earthquake-prone countries, attempts are being made to reduce the susceptibility of the existing building stock to seismic disruptions. As a result, Pre-1976 buildings are required by law to be strengthened to at least 34% of the current new building standard (NBS) or risk being demolished. However, the financial burden of adhering to the stipulated standard is ominous, particularly for commercial building owners who seem to justify seismic strengthening by their ability to recoup commensurate return on investment through sustainable rents or leases. Consequently, the rate of compliance of commercial property owners to

seismic strengthening is market-driven and below the expectation of policymakers. Recognising that seismic strengthening can be combined with other forms of building adaptation (e.g., renovation, refurbishment, remodelling, rehabilitation and recycling of the original building structure or components) to minimise the associated cost of maintaining a building throughout its lifecycle, this study investigates the relationship between building lifecycle and seismic adaptation. Adopting multivariate, descriptive statistical analysis of multi-storey commercial buildings, this study leveraged the city scope database and wellington building consent information from 1995 to 2019 to evaluate documented adaptations on commercial buildings in Wellington CBD. Insights from this study will serve as a basis for policy recommendations that could enhance the commitment of commercial building owners to seismic adaptation.

Boston, M., Kurata, M., Kawamata, Y., Gipson, J., Kanao, L., Otsuru, S., Matsuo, S., Fujita, K., Aida, S., Tsutsumi, T., Cho, K., Kojima, K.   38

Integrated Complex Structural / Non-Structural Assessment on Steel Hospital Building

As of recent years, determining the resilience of structures has come to the forefront of earthquake research. In particular, hospitals have come under recent scrutiny for their ability to absorb disasters and continue to function with minimal impact. Research has shown that it is not only crucial for hospitals to be capable of treating patients affected by a disaster but also have the capacity to continue to see patients that need continuous care for chronic illnesses. Primarily, the research previously done examined only the structural vulnerabilities of hospitals with very few published papers taking a more holistic approach to measuring the resilience of the entire facility. Generating more robust resiliency models can improve hospital disaster prevention preparation and foster better decision making support for business continuity post-disaster.

The research proposed is an attempt to measure and classify functionality and the current resilience in a hospital setting by using: (1) a full-scale representation of a complex two-building multi-story hospital with both a fixed and isolated base, (2) various nonstructural components and (3) critical medical equipment. The testing will take place in December 2020, which presents an opportunity to host a multi-phase blind prediction competition. Each phase of the contest will highlight a different challenge: (a) Phase I – Prediction Techniques and (b) Phase II: Modeling and Verification. Students, researchers, and practicing engineers are encouraged to participate.

Calderon, R., Wilson, T., Leonard, G.   57

Potential hazard scenarios from Taupo Volcanic Zone: Geological and historical records of large silicic systems

Taupo Volcanic Zone (TVZ) is a large silicic system capable of a diverse range of volcanic activity, thus includes multiple sources of hazard. Of these, an explosive eruption is the worst probable scenario, which includes the last known supereruption (over 1,000 km3 of volume) around 25 thousand years ago in Taupo caldera. Nowadays, in terms of volcanic activity, minor unrest could be the volcano peacefully stirring to shortly return to sleep, with not surface hazards, the same minor unrest could be a precursory signal of a major eruption, or fall somewhere on the spectrum between the two. This ambiguity increases the uncertainty in forecasting models. We need to be prepared.

Fortunately, in term of hazards, high-silica (explosive) eruptions do not occur often based on geological and historical records. Unfortunately for scientific knowledge these records are scarce, and the associated deposits are usually heavily eroded. However, volcanologists strive to define compositional gradients of silicic magmas from rhyolitic deposits in different caldera volcanoes such as Long Valley, Yellowstone, Campi Fligrei, Novarupta and of course TVZ, among others. The Chaiten volcano in 2008, Chile, is a good case-study to understand silicic activity and their potential impacts, being the first scientifically monitored silicic eruption. Chaiten is a small (~ 3km diameter) caldera volcano located 10km to the north from Chaiten town, which was severely impacted by secondary lahars (volcanic mudflows that occur after the eruption has ended). This work is an effort to collect geological and historical records related to silicic systems and define a scenario framework for TVZ potential activity and impacts.

Carradine, D.   39
Determining the Seismic Performance of Structural Insulated Panels for New Zealand Buildings

New Zealand has an urgent need for quality housing that can be built quickly and affordably. Construction using structural insulated panels (SIPs) has been suggested as one possible solution. SIPs are sandwich panels made of two face layers and an insulating inner core. They can be prefabricated and assembled quickly on site for walls, floors and roofs and are one potential solution which could be used to increase construction speed and reduce overall building cost. While SIPs have been widely used overseas, less is known about their performance in a New Zealand context.

The project objective is to determine how SIP structural bracing systems perform when subjected to seismic loading. Testing and analysis will provide load and displacement data on SIP wall configurations that will be compared with NZBC code requirements on structural performance. Control specimens will also be tested utilising bracing systems commonly used in New Zealand residential buildings. The intersection of durability and seismic performance will be also be considered through cyclic testing of aged SIP specimens and connections.

The project is funded by EQC and BRANZ and will provide understanding of SIPs seismic performance in the New Zealand context and will support development of a more simplified consenting process for buildings constructed with SIPs. The project aims to establish consistent ways of evaluating SIPs to ensure they are suitable for New Zealand housing, whether they are produced domestically or imported. Results will provide a "whole system" analysis of SIPs and how they perform when used in conjunction with other common New Zealand building materials.

Chandramohan, R., Dashti, F., Dhakal, R., Elwood, K.   23
Seismic performance of a 9-storey pre-1970s reinforced concrete wall building in Wellington

Reconnaissance reports have highlighted the poor performance of non-ductile reinforced concrete buildings during the 2010-11 Canterbury earthquakes. These buildings are widely expected to result in significant losses under future earthquakes due to their seismic vulnerability and prevalence in densely populated urban areas. Wellington, for example, contains more than 70 pre-1970s multi-storey reinforced concrete buildings, ranging in height from 5 to 18 storeys. This study seeks to characterise the seismic performance and evaluate the likely failure modes of a typical pre-1970s reinforced concrete building in Wellington, by conducting advanced numerical simulations to evaluate

its 3D nonlinear dynamic response. A representative 9-storey office building constructed in 1951 is chosen for this study and modelled in the finite element analysis programme DIANA, using a previously developed and validated approach to predict the failure modes of doubly reinforced walls with confined boundary regions. The structure consists of long walls and robust framing elements resulting in a stiff lateral load resisting system. Barbell-shaped walls are flanked by stiff columns with sufficient transverse reinforcement to serve as boundary regions. Curved shell elements are used to model the walls and their boundary columns, for which the steel reinforcement is explicitly modelled. Line elements are used to model the frame elements. The steel reinforcement in each member is explicitly modelled. The floor slabs are modelled using elastic shell elements. The model is analysed under short and long duration ground motions selected to match site specific targets in Wellington at the DBE and MCE intensity levels. The observed response of the building including drift profiles at each intesity level, strain localization effects around wall openings, and the influence of bidirectional loading are discussed.

Chigullapally, P., Wotherspoon, L., Hogan, L.   82

Pushover Testing of Isolated Piles of the Whirokino Trestle

In New Zealand over 60% of State Highway bridges were designed and built during eras with low seismic provisions and most of these bridges are supported by pile foundations. An improved understanding of the in-service performance of these bridge foundations is a key aspect of seismic resilience, however there is limited data on the performance of these foundations in the field. A unique opportunity to study bridge foundations from this period has been presented during the replacement and demolition of the Whirokino Trestle in Foxton. A field testing programme involving a series of static cyclic and monotonic pushover tests has been developed in order to characterize the behaviour of isolated pile foundations that are embedded in loose to medium dense sands. Five different loading protocols were defined and applied across ten isolated bridge piles. To better understand the ability of modelling techniques to capture the observed field behaviour, computational models of these piles were developed using OpenSeesPy. The observations and results from this research will be used to improve the assessment approach for existing bridge foundations and seismic design standards.

Crawford, M., Saunders, W., Leonard, G., Hudson-Doyle, E., Johnston, D.   58

A Review of Natural Hazard Risk Governance in New Zealand: Complexity, inertia and options for moving forward

Natural hazard risk is governed in New Zealand through a complex system of national and local level legislation and policies. Interviews with local government practitioners' on the application of these policies reveal a number of challenges as well as solutions. However, practitioners also report that due to the complexity of the policy system for natural hazard management, the solutions cannot be applied because they are inhibited by the challenges. The result is a state of inertia for the development and application of natural hazard risk management in New Zealand. We suggest how we can overcome this complexity and break the inertia for the application of natural hazard management – focusing on systems thinking, dynamic pathways and disruptive innovation as options for moving forward.

Darling, M., Wilson, T., Orchiston, C., Adams, B., Bradley, B.   59

Safety does not take a holiday: Towards real-time indicators of population exposure for disaster risk assessments

> *Global approaches to understanding population exposure are often limited to formal data capture means, such as population census. Recent experience in Aotearoa New Zealand has shown a series of significant and disruptive 'shocks' to the traditional understanding of [a] population movements and [b] population census counts. For disaster risk reduction activities to be effective they must be representative; as such we build an understanding from 'informal' data capture methods towards near real-time indicators of disaster risk exposure.*
>
> *We build off an understanding from a series of targeted interviews with disaster risk reduction (DRR) practitioners, and experience from localised disasters; including the Murihiku Southland floods (2020), Rangitata flood event (2019), the Kaikōura Earthquake (2016), and the current COVID19 crisis. Through this experience we consider opportunities for novel dataset to inform DRR activities. This ongoing research presents some of the initial findings from data capture exercises; practitioner requirements; and opportunities to improve exposure datasets in a near real time sense. We conclude by adopting these principles to develop a methodology to inform a localised disaster risk context and exposure; the road to Piopiotahi Milford Sound.*

de la Torre, C., Bradley, B., McGann, C.   1

Modeling Soil Heterogeneity and Wave Scattering in Geotechnical Site Response Analysis

> *This study describes an approach for modeling wave scattering in geotechnical site response analysis by accounting for 2D spatial variability through correlated random fields. The results of 2D analyses with spatial variability are compared to those from 1D analyses with a deterministic homogeneous velocity profile and randomised profiles extracted from the 2D velocity model. Many ground motion indicators (including mean and standard deviation of various intensity measures) are investigated to assess and differentiate the influence from 1D velocity heterogeneities and 2D wave scattering, refraction, and surface wave generation. A detailed parametric analysis is conducted to determine how the various random field input parameters (such as the length scale, and strength of the heterogeneities) influence the predicted site response.*

Dempsey, D., Eccles, J., Huang, J., Nicolin, E., Stolte, A., Wotherspoon, L., Bradley, B.   2

Ground Motions Simulation of Hypothetical Earthquake Sources in the Upper North Island, New Zealand

> *The upper North Island of New Zealand has low rates of seismicity compared to the rest of the country. However, large concentrations of population and infrastructure mean this region is exposed to moderate magnitude earthquakes on the Kerepehi Fault within the Hauraki Rift, and the Wairoa North Fault in the Hūnua Ranges. Using a physics-based simulator, we modelled ground motions for Mw 7.3 and Mw 6.6 characteristic earthquakes on these structures. Low-velocity sediments in basins beneath the Hauraki Rift and the city of Hamilton were explicitly represented. For the Hauraki Rift earthquake, there was a 2 to 3 times amplification of shaking in Hamilton and towns near the Firth of*

Thames for periods longer than 1 s. Severe to violent MMI 8-9 shaking with cumulative absolute velocity exceeding 2 g.s is modelled close to the source, which would be a potential liquefaction hazard to stop banks and farmland in the Hauraki depression. Auckland, Hamilton and Tauranga would experience moderate to very strong MMI 5-7 shaking. Simulated impacts in Auckland are larger for the Wairoa North Fault earthquake, which would generate spectral accelerations in excess of 1.0 g at reservoir dams in the Hūnua Ranges, 0.4 g at the international airport, and 0.3 g at the CBD and port. Road, rail and electricity networks are particularly vulnerable to disruption where they converge at Takanini (South Auckland) just 10 km from the fault.

Deng, T., Henry, R.   40

Numerical modelling of tall reinforcement concrete wall designed with the minimum vertical reinforcement limits

Reinforced concrete (RC) structural walls are effective lateral force-resisting components that are commonly implemented in tall buildings. Recent studies have investigated the impact of minimum vertical reinforcement limits on the ductility at the plastic hinge region of RC walls and resulted in revisions to design standard requirements in both New Zealand and the United States. These studies focused on rectangular walls with a clear plastic hinge region at the wall base, whereas tall buildings exhibit more distributed plasticity demands up the wall height. In order to investigate the tall wall performance designed in accordance with the current standard, distributed plasticity beam-column fiber element was implemented to simulate the behaviour of the walls. The modelling technique was validated against the experimental tests with a range of vertical reinforcement contents to ensure a full range of wall sections can be accurately modelled. Following calibration and validation of the model, a push-over analysis was conducted on a 10 and 20 - storey tall wall satisfying the minimum vertical reinforcement requirement over the full wall height to understand the wall critical section performance where the additional reinforcement required in the plastic hinge region terminates. The result obtained from this numerical study illustrated the upper storeys with the minimum required vertical reinforcement above intend plastic height are susceptible to unintended concentrations in inelastic demands and fracture of vertical reinforcement.

Dhakal, R., Cubrinovski, M., Bray, J.   16

Liquefaction Assessment of Reclaimed Land at CentrePort

The 2016 Mw7.8 Kaikōura earthquake caused widespread liquefaction in the port of Wellington (CentrePort) which produced substantial ground movements, damage to structures and thick surficial manifestation of ejected soil. Observations of liquefaction-induced damage provide an opportunity to evaluate the applicability of widely used state-of-the-practice simplified liquefaction evaluation methodologies on the end-dumped gravelly fills and hydraulically-placed silty and sandy fills at CentrePort. Liquefaction assessment of the gravel reclamation poses several challenges due to its large percentage of gravel-sized particles making it difficult to obtain high-quality in situ data. The hydraulic fills at CentrePort are also of significant interest as they relate to a range of issues in the simplified engineering assessment around effects of fines and their plasticity on the liquefaction resistance.

