



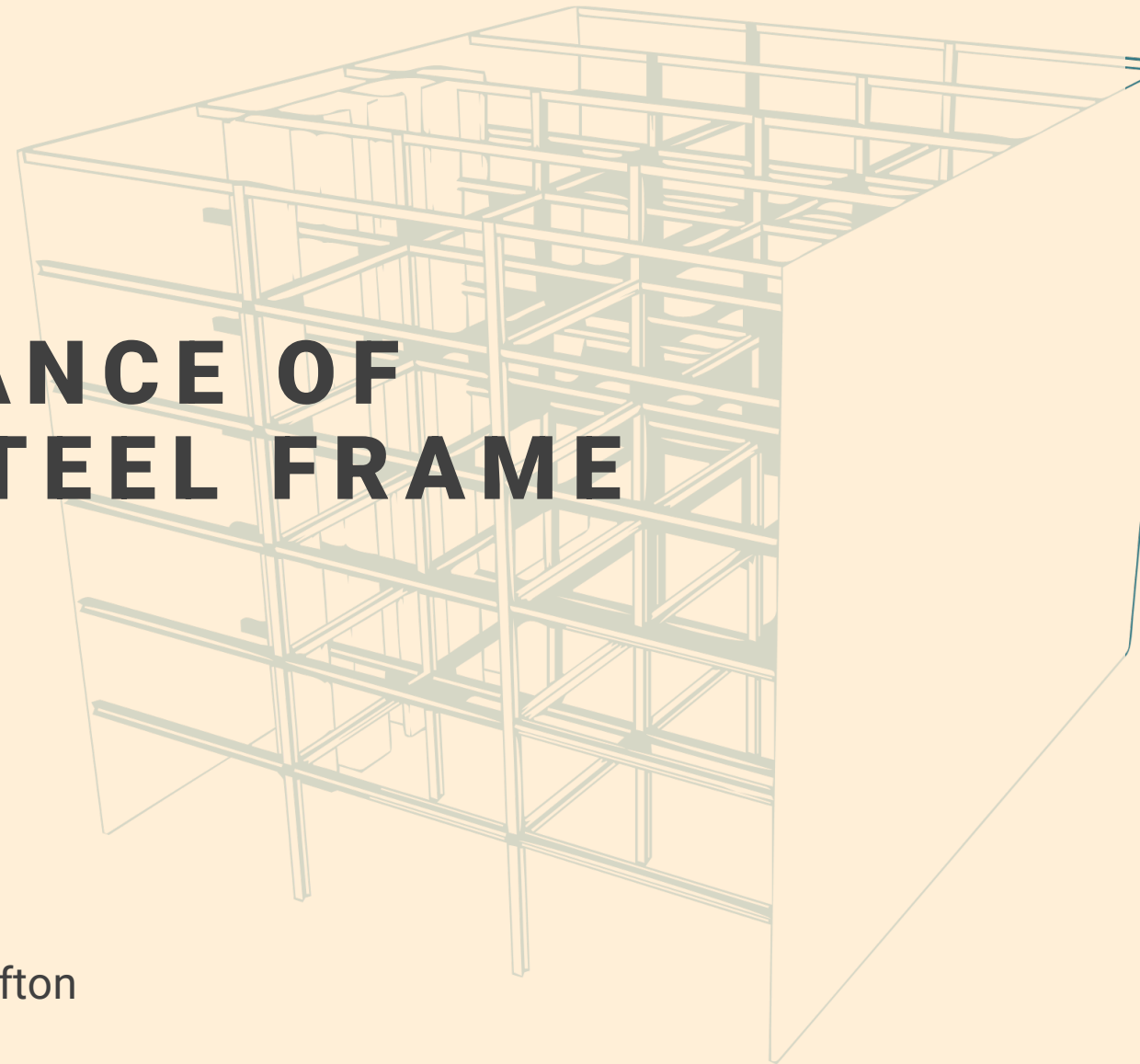
# SEISMIC PERFORMANCE OF CONCRETE WALL-STEEL FRAME HYBRID BUILDINGS

