STRUCTURAL ENGINEERING SOCIETY
NEW ZEALAND

Training and education of engineers and organisation of the engineering profession.

Submission to Canterbury Earthquakes Royal Commission

27 July 2012

Introduction

This submission has been prepared by members of the SESOC Management Committee. It is intended to reflect the views of the wider membership of the Society, although only limited consultation has been possible over the limited timeframe.

SESOC is a collaborating technical society of IPENZ, with a membership of approximately 1400, most of whom are practising structural engineers. Many of our members have participated in the review of buildings after earthquake, some as volunteers in the immediate safety evaluation phase, many more since in the detailed evaluations as the recovery begins.

The CERC discussion paper has raised a series of questions on the training and education of engineers and the organisation of the profession. These are discussed below in detail and a series of recommendations is made, where appropriate, following each.

Overview

The CERC paper discusses training and education in the context of building performance in the earthquakes. Implicit in this is the questions of what improvements may be made in order to arrive at better outcomes, namely more reliable performance of buildings.

It is important to consider the context of the issue, namely that the February earthquake was an event of unusual intensity and that many of the buildings in Christchurch were designed prior to the introduction of modern earthquake design methods. Given this point, it is important in these considerations (and others) to ensure that there is not an over-reaction to the perceived problems. In particular SESOC notes that the imposition of an increasingly complex and demanding compliance burden on designers is likely to do little to improve quality.

In SESOC's opinion two of the main contributors to poor performance in which rapid gains could be made are in addressing shortcomings in design review and construction review. Although standards of both design and construction would obviously benefit from improvement, currently too many errors and omissions go un-noticed. The earthquakes have revealed a surprising level of both. Both design and construction review have an element of education and training, but there are wider-reaching implications beyond this which should also be considered.

Responses to the Royal Commission Questions

Legislation – The Chartered Professional Engineers of New Zealand Act 2002:

1. What additional information, if any, should the CPEng Register disclose about a CPEng and how would this information improve, or potentially improve, earthquake building performance? What are the advantages and disadvantages of providing this additional information?

2. Comment, if possible, on the processes that Building Consent Authorities, and any other entities that have significant dealings with engineers, take or should take in reporting substandard performance of engineers to the Registration Authority which could underpin a future case taken by the Authority against a CPEng. What are the benefits, disadvantages and costs of creating mechanisms for reporting and recording poor performance in addition to those already available?

3. Provide well supported views and/or evidence about the potential magnitude of the problem of engineers practising outside their scope of expertise and what regulatory measures might be better employed to deter such behaviour.

4. Comment on the effectiveness of the current disciplinary procedures. What balance should be struck between deterring adverse behaviour and ensuring people are not deterred from entering the profession?

5. What are the key issues that arise from a voluntary registration process? How aware are consumers of engineering services of the differences between CPEng and non-registered engineers? What are the costs and benefits of formally requiring registration to enable an engineer to practice? Are there any other ways of increasing knowledge among consumers as to the merits of acquiring services from CPEngs over non-registered engineers?

Q1: The CPEng Register needs to disclose the Practice Area description for each engineer as described on the approved application form, noting that some engineers practice over more than one area, so the register needs to allow sufficient flexibility for this to be accommodated. An explanation of the importance of the Practice Area needs to be added as a footnote to the register. In particular (regarding earthquake damage) structural and geotechnical engineers need to be easily identifiable.

For further explanation refer to the response to Part 2 Question 2 below.

It should be noted however that this is simply a requirement to ensure that engineers are restricted to their established practice areas and experience - something that the existing code of ethics already requires. So this in itself is only a very small component of improving earthquake design, the majority of which will come from improved education, and design and construction review practices.

Q2: There are a variety of different consenting approaches used up and down the country. In some cases, BCAs complete their own review which may or may not include independent peer review conducted by engineers engaged directly by the BCA. Other BCAs require that all

significant work is peer reviewed by an independent consulting engineering practice prior to submission. This is often arranged by the client and BCA, who may rely solely on a PS1 and PS2 by independent practices to verify compliance with building standards. Where reviewers have been appointed by the owner directly, this has lead to questions as to the independence of the reviewer.

