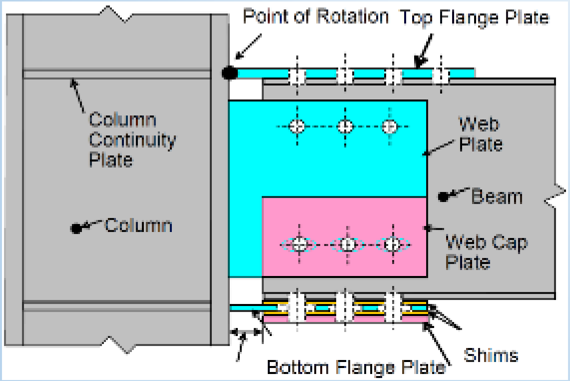
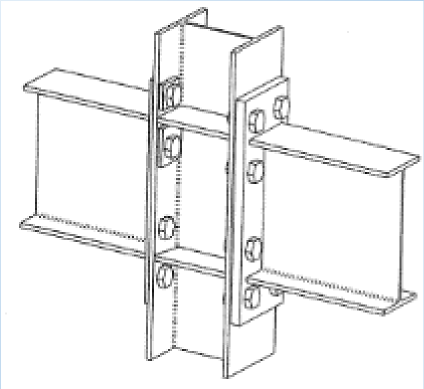
Are friction connections a cost-effective low-damage solution for steel frames?





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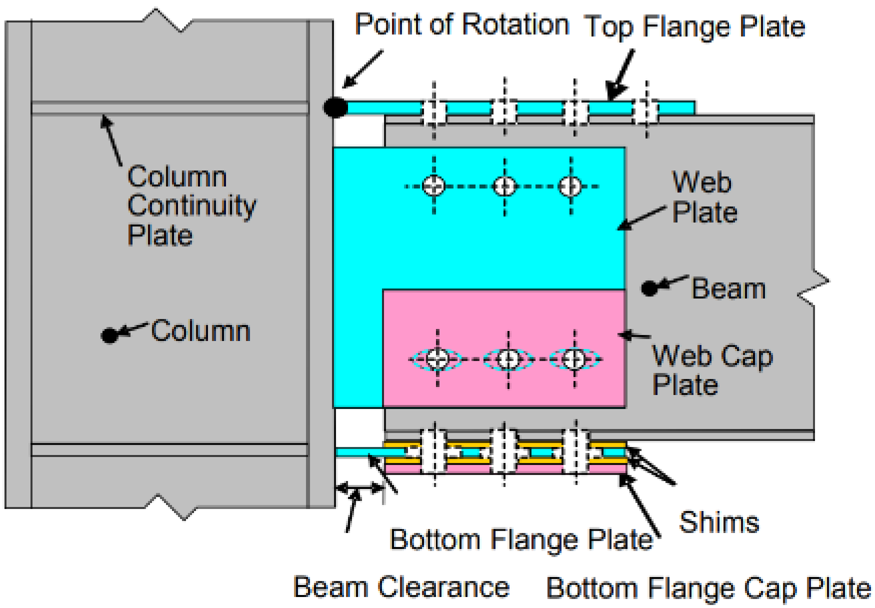
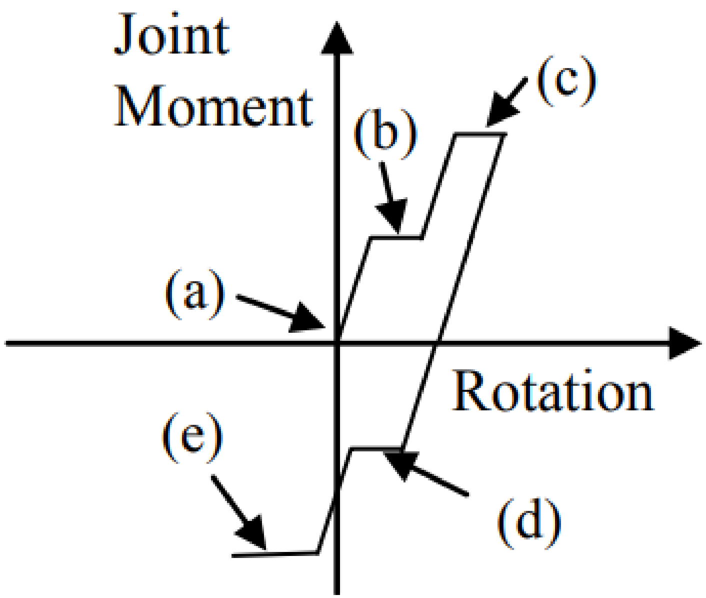
Contents

