Project 17137 – December update
Seismic loss assessment to motivate high performance building solutions

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Key Objectives

1. Demonstrate how loss assessment could be an effective means of quantifying the benefits of innovative construction technologies

2. Test and develop options for simplified loss-assessment appropriate for preliminary design phase

3. Identify and develop loss functions for non-structural elements for NZ usage

4. Identify functions from literature suitable for NZ construction, and develop fragility functions for components unique to NZ.

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3. Identify -structural element

4. Identify for NZ construction, and develop fragility functions for components unique to NZ.

Draft to be completed this week for review (Trevor)

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Analyses still underway (Amir)

4. Identify for NZ construction, and develop fragility functions for components unique to NZ.

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Draft to be completed soon (Shreedhar)

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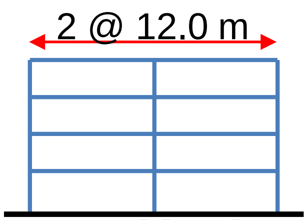
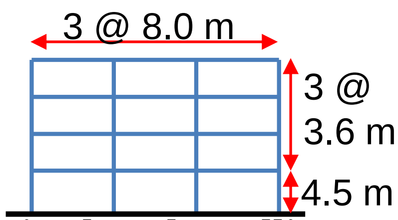
Part 1: Building design

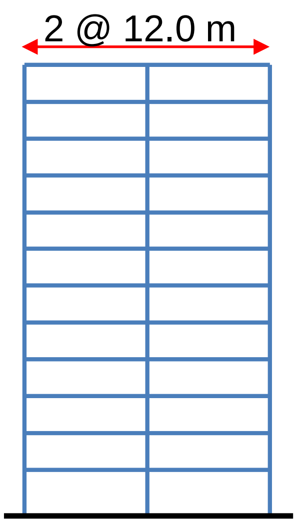
Different floor heights and building locations considered



