Quasi-static cyclic testing of a low-damage, drift-sensitive, non-structural components sub-assembly

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Why is this research important?

- It has been repeatedly observed that the performance of Non-Structural Elements (NSEs) is crucial to building performance
  - Significant Damage observed to NSEs after the 2010-2011 Earthquakes in Christchurch, New Zealand and in the 2016 Kaikoura Earthquake
  - Risk still presented by poor performance, despite current NZ design provisions focusing on ensuring life safety
- Even in cases where life-safety performance is sufficient, serviceability performance can still be compromised leading to several issues:
  - Loss of weather tightness (leading to further damage)
  - Limited access for emergency services
  - Large economic losses

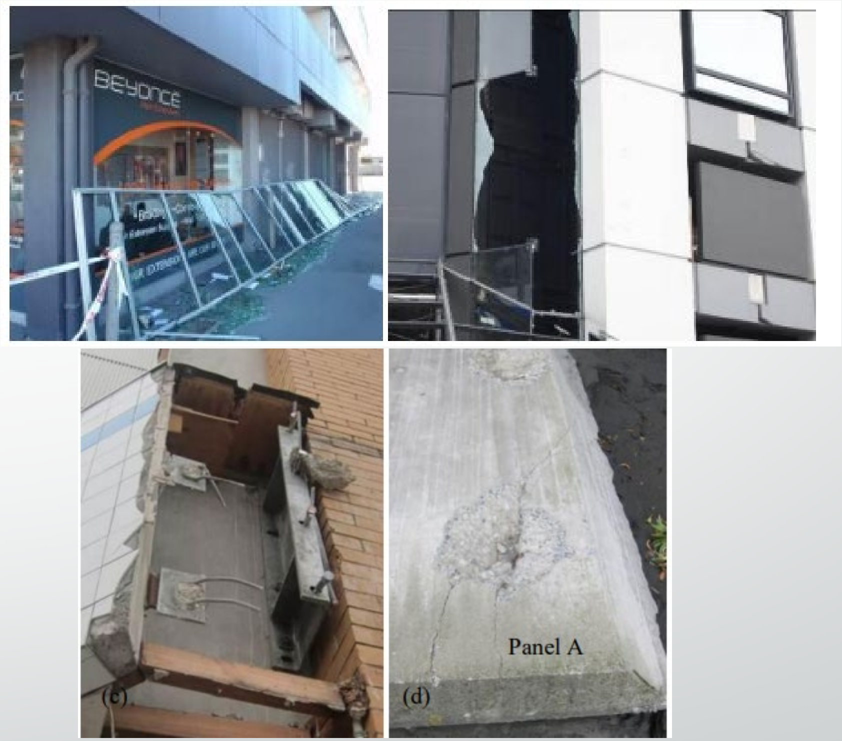

Figure 1: Photos of NSEs damage during the 2011 Christchurch Earthquake. a) and b) indicate damage to glazing systems [Baird *et al.*, 2011], c) and d) show damage to precast concrete panels [Kam *et al.*, 2011].

What am I researching?

- Examining both the seismic and serviceability performance of **non-structural elements**
- A focus on **low-damage** variations of drift-sensitive components:
  - Precast Concrete Panels -> Low-Damage Rocking Precast Panels
  - Curtain-Wall Glazing -> Seismic Frame Curtain Wall Glazing
  - Internal Plasterboard Partitions -> Dual-Slot Track (DST) Rocking Partition Panels
  - Return Wall Partitions -> DST Rocking Return Walls
- Examining the **interactions** between these low-damage systems to identify strengths and/or shortcomings from the combined behaviour

Low-Damage Non Structural Elements

Rocking Precast Concrete Panels

- Panels with novel rocking connections, allowing for vertical and horizontal translation, along with rotation
- Use of steel embeds consisting of vertical slots full of grease, and weld plates to act as points of contact to prevent chipping and spalling
- With adequate slot spacing can reach up to 4.2% interstorey drift with no visible damage

