

2018 Annual Report



Te Hiranga Rū | QuakeCoRE

Aotearoa New Zealand Centre for Earthquake Resilience

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Directors' Report 2018

Te Hiranga Rū QuakeCoRE formed in 2016 with a vision of transforming the earthquake resilience of communities throughout Aotearoa New Zealand, and in three short years, we are already seeing important progress toward this vision through our focus on research excellence, deep national and international collaborations, and human capability development.

In our third Annual Report we highlight our world-class research taking place both in our own backyard and overseas. With the Alpine Fault overdue for its next big shake, QuakeCoRE researchers have been focused on the development of physics-based models to identify where shaking will be strongest and what infrastructure will be most at risk. Working closely with decision-makers, this research has informed emergency response and mitigation plans for what is likely to be the largest earthquake to impact the region in many generations.

Meanwhile, in Shanghai, QuakeCoRE researchers generated their own earthquakes on one of the world's largest shake-table facilities at Tongji University. The goal was to assess the ability of NZ-developed construction technology to withstand multiple earthquakes with little or no damage. Developed in close collaboration with leading engineers from New Zealand, the knowledge gained from the unique experiments is quickly being integrated into the design of buildings across New Zealand.

QuakeCoRE continues to show leadership and translation of our world-class research into practice through the development of guidelines for industry identified after the 2016 Kaikōura Earthquake. These guidelines are critical to estimate the amplification of ground shaking expected in the Wellington Basin and the resulting potential for failure of precast concrete floors.

As we move into 2019, with a key change in our leadership, QuakeCoRE looks forward to another productive year, delivering on our vision for the future of earthquake resilience.

Ken Elwood – Director



Brendon Bradley – Deputy Director



Chair's Report 2018

Our motivation at Te Hiranga Rū QuakeCoRE is to provide the research and solutions that help our communities have the capacity and resilience to recover as rapidly as possible from earthquakes. In fact, everything we do is focussed on that outcome, and our innovative research in 2018 firmly places QuakeCoRE as the preeminent earthquake research centre in Aotearoa New Zealand.

Some of the highlights from 2018 include:

- ground-breaking testing showing new low-damage New Zealand construction practice can withstand earthquakes;
- an integrative project encompassing all of QuakeCoRE's flagship programmes to advance the underpinning science behind an Alpine Fault earthquake's impacts; and
- development of new guidelines for building design to ensure new construction reflects the latest in seismic research and knowledge.

At QuakeCoRE, we remain committed to collaborating across projects, institutions and other research programmes to support a best-for-NZ approach. This integration depends on the support and collaboration of our partners and on linkages between international and New Zealand research institutions, industry, iwi and the wider community. We thank them all for their support and contributions.

This year has also seen transition in QuakeCoRE leadership, with Brendon Bradley being appointed as the new Director and David Johnson as Deputy Director, effective

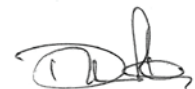
from 1 January 2019. Ken Elwood will continue as our Research Director, a role focussed on excellence and delivery of our current funded research programme. This ensures a strong transition of leadership and culture across the programme, and enables us to focus both on current research excellence, as well as future development and progress. A huge thanks to Ken for his vision and passion, and for the innovation and leadership he has provided in establishing QuakeCoRE and leading it for the first three years.

I also thank the Board for their wisdom, guidance and leadership. We have welcomed Bryony James (University of Auckland) and Mike Mendonça (Wellington City Council) to the Board, and thank Margaret Hyland (University of Auckland) for her service since establishment.

My on-going gratitude extends to the QuakeCoRE Leadership Team, and indeed our entire research community for their passion and the difference they make in this critical area for New Zealand.

On behalf of the Board, we are looking forward to 2019.

Dean Kimpton - Chair



About Us

Te Hiranga Rū QuakeCoRE is transforming the earthquake resilience of communities and societies, through innovative world-class research, human capability development and deep national and international collaborations. As a Centre of Research Excellence funded by the New Zealand Tertiary Education Commission, QuakeCoRE is a national network of leading Aotearoa New Zealand earthquake resilience researchers. QuakeCoRE is hosted by the University of Canterbury and has seven other formal partners.

We enhance earthquake resilience across the country and internationally, by working collaboratively on integrated, multi-disciplinary programmes of world-leading research. Our research supports the development of an earthquake-resilient New Zealand.

Our Vision

We are creating an earthquake-resilient Aotearoa New Zealand where thriving communities have the capacity to recover rapidly after major earthquakes through mitigation and pre-disaster preparation informed by research excellence.



Our Outcomes

1

Improved Earthquake Resilience

We will contribute to a step-change improvement in the earthquake resilience of the nation's infrastructure from research-informed national and local policies, implementation standards and disaster planning.

2

Improved Economic and Commercial Outcomes

We will support Aotearoa New Zealand's long-term economic benefit through significantly improved seismic performance of New Zealand infrastructure, rapid business recovery after future earthquakes and the growth of engineering resilience innovation and business in the New Zealand construction sector driving international competitiveness.

3

Improved Societal Outcomes

We will enable communities to recover rapidly after major earthquakes through mitigation and pre-disaster preparation, informed by research and public outreach.

4

Highly Skilled and Diverse Workforce

Our graduates will be sought after for their knowledge of earthquake resilience and work-ready professional skills. They are taught in the very best national and international multi-disciplinary environment, combining research and industry elements. Through our graduates, we will seek a growth in under-represented groups (Māori and Pasifika) and gender equality in engineering disciplines.

5

International Recognition

We will be a focal point for international earthquake resilience, attracting the best talent and business alongside national and international research collaborations.

6

Growing Mātauranga Māori

We will contribute by building close engagement with Māori leaders who have responsibility for earthquake planning and resilience and developing opportunities for Māori capability building. The distinctive contribution of Māori indigenous knowledge of earthquake resilience will enhance social, economic and environmental outcomes for Aotearoa New Zealand.

Research

Research overview

Te Hiranga Rū QuakeCoRE plays a leading role in supporting and linking multi-institutional, investigator-led earthquake resilience research programmes that are internationally networked and recognised. Our research programmes are advancing the science and implementation pathways of earthquake resilience through system-level science with highly integrated collaborations coordinated across the physical, engineering and social sciences and across multiple research institutions. The research is principally organised into technology platforms, flagship programmes, integrative projects and special projects.



Four technology platforms provide the underpinning experimental (lab and field), computational, and data infrastructure that are necessary to support our research programmes and realise QuakeCoRE's vision and mission. Our high-impact research is delivered via five flagship programmes, one integrative project and one special project. These programmes are advancing our research efforts to the next level through multi-institutional and multi-disciplinary research collaboration, engagement with end-users, and co-funding.

Our research programmes are supported by QuakeCoRE contestable and non-contestable funding and have strong links to end-users. Each of the flagship programmes has a named industry representative to facilitate communication at all levels between researchers and end-users.

Technology Platforms

TP1

Large-scale laboratory facilities

Leader: Rick Henry | Deputy Leader: Alessandro Palermo

This Platform supports enhanced collaboration across domestic and international large-scale experimental facilities, innovative testing procedures, and instrumentation.

TP2

Field- testing and monitoring

Leader: Liam Wotherspoon | Deputy Leaders: Quincy Ma & Geoff Rodgers

This Platform is building on Aotearoa New Zealand leadership in field testing and monitoring to focus on development of world-class testing technologies and urban system monitoring.

TP3

Multi-disciplinary community databases

Interim Leader: Brendon Bradley

This Platform fosters the contribution to, and utilisation of, existing community databases, as well as enabling the development of new multi-disciplinary databases for transformative research.

TP4

Computational simulation and visualisation

Leader: Brendon Bradley | Deputy Leader: Christopher McGann

This Platform provides computational workflows to connect the multi-disciplinary research activities within Te Hiranga Rū QuakeCoRE and to provide a pipeline by which research results can be understood in terms of their wider impacts on earthquake resilience.

Flagship Programmes

FP1

Ground motion simulation and validation

Leader: Brendon Bradley | Deputy Leaders: David Dempsey & Seokho Jeong |

Industry Representative: Didier Pettinga

This Flagship aims to provide a paradigm shift in ground motion prediction via theoretical developments in physics-based simulation methods and their utilisation in engineering design and assessment.

