Lateral load tests on earthquake damaged houses in Christchurch

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Overview

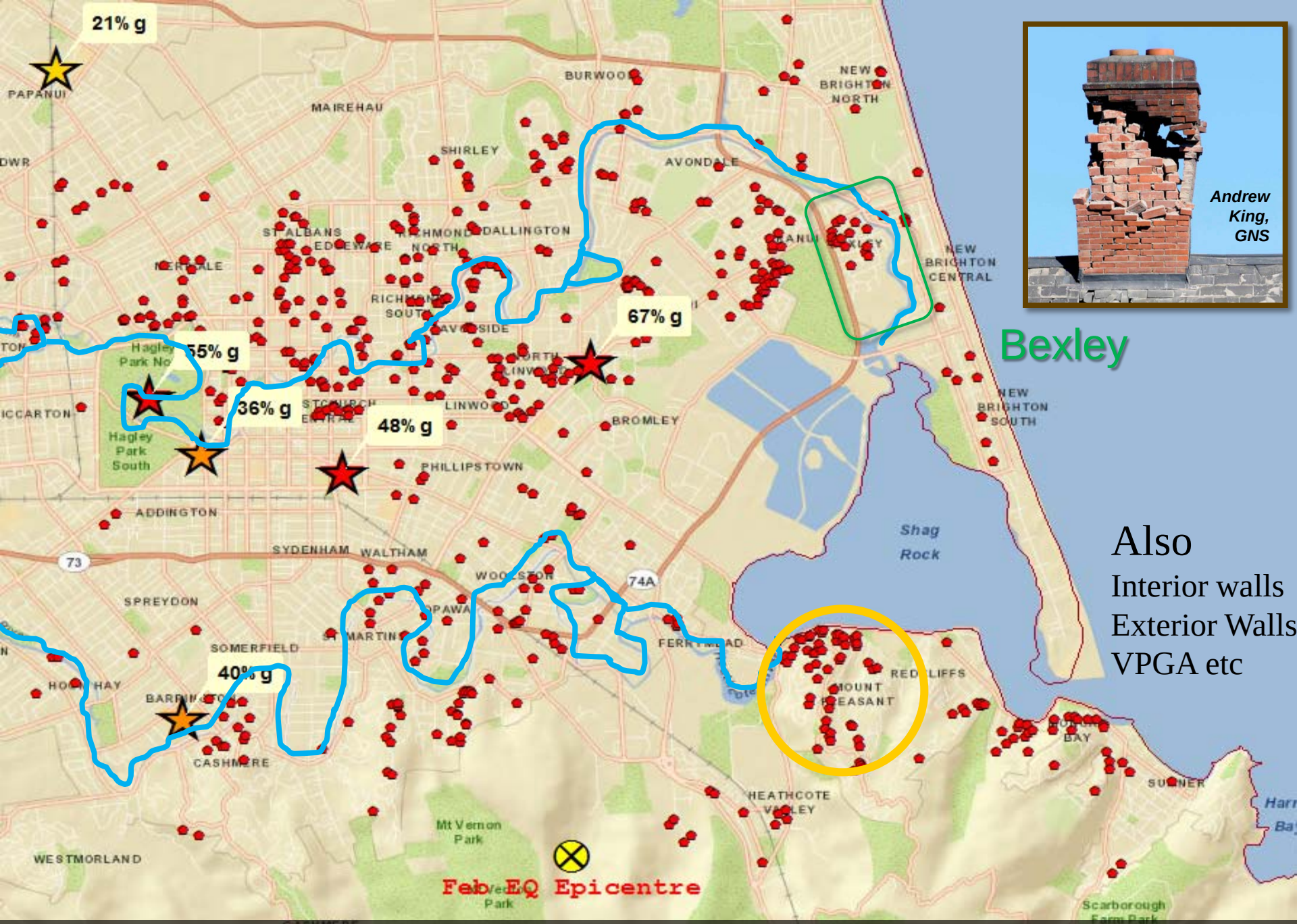
- Previous survey work on house damage
- House Test objectives and selection
  - Test Setup & Measurement systems
  - Results & Conclusions
  - Future proposal
- **COLLABORATORS**
- Joshua Briscoe, Logan Holt

  Auckland Students with construction experience
- David Carradine, David Yeoh

  University of Canterbury

Christchurch earthquakes - house assessments

- 100,000 houses damaged, ~$10 billion
- 3 main Causes of damage:
  - Liquefaction
  - Rock fall
  - **Shaking**
- Operation suburb rapid assessments
- 2011 students and data from Christchurch city
  - Very crude data, 3000 of 70,000 houses



Chimney Damage compared with Horizontal PGA (Shown as Stars)

BRANZ Survey

- BRANZ
  - 300 houses with rigorous sampling, detailed data
- Damage
  - Brick claddings -mostly cracking
  - Little damage to claddings such as weatherboard.
  - Gypsum plasterboard lining cracks
    - at sheet joints
    - and opening corners
  - Lath and plaster,fibrous plaster linings
    - diagonal cracking
  - Evaluation underway at Victoria (Geoff Thomas VUW)

In houses with little physical damage, residents noted that they creaked more in the wind

Objectives

- Measure the extent of reported stiffness degradation in moderately damaged houses
  - Good qualitative studies but nothing quantitative
- Determine likely residual strength in moderately damaged houses
  - typical of the less damaged houses in Christchurch
  - representative of the New Zealand building stock
- Validate the test methodology

House Selection for load assessment

- Moderate damage
  - Typical of what is being repaired
  - Likely to be typical of moderate event elsewhere
- Preferably flat site with access
- Single storey
- Light cladding
  - Stiffness not dominated by cladding

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Methodology

- Wairoa St
  - Heavy tile, gable, fibreboard, wood piles, 1980
- Bexley Rd
  - Heavy tile, hip, weatherboard, concrete ring foundn & piles, 1947

House 1: Wairoa St, Bexley

House 2: Bexley Rd, Bexley

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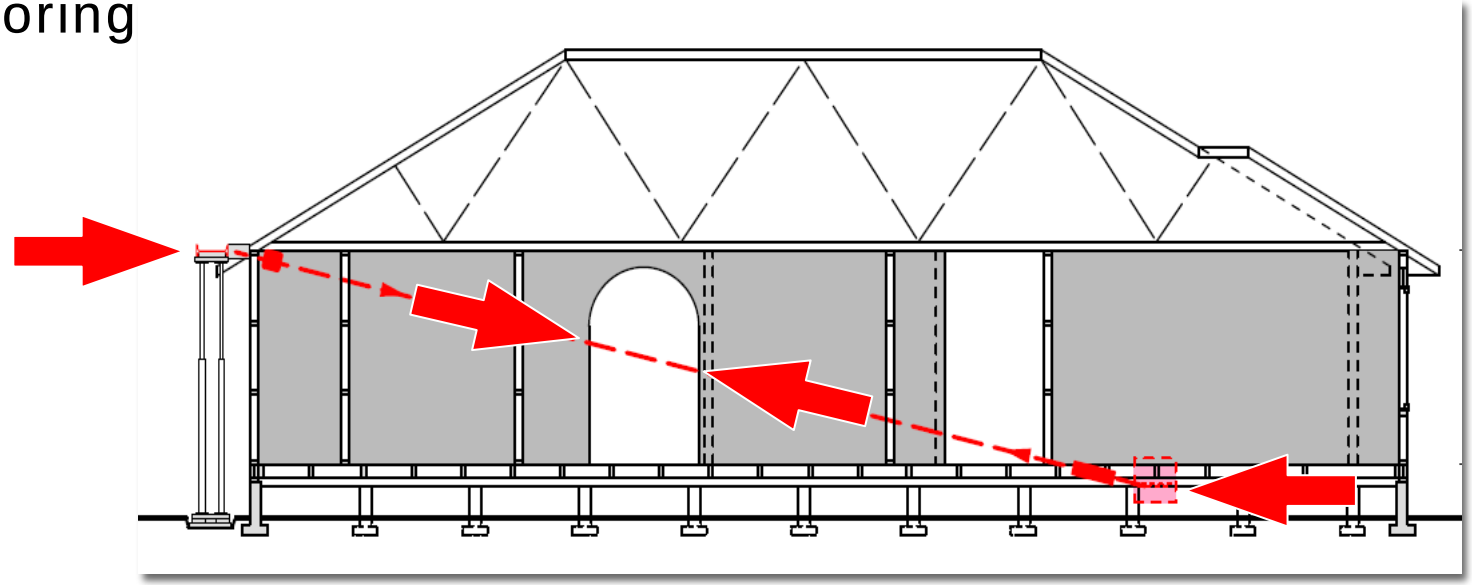
Methodology

