

The Evaluation and Management of Buildings Following Earthquakes



Presentation to the
Canterbury Earthquakes
Royal Commission

*Bret Lizundia
Rutherford + Chekene
San Francisco*

2 September 2012

Outline of Presentation

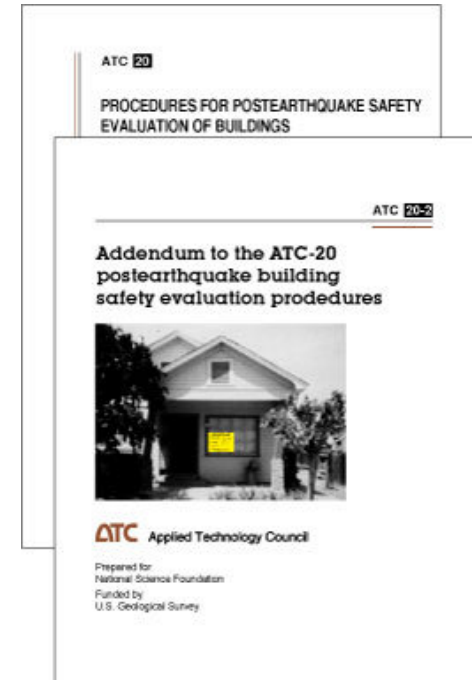
- Summary of present context, practice, and assumptions in the US regarding post-earthquake safety evaluation
- Review of Applied Technology Council (ATC) Reconnaissance trip findings regarding post-earthquake safety evaluation processes following the 22 February 2011 earthquake
- Comments on presentation by Dave Brunson
- Conclusions and considerations

Disclosures

- I am a practicing structural engineer in San Francisco, with experience in new buildings and seismic retrofitting of existing structures, earthquake reconnaissance efforts, guideline development, and applied research.
- The ATC team was only in New Zealand for a week.
- We did not participate in or observe the tagging while it occurred. Instead, we interviewed selected officials and participants and toured the affected areas several months later. We also gathered information from selected sources after returning. Mr. Brunsdon was one of the sources.
- My summary of ATC reconnaissance report findings is taken from the 13 August 2012 draft of our report.
- My review comments on Mr. Brunsdon's presentation and my conclusions are my own alone and do not necessarily represent those of ATC.

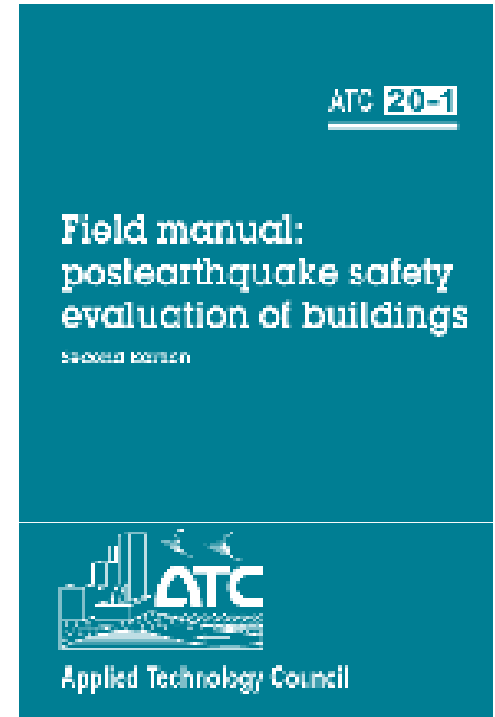
Post-Earthquake Evaluation in the US: Available ATC Documents

- ATC 20 and ATC 20-1(1989)
 - ATC 20 titled *Procedures for Postearthquake Safety Evaluation of Buildings*
 - ATC 20-1 was the companion *Field Manual*
 - Found widespread use one month after being published in the 1989 M7.1 Loma Prieta earthquake in the San Francisco Bay Area
- ATC 20-2 Addendum(1995)
 - Incorporates lessons learned in the Loma Prieta earthquake and 1994 Northridge earthquake in southern California
 - Includes revisions to the yellow tag, changing it from LIMITED ENTRY to RESTRICTED USE



Post-Earthquake Evaluation in the US: Available ATC Documents

- ATC 20-T (1993)
 - Training manual with over 160 slides
- ATC 20-3 (1996)
 - Provides over 50 case study examples
- ATC 20-1 Second Edition (2005)
 - The *Field Manual* was updated in 2005.
 - It represents the most current approach ATC has published.
 - It contains updated information not found in other documents regarding steel moment frames, manufactured housing, aftershocks, guidance on entering damaged buildings, and barricades.



Post-Earthquake Evaluation in the US: ATC 20 Levels of Assessment

- Reconnaissance Survey (NZ “Overall Damage Survey”)
 - Quickly conducted by building officials immediately after the event to determine general extent of damage and which areas have higher damage
 - Assists in planning subsequent inspections
- Rapid Evaluation (similar to NZ “Level 1 Rapid Assessment”)
 - Performed by qualified, trained civil/structural engineers, building officials, inspectors with knowledge of lateral load path
 - Rapid assessment of safety. Used to quickly post obviously unsafe and apparently safe structures, and to identify buildings requiring Detailed Evaluation.
 - 10-20 minutes, can include interior when possible

Post-Earthquake Evaluation in the US: ATC 20 Levels of Assessment

- Detailed Evaluation (similar to NZ “Level 2 Rapid Assess.”)
 - Performed by two structural engineers
 - Careful visual evaluation of damaged buildings and questionable situations. Used to identify building requiring an Engineering Evaluation.
 - 1-4 hours
- Engineering Evaluation (similar to NZ “Detailed Evaluation”)
 - Structural engineering consultants hired by owner
 - Detailed engineering investigation of damaged buildings, involving use of construction drawings, damage data, and new structural calculations
 - Often includes repair/stabilization recommendations
 - 1-7 days or more

Post-Earthquake Evaluation in the US: Context

- Seismic strengthening
 - Varies widely by community, building type, occupancy
 - Voluntary and mandatory programs exist
 - Only a few building types typically covered, such as URM bearing wall buildings, multi-story woodframe buildings with weak ground stories
- Seismic rating systems: Many available, but no common, widely accepted system in place.
- Database of expected building performance: Limited to few owners and institutions (such as the University of California system)
- Earthquake insurance: It is not mandatory, and many owners do not have it.

Post-Earthquake Evaluation in the US: Context

- Recent building codes (such as 2010 California Building Code Chapter 34) have requirements when “substantial” damage has occurred. “Substantial” damage means:
 - Lateral load-carrying capacity reduced by more than 20% from before earthquake and/or
 - Vertical gravity load-carrying capacity of groups of components that support more than 30% of the total area of a floor has been reduced by more than 20% and remaining capacity is less than 75% of new code
- When less than substantial damage has occurred, repairs can return building to pre-earthquake capacity.
- When substantial damage has occurred to lateral elements, repairs must be designed using forces at least 75% of those in current code. For gravity elements, repairs must comply with full code.

