STRUCTURAL ENGINEERING SOCIETY
NEW ZEALAND

Building Management after Earthquakes

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 for 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 overall building management process. These are discussed below in detail and a series of recommendations is made following each.

Overview

Building Management following earthquakes comprises mainly the safety evaluation processes defined in part in the New Zealand Society for Earthquake Engineering Rapid Safety Evaluation guidelines and the Engineering Advisory Group Detailed Engineering Evaluation procedures. However the application of these procedures is complex and the responsibility is spread across a number of bodies.

The building safety evaluation processes following the September 2010 earthquake through to the February 2011 earthquake have subsequently come under intense scrutiny. The tragic loss of life in the February event may have been inevitable, but there have been questions as to whether different procedures may have led to a different outcome. In particular this has focused on the assumption that buildings without obviously diminished capacity as a result of the earthquake may be occupied without further detailed evaluation, even acknowledging that the evaluation will follow the visual assessment.

It is SESOC's view that although there were some instances where the building reviews may have been better executed and there is room for further improvement in procedures, the overall outcome was probably as good as could have been expected given the scale of the task and the unusual nature of the events.

Notwithstanding that, there is much that has been learned form the earthquakes that should be taken forward for inclusion in future legislation and procedures. Perhaps the most valuable lesson is that there is no substitute for preparedness. In particular the need to review and improve the evaluation and implementation of the Earthquake Prone Building legislation.

Responses to the Royal Commission Questions

New Zealand's building safety evaluation framework:

1. What objectives should the building safety evaluation framework should target; should its main objective be ensuring public safety, or should it incorporate other aims? What would the process look like if other objectives were added? What are the risks associated with focussing on the one objective over another?

2. How did the building safety evaluation operation after the Canterbury earthquakes highlight any weaknesses and failures in the current system? Can these failures be addressed, or should we move to a different building safety evaluation model? What are the advantages and disadvantages of these models and approaches, and how do they compare with our current framework?

3. Who would be responsible for setting up and/or implementing any new framework? Should the roles and responsibilities in the building evaluation system be set at national or local level?

4. What are the risks, costs, and benefits of using a building safety evaluation system that uses volunteer engineers who have a liability waiver? Are there any options that address the risks associated with using volunteer engineers that do not discourage them from volunteering?

5. What framework should be used to evaluate buildings when a state of emergency is not declared but buildings are damaged (for example, after an aftershock)?

Q1: Public safety has to be the primary objective; however it needs to be tempered with the further objectives of not unnecessarily shutting down businesses, restricting the local economy or leaving people without basic amenities.

To focus solely on public safety at all costs would result in people and businesses being evacuated from serviceable buildings until given structural clearance to return. This may be possible for a small scale event that affects a very small number or structures, however in a large scale event it would cause unnecessary hardship, overload resources and not be reflective of the actual risks represented by the majority of structures.

The existing framework is sufficiently flexible to accommodate these secondary objectives and in fact was used in that way in some cases – those buildings which contained critical functions were generally given some latitude to allow operations to continue, with emergency repairs if required.

The safety evaluation framework needs to maintain simplicity and flexibility in order to be effective and quickly deployed when needed. Adding complexity with an increased range of considerations could reduce its effectiveness, noting that the framework already allows these broader considerations to be included. It is considered that these broader objectives are therefore more a consideration of overall emergency management either by Civil Defence, or the TA as controlling entity.

Recommendations:

- The current emphasis on public safety should remain, but the secondary objectives of minimising economic loss and maintaining amenity (particularly shelter) should be clearly articulated.
- Any amendments to the procedures to incorporate the secondary objectives should be limited in scope to ensure that the procedures remain as simple as possible.

Q2: The safety evaluation framework must transition into a recovery/re-occupation framework in a timely fashion. The fundamental philosophical questions that need to be asked are:

- Is the current practice of a 2 stage rapid evaluation followed by a non-mandatory detailed evaluation appropriate?
- Is the current model of reacting to seismic damage once observed appropriate?

One of the most obvious weaknesses with the safety evaluation process is the lack of preparedness, which manifested itself most in the wide variation in quality of the reviews. Although training would obviously overcome this in part, it should be noted that there is no substitute for experience. This was clearly demonstrated by the improved quality of reviews in subsequent earthquakes, noting that following the June 13th 2011 event that a relatively small group of experienced well-trained engineers was much more effective in completing a rapid safety evaluation in the CBD than a larger group of engineers without sufficient training or experience could have been.

This would be greatly assisted by the availability of field manuals that describe damage in some detail. Although it is debateable whether these could in practice be carried and referred to in the field, having a reference guide available for review and for training purposes would be invaluable.

One of the greatest problems prior to the earthquakes was the lack of a framework for the detailed evaluation of earthquake damaged buildings, both in the technical procedures and in the statutory framework. The Department of Building and Housing (DBH) Engineering Advisory Group (EAG) was instrumental in preparing a set of guidelines for the Detailed Engineering Evaluations (DEEs) in Canterbury, which were then made mandatory across Christchurch, enabled by the CER Act. In the future, this should be addressed within the Building Act, and the guidelines need to be reviewed and completed in comprehensive form for use across the whole country.

The DEEs have shown that, even allowing for the variation in ability and experience of the assessing engineers, there is often remarkably little correlation between assessed capacity and damage to many buildings. This further underlines the point that the completion of quantitative analysis should not be required before reoccupation of undamaged buildings. However, the identification of vulnerabilities in the buildings is considered of greater importance, as these have more impact on the future performance of the building. This suggests that the EPB legislation also could be reviewed in this light.

Looking for potential vulnerabilities as part of the DEE stage, in effect, is the first step in improving the robustness of our building stock. It takes essentially no additional time and allows owners/stakeholders to make informed choices on the level of risk they wish to accept.

