Lower-damage Walls

QuakeCoRE FP4 2017 project

Team

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NZ Centre for Earthquake Resilience

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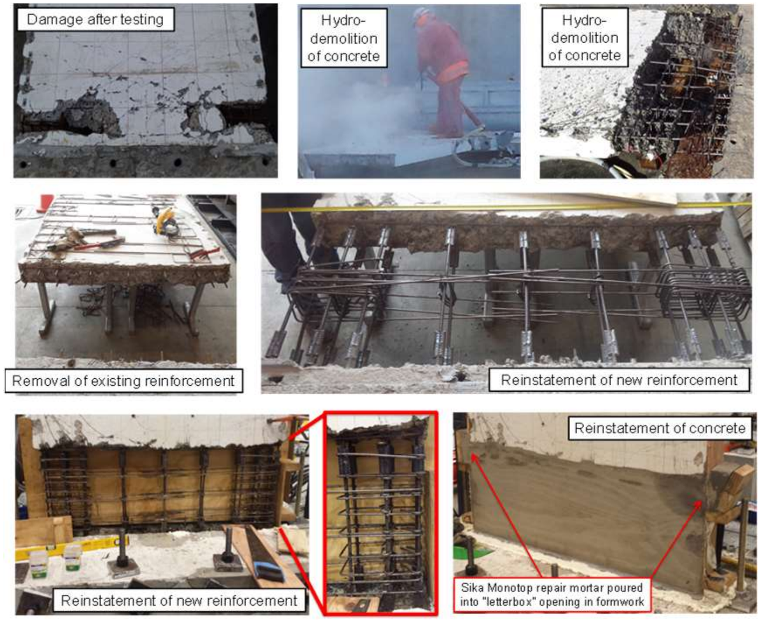
- Craig Stevenson (Aurecon)

Background

- Repair of conventional concrete walls possible but difficult [2016 QC project]

- Low-damage concrete walls mostly based on PT rocking systems

- Need a range of alternative solutions



Objectives

- Experimentally verify lower-damage modifications to conventional reinforced concrete walls
- Assess the reparability and residual capacity of the tested alternative wall solutions
- Verify existing numerical modelling techniques for the walls with lower-damage modifications

Progress

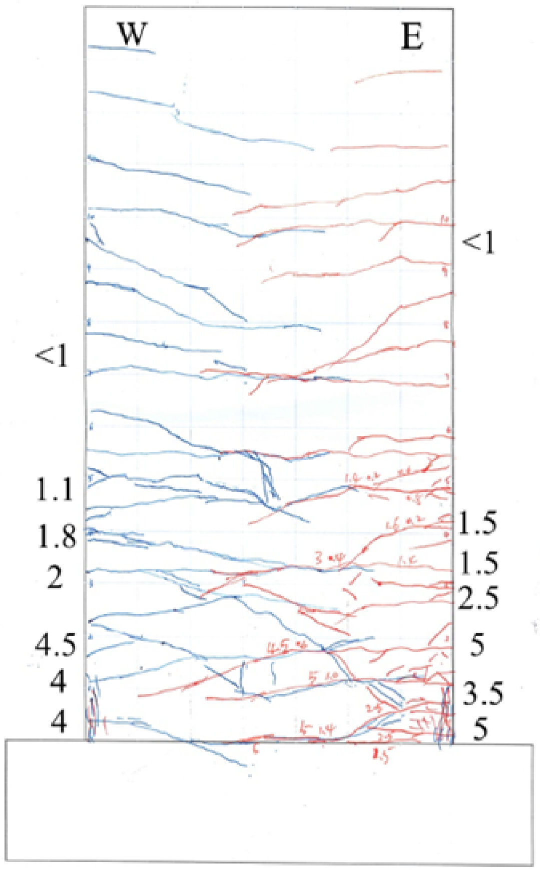
- Completed review of alternative low-damage techniques:
  - materials (ECC, SMA)
  - design (de-bonding, PT)

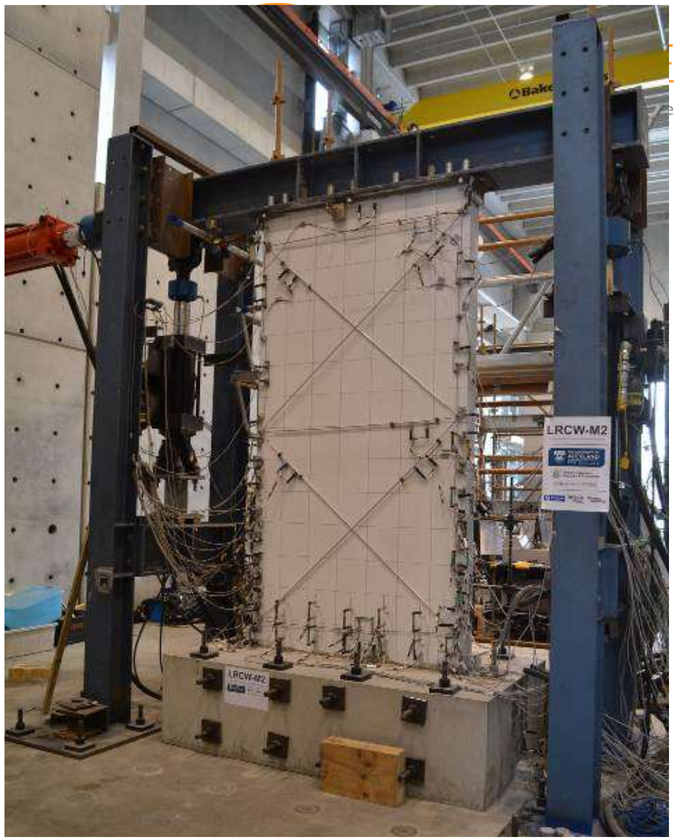
- Preliminary designs presented to industry group

