Te Hiranga Rū | QuakeCoRE

Aotearoa New Zealand Centre for Earthquake Resilience

Annual Meeting 2019

Annual Meeting Information:

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For details on how to:

- Find your poster number
- Access voting for the Lightning Talks audience award
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QuakeCoRE Annual Meeting Programme

Tuesday 3 September, 2019

5:00 PM - 6:00 PM	REGISTRATION DESK OPEN
6:00 PM - 7:00 PM	WELCOME RECEPTION

Wednesday 4 September, 2019

7:30 AM - 8:30 AM	REGISTRATION DESK OPEN
8:30 AM - 10:30 AM	OPENING SESSION - Mihi Whakatau - 2019 State of QuakeCoRE – Brendon Bradley - Distinguished Lecture – Ross Boulanger Liquefaction: Lessons, challenges and opportunities
10:30 AM	MORNING TEA – POSTER SESSION
11:00 AM - 12:30 PM	PLENARY SESSION Chair: Ilan Noy Does research talk loud enough for policy to listen, and does policy answer back?
12:30 PM	LUNCH – POSTER SESSION
1:30 PM - 3:00 PM	PLENARY SESSION Chairs: Mary Comerio & Tim Sullivan Resilient housing: Observations, challenges and opportunities
3:00 PM - 4:00 PM	AFTERNOON TEA – POSTER SESSION

6:00 PM - 7:00 PM	PRE-DINNER RECEPTION
7:00 PM	QUAKECORE DINNER

Thursday 5 September, 2019

8:30 AM -10:30 AM	CAPABILITY DEVELOPMENT SESSION Chairs: Chris McGann & Brandy Alger - Ka mate whare tahi, ka ora whare rua: Realising the value of merging mātauranga Māori and Western knowledge - Papa Wiri Cultural Knowledge Programme - QERC Lightning Talks
10:30 AM	MORNING TEA – POSTER SESSION
11:00 AM - 12:30 PM	PLENARY SESSION Chairs: Ken Elwood & Jan Stanway Repairable buildings serving resilient communities
12:30 PM	LUNCH – POSTER SESSION
1:15 PM - 2:45 PM	PLENARY SESSION Chairs: Misko Cubrinovski & Wendy Saunders Earthquake resilience challenges associated with land vulnerability
2:45 PM - 3.15 PM	DIRECTORS CLOSING REMARKS Brendon Bradley & David Johnston POROPOROAKI

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 (CoRE) funded by the New Zealand Tertiary Education Commission (TEC), QuakeCoRE is a national network of leading Aotearoa New Zealand earthquake resilience researchers. QuakeCoRE is hosted by the University of Canterbury and has seven 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 Aotearoa New Zealand.

Our Vision

We will create 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 Aotearoa New Zealand infrastructure, rapid business recovery after future earthquakes and the growth of engineering resilience innovation and business in the Aotearoa 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 environments, combining research and industry elements. Through our graduates, we will seek a growth in under-represented groups (Māori and Paskifika) 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.

Our Leadership

Directors

Brendon Bradley – *Director*
University of Canterbury

David Johnston – *Deputy Director*
Massey University

Ken Elwood – *Research Director*
University of Auckland

Board

Dean Kimpton – *Chair*

Mary Comerio
University of California, Berkeley

Jan Evans-Freeman
University of Canterbury

John Hare
Holmes Consulting Group

Bryony James
University of Auckland

Mike Mendonça
Wellington City Council

John Reid
Ngāi Tahu Research Centre

Mark Solomon

Leadership Team

Brendon Bradley
University of Canterbury

Misko Cubrinovski
University of Canterbury

Ken Elwood
University of Auckland

David Johnston
Massey University

Caroline Orchiston
University of Otago

Wendy Saunders
GNS Science

Tim Sullivan
University of Canterbury

Liam Wotherspoon
University of Auckland

Technology Platform Leaders

Technology Platform 1: Large-scale Laboratory Facilities
Leader: Rick Henry
Deputy Leader: Alessandro Palermo

Technology Platform 2: Field-testing and Monitoring
Leader: Liam Wotherspoon
Deputy Leaders: Quincy Ma & Geoff Rodgers

Technology Platform 3: Multi-disciplinary Community Databases
Leader: Ilan Noy
Supported by: TP3 Working Advisory Group

Technology Platform 4: Computational Simulation and Visualisation
Leader: Brendon Bradley
Deputy Leader: Christopher McGann

Flagship Programme Leaders

Flagship Programme 1: Ground Motion Simulation and Validation
Leader: Brendon Bradley
Deputy Leaders: David Dempsey & Seokho Jeong
Industry Representative: Didier Pettinga, Holmes Consulting

Flagship Programme 2: Liquefaction Impacts on Land & Infrastructure
Leader: Misko Cubrinovski
Deputy Leaders: Rolando Orense & Sjoerd van Ballegooy
Industry Representative: Sjoerd van Ballegooy, Tonkin + Taylor

Flagship Programme 3: Addressing Earthquake-vulnerable Buildings – A Multidisciplinary Approach
Leader: Ken Elwood
Deputy Leader: Ilan Noy
Industry Representative: Derek Baxter, WCC

Flagship Programme 4: Next-generation Infrastructure: Low-damage and Repairable Solutions
Leader: Tim Sullivan
Deputy Leader: Rick Henry
Industry Representative: Jared Keen, Beca

Flagship Programme 5: Pathways to Improved Resilience
Leader: David Johnston
Deputy Leaders: Caroline Orchiston & Wendy Saunders
Industry Representative: Dan Neely, WREMO

Special Project Leader

Special Project 1: Spatially-distributed Infrastructure
Leader: Liam Wotherspoon
Deputy Leader: Roger Fairclough
Industry Representative: Roger Fairclough, Neoleaf

Distinguished Lecture

Liquefaction: Lessons, challenges and opportunities

Speaker: Ross W. Boulanger
(Professor and Director, Center for Geotechnical Modeling, University of California at Davis)

Biography

Professor Ross W. Boulanger is the Director of the Center for Geotechnical Modeling in the Department of Civil and Environmental Engineering at the University of California, Davis. He received his PhD and MS degrees in Civil Engineering from the University of California at Berkeley, and his BASc degree in Civil Engineering from the University of British Columbia. His research and professional practice are primarily related to liquefaction and its remediation, seismic performance of dams and levees, and seismic soil-structure interaction. His honors include the TK Hsieh Award from the Institution of Civil Engineers, the Ralph B. Peck Award, Norman Medal, Walter L. Huber Civil Engineering Research Prize, and Arthur Casagrande Professional Development Award from the American Society of Civil Engineers, and election to the US National Academy of Engineering.

