

Overview of research into the seismic performance of non-structural elements

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Examples of earthquake damage to interior non-structural components

→ Damage to non-structural elements, such as partitions, ceilings, windows/cladding and piping, has been very extensive in recent earthquakes.



Images courtesy of Rajesh Dhakal and Andre Filiatrault

Examples of earthquake damage to interior non-structural components



Images from MacRae et al. 2012

Examples of earthquake damage to exterior non-structural components



Images from MacRae et al. 2012

Examples of earthquake damage to exterior non-structural components

(from Baird et al. 2011)



Figure 13: Examples of damage to spider glazing systems.

Images from MacRae et al. 2012

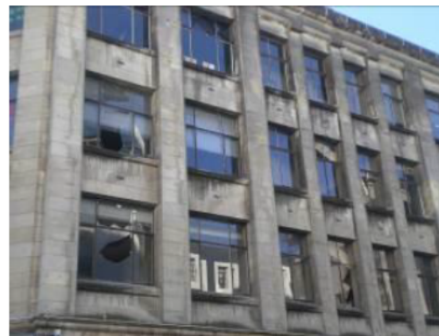


Figure 14: Examples of damage to infill systems.

Some systems in non-seismic frames were re-glazed after Sept 2010 event only to be damaged again in Feb 2011.

Does damage to non-structural elements matter?

Can be a life-safety issue... also sustainability issue.

Definitely an economic issue.

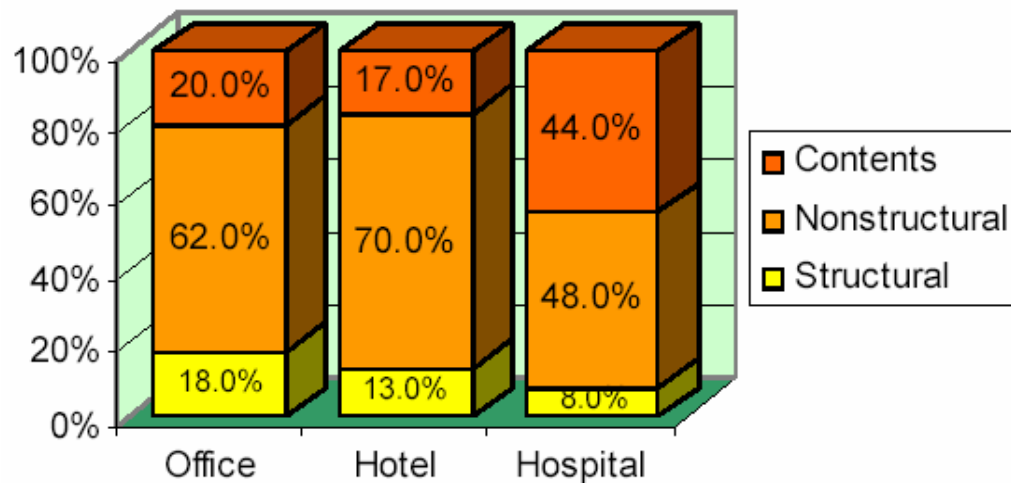
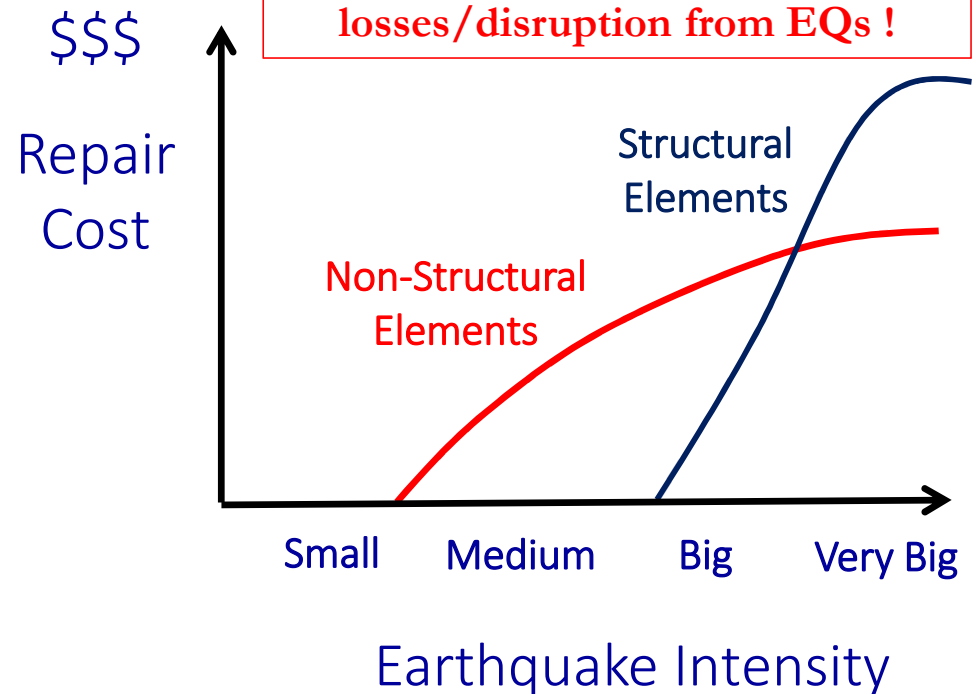


Fig 1. Investments in building construction (Miranda 2003)

Small/Medium EQs happen often.
Big EQs are rare.

→ Reducing non-structural damage is key to reducing losses/disruption from EQs !



What has been done in response to this?

The NHRP platform supported a review of design and installation practice for non-structural elements that focussed on the following:

1. General provisions (in codes/standards)
2. Ceiling Systems
3. Facades and Cladding Systems
4. Partition Wall and Infill Systems

The research also lead to proposals for improved design and detailing of such provisions.

