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**HAZARDS**CRC

# RESILIENCE & MITIGATION THROUGH HARDENING THE BUILT ENVIRONMENT (BUILDINGS & INFRASTRUCTURE)

A9: Cost-effective mitigation strategy for Earthquake Risk

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An Australian Government Initiative



# **A9: COST EFFECTIVE MITIGATION STRATEGY FOR BUILDING-RELATED EARTHQUAKE RISK**

## **Project Participants**

**Univ of Adelaide: MC Griffith, M Jaksa, AH Sheikh, C Wu, MMS Ali, T Ozbakkaloglu, A Ng & P Visintin**

**Univ of Melbourne: NTK Lam, H Goldsworthy**

**Swinburne University: JL Wilson, E Gad**

**Geoscience Australia: M Edwards, H Ryu, M Wehner**

**AERIAL VIEW OF CHRISTCHURCH SECONDS AFTER THE  
22 FEBRUARY 2011 EARTHQUAKE  
(only M6.3 but ~ 10km from CBD)**



# Summary

- 1) Design magnitude earthquakes (1 in 500 yr) will affect large area (~ 30km radius)
- 2) While the earthquake Hazard is low, the Risk (= probability x exposure) is high - a M6 earthquake in Sydney is ranked in the top 10 of financial risks for the world's reinsurance industry!
- 3) Damage will be widespread and take many years to repair  
– Christchurch damage ~ 20% GDP and at least 10 years to repair

# CHRISTCHURCH – 2012

(> 80% BLDGS DEMOLISHED AS OF JULY 2014)



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# **Aim:** to develop evidence base to inform decision making for earthquake risk mitigation

- ✓ **Establish seismic vulnerability classes for representative building types in Australia**
- ✓ **Survey existing retrofit techniques for known performance in recent earthquakes**
- **Develop new cost-effective Australia-specific retrofit techniques**
- **Develop decision-support and earthquake risk forecasting tools to support infrastructure managers**
- **Develop economic loss models for business interruption and casualty costs**

## **Expected Outputs:**

- **A cost-benefit analysis methodology for key retrofit options at both the building and regional levels**
- **Information and models to enable planning authorities to develop policies and legislation, backed up by substantiated economic benefits**

# Lessons from Christchurch



Christchurch corner shops



Adelaide corner shops



Christchurch theatre



Adelaide arcade





Out-of-plane wall bending failures in Christchurch (42 fatalities in URM buildings)