Abstract

Liquefaction during earthquakes has been the subject of extensive study for over half a century and is now routinely addressed in engineering practice using a wide range of technical approaches that depend on the project size and importance. These past studies have produced major advances in our scientific understanding of liquefaction phenomena and the engineering practices used to address liquefaction hazards, but there remain numerous situations where knowledge gaps and engineering practice limitations hinder the efficient mitigation of earthquake-induced liquefaction damages to our infrastructure and communities. This presentation examines a number of lessons, challenges, and opportunities regarding the evaluation and mitigation of liquefaction hazards, including aspects of site characterization, engineering analysis methods, challenging soil types, remediation methods, performance-based engineering procedures, and risk management approaches.

NOTES:

Plenary Session

Does research talk loud enough for policy to listen, and does policy answer back?

Chair: Ilan Noy

Speakers: Pam Johnston
Girol Karacaoglu
Juliet Gerrard

The session aims to identify and describe the channels leading from research to policy, and feeding back from policy needs to research. We start by describing specific pathways from research to policy and improving the transition of earthquake science into regulatory practice (Pam). We then identify the input that our research can make for investment in resilience for sustainable wellbeing (Girol). We end by providing a broader overview of the connections between general science and policy, and pointing some ways forward (Juliet).

Speaker

Identifying pathways to practice – opportunities for improving the transition of earthquake science into regulatory practice

Pam Johnston

Biography

Pam Johnston is a Planning and Risk Reduction Consultant with experience in both building and resource management policy. She holds a Master of Regional and Resource Planning degree and a Bachelor of Arts in Geography from the University of Otago, and a Master of Property Studies degree from Lincoln University. She recently worked on the development of a resilience strategy for natural hazard risk reduction at the Earthquake Commission. Prior to that, at the Ministry of Business, Innovation and Employment, she managed Canterbury rebuild earthquake engineering guidance projects, the Earthquake-prone Buildings Policy Implementation programme, and the Securing Parapets and Facades on Unreinforced Masonry Buildings programme. As a consultant to the Asian Development Bank she has presented at international fora on risk reduction through land use planning. She is a member of the science advisory groups for the MBIE Endeavour-funded Kaikōura landslides research project and the NZTA resilience research programme, and a Member of the International Council for Science task group - Linked Open Data for Global Disaster Risk Research. She is a Full Member of the New Zealand Planning Institute. Pam has a particular interest in implementing lessons from previous disaster events, connecting people across disciplines, and translating science into policy and practice to reduce risk.

Abstract

The Building Act and the Resource Management Act provide the regulatory levers and tools for the design and location of buildings in New Zealand. Effectively communicating earthquake science into national policy instruments and into local level plans is essential for achieving more resilient communities. Tracing the pathway of earthquake science into building and land use policy helps understand where research process improvements can be made. The scientific evidence base for past policy decisions and future setting changes that might be needed as a result of new science from the Canterbury and Kaikōura earthquake events will be examined in this presentation.

NOTES:

Speaker

Investing in Resilience for Sustainable Wellbeing – What role for public policy?

Girol Karacaoglu
(VUW)

Biography

Professor Girol Karacaoglu is the recently appointed Head of School of Government. He came to VUW from the New Zealand Treasury, where he was Chief Economist. Before then, he was the Chief Executive of the Co-operative Bank of New Zealand for nine years.

His previous roles included General Manager at Westpac NZ, Chief Economist at the National Bank of NZ, and lecturer in Economics at VUW.

His academic fields of specialisation were in Monetary and Financial Economics, International Finance, Econometrics, Corporate Accounting and Finance.
His current research interest is in public policy - an integrated approach to economic, environmental and social policies towards improving intergenerational wellbeing.

Abstract

Over centuries, resilience has contributed as much to sustained wellbeing, as has productivity. Resilience has two key dimensions, the capacity to absorb shocks, and the ability to adapt in the aftermath of shocks. Both are legitimate concerns of public policy – they can be enhanced through the creation of appropriate institutions. The fundamental role of public policy is to identify, and then invest in the creation of, such institutions.

NOTES:

Speaker

Connecting your research to policy

Juliet Gerrard
(PMCSA)

Biography

Professor Juliet Gerrard trained at Oxford University, where she completed a First Class Honours degree in Chemistry and a DPhil in Biological Chemistry.

In 1993, she moved to Aotearoa New Zealand, as a research scientist at Crop & Food Research. She was appointed as a Lecturer at the University of Canterbury in 1998, where she became Co-Director of the Biomolecular Interaction Centre.

In 2014, she moved to the University of Auckland as a Professor in the School of Biological Sciences and the School of Chemical Sciences and later became the Associate Dean for Research in the Faculty of Science.

Juliet has over 150 publications, as well as three books. She won a National Teaching Award for Sustained Excellence in Tertiary Teaching in 2004 and has taken more of a governance role in the research sector, including as Chair of the Marsden Council and a Director for Plant & Food Research, prior to her appointment in 2018 as the Prime Minister's Chief Science Advisor.

Abstract

Professor Juliet Gerrard will briefly describe her role as the Prime Ministers Chief Science Advisor and that of the Forum of Chief Science Advisors and then explore the gnarly interface between the research and policy communities.

NOTES:

Plenary Session

Resilient housing: Observations, challenges and opportunities

Chairs: Mary Comerio & Tim Sullivan

Speakers: Julia Becker Dan Neely

The damage inflicted on houses during the Canterbury earthquakes was extensive and costly, both from economic and social perspectives. The recovery process that followed this and other earthquakes has highlighted a number of difficulties we face in providing resilient housing post-earthquake. Given that New Zealand is arguably in the midst of a housing boom and public expectations around seismic performance are ever increasing, this session explores what it means to provide earthquake resilient housing. The first part of the talk will examine the human dimensions that influence earthquake resilient housing, drawing on findings from research and engagement that has taken place with communities over the past few years. The second part of the session will discuss the planning strategy that is evolving for temporary housing for the Wellington region after a significant earthquake.

