Research for resilience: **Highlights from 2019**

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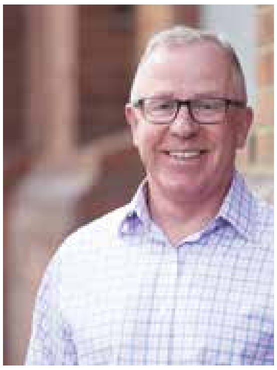


Sid Miller, Chief Executive

We live with the beauty of a land shaped by nature's forces, alongside the risks it brings such as earthquakes, volcanic eruptions and landslides.

At EQC we're on a mission to reduce the impact on people and property when natural disasters occur. Building natural hazards resilience for our homes, towns and cities is a very important part of our strategy.

As part of this, we invest more than $17 million each year in research and data that can be used to strengthen New Zealand's resilience.

I'm very pleased to be able to share some of our recent research highlights with you in this report.

Sid Miller

Dr Jo Horrocks, Head of Resilience Strategy and Research

Building a more resilient New Zealand is a goal that EQC shares with many other organisations. Each year EQC invests in a programme to deliver the New Zealand-specific data and knowledge that our experience as an insurer tells us will make the most difference for households and communities. We work closely with others to make sure this information becomes part of everyday decision-making.

EQC's research and data help support decisions that lead to stronger homes, on better land, resilient infrastructure and sustainable access to insurance for New Zealanders. Our unique position as both an insurer and science funder gives us the ability to drive research outcomes that can be used now, and for the big challenges that may take more than one generation of scientists to solve.

As is often said, we can't stop earthquakes, volcanoes and other hazards, but we can help minimise the impacts on communities, and ensure that, as a nation, we are as prepared as we can be to not just survive, but thrive, through periods of disruption.

Dr Jo Horrocks

Introduction

EQC's aim is to embed natural hazards resilience in all aspects of decision-making for our homes, towns and cities. Though known more for its role as an insurer, EQC invests around $17 million each year in data and research to support sound resilience decision-making that limits the impacts of our natural hazards before something happens.

We work in partnership with many other national and local organisations to get natural hazards knowledge to where it can be most effectively used to make New Zealand more resilient. EQC-funded research and data is freely available to all.

We also make a strong contribution to building the community of research talent that continues to grow knowledge of New Zealand's natural hazard environment, and how to reduce the impacts. We are delighted that many of the researchers we support are making their mark internationally even as they deliver research results that make a difference for our own communities.

Building data

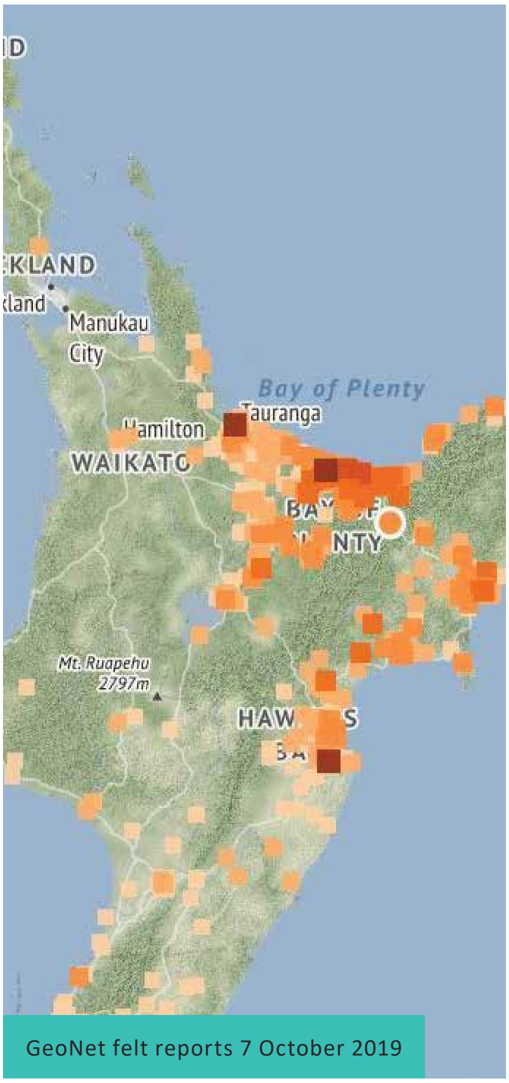
Good resilience decision-making relies on the availability of good data. Much of EQC's resilience investment is dedicated to providing data on natural hazards, providing information that gives researchers and decision-makers a solid base for understanding New Zealand's natural hazard risks, and finding ways to reduce the impacts.

GeoNet

EQC is a major partner in GeoNet, providing around $13 million in funding each year for the network of more than 600 sensors across the country that delivers fast access to high-quality information and data.

GeoNet data is the basis for nearly all natural hazard research in New Zealand and is freely available to all.

More than 200,000 New Zealanders have now downloaded the GeoNet app onto their phones.



GeoNet felt reports 7 October 2019

Event response exercise at the National Geohazards Monitoring Centre. Photo: Margaret Low GNS Science

They open the app almost one million times a month to stay updated and make their contributions to geohazards science through "felt" reports.

The GeoNet website reaches another 300,000 people a month, providing data, updates and information on the earthquakes, volcanoes, tsunami and large landslides monitored by the network.

In December 2018, the National Geohazards Monitoring Centre, with 24/7 live monitoring, was established following the provision of funding from The Ministry of Business, Innovation and Employment (MBIE). When an earthquake, tsunami, large landslide or volcanic activity is detected, it can be analysed almost immediately and information sent to people making decisions and managing response.

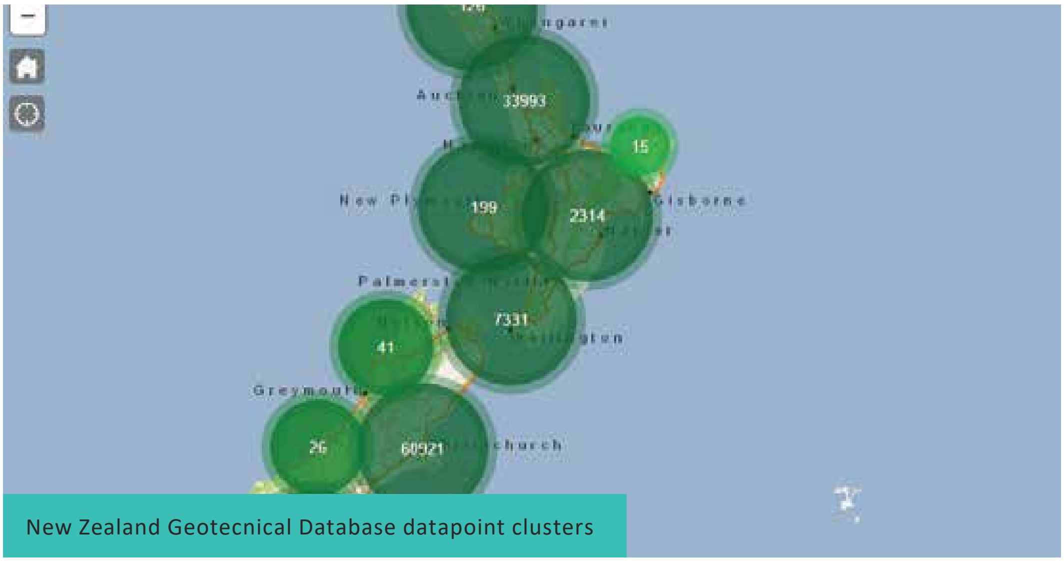
New Zealand Geotechnical Database

The New Zealand Geotechnical Database (NZGD) is a unique public/private shared resource of geotechnical test results, which allows data to be shared for geotechnical projects, land-use planning and identifying natural hazard risks. Over 5000 people are now contributors to, and users of, the NZGD.