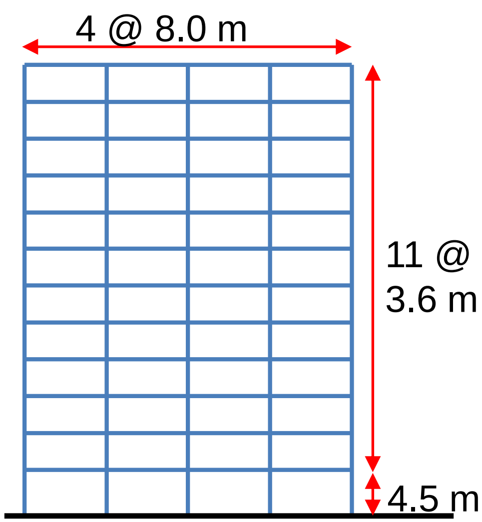
Auckland 4-storey



Christchurch/Wellington 4-storey

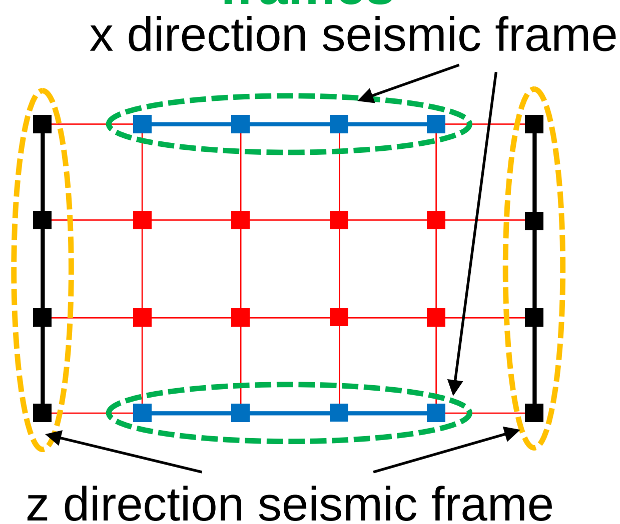


Auckland 12-storey

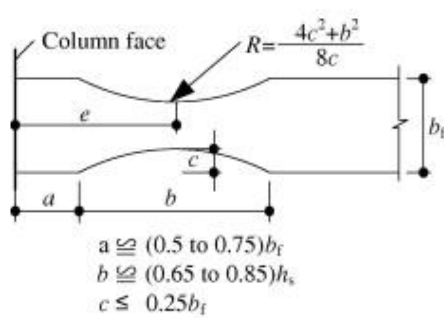


Christchurch/Wellington 12-storey

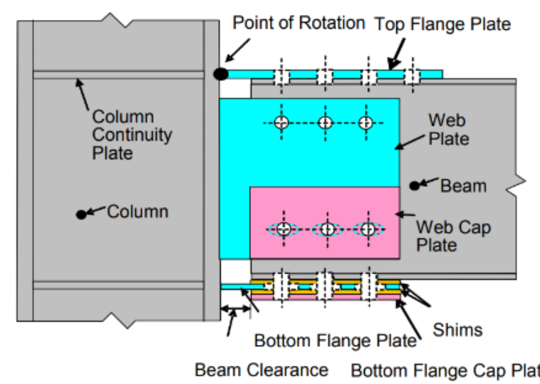
Exterior one-way moment resisting frames



Various connections considered



Reduced beam sections (Huang et al. 2010)



Sliding hinge joint (MacRae et al. 2010)

Part 1: Building design

Site locations:

- Auckland subsoil class C (Z = 0.13)
- Christchurch subsoil class D (Z = 0.3)
- Wellington subsoil class C (Z = 0.4)

Governing considerations for frame with reduced beam section for Christchurch and Wellington:

- Drifts under seismic ULS governs 4-storey
- P-delta stability factor governs 12-storey
- μ = 3.0 to reduce demands on panel zone and column

Part 1: Building design

Governing considerations for frame with friction connections for Christchurch and Wellington:

- Overstrength considerations governs selection of beam sections as $\phi_o/\phi = 2.0$, so beams generally larger than for RBS cases
- $\mu = 4.0$ to reduce demands on beams

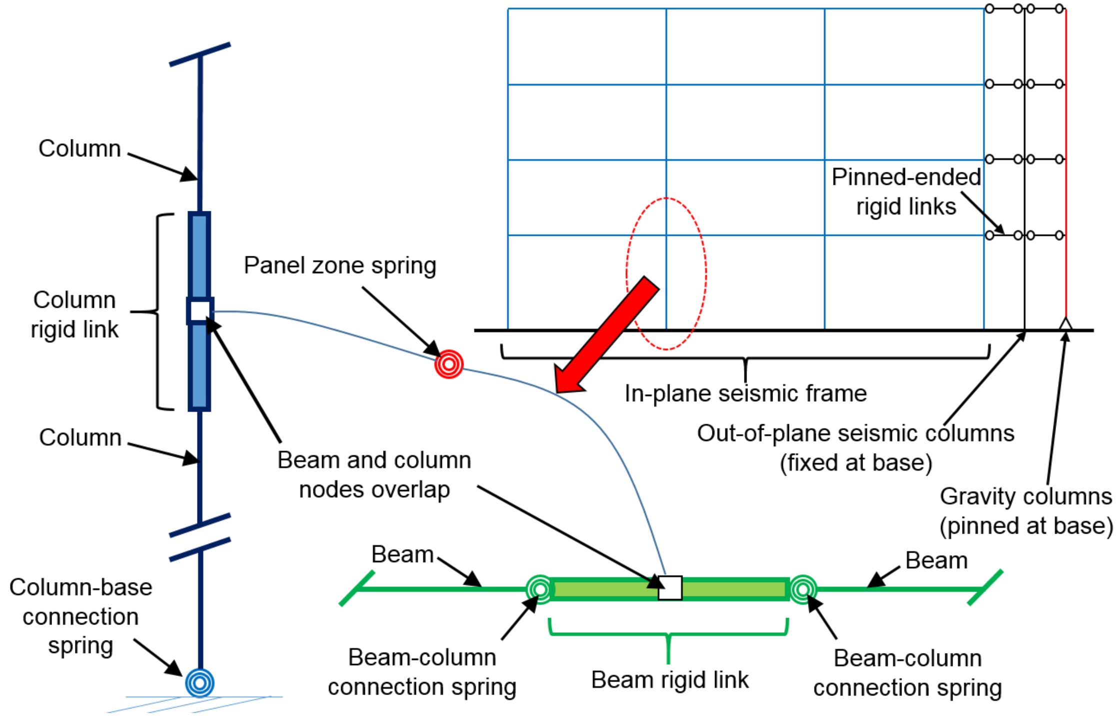
Governing considerations for frames in Auckland:

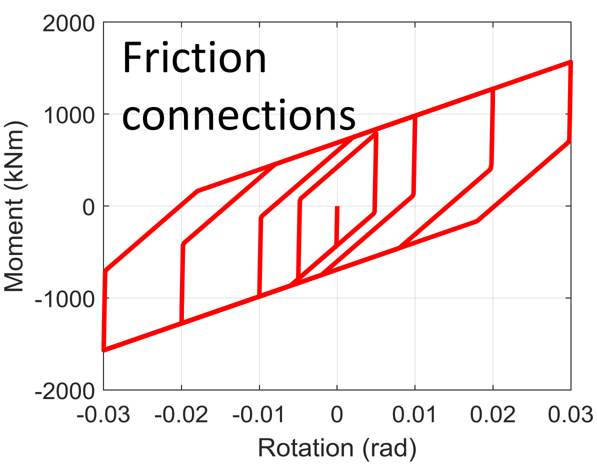
- Drifts under wind serviceability loading governs both 4-storey and 12-storey buildings
- μ is around 1.5 or less if considering seismic ULS

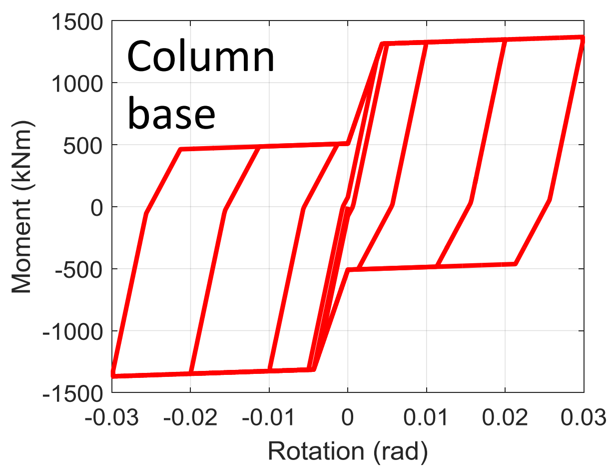
Part 2: Structural analysis

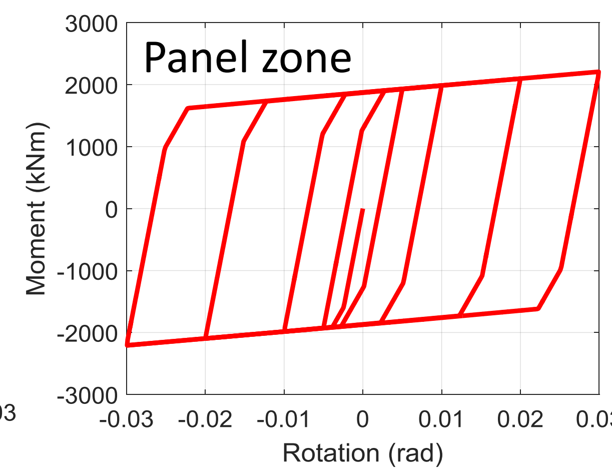
Analysis details:

- Ruaumoko2D
- Large displacement analysis
- 5% Caughey damping
- Torsion not considered at this stage



