Preliminary Study in Performance Evaluation of RC Shear Wall with Concrete Voids

Yongmoon Hwang[a*], Hye-Min Shin[a], Hyeon-Keun Yang[a], Jae-Wook Jung[a]
[a]*Korea Atomic Energy Research Institute, 111, Daedeok-daero 989 beon-gil, Yuseong-gu, Daejeon, 34057, Korea*
*Corresponding author: yongmoon@kaeri.re.kr

***Keywords : RC Shear Wall, Voids, Cyclic Loading Test, Diagonal Shear Cracking**

1. Introduction

Reinforced concrete structural components are widely used in conventional and nuclear power plant (NPP) structures [1-2]. The RC shear walls in NPP are designed to behave elastically under the design seismic load, and their reinforcement ratios are much larger than those of other structures.

Issues related to aging deterioration have recently received much attention in operational NPPs and continued operation NPPs. Moreover, voids in containment buildings were discovered in several countries for several reasons, such as poor construction conditions. However, previous studies are limited to performing the numerical and experimental performance of shear walls with voids and mainly deal with repair methods such as mortar or grout filling.

In this study, voids were considered as one of the physical degradation factors. A performance evaluation was conducted on each shear wall to analyze the effect of the voids. First, a case study of various parameters related to voids was performed numerically to analyze the parameters with the largest impact on maximum shear strength. Next, the shear walls with and without voids were designed based on the results of the numerical analyses. Finally, the performance of each shear wall was evaluated through a cyclic loading test, and the results were compared.

2. Numerical Analysis

Voids were identified as slight volumes in the structure but were considered to take up a certain amount of volume to identify the effect of voids. Other parameters were also considered: area, location, and angle. Here, the number of voids was fixed to one, and the analysis was performed on other variables, as mentioned before.

First, several numeral models were constructed according to the area of the void, as shown in Fig. 1, and the maximum shear strength was compared [3]. Next, the results were analyzed according to the location of the voids. It can be seen that the change in the shear strength is noticeable with respect to the diagonal shear cracking, which is one of the failure modes of the shear wall. Lastly, the angle of the voids did not have a significant effect on the shear strength of the shear wall. From the results of the numerical analysis, the critical points of each variable that have a significant impact on the shear strength were identified. Based on this, the shear wall was constructed, and a cyclic loading test was conducted. The results of the test were compared.

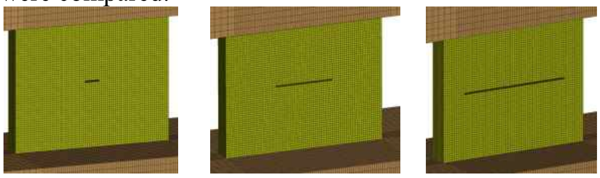
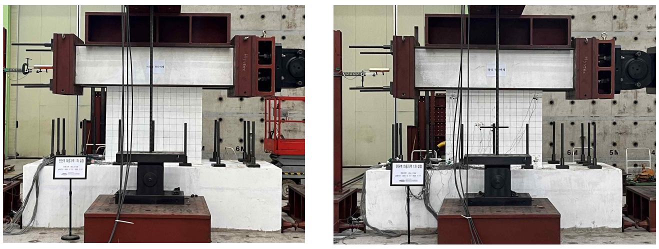


Fig. 1 Numerical Model of Shear Wall based on area [3]

3. Performance Evaluation

As mentioned before, two types of shear walls, with and without void, were constructed to perform the cyclic loading test. Fig. 2 shows the constructed each shear wall and the experimental setup. As shown in Fig. 2, the void was located at the center of the wall.



(a) without void (b) with void
Fig. 2 Experimental Setup of each shear wall

When performing the cyclic loading test, the loading protocol, as shown in Fig. 3, is based on ATC-24 and ACI 374.2R-13 [4, 5]. Three cycles were iterated for each drift ratio, and the crack propagation was measured in the last cycle of each drift ratio. For the cyclic loading test, a displacement meter and load cell were installed on the actuator. Three Linear Variable Displacement Transducers (LVDTs) were arranged as shown in Fig. 4. In addition, strain gauges were installed on the reinforcement and concrete to compare the responses (i.e., adhesion strength) according to the voids as shown in Fig. 5 and 6. The displacement-force curves of each shear wall are shown in Fig. 7.