Post-Earthquake Evaluation in the US: Context

- No devastating event on the scale of Christchurch has occurred in recent times where tagging was done.
- Programs are in place for training engineers and other professionals in safety evaluations, with some 7,000 in California alone. Leads to a certification.
- Structural Engineering Association of California is actively involved in training, coordination, and portions of program management.
- Good Samaritan laws are in place to protect authorized evaluators.
- Communities pass ordinances so that placards have legal standing.
- Aftershocks are assumed to typically be smaller, and they have been.

Purposes of ATC Reconnaissance Trip

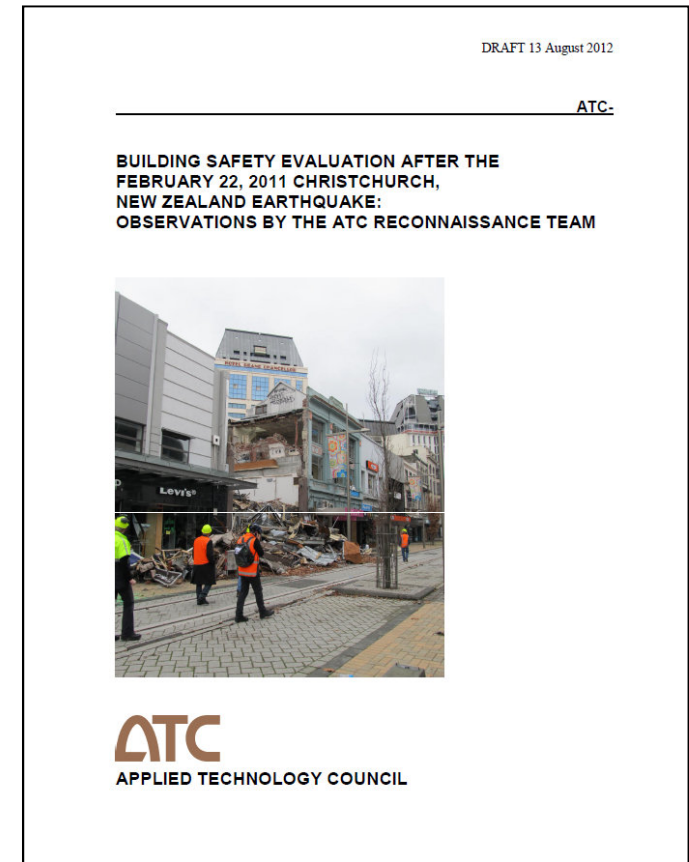
- Learn from New Zealand experiences with post-earthquake safety evaluation, both on a technical level and on a program implementation level, as a starting point for a potential update of *ATC 20 Procedures for Postearthquake Safety Evaluation of Buildings*
- Study the linkage between post-earthquake safety assessments and the repair and recovery process
- Investigate the availability of information and data that can support the development of ATC's ongoing earthquake hazard mitigation projects

Reconnaissance Trip Details

- Team
 - Bret Lizundia, Rutherford + Chekene and ATC President at the time
 - Ron Gallagher, RP Gallagher & Associates
 - Jim Barnes, California Emergency Mgmt Agency
- Dates: 26 June 2011 to 2 July 2011
- Scope
 - Reviewed damaged areas
 - Met with a wide range of evaluation participants
 - Spoke at local structural engrs meeting on ATC-52-4
 - Presented findings to NZ federal govt in Wellington

Outline of ATC Reconnaissance Report Findings

- Unique difficulties in Christchurch
- Useful ideas and practices
- Safety evaluation issues in Christchurch
- Post-earthquake safety evaluation program management issues
- Future needs
- Collaboration opportunities
- Recommended next steps for ATC



Unique Difficulties in Christchurch

- Scale and extent of liquefaction
- Combination of strong shaking and extensive liquefaction
- Large scale settlement in liquefaction zones leading to flood hazards from the Avon River



Unique Difficulties in Christchurch

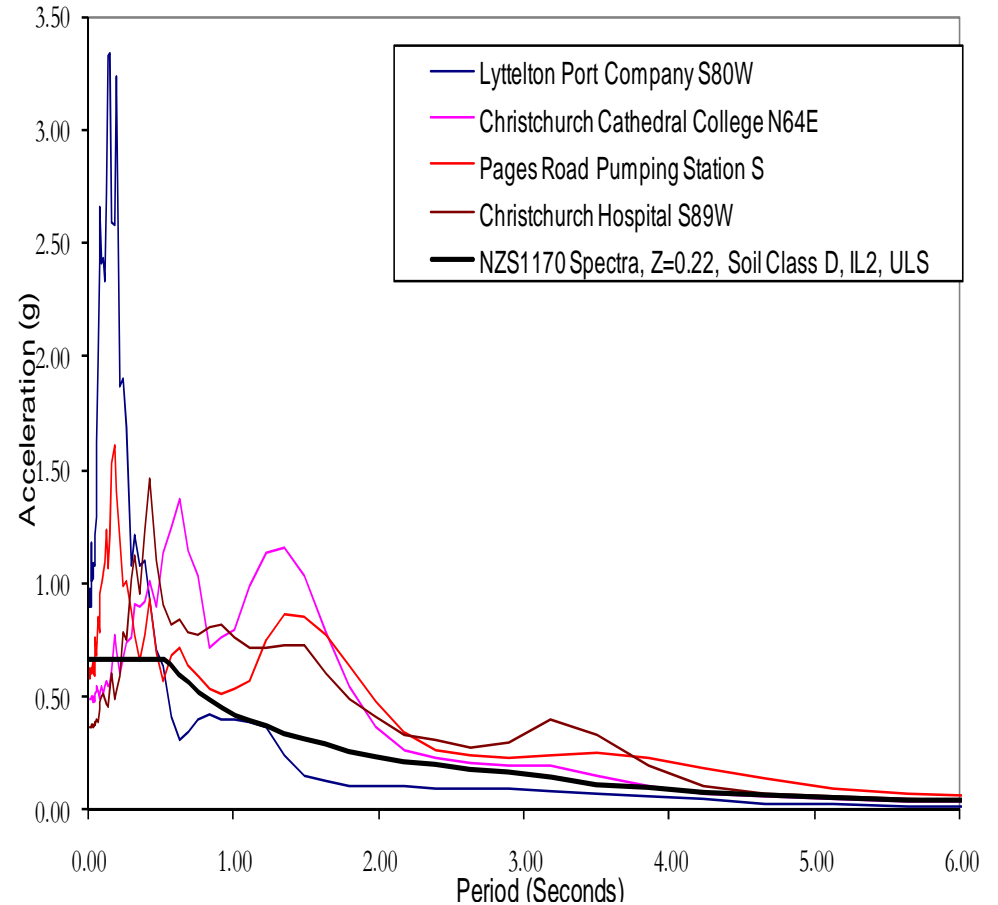
- Large proportion of damaged high-rise buildings
- Addressing the large number of buildings targeted for demolition
- Concentration of damage in the CBD
- Repeated large aftershocks
- Falling rocks and landslides
- Fractured rebar in shear walls with minimal surface indication
- Implementing a safety program with limited preparedness



