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## Post-Earthquake Repairs, Part 2

**ACI Spring 2012 Convention**  
March 18 – 21, Dallas, TX



**Kenneth Elwood** received his Ph.D. in Civil Engineering from the University of California, Berkeley in 2002, M.S. from the University of Illinois at Urbana-Champaign in 1995, and B.A.Sc. from the University of British Columbia in 1993. From 1995 to 1998, Dr. Elwood worked for Buckland and Taylor, Ltd. of North Vancouver.

Dr. Elwood is actively involved in research related to the seismic response of existing structures. In 2006, he chaired a committee for the American Society for Civil Engineers to update the concrete provisions in the Seismic Rehabilitation Standard (ASCE 41). Dr. Elwood is Chair of ACI Committee 369, Seismic Repair and Rehabilitation.



### Emergency Repairs for Concrete Buildings Immediately after the 22 February 2011 Christchurch Earthquake: *Hotel Grand Chancellor*

Alastair Cattanaach: Dunning Thornton Consultants  
Ken Elwood: University of British Columbia  
Noel Evans: OPUS Engineers  
Bruce Galloway: USAR Engineer (Holmes Consulting)  
David Hopkins: Critical Building Project Leader (Structural Consultant)  
Weng Yuen Kam: University of Canterbury Graduate Student  
Andrew McGregor: Lunds Contractor  
Mike Stannard: Department of Building and Housing  
Chris Van den Bosch: City of Christchurch  
Grant Wilkinson: Ruamoko Solutions

ACI Convention Dallas March 2012


### Christchurch Central Business District (CBD)

Christchurch:

- Pop. = 390,000
- 2<sup>nd</sup> largest in NZ

CBD:

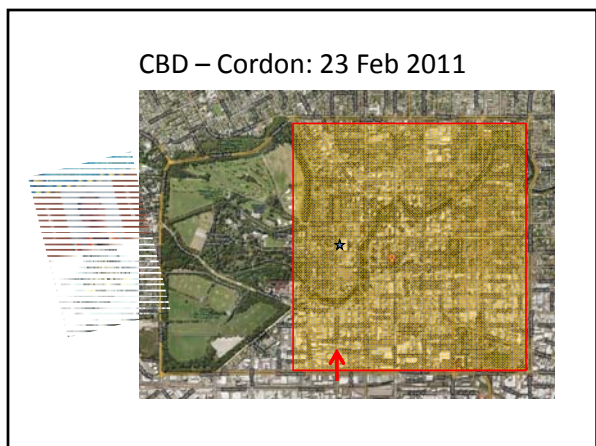
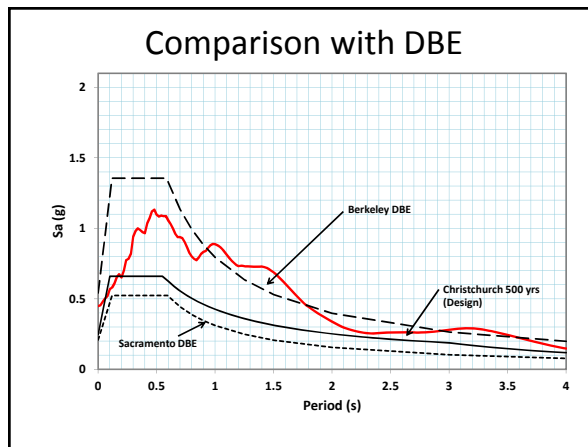
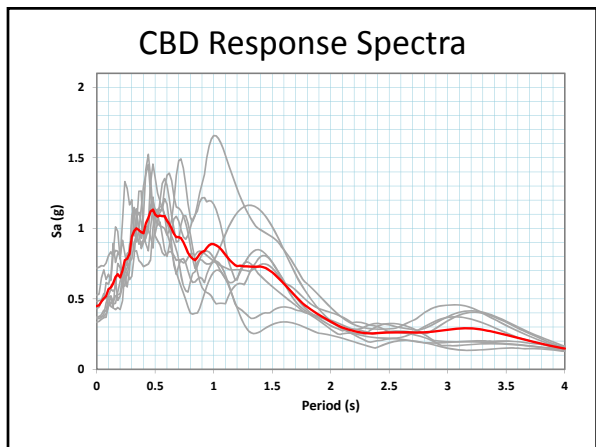
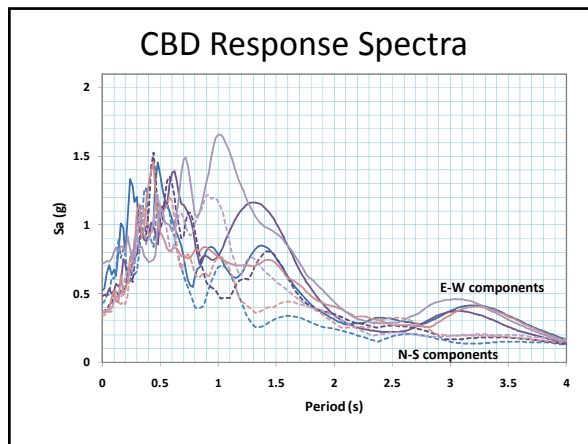
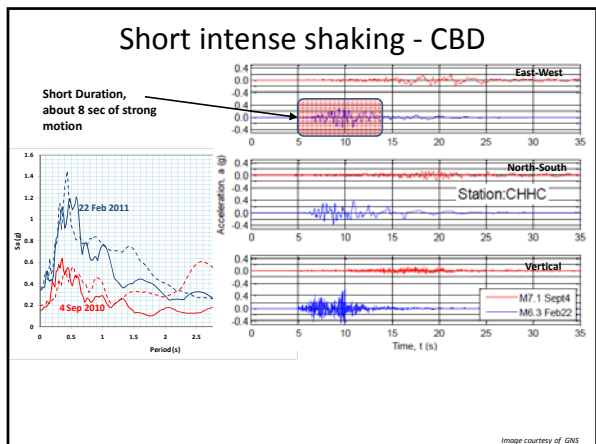
- Approx. 6,000 companies or institutions with over 50,000 employees.
- 25% of the total employment in the city.



