

In-situ testing of Unreinforced Masonry Building in Whanganui

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Seismic
Retrofit
Solutions



THE UNIVERSITY
OF AUCKLAND

FACULTY OF ENGINEERING

28th November 2012



Introduction



As-built URM building
following 22nd Feb 2011



Retrofitted URM building
following 22nd Feb 2011

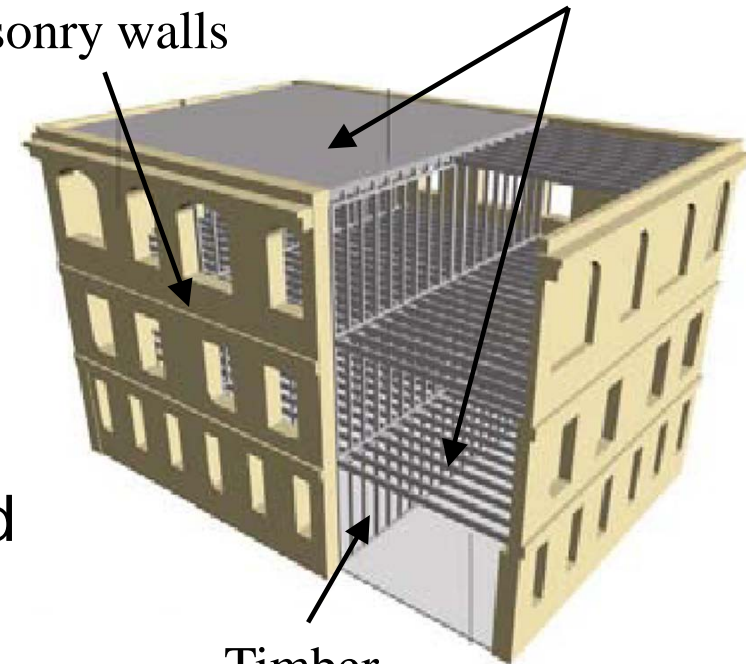


URM buildings

- What are URM buildings?
(Unreinforced Masonry Buildings)
- Poor seismic performance
- Large building stock in NZ and worldwide
- Required
 - Understanding of seismic performance
 - Seismic improvement

