System response of coupled wall systems

QuakeCoRE – Workshop 2024/04/18

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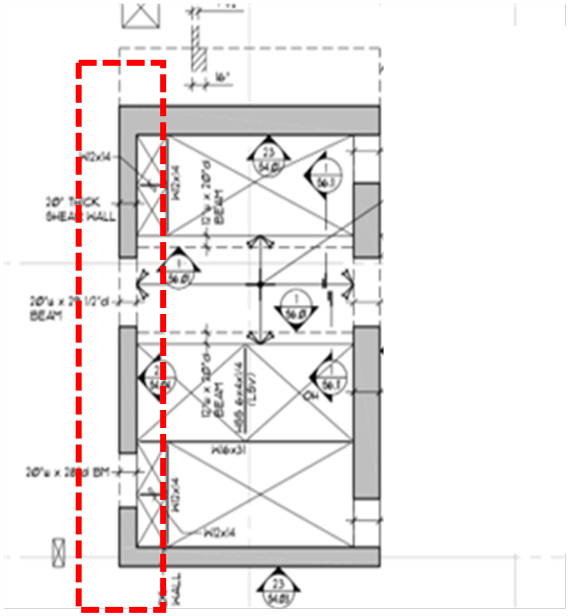
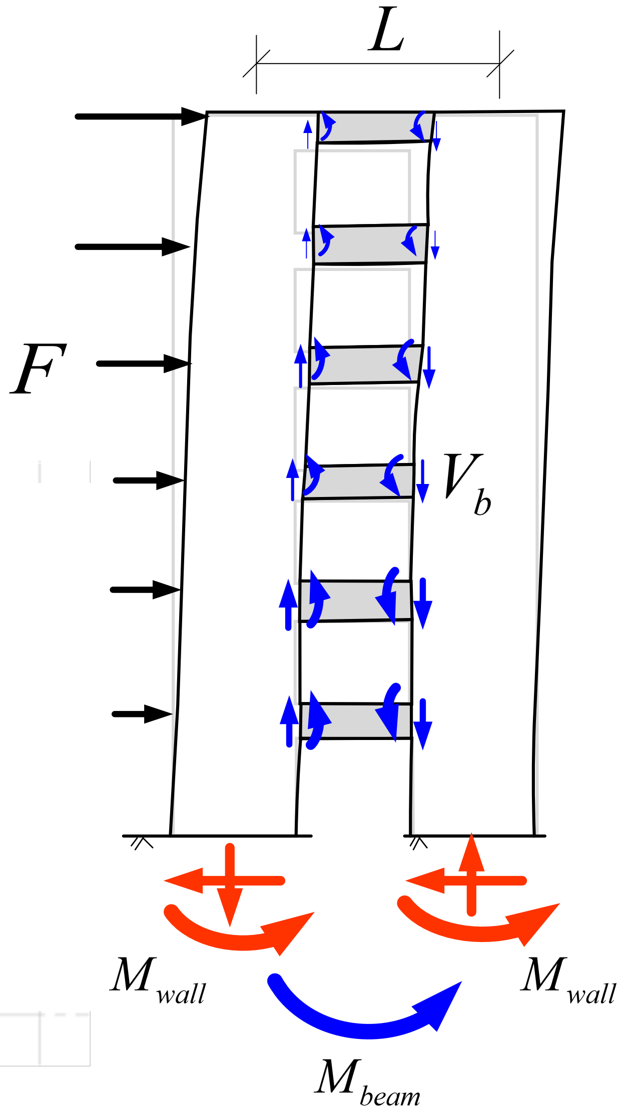
Coupled wall system

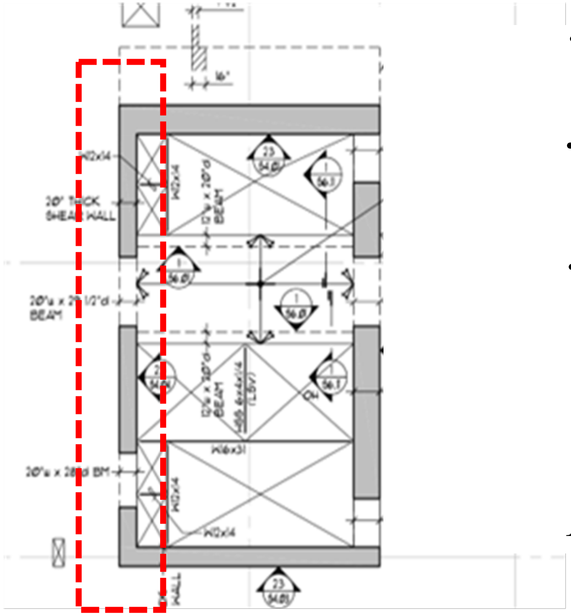


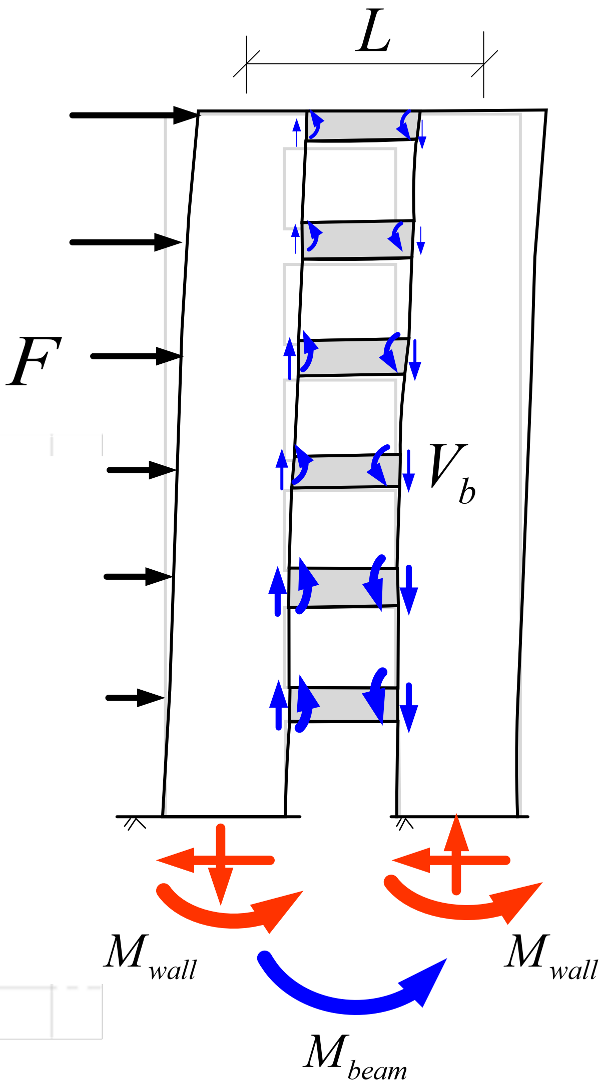


Coupled wall:

1. Accommodate architectural/mechanical requirements.
2. Provide a comparable lateral stiffness to that of a solid RC wall.
3. Has more ductility than solid RC wall.