In completing a peer review of another engineers work there is no formal procedure to report on substandard work. In an ideal world, a peer review would not find any errors or omissions in completing a review, however in reality the peer review will typically find items which require further clarification or change. Any change resulting from a peer review is a professional embarrassment to the designer and will require an explanation to the client. The client would at that stage have an opportunity to lay a complaint with IPENZ. There is in some cases some level of audit being carried out by the BCAs who may ask for copies of correspondence between the designer and peer reviewer.

Where the work is reviewed by the BCA, there is opportunity for the BCA to lay a complaint with IPENZ.

There is also an independent confidential reporting process, initiated by IPENZ, called CROMIE (confidential reporting of matters in engineering) that has been set up to report wider issues that are encountered, which could include repeated systematic errors or omissions in design practice.

The issue of the Certificate of Code Compliance generally relies on the completion of a PS4 to verify construction monitoring of project. The issue of a PS3 by the company supervising construction is not mandatory, but often required by the engineer issuing the PS4. The PS4 normally only covers monitoring of random samples of important work, accordingly without the issue of a PS3 a large portion of work on building sites is not certified at all. This is a significant shortfall in our building control systems for complex projects.

Only in small domestic or light industrial projects where there is little complexity, should it be acceptable for the BCA to issue the Certificate of Code Compliance without certification (PS4) from the design engineer. This is currently the case where work can be signed off by an LBP, who may be a carpenter or other technically qualified person responsible for the construction.

It has been observed that the design engineer responsible for the provision of the PS4 may be held responsible in whole or in part for errors that may be discovered some time after construction is complete, particularly where the development and/or building companies are no longer in existence. This highlights a dilemma faced by designers in construction monitoring – although the construction monitoring procedures (as noted above) may allow only a portion of the work to be reviewed for general adherence to the documents, it only needs one piece to be poorly performed, to compromise the whole.

BCA building inspectors are not qualified to inspect major structural engineering projects and are rarely qualified engineers. BCA inspectors do visit building sites as required by the Building Consent but information about their inspections, or any non-compliance issues are not copied to the design engineers.

Consideration should be given to instituting a system of Special Inspections, as used in the US. Items requiring additional inspection are nominated under the Building Code (and may be added to by the design engineer). These are then required to be inspected by an independent inspector engaged by the owner, who reports back to the owner and the engineer. This role is similar to

that performed in the past by a clerk of works, but at a reduced overall cost. This process may be performed at a technician level, further helping to reduce cost.

If fully instigated, the Producer Statement system is robust and is the minimum standard that should be adopted throughout New Zealand. This is not currently the situation as in many areas the BCA accepts a PS1 from an engineer as sufficient evidence to grant a consent. This is suitable for smaller projects that can be subject to BCA in-house review, but may not be effective where this review cannot be provided, or for more complex projects. This may require the development of guidelines on a national basis to provide a degree of consistency. It is important to establish a balance between ensuring enough review (PS1 and PS2) for large or complex projects and not imposing too heavy a compliance burden on smaller projects where a PS1 should be sufficient.

The system is less successful if the peer review is not carried out in an adequate manner. There have been advances over the last few years, led by SESOC and ACENZ which have developed practice guidelines for carrying out review of designs.[1,2]

More directly addressing the question, the laying of complaints by BCAs requires a level of expertise in review that most currently lack, or reliance on the part of reviewing engineers employed by the BCAs to initiate the complaints. This is problematic as engineers in general are reluctant to report other engineers in view of the likelihood that' the boot may one day be on the other foot'.

However, the point remains that repeat offenders should be reported to the CPEng board for review.