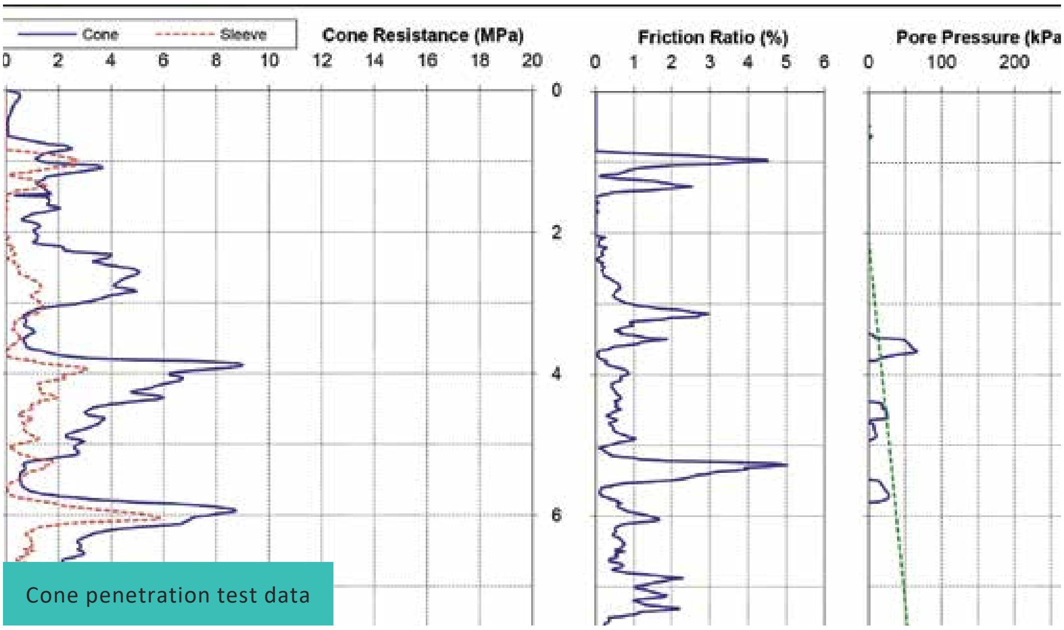
EQC established the Canterbury Geotechnical Database after the Canterbury earthquakes to ensure that the large amount of valuable test data being collected remained available for further use. The database has become a national resource, holding more than 110,000 data points with an estimated value of over $300 million.

EQC remains a co-funder of the database and has also helped increase database holdings by funding students to upload records held in files by councils and engineers in different parts of the country.

The database is proving hugely valuable for researchers, councils, engineers, developers and others to access geotechnical tests that have already been done, rather than commissioning their own.

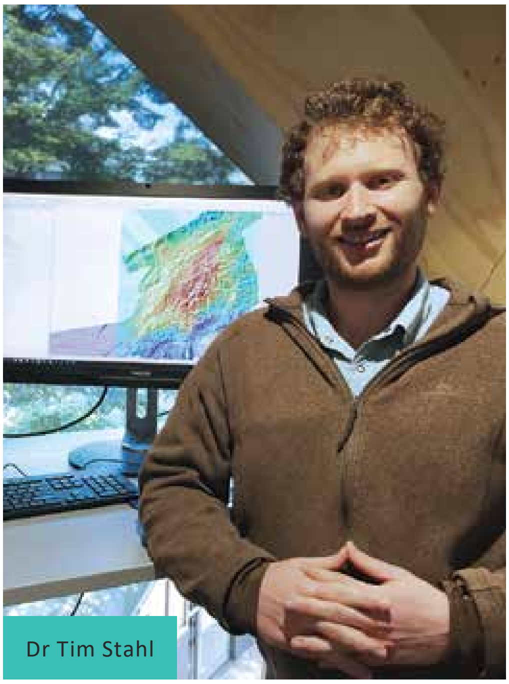


New Zealand Geotecnical Database datapoint clusters



Cone penetration test data

Data-gathering from above


Dr Tim Stahl

The use of leading-edge remote sensing technology to gather data is delivering new ways of understanding hazards.

In one EQC-funded project, satellite and aerial data is being used to help understand the most complex earthquake ever recorded – the 2016 Kaikōura earthquake. Dr Tim Stahl, lecturer in tectonics at the University of Canterbury, is leading the work.

(See page 29 for more about Dr Stahl.)

To collect the data, 3D models of the earth's surface before and after the earthquake were created. They were then analysed by earthquake geologists to determine the intricate patterns of displacements on faults that ruptured, and to provide insights into why all of these faults (>20 in total) ruptured to create a much larger earthquake than anticipated. Before the Kaikōura earthquake, the extent to which fault movements jump from one fault to another nearby was not fully appreciated. This work is revealing the behaviour of complex earthquakes.

Remote sensing data has provided valuable insights and may ultimately help scientists plan for, or even forecast, the largest quakes our plate boundary is capable of producing.

Data helps develop Wellington building improvement priorities

EQC co-funds a Chair in the Economics of Disasters at Victoria University of Wellington, held by Professor Ilan Noy. Professor Noy focuses on research and public and policy engagement to improve understanding of the economic impacts of geological, biological and other types of “natural” shocks in and provide insights to improve the management of hazard risks in New Zealand. He collaborates with other disaster risk mitigation and reduction organisations and initiatives, nationally and internationally.

Professor Ilan Noy

Professor Noy was on hand to help when the Kaikōura earthquake in November 2016 made it urgent to understand weaknesses within the Wellington building stock.

Working with engineers and other staff from QuakeCore, Wellington City Council and MBIE, Professor Noy’s team participated in a review to identify which buildings required seismic strengthening. As part of this, the team measured the urgency and the feasibility of implementation within a relatively short timeframe, and with relatively little cost.

The team concluded that strengthening street-facing facades and unreinforced masonry buildings (such as the ones in Cuba Street, Wellington) was the highest priority for preventing injury.

The cost-sharing arrangement that became part of the “Securing unreinforced masonry building parapets and facades” policy was also partly developed during the data study. The programme was implemented by the government, and concluded last year, after 18 months. Professor Noy and the team are now working with the city council and MBIE on collecting data to analyse how cost-effective the programme was.

Building research knowledge

At any one time, EQC is funding around 40 targeted research projects to deliver New Zealand-specific knowledge about our biggest natural hazard challenges and ways to reduce their impacts. Some projects deliver results for immediate use, and others are part of the long-term scientific investigation needed for the most difficult natural hazard issues such as forecasting earthquakes and volcanic eruptions. These long-term projects may well take more than one generation of scientists as they build on each other's science and discoveries.