Learnings from the work the Engineering Advisory Group (EAG) have done should be considered in the context of the above question. Many of their tasks were necessitated because

there were no existing systems or methodologies to solve the problems encountered. Particular attention is drawn to the need to develop and improve the DEE guidance and guidelines.

The following system issues are highlighted:

Legislative:

- Building evaluations have been carried out in Christchurch under three pieces of legislation, namely, the CDEM Act, the Building Act, the CER Act. Each of these acts has a differing responsible agency. This has the potential to create confusion because of potentially different requirements, different interpretations and different operational policies. In addition, role clarity is essential as is coordination of effort and agreement on operational policies to ensure smooth integration and where it occurs, transition from the role and authority of one agency to another as well as coordination when multiple agencies have concurrent roles..
- Lack of guidance on what does or does not constitute acceptable/unacceptable risk. This is particularly important in respect to occupation and temporary/permanent repair design. Particular attention is drawn to the order in council (OIC) regarding dangerous buildings and the subsequent need for DBH guidance on occupation.
- This is further compounded by the Health & Safety in Employment legislation. Under this, the responsibility of employers to identify risks and then mitigate or avoid them t the extent possible has been interpreted by many to include risk from earthquake safety of buildings. As the Department of Labour have so far declined to provide guidance, this has in a number of cases resulted in buildings been vacated that may otherwise be considered an acceptable risk under the Building Act or DBH guidance.

Communication:

- Due to legislative subtleties and a staged building inspection regime, the public and some building owners were not well informed, or were confused regarding building status during the evaluation process. Even with accurate information the significance of building status was often only partially understood by the public. Examples included public perception of what a green placard means (absolute vs. relative safety) or how some building owners thought the council would undertake all necessary inspections.
- Some requirements only developed as the rapid assessments and evaluation processes developed. . For example, early in the response it was necessary to brief engineers to write phone numbers and notes on placards so subsequent inspection teams could consult with previous inspectors.
- Christchurch was very fortunate in that whilst a large urban area, many of the engineers were familiar with each other and communication happened via informal channels as people knew who to contact for various pieces of information. This could be expected in smaller centres however more formal information sharing and communication channels would improve the emergency response in larger centres.
- After the initial voluntary inspection phase, more detailed inspections by engineers acting for clients were carried out. There was no compulsory, standard, universally understood system to convey this information to the controlling authority or the public. The result was that initially the controlling authority often did not have the most accurate, up-to-date information to allow informed decisions. Attention is drawn to consultants developing their own placarding system or consultants knowing about damage to buildings that the controlling authority did not and yet expecting the controlling authority to provide cordons on damage it know nothing about. This issue has been rectified in greater Christchurch by the CER Act s51 and the standard reporting spreadsheet.

- The role of the media in this should be considered carefully. Often misinformation was perpetuated by the wider media, and their potential positive role in communication of important information was not used as extensively as it could have been.

Roles and Responsibilities:

- Throughout the evaluation process there have been issues arising from:
  - The varying stages and controlling authorities discussed above.
  - The supply of information about building status discussed above.
  - When building owners need to take over from the controlling authority in dealing with their building(s)
  - Lack of common understanding regarding who is authorised to issue, attach and remove placards
  - Lack of common understanding regarding who is responsible for recommending, maintaining and removing cordons.

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Time frames:

- Placards placed under CDEM act have an expiry date automatically 60 days from the lifting of the declaration. These were extended subsequently by OIC. Section 124 notices have a 60 day expiration date and CERA s45 restrictions have no expiration date. In a large scale recovery operation such as Christchurch, the expiration dates of notices fixed under section 124 of the building act or CDEM act are often not sufficient to fix the problem.

Resources:

- The rapid assessment phase of the building safety evaluation relied on a combination of volunteer and paid staff. Private engineering staff were mostly voluntary while governmental and local authority staff were mostly paid. This meant that continuity of the voluntary staff over the long term was not sustainable.
- Many of the staff used had not had prior training in the tasks they were assigned, hence there was an element of on-the-job training required. To some extent this is inevitable as every disaster has a unique set of issues that requires continual learning and because resources need to be rapidly mobilised.

Data Management:

- Building safety evaluation relied on manual, paper forms being completed. These were then sent away for data entry/processing. These forms were often not easily available for review during subsequent re-evaluations and in some cases mislaid and unavailable.
- Multiple property descriptions, addresses and or differing street numbers also caused confusion. Individual building numbers were allowed by the CCC to lapse in the early 90s, resulting in there being no easy way to determine what buildings existed on a site and which were being referred to in reports.

Despite the observations above, balance is required in our assessment of the outcomes achieved. Given the scale of the event and the resulting impact, the recovery has been, in many ways, a positive demonstration of what can be achieved under difficult circumstances. Although training and experience are invaluable, the ability to adapt to circumstances is more important. The fact that evaluation systems have been developed and controls imposed in relatively short time, that are adapted to the particular circumstances of the event should be acknowledged. To the extent that future legislation, planning and training addresses these issues, flexibility must be maintained.

Recommendations:

- All legislation to do with Buildings should lie within the one Act, preferably the Building Act. It may be sensible to have a section in the Building Act that requires some form of disaster to trigger its use. But in any case, the legislation should be enabled under the CDEM Act or possibly the Local Government Act, for application by Civil Defence and/or the TAs respectively.
- A minimum level of risk should be described in the Building Act, and this should include what constitutes acceptable risk for occupation both before and after an earthquake. Caution on sole reliance of %NBS is advised.
- A national education programme on placarding is recommended. Pre-prepared press releases etc should be ready to go via media immediately after an earthquake.
- The placards should have room for damage summary and basic building information should be readily available.
- A central data base should be available for contacting engineering resources.
- A central data base containing basic building information, including EPB status should be developed and should be readily available on mobile data technology.
- A mandatory, consistent, way of recording building status should be adopted nationally. This could be similar to the CERA s51 system.
- Preparedness and training of staff is important.
- Databases and inspection forms should be continually monitored and advances in technology used. Real time data management should be used in future events and technology such as laptops/tablets/mobile phones should be used.
- Authorities need to ensure that property descriptors/addresses for individual properties are consistent no matter where they are recorded
- Roles and responsibilities need to be clear, communicated and documented so all parties understand where they fit into the process.