**CLAIRE PASCUA**

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## CONCRETE WALLS

- Stiffness, drift control
- Built-in fire rating and insulation
- Functionality



## STRUCTURAL STEEL

- Flexibility
- Good strength-to-weight ratio
- Reparability

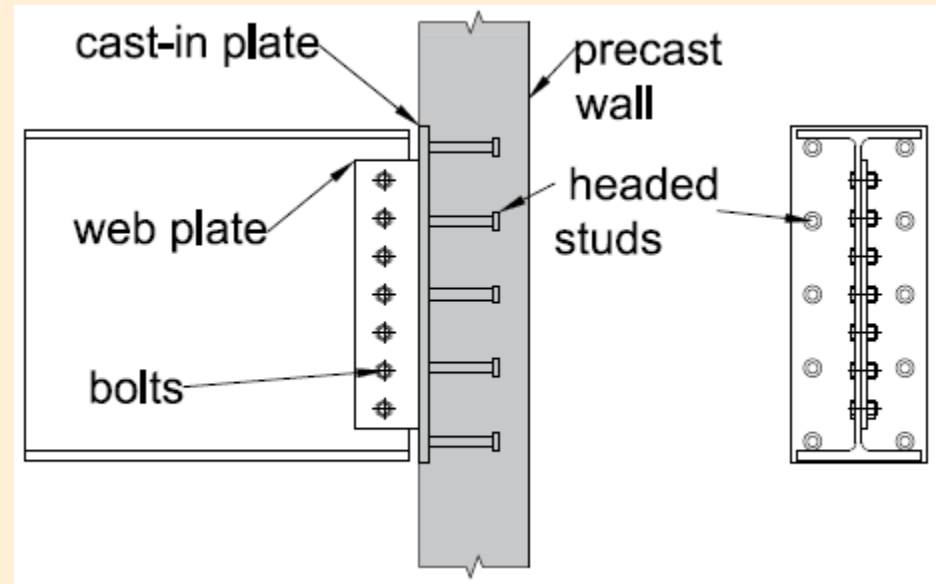
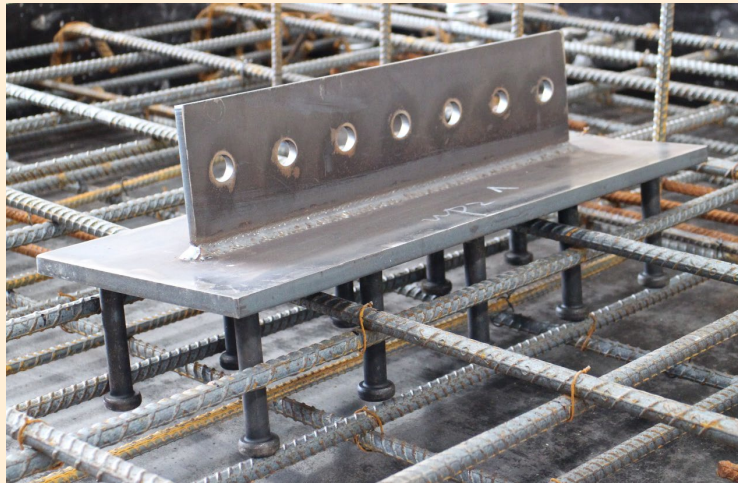


## HYBRID BUILDINGS WITH CONCRETE WALLS AND STEEL FRAMES

- Economy \$\$
- Efficiency

# WHAT IS THE ISSUE?

- Lack of connection design guidelines
- Few tests conducted previously
- Bolted web plate connections are usually assumed to act like a pin



**Need to identify and address any vulnerabilities  
before this building type becomes more dominant**



To **characterise recently constructed** concrete wall-steel frame hybrid buildings in New Zealand.