Introduction

- Friction connections:
  - Dissipates energy via friction rather than yielding of main steel elements
  - Reduces damage to beams





MacRae et al. (2010)

Introduction

- Friction connections are rarely used as the primary load resisting system
- One reason could be due to the benefits not being quantified in a manner easily understood by stakeholders
- This study looks to provide insight into the relative performance and cost-effectiveness of implementing friction connections against traditional joints

Objectives

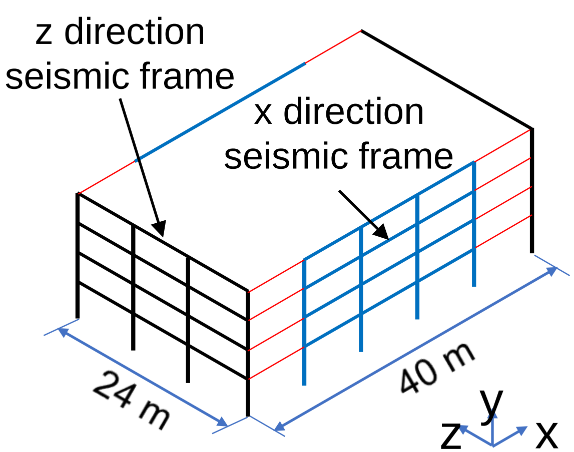
1. What is the impact of using friction connections on drifts and accelerations?

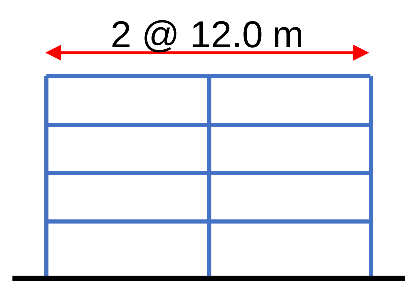
2. What is the impact of using friction connections on seismic losses?

3. Are friction connections likely to have lower expected overall costs within 50 years of being in service?

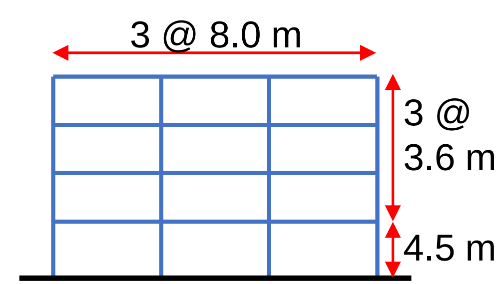
Methodology

- Building Design
  - 4 and 12-storey buildings considered for Auckland, Christchurch, and Wellington
  - Traditional frame designed with Reduced-Beam-Section (RBS) connections, and designed with beams as the “weak link”.
  - In alternative design, friction connections designed as “weak link”. As beams have to be designed for connection overstrength, a larger k_{μ} is needed for design to be feasible, and structural members are generally larger.





