Performance of Retrofitted Singly Reinforced Concrete Walls Under Simulated Seismic Loading

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EQC
EARTHQUAKE COMMISSION
KŌMIHANA RŪWHENUA

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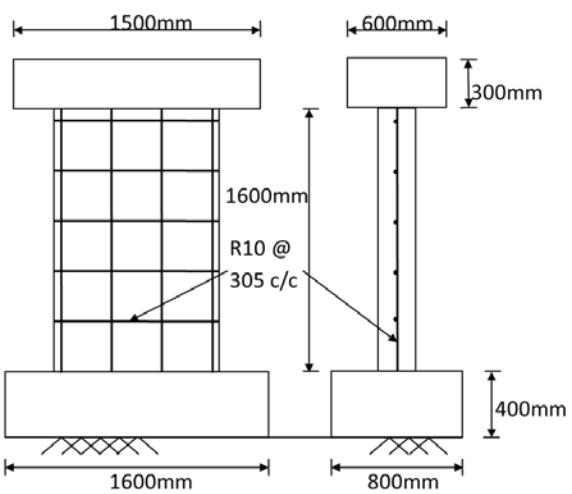
Background

- The Hope Gibbons Building
  - Built in 1928 before EQ codes were introduced in New Zealand
  - Architectural and historical significance
  - Wall elements identified as a critical structural deficiency

Background

- Gebreyohaness tested and modelled the behaviour of representative wall elements:
  - Degradation of flexural strength at low level drift cycles
  - Poor ductility due to lack of sufficient longitudinal reinforcement
  - Insufficient confinement reinforcement causing severe damage at the toe of the specimens

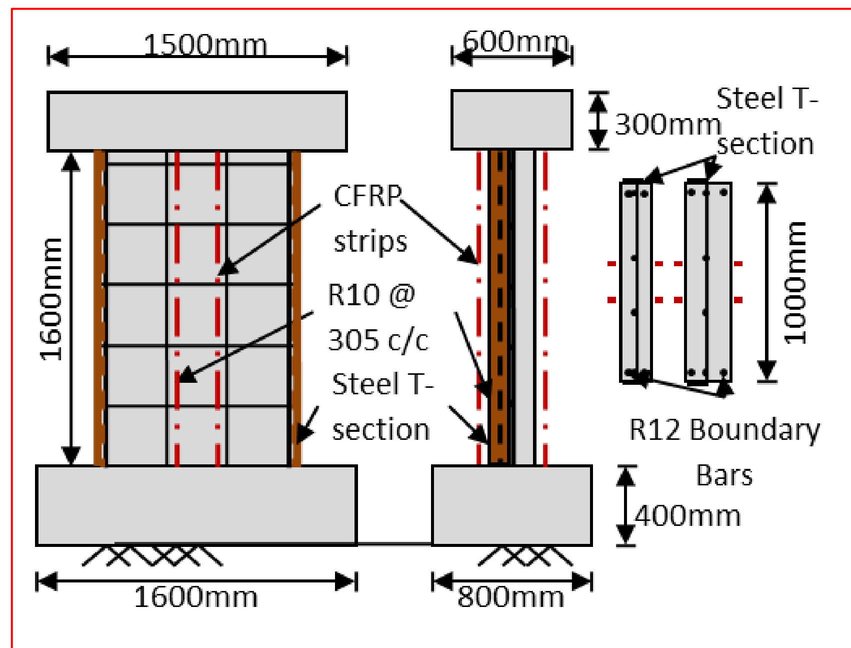


Objective

- To design, build and test two retrofit solutions that maintain the flexural strength of the wall specimens through drift cycles up to 5%
- The solutions were to be light weight and not significantly increase the flexural strength of the walls, suppressing additional demands on the building's foundations
- The solutions must be able to be implemented from the inside of the building
- The solutions must preserve the historic architectural appearance of the building