Speaker

The human dimensions that influence earthquake resilient housing

Julia Becker
(Massey University)

Biography

Dr Julia Becker is a Senior Lecturer at the Joint Centre for Disaster Research in the School of Psychology at Massey University. She undertakes social science research on a range natural hazard and environmental issues. Her areas of expertise include perceptions, preparedness, community resilience, emergency management and warnings. Her research has focussed on earthquakes as well as other perils such as flooding, volcanic and coastal hazards. She has worked extensively in New Zealand on recent events (e.g. Canterbury and Kaikōura earthquakes) and internationally (e.g. US, Australia, Japan).

Abstract

When thinking of earthquake resilient-housing, we often think of strong well-engineered buildings. However having a resilient building stock requires accounting for human influences. People's decisions about where to build and live can influence the resilience of buildings, as seen following the 2011 Christchurch earthquake where poor land-use planning decisions meant liquefaction caused significant building damage, and large tracts of land were retired. It can also prove challenging to retrofit or undertake structural mitigation on existing residential buildings. There are no legislative requirements to retrofit residential structures less than two storeys, and home-owners have a limited appetite to undertake retrofitting voluntarily. Despite public education about the benefits of retrofitting (e.g. via emergency management and insurance agencies) actual levels are still low. Barriers to voluntary retrofitting are related to people perceiving earthquakes to be low risk, a lack of experience of earthquakes, a lack of understanding of the benefits of mitigation, lack of skills and cost. Finally, resilient housing should also be considered in a broader context. A community with a strong built environment is important, but people still need to feel safe within that environment, and feel connected with others, so that they are happy to stay in those buildings after an event.

NOTES:

Speaker

Planning to Stay: Housing after the next big Earthquake in the Wellington Region

Dan Neely
(WREMO)

Biography

Dan is the Manager of Community Resilience and Group Recovery Manager at the Wellington Region Emergency Management Office (WREMO). Dan spent more than two years working in disaster recovery as a Peace Corps Volunteer in Honduras after Hurricane Mitch and later with the International Organisation for Migration in Sri Lanka after the Boxing Day Tsunami. He has worked at WREMO for the past ten years leading a number of community resilience initiatives such as Tsunami Blue Lines, Community Emergency Hubs and the development of a Regional Recovery Framework for councils and partners. Originally from Arizona, he knows a good taco when he sees one.

Abstract

While the emergency response to a large earthquake in or near the Wellington Region will be a daunting challenge, the bigger challenge will be maintaining the continuity of the region throughout the early and intermediate recovery. At the centre of this challenge is the availability of safe and accessible housing for people while the region is in transition. Many homes have foundations that are unsecured, compromised by rot or borer and/or will be severely damaged by liquefaction, landslip or seismic shaking. Consequently, the housing shortage that Wellington faces at present will be exacerbated exponentially with serious knock-on effects in the economic, social and cultural environments.

This project aims to enable Wellingtonians to remain as close to their property as possible after the earthquake. This will be achieved by developing planning policies and other potential solutions that can be made available soon after the event. Specifically, guidance will be developed that enables people to safely remain in their damaged home in the first instance. If this is not possible, then remain on their property, followed by residing on streets and then open spaces within their community and wider city.

NOTES:

Session

Capability development

Chairs: Chris McGann & Brandy Alger

Speakers: Jason Ingham, Tūmanako Fa'aui, Haukapuanui Vercoe & Nona Taute
Brandy Alger & Anne-Marie Midwood-Murray
Lightning Talk presenters

In this session Jason, Tūmanako, Huakapuanui and Nona will jointly present a talk entitled "Ka mate whare tahi, ka ora whare rua: Realising the value of merging mātauranga Māori and Western knowledge"

In the second part of the session Brandy and Anne-Maire will share the Papa Wiri Programme. This programme is a Te Ao Māori collaboration with the QuakeCraft school programme and Papa Wiri developers in Ngāti Tūwharetoa.

The final part of the capability development session will be the Lightning Talks.

Speaker

Ka mate whare tahi, ka ora whare rua: Realising the value of merging mātauranga Māori and Western knowledge

Speakers: Jason Ingham, Tūmanako Fa'aui, Haukapuanui Vercoe & Nona Taute

Biographies

Professor Jason Ingham's research interests are primarily focused on the earthquake behaviour of heritage buildings, and more recently the integration of mātauranga Māori knowledge and western science into aspects of civil and environmental engineering.

Dr Tumanako Fa`aui is a lecturer in the Department of Civil and Environmental Engineering at The University of Auckland, New Zealand. He is interested in the integration of indigenous knowledge systems and mātauranga Māori within western based methodologies and how the engineering decision making process can be best applied within indigenous contexts.

Nona Taute is doing a PhD in Civil and Environmental Engineering with the goal of facilitating the successful incorporation of Māori culture and values into the engineering and impact assessment of geothermal resource development in Aotearoa.

Haukapuanui Vercoe is an undergraduate engineering student specialising in Civil and Environmental Engineering. Haukapuanui was educated in full immersion Te Reo Māori from the age of 2 all the way through high school.

Having not been educated in a mainstream schooling system, he brings different outlooks; especially those pertaining to engineering.

Abstract

Mātauranga Māori represents the knowledge that Māori have accumulated throughout their history of co-existence with Aotearoa's natural environment. From the time that Māori first arrived on Aotearoa, their observations of many of the country's natural resources, phenomena, and disasters, have been described in ancient and mythological stories that formed the present Māori belief systems. These belief systems are an element of mātauranga Māori that influence the behaviour of many Māori towards the natural environment and perceive the consequences of human-intervention on the natural dynamics and spiritual element of the environment. Unfortunately, many professions have been modernised and tend to overlook mātauranga Māori in their practice. It is suggested that the inclusion of mātauranga Māori within these practices can only enhance such practices by drawing on contextual knowledge and personal experience that has been passed-down for many generations. The best way for these professions to incorporate mātauranga Māori into their practice is to engage with the appropriate Māori representatives or communities. However, it is acknowledged that such engagement requires understanding of the sensitivities of Māori culture, firstly; to initiate the engagement using genuine relationships, and secondly; to conduct the engagement meaningfully and in the appropriate manner. A series of tips are shared in this oral presentation to help technical professionals in their Māori engagement endeavours. These tips come from the presentation team's worked experiences in engineering, and lived experiences being of Māori and Pasifika descent who attended full-immersion Māori schools.