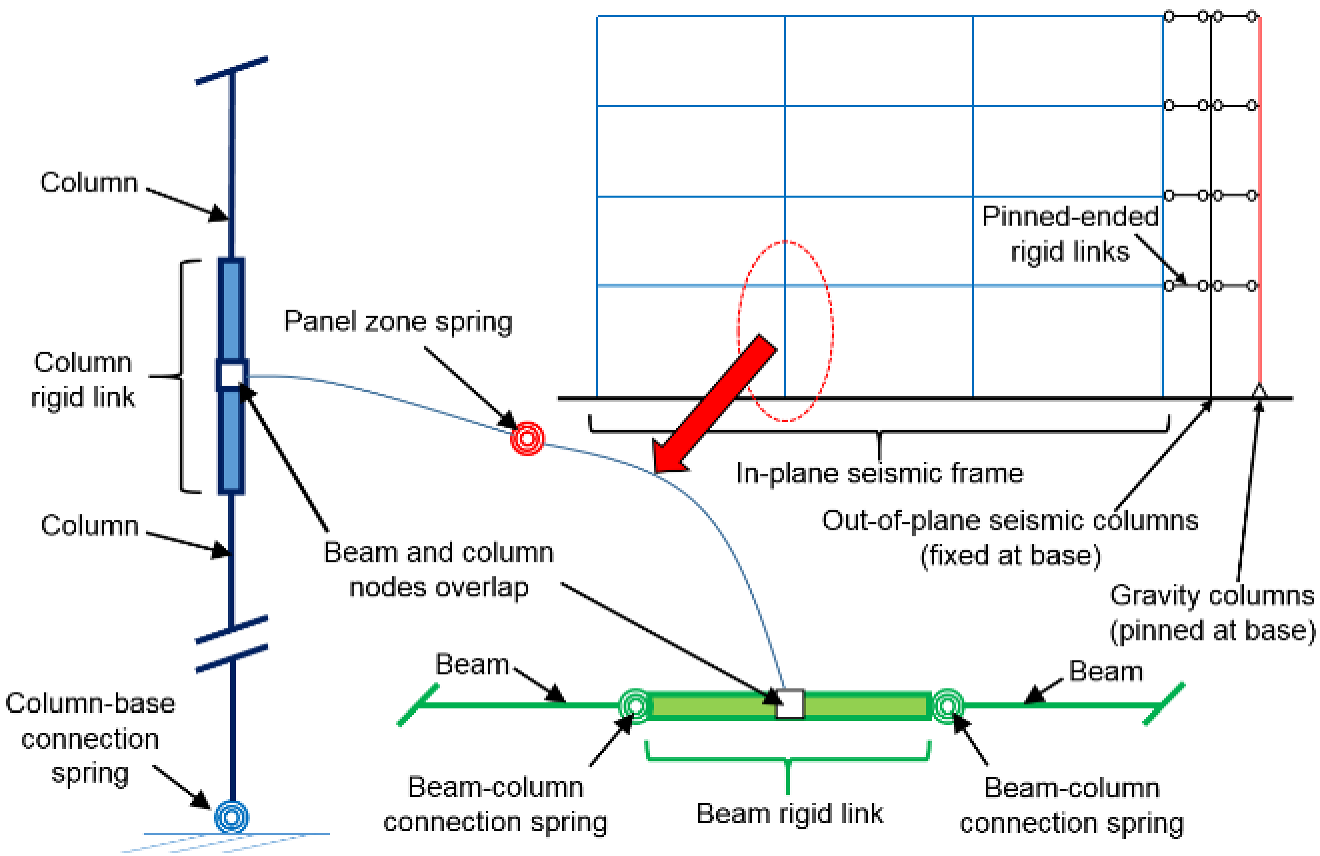
Auckland
4-storey



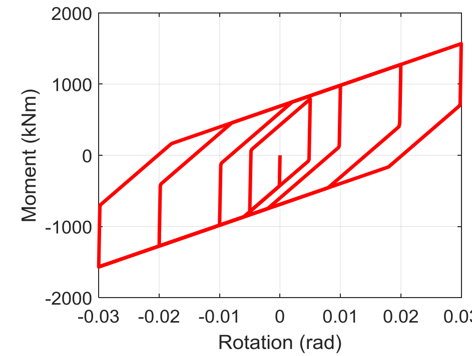
Christchurch/Wellington
4-storey

Methodology

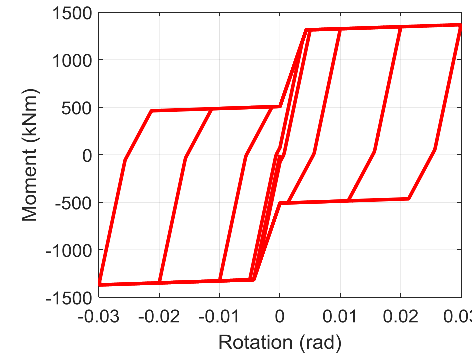
- Structural Analysis
  - ❑A 2D frame is adopted for each system in Ruaumoko (Carr 2004)