Coupled wall system





Coupling beams:

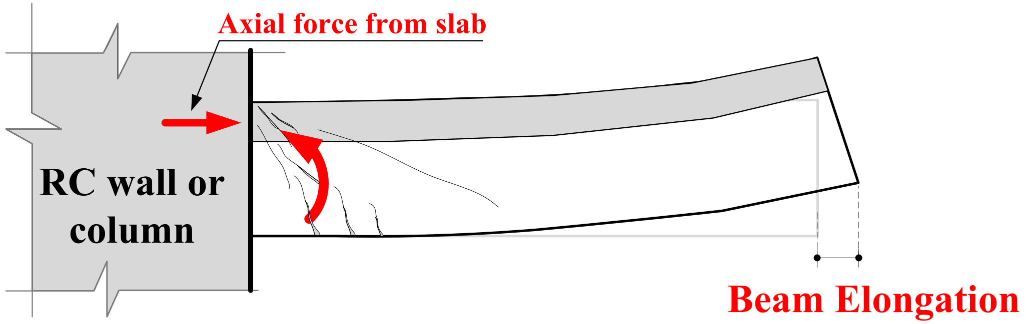
1. Transfer earthquake actions between the wall piers.
2. Reduce the moment demand on the wall.

   $$M_u = M_{wall,left} + M_{wall,right} + M_{beam}$$

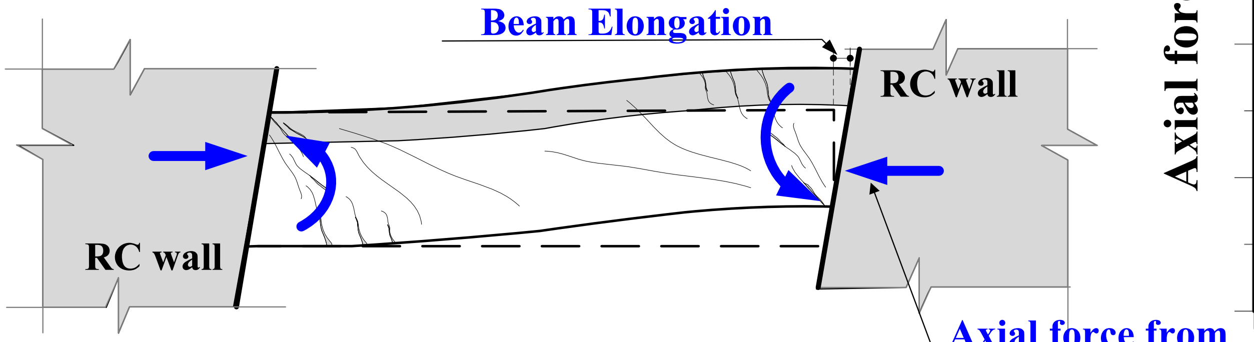
   $$M_{beam} = \sum V_{beam} \times L$$

3. Integrate the coupled system and act as energy dissipation members.

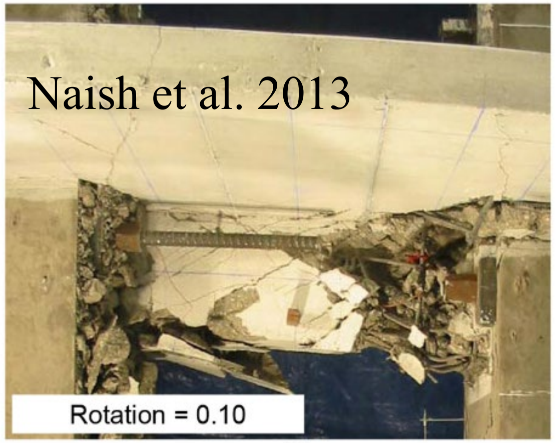
Axial restraint influence



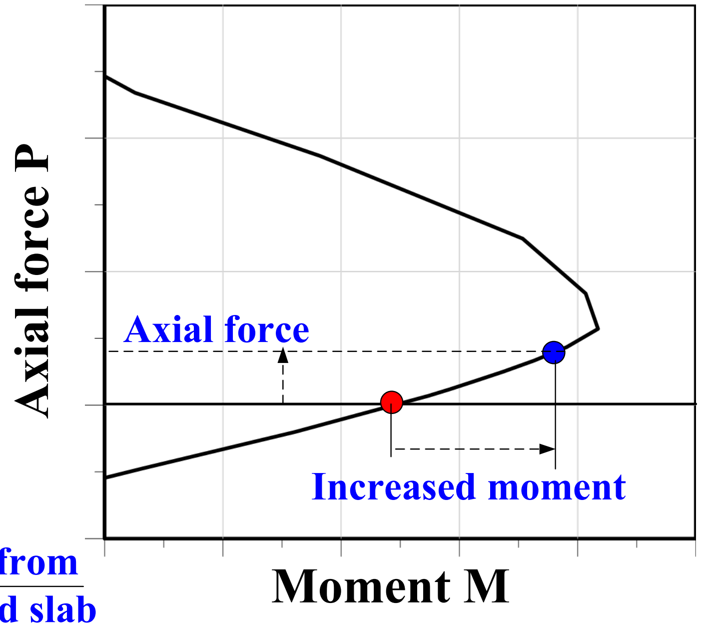
Cantilever beam or beam in frame system.



Coupling beam



(b)



The enhanced moment force increases the axial force demand on the wall piers and alters their deformation capacity.

