Developing a typology for recently constructed buildings that combine CONCRETE WALLS AND STEEL FRAMES

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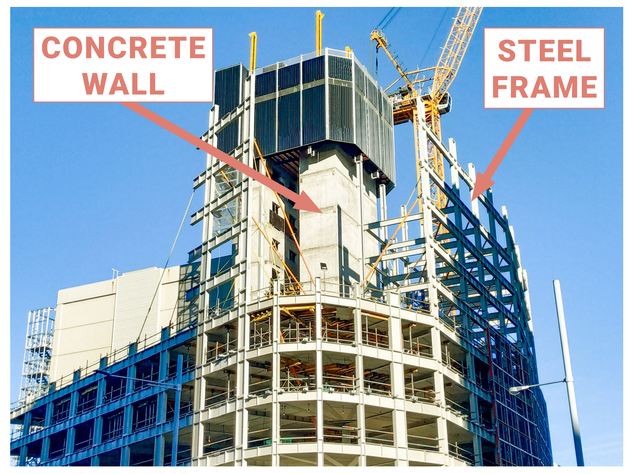
CONCRETE WALLS

- Stiff, good at controlling building drift during an earthquake
- Convenient for lifts, stairs and property boundaries
- Economical, provides built-in insulation and fire protection

STEEL FRAMES

- Flexible, able to absorb earthquake energy
- Relatively light, does not attract high seismic forces
- Quick to build and easy to repair after an earthquake



HYBRID BUILDINGS THAT COMBINE CONCRETE WALLS AND STEEL FRAMES

- The respective advantages of concrete walls and steel frames have given rise to a trend of 'hybrid buildings' in New Zealand that combine these two structural systems.
- Their combination results in smaller beam/column cross-sections, bigger floor areas and economic savings.

1. INTRODUCTION

A study conducted in Christchurch showed that ~35% of buildings constructed after the Canterbury eathquakes used combinations of concrete walls and steel frames.

Despite the emergence of these buildings, their structural performance have not been fully investigated. The applicability of past studies to the New Zealand context is also questionable.

Moreover, New Zealand building standards do not explicitly address mixed-material structural systems.

The aim of this study is to characterise these buildings by developing a typology that is relevant to understanding their seismic performance.

It focusses on buildings constructed in Christchurch and Auckland 2014 onwards.

2. METHODOLOGY

Building drawings were gathered and reviewed. Structural features relevant to seismic performance were identified.

Data was aggregated by city to determine any regional differences between Christchurch and Auckland buildings.

Meetings were conducted with structural engineers to further understand design philosophies and validate observations.

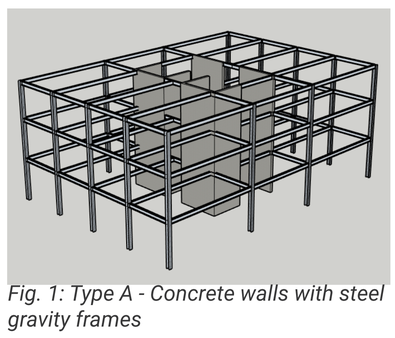


Fig. 1: Type A - Concrete walls with steel gravity frames

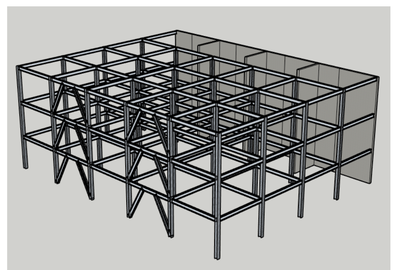


Fig. 2: Type B - Concrete walls and steel frames acting as a dual system

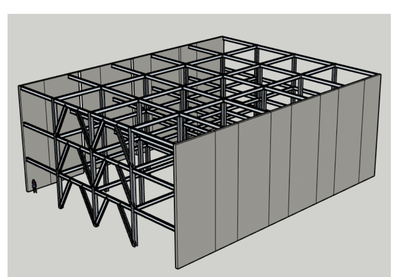


Fig. 3: Type C - Concrete walls and steel frames in orthogonal directions

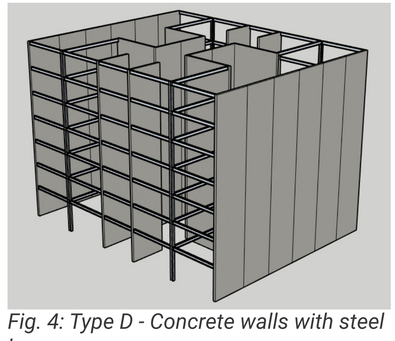


Fig. 4: Type D - Concrete walls with steel beams

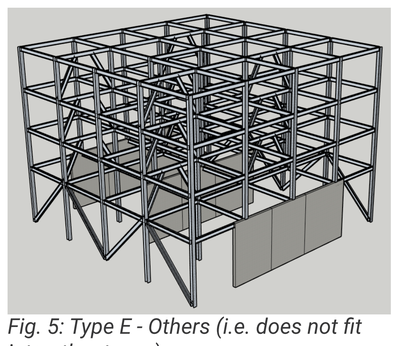


Fig. 5: Type E - Others (i.e. does not fit into other types)

