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Seismic performance of precast shear walls with different vertical connection strategies

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ABSTRACT

Precast wall as part of the seismic-force-resisting system should meet the seismic criteria. Shear connections as the connective element between adjacent precast walls play a critical role in the seismic performance of precast wall. An efficient shear connection is expected to provide effective composite action between adjacent precast walls and excellent constructability as well. To this end, this paper presents five different connection strategies between adjacent precast walls including cap beam, wire-loop, headed bar, steel box and lap splice. Five full-scale precast specimens were constructed and the reversed cyclic tests were conducted. The test results were evaluated in terms of strength and stiffness degradation, ductility and energy dissipation features. It was found that steel box can provide the highest strength but low ductility. Compared with the lap splice, the headed bar had both lower strength and ductility. The wire-loop had the best seismic performance by providing both the high strength and ductility and the highest energy dissipation as well while the cap beam had the worst seismic performance since its strength, ductility and energy dissipation were the lowest. ……

1. INTRODUCTION

The most common applications of precast concrete (PC) members associated with building construction are walls. A large variety of structural PC walls has been proposed as part of the seismic-force-resisting system, such as unbonded post-tensioned precast concrete shear walls (Hassanli 2016, Nurjaman 2014), composite shear walls that consist of several different construction materials such lightweight concrete, fiber reinforced concrete and light steel (Brunesi 2016, Chai 2005, Rassouli 2016, Zhi 2017). Attention has been paid on the influence of different connections on the seismic performance of precast shear wall. However, these researches just verified the effectiveness of the vertical connection between wall and base. Few researches have been made on the wall to wall side connection. In order to investigate the effect of different wall to wall side connection on the seismic performance of PC wall as part of

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the seismic-force-resisting system, five well-designed full-scale reversed cyclic tests were made. The test results were analyzed and discussed in terms of hysteretic behavior, strength and ductility, energy dissipation and stiffness degradation.

2. EXPERIMENTAL INVESTIGATION

2.1 Test specimens

Five precast concrete (PC) wall specimens with different connection details were manufactured, as shown in Fig. 1. All the five PC wall specimens consisted of two individual PC wall piers.

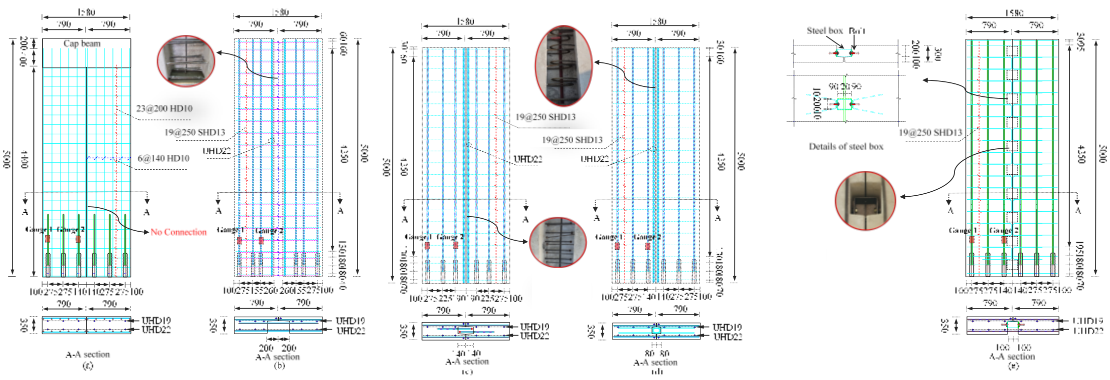

Fig. 1 Details of specimens: (a) Specimen CC; (b) Specimen CL; (c) Specimen CH; (d) Specimen CW; (e) Specimen CS

2.2 Test setup and loading protocol

The test setup employed to simulate the seismically-induced lateral cyclic displacement is shown in Fig. 2 (a) and (b).

