2018 QuakeCoRE Annual Meeting Poster List

4th – 6th September, 2018 – Wairakei Resort, Taupō, New Zealand

Bae, S., Polak, V., Huang, J., Lagrava, D., Motha, J., Bradley, B., Tarbali, K. 77

QuakeCoRE Ground motion simulation computational workflow

In the poster, we describe the latest development to QuakeCoRE Ground motion simulation computational workflow.

QuakeCoRE's implementation of an earthquake-induced ground motion simulation workflow is based on Graves and Pitarka (2010, 2015), which has been successfully used for investigating many scenarios of past and future earthquakes, and utilizes high performance computing resources provided by NZ eScience Infrastructure (NeSI). The use of HPC and continuous efforts to optimize and automate the workflow have enabled us to complete entire simulations within a few hours instead of several days. The multi-fold increase in computing capacity due to the recent NeSI's hardware upgrade has enabled launching an even more ambitious Cybershake NZ project, a simulation-based probabilistic seismic hazard analysis (PSHA) for New Zealand. Because of the large number of major seismic sources in NZ and uncertainties to consider, Cybershake NZ requires millions of core hours to include all the finite faults in the New Zealand national seismic hazard model, which is a substantial computational challenge. We devised a number of innovative solutions to improve and strengthen our simulation workflow to support the rapid growth in scale and complexity.

Balachandra, A., Chalian, S., Hayden, C, McGann, C., Wotherspoon, L. 14

Validating Numerical Simulation of SSI for Buildings on Liquefiable Deposits

The increasing shift towards performance based geotechnical earthquake engineering design requires an improved understanding of soil-structure interaction (SSI) for structures on liquefiable deposits. While a number of authors have used centrifuge tests and numerical modelling to study this phenomena, a limited number of studies have been undertaken where numerical models have been validated against well-instrumented physical model tests or centrifuge tests. As such, two of the centrifuge tests that were undertaken as part of the NEESR Seismic Performance Assessment in Dense Urban Environments project have been used to validate the ability of numerical simulations to model SSI for isolated structures on liquefiable deposits. The numerical simulations have been developed using FLAC and the PM4Sand constitutive soil model and OpenSees and PDMY02 constitutive soil model. The overall objective of the study is to validate the numerical model's ability to capture both volumetric and deviatoric mechanisms by comparing against settlement, pore water pressure and accelerations measured, using a large array of instruments, in the centrifuge tests. This poster presents the validation of the numerical model's ability to capture volumetric mechanisms by comparing 1D soil response simulations against free field measurements from the centrifuge tests. Additionally, an initial identification of the relative strengths and weaknesses of the two respective software packages and the two constitutive models is provided.

Bellagamba, X., Bradley, B., Wotherspoon, L., Dr Daniel Lagrava, D. 61

Inferred seismic performance and recovery of the Christchurch water supply network following the 22 February 2011 Mw6.2 Christchurch earthquake

This poster presents the performance and recovery of the Christchurch water supply network following the 22 February 2011 Mw 6.2 Christchurch earthquake. Results are presented from both geospatial and temporal perspectives, illustrating the extent of disruption and tracking the evolution of several city-scale performance metrics over time, respectively. The inferred performance and recovery are consistent with previous anecdotally-reported levels of disruption and completion of repairs from past studies, validating the presented results. It was found that the availability of power (from the electric power grid or from backup systems) plays a critical role in the water supply system performance and recovery. Nevertheless, pipe failures remained responsible for the predominant portion of the disruption. This research has formed the basis for subsequent research into optimized restoration methods which can improve community resilience.

Bhanu,V., Chandramohan, R., Sullivan, T. 35

Characterising the effect of ground motion duration on deteriorating structural models

A number of recent studies employing realistic, deteriorating structural models have been able to observe and quantify the influence of ground motion duration on cumulative damage indices and structural collapse capacity. These studies have, however, not attempted to study the underlying physical mechanisms that cause the observed effects of ground motion duration on structural response. This research project will study the influence of various model parameters on the sensitivity of structures to duration by conducting incremental dynamic analyses (IDA) using sets of spectrally equivalent long and short duration ground motions. Special attention will be given to the relation between ground motion duration and the ratcheting collapse mechanism aided by destabilising P-Δ effects. This study will serve as the starting point to understand the influence of ground motion duration on structural response, and to consider its effects in structural design and assessment.

Blake, D., Wotherspoon, L., Trotter, M., Stevenson, J., Ivory, V. 62

Data and decision making in the transport sector following the Kaikōura earthquake

The 14 November 2016 Kaikōura earthquake had major impacts on New Zealand's transport system. Road, rail and port infrastructure was damaged, creating substantial disruption for transport operators, residents, tourists, and business owners in the Canterbury, Marlborough and Wellington regions, with knock-on consequences elsewhere. During both the response and recovery phases, a large amount of information and data relating to the transport system was generated, managed, analysed, and exchanged within and between organisations to assist decision making.

To improve information and data exchanges and related decision making in the transport sector during future events and guide new resilience strategies, we present key findings from

a recent post-earthquake assessment. The research involved 35 different stakeholder groups and was conducted for the Ministry of Transport. We consider what transport information was available, its usefulness, where it was sourced from, mechanisms for data transfer between organisations, and suggested approaches for continued monitoring.

In many cases, information exchanges were effective, enabling the transport system to respond and adapt successfully, allowing continued mobility of users and goods. These exchanges were assisted by both existing and new partnerships. Organisations responding to transport disruptions drew on existing data sources in new ways, collected novel datasets, and maximised relationships to manage information exchanges. There is however, scope for improvement, with several restrictions to information exchanges and data usage identified. Based on the key findings, and acknowledging the challenges encountered, we make a series of recommendations to improve data and decision making in the transport sector before future events.

Boston, M. 36

Resilience by Design: Improving Hospital Functionality Following Earthquake

Earthquakes can cause extensive damage to the built environment and can led to injury of people in the affected area. It is critical that hospitals continue to remain functional following an earthquake in order to provide necessary treatment of the injured and ongoing treatment of those already in the hospital. However, current design codes aim for life safety goals and do not guarantee that buildings will remain operational following a major earthquake. This poster examines the operability and functionality of a hospital following a major earthquake by extending the performance-based earthquake design framework to a resilience-based design framework that considers the operability and functionality of hospital systems in addition to the performance of the building. Structural and non-structural damage is linked to specific hospital services through a fault tree analysis to estimate operability of individual hospital services and the overall functionality of the hospital as a whole. Hospital functionality can be plotted as a resilience curve to visualize the restoration of hospital services over time.

Ann Brown, A., Walker, B., Morrish, S., Ozanne, L. 47

Non-profit-business collaboration: Exploring the effects on non-profit resilience

Non-profit organisations (NPOs) play an important role in disaster response and recovery for communities, and yet they operate in environments characterised by increasing resource constraints and escalating delivery demands. At the same time, NPOs face pressure to radically adapt and transform the way they work, a challenge which many struggle to contend with. This turbulence drives NPOs to seek opportunities through collaboration with business. The problem is, we do not fully understand the effects on how NPOs adapt to, or navigate within, environmental turbulence. Through a multiple case study design, this research explores thirteen non-profit–business collaborations in New Zealand. Interviews were conducted with twenty-eight senior decision makers in order to explore the nature and dynamics of these relationships, and the effect they have on NPOs. Having identified a range of collaboration types, contexts, and dynamics, this research reveals that collaboration has the potential to create both positive and negative effects. By evolving with business, NPOs operate on shorter timeframes and often more local scales; as a result, they appear more effective in the short-term, but risk long-term efficacy and a misallocation of resources.

Individual actors play a powerful role; they have the potential to increase NPO impact, while also increasing risks associated with commercial activity. The potential implications of this study become important in increasingly complex environments, where man-made challenges and natural disasters affect political, social, and ecological domains. These factors reinforce the need to explore the impacts on NPO capacity to serve as a 'public safety net'.

Cappellaro, C., Cubrinovski, M., Bray, J.D., Chiaro, G., Riemer, M.F., Stringer,M. **15**

Cyclic Undrained DSS Testing of Christchurch Sands

Earthquake-triggered soil liquefaction caused extensive damage and heavy economic losses in Christchurch during the 2010-2011 Canterbury earthquakes. The most severe manifestations of liquefaction were associated with the presence of natural deposits of clean sands and silty sands of fluvial origin. However, liquefaction resistance of fines-containing sands is commonly inferred from empirical relationships based on clean sands (i.e. sands with less than 5% fines). Hence, existing evaluation methods have poor accuracy when applied to silty sands. Also, existing methods do not quantify appropriately the influence on liquefaction resistance of soil fabric and structure, which are unique to a specific depositional environment.

This study looks at the influence of fines content, soil fabric (i.e. arrangement of soil particles) and structure (e.g. layering, segregation) on the undrained cyclic behaviour and liquefaction resistance of fines-containing sandy soils from Christchurch using Direct Simple Shear (DSS) tests on soil specimens reconstituted in the laboratory with the water sedimentation technique. The poster describes experimental procedures and presents early test results on two sands retrieved at two different sites in Christchurch.

Chiaro, G., Kiyota, T., Umar, M., Massey, C., Chew, K., Su Kim, J. **16**

Experimental and numerical investigations of the Takanodai landslide caused by the 2016 Kumamoto Earthquakes, Japan

The 2016 Kumamoto Earthquakes, Japan, caused a number of geo-disasters in the Aso Volcanic Caldera, including a large-scale flow-type slope failure known as the Takanodai landslide. Between April and October 2016, the Authors conducted a series of post-earthquake geotechnical damage surveys and field investigations in the affected areas, and retrieved samples of volcanic soils to be characterized in the laboratory. In this poster, first, the Takanodai landslide is described. Then, results of monotonic and cyclic undrained torsional simple shear tests carried out on reconstituted specimens of Aso pumice are shown. Moreover, to provide insights into the failure mechanism of the Takanodai landslide, results of dynamic soil response and seismic slope stability analyses are presented. The numerical investigation confirmed that the pumice soil deposit was responsible for the landslide triggering. Besides, the combination of pore pressure build-up and large inertial forces were the key factors for the flow-type Takanodai slope failure.

