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Shaking table test of precast concrete frame with clamped headed bolt connection

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ABSTRACT

In this study, the clamped headed bolt connection was applied to precast concrete frames (PC) to effectively transmit stress in the beam generated by seismic loads to the joint. Shaking table tests were conducted to verify strength performance of the PC frame, and its failure mode and constructability. Design was conducted as per recommendations by ACI Committee 352 (2002). The results of the experiment demonstrated sufficient lateral load resistance performance during ground motions up to 0.8g and the specimens were deformed to a peak lateral drift ratio of about 3%. Finally, without brittle fracture of any connecting steel, the specimen showed ductile behavior.

1. INTRODUCTION

Demand for precast concrete (PC) is increasing due to advantages of high quality and reduced construction time. However, there is a limitation that conventional connecting methods are not fully integrated with other elements, often making them vulnerable to strong earthquakes at the joint where stress is concentrated. In addition, curing periods and support posts are required for stability in the half wet process, resulting in interference with subsequent processes.

In this study, to improve these problems, a clamped headed bolt connection system is applied that enables flexible and ductile behavior of the PC frame and at the same time eliminates the need for temporary posts. Uni-axial dynamic experiment was conducted by applying an actual earthquake ground motion of 1999 Chi-Chi Earthquake to examine the dynamic behavior of the PC frame with the clamped bolt connection system.

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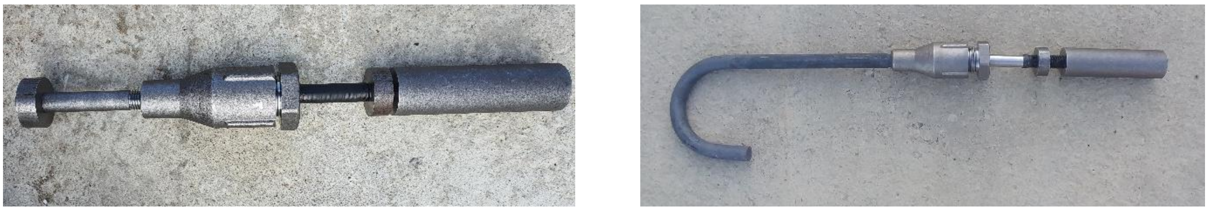
2. CONCEPT OF CONNECTION SYSTEM

The connection system consists of a rebar, a coupler, a headed threaded bar, a cap-nut, a socket, and an anchor rod or hooked anchorage for concrete embedment. By connecting the rebar and headed bar with the coupler and clamping the head inside the socket, each PC tension element is integrated (Fig. 1). It is a patented product of the second author.



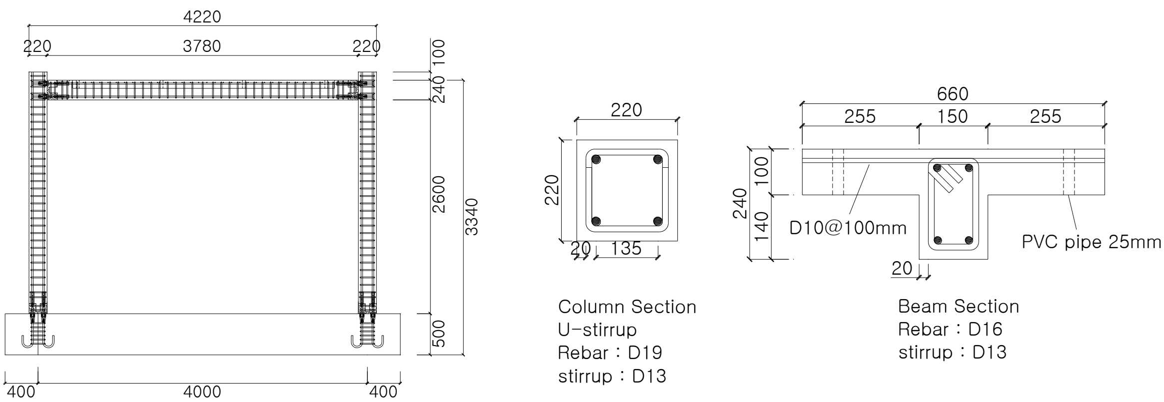
(a) Beam-column connection (b) Column-foundation connection

Fig. 1 Clamped headed bolt connection system

3. SPECIMEN AND METHOD

3.1 Specimen

A full-scale specimen was designed following ACI 352R-02. Details of the specimen are shown in Fig. 2. The connection system was applied at all the beam-column connections and column-foundation connections of the portal frame (all 4 locations). The beam was a precast T-section beam that allows for placing the mass steel on top of the flange. After connecting the members, only the gap between the column and beam was grout-filled to transmit compressive force (Fig. 3).