Q3: The current system of rapid safety evaluations has evolved largely through the efforts of the New Zealand Society for Earthquake Engineering (NZSEE) with support from DBH and the Ministry of Civil Defence and Emergency Management (MCDEM). It has drawn heavily from the US guidance, ATC-20[1]. The DEE procedures have been prepared by the EAG, operating under DBH, but issued through SESOC, to alleviate concerns over clashes with existing legislation and policy. The placarding has been problematic, initially issued under Civil Defence, and then transitioning to the local authorities (and CERA since the February 2011 earthquake).

The experience through the earthquakes has highlighted difficulties of having the guidance and administration of guidelines etc spread over too many organisations. Ideally, all of the above would be administered under the Building Act. The role of the learned societies in writing and editing the guidelines is pivotal, but as these societies are non-profits acting within the available unpaid time of their members, if there is to be a quicker, better coordinated development program, it will need to be supported by an official body, and paid for. The EAG structure appears to be working well, but may benefit from additional resource in the short term.

The assignment of roles and responsibilities may be determined according to the scale of the event, but an evident failing of the EPB legislation is the devolution of responsibility to a local level, resulting in a plethora of different approaches. If building safety is a national concern, policy should be determined at national level.

[1] ATC-20. Procedures for Post-earthquake Safety Evaluation of Buildings. *Applied Technology Council, California, 1989*

Recommendations:

- Setting, implementing and maintaining a building evaluation framework should be driven by a government body at a national level. Seeking help from, and consultation with, stakeholders is recommended.
- The majority of the framework should be national to ensure consistency, but there needs to be a mechanism for local input as deemed essential by a local community. This may include such matters as a local heritage policy or local structures of significance.

Q4: The need for voluntary engineering support in the emergency phase has been clearly demonstrated, and there must be no hurdles to participation from all who are capable and willing. Even the necessary process of the commission of inquiry has been (anecdotally) a deterrent to many engineers, who perceive the profession as being unfairly held to account for failings in procedures without the wider context being considered.

Perceived failings in the safety evaluation process post-September 2010 are coloured by the loss of life that occurred in February 2011. However, it is of considerable importance to note that although it the loss of life in February 2011 was one of NZ's greatest tragedies, had there not been the earlier events and the building evaluations that followed, the total loss of life may have been much greater. Although there is not total consensus, it has been generally concluded by expert review to date that the major building failures (PGC and CTV) are unlikely to have been significantly compromised by significant damage in the September 2010 event.

Although there may remain some questions with respect to individual buildings, it must be concluded that the procedures were adequate (although could be improved) and that the need for voluntary engineering effort remains.

There are a number of risks associated with relying on a volunteer force of engineers, including:

- There is no surety they will be available when needed
- They may only be available for a limited time period
- Continuity/corporate knowledge is lost if you have a rotating roster over a long period of time
- The controlling authority does not know what resources they have to plan with.
- The skills required for a particular situation may not be available from the volunteer base.
- Valuable time and resources may be required to supervise, re-do or manage volunteers who may not have the full knowledge or experience to undertake the tasks asked of them.
- Consistency of following systems/procedures may be lower than ideal
- Quality assurance may be compromised due to the relatively informal nature of the volunteer workforce.

  NB. Many of these risks could be minimised by preparedness training of volunteers, maintenance of a database and well thought out management plans.

Costs:

- Monetary costs are minimised for engineering resources but a small increase in management cost could be expected.
- Efficiency may be compromised initially through the additional training required and later through lack of continuity due to non-availability over an extended period of time as volunteers become unavailable and return to their normal duties.

Benefits:

- More engineers are available than if relying on an identified and dedicated engineering workforce.
- Out of town resources are able to respond with less emotional attachment.

Considering the question of the liability waiver in more detail, factors to consider in having a liability waiver (or not) may include:

- A lack of responsibility and accountability for the outcomes of the reviews. This is not considered a major risk. As a profession, engineers aspire to high standards and tend to have approached this work no differently, whether under a waiver or not. However, lack of such a waiver may discourage many from participating, in particularly those who are most conscious of the risks and therefore arguably of most value to the process.
- Having the waiver enables more engineers to participate; as otherwise, those who understand the professional risk would not join in. Conversely, some of the participants who were thus able to participate were not so well qualified to do so, with resulting poor outcomes. This caused most difficulty in the early stages, with repeat visits required in some cases.

The current system of liability waiver seems acceptable to most volunteers. However it is not clear if it requires a state of emergency to evoke under the CDEM Act. It is recommended that other models such as being seconded under a controlling authority and having that authority fully indemnify the volunteers would achieve the same result. It is also noted that while resources are scarce in an emergency, building evaluations should be undertaken in pairs so as there is opportunity for a review process on site that would reduce the actual and perceived risks that engineers take when exercising their professional judgement in the difficult and time-compressed circumstances that exist in emergencies.

Recommendations:

- A small, core, group of paid employees are maintained for building evaluations. This group should be geographically spread and provide a core of expertise to supplement volunteers.
- Potential volunteers should be identified and provided some level of pre-training and their contact details recorded on a data base, similar to the ATC 20 system.
- A method of full indemnification should be pre-agreed that can be enacted without the need for a state of emergency.
- The costs for maintaining this data base and training should be borne by society and not the individual volunteers.

Q5: This was illustrated in the case of the Boxing Day earthquake (December 26, 2010), for which no state of emergency was declared, although some consider this to have been a greater public safety issue than the September 2010 event, with members of the public in the affected areas, often with little awareness of the potential danger.