To quantify the **rotation capacity** and validate **failure modes** of existing concrete wall-steel beam connections.



To quantify the **expected seismic performance** of concrete wall-steel frame buildings.



To develop a reliable **design procedure** for concrete wall-steel beam connections.

## OBJECTIVES

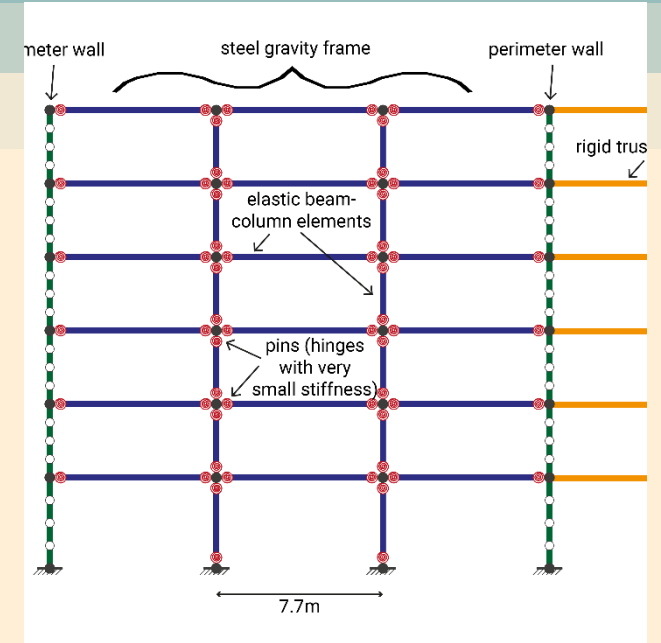
# METHODOLOGY



**BUILDING  
REVIEW**



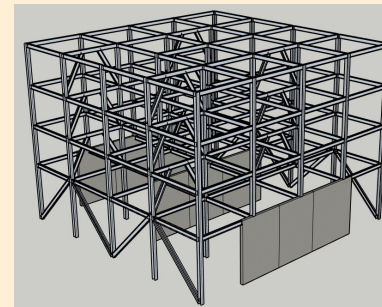
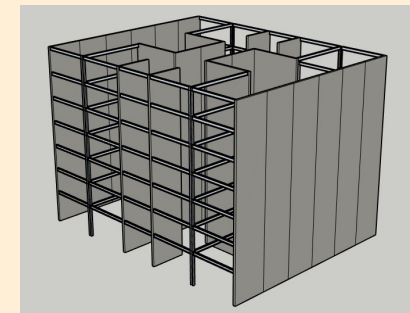
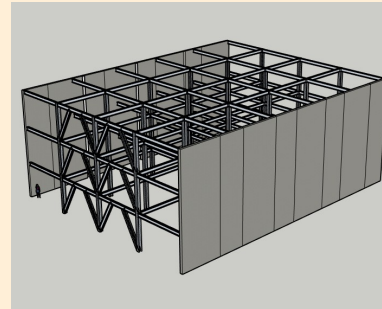
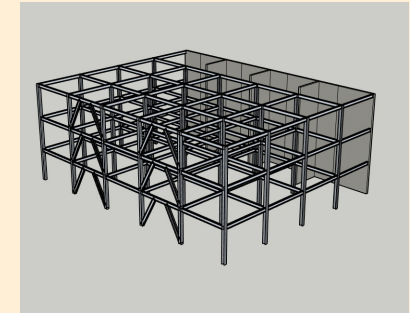
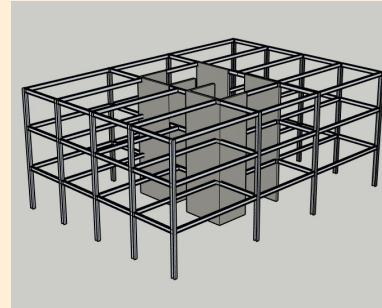
**EXPERIMENTAL  
TESTING**