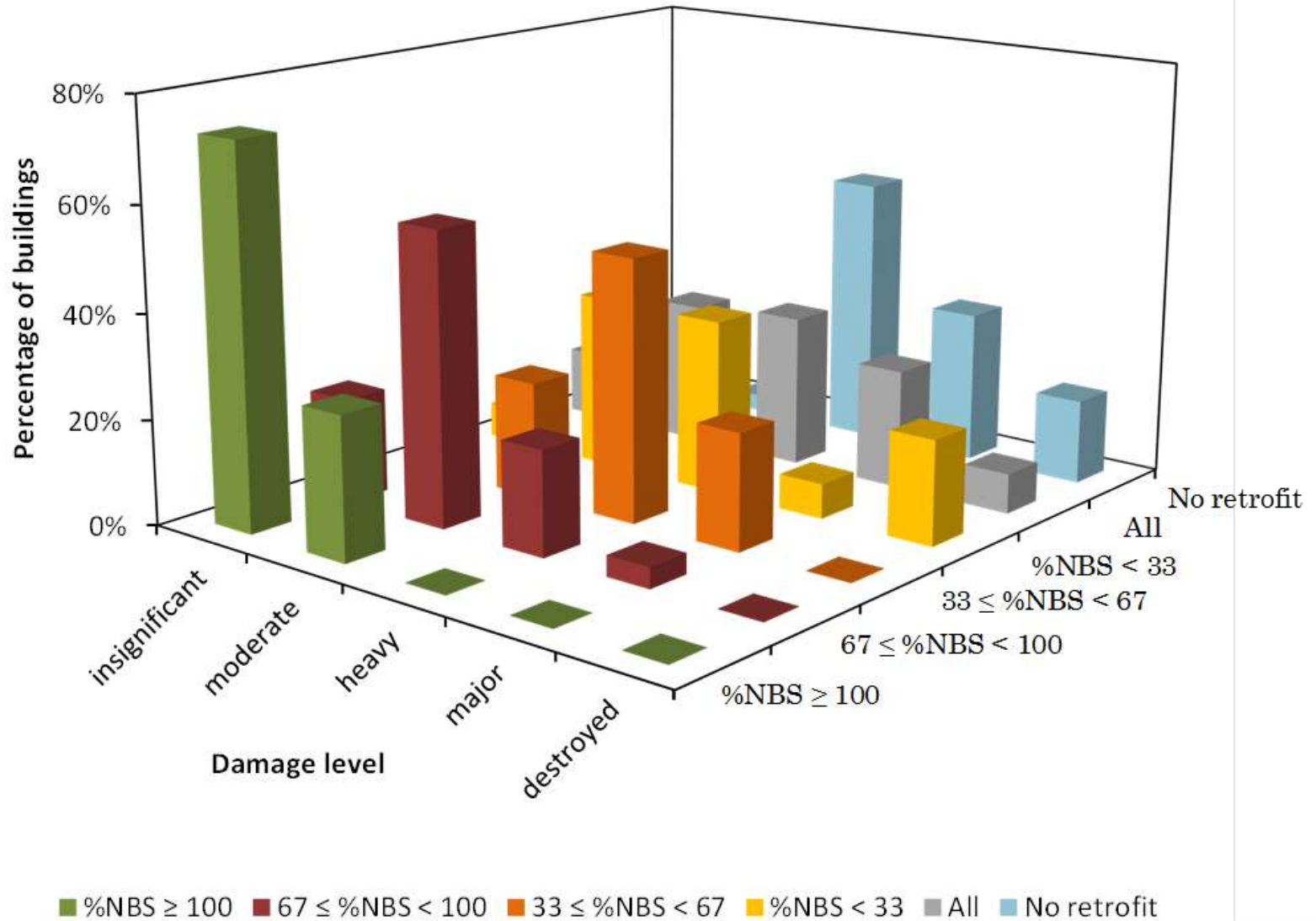


**PGC – 18 fatalities**



**CTV – 115 fatalities**

# DAMAGE LEVELS FOR DIFFERENT LEVELS OF RETROFIT



# KEY ACTIVITIES FOR THE PERIOD

## Post-docs (1.2 FTE) appointed:

Dr Wade Lucas at Adelaide and  
Dr Elisa Lumantarna at Melbourne/Swinburne

## Five PhD students (1 CRC supported) working on topics directly related to CRC:

2 students on seismic vulnerability of reinforced concrete structures;  
1 student on seismic performance of transfer structures;  
1 student on improved seismic assessment for URM buildings; and  
1 student on quantifying soil site amplification characteristics.

## Seismic Vulnerability of Australian Buildings:

Geoscience Australia researchers have produced first cut of ratings for the seismic vulnerability classifications for Australian buildings.

# Damage & Economic Loss Modelling

1. *Rank Vulnerability of Common Construction Types*
  2. *Estimate Structural Drift for Various Magnitude Events*
  3. *Develop Damage-Drift Relationships to Estimate Building Damage*
  4. *Develop Cost-Damage Relationships to Estimate Economic Impact\* of Natural Hazard*
- ❖ *costs to include fatalities & injuries, business interruption at a precinct level*

# New/Improved Retrofit Options

- 1. Rank Vulnerability of Common Construction Types*
- 2. Identify Failure Modes of High Risk Construction Types under Seismic Loading*
- 3. Identify Available Retrofit Techniques for High Risk Construction Types*
- 4. Use Christchurch Data to Identify Successful Retrofitting Techniques*
- 5. Use Christchurch Data to Identify Unsuccessful Retrofitting Techniques and Investigate Possible Improvements*

# Experimental Planning

- 1. Unreinforced Masonry Subjected to Out-of-Plane Bending***
- 2. Non-Ductile Reinforced Concrete Frames***

# Closing Remarks

- Have met all deliverables to date
- Most of the project team researchers attended the 2014 Australian Earthquake Engineering Conference in late November during which time we held informal project meetings in parallel with that conference.
- The Draft plans for further CRC project work were further fleshed out at that time. We now need feedback from end users.