**Review of Design and Installation Practices
for
Non-Structural Components**

Prepared for the Engineering Advisory Group by New Zealand Consultants,
Industry and Related Experts

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General Issues?

Reasons that non-structural elements are not performing well (Stanway et al. 2018):

- Issues with the existing procurement process in NZ.
- Issues with current NZ installation practices.
- Issues with compliance checks of completed installations.
- Issues with current code provisions for non-structural elements.
- Limitations of our understanding of the seismic behaviour of non-structural elements.



How do we reduce damage to ceiling systems?

- Importance of detailing understood.



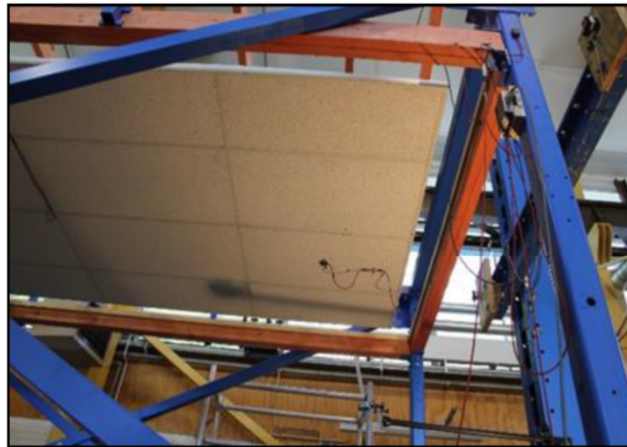
Image courtesy of Andre Filiatrault

How do we reduce damage to ceiling systems?

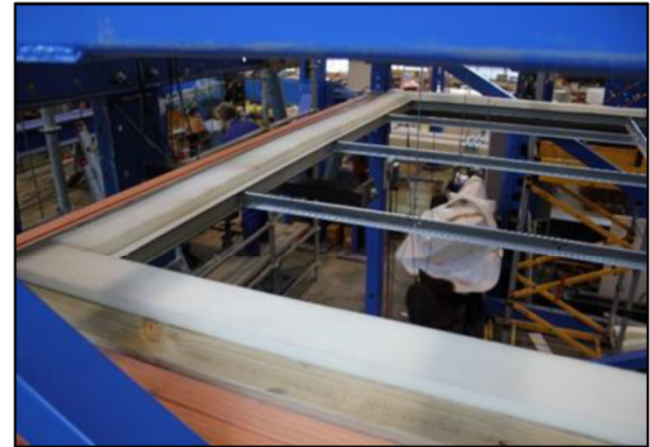
- Importance of detailing understood.
- New low-damage detailing approaches proposed.



Perimeter-Fixed



Fully-Floating

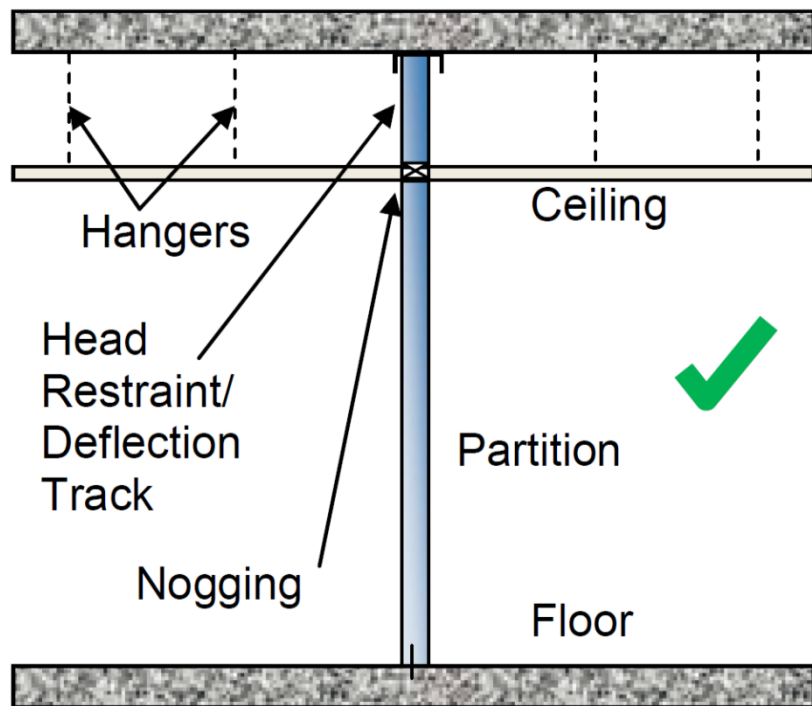


Fully-Floating with Isolation Foam

Images from MacRae et al. 2012

How do we reduce damage to ceiling systems?

Best-practice detailing guidance provided



(a) Partition Bracing Ceiling

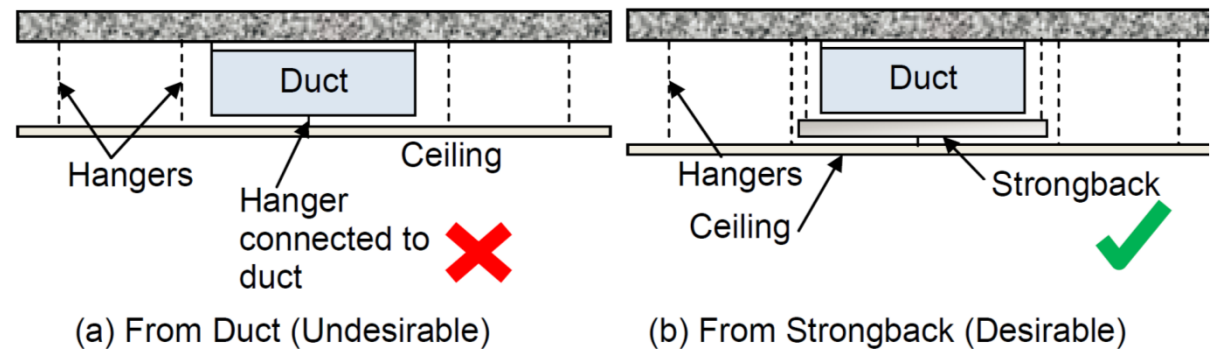


Figure 2.6.4 Suspension of Ceiling Hangers around Ducts

Images from MacRae et al. 2012

What was damage to facades and cladding systems?