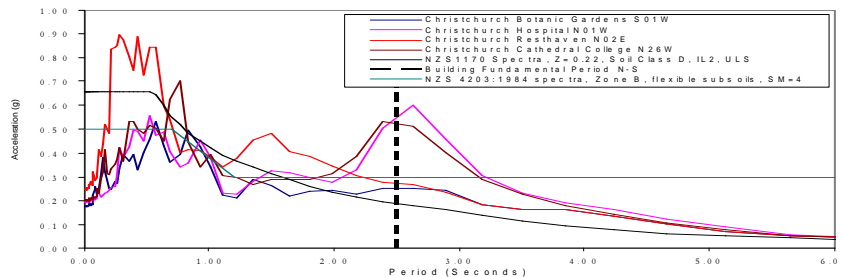
Unique Difficulties in Christchurch

The intensity and ground accelerations in Christchurch were much larger in the 22 February 2011 event.

Lyttelton Earthquake 22 February 2011



Darfield Earthquake 4 September 2010



Slide adjusted from that of Christchurch City Council

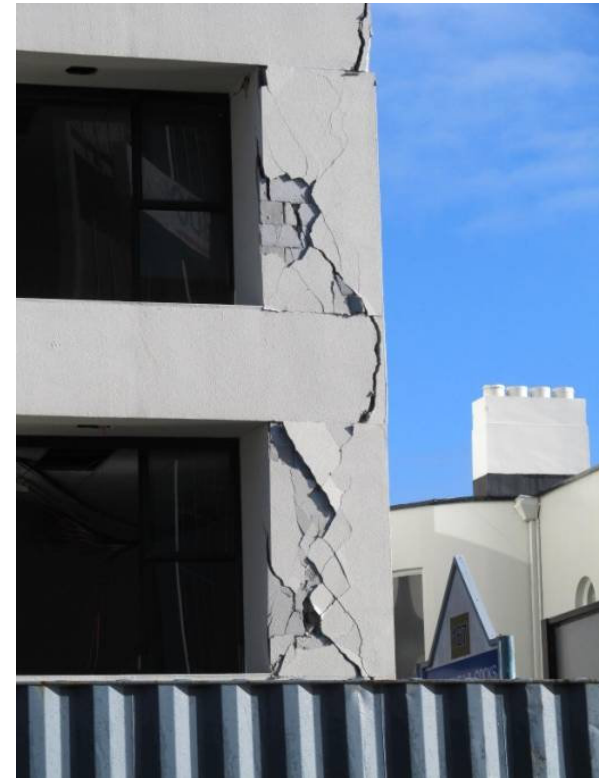
Useful Ideas and Good Practices

- Use of triage
- USAR personnel as safety escorts for building safety evaluations in the CBD
- Use of unmanned aerial vehicles (drones)



Useful Ideas and Good Practices

- Indicator buildings



Useful Ideas and Good Practices

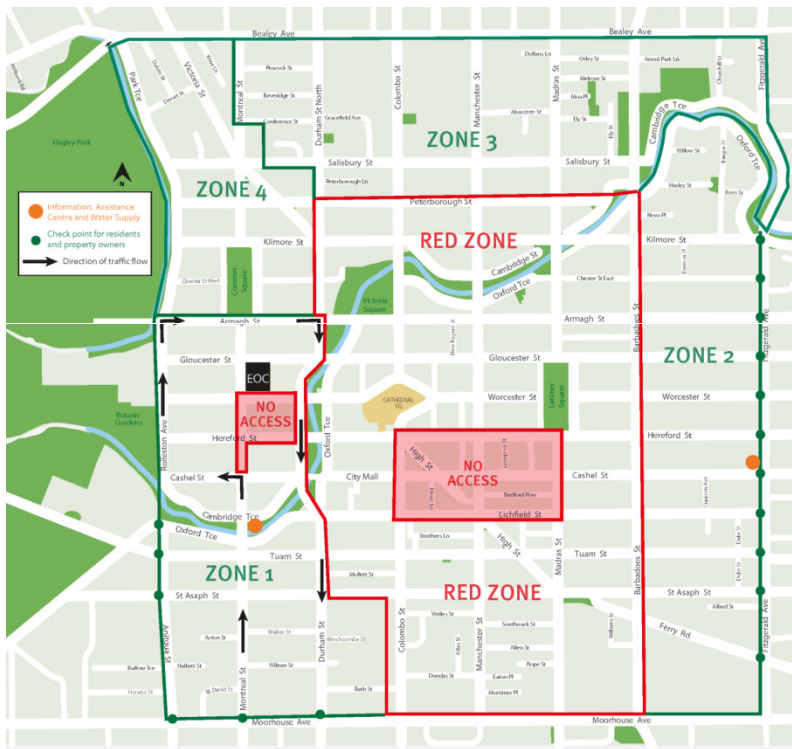
- Emergency stabilization of mid-rise and high-rise buildings



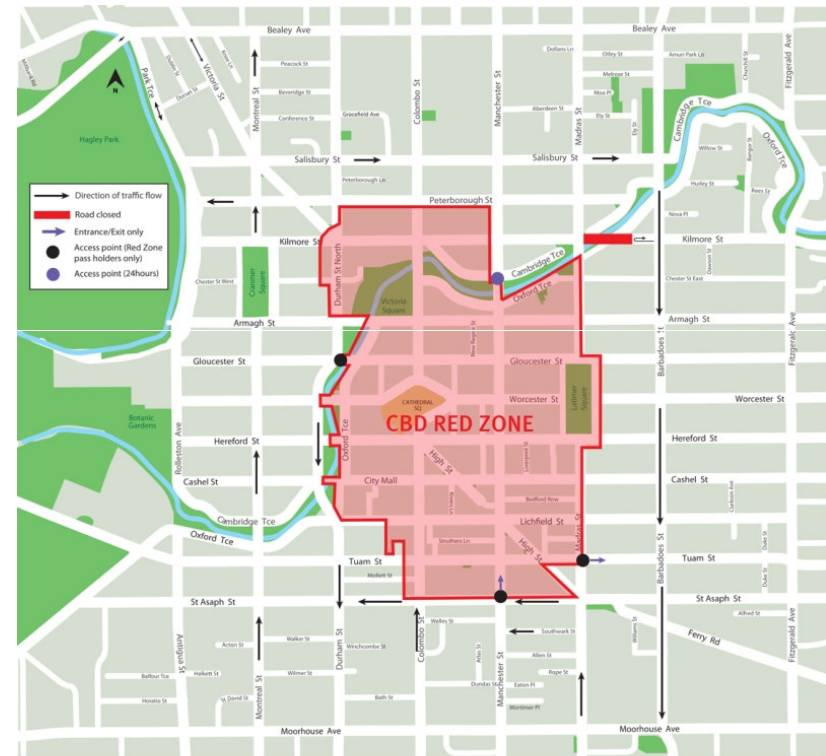
*Image Credit: Professor Sri Sritharan,
Iowa State University*

Useful Ideas and Good Practices

- CBD cordoning and dynamic management



CBD Red Zone after 11 June 2011 Earthquake



Current as of 12noon 27 August 2011

Temporary traffic management subject to change.
Drive with caution and obey traffic signage.
Cordon opening dates have been, and will continue to be,
dependent on the ability to make these areas safe to enter.