Chigullapally, P., Wotherspoon, L., Hogan, L., Pender, M. 37

Modelling of Bridge Pile-Column Dynamic Field Tests

A field testing programme involving static pushover and dynamic snapback testing of reinforced concrete pile-columns was performed for Henderson Creek Bridge on State Highway 16 in Auckland, New Zealand. The pile-columns were surrounded by clayey soils and extended 6.5m above the ground level to support the bridge superstructure. Two of these pile-columns were selected (Pile 1 and Pile 2) and a series of tests were performed in the field to quantify the nonlinear stiffness and damping characteristics of the pile-column foundations. Models of the test setup were developed using OpenseesPL to capture these static and dynamic characteristics, and sensitivity analyses were performed to assess the influence of structural and geotechnical properties. Key aspects of this were the effect of soil-foundation-structure interaction, soil gapping, and damping. During the static pushover modelling, it was observed that the top 2m of soil played a significant role in the total system behaviour of the pile-column. The final equivalent viscous damping ratios which simulated the field response of piles were compared to damping estimates typically used in foundation design of bridges, allowing us to assess their applicability in this situation.

Blake, D., Crawford-Flett, K., Pascoal, E., Wilson, M. 63

New Zealand Stopbank networks: Understanding Resiliency Challenges

New Zealand faces complex natural hazards due to active geomorphological phenomena in conjunction with changing climate and weather patterns. Levee ("stopbank") networks are an increasingly critical distributed infrastructure network in New Zealand, providing the primary means of flood protection for people and properties in all sixteen regions of the country. In order to better understand the make-up of levee assets in New Zealand, a university research program was founded in 2017 with the support of local government agencies in order to provide the first single, standardized, reliable and spatially-referenced inventory in the form of the NZ Inventory of Stopbanks (NZIS). Initial outputs of the NZIS provide a nation-wide geospatial overview of New Zealand stopbank networks, including over 4,800 km of council-maintained assets.

The compilation of this inventory has identified significant knowledge-gaps regarding design and construction characteristics of stopbanks networks. However, even with limited design and construction information, the spatial analysis framework can be extended to assess the impact of potential levee failure on other infrastructure, both in terms of flood hazard and the cascading effect of other natural hazard events using geospatial properties of the network in relation to other infrastructure, land-use, geology, and hazard datasets.

Ongoing research aims to address the potential impacts of undocumented stopbanks, such as those constructed privately by landowners. Ultimately, NZIS characterization outputs will to help asset owners and regulators manage risk, prioritize improvement works, and improve inspections following earthquake and flood events.

Davidson, R. 64

Probabilistic framework for modelling spatially distributed infrastructure

In this poster, we propose a computational framework to model spatially distributed infrastructure. The approach is based on probabilistic hazard and damage scenarios. For earthquakes, for example, it involves identifying a suite of probabilistic ground motion maps to represent the hazard. Each map has an associated annual occurrence probability such that together they represent the complete community-level hazard. For each of those ground motion maps, a suite of probabilistic damage scenarios are similarly developed to represent the community-level probabilistic risk of damage. Each damage scenario provides a possible realization of community-wide infrastructure damage and has an associated occurrence probability, and together they capture the probability distribution of possible system damage. Each damage scenario can then be used to develop a restoration curve showing the system functioning over time from earthquake occurrence through recovery.

The approach addresses some key issues. The analysis of each type of infrastructure (e.g., water supply, power, building portfolios) is based on the same suite of ground motion maps, enabling examination of interactions among the infrastructure types and assessment of community-level resilience based on their combined functioning. It can capture the spatial correlation of damage and loss of function among buildings and lifeline components within a community. The approach also assesses resilience based on the full hazard curve, and is designed to be computationally efficient enough to be used in practice. Example applications are provided. Gaps in the existing modelling are also discussed.

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

Modelling Nonlinear Site Effects in Physics-Based Ground Motion Simulation

This study examines the performance of nonlinear total stress wave propagation site response analysis for modelling site effects in physics-based ground motion simulations of the 2010-2011 Canterbury, New Zealand earthquake sequence. This approach explicitly models 3D ground motion phenomena at the regional scale, and detailed site effects and soil nonlinearity at the local scale. The approach is compared to a more commonly used empirical Vs30 (30 m time-averaged shear wave velocity)-based method of computing site amplification for simulated ground motions, as well as prediction via an empirical ground motion model. Site-specific response analysis is performed at 20 strong motion stations in Christchurch for 11 earthquakes with $4.7 \leq Mw \leq 7.1$ which resulted in ground motions of engineering significance in the affected region. While the wave propagation analysis improves overall model bias when compared to the empirical Vs30-based approach, the uncertainty in site-to-site residuals is similar between the two site response methods, suggesting that there is appreciable imprecision in the input motions from ground motion simulations, and deficiencies in the assumptions of 1D total stress site response analysis. The wave propagation site response analysis does, however, significantly reduce residuals compared to those from the empirical Vs30-based site amplification for soft or "atypical" sites that exhibit strong site amplification. The comparable performance in ground motion prediction between the physics-based simulation method and standard-of-practice empirical ground motion models suggests the former is a viable approach for generating site-specific ground motions for geotechnical and structural response history analyses.

de Raadt, A., Blick, G. 49

Mapping New Zealand 2025 – responding to the Kaikoura earthquakes

The Land Information New Zealand (LINZ) Mapping New Zealand 2025 programme is looking at seamlessly mapping New Zealand (NZ) from the top of Aoraki / Mt Cook right out to the edge of our continental shelf.

A number of initiatives under this programme contributed directly to the Kaikoura earthquake response, these including post-event aerial imagery, LiDAR, hydrographic LiDAR offshore and pulling together a building outline dataset. In addition, LINZ worked closely with GNS Science to resurvey the area to quantify ground movement and measure the impact of this event on spatial infrastructure, including property boundaries.

This work will presented in more detail in this poster.

Dempsey, D., Eccles, J., Wotherspoon, L., Bradley, B. 2

Ground motion simulation of Upper North Island earthquakes

Active faults in low strain-rate regions of New Zealand sill pose a significant hazard where they are near to large population centres. Such regions typically have sparse monitoring and few recorded events. About 40% of New Zealand's population is located within 50 km of the Wairoa North Fault, the Kerepehi Fault and its possible offshore extension in the Firth of Thames. Prior studies in the area indicate these faults have been active within the past 10ka, generating events between Mw 5.5 for single event rupture, potentially up to Mw 7.4 in the event of a multiple segment rupture. We have simulated ground motions arising from possible rupture scenarios on these faults, including uncertainty around directivity, the possibility of ruptures hopping multiple fault segments, and the effect of low velocity sediments within the Hauraki Rift. Our results point to several areas where further data collection could improve our understanding of seismic hazard in the Upper North Island.

Dhakal, R., Cubrinovski, M., Bray, J.D., de la Torre, C. 17

Site Characterisation and Liquefaction Assessment of the Reclamations at CentrePort

The 14 November 2016 Mw7.8 Kaikoura Earthquake caused widespread liquefaction in CentrePort, Wellington, resulting in substantial lateral ground movement, global and differential settlements, and large volumes of soil ejecta. Following the earthquake, a subsurface exploration program was executed consisting of CPTs and surface wave testing to characterize the thick end-dumped gravelly fills and hydraulically-placed dredged reclamations.

The complex subsurface soil composition for the gravelly fills contain mixtures of gravels, sands, and some non-plastic fines. The hydraulic fills were constructed recently by slurry deposition of seabed materials with little compaction. This study uses the extensive subsurface data to produce detailed subsurface soil profiles for the Port of Wellington, and then scrutinizes the applicability of simplified procedures for liquefaction assessment of the reclamations.

Ranges for the penetration resistance and soil behaviour type index values are provided for the characteristic soil layers at the port. The spatial distribution of the end-dumped gravelly fills and sandy hydraulic fills at the port are presented. Some of the areas of the port also contain soils with significant fines (both non-plastic and plastic). The liquefaction susceptibility and potential of the different soil deposits within the port are assessed and compared to the observed field performance. State of the practice simplified procedures are used to evaluate liquefaction triggering and ground damage indices. Emphasis is placed on the investigation of the robustness of conventional procedures in their ability to capture the liquefaction resistance and cyclic response of the reclaimed soil.

Dong, W. 38

The Lateral Seismic Performance of Multi-storey Heavy Timber Buildings with BRBs

This research is to investigate seismic performance of heavy timber frames integrated with buckling restrained braces (BRBs) that act as critical components to resist lateral seismic and wind loads in multi-storey timber buildings. In this hybrid system, BRBs will provide strength, stiffness, ductility and energy dissipation under seismic loading and protect heavy timber framing members such as glulam or LVL members. The research focus consists of two parts. The first part is to understand the behaviour of critical timber-BRB interface connections since these connections should be strong and stiff enough to transfer load between BRBs and heavy timber frame. Some connections will be tested and assessed to identify the most suitable connection type. The second part is to understand the hybrid system performance. Full-scale experimental testing on one-storey glulam frames with BRBs will be conducted with the interface connection type selected according to the outcome of the connection research. The experimental results will be used to calibrate numerical models of the timber-BRB hybrid structures and further conduct parametric studies on the hybrid structures.

Dunant, A., Davies, T., Bebbington, M., Gaillard, J. 3

Natural disaster system, a multi-hazard impact assessment methodology

The impact of natural disasters is increasing in the recent years. Despite the international interest, few studies quantify the dynamic interaction of multi-hazards events. It is argued that without taking into account the dynamic complexity of natural catastrophes, impact assessment will underestimate risk, increase vulnerability and distort emergency management priorities. This research hypothesises that we can use graph and network to assess the complex impact of natural hazard scenarios. In order to set this novel method, the Kaikoura earthquake event that occurred in 2016 is used as a calibrating point to study the cascading events that might threaten other part of New Zealand (Franz Josef Township on the Westcoast being a current point of interest). As follow ups from the selected initial tremor, the natural hazards interactions will consider landslides, landslide dams and floods as well as the exposed elements like roads and housing. To assess the compounded impact of those hazards, the combination of hazard footprints and exposed nodes are used to create the hazard network. Iterative simulation of the network is then expected to provide the overall impact following an initial earthquake. Those results are planned to inform challenging scenarios to prepare communities and emergency services.

Egbelakin, T., Malan, R. 23

Toolkit of Alternative Policies and Incentives for Resilience and Sustainable Reuse of Heritage Buildings

This project examined alternative polies and incentives that could be combined to make adaptive reuse of heritage buildings become commercially viable. Targeting four core strategic aspects of building/facilities management that include seismic strengthening, adaptive reuse, affordable housing and heritage preservation, alternative policy measures and incentives within these core areas were examined. A contextual analysis and evaluation of the efficiency and effectiveness of the different incentives and policy alternatives was conducted with inputs from partnering local councils such as Whaganui and Auckland Council, Heritage Trust groups and international organisations that have worked on successful case study exemplars. These organisations provided feedbacks that helped localised the incentives.

