Evaluating Expected Annual Losses For NZ Code Compliant Steel Structure Buildings

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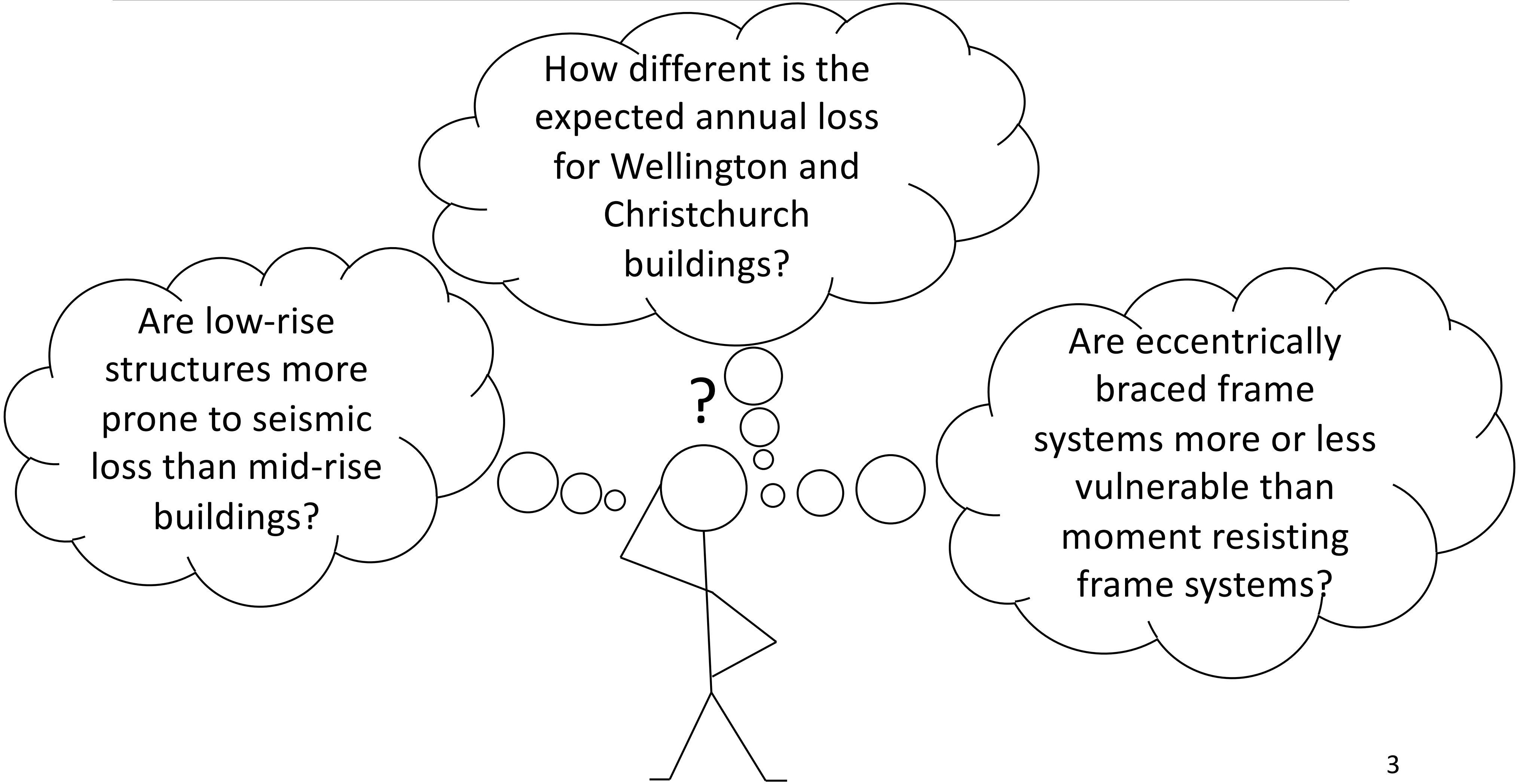
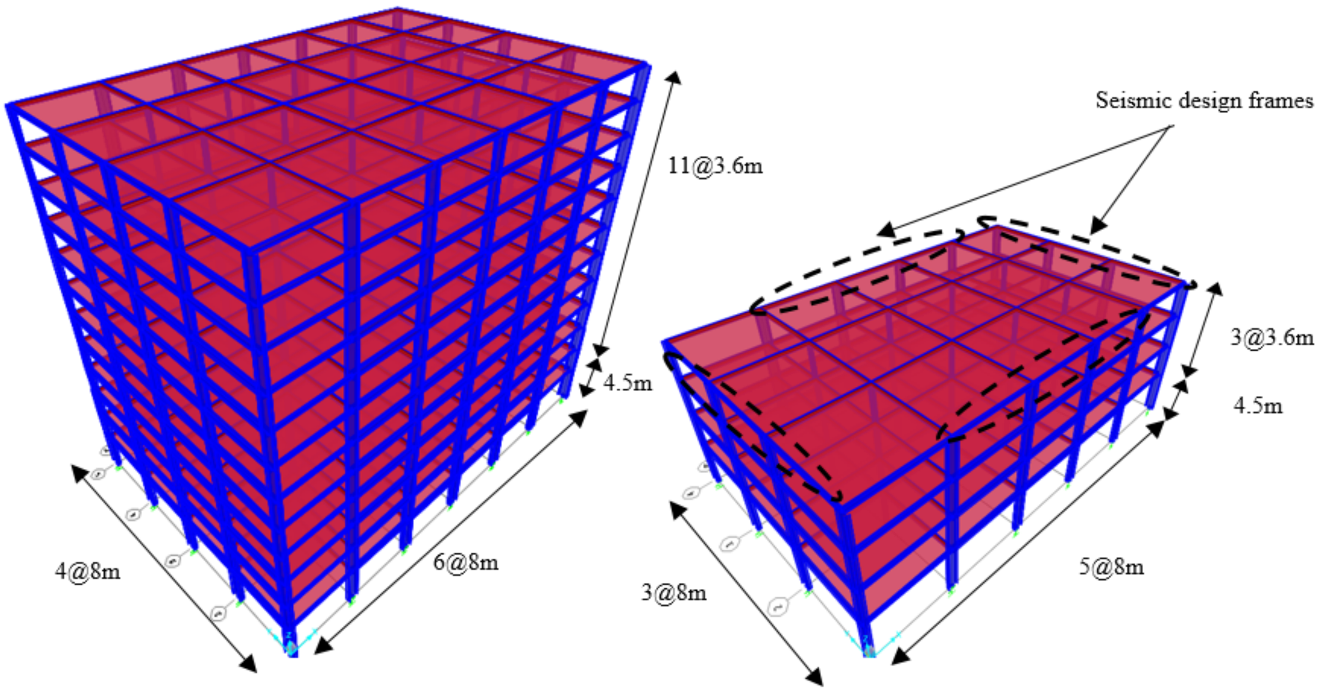
Objectives