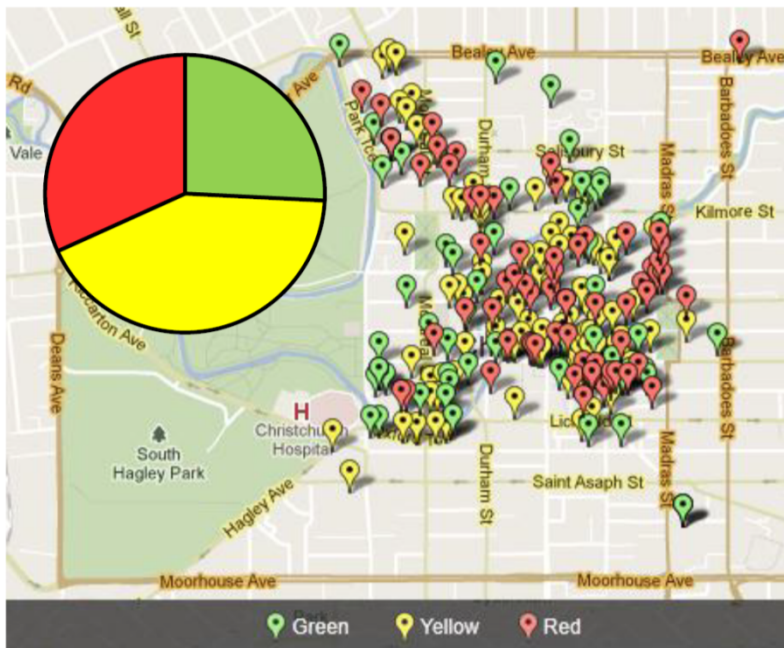
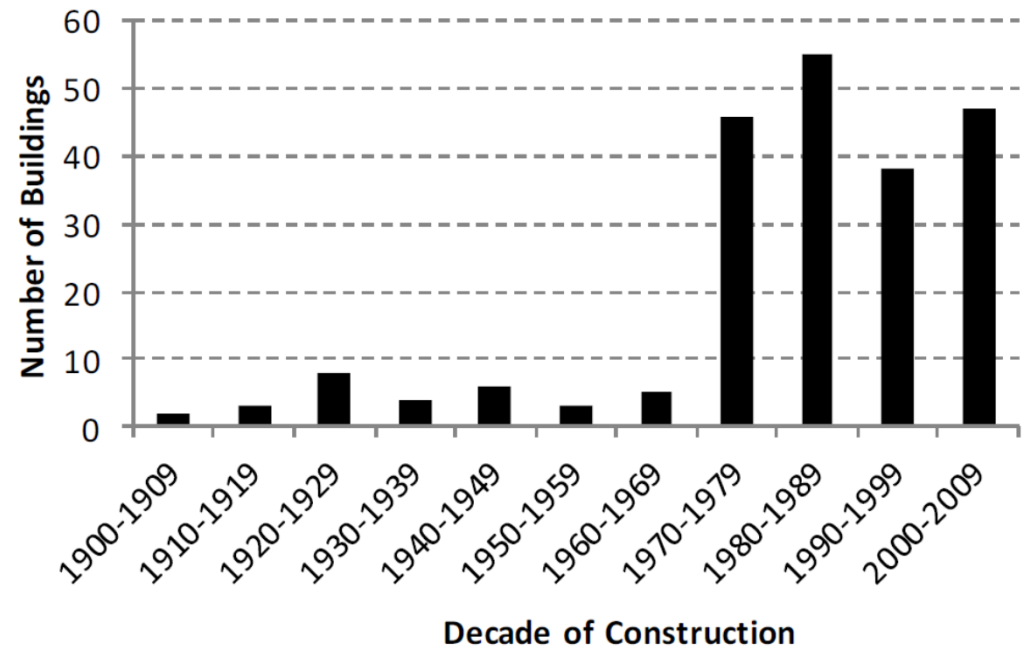


Figure 6: Locations of buildings surveyed and their placard composition.

217 buildings surveyed



Building façade survey conducted following Feb. 2011 earthquake by Baird, Palermo and Pampanin (2011)

Results of cladding/glazing survey

(from Baird et al.2011)