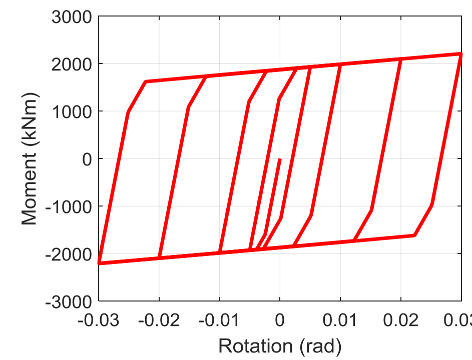
Friction connection



Column base

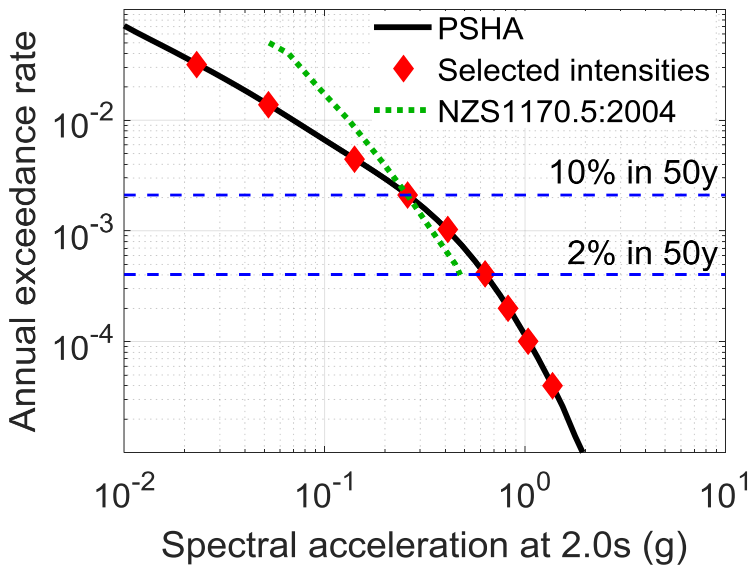


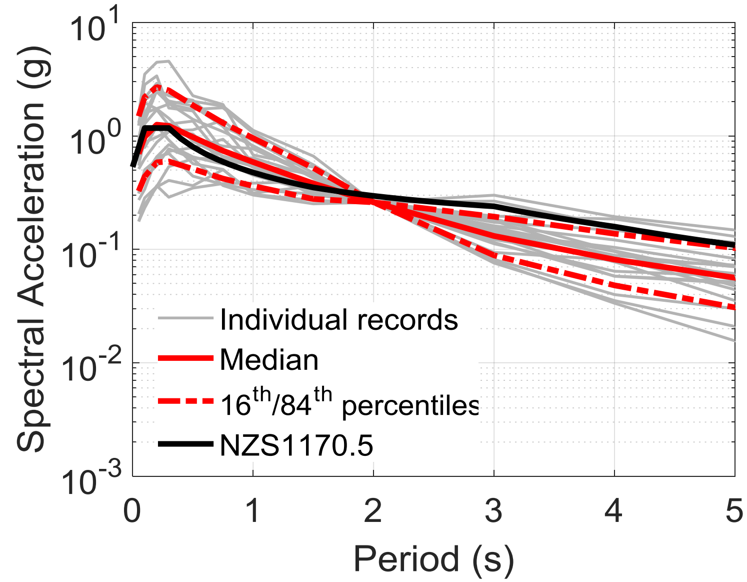
Panel zone



Methodology

- Probabilistic seismic hazard assessment and ground motion selection





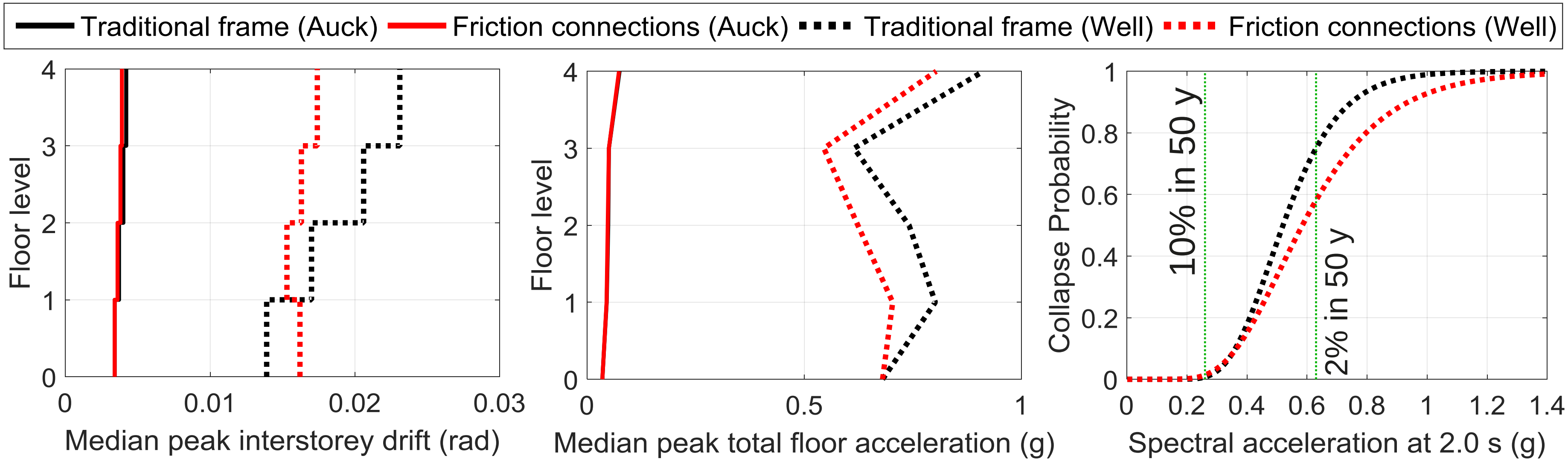
- Seismic loss estimation
  - Performed on SLAT (Bradley 2011)

$$\lambda(DV) = \int\int\int G\langle DV \mid DM\rangle d.G\langle DM \mid EDP\rangle .dG\langle EDP \mid IM\rangle .d\lambda(IM)$$

Deierlein et al. (2003)