Objectives

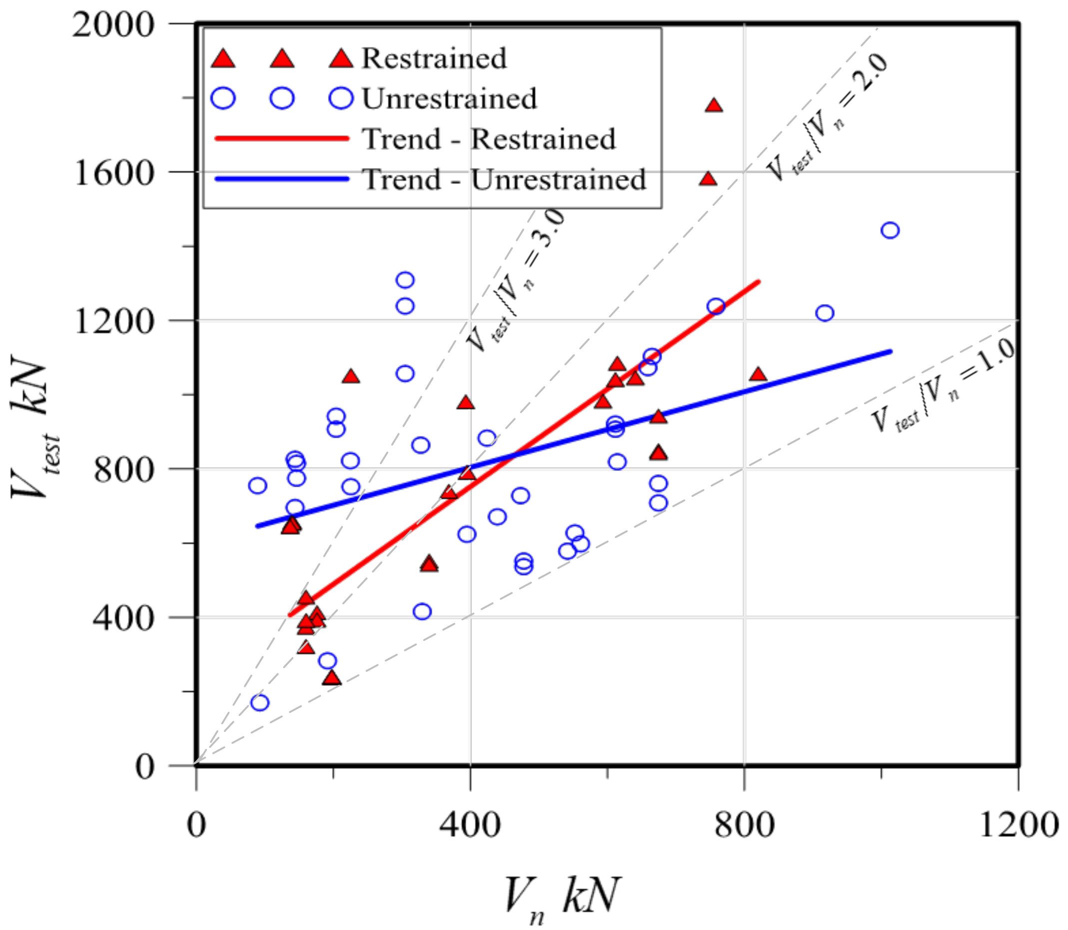
- Quality the axial restraint influence on seismic behavior of diagonally reinforced coupling beams.
- Investigate the impact on the wall pier from the restrained coupling beams.
- Improve design guideline for coupled walls.

Methodology

- Coupling beam database and modeling
- Numerical model of coupled wall and validation.
- Parametric study
- Design guidelines

Coupling beam database

- 70 diagonally reinforced coupling beams (Aspect ratio from 1 to 4)

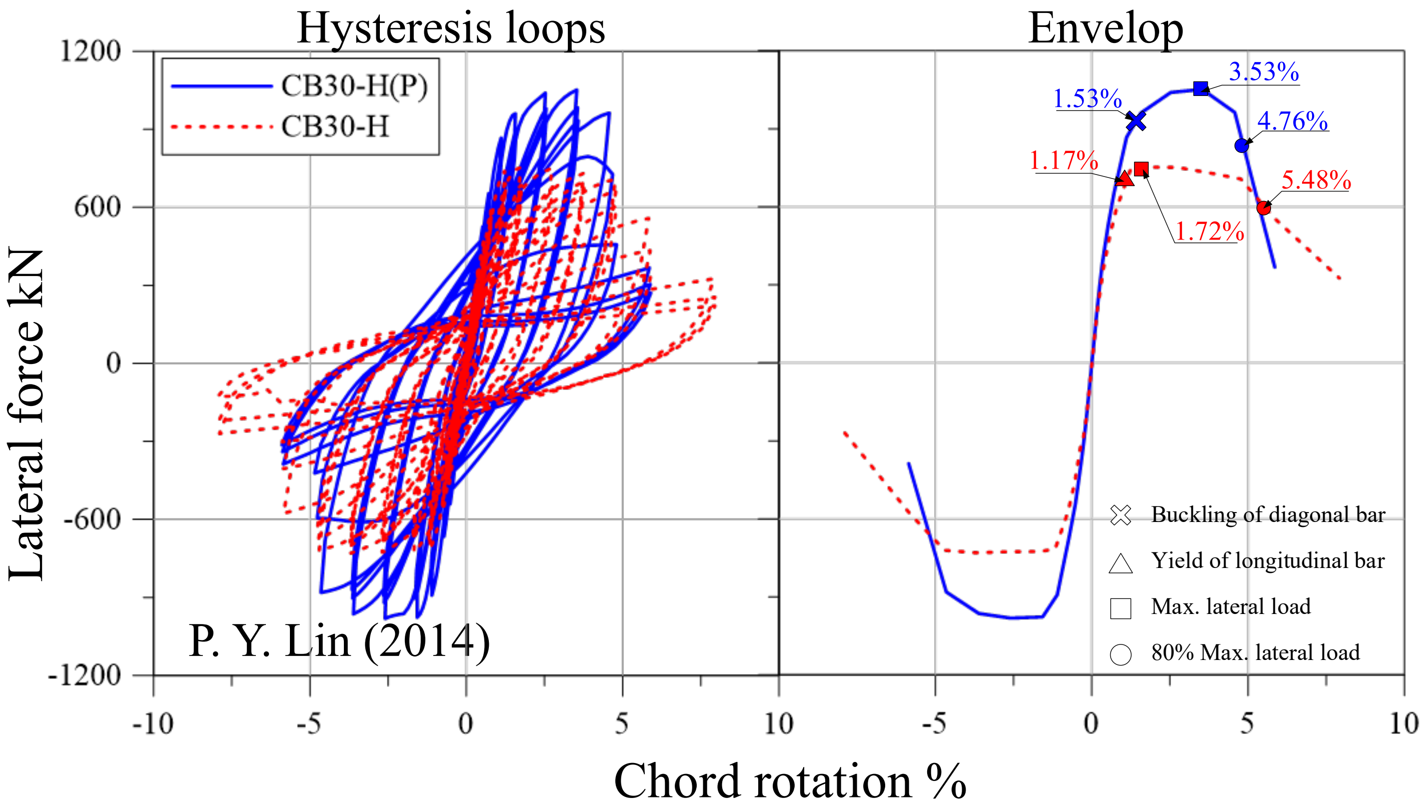


Design force. $V_n = 2A_d f_{yd} \sin\alpha$

The tendency of restrained specimen is stepper than that of the unrestrained specimens.

Limited tests included axial restraint.