Recommendations:

- The "Producer Statement" system comprising issue of a PS1 and PS2 should be adopted by all BCAs for projects over a certain size and complexity. They should also require issue of a PS3 (by on-site engineers for major projects, contractors for smaller projects) and PS4 (by the issuer of the PS1 who is monitoring construction) to verify the construction of the structure. Note that this should not over-ride current practices for Restricted Building Work on domestic-scale construction.
- Consideration should be given to establishing national guidelines as to when a full PS1/PS2 design review and PS3/PS4 construction review process should be required.
- An audit process needs to be established by –Ministry of Business Innovation and Employment (MBIE), the BCAs and IPENZ jointly to verify the Producer Statement system is being following. This audit process should then detect poor performance and respond with a requirement for remedial training or disciplinary procedures where appropriate.
- Mechanisms for complaints and disciplinary procedures should be followed. Questions of the competency of the BCAs to assess substandard performance need to be considered.

Q3: This question suggests there is a problem with engineers working outside their scope of expert, but without data to back this up, it cannot be verified. However there are probably more widespread problems with engineers working inside their scope of expertise, but without sufficient knowledge. A structural engineer needs to be expert in a number of structural codes, analytical techniques, construction practices, design guides and a vast amount of research and reference material used in developing in those guides.

[1] SESOC Practice Guideline – Independent Review of Structural Designs for Building Consent – September 2011 by Smith, Bradley and Vautier.
[2] ACENZ Practice Note A51 – Guideline to Review the Work of a Professional Consulting Engineer.

Every building project is unique and is therefore a prototype. The building industry could be compared with the aviation industry. The aviation industry requires every prototype to be extensively tested before it is commissioned. They then continue to log every defect throughout the life of a plane. Records of problems in one plane are used to rectify other planes before the same problem occurs. The building industry has some similar practices in the reconnaissance and research that follows earthquakes, but there is no log book for buildings, and retrofitting will normally only occur when a building is altered, or through BCAs earthquake prone building procedures.

The engineering input in to the design of a plane is far more extensive than the engineering input in to the design of a building – yet every building is a prototype and the life of a building is generally greater than the life of a plane.

Improvement can be made to the building industry by increasing the engineering input in to the design of buildings. However the industry is often cost-driven, and so competitive bidding for work (largely reviewed on fees, despite many suggestions to the contrary) inevitably drives the 'successful' engineers to deliver the project on tight margins, allowing little time for review. Any building design should be subject to the scrutiny of a number of experienced engineers as part of the QA process in a design office. This will reduce the risk of analytical errors, reduce the risk of engineers unwittingly working outside their scope of expertise, and reduce the risk of unknown unknowns. To quote Donald Rumsfield *"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. These are things we don't know we don't know"*. It is the unknown unknowns that present the greatest risk.

Smaller design offices are potentially at greater risk in not being able to host effective QA processes that incorporate the input of engineers who have sufficient experience to eliminate the unknown. Regulatory measures should be aimed at ensuring the correct QA processes take place rather than being aimed at individual engineers who unwittingly have failed to recognise unknown unknowns. A "Collective Knowledge" approach will be more effective in improving building designs than a "Big Stick" approach.

Consideration may be given to instituting a system of mandatory review for buildings over a certain size or assessed level of complexity. However it is critical in all cases, that design engineers assume full responsibility for their designs and perform adequate internal review. They must NOT assume that external review for Building consent purposes is their quality assurance procedure.

Notwithstanding this, there is a possibility that if it were widely known that disciplinary procedures under the CPEng act were being more strictly imposed, it may be an effective deterrent to those practicing outside their area of expertise.

Recommendations:

- A Practice Note be developed on the appropriate QA procedures for various building projects, including the review by appropriate engineers. Records of the QA process should be kept and submitted as part of the consent documents along with the PS1. A similar QA procedure should be adopted for the Peer review and QA records should be issued with the PS2. All buildings above a certain height/size/public risk should be independently peer reviewed as a mandatory requirement. The QA records should be audited by the DBH/BCA/IPENZ authority.
- Consideration should be given to introducing an independent reviewing process for key elements of buildings that may require continuous or 100% review.