Detailed damage inspections after the Kaikōura earthquake involved accurate measurements of ground deformations, well documented damage to structures, and good mapping of surficial evidence of liquefaction. Subsequent subsurface exploration investigated the thick end-dumped gravelly fills and hydraulically-placed dredged reclamations. Fieldwork included 121 CPTs, several shear wave velocity profiles, and logging of boreholes with soil samples collected from around the port. These investigations were utilised to develop detailed subsurface soil profiles for the reclamations. The spatial distribution, thicknesses, and depths of the fills were investigated and characteristic layers were identified. Grain-size curves and Atterberg test results gave insight into the properties of the fill material. Results of CPT-based liquefaction triggering and post-liquefaction reconsolidation settlement assessments using state-of-the-practice procedures were compared with observed damage and measured ground deformations. The next stage in this study is monotonic and cyclic loading of fill samples to determine the liquefaction resistance for characteristic densities/states of the fill deposits.

Dudek, T.   60

Examining the Association of Personality with Insurance Decisions

Personality plays a big role in people's decisions and behavior and hence affects their overall lives. For example, economic preferences and personality traits are important predictors of adult wellbeing (Friedman & Kern 2014) and socioeconomic outcomes (Borghans et al. 2008). Furthermore, personality traits are just as predictive of socioeconomic outcomes as cognitive measures (Almlund et al. 2011). We know little about the importance of personality with regards to financial decisions (Brown and Taylor 2014; Nyhus and Webley 2001; Salamanca et al. 2016). However, financial decisions are ubiquitous, and imprudent financial decisions can result in life disrupting problems: For example, lack of home insurance – which is a purely financial decision – can lead to the loss of one's home, which in turn might lead to mental health issues and loss of income. If personality is a significant predictor of insurance decisions, as is suggested by the association of personality with financial risk tolerance (Nicholson et al. 2005; Pinjisakikool 2018), then we would be wise to invest resources into promotion of those types of personality traits that are conducive to prudent financial decision-making, not only in the context of home insurance. In this study I elicit the big five personality traits and locus of control from participants who make insurance decisions in an incentivized online experiment administered on Prolific.ac. The goal of this study is to find out whether there is a connection between these traits and insurance decisions.

Dupuis, M., Schill, C., Lee, R., Bradley, B.   3

A neural network for ground motion quality classification from New Zealand earthquakes of variable magnitudes and tectonic types

High-quality ground motion records are required for engineering applications including response history analysis, seismic hazard development, and validation of physics-based ground motion simulations. However, the determination of whether a ground motion record is high-quality is poorly handled by automation with mathematical functions and can become prohibitive if done manually. Machine learning applications are well-suited to this problem, and a previous feed-forward neural

network was developed (Bellagamba et al. 2019) to determine high-quality records from small crustal events in the Canterbury and Wellington regions for simulation validation. This prior work was however limited by the omission of moderate-to-large magnitude events and those from other tectonic environments, as well as a lack of explicit determination of the minimum usable frequency of the ground motion. To address these shortcomings, an updated neural network was developed to predict the quality of ground motion records for all magnitudes and all tectonic sources—active shallow crustal, subduction intraslab, and subduction interface—in New Zealand. The predictive performance of the previous feed-forward neural network was matched by the neural network in the domain of small crustal records, and this level of predictive performance is now extended to all source magnitudes and types in New Zealand making the neural network applicable to global ground motion databases. Furthermore, the neural network provides quality and minimum usable frequency predictions for each of the three orthogonal components of a record which may then be mapped into a binary quality decision or otherwise applied as desired. This framework provides flexibility for the end user to predict high-quality records with various acceptability thresholds allowing for this neural network to be used in a range of applications.

Eade, C.   24

From Disaster to Resilience: A Comparative Study of Legal Models for Regulating Seismic Risk of Existing Buildings

Without addressing the underlying seismic vulnerabilities and risks of buildings, the consequences of a large earthquake can turn from minor disruptions of daily life into extensive disasters. While strong seismic building codes are now commonly enforced for new constructions, all seismically-active nations face the lingering issue of how best to regulate existing buildings to reduce vulnerability and strengthen resilience from earthquake risk. The current research hopes to examine this question by conducting a comparative study to understand how seismic risk for existing buildings is regulated between jurisdictions. Using the Sendai Framework for Disaster Risk Reduction 2015-2030 as a primary guide, the study aims to recognise the different legal methods employed by States to promote disaster resilience for existing buildings. Researched topics include financial and non-financial incentives, as well as the imposition of routine building inspections. Knowledge of legal approaches across jurisdictions helps to understand the strengths and weaknesses of different strategies, in an attempt to find a best practice regulation model of resilience for existing buildings to ensure the impact of future earthquakes is reduced.

Evans, A., Wilson, T., Hughes, M., Nilsson, D.   61

Assessing the evacuation capacity of remote rural communities highly exposed to tsunami hazard: a case study of Wairarapa coastal communities

Recent tsunami events around the world have produced devastating widespread impacts including large scale loss of life, displacement of coastal populations and economic disruption. In particular, the 2004 Indian Ocean tsunami and the 2011 Tohoku tsunami caused increased urgency globally for further research and understanding of the likelihood and consequences of such events occurring elsewhere. New Zealand is a tectonically active island country; thus, it is highly exposed to tsunami

hazard across its entire coastline, particularly on the east coast. Wairarapa, located on the lower east coast of the North Island in New Zealand is regarded as being a very high-risk area for tsunami. We undertook a preliminary study consisting of a tsunami exposure assessment to inform network-based vehicular evacuation modelling for a case study coastal area in the Wairarapa, Riversdale Beach. The findings revealed the potential for significant challenges in the evacuation procedure for Wairarapa coastal settlements due to a significant influx of visitors during the summer holiday period. This study aims to build on the preliminary research by using community engagement techniques to inform an agent-based evacuation model for Wairarapa and assess the overall evacuation capacity of the area. The research will fill a gap in tsunami literature both nationally and globally by using Wairarapa as a case study for assessing the evacuation capacity of remote rural communities which are highly exposed to tsunami hazard.

Faulkner, H., Hopkins, J., Collins, T.   25

Regulating for Resilience: The Wellington Case Study

The Regulating for Resilience project is funded by Flagship 3 of the QuakeCoRE Centre for Seismic Resilience.

The project will utilise the Wellington building database, developed by QuakeCoRE, to assess the effect of the current legal regime on the short, medium and long term seismic resilience of Wellington's CBD. In doing so, it will take the existing research on the legal framework and apply this to the current building stock. The nature of the current legal regime will require the researcher to develop methodologies and ideas beyond the narrow confines of the legal regime.

The primary method of the research will be using the QuakeCORE Wellington CBD database. The researcher will:

- *Map the current EQP labelled buildings (or those profiled as such) on the building database to understand the immediate impact of the current system.*
- *An assessment of buildings that are likely to be reviewed as to their seismic resilience. (e.g. Council buildings, buildings where change of use is likely, buildings in the process of redevelopment).*
- *An assessment of buildings that may have issues around seismic resilience but which will fall outside the current EQP building regime and are unlikely to be assessed.*
- *An assessment of the uses and impacts of these buildings in the various categories (i.e. economic impact of failure, priority buildings, etc).*

The key aim should be to assess (in broad terms) how effective the current regime will be in developing seismic resilience in Wellington. It is important to emphasise the work should look beyond just the risk of fatality or injury but consider the economic and social consequences of buildings being unavailable.

Filippova, O., Tong, Q., Ingham, J.   26

Can regulatory intervention be successful? Review of the Unreinforced Masonry Securing Fund

This research investigates performance of the Unreinforced Masonry Buildings Securing Fund (URM Fund) that was established under the Hurunui/Kaikōura Earthquakes Recovery (Unreinforced Masonry Buildings) Order 2017. This analysis contributed to the post implementation review of the Order in Council (Order) to inform MBIE about the effectiveness of the regulatory design and implementation of the URM building policy and the securing fund. The Order targeted street-facing URM buildings in areas with high pedestrian and vehicular traffic within Hurunui, Hutt City, Marlborough and Wellington where risk from falling facades and parapets was the greatest. The Order empowered these four territorial authorities to issues notices under section 124 of the Building Act 2004 (modified under the Order) to require work to secure parapets and/or facades, giving building owners 12 months to carry out the work. In February 2018, the Order was amended to extend the time to complete securing work by six months, until September 2018.

Review of the administrative data showed that the implementation of the URM Order was successful. As a result of the Order, 188 out of 189 buildings that have been issued with section 124 notices (under the Building Act) have been proven to be secure or were secured. Collectively, building owners and the government spent approximately $13 million on securing street-facing URM elements to ensure life safety of the public. The Order required significant resources to warrant success since its implementation would set the tone how for how local councils manage the wider EQPB programme.

Forcellini, D.   27

The role of location in the seismic assessment of Wellington CBD buildings

Past earthquakes have highlighted the influence of superficial soil deposits and wider sedimentary basin structures and the subsequent ground motion variability across the Wellington Central Business District (CBD). Dynamic response of buildings and soil-foundation-structure interaction (SFSI) effects depend on the dynamic characteristics of a structure, its foundation, and the underlying soil profile. In this regard, the seismic vulnerability of the combined system is a direct consequence of SFSI mechanisms that depend on the non-linear response of both the structure, such as plastic hinge development, and the foundation, such as compressive soil nonlinearity and uplift. The aim of this study is to quantify the influence of SFSI and location on the seismic response and vulnerability of low-rise buildings in Wellington and inform updated design guidance for these effects. A suite of low-rise building typologies are developed, along with representative foundation systems and regional soil profiles, based on an existing building database and representative designs for new buildings. A set of 3D numerical models of these typologies are developed using Opensees (the Open System for Earthquake Engineering Simulation) to capture the nonlinear response of the structure and foundation, and explore the influence of foundation modelling on the structural demand. Each model is sited at different locations around the CBD, with ground motion inputs representative of the variable site conditions used to assess the effect of location on seismic response.

Francis, T., Sulllivan, T.   41
Seismic Isolation of Light Frame Wood buildings in New Zealand

Seismic isolation is an effective technology for significantly reducing damage to buildings and building contents. However, its application to light-frame wood buildings has so far been unable to overcome cost and technical barriers such as susceptibility of light-weight buildings to movement under high-wind loading. The 1994 Northridge Earthquake (6.7 MW) in the United States, 1995 Kobe Earthquake (6.9 MW) in Japan and 2011 Christchurch Earthquake (6.7 Mw) all highlighted significant loss to light-frame wood buildings with over half of earthquake recovery costs allocated to their repair and reconstruction. This poster presents a value case to highlight the benefits of seismically isolated residential buildings compared to the standard fixed-base dwellings for the Wellington region. Loss data generated by insurance claim information from the 2011 Christchurch Earthquake has been used to determine vulnerability functions for the current light-frame wood building stock. By using a simplified single degree of freedom (SDOF) building model, methods for determining vulnerability functions for seismic isolated buildings are developed. Vulnerability functions are then applied directly in a loss assessment to determine the Expected Annual Loss. Vulnerability was shown to dramatically reduce for isolated buildings compared to an equivalent fixed-base building resulting in significant monetary savings, justifying the value case. A state-of-the-art timber modelling software, Timber3D, is then used to model a typical residential building with and without seismic isolation to assess the performance of a proposed seismic isolation system which addresses the technical and cost issues.

Ghasemi, A., Stephens, M., Elwood, K.   28
Wellington Building Inventory: Rapid Earthquake Response Framework

This research is focused on regional building responses to earthquakes and identification of broad vulnerability archetypes to allow for development of high-level retrofit strategies to increase resilience and limit human and economic loss. Wellington has been selected as the case study for this research due to the unique access to building data within the central business district. In the first phase of this research, a 'rough' near real-time seismic impact framework was designed to identify the response of buildings to an earthquake. This framework showcases the consequences on the Wellington building inventory caused by an earthquake by comparing accelerations recorded at GNS strong motion stations to building design accelerations both at the SLS and ULS levels. The outputs of the framework are presented on an interactive map, which facilitates the different stakeholders, i.e., building owners and decision-makers to provide a rough estimation of the severity of building-level seismic impacts. The next phase of the research is focused on two main objectives: (1) quantifying the direct repair costs associated with earthquake damage to common structural vulnerabilities in terms of annual monetary loss and disruption and (2) proposing high-level retrofit strategies to reduce financial and human loss. To address these objectives, ongoing work is focused on identifying structural vulnerabilities common among Wellington buildings, and classifying the buildings in the inventory into the vulnerability groups using high-level clustering methods. Candidate buildings from each vulnerability group will be selected for detailed modeling, and the seismic response of these buildings will be quantified to develop high-level retrofit strategies to mitigate the social/financial risks of Wellington buildings.

Gonzalez, R., Stephens, M., Toma, C., Elwood, K., Dowdell, D.   42

Holistic Evaluation of Resilient Structures: The Environmental Performance of Beyond New Zealand Building Code Structures.