Speaker

Papa Wiri Cultural Knowledge Programme

Brandy Alger
(QuakeCoRE & Quake Centre)
Anne-Marie Midwood-Murray

Biographies

Brandy Alger is the Outreach Coordinator for QuakeCoRE and Quake Centre. Brandy has a background in engineering and over ten years of experience in developing outreach programmes connecting engineering and social sciences through fun and engaging projects. Brandy's current role as Outreach Coordinator is to communicate earthquake resilience to the public through innovative programmes. By sharing information in the form of gifting education - Tihei Mauri Ora.

Anne-Marie Midwood-Murray (of Ngāti Tūwharetoa, Ngāti Hikairo ki Tongariro, Te Arawa, Ngāti Raukawa, Ngāti Maniapoto, Te Ati Haunui-a-Pāpārangi and Ngāti Hāuaroa) and her husband Benoir Midwood-Murray (of Ngāti Kuri, Te Rarawa, Te Aupōuri, Ngāpuhi, Waikato, Hauraki, Ngāti Hikairo, Ngati Maniapoto, Rereahau, Ngati Awa, Tuhoe, Te Arawa, Porourangi, Ngāti Koata and Waitaha) are education facilitators based in Taupō.

Together they have studied in Te Tohu Mātauranga i Te Reo Me Ōna Tikanga, Iwi Environmental Management, Disaster Management and Adult teaching having a diverse knowledge of te ao Māori.

As Māori educators, Anne-Marie and Benoir have a cultural connection to Papatūānuku and an understanding as Vision Mātauranga researchers. They are able to collaborate and merge te ao Māori alongside QuakeCoRE Outreach Programme to develop Papa Wiri Programme. Fusing te reo Māori and cultural knowledge with western engineering fostering a Ngākau Aroha for Tauira to aspire interest in.

Abstract

The Papa Wiri programme is a Te Ao Māori collaboration with QuakeCraft school programme and Papa Wiri developers in Ngāti Tūwharetoa. Papa Wiri begins with the story of Rūaumoko, the baby of Ranginui (sky father) and Papatūānuku (earth mother), and is the cause of volcanoes and earthquakes.

Taught bi-lingually in both te reo Māori and English, the students then build tall towers to withstand the shaking of Rūaumoko using a shake table and QuakeCraft education kits. The Papa Wiri programme is working to close the gap between Te Ao Māori and western engineering, but also encourages kids to think outside the box for the future.

NOTES:

Lightning Talks

Matt Brenin
(Massey University)

Frank Büker
(University of Auckalnd)

Kieran Haymes
(University of Canterbury)

Amelia Lin
(University of Auckalnd)

Lisa McLaren
(Massey University)

Gonzalo Munoz
(University of Auckalnd)

Sarah Neill
(University of Canterbury)

Lauren Vinnell
(Victoria University of Wellington)

Thomas M Wallace
(University of Canterbury)

Plenary Session

Repairable buildings serving resilient communities

Chairs: Ken Elwood & Jan Stanway

Speakers: Didier Pettinga Santiago Pujol

Our Vision is that of a community which can rapidly assess and repair its buildings immediately after strong earthquakes. This session explores the challenges and opportunities ahead of us in our journey toward this vision. After recent events, the time to return the building stock to original functionality has been hindered by the lack of understanding of residual capacity and repair. To enhance community resilience through faster recovery, the concept of reparability needs to be considered across the whole building stock, not just the small fraction of buildings implementing low-damage systems. In an effort to impact a broad spectrum of the building stock, the speakers in this session will explore how to quantify the reparability of conventional buildings and possible modifications to current design procedures which enable a building to be repairable after an earthquake. Changes to both structural and non-structural systems will be discussed.

Speaker

Repairable Buildings: A key component of achieving Functional Recovery

Didier Pettinga
(Holmes Consulting)

Biography

Didier is a Technical Director with Holmes Consulting LP, and Professor of Practice at the University of Canterbury. He spent five years working in Vancouver as an Earthquake Engineer, before moving back to Christchurch at the end of 2011. With Holmes he has been actively involved in a number of assessment and strengthening projects in Christchurch and Wellington, along with a range of low-damage design projects as part of the Christchurch rebuild. His research interests include practical application of simulated ground motions, displacement-based design methods, residual deformation of structures, and more recently design for residual capacity. Since the inception of QuakeCoRE he has been an Industry Representative to the Flagship Programme 1.

Abstract

With recent experience and research, we are gathering a number of pieces that simplify the puzzle to assessing or defining residual capacity. From this work we have a sense of what Repairability design could look like along with the potential benefits from explicitly considering this in design. But are we certain about what success looks like and how to achieve it? How do we move from low-damage structural design to Repairability design? How much of our building stock must be positively affected to give us success?

We have examples of good building population performance from recent earthquakes in Japan, and a better understanding of their underlying design code that we see as enabling this success. Can New Zealand take the opportunity to introduce changes to the Building Code that would improve our opportunities for Repairability?

Many of the questions that need answering will require much more than structural engineering input. The QuakeCoRE community provides us with the right channels needed to define success, and with this a more complete scope for Functional Recovery.

NOTES:

Speaker

What does it take to keep your building in operation after an earthquake?

Santiago Pujol
(Purdue University)

Biography

Santiago Pujol is Professor of Civil Engineering at Purdue University. His experience includes: earthquake engineering, evaluation and strengthening of existing structures, response of reinforced concrete to impulsive loads and earthquake demands, instrumentation and testing of structures, and failure investigations. He is a Fellow of the American Concrete Institute (ACI), and member of ACI committees 445 (Torsion and Shear), 314 (Simplified Design), 133 (Disaster Reconnaissance), and 318R (High-Strength Reinforcement). He is also member of the Earthquake Engineering Research Institute (EERI), and associate editor of Earthquake Spectra. He received the Chester Paul Siess Award for Excellence in Structural Research from ACI, the Educational Award from Architectural Institute of Japan, and the Walter L. Huber Civil Engineering Research Prize from ASCE.

