



THE UC QUAKE CENTRE – ENHANCING EARTHQUAKE ENGINEERING IN NEW ZEALAND

Greg PRESTON¹, Umut AKGUZEL² and Robert FINCH³

ABSTRACT

The UC Quake Centre, based at the University of Canterbury (UC), Christchurch, New Zealand, has been created to bridge a gap between academia and the engineering profession and assist in addressing the shortcomings in design philosophy, training and other capabilities exposed by the Canterbury earthquake sequence of 2010-2011. This paper highlights the background to the Centre's creation and development, its current programme of work and its vision for the long-term development as a centre of earthquake engineering excellence.

INTRODUCTION

The UC Quake Centre has been created by the University of Canterbury's Department of Civil and Natural Resource Engineering (CNRE) to address short and long term needs in the Civil Engineering profession that were exposed following the Canterbury earthquake sequence of 2010 and 2011. This paper describes the background to the formation of the Quake Centre, current activity within the Centre and plans for its further development.

The Canterbury earthquake sequence inflicted enormous damage to Christchurch and surrounding towns. A direct hit on the city on 22 February 2011 caused the loss of 185 people making this event the second most deadly natural disaster to occur in New Zealand. Despite the death toll, the vast majority of buildings in Christchurch performed remarkably well in terms of life safety considering that the M6.3 earthquake was more than double the Maximum Conceivable Earthquake (MCE) allowed for in the design codes (DBH, 2011). However, the significant economic losses due to damage to infrastructure and buildings as well as disruption to business activities, exposed shortcomings in both the design philosophy and the capabilities of engineers (Canterbury Earthquakes Royal Commission, 2011). A number of deficiencies within: the planning system; past design and construction systems and; education and training within the profession, have been exposed (Hughes et al., 2013).

This paper summarises the current structure of earthquake engineering in New Zealand, the academic environment and the role of the Quake Centre in creating a collaboration between the profession and academia to enhance the quality of earthquake engineering training and practice.

¹ Manager of Education and Research, UC Quake Centre, Christchurch, greg.preston@canterbury.ac.nz

² PhD, Senior Structural Engineer, Beca Ltd, Christchurch, umut.akguzel@beca.com

³ PhD, Director, UC Quake Centre, Christchurch, director@quakecentre.ac.nz

OVERVIEW OF EARTHQUAKE ENGINEERING EDUCATION IN NEW ZEALAND

As New Zealand is a highly seismic region, earthquake engineering plays a significant part in education, training and practice for civil engineers. There are two primary engineering schools; the University of Canterbury (UC) and the University of Auckland (UoA). The two Civil Engineering departments are ranked highly internationally (QS Top Universities, 2014). Both universities offer a four-year Bachelor of Engineering (Honours) (BE (Hons)) in Civil Engineering which is accredited by the Institute of Professional Engineers (IPENZ) in New Zealand as meeting the initial academic requirements for professional engineers under the Washington Accord (IPENZ, 2014).

Both degrees are general in nature and involve study across all aspects of Civil Engineering including structural, geotechnical, hydraulic and transport engineering. For engineers planning to practise in earthquake engineering, there are two broad specialities, structural and geotechnical engineering depending on course selection. However, there is no distinction when conferring the degree. There is a well-understood tension between providing a general education in the disciplines of Civil Engineering as opposed to a more specialist structural or geotechnical engineering education. There is continual discussion over the need to extend the Degrees to compensate for this. The extra time, cost and the nature of engineering practice within New Zealand, which often requires engineers to display a degree of flexibility, make the provision of specialist undergraduate degrees a difficult path to take.

In addition to the undergraduate programmes there are a number of postgraduate degrees available from UC and UoA including Postgraduate Certificates, Masters of Engineering Studies, Masters and Doctorates. Some of these, delivered by UC, may be endorsed in Earthquake Engineering depending on the courses selected.