2-4 leaf thick
load bearing
masonry walls

Timber joist with
timber flooring



Timber
partition walls



Motivation

Out-of-plane
failure of
wall

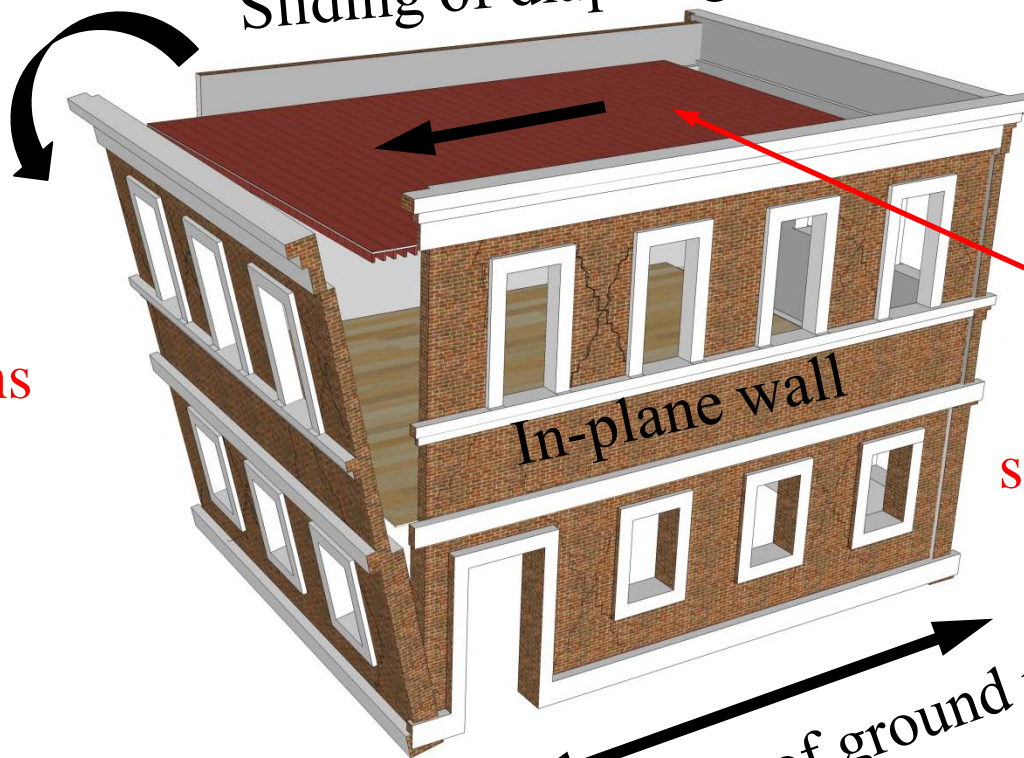
Part 1
Anchoring
connections

Sliding of diaphragm

Part 2
Shear transfer
connections

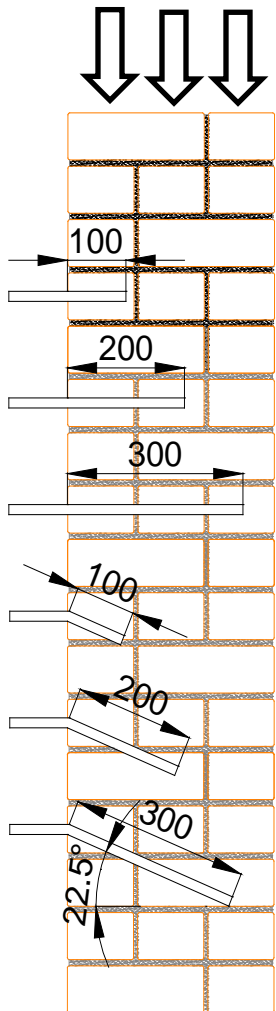
Part 3
Diaphragm
strength/stiffness

Direction of ground motion

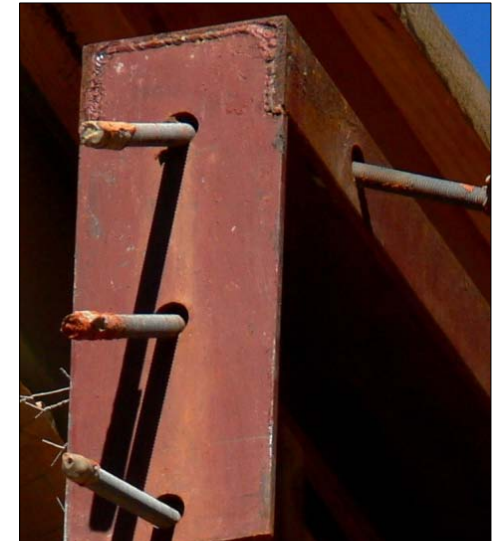




Part 1a - Anchoring Connections



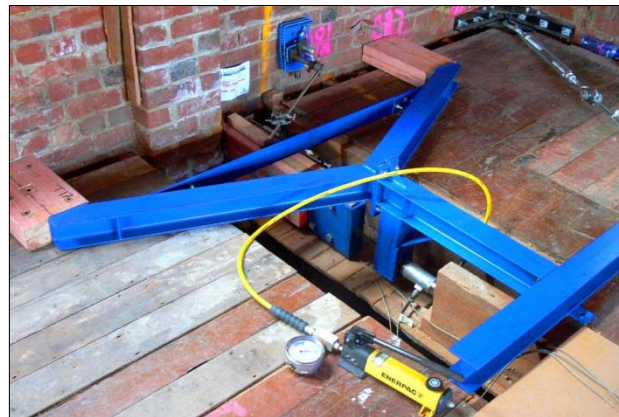
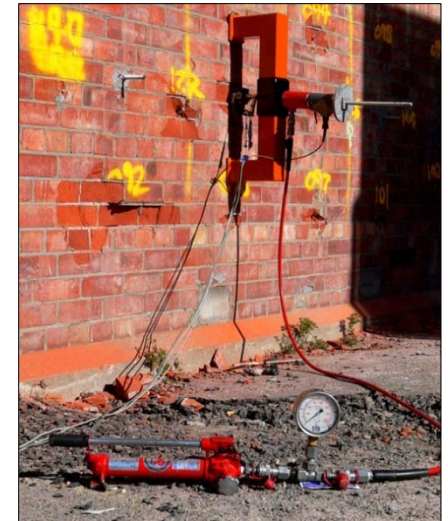
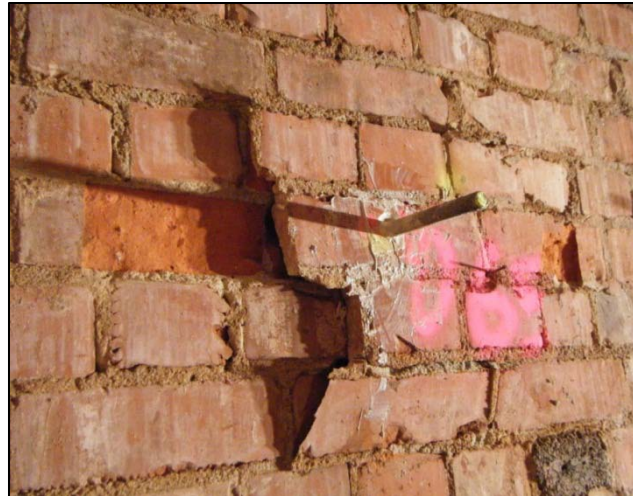
- Anchor type
 - Epoxy and grout
 - Mechanical
 - Through bolts
- Orientation
 - Straight and bent
- Embedment depths
 - 100, 200, 300, 400 mm
- Rod diameters
 - M12, M16, M20
- Overburden weights
 - Ground floor, first floor and parapets