Abstract

Through a number of examples from the field and laboratory the talk addresses the following questions:

- Does adequate structural performance always lead to continued operation?
- What can be regarded as adequate structural performance?
- Is a cracked RC structure that may have yielded during an earthquake more vulnerable to future earthquakes than a similar but pristine structure?
- Does structural strengthening always help?

The evidence presented suggests that, within a wide range of 'code-conforming' RC structures, and in the absence of obvious structural failures, one is often better off worrying about the devil in structural and nonstructural details instead of worrying about the cracking and yielding that are almost inevitably caused by strong ground motion.

NOTES:

Plenary Session

Earthquake resilience challenges associated with land vulnerability

Chairs: Misko Cubrinovski & Wendy Saunders

Speakers: Carlo Lai
Keith Jones
Hugh Cowan

Widespread ground failures and poor land performance are often some of the most difficult consequences of earthquakes to deal with in the recovery and reconstruction phases. Such failures usually affect large areas, cause significant economic losses, and have profound long-term impacts on communities. The Red Zone of Christchurch and landslides triggered in the Kaikōura earthquake are the most recent reminders of such impacts in New Zealand. This session will address issues associated with seismic land vulnerability ranging from engineering considerations to important implications on societal and economic resilience. Profs. Carlo Lai (Italy) and Keith Jones (UK) will briefly introduce a large European project focusing on mitigation of liquefaction-induced disaster risk in Europe. Liquefaction hazard mapping of Europe will be presented including challenges associated with the macro-zonation of liquefaction at national and municipal scales. Propagation of liquefaction consequences and impacts on societal resilience will be demonstrated through an example for a specific public sector. In a complementary part of the session, Dr. Hugh Cowan will provide unique perspectives on the available options for treatment of earthquake risk using his vast experience from the 2010-2011 Canterbury earthquakes. Avoidance, control and transfer of risk options will be discussed, and challenges associated in understanding the trade-offs between these options explored. The benefits of improved integration of knowledge to build broader partnerships and community resilience will be highlighted.

Speaker

Macro- and Micro- Zonation of a Territory for Earthquake-Induced Liquefaction

Carlo Lai
(University of Pavia)

Biography

Carlo G. Lai is Professor of Geotechnical Engineering at the University of Pavia, Italy. He is also the advisor at EUCENTRE, of the Department of Risk Scenarios and affiliate faculty at the Institute of Advanced Studies of Pavia. Dr. Lai holds a MSCE from Politecnico di Torino and a MSCE, a MSESM and a PhD from the Georgia Institute of Technology in Atlanta (USA). His primary research interests are in earthquake geotechnics, theoretical modeling of seismic wave propagation in geomaterials and engineering seismology. He is the author/co-author of more than 200 scientific publications including two books. In 2003, he was awarded the Bishop Research Medal for the best research paper in Geotechnical Engineering published in 2002 by the British Institution of Civil Engineers. He is currently the technical lead of a 3.5 years European project on the assessment and mitigation of soil liquefaction potential across Europe.

Abstract

Excessive deformations of the ground surface caused by earthquakes are of great concern in civil engineering and the environment. Such deformations are often associated with a phenomenon of soil instability called liquefaction. Recent earthquakes worldwide have shown that earthquake induced liquefaction disasters are responsible for massive infrastructural damages causing in some cases up to half of the global economic loss produced by earthquakes. Zoning a territory for liquefaction hazard at different geographical scales is one of the objectives of LIQUEFACT, a three-year European project initiated in May 2016. In this talk, the liquefaction hazard map of Europe will be presented with a close-up view to the Mediterranean region. At a level of a single country, the availability of a macro-zonation map of liquefaction hazard may be useful to policy makers in identifying the territories of that country that are potentially at risk with respect to liquefaction and thus allocate funds for in-depth studies. The LIQUEFACT project also addressed the zonation of a territory for liquefaction hazard at a municipal scale. A micro-zonation map aims at showing the spatial variability of the liquefaction hazard of a town and it may be useful to local administrators for urban and land-use planning.

NOTES:

Speaker

Improving community resilience to earthquake induced liquefaction: The application of the LIQUEFACT Resilience Assessment and Improvement Framework to a typical health sector infrastructure.

Keith Jones
(Anglia Ruskin University)

Biography

Keith Jones is Professor of Facilities Management and Head of the School of Engineering and the Built Environment at Anglia Ruskin University.

Professor Jones' research covers a wide range built environment and management issues including:

- *vulnerability and resilience modelling of communities to natural and man-made disasters;*
- *sustainability analyses of existing social, economic and technical systems within the built environment;*
- *design and development of new sustainable systems/practices for built asset management;*
- *occupant behaviour and carbon reduction; public engagement; and*
- *innovation change management in the built environment.*

Prof Jones is the coordinator of EU H2020 LIQUEFACT project which has developed a set of business decision support tools to help policy and business stakeholders evaluate the effectiveness of different mitigation interventions to reduce the impact that earthquake induced liquefaction has on community resilience and critical infrastructure.

Abstract

As future urban communities become larger and ever more interconnected, the impacts that earthquake disasters have on community resilience will become more severe. The LIQUEFACT project has developed a Resilience Assessment and Improvement Framework (RAIF), and associated tools, to help policy and business stakeholders evaluate the potential of a range of ground mitigation interventions to improve critical infrastructure, and community resilience, to an earthquake induced liquefaction disaster (EILD) event.

This presentation will describe the development of the RAIF and show its application using a case study of a typical health sector scenario. The presentation will show how the LIQUEFACT Reference Guide software tool, developed by NORSAR, supports technical decision making at each stage of the RAIF: antecedent vulnerability/resilience; impact assessment; mitigation evaluation; and built asset management to support improved resilience through better business continuity and resilience planning.

The presentation will also describe the development and application of two community level toolkits that integrate the outputs from the RAIF's into critical infrastructure and community resilience models.