OVERVIEW OF CONTINUING PROFESSIONAL DEVELOPMENT (CPD) FOR CIVIL ENGINEERS IN NEW ZEALAND

After graduating, a civil engineer is expected to achieve Chartered Professional Engineer (CPEng) status within 5-6 years. IPENZ is the CPEng registration body. Chartered Professional Engineer is a statutory title under the Chartered Professional Engineers Act of New Zealand 2002, which established a register of professional engineers whose competence is up-to-date. Some regulatory authorities specify that certain kinds of work must be carried out or supervised by a CPEng – for example, certification of the integrity of structures under the Building Act (IPENZ, 2014). However, there is no legal requirement to achieve chartered status to practise as an engineer.

To obtain or retain CPEng status an engineer must demonstrate competency in 12 areas. This is assessed by a panel which make recommendations to the Competency Assessment Board. Reassessment occurs after a maximum of six years (IPENZ, 2014). One requirement is that an engineer undertakes a minimum of 50 hours Continuing Professional Development (CPD) per year. This is self-reported and can include reading, research, conferences, courses, etc. Topics should be both of a professional and technical nature.

There are several learned societies in New Zealand which contribute to the profession in both a technical and professional capacity. The most important of these are:

- The New Zealand Society for Earthquake Engineering Incorporated (NZSEE)
- The New Zealand Geotechnical Society Incorporated (NZGS)
- The Structural Engineering Society New Zealand Incorporated (SESOC).

All three organisations are collaborating technical societies of IPENZ and are run on a voluntary basis. These organisations are active in providing technical development opportunities for their members via regular conferences, facilitating overseas speakers and running ad hoc courses. IPENZ also runs a training calendar and organises ad hoc courses of both a technical and professional nature. Courses are generally in the form of a day-long seminar delivered by a recognised professional or academic but may also be delivered as webinars.

Whilst these development opportunities in themselves can be high quality, there is little coordination between the societies and IPENZ and there is no agreed technical curriculum. As a

consequence there may be few formal opportunities to address some important technical aspects that are current or, long-term issues within the profession and there is no formal way of assessing gaps in essential skills and knowledge across the profession.

OVERVIEW OF EARTHQUAKE ENGINEERING RESEARCH IN NEW ZEALAND

New Zealand has a long history and proud reputation of research in earthquake engineering. The concept of Capacity Design was developed at UC by Professors Park and Paulay in the 1960s and 70s and both UC and UoA continue to make significant contributions to international research. However, investment has not always kept up with New Zealand's international partners. In particular, laboratory facilities to undertake large scale testing are not available in New Zealand. UoA is currently building a new laboratory facility for Civil Engineering and UC has received a multi-million dollar capital investment from the New Zealand Government to refurbish its laboratory facilities following the Canterbury Earthquakes. This includes the construction of a new earthquake engineering laboratory.

The major research funding source is the Natural Hazards Research Funding Platform (NHRP). This was created by the New Zealand Government in 2009 to provide secure, long-term funding for natural hazard research, and to help research providers and end-users work more closely together. The Platform is led by the Crown Research Institute, GNS Science and includes the National Institute of Water & Atmospheric Research (NIWA) as a co-anchor organisation with the University of Canterbury, Massey University, Opus Research, and University of Auckland as partners (NHRP, 2014). There are five themes:

- Geological hazard models
- Predicting weather, flood, and coastal hazards
- Developing regional and national risk evaluation models
- Societal resilience: social, cultural, economic and planning factors
- Resilient buildings and infrastructure.

