Design of a large-scale test structure for whole-of-building seismic performance

Will Pollalis

Thematic focus of QuakeCoRE DT2:

Whole-of-building seismic performance

DT2 Research Objectives

- Assessment Methods
  - Faraz – Vulnerabilities, hazards, and casualty risk
- Implications of Design
  - Liam - Comparison of design philosophies
    - “Stiff” buildings (Japan, Chile)
    - “Flexible” buildings (USA, NZ)
  - Charles – Lap splice vulnerabilities

DT2 Research Objectives

- Interactions between structural components
  - Vinu, Soheil - Material Selection and detailing
  - Zhenduo, Anqi - Seismic Force Resisting System (SFRS, LLRS) selection
  - Ren-Jie - Member connections and interactions (Coupling beams)
  - Claire - Hybrid SFRS
- Diaphragm Assessment and design
  - Junrui - Strengthening and Retrofit
  - Soheil, Junrui - Diaphragm forces and performance

DT2 Research Objectives

- Representative testing of Non-Structural Elements (NSEs)
  - Kieran - Story response vs Ground motion
  - Robert - Structural + Non-Structural Interaction
  - Robert, Liam - Non-Structural + Non-Structural Interaction
  - Liam - “Stiff” vs “Flexible” response

Thematic focus of QuakeCoRE DT2:

Whole-of-building seismic performance

Actionable translation:

Design and test a building where “Everything works”

Preliminary Idea

Test platform incorporating many DT2 objectives

International collaboration - NCREE

NCREE-QuakeCoRE shake-table tests of 7-storey specimen
Elwood et al.

Preliminary Idea

Steel Moment Frame (MRF) and Reinforced Concrete Core Wall (CW)

