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UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

3 August 2011

Justice Mark Cooper
Chairperson
Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes
PO Box 14053
Christchurch Mail Centre

Dear Justice Cooper,

This letter is written in response to your request regarding the Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes. It concerns the education of Civil Engineering undergraduates in structural and geotechnical sub-disciplines at the University of Canterbury as well as the professional development of graduate engineers.

The University of Canterbury offers a Bachelor of Engineering with Honours (BE(Hons)) degree which may be awarded in any one of eight professional programmes, including Civil Engineering. Approximately 800 students are enrolled in the first year of the BE(Hons) degree. This first year is not discipline specific; it provides students with a foundation in basic sciences and an introduction to applied engineering subjects. All of the academic requirements for the first year must be completed to an acceptable academic standard and within a specified timeframe before students are eligible to apply for one of the Professional engineering programmes. About 450 students meet the entry criteria each year. From then on, students are in either the 1st, 2nd or 3rd Professional years.

The Civil Engineering degree is a nationally and internationally accredited professional level qualification. Students accepted into Civil Engineering are taught essential compulsory courses in their second and third years of study. Once students have passed year three they have demonstrated that they have the ability to analyse structural and geotechnical engineering systems to a level which is consistent with the normal activities of a practising engineer. NB. This does not mean that a student is ready to practise as a structural or geotechnical engineer. In the fourth year of the Civil Engineering degree, students planning to become structural and geotechnical engineers can focus their study by selecting courses in these subject areas.

The role of universities offering professional level engineering qualifications is to ensure that graduating engineers enter the workforce understanding, and able to apply the principles that underpin, core subject areas. Furthermore, universities provide graduating engineers with the potential for transferring new techniques, learnt from undergraduate and postgraduate study, into industry. After graduation it is the responsibility of an engineer to remain up-to-date in his or her technical field. Those graduates working in structural and geotechnical areas must develop their technical competence under supervision of professionally qualified engineer during the first four or five years of full time employment. In order to certify the structural integrity of buildings in New Zealand, engineers must be working within their area of expertise and are required to have Chartered Professional Engineer (CPEng) status. The Institute of Professional Engineers New Zealand (IPENZ) requires a formal competence assessment and continuous professional development for engineers to hold a current CPEng status.

Researchers at the University of Canterbury have for many years contributed to the understanding of how structures and foundations behave under earthquake conditions. Research findings are peer reviewed and published in international journals and conference proceedings. Following the circumstances of the recent Canterbury earthquakes, with the catastrophic consequences, it is appropriate to thoroughly review the education and training process for engineers involved in the design of large buildings and structures. Such a review is currently underway at the University of Canterbury as described in the attached report: "Education of Structural and Geotechnical Engineers at the University of Canterbury". This report was prepared specifically for the Royal Commission of Inquiry and offers commentary on the issues from the viewpoint of the Civil Engineering Department. The report proposes increasing structural and geotechnical knowledge of engineers entering the profession.

Further commentary and input from industry, professional organisations and specialist individuals is invited and encouraged during these preliminary deliberations.

Yours sincerely,

Dr Shayne Gooch
Dean of Engineering and Forestry
University of Canterbury

Report to the Royal Commission of Inquiry into Building failure Caused by the Canterbury Earthquakes

Education of Structural and Geotechnical Engineers

at the University of Canterbury

Professor Andy Buchanan
and
Head of Department, Associate Professor Roger Nokes

Department of Civil and Natural Resources Engineering, University of Canterbury

Executive Summary

The University of Canterbury currently offers a nationally and internationally accredited four year honours degree in civil engineering. The first year is to assess academic suitability to progress to the remaining three years of professional engineering education.

Due to the expansion of the body of knowledge in the many sub-disciplines of civil engineering in the last 50 years the proportion of the undergraduate degree that is dedicated to structural engineering has reduced in recent times.

The structural and geotechnical engineering knowledge of civil engineers entering the profession should be increased in order to supply the engineering profession with better educated personnel who can design infrastructure appropriate for a seismically active region such as New Zealand.