Approximately NZ\$ 17 Million of research funding is committed in the period 2012-2015 of which approximately NZ\$ 2 Million is allocated to engineering research at UC and UoA. This covers such topics as:

- Eccentrically Braced Frame Inelastic Demand and Repair in Severe Earthquakes
 - Residual Capacity and Repairing Options for Reinforced Concrete Buildings
 - Novel physical and numerical modelling of tsunami loading on Port structures
 - Preservation of heritage unreinforced masonry buildings through more appropriate retrofit solutions
 - Improving the seismic performance of reinforced concrete walls
 - Stochastic Simulation of Ground Motions Observed in the Christchurch Earthquakes Including Site-Specific Effects
 - Seismic site response effects on surface ground motions and ground deformations.
- (NHRP, 2014)

Other contestable funding is available for smaller projects including funding from the Earthquake Commission (EQC). EQC provides natural disaster insurance for residential property and land; administers the Natural Disaster Fund; and funds research and education on natural disasters and ways of reducing their impact (EQC, 2014).

THE CANTERBURY EARTHQUAKES ROYAL COMMISSION (CERC)

The Canterbury Earthquakes Royal Commission of inquiry was established to report on the causes of building failure as a result of the earthquakes as well as the legal and best-practice requirements for buildings in New Zealand Central Business Districts. The inquiry began in April 2011 and was completed in November 2012 (CERC, 2014). This was an extremely thorough and erudite process

which resulted in a final report over seven volumes. The Royal Commission made 189 recommendations of which most were accepted in full by the New Zealand Government. Some of these recommendations require specific research. This research agenda has been passed to the Ministry of Business Innovation and Employment (MBIE) to fund and manage.

Volume 7 of the Royal Commission’s final report looked at Roles and Responsibilities including a review of the engineering profession and the education and training of engineers. The Commission recommends the creation of the qualification of a Recognised Structural Engineer who would be responsible for the design and review of any structure deemed to be complex. This qualification would be further to the requirements for CPEng status.

THE ROLE OF THE QUAKE CENTRE

Following the Canterbury earthquakes it was recognised that there was a need to highlight and expand the role of the University of Canterbury’s Civil and Natural Resources (CNRE) Engineering Department’s to assist in the rebuild of the City. Also, there was an opportunity to develop a globally recognised Centre that would assist the development of earthquake engineering practice in New Zealand and abroad. To this end the Department put resources into the development of the UC Quake Centre.

The vision for the Quake Centre is:

A nationally and internationally recognized Centre providing tomorrow’s earthquake engineering solutions today.

The Centre’s mission statement is:

- To partner with industry to create collaborative earthquake engineering solutions.
- To enhance New Zealand’s capability to evaluate seismic risk to structures and lifelines.
- To up-skill professionals in earthquake engineering.
- To raise the level of community awareness of seismic risk and earthquake engineering solutions.

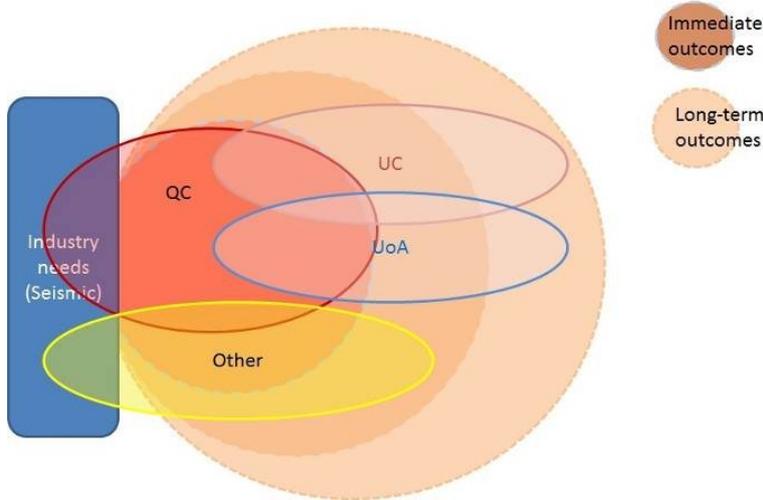


Figure 1. Relationship between Quake Centre, Universities and Industry

It was soon recognised that a business-as-usual approach was not sufficient to deliver training and research to industry in an effective manner. The Quake Centre needed to develop more effective ways for academia and the profession to interact. Central to this was an understanding of the commercial and time constrained nature of professional practice whilst being cognicent of the long-term, visionary focus of academia and the requirements of academic publishing and student education. It was also important to understand that the two world views are often at odds with each other and that knowledge

is spread between the two domains. The Quake Centre needed to create an effective bridge between these two conflicting ways of operating. The positioning of the Quake Centre in this way is visualised in Figure 1 above.