The loading protocol followed the ACI 374. 2R-13 (Guide for Testing Reinforced Concrete Structural Element Under Slowly Applied Simulated Seismic Loads) (2013), as shown in Fig. 2 (c).

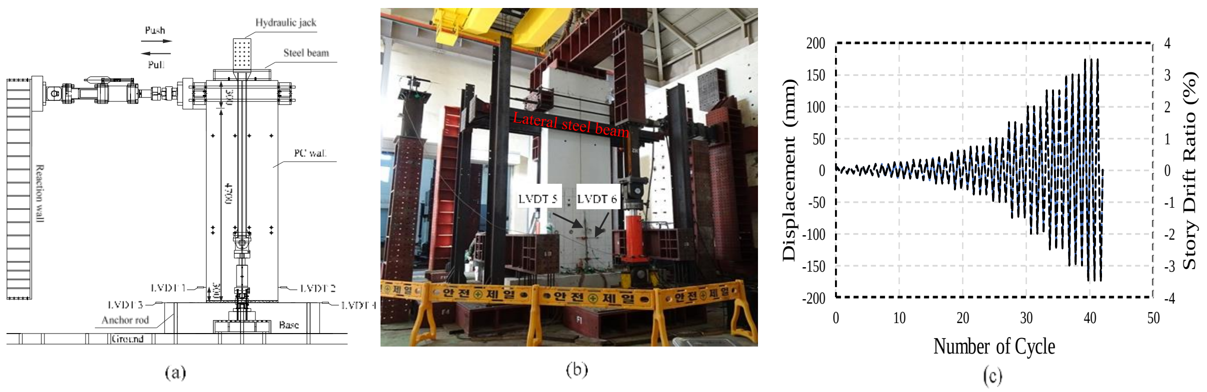

Fig. 2 Test setup and instrumentation: (a) schematic; (b) photograph; (c) loading

3. TEST RESULTS

3.1 Hysteretic behavior

The moment-drift curves of the five test specimens are presented in Fig. 3. An idealized elastic perfectly plastic response (IEPPR) is also added for the convenience of characterizing the hysteresis curves.

