RNC2: Benchmarking the risk of code-compliant buildings

Researchers:
Amir Orumiyehei, Tim Sullivan
Department of Civil & Natural Resources Engineering
University of Canterbury

Previous research: Benchmarking performance of steel buildings and value proposition for next-generation systems

Various design solutions developed according to NZ standards for 4- & 12-storey case-study buildings.

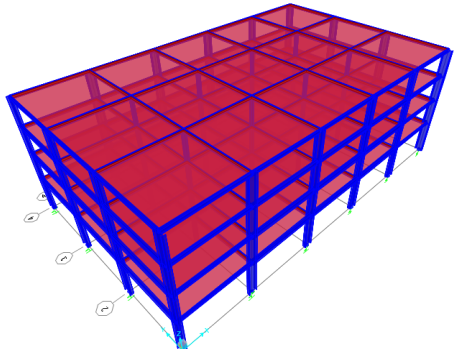
Non-linear time-history analyses and loss assessment used to quantify relative benefits of different systems, considering structural & non-structural elements.

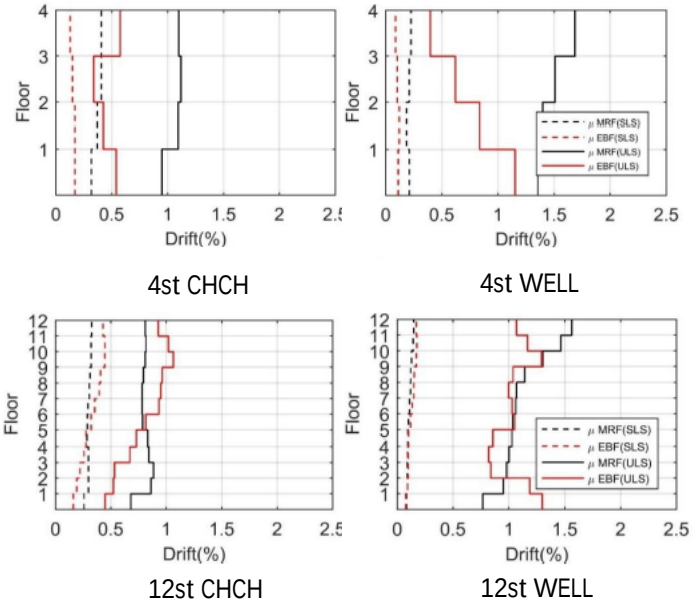
NZ-specific fragility and consequence functions were developed/identified as part of this research (Yeow et al. 2018).

Systems considered:

- Traditional Steel MRFs
- Traditional Steel EBF systems
- Steel MRFs with friction joints

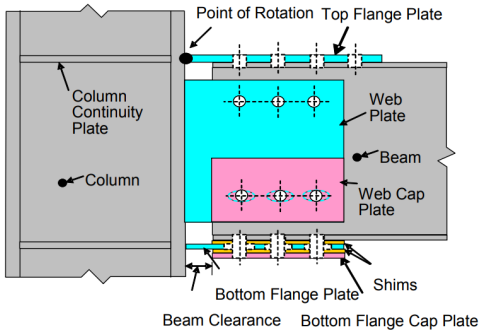
4-Storey MRF		4-Storey EBF		12-Storey MRF		12-Storey EBF	
WELL.	CHCH.	WELL.	CHCH.	WELL.	CHCH.	WELL.	CHCH.
0.17%	0.09%	0.15%	0.06%	0.09%	0.04%	0.14%	0.06%





Value proposition for next-generation infrastructure

Comparison of expected annual losses for traditional steel MRFs versus MRFs with friction connections?



(MacRae et al. 2010)

Location	4-storey building						12-storey building					
	Traditional frame			Friction connections			Traditional frame			Friction connections		
	EAL (NZD)	EAL (% of FRC)	•	EAL (NZD)	EAL (% of FRC)	•	EAL (NZD)	EAL (% of FRC)	•	EAL (NZD)	EAL (% of FRC)	•
Auckland	706	0.007	3.4	601	0.006	3.4	1,270	0.003	3.5	1,140	0.002	3.4
Christchurch	11,400	0.107	3.6	9,030	0.084	3.5	25,800	0.050	3.7	22,100	0.043	3.6
Wellington	18,100	0.184	3.9	15,000	0.151	3.9	41,000	0.087	4.1	35,000	0.074	4.1

(Yeow et al. 2018)

RNC2 extension of benchmarking study

Following on from previous studies, this project aims to broaden scope:

- Design suite of case-study buildings in accordance with NZ standards (gravity, wind and seismic loading). RC buildings (traditional and low-damage), base-isolated buildings, hybrid systems, timber buildings, residential vs commercial vs industrial.
- Develop non-linear models to permit non-linear dynamic analyses of the design solutions.
- Evaluate performance in line with FEMA P-58 (or SLAT) but utilising NZ-specific fragility and consequence (loss) functions.

Research Outcomes

1. Indications of expected annual loss (EAL) for broad range of building typologies designed in accordance with current code recommendations. Target to have this completed within 1 year.
2. Identification of design criteria that appear to affect EAL most for different building use typologies and structural systems.
3. Dataset of buildings that can be re-designed or re-examined to consider how alternative provisions, interventions and general research findings could impact overall risk profile of NZ building stock.

RNC2: Reconsidering Design Criteria for the Serviceability Limit State

Researchers:
PhD student, Tim Sullivan and others (including industry rep to be confirmed)
Department of Civil & Natural Resources Engineering
University of Canterbury

Previous/On-going research

Various publications post-Canterbury earthquakes have highlighted challenge facing engineering community: reduce post-earthquake losses and disruption.

Pettinga (2018, 2019) has proposed that serviceability limit state (SLS) design criteria be revised to reduce damage and losses. Proposal made to change SLS intensity return period. Also option to introduce an SLS drift limit.

Stanway et al. (2018, 2019) have identified that revisions should be made to design criteria (e.g. drift limits) and conformance requirements for non-structural elements.

Building component	Median SLS drift capacity*
Plasterboard partitions	0.3%
Curtain-wall glazing non-seismic detailing	0.35%
Curtain-wall glazing seismic detailing	1.5%
Pre-cast cladding	0.6%
*illustrative values not finalised	

What changes should be made to SLS criteria that lead to best overall outcome for NZ?

Research needs to consider design criteria for non-structural elements as well as suitable return period within a risk-context.

Proposed research into design criteria for SLS

To advance criteria for SLS design:

- Identify factors affecting damage and losses in buildings (linkages to benchmarking study as well as on-going research into seismic performance of non-structural elements in MBIE-QuakeCentre BIP project).
- Develop, in consultation with industry, a number of options to change SLS design criteria.
- Re-design suite of case study buildings using revised criteria and estimate impact of SLS criteria on likely construction costs.
- Evaluate performance of alternative design approaches via loss-assessment. Use loss assessment results to inform suitable changes to SLS design criteria.

Research Outcomes

1. Recommendations to change SLS design criteria in NZ standards supported by research findings.
2. Improved quantification of risk (monetary losses) of New Zealand building stock.