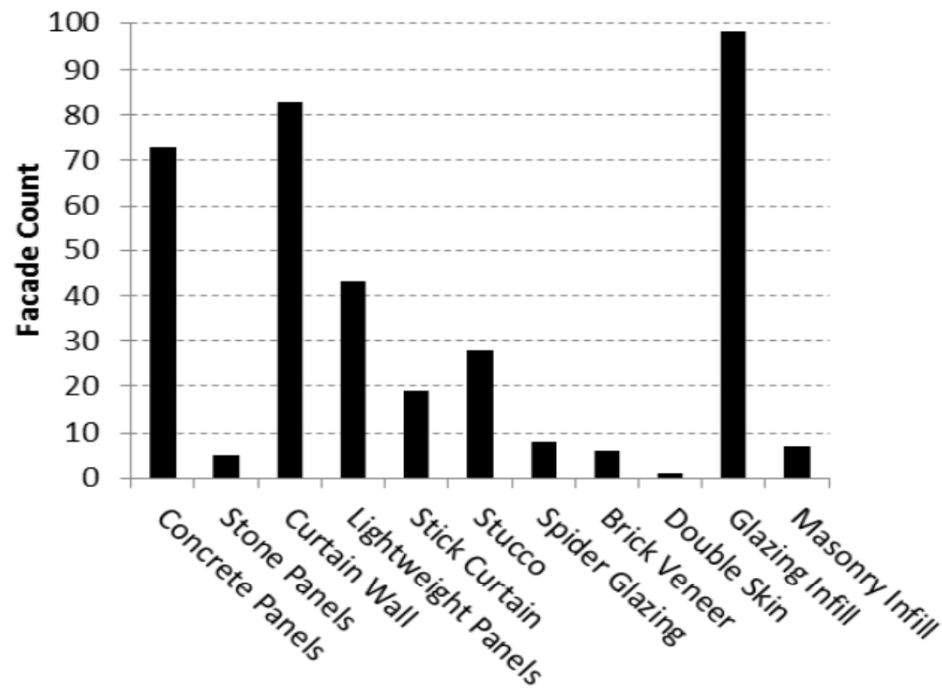


Figure 18: Facade typology composition.

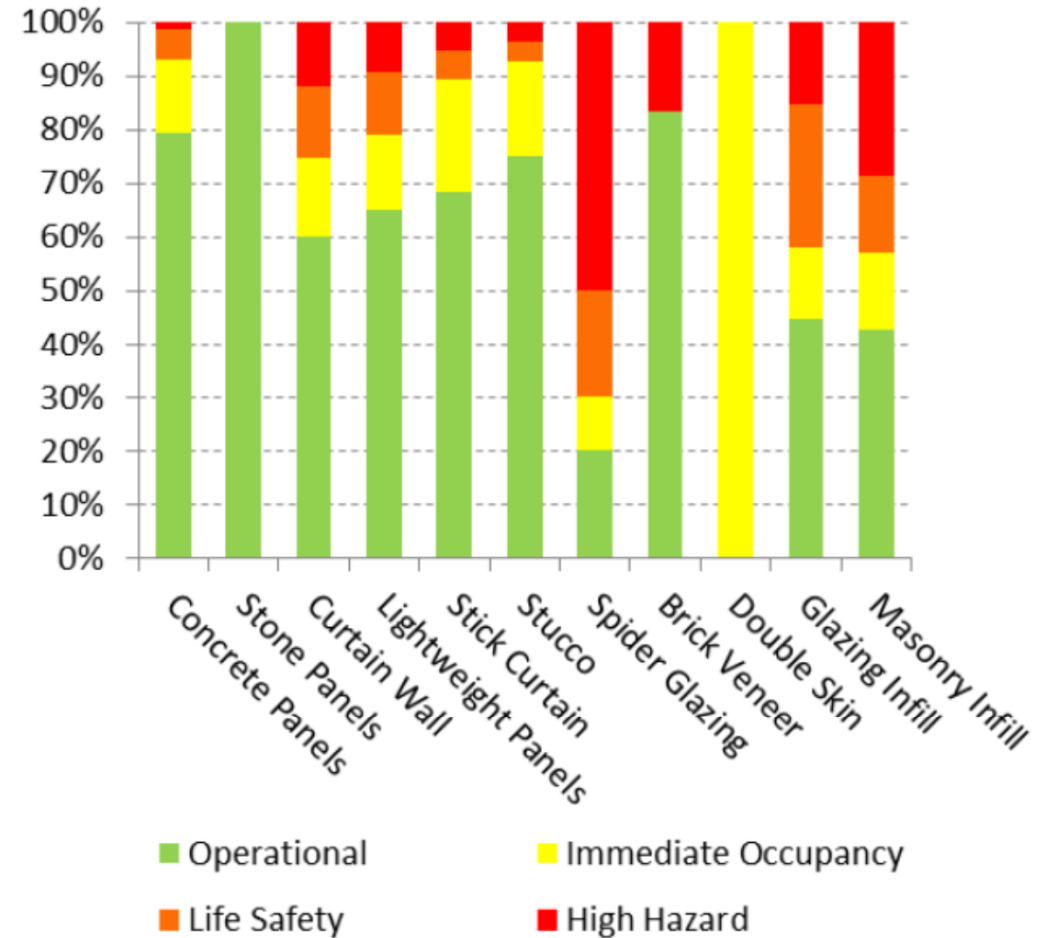


Figure 19: Facade performance by facade typologies.

How do we stop concrete panels falling off buildings?