**CBD Red Zone
Cordon Map**

Useful Ideas and Good Practices

- Shelter-in-place strategies
 - Port-a-loos and temporary water lines
 - Portable showers



Useful Ideas and Good Practices

- Using shipping containers for barricades, shoring, and safe entry



Useful Ideas and Good Practices

- High priority on evaluating shopping centers
- Specific task force concept for targeted safety assessments
 - *Operation Shop*
 - *Operation Suburb*
 - *Operation Critical Building*
 - *Operation Cordon and Access*
 - *Operation Demolition*

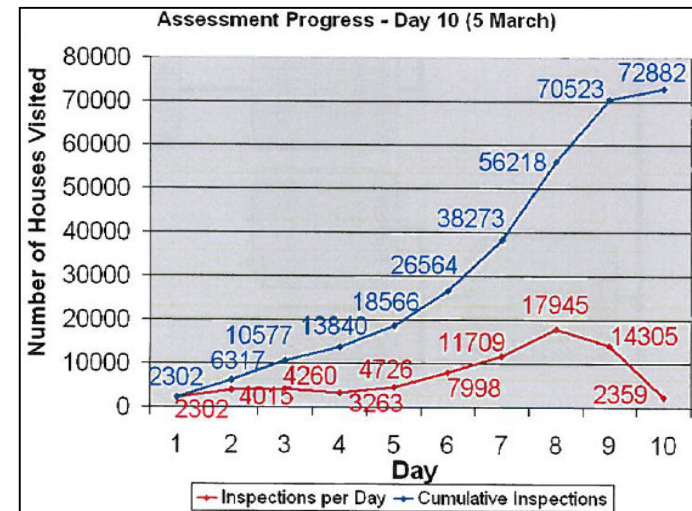
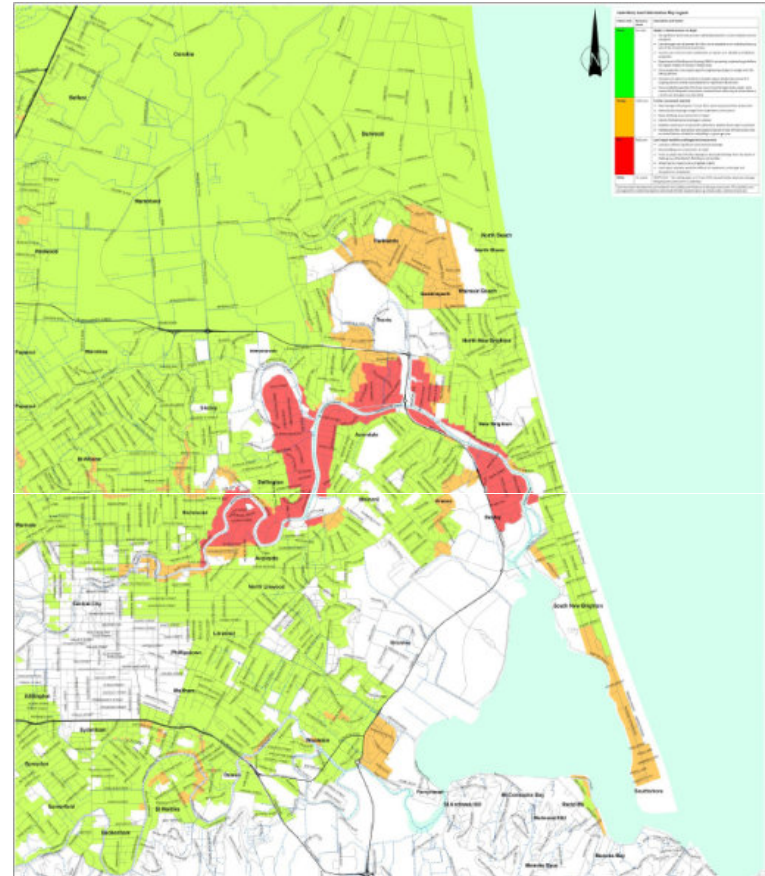


Image Credit: Christchurch City Council

Useful Ideas and Good Practices

- Land management zonation program
 - Targets repairs where most cost effective
 - Aids in mitigating damage in future earthquakes
- On-call locksmiths for building access
- Use of private engineers for safety evaluations
- Use of internet and social media for information updates



Useful Ideas and Good Practices

- Introduction of Usability Categories

<u>Damage Intensity</u>	<u>Posting</u>	<u>Usability Category</u>
Light damage (Low risk)	Inspected (Green)	G1 Occupiable, no immediate further investigation required.
		G2 Occupiable, repairs required
Moderate damage (Medium risk)	Restricted Use (Yellow)	Y1 Short-term entry
		Y2 No entry to parts until repaired or demolished
Heavy damage (High risk)	Unsafe (Red)	R1 Significant damage: repairs, strengthening possible
		R2 Severe damage: demolition likely
		R3 At risk from adjacent premises or from ground failure

Safety Evaluation Issues in Christchurch

- New Zealand guidelines were under development.
- No training manual and less guidance than ATC 20 family

Building Safety Evaluation

During a State of Emergency

Guidelines for Territorial Authorities



Prepared by the

**New Zealand Society for
Earthquake Engineering**

With support from



Department of
Building and Housing
Te Tari Kaupapa Whare



August 2009

Safety Evaluation Issues in Christchurch

- Evaluations were performed by personnel with limited training.
- Evaluations were slowed by a lack of a pool of prequalified personnel.



*Photo Credit: Professor Ken Elwood,
University of British Columbia*

Safety Evaluation Issues in Christchurch

- Old placards were not consistently removed after a new placard was installed.
- Ink faded on some placards over time.



Safety Evaluation Issues in Christchurch

- Did not always take full advantage of the flexibility of the “Restricted Use” placard
- “No Entry Except on Essential Business” confuses the issue.
- Discussed in detail in ATC 20-2 and ATC 20-1 second edition

YELLOW L1

RESTRICTED USE

NO ENTRY EXCEPT ON ESSENTIAL BUSINESS

WARNING:
This building has been damaged and its structural safety is questionable. Earthquake aftershocks present danger. Enter only at own risk. Subsequent events may result in increased damage and danger, changing this assessment. Reinspection may be required. The damage is as described below:

Rear East wall bulging out

Facility Name and Address:
Snoclothes + Milly May
8A LONDON ST.