Retrofit

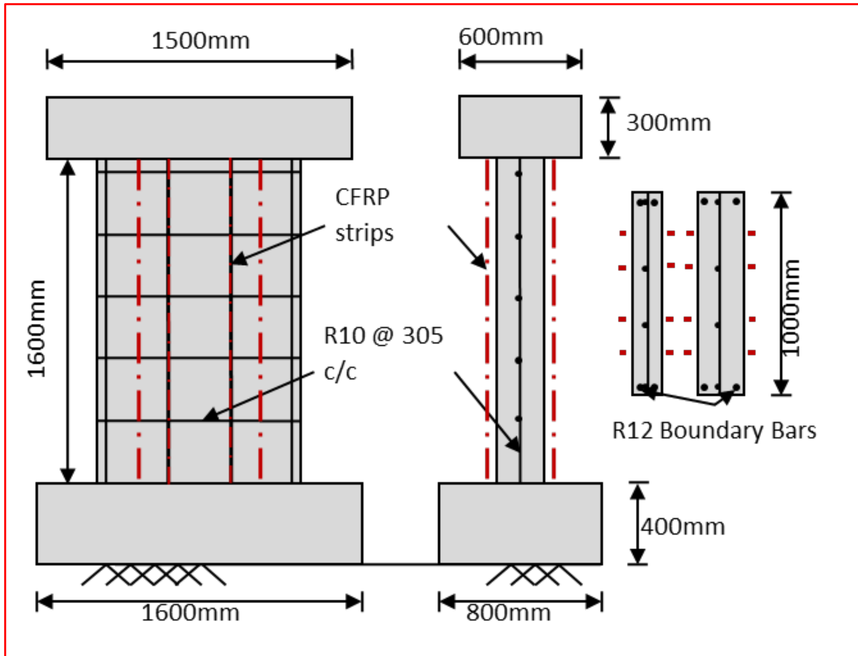
- SOLUTION 1- Steel T-section and CFRP strips
  - Isolated steel T-section:
    - » Provides high ratio compression reinforcement
    - » Do not provide tension reinforcement
  - 4 CFRP strips, external tension reinforcement
    Un-bonded wall height:
    - » High strains,
      elongations and displacements



Retrofit

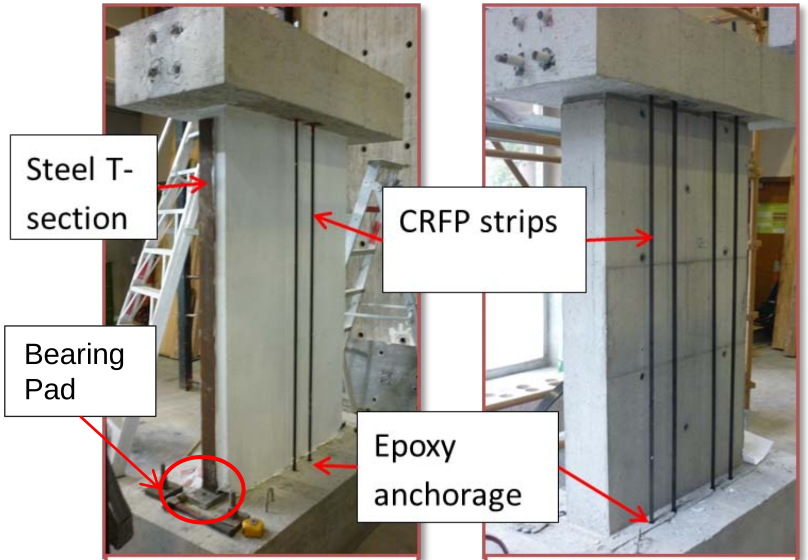
- SOLUTION 2: CFRP strips
  - » 8 CFRP strips, external tension reinforcement Un-bonded wall height:
    - » Provides high ratio tension reinforcement
    - » Achieves high strains,

      elongations and displacements



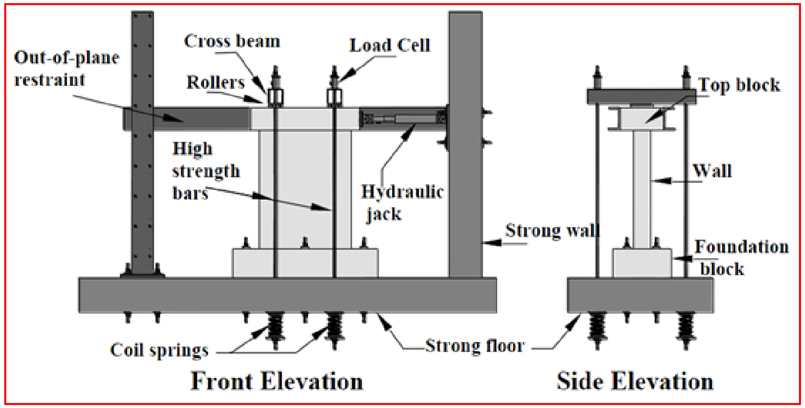
Methodology and Testing

Retrofitted Specimens		
Specimen	Thickness (mm)	Retrofit
RWS1	150	Solution 1
RWS2	230	Solution 1
RWS3	150	Solution 2
RWS4	230	Solution 2