### Christchurch Central Business District (CBD)







### Critical Building Project

- Identify buildings that pose a threat of collapse or a hazard to adjacent buildings and roads.
- ~40 "Critical buildings"
- Advise City on action to reduce hazard during State of Emergency.
  - Stabilize, Demolish, or Leave it for the owner?

### Hotel Grand Chancellor

### Initial Information: 23 Feb 2011

*Photo of wall failure in foyer:*

### The Challenge: 24 Feb 2011

East Face

South Face

Survey: No movement in aftershocks (Feb 23 - Feb 24)

### Drawings: 24 Feb

- Constructed mid-1980s
- 22 full stories
- East bay cantilevered

Perimeter frame (above Level 14)

Core wall (up to Level 14)

### Drawings: 24 Feb

#### W-E Elevation

Perimeter moment frame

Shear walls

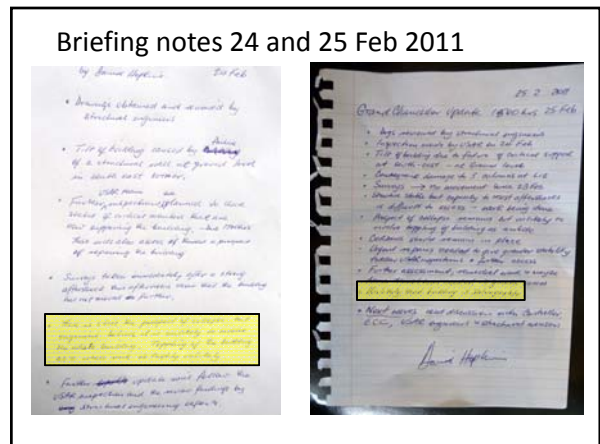
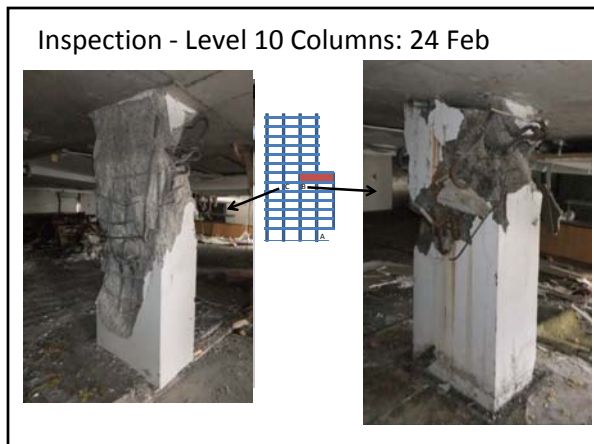
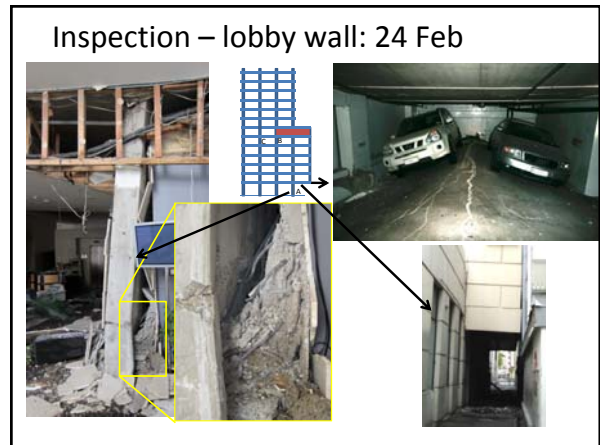
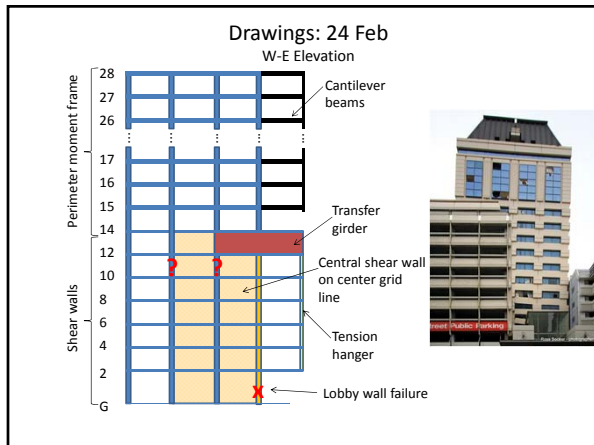
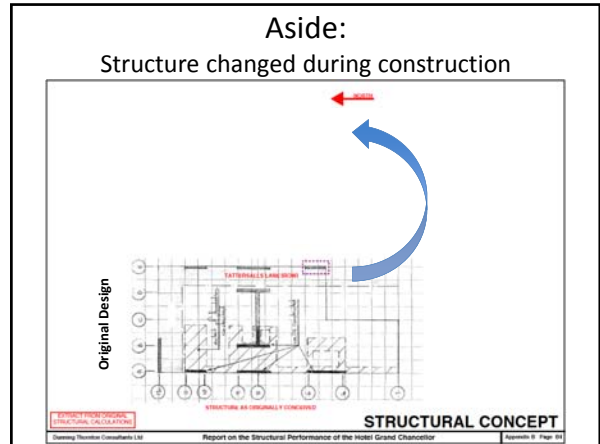
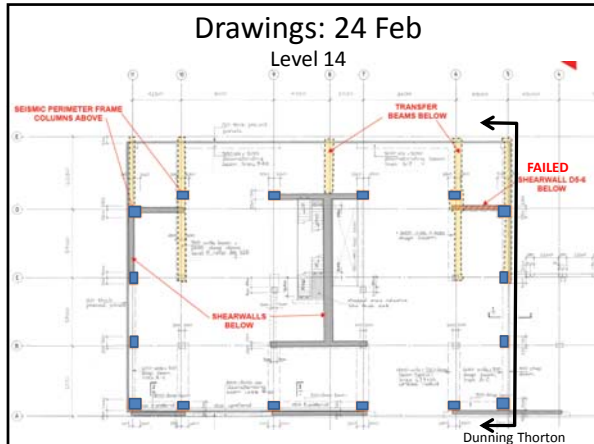
Cantilever beams

