LESSONS FROM THE POSTEARTHQUAKE SAFETY EVALUATION IN THE 2010-2011 CANTERBURY, NEW ZEALAND EARTHQUAKES AND IMPLICATIONS FOR UPDATING ATC-20

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Abstract

The Applied Technology Council (ATC) sent a reconnaissance team to Christchurch, New Zealand following the 2010-2011 Canterbury earthquake swarm that caused significant damage, disruption, and loss of life. The reconnaissance team focused on learning from New Zealand experiences with postearthquake safety evaluation, both on a technical level and on a program implementation level, as a starting point for a potential update of ATC-20 *Procedures for Postearthquake Safety Evaluation of Buildings.* This paper provides a brief overview of what happened in the earthquakes and the subsequent response, and then discusses useful ideas and good practices that were observed, postearthquake safety evaluation implementation and management issues, and future research and development needs, including revision and expansion of ATC-20.

Introduction

The *de facto* national standard in the U.S. for the postearthquake safety evaluation of buildings is ATC-20 (ATC, 1989). New Zealand's guidelines (NZSEE, 2009) were based upon those of ATC-20. Building stock in Christchurch is similar to that in the U.S. The extent of liquefaction, the extensive damage to taller buildings, and the challenges posed in the evaluation, repair, and recovery process in the Canterbury earthquakes were significant. ATC believed that the earthquakes presented an important opportunity for study, and sent a reconnaissance team following the 22 February 2011 M6.2 event. The team included Bret Lizundia, Ron Gallagher, and Jim Barnes. The team was in Christchurch from 26 June 2011 to 1 July 2011. The primary purpose of the visit was to observe the damage, meet with individuals involved in the safety assessments, and examine the safety evaluation process used. In particular, the team sought to identify implications for U.S. practice, to identify needed research and development for the future, and to gain ideas for the future improvement of ATC-20.

A draft of the ATC reconnaissance team report (Gallagher, et al., 2012) summarizing the team's findings has been issued; the final report is in publication. This paper summarizes the findings of the report and includes text taken directly or paraphrased from the draft report. The paper also provides some additional discussion on issues that have been raised since report preparation in late 2011 and early 2012.

Brief Overview of the Earthquakes

Detailed descriptions of the earthquakes and associated damage are provided in other publications. The brief overview given below of three major events is based on two New Zealand reports (GNS Science, 2011 and Royal Commission, 2011). Moment magnitudes (M_w) are used in this paper.

The 4 September 2010 M7.1 earthquake damaged some older masonry buildings in the Central Business District (CBD) of Christchurch and caused liquefaction in the eastern suburbs of the city. The epicenter was near the town of Darfield, about 40 km west of the CBD. Modified Mercalli Intensities (MMI) of VIII and IX were reported, with the highest intensities in the epicentral area and moving eastward to Christchurch. Peak ground accelerations (PGAs) reached 0.8g horizontal and 1.26g vertical near the epicenter and 0.3g horizontal and 0.2g vertical in the CBD. There were no deaths. There were extensive aftershocks. The two most significant occurred on 22 February 2011 and 13 June 2011.

The 22 February 2011 M6.2 Christchurch earthquake had an epicenter only 6 km southeast of the CBD and caused extensive damage and liquefaction in Christchurch. PGAs of 1.7g horizontal and 2.2g vertical were recorded near the epicenter with values of 0.7g horizontal and 0.8g vertical in the CBD. Response spectra for a number of recorded sites exceeded 500-year design levels, in some cases by a substantial margin. For some periods, spectral values corresponded to a 2,500-year or higher hazard level. Deaths caused by this event totaled 182, with 42 related to unreinforced masonry buildings (Royal Commission, 2011). The CBD was cordoned off. Many older brick buildings were severely damaged and collapsed. The CTV and Pyne Gould Corporation concrete buildings collapsed with significant loss of life. More than 40 major buildings were so badly damaged as to require demolition, including many high-rises. The reconnaissance team was told that eventually, of the approximately 4,000 buildings in the CBD, some 1,000 may be demolished. This is due in part to insurance coverage limits that are less than the cost to repair and strengthen damaged buildings to required levels. Large areas of the city experienced ground settlement and liquefaction, and over 5,000 homes in the liquefaction areas have been permanently abandoned, with the possibility of this number growing substantially. There were numerous slides and rockfalls in the Redcliffs, Sumner and Lyttleton areas southeast of the Christchurch along the coast.