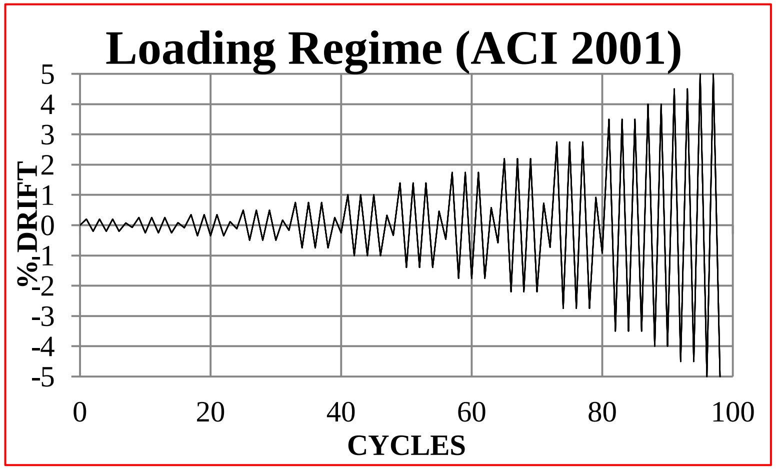


Solution 1: Retrofitted Wall Specimen 1 (RWS1)

Solution 2: Retrofitted Wall Specimen 4 (RWS4)