How different is the expected annual loss for Wellington and Christchurch buildings?
Are low-rise structures more prone to seismic loss than mid-rise buildings?
?
Are eccentrically braced frame systems more or less vulnerable than moment resisting frame systems?

Methodology: Case Study Buildings

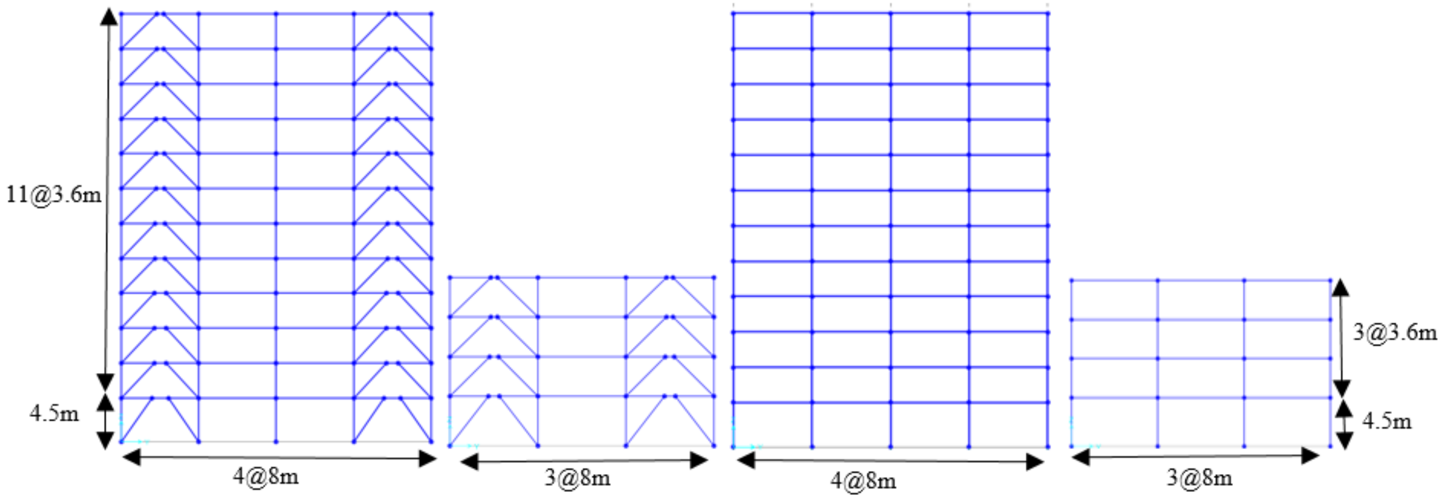
- Site
  - Christchurch
  - Wellington
- Building function
  - Office
- Structural system
  - Moment resisting frame
  - Eccentric braced frame
- Number of floors
  - 4-storey
  - 12-storey



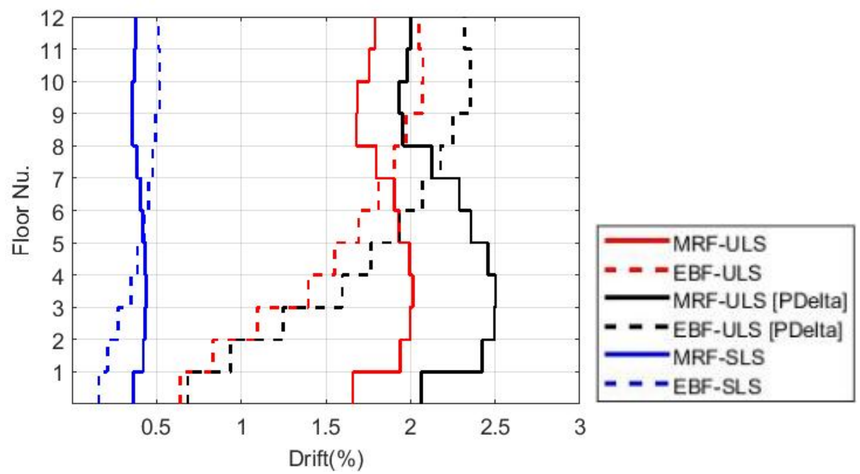
Methodology: Design

Design approach:

- Designed according to NZ standards
- Response spectrum analysis.
- 3D model is generated in SAP 2000
- Reduced beam section connection is applied for MRF.
- Short active link (shear Behavior) is opted for EBF.