Q4: There must be disciplinary procedures to respond to adverse behaviour. To be effective, these must be applied fairly and obviously. Current disciplinary actions are publicised by IPENZ and read with interest by engineers. However SESOC members are aware of instances where designers should have been held to account but discipline has not been applied. There may also be wisdom in a mechanism to provide coaching and support to engineers who are struggling within their competency area, before applying disciplinary mechanisms.

Current disciplinary procedures are of no benefit to the vast majority of engineers who are diligently working to achieve successful code complying designs, and to monitor construction activities. The legal and associated financial consequences of having to remedy any shortfall in design or construction activities are a compelling motivation to achieve competency.

Unfortunately, there is a need for disciplinary measures to control a minority group who are impervious to professional responsibilities. This should be undertaken by the profession.

Achieving this balance is critical, but there is no easy measure of where this lies. Every engineer knows that mistakes are a fact of life, so are reluctant to be too judgemental. This makes the profession itself the best group to judge whether professional standards have been met.

Although it is possible that the imposition of harsh disciplinary procedures may be a deterrent to some people entering the profession, it also could be seen as a strong profession that takes pride in its standards, that would therefore encourage the right people to enter it.

Q5: Non registered engineers are working within the profession and may lack the benefits and controls of CPEng training and registration. Where they are working under the supervision of a CPEng engineer, this is simply a natural progression, but there are other cases where they have simply not bothered getting chartered as they do not see the point in doing so. Registration should be mandatory for signing of Producer Statements, following which it is likely that the latter will become chartered.

This assumes that CPEng is the appropriate quality mark for professional engineers. By everyone's admission, it is currently an 'entry-level' professional qualification. If it is considered that a higher level qualification is required for projects of greater complexity, a further qualification will need to be developed.

Non-registered engineers working on building sites are common, and these engineers should be encouraged to become chartered. A requirement for a CPEng to sign a PS3 Producer Statement on major buildings should be mandatory, and would be beneficial in eliminating un-professional practices that are widely recorded on building sites.

Training and Education of Engineers:-

1. Should a graduate programme of development (continuing professional development) be prescribed? There are a number of questions underpinning this question:-
    - Where would responsibility lie for prescription of a graduate programme?
    - How would a prescribed programme be quality assured?
    - Compare the advantages and disadvantages of this approach to the status quo, which includes the tacit approval of employers for courses selected (since the employer pays).
    - How would a prescriptive approach manage the differing needs to engineers in their respective workplaces, if any?
    - How could competency requirements be provided where those skills are considered valuable by the New Zealand public but have less or no value to an employer? Who would pay?
2. Comment on, and where possible, provide evidence or well supported analysis on the issues raised above by the Royal Commission.
3. Comment on the current process of development of continuing professional development course options. In particular, what roles are taken by employers, engineers and education providers in determining the appropriateness of content to be taught and the demand for courses?
4. Should CPEng re-registration, with its associated competence assessment, be required at shorter intervals than the current 5-6 years, and what are the associated issues? Could some other method of competence confirmation be implemented mid-term instead?

Q1: Many organisations have IPENZ approved graduate programmes. Commonly this is based around mentoring and commitment to training. Enrolling as a Graduate Member of IPENZ/SESOC should be encouraged and should help demonstrate competency when going for registration.

It will be difficult for prescribed graduate programme of development as suggested to cater for the diverse and complex nature of structural engineering. A graduate programme targeting structural engineers destined to design multi-storey buildings would be enormously beneficial to many larger offices. However the same programme may be of little value to engineers in smaller centres around NZ, or for engineers that specialise in areas such as construction, precast flooring design, management tasks, façade engineering, civil engineering etc.