This facility was inspected pursuant to (Act):

Inspector ID:
A. TAYLOR (CPeng) 0274377627

Acting on authority of:
CCC

Date: *29/4/11*

Time: *10:30 am*

Restrictions on use:

- No public entry nor residential occupation
- Entry for
 - emergency purposes
 - damage assessments, making safe
 - ~~conducting essential business with minimum staff~~
- *Removal of essential property.*

Do Not Remove this Placard. Placed by order of the Territorial Authority

CHURCH COUNCIL ENVIRONMENT


Preparation and Management of Safety Evaluations

- Lack of a prior program to train safety evaluators
 - Limited training had occurred for building control officials prior to the September 2010 event in some communities.
 - No large training program for volunteer engineers in place
 - No credentialing or certification program in place
- However, volunteer efforts were heroic and management of many operations were extremely impressive as lessons were learned and practices evolved.

Preparation and Management of Safety Evaluations

- Placard meanings were not well understood by the public.
- Confused “Safe” in the future with “Inspected”
- “Inspected” only means the original seismic resistance is not significantly decreased.
- Building safety is the primary responsibility of the building owner.

GREEN

Christchurch City Council 

INSPECTED

NO RESTRICTION ON USE OR OCCUPANCY

This building has received a brief inspection only. While no apparent structural or other safety hazards have been found, a more comprehensive inspection of the exterior and interior may reveal safety hazards.

Exterior Only
 Exterior and Interior

Facility/ Tenancy Name and Address

Please ensure the owners are advised of this notification. Owners are encouraged to obtain a detailed structural engineering assessment of the building as soon as possible. Report any unsafe conditions to the Territorial Authority. Subsequent events causing damage may change this assessment. Re-inspection may be required. Secondary damage (partitions, windows, fittings and furnishings) may be hazardous. Electrical and mechanical equipment, gas connections, water supplies and sanitary facilities have not been inspected.

This facility was inspected pursuant to the Civil Defence Emergency Management Act 2002

Inspector ID: _____

Acting under the authority of the Civil Defence Emergency Management Controller:

Date: _____
 Time: _____

Contact for information: ph(03) 941 8999

Or
 TXT: 021 02069179 with following details: Address, Placard colour, contact name, contact phone number

Do Not Remove this Placard. Placed on Behalf of the Civil Defence Emergency Management Controller Under the Authority of the Civil Defence Emergency Management Act 2002

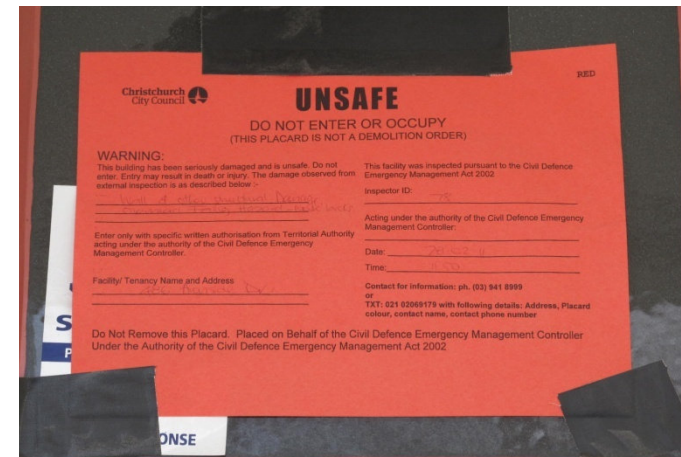
Preparation and Management of Safety Evaluations

- Number and locations of URM buildings were not fully known
 - Christchurch City Council list had 2,300 buildings.
 - Investigators later estimated only 958 at time of September 2010 event (from *The Performance of Unreinforced Masonry Buildings in the 2010/2011 Canterbury Earthquake Swarm*, Ingham and Griffith, 2011).



Preparation and Management of Safety Evaluations

- Laws are confusing and hampered the placarding process.
 - Placards were only permitted under emergency declarations.
 - Placards expire.
 - Local jurisdictions are not allowed to adopt placards.
 - Building Act of 2004 did not address earthquake-damaged buildings.



Preparation and Management of Safety Evaluations

- There was a lack of guideline documents for “Detailed Evaluations” (or “Engineering Evaluation” in the US).
- There was also a lack of repair and strengthening guidelines for damaged buildings.
- Drafts for Detailed Evaluations have now been developed in NZ.

Future Needs

- Research
 - Understanding fractured bars in shear wall buildings
 - Possibly deficient adhesive anchors in masonry buildings
 - Out-of-plane strengthening of cavity wall masonry
 - Performance of building shoring and stabilization methods
 - Strong motion instrumentation of buildings and related damage assessment



Future Needs

- Documents
 - Engineering Evaluation guidelines
 - Repair and strengthening guidelines for damage including liquefaction
 - Post-earthquake safety evaluation program management guidelines
 - Cordoning/barricade/shoring/stabilization guidelines
 - Private engineer posting guidelines
 - Training for structural engineers to perform ATC-20 Detailed Evaluation

Future Needs

- Documents
 - Usability categories guidelines
 - Aftershock risk research and guidelines
 - Shelter-in-place guidelines
 - Digital record management guidelines
 - Detailed discussion on the interrelationship between post-earthquake safety evaluation and long-term recovery issues.

Collaboration Opportunities with New Zealand

- Future international workshop
- International reviewers of national documents
- Review of critical building findings so that other countries can learn whether code changes are needed
- Shared production of documents
- Potential collaborators
 - New Zealand Society of Earthquake Engineering (NZSEE)
 - New Zealand Ministry of Building, Innovation and Employment (MBIE)

High Priority Steps for ATC

- Publish final version of reconnaissance report
- ATC 20 technical guidelines update
- Make sure field manual is consistent with larger technical guidelines document
- Initiate post-earthquake safety evaluation program management guidelines document development:
How do you run a good program?
- Shelter-in-place guidelines
- Training of structural engineers in ATC 20 detailed evaluations
- Cordoning, barricading, shoring and stabilization guidelines
- Assessment and repair of liquefaction-induced damage
- Engineering evaluation guidelines
- Repair guidelines beyond ATC 52-4

Review of Presentation by Dave Brunsdon

- Based on presentation received 31 August 2012 and discussion on 7 August 2012 in San Francisco
- Also included review of selected submissions to the Royal Commission on the same topic

The Evaluation and Management of Buildings Following Earthquakes

Overview Presentation to the Canterbury Earthquakes Royal Commission
3 September 2012

Dave Brunsdon
FIPENZ
Kestrel Group

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Areas of Comment

- NZSEE (2009) approach of initial overall damage survey, then rapid assessments, then more detailed assessments is generally consistent with US approach, as is the purpose of each level of assessment.
- Mr. Brunsdon's summary of events and processes used is generally consistent with what we learned from various interviews and other sources.