FP2

Liquefaction impacts on land and infrastructure

Leader: Misko Cubrinovski | Deputy Leaders: Rolando Orense & Sjoerd van Ballegooy |

Industry Representative: Sjoerd van Ballegooy

This Flagship focuses on next-generation assessment methods and mitigation strategies for soil liquefaction, one of the principal earthquake hazards affecting land and infrastructure in Aotearoa New Zealand.

FP3

Addressing earthquake-vulnerable buildings – A multi-disciplinary approach

Leader: Ken Elwood | Deputy Leader: Ilan Noy | Industry Representative: Derek Baxter

This Flagship addresses the risk posed by collapse-vulnerable earthquake-prone buildings through a multi-disciplinary lens.

FP4

Next-generation infrastructure: Low-damage and repairable solutions

Leader: Tim Sullivan | Deputy Leader: Rick Henry | Industry Representative: Jared Keen

This Flagship seeks a new design paradigm where reparability and damage control is explicitly considered in the design process of buildings and infrastructure.

FP5

Pathways to improved resilience

Leader: David Johnston | Deputy Leaders: Caroline Orchiston & Wendy Saunders |

Industry Representative: Dan Neely

This Flagship focuses on determining how we decide where to invest our limited resources to most effectively improve Aotearoa New Zealand's resilience to earthquakes.

Other Projects

INTEGRATIVE PROJECT

Earthquake case study: Alpine Fault earthquake impacts

Leader: Brendon Bradley | Deputy Leader Tom Wilson

This case study focused around an Alpine Fault earthquake rupture scenario in order to contextualise each aspect of the earthquake resilience ‘pipeline’, the expertise for which resides within our flagship programmes. This project, aligned to the “Project AF8” programme funded by the National Resilience Fund seeks to apply the latest research understanding for impacts of Alpine Fault earthquakes, and through end-user engagement, use the results of this project toward tangible improvements in Aotearoa New Zealand’s earthquake resilience. Notably, this case-study project will learn from the Kaikōura Earthquake to better understand the impacts of future Alpine Fault earthquakes.

SPECIAL PROJECT

Spatially distributed Infrastructure

Leader: Liam Wotherspoon | Deputy Leader & Industry Representative: Roger Fairclough

This Special Project is a joint research initiative with the National Science Challenge 10: Resilience to Nature’s Challenges. The programme is developing tools to assess the performance of spatially distributed infrastructure networks subject to extreme natural hazards.

Ground-breaking test shows new low-damage New Zealand construction practice can withstand earthquakes

A team of Te Hiranga Rū QuakeCoRE researchers have completed a significant test of Aotearoa New Zealand building construction that shows new design methods will withstand future earthquakes without the damage observed during the Christchurch and Kaikōura Earthquake Sequences. A two-storey precast concrete building was tested on one of the world's largest and most flexible shake-table arrays.

The shake-table is part of the world-class earthquake engineering facilities at the International Joint Research Laboratory of Earthquake Engineering (ILEE) at Tongji University in China. QuakeCoRE joined a partnership with ILEE in 2016, which has given New Zealand researchers the opportunity to access some of the world's top earthquake engineering testing facilities.

QuakeCoRE researcher Rick Henry says, "This type of test would not be possible with available equipment in New Zealand because of the size of the shake-table. This means the test can be done on the whole building (10m by 6m and 8m high), rather than on individual building components as is current practice in New Zealand. This creates a much more realistic testing environment."

The main objective of the test is to validate low-damage building designs being used in new construction in New Zealand. No similar tests have been conducted on New Zealand construction methods, and thus in the past, it was not always possible to determine if the design would perform as expected when considering the entire building system.

Rick says, "Since the test building performed well, New Zealand engineers can be confident that the new design methods will protect buildings from significant damage during earthquakes, avoiding the need for costly and disruptive structural repairs or demolition."

The test building walls rock back and forth, so it can be subjected to a large number of earthquakes without sustaining significant damage. The test therefore was able to simulate different types of earthquakes, rather than a single event.

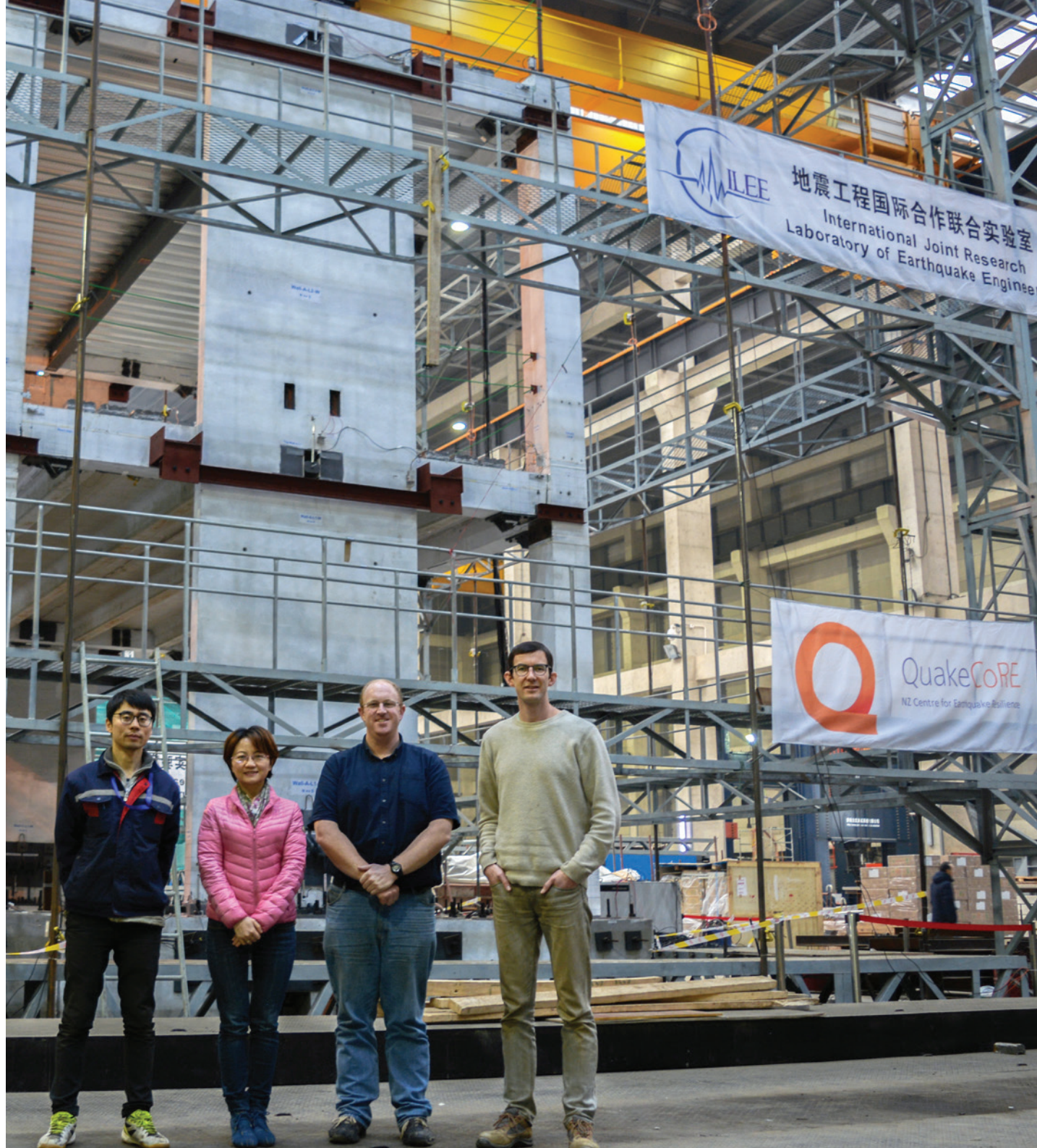
The tests started at a low intensity and gradually increased. The building was then reconfigured and the dissipating devices, which are attached to the outside of the building and reduce the impact of the shaking, were taken out and replaced. Testing was then resumed again.