The safety evaluation procedures to be followed in such cases should be no different to those used during the state of emergency. .

Ideally a building evaluation framework would be undertaken under the Building Act. The current framework could and should be improved and modified for this purpose. Whoever has the delegation to declare (or not) a state of emergency should have the authority to second and fully indemnify people under the controlling authority (council). This model could/should have been used for the Boxing Day earthquake and was used for the June 13, 2011 event. The CBD building evaluation for June 13 2011 event was undertaken quickly and effectively by CERA secondees, who were fully indemnified under CERA.

When considering aftershocks it is important to have a clear decision process and criteria for when to start re-inspections if valuable resources are to be used efficiently. Indicator buildings in Christchurch were used for this purpose. An additional refinement that should be considered is the use of real time accelerograph technology. This is more accurate than Richter scale and is being proposed for risk associated with the Port Hills.

Recommendations:

- The current system is able to be used for aftershocks.
- Clear decision processes and criteria should be adopted so that re-inspection as a result of aftershocks is instigated as required. This will ensure maximum efficiency of resource use and will ensure data management/collection is up-to-date while minimising effort.
- During the rapid assessment phase buildings are considered safe until proven otherwise[2]
- Any potential vulnerability discovered during the DEE phase need to be communicated to the relevant stake holders so the risk can be properly understood.

[2] An exception for URM buildings may be justified. It may be prudent to confirm parapet/appendage/façade connections are robust. Ideally this would be done prior to an earthquake as part of an EPB policy.

Specific issues with the placard system used in Christchurch:-

1. What were the issues with how people placed, maintained, and removed the placards? How did understanding or misunderstanding of the placard's meaning affect people's behaviour; think about whether the wording and/or colour of the placards contributed to any problems. What was the extent of these problems, and could they occur in other parts of the country?

2. Do you know of any situations where building owners brought in engineers to assess a building and they used a different placard system? If so, can you give reasons why this approach was taken? What did buildings owners and/or engineers do to inform officials of the results? How should we address any issues?

3. How well did individuals, organisations, agencies and the wider public communicate and share information with each other after the Canterbury earthquakes; identify any gaps, failures and good performance. What could have improved how people communicated and shared information?

4. What skill-sets do engineers need to accurately or adequately evaluate a building following an earthquake or aftershock? Are different skills needed to assess buildings of different ages and for different purposes? What are the advantages and disadvantages of requiring engineers to possess certain expertise/capability before they can become building safety evaluators?

5. What are the relative advantages, disadvantages, costs, benefits and risks of adopting a damage-based assessment, or other assessment methodology? Do fundamental changes need to be made to how people assess whether, how and when a building is at risk from aftershocks; for example, when it is appropriate to work out the residual seismic capacity of a damaged building?

Q1: Both official and unofficial placers were placed after the Christchurch earthquakes.

Unofficial placards were issued without any legal authority or meaning. These tended to fall into two generic types, those that followed closely the wording and intent of the official ones and those that differed significantly. Understanding the reason behind these placards is important as it will indicate what public perception was at the time.

In support of the unofficial placards, it seems evident that there was a need/desire by building owners to convey building status information to the public or occupants. However, these unofficial placards were uncontrolled in terms of placement, maintenance and removal. More discussion is given below on this.

Official placards also sometimes caused confusion. Official placards could be issued under CDEM Act by the controller or delegated persons, the Building Act by the Council or its delegated persons, or the CER Act by the Chief Executive or delegated persons. There were also differing placards for residential vs. commercial, which caused further confusion. We are only considering those issued for buildings here, but there were (and still are) those issued for land also.

Of the official placards issued the following issues were encountered:

- There was initially no indication on placards if they resulted from level 1 or 2 rapid inspections or even more detailed inspections had been carried out.
- There differences in approach amongst reviewers as to what constituted a yellow vs. red placard. The arguments often went along the lines of "if I give it a red placard people will not be able to retrieve any items, however it is possible to do limited retrieval of there is a yellow placard." Or "if I give it a red placard then further inspection/repair will not be able to happen."
- People thought that a green placard meant that the building had passed a rigorous inspection, where-as this was not the fact or the intent.
- With the exception of the CERA s45 notice, there is no public database to check placard status. Anecdotal rumour suggests some owners removed placards they did not agree with.
- Multiple placards were often assigned to a building, this generally happened for following reasons:
    - Level 1 vs. Level 2 Rapid inspection.
    - The one building was split into multiple tenancies with multiple street addresses
    - As more/additional inspections were carried out or increasing damage due to aftershocks then placards may be updated. This could also see different inspectors having a different opinion of damage level.
    - Many buildings had multiple entrances sometimes on differing street frontages and placards could be different on different entrances.
- Over time, the information on some placards faded to the point it was not legible, as did the colour of the placard.
- There was no consistent, formalised inspector identification system. This meant it was difficult to contact previous inspectors. This eventually led to people putting cell phone numbers on placards or developing their own inspector identifier.

While the wording on the placards is adequate to those that understand the system, many only registered Green = Good, Yellow = Not too Good & Red = Bad. It is the Green that is the most contentious, due initially to there being no compulsory requirement for a more detailed assessment and as there was no apparent damage, there was no mechanism to discover hidden defects. This was later addressed with the DEE procedures.

Removal/placing of placards due to neighbouring hazards was not always consistent. This became a particular problem when there was a combination of land damage and building damage. In some cases, when one hazard was mitigated, the notice was removed as the other problem was not recognised by the reviewer considering only their own area of expertise.

Most of these problems are likely to happen again in a large scale event unless there is:

- A mandatory requirement for building owners to engage engineering advice rather than rely on the free rapid assessment
- There is a publicity campaign after any seismic event that educates the public as to placard meaning.