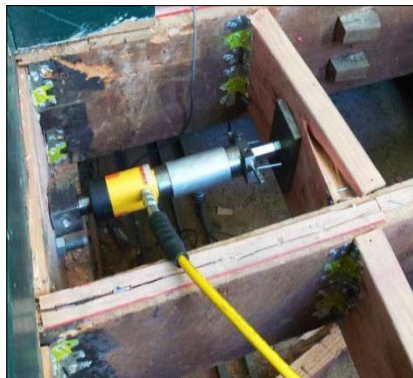
Part 1a - Anchoring Connections

- ~400 tests conducted

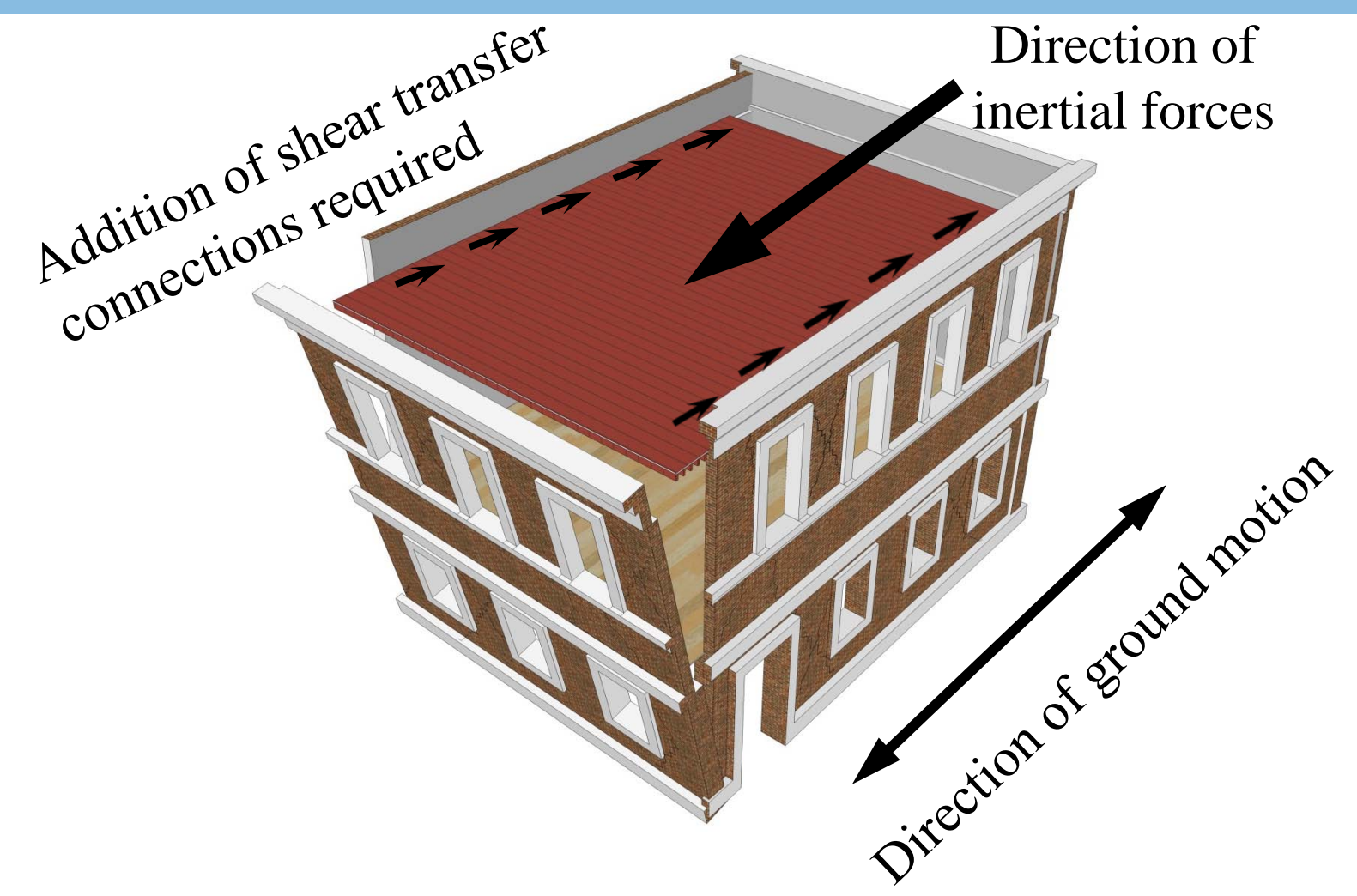




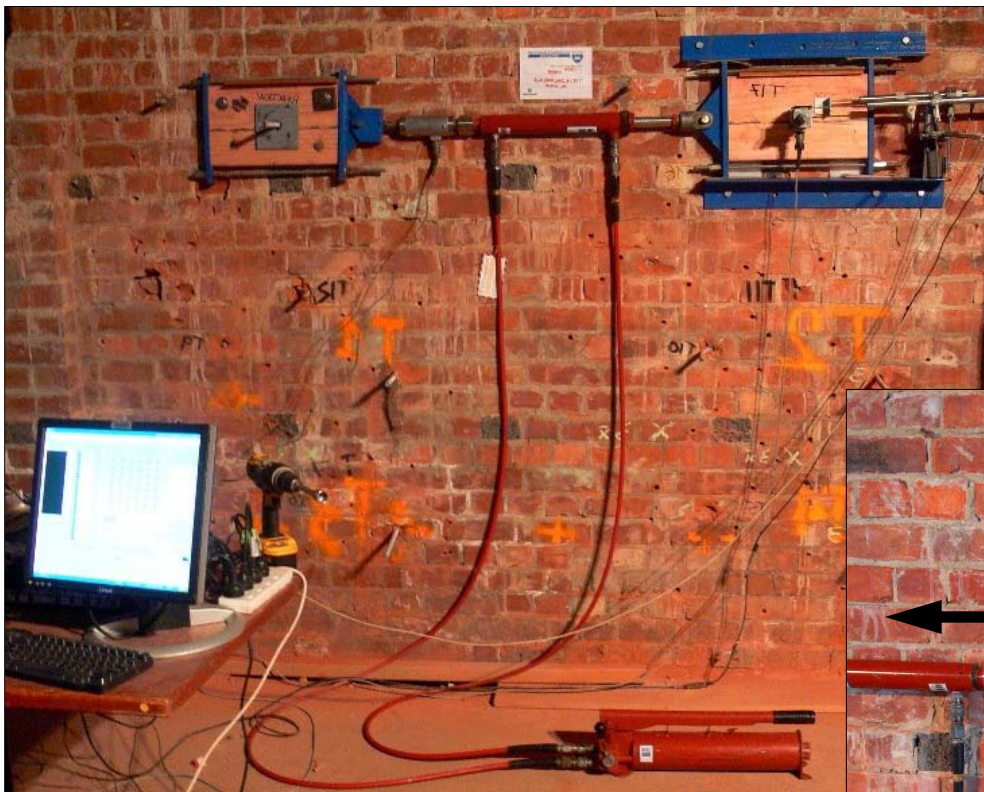
Part 1b - Anchoring Connections



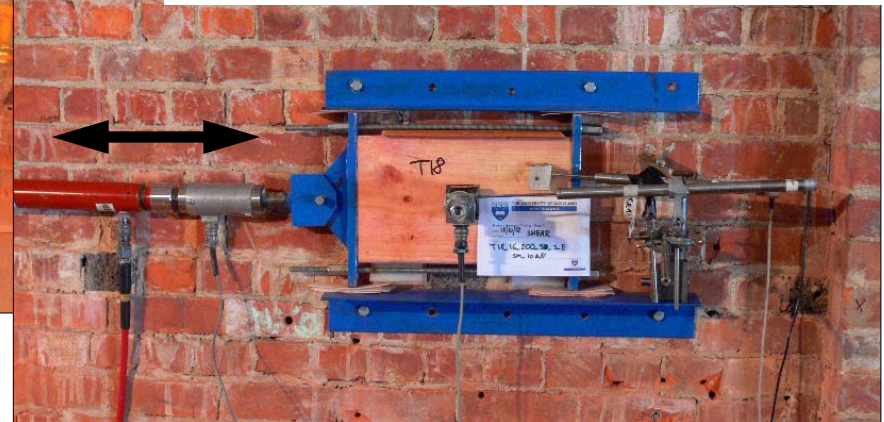
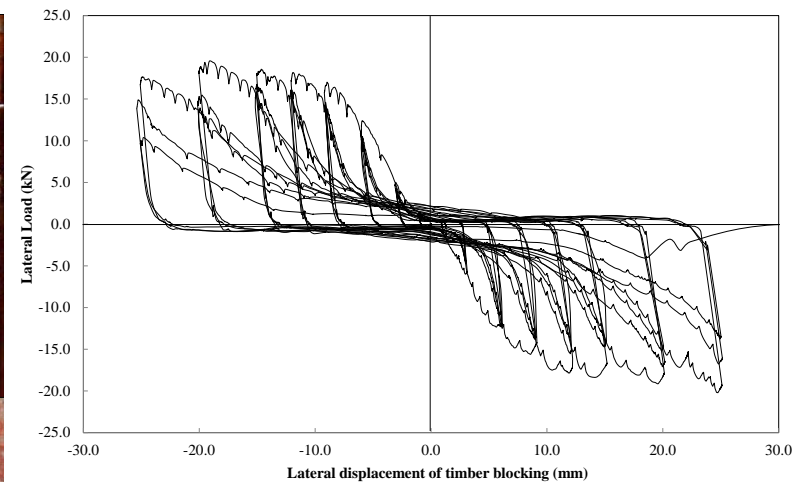
