QuakeCoRE2.0 White Paper Template

QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

Topic title:

Integrated seismic demands and consequent geohazards

Aim

The intent of this white paper is to summarise this reasearch topic: The need, opportunity, and research priorities. An initial draft of the white paper is intended to provide guidance for a workshop to facilitate collective input and enable further refinement for the purpose of considering this topic area for inclusion into the rebid of the QuakeCoRE research programme for the period beyond 2020.

Is this workshop for a Grand Challenge or a Disciplinary focus area?

☒Disciplinary Focus
☐Grand Challenge
☐Neither or Not sure

Research question:

What are the salient physics and mechanics the govern seismic geohazards and how can we advance prediction accuracy and precision through observational, empirical and physics-based tools?

Problem statement:

Earthquake-induced ground motions, liquefaction, and slope instability are the principal geohazards causing damage and disruption to the built and natural environments. Recent NZ earthquakes (e.g. 2010/2011 Canterbury, 2016 Kaikōura) have aptly illustrated the significant ground motions and near-surface amplifications that are possible in the basins that NZ's urban areas often reside on; extensive liquefaction of land and damage to residential areas in Christchurch, and port facilities in Wellington; and landslides and slope instability along State Highway 1 on the Kaikōura coastline causing closure for over 1 year. Advances in understanding and modelling these geohazards individually, as well as unified data collection and modelling approaches to enable an integrated prediction are needed to more efficiently mitigate future impacts.

Research Priorities

This disciplinary focus area spans three different earthquake-induced geohazards: (i) Ground motion; (ii) Liquefaction; and (iii) Slope instabilities (incl. landslides and rockfall).

These geohazards span the traditional disciplines of engineering seismology, geotechnical engineering, and engineering geology. We advocate that significant advances in understanding and predictive modelling will occur through and integrated research programme that breaks down traditional disciplinary barriers. Furthermore, utilizing modern tools and methods also provide new avenues, in particular: (i) monitoring and sensing (both explicit and remote sensing); (ii) application of machine learning methods to data-rich problems to infer salient physics that is poorly understood; (iii) physics-based models that attempt to honour the governing mechanics. These three geohazards and subsequent inference tools and methods provide a two-dimensional structure within which the research will be undertaken. Additional laboratory and field experiments would be undertaken toward achieving the overall programme aim.

Focus areas	Sensing & monitoring for real-time applications	Multi-physics integrated modelling	Data-driven models using machine learning
Ground motion	1.1	1.2	1.3
Liquefaction	2.1	2.2	2.3
Slope instability	3.1	3.2	3.3

High-priority research areas, by geohazard, identified are:

1. Earthquake-induced ground motion:
   - 1.1. Advancement of physics-based ground motion modelling
     - i. Refined modelling of sedimentary basins that urban areas reside on to enable site-specific ground motion prediction
     - ii. Explicit incorporation of simulation uncertainties to enable simulation-based probabilistic seismic hazard analysis for prospective design and assessment
     - iii. Extension of physics-based methods to the maximum frequencies of engineering interest
     - iv. Spatial correlation modelling for seismic risk applications
   - 1.2. Remote sensing and monitoring
     - i. Low-cost ground motion instrumentation deployment and application to real-time seismic hazard estimation and ground motion early warning
   - 1.3. Machine learning for surrogate modelling of ground motion prediction and near-real-time impact forecasting
2. Earthquake-induced site response and liquefaction:
   - 2.1. Physics-based modelling:
     - i. Integrated modelling of geotechnical site response with ground motion simulation
     - ii. Integrated pore pressure generation and consequent liquefaction, through physics-based seismic effective stress analysis
       1. Laboratory studies to understand constitutive behaviour of critical NZ soils in regional focus areas
     - iii. Performance of structures and infrastructure founded on liquefaction-prone land.

2.2. Remote sensing and monitoring:
   i. ?

2.3. Application of machine learning methods for liquefaction triggering and impacts based on NZ's unique publically-available databases
   i. Further field data collection to exploit historical earthquake case histories.

3. Earthquake-induced slope stability:

3.1. Use of case history data to understand salient mechanics of slope instabilities and development of NZ-specific modelling (from global 'base' models) that accounts for NZ's local geology.

3.2. Application of sensing technologies (both direct (instrumentation), and remote (satellite-based)) to monitor the temporal evolution of slope movements; and enable real-time prediction and impact assessment.

3.3. Application of NZ-specific modelling and real-time-monitoring to transportation corridors (e.g. state highways) and undulating urban areas (e.g. Wellington residential).

Opportunity

The outcome of this DFA is improved accuracy and precision by which predictions of these earthquake-induced geohazards will manifest in future earthquakes; which will consequently enable improved decision making as to their mitigation in the built and natural environment.

Key personnel:

Who are the key people that are critical to its success?

Current QuakeCoRE investigators: [Investigators from current QuakeCoRE community that will drive the strategic direction]

Research leaders: Brendon Bradley, Misko Cubrinovski, Liam Wotherspoon, Rolando Orense

Industry R&D collaborators: Sjoerd van Ballegooy, Jeff Fraser, Didier Pettinga

Other key personnel: Chris Massey, Clark Fenton, Chris McGann, Gabriele Chiaro, Mark Stringer, Connor Hayden, Seokho Jeong.

International and national links:

TBC

SECTIONS TO BE COMPLETED AFTER THE WORKSHOP

Design and Rationale:

[Give a brief overview of the design of the proposed research, and indicate how it relates to work already done, by yourself and/or others, in this field.]

Research objective(s) and method(s)

[State your proposed research objectives, methods, timetable, data sources and how you plan to transfer the knowledge gained from your research, all white papers must have between 3-5 objectives]

Research Objectives:		Time period
Obj1.	[add objective name] • [Detail key methodologies, data sources and knowledge transfer plan]	[please state how long it will take to complete this objective]

References:

We anticipate that you will be interacting with Brendon Bradley and/or David Johnston during the preparation of this white paper.

Stage one – consider areas you'd like to champion and note them in the Google doc
Stage two – engage with Brendon or David
Stage three- submit this form as a draft white paper. Please submit by 31 January 2019 to QuakeCoRE@canterbury.ac.nz