Recommendations:

- Education of building owners, tenants and the general public is required regarding the meaning of placards.
- Placards should clearly state the level of inspection used to derive them.
- Un-official placards that have a similar appearance to official ones should be discouraged.
- A public data base of placard status should be available.

- Training for inspecting engineers, public, owners and tenants on what does or does not constitute a red vs. yellow placard is required.
- Ideally placards would be issued under the one Act of Parliament and would not expire until the building is repaired or demolished.

Q2: A number of facilities such as shopping centres, public buildings, and schools requested their consulting engineers to provide statements that could be attached to the face of the building, to notify the public of the extent of inspections and the status of the building, and to reassure them over a measure of safety.

In some cases, this was responding to a lack of any official placard (typically in the outer-lying areas). In others it may have been either to provide further detail or to provide the apparent support of a reputable organisation (as opposed to an anonymous assessor).

An implicit risk with this is the influence of building owners seeking to have their building re-occupied and their income re-instated. Engineers need to be prepared and skilled so that they are not distracted from the task at hand and do not become swayed by commercial pressures of their own.

In general, the placards used similar terminology and wording to the official placards. However there were concerns in some cases (particularly following the September 2010 earthquake) where appropriate wording was not used, and where engineers appeared to be assuming unreasonable liability. An education process may be required to ensure this is not repeated. In no case should the engineers' own notices be able to contradict the official placards.

The distribution of such placards was seldom clear to officials and generally there was no notification of the review or the placards back to Civil Defence, the council, or CERA.

Following the June 13th earthquake and some other aftershocks, Civil Defence/CERA communicated with the local engineers on the use of standard terminology in reports and requested L2 reviews where appropriate, if the engineers considered that a change in placarding status was required. This appeared to work reasonably well.

Recommendations:

- Engineers may continue to use their own notices where there is no official placard in place or where more detail may be required. However, it is recommended that guidelines be developed for doing so, and that engineers are notified as to their legal obligations.
- Review processes may need to be put in place to ensure that independent reviews adhere to the same principles as the official reviews.
- Procedures for incorporating private assessments into the official public review and notification process should be developed.

Q3: Information sharing/communication ranged from very good to very poor. Often the quality of the communication was limited by the lack of a common vernacular, although the passage of time has resulted in many more people becoming familiar with the technical terms that have been repeated over and over.

The quality of the communication within the broader public arena was often subjectively viewed according to the priorities and needs of the public. For example EQC seems to be criticised over its communication by the general public, whereas Orion would generally be considered as a good communicator. However it could be argued in many cases, that the quality of the communication was really more to do with whether the news was good or bad.

Within the technical space, communication was generally good. The Canterbury Technical Clearinghouse (CTC), the Canterbury Structural Group (CSG) and the technical societies arranged joint meetings, which were well-attended and provided a good forum for other groups such as the EAG to disseminate information. Industry organisations such as these are critical in such times. However, it is also noted that there are many organisations or people that do not participate in these processes. These are often the 'out-layers', who would probably most benefit from participating. However, it is probably impossible to do much about this, other than for the industry bodies to monitor this and talk to the offending individuals as the opportunity arises.

From a broader perspective, the need to develop a common understanding between the wider public and the technical groups has been repeatedly demonstrated. Once again the media's role in this should come under scrutiny. There are many examples of misinformation being spread trough the media, where more research would have resulted in a better outcome. The Royal Society attempted some such communication, but it is unclear if this has much beneficial effect. It is suggested more use of the media could be made by the authorities, aimed at increasing the public's awareness of technical matters.

Communication between the public and private sector could also be improved. This would reduce the amount of duplication of effort, allowing scarce resources to be deployed more effectively. This could be improved if it were compulsory for every engineer to notify the controlling authority that they have been engaged to look at a building. With this knowledge the controlling authority should be able to know how many buildings are being assessed and how many are not.

Recommendations:

- Better use of the media should be made by the controlling authorities to improve the public understanding of technical issues affecting them.
- It should be compulsory for engineers to notify the authority when they have been engaged to inspect a building.

Q4: It may not be obvious, but the assessment of existing buildings is far more technically challenging than the design of new buildings. This is compounded when buildings are damaged. However, the training of most engineers is focused almost exclusively on new building design.

Engineers need to be able to accurately assess load paths and look for/understand redundancy. They need to be able to "read" the building. For example if it is obvious that the building has moved significantly, by looking at visible damage and by understanding the building type, the engineer should be able to determine where intrusive inspections may be required. Once the building behaviour and damage is understood, the engineer needs to be able to determine the consequence of the damage, and what may be required to repair and/or improve the building.

Engineers need to have sufficient skill and experience in different materials and construction techniques to understand the load paths and damage patterns, which are often material specific. Although most engineers are skilled across a range of materials, there are some materials that are widely taught or worked on in normal times, particularly unreinforced masonry.

The advantage in having assessors with specific expertise is that the assessments should be more accurate. The disadvantage is that many older construction techniques and materials are no longer taught so the pool of expertise in this area is diminishing. Thus the skills may not be available when required.

Conversely, if the review work is limited to only those with the specific expertise and experience, the pool of engineers available to complete the reviews is too limited. Equally, if engineers consider that the qualifications for review work are too restrictive, they will not volunteer. This puts further emphasis on training and development of a field guide to assist reviewers.

In the immediate post-earthquake recovery phase, there is seldom sufficient time to perform quantitative analysis. Therefore the process described above must be determined qualitatively, and is a highly intuitive process, relying on judgement and experience. Clearly, experience in this context was limited at September 2010 to experience of building evaluation in general, as few engineers had had the opportunity to perform post-earthquake building evaluation prior to that date.

Engineers becoming involved in the recovery should ideally have exposure to demolition work: They need to both see how different materials (RC, URM, concrete block etc) behave during demolition.

Knowledge of the Christchurch earthquake findings (e.g., the unexpected fracture of bars at the base of a shear wall) is also important. This requires the collation of the data which has been gathered from the earthquakes and publication in a form accessible to engineers for future education and preparedness.