The research culminated into a toolkit of available and potential incentives that could be collectively used to make a business case for public and private investments in earthquake resilience, while recognising the environmental, economic and community benefits of reusing these buildings. The toolkit also offers recommendations for policy reforms about approaches and strategies that could help to accommodate and spur transit-oriented growth in provincial towns while promoting heritage preserving and seismic resilience of earthquake-prone buildings. The research thus create a pathway for improving the earthquake resilience of older character buildings in both provincial towns and mega cities in New Zealand.

Elwood, K., Filippova, O., Pastor, J., Noy, I. 24

Creating GIS-ready building inventory dataset for seismic risk assessment and management

We describe the creation of a building inventory database developed for Wellington, whose ultimate aim is to assist the generation of research on the risks, impacts, and viable solutions for reducing the seismic risk of existing multi-story concrete buildings in city's Central Business District (CBD). The database's primary purpose is to inform a multi-disciplinary project whose aims are: (1) to provide best scientific knowledge about the expected seismic performance of concrete buildings; (2) to assess the impact of multiple building failures including the downstream consequences of associated cordoning; (3) to provide a path for seismic retrofitting that includes prioritization of retrofits and (4) to inform the design of a regulatory structure that can facilitate the reduction of risk associated with earthquake vulnerable concrete buildings as described in aims (1)-(3). In addition, the various information associated with each building within project's scope area (for example, structural system, number of stories, age, occupants, building use etc.) is GIS-ready and allows users access all the information directly on mapping applications and perform queries in a GIS viewer developed specifically for the project.

Filippova, O., Sullivan-Taylor, B. 48

Reducing risk and building resilience: Establishing the public good value of earthquake-vulnerable heritage buildings

Due to New Zealand's dynamic landscape, unpredictable hazards pose a potentially catastrophic threat to historic sites. Additionally, historic heritage is under constant development pressure (Rouse & McCracken, 2014). These primarily revolve around a lack of appropriate recognition of their public good value. As a source of financial and public good, or non-financial, value (Cowell, 2004), civic pride plays a key role in the cultural well-being and resilience of communities. Historic resources are important for building resilience in communities because they are places of memory and stability during times of crisis, helping to preserve community identity even in the face of traumatic change (Appler & Rumbach, 2016). These should be considered equally alongside economic value, but are often under-represented or ignored because of the difficulties in their quantification.
This study examines public awareness of heritage buildings in Invercargill. Data for this study were collected from over 600 residents using an online survey. The findings of this study provide important information for planning specialists and policy makers.

Francis, T., Filiatrault, A., Sullivan, T. 39

Using loss assessment to provide a value case for implementation of seismic isolation of light-framed timber houses in New Zealand.

The September 2010 and February 2011 Canterbury earthquakes caused significant damage to both commercial and residential buildings. While a substantial portion of research effort since these events has been in the commercial space, only a very small portion has considered the effect of earthquakes on light-framed, timber houses. The design philosophy for these structures has not changed significantly for many years, with the assumption that they perform well for life safety. However, increasingly, performance assessment procedures are preferred by stake-holders as a means of quantifying more meaningful performance measures for their assets, including monetary losses. This research aligns well with this performance assessment focus by investigating the implementation of innovative seismic isolation devices for reducing monetary losses to residential buildings.
Using risk analysis through the open-source software, OpenQuake, as well as innovative research in New Zealand in the field of ground motion prediction modelling, the first part of this PhD research topic aims to show that an innovative isolation system for light-framed timber buildings will substantially reduce annual expected losses for the Wellington and Christchurch regions.
This poster presentation outlines preliminary findings from the OpenQuake loss assessment and provides a methodology for continued research. In addition, a summary of findings in the field of seismic isolation of light-framed timber structures from other from other invested countries, specifically Japan and the United States, will be presented. This prior research will hope to provide a framework for development of base isolation systems that would be effective for the New Zealand building industry.

Galvez, F., Ingham, J., Dizhur, D., Giaretton, M. 25

Discrete Element Modelling of Unreinforced Masonry Buildings and Parts

Post-earthquake inspections have highlighted that out-of-plane failure of unreinforced masonry (URM) walls is one of the most life threatening hazards related to earthquakes. Connections between structural elements and interlocking across the wall section play an important role in the capacity of a URM building to withstand earthquakes. Consequently, the seismic assessment of existing URM buildings requires an appropriate methodology to correctly estimate the performance of the investigated element. International standards and guidelines for seismic assessment are often based on simplified methodologies that incorporate assumptions regarding the collapse mechanism and general behaviour of the wall. Alternatively, the Discrete Element Method (DEM) is an advanced modelling technique that can accurately predict and simulate from wall behaviour to scaled model building without any prior assumption about the failure mechanism. Solid rigid and deformable elements were used to represent the distinct clay brick units and an inelastic law was assigned to the contact surfaces to simulate the mortar joints. Pushover and non-linear time history analyses were conducted and the resultant capacity curves and collapse mechanisms of each analysis were studied.

Garcia, M. 50

Community Resilience Capital Framework: An action-research approach to Earthquake Community Resilience in Aotearoa New Zealand.

Earthquakes and geo-hazards constitute a major risk for New Zealand communities. Fostering community resilience to earthquakes is therefore vitally important, but, how can current New Zealand governance structures effectively operationalize this complex and sometimes contested concept? This project seeks to provide insights to this question by critically evaluating how community resources are currently framed as community capitals and how these operate in relation to the broader ideas of community resilience and well-being in the context of the Waimakariri District recovery and regeneration following the 2010/11 Canterbury earthquakes. Preliminary results based on the partial analysis of fifty-one semi-structured interviews with a broad diversity of local stakeholders point in exciting directions. In terms of community well-being, the interviews provided rich information that shows that social relations are considered the pillar of community well-being in the Waimakariri District. But preliminary results also speak of the subjective, contested, and multidimensional nature of community well-being as a concept. In terms of community capitals and community resilience, the preliminary analysis of the data shows that capitals are perceived differently by different people and in different moments of time. Interview data also shows that tangible and intangible capitals do not operate in individual and isolated silos, on the contrary, they operate through tightly knit and dynamic networks of relations shaped by human decisions, spanning across space and time, making pre-existing positive and negative elements associated to multiple tangible and intangible capitals key determinants of what appears to be a continuous and always evolving community resilience building process.

Gray, L. 51

Prepared for the Big One? An exploratory study with emergency managers, planners and responders in Aotearoa New Zealand

Overview: The capacities and vulnerabilities of people with extreme obesity have yet to be explored in the disaster risk reduction literature. While people have been impacted in disasters in relation to their size, shape and weight, the literature is 'conspicuously invisible' on this topic and no empirical research was located (Gray, 2017; Gray & MacDonald, 2016).
Background: New Zealand is a signatory to the UNISDR Sendai Framework for Disaster Risk Reduction 2015-2030. The Framework sets out four priorities: the first involves understanding disaster risks across all dimensions of vulnerability (UNISDR, 2015).
Question: In what ways are people with extreme obesity presently considered in emergency planning in Aotearoa New Zealand?
Study: Exploratory survey of emergency managers, planners and responders.
Emergency managers, planners and responders were surveyed utilising an online questionnaire tool between 17 May – 30 June 2018. The questionnaire was issued to agencies such as regional emergency management organisations, health agencies, civil defence, fire, police, and ambulance services via email and a snowballing technique (Morgan, 2008). Information was collected about current and planned considerations for this particular population in Aotearoa New Zealand given the levels of population exposure (current estimates signal extreme obesity rates to be around 20% amongst Pacific people's and 10% amongst Maori) (MoH, 2017).
Results: Initial results will be presented at QuakeCore.
Forty seven responses were received from a wide range of agencies and a large geographic spread across Aotearoa New Zealand.
Implications will be presented in the poster.

Green, R., Lasley, S., Rodriguez-Marek, A., Ulmer, K. 18

Accounting for Ground Motion Duration in Evaluating Liquefaction Triggering

The "simplified" liquefaction evaluation procedure is the most widely used approach for evaluating liquefaction triggering potential worldwide. In most variants of the simplified procedure, the influence of the ground motion duration on liquefaction triggering is accounted for using Magnitude Scaling Factors (MSF), designated as such because early studies correlated ground motion duration solely to earthquake magnitude, where ground motion duration was quantified in terms of number of equivalent cycles (neq). Recent studies have shown that neq, and hence MSF, are dependent on site-to-source distance, soil density, induced shear strain, and induced excess pore water pressure, as well as earthquake magnitude. However, in the study performed by the authors using a low-cycle implementation of the Palmgren-Miner fatigue theory, neq, and hence MSF, are shown to primarily be a function of peak ground acceleration (amax) at the surface of the soil profile and earthquake magnitude, and to be relatively independent of soil density, effective confining stress, etc. The dependence of neq and MSF on amax is consistent with the authors' finding that neq correlates to the 5%-75% significant duration (D5-75%) of the ground motions and the findings by others that amax and D5-75% and are negatively correlated. The implications of the authors' findings and proposed MSF on liquefaction triggering evaluations in New Zealand and worldwide are presented in this poster.

Shrestha, S., Chandramohan, R., Dhakal, R. 40

Effect of ground motion duration and response spectral shape on seismic performance of steel moment resisting frame buildings

This study aims to assess sensitivity of typical steel moment resisting frame (MRF) buildings constructed in New Zealand by implementing hazard consistent incremental dynamic analysis (H-IDA). H-IDA is a recently developed framework, which is performed using multiple sets of ground motions each of which represent key ground motion characteristics consistent with different levels of seismic hazard. Unlike the current trend of seismic design and analysis of structures, which explicitly consider only amplitude measure of the ground motion, such as spectral acceleration at the fundamental period of the structure (Sa(T1)), this study takes into account the effect of ground motion duration as well as response spectral shape on the performance of structures. In order to quantify the effect of duration of ground motion on a structure, significant duration (Ds) is used while SaRatio is implemented to quantify the response spectral shape. A typical office building plan developed for consistent case study between different QuakeCoRE projects is adopted to model 4 and 12 storey steel MRF buildings in OpenSees. Rotational spring is incorporated in the model to capture nonlinear behaviour of the steel MRF, which employs a bilinear hysteretic response based on the Modified Ibarra, Median and Krawinkler (IMK) Deterioration Model. Empirical equations developed by Lignos and Krawinkler (2010) are used to compute deterioration parameters for rotational behaviour of the hinges. The results of IDA analyses of these two building models are used to investigate sensitivities of typical mid-rise and low-rise steel buildings towards ground motion duration and spectral shape.