- Loading concepts
  - Load beam
  - Tension
  - Anchoring



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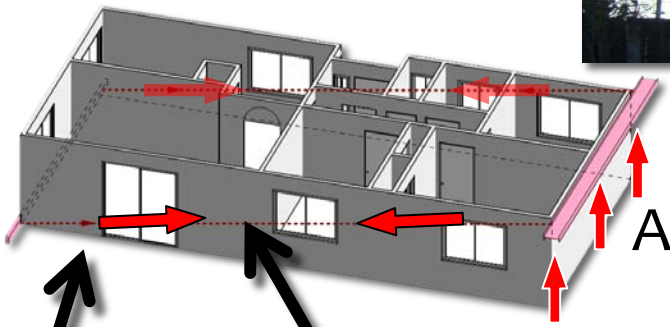
House 1

150 RHS Anchor beam

360 UB Load beam

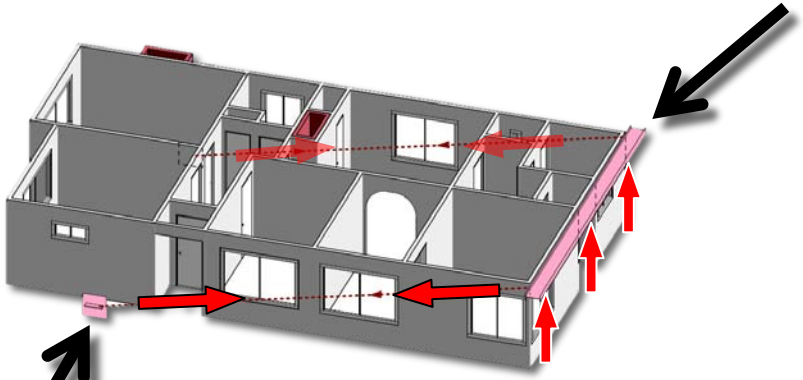


Acrow prop towers

Load Cell

Reaction Chain & 7.5 Tonne Chain Pulley

Test Rig – House 2



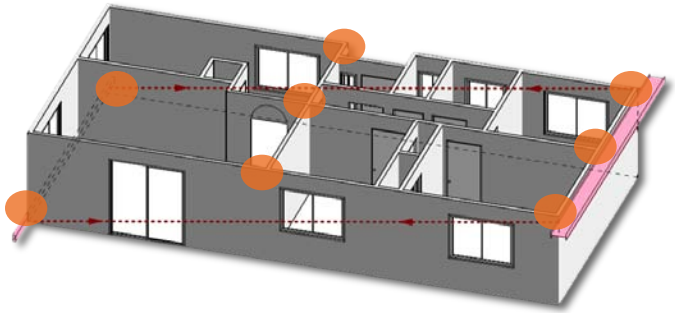
Sliding plate

Anchor plate

Measurement System

- Deflection recording
  - Electronic
  - Manual

Electronic Potentiometers



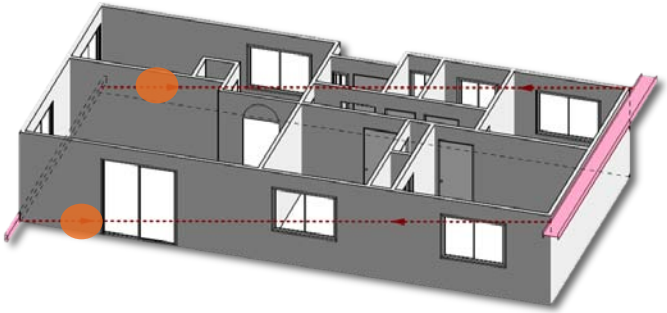
Gauge locations

Manually recorded deflection gauges

Measurement System

- Tension measuring
  - Load cell

- Computer data logging



Load cell locations

Load cell in tension

Data recording

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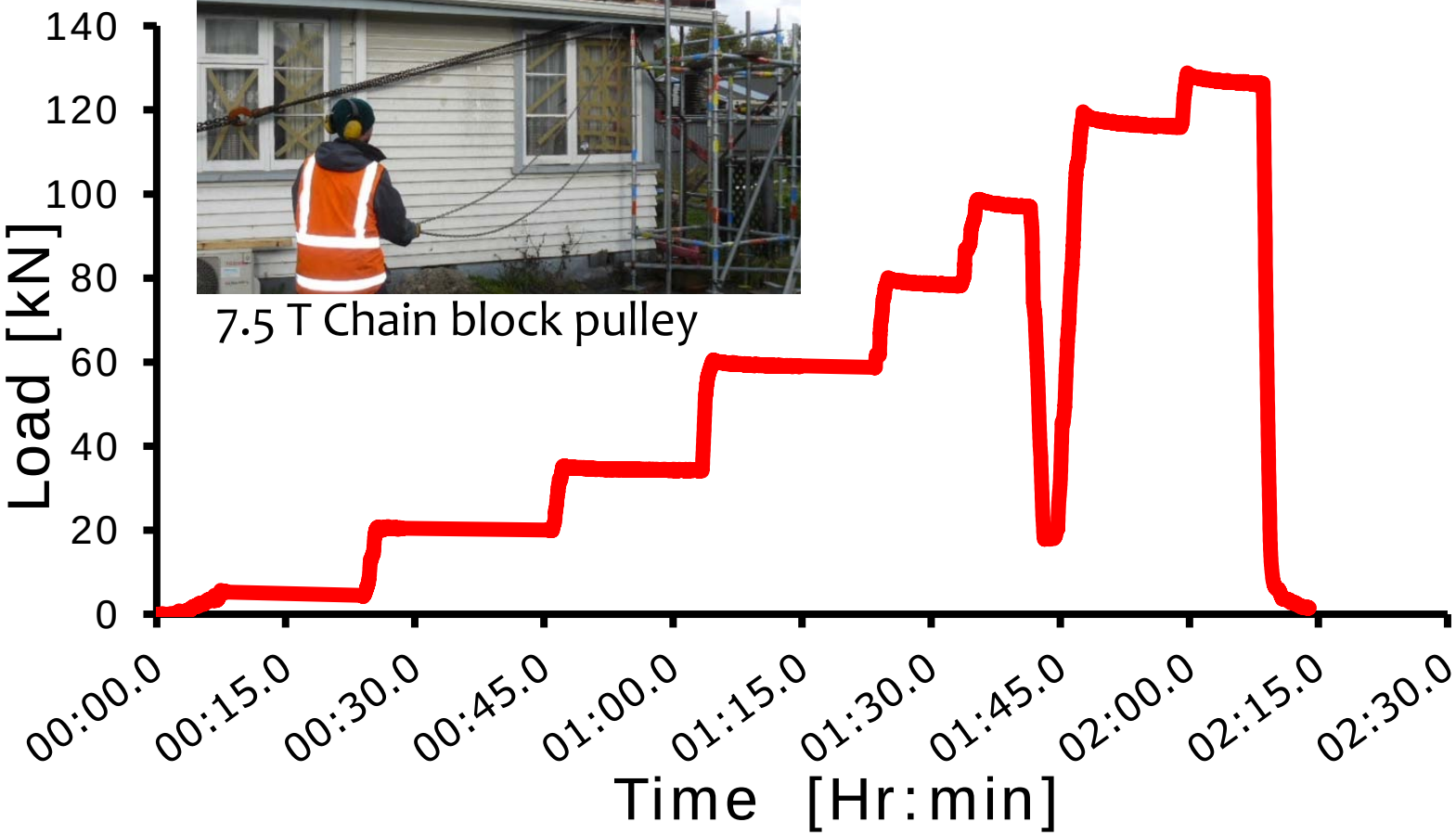
Loading Sequence