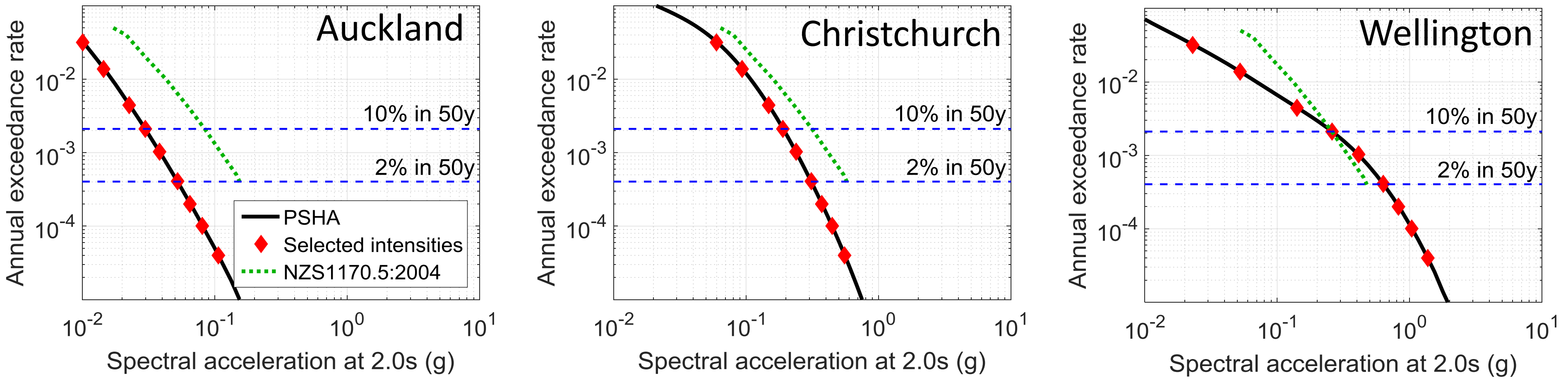






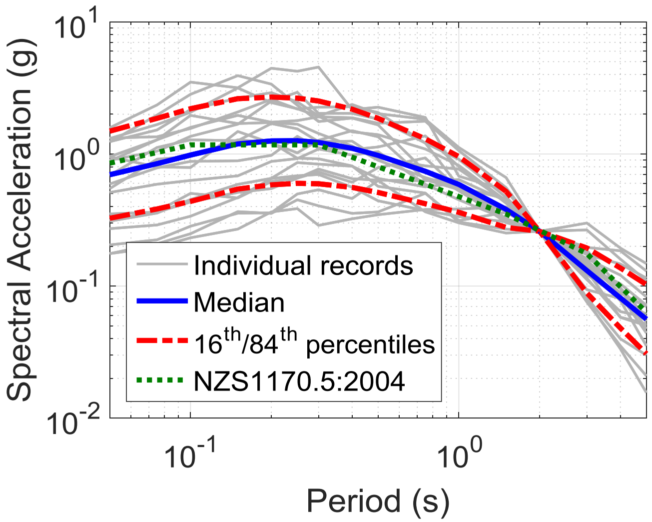
Part 3: PSHA and record selection

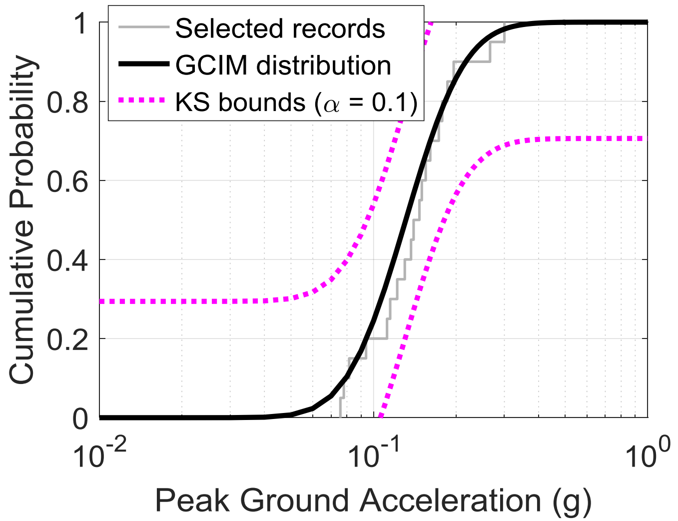
- Performed on OpenSHA using New Zealand rupture forecast models and ground motion prediction equations
- Noticeable difference with NZS1170.5
  - McVerry et al (2006) "over-predicts" for M_w<6
  - *Z* value determined based on T = 0.5s, and assumed shape is "conservative" for subsoil class C (no comparisons for classD)