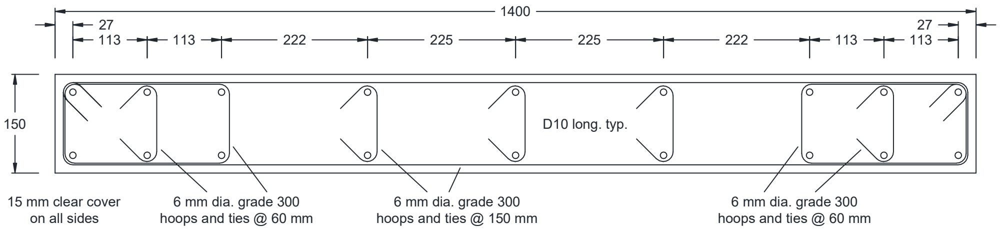
- Revised test plan and starting construction

Baseline Walls

- M5 (Lu et al.)
- NZS 3101:2006 – Amendment 3







Originally Proposed Tests

Modifications

Test #1: Crack initiators w/ low axial load

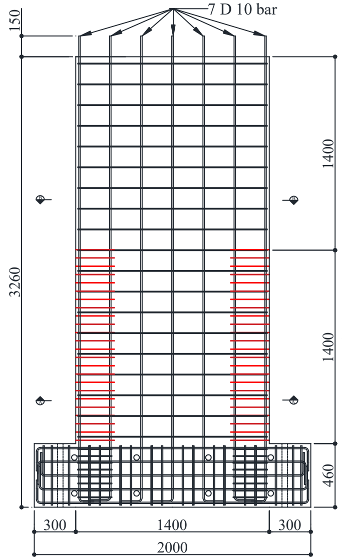
Test #2: Debonded steel w/ low axial load

New solutions

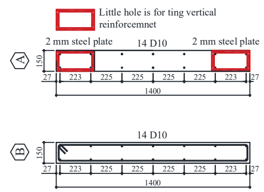
Test #3: Debonded steel + ECC w/ low axial load

Test #4: Debonded steel + ECC w/ high axial load

Test #5: Debonded steel + ECC + UBPT w/ low axial load



Wall C1-Crack initiator-1



Revised Proposed Tests

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Modifications

Test #1: Fiber reinforced concrete

Test #2: Debonded steel w/ low axial load

New solutions

Test #3: Debonded steel + ECC w/ low axial load

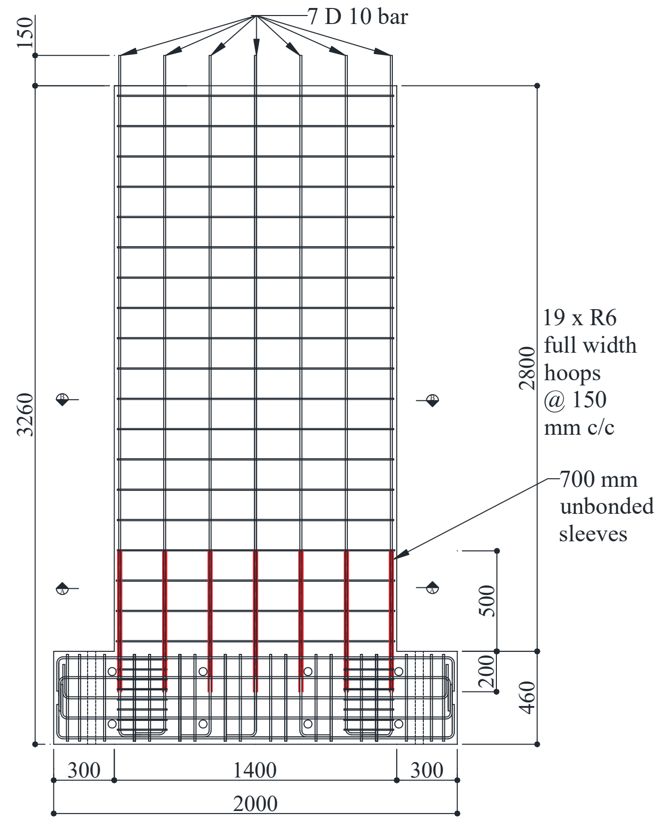
Test #4: Debonded steel + ECC w/ high axial load

Test #2: Debonding

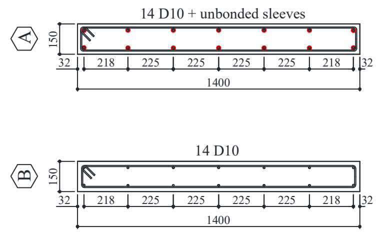
- Allow single crack
- Reduced reinforcement strains

- Method:
  - Debonded bar within sleeve to prevent buckling
  - Crack initiator at debonded location?
  - Armouring?