The 13 June 2011 M6.0 aftershock had an epicenter southeast of the CBD. It was preceded by a M5.7 event. It caused further damage to buildings in Christchurch as well as Lyttleton, widespread liquefaction, and more rockfalls in the Port Hills suburbs. One fatality occurred. PGAs of 2.0g horizontal and 1.1g vertical were recorded near the epicenter, with 0.4g horizontal and 0.2g values recorded in the CBD.

Brief Overview of Building Safety Evaluation in Christchurch

In a massive effort by local officials, with considerable outside assistance, over 72,000 buildings in Christchurch were inspected in the 10 days immediately after the February earthquake. Over 130,000 buildings were inspected in the first 21 days (NZSEE, 2011).

ATC-20 uses a hierarchy of three levels of safety evaluation (Rapid, Detailed and Engineering Evaluations). The NSZEE approach also uses three levels (Level 1 and Level 2 Rapid Assessments and a Detailed Engineering Evaluation). The ATC-20 Rapid Evaluation is similar to the Level 1 Rapid Assessment and is done by similar personnel, but the NZSEE Level 1 is typically only an exterior inspection. The ATC-20 Rapid Evaluation may be used for only the exterior, or both the exterior and interior. The Level 2 Rapid Assessment is similar to the ATC-20 Detailed Evaluation procedure and is done with similar personnel, but NZSEE written procedures do not offer the degree of guidance found in the ATC-20 document. It appeared to the ATC team that Level 2 Rapid Assessment may be more cursory.

The placarding (i.e., posting) systems of the ATC and NZSEE procedures are the same, but the placarding procedure was done somewhat differently. Generally, UNSAFE, RESTRICTED USE, and INSPECTED placards were used only on commercial buildings. For most residential buildings, if a building was not posted UNSAFE, the occupant was given a small flyer that advised them that part of the building might be unsafe and that they should contact an engineer.

Useful Ideas and Practices Observed

Faced with an unexpected disaster, local officials exhibited considerable innovation and resourcefulness. The ATC team observed and through discussions learned of a number of ideas and practices that can be used in the U.S. and elsewhere. These are summarized below.

Use of Triage: On the first day after the earthquake, before the formal building safety evaluations were begun, teams were sent into the field to "triage" all city blocks in the CBD. The intent of the triage was to gain an overview of the damage, identify collapse-vulnerable buildings and ensure people were not trapped in any of the buildings, and inform urban search and rescue teams.

Use of Indicator Buildings: Following a large earthquake, many buildings become damaged and are susceptible to additional damage from aftershocks. Some aftershocks may be strong enough to damage previously undamaged buildings. An important decision officials must make is when to require the re-inspection of previously inspected buildings. One innovation in Christchurch was the use of "indicator buildings" typical of the local building stock. If an indicator building showed new damage after an aftershock, similar buildings nearby that likely experienced the shaking could then be re-examined for safety. This can also be combined with strong motion instrumentation reports to assist decision makers.

Targeted Safety and Evaluation Operations: Another innovation was the creation of specialized task forces or operations to address sections of the city or issues of the community, rather than the block-by-block method that has often been used in other cities. A brief description of the operations is as follows.