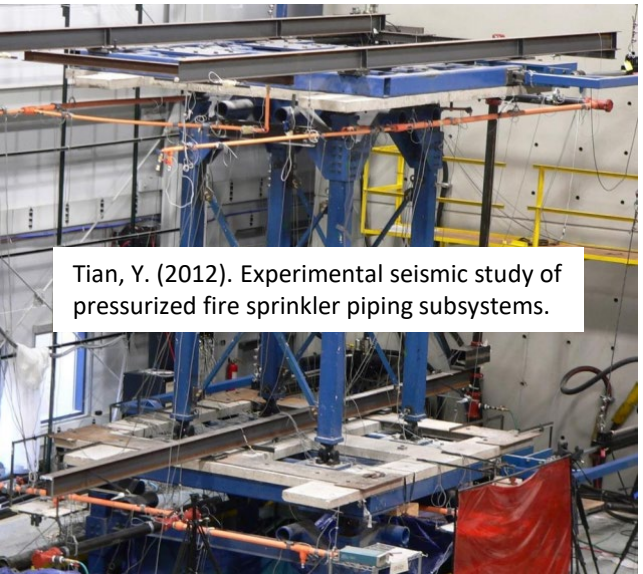
Removable “Link” Between MRF and CW

Non-Structural Elements on each floor

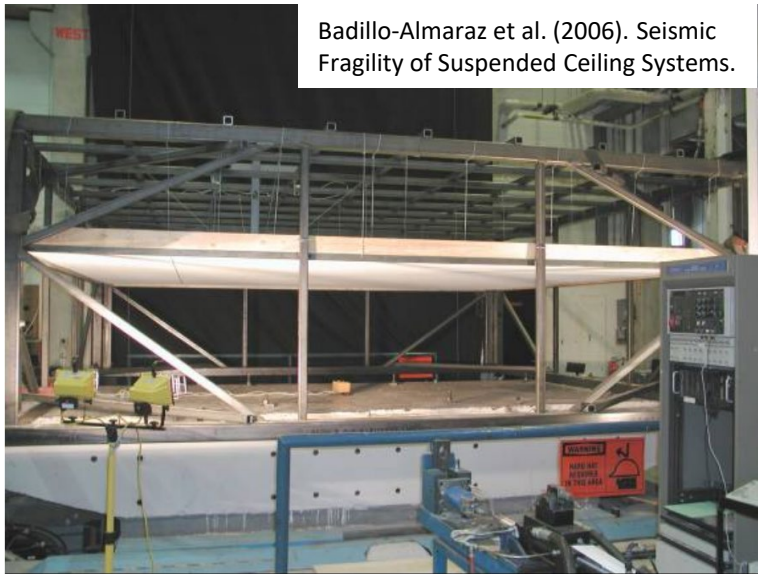
Preliminary Idea

Non-Structural Elements on each floor

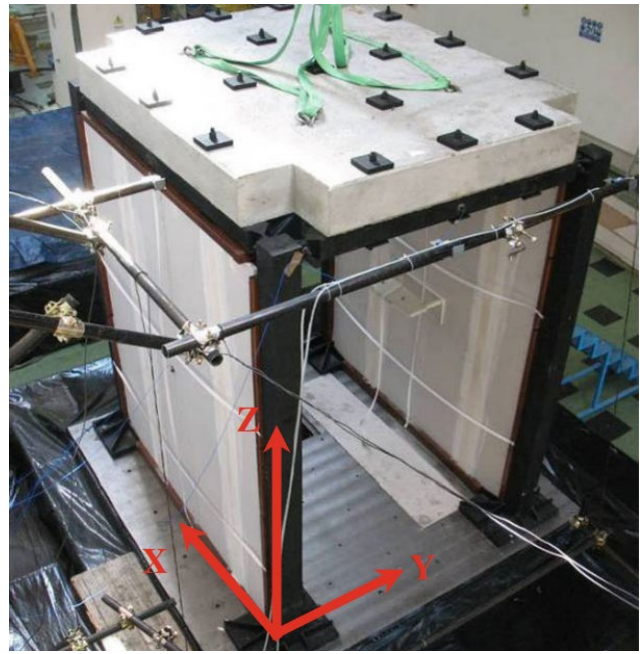
- Partitions
- Suspended ceilings
- Sprinkler systems



Tian, Y. (2012). Experimental seismic study of pressurized fire sprinkler piping subsystems.



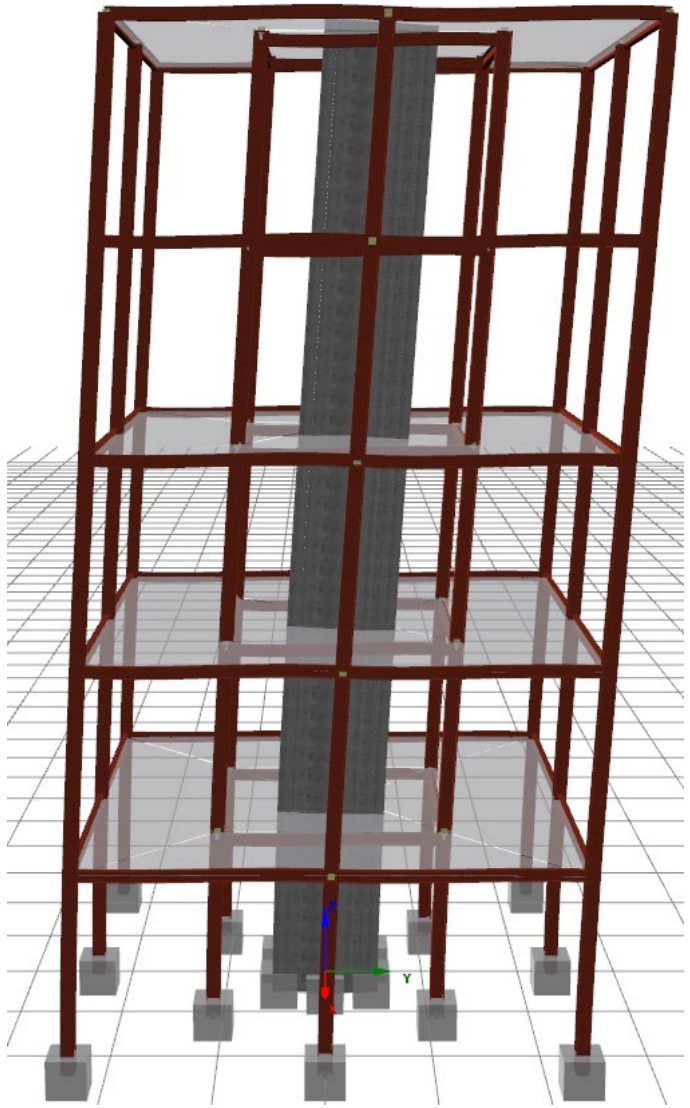
Badillo-Almaraz et al. (2006). Seismic Fragility of Suspended Ceiling Systems.



Magliulo, G et al. (2014). Seismic performance evaluation of plasterboard partitions via shake table tests. Bulletin of Earthquake Engineering, 12(4), 1657–1677.

