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NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

Geotechnical outputs from the EQC – Quake Centre Industry Fellowship Programme

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ABSTRACT

The Earthquake Commission (EQC) has, for a long time, been an important investor in high quality research in New Zealand. EQC's research programme spans science, engineering and social science and has played a vital role in supporting New Zealand's improved resilience to natural hazards. Through its support of the Quake Centre, a series of EQC-Quake Centre Industry Fellowships have been implemented over the past five years

A series of projects have come to fruition and will be published in the near future which have strong geotechnical earthquake engineering themes. Most of these outputs will be standalone documents that can be used straight away by practitioners. However, some of the projects are best seen as contributing to guidance and processes that are already under development such as the NZGS Guidelines. The publications include:

- A Risk Based Framework for Earthquake Ground Motion Hazard Estimation, New Zealand;
- Spatial correlations of underground pipeline damage with liquefaction-induced ground surface deformations and CPT-based liquefaction vulnerability index parameters
- Invasive Seismic Testing – a summary of methods and good practice
- Guideline for Assessing Technical Resilience of Three Waters Networks – Simplified Assessment Method
- Rock Fall Risk Mitigation: Capturing experience from the Kaikoura and Canterbury earthquakes

This paper gives an outline of the EQC-Quake Centre Industry Fellowship Programme and an overview of recent outputs.

1 BACKGROUND TO THE QUAKE CENTRE

The Quake Centre was formed in September 2012 in response to the Canterbury Earthquakes. It is an Industry funded body that has around 20 partners who contribute both financially and in-kind to the Centre. The Centre also has significant support from the Department of Civil and Natural Resource Engineering (to which it belongs) at the University of Canterbury. The Quake Centre is governed by an Industry led Board with seven members. Four of those members are voted in from the partnership base and the other three are university appointments. The Board Chair is elected by the Board from the Industry representatives. Decisions on the release of funds to the Centre's programmes are the responsibility of the Quake Centre Board.

The role of the Quake Centre is best summarised by its tag line:

Funded by Industry to deliver solutions to Industry identified needs.

As such, the Centre focuses on applied resilience projects that can be used immediately by Industry. These projects may involve research; research translation and compilation; business and professional issues, training; project management or facilitation. Central to the Quake Centre's approach is ensuring that each project has an industry reference and review group to ensure that the project is always focused on the industry need.

In the past year the Centre has also gained funding from the MBIE's Partnership Scheme to form the Building Innovation Partnership (BIP). This programme allows some of the Quake Centre's partner funds to be matched with funds from MBIE. The focus of the BIP is assisting the horizontal and vertical infrastructure sectors to improve coordination and improve quality whilst reducing cost and risk through the development and implementation of Digital Engineering. One of the three themes of BIP focuses on good investment decision-making in the 3-waters sector and the best ways to use data. The second theme includes the implementation of Building Information Management (BIM) across the whole of a building's life. The final theme looks at the design, construction and seismic performance of non-structural elements.

2 EQC – QUAKE CENTRE INDUSTRY FELLOWSHIP PROGRAMME

Since its inception, the Quake Centre has had a strong relationship with the Earthquake Commission (EQC). For the past few years EQC has funded the EQC – Quake Centre Industry Fellowship Programme.

The aim of the Programme is to provide a long-term funding mechanism to allow experienced engineers the opportunity to increase the profession's knowledge and skills in Earthquake Engineering. The fund will typically cover reasonable salary (preferably on a cost basis and not a full commercial one) and additional costs for a fixed period of time to allow the engineer to undertake any or all of the following:

- Carry out research.
- Capture and document knowledge and experience gained.
- Develop and deliver courses.

Normally, Fellows are selected from mid-late career professionals who want to give something back to the industry and who have identified an opportunity to capture lessons learnt from previous experiences. Alternatively the Fellow may be leading or supporting a broader initiative that has been identified by the Industry as being of high importance. This may be by developing the technical foundation on which guidance or other industry documents can be created by the Learned Societies. There may also be guidance document created directly by the Fellow for use by engineers, clients or other professionals.