Test Setup

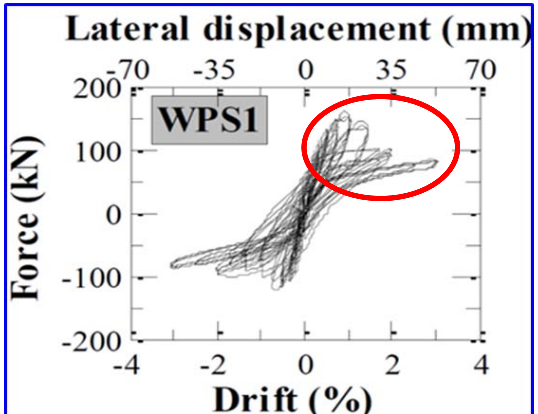


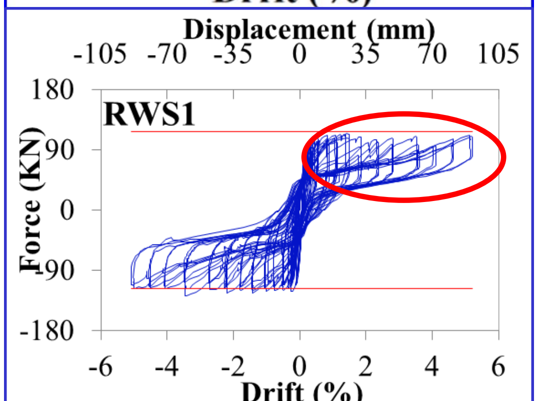
Testing

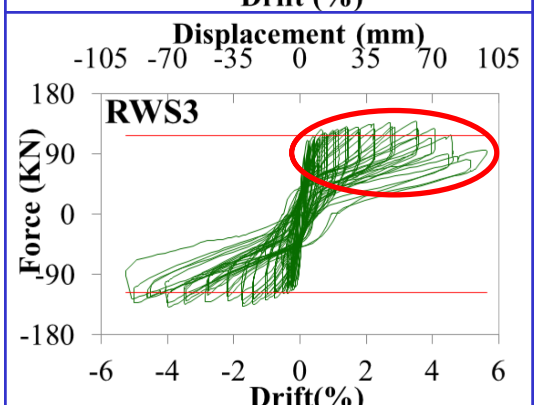
150mm specimens

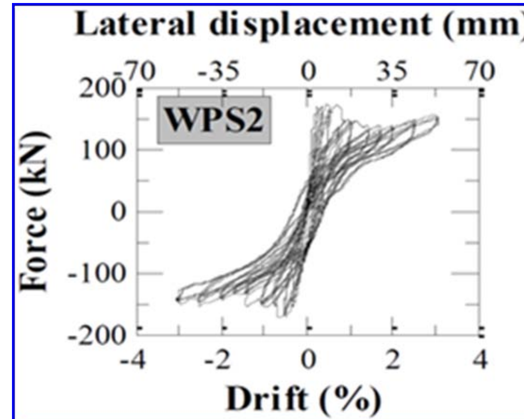
230mm specimens

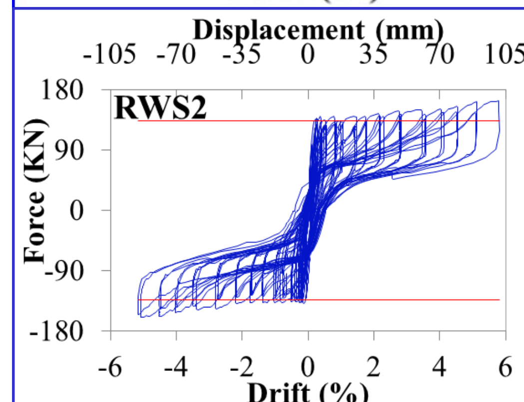
- Greater energy dissipation in the retrofitted specimens
- Highest degradation observed in 150mm specimens