Skurak, H. 52

The role of self-determination in motivation in the context of corporate volunteering?

We present a model that applies the self-determination theory (SDT) to explain the role of motivation and employer support for corporate volunteering in the emergence of organisational CSR climate. In addition, we explored the link between CSR climate and employee and organisational outcomes such as employee volunteering satisfaction, community impact efficacy and organisational commitment in the domain of corporate volunteering. Data were collected from 264 employees from five organisations. In general, our results supported the importance of autonomous forms of motivational states and the availability of paid time off for corporate volunteering as contributors to a positive CSR climate perception in an organisation. In addition, CSR climate is suggested as an explanatory link in the relationships between employee corporate volunteering motivation and employer support and the various outcomes examined in our study. These results also emphasise the relative and differential contribution of various motivational states to the outcomes under investigation. Moreover, we have found that the corporate volunteering specific construct, community impact efficacy, is associated with CSR climate and the most autonomous forms of employee corporate volunteering motivations. The present study underlines the importance of the psychological processes through which positive individual, organisational and community related attitudes in a corporate volunteering context occur.

Harrison, S. 53

Alternative Data Sources for Impact Warnings and Impact Modelling

Impact modelling and early warning systems play a key role in community resilience to a given hazard. Identifying the specific social, economic, and environmental impacts of a hazard allows communities to adjust their plans and actions to better adapt to, and cope with, the consequences and outcomes of the hazard. Rather than only preparing for a hazard with no specific knowledge of exactly how they could be, or will be, affected (or impacted), communities and individuals can plan for impacts that are specific to their situation. However, the challenge with identifying these specific impacts resides in the availability of and access to impact, vulnerability, and exposure data before, during, and after an event.

In the past decade crowdsourcing, social media, and volunteered geographic information (VGI) have played increasingly important roles in disaster management. The role of crowdsourcing has solidified during and after a disaster by enhancing situational awareness and aiding in coordinating response and rescue efforts. With the accessibility to this highly localised impact information online, the proposed aim of this study will be to investigate how these alternative data sources and processes can improve impact modelling and impact warnings. Additionally, these online platforms may offer a novel way of engaging with stakeholders and facilitating open collaboration in disaster risk reduction.

Hashemi, A., Zarnani, P. 41

An analysis and design procedure for seismic resilient buildings using Resilient Slip Friction Joint (RSFJ) technology

The innovative Resilient Slip Friction Joint (RSFJ) technology has recently been developed and introduced to the New Zealand construction industry. This damage avoidance technology not only aims to provide life safety, but also to minimise the earthquake-induced damage so that the building can be reoccupied quickly with minimum business disruption. The RSFJ technology, which is in fact provided the required seismic performance regardless of the material used for main structural components, can be used in various arrangements and applications to provide self-centring damage avoidance lateral load resisting systems. These applications include (but not limited to) shear walls, tension-compression braces, tension-only braces and moment resisting frames. The performance of the RSFJ technology has previously been verified by joint component testing and full scale experimental tests.
This study aims to provide a simple analyse and design procedure for the structural engineers when considering RSFJs in a structure. A step-by-step forced-based design procedure is provided which generally includes the use of Equivalent Static Method (ESM) based on the New Zealand standard for structural design actions together with non-linear static push-over and non-linear dynamic time-history simulations. A case-study prototype structure is considered the follow the proposed design procedure. Furthermore, the same structure is analysed using the Displacement Based Design (DBD) and the results are compared with those from the Forced-Based Design (FDB). Overall, the findings of this paper confirms that the proposed approach can be efficiently used when a seismic resilient design with the RSFJ technology is targeted.

Haymes, K. 42

Developing procedures for the prediction of floor response spectra

The seismic engineering industry has been shifting its focus towards performance based engineering and as it does, the importance of adequately predicting the performance of the often-overlooked non-structural elements has become clear. A lack of simple but reliable methods for predicting the acceleration demands on non-structural elements is considered a significant challenge for the industry. Recent studies have highlighted the shortcomings that current international design codes have in accurately assessing floor acceleration response spectra. This research, therefore, attempts to find the optimum balance: proposing a procedure for the prediction of floor response spectra which is reliable and sufficiently accurate whilst maintaining a level of simplicity suitable for widespread adoption. Several methods are examined, with the importance of critical parameters quantified. Different means of simplifying the methods is then explored. The verification of each method is undertaken using four instrumented case-study buildings which have accelerometer records from real or simulated seismic events. The acceleration floor spectra spectra obtained from these records are compared with those predicted by the methods. The desired outcome of this research is a fully implementable and reliable procedure that can reduce the losses from damage to non-structural elements.

Hopkins, J., Collins, T. 26

Regulating for Resilience in an Earthquake-Vulnerable City – The Wellington Case Study (Stage 1)

Working from a functionalist legal perspective, using the current New Zealand experience and a comparative examination of overseas practice, the project will provide guidance on the specific regulatory requirements for the resilience and recovery in Wellington's CBD. Working with other partners in Flagship 3 and the wider Wellington Resilience project, this socio-legal study will help ensure that when it comes, Wellington can survive its inevitable time of challenge.

The overall aims of this three year project are to provide:
1. An understanding of risks and likely impact of the current regulatory environment for multi-storey buildings Wellington region.
2. Regulatory solutions for reducing the risk and likely impact of a major event in the Wellington region.
3. A regulatory framework for managing the loss of significant building stock in the post event environment.

At the annual meeting we will provide preliminary findings around stage one of the project relating to the following:

a) An examination and analysis of the current Earthquake Prone Building (EPB) scheme in relation to the Wellington CBD.
b) The legal consequences of cordoning in the Wellington CBD
c) The possibility of using non-EPB regulatory tools to address Earthquake Vulnerable Buildings (above NBS 33%).
d) The impact of the current regulatory models on the Wellington CBD (using the CBD mapping data provided by FS3).

Horspool, N., Elwood, K., Johnston, D., Ardagh, M. 27

Drivers of Injuries from Recent New Zealand Earthquakes

In the past 8 years, earthquakes in New Zealand have injured over 12,000 people and killed 187. This has had a huge impact on the affected individuals, families, businesses and communities across the country. Understanding the key drivers of earthquake injuries and fatalities are critical for reducing the future socio-economic impact of future earthquakes. Previous studies on earthquake injuries (e.g. Cousins et al, 2008. Spence et al, 2011), globally and in New Zealand, have significant limitations. This include injury data that is biased towards the more severe injuries as this is what is generally reported internationally, or the data is dominated by countries where building codes are not present or not enforced. This poster will present preliminary results from a transdisciplinary approach to understanding what drives earthquake injuries. The research draws on a globally unique injury dataset from ACC that contains reported injuries from 8 New Zealand earthquakes that span from the 2010 Darfield earthquake through to the recent 2016 Kaikoura earthquake.

Ijaz, R. 54

Resilience of Business Models of Small and Medium Enterprises

This research aims to explore how business models of SMEs revolve in the face of a crisis to be resilient. The business model canvas was used as a tool to analyse business models of SMEs in Greater Christchurch. The purpose was to evaluate the changes SMEs brought in their business models after hit by a series of earthquake in 2010 and 2011.
The idea was to conduct interviews of business owners and analyse using grounded theory methods. Because this method is iterative, a tentative theoretical framework was proposed, half way through the data collection. It was realised that owner specific characteristics were more prominent in the data than the elements business model. Although, SMEs in this study experienced several operational changes in their business models such as change of location and modification of payment terms. However, the suggested framework highlights how owner specific attributes influence the survival of a small business. Small businesses and their owners are extremely interrelated that the business models personify the owner specific characteristics. In other words, the adaptation of the business model reflects the extent to which the owner possess these attributes. These attributes are (a) Mind-sets – the attitude and optimism of business owner; (b) Adaptive coping – the ability of business owner to take corrective actions; and (c) Social capital – the network of a business owner, including family, friends, neighbours and business partners.
This research open avenue for owner specific characteristics and their importance for the business survival in post-disaster context.

Jeong, S., Foster, K., de la Torre, C., Wotherspoon, L., Bradley, B. 4

What caused the spatial variability of strong ground motions near the epicentre of 2016 M7.8 Kaikōura earthquake? The role of the local geological condition

During the 2011 M7.8 Kaikōura earthquake, ground motions recorded near the epicentre showed a significant spatial variation. The Te Mara farm (WTMC) station, the nearest to the epicentre, recorded 1g and 2.7g of horizontal and vertical peak ground accelerations (PGA), respectively. The nearby Waiu Gorge (WIGC) station recorded a horizontal PGA of 0.8g. Interestingly, however, the Culverden Airlie Farm (CULC) station that was very closely located

to WIGC recorded a horizontal PGA of only 0.25g. This poster demonstrates how the local geological condition could have contributed to the spatially variable ground motions observed in the North Canterbury, based on the results of recently conducted geophysical investigations. The surficial geology of this area is dominated by alluvial gravel deposits with traces of silt. A borehole log showed that the thickness of the sediments at WTMC is over 76 metres. Interestingly, the shear wave velocity (Vs) profiles obtained from the three strong motion sites suggest unusually high shear wave velocity of the gravelly sediments. The velocity of sediments and the lack of clear peaks in the horizontal-to-vertical (H/V) spectral ratio at WTMC suggest that the large ground motion observed at this station was likely caused by the proximity of the station to the causative fault itself; the site effect was likely insignificant. Comparisons of H/V spectral ratios and Vs profiles suggest that the sediment thickness is much smaller at WIGC compared with CULC; the high PGA at WIGC was likely influenced by the high-frequency amplification caused by the response of shallow sediments.

Kowal, A., Stirling, M., Sangster, C., Gorman, A. **5**

Strong Ground Motions Simulations for Dunedin: First step using the SCEC Broadband Simulation Platform

Our poster will present on-going QuakeCoRE-founded work on strong motion seismology for Dunedin-Mosgiel area, focusing on ground motion simulations for Dunedin Central Business District (CBD). Source modelling and ground motion simulations are being carried out using the SCEC (Southern California Earthquakes Center) Broad Band simulation Platform (BBP). The platform computes broadband (0-10 Hz) seismograms for earthquakes and was first implemented at the University of Otago in 2016. As large earthquakes has not been experienced in Dunedin in the time of period of instrumental recording, user-specified scenario simulations are of great value. The Akatore Fault, the most active fault in Otago and closest major fault to Dunedin, is the source focused on in the present study. Simulations for various Akatore Fault source scenarios are run and presented.