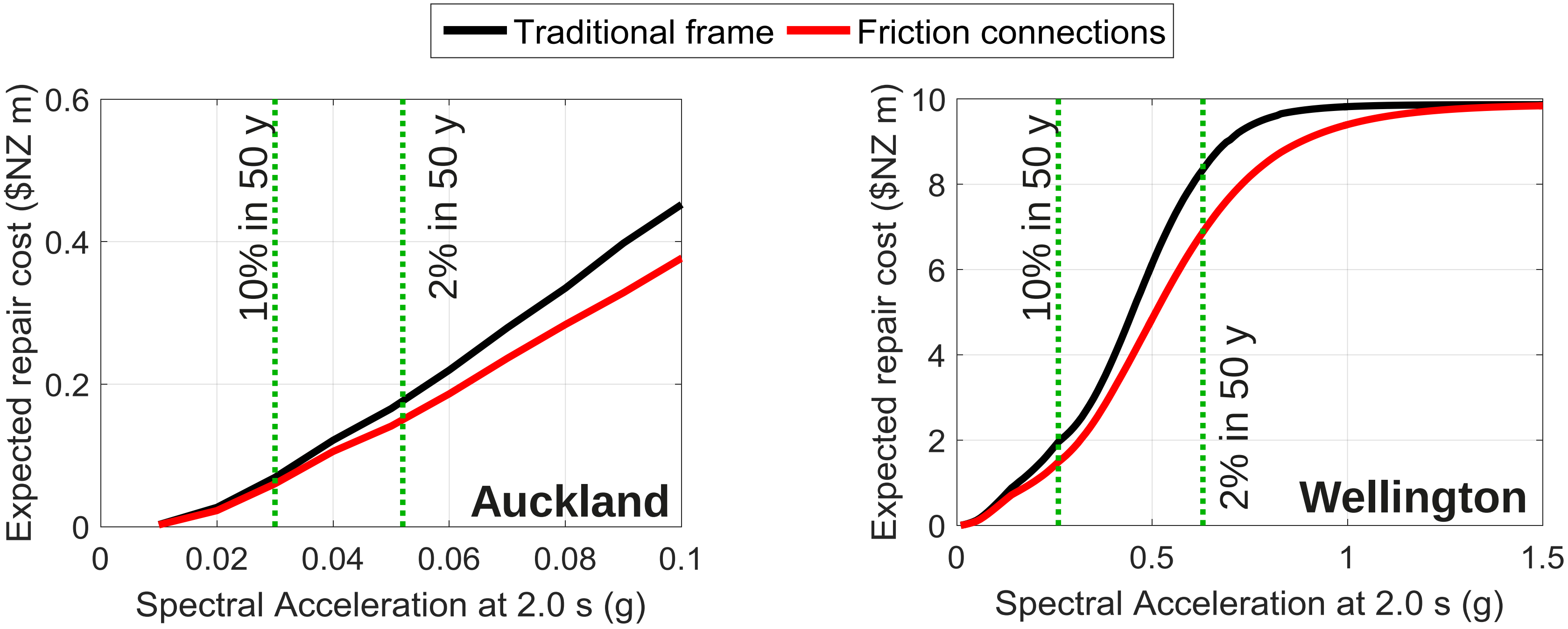
Building response

- Use of friction connections generally resulted in:
  - Lower interstorey drifts (from using larger sections)
  - Lower peak-total floor accelerations (from design with a larger k_μ)
  - Lower probability of collapse



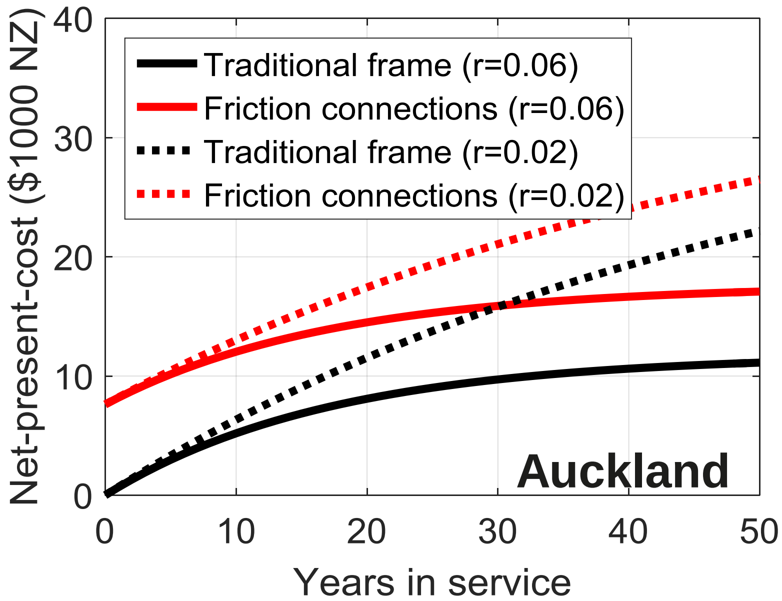
Intensity-based loss assessment