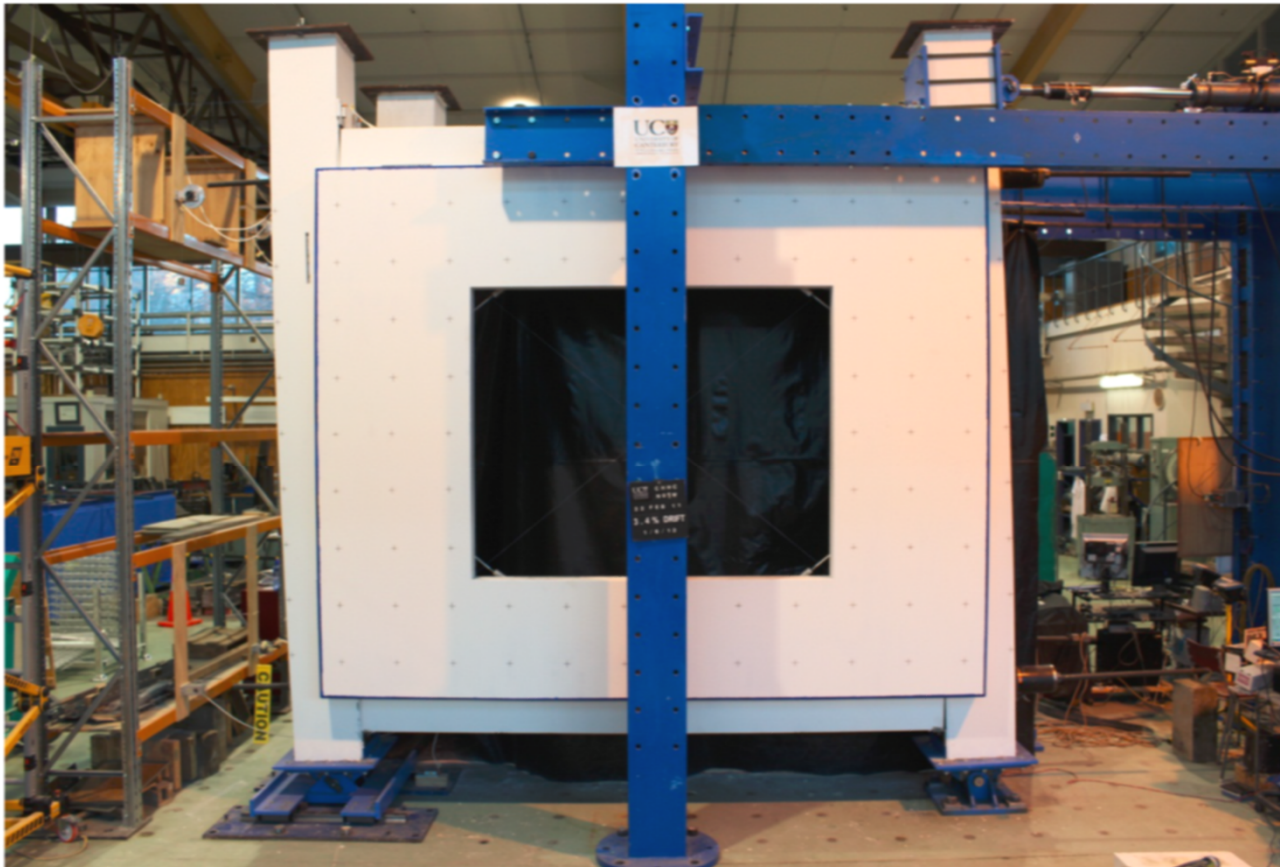
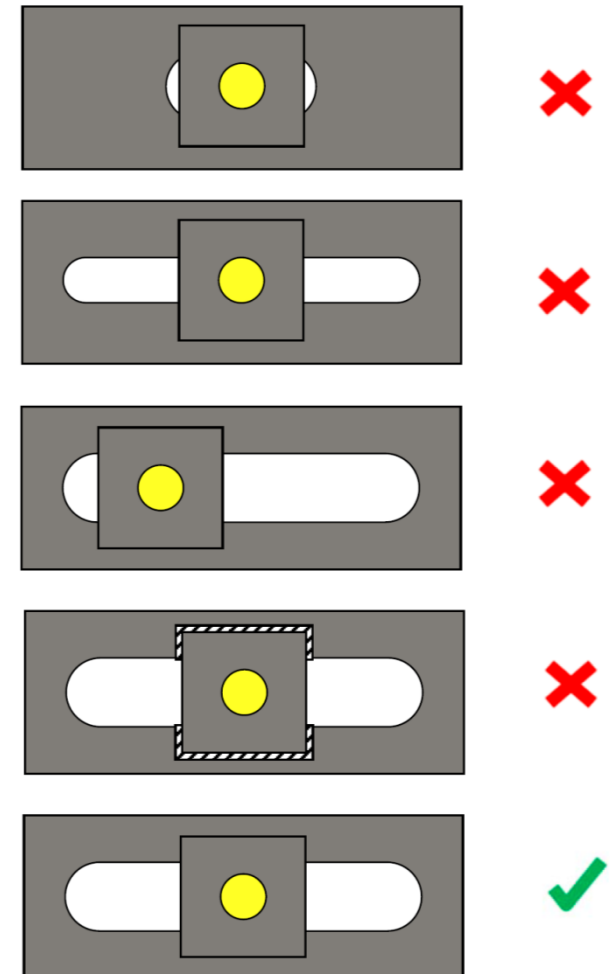
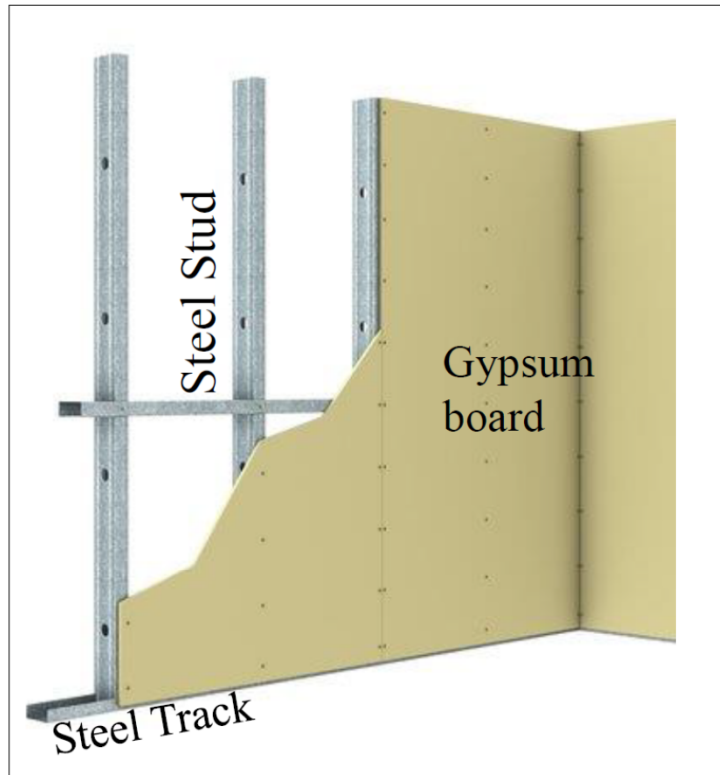


Figure 3.7.1 Precast concrete cladding at 3.5% drift level,
part of experimental testing at University of Canterbury (Baird et al. 2012)



How do we reduce damage to plasterboard partition walls?