Path and site effects are key components considered in the simulation process. A 1D shear wave velocity profile is required by SCEC BBP, and this is being generated to represent the Akatore-to-CBD path and site within the BBP. A 3D shear velocity model, with high resolution within Dunedin CBD, is being developed in parallel with this study (see Sangster et al. poster). This model will be the basis for developing a 3D shear wave velocity model for greater Dunedin-Mosgiel area for future ground motion simulations, using Canterbury software (currently under development).

Lee, R., Bradley, B. 6

Hybrid Broadband Ground Motion Simulation Validation of New Zealand Earthquakes

With recent advances in computational performance and physics-based ground motion simulation methodologies, physics-based seismic hazard analysis is at the critical point of becoming conventionally feasible. However, before the physics-based ground motion simulations can be adopted, they must first be validated against observations to quantify their performance. This paper presents results of ground motion simulations of small-to-moderate magnitude (3.5≤Mw≤5.0) earthquake events across New Zealand, with clusters of earthquakes generally located along the tectonic plate boundary. Source characteristics are obtained from centroid moment tensor solutions provided by GeoNet and the New Zealand Velocity Model is utilised to provide crustal seismic velocities. A total of 668 earthquake*

ruptures, modelled as point sources, are considered with over 5000 quality-assured ground motions recorded at 380* recording stations. The performance of the simulations, and conventional empirical ground motion models (for benchmarking purposes), are quantified using a non-ergodic analysis framework where the biases and uncertainties associated with the simulation methodology and systematic source, site and paths effects are explicitly determined.*

Lin, A., Al-Ani, M., Chigullapally, P., Hogan, L., Lew, S., Reynolds, J., Sadashiva, V., Wood, J., Wotherspoon, L., Blake, D. 66

Historic performance and seismic hazard exposure of national infrastructure networks

Liquefaction hazard maps are an important tool for the assessment of exposure and the potential for damage to the built environment. The most robust approach for the development of these maps is using in-situ investigation data and simplified liquefaction evaluation procedures. When infrastructure networks are the focus of assessments, this approach can be expensive and labour-intensive. In these cases, geospatial methods can be used as an alternative approach. This work focusses on the assessment of the potential exposure of New Zealand's national transportation and power transmission networks to liquefaction induced damage. Liquefaction susceptibility was assessed nationally making use of geospatial national datasets that included a newly developed New Zealand Vs30 model. This initial approach enabled the quantification of the overall national exposure across each network for different liquefaction susceptibility categories, highlighting regions where large portions of these networks were in highly susceptible soils. Moving beyond susceptibility, geospatial estimates of the probability of liquefaction were defined using ground motions from a suite of physics-based simulations of sources. Exposure to liquefaction hazard probabilities was assessed for each scenario, and by combining these exposure characteristics across the suite of earthquakes, network locations that were exposed to higher probabilities across multiple earthquakes were identified. These were combined with the criticality of network sections and components to identify significant exposure hotspots where more detailed assessments would be beneficial. This approach will either confirm the liquefaction hazard estimates, prompting actions to mitigate these effects, or eliminate hotspots due to the misprediction of the geospatial methods.

Liu, L., Austin, A., Latif, F., Liu, Y., Maina, D., Rehman, E., Shirzadi, S., Nair, N. 67

Electricity Distribution Resilience Framework through West Coast Alpine Fault Scenario

The poster gives an overview of the research for the funded project "Electricity Distribution Resilience Framework through West Coast Alpine Fault Scenario". This research is being undertaken through four tracks: quantification of disaster impacts, micro-grid solution to boost electricity distribution network resilience, power system optimum recovery from disasters and communication lifeline resilience and its inter-dependency to electricity.

The first track aims to provide quantitative estimate on the likelihood of different levels of damage and extent of affected areas under different earthquake intensities, which is worthwhile for determining the necessary upgrading of an existing system and for emergency planning and disaster reduction preparedness, including restoration of power.

Widespread sustained blackouts is highly likely to happen after an AF8 earthquake. Microgrid is a potential possibility to bring power back up within the shortest possible time frame. In collaboration with West Coast distribution system operator, the feasibility of forming microgrids on West Coast after a major earthquake is being investigated from technical perspective.

Optimum distribution network restoration for Westpower network is also being undertaken. The generator's black start capability with all available network components are examined after which critical assets required for this activity are mapped.

Communication is integral for infrastructure resilience. The mechanisms by which communication networks are affected following large-scale natural disasters are studied. This research track will investigate the extent to which wireless systems can be dynamically reconfigured to provide coverage to 'cut-off' regions, while still maintaining acceptable levels of interference and quality of service

Loghman, V., Tarbali, K., Bradley, B., Chandramohan, R., McGann, C., Pettinga, D. 7

Seismic response of complex structural systems using code-compatible as-recorded and simulated ground motions

This research investigates the validation of simulated ground motions on complex structural systems. In this study, the seismic responses of two buildings are compared when they are subjected to as-recorded ground motions and simulated ones. The buildings have been designed based on New Zealand codes and physically constructed in Christchurch, New Zealand. The recorded ground motions are selected from 40 stations database of the historical 22 Feb. 2011 Christchurch earthquake. The Graves and Pitarka (2015) methodology is used to generate the simulated ground motions. The geometric mean of maximum inter-story drift and peak floor acceleration are selected as the main seismic responses. Also, the variation of these parameters due to record to record variability are investigated. Moreover, statistical hypothesis testing is used to investigate the similarity of results between observed and simulated ground motions.
The results indicate a general agreement between the peak floor acceleration calculated by simulated and recorded ground motions for two buildings. While according to the hypothesis tests result, the difference in drift can be significant for the building with a shorter period. The results will help engineers and researchers to use or revise the procedure by using simulated ground motions for obtaining seismic responses.

Maguire, J., Tang, Z., Clifton, C., Teh, L., Lim, J. 43

Shaking table tests of full-scale rocking selective pallet racks

Cold-formed steel pallet racks are used worldwide as a cost-effective structural system for storing goods. These light structures offer an efficient solution for carrying heavy loads, but are susceptible to collapse during strong ground motion, as seen in recent major earthquakes. To understand the cross-aisle response to strong ground motion and improve the design of pallet racking, a series of shaking table tests has been conducted on a full-scale three-storey selective pallet racking system. The test series consisted of three strong ground motion records applied at increasing intensities until structural collapse. The tests were repeated for three baseplate types: rigid, yielding and unanchored. The latter two allow the racks to rock during ground shaking.

The rigid baseplate system failed as the anchor pulled-out of the concrete slab at 150% of the design earthquake for a sample site in Wellington. Collapse was not achieved for the yielding baseplate system after it survived up to 250% of the design earthquake, and the unanchored baseplate system collapsed by overturning at 150% of the design level. It was found, for the two rocking systems that the upright axial load at maximum displacement was up to 30% lower than values determined by the equivalent static method of NZS 1170.5. However, the rocking response introduced impulse loading to the upright bases during stomping that was sustained without damage. Overall, the rocking baseplate designs of the yielding and the unanchored systems reduce the cross-aisle load demand on the rack structure during strong ground motion.

Cosma, C., Shirzadi, S., Maina, D., Wilson, S., Griffiths, R., Nair, N. 68

Islanded grid operation and restoration in distribution electricity networks following large-scale natural hazards

This project is aligned to Electricity Distribution Resilience framework and funded by Resilience to Nature's Challenges. The goal of this project is to make New Zealand's electricity infrastructure resilient to natural disasters. Recovery in the immediate disaster aftermath is a major component in this activity. Network restoration is complex from both a strategic and technical view point. From a strategic view point, the distribution network utility should be able to optimise their available resources in terms of crews and spares to determine the best repair schedule. In this case, a priority list is determined from the viewpoint of asset criticality. Also, the interdependency between the electricity infrastructure and other critical lifeline infrastructure should be considered in developing a network restoration strategy. From the technical point of view, the network should utilize the available firm generation (assuming grid connection is lost) to either re-energise (black start) the network to form an island that is self-sustaining or can last for a few weeks. This is complex in nature as distributed generation connected to utility is normally designed to provide power when the grid is available. Technical analysis should be done to evaluate the capability of available generation to both energise and sustain the island. The approach taken in the ongoing work is first examination of the generator's black start capability with all available network components after which critical assets required for this activity are mapped and this can feed into the repair priority list. This will then influence the strategic restoration strategy.

Maurer, B., Baird, A., Geyin, M. 8

On the Relationship Between Geospatial Liquefaction-Model Performance and Quality of Geospatial Data: A Case Study of the 2010-2016 Canterbury Earthquakes

So-called "geospatial" liquefaction models aim to predict liquefaction for rapid response and loss estimation using readily-available data. This includes (i) common ground-motion intensity measures (e.g., PGV); and (ii) geospatial parameters (e.g., among many, distance to rivers, distance to coast, and Vs30 estimated from topography) which are used to infer characteristics of the subsurface without in-situ testing. Such models have quickly become popular have been used to predict geohazard impacts throughout New Zealand (e.g., in conjunction with ground-motion simulations). Past studies have shown that while popular geospatial liquefaction-models show great promise, the resolution and accuracy of the geospatial data underlying these models are notably poor. As an example, mapped rivers

and coastlines often plot hundreds of meters from their actual locations. This stems from the fact that geospatial models aim to predict liquefaction worldwide and thus utilize the lowest common demo nominator of available data, even though much higher quality data is often available (e.g., in New Zealand). Accordingly, this study aims to investigate the relationship between geospatial liquefaction-model performance and quality of geospatial data. This will be accomplished using (I) over 10,000 liquefaction case studies compiled from the 2010-2016 Canterbury Earthquakes; and (ii) various geospatial datasets available in New Zealand. In particular, we will utilize alternative, higher-quality data to estimate: locations of rivers and streams; location of coastline; depth of ground water; and Vs30. The results of this study will have implications for geospatial modelling both in New Zealand and in locales worldwide where high quality geospatial data is available.