7.5 T Chain block pulley



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Results – Damage observed

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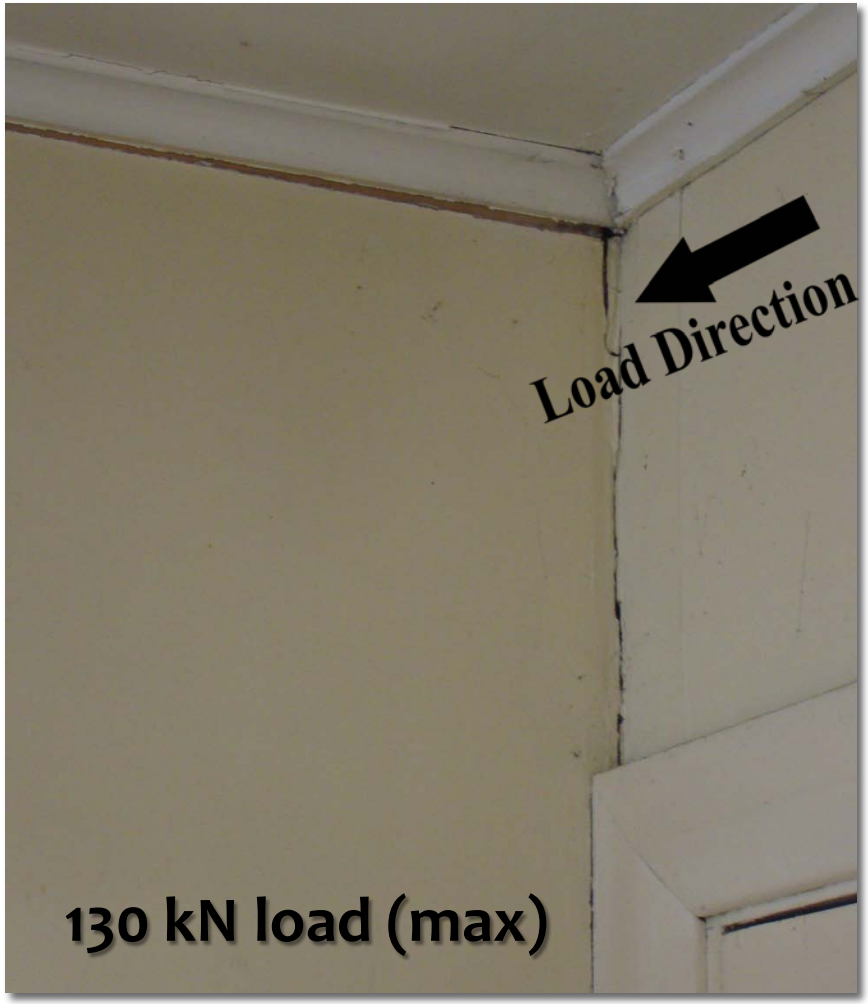
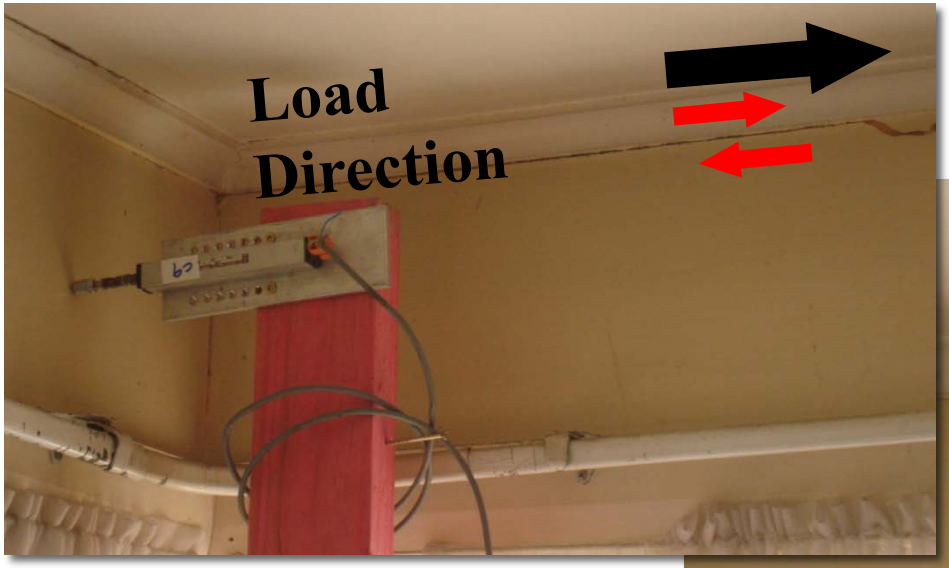
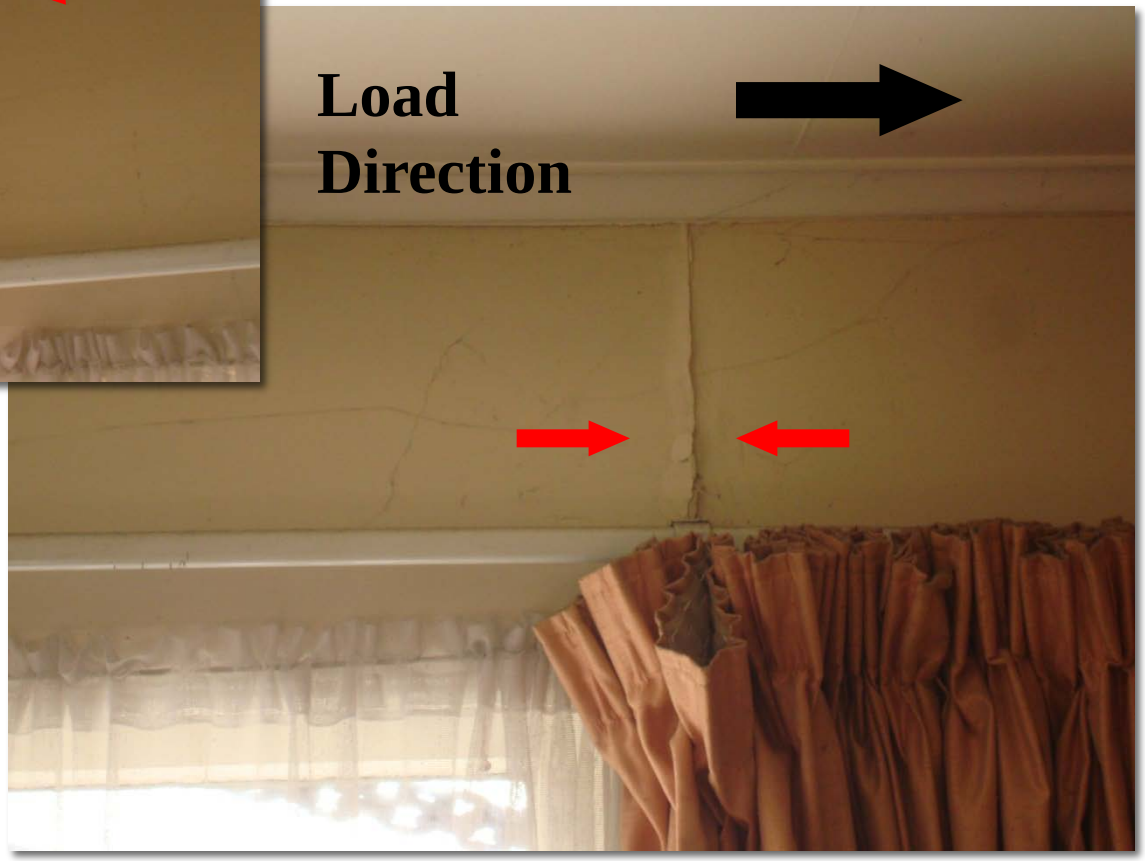