A greater variety of post-graduate training and development options needs to be offered, but it is not recommended that this be imposed prescriptively. Several members commented specifically along these lines, including one particular member, who submitted: "*I do not favour a prescribed programme of development. I think that a stronger profession will result where engineers take*

personal responsibility to seek out the training and input to keep current and develop with senior engineers and mentors providing oversight & coaching along the way. As a senior engineer/mentor for Downer, I skim all the CPD courses that come across my desk with a view to attending or sending graduates. There are not many that are both relevant and affordable but we have a strong mentoring network and run several in-house courses. I accept that there needs to be more input, especially from Contractors into course content - particularly with associations like SESOC and the NZ Concrete Society. I would not favour a shorter period than the current 5-6 yrs for competence assessment"

The responsibility for ensuring that engineers have adequate training is primarily their own, with support from their employers and professional bodies. The verification of this is part of the CPEng review process.

Q2: A common misconception within the building industry and public at large is that a CPEng is knowledgeable and expert at all matters relating to engineering. Better informed people understand that structural engineers are a distinct branch of engineering but still harbour a misconception that a CPEng, who is a structural engineer, is knowledgeable and expert at all matters relating to structural engineering.

The following was provided by a member of our management committee:

Your discussion paper (section 6.1) describes IPENZ advice on the appointment and training of Practice Area Assessors. I have been a practice area assessor for several years and recently attended an IPENZ refresher course. At that course I noted a wide variety of assessor backgrounds varying from retired engineers from small rural towns to engineers who have recently immigrated form other countries. Of approximately 20 engineers at the course only one other engineer would have a background similar to my own in designing large building projects, yet I believe a large number of the attendees are structural Practice Area Assessors. Although IPENZ draws on learned societies for selection of assessors, I am convinced that these societies do no more that provide contact information about their members to IPENZ.

It is clear that Practice Area Assessors come from a wide variety of backgrounds with varying structural engineering expertise. The candidates also come from a wide variety of backgrounds and may demonstrate competence in the projects that they have highlighted in their CPEng application. The assessors and candidates meet and discuss the 12 elements required of them for admission to IPENZ and granting of a CPEng. However the granting of a CPEng to an applicant, even with a well described practice area, is no guarantee that the applicant is knowledgeable and expert in all matters relating to structural engineering.

The requirement for continuing professional development is in effect an acknowledgement that CPEng engineers are not knowledgeable in all areas of their practice fields.

All engineers, with or without CPEng, will have gaps in their knowledge, will be prone to errors or oversight, and will be prone to misinformation or misinterpretation by others.

Recommendation:

- The CPEng registration process is successful in recording engineers who have attained a level of knowledge, and understand good practice in engineering, but the involvement of a CPEng alone, is not an adequate mechanism of ensuring that a building design and construction meets the objectives of the building code.

Q3: The various professional bodies referred to below, as well as our universities, are actively canvassing engineers to determine the demand for professional development courses. Such courses are regularly advertised. This supply and demand chain works well.

CPD courses are an important means of developing engineering knowledge. Equally important is the on-the-job experience gained in tackling various design tasks in the design office, and stepping on to building site witnessing the problems that occur on building sites. The role of the employer in providing this training is critical.
There is concern over engineers who are isolated either through working in small practices or in outer-lying areas, who do not have access to CPD opportunities. It is important that these engineers are prepared to travel and read widely to compensate. Membership of (and participation in) the learned societies is a further important initiative to ensure adequate CPD.

Q4: This question again suggests there is a problem with the registration process. The level of competency of engineers is unlikely to rapidly change – except for when one might retire or cease to practice. The reassessment of an engineer is not an automatic guarantee that they will be faultless in all their work. Accordingly there will be no benefit from shortening the re-registration duration period.

The Role of Professional Societies in the Engineering Sector:

Comment on the efficacy and efficiency of the conduct of the engineering learned or professional societies in respect of the:-

- interactions between structural engineers and geotechnical engineers and others, and between engineers and architects on the construction of buildings;
- engagement by learned or professional societies, both internally and with one another for the purposes of bringing attention to and resolving contentious issues, and achieving improved outcomes across the industry;
- the appropriateness and durability of, and risks that could arise through, the engagement of volunteers (society members) to formally inform or develop policy and/or standards of practice; and
- the standing of guidance or advice issued by societies, and monitoring and consequences (if any) of non-compliance.