Part 3: PSHA and record selection

- Ground motions selected following the Generalized Conditioning Intensity Measure approach
- Sa(2.0s) selected as the conditioning intensity measure (in-between period of Chch and Well frames)
- Various other Sa(T), PGA, PGV, Ds575, Ds595, CAV selected as other intensity measures
- Records selected at 9 different hazard levels



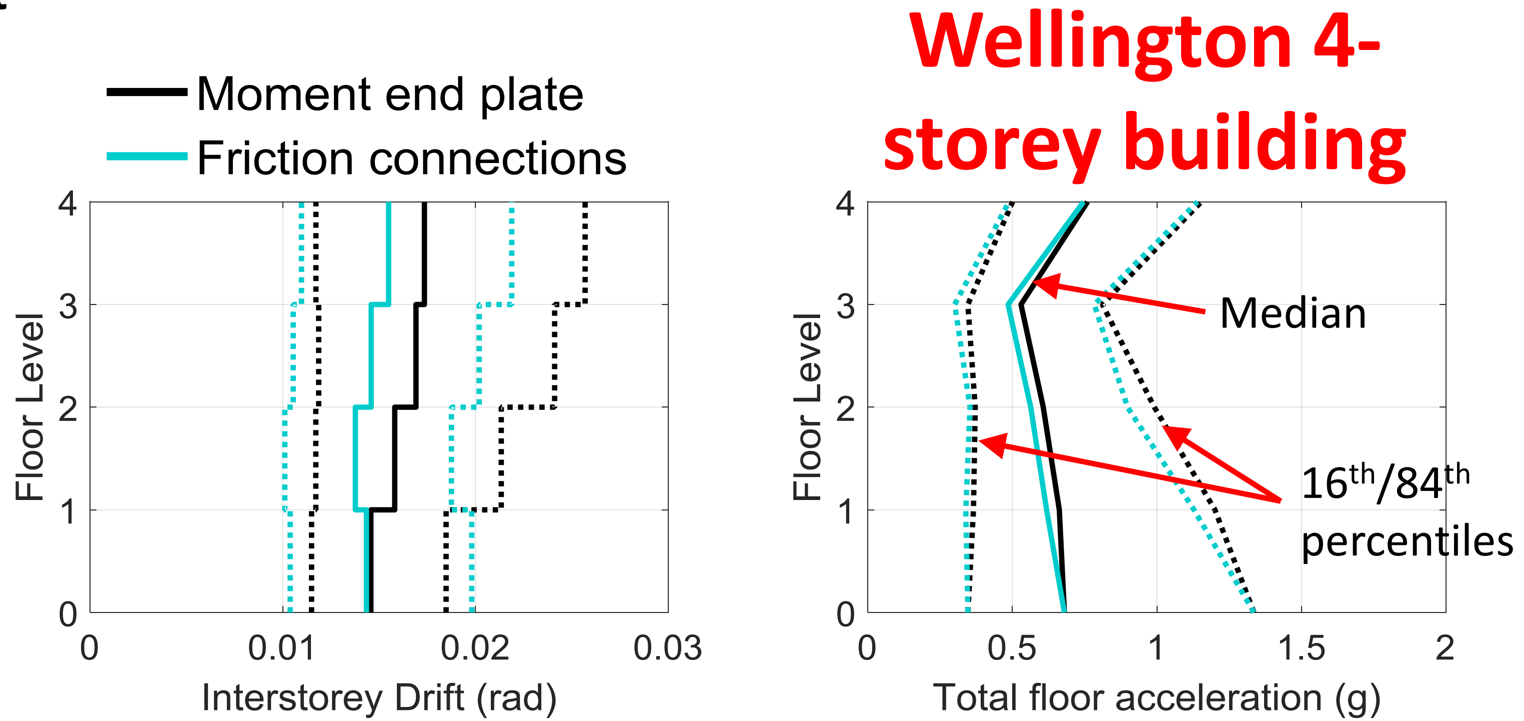


Part 4: Seismic Loss Estimation

- Performed on SLAT (uses less computational resources compared to PACT)
- Fragilities obtained from literature, PACT database, or from expert opinion
- Components considered:
  - Structural: beam-column connection, column base connection
  - Non-structural drift: partitions, precast concrete cladding, curtain wall, stairs
  - Non-structural acceleration: ceilings, sprinklers, water and sanitary distribution pipes, HVAC, transformer, elevator
- Note that friction connections were assumed to cost 50% more than moment-end-plate connections