- *Operation Shop:* ATC-20 offers the advice to conduct safety evaluations of essential facilities first, including hospitals, police and fire stations, and emergency operations centers. In Operation Shop, officials in Christchurch added shopping centers, drug stores, and hardware stores to the list of high priority inspections. It was felt that the public need for items such as food, diapers, medicines, and hardware was important and that the best way to ensure supply was to inspect the buildings of these businesses and identify those that could be left open.
- *Operation Suburb:* The largest task force effort was Operation Suburb, which focused on the rapid safety assessment of homes in the suburbs. About 1,000 people were briefed and deployed each day from a sports stadium. Approximately 72,000 homes were eventually evaluated for safety.
- *Operation Critical Buildings:* Operation Critical Buildings focused on damaged buildings six or more stories in height that affected street and road traffic, adjacent buildings, or that were considered critical infrastructure. The operation was managed by experienced engineers. Drawings were obtained. Outside expert opinion was solicited on selected buildings and issues. Surveys were regularly conducted to track building movements in aftershocks. Special temporary stabilization measures were employed both to allow inspections within the building and to gain access to neighboring structures.
- *Operation Cordon and Access:* Operation Cordon and Access focused on the extent of cordoning needed to keep the public safe from dangerous buildings. As a result, 22 km of fencing was installed to barricade the public from dangerous areas. An inner city cordon was established around the CBD, while an outer cordon was initially installed about four avenues away and gradually reduced in size as they areas were cleared for safety. Only officials, emergency workers, and safety evaluation teams were allowed entry inside the cordon. Because of the aftershock hazard and the unstable state of many damaged buildings, entry to the CBD was controlled. At the time the ATC team was there, the New Zealand Army controlled and monitored both individual entry and exit. This was done to keep track of the number and names of individuals in the CBD at any one time in case of an aftershock.
- *Operation Demolition:* Operation Demolition focused on identifying and disposing of those buildings that presented a hazard to the public and adjacent structures and streets.

Shelter-in-Place Strategies: In the liquefaction areas, residents were sometimes permitted to remain in their homes even though utilities had been damaged and were not usable. A "shelter-in-place" strategy was developed where if a home was not damaged sufficiently to trigger an UNSAFE posting, the occupants were permitted to remain. Temporary above ground water lines, portable and/or chemical toilets, and portable communal showers were installed. The desire to shelter-in-place has received growing attention by U.S. policy makers, and the strong emphasis in Christchurch provides a valuable case study in its implementation. An important lesson is the difference between structural safety and habitability. ATC-20 focuses on damage to the structure and life safety risks. Whether power, water, sewer, and communication services remain operational is not explicitly addressed, nor is whether the building can still be locked or otherwise secured against intruders. For residential placards, New Zealand's Earthquake Commission adopted a "3S" approach, meaning if a building was "Safe" per the structural evaluation, Sanitary, and Secure (lockable), then the residence was considered usable for shelter-in-place.

Use of Shipping Containers as Barricades: There was extensive use of shipping containers as barricades where falling hazards were severe. These were placed against, or close to, buildings to keep parapets, walls, and store fronts from falling into the street. This permitted street traffic to be relatively close to heavily damaged buildings. Shipping containers were also used as barricades in the Sumner and Redcliffs areas to impede the flow of landslide and rock fall debris from damaging dwellings or blocking roads.

Use of Private Engineers for Safety Evaluations: Private engineers were permitted to inspect and post buildings under the authority of the Christchurch City Council. In the early stages of the emergency phase, engineers were signed up per an agreement with the city, and then deployed as part of an assessment team. Those volunteering to perform assessments were protected from liability. At later stages, especially following some of the more significant aftershocks, private engineering consultants were requested to submit Level 2 Rapid Assessment forms and to advise if changes in status of the placards were required.

Land Management Issues and Recovery: ATC-20 primarily focuses on the safety evaluation and posting of an individual building. Metaphorically, it is the tree in the larger urban forest. The widespread damage to buildings and infrastructure from strong ground shaking, liquefaction, landslides, and rockfalls and the potential for further damage in future earthquake events led the government to create zonation maps of the Canterbury region which effectively tagged the entire "forest" of buildings. The zonation maps and associated land management and recovery process are managed by the Canterbury Earthquake Recovery Authority (CERA). CERA made the determination not to repair, reconstruct, or reoccupy certain areas which are subject to high degrees of liquefaction, have a high risk of further damage due to aftershocks, and have buildings and infrastructure which are mostly uneconomical to repair or where repairs would be prolonged and disruptive. CERA presented government buy-out offers to homeowners in the areas to be abandoned.