Results – Damage observed





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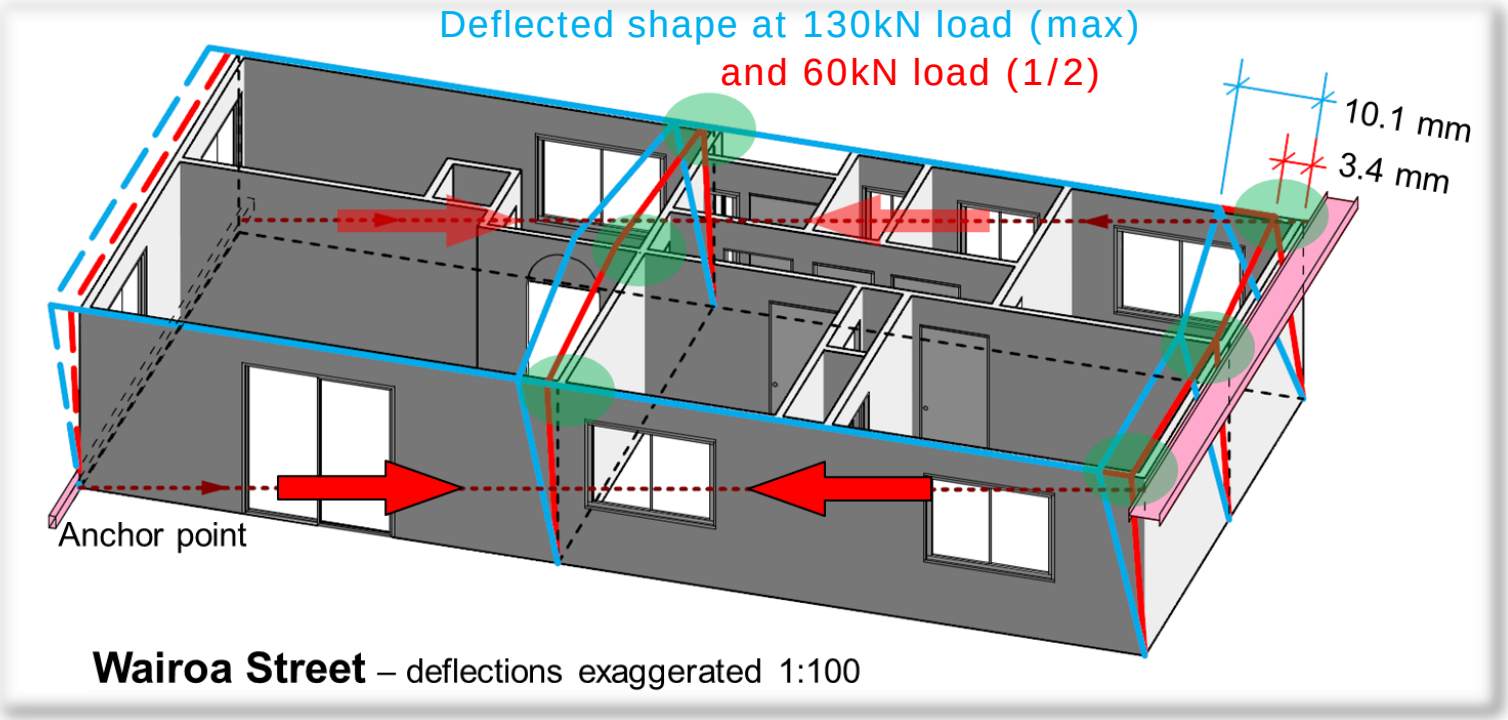
Results – Deflections

Expected: 30-50mm under 100kN load

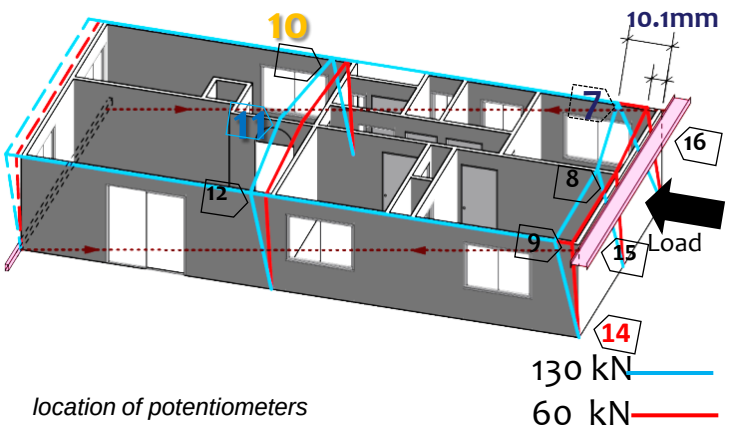
Observed: 3-12mm local under 130kN load
(6mm average at ceiling level)



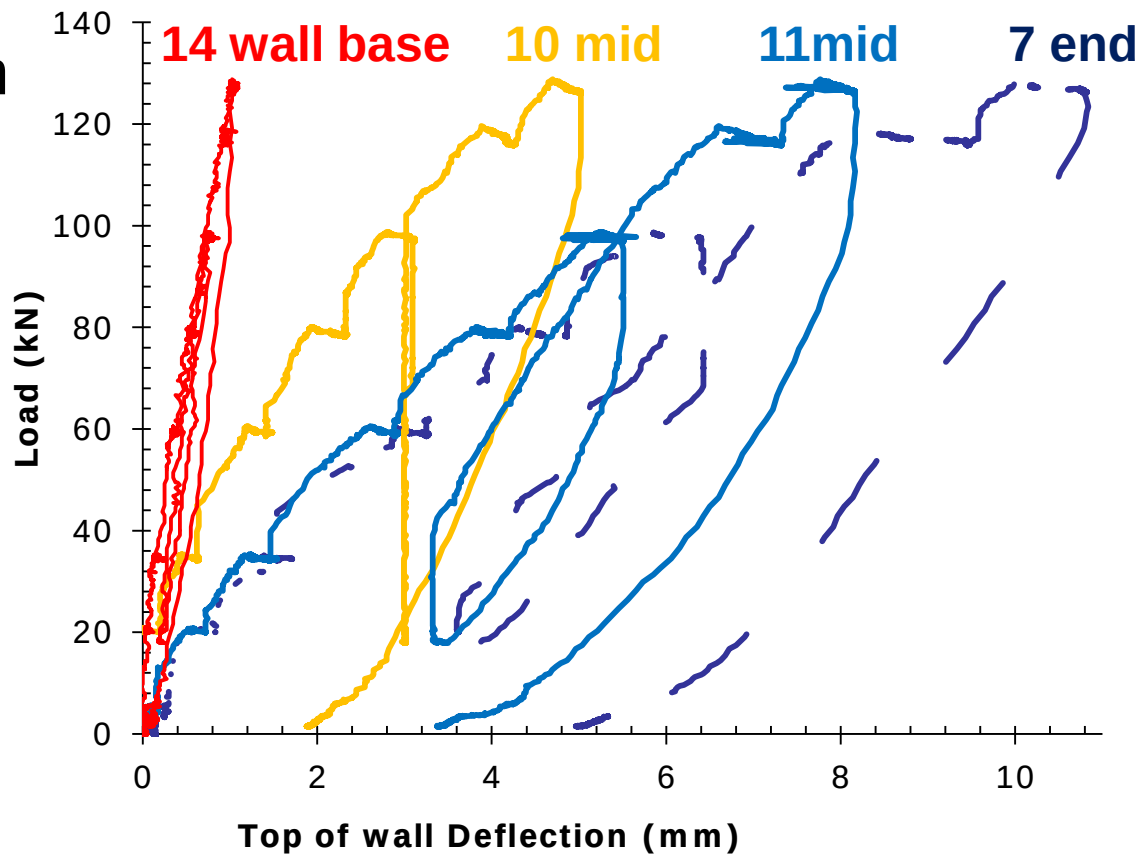
Results – individual gauges

- Deflection variation along building Wairoa St

Deflections at Wairoa St (exaggerated 100:1)