The collaboration with China offers tremendous benefits to the QuakeCoRE team in being able to access globally unique facilities. In addition, it has raised Chinese interest in New Zealand construction practice and seismic design methods, such as using post-tensioned pre-cast concrete walls.

The project is led by Rick with support from project co-leader Ying Zhou (Tongji University). QuakeCoRE researchers Geoff Rodgers (University of Canterbury) and Ken Elwood (University of Auckland) have also played a key role in the project, and research fellow Yiqiu Lu (University of Auckland) has been based at Tongji University to coordinate and supervise the building construction and testing.

An industry advisory group with representatives from leading engineering consultancies have provided valuable input to the test objectives and building design.

In addition to funding from ILEE and QuakeCoRE, significant funding was provided by the Building System Performance Branch of MBIE.



 Yiqiu Lu, Ying Zhou, Geoff Rodgers and Rick Henry (Yiqiu Lu)

Alpine Fault case study helps decision makers integrate cutting-edge research

In mid-2017, Te Hiranga Rū QuakeCoRE initiated a one-year Alpine Fault Integrative Project to use a major future earthquake scenario to demonstrate the connectivity among QuakeCoRE's research activities along the earthquake resilience pipeline. The project was the first example of an Integrative Project encompassing all of QuakeCoRE's Flagship Programmes to advance the underpinning science behind an Alpine Fault earthquake's impacts. Novel research contributions included integrated modelling of geohazards, direct damage impacts on earthquake-prone heritage buildings and transportation, electricity and water infrastructure, and the ability of emergency services to plan for, and respond to, such potential consequences.

Project AF8's Science Lead and QuakeCoRE Leadership Team member Caroline Orchiston welcomed the contribution of the Alpine Fault case study, saying it plays a significant role in enabling our response and recovery agencies to understand what a future major earthquake might mean for them.

This Integrative Project has continued in 2018 bringing the latest science to a nationally significant problem: a future large earthquake on the Alpine Fault. In 2018, the project has built on the first year's momentum to develop a South Island case study area that is enabling an integrative focal point for earthquake resilience research.

The case study includes integrated modelling of the effects of primary ground shaking and secondary hazards such as liquefaction and landslides throughout the South Island. The modelling was used to estimate potential damage to buildings and other infrastructure, as well as the potential impacts on rural South Island populations, distributed infrastructure, and the dairy and tourism industries. Modelling also examined the impacts of an Alpine Fault rupture on the performance of transportation and electricity networks.

QuakeCoRE Deputy Director Brendon Bradley says, "The project has been valuable as a way to connect all of the flagship programmes within QuakeCoRE to develop a more integrated research portfolio."

Integration across multiple disciplines has also led to research that end-users can quickly and easily implement. The original AF8 concept, funded by the Ministry of Civil Defence and Emergency Management Resilience Fund, was focused on using the best available science at the time. Brendon says, "We thought that while this was a valuable exercise, let's also create new science and use the momentum generated by the initial project to make sure hot-off-the-press science is used immediately."

This integration has required strong end-user and stakeholder participation. Thomas Wilson, an Associate Investigator in QuakeCoRE, says, "This is one of the best examples in New Zealand of science being quickly integrated into decision-making."

"Embedding practitioners and policy makers at the local, regional and national levels into the research team has made it quick and easy to use scientific research in policy, by facilitating input and feedback from stakeholders that can be incorporated into the scientific models."

The deep collaboration with practitioners and policy makers, and transformative impacts in these organisations' preparedness, has only been possible because of the high quality of the data produced by the world-leading ground motion and infrastructure modelling within QuakeCoRE. Previous efforts have attempted to use modelling approaches that provided only crude estimations of such causes and effects, which led to low stakeholder trust and uptake.

Cutting-edge scientific research has allowed Civil Defence teams to make more informed decisions and to work with the community to develop the most practical solutions for natural disaster remediation. The research identified a range of requirements that emergency managers needed for additional decision support, combining the best available research and direct practitioner expertise to co-produce novel casualty and habitability assessments.

Manager of Emergency Management Southland Angus McKay says, “Project AF8 links science with communities of practice, and it is essential to have highly trusted and credible science to provide the foundation required for advanced emergency management planning. The QuakeCoRE Alpine Fault case study has delivered the science that was needed.”

 (Jacques Descloîtres)



Liquefaction research gains international acclaim

Under Misko Cubrinovski's leadership, Te Hiranga Rū QuakeCoRE's Flagship Programme 2 has undertaken liquefaction research that has improved Aotearoa New Zealand's resilience to earthquakes and led to internationally significant findings. Flagship 2 focuses on next-generation assessment methods and mitigation strategies for soil liquefaction, one of the principal earthquake hazards affecting land and infrastructure in New Zealand.

Liquefaction is one of the most complex problems in earthquake engineering, because of the intricate web of processes and interactions affecting soil response during an earthquake. Flagship 2 has aimed to understand the complexities of liquefaction and to identify the governing factors on soil behaviour to determine what makes certain soils liquefy and not others. As a result, this work is significantly improving earthquake engineering practice and assessment methods here and internationally.

There are three ways in which soil can influence liquefaction: through its composition (or grain size and plasticity), the in situ state (density) of the soil, and dynamic interactions within the soil deposit during earthquakes, or what Misko calls "system response effects". Conventionally, practitioners use what are known as "simplified procedures" to quantify liquefaction effects, but their accuracy has been limited because of the difficulty describing system interactions.

To address this problem, Misko and his team have been using a range of advanced field and lab investigations, numerical analyses, and well-documented case histories from the 2010-11 Canterbury Earthquake Sequence and the 2016 Kaikōura Earthquake.

Misko says, "The key challenge is to uncover the critical factors determining the observed behaviours. Case histories present a challenging but unique opportunity to untangle these effects."

In the Canterbury study, 55 sites affected by the 2010-11 Canterbury Earthquakes were investigated. All sites had the same critical soil layer that was most likely to liquefy, but one group of sites experienced severe liquefaction, while a second group was unaffected by the earthquakes. Simplified methods of analysis could not explain this difference.

Misko's advanced analyses of the sites, however, identified interactions amongst the soil layers outside of the critical layer that determined whether liquefaction manifested at the site or not. The result has been used to modify simplified methods to account for soil interactions and more accurately predict the impacts of liquefaction.

The second case history focused on the effects of the Kaikōura Earthquake on CentrePort, Wellington. The port sits on reclaimed land, which is particularly vulnerable to liquefaction. This work has quantified the effects of various factors such as type of fill and construction method on the severity of liquefaction impacts in order to develop more robust methods of assessing reclaimed land.

Misko says his team's key contribution is the "incorporation of system response effects in the liquefaction assessment", which is very novel and has received international recognition. The team has published a number of high-impact papers that illustrate the importance of soil interactions, which has enabled them to identify the key factors that govern soil response in an extremely complex environment. Misko's research in this area was recently recognised by the American Society of Civil

Engineers with the prestigious Ralph B. Peck Award for outstanding contributions to the geotechnical engineering profession.

The nomination for the award states, “Through his research and professional activities, Cubrinovski has earned great scholarly distinction and international recognition. He is one of the top geotechnical earthquake engineers in the world.”



Collaboration to Impact

Development of guidelines for building assessment

The 2016 Kaikōura Earthquake caused significant ground shaking and damage in Wellington, which led Te Hiranga Rū QuakeCoRE researchers to two important research findings. First, it became clear that buildings with precast concrete floors needed special attention to ensure life-safety performance. Second, a large variation in the ground motion intensity in Wellington depending on the underlying soil conditions suggested that current design specifications underestimate the intensity of shaking that will occur in a major earthquake.

These two observations have led to further QuakeCoRE research and the development of new guidelines for building design to ensure new construction reflects the very latest in seismic research and knowledge.

Guidelines for precast floors

The investigation of damage to buildings like Statistics House after the Kaikōura Earthquake showed that precast floors are more vulnerable to damage in a major earthquake than most forms of concrete construction. They have both lower damage thresholds and less reliable behaviour once initial damage occurs, and when precast floors are damaged in an earthquake, this damage can be difficult to identify and repair. Collapse of floor units during a strong earthquake is a real concern for buildings constructed prior to 2006.