McGann, C., Chandramohan, R., Wotherspoon, L., Hayden, C., Pettinga, D., Jeong, S. 19

Soil-Foundation-Structure Interaction Analysis of an Instrumented Building in Wellington, New Zealand

There has been a general lack of previous validation studies seeking to demonstrate the predictive abilities of numerical models for structural and geotechnical systems despite the critical role that such validation plays in any forward prediction analysis or design activity. This paper presents the initial development and validation for a numerical model of a building in Wellington, New Zealand that was instrumented with strong motion recording devices during a number of large earthquakes and aftershocks. The model considers both the structural systems and the underlying soil and makes consideration for soil-foundation-structure-interaction (SFSI) effects, and all of the model properties are developed using only the conventional means that would be available in a forward-prediction analysis (i.e. the model is not calibrated to match the recorded response). This validation study demonstrates the predictive capability of the SFSI model through comparison with the responses recorded by the instrumented structure and provides a quantitative benchmark for the level of confidence that is reasonable to assign to forward prediction analyses using similar models.

McKibbin, D., Blake, D., Wilson, T., Wotherspoon, l., Hughes, M. 69

Critical infrastructure impacts in small towns following the Kaikōura earthquake, and pre- and post- event adaptations to manage these impacts

Small rural towns in New Zealand face a number of challenges following major earthquakes. Geographically remote communities in and around these towns typically rely on multiple critical infrastructure networks with limited redundancies to support key services. Additionally, facilities that people take for granted in larger population centres, such as supermarkets and schools, are less common and more widely distributed in low population density regions. However, behavioural, infrastructure and legislative adaptations can be inherent or quick to evolve in small towns with frequent service disruptions. Despite these factors, small towns are often underrepresented in impact assessments and appear to have been a low priority for investigation in the past.

We adopt the 14 November 2016 (Kaikōura) earthquake in New Zealand as a primary case study to explore critical infrastructure impacts, service disruption, and community adaptations in four small North Canterbury and Marlborough towns – Waiau, Culverden, Seddon and Ward. An initial assessment was conducted following an extensive literature and data review. Existing records of impacts and adaptations were combined with known

hazards and emergency management activities to produce a preliminary timeline of events following the Kaikōura earthquake and series of maps. We then conducted semi-structured interviews with critical infrastructure managers and emergency management officials involved with response and recovery activities in the four towns to further explore impacts, adaptations and on-going recovery activities. We present the latest findings and provide suggestions for future disaster risk reduction efforts in small rural towns.

McLaren, L. 55

The science behind citizen science: how citizens could be engaged in disaster risk management research projects in Aotearoa New Zealand.

Citizen science is a developing field which has its roots in the physical sciences, especially biology and environmental science. It has been slower to develop in the emergency and risk management space. However, there are now many hazard based citizen science projects, including New Zealand's own GeoNet which is very popular amongst citizens' post-earthquake events. Internationally there are citizen science projects for a wide range of hazards including earthquakes, tornadoes, volcanoes, tsunami, flooding, and storms.

Authors such as Bonney et al., (2014) and Orchiston et al., (2016) suggest that a lack of relevant data is one of the challenges faced by Disaster Risk Management communities and that many existing citizen science projects could be used to collect data before, during and after disaster events. An example of this is community based risk assessments, where community members submit data with the help of local government and relevant agencies. The communities can assess their own vulnerabilities and capacities, as well as the specific hazards they face.

A thematic analysis of the literature on citizen science was conducted and the poster will highlight the findings around citizen science as a concept - how to define it, what types of projects exist and what goes into their design. Examples will be given to show how the New Zealand Disaster Risk Management sector can engage citizen science projects in their research more effectively.

Nair, N., Davies, A., Pant, R., Robinson, T., Wotherspoon, L., Zorn, C. 70

Infrastructure Failures and Recovery from an Alpine Fault Earthquake Scenario

In this poster, utilising the core Project AF8 Alpine Fault earthquake scenario, we detail hazard exposure, impacts, and recovery of interdependent critical infrastructure networks across the energy, transportation, water & waste, and telecommunications sectors across the South Island of New Zealand. Asset failures are simulated across each individual network, based on shaking intensities, exposure to co-seismic hazards and estimated component fragilities, which have been further refined and validated through expert elicitation. Network disruptions are then propagated across an interdependent network framework to quantify and delineate the spatial reach of both direct and indirect failures. By incorporating recovery strategies, temporal changes in service levels are quantified to offer insights into expected interdependent network performance and the possible disconnection of communities from the nationally connected networks, otherwise not apparent when studying each infrastructure in isolation.

Neeraj, S. 56

Developing a Build Back Better tool for Post-Disaster Recovery and Reconstruction

Recovering community after a disaster can be a challenging task for stakeholders involved in the recovery process. Build Back Better (BBB) concepts considers disasters as an opportunity to recover, reconstruct and rehabilitate by integrating disaster risk reduction measures to restore physical, social, and economic and environmental aspects of a community. Hence, BBB can be used as a starting point to develop recommendations to improve the applicability of BBB concepts in the areas of risk reduction, community recovery and effective implementation. Guidelines for Many guidelines and approaches are proposed which often create confusion among the stakeholders involved in the restoration process. A holistic BBB framework is developed to avoid confusion and helps stakeholders to determine solutions for previously overlooked but commonly encountered issues during post-disaster reconstruction and recovery planning. To make things easier for stakeholders a BBB tool with indicators derived from BBB framework is developed to assess the resilience of a community. The developed tool is a straightforward, a non-prescriptive ideal assessment tool which can also be used for planning and implementing post-disaster recovery and reconstruction activities. This tool can be tailored according to the needs of stakeholders as well as it identifies the areas that to be improved in ongoing recovery activities by providing feedback.

Nguyen, C., Noy, I. 28

Measuring the Impact of Insurance on Urban Recovery with Light: The 2010 -2011 New Zealand Earthquakes

We measure the longer-term effect of a major earthquake on the local economy, using night-time light intensity measured from space, and investigate whether insurance claim payments for damaged residential property affected the local recovery process. We focus on the destructive Canterbury Earthquake Sequence (CES) 2010 -2011 as our case study. Uniquely for this event, more than 95% of residential housing units were covered by insurance, but insurance payments were staggered over 5 years, enabling us to identify their local impact. We find that night-time luminosity can capture the process of recovery and describe the recovery's determinants. We also find that insurance payments contributed significantly to the process of economic recovery after the earthquake, but delayed payments were less affective and cash settlement of claims were more effective than insurance-managed repairs in contributing to local recovery.

Noy, I., Nguyen, C. **29**

Red Zoning in Christchurch: What were the Consequences?

After the Christchurch earthquakes, the government declared about 8000 houses as Red Zoned, prohibiting further developments in these properties, and offering the owners to buy them out. The government provided two options for owners: the first was full payment for both land and dwelling at the 2007 property evaluation, the second was payment for land, and the rest to be paid by the owner's insurance. Most people chose the second option. Using data from LINZ combined with data from StatNZ, this project empirically investigates what led people to choose this second option, and what were the implications of these choices for the owners' wealth and income.

Nwadike, A., Wilkinson, S., Chang-Richards, A. 30

Rebuilding Christchurch: Amended Building codes and their impact in New Zealand

The level of destruction from the 2011 Christchurch earthquakes led to changes in the New Zealand seismic building code. The destruction showed that the NZ building codes did not fully performed to expectation and needed improvement to ensure that impact of future earthquakes would be minimised. The building codes have been amended to improve buildings resilience to an earthquake and other related extreme loading conditions.
Rebuilding Christchurch with the new modifications in the seismic building code comes with its own unique challenges to the entire system. This project investigates the impact of rebuilding Christchurch with the new seismic building codes in terms of how the new changes affected the building industry and the management of construction.

Orchiston, C., Shrestha, S. 32

Wellington Cordon Project

The Wellington Cordon Project falls under the Flagship Programme (FP) 3: Wellington Coordinated Project. It supports other projects within FP3 to create a holistic understanding of risks posed by collapsed buildings due to earthquake/s and the secondary consequences of cordoning in the short-term, mid-term and long term for Wellington.

Cordoning of the Christchurch CBD for more than two years and its subsequent implications on people and businesses had a significant impact on the recovery of Christchurch. Learning from this and experiences from the Kaikōura earthquake (where cordons were also established around selected buildings, Figure 3) have highlighted the need to understand the effects of cordons and plan for it before an earthquake occurs.

Orumiyehei, A., Sullivan, T., Elwood, K. 44

Simplified Performance Based Design/Assessment: Towards an improved SAC-FEMA Approach

Probabilistic seismic assessment offers a rational means of quantifying the risk posed by earthquakes. However, rigorous probabilistic seismic assessment and design methods are quite onerous and require a considerable level of expertise. In this context, efforts have been made to reduce barriers to implementation by developing simplified probabilistic seismic assessment methods. One approach, by Cornell et al (2002), permits simplified probabilistic seismic assessment by introducing fundamental assumptions regarding the relationship between displacement demand and seismic intensity measure, in addition to demand and capacity uncertainties. The simplified method aims to facilitate engineers with the ability to quantify the probability of collapse or some other limit state of interest. However, due to the assumptions inherent in the procedure, a number of criticisms of the accuracy of the approach have been made. In this study, the adequacy of the key assumptions being made in the method are examined further and subsequently, possible modifications to improve the accuracy of the approach are proposed.

Pender, M., Asadi, B., Asadi, S., Orense, R. 21

Maximum shear modulus of crushable natural pumiceous soil and hard-grained sand: A comparison

This poster focuses on the maximum shear modulus (Gmax) of natural pumiceous (NP) sands, found in the central part of the North Island. These pumiceous sands are highly crushable, compressible and lightweight due to the vesicular nature of the pumice particles. When performing geotechnical assessments of these deposits, engineers are often faced with the dilemma as to whether these soils can be treated in the same way as regular (hard-grained) soils. To shed light on this, several series of bender element tests were performed on different reconstituted NP sands sourced from various sites in the Waikato Basin over a wide range of effective confining pressure (σ'c) and void ratio (e). For comparison purposes, the same series of tests was performed on hard-grained Toyoura sand, which is routinely used in laboratory. The results showed that the Gmax of NP sands are considerably lower than that of Toyoura sand under similar relative density and σ'c and the effect of σ'c on Gmax is more significant for NP sands compared to Toyoura sand. With respect to Gmax - e relation, the NP sands show Gmax that is less dependent to e, compared to Toyoura sand. The difference in Gmax between crushable and hard-grained sands to changing σ'c and e could be explained, partly at least, in terms of the micro-properties of the particles, especially the occurrence particle crushing, and difference in particle morphology and particle size distribution.