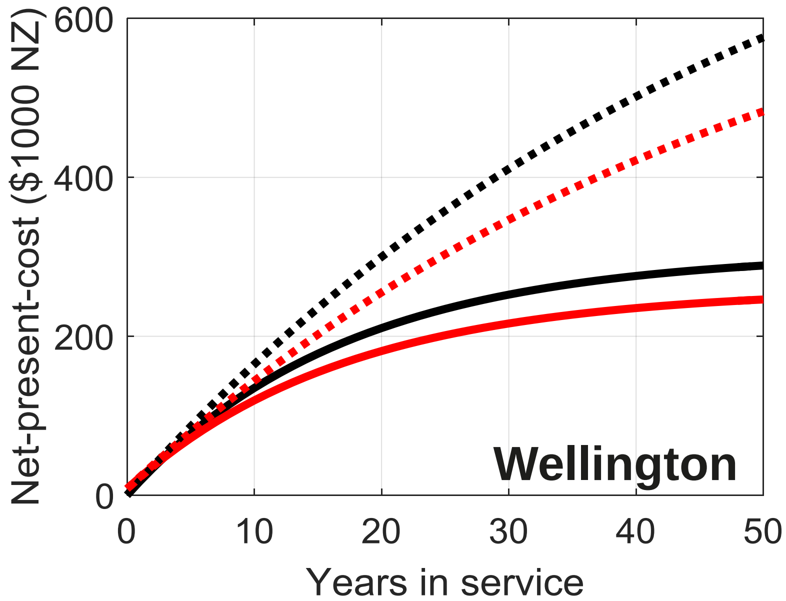
- Use of friction connections generally resulted in lower intensity-based losses



Net-present-cost assessment

- Time to return on investment for frame with friction connections in Wellington is 3 years
- However, this is over 50 years in Auckland, indicating that friction connections are likely more cost-effective in regions of higher seismicity