Fellowships are full or part-time and range from 3-12 months however, there is a great deal of flexibility as to how the Fellowship is structured. Any project that meets EQC's Mission Statement *To reduce the impact on people and property when natural disasters occur,* can be considered. (Earthquake Commision, 2018)

3 RECENT GEOTECHNICAL OUTPUTS AND WORK IN PROGRESS

Recently there has been a focus on geotechnical projects. Several of these reflected the experiences from the Kaikoura earthquakes and lessons learnt as part of the re-construction of State Highway 1 by the North Canterbury Transport Infrastructure Recovery (NCTIR) alliance as well as lessons from the rebuild of Christchurch.

The following gives an overview of the current geotechnical projects:

3.1 A Risk Based Framework for Earthquake Ground Motion Hazard Estimation, New Zealand

Authors: James Dismuke and Jeff Fraser, Golder Ltd

NZS1170.5 has provision for engineers to use special studies to develop the seismic loads for a particular site. Whilst these site specific seismic hazard analyses are allowed for in the code, there is no guidance as to when their use may be appropriate.

The *Risk Based Framework for Earthquake Ground Motion Hazard Estimation* report provides a framework for decision makers, policy makers, developers, owners, engineers, and others to select the level of effort (i.e. appropriate ground motion hazard analysis techniques) to suit the risk-profile of their specific projects. Detailed technical guidance about how to perform these hazard analyses is not in the scope of this report. The report comprises:

- Definition of terms and concepts used in the report;
- Summary of current New Zealand earth ground motion estimation guidance;
- Methods and techniques for determining ground motions for design;
- Risk-informed framework for determining which earthquake ground motions approach is appropriate to the situation; and
- Answers to frequently asked questions.

Publication is due by the middle of 2020.

3.2 Spatial correlations of underground pipeline damage with liquefaction-induced ground surface deformations and CPT-based liquefaction vulnerability index parameters

Authors: Dr Sjoerd van Ballegooy and Dr Luke Storie, Tonkin + Taylor

Dr Dimitra Bouziou, Cornell University / GEK TERNA

Prof Thomas O'Rourke, Cornell University

Based on the lessons from the Canterbury Earthquake Sequence, this report develops tools to assess the potential for pipeline damage based on correlations with liquefaction-induced ground movement and soil cone penetration test (CPT) based liquefaction measures and indicators. The correlations and indicators can be used for pre-earthquake event estimates as well as post-event rapid triage of pipe damage. Key inputs to the assessment are a comparison between pre and post-event LiDAR surveys; satellite imagery; CPT-based assessments of liquefaction vulnerability and earthquake induced Peak Ground Velocity data (PGV).

The report explains how the data sets were collated and analysed to develop functions for pipe repair rates expressed in the number of predicted breaks per kilometre of pipeline. These repair rates cannot predict

specific damage at any one location, rather they can identify areas and pipe types where damage is more likely to occur and areas where it is less likely to occur and provide an expected damage rate for those respective areas. Tools have been developed to facilitate this approach which can be readily applied by practitioners when responding to liquefaction induced damage.

The report can be found here: http://resources.quakecentre.co.nz/spatial-correlations-of-underground-pipeline-damage-in-christchurch/

3.3 Invasive Seismic Testing – a summary of methods and good practice

Author: Rick Wentz, Wentz-Pacific ltd

In the aftermath of the 2010-2011 Canterbury and 2016 Kaikoura earthquakes, seismic shear wave testing has become more commonly used in geotechnical earthquake engineering. However, several critical aspects of both data collection and data processing are commonly not well understood by either the contractors collecting and processing the data or the geotechnical and structural engineers using the data. This can lead to incorrect and possibly unconservative design assumptions.

This report summarises the invasive seismic test methods typically used in New Zealand geotechnical engineering practice to measure shear and compression wave velocities. It describes the test procedures and data processing that are generally accepted as "good practice" – i.e. the procedures and processing that are necessary to obtain accurate and representative data that can be relied upon by geotechnical engineers for analysis and design. The report also describes the uncertainty inherent in all of the testing methods, including sources of uncertainty and how to quantify it. An example of an assessment of uncertainty using actual field data is provided, as are recommendations for what information should be included when reporting test results.