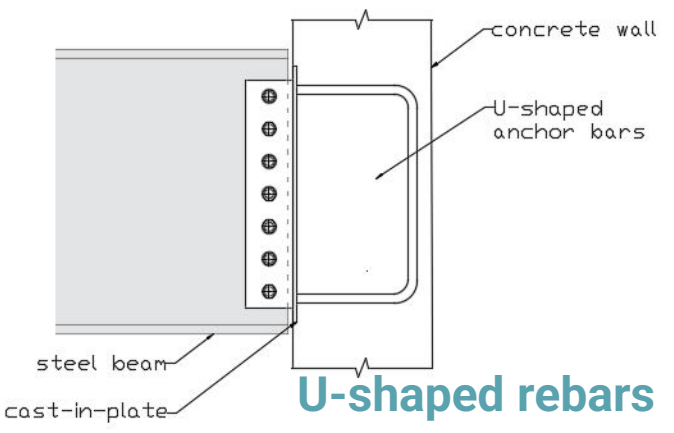
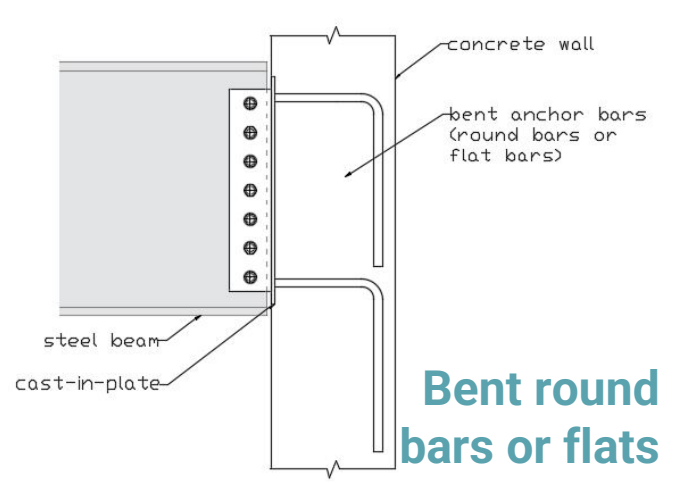
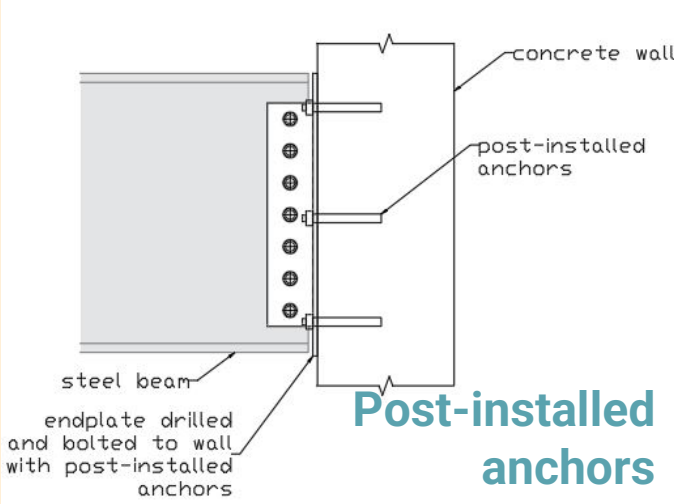