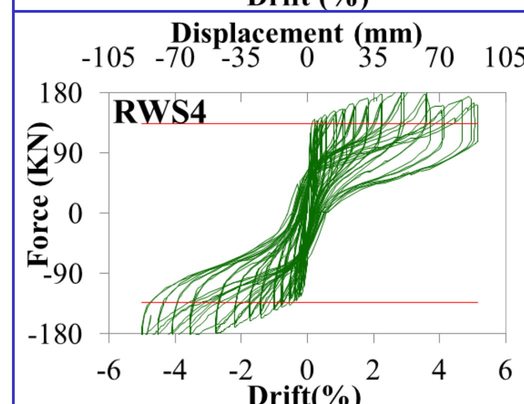




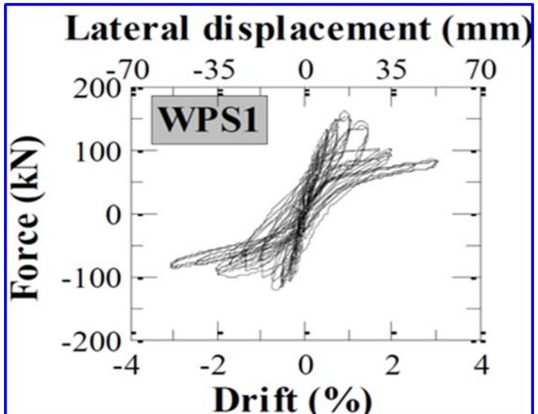


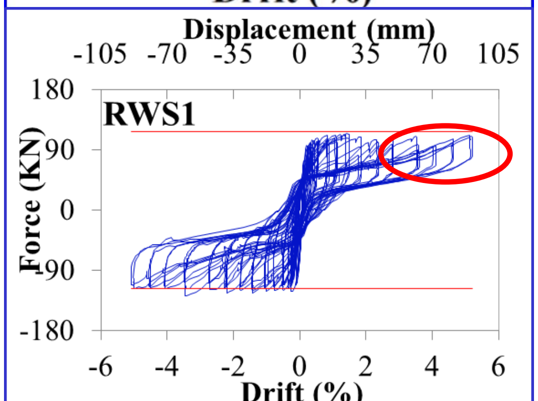


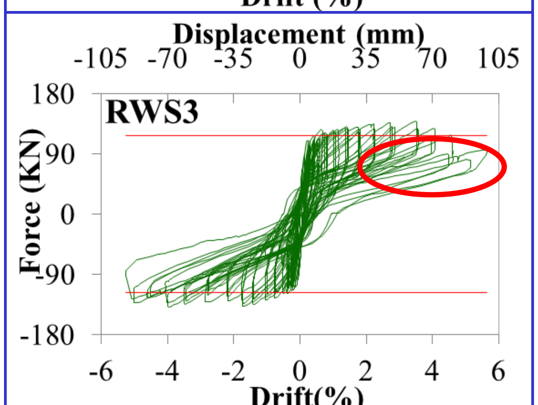




150mm specimens

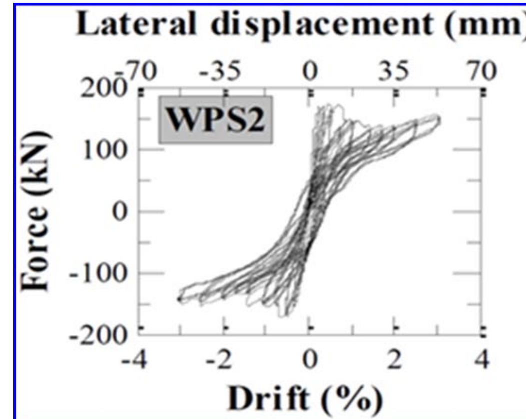


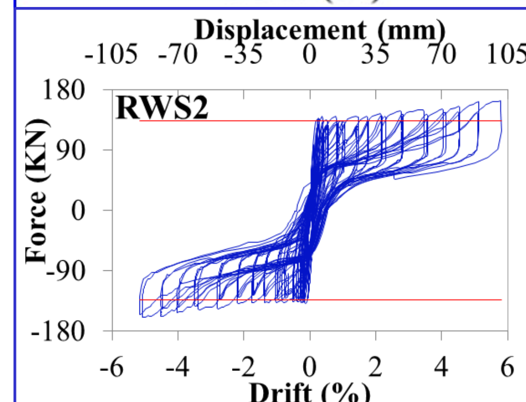


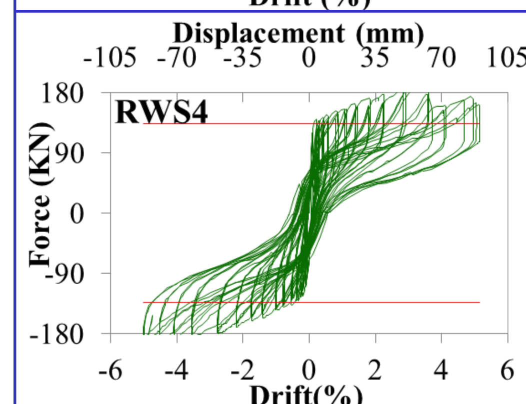


- Greater energy dissipation in the retrofitted specimens
- Highest degradation observed in 150mm specimens