Use of USAR Personnel as Safety Escorts: The Christchurch City Council made extensive use of Urban Search and Rescue (USAR) personnel as safety escorts for the building safety evaluation teams within the CBD. Their roles on the safety assessment teams were to ensure that the safety evaluation teams were conducting their field work in a safe manner. They had two-way radios, first aid kits, and were in radio communication with the EOC (Swanson, 2012).

Use of On-Call Locksmiths for Building Access: In the cordoned CBD, on-call locksmiths were contracted by and deployed by the Christchurch City Council EOC to open locked doors in private commercial buildings so the safety evaluation teams could access damaged buildings (Swanson, 2012).

Use of Internet and Social Media for Information Updates: The Christchurch City Council made relatively extensive use of the internet and social media to provide near real-time updates to the public on the response and recovery process of the region. This included maps showing the specific zones within the CBD cordoned areas and planned dates for these area cordons to be lifted, and maps of the CBD that showed areas of higher risk from buildings that could potentially collapse in a strong aftershock.

Introduction of Usability Categories: Usability Categories were used for some assessments in Christchurch as part of the Level 2 Rapid Assessment to provide an additional level of information to building occupants, managers, and owners. For the INSPECTED (Green) posting, the Usability Categories were G1 – occupiable, no immediate further action required and G2 – occupiable, repairs required. For the RESTRICTED USE (Yellow) posting, the Categories were Y1 – short-term entry, and Y2 – no entry to parts until repaired or demolished. For the UNSAFE (Red) posting, the Categories were R1 – significant damage; repairs strengthening possible, R2 – severe damage, demolition likely, and R3 – at risk from adjacent premises or from ground failure.

Safety Evaluation and Management Issues in Christchurch

Christchurch and New Zealand officials were faced with an unprecedented disaster. This section describes some of the issues observed by the ATC team regarding conducting and managing the postearthquake safety evaluation program.

New Zealand Safety Evaluation Guidelines Were Under Development: The NZSEE (2009) guidelines were the “official” version at the time of the February 2011 earthquake. An updated version (NZSEE, 2010) was developed and made available in July 2010 as a “draft,” but this was generally not used. The NZSEE document covered primarily Rapid Assessments and, because it was under on-going development, provided somewhat limited safety evaluation guidance. It did not contain instructions on how to inspect various types of buildings, examples of posting and barricading, guidance on filling out safety assessment forms and placards, or advice for dealing with occupants and owners of damaged buildings. The current ATC-20 methodology is summarized in the second edition of the ATC-20-1 Field Manual (ATC, 2005). This document was published in 2005. It contains discussions and new topics not covered in the original ATC-20 (ATC, 1989) and the 1995 ATC-20-2 Addendum (ATC, 1995). Unfortunately, both in the U.S. and elsewhere, this was not widely known among users and potential users of the ATC-20 documents.

Safety Evaluations were Performed by Personnel with Limited Training: Unlike parts of the U.S., there was no prequalification and certification program for Christchurch safety evaluation personnel. Prior to the earthquakes, only a limited number of engineers had undertaken training in building safety evaluation. Safety evaluation personnel received a short training introduction before going into the field in Christchurch. Training of safety evaluators is essential to achieve uniform evaluations. Reportedly, the quality and consistency of the evaluations varied widely, and re-evaluations were needed in some cases.

Fading Ink on Placards: At the time of the ATC visit, many of the placards in Christchurch had been in place for up to four months. The color of some placards was faded, and the writing on many was difficult to read because the ink had faded.

Old Placards were Not Always Removed: It was observed that a number of buildings had two placards. One placard was typically from the first inspection, and the second from a subsequent follow-up inspection. Both were sometimes left in place. Often they had different postings. This became confusing when the ink faded, and it was sometimes difficult to determine which placard was the most recent.

Full Advantage of the RESTRICTED USE Placard was not Taken: The ATC-20 RESTRICTED USE placard is designed to provide local jurisdictions with flexibility in posting. Occupants can continue to use a damaged building, provided the use is in accordance with the restrictions that have been identified. For example, if an otherwise undamaged house has a damaged chimney, the occupants can continue to live there, but the fireplace and area within falling distance cannot be used. The ATC team observed that many placards used in Christchurch had the phrase “No Entry Except on Essential Business” under the RESTRICTED USE title. This statement appears to be inconsistent with the general intent of the RESTRICTED USE posting which is to permit safe use of damaged buildings. In contrast, ATC-20 expressly allows for evaluators to select a variety of options for restricting the use of a building.