(a) Full-scale frame specimen (b) Column section (c) Beam section

Fig. 2 Specimen details

(a) Beam-column connection

(b) Column-foundation connection

Fig. 3 End of members

3.2 Experiment method

To check the safety and stability of the specimen, a uni-axial 1998 Chi-Chi Earthquake ground motion (PGA = 0.8g) is applied.

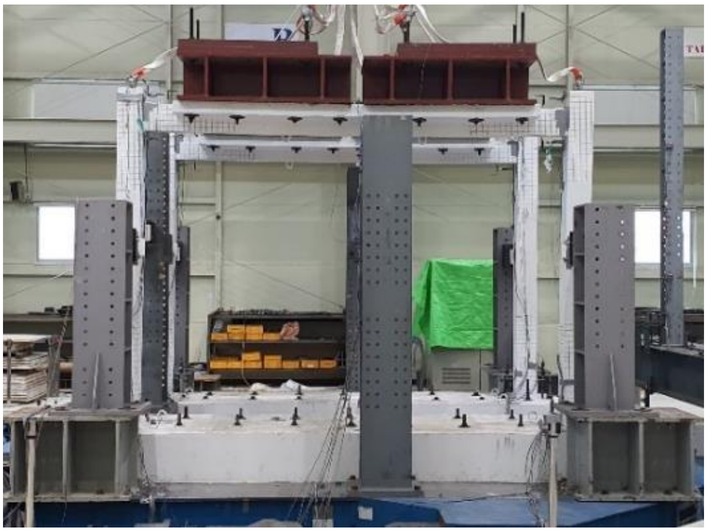
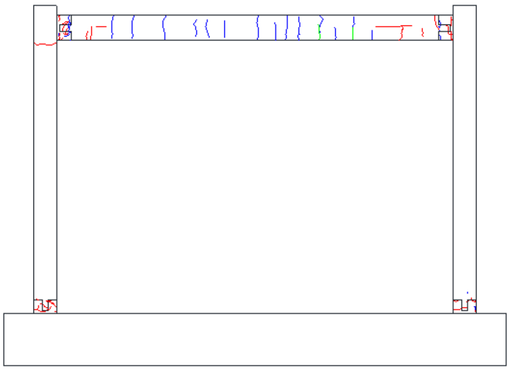


Fig. 4 Setup for specimen

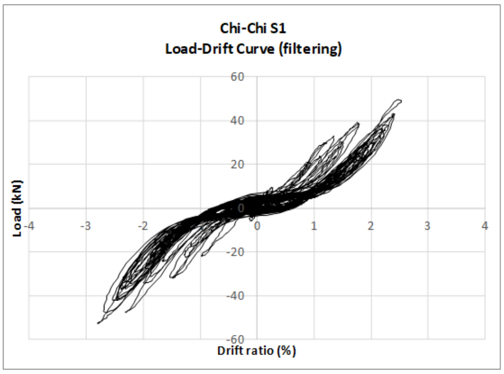
4. RESULT

Main cracks were formed by bending at the bottom of the column, at both ends of the beam member, and at the middle of the beam. It appears that the stress was concentrated on the joint of the grout, resulting in cracks. No other significant failure occurred (Fig. 5(a)).

The maximum lateral load was 52.7 kN, and the maximum lateral displacement was 76.2 mm (lateral drift of 2.8%). Furthermore, the specimen experienced plastic stage of deformations without a loss of capacity (Fig. 5(b)).



(a) Cracking aspect



(b) Load-displacement curve

Fig. 5 Result of test

4. CONCLUSIONS

Shear failure at the beam-to-column joints was effectively restrained and the anchor rods were not pulled out of the joint. In other words, the anchor was developed to yield. Then, it induced ductile behavior without brittle fracture of any connecting steel. Using the connection system, it enabled members to maintain their intended safety and self-supporting capability. Once fastened, theoretical moment capacity was fully performed immediately without support posts.

As a result, sufficient lateral load resistance performance and lateral stability of the PC frame was demonstrated through the shaking table experiment. The connection is expected to prevent structural collapse and at the same time to contribute to reduction of construction time and cost by simplifying the construction process.

REFERENCES

ACI Committee 352 (2002), “Recommendations for Design of Beam-Column Connections in Monolithic Reinforced Concrete Structures (ACI-352R-02)”, *American Concrete Institute, Farmington Hills, MI.*