location of potentiometers



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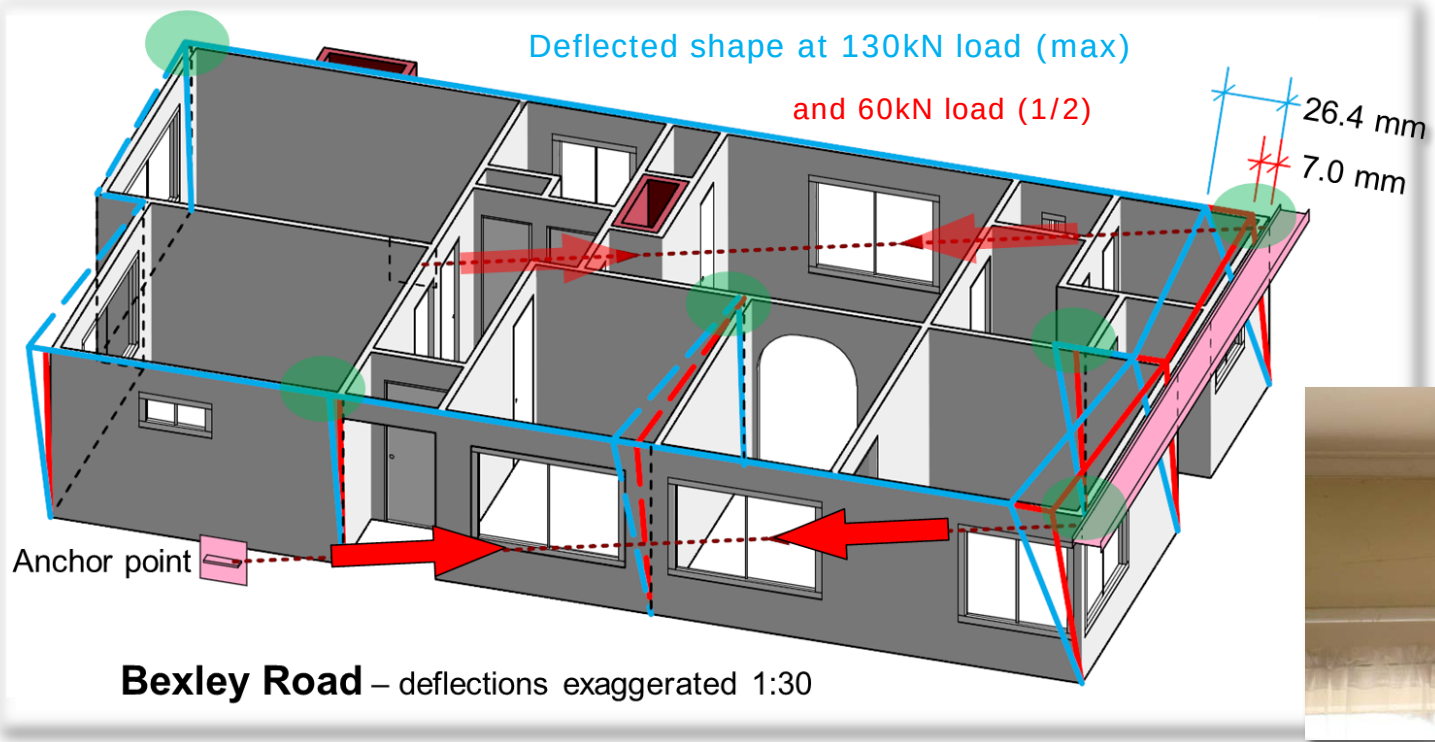
Results – Deflections

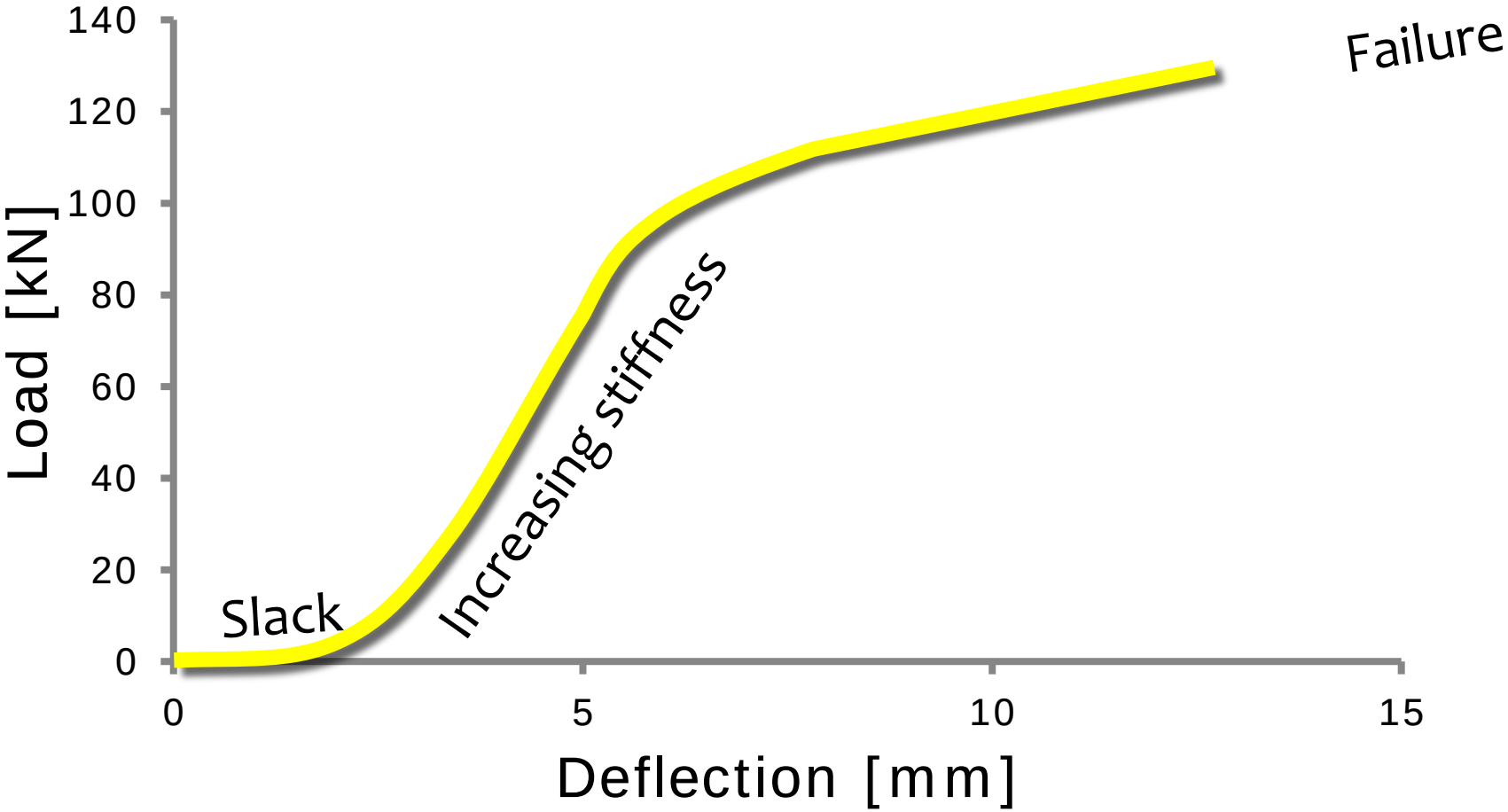
Expected: 30-50mm under 100kN load

Observed: 2-30mm local under 130kN load
(15mm average at ceiling level)