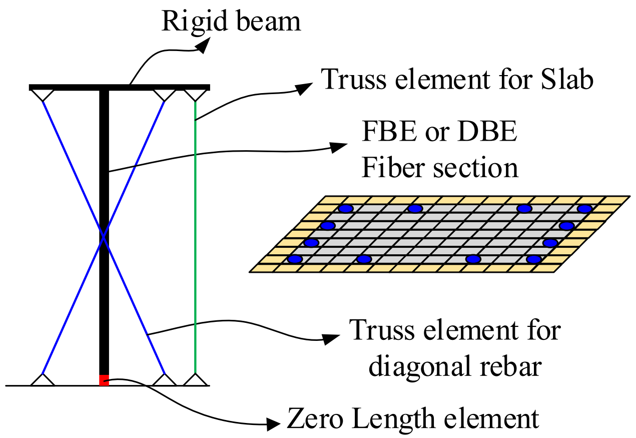
Two identical specimens, one was fully restrained and the other one was unrestrained

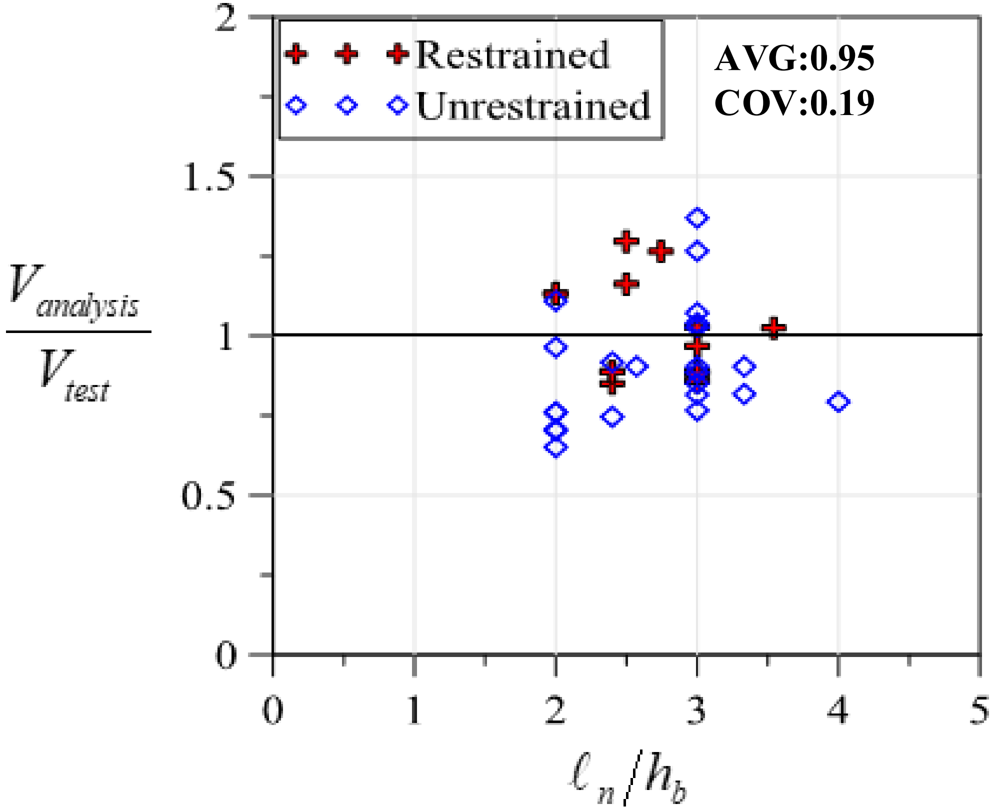


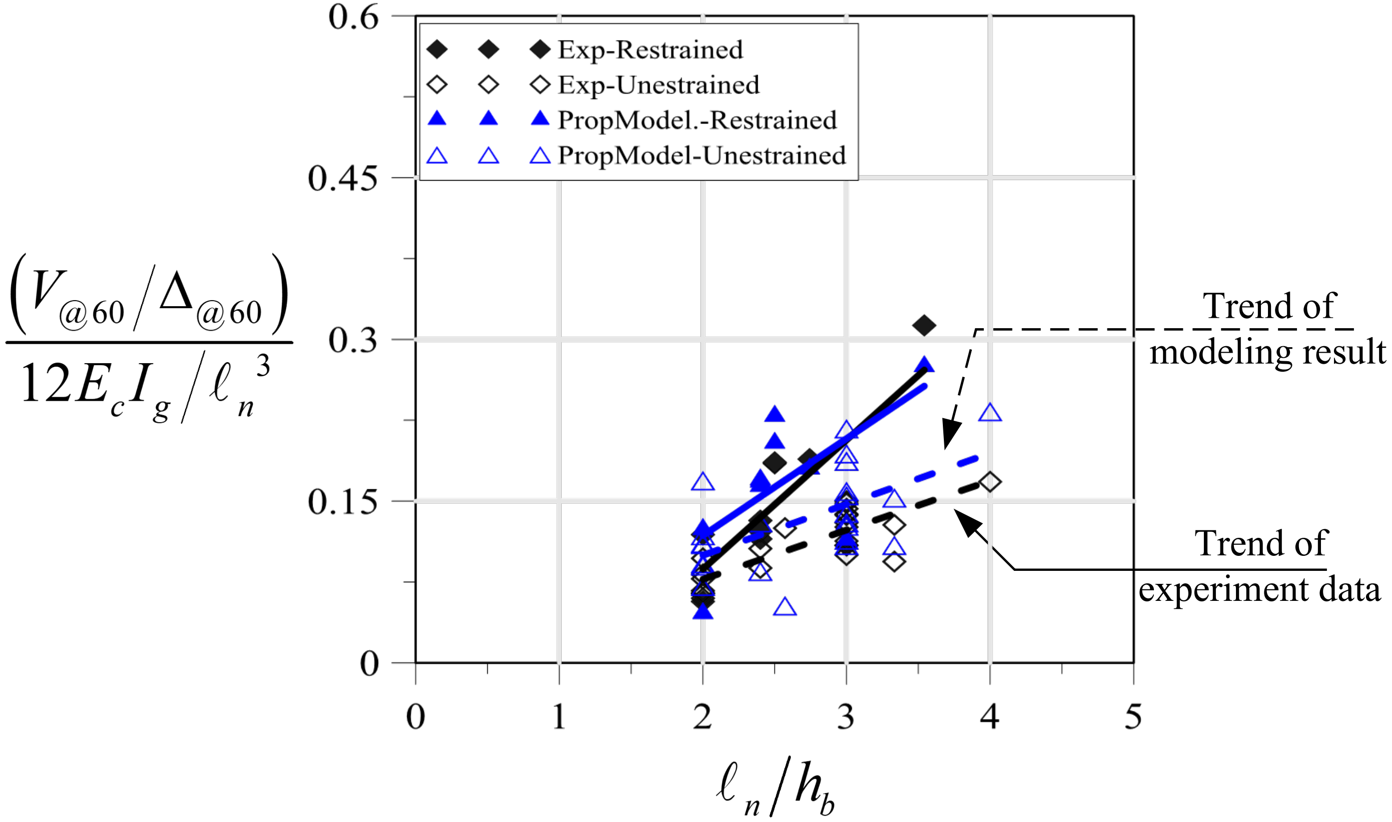
1. The lateral strength was enhanced by 40%
2. The ductility was reduced to 66%.
3. Pinching effect was slightly improved.