To address this need the preferred option is to work with IPENZ to require a specialised masters degree in earthquake engineering as the entry point into the structural engineering and geotechnical engineering professions. Such a specialised masters programme is already under development at the University of Canterbury.

A specialised masters programme, taught in an approprate format, could also provide a pathway for practising structural and geotechnical engineers to upgrade their skills on a progressive basis.

High level education in earthquake engineering must be underpinned by cutting edge research in the disciplines of structural and geotechnical engineering. This research is currently being undertaken at the University of Canterbury, funded by the Natural Hazards Research Platform and Earthquake Commission, and in many cases this research has a direct impact on engineering practice.

1 Background

This report is written in response to a request from the Chair of the Royal Commission dated 1 July 2011 to the Dean of Engineering and Forestry at the University of Canterbury. The main thrust of the request is copied in Appendix 1.

This report concentrates on the University of Canterbury, but much of the discussion could also apply to the University of Auckland. These are the only two New Zealand universities offering degrees in structural engineering and geotechnical engineering.

2 Current Education of Structural and Geotechnical Engineers at UC

The University of Canterbury offers a four year BE (Honours) degree in Civil Engineering. This degree is administered and taught by the Department of Civil and Natural Resources Engineering, in the College of Engineering. Students do not select Civil Engineering until the end of their Intermediate Year (Year 1) and their programme of study in the following two years -1st Professional (Year 2) and 2nd Professional (Year 3) – contains a sequence of compulsory courses covering the core sub-disciplines in civil engineering. These include environmentral engineering, hydraulics and hydrology, structural engineering, transpotation engineering, geotechnical engineering, surveying, management, design and support courses in mathematics and computation. At the conclusion of Year 3 all students are seen as having received a basic education in these sub-disciplines. In the fourth year of study, 3rd Professional, students are provided with a range of elective options and one compulsory course in management. It is at this time that an undergraduate student can chose to specialise in one of the sub-disciplines. The lack of course choice until the final year has often attracted discussion, with the majority of academics and professional engineers supporting a broad general two-year education in civil engineering, with specialisation in 3rd professional.

A brief overview of the degree is given in Table 1.

Table 1: A summary of the 4 year programme in Civil Engineering at the University of Canterbury.

Year	Name of year	Summary of content
1	Intermediate year	Introductory year for all branches of engineering.
2	1st Professional year	All civil engineering subjects. No choices.
3	2nd Professional year	All civil engineering subjects. No choices.
4	3rd Professional year	One compulsory course, and free choice of subjects.

The Department accepts approximately 135 students each year into the 1st Professional year of the BE (Honours) degree in Civil Engineering. In addition approximately 25 students are offered places in the BE (Honours) degree in Natural Resources Engineering. The two degrees have considerable overlap but beyond 1st Professional Natural Resources students do not take structural engineering courses.

Until recently the BE (Honours) degree in Civil Engineering at the University of Canterbury consisted of 10 courses in each year. That is in the process of being changed to 8 slightly larger courses. The 2011 courses for Civil Engineering students are shown in Table 2.

Table 2: A breakdown of the courses offered in the three professional years of the BE (Honours) programme in Civil Engineering at the University of Canterbury.

1st Professional year (all compulsory)

Semester 1	Semester 2
EMTH 210 Engineering Mathematics	ENCN 213 Design Studio 1
ENCN 221 Engineering Materials	ENCN 242 Fluid Mechanics and Hydrology
ENCN 231 Solid Mechanics	ENCN 253 Soil Mechanics
ENCN 261 Transport and Surveying	ENCN 281 Environmental Engineering

2nd Professional year (all compulsory)

Semester 1	Semester 2
ENCI 302 Engineering Mathematics 3 (Civil)	ENCI 303 Engineering Decision-making
ENCI 312 Design Studio 2	ENCI 333 Structural Steel
ENCI 332 Structural Concrete	ENCI 334 Computational Mechanics
ENCI 363 Infrastructure Management	ENCI 341 Fluid Mechanics 2
ENCI 383 Environmental Engineering 2	ENCI 351 Geotechnical Engineering 2

3rd Professional year (ENCI403 + 9 electives)