Steel-Framed Internal Partition Walls

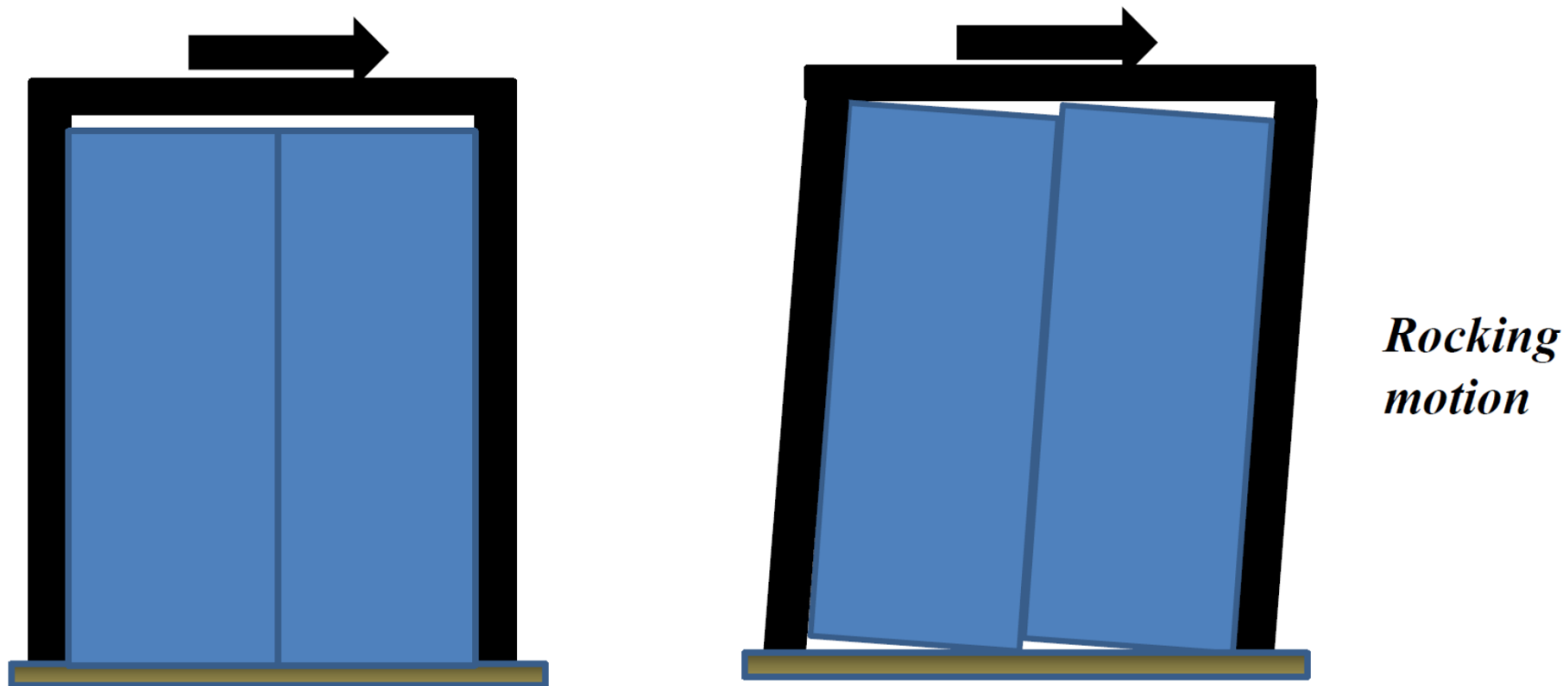


Gypsum boards are screwed to the steel studs



The top and bottom steel tracks are anchored to the top and bottom floor, respectively.