Designing a structure for higher- than-code seismic performance can result in significant economic and environmental benefits. This higher performance can be achieved using the principles of Performance-Based Design, in which engineers design structures to minimize the probabilistic lifecycle seismic impacts on a building. Although the concept of Performance-Based Design is not particularly new, the initial capital costs associated with designing structures for higher performance have historically hindered the widespread adoption of performance-based design practices. To overcome this roadblock, this research is focused on providing policy makers and stakeholders with evidence-based environmental incentives for designing structures in New Zealand for higher seismic performance. In the first phase of the research, the environmental impacts of demolitions in Christchurch following the Canterbury Earthquakes were quantified to demonstrate the environmental consequences of demolitions following seismic events. That is the focus here. A building data set consisting of 142 concrete buildings that were demolished following the earthquake was used to quantify the environmental impacts of the demolitions in terms of the embodied carbon and energy in the building materials. A reduced set of buildings was used to develop a material takeoff model to estimate material quantities in the entire building set, and a lifecycle assessment tool was used to calculate the embodied carbon and energy in the materials. The results revealed staggering impacts in terms of the embodied carbon and energy in the materials in the demolished buildings. Ongoing work is focused developing an environmental impact framework that incorporates all the complex factors (e.g. construction methodologies, repair methodologies (if applicable), demolition methodologies (if applicable), and waste management) that contribute to the environmental impacts of building repair and demolition following earthquakes.

Gray, L.   62

Explicit, implicit and internalised: Bias and large bodies in disaster risk reduction - a multi-method study

Background: Bias is well recognised in job recruitment: those we favour, those we are less likely to employ, and those who do not even get on the shortlist. Some decisions are purposeful and explicit, other decisions are unconsciously made (implicit). At a time when implicit bias relating to sexual orientation and ethnicity move towards a more neutral stance, implicit bias has increased for large bodied people.

Method: Multi-method research was undertaken. Fifty-one emergency managers participated in an exploratory online survey. Data were analysed and described. Sixteen large bodied people and eleven health or emergency managers participated in semi-structured interviews. Interviews were audio-recorded and transcribed and inductive thematic analysis undertaken.

Results: While large bodied people believe that emergency management should consider their additional needs, emergency managers are not currently planning for or specifically considering large bodied people. Planning decisions for evacuation were likely to be influenced by how much time and

resource one larger person would require versus several smaller people. Some of the large bodied people interviewed also suggested that the needs of others should take priority over themselves Conclusion: Despite significant numbers of large bodied people in Aotearoa New Zealand (population prevalence: total population 5.5%, Pacific People's 21%, Māori 12%) size, shape or weight is not currently considered in disaster planning. Disaster triage or evacuation decisions by emergency managers may be influenced by implicit and explicit bias. Similarly, a larger bodied person volunteering for others to be 'saved' ahead of themselves may involve internalised bias. Individuals, health and emergency personnel need to recognise and explore their own biases and how these may shape planning and response decisions made.

<u>Gurung Shrestha, S.,</u> Chandramohan, R., Dhakal, R.   43

Using Genetic Algorithms to Select Ground Motions for conducting HC-IDA

This study applies genetic algorithms to select a set of generic ground motions for conducting hazard-consistent incremental dynamic analysis (HC-IDA). HC-IDA is a recently developed analysis procedure that overcomes the primary drawback of traditional incremental dynamic analysis (IDA) by enabling the computation of a hazard-consistent collapse fragility curve. HC-IDA has been shown in previous studies to produce results comparable to multiple stripe analysis (MSA), while not requiring any selecting site or structure specific ground motion selection. The set of ground motions required to conduct HC-IDA should ideally cover the broad range of response spectral shapes and durations expected at the site of interest, and they should be uniformly distributed to minimise the uncertainty in predicting ground-motion collapse intensity. This study employs genetic algorithms, which imitates the process of natural selection, to select an optimal set of ground motions. The selection procedure starts with an initial guess of the optimal record set, obtained via Latin hypercube sampling. The fitness of the selected record set, which is quantified using the Kolmogorov-Smirnov test, is then optimized over successive generations by crossover and mutation operations. Using this procedure, a set of 100 ground motions covering the range of ground motion response spectral shapes and durations anticipated at Wellington is selected. The wide range of ground motion response spectral shapes and durations expected in Wellington ensures that this set is also usable for a wide range of other sites in New Zealand. The selected record set is demonstrated to perform significantly better than other commonly used record sets such as the FEMA P695 far field set.

<u>Harrison, S.</u>, Potter, S., Prasanna, R., Doyle, E., Johnston, D.   63

Accessing, Sharing, and Using Impact Data in New Zealand for Disaster Risk Reduction

Understanding disaster risk is the first priority of the Sendai Framework for Disaster Risk Reduction for informed policy development and implementation. To achieve this countries and regions must promote the collection, analysis, management, use and dissemination of relevant data and practical information according to the needs of various users. Losses and damage, social and cultural impacts, and vulnerability, exposure, and hazard data are key datasets highlighted in the Sendai Framework. In practice these datasets enable enhanced disaster risk modelling, assessment, mapping, monitoring and multi-hazard impact-based early warning systems.

Collecting and accessing this data is wrought with social and technical challenges. Methods for collecting data differ by country and region, making it difficult to collect and use standardised data. As such, there is a need for better collection and access to impact, vulnerability, and exposure information.

This poster presents a portion of an ongoing PhD study investigating the current data sources and datasets available in New Zealand for understanding disaster risk. This study aims to map out existing and potential impact data sources in New Zealand to build an understanding of optimal impact data collection, sharing, and storage, drawing from both national and international practices. The objective is to help stakeholders understand what is available to them, and how they can access and contribute impact information. This will contribute to the implementation of impact-based forecasts and warnings in New Zealand and support efforts towards meeting the requirements of the Sendai Framework to build a national impacts and losses database.

Hashemi, A., Zarnani, P., Quenneville, P.   44

The innovative Resilient Slip Friction Joint (RSFJ) technology has recently been developed and introduced to the New Zealand construction industry. This low damage system aims to minimize the earthquake-induced damage and downtime while providing life-safety. The RSFJ is a self-centring friction-based energy dissipation device that provides the required seismic performance regardless of the material used for the main structural components. It can be used in various lateral load resisting systems including (but not limited to) shear walls, rocking columns, tension-compression braces, tension-only braces and moment resisting frames.

Given the nature of this technology, it can be implemented in different lateral load reissuing systems with different configurations. Since 2016, this technology has been implemented in different projects in New Zealand and overseas. This poster provides a summary of different projects that the technology was implemented, and the design approach used for each project is presented and discussed. Furthermore, recent outcomes of the research on this technology is presented. This includes large-scale testing of tension-only braces, tension-compression braces, moment -resisting frames and specimen design for a full-scale shake table test.

Overall, this paper intends to give an insight to the earthquake engineering society about the advantages of the technology, design methods and implementation techniques.

Algiriyage, N., Prasanna, R., Stock, K., Doyle, E., Johnston, D.   64
Real-time Disaster Event Extraction from Unstructured Text Sources

Emergency response has to start within seconds of the onset of a disaster. However, getting a quick understanding of the situation as it unfolds is a challenging task for responding organisations due to time-consuming and labour-intensive traditional approaches. The rapid advancement of technology has provided non-traditional ways of getting to know more information, such as social media and online news.

Automatically extracting events from the unstructured text can address the challenge of information scarcity currently faced by emergency responders. The task is to identify the main event from online

text sources such as online news and tweets by answering 5W1H questions (who did, what, when, where, why and how).

In this poster, we present our early work of detecting disaster events in real-time from unstructured text sources to improve the situation awareness of emergency responders. We have collected news headlines from the National Institute of Water and Atmospheric Research (NIWA) about historic weather events in New Zealand over a period of more than 20 years from 01.01.2000-01.06.2020. Also, we incorporated human-labeled tweets collected from the 2015 Nepal earthquake and the 2013 Queensland floods downloaded from crisisNLP . We propose a novel algorithm that uses syntactic and domain-specific rules to automatically extract the relevant phrases from news articles and tweets to provide answers to the 5W1H questions. The algorithm identifies disaster events from unstructured text sources in real-time by providing answers to these questions.

Hoang, T., Noy, I.   29

The effects of managed retreat (red zoning) on the relocated households in New Zealand

The question of whether forced relocation is beneficial or detrimental to the displaced households is a controversial and important policy question. After the 2011 earthquake in Christchurch, the government designated some of the worst affected areas as Residential Red Zones. Around 20,000 people were forced to move out of these Residential Red Zone areas, and were compensated for that. The objective of this paper is twofold. First, we aim to estimate the impact of relocation on the displaced households in terms of their income, employment, and their mental and physical health. Second, we evaluate whether the impact of relocation varies by the timing of to move, the destination (remaining within the Canterbury region or moving out of it) and demographic factors (gender, age, ethnicity). StatisticsNZ's Integrated Data Infrastructure (IDI) from 2008 to 2017, which includes data on all households in Canterbury, and a difference-in-difference (DID) technique is used to answer these questions. We find that relocation has a negative impact on the income of the displaced household group. This adverse impact is more severe for later movers. Compared to the control group (that was not relocated), the income of relocated households was reduced by 3% for people who moved immediately after the earthquake in 2011, and 14% for people who moved much later in 2015.

Hogan, L.   45

Improved panel-to-foundation connections for low-rise precast concrete buildings

Low-rise precast concrete panels are commonly used in the construction of commercial, industrial, and residential buildings across New Zealand. This prevalence is mainly due to the significant reductions in construction time they offer, while also being readily available from precast companies. Concerns surrounding the seismic performance of low-rise precast concrete buildings have been identified after the Christchurch Earthquakes in 2010/2011. These panels were designed with threaded inserts as part of the panel-to-foundation joint connections that were vulnerable to brittle failures when loaded in the out-of-plane direction. As this construction form continues to be very popular in New Zealand, two alternative panel-to-foundation connections were developed and tested in the out-of-plane direction. One connection utilized a foundation block on the exterior of the panel while the second connection utilized a double layer of reinforcement and threaded starter bars. Both

panels were able to develop the full moment capacity of the panel without damage to the foundation, and were able to sustain rotations up to 6% drift.

Holden, C., Sklowdowska, A., Gueguen, P.   4

Testing advanced seismological methods towards a better understanding of the built environment response to earthquakes in New Zealand

Earthquakes of the last decade have shown that while most structures were able to prevent loss of lives, the costs associated with assessing building integrity were affecting the New Zealand economy excessively. Detailed, automated, near real-time use building monitoring data can be used to inform decisions on re-entering or abandoning buildings after an event.

New Zealand benefits from a world class network of seismic instruments (GeoNet.org.nz), and the Building Instrumentation Programme has been recording earthquakes in numerous buildings for ten years. Recent research has demonstrated the value of applying system identification and damage detection methods to seismic structural monitoring data. We present results applying advanced seismological methods to two Wellington buildings with different typologies and design periods. Our analysis provides a robust and detailed assessment of structural responses over time and for various earthquake loadings.

Horsfall, S., Hatton, T., Collins, T., Brunsdon, D.   65

Earthquake Risk Reduction Behaviours in Organisations: Understanding what organisations are doing to stay safe in New Zealand's seismically active environment.

Creating a resilient New Zealand requires effort from all of society. Organisations, in particular, have the potential to be a catalyst in building a resilient nation. Organisations that effectively manage natural hazard risk provide safety for their employees, minimise economic losses through downtime, and are able to support community recovery by providing key services, employment, and economic stimulus.

Organisations have a number of regulatory obligations to protect their employees and other stakeholders, such as those in the Health and Safety at Work Act 2015 (HSWA). The HSWA has a core purpose to "protect workers and other persons against harm to their health, safety, and welfare by eliminating or minimising risks arising from work….". On the surface, the legislation is well placed to promote seismic risk reduction activities, however we currently have little understanding of how organisations interpret and act on obligations within the HSWA to reduce seismic risk. Similarly, it is unclear how the HSWA would be enforced in relation to seismic hazards.

In this EQC-funded project, we will investigate the application of HWSA to seismic risk. We will seek to understand the legislative and policy environment and compare this with organisations' a) understanding of likely earthquake impacts, b) steps taken to reduce risk, and c) enablers and barriers to action by organisations. The research will help policy-makers and regulators understand how organisations are managing seismic risk and how existing legislative tools, such as HSWA, can be better leveraged to promote disaster risk reduction.

Horspool, N., Elwood, K., Gerstenberger, M.   5

Risk targeted hazard spectra for seismic design in New Zealand

New Zealand, like many other countries, designs buildings for ground motions with a uniform probability of occurrence such as the 1 in 500-year ground motion. If the expected response of a structure to the design ground motion is known with certainty, then this uniform hazard approach results in uniform risk of exceeding this limit state across a region. However, in reality, structures have uncertainty in their response due to variations in design, construction practices, strength of materials, and code compliance and this variability leads to non-uniform risk across a region. An alternative approach is to use risk targeted hazard spectra that are derived through convolution of hazard curves with representative fragility functions and result in uniform risk across a region. The use of risk targets allows performance objectives of building codes to be set in terms of acceptable levels of risk such as life safety, economic loss and downtime, and be developed with societal input. In this study, risk targeted hazard spectra are developed for New Zealand using multiple risk targets for individual and societal risk at the building and city scale. The results show how risk targeted hazard spectra can be incorporated in the existing NZS1170.5 loading standards with minimal changes. The proposed framework can be used to achieve uniform seismic risk in the building code and design for the performance of individual buildings as well as the performance of cities using multiple risk targets.

Hudson-Doyle, E., Paton, D., Johnston, D., Smith, R.   66

Effective communication of model uncertainty: moving towards decision-relevant communications

Disaster risk management requires effective communication of complex technical information: in pre-event planning and mitigation, in response activities, and during recovery processes. These range from technical risk assessments to impact projections, and simulations of the outcomes of recovery and adaptation decisions. Each relies on a suite of numerical models, from models of the hazard (e.g., tsunami) to economic projections of decision impacts. Many novel processes exist to communicate these models to both the public and decision makers in policy and practice settings. However, how we communicate the uncertainty inherent to these models remains a challenge. Non-communication of uncertainties is problematic: interdependencies between event characteristics over time create evolving uncertainties that can eclipse any simulated outcome uncertainties. We review the literature covering the many challenges of communicating uncertainty, and present the findings of a metasynthesis literature review for effective communication of model uncertainties. Themes identified include: a) clear typologies to identify and communicate uncertainties, b) effective engagement with users to identify uncertainties to focus on and when, c) managing ensembles, confidence, bias, consensus and dissensus, d) methods for communicating uncertainties., e.g., maps, graphs, time, and e) the lack of evaluation of many approaches currently in use. We propose communicators move from a one-way dissemination of advice, towards two-way and participatory approaches that identify decision-relevant uncertainty and data information needs pre-event, via a shared uncertainty management scheme. This will help identify what communication efforts should focus on during a crisis, and thus enhance situation awareness and data sharing throughout the disaster cycle.