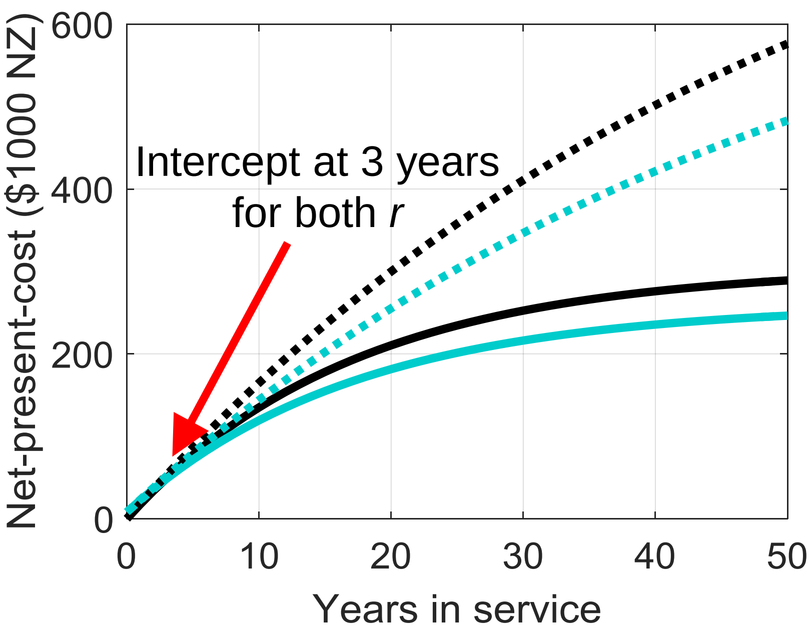


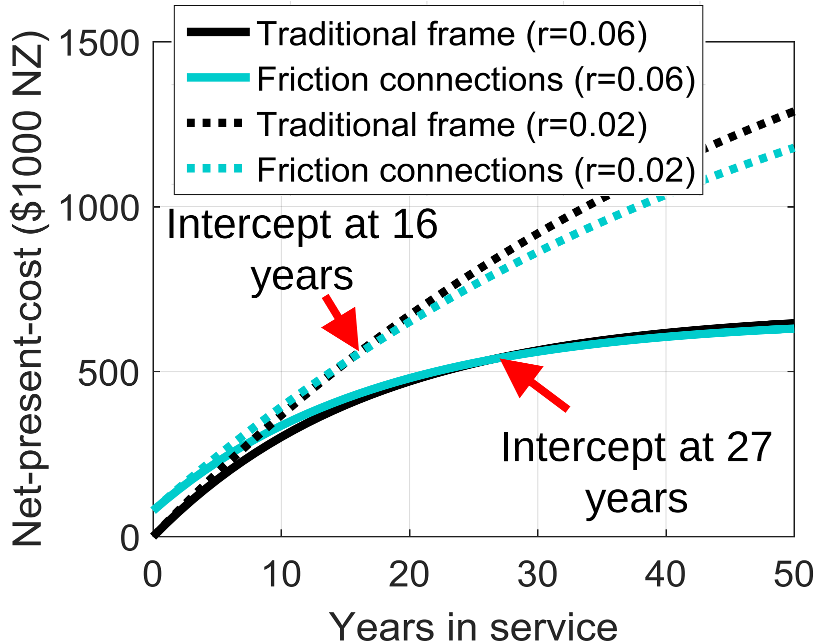


Net-present-cost assessment

- Taller buildings appear to be less cost-effective. Possible reasons include:
  - Taller buildings have a larger k_{dm} in design
  - Repair cost of individual elements may not have increased significantly despite the larger beam sizes required in taller buildings (e.g. inspect costs)

$$NPC(r,t) = C_i + \frac{(1-e^{-rt})}{r}EAL$$ Bradley (2009a)





Conclusions

1. Frames with friction connections generally exhibit smaller peak interstorey drifts, peak total floor accelerations, and lower probability of collapse.

2. Frames with friction connections generally incurred lower damage direct-repair costs.

3. The use of friction connections is more cost effective for shorter buildings lowered in regions of high seismic activity. The time to return of investment was as low as 3y in some cases.

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Project-related publications

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QUESTIONS?