At all-times engineers need to understand their ethical obligations not to practice outside their competency. However in the rapid safety evaluation phase, this must be balanced against the need to complete the process as quickly as possible, and it is not always possible to assign people with specific expertise to specific buildings, without comprehensive knowledge of the buildings. This was generally not available during this phase.

Local knowledge must be better used than was initially the case. It is considered that there is a core of people in most centres that are highly knowledgeable about the local building stock. They may be able to advise quickly on high-risk buildings that are not necessarily readily identifiable externally.

The make-up of the evaluation teams may be more carefully considered in the future. In the September 2010 RSE phase, teams were initially assigned fairly randomly but in successive aftershocks this was more considered. A proposed system for team assignments may be structured as follows:

1. An immediate safety evaluation should be made by high-level experienced assessors, by helicopter or dashboard (ground-based) survey. This will allow early decisions about deployment of further assessment teams and for the scale and extent of the emergency
2. Level 1 assessment may be made by mixed teams, with at least one CPEng (structural, preferably with post-earthquake evaluation experience) per team. The L1 surveys should be completed in a short timeframe, with a view primarily to establishing those buildings most in need of L2 reviews and in verifying the overall scale of damage.
3. Level 2 teams comprising at least 2 people, one a CPEng (Structural) can then be assigned to specific buildings or groups of buildings on the basis of relevant experience.
4. A group of material and/or configuration specialists should be assembled at the emergency command centre (EOC) to be available to consult on specific buildings. These people may be despatched to buildings as required.
5. For the most critical buildings only, further groups of analytical specialists may also be retained at the EOC in order to provide rapid safety reviews for rescue support. This

should be limited to consideration of collapse likelihood and temporary shoring if required.

6. In addition to the above, a group of local experienced engineers should be assembled to quickly identify any buildings that require specific investigation.

Recommendations:

- Engineers need training to understand the load path, material properties and likely construction of the buildings they are assessing. When assumptions need to be made these need to be clearly stated.
- Data gathered form the earthquakes needs to be collated and published in forms suitable for future education and training of engineers.
- Thought needs to be given to structuring teams as noted above. Where relevant, it may be possible to identify key people throughout the country and have them on an 'as-needed' retainer in the event of further emergency, so that if required, they can be quickly deployed.

Q5: Clearly one of the greatest areas of public concern is whether it is appropriate to evaluate buildings on the basis of diminished capacity, or whether a more detailed evaluation of absolute capacity must be undertaken before buildings can be reoccupied. It is important however that we do not over-react to the outcomes, noting the unusual circumstances of the February 2011 earthquake.

Damage based assessments are used worldwide. Damage based assessments are used worldwide. The Christchurch earthquakes were unique in that the Feb 22 event caused more damage in the CBD. General understanding prior to this would not have been to anticipate such an event, and nor is it clear that a better appreciation of the underlying seismicity data would have changed this view.

There are two scenarios worthy of consideration here:

- Firstly, if the February 2011 earthquake had in fact been the first event of the series. In this case, the loss of life may have been much more extreme, but the evaluation process would have thereafter been in line with expectations, i.e. the aftershocks would most likely have been of lesser intensity. In this case, there current procedures would be appropriate.
- Or alternatively, if following the September 2010 and Boxing Day earthquakes buildings had been closed pending a quantitative review, but the February 2011 event had not happened (noting that on balance, even though there was a reasonably high possibility of this event, it was still a lower than even probability). In this case, there would have been significant economic impact for no benefit.

The current approach is primarily based on identification of damage in the primary lateral load resisting mechanisms, as a means of identifying whether a building's capacity to resist further seismic loading is diminished. Although this is not quantitative, it gives a reasonable assessment of the building's ability to resist aftershocks, assuming these are generally of an order of magnitude less than the original event. The February 2011 earthquake was unusual in not following this pattern, but the imposition of a more stringent approach may potentially harm a future recovery, for no tangible benefit.

However, it is not clear that all engineers involved in the review process post-September had this clear an understanding or even the ability to identify the lateral loads resisting systems. SESOC

endorses the recommendations of Galloway & Hare[3], that there should be more explicit consideration of this, so that if the lateral-load resisting system cannot be readily identified, the building should be yellow-tagged pending more detailed evaluation.

Unreinforced masonry (URM) buildings may be a special case. It has been observed that continuing aftershocks cause deterioration in most buildings, but more so in the case of URM. Further, that many of the observed vulnerabilities are not easily seen through the rapid evaluation process. It may therefore be considered prudent to require URMs also to be yellow-tagged pending more detailed review.

The current model works best with the assumption that the existing building stock does not present an unacceptable risk. In practice this is not necessarily the case, as the Earthquake Prone Building policies throughout NZ are yet to have run their course. It follows that there was a variety of building conditions to consider, from those which were fully or nearly code compliant, to those which might have been regarded as 'dangerous' even before the earthquake. Even though there was societal tolerance of this situation prior to the earthquakes, this position changed immediately following. However, if the overall building stock was of an acceptable quality, this assumption would be validated, and there would be less concern over under-capacity buildings. The point here is that the best way to address this issue is to be better prepared before the event by the imposition of a country-wide risk-reduction process that identifies those buildings that represent the greatest risk, and upgrades or removes them.

The calculation of residual strengths prior to reoccupation is problematic. Firstly, it is not worthwhile unless or until there is clear guidance as to a 'safe' legal minimum capacity. Secondly, it is clear from the outcomes of the DEEs, that there is great variation in the calculated building capacities, and often little correlation between the building capacity and damage suffered. Thirdly, there is often not ready access to information that would allow this assessment to be made without significant testing and destructive investigation.

A further consideration is changes made during construction, which may or may not be documented - much more difficult as most of the important information is hidden. However, some information such as dimensional changes or omissions may still be observable and some tests (destructive and non-destructive) could still be done.