Ultimately all the research helps EQC to fulfil its mission of reducing the impact on people and property when natural disasters occur.

How do house foundations on slopes behave in an earthquake?

EQC, BRANZ and Victoria University of Wellington have joined forces on a project to test how well four common types of foundations for timber-framed homes stand up to earthquakes when they are sited on a slope.

BRANZ research after the Christchurch earthquakes showed that damage to homes in Port Hills areas like Cashmere and Redcliffs was significantly higher than on the flat areas for the same level of shaking, and this was because the foundations of some homes on slopes performed poorly in the earthquakes.

With many New Zealand homes built on the side of a hill, especially in earthquake-prone areas like the Wellington region, EQC and BRANZ have invested in research to better understand how foundations on slopes respond in an earthquake.

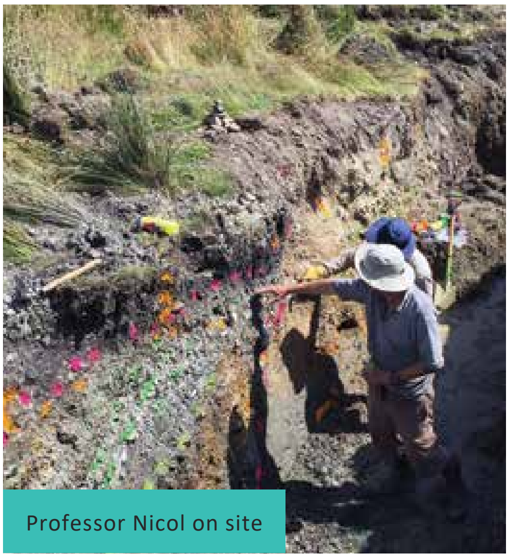
Houses built on slopes may have foundations that are significantly taller at one end than the other, or there may be different types of foundations under the same home. This can result in a twisting motion in an earthquake.

For the testing, the project team has built four different types of foundations on a sloping paddock using pile foundations, and combinations of pile and foundation walls meeting building standard NZS 3604. The team has added dead weight to the floor of each foundation to replicate the mass of a house, and is using a counter-rotating shaker to simulate the effects of an earthquake.

During the study they are also testing different techniques to reduce damage, with a view to being able to provide information on how homeowners can strengthen foundations under existing houses.

Results from the study are expected to help update the current building standard for foundations, which was largely developed after tests carried out on flat land.

Studying a fault's past to understand its future behaviour



Professor Nicol on site

A project underway in North Canterbury aims to unlock one of the mysteries posed by the 2016 Kaikōura earthquake. Scientists internationally were puzzled by the quake, which ruptured more than 17 active faults but did not break some other active faults in the area of the earthquake.

Structural geology Professor Andy Nicol at the University of Canterbury is leading a team to study why some faults ruptured, and others did not, to see what this could mean for forecasting earthquakes.

Studying a fault's past to understand its future behaviour (continued)

Professor Nicol's team is looking at whether seismic cycles, where faults build up stress over time and eventually rupture as an earthquake, could be involved. Cycles are observed over very long timeframes, possibly tens of thousands of years. The research team is investigating faults and comparing cycles for some faults that ruptured in the quake with some that did not to test the idea that faults that ruptured were already stressed as part of their historical cycle, and were in effect ready to go.

Professor Nicol's work could help forecast the timing, location and complexity of a quake in the future.

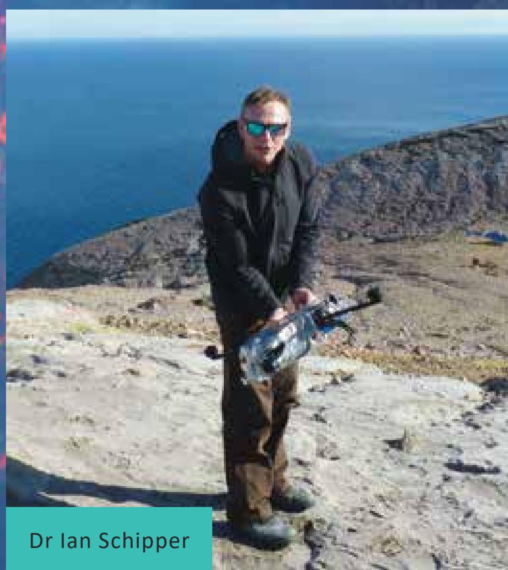
Getting to the heart of volcanic chemistry

Taking samples directly from a volcanic plume has long been on the wish list of many a volcanologist. Gases sometimes change before an eruption as different chemicals are released from different depths. A change in the chemistry of the plume could potentially be a signal of an imminent eruption.

But until now, researchers have not been able to get close enough to the hot and toxic cloud to know they are getting the right data.

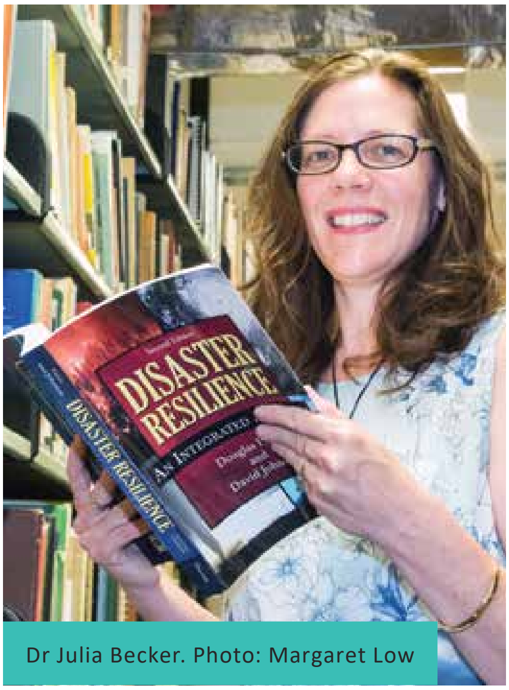
Dr Ian Schipper from Victoria University of Wellington has been leading a team working on an EQC-funded project to develop a drone that can cope with the acidity of the plume, and a system that can take chemical samples and bring them back for analysis.

With White Island being the perfect laboratory, Dr Schipper proved that his technology was successful, and was asked to join international scientists at a Deep Carbon Observatory meeting in Papua New Guinea to show the specially hardened drone and instruments at work. Dr Schipper has also received additional funding through the Marsden Fund to sample gas emissions on some of the world’s most inaccessible volcanoes. This will allow him to lead a project to sample gases from volcanoes around the Pacific, an area that could produce an eruption that affects the whole region.



Dr Ian Schipper

An earthquake early warning system for New Zealand?