Semester 1	Semester 2
ENCI 403 Engineering Management - (COMPULSORY)	ENCI 415 Pavement Engineering
ENCI 412 Traffic Planning	ENCI 425 Steel Structures
ENCI 423 Structural Analysis	ENCI 426 Concrete Structures
ENCI 429 Structural Systems	ENCI 482 Solid Waste Management
ENCI 445 Coastal and Inland Waters	ENCI 495 Civil Engineering Project
ENCI 452 Geotechnical Engineering 3	ENCI 498 Special Topic - Design Project
ENCI 472 Engineering Geology 2	ENCI 499 Special Topic - Timber Eng
ENCI 481 Wastewater Treatment Design	ENNR 407 Advanced Hydrology
ENCI 494 Civil Engineering Project	ENNR 451 Engineering in Developing Countries
ENCI 496 Site Remediation	
ENCI 493 Civil Engineering Project (whole year, worth 2 courses)	

The proportion of the BE (Honours) in Civil Engineering programme dedicated to the sub-disciplines of structural and geotechnical engineering varies from professional year to professional year. As a rough guide, approximately 50% of the 1st Professional year, is in structural and geotechnical subjects (ENCN 221, 231, 213 and 253) - note that ENCN 213 Design Studio 1 is almost entirely an introduction to structural design. In the 2nd Professional year, this drops slightly to approximately 40% (ENCI 332, 333, 334 and 351) - note that ENCI 312 Design Studio 2 contains no structural engineering and minimal geotechnical engineering. And in the 3rd Professional year, those students planning to become structural and geotechnical engineers can populate up to 80% of their programme of study with courses in structural and geotechnical engineering if they take the six subjects ENCI 423, 425, 426, 429, 452 and 499, and also enrol in a full year project in a related topic. It is also possible for able students to select an elective course from the suite of 600 level masters level courses if they so wish, thus enabling them to extend their training in this specialised area. It is worth noting that ENCI 499 is a special topic because there are only sufficient resources to offer this course if there is an industry-funded staff member available to teach it.

Very few students in the final year of their degree will take all of the structural and geotechnical electives listed above as most feel that they need to retain some degree of breadth as they move into the workforce.

Ever since the Napier earthquake of 1931, the primary concern of structural engineering in New Zealand has been the impact of earthquakes on building performance. However, it is not possible to teach earthquake engineering until a large body of fundamental structural engineering concepts has been taught and well understood, along with the underlying mechanics and mathematics.

Serious consideration of seismic engineering does not come into the structural or geotechnical teaching in the 1st or 2nd Professional years, but it contributes up to half of the content in the structural and geotechnical engineering in the 3rd Professional elective courses.

3 Changes over Time

The range, content and depth of material taught in the BE (Honours) in Civil Engineering degree has changed over the past half a century. In the 1960s the degree at the University of Canterbury was primarily a structural engineering degree with very significant amounts of time dedicated to structural design. The staff profile within the department at the time reflected the predominance of the structural engineering sub-discipline. In the last 50 years the body of knowledge in civil engineering, like all disciplines of engineering, has expanded and, in some instances, structural engineering for example, has changed substantially. A narrow degree programme in one core sub-discipline was unsustainable and areas such as environmental engineering needed to be added to the core curriculum. However, as the four year degree structure was not expanded to cater for the expanding body of knowledge, the introduction and expansion of some sub-disciplines meant that the other sub-disciplines needed to contract.

The geotechnical engineering content of our degree programme has remained relatively unchanged over this period but a shift towards geotechnical earthquake engineering has occurred.

4 Post Graduation Education

The education of civil engineers does not terminate with their undergraduate degree. On joining the engineering profession they will have two opportunities to further their knowledge and skills. Firstly they will experience on the job training and mentoring from senior engineers working in their organisation. Secondly they have the opportunity to return to formal education, for example by undertaking a post-graduate degree (masters) or at least taking courses that could contribute to a post-graduate degree.