Part 5: Building response

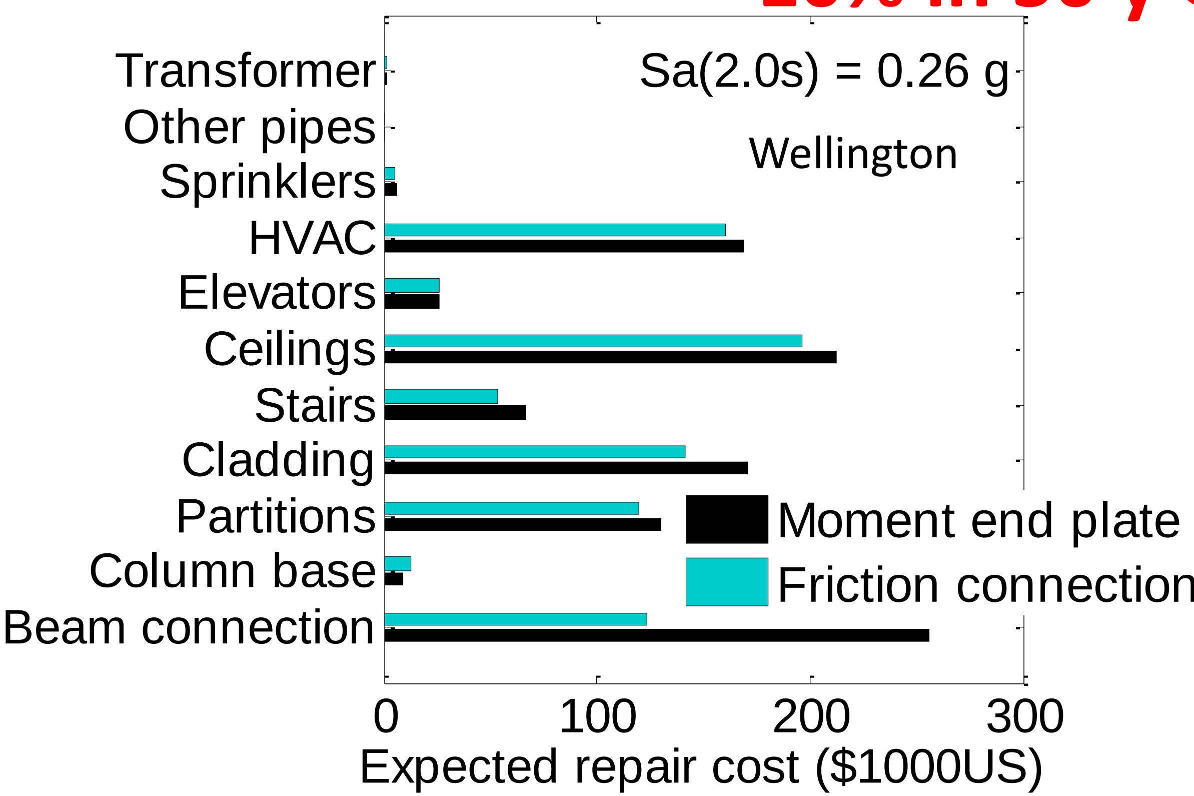
- Frames with friction connections generally had smaller drifts on most floors due to having larger beams
- Frames with friction connections also generally had smaller accelerations due to being designed to a larger μ

