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Behavior of Wall Boundary Elements under Cyclic Axial Loading

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ABSTRACT

In this study, to quantitatively evaluate the deformation performance of the RC wall boundary element, cycle axial loading test was performed. In particular, in order to evaluate the performance of simplified transverse reinforcement using seismic rebar, the types of rebars, types of details, the spacing of the detail, and loading protocol were applied as experimental variables. In addition, the performance of the detail was verified through the lateral cyclic load test of the RC wall with the simplified transverse reinforcement. As a result of the experiment, the variables affecting the maximum strength and the ductility of the wall were mainly shown by the spacing and types of details.

1. INTRODUCTION

The recent two major earthquakes, the Gyeongju earthquake and the Pohang earthquake, have occurred, increasing the risk of earthquake loads in Korea. Accordingly, social interest in the safety of buildings against seismic loads has increased, and the legal standards for applying seismic design have been strengthened. In particular, more than 90% of domestic apartments adopt a load-bearing wall system, and in order to secure the safety of a residential space, it is necessary to strengthen the seismic design standards for wall-type apartments.

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According to KDS 41 17 00 (2019), special boundary element(SBE) must be installed on the boundary elements of wall structures located in seismic design category D with a height of 60 m or more. However, the ductility details of the special boundary element can deteriorate the constructability due to high rebar ratio of the transverse reinforcement, and may cause difficulties in concrete quality control. Therefore, the ductility details of the reinforced concrete boundary elements that can secure the ductility of the wall while shortening the process time are required. In addition, it is necessary to quantitatively verify the deformation capacity of boundary elements under seismic loads through cyclic load tests as well as monotonic load.

Many verifications have been implemented on the seismic performance of structural members using closed hoops and cross ties, used for special shear walls and special moment frames. In particular, many research has been carried out to investigate the deformation capacity and failure mode through the axial cyclic loading test for the details installed at the end region of the special shear wall. Hilson et al(2014) performed reinforced concrete prisms representative of thin structural wall boundary elements. In one test group, axial compressive strains were limited and tension strains escalated until failure was observed upon reloading into compression. In other group, both tension and compression strains were increased incrementally to assess compressive strain limit. And Prism specimens were tested to study the influence of isolated confined boundary regions of RC rectangular walls(Taleb et al, 2016). Also, Travis et al(2017) studied behavior of rectangular reinforced concrete prism. The rectangular prisms tested under cyclic axial loading or monotonic compression, with a focus on the boundary element detailing classification, detailing of transverse reinforcement, maximum tensile strain preceding compressive demand, and cross-sectional ratio. However, the simplified confinement detail has not yet been verified through the cyclic axial loading test of the boundary element. Therefore, in this experiment, cyclic axial loading test was performed to analyze the effect of tensile strain on boundary element deformation capacity, failure mode, buckling performance, and compressive deformation capacity.

2. TEST PLAN

A typical Korean apartment bearing wall has rebar ratio of about 0.5%, but the high rebar ratio is used for boundary elements because large compressive and tensile strains occur during earthquake loads. Therefore, in this test, boundary elements were designed with a rebar ratio of about 3%, and a total of 10 specimens were manufactured. The main variables include the type of longitudinal rebar, the vertical spacing of the transverse reinforcement detail, the type of transverse reinforcement detail, and the loading history. The experiment was performed using 5000kN UTM, and the load history was applied with compressive strain : tensile strain of 1:5 and 1:10, respectively. Fig. 1 shows the test setup.