Kahandawa, R., Domingo, N., Chawynski, G., Uma, S.   46

Post earthquake cost estimation model for damage repair work

Cost estimation of the repair or rebuild work for damaged buildings is a crucial ingredient for the recovery effort after an earthquake. Due to the vast number of houses that can be damaged after an earthquake, a quick and accurate cost estimation process is required to start the rehabilitation work. Currently, cost estimation work is conducted by manual human input, and there are no post-earthquake cost estimation models available. There are pre-earthquake cost estimation tools like HAZUS, PACT, SLAT and SP3 and research on the factors affecting the inaccuracies of these tools. This model focuses on using processes of the pre-earthquake cost estimation tools, improving on their drawbacks to build a post-earthquake cost estimation tool for broader use. The model is a combination of both pre-earthquake tools and post-earthquake manual process. This method enables the model to produce more accurate costs that pre-earthquake models and more rapid estimates than manual cost estimation done after an earthquake. The method was verified by 15 cost estimators, builders and engineers. This method is currently being built into a tool for practical use.

Kaiser, L.   67

Investigating Tangata Whenua Views and Responses to Climate Change

Tangata Whenua residing in Murihiku (Southland region), Aotearoa/New Zealand have experienced a long history of seismicity, resulting from their proximity to the Alpine Fault system. Earthquakes have significantly shaped the land, and exacerbated the ongoing impacts of other environmental hazards. Climate change-related events such as sea level rise, ex-tropical cyclones, and severe storms (e.g. February 2020 Southland Floods) have added to the complex hazardscape in the region, and adversely impacted Tangata Whenua, physically, culturally, economically and spiritually. Iwi, hapū and marae frameworks such as Ngāi Tahu ki Murihiku's Te Tangi a Tauira environmental management plan (2008) and Te Rūnanga o Ngāi Tahu's 'He Rautaki Mō Te Huringa o te Āhuarangi' climate change strategy (2018) take into account these change-related impacts and provide mechanisms for preparing, mitigating and responding to them.

Kaushal, S., Ingham, J., Dizhur, D.   30

Using Machine Learning techniques to predict seismic damage in Dunedin

Unreinforced masonry (URM) structures comprise a majority of the global built heritage. The masonry heritage of New Zealand is comparatively younger to its European counterparts. In a country facing frequent earthquakes, the URM buildings are prone to extensive damage and collapse. The Canterbury earthquake sequence proved the same, causing damage to over _% buildings.
The ability to assess the severity of building damage is essential for emergency response and recovery. Following the Canterbury earthquakes, the damaged buildings were categorized into various damage states using the EMS-98 scale. This article investigates machine learning techniques such as k-nearest neighbors, decision trees, and random forests, to rapidly assess earthquake-induced building damage. The damage data from the Canterbury earthquake sequence is used to obtain the forecast model, and the performance of each machine learning technique is evaluated using the remaining (test) data. On

getting a high accuracy the model is then run for building database collected for Dunedin to predict expected damage during the rupture of the Akatore fault.

Kowal, A., Jeong, S., Wotherspoon, L., Stirling, M.   **6**

Ground motion simulations for the Dunedin - Mosgiel area

The research addresses Dunedin-Mosgiel seismic hazard. We use scenario earthquakes from local active faults and 2D basin modelling to develop ground motion simulations for the two urban areas. The simulations utilise numerical methods and models that explicitly incorporate the physics of the earthquake source and the propagation of seismic waves in the areas of interest..The simulation method used is that of Graves and Pitarka, and the software platform used is the SCEC BBP.

A major part of the research is dedicated to modelling site effects. Based on 1D wave propagation theory the large impedance contrast resulting from shallow soft soils overlying the harder rocks may cause strong amplification of ground motions at high frequencies. Site response analyses are performed with the nonlinear finite element software OpenSees. The dynamic response characteristics of soft layers are simulated by a pressure dependent multi yield plasticity model, developed specifically for modelling the behaviour of cohesionless soils. The input ground motions are single components developed by deconvolution of ground motion simulations, so they are modelled below the rock-soil interface, and then convolved via nonlinear wave propagation site response analysis within the soil column.

Two profile lines are selected for 2D-based ground motion simulations, which represents a progression from the 1D analyses: The two lines are, namely: the Kettle Park line, which runs east-west across south Dunedin; and the Taieri basin line, which runs northwest-southeast through Mosgiel. The area of Kettle Park has been the focus of previous QuakeCoRE-funded field investigations of site response. The Taieri basin line crosses the deepest fault-controlled sedimentary basin in the greater Dunedin area.

Noy, I., Syed, Y., Lambie, E., Pastor, J.   **92**

A GIS platform linking building attribute datasets for seismic research and societal resilience in Dunedin and Palmerston North

This poster describes the initial steps and benefits in the creation of a GIS building inventory platform that links spatial, geotechnical, structural, non-structural, occupancy, and economic datasets in urban areas for multidisciplinary seismic-related research. This will enable interested parties to pursue research projects that aim to solve what are inherently complex and multi-faceted problems, such as modelling building behaviour and performance, prioritising earthquake retrofitting and cordon management. A span of datasets are linked to existing multi-storey buildings and integrated into an easy-to-use ArcGIS online platform that has a range of purposes, including: (1) providing the best scientific knowledge spanning numerous disciplines to inform earthquake resilience research; (2) allowing different organisations, including local councils and iwis to make evidence based decisions regarding event-based planning and emergency management and (3) fostering engagement and sharing of data between separate research communities across different disciplines. Urban areas of Dunedin and Palmerston North are currently being used as case studies to test the feasibility and

relationships required to enable the GIS platform's capabilities. Researchers have been involved in a collaborative, multi-disciplinary, and flexible approach to ensure the GIS platform can benefit a wide array of groups and individuals. The long-term goal for this project is to extend the GIS platform nationwide to construct a national, multi-disciplinary building database using consistent data standards.

Lee, R., Bradley, B., Graves, R., Paterson, J., Motha, J., Huang, J., Schill, C., Polak, V., Bae, S.　　**7**

Source Considerations for Moderate Magnitude Earthquake Ground Motion Simulation Validation

In New Zealand, previous hybrid broadband ground motion simulation validation efforts were initially focussed on large magnitude (Mw) earthquakes, and more recently on small magnitude earthquakes (3.5<Mw≤5.0). Both regional and nation-wide validation exercises have led to improvements to the Graves and Pitarka (2010,2015) simulation methodology and/or velocity modelling, both crustal and shallow. Naturally, the next step is to consider moderate magnitude earthquakes (5.0<Mw≤6.0) which bridge the gap between previous studies. This study presents preliminary results on the validation of moderate magnitude active shallow crustal earthquakes in New Zealand with emphasis on source modelling considerations. 62 earthquakes are considered with 1726 ground motions across 202 recording stations. The earthquake fault ruptures are kinematically modelled as single plane finite faults given there are no detailed source inversion studies for these events (with few exceptions). The effect of kinematic slip generator, fault dimension aspect ratio and choice of centroid moment tensor nodal plane on the simulated ground motions are examined. The simulations are compared against observed records to quantify their predictive capability for moderate magnitude earthquakes, identify aspects for future improvement and provide insights into the salient ground motion characteristics observed.

L'Hermitte, C., Wotherspoon, L.　　**83**

Resilient and adaptable transport across modes: key enablers and existing barriers in New Zealand

As illustrated by the 2016 Kaikōura event, earthquakes can severely disrupt freight movements. To ensure supply chain continuity, commercial operators need to swiftly adjust their transport operations across modes (e.g. from road to coastal shipping). Rapid shifts require coordination because modes operate differently and actors typically control only a part of the transport chain.

Little is known about transport reconfigurations in the New Zealand context. Therefore, this study addresses the following research question: what facilitates/impedes rapid modal shifts in the aftermath of an earthquake in New Zealand?

The focus is on the physical, data and business interfaces that interconnect the various transport modes and make them fit together. Qualitative data was collected through 18 interviews with 26 key informants, including policy makers, industry representatives, transport practitioners and users of freight transport.

The preliminary results of a thematic analysis of the data show that multiple factors contribute to the building of transport resilience and the ability of the New Zealand transport system to deal with

shocks. In particular, the following elements are among those mentioned by the interview participants in relation to the 2016 Kaikōura event:

Physical	_Enablers:_	Use of standard load units (shipping containers)
		Intermodal terminals (e.g. Spring Creek)
	Barriers:	Lack of capacity (e.g. shipping containers)
		RO-ROs unable to berth, had the ferry terminals be taken out
Data	_Enablers:_	Truck drivers reporting ground information
		Rapid exchange of information (e.g. transport capacity available, bookings)
	Barriers:	Different data standards and lack of interoperable information systems
		Advanced technologies (e.g. tracking, analytics) not sufficiently leveraged
Business	_Enablers:_	Pre-established contacts with multiple transport operators
		Synchronised timetables
	Barriers:	Lack of understanding of the specific transport requirements of each mode

Lin, A., Wotherspoon, L., Blake, D., Bradley, B., Motha, J.   17

Liquefaction exposure and impacts across New Zealand State Highways

New Zealand State Highways are exposed to a range of natural hazards including earthquake triggered liquefaction and lateral spreading. Using a recently developed geospatial model, a framework to assess the liquefaction risk across the State Highway network was proposed, combining liquefaction probability, recurrence and potential socio-economic impact. To demonstrate this framework, liquefaction susceptibility and probability was estimated across the State Highway network for a set of ten earthquake scenarios. Overall exposure was measured for each network section by counting the number of earthquakes that result in a liquefaction probability of 40 % or higher (liquefaction recurrence). In addition, results were linked to the One Network Road Classification (ONRC) in order to quantify the potential socio-economic impact. Model outcomes suggests that network sections with a high liquefaction exposure do not necessarily lead to extensive consequences, and vice versa, suggesting that both exposure and impact are important to evaluate liquefaction risk across the State Highway network. Further research needs to include more seismic events, elaborate on network criticality, such as the consideration of indicators specific to freight movement, and take alternative routes as well as alternative transport modes into account. This research aims to support decision making processes regarding infrastructure investment, emergency planning, and prioritisation of post-earthquake reconstruction projects.

Logan, T.   84
Resilience as a function of equitable access to services and essentials - integrating infrastructure and community resilience approaches

Despite extensive discussion surrounding community resilience, operationalizing the concept remains challenging. The dominant approaches for assessing resilience focus on either evaluating community characteristics or infrastructure functionality. While both are useful, they have several limitations to their ability to provide actionable insight for community resilience. More importantly, the current conceptualizations do not consider people's access to services and essentials or how that access is impaired by hazards. We argue that people need access to services such as food, education, healthcare, and cultural amenities, in addition to water, power, sanitation, and communications, to get back some semblance of normal life. Providing equitable access to these types of services and quickly restoring that access following a disruption is paramount to community resilience. We present a framework for community resilience and a data-driven methodology that could be used to enhance community resilience through equitable access to amenities.

Loghman, V., Bradley, B., Chandramohan, R., Lee, R., McGann, C.   8
Validation of ground-motion simulations using Advanced Intensity Measures - New Zealand small magnitude events

Validation is an essential step in evaluating the applicability of simulated ground motions for utilization in engineering practice and also provides valuable insights towards improving the simulation methodologies by highlighting specific limitations of simulation methods. Simulated ground motions can be validated with a range of model complexity, from a single degree of freedom (SDOF) through to complex 2D/3D systems.

A novel analysis framework has been developed to infer the probable causative sources related to the discrepancies between observed and simulated ground motions. This framework enables differences in the response of a complex system to be correlated to the differences in simplified intensity measures as well as remaining "unexplained" variability. This procedure therefore, provides valuable feedback for improving the simulation methodologies by linking the identified biases to causative model assumptions.

As a case study, validation of simulated ground motions was investigated by comparing the dynamic responses of two steel special moment frames (SMRF) subjected to the observed and simulated ground motions of 498 small-magnitude earthquakes (3.5≤Mw≤5.0) across New Zealand. The seismic responses of the structures are principally quantified via the peak floor acceleration and maximum inter-storey drift ratio. Overall, the results indicate that the majority of the bias between the observed and simulated responses can be explained by the difference of the spectral acceleration at the main modes of vibration contributed to the selected response. This study will be extended to consider higher magnitude events and various structural models.

Miranda, C., Becker, J., Jonhston, D., Toma, C., Elwood, K.   **31**

Future seismic performance expectations of the wooden-framed houses by homeowners

New Zealand has a long tradition of using light timber frame for construction of its domestic dwellings. After the most recent earthquakes (e.g. Canterbury earthquakes sequence), wooden residential houses showed satisfactory life safety performance which aligns with New Zealand design codes requirements. However, poor performance was reported in terms of their seismic resilience that can be generally associated with community demands.

Future expectations of the seismic performance of wooden-framed houses by homeowners were assessed in this research. Homeowners in the Wellington region were asked in a survey about the levels of safety and expected possible damage in their houses after a seismic event. Findings bring questions about whether New Zealand code requirements are good enough to satisfy community demands. Also, questions whether available information of strengthening techniques to structurally prepare wooden-framed houses to face future major earthquakes can help to make homeowners feel safer at home during major seismic events.