Building Safety Evaluation

During a State of Emergency

Guidelines for Territorial Authorities



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Te Tari Kaupapa Whare



August 2009

Areas of Comment

- I agree with these identified shortcomings.
- A few other issues were noted in ATC report findings review.

Main Shortcomings Identified (1)

Rapid Assessments

- Insufficient numbers of trained engineers and building officials
- Field guidance to assist assessors not available
- Yellow placards didn't allow for clear indication of restricted access areas
- Public communications around placards not developed

Areas of Comment

- I agree with these identified shortcomings, except as follows.
- In the ATC 20 approach, there is no intent for there to be a Detailed Engineering Evaluation if the building receives a “Green” placard.

Main Shortcomings Identified (2)

Transition and Detailed Evaluations

- Transition arrangements from declared emergency to ‘business as usual’ not developed
- No ability for Councils to require owners of green placarded buildings to obtain a Detailed Engineering Evaluation
- Detailed Engineering Evaluation technical procedures not prepared

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Areas of Comment

- Some differences include the following.
- ATC Rapid can include interior when possible or desired.
- ATC Rapid is 10-20 minutes, but ATC Detailed is 1-4 hours by two structural engineers.

Comparison with International Arrangements (2)

- NZ Rapid Assessment levels differ slightly from ATC-20

NZ	ATC-20
Rapid Level 1	Rapid
Rapid Level 2	Detailed

Areas of Comment

- This is getting similar to the ATC 20 Detailed Evaluation.
- The search for hidden damage in some buildings can be very expensive and disruptive, such as beam-column connection damage in Pre-Northridge steel buildings, due to asbestos and access.

Interim Use Evaluation Developed

- Intermediate step prior to a DEE
- Takes the Level 2 Rapid Assessment one stage further to check that there is no significant hidden damage that may
 - impair the overall capacity of the building
 - represent life safety hazards from toppling, critical elements (eg. stairs) or neighbouring buildings

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Areas of Comment

- The notion that there is a non-earthquake prone URM in moderate to high seismicity areas is flawed.
- The June 2012 NZ Guidance for Engineers document recommendation to use the *2006 NZSEE Guidelines* to assess a URM building is problematic (per my previous testimony).

Interim Use Evaluation Developed (3)

- **Not to be used for unreinforced masonry buildings unless strengthened above earthquake prone levels**
 - DEE required for unreinforced masonry buildings not meeting this requirement
 - Careful check of parapets and floor-to-wall connections required for all unreinforced masonry buildings

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Areas of Comment

- I concur that these are key issues to be considered.

Future Arrangements Core Issues to be Addressed

- **Goals and Objectives**
 - Scope of Rapid Assessment - rapidity vs thoroughness
 - Re-occupancy criteria
- **Roles and responsibilities**
 - Preparation
 - Activation and response
 - Transition to normal regulatory arrangements
- **Training and resourcing for Rapid Assessment**
 - Capability and capacity objectives
 - Annual/ ongoing maintenance costs

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Areas of Comment

- I concur that these are key arrangements that need development.

Future System and Arrangements Key Components (NZSEE, 2011)

1. Appropriate legal mandate (building legislation)
2. Central government agency providing a focal point, guidance and support for preparedness activities
3. Criteria and process for building re-occupancy established
4. Local authorities prepared to set up and manage a building evaluation operation (with national support)
5. Appropriate numbers of trained and warranted building professionals
6. Effective mobilisation arrangements for warranted building professionals (locally and nationally)

Areas of Comment

- An analytical assessment of residual capacity cannot be done rapidly.
- In the US, this is done at the “Engineering Evaluation” level (or the “Detailed Evaluation” level in NZ).
- Documents include FEMA 306, FEMA 351, and ATC 52-4.

Future System and Arrangements

Key Considerations (1)

Whether a **rapid** evaluation system based on damage assessment should incorporate any elements of residual capacity assessment?

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Areas of Comment

- Aftershocks are generally not larger. The presumption underlying tagging has generally been that aftershocks will be equal or smaller.
- Shifting the line to capture the Christchurch experience could lead to significant costs, greater homelessness and disruption, and raises the question of where to stop.

Future System and Arrangements

Key Considerations (2)

Making appropriate allowance for the possibility of large aftershocks with the potential for

- greater intensity of shaking
- different directionality of shaking

Areas of Comment

- ATC 20 focuses on structural damage and safety, not security and sanitation. Utility damage in Christchurch raises important questions about longer term occupancy.
- The efforts in Christchurch of installing utility lines and community showers permitted a higher degree of sheltering in place than we've achieved in the US. This is desirable.

Future System and Arrangements

Key Considerations (3)

Clarifying Occupancy Criteria and Process

- What does 'occupiable' or 'usable' mean?
- The concept of 'interim occupancy'
- Avoiding placing 'Inspected' placards on buildings of known low capacity (EQ Prone buildings)
- Requiring owners of 'Inspected' placarded buildings to move swiftly to get Detailed Engineering Evaluations undertaken
- Proposal of 'White' colour for this placard

Areas of Comment

- In the US, the “Inspected tag” is placed on a building with no significant damage, regardless of its relevant seismic capacity prior to the earthquake.
- In the US, we do not have a comprehensive database of known poor buildings.

Future System and Arrangements

Key Considerations (3)

Clarifying Occupancy Criteria and Process

- What does ‘occupiable’ or ‘usable’ mean?
- The concept of ‘interim occupancy’
- Avoiding placing ‘Inspected’ placards on buildings of known low capacity (EQ Prone buildings)
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- Proposal of ‘White’ colour for this placard

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Areas of Comment

- In the ATC 20 approach, there is no intent for there to be a Detailed Engineering Evaluation if the building receives a “Inspected” placard.

- This essentially makes all buildings (even undamaged ones) and their owners “guilty until they prove themselves innocent” just because they happened to be in the vicinity of another owner’s damaged building. This would be a very difficult proposition to implement in the US.

Future System and Arrangements

Key Considerations (3)

Clarifying Occupancy Criteria and Process

- What does ‘occupiable’ or ‘usable’ mean?
- The concept of ‘interim occupancy’
- Avoiding placing ‘Inspected’ placards on buildings of known low capacity (EQ Prone buildings)
- Requiring owners of ‘Inspected’ placarded buildings to move swiftly to get Detailed Engineering Evaluations undertaken
- Proposal of ‘White’ colour for this placard

42

Areas of Comment

- Integrating repair requirements with existing mandatory strengthening programs is desirable.
- San Francisco had a mandatory parapet safety ordinance before the 1989 earthquake. Thus, a special emphasis on checking parapets was not as necessary.
- In the US, we do not have a comprehensive database with the structural capacity of significant structures.