Results - Stiffness

Predicted: Variations in stiffness



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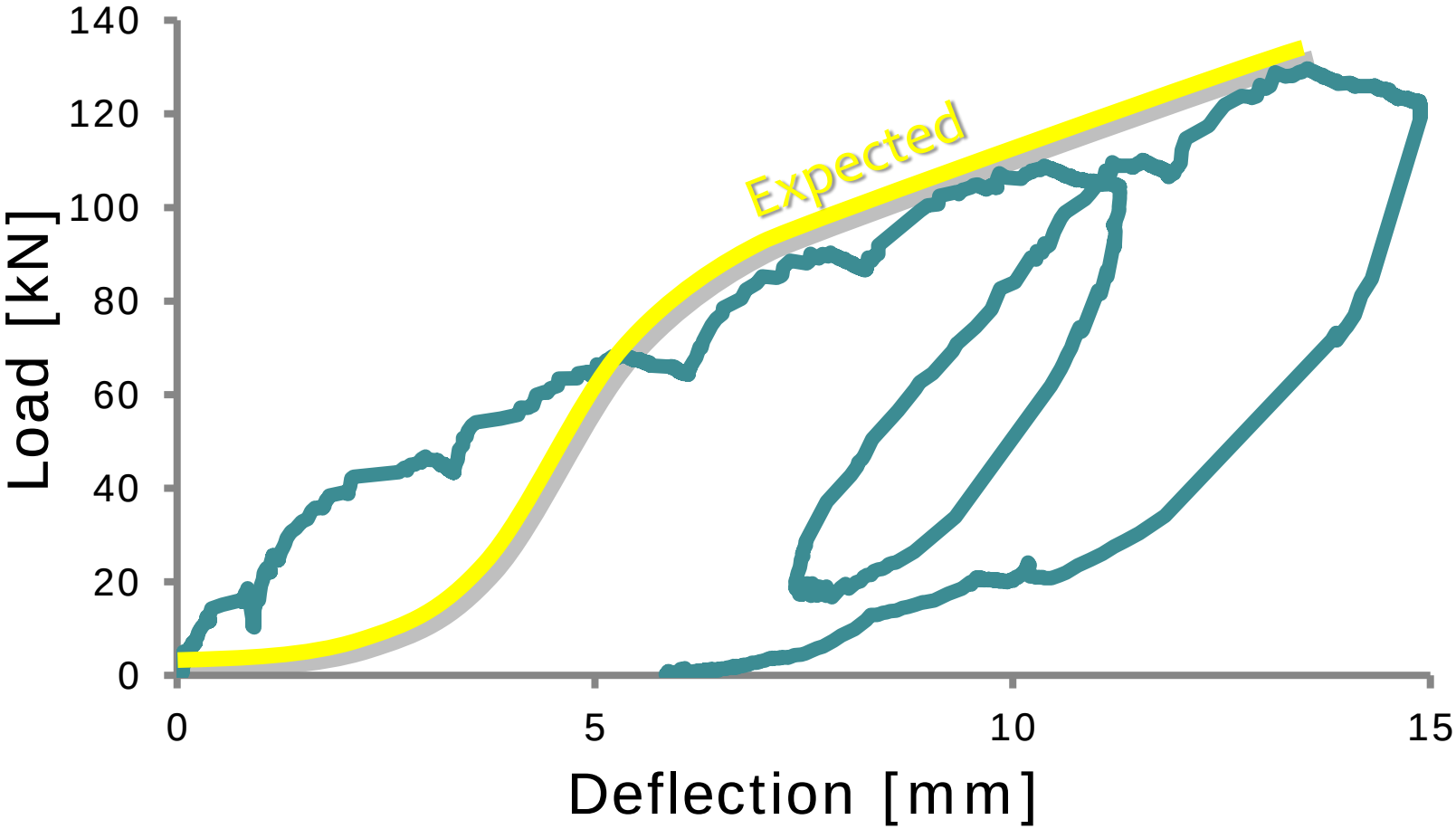
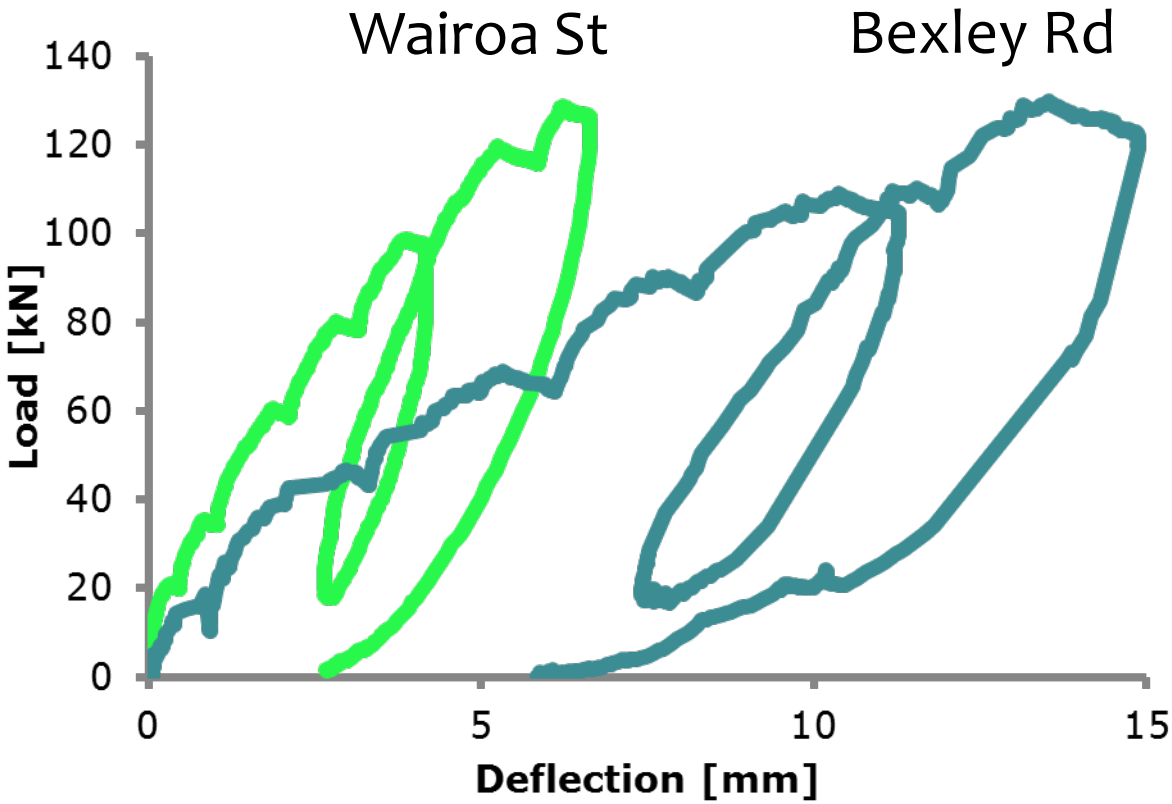
Results - Stiffness

Observed: consistent pattern, <u>different</u> to expected

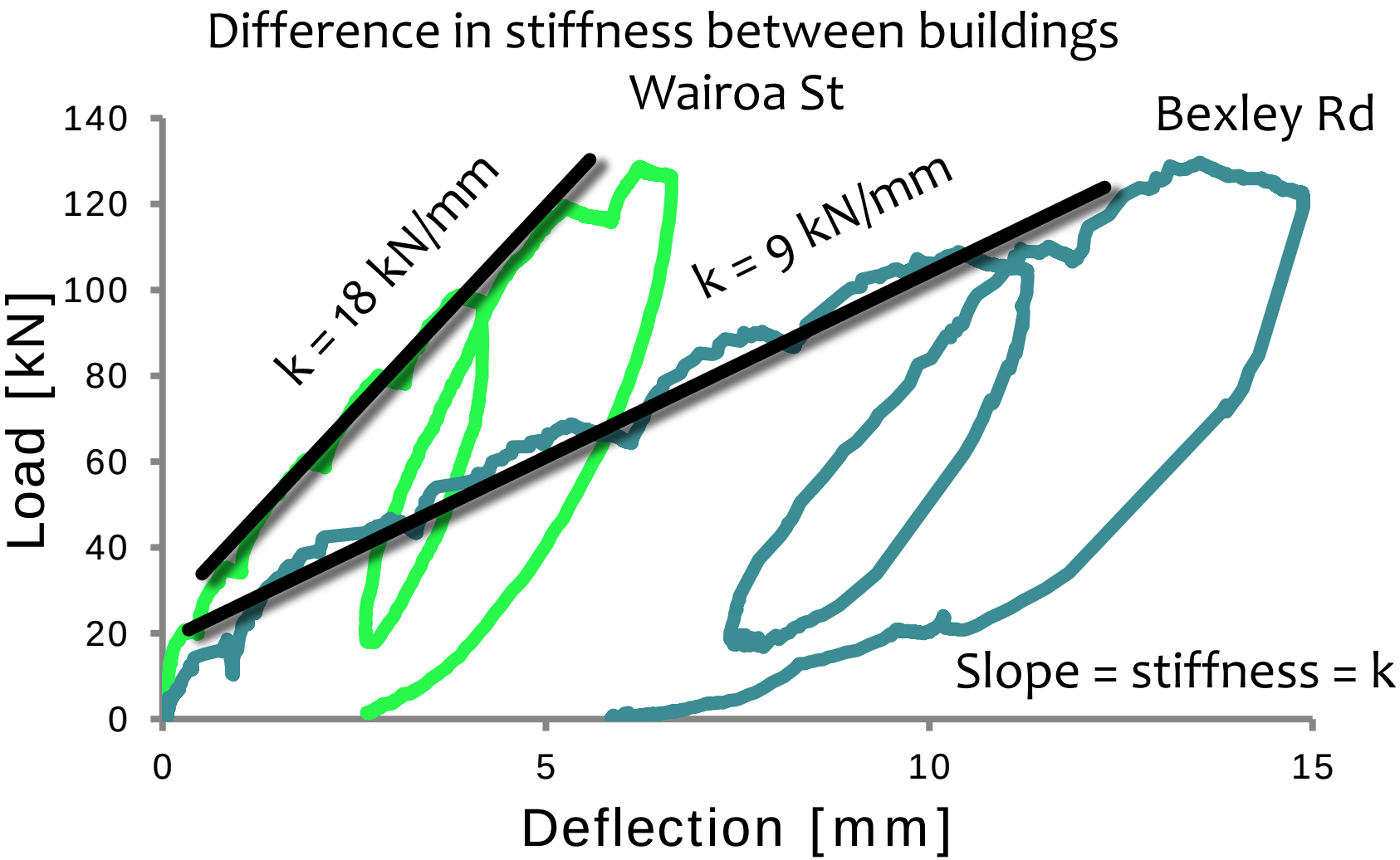


Results Stiffness

- Wairoa St
  - 1980,Pine
  - Gib-board
  - Steel brace?
- Bexley Rd
  - 1947, Rimu
  - Fibrous plaster
  - Wood brace?