Mostafa, M., Bueker, F., Parr, M., Jenkins, M., Hogan, L., Elwood, K., Bull, D., Brooke, N., Henry, R.,   **32**
Sullivan, T., Liu, A.

Seismic assessment and retrofit development of precast prestressed hollow-core floors

Precast floors are the dominant flooring system in New Zealand's multi-storey buildings stock, where hollow-core floors are the most ubiquitous flooring system. Following the 2016 Kaikōura Earthquake, significant damage was observed in multiple buildings that incorporated hollow-core floors. Hollow-core flooring systems vulnerability in regions of high seismicity were exposed, and concerns were raised about the performance of these floors in future seismic events. Due to the prevalence of hollow-core floors it was clear that there is an urgent need for retrofit solutions and guidance, especially for areas with high seismicity such as Wellington. As a response to those needs the 'ReCast Floors' research group was formed with the objectives of improving the current understanding of the seismic performance of precast floors and develop suitable retrofit techniques.

In the poster, results of the experimental investigations undertaken by the 'ReCast Floors' project so far are presented. Where multiple sub-assembly (single unit) tests with different retrofits have been tested and results analysed. Furthermore, initial results from recently completed super assembly (full scale single storey) test and plans for upcoming super assembly test will be presented. In addition to the laboratory testing, field investigation was undertaken. Extensive damage documentation of a case study building was performed to capture the severity and distribution of the damage sustained utilizing laser scanning and structure from motion techniques. This field investigation is expected to provide a means of determining the extent to which laboratory testing is representative of 'real' floors performance. Moreover, another flooring system, namely double tee floors is currently under investigation, and the proposed experimental testing will also be presented herein. This project is supported by Branz, Quakecore and Concrete Society.

Motha, J., Bradley, B., Paterson, J., Lee, R., Thompson, E., Tarbali, K., Bae, S., Huang, J., Schill, C., Polak, V., Lagrava, D.   9

Cybershake NZ v20.8: New Zealand simulation-based probabilistic seismic hazard analysis

This poster presents the computational components and results of the August 2020 version (v20.8) of probabilistic seismic hazard analysis (PSHA) in New Zealand based on physics-based ground motion simulations ('Cybershake NZ'). A total of 11,875 finite fault simulations were undertaken and seismic hazard results are computed on a spatially-variable grid of 25,948 stations with distributed seismicity sources considered via conventional empirical ground motion models. In this latest version, a NZ-specific modification of the Graves and Pitarka (2010,2015) hybrid broadband ground motion simulation approach was utilized based on improvements identified from extensive validation efforts (including the inclusion of moderate magnitude in our validation dataset). Specific simulation features include a transition frequency of 0.5 Hz (previously 0.25Hz), a detailed crustal model (NZVM v2.03) that represents eight distinct sedimentary basins in NZ using a grid spacing of 0.2 km, and an empirically-calibrated local site response model. A Monte Carlo scheme is used to sample variability in the seismic source parametrization (i.e. varying the hypocentre location and slip distribution for each realization) with the total number of ruptures for each source being a function of the source magnitude. The generated non-uniform hazard maps across the country are presented. Comparisons with previous versions also highlight the advancements that have been made. Immediate near-term plans associated with new features associated with crustal velocity modelling, simulation methodology, and treatment of modelling uncertainty are also discussed.

Mowll, R.   85

Infrastructure 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 either the lifeline utilities or CDEM has to mitigate against outages. If community needs of delivery of utility services requirements (or infrastructure emergency levels of service) can be defined, the gap between recommendations and delivery of services by the lifeline utilities 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 expectations 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. Essentially, can a framework be developed that defines recommended levels of service across utilities for individual needs following an emergency event? Can this framework then be used to define the gaps of delivery of services?

Muñoz, G., Henry, R., Elwood, K.   33

Repairability of earthquake damaged RC walls

After the 2010-2011 Canterbury earthquakes, close to 60% of the multi-stories reinforced concrete (RC) buildings were demolished, and many of them used RC walls to resist the earthquake demands. Despite satisfactory results in terms of life safety performance, a lack of knowledge was revealed regarding the post-earthquake condition of damaged reinforced concrete (RC) buildings. The assessment of residual capacity and the effectiveness of repair techniques for earthquake damaged RC buildings is not well understood among researchers and engineers. A deeper understanding of the performance of these structures in a post-earthquake scenario will help to improve society resilient and decrease uncertainties and time during city recovering.

This study will assess the residual and repaired capacity of ductile slender RC walls according to current standards in New Zealand, NZS 3101.1 2006 A3. First, a Repaired RC Walls Database is created to collect existing information and to evaluate the effectiveness of the repair techniques applied to the walls. Then, an archetype building is designed, a wall is extracted and scaled. Four half-scale walls were designed and constructed to be tested at the Structures Testing Laboratory at The University of Auckland. The overall dimensions are 4 [m] height, 2 [m] length and 0.175 [m] thick. All four walls are identical, with differences in the loading protocol and type of repair technique. Results are going to be useful to assess the residual capacity of a damaged and the effectiveness of the repair technique in the wall performance. The expected behaviour is focussed on big changes in lateral stiffness, and good displacement capacity recovery if the observed damage does not include bar buckling, or if proper steel replacement is conducted.

Naguit, M   10

GeoNet strong motion data products - modernizing & future-proofing our services

GeoNet is an integrated data collection and geological hazards monitoring system. As a non-profit project established in 2001 and operated by the Institute of Geological & Nuclear Sciences Limited (GNS Science), GeoNet offers a highly-integrated facility with a network of geophysical instruments, data collection, real-time monitoring, rapid response and event analysis for natural hazards such as earthquakes, volcanic eruptions, tsunamis and landslides.

One of the key components of GeoNet is the strong motion network. Over 315 strong motion stations in strategic locations all over NZ are equipped with modern instrumentation. This network delivers valued data products including raw and processed data, with services that cater to the requirements of the scientific community.

Currently, GeoNet delivers an ensemble of publicly available strong motion products including time series data, peak ground motion values, response spectral data and Fourier spectra. The wide applicability of these products offers a significant data resource for engineers, seismologists, researchers, and other professionals working on seismic design, ground motion modelling and prediction, hazard and risk assessments and engineering seismology researches.

A continued enhancement and improvement of GeoNet services comes with a more modernized strong motion data products, aligned with the requirements of our end users. As part of modernising and future-proofing our data services, GeoNet has begun streaming the strong motion seismic data

continuously at a high sample rate. This unblocks the strong motion product development for better data access and support services.

Neill, S., Bradley, B., Lee, R. **11**

Ground motion simulation validation with explicit uncertainty incorporation for small magnitude earthquakes in New Zealand

This study investigates the uncertainty of simulated earthquake ground motions for small magnitude events (Mw 3.5 – 5) in New Zealand. 600 ground motion events were simulated with specified uncertainties in: magnitude, hypocentre location, focal mechanism, source rupture shear wave velocity, high frequency rupture velocity, Brune stress parameter, the site 30m time averaged shear wave velocity (Vs30), anelastic attenuation (Q) and duration. In order to capture these parameter uncertainties, 50 realisations for each scenario was generated using the Graves and Pitarka (2015) hybrid broadband simulation approach. Ground motion intensity measure results were used to assess the systematic source, path and site effects across all realisations of the ground motion records. Validation of these effects was undertaken using the residual variances of past event observation data. The acceptability criteria for this study was to produce lower total standard deviation than the New Zealand empirical prediction models. Which would indicate that the ground motion simulations for small magnitude events in New Zealand can more accurately predict intensity measures of engineering interest. It is intended in future studies to extend this research to higher magnitude events.

Nguyen, T., Lee, R., Bradley, B., Graves, R. **12**

Full Waveform Seismic Tomography for geophysical velocity model in South Island region, New Zealand based on Adjoint-Wavefield method

In this poster we present the results of applying Full Waveform Tomography (FWT), based on the Adjoint-Wavefield (AW) method, to iteratively invert a 3-D geophysical velocity model for the South Island region (Eberhart-Phillips et al., 2010). The seismic wave fields were generated using numerical solution of the 3-D visco-elastodynamic equations (Graves, 1996) with sources represented as point sources, and through the AW method, gradients of model parameters (compressional and shear wave velocity) were computed by implementing the cross-adjoint of forward and backward wavefields. The misfit measure is a frequency-dependent multi-taper travel-time difference using a period range 10–40s. The main computational cost relates to the computation of the gradient of the misfit function for each event (event kernel). The event kernels are then combined by summing, preconditioning, and smoothening; and using the L-BFGS/ parabola fitting line search algorithms to obtain the model update.

To verify the method's performance, a synthetic study using 16 events and 25 stations equally distributed shows good convergence of the inverted velocity models to the given true model (with checkerboard perturbations). For real data analysis, simulation-to-observation misfit measurements at frequencies from 0.025 - 0.1 Hz, based on 13 sources and 10 seismic broad band stations, in the Northern part of the South Island region, New Zealand were used in the first stage of our inversion. 14 more events were included at the second inversion stage. Each inversion stage was run for up to

10 iterations or if no appreciable misfit reduction occurs. After the first stage of inversion runs, the simulated seismograms computed using our final velocity model show a significant reduction of the misfit. The histograms of the relative waveform misfit and travel time difference between observed and simulated data for a fixed set of windows also indicate the improvement of the inverted velocity model toward the true model. A set of ground motion validation tests was also performed which shows the improvement of the ground motion prediction.

Nicolin, E., Dempsey, D.   13

Adversarially Constrained Autoencoder Interpolation for Prediction of Ground Motion Intensity Measures

Numerical physics-based methods for ground motion simulation (GMS) are becoming increasingly widespread. While having certain advantages over empirical methods, they are also computationally intensive. As such, more efficient ways of producing ground motion Intensity Measures (IM) are desirable. In this study, we considered machine learning and neural network-based methods to emulate physics-rich models. Using full-physics simulations of Hauraki Rift earthquakes as training data, we developed an Adversarially Constrained Autoencoder (ACA) that could make IM predictions from low dimensional inputs like event magnitude. The generation of a large training sample is itself time intensive and, therefore, this study used limited simulations as a proof-of-concept.

ACAs make predictions via a convex combination of lower dimensional representations of training data. A study by Berthelot et al. (2018) has shown this type of autoencoder can provide more accurate predictions compared to traditional methods. With a small training sample, we have been able to capture the average behaviour of IMs with varying degrees of accuracy and demonstrate reasonable interpolation of unseen events. In future work, we will investigate how prediction error relates to the size of the training dataset, as well improved optimisation of the autoencoder architecture. Finally, the methodology should be generalised to allow for multiple predictors.

Ntritsos, N., Cubrinovski, M.   18

A CPT-based effective stress analysis procedure for liquefaction assessment

There is a growing awareness of the need for the earthquake engineering practice to incorporate in addition to empirical approaches in evaluation of liquefaction hazards advanced methods which can more realistically represent soil behaviour during earthquakes. Currently, this implementation is hindered by a number of challenges mainly associated with the amount of data and user-experience required for such advanced methods. In this study, we present key steps of an advanced seismic effective-stress analysis procedure, which on the one hand can be fully automated and, on the other hand, requires no additional input (at least for preliminary applications) compared to simplified cone penetration test (CPT)-based liquefaction procedures. In this way, effective-stress analysis can be routinely applied for quick, yet more robust estimations of liquefaction hazards, in a similar fashion to the simplified procedures. Important insights regarding the dynamic interactions in liquefying soils and the actual system response of a deposit can be gained from such analyses, as illustrated with the application to two sites from Christchurch, New Zealand.

Nwadike, A., Wilkinson, S.   47

Validation of a framework to improve building code amendment in New Zealand

New Zealand building code may be serving its purpose to an extent, however, there is still a need to improve the use and application of building code for better building performance, quality, and other services. This paper aims to validate the identified parameters in the developed framework to improve building code practice in New Zealand. subject matter experts interview was conducted with key stakeholders that use building code, standards, and other associated compliance documents across New Zealand. The findings from this study established the importance of improving the building code, and the efficacy of validated framework helps to identify the areas with the most pressing needs within the building regulatory system. Almost all the subject matter experts unanimously agreed on training the building code users, competent technical staff, reduced bureaucracy, promote enforcement, simplify building code requirement, awareness, and technical assistance. Besides, the validated framework will enable the policy decision-makers in the building regulatory system to promote the use of building code and the utilization of its potentials in reducing disaster while increasing resilience in the built environment.

O'Connor, H., Johnston, D., Hopkins, J.   93

For The Greater Good? Data and Disasters in a Post-COVID World

The current debate around the use of tracking apps, websites and other data collection mechanisms in the wake of the COVID-19 pandemic provides significant challenges around the use of personal data. This work examines the use of such data in the context of disasters generally and COVID-19 specifically and considers how the benefits of sharing such data can be achieved in a context that protects individual privacy and complies with New Zealand's legal framework. In addition is considers the wider question of when and if the community's expectation of a safe environment trump the rights of individuals to retain personal data, in the context of pandemics and other emergency/disaster scenarios.

Lake-Hammond, A., **Orchiston, C.,** Scally-Irvine, K.   97

Evaluating the relevance and effectiveness of AF8 since the project began in 2016

The work of AF8 is fundamentally about supporting good planning and coordination of all key agencies in the South Island to effectively respond (in the first seven days) to a significant future earthquake on the Alpine Fault. Work to date has focussed on bringing leading science research into the development of an Alpine Fault magnitude 8 scenario, which then informed the response planning phase, culminating in the SAFER Framework.

Engaging in wider engagement and outreach activities has been on-going, aimed to increase the understanding and access to information by the wider community around how to plan and respond to a future Alpine Fault earthquake.

A key feature of AF8 has been that is has represented a collaborative effort across a range of agencies, organisations, and locations. An additional aspect of AF8's work has therefore been testing and demonstrating how to undertake a complex collaborative project, that requires the integration of knowledge, skills and expertise.