As a result, in August 2017 MBIE set up a committee, chaired by QuakeCoRE Director Ken Elwood, to develop guidelines for assessing the seismic vulnerability of precast floors. At the same time, the committee worked to improve the assessment of concrete buildings more generally.

The committee's work led to the release in November 2018 of a proposed revision to the concrete building provisions of the Technical Guidelines for Seismic Assessment of Existing Buildings. The proposed revision reflects learnings from the Statistics House investigation as well as an update of other provisions relating to concrete buildings.

These guidelines for precast floors are internationally unique, largely because this construction method is uncommon outside of New Zealand, whereas precast floors are prevalent in New Zealand buildings constructed from the early 1980s onwards.

Revising the guidelines was a significant task and has resulted in practical benefits for practitioners. Chief Resilience Officer at Wellington City Council, Mike Mendonça, says that "More than in other cities, Wellingtonians are acutely aware of the challenge around pre-cast concrete floors. It's a problem that sits uncomfortably with existing regulatory frameworks and cannot be easily 'solved'."

"As the Building Consent Authority and as guardian of the City's resilience, the Wellington City Council is strongly supportive of this project, which will help us understand the extent of the real risk to Wellingtonians, and how it might be mitigated."

The effects of soil conditions on ground motion

Brendon Bradley led a stream of QuakeCoRE research after the Kaikōura Earthquake showing increased ground motion on locations with sedimentary soils relative to locations directly resting on bedrock. These 'soil amplifications' were much larger than current building design specifications allowed for.

Moreover, when examining over 200 historical earthquakes near Wellington, the researchers found these soil amplifications occur consistently in all events. More detailed simulations have also provided a strong physical explanation for why this amplification occurs.

As a result of this initial research, Brendon and his colleagues developed a model to modify the current design approach to reflect these findings to guide the seismic design of structures in Wellington. These changes have been incorporated into a revision of the New Zealand Loadings Standard (NZS1170.5), which is currently receiving public comment and will subsequently be used by all practitioners.



The revision to the loading standards results in an increase of up to 250% in design loading for some structures in isolated geographical areas. Brendon says, "Such large increases would generally not be seriously considered, but the robustness of the research has made the reality hard to refute and as a result has been pushed for adoption."

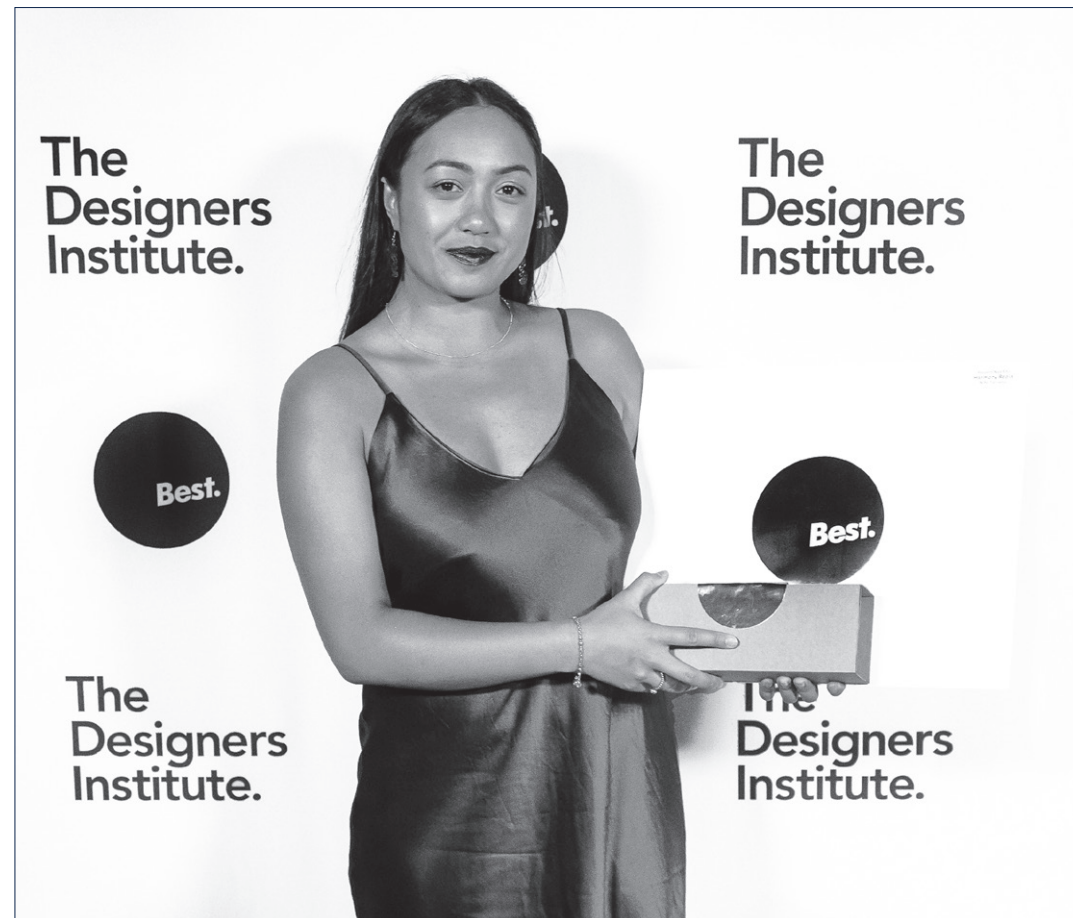
Niho Taniwha: A site-specific case study in communicating tsunami risk to Tūranganui-a-Kiwa

In 2017, Te Hiranga Rū QuakeCoRE researchers identified that the Aotearoa New Zealand public do not sufficiently understand tsunami risk. In response, this year the Joint Centre for Disaster Research and GNS Science sponsored a Master of Design research project to investigate new tsunami communication and warning systems that could encourage communities to respond urgently to tsunami warning signs and to raise tsunami preparedness.

The resulting design, created by Harmony Repia, a student in the School of Design at Massey University, received the Ngā Aho award in the New Zealand Best Design Awards for its exceptional community engagement and well-considered design based on a Māori understanding of natural disasters. The project was conducted in Harmony's hometown, Tūranganui-a-Kiwa (Gisborne), which is at high risk from tsunamis given its proximity to the Hikurangi subduction zone off the east coast of the North Island.

Harmony began the project by conducting ethnographic research to determine how much the community knew about tsunamis and their awareness of existing tsunami messaging, such as the "Long or Strong: Get Gone" campaign. The research showed a high degree of complacency amongst members of the Tūranga community towards tsunamis and a low level of awareness and preparedness. Many had never heard of the "Long or Strong" campaign, and those who had did not have realistic ideas about how 'long or strong' an earthquake needed to be before they should leave.

This research allowed Harmony to build a prototype for a new warning system that would be more effective and culturally relevant to the Tūranga community.



 Harmony Repia (Best Design Awards)

The new system aligns and connects with local history, atua (gods), and cultural understandings of tsunamis and earthquakes.

Harmony describes the finished product as “a combination of design thinking and Mātauranga Māori understandings. The result is a balance between the community needs and my own artistic skills and desires as a designer.”

The design is a powhenua, which is a freestanding post that signifies territorial boundaries or places of significance to tangata whenua. In this context, the powhenua demarcates areas of tsunami risk.

The bottom of the powhenua relates to Rūaumoko, the Māori god of earthquakes, while the top represents Tangaroa, god of the sea. A sensor plate at the bottom of the column triggers an animation of blue waves that ascend and then descend the powhenua, signifying a tsunami. The design helps people understand that earthquakes are the triggers of tsunamis, and that multiple tsunami waves can occur.

Harmony plans to take her prototype back to the Tūranga community as part of a participatory exhibition where people can give feedback and add to the current design. She says that the co-design process developed could be used as a model for developing warning systems in other regions, although she cautions that the design will always need to be tailored to the site-specific cultural and historical context.