Rehman, E., Elliot, P., Hughes, M., Wotherspoon, L., Nair, N. 71

Performance of underground electricity cables during the 2010-2011 Canterbury Earthquake Sequence: Insights for assessing criticality and resilience

Asset management in power systems is exercised to improve network reliability to provide confidence and security for customers and asset owners. While there are well-established reliability metrics that are used to measure and manage business-as-usual disruptions, an increasing appreciation of the consequences of low-probability high-impact events means that resilience is increasingly being factored into asset management in order to provide robustness and redundancy to components and wider networks. This is particularly important for electricity systems, given that a range of other infrastructure lifelines depend upon their operation.

The 2010-2011 Canterbury Earthquake Sequence provides valuable insights into electricity system criticality and resilience in the face of severe earthquake impacts. While above-ground assets are relatively easy to monitor and repair, underground assets such as cables emplaced across wide areas in the distribution network are difficult to monitor, identify faults on, and repair. This study has characterised in detail the impacts to buried electricity cables in Christchurch resulting from seismically-induced ground deformation caused primarily by liquefaction and lateral spread. Primary modes of failure include cable bending, stretching, insulation damage, joint braking and, being pulled off other equipment such as substation connections. Performance and repair data have been compiled into a detailed geospatial database, which in combination with spatial models of peak ground acceleration, peak ground velocity and ground deformation, will be used to establish rigorous relationships between seismicity and performance. These metrics will be used to inform asset owners of network performance in future earthquakes, further assess component criticality, and provide resilience metrics.

Rodrigo, W. 57

Reviewing issues with anchor projects in Christchurch following 2010-2011 earthquakes: Christchurch Justice and Emergency Services Precinct

Post-earthquakes of 2010/2011, many buildings in Christchurch City Centre required demolishing and rebuilding. The government in its blueprint proposed 16 "anchor" projects to rebuild and revitalise Christchurch. According to the schedule on the blueprint, all projects should have been completed mid-2017 yet only 5 have reached completion.

Christchurch Justice and Emergency Services Precinct (CJESP) as one of few completed, is also one of the costliest anchor projects to date. Criticism has been particularly focused on poor project management and product management failures.

This poster will present case study findings of the CJESP with special focus on difficulties faced by the precinct. A wider issue displayed is the value and costs of anchor projects.

Anchor projects, in general, create a loss of identity and heritage in a city, and this appears the case in Christchurch. In Christchurch a low population return, inability to keep to time frames and cost overruns have decreased anchor projects' success.

The CJESP in particular faced practical issues of housing different layers and categories of justice, civil defence and emergency related services in one precinct type of building. This led to design problems which resulted in time overrun. Delays were further fuelled by tendering issues that were overlooked by the project owners.

The poster suggests that anchor projects are not created from public demand and can be too costly to develop and run. The poster questions if these anchor projects actually befit the purpose justified on the blueprint.

Roeslin, S., Ma, Q., Elwood, K. 33

Development of a Seismic Damage Prediction Model Using Data Science Techniques

Natural catastrophes are increasing worldwide. They are becoming more frequent but also more severe and impactful on our built environment leading to extensive damage and losses. Earthquake events account for the smallest part of natural events; nevertheless seismic damage led to the most fatalities and significant losses over the period 1981-2016 (Munich Re). Damage prediction is helpful for emergency management and the development of earthquake risk mitigation projects. Recent design efforts focused on the application of performance-based design engineering where damage estimation methodologies use fragility and vulnerability functions. However, the approach does not explicitly specify the essential criteria leading to economic losses. There is thus a need for an improved methodology that finds the critical building elements related to significant losses. The here presented methodology uses data science techniques to identify key building features that contribute to the bulk of losses. It uses empirical data collected on site during earthquake reconnaissance mission to train a machine learning model that can further be used for the estimation of building damage post-earthquake. The first model is developed for Christchurch. Empirical building damage data from the 2010-2011 earthquake events is analysed to find the building features that contributed the most to damage. Once processed, the data is used to train a machine-learning model that can be applied to estimate losses in future earthquake events.

Sangster, C., Gorman, A., Stirling, M., Wotherspoon, L. 9

Getting ready to rock Dunedin: 3D velocity model for Dunedin ground motion simulations.

The Akatore Fault is located to the southwest of Dunedin city and is thought to represent the most significant source of seismic hazard for the city. As Dunedin has not experienced a large earthquake in recorded history, modelling is the only way to estimate the likely levels of earthquake shaking that could impact the city in a future Akatore Fault earthquake.

Physics-based ground motion simulations offer an explicit way to model earthquake phenomena not reliant upon past ground motion records. Numerical models that contain the physical properties known to influence seismic wave generation and propagation are critical to the modelling process.

The scope of my study is to undertake groundwork for the development of such models by acquiring, processing and integrating three strategically located land seismic lines with existing borehole data, gravity data, and geological maps in the area to build a 3D seismic velocity model for the geological units of the Dunedin area. Particular focus is given to the near surface in the city, as this is the area of greatest potential human impact

This poster will present:

- *The collection and processing of seismic data conducted as a part of this study*
- *The reflection profiles and their interpretation*
- *The P-wave stacking velocity models*
- *The near-surface structures and P-wave velocities determined through refraction modelling*
- *Multichannel analysis of surface waves at inner-city sites.*
- *Preliminary modelling efforts*

The present study represents a significant step toward understanding the seismic hazard in Dunedin City.

Somerville, P., Bayless, J., Skarlatoudis, A. 10

Rupture model of a Hikurangi megathrust earthquake

We develop a rupture model of a Hikurangi megathrust event, including unilateral rupture with propagation towards the northwest, in accordance with Schellart and Rawlinson (2012). We use the Graves and Pitarka hybrid Irikura method (Pitarka et al. (2018); GP-IM) for developing the source model. We use the geometric model from GNS Science (Stirling et al., 2012) as the basis for the Hikurangi rupture geometry. The full Hikurangi scenario is composed of three segments: northern (Raukumara), central (Hawke's Bay), and southern (Wairarapa) as identified in Wallace et al., (2009). The GNS northern and central segments have identical dip angle and down-dip extent. The GNS southern segment has a shallower dipping angle and extends to greater depth. We used the generic 1D seismic velocity and density model for the Hawke's Bay region that we developed in our 2016 report. We use the Skarlatoudis et al., (2016) self-similar magnitude scaling relationship for subduction earthquakes to determine the scenario magnitude, using the rupture area from GNS. The total rupture area is 75,816 square km, which yields Mw 8.6. The Pitarka et al. (2018, in

preparation) broadband strong motion simulation method combines the Irikura and Miyake (2011) asperity-based kinematic rupture generator with the Graves and Pitarka (2015) rupture generation methods for stochastic spatial variability and background slip. A GP source is described by the fundamental scenario parameters: Mw, strike, dip, rake, fault dimensions, hypocentre location, and fault location. Up to now, the model input parameters have been only calibrated for crustal earthquakes. Based on our communication with Graves and Pitarka, we made modifications to their crustal earthquake model that need to be validated with recordings from subduction earthquakes. The standard GP rupture model generator uses relationships for crustal earthquakes for scaling the corner wavenumbers. We use the Skarlatoudis et al. (2016; Equation 4) scaling for the corner wavenumbers in the along strike and down-dip direction for great interface subduction earthquakes. The corner wavenumbers have self-similar scaling with Mw. Using this wavenumber model with a Mw8.6 scenario introduces smoother background slip than the crustal earthquake wavenumber relationships. With input from Graves, we modified the perturbations to the rupture times for large earthquakes to make them smoother. We also modified the parameters that control the average rupture speed and rise time. Relationships between seismic moment, rupture area, asperity area, and stress parameters were based on work by Murotani et al. (2008), Tajima et al (2013) and Miyake (2018, personal communication). Figure 1 shows the slip on the fault plane in shades of red, with rupture initiation contours (black lines) at 10 s intervals. The break between the northern and southern segments is identified by the dashed blue line. The maximum slip over the rupture planes is approximately 14 m, and the average slip is approximately 3.5 m.

Stolte, A., Cox, B., Wotherspoon, L. 76

The Methodology and Application of the Direct-Push Crosshole (DPCH) Test for the In-Situ Evaluation of Near-Surface P- and S-wave Velocities

The direct-push crosshole (DPCH) test is an invasive, near-surface seismic testing method, which combines the high-quality, high-resolution velocity measurements of borehole-based crosshole (CH) seismic testing with the relative cost effectiveness and speed of direct-push testing methods, such as cone penetration testing (CPT). At each measurement depth (typically, at 20 to 50 cm intervals), constrained compression (P) and shear (S) waves are generated simultaneously by tapping on one of the cone push rods (an in-ground source may also be used). These P- and S-waves are propagated between two instrumented seismic cones (i.e., a source and receiver cone) along a predominantly horizontal direct travel path. The instrumented cones contain a sensor package with two or three orthogonally oriented geophones to measure the seismic waveforms and a tri-axial MEMS accelerometer to track the deviation/position of each cone as it is advanced into the ground. DPCH testing enables the measurement of high-resolution profiles of P- and S-wave velocity over the top 20 – 30 m of the subsurface for use in geotechnical engineering analyses, such as the evaluation in-situ degree of soil saturation, liquefaction triggering potential, and seismic site response analyses. Another potential application of high-quality velocity measurements obtained via DPCH testing is the evaluation of in-situ soil porosity/void ratio. The DPCH method also allows for testing across/through ground improvement elements such as stone columns.

Stringer, M., Orense, R., Asadi, B., Asadi, S. 22

Cyclic testing on undisturbed samples of pumice-rich soils from the North Island.

Soils rich in pumiceous material are encountered on many engineering projects of significance across the central North Island of New Zealand. These soils are considered problematic due to their lightweight nature and low crushing strength. These characteristics create a number of difficulties in the evaluation of these soils against cyclic failure using conventional simplified methodologies.
In this paper, the authors will present the results from a series of cyclic triaxial tests which were performed on undisturbed soil samples. Key observations of the material response during the tests will be presented, as well as a comparison of cyclic resistance against predictions of strength expected from conventional simplified methods.