Part 2 – Shear transfer connections



Part 2 – Shear transfer connections



Typical shear test setup



Close-up - typical shear test setup

Part 2 – Shear transfer connections

- Data not available in literature
- Failure modes
 - Double shear of anchor
 - Timber crushing



Crushing of brick substrate



Crushing of timber

Building in Whanganui

- Built 1913
- Lime mortar and clay brick masonry
- Two stories
- Original flexible timber diaphragms
- Derelict for >5 years
- Up for demolition



35 Drews Avenue, Whanganui

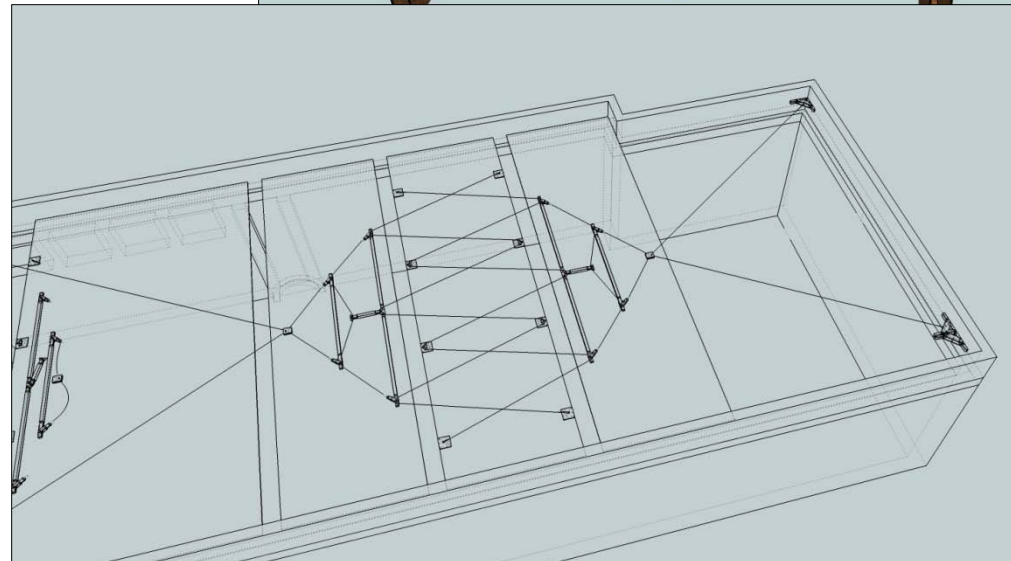
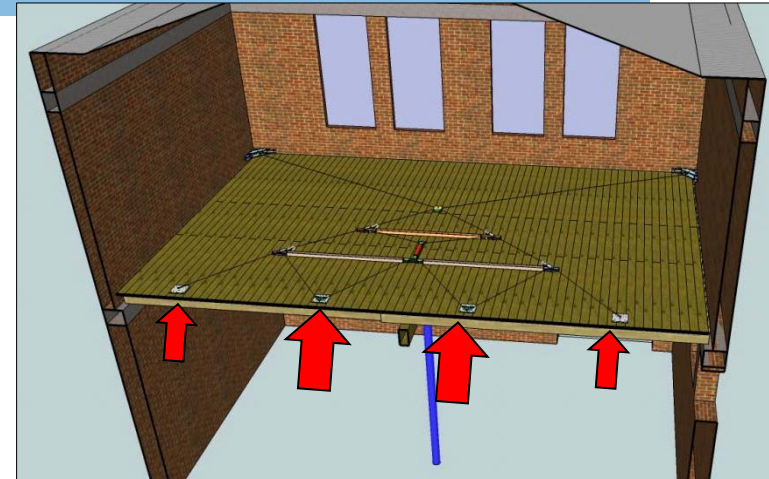