STRUCTURE, FUNDING AND GOVERNANCE

The Quake Centre is part of the Department of Civil and Natural Resource Engineering (CNRE) within the College of Engineering at the University of Canterbury. Funding comes from investment by Industry and local government and in-kind support from the Department. There is an understanding that the Centre will move to become a national NZ Quake Centre at a suitable time in its development. Consequently, the relationship and engagement with the Department of Civil and Environmental Engineering, University of Auckland, is of primary importance which is reflected in a collaboration agreement with UoA. In addition, since its launch in March 2013, the Quake Centre has entered into a number of collaboration agreements with similar international earthquake and disaster research institutions with the aim of increasing dialogue and collaboration.

Expenditure is approved by the Quake Centre Board which comprises four industry representatives and three from the Universities (UC and UoA). The industry representatives are elected from Quake Centre investors and represent four general areas:

- Consultants
- Construction and suppliers
- Large asset owners
- Local government.

The other board members are appointed by the University of Canterbury and one of these positions is taken by the Head of Department of Civil and Environmental Engineering, UoA. This serves to strengthen the collaboration between the two Engineering Schools at the highest governance level.

EDUCATION AND TRAINING

It was identified that there was an influx of engineers working on the Christchurch rebuild from overseas who were lacking experience and training in earthquake engineering. At the same time it has been recognised that the on-going technical training of civil engineers working in earthquake engineering in general was lacking structure. The Quake Centre is beginning to address this in a number of ways:

1. Delivery of short courses and seminars that cover immediate gaps in practitioners' knowledge. This has involved courses delivered locally for technicians involved in construction site management, overseas trained structural engineers and engineering geologists working in the geotechnical field.
2. Supporting the Learned Societies in initiatives to train and develop engineers' skills in relation to building and ground assessment. This involves the nationwide roll-out of material developed by the NZSEE on the Initial Seismic Assessment (ISA) of buildings including nationally benchmarked courses to improve consistency in building assessment procedures.
3. Building a structured series of online courses, available on demand, that provide a longer term solution to skills gaps in the profession, particularly for junior engineers between graduating with a BE and their first CPEng assessment. These courses are developed by practising engineers, providing in-kind support to the Quake Centre, under the guidance and review of senior practitioners and academics from both UC and UoA. The first of these courses was launched in December 2013 and in due course will include:
 - a. Introduction to Earthquake Engineering
 - b. Structural Dynamic Concepts for Seismic Design
 - c. Seismic Response of Structures and Analysis Methods

- d. Seismic Design Approach in New Zealand and Introduction to Loading Codes
- e. Introduction to the Seismic Design of Concrete Structures
- f. Introduction to the Seismic Design of Steel Structures.
- g. Introduction to the Seismic Design of Masonry.

It is aimed to have 20-30 such courses available nationally and internationally within the next 3-5 years. These will be augmented by face-to-face courses as required for subject matter that is less suited to online delivery. The focus of each course will be on the application of theory into practice. There is a particular focus on enhancing the understanding of the assumptions behind the standards. The Quake Centre online portal is shown in Figure 2 below.



Figure 2: Quake Centre Online course portal, <http://www.quakecentre.co.nz/>

Other education initiatives are being scoped in respect to:

- Architects
- Building Consent Authority Managers and Building Control Officials
- Local Government Councillors
- Construction supervisors.