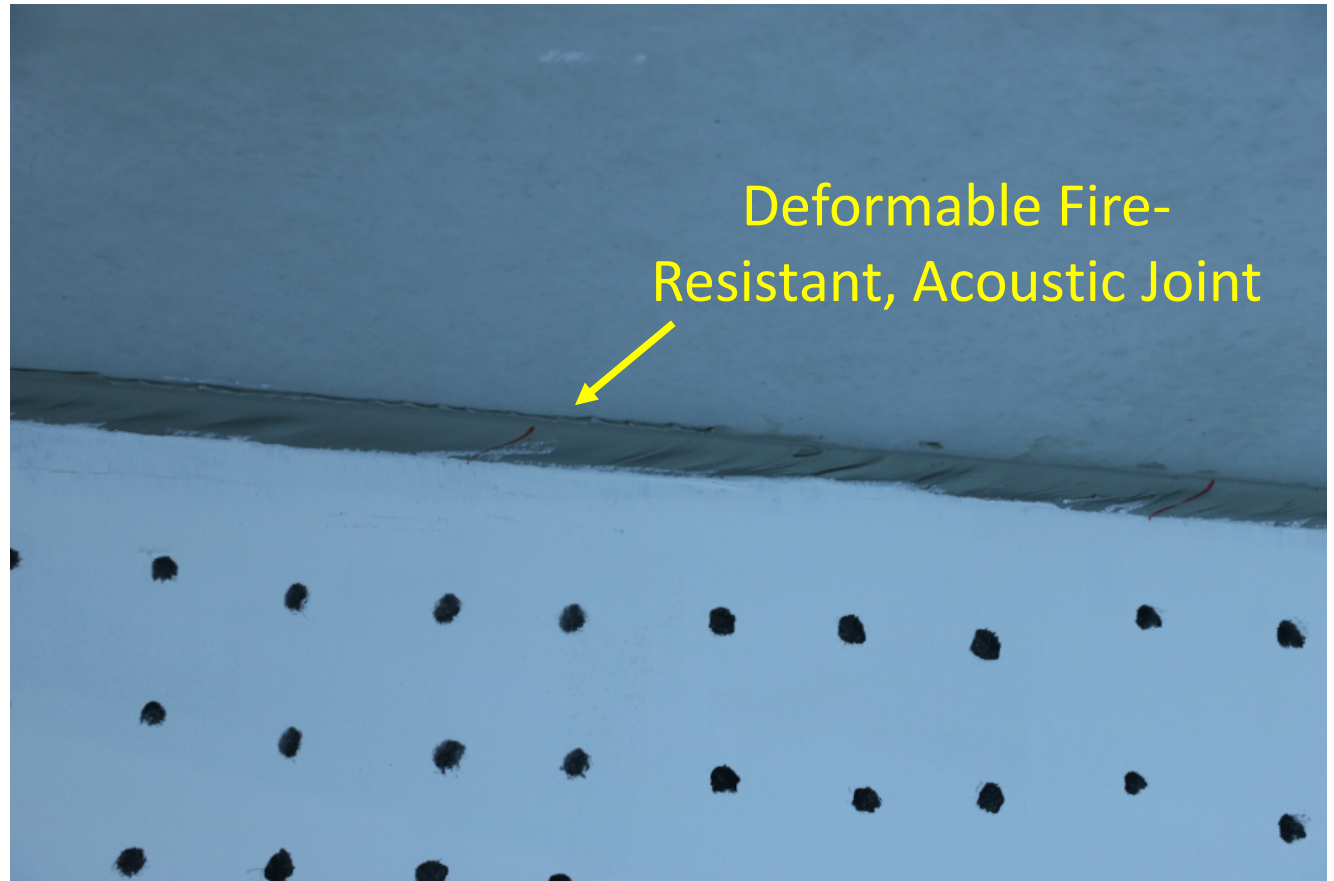
How do we reduce damage to plasterboard partition walls?



[Schematic diagram of intended behavior of 'low-damage' partition walls](#)

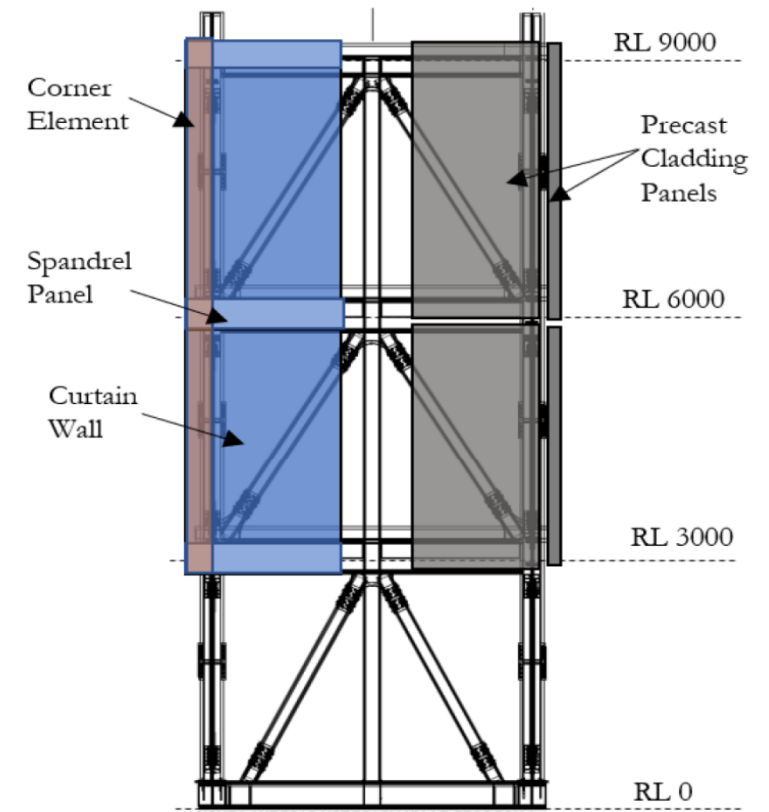
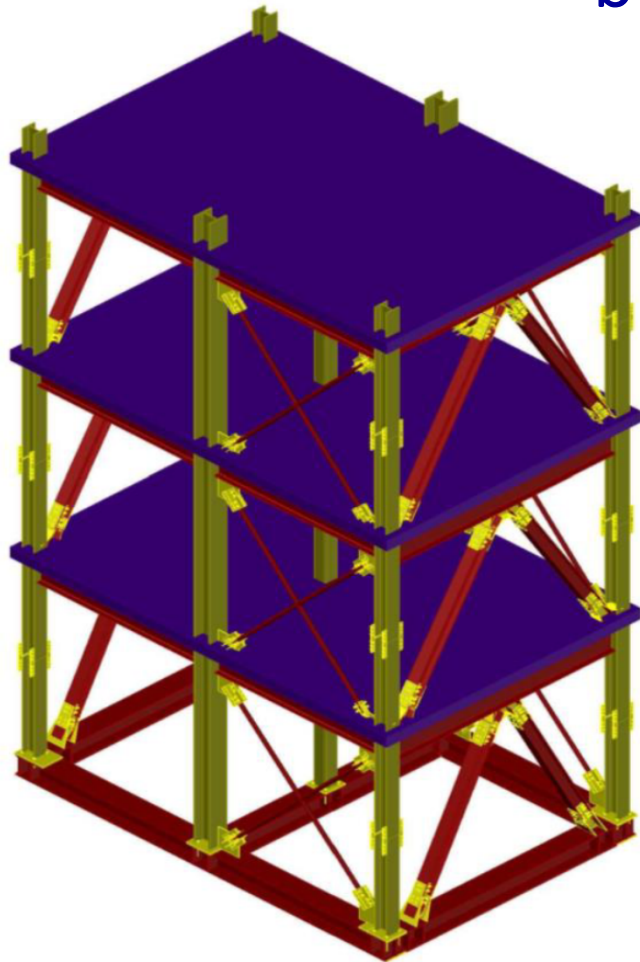
Images from MacRae et al. 2012

How do we reduce damage to plasterboard partition walls?