Given the period of time that has elapsed since the AF8 was established, it is timely to conduct an evaluation of the project to identify:

- *the extent to which it is contributing to its intended outcomes*
- *any other unintended outcomes (positive and negative)*
- *lessons learned, that could be usefully applied to other similar types of projects.*

In essence, this evaluation research aims to understand the relevance, need and coherence of AF8's efforts, as well as the effectiveness and efficiency of the work produced. Key informant interviews will be conducted over the next two months to ascertain the contribution AF8 has made to building resilience. This process is vital to continuing the co-creation approach taken by AF8, which requires reflection and listening to feedback from across the network of stakeholders who have helped to make AF8 a success.

Osborne, M.   68

Tourism Resilience to disruptive events: Lessons from COVID-19 in the preparedness, response, and recovery of New Zealand tourism destinations

The COVID-19 global pandemic has been the most significant disruption to the New Zealand tourism sector this century. Prior to COVID-19, tourism was New Zealand's largest export sector, contributing 8.4% of direct employment of the national work force and 5.8% to GDP in the year ending March 2019 (Statistics New Zealand, 2019). With border closures restricting international visitor numbers for the foreseeable future, the tourism sector is facing unprecedented challenges to financial viability, with a decrease in revenue resulting in employee reductions and business closures. A decrease in visitor numbers has also indirectly affected the retail and hospitality sector, especially in destinations with high proportions of international visitor expenditure.

This research explores the concepts of crisis management and tourism business resilience at a destination level in the preparedness, response, and recovery phases of a disaster. It utilises the COVID pandemic as a contextual study to evaluate the resilience of selected South Island destinations. The research method includes qualitative interviews with tourism stakeholders with a primary focus on destination managers of Regional Tourism Organisations (RTOs). Data collection will explore the role of destination-level organisations in a crisis, the suitability and use of support resources provided by local and national government in response to COVID, and key learnings from case study destinations in the COVID pandemic. This work builds on previous research undertaken in the New Zealand tourism context (e.g. Orchiston 2013) that explored the resilience of tourism operators to seismic hazards.

The outputs of this research will identify actionable recommendations to enhance the resilience of tourism destinations at regional scales in response to future disasters, including earthquakes and other natural events.

Pascua, C., Henry, R., Toma, C.   48

Developing a typology for recently constructed buildings that combine steel frames and concrete walls

Recent building construction in New Zealand has exhibited a massive increase in the use of structural steel due to its availability and perceived seismic performance. Despite the renewed popularity of structural steel, concrete walls remain a reliable choice of lateral force resisting system, leading to a

trend of 'hybrid' buildings that combine steel frames and concrete walls. This study aims to characterise this emerging building type by developing a typology that is relevant to understanding their seismic performance. It focusses on buildings constructed in Auckland and Christchurch from 2014 onwards. Through sidewalk surveys and desktop research, an initial list of buildings of interest was developed, and structural drawings were obtained from council property files or from structural engineers. The drawings were reviewed and relevant structural features were identified. A typology consisting of five building types was developed according to the buildings' lateral load-resisting system in two directions. The results of this study will serve as basis for creating archetypes of steel frame-concrete wall buildings, which will be further investigated through testing and modelling.

Paterson, J., Bradley, B., Lee, R.   14

Effect of Hikurangi subduction interface geometry on simulated ground motion intensities

The Hikurangi subduction fault runs under the eastern side of the North Island and has a large down dip curvature (Williams et al. 2013). The six current Hikurangi fault rupture scenarios provided by the National Seismic Hazard Model (NSHM) all provide for a planar fault geometry that is adopted in predictions using both empirical ground motion models (GMMs) and also prior simulations performed by the authors.

In this poster we examine the effect of more realistically representing the curved geometry in the source description, and its influence on simulated ground motions. The mathematical approach by which a 2D planar geometry is mapped onto a curvilinear surface is described, followed by a comparison of the results obtained through ground motion simulations.

Pepperell, P.   69

Leadership in Extreme Contexts

This research aims to critically examine how people exercise authority (including governance, leadership, management, and command); to determine those capabilities and systems necessary to deliver more successful outcomes during situations of extreme context; and how through effective leadership, society can leverage unfortunate events to thrive, rather than merely survive?

To achieve this, it is necessary to deconstruct the term leadership and examine the DNA of each of its components. To date, this has revealed concepts that had been lost to contemporary leadership thought and a theoretical spectrum which at times, struggles to cope with the dynamism present in extreme contexts.

QERC Auckland, QERC Christchurch, QERC Wellington   96

QERCs during lockdown: Turning obstacles into opportunities

The QuakeCoRE Emerging Researchers Chapter (QERC) is a network of students and emerging researchers composed of three chapters: Auckland, Canterbury, and Wellington. Our aim is to promote networking, collaboration, and knowledge sharing among emerging researchers in the earthquake resilience community. QERC does this by organising technical, social, and outreach events. As with everyone else during the pandemic crisis, QERC had to change its approach in organising events. However, instead of treating it as an obstacle, QERC utilised the lockdown period as an opportunity to connect the three chapters and organised more events than they usually would during

normal times. In the 11 weeks that universities were closed and New Zealand was under Alert Levels 2, 3 and 4, QERC organised 15 various events such as research presentations, well-being workshops, a women's catch-up, and a trivia night. However, as the weeks went by, the novelty of online meetings faded and fewer people came to the virtual events. Therefore as soon as the country moved to Alert Level 1, the Chapters started organising in-person events, which members were eager to attend. Nonetheless, the option to join events remotely still remains and the three chapters continue to collaborate for various events.

Raynor, S., Boston, M.   70

Multi-Hazard Analysis and Mapping in Support of Coastal City Growth Planning and Resilience Building

High growth in Tauranga is causing increased pressure to develop hazard-prone land. A key tool in evaluating safer potential growth areas is the quantification and spatial mapping of individual natural hazards. In a hazard-rich, coastal environment like Tauranga a newly developed multi-hazard mapping technique gives additional clarity through direct comparison of total hazard levels across the city. By aggregating individual hazards, a summative multi-hazard rating for each part of the city can be developed as a strategic decision support tool, aiding in city planning and engineering decision-making.

This study initially quantifies Tauranga's natural hazards of sea-level rise, tsunami, flooding, storm surge, earthquake, coastal erosion, liquefaction and landslides. Each hazard is spatially represented through hazard maps and additionally processed to enable aggregation with other hazards to produce the multi-hazard rating.

Individual hazards are combined by application of a new technique to create a summative multi-hazard model representing the aggregated hazard at each point of the city. This allows an area with tsunami, liquefaction and storm surge as dominant hazards to be directly compared with an area of different hazards such as flooding and landslides. The resultant spatial map provides a visual interpretation of the accumulated hazard level at all points of the city.

Map results show the highest aggregated hazard areas in Tauranga are along the coast. Lower hazard areas suitable for urban growth are distributed mostly away from the open coast on slightly elevated topography. Isolated high exposure pockets are additionally located throughout the city.

This multi-hazard comparison can be adopted to guide city growth and enable targeted investment in resilience building projects.

Roeslin, S., Ma, Q., Chigullapally, P., Wicker, S., Wotherspoon, L.   49

Development of a seismic loss prediction model for residential buildings - Christchurch, New Zealand

The Canterbury Earthquake Sequence (CES), induced extensive damage in residential buildings and led to over NZ$40 billion in total economic losses. Due to the unique insurance setting in New Zealand, up to 80% of the financial losses were insured. Over the CES, the Earthquake Commission (EQC) received more than 412,000 insurance claims for residential buildings. The 4 September 2010 earthquake is the event for which most of the claims have been lodged with more than 138,000

residential claims for this event only. This research project uses EQC claim database to develop a seismic loss prediction model for residential buildings in Christchurch. It uses machine learning to create a procedure capable of highlighting critical features that affected the most buildings loss. A future study of those features enables the generation of insights that can be used by various stakeholders, for example, to better understand the influence of a structural system on the building loss or to select appropriate risk mitigation measures. Previous to the training of the machine learning model, the claim dataset was supplemented with additional data sourced from private and open access databases giving complementary information related to the building characteristics, seismic demand, liquefaction occurrence and soil conditions. This poster presents results of a machine learning model trained on a merged dataset using residential claims from the 4 September 2010.

Sriparna. S., Kennedy, B., Tolbert, S.   71
Digital Storytelling in Mediating Caldera Risk Literacy in Secondary School Students

Lake Taupō in New Zealand is associated with frequent unrest and small to moderate eruptions. It presents a high consequence risk scenario with immense potential for destruction to the community and the surrounding environment. Unrest associated with eruptions may also trigger earthquakes. While it is challenging to educate people about the hazards and risks associated with multiple eruptive scenarios, effective education of students can lead to better mitigation strategies and risk reduction.

Digital resources with user-directed outcomes have been successfully used to teach action oriented skills relevant for communication during volcanic crisis [4]. However, the use of choose your own adventure strategies to enhance low probability risk literacy for Secondary school outreach has not been fully explored.

To investigate how digital narrative storytelling can mediate caldera risk literacy, a module "The Kid who cried Supervolcano" will be introduced in two secondary school classrooms in Christchurch and Rotorua. The module highlights four learning objectives: (a) Super-volcanoes are beautiful but can be dangerous (b) earthquake (unrest) activity is normal for super-volcanoes (c) Small eruptions are possible from super-volcanoes and can be dangerous in our lifetimes (d) Super-eruptions are unlikely in our lifetimes.

Students will create their digital narrative using the platform Elementari (www.elementari.io). The findings from this study will provide clear understanding of students' understanding of risk perceptions of volcanic eruption scenarios and associated hazards and inform the design of educational resources geared towards caldera risk literacy.

Sarkis, A., Sullivan, T., Brunesi, E., Nascimbene, R.   34
Finite element modelling of nonlinear seismic behaviour of precast pre-stressed hollow-core floors

As it has been learned from recent earthquakes, reinforced concrete buildings have historically been designed and constructed in ways that jeopardize their seismic performance. In particular, the early use of Precast Pre-stressed Hollow-Core (PPHC) floors saw the use of support connections that are susceptible to undesirable failure modes when subjected to earthquake-induced deformations. In the past twenty years, extensive experimental research programs in New Zealand have helped identify

some of the main vulnerabilities of these floors and led to the development of support connection detailing capable of accommodating larger earthquake demands.

While improved connection details have been developed, concerns regarding the seismic performance of buildings containing PPHC slabs have been raised following the 2016 Kaikōura Earthquake. The earthquake dynamic characteristics caused high drift demands on some multi-story moment frame buildings resulting in damage to floor diaphragms, in particular. Furthermore, post-earthquake observations evidenced inconsistencies between the observed damage conditions and the damage states identified by past research, bringing into question the seismic assessment of buildings with this type of floor system, the residual capacity of the floors once the damage has been sustained, and the effectiveness of existing retrofit techniques.

This research presents a comprehensive three-dimensional finite element modeling approach for PPHC units, seating connections, and diaphragms, validated against experimental data collected from previous and ongoing research. This research permits investigation on the impact of a wider range of parameters than could practically be considered in laboratory testing and with more precise control of variables such as material properties, helping to inform methods for assessing, and improving the seismic performance of PPHC floors in New Zealand.

Sarrafzadeh, M.   50
Stiffness Degradation in Earthquake Damaged and Repaired Reinforced Concrete Beams

The design of high ductility reinforced concrete (RC) moment frame structures is a well-established practice in regions of high seismicity in New Zealand. Such structures will commonly experience distributed damage and the formation of plastic hinges in the beams of their frames. Understanding the changes in component behaviour can provide context to the post-earthquake performance of ductile RC structures, particularly variations in component stiffness. As part of an experimental investigation on the repair of earthquake damaged RC beams, the degradation in stiffness both prior to and following repair via epoxy injection were assessed. The results suggest that the repair of moderately damaged RC beams via readily available techniques such epoxy mortar and crack injection can have a significant impact on the recovery of stiffness, particularly at smaller levels of deformation, comparable to demands from serviceability level events. The impacts of the epoxy repair were diminished at higher levels of deformation where all specimens under, undamaged, damaged and repaired conditions performed in a similar manner. The results indicate that under moderate levels of damage, where the collapse and life safety performance of a structure can be assessed to no be of concern, simple repair techniques can have an impact at lower levels of shaking, beyond simply cosmetic and durability enhancement.

Saunders, W., Smith, G.   72
A Comparative Review of Hazard-Prone Housing Acquisition Laws, Policies and Programs in the United States and Aotearoa New Zealand

There is no one action that will reduce risks from natural hazards; a combination of actions is required for effective risk management and enhancing the resilience of at-risk communities. These include: land use planning, emergency management, insurance, catchment management, monitoring and

warning systems, structural engineering, infrastructure provision, and building codes. Property acquisition should be used as a last resort option; ideally, good land use planning should proactively locate activities out of significant hazard areas, or have mitigation measures in place to reduce the consequences of events.

Research is underway comparing the laws, policies, and programs guiding hazard-prone housing acquisition programs in United States and Aotearoa New Zealand. The two nations were selected because they both possess mature disaster management programs, somewhat similar, yet sufficiently different, governance structures; significant exposure to differing natural hazard types; and varied approaches taken to address the many challenges associated with the acquisition of hazard-prone housing.

This poster will provide a general overview of the hazard-prone housing acquisition process, followed by a comparative overview of the laws, policies, and programs found in the United States and Aotearoa New Zealand. These include pre-event planning, funding strategies, open space management rules, climate change adaptation requirements, building code compliance, and equity concerns. A series of policy recommendations is made, to address identified opportunities for improvement, including cross-cultural lesson-drawing which will also be useful for other countries implementing buyout programs.