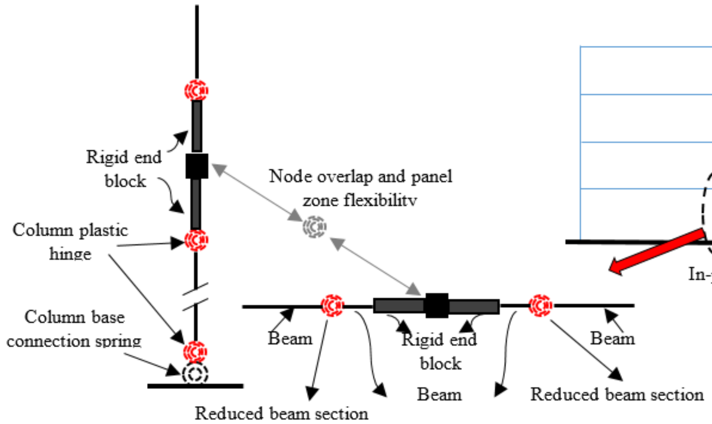


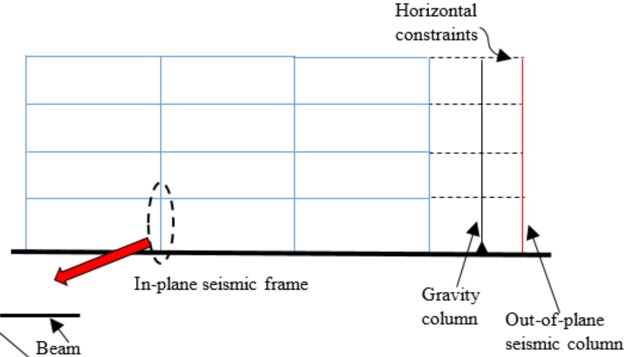
Comparison between 12-storey EBF and MRF structure drift profiles shows that drift demand is larger for EBF than MRF for the upper half of the building.



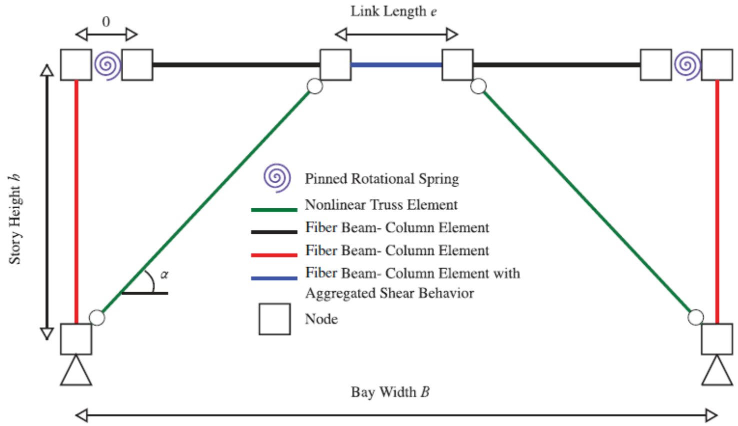
Methodology: Modeling And Analysis

- A 2-D model is developed in OpenSees.
- The modified Ibarra and Krawinkler model is adopted for MRF. (Lignos et al., 2011,2013)
- Panel zone flexibility is accounted for adopting Kim et al. (2001) approach.





- The modeling methodology developed by O'Reilly et al., (2016) is applied for EBF.