 (School of Design, Massey University)



Technology Platform 2 leads to guidelines for field research best practice

The main purpose of Te Hiranga Rū QuakeCoRE's technology platforms is to develop experimental technology and tools to support researchers in realising QuakeCoRE's vision and mission. In Technology Platform 2 this has involved a combination of guidelines and analysis workflows for researchers to help them conduct best-practice field-testing and monitoring easily and efficiently.

Technology Platform 2 Leader Liam Wotherspoon says, "We are pushing best practice while at the same time encouraging collaboration between research and industry to improve the state of practice in the profession."

One capacity that the group has focused on is building a better understanding of basin structures throughout Aotearoa New Zealand. The group has collected detailed information on soil characteristics and profiles to provide a basis for the development of basin and velocity models that underlie ground-motion models. This will enable a better understanding of the effect of local site conditions on earthquake shaking and improve regional site characterisation for seismic design.

An improved understanding of soil properties has been made possible because of a new method for collecting data developed by Andrew Stolte, the Field Research Engineer at QuakeCoRE. Andrew completed a PhD on the refinement and application of the direct-push crosshole testing method at the University of Texas at Austin in collaboration with QuakeCoRE investigators.

Direct-push crosshole is an invasive, seismic geophysical testing method used to evaluate the stiffness and degree of saturation of near-surface soft soils. This allows researchers and practitioners to investigate liquefaction, ground improvement methods and soil characteristics more generally.

The resulting guidelines have been used and revised for testing in Dunedin, Marlborough, Hauraki, Hawkes Bay, and Tauranga. The group's findings have also been developed into a short course for industry on best practice site investigation and characterisation. The course was run through the New Zealand Geotechnical Society (NZGS) in 2018 in Auckland, Wellington and Christchurch.

Eleni Gkeli, Education Officer of the NZGS Management Committee, says "The course had an impressive response from the geotechnical industry, and the feedback from the attendees was very positive. The attendees found the content and state-of-the-art knowledge in site characterisation techniques very useful and entirely applicable for their day-to-day practice. NZGS would definitely support a repetition of the same or similar course in the future, as part of its professional development program."

 Liam Wotherspoon and Andrew Stolte (Paul Daly)



Innovation improves new library's earthquake resilience

Christchurch's new state-of-the-art library, Tūranga, incorporates an innovative engineering solution to help it endure a large earthquake with minimal damage.

Geoff Rodgers designed the low-cost solution, which utilises 20 “dampers” to absorb energy in a big earthquake and prevent building damage. The dampers have been strategically bolted between key base walls and the foundation to act as motion restraints in the event of a large earthquake. Each of the dampers is a metre long and weighs 185 kilograms.

The dampers, which are an attractive alternative to old building methods that save lives but don't prevent building damage, have also been used on other significant projects including the Christchurch Forte Health building and a public housing project in San Francisco.



 Geoff Rodgers (University of Canterbury)

Capability Development

QuakeCoRE directorship changes hands

From 1 January 2019, Brendon Bradley will take over from Ken Elwood as Director of Te Hiranga Rū QuakeCoRE. Ken will move into the new position of Research Director and David Johnston takes on the Deputy Director role. Brendon and David will focus on the development of the next stage of QuakeCoRE's research programme, while Ken focuses on the delivery of the current plan.

Ken says, "QuakeCoRE is fortunate to have a strong depth of leadership, as shown by our ability to seamlessly transition our directorship to someone of Brendon's calibre. The CoRE has always ensured it had a succession plan, which has involved having a Director and Deputy Director of the Centre and within each flagship research area. Through these roles and mentoring relationships, the next generation of leaders are developed and ensure the longevity of QuakeCoRE. I look forward to continuing to contribute to QuakeCoRE as the Research Director."

Ken has shown outstanding leadership over the last three years as Director of QuakeCoRE. Consulting Engineer David Brunsdon says, "Ken has maintained a very strong relationship with practitioners – he is passionate about understanding what issues in design and assessment are concerning engineers, and shaping research to address these needs."

"When it comes to research collaboration, Ken really 'walks the talk'. He has connected people and organisations in both multi- and single-discipline research programmes in very innovative ways – and that is one of his and QuakeCoRE's key achievements."

Brendon says, “It has been a privilege working closely with Ken through the establishment phase of QuakeCoRE. Ken’s inclusive leadership style has brought our community together in teams to focus on our key research questions. As I transition into the Director role, I look forward to building on Ken’s directorship and our culture to ensure QuakeCoRE continues to deliver a strong and aspirational research programme together with a robust plan for long-term success.”



 Brendon Bradley and Ken Elwood (Jonny Knopp)

QuakeCoRE strengthens capability in land-use planning to reduce seismic risk

The addition of GNS Science researcher Wendy Saunders to Te Hiranga Rū QuakeCoRE's Leadership Team in 2018 is strengthening the Centre's capability in land-use planning and risk reduction for communities from earthquakes.

David Johnston, Leader of QuakeCoRE's Resilience Pathways Flagship Programme, says, "Wendy's expertise in natural hazards land-use planning provides invaluable support for QuakeCoRE's goal of reducing seismic risks for communities throughout New Zealand. She has worked with both local and central government to provide evidence-based practice, introducing a risk-based approach to land-use planning policy development."

A core part of Wendy's work is engaging with communities, councils and others to improve the way natural hazards are incorporated into planning for land use. She has developed an award-winning risk-based framework for land-use planning that allows risks from natural hazards such as earthquakes in Aotearoa New Zealand to be reduced, and encourages better decision-making for natural hazard risk reduction.

Focused on consequences of events, the framework consists of an online toolkit for councils to review multiple natural hazard risks within their regions and to engage with stakeholders and the wider community. Wendy's framework has been used by a number of local governments throughout New Zealand, including the Bay of Plenty Regional Council, which adapted the framework into their Regional Policy Statement to avoid and mitigate natural hazards through risk-based planning. This partnership has won several prestigious awards, including the New Zealand Planning Institute award in 2017 and the Commonwealth Association of Planners Award in October 2018.

The judges for the Commonwealth Association of Planners award commented on the project's "thorough and innovative approach" that "has particular relevance across the Commonwealth when thinking about climate change, hazards and other resilience challenges." The judges also noted "the use of a natural hazard integrated approach, planning science and wider considerations of risk."

Wendy is also a member of the Mātauranga Māori and Governance programmes in the Resilience to Nature's Challenges National Science Challenge, where she has received funding to investigate the role of iwi management plans in the management of natural hazards such as earthquakes. Wendy would like to see more researchers use iwi management plans to inform their research design, as well as the cultural context for their research.

Wendy says, "The plans are a key resource for researchers. They can flag issues that iwi need assistance with, and are a way to share information with iwi so that research on disaster planning can be incorporated into the iwi management plans. They also outline expectations and provide a process for engagement with iwi."

Wendy also leads the Engagement Programme for The Deep South National Science Challenge.



Wendy Saunders (Simon Woolf)



Supporting the next generation of earthquake researchers

The Te Hiranga Rū QuakeCoRE Emerging Researcher Chapters (QERC) continue to provide a forum for postgraduate students and new researchers to develop their skills and share knowledge in ways not facilitated under typical university programmes. Currently QuakeCoRE has three chapters located in Auckland, Wellington and Christchurch.

Head of the Christchurch QERC Ribu Dhakal says, “QERC is providing a wonderful platform for young researchers to share, discuss and collaborate using our different backgrounds in the field of disaster resilience.”

Head of the Wellington QERC Lauren Vinnell says, “Studying at the postgraduate level can be a very isolating experience, with potentially negative impacts on both academic success and mental health. The QERC meetings create and strengthen a support network which we can use when we need advice from other students and to avoid feeling isolated.”

This sense of community is a key goal of the QERCs. The Chapters held more than 35 activities for their community in 2018, with an emphasis on skills-based workshops. For example, a workshop called “The Importance of Effective Communication” was held at the QuakeCoRE Annual Meeting in September.

Also at the Annual Meeting, postgraduate students presented in the Lightning Talk Session. This year’s winner of the competition was Marion Tan (PhD student at Massey University) with a talk entitled “Disaster Apps: Usability and continued intention to use.”