The LIQUEFACT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 700748.

NOTES:

Speaker

Earthquake risk treatment – understanding trade offs and building buy-in

Hugh Cowan

Biography

Hugh Cowan has fostered science and engineering research and its application to natural hazard assessment and risk reduction for more than 25 years. Until recently, he guided the Earthquake Commission's research and education programme and supported engagement with global reinsurance markets during the past decade.

Hugh earlier led the establishment of "GeoNet" at GNS Science and has contributed to international infrastructure projects and hazard risk reduction programmes. Hugh is a Fellow of the New Zealand Society for Earthquake Engineering and a member of the New Zealand Institute of Directors. Hugh holds an MSc (First Class Hons) in Engineering Geology and a PhD from the University of Canterbury.

Abstract

At a fundamental level awareness and perception of 'risk' regardless of its origin or outcome, is about proximity - the timing and location of potential losses or gains, future, imminent or past. For this reason, response or survival actions typically are prioritised over those which might reduce or avoid risk; the benefits of the former are attributable and instantaneous whereas the latter tend to be more widely distributed and accrue incrementally. The earthquake problem calls for avoidance (land use), control (construction practices), or its transfer to risk capital markets to mitigate financial impacts. These choices are not mutually exclusive, but there are challenges understanding the trade-offs even in the aftermath of losses such as experienced in New Zealand since 2010. Competitive forces in commerce and distributed accountabilities for public management also add complexity to the sharing of information and management of risk. At the same time, heightened expectations of sustainable development and economic resilience are a significant and growing determinant of planning outcomes at community level. This presentation will illustrate the trade-offs in risk treatment options and secondly, the benefits of improved integration of knowledge to build broader partnerships and community resilience.

NOTES:

Posters

Flagship 1: Ground Motion Simulation and Validation – Posters 01-10

1	Cybershake NZ v19.5: New Zealand simulation-based probabilistic seismic hazard analysis **Brendon Bradley**, Jonney Huang, Jason Motha, Karim Tarbali, Robin Lee, Sung Eun Bae, Viktor Polak, Melody Zhu, Claudio Schill, James Paterson, Daniel Lagrava
2	Dynamic site characterisation of the Waikato basin using passive and active surface wave methods **Ashley Cave**, Seokho Jeong, Andrew Stolte, Liam Wotherspoon
3	3D seismic site response with soil heterogeneity and wave scattering **Chris de la Torre**, Brendon Bradley, Christopher McGann
4	Capturing the influence of soil density on surface fault rupture propagation using the discrete element method **Estefan Garcia**, Jonathan Bray
5	Strong ground motions simulations for Dunedin: Recent progress **Anna Kowal**, Mark Stirling, Andrew Gorman, Liam Wotherspoon
6	Hybrid broadband ground motion simulation Validation of New Zealand earthquakes with an updated 3D velocity model and modified simulation methodology **Robin Lee**, Brendon Bradley
7	Validation of ground motion simulations via response history analysis of special moment resisting frames using an automated workflow **Vahid Loghman**, Brendon Bradley, Reagan Chandramohan, Christopher McGann
8	Ground motion simulation validation with explicit uncertainty incorporation for small magnitude earthquakes in the Canterbury region **Sarah Neill**, Robin Lee, Brendon Bradley
9	Synthetic study of full waveform seismic tomography for geophysical velocity model in Canterbury region based on the adjoint-wavefield method **Trung Dung Nguyen**, Robin Lee, Alan Juarez, Brendon Bradley
10	What should Auckland expect from a Magnitude 7 Hauraki Rift Earthquake? **Elia Nicolin**, David Dempsey, Jonathan Kah

Flagship 2: Liquefaction Impacts on Land and Infrastructure – Posters 11- 20

11	Cyclic undrained DSS testing of Christchurch sandy silty soils **Claudio Cappellaro**, Misko Cubrinovski, Jonathan Bray, Gabriele Chiaro, Michael Riemer, Mark Stringer
12	Liquefaction constitutive model validation using pore pressure records from the Canterbury Earthquake Sequence **Tahoura Khansari**, Connor Hayden, Liam Wotherspoon
13	Liquefaction exposure across New Zealand transport networks **Amelia Lin**, Liam Wotherspoon, Daniel Blake, Brendon Bradley, Jason Motha
14	Assessment of empirical lateral spreading displacement models using data from the 2011 Christchurch Earthquake **Michael Little**, Ellen Rathje, Gregory DePascale, Jeffrey Bachhuber
15	Compilation and comparison of pipe fragility relationships based on liquefaction severity **Jose Moratalla**, SR Uma, Sally Dellow
16	System response of liquefiable deposits **Nikolaos Ntritsos**, Misko Cubrinovski
17	Seismic site response at CentrePort, Wellington **Aimee Rhodes**, Campbell Keepa, Misko Cubrinovski, Tiffany Krall
18	Quantifying pumice content in soil mixtures **Mark Stringer**
19	Seismic performance of adjacent mat-supported structures on liquefiable soil: Validation of numerical model using centrifuge tests **Farbod Yarmohammadi**, Connor Hayden, Liam Wotherspoon
20	Stress density model validation for liquefaction analysis **Majid Zakerinia**, Connor Hayden, Christopher McGann

Flagship 3: Addressing Earthquake-vulnerable Buildings – A Multidisciplinary Approach – Posters 21-37