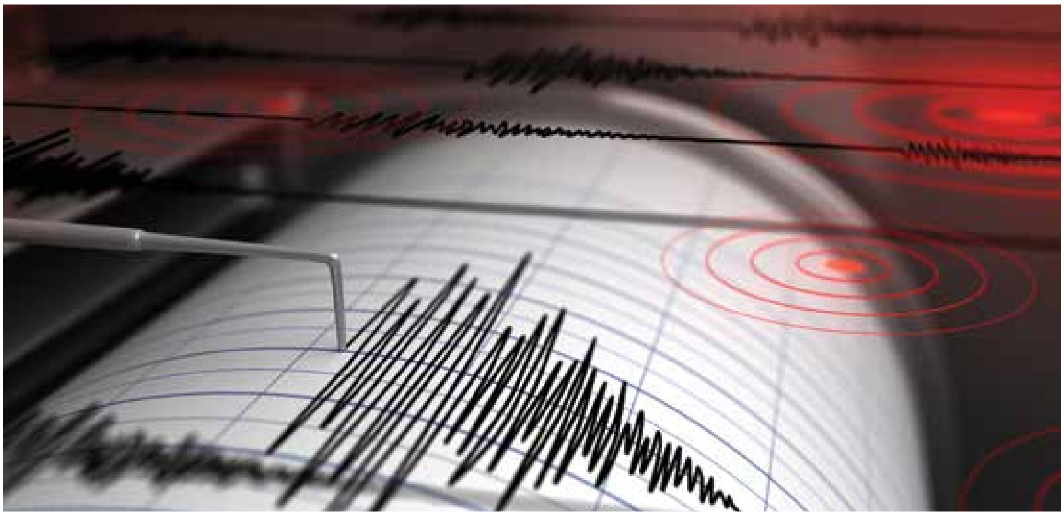
Dr Julia Becker. Photo: Margaret Low

With several other countries using earthquake early warning systems giving from several seconds' up to two minutes' warning that shaking is coming, EQC is funding research to look at how New Zealanders say they would use one.

Led by Dr Julia Becker from Massey University, a team of earthquake scientists, engineers, statisticians, modellers and social scientists is taking a "user first" approach to assessing how useful it would be to invest in this type of technology.

More than 3000 New Zealanders responded to a survey on the issue, with 97% stating that they thought an earthquake early warning system would be useful, particularly for taking some sort of action to keep themselves safe, and 81% saying they would "drop, cover hold."

The team also ran a similar survey in Japan, which has had an earthquake early warning system in place for some years, to find out what people most value about the service. A surprising result so far is that both New Zealand



and Japanese respondents gave the same rate of 83% of people saying that an early warning system would help them prepare mentally for an earthquake.

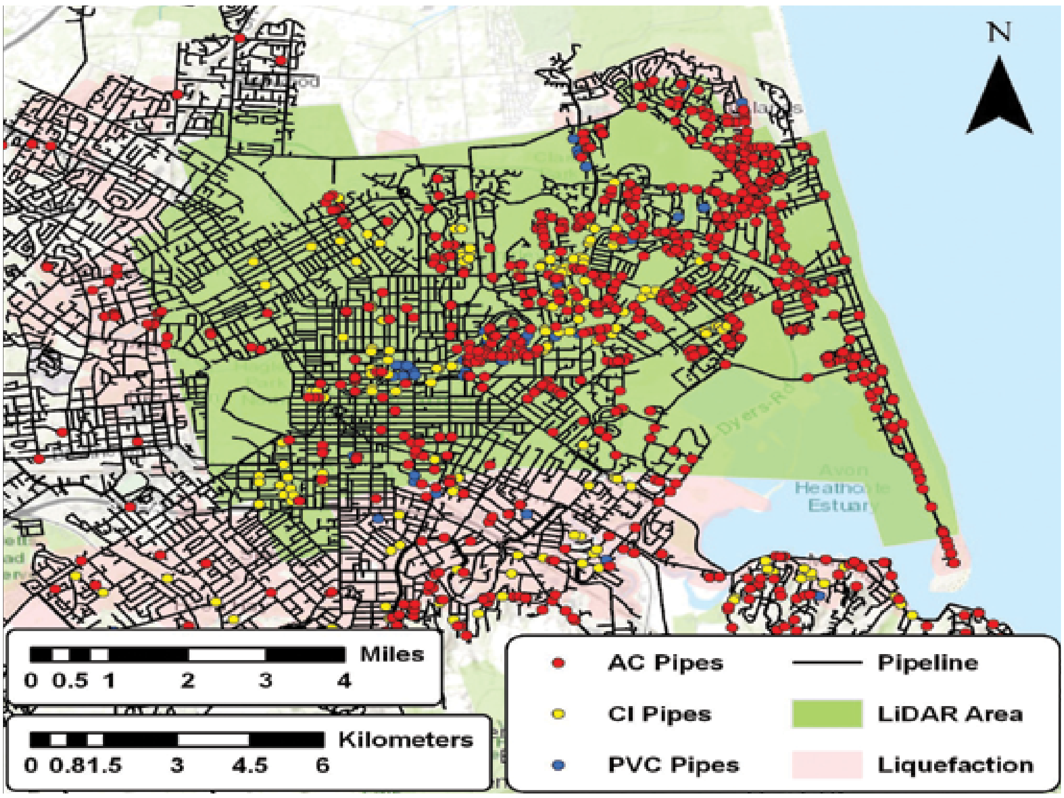
The team has also spoken to groups of service providers including power, water, rail and hospitals to see how they would make use of an early warning system.

Analysing mission-critical pipe fixes

Fast repair of infrastructure like water and sewerage pipes is critical to reducing the impact of earthquake disasters on communities. Through its industry partnership programme with Quake Centre, EQC has funded a project to develop a way of determining where the most pipe breaks are likely to be after an earthquake.

International engineering expert Professor Tom O'Rourke from Cornell University and leading New Zealand geotechnical engineer Dr Sjoerd van Ballegooy have used Christchurch data to establish a method of analysis that can be adjusted and used in any location.

Although newer pipes are more flexible and reliable in disasters like earthquakes, much of New Zealand's pipe network is old and brittle. These pipes are more liable to break in an earthquake due to liquefaction-induced ground movement, particularly in softer-soil sites. Professor O'Rourke and Dr van Ballegooy used pipe damage



data, ground strength data and post-earthquake ground movement data from the Christchurch earthquakes to create a method for understanding where the first priority for action should be after an event. The technique also allows a very rapid estimate of the cost of the damage, which is important for insurance and recovery planning.

Until now, the main way of knowing where pipes have broken has been to dig into the ground or put a camera up the pipeline. Both of these methods are slow and expensive. But without that information, repairers do not have a way of prioritising the huge amount of work required following an earthquake. Although the new method will not pinpoint each break, it will give an estimate of the number of breaks per kilometre (the measure used for pipe health) depending on the type of pipe and ground movement in any given location, and therefore help repair teams prioritise their efforts.

The method will also be useful for councils and infrastructure owners planning to upgrade their pipes as it will give a good estimate of the location of pipes most likely to break in a future large earthquake, so these can be upgraded first.

Fast monitoring for slow landslides

Slopes and high rainfall are often a recipe for landslides, and Auckland can often provide the right ingredients.

For Dr Martin Brook, an engineering geologist at the University of Auckland, the most interesting landslides move very slowly, up to a few centimetres a year. Even so, this movement can damage houses and roads built near them, or even build up to the torrent of mud and rocks more generally recognised as a landslide.

With EQC funding, Dr Brook and master's student Vivek Vaidya have been developing and testing a cost-effective way to help councils and other agencies keep an eye on these "creeping" landslides in their area.