On-going Research Activities?

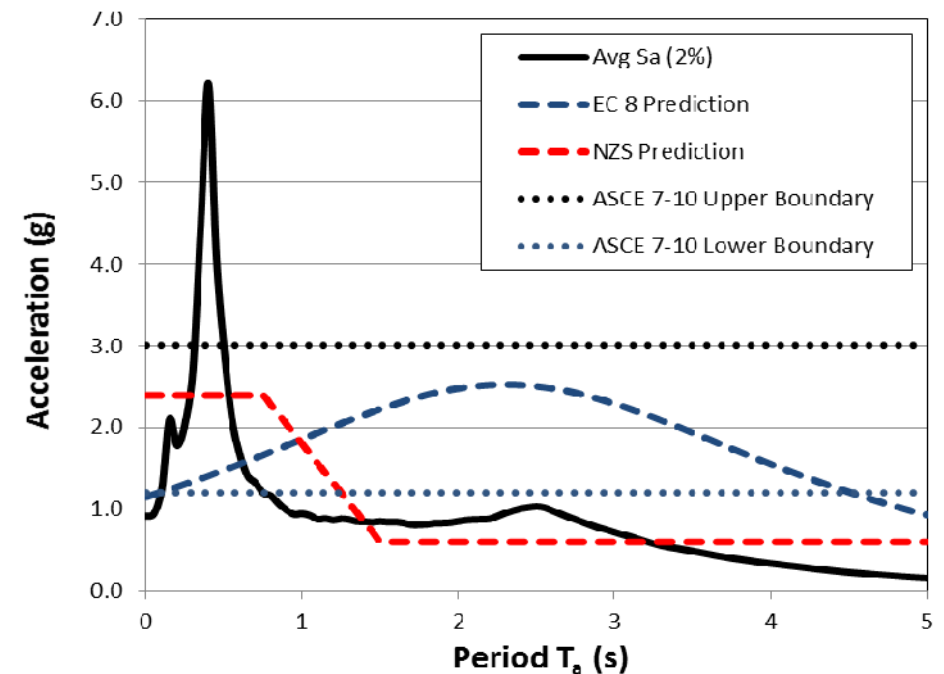
How do non-structural systems perform within a whole-building system?



b) East Elevation

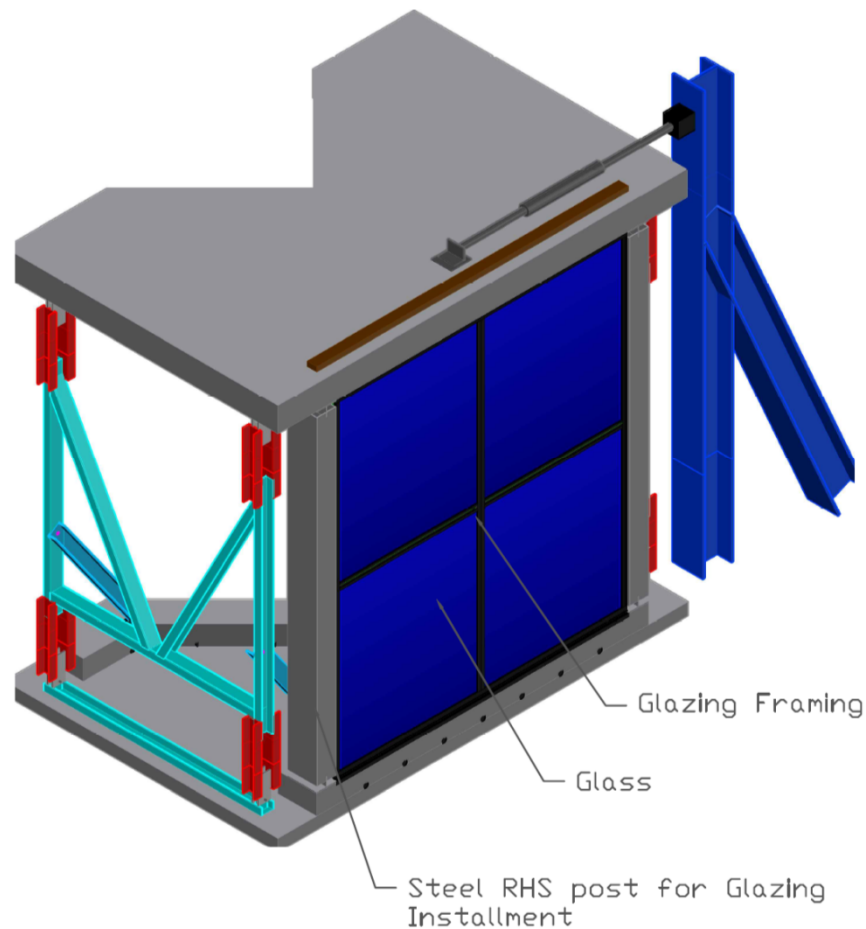
How strong do non-structural braces need to be?

All international design standards are not good at telling engineers how much acceleration (and hence force) could develop in non-structural elements.



Comparison of predicted floor acceleration response spectra at top level of an 8-storey RC wall building.

How do we improve performance of glazing?



- How much can the building deform until the glass breaks?
- How much can the building deform until the glazing leaks?

How do we effect change?

While more research is needed, better technologies and guidance do exist.

Uptake is not high.

What is the answer?

- Revised design standards?
- New procurement practices?
- New legislation?
- Alternative pathways to compliance?
- Better Communication?

Thank you

Kia ora