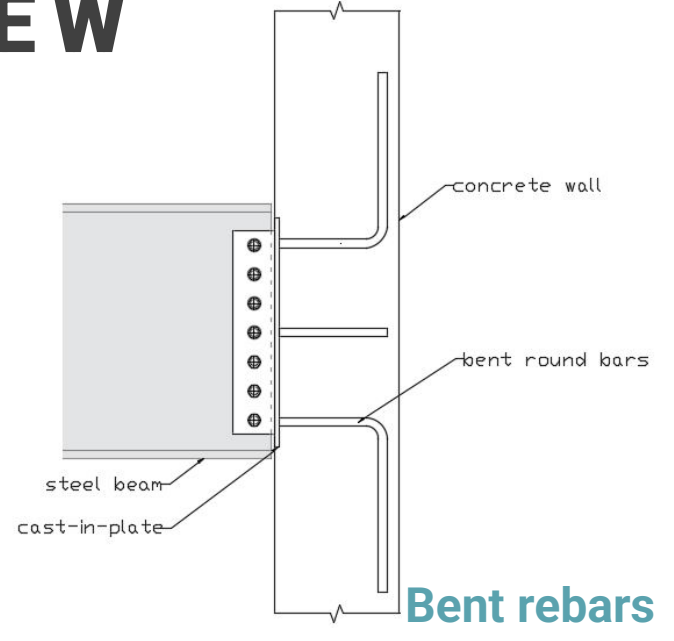
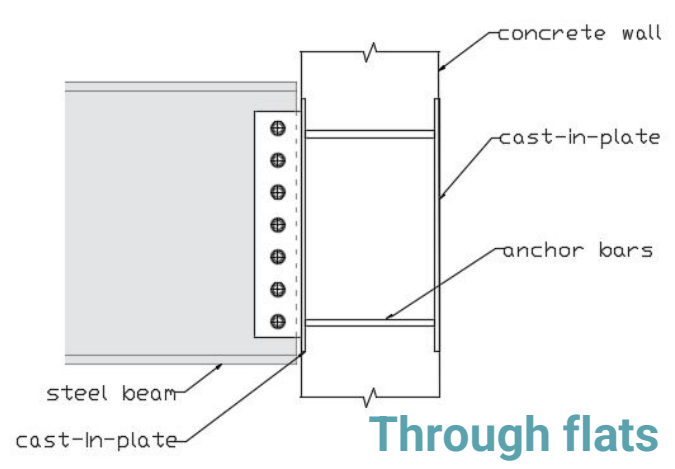
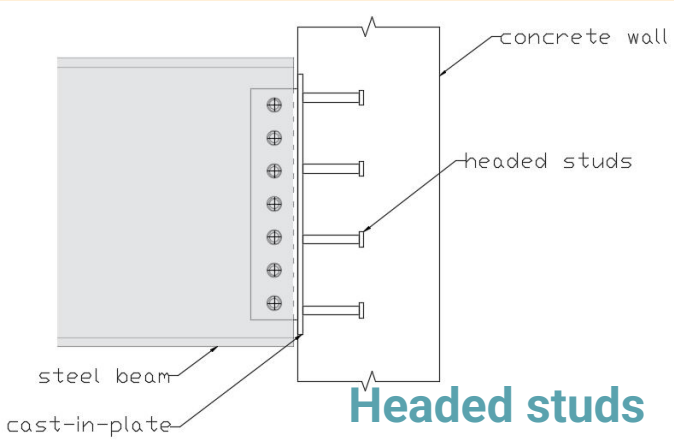
**NUMERICAL  
MODELLING**

