The 14 November 2016 M7.8 Kaikoura, New Zealand Earthquake

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Overview

1. Event Context
2. The Earthquake in Overview
3. Wellington City: Keeping a Damaged City Running ....
4. Seismic Risk Perceptions
5. Key Observations and Learnings
1. Event Context

- The Canterbury Earthquake Sequence 2010/11
- The Cook Strait earthquakes 2013
- Increasing awareness of the risks posed by a rupture of the Alpine Fault, the Wellington Fault or the Hikurangi subduction zone
2. The Earthquake in Overview

- 12.05am on a Monday
- Complex SW to NE rupture involving up to nine possibly disconnected fault segments
- Triggered widespread movement on the subduction megathrust fault (tectonic plate boundary)
- Two main pulses of energy release
- Significant slip / energy release in northern rupture area (approx. 80 seconds after rupture initiation)
- Ground motions mostly within design levels in central Wellington, but a few exceptions at periods of ~1.5s due to a combination of rupture characteristics and site effects
Faults that moved
Ground Motions: Peak Ground Acceleration

NOTE: Vertical value at WTMC unconfirmed. Possibly contaminated by other effects.

Anna Kaiser, GNS Science
Wellington Ground Motions

- Duration of ground shaking significantly longer than 2013 Cook Strait sequence (~4 times)
- Significantly greater long-period energy than Cook Strait sequence
- PGA 0.16 – 0.28 g (similar to Cook Strait sequence)
- MM VI – VII
- Spectral accelerations mostly within design spectra, but exceeded serviceability design levels in many cases.
What we knew in Wellington.... Day 1

- 90 seconds of strong ground shaking

- Buildings damaged in 2013 had received repeat damage, and in some cases greater damage

- No significant damage to Unreinforced Masonry buildings

- Structural failure in a relatively modern building in the port area
What we knew…. Days 2 and 3

From analysis of Geonet recorded ground motions

- Many buildings in the range 6 to 15 storeys had received full design loading (500 year return period)

From initial Rapid Building Assessments

- Some buildings with certain structural characteristics had sustained significant damage

Technical Clearinghouse established

- Initial physical meeting at the end of Day 3
- Virtual, with assistance from EERI

http://www.eqclearinghouse.org/2016-11-13-kaikoura
Day 4 - Wellington City Council Critical Buildings Team

Scope and Focus

1. Assist WCC with decision-making in relation to buildings that are of could be in imminent danger of collapse or loss of façade elements

2. Assist WCC to actively identify other buildings that may have sustained significant structural damage

3. Provide an active linkage between WCC and building owners’ engineers

4. Provide support to owners’ engineers where complex decisions around building risk are required
3. Wellington – Keeping a damaged city running......

- No state of emergency declared in Wellington
  - Impact not considered significant enough
  - Awareness of the economic implications of a declaration

- However, this meant that Wellington City Council was unable to obtain timely information about damaged buildings

- Government had recently passed an amendment to the Civil Defence Emergency Management legislation to address process learnings from the Canterbury Earthquakes
  - Emergency powers for transition (or non-declared) situations passed under urgency two weeks after the earthquake
Wellington City Targeted Building Assessment Programme

- To address public safety issues and to provide confidence that appropriate engineering investigations of buildings most affected by the earthquake have been carried out.

- Targeted Damage Evaluations requested using new emergency powers for buildings within the *Affected Building Profile* (approximately 80)

- Engineering Guidance and a reporting template were quickly produced and issued with the requests on 19 December (Week 5)
Targeted Damage Evaluation Framework

1. Identify buildings that are within the Affected Building Profile
2. Targeted Damage Evaluation, to include targeted inspections
3. Consider impact on usability
4. Report against consistent damage criteria
The Affected Building Profile:
Buildings that Need Careful Damage Evaluation

- Building Characteristics
  - Flexible concrete buildings typically 8-15 storeys with precast floors ($T = 1$ to $2$ seconds)
  - Sited in areas of shaking amplification – soft soils or basin or ridge effects

- Damage Characteristics
  - Significant loss of contents or non-structural damage (partitions, ceiling tiles etc.)
  - Signs of significant movement
    - e.g. cladding damage, stairwell enclosure damage
Critical Damage States Defined

A - Damage posing collapse risk (possibly without aftershock) – *precast concrete floors*

B - Damage posing local and global collapse risk (in case of aftershock) – *precast concrete floors and separation of perimeter seismic frames*

C - Damage to primary structure posing lower risk – *other damage to ductile seismic elements*

D - Damage to secondary structural and non-structural elements that may cause increased life safety risk – *concrete stairs and precast concrete cladding panels*
Precast Floors

- Used extensively from the mid-1970s to achieve longer spans without formwork
- Most common configurations of pre-stressed units:
  - Ribs and infill
  - Double tee sections 1200mm wide
  - Hollowcore (voided) sections 1200mm wide
- Typically with 65mm in situ concrete topping with non-ductile steel mesh
Transverse Cracking in Hollowcore Floor Units
Precast Concrete Panel fixings
Shoreline prior to 1855 M8.2 Wairarapa Earthquake
4. Seismic Risk Perceptions

- Context: most people were in their own homes at the time of the earthquake, rather than in their workplaces
  - Not exposed to the full trauma of the response of multi-story buildings and a city emptying out
- General discomfort that some buildings were found to need demolition after the city was declared ‘open’, and that issues are still being found with others
  - Compared to the perceived ‘cocoon’ of the commercial red zone in Christchurch
Balancing Safety and Economic Objectives

Incautious

- Occupying buildings with damage that may not be fully understood

Overly Cautious

- Not occupying buildings whose damage is understandable and limited

Precautionary Approach

- The need to undertake further investigation where appropriate
Risk Communication Themes

- People still expect that engineers will make statements about whether or not a building is ‘safe’
- Reduced confidence in pre-earthquake seismic assessments, given that some of the previously higher rated buildings performed poorly
  - The misplaced focus on ‘accuracy’ from these assessments can’t easily be dialled back, given the commercial values at stake
- Unreinforced Masonry – no damage??
What About URM Buildings?
Facing the Media
5. **Key Observations and Learnings**

- The value of instrumentation
- Underscoring the vulnerability of the South Island hinterland to landslides
  - Emergency access, supporting the rural sector and tourism
- Sharper focus on making Wellington more resilient
  - Reflecting both the hazard and the consequences
  - Support now for active investment in resilience
- The vulnerability of certain forms of relatively modern construction
- *Much more information to come!!*