Results - Stiffness



Discussion – Actual Earthquake Loads

Natural period and Pseudo-spectral acceleration

Wairoa St

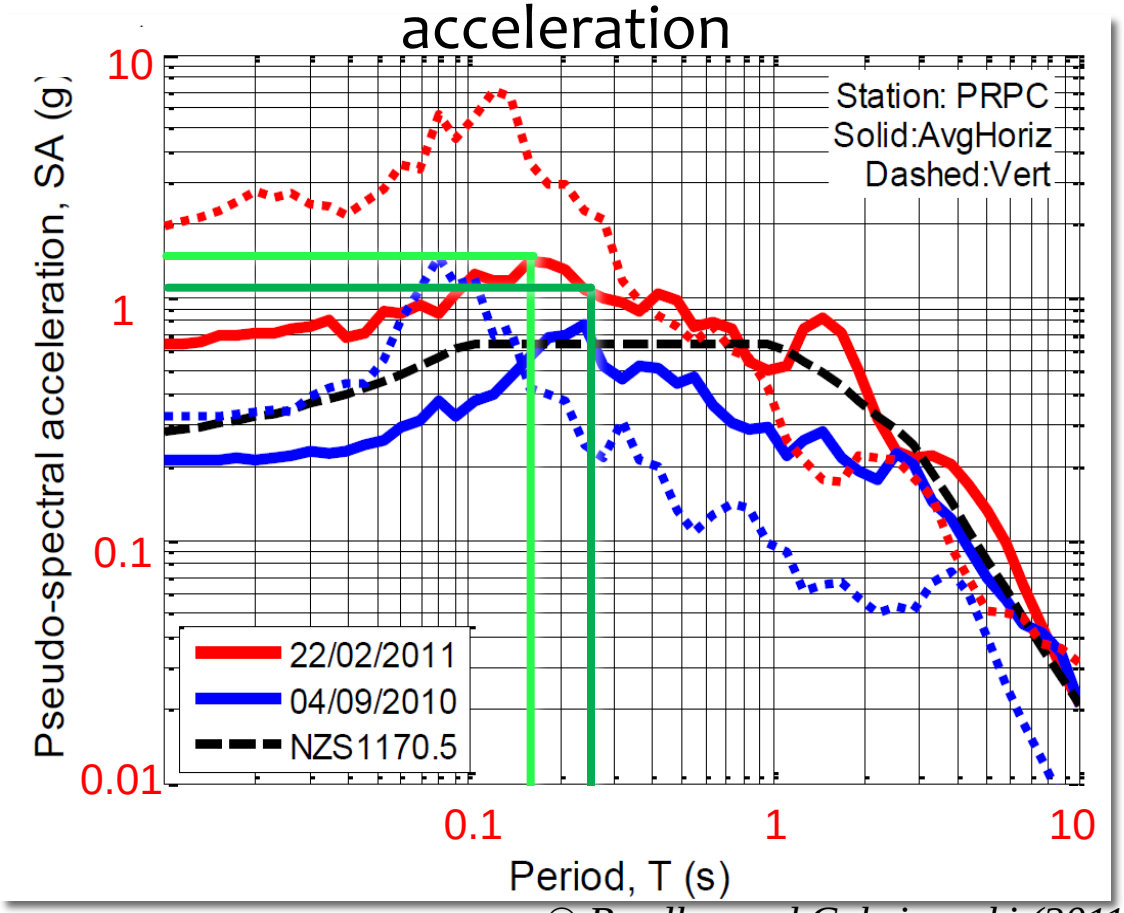
Period: 0.16 seconds (SDOF)

SA: 1.3g

Bexley Rd

Period: 0.26 seconds

SA: 1.0g



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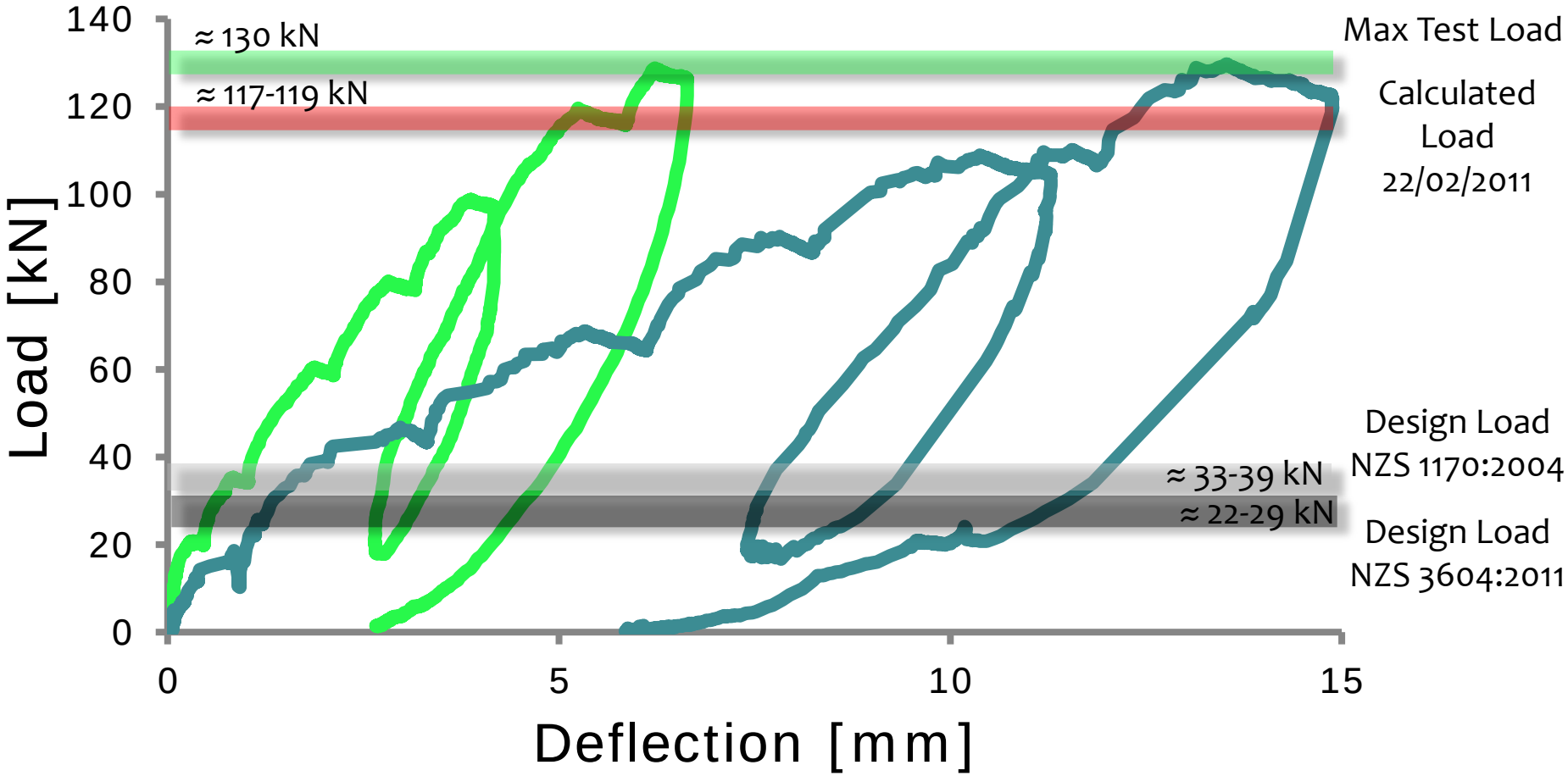
Discussion – Loading Comparison

