

Shear Capacity Evaluation of RC Shear Wall by Bi-directional Horizontal Loading Test

Junhee, Park^{a*}, Kunsoo, Kim^a

^aKorea Atomic Energy Research Institute, 1045 Daedeok-daero, Yuseong, Daejeon, 305-353

*Corresponding author: jhpark78@kaeri.re.kr

1. Introduction

From 2010 Chile earthquake and 2011 New Zealand earthquake, a peculiar damage was observed in the reinforced concrete (RC) shear wall structures. The damage of RC shear wall due to the bi-directional horizontal loading was observed from this earthquakes. In general, the RC shear walls are designed to resist the horizontal load in the direction of the principal axis. This design method can be used to ensure the design strength based on the elastic design. However, if the seismic design or performance is based on the inelastic behavior of the structure, the effect of bi-directional horizontal loading on the behavior must be ensured in another viewpoint.

Recently, Kabeyasawa et. Al. and Rosso et. Al. performed the test to analyze the effect of bi-directional horizontal loading on the strength and deformability of RC shear wall [1,2]. Most of the previous studies have focused on the analysis of the behavior of the RC shear wall under bi-directional loading. It is necessary to analyze the seismic capacity of RC shear wall to perform the seismic risk assessment of shear wall structures.

In this study, the seismic capacity of RC shear wall under bi-directional horizontal load was evaluated by using the cyclic loading test.

2. Test model and loading protocol

2.1 Target building selected for RC shear wall test

The various structures are located in the nuclear power plant (NPPs). (i.e. the containment building, the auxiliary building, turbine building, nuclear fuel building, etc.) In this study, the irregular RC building which have many important component was selected as target building for the cyclic loading test. The selected building was auxiliary building.

The RC shear walls were designed based on the exterior wall of auxiliary building.

2.2 Test specimens

The 10 test specimens were created considering the capacity of actuator.

The compressive strength of concrete and the yielding stress of rebar were 6,297 psi and 67,000 psi, respectively.

The RC shear walls were made as close as possible to the prototype wall as shown in figure 1. The thickness and height of wall were 0.41m and 0.93m, respectively. The length of wall was 1.2m. The foundation was made to fix at the strong floor. And the head block was installed to link the actuator in the in-plane and out-of-plane directions.

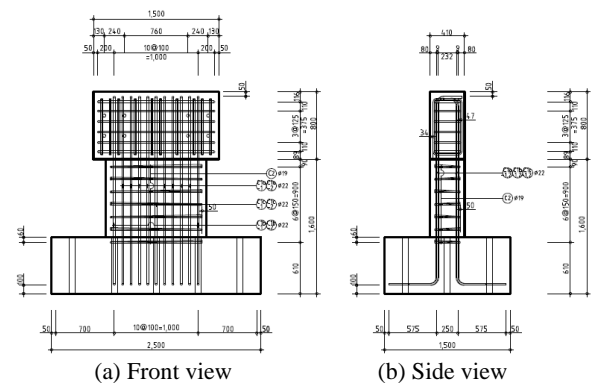


Fig. 1. Detail of test specimens

2.3 Test setup

Figure 2 shows the test setup. The in-plane loading and the out-of-plane loading was applied by the one of 3000 kN dynamic actuator and the two of 500 kN dynamic actuators. If the two actuators of out-of-plane is controlled so as to have the equal displacement, the torsion of wall can be prevent. On the assumption that the axial load is small compared to the axial stiffness of the shear wall, the axial loading was removed in this test. The displacement and force of shear wall was obtained by the linear variable displacement transducer (LVDT) and the load cell installed in actuator.

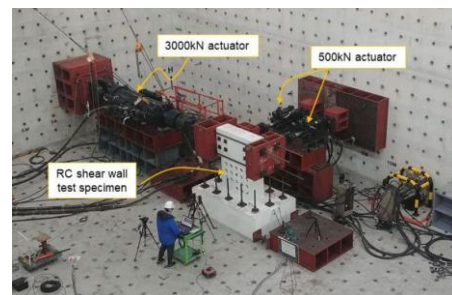


Fig. 2. Test setup for RC shear wall under bi-directional loading test

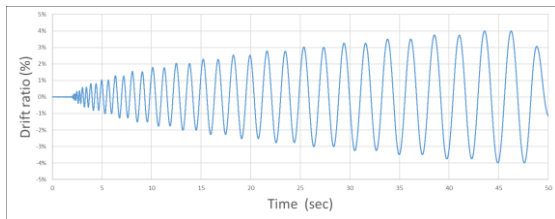
The total number of test specimens was 10. The bi-directional and fast velocity was performed with the uni-

directional and slow velocity test. The each cyclic loading test was repeated twice because the test results of RC shear wall may have different results considering the variation of concrete material.