Until now, the only way to measure slow land movement over large areas has been through LiDAR studies from a plane at high cost, and therefore has been done only every few years.

Dr Brook aims to provide a fast, inexpensive way of monitoring slow landslides using quadcopter drones mounted with cameras and software that converts images into 3D models. The team is trialling the new technology on 10 slopes selected for their different soil types and speed of movement. Though the slopes in the study do not have any houses or roads on them, they do have trees and other vegetation that can be problematic for drone data-gathering.

Checking that the accuracy of the drone-based results is comparable with LiDAR-generated 3D models is a critical part of the research. With two or three rounds of monitoring done on each slope so far, the results are looking good, although there is still some software development to do to maintain accuracy in high vegetation areas.

Once fully tested, the technique should be applicable to any type of land movement including how ground settles after developments like tunnelling, or even measurement of seasonal changes in highly expansive soil – all useful data for ensuring that any development is suited to the land it’s on.

Dr Brook is also keeping an eye on new developments in the field to see what technology advances can be incorporated into aerial surveying approaches.

Vivek Vaidya and Dr Martin Brook

Putting results into decision-makers' hands

We want our data and research to make a difference as fast as possible. This means making it easy for decision-makers to access, understand and use research findings and data to make cost-effective decisions on natural hazard risks. Modelling, guidance material and training sessions are some of the ways we take research results and data to where they make a difference.

Modelling the impact of natural hazards

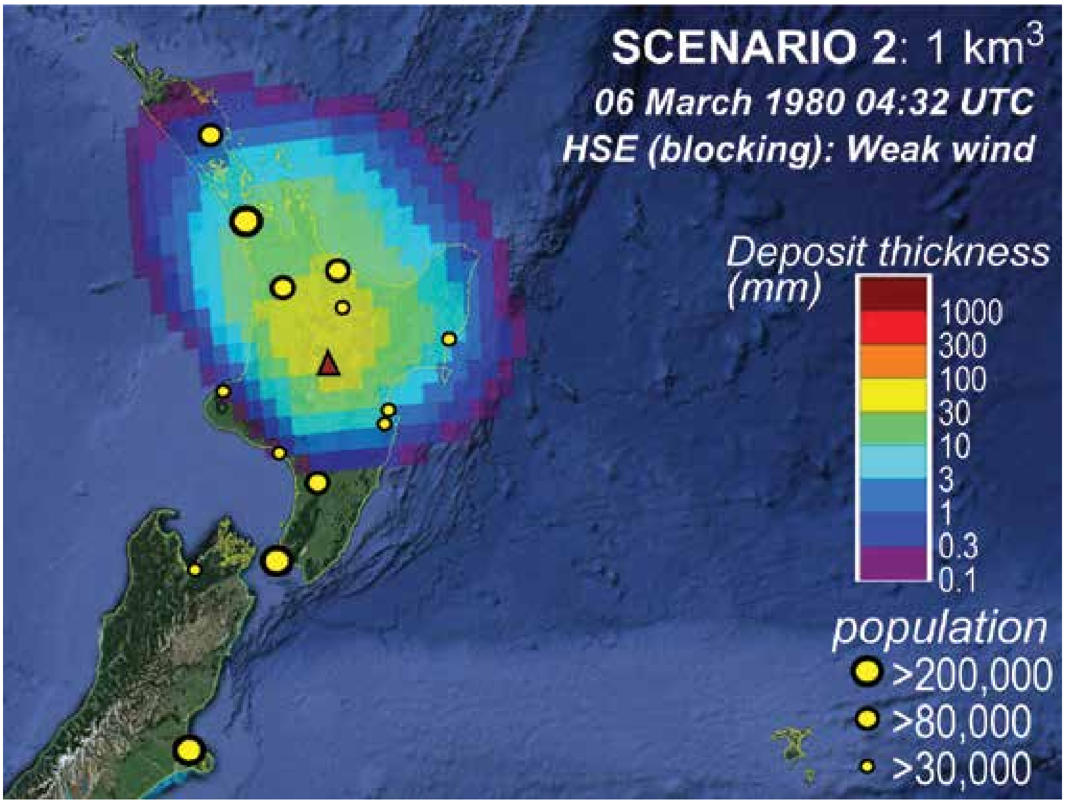
Catastrophe modelling is a powerful tool for delivering insights in a way that researchers, council staff, emergency managers and others can use to assess the likely impacts of natural hazards before they happen.

EQC's modelling estimates the likely damage, to, and costs of repair for residential buildings from tens of

thousands of hypothetical earthquakes. Outputs of this modelling help EQC discuss New Zealand risk with international reinsurers. It also helps EQC and other government agencies understand the economic effects of a hypothetical earthquake on New Zealand, assess how many homes are likely to be damaged or unliveable, and can help inform response plans for where assistance would be most needed.

The next generation of EQC modelling is being developed on the GNS Science/ NIWA RiskScape platform. This will allow us to extend our modelling to a wider range of hazards and impacts in future.

EQC-funded research, along with other New Zealand natural hazards research, is used as a key input to the modelling.



How and where volcanic ash will fall

Supported by an EQC grant, Dr Simon Barker has developed a way of modelling where ash is likely to travel from a future eruption of the Taupō caldera volcano given the many different possible weather patterns and a range of plausible eruption sizes.

The 3D model takes into account atmospheric conditions such as variable wind directions and speed at different heights.

Knowing where ash is most likely to accumulate on the ground could be vital information for emergency managers and planners.

Dr Barker worked closely with scientists from the United States Geological Survey to develop the New Zealand model, using previous scientific research on Taupō eruptions. The modelling can also be applied to other New Zealand volcanoes, helping emergency planners work out priority areas that will likely need to be evacuated during an eruption.

Making information on liquefaction easy to access

EQC data shows around 15% of EQC Canterbury claims were liquefaction-related. However, 55% of total EQC claim costs for the 2010/11 earthquakes were due to liquefaction-related ground damage either directly or indirectly. Following the Canterbury earthquakes, EQC identified other areas around New Zealand that have already developed, or are developing, land that is similar to the eastern parts of Christchurch and potentially vulnerable to liquefaction-related damage.

To assist regional and local government organisations and their advisors on land planning, understanding the risks and how to mitigate them, EQC and Engineering New Zealand (ENZ) combined forces to deliver training on liquefaction planning guidance. The guidance was developed by MBIE with support from the Ministry for the Environment and EQC.

EQC's research programme provided scientific and engineering information underpinning the guidance. This included ground data, ground improvement and foundation testing and other learnings from the Canterbury earthquake sequence.

Training sessions around the country are providing engineers and planners with the knowledge and skills to implement the guidance and make more informed decisions about land use and buildings and liquefaction. This helps councils to focus their planning and investment in a way that supports their local communities.

The guidance is part of EQC's aim to work closely with local councils to determine what land is developed and what engineering and building methods can be used to help communities be more resilient and recover if an earthquake occurs.

Building partnerships for action

Building New Zealand's resilience to natural hazards involves many organisations operating at national, regional and local levels. We know that strong partnerships will help us make our most effective contribution. Recent partnerships have ranged from working with on-the-ground researchers to multi-agency groups grappling with how to translate complex natural hazard science into practical information and guidance for end users.