21	Fragility and vulnerability curves of unreinforced masonry buildings using empirical data from the 2010/11 Canterbury earthquakes **Shannon Abeling**, Jason Ingham, Dmytro Dizhur, Nick Horspool
22	Unintended consequences of the earthquake-prone building legislation: An evaluation of city centre regeneration strategies in two New Zealand's provincial areas **Esther Aigwi**, Jason Ingham, Olga Filippova, Robyn Phipps
23	Expectations vs Reality: Institutional analysis of property investors' decision-making behaviour in a seismically active country **Muhammed Temitayo Bolomope**, Olga Filippova, Abdul-Rasheed Amidu, Deborah Levy
24	Development and testing of hollow-core retrofits **Frank Bueker**, Michael Parr, Ken Elwood, Des Bull
25	Legal responsibility for the mitigation of risks associated with earthquakes **Toni Collins**, Cameron Eade
26	Testing of a seven-storey reinforced concrete soft-storey structure with torsional and damaged irregularities under unidirectional ground motion **Tomomi Suzuki**, Aishwarya Puranam, Ken Elwood, Hung-Jen Lee, Ren-Jie Tsai, Fu-Pei Hsiao, Shyh-Jiann Hwang
27	Analytical and numerical prediction of the vulnerability of post-earthquake observed URM macroblocks **Francisco Galvez**, Dmytro Dizhur, Jason Ingham
28	Prioritising earthquake retrofitting in the high seismic risk city of Wellington **Thoa Hoang**, Ilan Noy
29	Regulating seismic risk in existing multi-storey buildings in NZ: The Wellington case study **Kirsty Jacomb**, W. John Hopkins, Toni Collins
30	Investigation into the factors affecting costs of earthquake damage repair work **Ravindu Kahandawa**, Niluka Domingo, Gregory Chawynski, SR Uma
31	Experimental and analytical investigations of uncertainty in seismic response of reinforced concrete components **Eyitayo Opabola**, Ken Elwood
32	Making Wellington [earthquake] resilient: Creating building inventory dataset for seismic risk assessment and management **Jacob Pastor**, Olga Filippova, Ken Elwood, Ilan Noy
33	Estimation of seismic drift demands in torsional structures **Santiago Pujol**, David Gale

34	To cordon or not to cordon: The inherent complexities of post-earthquake cordons learned from New Zealand experiences **Shakti Raj Shrestha**, Caroline Orchiston
35	Accounting for building torsional behaviour during strong earthquake shaking **Hossein Soleimankhani**, Gregory MacRae, Timothy Sullivan
36	Machine learning for city-scale building information model procurement **Chaofeng Wang**, Qian Yu, Barbaros Cetiner, Frank McKenna, Stella Yu, Kincho Law, Ertugrul Taciroglu, Sanjay Govindjee, Gregory Deierlein
37	Seismic retrofit of automated storage systems in a high-tech fabrication plant **George Yao**

Flagship 4: Next-generation Infrastructure – Low-damage and Repairable Solutions – Posters 38-53

38	Investigating the influence of earthquake ground motion duration on structural dynamic deformation capacity **Vishvendra Bhanu**, Reagan Chandramohan, Timothy Sullivan
39	Eco-rubber seismic-isolation foundation systems: A sustainable and cost-effective way to build resilience **Gabriele Chiaro**, Alessandro Palermo, Laura Bansiak, Gabriele Granello, Ali Tasalloti, Ernesto Hernandez
40	Development of a local approach for tangent-stiffness-proportional damping model **Giovanni De Francesco**, Timothy Sullivan
41	A preliminary study on cyclic behaviour of SFS dowelled connections in glulam frames **Wenchen Dong**, Minghao Li
42	A value case for seismic isolation of residential buildings **Tom Francis**, Timothy Sullivan, Andre Filiatrault
43	The equivalent ductility approach for designing the structures using Resilient Slip Friction Joints (RSFJs) **Ashkan Hashemi**, Hamed Bagheri, Seyed Mohammad Mahdi Yousef Beik, Pouyan Zarnani, Pierre Quenneville
44	A practice-oriented method for predicting elastic floor acceleration response spectra **Kieran Haymes**, Timothy Sullivan, Reagan Chandramohan

45	ILEE-QuakeCoRE shake table test on a full-scale low-damage concrete wall building **Yiqiu Lu**, Rick Henry, Ken Elwood, Geoff Rodgers, Ying Zhou, Anqi Gu, Tony Yang
46	Effects of simulated Magnitude 9 earthquake motions on reinforced concrete wall structures in the Pacific Northwest **Nasser Marafi**, Jeffrey Berman, Andrew Makdisi, Marc Eberhard
47	Repairability of earthquake damaged reinforced concrete walls **Gonzalo Munoz**, Rick Henry, Ken Elwood
48	Simplified seismic risk assessment of systems with two failure mechanisms using the improved SAC/FEMA approach **Amirhossein Orumiyehei**
49	Review of recently constructed buildings with dual systems combining steel frames and concrete walls **Claire Pascua**, Rick Henry
50	Shaking table test of a near full scale low damage structural steel building: Structural aspects **Shahab Ramhormozian**, Charles Clifton, Zhenduo Yan, Gregory MacRae, Rajesh Dhakal, Pierre Quenneville, Xianzhong Zhao, Liangjiu Jia, Ping Xiang
51	Numerical seismic performance assessment of precast pre-stressed hollow-core concrete floors **Ana Isabel Sarkis Fernández**, Timothy Sullivan, Emanuele Brunesi, Roberto Nascimbene
52	Performance of earthquake damage beams repaired via epoxy injection **Mehdi Sarrafzadeh**
53	Trust to new seismic-proofing technologies: The influential factors **Shermineh Zarinkamar**, Mani Poshdar, Pierre Quenneville, Suzanne Wilkinson

Flagship 5: Pathways to Improved Resilience – Posters 54-81

54	Understanding the need for, availability of, and interpretation of information by the public during large scale hazard events. Co-production role **Kate Akers**
55	Multi-volcanic hazard impact assessment for residential buildings in the Auckland Volcanic Field **Nicole Allen**, Thomas Wilson, Ben Kennedy, Allan Scott, Carol Stewart
56	Creating a tool for rapid holistic assessment and rating of post-earthquake hospital functionality **Megan Boston**