RESEARCH

The Quake Centre plays an important role as both a research centre and a translator of research into a format that is readily available for engineering practitioners. To this end an active research register has been developed to address stakeholders' immediate earthquake engineering needs. The register is the

primary tool for the Board to prioritise and allocate resources. (UC Quake Centre, 2014). Initial research and research translation projects include:

- The seismic response of non-structural elements
- The seismic response of large earth structures.
- Updates to retaining wall guidelines.
- Guidelines for Seismic Retrofit of Reinforced Concrete Structures.

The Centre has also been tasked by the New Zealand Ministry of Business, Innovation and Employment (MBIE), to coordinate aspects of research in response to the Canterbury Earthquakes Royal Commission's recommendations. This involves the development of the reinforced concrete research strategy and project managing a suite of concrete related projects across UC, UoA and the Cement and Concrete Association of New Zealand (CCANZ).

The projects address the following areas:

- Effects of diaphragm interaction on coupling beam strength and distribution and magnitude of shear forces in multi-storey coupled RC walls.
- Torsion and flexure in shear cores
- Rate of loading / concrete ageing strength
- Singly reinforced walls – best practice guidelines
- Diaphragm design handbook.

In addition to these projects a significant Christchurch building, damaged in the earthquake sequence and due for demolition, is being scoped for a large cross-disciplinary study. The project will be a collaboration of industry, academia, the demolition company and the property owner.

SCIRT LEARNING LEGACY

The Stronger Canterbury Infrastructure Rebuild Team (SCIRT) is the alliance of owners and construction companies that are repairing the multi-billion dollar damage to the horizontal infrastructure of Christchurch. The SCIRT alliance model, leadership, management, processes and technical innovations have been highly successful and may provide a model for other disaster recovery programmes. The Quake Centre is project managing the creation of the Learning Legacy for the SCIRT. The aim is to capture the SCIRT model in its entirety including all the processes, design guides, tools, etc. These will be integrated with research undertaken by a range of entities. The Learning Legacy will integrate the stories of SCIRT, the research and the data underlying the research through an easily accessed web portal. There is a high degree of urgency in this project as SCIRT is due to disband in late 2016. (SCIRT, 2014)

OTHER SIGNIFICANT ACTIVITY

The Quake Centre is active in a range of areas including:

- Facilitating international research coordination between New Zealand and India.
- Coordinating visits to UC and the Christchurch rebuild.
- Funding and coordination of PhD and Masters scholarships
- Conferences and expos.
- Commercial testing of locally designed earthquake engineering solutions.

LONG-TERM PLANS FOR THE QUAKE CENTRE

True to its vision, the Quake Centre aims to become an international centre of excellence in earthquake engineering. For this to occur, the Centre must grow the capability of its researchers and deliver first class education and training. Whilst the initial focus is on some of the shorter-term goals

associated with ensuring a stable funding base, boosting the technical capabilities required for the Christchurch rebuild and forging effective relationship, etc., there will be an inevitable shift in focus to the long-term development of earthquake engineering capability in New Zealand. Two areas that have been selected as important initial areas of growth are:

- The seismic performance of large earth structures, predominantly dams and levees.
- The seismic performance of non-structural elements. The impact of the failures of these elements has been identified as a significant economic risk to New Zealand.

Resources have been allocated to employ postdoctoral research engineers in these areas. These will augment the capability of researchers and educators at UC and UoA with the long-term goal of increasing the engineered resilience of New Zealand.

It is envisaged that within the near future, the UC Quake Centre will transition to become the NZ Quake Centre hosted at the University of Canterbury and the University of Auckland. Within 10 years the NZ Quake Centre will employ a significant number of researchers who will be delivering industry ready outputs. This will be backed up by courses that are practitioner focused and speed the transfer of skill and technology to the profession. In addition there will be 20-30 online and face-to-face courses that provide a significant part of the technical post-graduation curriculum for CPEng in New Zealand.

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