- Variables:
  - Length (keep strains to certain limit)
  - Location (within wall or foundation?)



Wall C1-Debonding

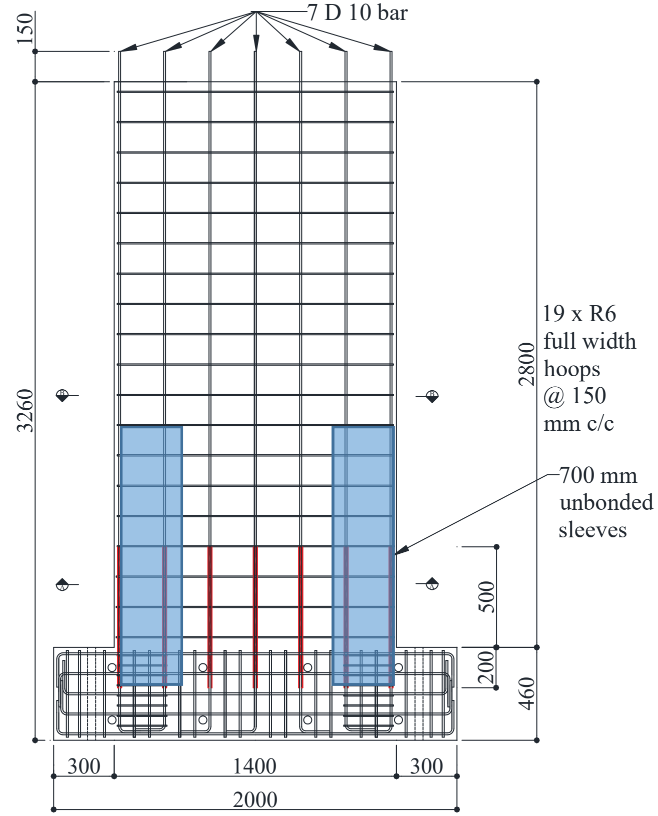


Test #3: Debonding + ECC

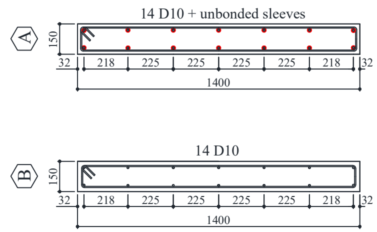
- Highly distributed microcracking
- Increased tensile ductility
- Reduced spalling

- Method:
  - Replace concrete with ECC in plastic hinge region
  - Debonded bar within sleeve to prevent buckling (identical to Test #2)

- Variables:
  - Location and quantity of ECC
  - Construction methodology



Wall C1-Debonding



Test #4: Debonding + ECC + High Axial Load

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- Verify ECC performance with higher compression demand

- Method:
  - Specimen identical to Test #3
  - Increase axial load
  - Retain existing confinement (less than code)

Schedule

Task	Description
January - February 2017 **Literature review**	Collate general information on past experimental testing of lower-damage wall solutions (inc. relevant solutions for bridge piers). Coordinate with TP1 and TP3 for input into relevant databases.
February - March 2017 **Selection of lower-damage modification options**	Evaluate solutions developed during 2016 QuakeCoRE wall repair project and alternatives from NZ and international research. Select test designs that cover a range of objectives and complexity. Consultation with industry partners throughout this task.
April - May 2017 **Wall design and construction**	Design and build test walls. Use past test walls and FP4 case study buildings were possible, including the test building for ILEE shake-table test.
June-October 2017 **Wall testing**	Experimental testing of the three concrete walls incorporating lower-damage modifications; two lower-damage modifications to conventional lightly reinforced concrete walls, and one innovative wall design to mitigate plastic hinge damage. Repair and retest walls (if the damage condition allows).
August - October 2017 **Verification and refinement of numerical models**	Compare experimental results to existing numerical models and update models as required to capture response.
October - November 2017 **Case-study building analysis and fragility estimates**	Evaluate each solution using the common FP4 case-study buildings. Provide initial estimates of fragility curves for use in FP4 loss-assessment projects.
November-December 2017 **Analysis and reporting**	Analyse test and simulation results and prepare a paper to summarise.

Milestones

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Milestone	End Date	Related objective
Two modified lightly reinforced concrete walls tested	31st October, 2017	Testing of lower-damage wall designs
One innovative wall design tested	31st October, 2017	Testing of lower-damage wall designs
At least one test wall repaired and retested	31st October, 2017	Assessment of reparability and residual capacity
Comparison of test results to models and refinement of modelling techniques	31st October, 2017	Verify existing numerical modelling techniques
Preliminary estimates of fragility curves	31st December, 2017	Verify existing numerical modelling techniques
Submission of a journal article to a peer-reviewed journal	31st December, 2017	