Future System and Arrangements

Key Considerations (4)

The building evaluation system must be integrated with both Earthquake Prone Building Policy requirements and Dangerous Building provisions

- There needs to be a priority given to restraining masonry parapets and addressing vulnerable elements
- The register of earthquake prone buildings held by each council should ideally extend to a summary of the structural capacity of all significant structures

Areas of Comment

- I concur that these training and accreditation goals should be implemented.

Future System and Arrangements

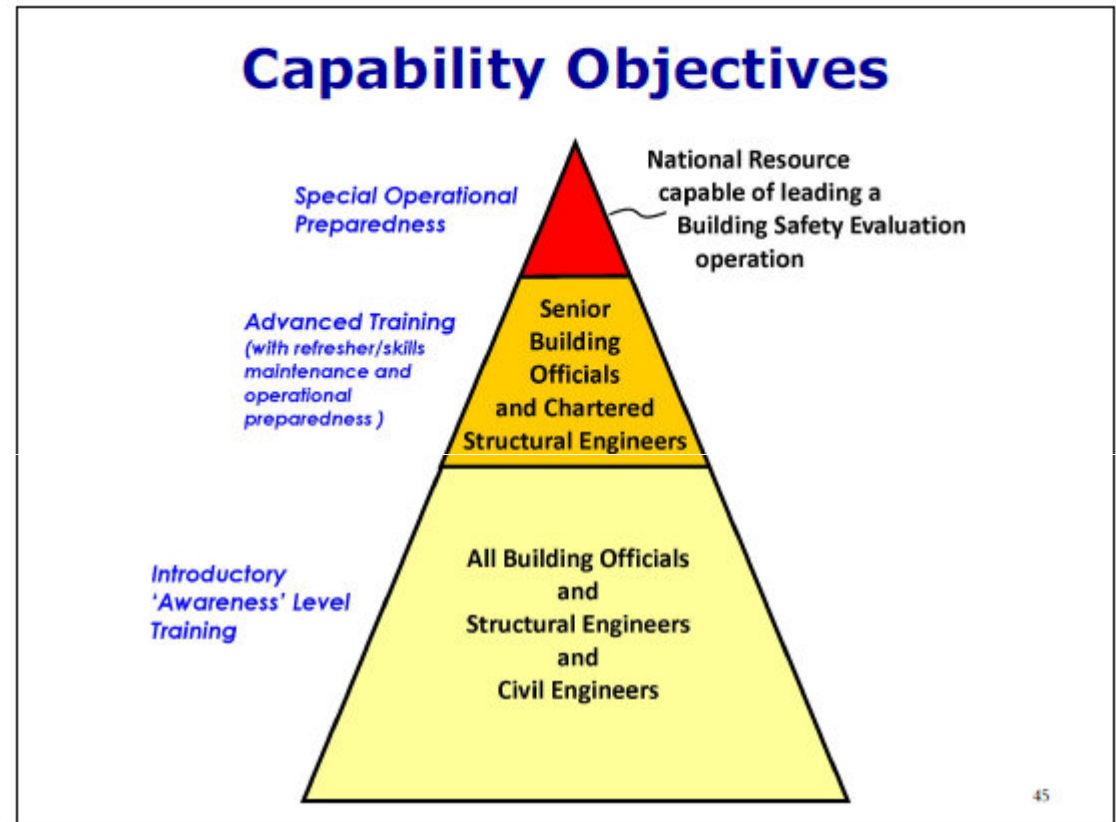
Key Considerations (5)

Training & Accreditation

- Training outcomes should be linked with operational accreditation and liability cover
- Capability and capacity objectives to be carefully considered

Areas of Comment

- I concur that these capability objectives are desirable.
- One conclusion from the ATC reconnaissance report is the desirability of a higher level of training like the “Advanced Training” proposed here.



Areas of Comment

- The difficulty of establishing unique building identifiers has been raised in every earthquake and should be a key focus for government staff.
- Publishing placard status appears desirable as the information is already publicly posted on the face of the building.
- However, making drawings and capacity assessments available online has potentially significant costs and raises privacy concerns.

Future System and Arrangements

Key Considerations (6)

Building Information Management

- Unique identifiers required for each land parcel, each building and street address within property records
- Placarding status of buildings to be readily available
- Structural drawings and relevant information (including previous capacity assessments) to be readily accessible from council records

Areas of Comment

- Having different evaluations procedures and placards for residential buildings bears further study. With growing emphasis on shelter-in-place, this is important.
- Better coordination and greater detail in evaluation training and manuals on geotechnical issues are needed.

Future System and Arrangements

Key Considerations (7)

Allowance for the differences between rapid building evaluation operations in commercial and residential areas

- Issues of sanitation require more specific consideration in residential situations (earthquake and flood events)
- Enable better co-ordination of structural and geotechnical processes (earthquake or flooding and landslip/ rockfall)

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Areas of Comment

- I concur with these summary comments.

Summary Comments

1. NZ's post-disaster building evaluation process is based on international best practice
2. These arrangements were under development at the time of the September 2010 earthquake
3. The February 2011 earthquake represented an extremely large aftershock that would pose a significant challenge for any post-disaster building management system

Areas of Comment

- I concur with these summary comments.

Summary Comments (2)

4. The main shortcomings and gaps identified are in the areas of
 - regulatory context and provisions
 - the communication of risk, expectation and process to the public
 - capability and capacity, and
 - technical procedures following the emergency phase

Areas of Comment

- I concur with these summary comments.
- We in the US look forward to working together with our colleagues in NZ in developing improved post-earthquake safety evaluation procedures and the associated documents.

Summary Comments (3)

5. Many of the technical procedures needed to address the gaps have subsequently been developed
 - further enhancement through international collaboration planned
6. A legal framework that provides an effective linkage between post-disaster and normal regulatory processes is a fundamental requirement

Observations

- Most significant earthquakes have unique features that affect the approach and our perception of what is needed.
 - 1989 Loma Prieta – transportation infrastructure and soft story woodframe damage, difficult recovery of poorer communities, test of ATC-20 procedures
 - 1994 Northridge – steel moment frame damage leads to SAC research project, parking garage damage leads to ACI 318 changes, difficulty of determining meaning and repair requirements for concrete and masonry buildings leads to FEMA 306/307/308
 - 2010 Chile – raises concerns about detailing and certain practice with concrete wall buildings and identifies large disconnect between performance targeted by engineers and that expected or assumed by the public

Observations

- Most significant earthquakes have unique features that affect the approach and our perception of what is needed.
 - 2010-2011 Christchurch – large aftershock, extensive liquefaction and infrastructure damage, enormous impact on CBD, tragic loss of life, fractured rebar issue to be studied, extensive use of tagging, complicated legal framework, thoughtful review of procedures, development of many new documents and guidelines for evaluation



*Image Credit:
Steve McCarthy,*

Observations

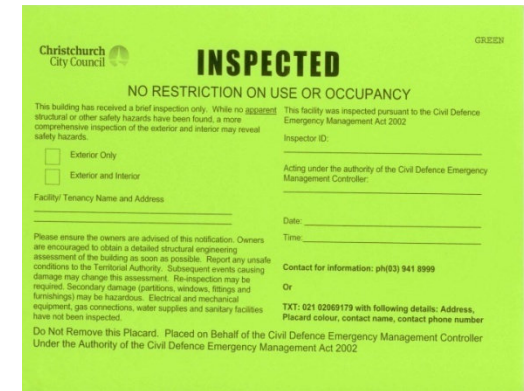
- Risk is unavoidable.
- We need to do a better job in the engineering community in communicating matters of risk.
- The Christchurch earthquakes and the Royal Commission process have provided a unique opportunity for a considered review in public of what risks are acceptable.
- Changing the definition of what is acceptable after an event could be considered as unfair to building owners.