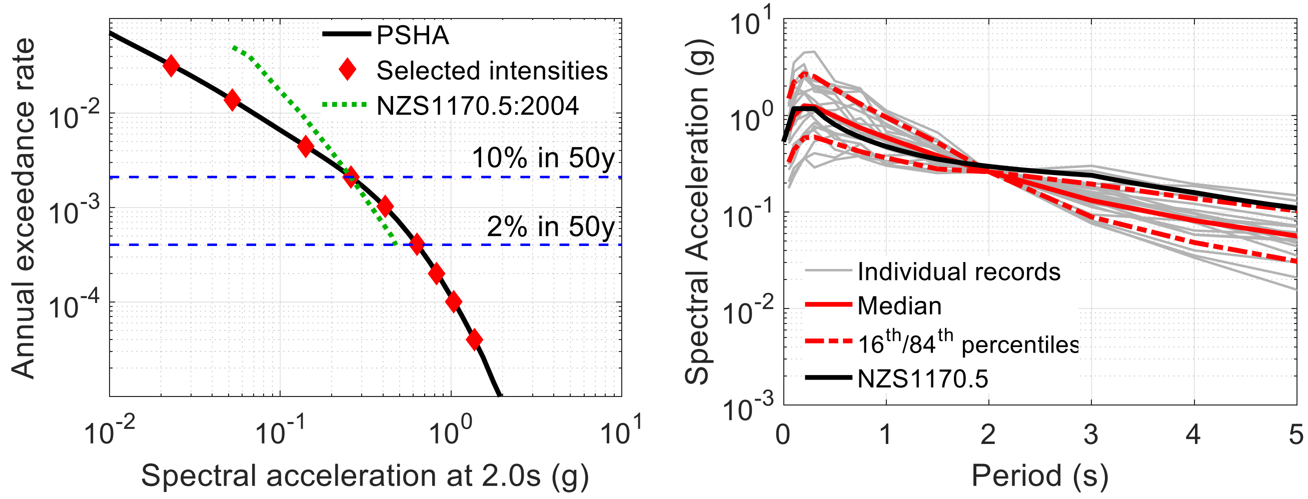


Methodology: Ground Motion Selection

- Probabilistic seismic hazard assessment and ground motion selection

Multi Stripe Analyses:

- Nine different stripes with different return periods are chosen.
- The ground motion selected based on GCIM (Bradley 2010) is used (Yeow et al., 2018).



Wellington (T^*=2.0s)

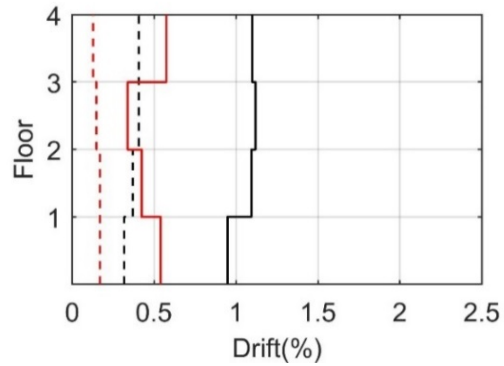
- Seismic loss estimation
  - Performed on SLAT (Bradley 2011)

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

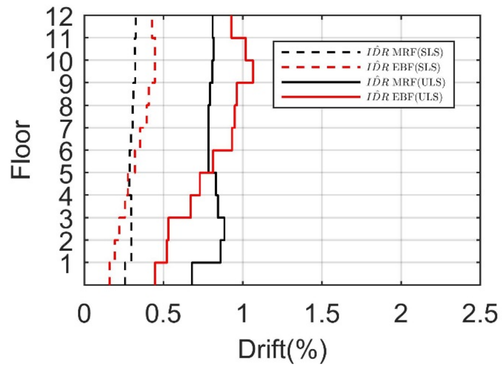
Deierlein et al. (2003)

Building Response

Drift/Acceleration building response

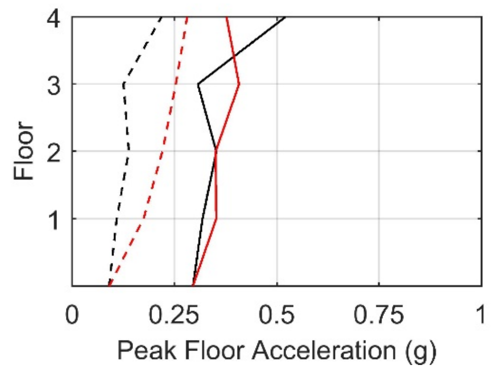


4-St. Christchurch

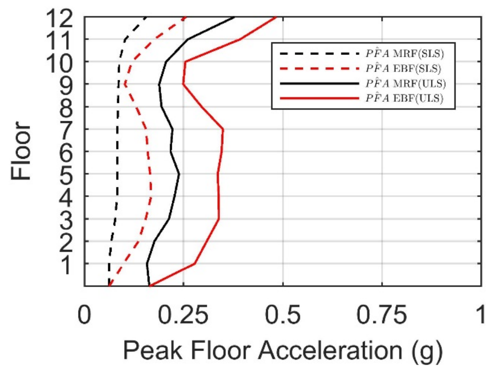


12-St. Christchurch

Median peak drift demands obtained from NLTH analyses for SLS and ULS intensity levels.