New Zealand has a disparate group of professional bodies and learned societies that serve the profession in different ways. Examples that just one engineer could be a member of include:

- IPENZ
- IPENZ Branch
- Structural Group
- ACENZ
- Structural Engineering Society
- Concrete Society
- NZ Society of Earthquake Engineers
- HERA
- Timber Design Society
- NZIOB

The number of bodies that a structural engineer should belong to reflects the complexity of the structural engineering professional and diverse knowledge that is required of an engineer. Each the above bodies makes an important contribution to the industry but there are many more.

The guidance offered by societies is not mandatory, which is appropriate. However, they represent industry best practice and so those who choose not to follow this advice should do so only with adequate consideration of the alternatives.

At present, Standards NZ is ineffective in keeping design standards up to date (e.g. NZS 3603 was published 19 years ago) and it is falling more to societies to try and provide design guidance to fill the gaps. They are all more or less reliant on volunteer time to develop such guidance and to develop standards. This time is harder and harder to find.

Better distinction needs to be drawn between the role of industry guidance and Standards or the Building Code, and more support needs to be given to the appropriate people to be involved in developing each. Without this, the development of codes and standards is open to abuse from vested interests.

Interaction between engineers and architects, property developers and contractors is an area where improvements can be made which will improve the design of building structures. There has been a much publicised comment about the Hotel Grand Chancellor, where an engineer appearing before your commission implied the architect was the reason why an external wall of the building did not continue to the ground. To suggest an architect is to blame for a structural weakness is not plausible, however there is an element of truth in this statement. The SESOC Bulletin recently published a paper by Kam & Pampanin & Elwood calling for a stronger emphasis on a ductile inelastic mechanisms, robustness and redundant load paths.

It is common for architects to lodge drawings for Resource Consent without engineering input. Once granted the structural engineer commences work on the back foot trying to fit a good structural solution into a design which is locked in to a Resource Consent approval.

Geotechnical and structural engineering interaction is a most critical area which has been acknowledged to require greater attention. However this is something that can be facilitated by the societies, not enforced.

Recommendation:

- The Resource Consent process needs to include a requirement to demonstrate a robust structural system, so that the structural system is brought to the forefront of the design. As part of the Resource Consent review the structural concept could be reviewed by a suitably experienced engineer to ensure it meets the requirements of Kam & Pampanin & Elwood.
- A joint practice advisory may be developed between the NZ Institute of Architects and IPENZ/SESOC etc which gives guidance on the type of engineering advice that should be obtained at each stage of a project.
- This could be extended to a common English engineer/architect practice note aimed at building owners/clients on the advantages of good advice and early engagement of design consultants, including geotechnical advice.

Conclusion

Improvements to the organisation of the engineering profession are best targeted towards the processes that are followed through the design and construction of buildings. The key requirements of the design and construction process should be:-

- A rigorous design process including QA procedures that involve input from a sufficient number of engineers to verify Building Code objectives are met.
- A robust peer review of the design, including QA procedures that involve input from experienced engineers.
- Site engineering supervision of construction work by engineers employed by contractors.
- Engineering construction monitoring by the design engineer to peer review site engineering supervision.

Specifically the following actions should be taken:-

- A structural requirement should be added to the Resource Consent process to demonstrate that a robust building structure is achieved as part of the building concept.
- The Producer Statement regime should be legislated. CPEng signatures should be mandatory for all design and design review producer statements. For projects over a certain scale, this should extend to construction and construction review also (PS3/PS4).

- A Practice Note on QA processes for building structures should be developed, incorporating requirements for broad engineering input in to the Design, Design Review, Construction and Construction Review of building projects.
- An auditing body should be jointly created by MBIE, TA's and IPENZ for the enforcement of these procedures. This auditing process should be linked to remedial training or disciplinary procedures as appropriate.