Conclusions and Considerations

- The Christchurch earthquake sequence was unusual, with a much more damaging aftershock.
- The evaluation program were quite successful, with many useful ideas and practices implemented that will be of value in the future, both in New Zealand and around the world.
- Issues were identified that need further study and improvement.
- Rapid assessments are essential to understanding the extent of damage, in identifying buildings that have not been significantly damaged and those that have, and in helping the community to quickly achieve reoccupation where warranted.

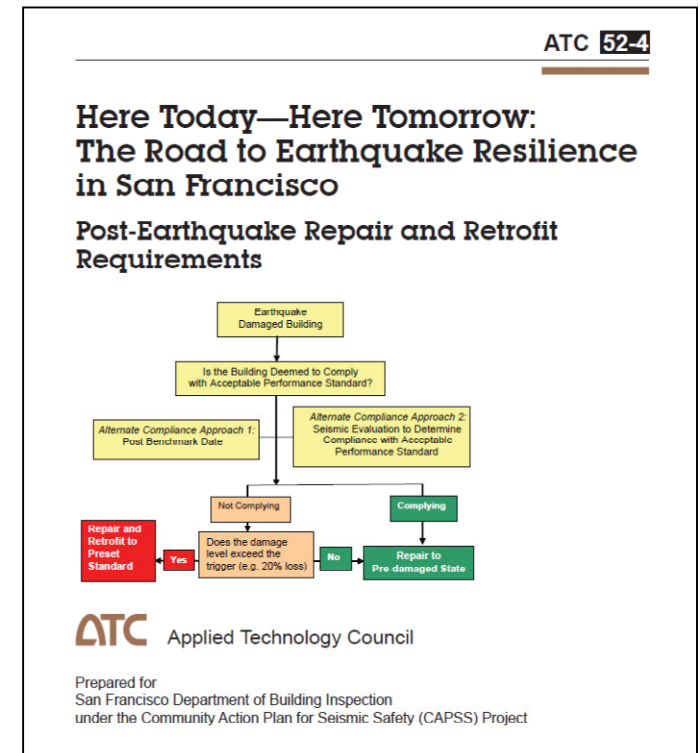
Conclusions and Considerations

- Requiring owners of buildings with an “Inspected” placard to obtain a more detailed evaluation before reoccupation is not practical or warranted.
- Requiring owners of all buildings with an “Inspected” placard to obtain a more detailed evaluation within an certain time frame would be a major change in US practice, have significant costs, and likely raise many objections from various stakeholders.
- Requiring owners of selected building types or those subject to mandatory ordinances with an “Inspected” placard to obtain a more detailed evaluation within an certain time frame might be more viable.



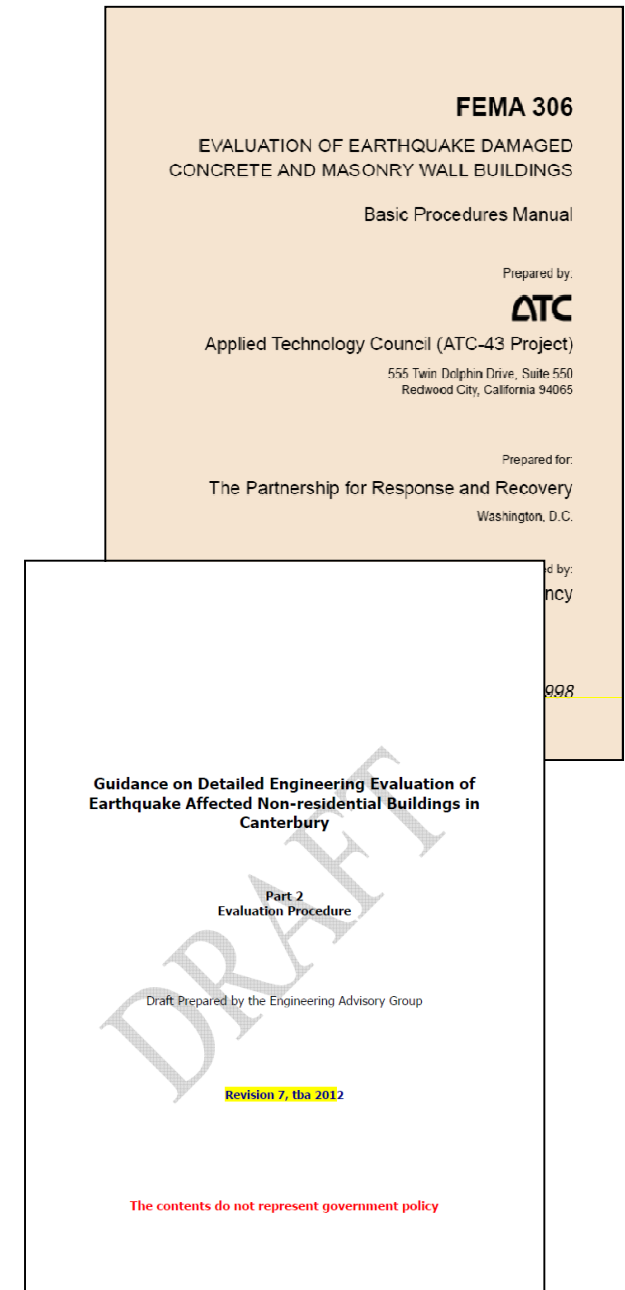
Conclusions and Considerations

- NZ may wish to consider the concept of “disproportionate damage”.
- This is described in the ATC 52-4 document prepared for San Francisco.
- Repair requirements are more stringent for those buildings that suffered higher levels of damage in moderate to low levels of shaking.
- Triggering loss for disproportionate damage is approximately half of full damage trigger at ground motion of $Sa_{0.3} \leq 0.4g$.



Conclusions and Considerations

- In my opinion, a change to a residual capacity assessment for rapid assessments is not practical.
- Use of residual capacity in more detailed assessments (NZ “Detailed Evaluation” or US “Engineering Evaluation”) is desirable.
- Guidelines for residual capacity assessments exist. Others are under development. More work is needed.



Questions?