However, it is practical and achievable to quickly verify that there is a load path. It is often more beneficial to ascertain that there is a valid load path than know residual capacities, particularly for URM buildings. This flows further to the observation that the identification of vulnerabilities is of more practical value as these are what cause buildings to collapse, more than simple over-stressing of the primary load-path.

Advantages/Benefits of damage-based assessment:

- Via rapid assessment it is possible to allow occupation of buildings faster.
- It does not penalise those owners with well designed, well-constructed, and well maintained buildings.
- It allows the community and commerce to function as close to normal, as quickly as possible.
- It is the least disruptive methods available.

[3] Galloway & Hare A review of post-earthquake building control policies with respect to the recovery of the Christchurch CBD, Proceedings of the NZSEE Conference, May 2012

Disadvantages/Risks:

- Latent defects that could cause failure in aftershocks may be missed in the short term. They should however be identified if a mandatory DEE process is adopted.
- Detailed inspections may be delayed due to resource availability and this may mean buildings and other structures suffer unexpected damage or failure in aftershocks.

Tools exist for assessing how a building will behave in an aftershock. It is recommended that caution is adopted with what we know are vulnerable aspects of our building stock. For example it may be prudent to require all URM parapets to be secured before an area is re-occupied. Or it may be prudent to insist on inspecting the floor and roof connections to all URM facades before allowing people to be in front of them.

Recommendations:

- In general, a damage based assessment process is recommended as the most expedient without unnecessarily closing buildings. It is important that all parties understand that this assumes a diminishing sequence of earthquakes and that detailed inspection will be mandatory in the future.
- Extra caution is recommended for URM buildings and appendages/features that historically perform badly. Most of these features require little additional effort at the rapid assessment phase to investigate.

Barriers to action, particularly in the recovery phase:

1. What mechanisms and tools could be used to transition the building safety evaluation process from an emergency situation to normal "business as usual"? What do other countries do? How should buildings be followed up on after a state of emergency?

2. How do we manage the tradeoffs between closing buildings until the safety of the public can be ensured in the long-term, managing impacts (such as heritage concerns) when making decisions about the repair or demolition of a building, and acting quickly to promote recovery? What are the risks of trading one goal off against another, and who bears any costs or benefits (either directly or indirectly)?

3. What administrative issues caused barriers to repairing, re-opening or demolishing damaged buildings? Were any solutions developed in response to the Canterbury earthquakes that could improve New Zealand's building safety evaluation process? What are the advantages and disadvantages of adopting any of these solutions?

4. What should central and local government, engineers, insurers and building owners be responsible for when changing and removing placards; following up on engineering recommendations for further evaluations or work; and making sure that building owners comply with their obligations. What role does each of these groups play in making sure that damaged buildings are safe for long-term occupation? How do we improve the system?

Q1: Communication and hand over of comprehensive and reliable data is crucial for any transition. It is vital that there is a single source of truth for each building that accurately records it status.

The process that CERA is following is that once a building has a completed DEE, then responsibility for subsequent action in regard to that building is handed over to the relevant council. The relevant council then either requires repair/upgrade under its EPB policy or if satisfied with its status, permits the building to be returned to full use.

Whether there is an intermediate structure such as CERA, or whether the handover is directly from Civil Defence, it is vital that the information is managed efficiently and accurately. It would be helpful if there were a common database that all agencies were able to access, in any one area.

There is a need for preparation to ensure that this is achieved. Consideration may be given to a national database that holds all such information.

Recommendations:

- Consideration be given to a national database to hold all relevant information that can hold the relevant information for all of the agencies to access.

Q2: Inevitably, there is a need for compromise, underpinned by good communication. In the period where there is greatest risk to building users, there is also the most awareness of risk and the greatest concern. This makes it difficult to achieve an outcome that is satisfactory for all. It is important that decisions are made on a considered basis, and that this basis is well understood

and communicated, not just to the engineers and others that must interpret it, but also to the public and others that are using the buildings.

There was considerable criticism of the delays in dealing with 'unsafe' buildings after the September 2010 and subsequent events leading up to the February 2011 earthquake. However, this was partly at least a function of the lack of any legislative framework to speed up the decision-making process in this regard. Conversely, there has been concern expressed since February 2011 that the process has lurched to the other extreme, with too many buildings being demolished, and too much interference by the authorities.

The demolition of buildings has often been determined by insurance entitlement, which has little to do with safety, but it is undeniable that many buildings were demolished in the emergency phase that may have been saved.

Heritage buildings or potential heritage buildings will always be an emotionally charged topic and society as a whole ultimately needs to decide what happens. The best outcome for heritage buildings is that owners are proactive and seismically upgrade prior to an event. However once damaged, it is recommended that where possible they are quickly secured in their current state so as not to deteriorate any further and then isolated until informed decisions on their fate can be decided.

There is a strong argument that if retention of heritage buildings is in the pubic interest, then the pubic should have a part in determining their fate, but the corollary of this is that the cost of retention may therefore also be partly paid by the public. Much of the argument in favour of retention of damaged buildings swings on whether it can be economically achieved. How fair is it to say that a single owner should carry the cost for the benefit of all?

However, owners of heritage buildings need to understand that they have certain responsibilities that go along with ownership. In many cases, particularly with buildings of 'character' or lower (category 2&3) heritage ratings, owners may have paid relatively little for the buildings. At the same time, they have lower rental returns than most, more modern buildings. But in buying these buildings, they should all be cognisant of the higher risk. Many owners in recent years have cried poor when EPB policies have been reviewed, offering objections to more onerous policies.

Inevitably, there will be an adjustment of property values that reflects the risk and cost of remediation, now that this has been highlighted. This will put further pressure on owners, who may determine that replacement is more economic. Again society as a whole needs to consider the value of these buildings and the need to intercede.

