Hardening Building and Infrastructure Cluster

PROJECT A9: Cost-effective mitigation strategy development for building related earthquake risk
Project Participants

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End Users:
WA DFES, York Shire Council, ABCB, Standards Australia, EMA, State/Local Governments
**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 cost-effective Australia-specific retrofit solutions
  - Develop decision-support and earthquake risk forecasting tools to support infrastructure managers
  - Develop economic loss models that include business interruption and casualty costs
End User Engagement

- WA Dept Fire & Emergency Services
- York Shire Council
- WA Dept Planning, Lands & Heritage
- Standards Australia - AS 3826
- Other indirect
  - EMA
  - State & local governments
  - Bldg Code of Australia
Out-of-plane wall bending failures in Christchurch (42 fatalities in URM buildings)
Some statistics

• 39 of the 42 fatalities associated with unreinforced masonry buildings were outside the building

• NZ law has existed for several decades requiring ‘Earthquake Prone’ building owners to strengthen or demolish it.

• However, it was up to ‘local authorities’ to enforce it.

• Often, cost-benefit arguments were used to ‘avoid’ strengthening
BUILDING SURVEY DATA CAPTURE INCLUDED:
(1463 BUILDINGS SURVEYED, 307 URM BUILDINGS IDENTIFIED)

- Building type and usage
- Building plan dimensions, # of storeys and storey heights
- Roof shape
- Presence/detail on chimneys, parapets, awnings/verandahs
- Presence/detail on existing retrofit
- Masonry wall material and bond pattern
- Separation with respect to adjacent buildings
- Presence of neighbour falling hazards
GENERIC BUILDING TYPOLOGIES

(a) Residential

(b) Pub

Falling Hazards: chimneys, gable end walls, parapets, out-of-plane wall failures
COMMERCIAL (ROW) BUILDINGS

(a) Single storey

(b) Two/three storey

Falling hazards: parapets, OOP wall failures in multi-storey bldgs.
2 STOREY INSTITUTIONAL BUILDINGS

(a) Isolated

(b) Row

Falling hazards: Parapets, chimneys, OOP wall failure
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 for unstrengthened and strengthened buildings
4. Develop Cost-Damage Relationships to Estimate Economic Impact* of Natural Hazard

- costs to include fatalities & injuries, business interruption at a precinct level

1, 2 ‘done’; 3 & 4 in progress
PGA CAPACITIES AND PROBABILITY OF EXCEEDANCE OVER 30 YEAR TIME HORIZON

Parapets

![Graph showing probability of exceedance over 30 years for different parapet capacities.](image)

- **Capacity**
  - $H = 1200$ mm: 0.20
  - $H = 1500$ mm: 0.18
  - $H = 1800$ mm: 0.16
  - $H = 2100$ mm: 0.14

**Thickness [mm]**
- 450
2010 Kalgoorlie Earthquake

Parapet/awning damage in URM buildings in M5.0 earthquake
• WA DFES and York Shire Council end user engagement has been fantastic:
  ➢ Community engagement has been good;
  ➢ Seismically vulnerable buildings have been identified;
  ➢ Seismic strengthening options being developed for typical York buildings;
  ➢ DFES and York Shire successfully applied for a $250,000 NDRP 2019-21 grant to expand scope across all of WA;
• Much of the assessment and retrofit solutions being developed for York will have national application
• Update of AS 3826 “Earthquake strengthening of existing buildings”