# BUILDING REVIEW

- **Survey** of 50 buildings in Auckland and Christchurch + **interviews** with engineers
- **Variety** of wall configurations and steel framing systems.
- Different **trends in structural features** in Christchurch and Auckland.
- Categorized buildings into **five typologies**.



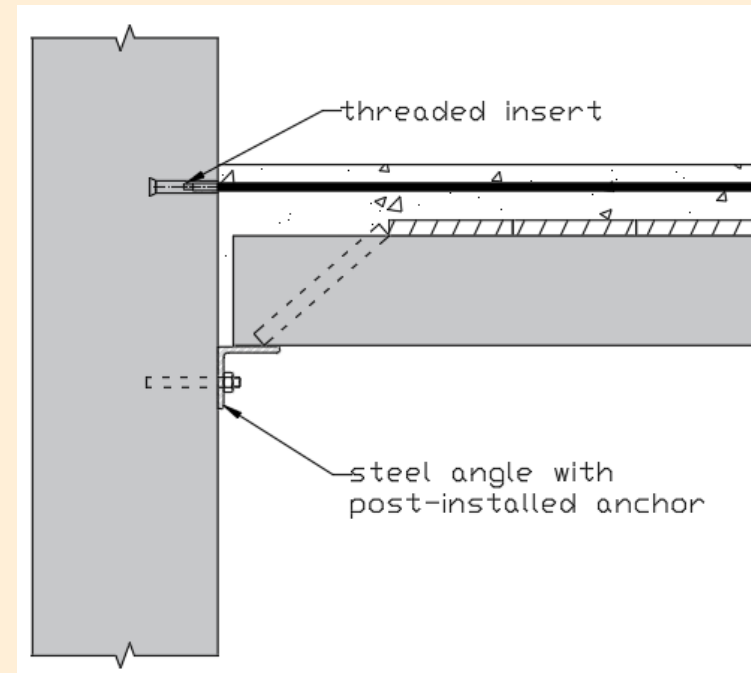
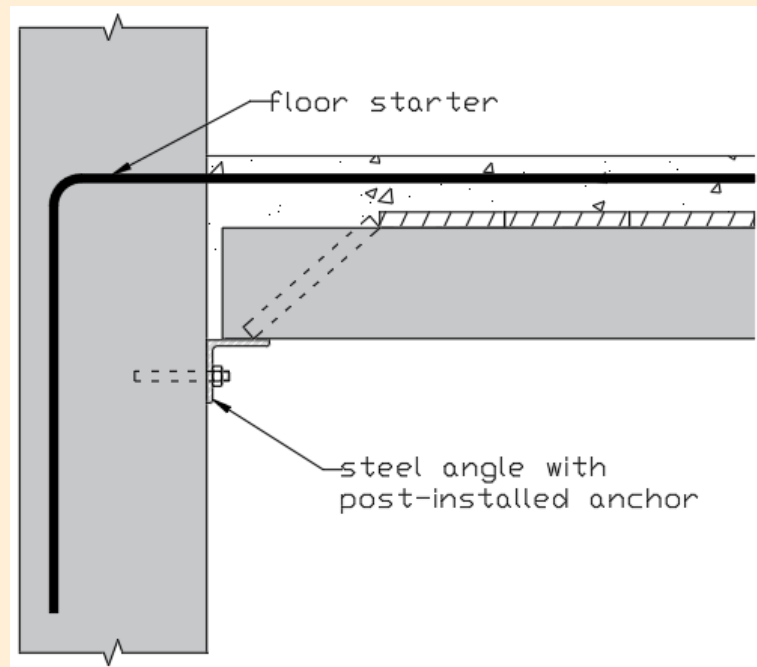
# BUILDING REVIEW



- Wide range of **connection detailing** highlights lack of design guidelines.