Placard Meanings were Not Well Understood by the Public: Royal Commission (2012) notes that authorities used flyers, posters, and public meetings—mostly for residential owners—to try to explain the building safety evaluation process and the placarding categories. Nonetheless, the ATC team was told by a number of individuals that the public was confused by the INSPECTED placard. Under both NZSEE and ATC-20 procedures, the INSPECTED placard signifies that a building has been given a safety evaluation and found to have little or no damage. In other words, the seismic resistance of the building has not been significantly changed by the earthquake, and no other hazards are present. After the Christchurch earthquake, many members of the public believed that the INSPECTED placard meant that the building was "safe," even in future earthquakes. Under both NZSEE and ATC-20 procedures, a building that is undamaged and posted INSPECTED after a small earthquake may suffer significant damage or even collapse in a subsequent event that subjects the building to additional and/or stronger ground motions. In some cases, that is exactly what occurred in Christchurch, with downtown buildings being posted as INSPECTED after the distant September event, only to be damaged and posted UNSAFE following the much stronger shaking in the February event. The Pyne Gould and CTV buildings had been posted as INSPECTED following the September event. Both collapsed in February, killing many occupants. This scenario was highlighted by lawyers representing the victims in hearings on the earthquakes.

Laws Hampered the Placarding Process: The posting of buildings following safety evaluation had the force of law only during the term of the New Zealand government's "emergency declaration." The placards expired on 12 July 2011. As such, a building owner could in theory remove an UNSAFE placard, without legal consequence once the term of the emergency passed. CERA addressed this by progressively reposting buildings, but New Zealand is considering revisions to applicable laws.

Lack of Guidelines for Engineering Evaluations and Repair of Damaged Buildings: Both ATC-20 and the updated NZSEE (2010) guidelines lack detailed guidance for conducting an "Engineering Evaluation" of a damaged building and for how to repair a damaged building. The Engineering Evaluation typically involves review of plans (if available), preparation of calculations and estimates of residual capacity, and may involve destructive exploration and materials testing. It is normally done after visual examinations cannot provide the information needed to properly assess the safety of a building. Outside of ATC-20, there is guidance in the U.S. for conducting an engineering evaluation and repairs only for selected structural types such as steel moment frame structures (FEMA, 2000); concrete and masonry wall structures (FEMA, 1999); and single family residences, multi-unit multi-story wood frame residential structures, and older concrete buildings (ATC, 2010). In New Zealand, the Engineering Advisory Group of the Department of Building and Housing or DBH (which is now part of the Ministry of Business, Innovation and Employment) has been developing guidance for conducting engineering evaluations and repairs, with draft updates being issued periodically (EAG, 2011).

Research Needs

Research needs include the following.

- *Understanding fractured bars in shear walls:* In some concrete shear wall buildings, vertical wall reinforcement was found to be fractured, usually at the location of a thin horizontal crack. This phenomenon has the potential to be an extremely important finding. The fractured bars cannot be seen from the surface, and a horizontal crack may not necessarily be related to fractured bars within the wall. It will be valuable to determine if there are reliable indicators of underlying rebar damage that can be seen in a rapid visual assessment and added to postearthquake safety evaluation guidelines.
- *Seismic strengthening of URM cavity walls:* Many of the URM buildings in Christchurch utilized hollow cavity wall construction for the exterior walls. The exterior and interior wythes of these walls are separated by an air gap and are typically interconnected by nominally-spaced metal ties, reducing their resistance to out-of-plane loading. Many of these walls experienced spectacular failures with the

exterior wythe spalling, and often large portions of the wall suffered significant damage. ATC-20 lacks guidance for evaluating these buildings after earthquakes and does not address the significant life safety risks associated with them.