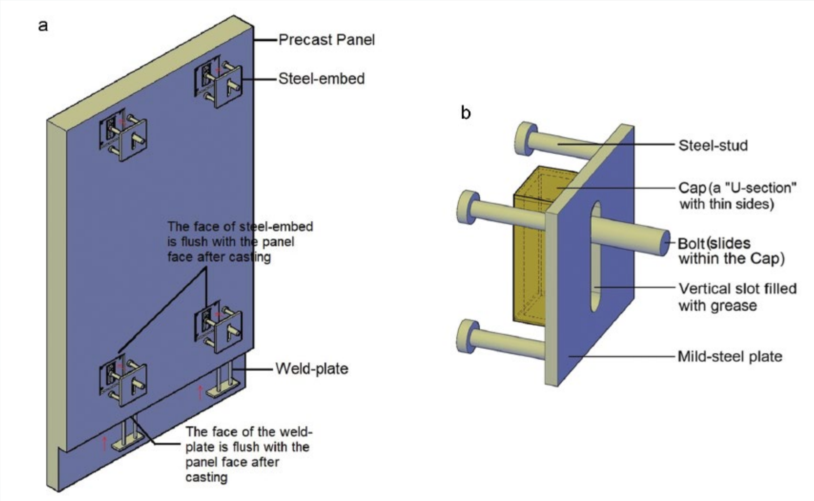

Figure 2: Renders of a) The precast panel with the embeds and weld plates, and b) The steel-embed [Bhatta et al., 2020].

Figure 3: Photo of the Precast Panels.

Low-Damage Non Structural Elements

Seismic Frame Glazing

- Glazing system with a secondary internal seismic frame
- Frames separated by a rubber gasket to allow for greater deformations
- Found to delay the onset of water leakage in comparison to standard glazing frame

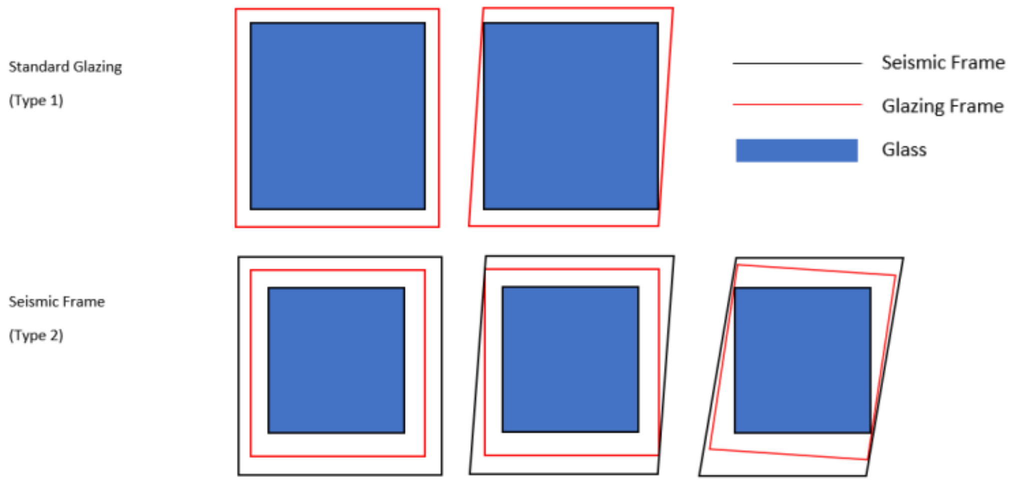

Figure 4: Illustration showing the behaviours or standard versus seismic glazing systems under deformation[Arifin et al, 2020]

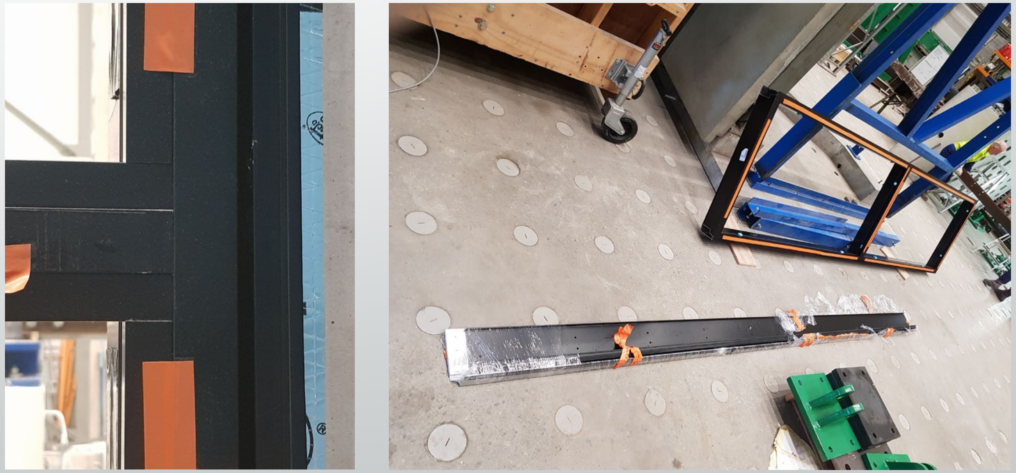

Figure 5: Photos of A) The glazing seismic frame in place B) The unassembled two sections of the seismic frame.