Preliminary Idea

MRF + CW



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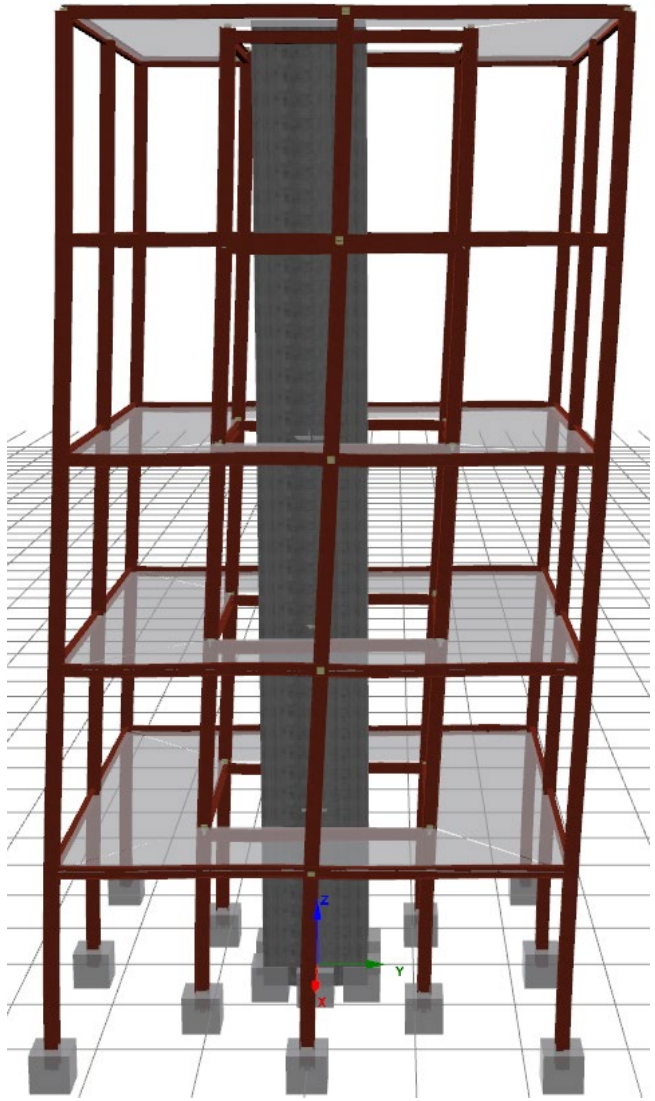

MRF

Preliminary Idea

Removable “Link” Between MRF and CW

- Quickly modify structural properties
- Measure diaphragm forces
- Potential for dissipative mechanisms

Research Objectives

- Comparison of design philosophies
- Vulnerabilities, hazards, and casualty risk
- Material Selection and detailing
- Seismic Force Resisting System (SFRS, LLRF) selection
- Wall connections and interactions
- Hybrid SFRS
- Strengthening and Retrofit
- Diaphragm forces and performance
- Story response vs Ground motion
- Structural + Non-Structural Interaction
- Non-Structural + Non-Structural Interaction
- NSE “Stiff” vs “Flexible” response

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Room for improvement

- More areas of interest
- Other structural systems
- Testing methods
- Different Building configurations
- Selection and integration of NSEs

Integration of research into large-scale tests

Break-out sessions

- Form 4-5 groups
- Suggest changes to current ideas
- Share ideas about specific areas of interest
- Brainstorm new ideas

First topic: Structural Systems

Integration of research into large-scale tests

Break-out sessions

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Second topic: Non-Structural Elements

General discussion

Create a powerful image to convey a point

…budget?

Component tests?

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Breakout group discussions

1. Design implications
    1. Make it simple
    2. Focus on stiff vs flexible -> Goal to lower drift limits in NZ, move away from force-based design
    3. Is simple representative, or can it be made representative of current practice?
        1. Take something that doesn't work normally and retrofit to make it work (precast)
    4. Unknowns addressed by large scale that can't be addressed by component tests
    5. "Slim" frame vs stiff hybrid
    6. Link compromises interaction between floor and wall. Good for NSE, less good for Structural
2. Interactions
    1. Test beam to wall connection – make sure it works on a component level first
    2. 2 tests: Hybrid that doesn't work (assessment lessons) and then Hybrid that does work
    3. Coupling beam: accept damage? Epoxy and test again?
    4. Current design not representative. If made representative will international collaborators benefit? Precast Rectangular RC section is common in NZ
    5. Directional testing – x direction nominally ductile, y direction ductile->demonstrate that ductility is needed
    6. Sliding hinge joint can produce gravity frame

Breakout group discussions

3. Diaphragm
    1. Floor types – Timber CLT Precast Cold-form steel or conventional. Show that systems can be made to work?
    2. Beam-slab connection: change MRF to pinned connection
    3. Details of floor around column. Gap leads to twisting?
    4. Diaphragm to CW – choice to make. “Link” or conventional connection
    5. T-shaped (Asymmetric) Core wall
    6. Replaceable ED coupling beams
    7. Potential for BRB in frame
    8. Single, 5 story test, or multiple 2-3 story tests
    9. Make a test that “works” and then can be changed to not work
    10. 5-story: put openings on different floors
    11. What is needed to put out practice advisory to not connect steel beams directly to concrete walls
    12. Shear forces in core wall
    13. Biaxial bending in core wall

Breakout group discussions

4. NSE
    1. Conventional gib-board partition on one floor and low-damage system on another floor
    2. Partition performance at higher velocities
    3. Make sure system is representative of what would be seen in a building
        1. Include HVAC and desks/shelves etc?
        2. Baffles
        3. Penetrations
        4. Fire protection
    4. Quantify/standardize “standard” practice.
    5. Serviceability issues -> not “failed” but leakages, etc. that need repaired

Thank you all!