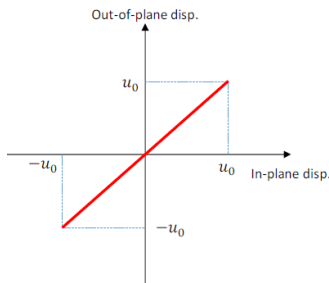
2.4 Loading protocol

In this study, the loading protocol of sine wave was used for the input motion of RC shear wall. The loading protocol of saw-tooth type is not appropriate for the fast cyclic loading test because the velocity is sharply changed at maximum/minimum displacement.

The maximum drift ratio was 4% and the maximum velocity was 125mm/s. The displacement of figure 3 (a) is simultaneously input to the in-plane and out-of-plane actuators. The bi-directional horizontal loading have can be input in various combinations. In this study, the loading was applied with in phase as shown in figure 3 (b) because the conservative results can be produced.



(a) Loading protocol



(b) Loading pattern

Fig. 3. Input motion for cyclic loading test

3. Test results

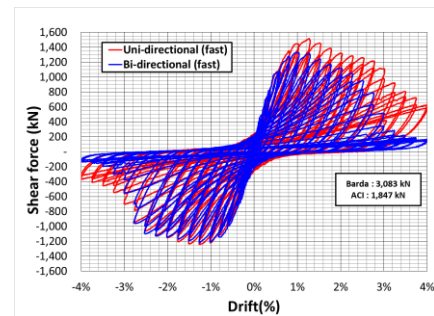
Figure 4 shows the load-displacement curves according to the loading direction and loading velocity. From the test results, it was found that the shear strength of shear wall under bi-directional loading was lower than that under uni-directional loading. The reason for this result is that the shear force in the in-plane direction and the moment in the out-of-plane direction applied. Also, the bi-directional horizontal loading caused the damage concentration at the corner of the RC shear wall.

When the loading velocity is fast, the damage is concentrated at the bottom of shear wall due to the dynamic effect. When the loading velocity is slow, the cracks in the web of shear wall are distributed. As a result, the strength reduction after maximum shear

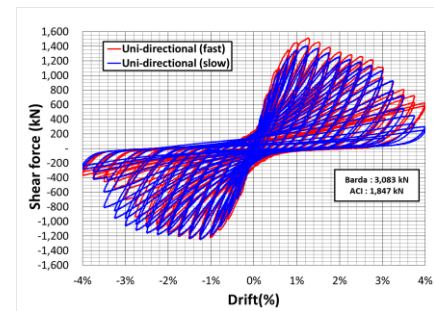
strength of fast loading condition was higher than that of slow loading condition.

4. Conclusion

In this study, the cyclic loading test was performed to evaluate the seismic capacity of RC shear wall according to the loading direction and the loading velocity. From the test results, it can be recommended that the effect of bi-directional horizontal loading is considered to design of RC shear wall. Also the fast loading test is suitable for evaluating the realistic seismic response of RC shear wall.



(a) Hysteresis curves by loading pattern



(b) Hysteresis curves by loading velocity

Fig. 4. Load-displacement curves of test specimens

5. Acknowledgement

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20181510102410).

REFERENCES

- [1] Kabeyasawa, T., Kato, S., Sato, M., Kabeyasawa, T., Fukuyama, H.m Tani, M., Kim, Y. and Hosokawa, Y., "Effect of bi-directional lateral loading on the strength and deformability of reinforced concrete walls with/without boundary columns. 10 US NCEE, 2014.
- [2] Rosso, A., Almeida, J. P., & Beyer, K. (2016). Stability of thin reinforced concrete walls under cyclic loads: state-of-the-art and new experimental findings. *Bulletin of Earthquake Engineering*, 14(2), 455-484.