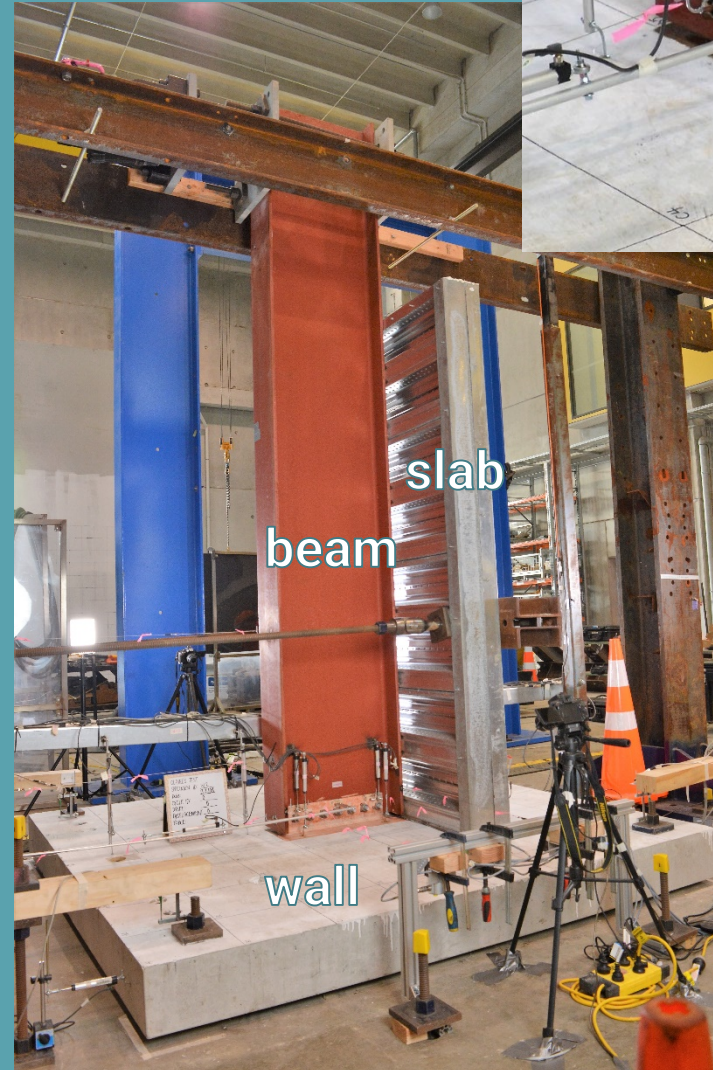
# BUILDING REVIEW



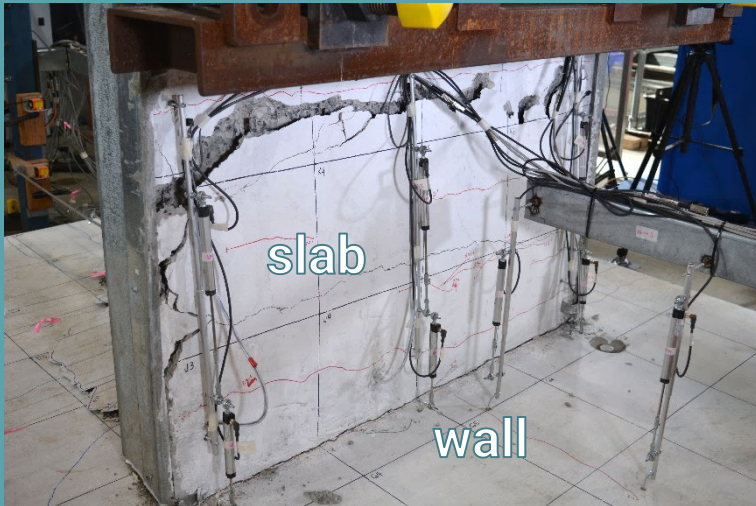
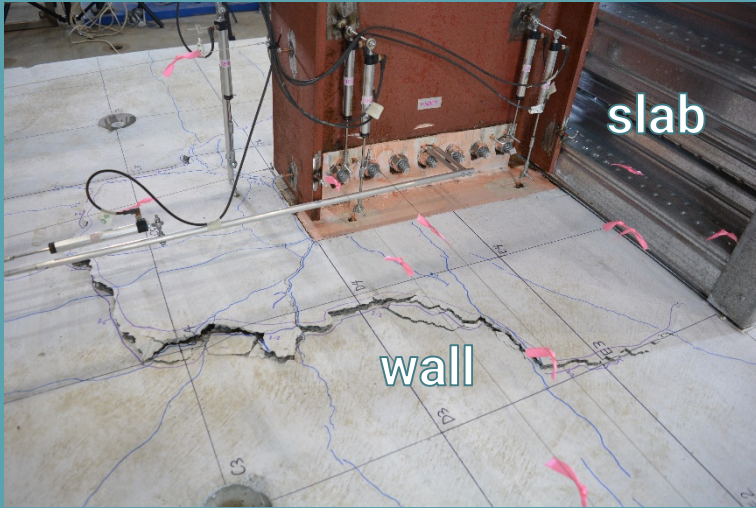
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# EXPERIMENTAL TESTING