3. RESULTS & DISCUSSION

- A total of 50 buildings were studied. Five typologies (Fig. 1-5) were proposed based on the lateral load resisting system.
- Based on Fig. 6-8, surveyed Christchurch buildings were generally mid-rise commercial buildings classified as Type B or Type C, while Auckland buildings were high-rise residential buildings classified as Type A or Type D.
- These trends are mainly influenced by construction demand and level of seismic hazard in each city.

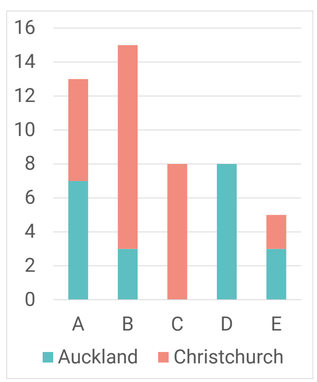


Fig. 6: Typology of surveyed buildings in each city

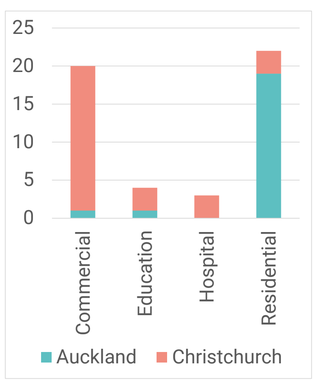


Fig. 7: Occupancy of surveyed buildings in each city

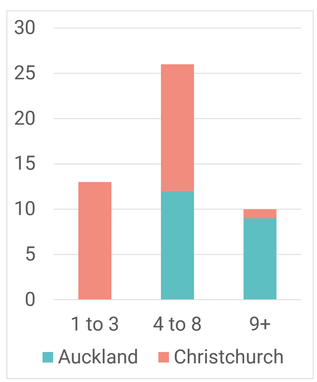


Fig. 8: Height (# of storeys) of surveyed buildings in each city

4. CONCLUSION & FUTURE WORK

- A building survey and typological analysis of 50 buildings in Christchurch and Auckland showed a wide variety of concrete wall-steel frame hybrid buildings in New Zealand, which are not comparable to those found in past literature.
- The typologies developed in this study will serve as basis for creating archetypes of steel frame-concrete wall buildings.
- A full-scale experimental test will be conducted on a concrete wall-steel beam connection (Fig. 9) and a numerical model of a case study building is being developed. (Fig. 10)
- Findings will be used to develop a design procedure for concrete wall-steel frame hybrid buildings, which can help inform New Zealand building design standards.

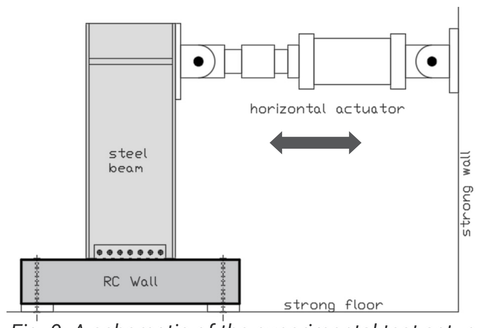


Fig. 9: A schematic of the experimental test setup.

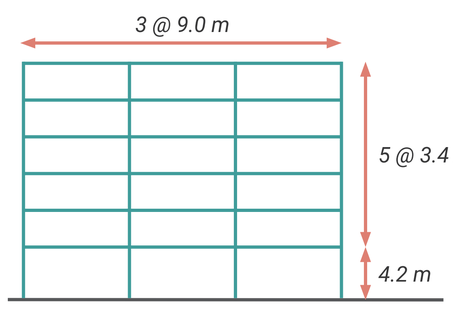


Fig. 10: The numerical model is based on a six-storey, three-bay commercial building located in Christchurch.

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November 2020

- Bruneau, M., & MacRae, G. (2017). Reconstructing Christchurch: A seismic shift in building structural systems. Canterbury, New Zealand: The Quake Center, University of Canterbury.
- Garcia, R., Sullivan, T., & Della Corte, G. (2010). Development of a displacement-based design method for steel frame-RC wall buildings. Journal of Earthquake Engineering, 14(2), 252-277.
- Standards New Zealand (1997). NZS3404: Steel structures standard Part 1. Wellington: Standards New Zealand.
- Standards New Zealand (2006). NZS3101: Concrete structures standard Part 1: The design of concrete structures. Wellington: Standards New Zealand.

QuakeCoRE NZ Centre for Earthquake Resilience Te Hiranga Rū

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