57	Minimising public health risks from human waste after a large Wellington Fault earthquake: What shall we do with the poo? **Matthew Brenin**, Carol Stewart, Jacqui Horswell, David Johnston, Virginia McLaughlin, Lucy Kaiser, Liam Wotherspoon
58	Communicating earthquake risk information to tamariki: Challenges and opportunities in a digital world **Emily Campbell**
59	Understanding disaster risk exposure to visitors to the South Island of New Zealand **Mathew Darling**, Thomas Wilson, Brendon Bradley, Caroline Orchiston, Ben Adams
60	Balancing [EQPB] act: Heritage preservation, regulations and their impact on the future of small towns **Olga Filippova**, Bridgette Sullivan-Taylor
61	Temporal drivers of disaster risk and resilience in rural New Zealand **Becca Fraser**
62	Governing community resilience: Interconnections between community resilience, well-being and capitals **Martín García**
63	Conspicuous invisibility in disaster risk reduction **Lesley Gray**, Julia Becker, Carol MacDonald, David Johnston
64	Capturing impacts, experiences, and behaviour during disaster: An online participation and crowdsourcing approach for resilience **Sara Harrison**
65	Identifying research gap and opportunities in the use of multimodal deep learning for emergency management **Nilani Algiriyage**, Raj Prasanna, Kristin Stock, Emma Hudson-Doyle, David Johnston
66	Cause of injury and death from recent New Zealand earthquakes **Nick Horspool**, Ken Elwood, David Johnston, Joanne Deely, Michael Ardagh
67	Stories from a Hazardscape: Living with chronic illness in Petone **Nardia Kearns**, Denise Blake
68	Smart resilient cities **Emily Lambie**, Emily Campbell, David Johnston, Ken Elwood, Max Stephens, SR Uma, Raj Prasanna, Julia Becker, Nilani Rangika, Marion Tan, Yasir Imtiaz-Syed, Emma Hudson-Doyle, W. John Hopkins
69	Risk judgments and social norms: Do they relate to preparedness after the Kaikōura earthquakes **John McClure**, Millie Ferrick, David Johnston

70	Community science as a tool for increased disaster resilience **Lisa McLaren**, David Johnston, Emma Hudson-Doyle, Julia Becker, Abi Beatson
71	The effectiveness of retrofit technologies in wooden-framed houses in Wellington **Catalina Miranda**, Gary Raftery, Charlotte Toma, David Johnston
72	Building code amendment and compliance in post-disaster reconstruction in New Zealand **Amarachukwu Nwadike**, Suzanne Wilkinson, Charles Clifton
73	Bayesian updating of earthquake-induced building downtime parameters **Morolake Omoya**, Henry Burton
74	Leadership challenges and opportunities in extreme contexts **Bruce Pepperell**
75	"Puck it up and do your role": Men and the Kaikōura earthquake **Ashleigh Rushton**, Christine Kenney, Suzanne Phibbs, Cheryl Anderson
76	Modelling post-disaster habitability, human displacement and population needs **Finn Scheele**, Thomas Wilson, Julia Becker, Nick Horspool, Emily Lane, Kate Crowley, Matthew Hughes, Tim Davies, James Williams, Lina Le, SR Uma, Biljana Lukovic, Marion Schoenfeld, James Thompson
77	Energy – Communication resilience **Samad Shirzadi**
78	Conceptualising a disaster app: Consolidating public alerting authorities' social media and broadcast messages **Marion Tan**, Raj Prasanna, Kristin Stock, Emma Hudson-Doyle, Graham Leonard, David Johnston
79	Disaster memorial events for increasing awareness and preparedness: Commemorating the 150th anniversary of the 1868 Arica tsunami, Aotearoa-New Zealand **Kristie-Lee Thomas**, Lucy Kaiser, Emily Campbell, David Johnston, Hamish Campbell, Rana Solomon, Debbie King, Helen Jack, Jose Borrero, Ali Northern, John Callan
80	Understanding tsunami evacuation dynamics: Informing agent-based evacuation modelling through a case study of the 2016 Kaikōura Earthquake **Laura Tilley**, Danielle Barnhill
81	Identifying cognitive predictors of natural hazard preparedness using the theory of planned behaviour **Lauren Vinnell**, Taciano Milfont, John McClure

Special Project 1: Spatially Distributed Infrastructure – Posters 82-90

82	A data-driven approach for granular simulation of potential earthquake damage to bridge networks and resulting decreases in mobility **Barbaros Cetiner**, Eyuphan Koc, Ertugrul Taciroglu, Lucio Soibelman
83	Seismic response of an instrumented reinforced concrete bridge subjected to varying excitation levels **Pavan Chigullapally,** Liam Wotherspoon, John Wood, Lucas Hogan, Michael Pender
84	Assessment of the historic seismic performance of the New Zealand bridge stock **Shong Lew**, Liam Wotherspoon, Lucas Hogan, Moustafa Al-Ani
85	ynamic behaviour of reinforced concrete bridges in freezing conditions **Anastasiia Plotnikova**, Liam Wotherspoon, Sherif Beskhyroun
86	Development of a decision support system using a critical infrastructure interdependency modelling framework **Yasir Imtiaz Syed**, Raj Prasanna, SR Uma, Kristin Stock, Denise Blake
87	Quantifying the systemic vulnerability of critical infrastructure networks to volcanic multi-hazards at Mt Taranaki, New Zealand **Alana Weir,** Thomas Wilson, Mark Bebbington, Natalia Deligne
88	Tsunami vulnerability of critical infrastructure: Development and application of functions for infrastructure impact assessment **James Williams**
89	Simulation of direct and indirect infrastructure failures for Alpine Fault earthquake scenarios **Liam Wotherspoon**, Leo Liu, Conrad Zorn, Ali Davies
90	Quantifying the seismic risk for electric power distribution systems **Leo Yang Liu**, Liam Wotherspoon, Nirmal Nair, Daniel Blake

Capability Development: Technology Platforms & Outreach – Posters 91-95

91	On-demand web-enabled ground motion simulation and seismic hazard information **Sung Eun Bae**, Claudio Schill, Viktor Polak, Jason Motha, James Paterson, Jonney Huang, Daniel Lagrava, Brendon Bradley
92	Automated workflow for validation of ground motion simulations using conventional and complex intensity measures **Jason Motha**, Vahid Loghman, Brendon Bradley, Robin Lee, Daniel Lagrava, Claudio Schill, Melody Zhu, Paterson James
93	Development of a GIS platform for multi-disciplinary community databases to enable earthquake resilience and research **Ilan Noy**, Emily Lambie, Sally Owen, Rickard Hayden
94	Recent research activities of QuakeCoRE Technology Platform 2 **Andrew Stolte**, Liam Wotherspoon, Seokho Jeong, Quincy Ma, Geoff Rodgers
95	Fostering natural hazard resilient communities through gameplay **Brandy Alger**

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Meeting Participants

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