First floor interior



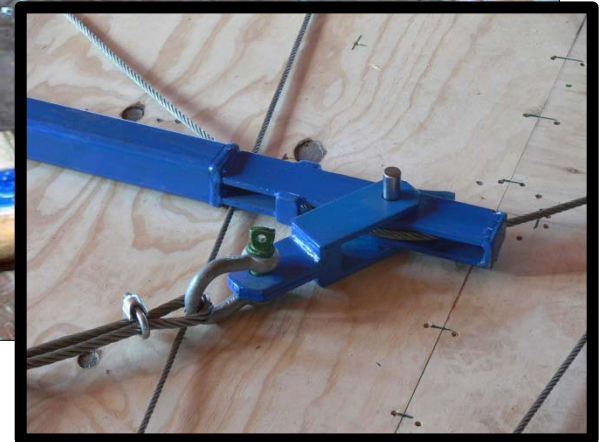
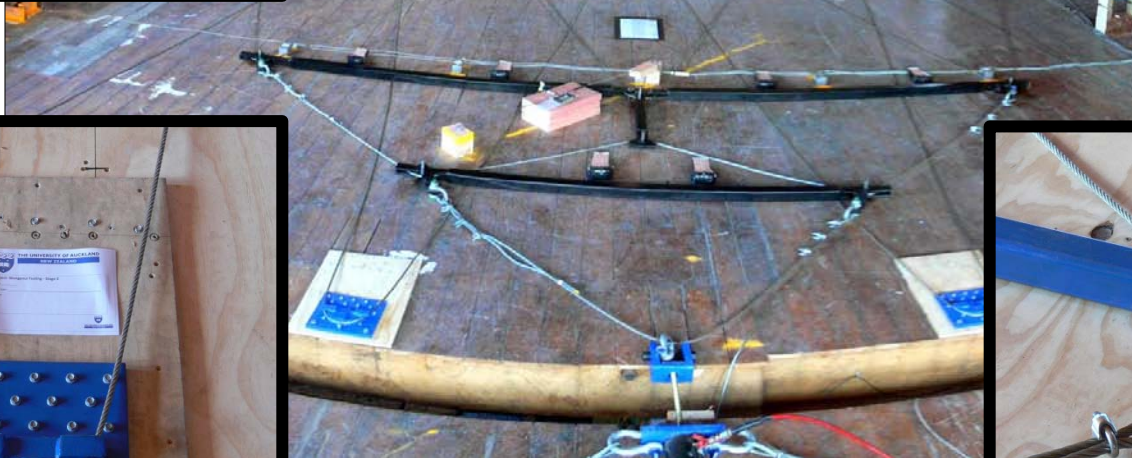
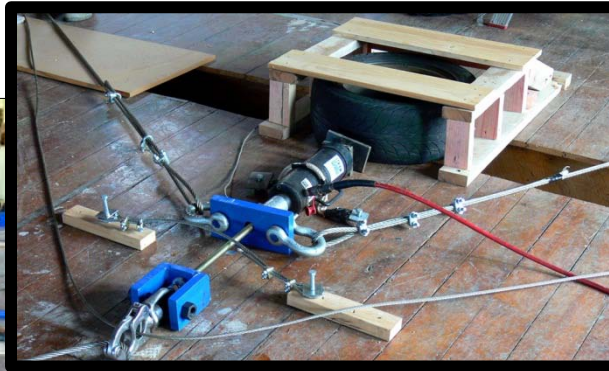
Part 3 – Existing floor diaphragms