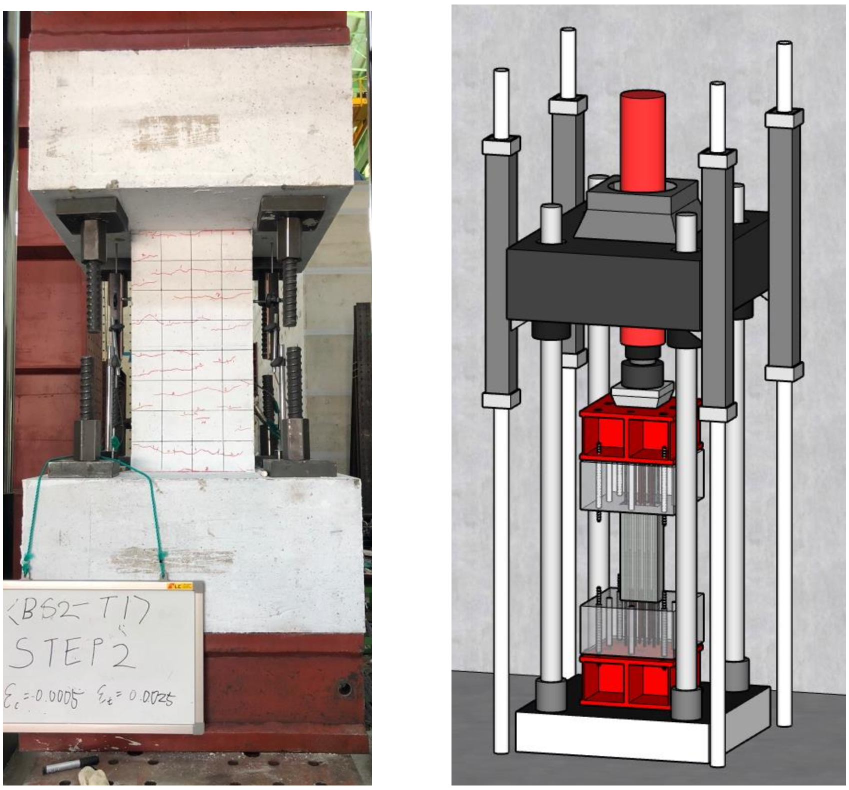
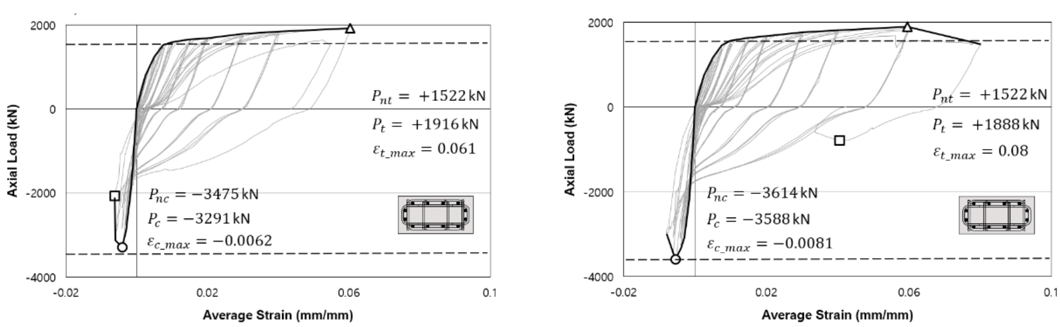


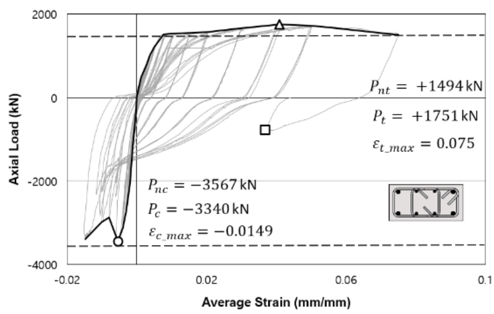
Fig. 1 setup of cyclic axial loading test

3. TEST RESULT

Fig.2 shows the test results of BS1-T2, BS2-T2 and BS3-T2. The spacing of the transverse reinforcement details was 130mm, 100mm, and 65mm, respectively. The failure modes are buckling of rebar and crushing of concrete in BS1-T1, and buckling of rebar occurred after fracture of rebar in BS2-T2. And BS3-T2 was destroyed as the cross-tie was loosened and the specimen buckled out-of-plane. The maximum compressive strength was 3291, 3588, and 3844 kN, respectively, the maximum compressive strains were 0.0062, 0.0081, 0.0081. The maximum tensile strain was 1,2,3



(a) BS1-T2 (b) BS2-T2



(b) BS2-T2

Figure. 2 Load – Average strain relationship

4. CONCLUSION

In this experimental result, the effect of vertical spacing and type of detail on the deformation performance of boundary elements was shown. BS2-T2 and BS3-T2 specimens, which have narrower transverse detail compared to specimen BS1-T2, in which the spacing of transverse reinforcement details is 2/3 of the wall thickness, each have 1.31 times the compressive deformation performance, so it can have better deformation performance. Also, under the load history where the relationship between compressive strain and tensile strain is 1:10, the simplified confinement detail and special seismic detail showed the same deformation performance except for the failure mode.

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