Low-Damage Non Structural Elements

Dual-Slot Track Partitions

- Two partition wall deflection tracks of different widths to constrain both the studs and the plasterboard
- Use of Aluminium Angles at the corners to allow the paritions to recenter after loading
- Timber planks at these corners to prevent deflection of the studs
- Use of silicone sealant between partition panels in larger frames to provide additional deformation capacity

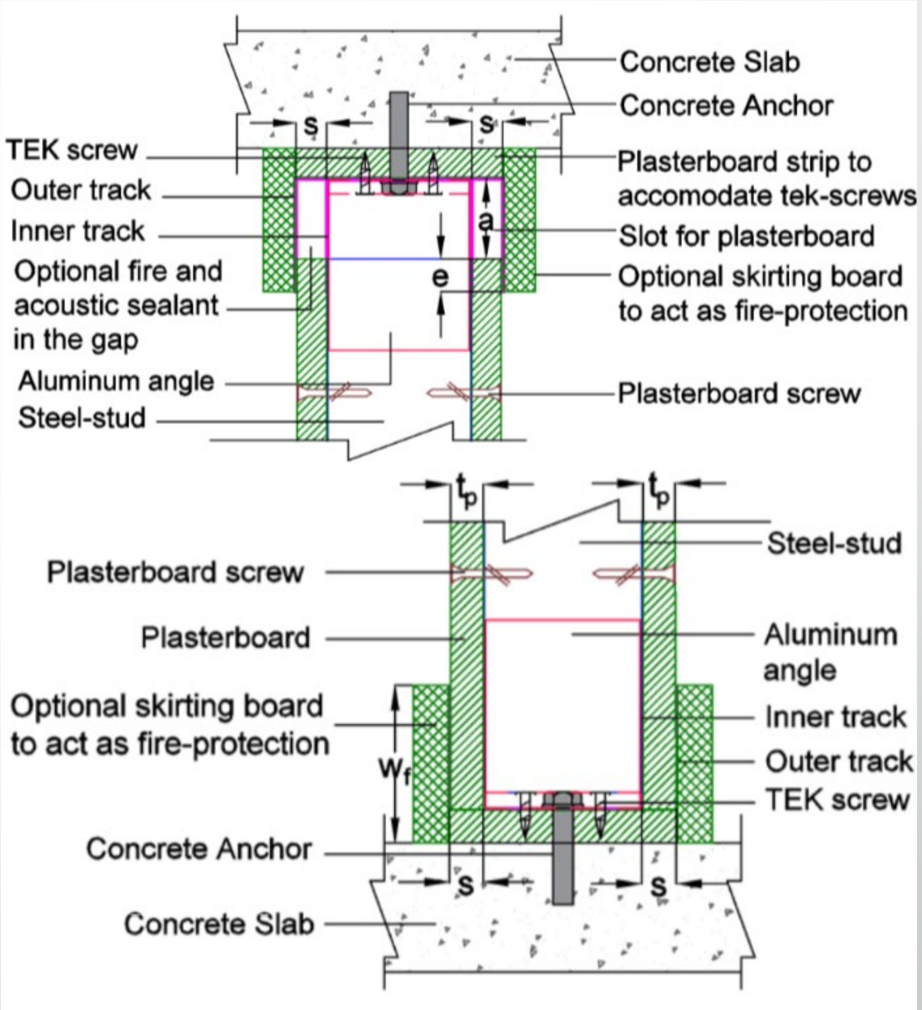

Figure 6: Section drawings of the top and bottom DST connections [Bhatta, 2022]

Test Setup

- Sub-assembly of all the low-damage NSE’s within a pin-pin experimental frame
  - Quasi-static cyclic testing to 4.2% Inter-story drift
  - Weather-tightness (water-tightness and air leakage) testing at the end of each cycle
  - Instrumentation to monitor the relative movement between components, and relative to the strongfloor / strongwall