Modeling result

- For specimens with aspect ratio between 2.0 to 4.0

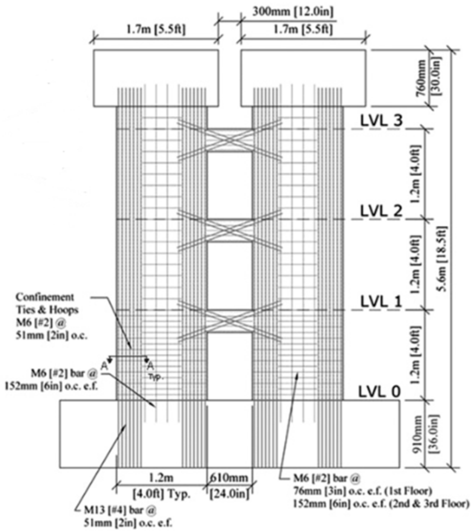


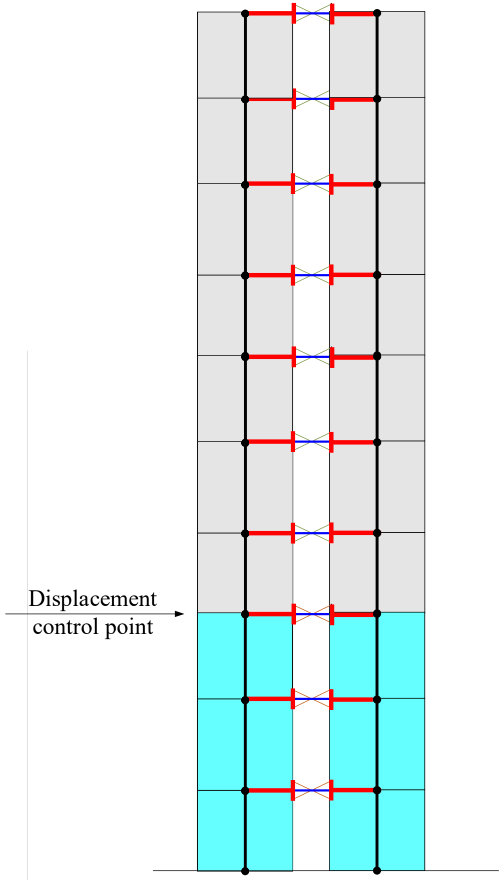


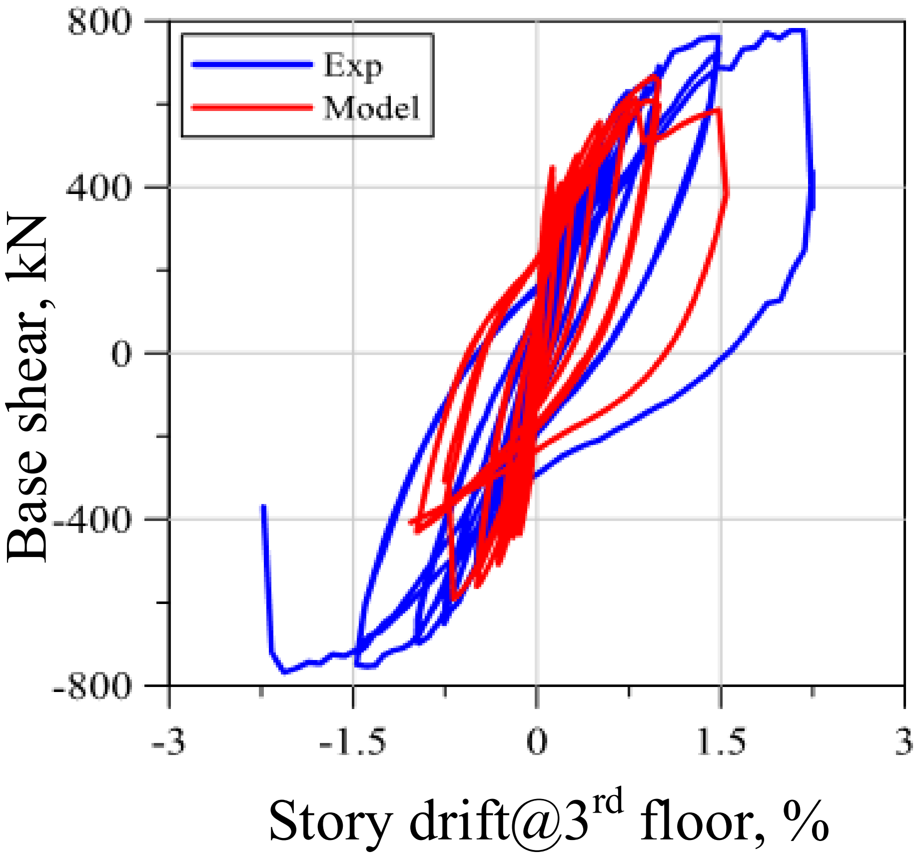


Coupled wall simulation

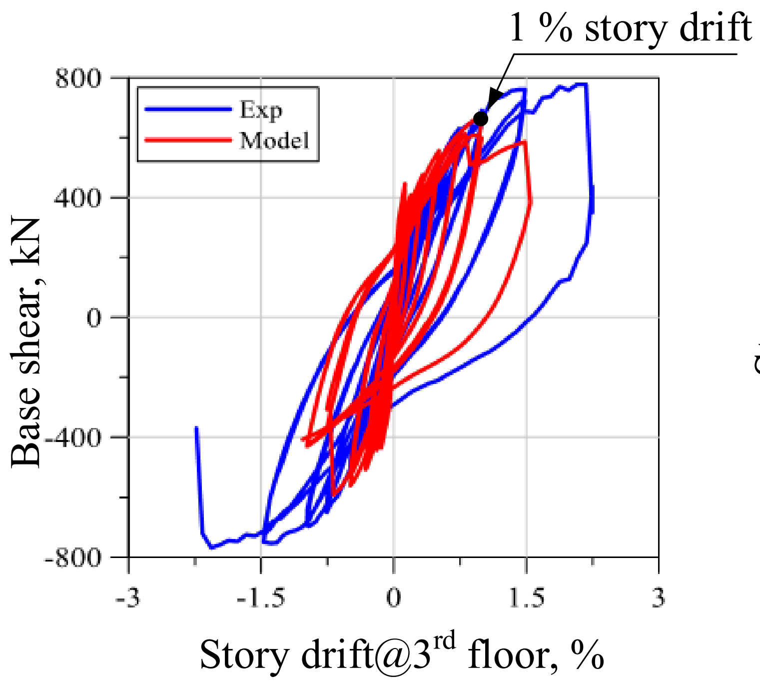
- Lehman et al. (2013) Mid-to high-rise coupled wall. (10-story)