Seeing beneath the soil in Dunedin

EQC facilitated and co-funded a project with Dunedin City Council, Otago Regional Council, GNS Science and the universities of Otago and Canterbury to test soil strength and set up piezometers to measure groundwater levels in South Dunedin. There are large areas where the water table is shallow, and saturated ground is less than one metre below the surface. Understanding groundwater helps give a picture of the soil strength and essential information for building on the land.

With flooding being a major hazard for South Dunedin, and remote large or smaller closer earthquakes having stronger effects on the suburb than in other areas of Dunedin, the project provides important data for planning. The results from soil testing and water measurement help local decision-makers understand what is happening in the ground, and to develop models of the impacts of storms and future sea-level rise. This in turn allows the local community to better understand options for the future, and the most cost-effective solutions for current and future natural hazard challenges.

Dunedin now has a dense monitoring network, with groundwater levels and temperatures measured every 15 minutes at 23 sites spaced less than one kilometre apart along the harbour and in South Dunedin.

Some sites also measure electrical conductivity and changes that occur as tides drive sea water in and out of ground beneath the city. Researchers on the project say the data clearly shows the effects of rainfall and tides on groundwater levels and chemistry.

Modelling will provide a better understanding of relationships between surface flooding, groundwater levels, infrastructure and the effects of sea-level rise. This will help emergency managers, land-use planners and infrastructure designers understand how much capacity the ground has to hold rainfall at any particular time, and support decisions to mitigate or avoid associated hazards.

Data from the project is available from the New Zealand Geotechnical Database or Otago Regional Council and GNS Science.

Determining volcanic risk in Auckland

With New Zealand's largest city built on a volcanic field that has produced 53 volcanoes so far, understanding the risk and what we can do about it is critical.

EQC is a founding partner of DEVORA – Determining Volcanic Risk in Auckland – bringing together Auckland Council, the University of Auckland and GNS Science to assess the risk of volcanic hazard in Auckland, and strategies for mitigating risk.

Scientists, emergency managers, economists and other experts work together on a research and action programme to understand in detail the likely impacts of potential volcanic eruptions, and to improve decision-making and risk management practices to make Auckland a safer place.

One of the key tools developed through DEVORA is a series of science-based scenarios of different eruptions in the Auckland volcanic field. This gives emergency managers and other decision-makers a realistic base for their planning. DEVORA also engages the public directly on volcanic hazard in their city through presentations, events, fact sheets and an annual Auckland eruption exercise at the Auckland Emergency Management Emergency Operations Centre. University of Auckland geohazards students are involved in the exercise, giving them hands-on experience of the pressures and challenges scientists and emergency managers face in crises.

Quake Centre

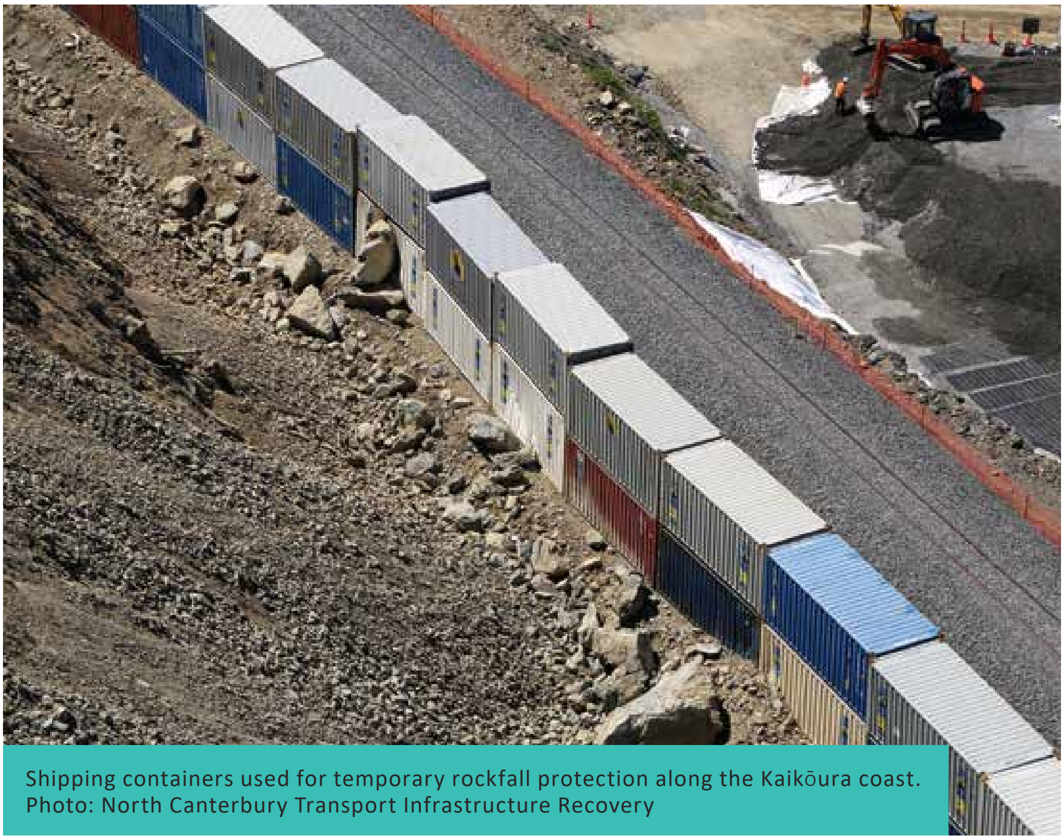
EQC's partnership with the University of Canterbury-based Quake Centre gives working engineers time to look at practical earthquake engineering problems and develop recommendations, guidance and solutions.

EQC funds at least one sabbatical (salary and additional costs) annually for an experienced engineer to conduct applied research and pass on the results of that research to others in the profession.

Recent subjects tackled by engineers on sabbatical include rock fall protection on roads and rail, a framework for undertaking site soil shear wave testing that helps work out how much the ground will shake in an earthquake, how to prioritise pipe fixes after an earthquake and guidance for assessing the resilience of local authorities' "three waters" (drinking water, sewerage and stormwater) networks.

One of the latest results from the sabbatical programme is a framework for decision makers, policy makers, developers, building owners, engineers and others to select the most appropriate ground motion analysis technique. Golder Associates' James Dismuke (Principal Geotechnical Engineer) and Jeff Fraser (Senior Engineering Geologist and Ground Engineer Team Leader), looked at what techniques were available internationally for understanding the ground motion that leads to building damage and liquefaction.

Each technique has its pros and cons, with some techniques better suited to some projects than others. The framework will help people working with building projects analyse the effort required, and the cost and suitability of techniques to assess the ground motion hazards for their particular projects.



Shipping containers used for temporary rockfall protection along the Kaikōura coast.
Photo: North Canterbury Transport Infrastructure Recovery

Building research talent

The more we understand our natural hazard risks, how they can impact homes and communities, and the ways we can reduce the impacts, the more we can build New Zealand's long-term resilience.

A strong New Zealand science and research community is essential for building hazard risk knowledge and providing a sound science base for decisions and actions to increase resilience.

EQC has helped fund development of New Zealand's natural hazards research expertise for more than 20 years and we continue to support university-based researchers and research programmes focused on the issues that will make the biggest difference for resilience.