Design Loads – Actual Earthquake Loads – Test Loads



Conclusions

- No indication of earthquake softening
- Large amount of residual strength, rigidity and resilience in damaged houses
- Test rig performed well and applied loads comparable with design standards and 2011 earthquakes

Future:

Remove linings after initial test, try different repairs

Use higher stiffness load system

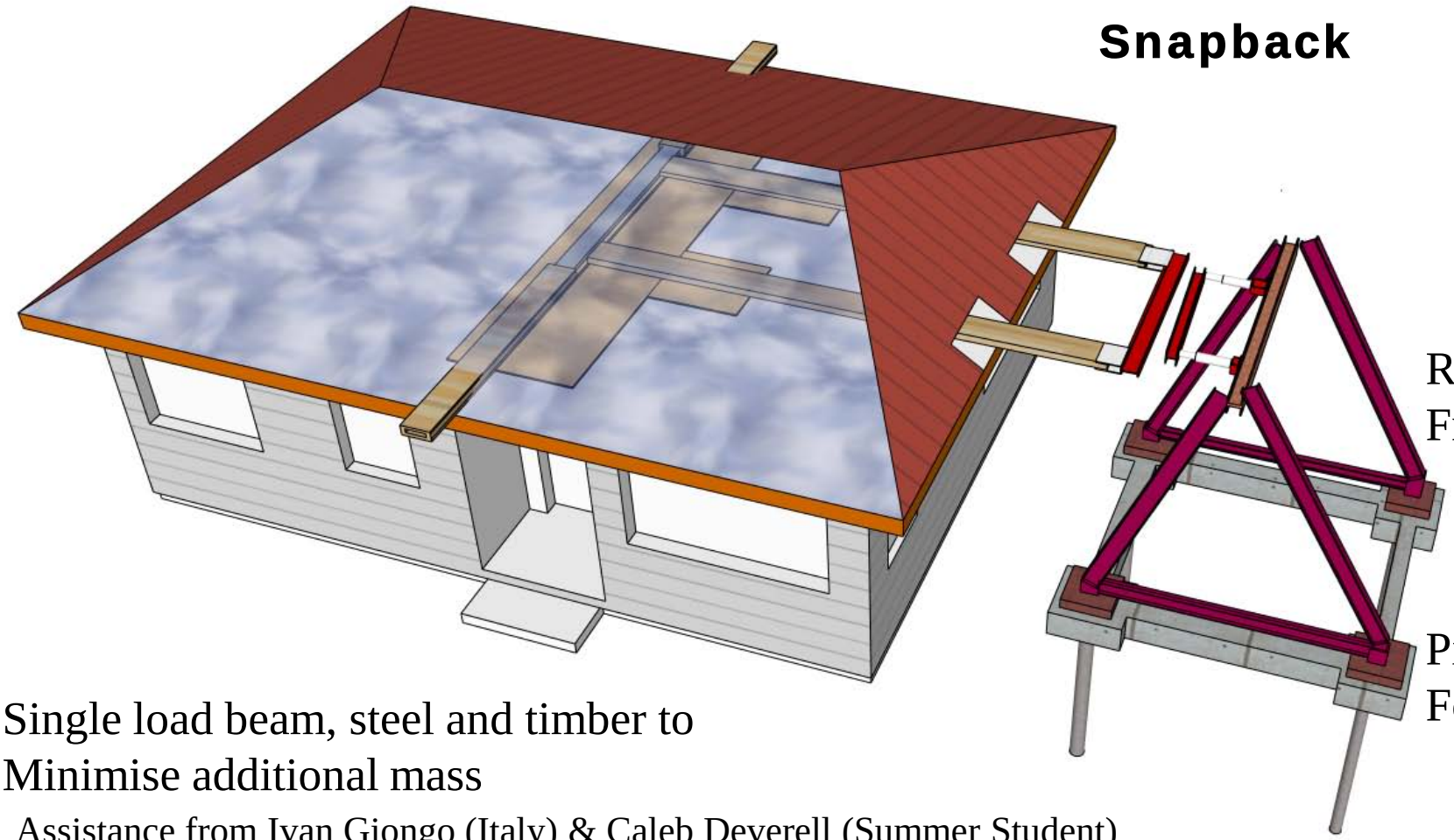
Pseudo static cyclic loads and dynamic snap back

Proposed Tests

Low loads - stiffness

Cyclic Quasi- static loads

Snapback



Single load beam, steel and timber to Minimise additional mass

Assistance from Ivan Giongo (Italy) & Caleb Deverell (Summer Student)

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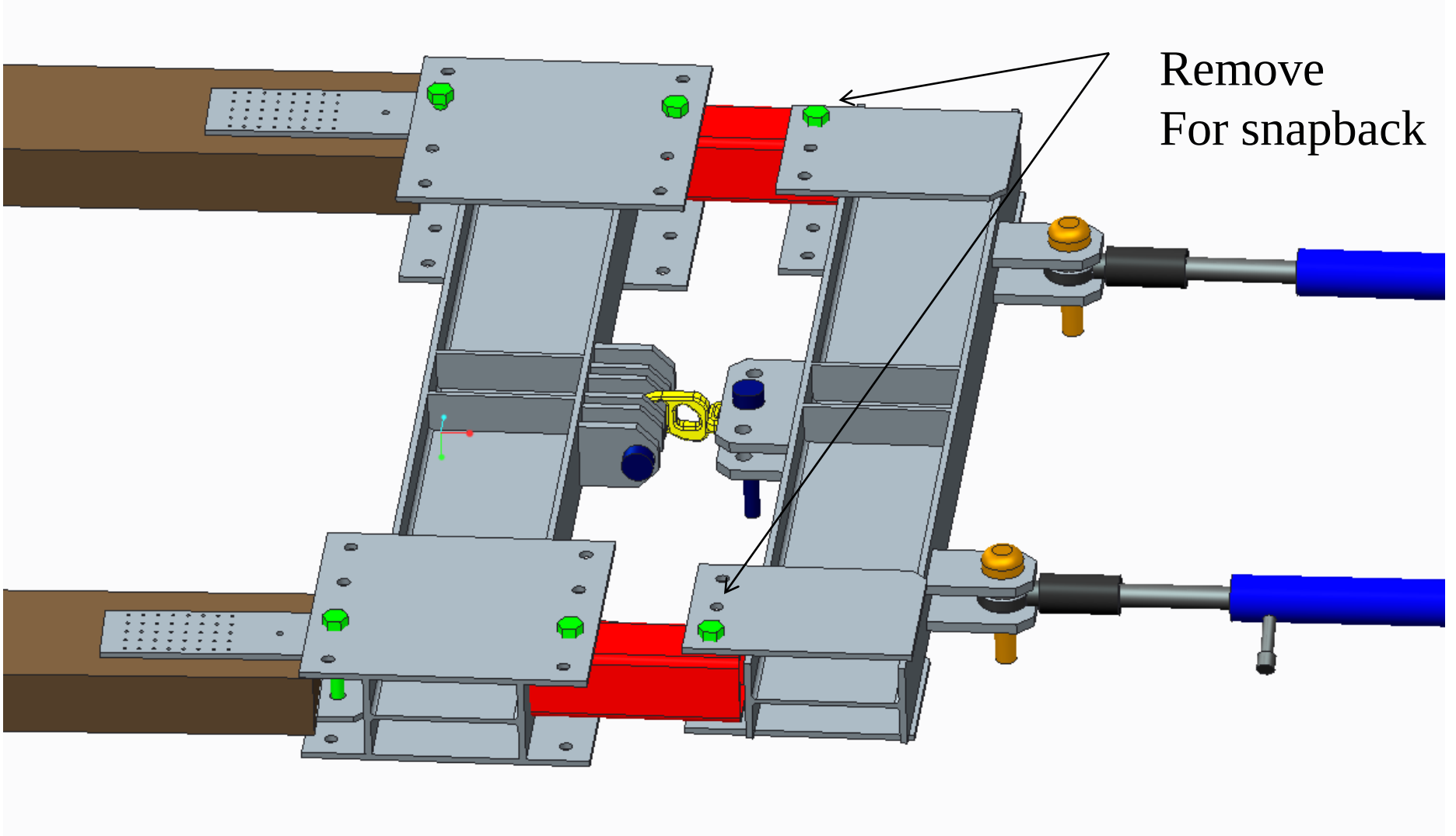
Proposed Load System



Acknowledgments

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