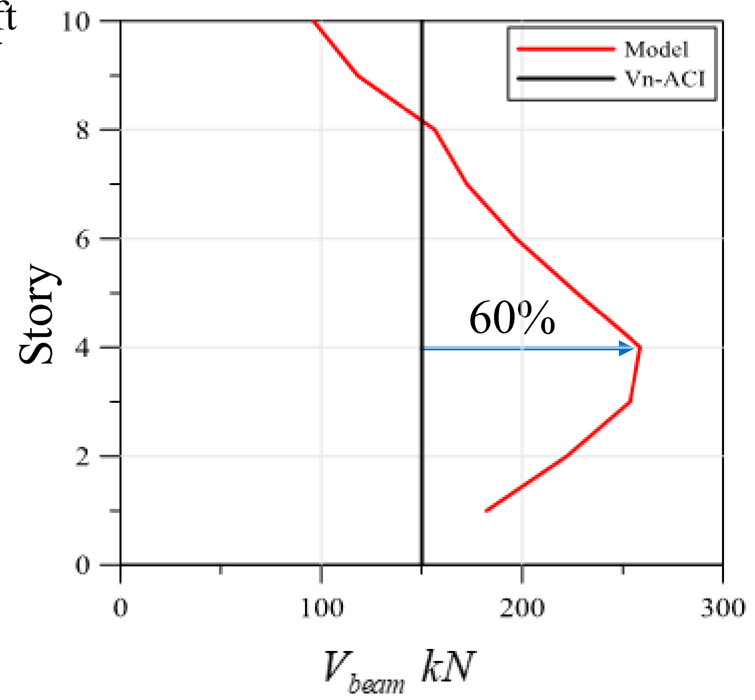


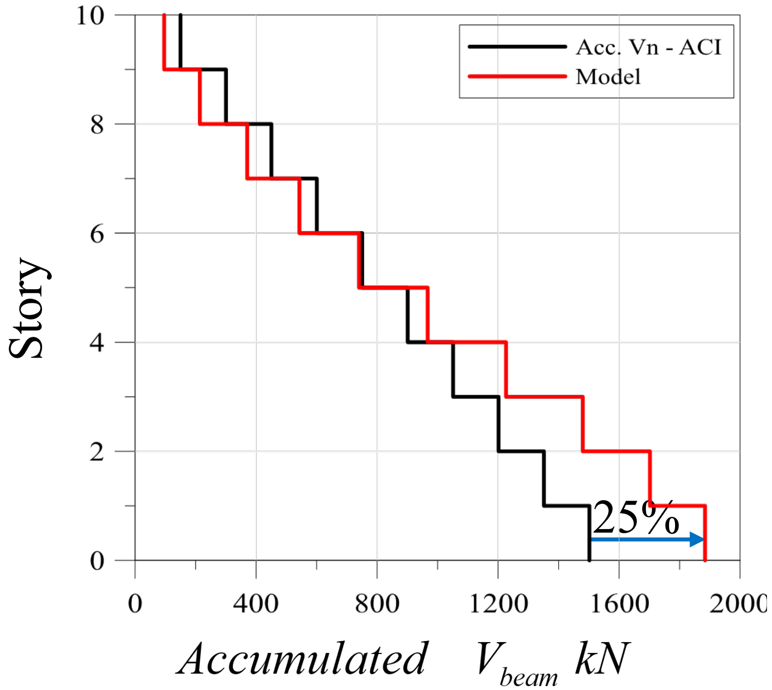




The coupling axial force







1. The coupling beam shear force at the lower level was enhanced by 60% of design strength.
2. The accumulated axial force increased by 25%.

Coupled wall simulation

- Cheng et al. (2015) Low-rise coupled wall. (4-story)

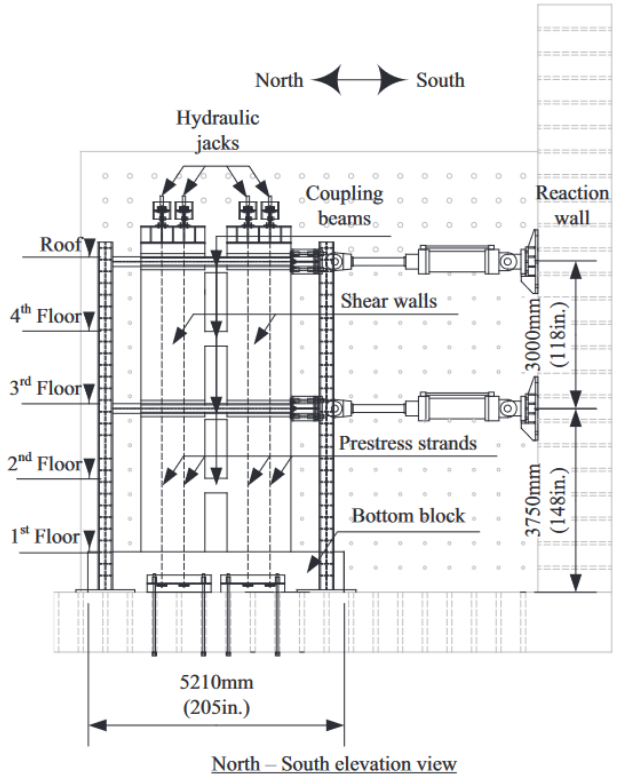
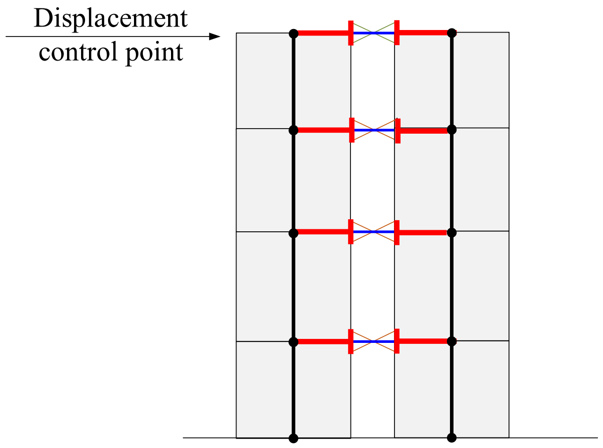
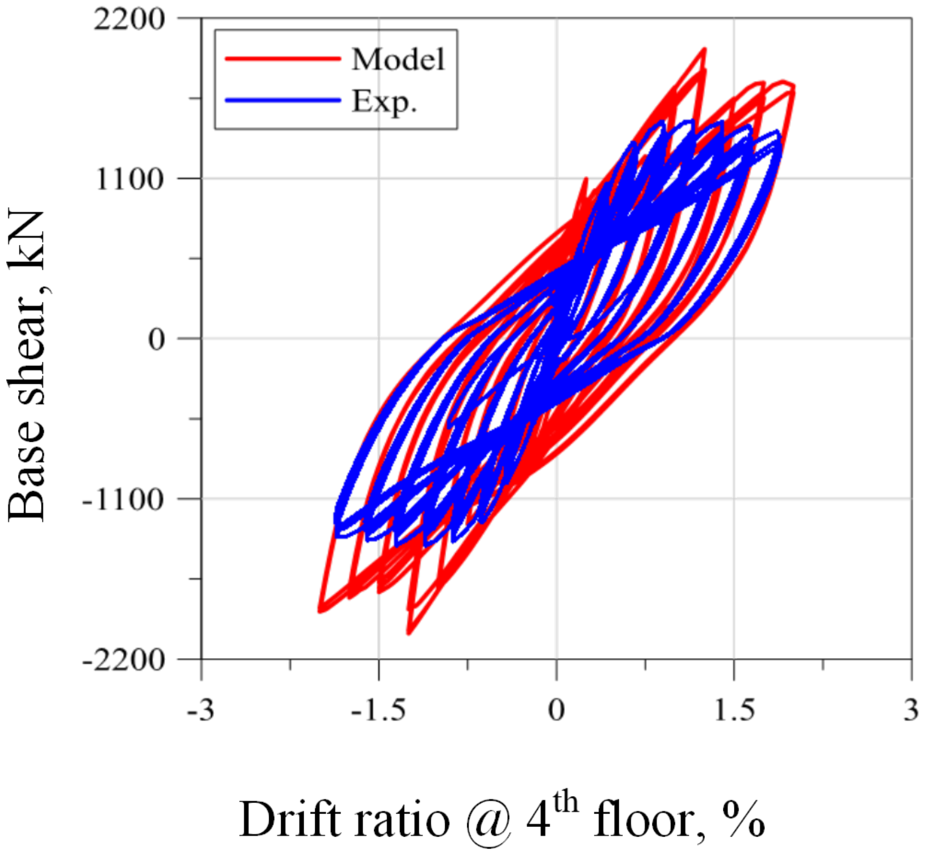
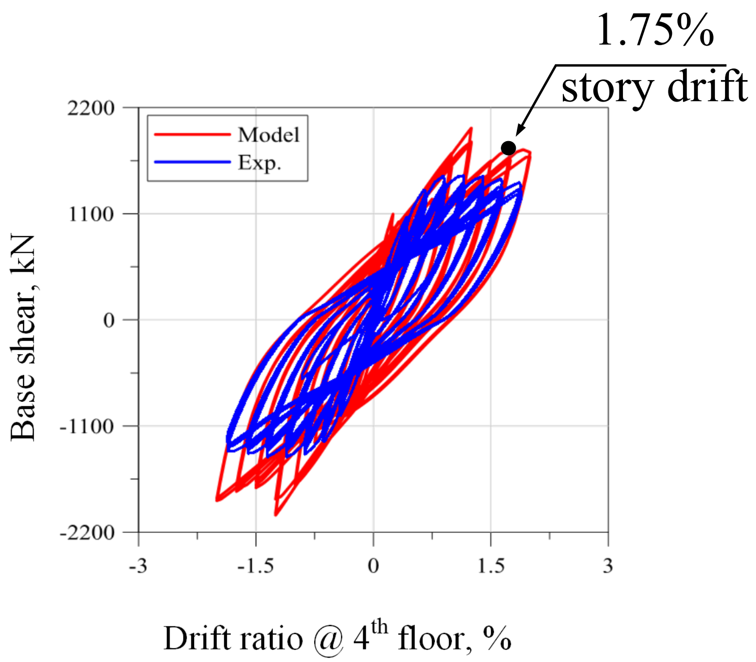