- *Performance of building shoring and stabilization methods:* The September 2010 Darfield earthquake and the February 2011 Christchurch earthquake just 5½ months later provide a unique laboratory to investigate and evaluate the performance of temporary building shoring and seismic stabilization methods. Many of the buildings damaged in the 2010 Darfield earthquake had seismic stabilization and shoring installed that had varying levels of success and performance in the stronger 2011 Christchurch earthquake.

Guideline Document and Training Needs

There are a number of guideline documents and training programs that should be developed. The ATC reconnaissance team believed that ATC is an excellent organization to lead this effort, provided funding can be obtained. The reconnaissance team has prioritized its recommendations into initial steps, high priority items, and other important items.

Initial Steps: The following initial steps are recommended to be done in the near term.

- Convene a small working group to establish goals, an agenda, and identify potential participants for a focused workshop to initiate the ATC-20 update process. For this, international participation is desired.
- Conduct the workshop. At the workshop, solicit ideas for the future of ATC-20. For example, should it be a large single document, with many chapters covering the topics noted above, or should it be a family of related ATC-20 documents, or some combination? The workshop should consider recent experiences in Italy and Japan, in addition to New Zealand.

High Priority Guideline Documents and Training Programs: The following guideline documents and training programs are considered to be of high priority. It is recommended these be developed within two to four years.

- *Update the basic ATC-20 document guidelines and the ATC-20-1 Field Manual:* The two documents need to be consistent and current. This would include more research and observations made since the 2005 update of the Field Manual, and provide additional detail on such issues as liquefaction-induced damage, nonductile concrete building evaluation, and cavity wall URM building inspection. Consideration should be given to the introduction of Usability Categories, or something similar.
- *Aftershock risk:* Relatively large aftershocks occurred in Christchurch that produced new significant damage and required re-inspections. The ATC-20-1 Field Manual (ATC, 2005) provides guidance with "wait periods" before entry and "time limits" on the length of entry. These are from ATC TechBrief 2 (ATC, 1999) and are based on aftershock research by the U.S. Geological Survey, primarily for California earthquakes. The guidance given in the Field Manual (and TechBrief 2) should be updated for new information and research broadened for applications beyond California. Discussion of "foreshocks" should be included. ATC-20 advice on aftershocks can also be expanded to include discussion of those buildings and situations (e.g. URM falling hazards, nonductile concrete buildings) most susceptible to further damage of a life-threatening nature.
- *Guidelines for managing the postearthquake safety evaluation process:* Identify steps needed to run a successful program and the preparations required before the event. This will draw on lessons learned by Christchurch building officials and officials from other areas who have been through a major earthquake. Gallagher, et al. (2012) provides a list of issues to cover.

- *Guidelines for private engineer posting of buildings:* The Christchurch City Council authorized private structural engineers to inspect and post commercial buildings. The private engineers were paid by the building owners. Provision for this concept, or some variation of it, should be added to the ATC-20 procedures.
- *Guidelines for cordoning, barricading, shoring, and emergency stabilization:* ATC (2005) has some guidelines on barricading, but only briefly mentions cordoning areas. Additional guidelines should be developed on cordoning, barricading, shoring and emergency building stabilization.
- *Seismic design and evaluation criteria for stairs:* Stairs collapsed in a number of buildings and occupants were trapped in the upper stories. The issue of designing stairs to withstand, and be usable, after the worst expected earthquake shaking needs to be addressed, and evaluation criteria for existing structures need to be developed. This topic is not fully addressed in either U.S. or New Zealand codes with rigorous design criteria, though DBH has issued a Practice Advisory (DBH, 2011).
- *Guidelines for sheltering residential occupants in place:* Formal guidelines need to be developed to allow shelter-in-place for those homes and residences safe to do so. This involves not only building structural and nonstructural safety, but includes concerns about public health, sanitary issues, and fire protection concerns. Can a toilet be used, or must portable toilets be brought in? Are the electrical and gas services safe to use?
- *Training of structural and geotechnical engineers on conducting Detailed Evaluations:* Currently, most ATC-20 training consists of a four to six hour basic introductory program. In the U.S. presently, there is no publically available program for training structural engineers (or geotechnical engineers) in performing ATC-20 Detailed Evaluations. Similarly, there was no such program reported in New Zealand. Given the difficulties and challenges of performing ATC-20 Detailed Evaluations, it is thought that at least a four-hour program for structural engineers would result in a much better trained workforce to provide Detailed Evaluations following earthquake disasters. A similar program for geotechnical engineers and specialists in liquefaction, subsidence, and landslide/slope stability problems is also desirable.