 Richard Smith, Marion Tan and Ken Elwood (Debbie Cameron)



QERC Highlights

Auckland Chapter: In July 2018, the Auckland Chapter hosted a one-day Mātauranga Māori workshop for the Chapter members. Participants described it as a fantastic opportunity to learn about Māori concepts, and to gain a better understanding of how they can engage and collaborate with Māori as researchers.

Wellington Chapter: Communication was the focus for the Wellington QERC, with a two-day writing retreat in Waikanae for focused writing time as well as collaborative discussions to address some of the challenges faced by PhD students in general and those researching in the disaster area.

Canterbury Chapter: A highlight of the Canterbury activities in 2018 was a workshop on the ethics of post-disaster recovery presented by Sarah Beaven. This workshop introduced the group to ethical issues associated with post-disaster research, including concerns about research involving human subjects and the growing recognition of ethical risks that post-disaster environments pose to researchers.



Sarah Beaven (Paul Daly)

Recognition highlights

Ann Brower, University of Canterbury

In May 2018, Te Hiranga Rū QuakeCoRE investigator Ann Brower received the 2017 Critic and Conscience of Society Award from Universities New Zealand. Ann was the sole survivor of a bus crushed by a falling building during the 2011 Canterbury Earthquake. She successfully lobbied for a change to the Building Act, which was passed in 2016 as the Brower Amendment.

One of the judges, Professor Steve Weaver, said that “Without doubt her interest in earthquake-prone buildings and the threat of unreinforced masonry stemmed from her traumatic experience. Dr Brower identified an issue of national significance and used her academic credentials and training to research the issue and quickly became a recognised expert on building safety.”

Ann was also a finalist for the 2018 Next Magazine’s Woman of the Year awards. The awards shine a spotlight on Kiwi women who are achieving in all aspects of their lives while making a remarkable contribution to others.

 Ann Brower (University of Canterbury)





Erica Seville, Resilient Organisations

In November 2018, Te Hiranga Rū QuakeCoRE Principal Investigator Erica Seville was made an honorary fellow of the Business Continuity Institute, a prestigious award that recognises her innovation at the forefront of research in organisational resilience globally.

The highest honour granted by the Business Continuity Institute, the honorary fellowship has only been gifted to 26 others since its inception in 1994, and this is the first time it has been awarded to a New Zealander. Recipients must be nominated by their peers for the award.

Erica's research over the last 15 years has translated into practical tools that industry and stakeholders can use to raise their resilience. The Christchurch Earthquakes allowed her team to collect a strong evidence base for their theory about what enables recovery after a disruptive event. In recognition of Erica's contribution to the field of resilience, she has been appointed to the EQC Board.



James McAlister, Erica Seville and Iain Taylor (BCI)

New Zealand Geotechnical Society Recognitions

In 2018, the New Zealand Geotechnical Society (NZGS) recognised Te Hiranga Rū QuakeCoRE researchers for the following contributions:

- Misko Cubrinovski was awarded the 2018 NZGS Geomechanics Lecture Award. This award was established to honour individuals who have made a notable contribution to New Zealand Geomechanics. Misko will present his lecture at the 13th Australia New Zealand Conference on Geomechanics in Perth in April 2019.
- QuakeCoRE researchers Chris McGann, Brendon Bradley, Misko Cubrinovski and Liam Wotherspoon, together with Merrick Taylor (Arup), received the NZGS Geomechanics Award. This award is presented every three years for the publication that best contributes to the development of geotechnics in Aotearoa New Zealand. Their paper entitled “Development of an empirical correlation for predicting shear wave velocity of Christchurch soils from cone penetration test data” was published in *Soil Dynamics and Earthquake Engineering* in 2015.

New Zealand Society for Earthquake Engineering Recognitions

In 2018, Te Hiranga Rū QuakeCoRE researchers were acknowledged by the New Zealand Society for Earthquake Engineering (NZSEE) with various awards and recognitions:

- Ken Elwood was awarded the President’s Award for his significant contribution toward enhancing public safety through the increased understanding of earthquake effects on reinforced concrete buildings following the Canterbury and Kaikōura Earthquakes.
- Tim Sullivan and Rick Henry received the EQC/NZSEE Ivan Skinner award for the advancement of earthquake engineering research.
- Liam Wotherspoon was elected as a Fellow of NZSEE for his services to earthquake engineering in New Zealand.
- QuakeCoRE investigators Rajesh Dhakal, Alessandro Palermo and Liam Wotherspoon, together with Caroline Holden (GNS Science), were jointly awarded the 2018 Otto Glogau Award. This award is offered annually to the best publication during the past 3 years. This year’s winners were the editors of the Special Issue on the 2016 Kaikōura Earthquake, *NZSEE Bulletin* 50(2) published in June 2017.

Financials, Community & Outputs

Financials

Category	Total (\$000s)
CoRE Funding	4,163
Total Revenue	4,163
Directors and Principal Investigators	246
Associate Investigators	0
Postdoctoral Fellows	183
Technology Platform Staff & Research Technicians	480
Others	256
Total Salaries & Salary-related Costs	1,165
Overheads	850
Project Costs	403
Travel	180
Postgraduate Students	689
Equipment Depreciation/Rental	0
Subcontractors(s)	289
Total Other Costs	2,411
Less: Host and Partner Support	(111)
Total Expenditure	3,465
Net Surplus/(Deficit)	698

2018

At a glance

Category	Detailed category	FTE	2018
<i>People</i>	Principal Investigators	1.60	8
	Associate Investigators	0.00	53
	Postdoctoral Fellows	2.45	11
	Technology Platform Staff/ Research Technicians	5.45	13
	Administration/Support	4.05	8
	Research Students	103.62	122
	Total	117.17	215
<i>Peer-reviews research outputs</i>	Journal Articles		57
	Conference Papers		73
	Total		130
<i>Value of external research contracts awarded</i>	Vote Science and Innovation Contestable Funds		\$4,253,595
	Other NZ Government		\$636,291
	Domestic – Private Sector Funding		\$156,689
	Overseas		\$302,316
	Domestic – Other Non-government Funding		\$8,000
	Total		\$5,356,890
<i>Students studying at CoRE</i>	Doctoral Degree		89
	Other		33
	Total		122
<i>Number of students completing qualifications</i>	Doctoral Degree		4
	Other		10
	Total		14
<i>Immediate post-study graduate destinations</i>	Further study in NZ		1
	Further study Overseas		0
	Employed in NZ		6
	Employed Overseas		4
	Other		3
	Total		14
<i>Commercial activities</i>	Number of licenses		0
	Income from licenses		\$20,000

Community

61

Investigators

27

Industry
Affiliates

9

Affiliate
Organisations

Board

Dean Kimpton (Chair)
Mary Comerio
Jan Evans-Freeman
John Hare
Bryony James
Mike Mendonça
John Reid
Tā Mark Solomon

Auckland Council
University of California, Berkeley
University of Canterbury
Holmes Consulting Group
University of Auckland
Wellington City Council
Ngāi Tahu Research Centre

International Science Advisory Panel

Mary Comerio (Chair)
Jack Baker
Tom O'Rourke
Ellen Rathje

University of California, Berkeley
Stanford University
Cornell University
University of Texas at Austin

Leadership Team

Ken Elwood (Director)
Brendon Bradley (Deputy Director)
Misko Cubrinovski
David Johnston
Caroline Orchiston
Wendy Saunders
Tim Sullivan
Liam Wotherspoon

University of Auckland
University of Canterbury
University of Canterbury
Massey University / GNS Science
University of Otago
GNS Science
University of Canterbury
University of Auckland

Principal Investigators

Brendon Bradley	University of Canterbury
Misko Cubrinovski	University of Canterbury
Ken Elwood	University of Auckland
Jason Ingham	University of Auckland
David Johnston	Massey University / GNS Science
Erica Seville	Resilient Organisations
Tim Sullivan	University of Canterbury
Liam Wotherspoon	University of Auckland