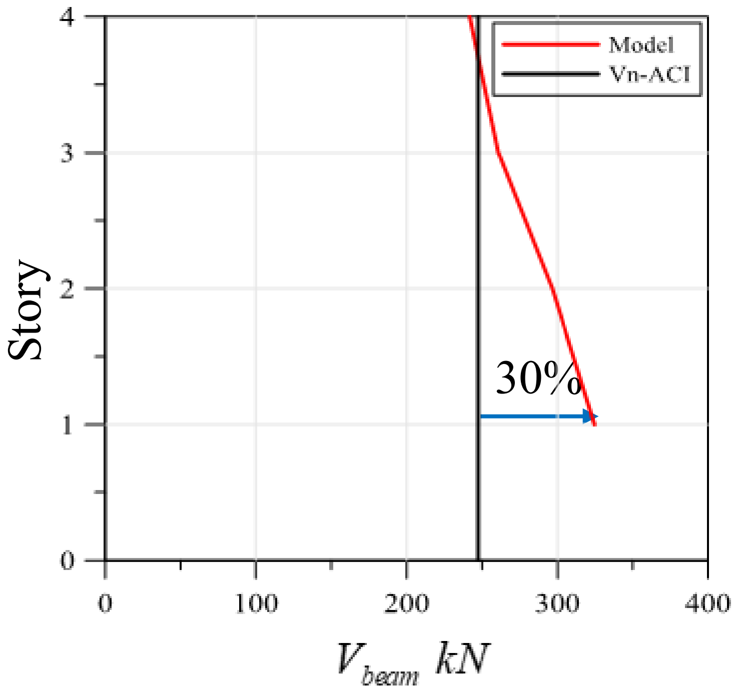
Fig. 6. Experimental test setu

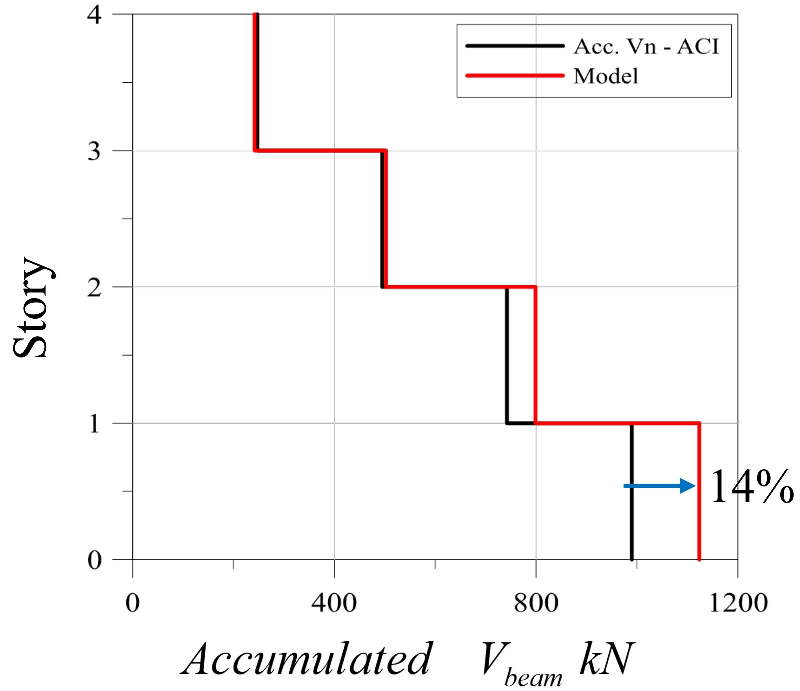




The coupling force







1. The restraint effect is not significant as that in mid-to high-rise coupled walls.
2. Due to the number of coupling beams, the accumulated axial force was increased by 14%.