Heritage buildings on lifeline routes or that can't be isolated and that are badly damaged should have specialist evaluations carried out as early as possible. These evaluations must be by specialists and should be peer reviewed. Where full demolition is recommended this should proceed quickly. In all cases building owner, council heritage and national heritage representation should be sought and where possible consensus reached.

One of the problems with this is that there has been insufficient prioritisation of heritage buildings. Therefore the 'battles' have been fought one at a time, rather than with a coherent view of which buildings are most important to retain. However, it is not possible to anticipate this completely as the damage cannot be anticipated in detail.

Consideration should be given to the creation of a fund available for preservation of heritage, with emphasis on retaining precincts where possible. The ability to allocate funds quickly and fairly is essential, requiring a mechanism for rapid evaluation. If there are to be imposed controls that override individual owners' right to determine the fate of there own buildings, there also needs to be a mechanism for review and/or compensation. This will need consideration along with the fund.

Recommendation:

- Expert heritage advice is required, preferably from all stakeholders and a consensus reached.
- Heritage building owners should be proactive in upgrading buildings.
- Heritage retention funds should be established and mechanisms put in place for rapid allocation of funds and resources.

Q3: The main administrative activity required for repair or demolition is consenting (building/resource). Systems that fast track or streamline this will speed up the recovery, assuming design and construction resources are available.

In the immediate aftermath of the earthquakes, it was announced that emergency repairs could be undertaken by owners without consent and a Certificate of Acceptance (CoA) could be issued later. In practice there were administrative difficulties with this that have caused problems, primarily around the question of whether a CoA establishes compliance with the Building Act.

There have been many conflicts over interpretation related to Building consents and the Building Code, including:

- The question of what work is exempt from Building Consent and what the implications of this are in respect of Code compliance.
- Noting that all new work must comply with the Building Act, how far does this extend in cases where partial strengthening is required? Logically, detailing provisions apply in full, but an element being added to bring a building into compliance with the EPB policy may only have the strength level associated with that.
- To what extent can archaic material be re-used – particularly in respect of heritage buildings?

A further issue that has been highlighted is the requirement for added upgrades triggered by a building consent for seismic repair or upgrade. Currently, under s112 (alterations to existing buildings) application to upgrade a building seismically triggers the requirement to upgrade disabled access and fire egress. This is a significant disincentive to owners who want to improve safety. This also hits when implementing repairs to earthquake damage. While it is desirable to include disabled facilities for example it may be cost or time prohibitive or detrimental to the recovery. This issue should be explored.

Re-opening of buildings may be resource constrained by DEE process.

One of the major hurdles to progress in Christchurch has been insurance. The insurers, and to a lesser extent, building owners hold the keys to the flow of money for the recovery and need to respond more quickly. They also need to appreciate that good information for decision making take time and effort on the part of advisors, who need to be paid to prepare and supply this information. Often, progress has been delayed by repeated reviews or alternative decisions being sought, during which time there is no cash flow.

It is further observed that there appears to be no legal requirement for timeliness in reaching settlement, or even in commencing genuine negotiations, as exists anecdotally in California, for example. While the scale of the event is part of the reason for this, it is suggested that this be reviewed in the future.

Recommendation:

- Stream lined consenting and or additional resources for processing a higher than normal demand needs to be given priority.
- Regulations requiring owners to upgrade disabled access and fire egress in parallel with earthquake repairs and strengthening should be reviewed.
- Consideration should be given to introducing 'good faith' requirements for insurers, to facilitate more rapid settlements and to help speed up the recovery.

Q4: Safety is one of the fundamental responsibilities of building ownership. Appropriate management of buildings and their maintenance is critical to this.

Central government should provide the rules or framework that set the minimum acceptable level of risk for the community, including minimum occupation rules. It is noted that currently some government departments have policies of not being in any building <67% and yet the legal EQPB limit is 33%. Central government may also assist in the determination of acceptable practices for the building evaluation process.

Local government should be responsible for administering and enforcing central government policy. They should also be required to stipulate, administer and enforce any local rules that are required to supplement the central government minimum rules.

Engineers should be responsible for giving technical advice to the stakeholders (often just their client) and explaining the options and risks to the stakeholders. They must make recommendations in line with the legal minimum requirements and should give advice as appropriate, on betterment above that level. However it is for the building owners to then determine the actions that are to be taken to mitigate the risk.

Insurers must be responsible for complying with the contractual arrangements between them and the building owner (noting the suggestion of good faith insurance requirements as discussed above). How (or whether) an owner chooses to insure against loss is and should be a commercial decision.

These principles apply regardless of the circumstance, i.e. whether buildings have been damaged or not.

When buildings have been damaged, requiring placarding, the procedures for having the placards removed should be clear and simple. Essentially, whatever hazard required the placard to be issued must be removed, repaired or otherwise mitigated to the satisfaction of the approving authority. Provided this is documented in satisfactory way, the placard removal can be permitted. Ordinarily, this would be achieved through a conventional building consent process. This is complicated slightly with the relationship between CERA and the CCC, but in principle, wherever there is a placarding process enabled by law, there should be a defined process for the removal of the placard.

Changing or removing a placard must follow a process such as: the owner engages engineering advice; the engineer gives that advice to the owner and informs the relevant local government/authority. Where damage/loss is covered by the insurer, this should be settled

quickly. Local government consent must be sought unless exempt, the work carried out, the engineer/council inspect/accept and the placard changed/removed. If the work is not covered by insurance or partially funded by insurance and the owner is not able to provide the funds then the relevant council must be notified.

Depending on damage, the options are then to sell the property, have the council carry out the work under the building act and take a charge on the property or the danger is isolated. Occupation should not occur until all work requiring consent is completed and approved by the authority administering the placards.

Recommendations:

- Procedures for removal of placards must be identified alongside the placarding process itself.