Figure 6: Photo of the waterbox used for weather-tightness testing

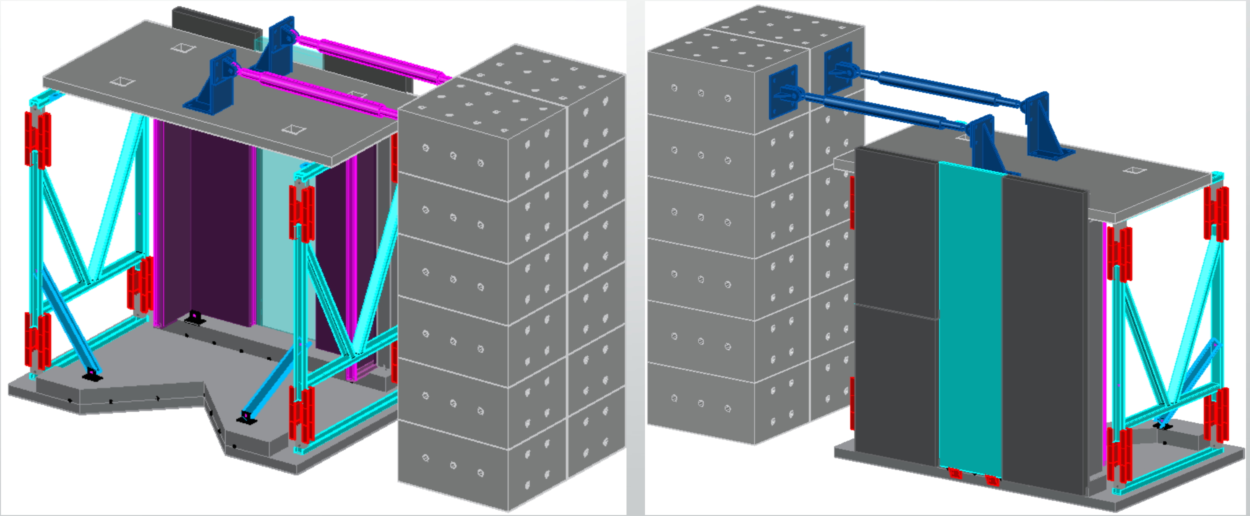

Figure 7: 3D renders of the test setup form the A) rear view B) Front View.

Current Progress

- Precast panels and the seismic glazing system have been installed, working with the partition company to source materials
- Initial testing with just the precast panels has been done up to 2.5% drift
  - Early locking of the precast panels was noticed, so the slots were widened to accommodate larger horizontal translation

Figure 8: Photo of the current progress of the test setup, with the precast panels and the seismic glazing system installed.

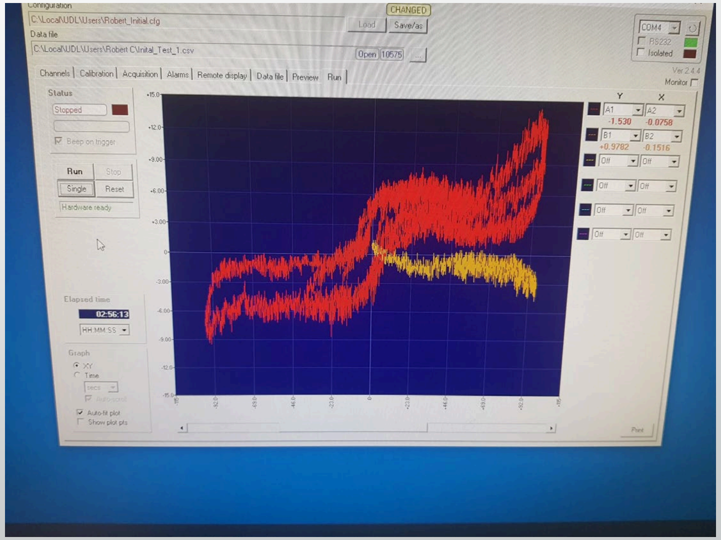

Figure 9: Force-Displacement Graph from the first initial test, showing the rocking of the panels and the points at which the precast panels exhausted the horizontal slots.

Application of large-scale testing for this research

- This research is already examining the interactions between components, but has limitations:
  - Adaptation to an existing rig – compromises needed to be made to fit within the frame
  - Uplifting of the top slab due to locking of the precast panels
  - Only examining interactions between certain drift-sensitive NSEs

Application of large-scale testing for this research

- Large-scale testing offers a chance to push beyond these limitations and ask other questions:
  - How can these panels be integrated with other NSEs (drift-sensitive and non-drift-sensitive) AND within the structural system, and still provide the same benefits?
  - How will the precast panels react when they exhaust the horizontal slots and attempt to push vertically against the weight of an actual floor slab?
  - What additional alterations to other existing NSE connection systems would need to be made in order to accommodate these low-damage designs?
  - Do these changes to the standard installation procedure procedures provide a sufficient benefit with a large-scale project when you consider changes that need to be made to other components?

Thank you

- Questions
- Comments