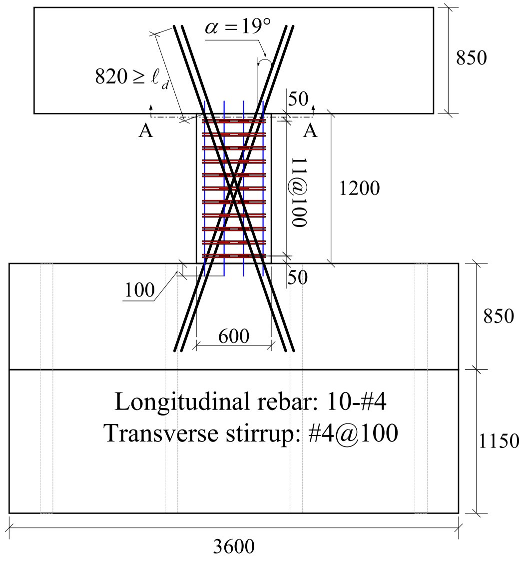
Next works

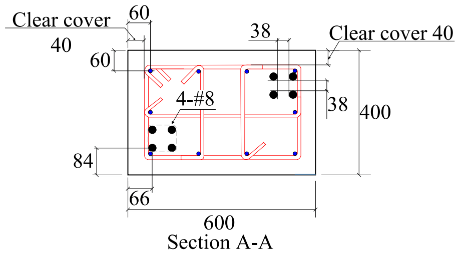
- Conduct a coupling beam experiment with different magnitudes of axial restraint. (NTUST at NCREE)

$$0.33\sqrt{f_c^{'}(MPa)}A_{cw} \le V_n = 2A_d f_{yd} \sin\alpha \le 0.83\sqrt{f_c^{'}(MPa)}A_{cw}$$

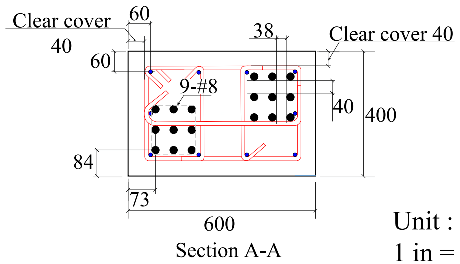
Low shear demand

High shear demand



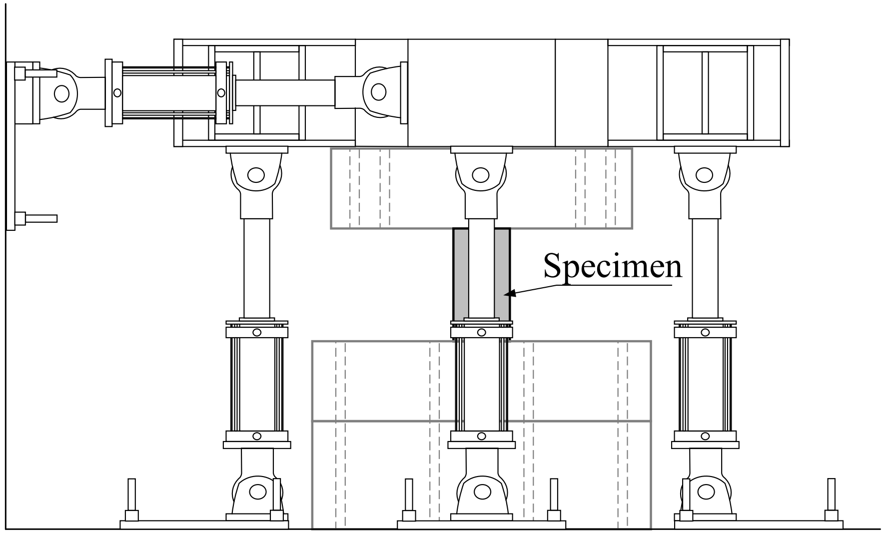


(a) Low shear demand

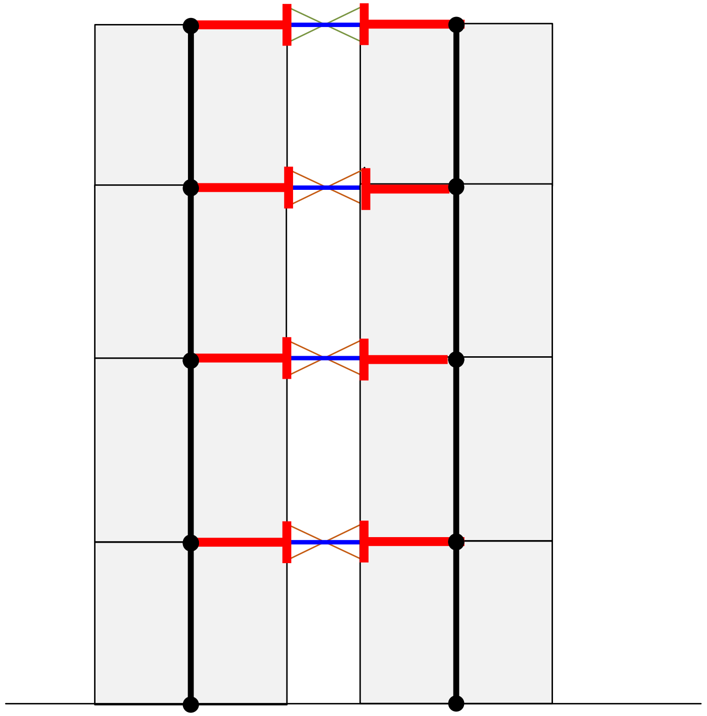


(b) High shear demand

Unit : mm
1 in = 25.4 mm



Next works



- Parametric study
  - Story height effect
  - Coupling beam effect: aspect ratio
  - Wall factor: the length ratio and thickness ratio between wall and coupling beams.
  - Elastic-perfect and strain hardening of diagonal rebar, clarifying the material overstrength factor and restraint factor.
  - Includes slab.

Summaries and Conclusions

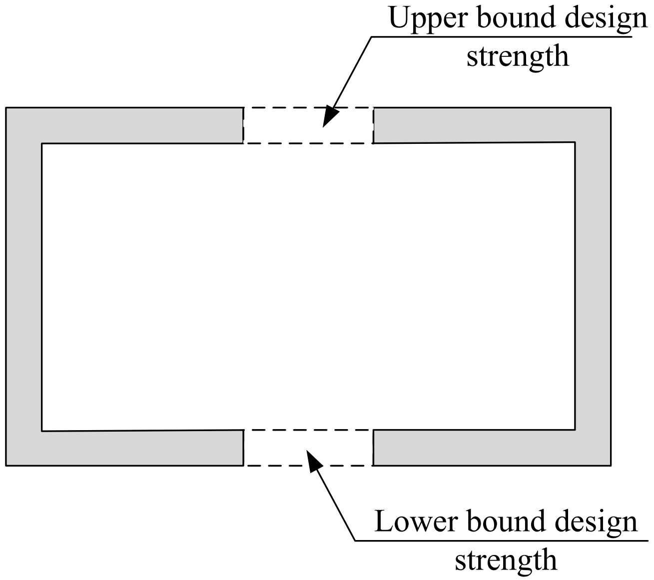
- Axial restraint effect affects the seismic behavior of coupling beams significantly.
- The magnitude of axial restraint varies along the building, this would be relevant to the lateral stiffness of the wall pier, story height.

Recommendation and future work

- Due to limited coupled wall test, more coupled wall or core coupled wall tests are needed.
- Having a core coupled wall in large-scale shake-table test.

Expected benefits from the test.

- Investigate the influence of different design coupling beam under similar restraint condition



- Investigate the dynamic response of a coupled wall and the coupling beams

Expected benefits from the test.

- Investigate the influence of slab restraint effect.