4-St. Christchurch

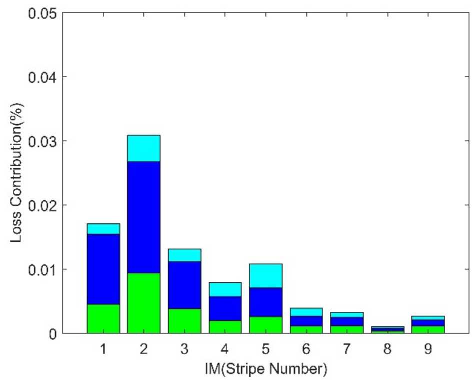


12-St. Christchurch

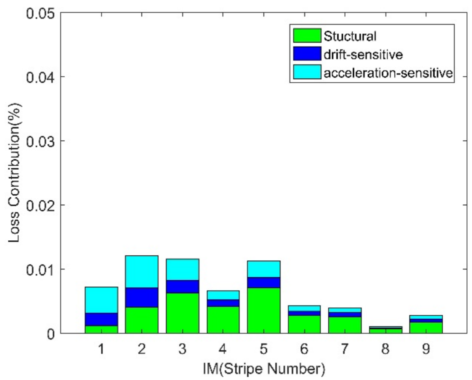
Median peak floor acceleration demands obtained from NLTH analyses for SLS and ULS intensity levels.

Loss Results

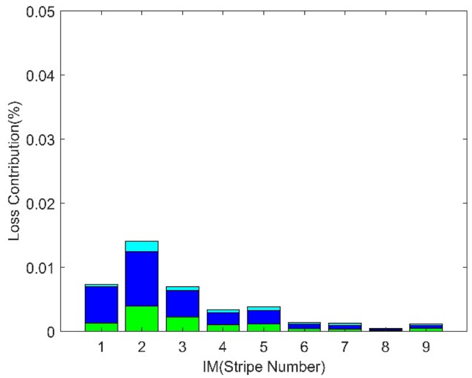
4-Storey MRF		4-Storey EBF		12-Storey MRF		12-Storey EBF	
WELL.	**CHCH.**	**WELL.**	**CHCH.**	**WELL.**	**CHCH.**	**WELL.**	**CHCH.**
0.17%	**0.09%**	**0.15%**	**0.06%**	**0.09%**	**0.04%**	**0.14%**	**0.06%**



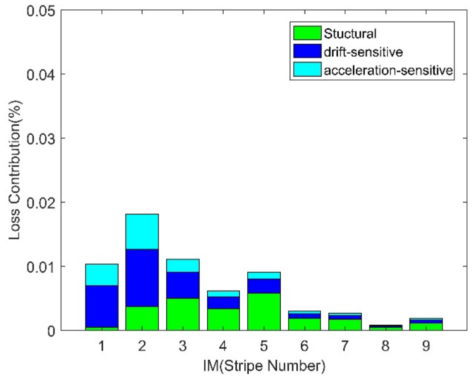
4-St. MRF CHCH



4-St. EBF CHCH



12-St. MRF CHCH



12-St. EBF CHCH

Conclusions

- Low-rise buildings appear to have higher seismic risk than mid-rise buildings (considering same function and structural system)
- Low-rise MRF systems experience larger monetary loss than EBF systems.
- Wellington infrastructure is more prone to seismic monetary loss than Christchurch.
- Mid-rise EBF systems experience larger EAL in comparison with MRF systems.

Acknowledgments

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