Scheele, F., Wilson, T., Becker, J., Horspool, N.   73

Modelling post-disaster habitability and displacement

Issues of habitability, sheltering and the needs of populations following disasters is a key issue for emergency management, asset management, planning and prioritisation. Loss of habitability may result in the displacement of occupants from both residential and commercial buildings, with some of those displaced requiring temporary shelter, whereas some residents will prefer to shelter in place. The displacement of populations and assessment of needs following a disaster is a complex process that is influenced by many factors. These include physical factors (e.g. building damage, loss of utilities), social or demographic factors explaining relative levels of vulnerability, and decision-making by affected populations.

We have developed a new model for estimating habitability, displacement and sheltering needs for tsunami (HDS-T). The model uses an additive scoring system incorporating both physical and demographic factors, weighted according to their relative influence. HDS-T is designed to be adaptable to other natural hazards and contexts, such as earthquakes.

Further research is underway into developing a framework and model for assessing the needs of populations following disasters, expanding on the existing HDS-T model. One to two major NZ scenarios will be considered (e.g. Hikurangi earthquake and tsunami, Alpine Fault earthquake). The outcomes of this research are directed towards supporting decision-makers with rapid impact assessment information, to assist in planning and response to events.

Schill, C., Thomson, E., Bradley, B., Lee, R.   15

An Neural Network-based Ground Motion Model trained on Ground motion Simulations in New Zealand

This poster presents a New Zealand-specific simulation-based ground motion model (GMM) developed using an artificial neural network (ANN). The rationale behind the model development is to leverage the advantages of physics-based ground motion simulations in a manner that is computationally tractable for use in probabilistic seismic hazard analysis (PSHA), when a large number of seismic sources are considered, principally in the representation of background, area, and distributed seismicity sources; as well as another means for synthesis of simulation results.

We demonstrate the development of such a model using simulation data from both validation of historical events (Lee et al. (2020); approximately 1000 simulations), as well as future potential events ((Motha et al. (2020); approximately 17,000 simulations) in New Zealand. A multi-layer perceptron ANN with multiple hidden layers was used and trained using the back-propagation algorithm. Evaluation was done on 10% of the simulated events, selected randomly. To illustrate the predictive capabilities of the model we compare the results obtained against empirical GMMs, as well as examining the predicted variation in ground motion amplitudes as a function of features such as source and site location, tectonic type etc.

The principal caveat of this approach is that it is limited by the validity of the underlying simulations, however, as these continue to improve the developed models can be iteratively improved to provide a seamless means for use in simulation-based PSHA.

Shaik, A., Prasanna, R., Stock, K., L'Hermitte. C.   74

Identifying the needs and concerns related to blood supply chain management under crisis using technology

As part of a health care system, the blood supply chain (BSC) plays a prominent role in maintaining health within communities and supplying blood for daily needs. During a disaster, which can be characterised as circumstances where we can anticipate considerably higher blood requirements than usual, limits/prevents the use of an inventory of blood products requiring immediate replacement or replenishment from another region or generates an unforeseen influx of donors to cope with an emergent need.

Given the uncertainty caused during disasters, the development of decision support models in the field of blood supply chain management has become a challenge for researchers, where demand for supply typically does not match in major incidents/disasters as demand for blood is highly unpredictable.

There were many suggested approaches to mitigate the above situations. But new methods are being studied with the development of modern technology to answer a lot of real-time problems. One of them is using Artificial Intelligence (AI) to manage complex environments in various fields to capture big data and learn to recognise patterns as needed.

Therefore, this research aims to use AI to focus on developing a real-time decision support system that demonstrates how this scarce resource can be managed and maintained, and how this precious resource, i.e. blood, can be delivered at the right location and at the right time and in the right quantity during a crisis. Thus, developing such decision support tool will not only help promote and enhance

stakeholder's efficiency in managing the blood supply chain but will also help health professionals and emergency medical services to save people's lives.

Shaikh, S.   75
Investigating Disaster knowledge management in rural construction mechanism

Of particular concern against other earthquakes, the earthquake of October 2005 was un-doubtfully the most devastating event, 2.8 people homeless 73,000 people died and more than 70,000 injured, due to mainly more than 400,000 housing units were destroyed and damaged (ADB, 2015-WB, 2011). The government agencies have looked at addressing this issue and developed the first ever national policy in 2006 which relied on seismic guidelines, but some of the particular challenges are still found in the safer construction that directly relates to ineffective seismic knowledge. One of the main factor is people built their own houses in rural areas and authorities are not able to supervise the construction process.

In this context, this research aims to investigate, how the disaster knowledge management has been taken since 2005 earthquake in Pakistan for the safe rural buildings today. In other words, through the best mitigation practices from US, UK, New Zealand and Australia, the research is looked to develop effective knowledge transfer framework in Rural Pakistan, that could further contribute in the developing countries like Nepal, India, Sri Lanka, Philippines and Indonesia that having same construction practices in rural settlements.

Sharma, S., Wotherspoon, L., Hogan, L.   86
Modelling the Dynamic Response of Whirokino Viaduct

New Zealand has many long viaducts constructed back when seismic design provisions were not accounted for during design and construction phases. A study of such structures can present a unique dataset for the researchers for understanding the behaviour of these bridges that are on critical transportation networks. This research aims to capture the key parameters controlling response of the eighty-two year old Whirokino Viaduct that spans one kilometre over the Manawatu River floodplain. 20 triaxial accelerometers were installed along its length during two recording periods to collect ambient vibration data, first when the bridge was fully intact, and second with several spans at the southern end removed. This data will allow for an assessment of the effects of the abutment on the dynamic response. Data was analysed using the Modal Parameters Identification Toolbox developed at The University of Auckland to identify the dynamic characteristics such as natural frequencies and mode shapes. Also, a computational model of the bridge was developed using OpenSeesPy to represent the elastic characteristics of superstructure and substructure components. The obtained mode shapes and natural period were compared with that from sensor data and the influence of a range of structural and foundation system parameters was assessed in order to identify the key parameters controlling the dynamic characteristics of the Viaduct. It is hoped that the outcomes of this study will improve the understanding of the in-service response of bridges and inform design assumptions related to the contribution of different bridge components to overall dynamic response

Shrestha, S., Orchiston, C., Elwood, E., Becker, J., Johnston, D.   35

Impacts of site specific information on post-earthquake cordons: A comparative case study of Christchurch, New Zealand and L'Aquila, Italy

Post-earthquake cordons have been used after seismic events around the world. However, there is limited understanding of cordons and how contextual information of place such as geography, socio-cultural characteristics, economy, institutional and governance structure etc. affect decisions, operational procedures as well as spatial and temporal attributes of cordon establishment. This research aims to fill that gap through a qualitative comparative case study of two cities: Christchurch, New Zealand (Mw 6.2 earthquake, February 2011) and L'Aquila, Italy (Mw 6.3 earthquake, 2009). Both cities suffered comprehensive damage to its city centre and had cordons established for extended period. Data collection was done through purposive and snowball sampling methods whereby 23 key informants were interviewed in total. The interviewee varied in their roles and responsibilities i.e. council members, emergency managers, politicians, business/insurance representatives etc. We found that cordons were established to ensure safety of people and to maintain security of place in both the sites. In both cities, the extended cordon was met with resistance and protests. The extent and duration of establishment of cordon was affected by recovery approach taken in the two cities i.e. in Christchurch demolition was widely done to support recovery allowing for faster removal of cordons where as in L'Aquila, due to its historical importance, the approach to recovery was based on saving all the buildings which extended the duration of cordon. Thus, cordons are affected by site specific needs. It should be removed as soon as practicable which could be made easier with preplanning of cordons.

Stolte, A., Wotherspoon, L., Girgis, P.   94

Dynamic site characterisation of the Hawkes Bay sedimentary basin using H/V and surface wave methods

The Hawkes Bay region is subject to relatively high levels of seismicity, as evidenced by several large historical earthquakes. For example, the MW7.9 1931 Hawke's Bay earthquake, severely damaged the cities of Napier and Hastings. Additional seismic hazard is presented by the nearby Hikurangi Margin, an offshore subduction zone, which is expected to generate a large MW8.9+ earthquake. Furthermore, the most populated and developed areas within the Hawke's Bay region have been founded upon a deep, soft sedimentary basin, which increases potential for ground motion amplification due to the entrapment and amplification of seismic waves, and the generation of localised surface waves within the basin. To improve understanding of these basin effects and characterise the local soils, a seismic field testing programme was undertaken in the region. At 120+ sites, the horizontal-to-vertical spectral ratio (HVSR or H/V) method was used to develop a map of fundamental site period (T0) across the Hawkes Bay region. Active- and passive-source surface wave testing methods were used to characterise the small-strain shear stiffness (i.e. shear wave velocity) of the local soils. This new knowledge will inform regional seismic hazard studies and help improve estimates of the level of damage across the region for a range of earthquake scenarios.

Stringer, M., Orense, M., Asadi, B.   **19**

Effect of stress level on cyclic resistance of undisturbed samples of pumiceous soil

Geologically recent volcanic eruptions from the Taupo Volcanic Zone (TVZ) have resulted in the deposition of pumice materials across significant areas on the North Island of New Zealand. In particular, these volcanically derived materials are often encountered on engineering projects in the areas of Hamilton and Tauranga.

Pumiceous soils are problematic from a geotechnical perspective due to their high crushability and low weight. These properties mean that practicing engineers must exercise extreme caution when these soils are encountered on a project, since these soils are not captured in the existing databases used to develop the correlations between parameters of engineering interest and in-situ characterisation techniques. The crushable nature of the pumiceous material introduces some interesting questions surrounding the cyclic behaviour of these soils at different stress levels; whether increased stress levels results in significantly different cyclic resistance, and whether this change will result in increased or decreased strength.

This poster will present results from a recent sampling campaign where pumice rich materials were obtained from a site close to the town of Edgecumbe in the North Island. The poster will discuss results from a suite of triaxial tests which aimed to examine the effects of initial effective stress level on the cyclic resistance of soil layer with a moderate pumice content.

Suzuki, T., Elwood, E., Puranam, A., Lee, H., Hsiao, F., Hwang, S.   **36**

Testing of Seven-storey Reinforced Concrete Structures with Soft First Story and Torsional Irregularities

In past earthquakes, a number of reinforced concrete buildings have experienced localization in damage and resulting collapse in some cases. Buildings with torsional irregularities are susceptible to the localisation issues due to large displacement demand in critical sides during earthquakes. Although effects of torsional irregularities are considered in seismic assessment guidelines, there are uncertainties in assessing torsional demand associated with inelastic response. Notably, recent post-earthquake investigations have indicated symmetric systems can also experience torsional response and resulting localized damage due to asymmetric damage or ductile behaviour of structural elements. However, displacement demand due to such torsional response associated with inelastic behaviours has not been fully understood because of the lack of experimental data for system level structures. It is prudent to obtain proper inelastic torsional demand and improve seismic assessment methods for existing building to prevent catastrophic disaster in future earthquakes.

This experimental study aimed to provide benchmark dataset for structures subjected to inelastic torsion and to obtain displacement demand due to three different sources of irregularities: i) torsional stiffness irregularity, ii) damage irregularity, and iii) ductility irregularity. Shake-table tests for two half-scale seven-story concrete structures were conducted on the high-performance shake table in the NCREE Tainan Laboratory, Taiwan. The test specimens represented structural weaknesses in two of the concrete buildings collapsed during 2016 Meinong Earthquake and were subjected to uni-directional excitation from a 1999 Chi-Chi Earthquake record. This poster presents overall outcomes from the shake-table tests for both specimens.

Syed, Y., Prasanna, R., Uma, S., Stock, K., Blake, D.   87

Development of a Decision Support System through Modelling of Critical Infrastructure Interdependencies

Critical Infrastructures (CI) such as electricity, water, fuel, telecommunication, and road networks are a crucial factor for secure and reliable operation of a society. In a non-emergency situation, most businesses operate on an individual infrastructure. However, after major natural disasters such as earthquakes, the conflicts and complex interdependencies among the different infrastructures can cause significant disturbances, as a failure can propagate from one infrastructure to another. To overcome these concerns, this study has developed a Knowledge-Centered Decision Support System (KCDSS) through an integrated impact assessment framework to model CI interdependencies. The KCDSS can predict the CIs' dynamic behaviour, as well as their reliability and flexibility in response to large-scale disturbances. The KCDSS can be used as an interface between risk assessment and economic modelling tools to quantify the economic consequences resulting from the infrastructure damage. The KCDSS can show the overall level of service (LOS) of a selected region using the information about damage to infrastructure components. The output of the KCDSS are shown through Geographical Information System (GIS) based time stamped outage maps, which can be used by emergency management stakeholders to decisions about the various impacts of infrastructure failure and examine post-disaster recovery options including reinforcement planning, identification of vulnerabilities, and adding or discarding redundancies in an infrastructure network.

Tan. M., Prasanna, R., Becker, J., Holden, C., Waidyanatha, N., Punchihewa, A., Jeong, S., Stock, K.,   77
Brown, A., Kenney, C, Lambie, E., Johnston, D., Nandana, R.

An ongoing project for conceptualising a community-engaged network of low-cost sensors for earthquake early warning in Aotearoa New Zealand

Earthquake-prone countries are exploring earthquake early warning (EEW) systems as a risk mitigation measure. However, establishing a comprehensive EEW system would require a substantial financial investment, and for many countries, such systems are not economically viable. For Aotearoa New Zealand, with a population of just under five million people, appropriating significant financial investments towards development of an EEW system cost-effectively is likely to be challenging.