- As-built
 - Timber ceiling & decorative steel sheets
 - Flooring only
- Retrofit
 - Re-nailing
 - Plywood overlays
- 4 point cycle loading
- Snapback tests





Part 3 – Existing floor diaphragms





Part 3 – Existing floor diaphragms

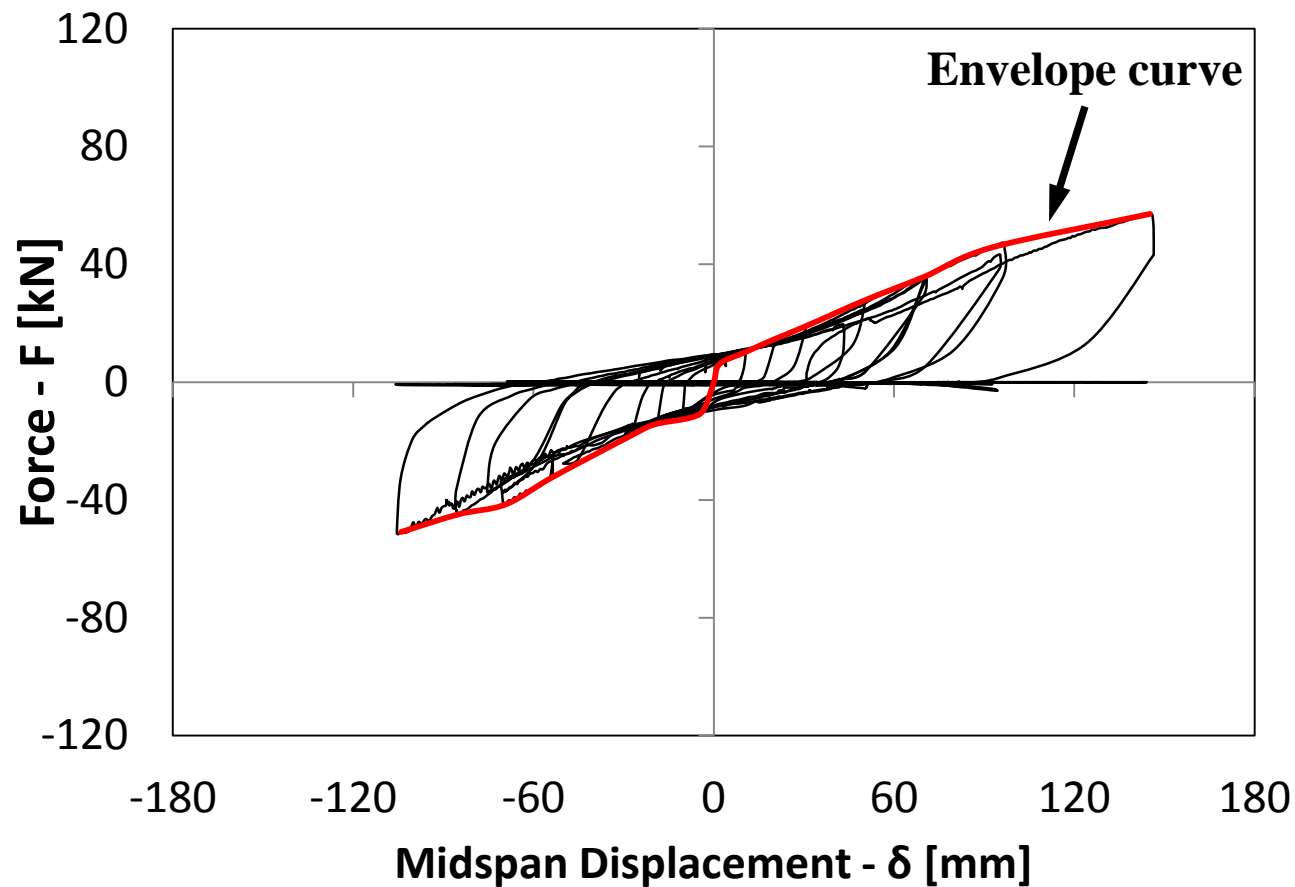


Part 3 – Existing floor diaphragms

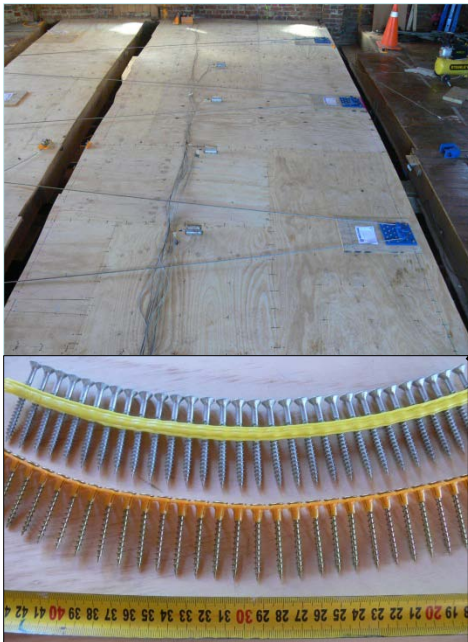




Part 3 – Results snapshot



Part 3 – Retrofitted floor diaphragms



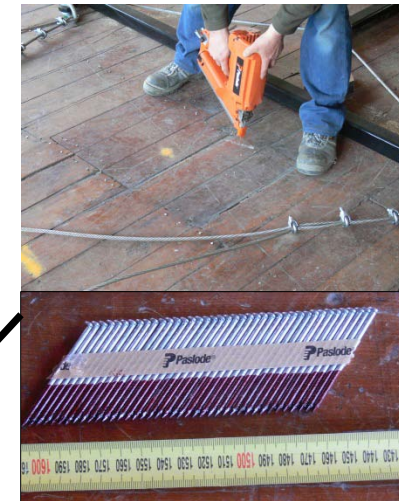
9mm thick plywood overlay