- Four full-scale specimens designed according to current practice
- Test variables:
  - Floor slab and starters
  - Round vs slotted holes
  - Headed studs vs bent rebar anchors



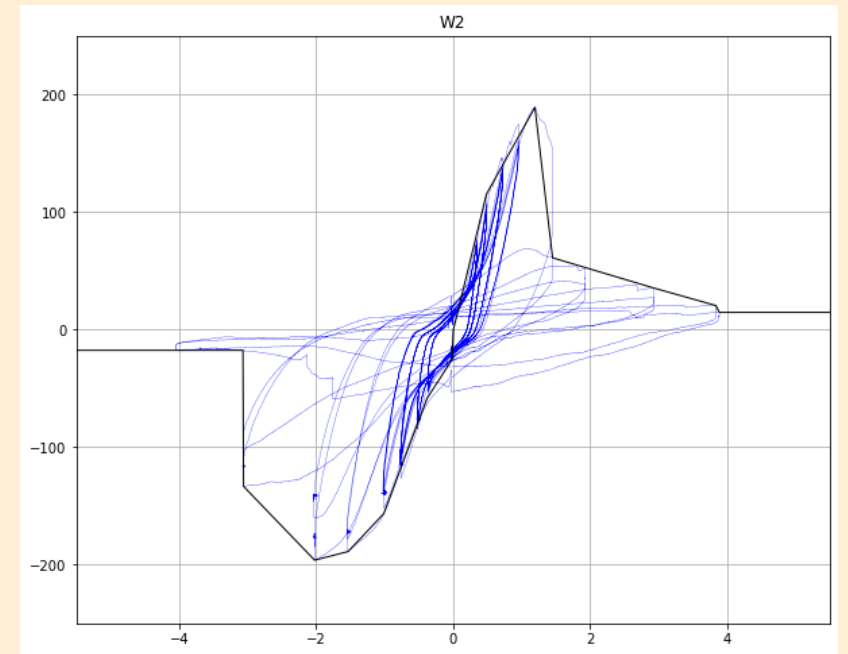
# EXPERIMENTAL TESTING



- **Brittle failure** by concrete breakout.
- **Rotation capacity** is dictated by bolt slippage, web plate bearing, and wall deformation.
- **Floor slab and starters** drastically reduced rotation capacity and increased connection stiffness.
- **Slotted holes** and **bent rebar anchors** improved rotational capacity.

# NUMERICAL MODELLING

- In progress
- **Pushover analysis** on a six-storey office building located in Christchurch using OpenSeesPy.
- Results of experimental testing is used to simulate **different connection conditions**.
- **Parametric study** will be conducted to benchmark seismic performance and to quantify **connection and wall demands**.



- An understanding of **current state of practice**
- Identification of **future areas of research**
- Identification of **possible vulnerabilities** of this emerging building type
- An **improved design procedure** for concrete wall-steel beam connections, which can be used to revise New Zealand design standards.

## STUDY OUTCOMES

# POSSIBILITIES WITH LARGE-SCALE WHOLE-OF-BUILDING TESTS

- No existing large-scale tests at system-level
- Can the connection **sustain gravity load** after concrete breakout?
- Will the **floor starters detach** and drop the slab?
- Whole-of-building test will subject the connection to **additional diaphragm forces** not included in previous tests.
- How can **design ductility** affect connection performance?