Associate Investigators

Julia Becker	GNS Science
Ann Brower	University of Canterbury
Deidre Brown	University of Auckland
Reagan Chandramohan	University of Canterbury
Alice Chang-Richards	University of Auckland
Gabriele Chiaro	University of Canterbury
G Charles Clifton	University of Auckland
Toni Collins	University of Canterbury
David Dempsey	University of Auckland
Rajesh Dhakal	University of Canterbury
Dmytro Dizhur	University of Auckland
Temitope Egbelakin	Massey University
Olga Filippova	University of Auckland
Sonia Giovinazzi	University of Canterbury
Connor Hayden	University of Auckland
Richard Henry	University of Auckland
Lucas Hogan	University of Auckland
John Hopkins	University of Canterbury
Nick Horspool	GNS Science

Emma Hudson-Doyle	Massey University
Matthew Hughes	University of Canterbury
Seokho Jeong	Waikato University
Christine Kenney	Massey University
Minghao Li	University of Canterbury
Quincy Ma	University of Auckland
Gregory MacRae	University of Canterbury
Chris Massey	GNS Science
John McClure	Victoria University of Wellington
Christopher McGann	University of Canterbury
Mark Milke	University of Canterbury
Hugh Morris	University of Auckland
Nirmal Nair	University of Auckland
Katharina Naswall	University of Canterbury
Ilan Noy	Victoria University of Wellington
Caroline Orchiston	University of Otago
Rolando Orense	University of Auckland
Alessandro Palermo	University of Canterbury
Michael Pender	University of Auckland
Suzanne Phibbs	Massey University
Raj Prasanna	Massey University
Venkateswarlu Pulakanam	University of Canterbury
Geoffrey Rodgers	University of Canterbury
Vinod Sadashiva	GNS Science
Wendy Saunders	GNS Science
Allan Scott	University of Canterbury
Mark Stirling	University of Otago
Mark Stringer	University of Canterbury
Bridgette Sullivan-Taylor	University of Auckland
SR Uma	GNS Science
Chris Van Houtte	GNS Science
Bernard Walker	University of Canterbury
Colin Whittaker	University of Auckland

Industry Affiliates

Richard Apperley	Aurecon
Jawad Arefi	Beca
Jeff Bayless	AECOM
Nicholas Brooke	Compusoft Engineering
Dave Brunsdon	Kestrel Group
Nigel Colenso	ABI Piers
Patrick Cummiskey	Auckland Council
James Dismuke	Golder Associates
Michael Drayton	Risk Management Solutions
Roger Fairclough	Neo Leaf Global
Jeff Fraser	Golder Associates
Reza Jafarzadeh	Auckland Council
Weng Yuen Kam	Beca
Jared Keen	Beca
Alan McMahon	Colliers International
Rebecca McMahon	Beca
Gareth Morris	Holmes Consulting
Dan Neely	WREMO
Aasha Pancha	Aurecon
Didier Pettinga	Holmes Consulting
Dario Pietra	WSP Opus
Sean Rees	Tonkin & Taylor
Aimee Rhodes	WSP Opus
Andreas Skarlatoudis	AECOM
Paul Somerville	AECOM
Richard Voss	Warren and Mahoney Architects
Rick Wentz	Wentz Pacific

Postdoctoral Fellows

Jagdish Vyas	University of Canterbury
Hoby Razafindrakoto	University of Canterbury
Yiqiu Lu	University of Auckland
Sarah Bastin	University of Canterbury
Trevor Yeow	University of Canterbury
Aishwarya Puranam	University of Auckland
Samuel Corney	University of Auckland
Daniel Blake	University of Canterbury
Royce Liu	University of Canterbury
Saree Lawler	Resilient Organisations
Joanne Stevenson	Resilient Organisations

Students

QuakeCoRE Scholarship Recipients

Shannon Abeling	University of Auckland
Rizwan Ahmed	University of Canterbury
Xavier Bellagamba	University of Canterbury
Annie Brown	University of Canterbury
Claudio Cappellaro	University of Canterbury
Pavan Chigullapally	University of Auckland
Chris de la Torre	University of Canterbury
Ribu Dhakal	University of Canterbury
Tom Francis	University of Canterbury
Paco Gálvez	University of Auckland
Martin Garcia	Massey University
Henrieta Hamilton Skurak	University of Canterbury
Rabia Ijaz	University of Canterbury
Anna Kowal	University of Otago
Vahid Loghman	University of Canterbury

James Maguire	University of Auckland
Nikos Ntritsos	University of Canterbury
Tayo Opabola	University of Auckland
Ana Sarkis Fernandez	University of Canterbury
Mehdi Sarrafzadeh	University of Auckland
Alex Shegay	University of Auckland

Students

In addition to the students listed below, that received direct support towards their postgraduate studies, there are a significant number of additional aligned students that are funded with external funding.

Mina Adhikari	Massey University
Esther Aigwi	Massey University
Reza Ansari	Massey University
Ananth Balachandra	University of Auckland
Tyler Best	University of Auckland
Jay Bhanu	University of Canterbury
Muhammed Bolomope	University of Auckland
Nancy Brown	Massey University
Frank Bueker	University of Auckland
Sara Chalian	University of Auckland
Miles Crawford	Massey University
Signy Crowe	University of Auckland
Mat Darling	University of Canterbury
Alistair Davies	University of Canterbury
Wenchen Dong	University of Canterbury
Darsh Dorn	University of Canterbury
Kemron Dufont	University of Auckland
Cameron Eade	University of Canterbury
Ahmad Ebadati	University of Auckland
Kevin Foster	University of Canterbury
Trevor Garrett	University of Canterbury

Lesley Gray	Massey University
Srijana Gurung Shrestha	University of Canterbury
Sara Harrison	Massey University
Mahdi Hatami	University of Canterbury
Kieran Haymes	University of Canterbury
Nick Horspool	University of Auckland
Gregory Jackson	University of Otago
Dan Jones	University of Canterbury
Alex Kirby	University of Auckland
Andre Knops	University of Canterbury
Alan Kwok	Massey University
Ming Lee	University of Canterbury
Amelia Lin	University of Auckland
Duncan Maina	University of Auckland
Wasay Majid	University of Auckland
Kai Marder	University of Auckland
Jessica McHale	University of Canterbury
Damon McKibbin	University of Canterbury
Lisa McLaren	Massey University
Rebecca McMahon	University of Auckland
Aina Misnon	University of Auckland
Joshua Mulligan	University of Canterbury
Gonzalo Munoz	University of Auckland
Sarah Neill	University of Canterbury
Aram Nikpai	Massey University
Matt Ogden	University of Auckland
Bruce Pepperell	Massey University
Hannah Petrie	University of Canterbury
Zaid Rana	University of Auckland
Kiran Rangwani	University of Canterbury
Ebad Rehman	University of Auckland
Harmony Repia	Massey University
Shakti Shrestha	University of Otago

Vicky Southworth
 Hasib Suenu
 Nitesh Suthar
 Tomomi Suzuki
 Moustafa Swidan
 Marion Tan
 Ethan Thomson
 Stacy Vallis
 Lauren Vinnell
 Amanda Wallis
 Clare Wilkinson
 Sam Wilson
 Natacha Wisstt
 Robin Xie
 Majid Zakerinia

University of Canterbury
 University of Canterbury
 Massey University
 University of Auckland
 University of Auckland
 Massey University
 University of Canterbury
 University of Auckland
 Victoria University Wellington
 Victoria University Wellington
 University of Canterbury
 University of Auckland
 University of Canterbury
 University of Canterbury
 University of Auckland

Affiliate Organisations

Building Research Institute (BRI)
 DesignSafe
 International Joint Laboratory of
 Earthquake Engineering (ILEE)
 Liquefact
 National Center for Research on
 Earthquake Engineering (NCREE)
 National Hazards Center (NHC)
 National Hazards Engineering Research
 Infrastructure (NHERI) @UTexas
 National Hazards Engineering Research
 Infrastructure (NHERI) SimCenter
 Smart Structures Lab, Swinburne
 University of Technology

Tsukuba , Japan
 Austin, USA

Shanghai, China
 Chelmsford, UK

Taipei, Taiwan
 Boulder, USA

Austin, USA

Berkeley, USA

Melbourne, Australia

Other Staff

Technology Platform Staff

Sung Bae	IT Architect, TP4
Andrew Stolte	Field Research Engineer, TP2
Viktor Polak	Software Engineer
Sharmila Savarimuthu	Software Engineer, TP3