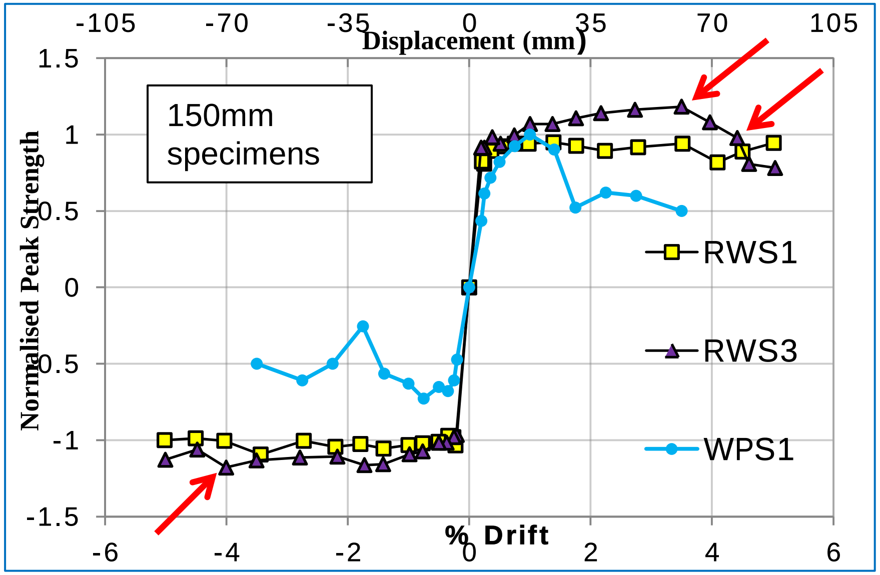
230mm specimens

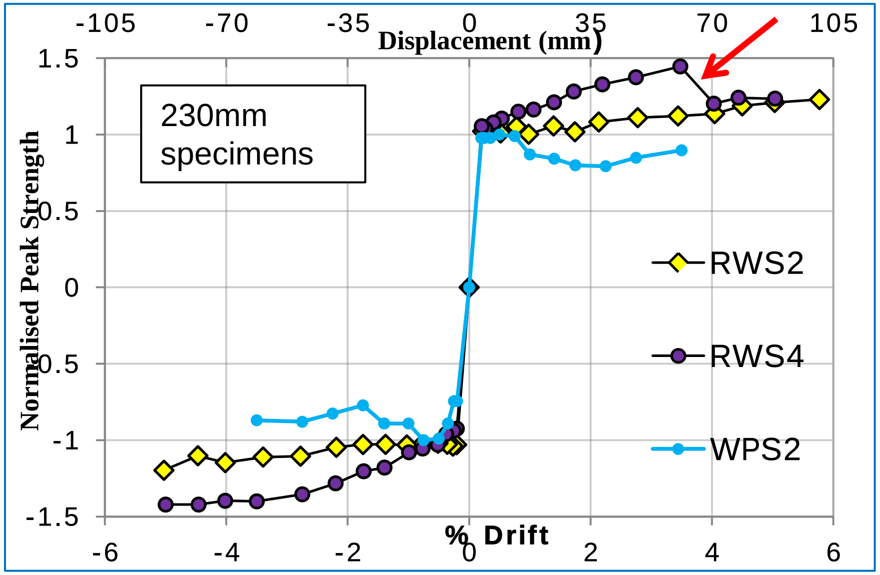






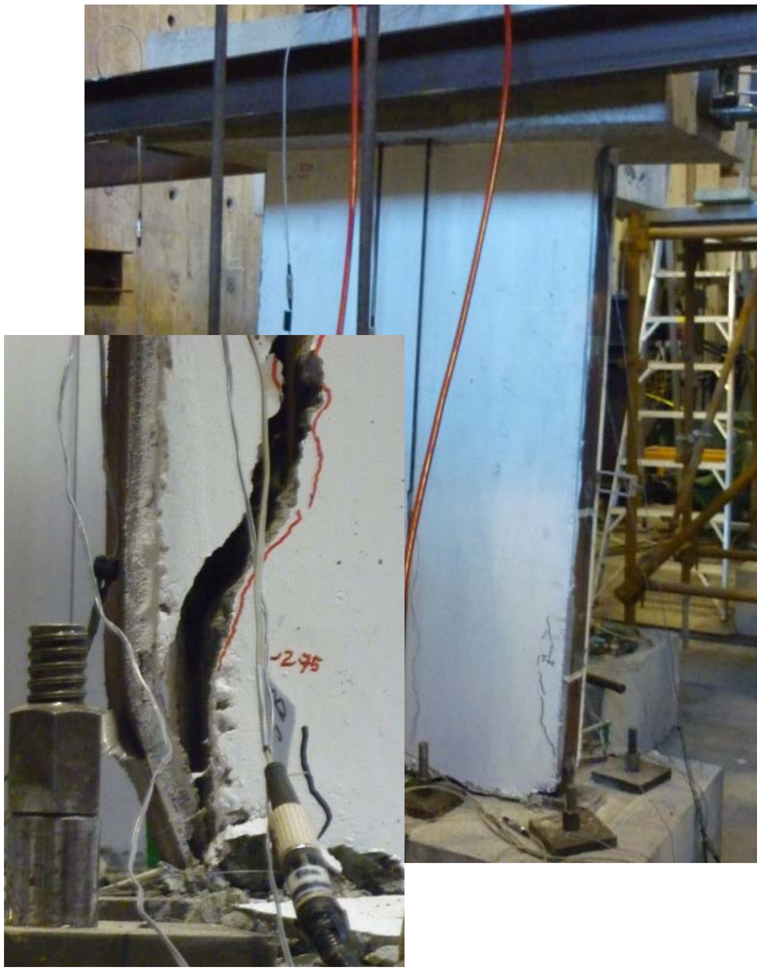
Results

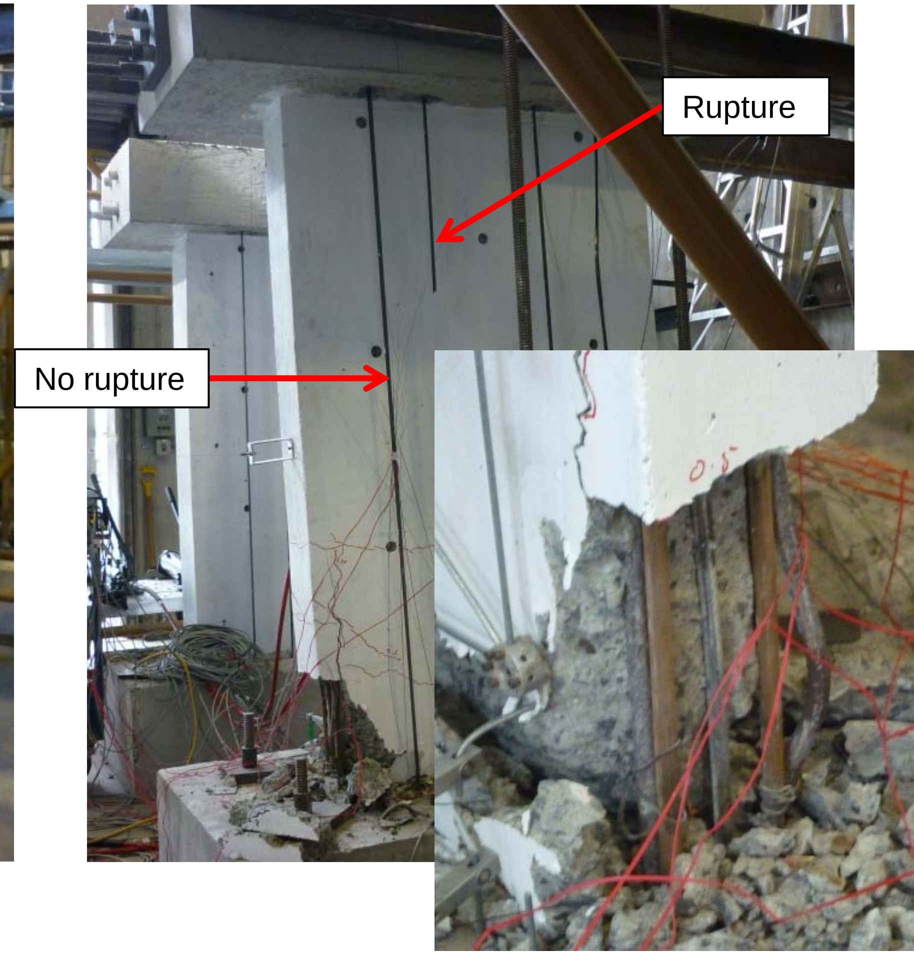




- All specimens maintained within 15% of peak strength to 5% drift
- Solution 1 specimens demonstrated a strength plateau
- Solution 2 specimens continued to gain strength before CFRP rupture
- CFRP rupture accompanied by sudden loss of strength

RWS1 and RWS3





Conclusions

- Both solutions maintained within 15% of peak strengths to drifts of 5%
- Different levels of energy dissipation in solution 1 and solution 2, but both greater than un-retrofitted
- Greater protection from flexural and shear deformation was observed in Solution 1 specimens due to steel T-sections
- CFRP rupture lead a to sudden degradation in strength and point of rupture was difficult to predict.

Significance

- Strength in it’s simplicity- relatively low cost and easy to implement into the Hope Gibbons Building (one side of building)
- Does not need to change architectural appearance of the Hope Gibbons Building
- CFRP anchorage lengths were minimum recommendations yet performed well.
- Isolated steel T-section and CFRP detailing has never used in this way before.

Recommendations

- Further investigation:
  - How rupture occurs in un-bonded CFRP strips
  - The in-elastic response of steel T-sections
- FEM of the failure mechanism of the retrofitted walls

Questions?