Other Important Guideline Documents: The following guideline documents are considered important to develop, but these may not have the same priority as those in the section above, or may take longer to develop. It is recommended these be completed within the next four to six years.

- *Guidelines on conducting Engineering Evaluations (as defined by ATC-20) of damaged buildings.*
- *Guidelines for the evaluation, repair, and strengthening of damaged buildings:* This broad topic can take the form of individual documents for a specific building type. A document is also needed to address the evaluation, repair, and strengthening of buildings damaged by liquefaction.
- *Seismic strengthening criteria and methodology for URM buildings with cavity wall construction:* This task may take some time to resolve, but many parts of the U.S. have the same type of vulnerable URM cavity wall buildings found in Christchurch and could also experience significant damage.

Issues to be Resolved

In updating ATC-20 and developing the related guideline documents noted above, there are several issues that have come into greater focus as Christchurch has begun to recover that need discussion and resolution. They include the following.

- *Retain multiple levels of evaluation?* Postearthquake evaluation must balance rapidity with thoroughness. Is the ATC-20 approach of having three levels of evaluation appropriate?

- *The "bad" building problem:* Is it appropriate to provide an INSPECTED tag to a building with a known form of hazardous construction (such as unreinforced masonry or nonductile concrete) even if it is undamaged? In the U.S., building safety is always the primary responsibility of the building owner. The INSPECTED placard merely means that the building is as viable and safe as it was before the event, with no guarantee of future performance. Building owners who are concerned about the overall structural safety of their buildings, particularly older buildings, must pursue an investigation and possible structural upgrade to mitigate against future events. This is difficult to communicate to the public. Should this approach remain or should there different requirements for tagging "bad" buildings?
- *Should allowances be made for larger aftershocks?* The underlying concept in ATC-20 is that the building should be able to withstand another event of the same intensity without collapse since aftershocks are generally not larger. Should larger aftershocks or those with different directionality be considered in the evaluation process, or should the Christchurch experience of a more damaging aftershock be deemed too unusual to warrant a philosophical shift?
- *Should the disproportionate damage concept be used?* ATC (2010) promotes the concept of requiring more stringent repairs to buildings that suffered disproportionately more damage than other buildings with the same level of shaking. Should this become part of general repair guidelines?
- *Should postearthquake assessments include estimates of residual capacity?* Should the focus remain on observed damage, rather than residual capacity? Residual capacity estimates are not possible in an ATC-20 Rapid or Detailed Evaluation, but they could be a larger part of Engineering Evaluations.
- *How far should the search go for hidden damage?* After the 1994 Northridge earthquake, procedures were needed to investigate hidden damage to steel moment frame buildings. There is growing interest in requiring more detailed investigations for hidden damage in New Zealand, and this might be needed for the issue of finding fractured rebar inside concrete walls.
- *Should there be different procedures and/or placards for commercial and residential buildings?* This was rejected in the development of ATC-20, but there were differences in implementation between the building types in Christchurch. Should this be rethought as ATC-20 is updated?
- *Are time limits on evaluations appropriate?* The primary focus of postearthquake safety evaluations is on rapid evaluations to determine which buildings have suffered significant damage that should prevent reoccupancy. The evaluations are intended to occur quickly and take place when aftershocks pose potentially significant risks. As time passes, aftershock potential diminishes, recovery becomes the primary focus, and yet the placards may remain. The sheer scale of damage in Christchurch meant that there were still many buildings with red and yellow tags more than a year after the earthquake. There has been a constantly evolving set of policies and ordinances related to addressing placard status and requirements as recovery has proceeded. The interrelationship between the original placard; changing seismicity; and the community's recovery goals, policies, and legal requirements is an issue that bears discussion from a diverse set of stakeholders.
- *At what level of shaking, should reevaluation and retagging be done?* When there are many large aftershocks, at what point should re-inspection be triggered?

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