Transfer girder

Central shear wall on center grid line

Tension hanger

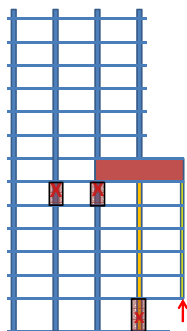
Lobby wall failure



### Solution?

- Demolition?
- Reduce mass?
- Stabilize?
  - “Fix” ground floor wall?
  - Support under tension columns?
  - “Fix” Level 10 columns?

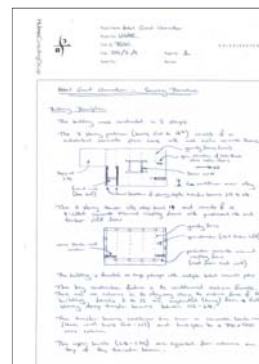
**Must all be done with limited exposure in and around building!!**



### USAR Proposal: 25 Feb

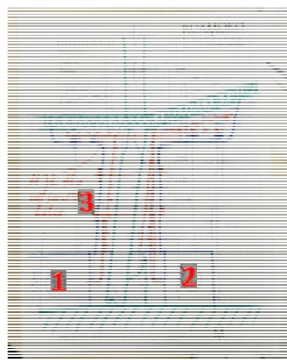
Proposal made by Urban Search and Rescue (USAR) Engineer, Bruce Galloway, 25 February 2011.

This proposal provided vital information on the damage to the building based on USAR engineer observations. It provided the stimulus for and formed the basis of the final proposals which were developed and implemented.

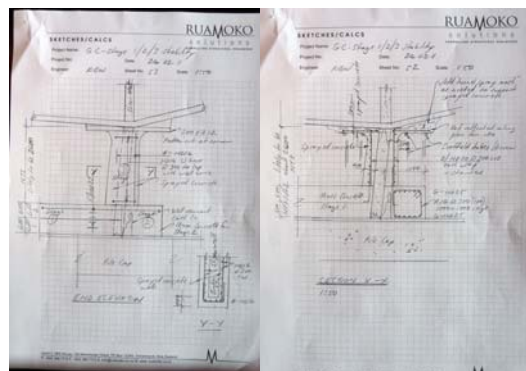


### Brainstorming: 25 Feb

- Stage 1:
  - Mass concrete to brace wall from east.
  - Pumped from outside potential fall zone.
- Stage 2:
  - Mass concrete to confine base of wall.
- Stage 3:
  - Reinforce and shotcrete wall and slab above.
- Plan B – Prop cantilever in lane



### Stabilisation Repair Drawings: 26 Feb



### Clearing the work area: Feb 27



### Preparing the formwork: Feb 27



Pump concrete – east support: Feb 28



Complete wall support: March 1



→ Room-by-room building inspection  
March 1-2 (7 days after earthquake)

Shotcrete lobby wall: March 2-5



Stabilization - Level 10 Columns: March 5+



Plan B: Cantilever propping proposal



Deconstruction...



### Hotel Grand Chancellor Acknowledgement

- The constructive approach of all involved was outstanding and is gratefully acknowledged
- People contacted included the original designer in Sydney and the person responsible for the drawings
- Special thanks are due to Steve McCarthy of Christchurch City Council who liaised with and directed the Critical Buildings Group

### Concluding remarks

- Unprecedented context
- Urgent need to stabilise major buildings
  - USAR access
  - Road clearance
- Immense challenge
  - Building data and **drawings**
  - Surveys to check movement
  - Stabilisation solutions
  - Innovative implementation
- Sustained co-operative effort of all involved
- Many subsequently demolished but initial stabilisation critical