As a result, New Zealand now has outstanding academic research leaders at our major universities who have put New Zealand on the international map in geosciences, geotechnical engineering, seismology, disaster economics and natural hazards resilience planning. They have also established internationally recognised research hubs that attract the next generation of researchers, and major international research collaborations.

EQC's funding for university research has also played an important role in enabling an immediate research response after events. For example, research teams were able to mobilise quickly to gather data that would otherwise likely have been lost during the Canterbury earthquake sequence, the 2013 Cook Strait earthquake sequence, and following the 2016 Kaikōura earthquake.

For the future, EQC is looking to target funding of university research to support our Resilience Strategy for Natural Hazard Risk Reduction 2019 - 2029.

Earthquake engineering – University of Auckland

Dr Liam Wotherspoon (left) with Andre Stolte postdoctoral researcher

Dr Sherif Beskhyroun testing bridge vibration with PhD student Niusha Navabian

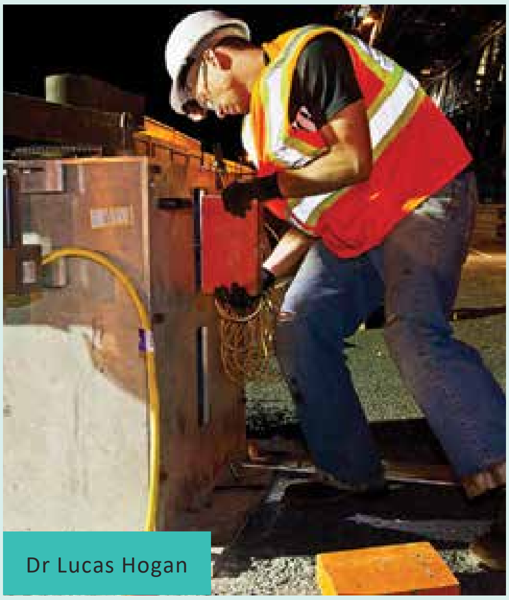
EQC has supported earthquake engineering at the University of Auckland since 2008 when Dr Liam Wotherspoon and Dr Sherif Beskhyroun arrived as EQC Research Fellows. Dr Wotherspoon was appointed to the position of Senior Lecturer in the Civil and Environmental Engineering Department at the University of Auckland in March 2015 with EQC funding support, and Dr Beskhyroun took up a position as lecturer at Auckland University of Technology in November 2015.

Shortly afterwards, the University of Auckland took over funding Dr Wotherspoon's position and EQC's funding shifted to support developing new academic and student researchers and enabling long-term research projects in the engineering research programme. One key focus area has been the natural hazard resilience of infrastructure, such as the seismic performance of bridges, ports and infrastructure networks.

Dr Wotherspoon and Dr Beskhyroun have become national leaders in field testing and monitoring research, demonstrating the effects of different ground conditions on earthquake shaking intensity, and developing new ways of quickly assessing structural damage after earthquakes.

As leaders in their fields, they are developing new generations of engineering researchers who are making their own contributions to increasing New Zealand's resilience.

Earthquake engineering – University of Auckland (continued)


Dr Lucas Hogan

Dr Lucas Hogan completed his PhD at the University of Auckland in 2014 with support from EQC. His research focused on the seismic response of bridges and the development of large-scale field testing methods for foundation components. After he completed his PhD, EQC continued its support to expand these field testing capabilities. This led to co-funding from the NZ Transport Agency and presentations at large industry conferences to share what he had learnt.

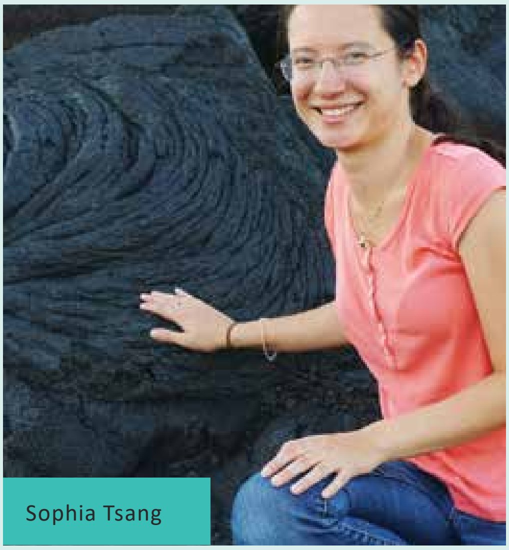
Dt Hogan's approaches to testing have since been used by a range of PhD students, at both the University of Auckland and University of Canterbury. Dr Hogan is now a lecturer at the University of Auckland and Director of the University of Auckland Structures Testing Lab.

Volcanic hazards – University of Auckland


Associate Professor Jan Lindsay

Associate Professor Jan Lindsay's internationally recognised work on volcanic hazards has been supported by EQC since she became an EQC Research Fellow in 2006. Since then, along with her own research, Jan has established a world-leading research hub in volcanic and other geohazards at the University of Auckland. In 2016 the University took over the funding of Associate Professor Lindsay's position, freeing up EQC funding to support a range of student and early- to mid-career researchers who are working on everything from user-friendly applications and maps to assist decision-makers during volcanic crises, through to understanding how the properties of rocks affect their susceptibility to fail in large landslides.

Volcanic Hazards – University of Auckland (continued)



Sophia Tsang is currently a PhD student at the University of Auckland

studying the consequences of lava flows in an urban environment. As part of her research, Ms Tsang received EQC funding to test how a lava flow would affect critical underground infrastructure like water pipes and power cables in a volcanic eruption in Auckland. Testing involved creating lava at Syracuse University's lava Project (the only place in the world with a furnace hot enough to melt rocks at large scale) and pouring it over Auckland soil types, asphalt and concrete footpaths to see how much heat is transferred beneath the surface, where a lot of infrastructure is buried.

Geological science and geotechnical earthquake engineering – University of Canterbury

EQC has supported research and teaching at the University of Canterbury since 2009 to address gaps in New Zealand's capacity to assess and mitigate geological risks, particularly in the South Island.

The research programme integrates earthquake-related research from the geosciences and geotechnical engineering, and has been led by Professor Misko Cubrinovski, (geotechnical engineering) and Professors Andy Nicol and Jarg Pettinga (geological sciences).

In 2019, the American Society of Civil Engineers (ASCE) honoured Professor Misko Cubrinovski with the Ralph B. Peck Award, for outstanding contributions to the geotechnical engineering profession. The Ralph B. Peck Award is a premier award of ASCE, the oldest national engineering society in the USA, with 152,000 members of the civil engineering profession in 177 countries. Professor Cubrinovksi is the second recipient from outside of North America to receive the Ralph B. Peck Award in its 21-year history.

Professor Cubrinovski has built international collaborations with expert American researchers funded by the USA National Science Foundation, which has matched EQC funding for the past 10 years.

Geological science and geotechnical earthquake engineering – University of Canterbury (continued)

Linkages with geotechnical earthquake engineering research teams in the USA have resulted in research efforts and outputs that could not have been achieved here as New Zealand has not had all the research capabilities needed.