This report will be a key reference document underpinning an update of the *Earthquake Geotechnical Engineering Module 2 – Geotechnical Investigations for Earthquake Engineering.*

The document can be found here: http://resources.quakecentre.co.nz/invasive-seismic-testing-a-summary-of-methods-and-good-practice/

3.4 Guideline for Assessing Technical Resilience of Three Waters Networks – Simplified Assessment Method

Authors: Marcus Gibson, Melanie Liu and David Heiler, Beca Ltd

The guideline has been prepared, based on lessons from the Canterbury earthquake sequence, to support local authorities and the private sector (including asset managers, operators and engineers) at local and regional levels with assessing technical resilience of their three waters infrastructure and in developing strategies to improve network resilience, inform pre-event planning, and post-event emergency support and recovery. The focus is on infrastructure placed in land potentially vulnerable to any geotechnical natural hazard. A particular example is shown in relation to liquefaction prone land - which includes many areas around New Zealand commonly near rivers, harbours and the coast.

The guideline aims to standardise the assessment of technical resilience across New Zealand and to encourage collaboration, while maintaining the ability for users to tailor the assessment approach to fit the specific requirements and needs of their community. The document will form the basis of part of a course being run around the country by Water New Zealand. The report will be available via the Quake Centre Resource Portal here: http://resources.quakecentre.co.nz/

3.5 Rock Fall Risk Mitigation: Capturing experience from the Kaikoura and Canterbury earthquakes

Author: Rori Green, Rori Green Consulting Ltd

Landslides and rock falls that occurred as a result of the 2010/2011 Canterbury and the 2016 Kaikoura earthquakes caused significant damage. This threatened critical transportation infrastructure particularly SH1 and the main rail corridor running down the top half of the east coast of the South Island. Various measures were used to mitigate rock fall risk to the infrastructure and the public who utilises this infrastructure. This document will capture the knowledge and experience related to two separate aspects of the mitigation works: helicopter sluicing and temporary rockfall protection works. This document will provide practical information to designers, client representatives/decision makers and project managers that can be utilised on future projects in similar situations. In addition, there will be a database of helicopter sluicing case studies as useful examples and to facilitate further analysis.

4 OTHER EARTHQUAKE ENGINEERING OUTPUTS

There are also some non-geotechnical outputs from the Fellowship programme.

4.1 So you own a building that is or may be an 'Earthquake Prone Building' – What next?

Authors: Warren Batchelar and Graham McDougall, Batchelar McDougall Consulting Ltd

There is still some confusion amongst property owners about the implications of the revised earthquake-prone provisions of the Building Act that have been in effect since 1 July 2017. To counter this, a guidance document focused at structural engineers and their clients has been produced. This aims to provide a simple guide for building owners to navigate through the sea of information. As such it provides a pathway through the process of responding to notification that a building has:

- either been identified as potentially earthquake prone (following receipt of letter from a local Territorial Authority (TA),
- or has been determined to be earthquake prone (following receipt of an earthquake prone building (EPB) Notice) by the TA following their review of an engineering assessment report on your building which they have previously received.

This document is freely available on the Quake Centre Resource Portal. http://resources.quakecentre.co.nz/

4.2 Recast

Project manager: Nic Brooke, Compusoft Ltd.

The Recast programme of research is a collaborative project funded by BRANZ and EQC based at UC and UoA. Its purpose is to develop retrofit solutions for seismically sensitive precast concrete floors. These were shown to be vulnerable to earthquake damage during the Seddon and Kaikoura Earthquakes. Nic has the vital role of coordinating the Industry inputs to the testing programme and to ensuring that the outputs are appropriate and useable by Industry. The EQC-Quake Centre Fellowship is funding him part-time for a year to undertake these tasks.

5 CONCLUSIONS

The EQC-Quake Centre Industry Fellowships scheme is an important opportunity to deliver applied research that is readily applicable for Industry. It allows an engineer (or related professional) to take time to develop discrete pieces of work that align with EQC and the Quake Centre's objectives. The programme works best when the Fellow draws on their own experience but also integrates that with other professional and academic

input. The opportunity to undertake a Fellowship is open for mid-late career professionals working on issues related to New Zealand's resilience to natural hazards. Any person who has a project they wish to pursue should contact:

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6 REFERENCES

Earthquake Commission (2018). Statement of Intent 2018-22. Wellington: Earthquake Commission