Syed, Y., Uma, S. R., Prasanna, R., Stock, K., Blake, D. 72

An integrated simulation framework to model 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 normal situation, most of the 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 because a failure can propagate from one infrastructure to another. This poster discusses the development of an integrated simulation framework that models interdependencies between electricity and road infrastructure networks of Wellington region. The framework uses a damage map of electricity network components and integrates them with road access time to the damaged components for determining electricity outage time of a region. The results can be used for recovery planning, identification of vulnerabilities, and adding or discarding redundancies in an infrastructure network.

Tan, M., Prasanna, R., Stock, K., Hudson-Doyle, E., Leonard, G., Johnston, D. 58

Disaster apps: usability factors affecting continued intention to use

Smartphone applications (apps) have the potential to improve disaster resilience by providing an avenue to communicate relevant and time-critical information to the public. Multiple disaster apps already exist; however, availability does not automatically translate to continued use. Limited research has explored what influences users' intention to continue using disaster apps.

The study theorises that users' perception of usability affects their continued intention to use disaster apps. We hypothesised seven usability factors (app design, app utility, app dependability, interface graphics, interface output, interface input, and interface structure) to influence continuance intention. We gathered user experience data through an online usability survey from disaster app users. We analysed the data through structural equation modelling; initial results show five of the seven theorised factors significantly affect continuance intention. Although the relationships have varied weights and directions; key factors to users' intent to continue usage are their perceptions of app utility, app dependability, interface output, interface input, and interface graphics.

Future work will employ the findings from this study to develop a usability framework; providing usability guidance that will help encourage continued use of disaster apps.

Tarbali, K., Bradley, B., Huang, J., Lagrava, D., Polak, V., Motha, J., Bae, S. 11

Cybershake NZ v18.6: New Zealand Simulation-Based Probabilistic Seismic Hazard Analysis

This poster presents the computational workflow and results of version 18.6 of probabilistic seismic hazard analysis in New Zealand based on physics-based ground motion simulations ('Cybershake NZ'). In the current work completed to date, the Graves and Pitarka (2010, 2015) hybrid broadband ground motion simulation approach is utilized. Variation in hypocentre location and slip distribution are considered to partially account for the variability in ground motion characteristics. Ruptures from the distributed seismicity model are considered in the total hazard via empirical ground motion models. Intensity measures for sample scenario ruptures and subsequently generated hazard curves, disaggregation results, and uniform-hazard ground motion maps are presented. Improvements for future versions of the ongoing effort are also outlined.

Thomas, K., Wilson, T., Crowley, K., Hughes, M., Davies, T., Jack, H., King, D, Lane, E., Johnston, D., Leonard, G. 59

An Example of How Community Participation can be Successfully Incorporated into the Disaster Risk Assessment Process, Aotearoa-New Zealand

During disasters, exposed communities bear the brunt of impacts and are first to respond. People of these communities obtain local and/or indigenous understanding of locally-specific challenges and opportunities, which no external expert could derive alone. Community-based, participatory disaster risk assessments involve participation of people who may be directly impacted by disasters, to: encourage sharing of valuable local knowledge, empower communities and local authorities to reduce vulnerabilities and strengthen capacities, and to form Disaster Risk Reduction initiatives that are well-informed and invested in by those involved.

Kristie-Lee Thomas, a Master of Disaster Risk and Resilience student at the University of Canterbury and her supervision cohort set out to assess tsunami risk to her tūrangawaewae, Wharekauri - the Chatham Islands. This assessment was carried out for, with and by the Chatham Islands community to engender community-led action to reduce future tsunami impact.

The study involved:
a) Hazard assessment, including an investigation of historical tsunami impacts and inundation extents preserved in local archives and Māori knowledge.
b) Assessment of potential impacts on infrastructure, to evaluate resultant levels of services based on expert judgment from local infrastructure personnel to form a credible high-impact tsunami scenario.
c) Sharing this information with the community to co-develop actions to reduce future tsunami impact through participatory tools during workshops.

Participation of the Chatham Islands community throughout the risk assessment process produced useful and usable outcomes. The study provides a demonstrable application of how community participation can be successfully incorporated into the disaster risk assessment process.

Vinnell, L. 60

Using the Theory of Planned Behaviour to increase individual-level disaster preparedness among citizens of Wellington

New Zealand is prone to a range of natural hazards such as earthquakes and tsunamis, but many citizens are unprepared for potential disasters. Encouraging actions to reduce the impact of a hazard and to help individuals survive after a disaster has occurred is of significant importance. This research examines how attitudes, such as outcome expectancy, social norms, including descriptive and injunctive, and perceptions of behavioural control, such as self-efficacy, motivate individuals' disaster preparation. The Theory of Planned Behaviour has been used to both predict behaviour and inform behaviour-change interventions in other domains such as health and environmentalism, but the application of the theory to disaster preparation is limited. This research will test the predictive capability of the theory, and use these findings to design a behavioural intervention to encourage disaster preparation actions within the Wellington hazard context.

Vyas, J., Bradley, B., Razafindrakoto, H., Thomson, E., Lee, R. 13

Simplified-physics high frequency ground-motion simulations using site-specific parameters

Hybrid broadband simulation methods typically compute high-frequency portion of ground-motions using a simplified-physics approach (commonly known as "stochastic method") using the same 1D velocity profile, an elastic attenuation profile and site-attenuation (κ0) value for all sites. However, these parameters relating to Earth structure are known to vary spatially. In this study we modify this conventional approach for high-frequency ground-shaking by using site-specific input parameters (referred to as "site-specific") and analyse improvements over using same parameters for all sites (referred to as "generic"). First, we theoretically understand how different 1D velocity profiles, an elastic attenuation profiles and site-attenuation (κ0) values affects the Fourier Acceleration Spectrum (FAS). Then, we apply site-specific method to simulate 10 events from the 2010-2011 Canterbury earthquake sequence to assess performance against the generic approach in predicting recorded ground-motions. Our initial results suggest that the site-specific method yields a lower simulation standard deviation than generic case.

Wang, Q., Henry, R., Hogan, L., Scott, A. **46**

Effect of Loading Rate on the Response of Reinforced Concrete Prisms

Research following the 2010-2011 Canterbury earthquakes investigated the minimum vertical reinforcement required in RC walls to generate well distributed cracking in the plastic hinge region. However, the influence of the loading sequence and rate has not been fully addressed. The new minimum vertical reinforcement limits in NZS 3101:2006 (Amendment 3) include consideration of the material strengths under dynamic load rates, but these provisions have not been validated at a member or system level. A series of tests were conducted on RC prisms to investigate the effect of loading rate and sequence on the local behaviour of RC members. Fifteen axially loaded RC prisms with the designs representing the end region of RC walls were tested under various loading rates to cover the range of pseudo-

static and earthquake loading scenarios. These tests will provide substantial data for understanding the local behaviour of RC members, including hysteretic load-deformation behaviour, crack patterns, failure mode, steel strain, strain rate and ductility. Recommendations will be made regarding the effect of loading rate and reinforcement content on the cracking behaviour and ductility of RC members.

Williams, J., Whittaker, C., Wilson, T., Hughes, M., Horspool, N., Lane, E., Wotherspoon, L. 73

Tsunami Vulnerability – Developing Tools for Infrastructure Impact Assessment

Recent international tsunamis, including the 2011 Tohoku Tsunami, Japan, and the 2015 Illapel Tsunami, Chile, have highlighted the potential for impacts on the built environment. International research in the tsunami impacts domain have been largely focused towards impacts on buildings and casualty estimations, while only limited attention has been placed on the impacts on critical infrastructure. New Zealand, a developed and tectonically active island nation in the South Pacific, has a large amount of coastal infrastructure exposed to many local, regional and distal source tsunamis. To effectively manage tsunami risk for New Zealand critical infrastructure, including energy, transportation and communications, the vulnerability of infrastructure networks and components must first be determined. This research develops relevant asset vulnerability, functionality and repair-cost functions based on international post-event tsunami impact assessment data from technologically similar countries, including Japan and Chile. Utilising these functions within a New Zealand based framework allows for cost benefit analyses, determining effective tsunami risk management strategies and mitigation options for exposed critical infrastructure.

Wilson, S., Chang-Richards, A. 74

Quantification of infrastructure downtime in earthquake reconstruction

Knowing how to rapidly rebuild disaster-damaged infrastructure, while deciding appropriate recovery strategies and catering for future investment is a matter of core interest to government decision makers, utility providers, and business sectors. The purpose of this research is to explore the effects of decisions and outcomes for physical reconstruction on the overall recovery process of horizontal infrastructure in New Zealand using the Canterbury and Kaikoura earthquakes as cases. A mixed approach including a systematic review, questionnaire survey and semi-structured interviews is used to capture perspectives of those involved in reconstruction process and gain insights into the effect of critical elements on infrastructure downtime. Findings from this research will contribute towards advancements of a systems dynamics model considering critical decision-making variables across phases of the reconstruction process to assess how these variables affect the rebuild process and the corresponding downtime. This project will improve the ability to explore alternative resilience improvement pathways and test the efficacy of alternative means for facilitating a faster and better reconstruction process.

Wotherspoon, L., Bertelli, S., Giovinazzi, S., Lopez-Querol, S., Rossetto, T., Ruiter, R. 75

Resilience of Telecommunications Networks and Services: Practical improvements in the data collection in a post-disaster scenario

Nowadays the telecommunication systems' performance has a substantial impact on our lifestyle. Their operationalist becomes even more substantial in a post-disaster scenario when these services are used in civil protection and emergency plans, as well as for the restoration of all the other critical infrastructure. Despite the relevance of loss of functionality of telecommunication networks on seismic resilience, studies on their performance assessment are few in the literature. The telecommunication system is a distributed network made up of several components (i.e. ducts, utility holes, cabinets, major and local exchanges). Given that these networks cover a large geographical area, they can be easily subjected to the effects of a seismic event, either the ground shaking itself, or co-seismic events such as liquefaction and landslides. In this paper, an analysis of the data collected after the 2010-2011 Canterbury Earthquake Sequence (CES) and the 2016 Kaikoura Earthquake in New Zealand is conducted. Analysing these data, information gaps are critically identified regarding physical and functional failures of the telecommunication components, the timeline of repair/reconstruction activities and service recovery, geotechnical tests and land planning maps. Indeed, if these missing data were presented, they could aid the assessment of the seismic resilience. Thus, practical improvements in the post-disaster collection from both a network and organisational viewpoints are proposed through consultation of national and international researchers and highly experienced asset managers from Chorus. Finally, an outline of future studies which could guide towards a more resilient seismic performance of the telecommunication network is presented.