Support Staff

Susie Meade	Manager
Brandy Alger	Outreach Coordinator
Ruth Hartshorn	Research Coordinator
Susannah Hawtin	Administrator
Rosemary Walton	Senior Finance Administrator

Partners

University of Canterbury
 BRANZ
 GNS Science
 Massey University
 Resilient Organisations
 University of Auckland
 University of Waikato
 Victoria University of Wellington

(Host)

Publications

130

Peer-reviewed
Outputs

71

Annual Meeting
Posters

Journal Publications (Direct Peer-Reviewed)

Abeling, S., Dizhur, D., & Ingham, J. (2018) An evaluation of successfully seismically retrofitted URM buildings in New Zealand and their relevance to Australia. *Australian Journal of Structural Engineering*, **19**(3), 234-244. doi: 10.1080/13287982.2018.1491820

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Bagriacik, A., Davidson, R., Hughes, M., Bradley, B., & Cubrinovski, M. (2018) Comparison of statistical and machine learning approaches to modeling earthquake damage to water pipelines. *Soil Dynamics and Earthquake Engineering*, **112**, 76-88. doi: 10.1016/j.soildyn.2018.05.010

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Wairau plains, New Zealand, following the 2016 Kaikōura earthquake. *Bulletin of the Seismological Society of America*, **108**(3B), 1683-1694. doi: 10.1785/0120170248

Beyzaei, C., Bray, J., Cubrinovski, M., Riemer, M., & Stringer, M. (2018) Laboratory-based characterization of shallow silty soils in southwest Christchurch. *Soil Dynamics and Earthquake Engineering*, **110**, 93-109. doi: 10.1016/j.soildyn.2018.01.046

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Bruce Worden, C., Thompson, E., Baker, J., Bradley, B., Luco, N., & Wald, D. (2018) Spatial and spectral interpolation of ground-motion intensity measure observations. *Bulletin of the Seismological Society of America*, **108**(2), 866-875. doi: 10.1785/0120170201

Corney, S., Ingham, J., & Henry, R. (2018) Seismic testing of support connections in deep hollow-core floor units. *ACI Structural Journal*, **115**(3), 735-748. doi: 10.14359/51702062

Cox, B., Stolte, A., Stokoe, K., & Wotherspoon, L. (2018) A Direct-Push Crosshole (DPCH) test method for the in-situ evaluation of high-resolution P- and S-wave velocities. *Geotechnical Testing Journal*. doi: 10.1520/GTJ20170382

Crawford, M., Crowley, K., Potter, S., Saunders, W., & Johnston, D. (2018) Risk modelling as a tool to support natural hazard risk management in New Zealand local government. *International Journal of Disaster Risk Reduction*, **28**, 610-619. doi: 10.1016/j.ijdr.2018.01.011

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Deschenes, M., Wood, C., Wotherspoon, L., Bradley, B., & Thomson, E. (2018) Development of deep shear wave velocity profiles in the Canterbury plains, New Zealand. *Earthquake Spectra*, **31**(3), 1065-1089. doi: 10.1193/122717EQS267M

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Egbelakin, T., Poshdar, M., Walsh, K., Ingham, J., Johnston, D., Becker, J., Mbachu, J., & Rasheed, E. (2018) Preparedness of small to medium-sized enterprises to earthquake disaster: Napier and Dunedin case studies. *Bulletin of the New Zealand Society for Earthquake Engineering*, **51**(4), 171-182. doi: 10.1016/j.proeng.2018.01.117

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Giongo, I., Rizzi, E., **Ingham, J.,** & **Dizhur, D.** (2018) Numerical modeling strategies for in-plane behavior of straight sheathed timber diaphragms. *Journal of Structural Engineering (United States)*, **144**(10), 4018163. doi: 10.1061/(ASCE)ST.1943-541X.0002148

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response of a cold-formed steel pallet rack. *New Zealand Society for Earthquake Engineering Conference*.

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Wotherspoon, L., Zorn, C., & Davies, A. (2018) Infrastructure failures and recovery from an Alpine Fault Earthquake scenario. *ISCRAM Asia Pacific 2018 Conference*

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Zhang, T., **Elwood, K.**, & **Henry, R.** (2018) Testing of singly reinforced concrete walls used in existing buildings. *New Zealand Society for Earthquake Engineering Conference*.

Zhang, T., **Elwood, K.**, & **Henry, R.** (2018) Testing of reinforced concrete walls in pre-1970s multi-storey buildings. *11th National Conference on Earthquake Engineering*.

Zhou, Y., Gu, A., Lu, Y., Xiao, Y., **Henry, R.**, **Elwood, K.**, **Rodgers, G.**, & Yang, T. (2018) Large-scale shake-table test on a low damage concrete wall building: Numerical modelling and analysis. *11th National Conference on Earthquake Engineering*.

QuakeCoRE Annual Meeting Posters

71 posters were presented at the QuakeCoRE Annual Meeting in Taupō from 3-6 September 2018.

Bae, S., Polak, V., Huang, J., Lagrava, D., Motha, J., **Bradley, B.**, & Tarbali, K., QuakeCoRE Ground motion simulation computational workflow.

Balachandra, A., Chalian, S., **Hayden, C.**, **McGann, C.**, & **Wotherspoon, L.**, Validating numerical simulation of SSI for buildings on liquefiable deposits.

Bellagamba, X., **Bradley, B.**, **Wotherspoon, L.**, & Lagrava, D., Inferred seismic performance and recovery of the Christchurch water supply network following the 22 February 2011 Mw6.2 Christchurch Earthquake.

Bhanu, V., **Chandramohan, R.**, & **Sullivan, T.**, Characterising the effect of ground motion duration on deteriorating structural models.

Blake, D., **Wotherspoon, L.**, Trotter, M., Stevenson, J., & Ivory, V., Data and decision making in the transport sector following the Kaikōura Earthquake.

Boston, M., Resilience by design: Improving hospital functionality following earthquake.

Brown, A., **Walker, B.**, Morrish, S., & Ozanne, L., Non-profit-business collaboration: Exploring the effects on non-profit resilience.

Cappellaro, C., **Cubrinovski, M.**, Bray, J., Chiaro, G., Riemer, M., & Stringer, M., Cyclic undrained DSS testing of Christchurch sands.

Chiaro, G., Kiyota, T., Umar, M., **Massey, C.**, Chew, K., & Su Kim, J., Experimental and numerical investigations of the Takanodai Landslide caused by the 2016 Kumamoto Earthquakes, Japan.

Chigullapally, P., **Wotherspoon, L.**, **Hogan, L.**, & **Pender, M.**, Modelling of bridge pile-column Dynamic Field Tests.

Blake, D., Crawford-Flett, K., Pascoal, E., & Wilson, M., New Zealand stopbank networks: Understanding resiliency challenges.

Davidson, R., Probabilistic framework for modelling spatially distributed infrastructure.

de la Torre, C., & **Bradley, B.**, Modelling nonlinear site effects in physics-based ground motion simulation.

de Raadt, A., & Blick, G., Mapping New Zealand 2025 – responding to the Kaikōura Earthquakes.

Dempsey, D., Eccles, J., **Wotherspoon, L.**, & **Bradley, B.**, Ground motion simulation of upper North Island earthquakes.

Dhaka, R., **Cubrinovski, M.**, Bray, J., & de la Torre, C., Site characterisation and liquefaction assessment of the reclamations at CentrePort.

Dong, W., The lateral seismic performance of multi-storey heavy timber buildings with Buckling Restrained Braces BRBs.

Dunant, A., Davies, T., Bebbington, M., & Gaillard, J., Natural disaster system, a multi-hazard impact assessment methodology.

Egbelakin, T., & Malan, R., Toolkit of alternative policies and incentives for resilience and sustainable reuse of heritage buildings.

Elwood, K., **Filippova, O.**, Pastor, J., & **Noy, I.**, Creating GIS-ready building inventory dataset for seismic risk assessment and management.

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