This research project, launched in February 2020, explores the feasibility of a socio-technical EEW solution for Aotearoa New Zealand. An EEW system may be viable through interconnecting low-cost sensors and recorders through existing communication infrastructures. The project explores the possibility of utilising emerging internet-of-things (IoT) technologies such as micro-electromechanical systems (MEMS) embedded sensors. The sensors may have lower sensitivity and coarse recording systems. Hence, to operationalise this approach it may require a denser network of sensors to achieve an acceptable level of reliability and also rely on the participation and acceptance of engaged citizens. The project seeks to answer the research question: Is it feasible to form an EEW system through a community-engaged network of low-cost sensors? The project is conducting two initial concurrent phases to explore the social and technical challenges and opportunities:

- *Phase-1: Community-of-practice development and engagement with various communities to scope the challenges and opportunities of establishing an EEW system.*
- *Phase-2: Explore and examine the opportunities, capabilities, challenges and limitations of developing an earthquake early warning system and applications driven by a network of off-the-shelf MEMS devices and IoT infrastructure.*

This poster shows the project's progress-to-date on these two phases. The poster also outlines planned activities and expected outputs.

Tasalloti, A., Chiaro, G., Palermo, A., Hernández, E., Liu, R., Granello, G., Banasiak, L.   51

Enhancing the seismic resilience of residential buildings in Aotearoa through the reuse of waste tyres

Recycling and reuse of end-of-life tyres (ELTs) in civil engineering applications is an effective way to minimise environmental and health issues associated with such waste materials and reduce demand of natural resources such as gravel and sand. In New Zealand, only 30% of the 5 million ELTs produced annually are recycled. The residual 70% of ELTs are mainly disposed of through landfill, stockpiles or illegal disposal. A multi-disciplinary geo-structural-environmental engineering project, funded by the Ministry of Business Innovation and Employment (MBIE), is being carried out jointly by the University of Canterbury and the Institute of Environmental Science and Research Ltd. (ESR). The project aims to develop an eco-friendly geotechnical seismic isolation (ERGSI) foundation system for improving the seismic performance of medium-density low-rise buildings in Aotearoa, New Zealand. The ERGSI foundation system is characterised by two components: 1) a horizontal layer of granulated tyre rubber mixed with gravelly soils (rubgravel) placed beneath the foundation and 2) a basement raft made of steel-fibre reinforced rubberised concrete (rubcrete). The components of this system work together to improve seismic performance. The rubgravel layer dissipates part of the seismic energy before it reaches the superstructure and the steel fibre reinforced rubcrete enhances the crack control properties and flexural deformation capacity of the raft foundation. In this poster, a summary of the engineering properties of the rubgravel and rubcrete will be provided.

Thomas, K., Kaiser, L., Campbell, E.   78

Ehara taku toa i te toa takitahi, engari he toa takitini: Learnings from emerging wāhine researchers undertaking community-based resilience projects

Despite increasing attention on the importance of earthquake and tsunami risk reduction for Aotearoa New Zealand communities, there are limited Māori-medium resources available, and more representation of Māori, and wāhine (women) researchers is needed within the field. This poster illustrates key learnings from three emerging wāhine researchers who utilised a range of novel approaches to engagement and collaboration including traditional story-telling, Mātauranga Māori (Māori knowledge) and design technologies to increase resilience for Māori communities from tamariki (children) to kaumatua (elders) during recent community-based research projects. These projects were: Te Hīkoi a Rūaumoko (digitising a bilingual book based on Ngāti Kahungunu iwi pūrākau), Te Kura e Te Āniwhaniwha (educational outreach programme piloting a tuakana/teina (sibling) mentorship model for Māori-medium schools), and memorialising the 1868 tsunami in

Wharekauri-Rekohu (the Chatham Islands) through interactive and recipricol hui and event. Weaving together these three projects is a wider narrative of ethnographic reflection exploring the role of three emerging wāhine researchers collaborating in the discipline of seismic research and the challenges and successes involved within this. A number of themes emerged from our collective experiences including the importance of maintaining a Te Ao Māori or bicultural lens, engagement, reciprocity and academic and cultural support. From our experiences as early career Māori researchers and in light of the suggestions in the work of our Māori and indigenous colleagues we offer a number of initiatives for universities, research institutions and researchers to consider, for supporting a pathway to a strengthened, inclusive and diverse earthquake/tsunami resilience field.

Tilley, L., Wilson, T., Hughes, M., Beaven, S., Jack, H., Scattergood, K.   79

Tsunami evacuation behaviour and dynamics of the 2016 Kaikōura earthquake: Informing network-based modelling for Kaikōura, New Zealand

Understanding evacuation behaviour and associated dynamics of an earthquake response provides valuable information to consider for future disaster risk management and response planning. Whilst the majority of evacuation behaviour literature focus on a specific phase during the evacuation response such as tsunami preparedness, risk awareness, or evacuation intentions, limited survey research has captured a comprehensive overview of a complete evacuation process of real earthquake-tsunami events. This research addresses this gap by analysing the evacuation response of Kaikōura residents following the 2016 Kaikōura earthquake and subsequent tsunami, with the intention to inform realistic rules and interaction inputs for evacuation modelling.

A questionnaire survey was developed to better understand risk awareness influence on warning and evacuation decision-making processes and origin-route-destination location response. The survey results of 131 Kaikōura residents showed that the majority of respondents had a 'good' or 'very good' level of knowledge on tsunami hazard and the need to evacuate prior to the Kaikōura earthquake, which resulted in a high proportion of respondents evacuating because of a potential tsunami. Furthermore, many respondents attributed their high level of awareness to Civil Defence information which reflects the extensive emergency management public education and awareness campaigns on disaster risk in Kaikōura over the last ten years. Geospatial information of origin-route-destination locations revealed common safe zone locations along Kaikōura peninsula, prevalent evacuation routes and congestion barriers experienced during the 2016 event. This information informed key parameters for the development of a network-based vehicular evacuation model to estimate evacuation time for individual households and Kaikōura's road network. The results of this research provides new and insightful information for local, regional and national level emergency response planning and enhance disaster resilience in New Zealand.

Vinnell, L., Milfont, T., McClure, J.   80

Why do people prepare for natural hazards? Identifying relevant behavioural beliefs

Natural hazards such as earthquakes and tsunami can have adverse impacts on infrastructures and populations globally. In Wellington, New Zealand, perception of these risks is high but preparation is low. Using the Theory of Planned Behaviour, we assessed intentions, cognitions, and beliefs about the

behaviour of preparing for natural hazards at one point in time and behaviour one month later with a sample of 61 participants across both time points. Intentions predicted preparation, while experiential attitudes, instrumental attitudes, self-efficacy, and perceived descriptive norms explained approximately 34% of the variance in intentions. Further, this study identified several key beliefs related to preparing such as the belief that preparing helps people to get through a natural hazard event better, that people can make the effort to prepare, and that preparing can be fun and rewarding. These beliefs offer specific and tangible factors which can be efficiently addressed in public education campaigns.

Wallace, T., Crawford-Flett, K. **88**

Understanding geomechanical and hydraulic vulnerabilities in dam-stopbank systems

Floods are New Zealand's most frequent and damaging natural events. Stopbanks and dams provide the primary means of physical protection for many communities and are, therefore, critical for protecting life, property, and other infrastructure.

Embankments within catchments are often constructed from similar local materials. The geotechnical properties of these materials are often poorly characterised, understood and/or documented. Uncertainties in the performance of embankments are compounded due to the practice at the time of design and construction, as most embankments were constructed between ~1880 and 1980.

In this study an experimental programme will be undertaken to improve the understanding of how geomechanical and hydraulic parameters influence failure modes. By understanding the relative influence of certain geotechnical and hydraulic parameters, such as relative flow-embankment orientation, defect orientation, and soil collapsibility, a generic vulnerability assessment framework will be developed.

While the NZSOLD Dam Safety Guidelines provide performance criteria for dams, there is currently no equivalent for stopbanks. This can lead to differences in levels of resilience provided by dams and stopbanks which may not be proportional to the relative importance of the structures. To this end, the potential consequences of failure of individual embankments within larger systems will be examined. Findings from this will inform a broader method for assessing the vulnerability and consequences of other dam-stopbank systems.

This project aims: (1) A deeper understanding of the importance of individual embankment elements, (2) a framework to identify "weak links" in stopbank-dam embankment networks, and (3) tools to prioritise maintenance, and investment in embankment systems. Ultimately, this project aims to move flood risk management towards a broader system wide view to improve resilience and safety in downstream communities.

Bebbington, M., **Weir, A.**, Wilson. T., **89**

Quantifying systemic vulnerability to critical infrastructure systems

Critical infrastructure are the infrastructural networks and systems deemed essential for the functionality of society and economy. Critical infrastructure systems are globally recognised to be highly interdependent, meaning that the loss of function of an asset within one sector can greatly reduce the functionality of assets that rely on its continued supply. Due to the complexity of such

networks, systemic vulnerability (the propensity of a system or network to experience loss of service due to physical damage) is typically qualitatively ascertained, or neglected entirely in impact assessment frameworks. Furthermore, current quantitative methods for systemic vulnerability calculation (such as criticality metrics) tend to be sector-specific, therefore not accounting for trans-sector interdependencies inherent in infrastructural networks.

We propose a new methodology for determining asset criticality, incorporating interdependencies inherent in infrastructural networks. We also demonstrate a new methodology for the quantification of systemic vulnerability, by integrating the new asset criticality classification scheme with hazard-plausibility information. We demonstrate this new methodology in Taranaki, New Zealand, where spatially extensive critical infrastructure networks supply substantial agricultural and energy industry, and also circumnavigate Mt Taranaki volcano, where a large explosive eruption in the next 50 years has a 33 – 42 % likelihood.

Wilkinson, C., Hikuroa, D., Hughes, M., Macfarlane, A., Stahl, T.   **81**

Mātauranga Māori refines perceptions of landscape healing following major disturbances

Major disturbances such as earthquakes, volcanic eruptions, floods, tsunami and anthropogenic activity have the potential to cause significant landscape modifications. Typically, the concept of landscape healing is understood by Earth scientists as the processes by which a landscape returns to its pre-disturbed, or "healed", state. This concept is often characterized by landscape-scale mass balance relationships or dynamic equilibriums. We posit that, in reality, the only constant within landscape systems is change, and that terming a landscape "healed" is not realistic for dynamic landscapes. This research critiques the concept of landscape healing by viewing landscapes through a Te Ao Māori (Māori worldview) lens.

Mātauranga Māori (Māori knowledge) specifies that major disturbances are part of a landscape's natural evolution. Here, we expand upon this idea by presenting the results of ten semi-structured interviews with five ahi kā Māori individuals (people who have strong ties to their ancestral lands) from different hapū (sub-tribes) around Aotearoa New Zealand. Interview participants indicated that the various elements of post-disturbance landscapes—physical, cultural, and social—all have unique ways of responding to major changes. Māori perspectives indicated some contrasting opinions about human and non-human catalysts of landscape change but revealed many consistent attitudes regarding how people can best respond to major disturbances. Connection, sustainability, reciprocity, adaptability, and an appreciation for time and natural healing were the main themes that arose from the interviews, indicating that landscape healing is about the relationships among people, between people and land, and between non-human elements of the environment. With these insightful Te Ao Māori perceptions, we re-evaluate the traditional concept of landscape healing and provide a refined understanding informed by holistic Māori perspectives.

Yang, Q., Henry, R., Lu, Y.   52

Wall-to-floor connection behavior in a low-damage concrete wall building

Following the 2010/2011 Canterbury earthquakes, approximately 60% of multi-story buildings with reinforced concrete walls required demolition. Both practitioners and researchers have increasingly realized that low-damage structural systems could be an alternative to improve the seismic behaviour of concrete buildings and to reduce the economic and social impact of structural damage in future earthquakes. To verify the seismic response of a low-damage concrete wall building representing state-of-art design practice, a shake table test on a two-story concrete building was recently conducted as part of an ILEE-QuakeCoRE collaborative research program. The building utilized flexible wall-to-floor connections in the long span direction and isolating wall-to-floor devices in the short span direction to provide a comparison of their respective behaviour. Additionally, the wall-to-floor interaction such as effects of wall uplift on the link slab, and force transfer mechanism from floor to the wall will be discussed in this paper.

Zakerinia, M.   20

Cross-Platform Validation of the Stress Density Model

Liquefaction-induced damages has proved to be severe, widespread and complex in recent earthquakes. Dynamic effective stress analysis is a procedure for evaluating the seismic response of geotechnical systems experiencing liquefaction due to earthquakes. The robustness of an effective stress analysis significantly depends on the suitability of the constitutive model used. Rigorous verification and validation of constitutive models are crucial to assess the capabilities and limitations of a model for further analyses. Comprehensive documentation of such studies provides the engineers and researchers with insight into selecting the best model for any existing circumstances. The stress density model is a constitutive model for effective stress analyses involving liquefaction, which has been recently implemented in OpenSees and FLAC. This study presents cross-platform comparisons of the stress density model implementation in both platforms through 1D free-field site response modelling of previously conducted centrifuge tests. The performance of the model when capturing the acceleration response and pore water pressure accumulation/dissipation at critical locations is evaluated.

Zarinkamar, S.   53

Trust to new seismic-proofing technology: the influential factors

Earthquakes have hit New Zealand in quick succession with no respite expected in their frequency in the future. Therefore, several new methods and technologies are proposed to the construction industry that aims at reducing the side effects of damages, including seismic-resistant technologies. However, the low level of trust towards the performance of these new technologies poses the main challenge that could also affect the adoption process to them . The literature review associates the level of trust to 36 factors. A survey of the New Zealand construction industry identified 17 of them as significant influencers. Another survey provides further details on the role that these 17 factors play as enablers or barriers in the adoption process to seismic-resistant technologies. The data collection stage involved online surveys from a random population of the construction industry, including clients,

contractors, and consultants. Four seismic-resistant technologies, Resilient Slip Friction Joint (RSFJ), Pres-Lam , Lead Extrusion Damper and the Sliding Hinge Joint were considered as the case studies. In this paper, developer of each technology and two users who had the experience of using the seismic technology in a project have been interviewed to firstly describe the challenges they faced during their projects by implementing the case studies and secondly the three most critical barriers and enablers in process of technology adoption had been finalized.