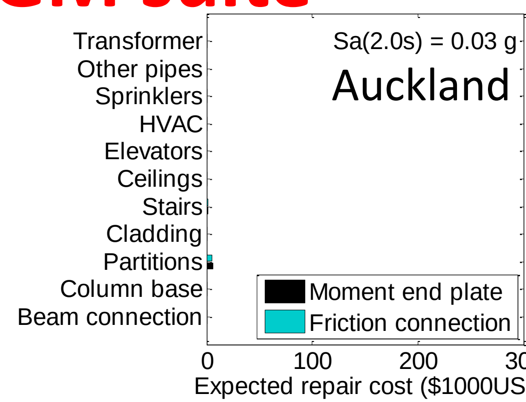


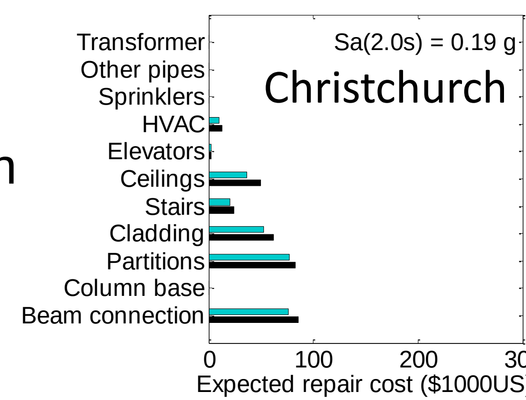
Part 6: Seismic losses

- Frame with friction connections generally incurred lower losses
- Biggest difference is on structural-related losses

10% in 50 y GM suite





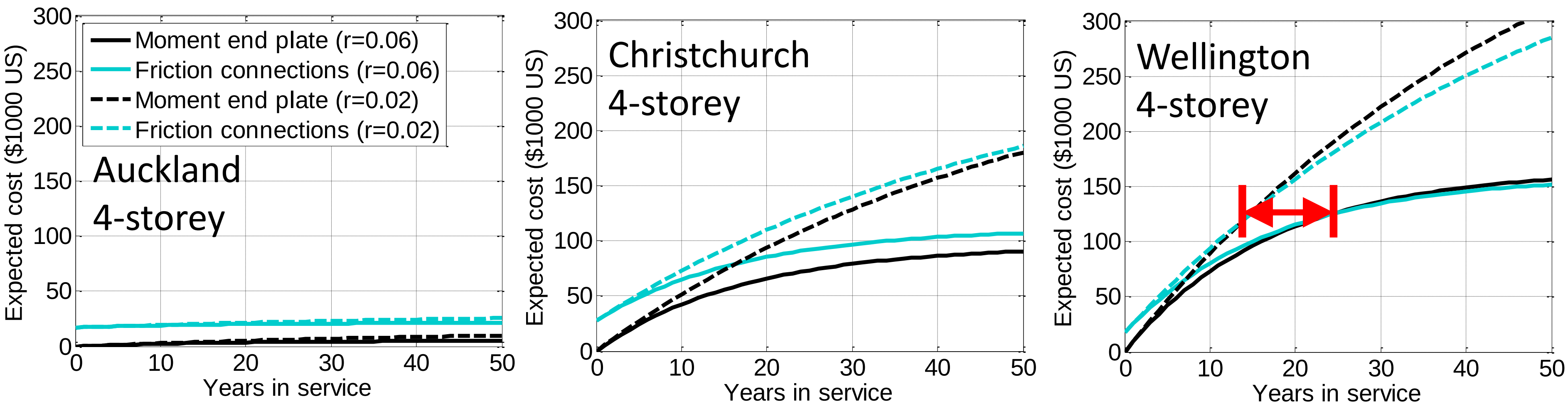


Part 7: EAL and Net-present-cost

- Wellington is the only case where NPC analysis shows a net benefit after 50 years
- Christchurch is comparable, while there are almost no benefits for Auckland due to its low seismicity

Location	4-storey building	
	Moment end plate	Friction connections
Auckland	$310	$270
Christchurch	$5,730	$5,030
Wellington	$9,910	$8,510

Location	Increase in cost
Auckland	$17,000
Christchurch	$28,000
Wellington	$18,000



Conclusions

- Seismic frames with friction connections have lower drifts and accelerations
- Seismic frames with friction connections also generally incurs lower seismic losses and exhibits better seismic performance.
- Net-present-cost analysis shows that frames with friction connections are more economically beneficial within 50 years for low-rise buildings in Wellington
- Auckland and Christchurch do not exhibit the same benefits due to lower seismic hazard