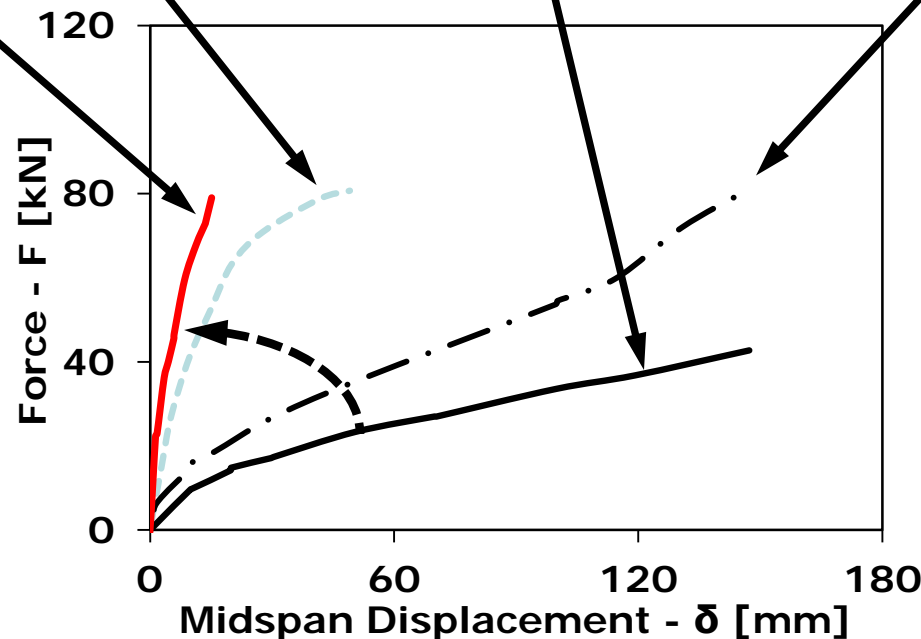
Original



Ceiling removed



Re-nailing



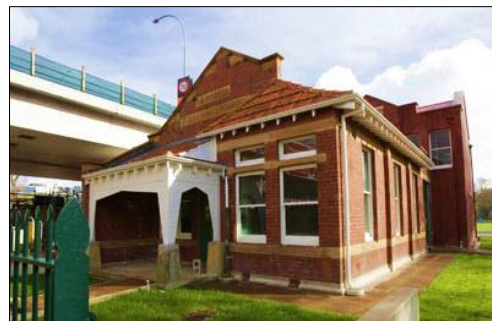


Future Research

- Parapet restraints
- Diaphragm connection testing
- Floor to joint nail connections
- More in-situ testing
 - Opportunity dependent
 - Diaphragm testing
- Future projects



Birdcage Tavern



CFK – parapet strengthening



Chimney strengthening

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Thank You!

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