Beth Gross, President of Geo-Institute of ASCE, presents the Ralph B. Peck Medal to Professor Misko Cubrinovski, University of Canterbury, at the 2019 Geo-Congress in Philadelphia

Professor Andy Nicol also collaborates widely with international researchers and is well known for his work on prehistoric and historic earthquakes. He has recently led field teams to study why and how the Kaikōura earthquake in November 2016 ruptured so many faults (see page 9). As well as being an extensively published researcher, Professor Nicol is co-leader of the Resilience to Nature's Challenges Earthquake and Tsunami theme, and is developing a new generation of researchers to use a wide range of field technologies and desktop analysis tools for the future benefit of New Zealand. Through EQC funding, many students have been supported on to major geotechnical and geological research projects and positions where they can make a difference to New Zealand's resilience.

EQC funding of Professor Nicol's research programme also played a critical role in the efforts after the Christchurch and Kaikōura earthquakes to quickly to mobilise and coordinate researchers, students and international scientists on the ground to gather data.

Professor Andy Nicol

Geological science and geotechnical earthquake engineering – University of Canterbury (continued)

Dr Tim Stahl

EQC funding supported the majority of Dr Tim Stahl's PhD research at the University of Canterbury investigating the seismic hazard of active faults in South Canterbury and Central Otago, as well landslides that occurred during the Canterbury earthquake sequence.

After his doctoral studies, Dr Stahl won a USA National Science Foundation (NSF) Postdoctoral Fellowship to continue paleoseismology research at the University of Michigan. During this time (2015-2017), Dr Stahl was a Science Communication Fellow at the University of Michigan Museum of Natural History and later joined the National Science Foundation's Geotechnical Extreme Event Reconnaissance team for the Kaikōura earthquake, where he participated in EQC-funded research with University of Canterbury scientists.

Dr Stahl then joined the University of Canterbury's Department of Geological Sciences as a lecturer in tectonics.

Seismology and fault mechanics – Victoria University of Wellington

Professor John Townend

EQC has supported research and teaching capability in seismology at the Victoria University of Wellington since 1994, via the EQC Fellowship in Seismic Studies and its successor, the EQC Programme in Seismology and Fault Mechanics (since 2015).

This is one of the longest-standing funding relationships held by the University.

Professor John Townend held the position of EQC Fellow in Seismic Studies between 2003 and 2015 and has been the Director of the

EQC Programme in Seismology and Fault Mechanics since 2015. He was appointed Professor of Geophysics in 2017 and was head of the University's School of Geography, Environment and Earth Sciences between 2016 and 2019.

EQC's support underpins a substantial amount of research and teaching in earthquake mechanics, the detection and analysis of microseismicity, the ambient seismic field and fault zone structure hydrology, much of it involving graduate students and postdoctoral fellows.

The support also facilitates significant public outreach, including annual lectures, and regular media contributions on aspects of earthquake science and natural hazards.

Dr Calum Chamberlain

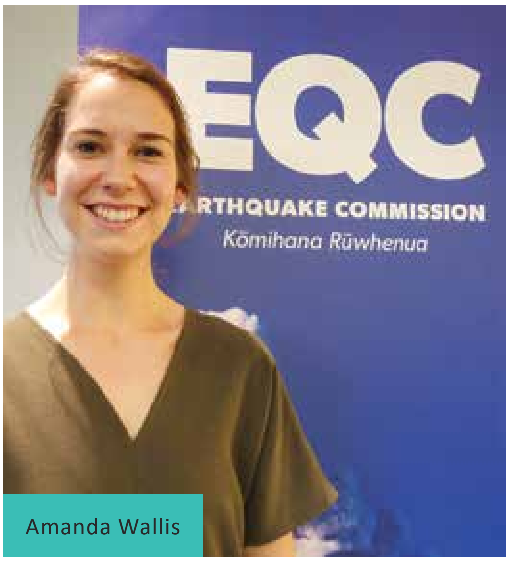
Dr Calum Chamberlain first came to New Zealand in 2010 to study geophysics at Victoria University of Wellington, on a one-year exchange from the University of Leeds. On finishing his studies in the United Kindom, Dr Chamberlain returned to New Zealand in 2012 as a PhD student, working on recently detected seismic tremor and low-frequency earthquakes associated with the deep Alpine Fault. His PhD research, supervised by Professor John Townend, involved extensive fieldwork deploying and servicing seismometers in the Southern Alps and on the West Coast. Dr Chamberlain played a key role in setting up and operating the 24/7 seismic monitoring procedures used during the second phase of the Deep Fault Drilling Project in 2014 to provide near-real-time analysis of local seismicity and to inform operational decision-making.

Since 2016, Dr Chamberlain has been working as a Postdoctoral Research Fellow, funded by EQC and Victoria University of Wellington. In addition to continuing his field-based seismological research and teaching and supervising graduate students, Dr Chamberlain is developing new computational methods for detecting earthquakes for fundamental earthquake science and seismic hazard analysis supported by a Marsden Fast Start grant and EQC Biennial grant funding.

Fulbright-EQC Graduate Award in Natural Disaster Research

In 2019 Fulbright-EQC award winner Amanda Wallis returned from a year as Visiting Student Researcher at the Natural Hazards Center at the University of Colorado. Ms Wallis is a PhD student in psychology at Victoria University of Wellington focused on finding creative ways to encourage people to be more prepared for natural disasters.

The award allowed Ms Wallis to work with world-class researchers on how to move people from awareness of a risk to action. Her research aim is to understand what motivates people to move to action, and to help develop practical strategies that can be used in New Zealand to reduce the impact of our natural hazards.



Amanda Wallis

Current Fulbright-EQC Graduate Award holder Danielle Lindsay has started PhD studies in geophysics at the University of California, Berkeley focusing on the link between slow slip earthquakes and larger earthquakes. Ms Lindsay says that understanding the fundamental geological forces at work will help New Zealand prepare better for potential earthquakes generated by risk areas like the Hikurangi subduction zone.

Ms Lindsay completed her BSc (Hons) and MSc degrees at Victoria University of Wellington and in that time received support from the EQC Programme in Seismology and Fault Mechanics. During her studies, she gained extensive experience in field work on major projects, including seismic studies undertaken as part of the Deep Fault Drilling Project, a large international collaborative research effort addressing the structure and earthquake-generating characteristics of the Alpine Fault, EQC-funded research in the Hikurangi rift, earthquake studies in the East Coast and Fiordland regions, and geodetic surveys led by GNS Science following the Kaikōura earthquake.


Danielle Lindsay

Disastrous Doctorates

Disastrous Doctorates is a two-day conference organised by PhD students for PhD students in the natural hazards field to share their research, learn new skills and build their research networks. The event, hosted by the Joint Centre for Disaster Research at Massey University, brings together student researchers from engineering, geography, psychology, law, business, and emergency management backgrounds.

EQC was a key funder of the 2019 Disastrous Doctorates workshop, where 40 students presented their research on topics ranging from where and how far unreinforced masonry is likely to fall in an earthquake, to mapping earthquake risks to road and rail, and working out what to do with volcanic waste after an eruption.

A focus of this year's Disastrous Doctorates was on communicating research in an easy-to-understand way in a three-minute presentation, a critical skill for these researchers' futures.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