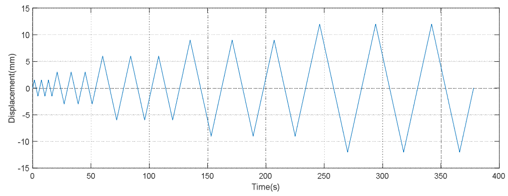
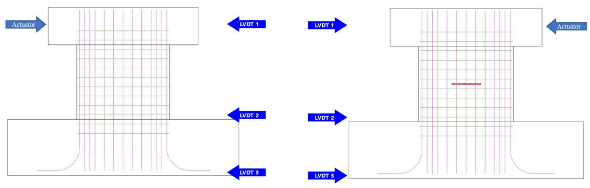
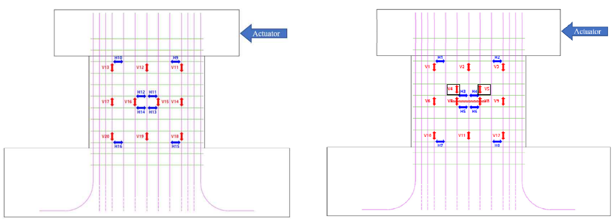


Fig. 3 Load Protocol



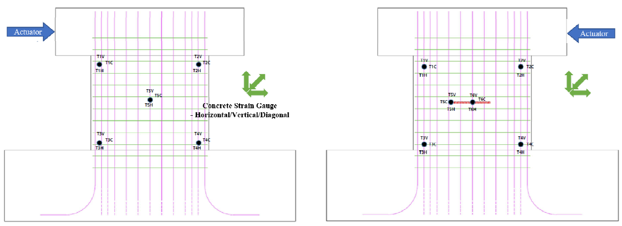
(a) without void (b) with void

Fig. 4 LVDT deployment of each shear wall



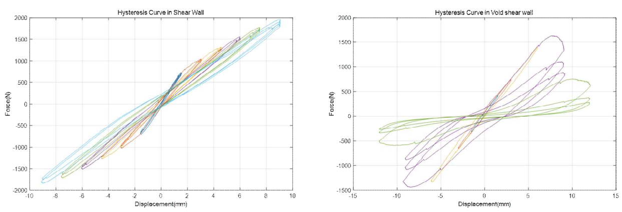
(a) without void (b) with void)

Fig. 5 Strain gauges in reinforcement



(a) without void (b) with void)

Fig. 6 Strain gauges in concrete



(a) without void (b) with void

Fig. 7 Displacement-Force Curve of each shear wall

4. Conclusion

In this study, numerical and experimental validation was performed by considering the voids as one of the degradation factors during the aging deterioration. First, parametric analyses were conducted through numerical analysis to identify the change in shear strength according to each parameter (i.e., area, location, and angle). Based on the results of the numerical analysis, the shear walls with and without void were constructed. A cyclic loading test was conducted to evaluate the performance of each shear wall. From the test, the strain responses of reinforcement and concrete were compared. In addition, the maximum shear strengths of each were also analyzed.

Acknowledgment

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. 20224B10200080).

REFERENCES

[1] Gulec, C. K. (2009). Performance-based assessment and design of squat reinforced concrete shear walls. State University of New York at Buffalo.

[2] Gulec, C. K., Whittaker, A. S., & Stojadinovic, B. (2008). Shear strength of squat rectangular reinforced concrete walls. ACI Structural Journal, 105(4), 488.

[3] Jung, J. W., Hwang, Y., & Park. J. (2023). Capacity Evaluation of Shear Wall with Concrete Voids Using Numerical Simulation. Transactions of the Korean Nuclear Society Spring Meeting.

[4] ATC-24. (1992). Guidelines for Cyclic Seismic Testing of Components of Steel Structure.

[5] ACI 374.2R-13. (2013). Guide for Testing Reinforced Concrete Structural Elements under Slowly Applied Simulated Seismic Loads. American Concrete Institute