Post-graduation training of structural engineers was once heavily influenced by the Ministry of Works and Development. There was once a time when up to half of all civil engineering graduates entered employment with the Ministry of Works and Development, ensuring excellent on the job training for those engineers, with private employers doing their best to provide similar levels of professional development. Many older engineers have commented on the reduced level of post-graduation training since the demise of the Ministry, exacerbated by commercial pressures in private consultancies.

The University of Canterbury has no formal role in post-graduation training or education of structural and geotechnical engineers, other than offering masters level courses to the small

number of practising engineers who seek them out. However initiatives are already underway in the development of a specialised Masters programme in earthquake engineering that will be introduced at the University of Canterbury in 2013. This development is in direct response to the perceived need, post Canterbury earthquakes, for the upskilling of not only new graduates but also practising professionals who have a need for professional development in certain elements of earthquake structural and geotechnical engineering.

5 The Future: How to produce experts

As the science and art of structural engineering have grown steadily over recent decades, it has become increasingly difficult and time-consuming for young engineers to become expert in the design of large complex building structures. It is becoming apparent that something must be done to ensure a more thorough education of structural engineers in a seismically active country like New Zealand.

There are two options for increasing the structural and geotechnical content in graduating civil engineers:

1. To offer a specialised BE (Honours) degree in Structural and Geotechnical Engineering, by removing much of the general civil engineering content in the BE (Honours) degree in Civil Engineering.
2. To make a compulsory masters degree the entry point into the structural/geotechnical engineering profession, at least for the design of major buildings.

The first option goes against the prevailing view that in a country the size of New Zealand civil engineers should have a broad discipline base.

The second option is consistent with the trends internationally and would raise the status of engineering as a profession. It also provides a path for practising structural engineers to upgrade their skills on a progressive basis, by full-time or part-time enrolment in a masters degree programme. A taught masters degree (Masters of Engineering Studies in Earthquake Engineering) could be obtained in 9 months of full time study. A research masters degree with a thesis (Master of Engineering in Earthquake Engineering) would take 18 months full time, but this would only be available to a small number of students due to the supervisory demands of research based degrees.

The University of Canterbury would strongly support the move to a masters level qualification for practising engineers wishing to be involved in the design of complex buildings and their foundations, and has already made a commitment to provide masters degrees that will satisfy this need.

6 Research

In order to keep at the forefront of structural and geotechnical engineering education, it is essential for the University of Canterbury to maintain its leading position as a world-class research organisation with world-class academic staff. Improved understanding of building and ground performance under earthquake conditions and the development of new design methodologies come only through research endeavour. We aim to keep our position as providers of leading edge research and we will be seeking funding to refurbish our laboratory facilities to enable us to achieve this aim. It is our hope that the provision of the new specialist masters programmes described in Section 5 will also help to attract high quality research students.

7 Conclusions

The recent Christchurch earthquakes present a huge challenge and a huge opportunity to professional structural and geotechnical engineers. Education of future earthquake engineers and research into building and ground performance during seismic events are critical. In fact these two components are intrinsically linked, as education can only move forward if it is underpinned by critical research.

The University of Canterbury currently provides an internationally recognised and accredited degree in civil engineering. However because of the constraint imposed by the duration of a 4 year degree and the desire to train civil engineers with breadth it is not currently possible to train experts in structural or geotechnical engineering at undergraduate level.

It is therefore our view that the future education of civil engineers with expertise in structural or geotechnical earthquake engineering must come from a specialised masters degree, and that this advanced training must be supported by cutting edge research.

APPENDIX ONE

Excerpt from the letter to the Dean of Engineering and Forestry at the University of Canterbury from the Chair of the Royal Commission.

We see these matters as leading directly to a consideration of the way in which structural and geotechnical engineers are trained, the weighting given to those subjects in the degree courses at the Universities, how training continues after graduation, and the opportunities available or desirable for continuing education programmes to enable practitioners to keep up to date and to learn about recent development and research work. So we are very interested in the opinion of the universities with their core role of educating the engineers of the future. Your views on the process and time that may be required for an engineer to become expert in the design of large complex building structures would be welcome.

We want to reach a view, having heard from those with relevant interests, on whether there is adequate assurance that seismic considerations are adequately provided for in the training of engineers, and what improvements might be desirable.