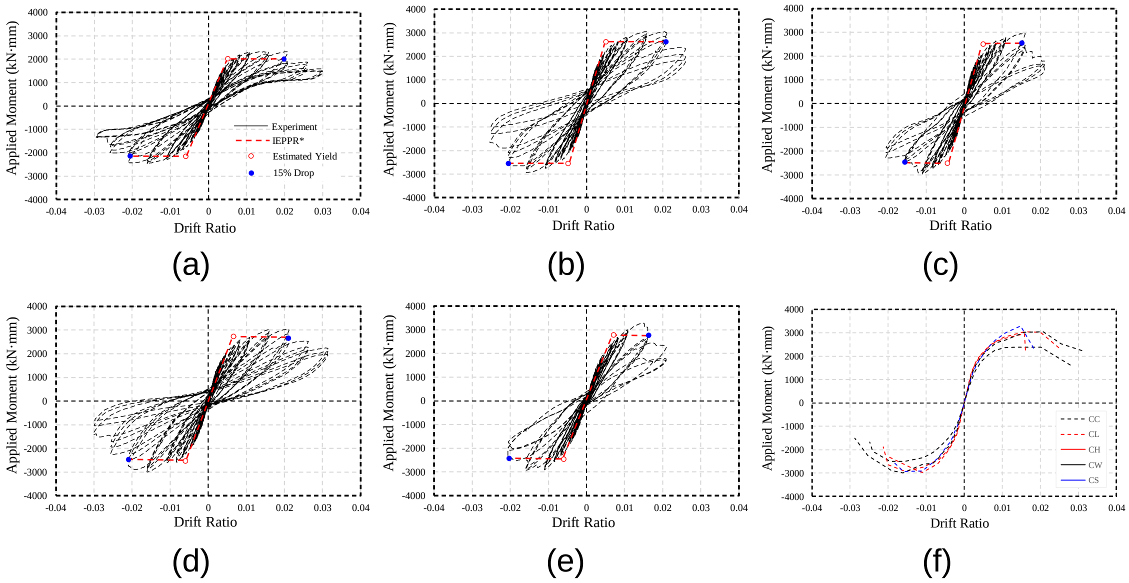

Fig. 3 Moment-drift curves of test specimens: (a) Specimen CC; (b) Specimen CL; (c) Specimen CH; (d) Specimen CW; (e) Specimen CS; (f) skeleton curves.

3.3 Energy dissipation and Stiffness degradation

Both the energy dissipation and stiffness degradation curves and equivalent viscous damping coefficient curves are presented in Fig. 4.

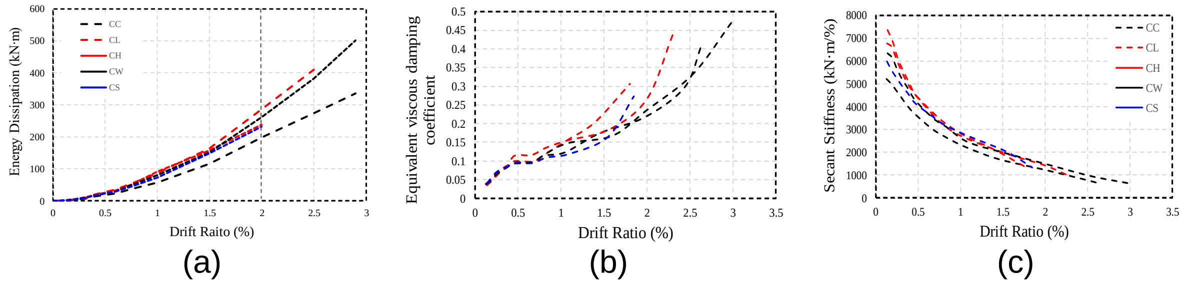

Fig. 4 Energy dissipation: (a) energy dissipation curves; (b) equivalent viscous damping coefficient curves; (c) stiffness degradation curves

4. CONCLUSIONS

Five different connection strategies i.e., cap beam, lap splice rebar, headed rebar, wire-loop rebar and bolted-in steel box were presented and full-scale reversed cyclic tests were conducted to investigate the effectiveness of the five connections and their influences on the seismic performance of the PC shear wall. The following conclusions can be drawn from this study.

1. Large and swelling hysteresis loops appeared only when specimens were in the plastic stage and the large hysteresis loops of Specimen CL and Specimen CW were more stable than the other three specimens. This proved that lap splice rebar and wire-loop rebar as interfacial connection can provide better hysteretic behavior.
2. Specimen CC had the lowest flexural strength 2385 kN·m which was smaller than the flexural strength 2572.9 kN·m obtained from the section analysis by treating the cross section of connected PC walls as an intact section, whereas the flexural strengths of other specimens were bigger than their corresponding flexural strengths from section analyses. These results indicated that topping cap beam was not able to provide full composite action between PC wall piers. The other four connection strategies can sustain enough interfacial shear connection strength and achieve full composite action between PC wall piers.
3. Specimen CS had the highest flexural strength 3288 kN·m but the lowest displacement ductility 2.24, whereas, both the Specimen CL and Specimen CW maintained relatively high strength and displacement ductility as well. This indicated that lap splice rebar and wire-loop rebar were the most reliable shear connection strategies.
4. Specimen CL had both the largest energy dissipation and equivalent viscous damping coefficient which demonstrated that lap splice rebar was the most efficient interfacial shear connection.
5. Specimen CH had the biggest initial stiffness, but its stiffness degradation was also the fastest. This proved that headed rebar as shear connection was not able to maintain the lateral strength, which led to drastic strength drop after the peak moment.

ACKNOWLEDGEMENT

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