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Seismic Retrofitting Methods for Bearing Wall-type Structures Constructed by Using Tunnel-form

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ABSTRACT

Most of existing bearing wall-type residential buildings in Korea had been built by a tunnel form method before incorporating the earthquake-resistance design in design code (1988). Since tunnel form arranges walls parallel only in one-direction, it makes the building vulnerable to a lateral force in the direction perpendicular to the wall axis. The objective of this study is to investigate the seismic performance of the wall-type structure constructed by the tunnel-form method and to suggest various retrofitting methods adding RC and masonry walls. Static cyclic tests on two-story 1/2 scale wall-type structures in Fig.1 were conducted and the lateral force resistances of the specimens were identified in terms of the strength and stiffness increases

1. INTRODUCTION

The Sendai earthquake in March 2011 has brought an increasing attention to seismic preparedness of buildings. Importance of seismic design is well described in the report by the Architectural Institute of Japan on damages by the earthquake that struck Hyogo Prefecture, the southern part of Japan, in 1995. According to the assessment of the damage extent depending on application of seismic design, it was reported that the seismic design buildings suffered significantly less damages than the non-seismic design buildings, which was the warning about importance of seismic design.

The country has also made it obligatory to take into consideration seismic design for buildings that exceed a certain building size since 1988. But such obligation to consider seismic design has not been imposed on buildings that were designed before 1988 or buildings that do not exceed a certain building size. Without any measures for seismic design, it is the reality that such buildings are exposed to risk of earthquake even in a

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relatively small scale. In particular, Korea had provided a huge number of houses that had the bearing wall-type structure with reinforced concrete, which is a unique building structure, due to housing shortage in the wake of industrialization and urbanization in the 1960s. Such construction method allows frame works that require tunnel form to maintain a short construction period. For this reason, no wall structures are placed in the direction of long side as shown in Fig. 1. As a result, plastic hinge is created in joint part when earthquake strikes, which may cause collapse of buildings with ease. Therefore, it is required to take some measures against such possibility.

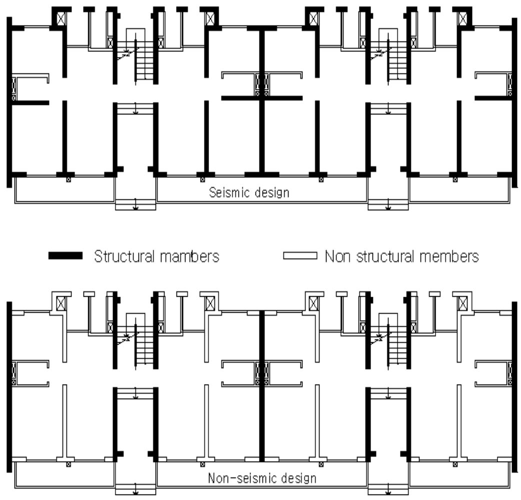


Fig. 1. Seismic and Non seismic designed on Wall-type apartment building

In general, apartment houses require However, the structures that required remodeling were constructed without seismic design considered so that they are actually predicted to suffer huge damages in case of earthquake outbreak. Despite the prediction, there are so many apartment house complexes where remodeling cannot be conducted, which urgently requires development of technology to work around such problem. In this study, we conducted the structural verification of the method to install additional shear wall that could provide seismic performance to high-rise and time-worn apartment buildings without seismic design considered after remodeling of such apartment buildings. Based on the verification, we intended to examine the performance improvement in terms of ductility and strength in the wake of retrofitting and to suggest retrofitting details, which are the purpose of this study.

2. CASE STUDY

Case study building is a residence built in 1982, and thus seismic load was not considered in the structural design. This structure can be classified to very important building because it has lived in people around the clock when earthquakes happen. But, because the structure was not designed with seismic consideration, it has not appropriate details for seismic resistance. Model structure is 30-years-old residential building 15 story building having 2.6m story height) and was built before seismic design code as shown in Fig. 2.

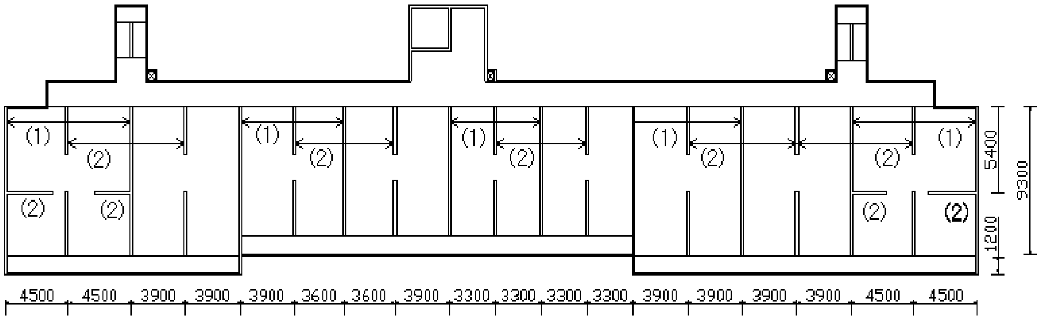
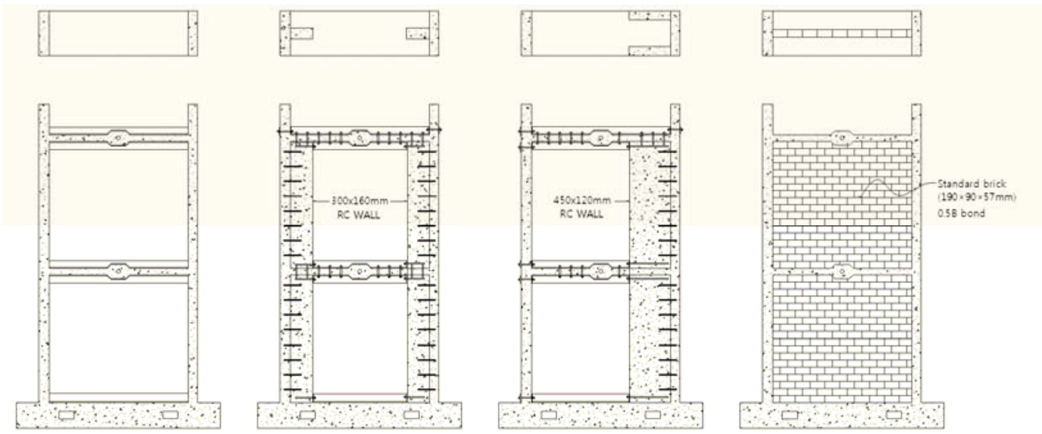


Fig. 2 Plan view of case-study building (unit:mm)

The specimens were manufactured as the model structure in 70% of the real in consideration of transport of experiment specimens and conditions of the laboratory. To this end, the law of similarity was applied to manufacturing reinforcing bars and concrete members in the reduced size.



(a) W-N (b) W-SW-A (c) W-SW-B (d) W-BW

Fig. 3 Retrofitting model for case study

In order to improve seismic performance of structures, we used the retrofitting method to improve the capability of lateral load resistance by installing additional wall to the reference specimen. We used the W-SW-A experiment specimen where walls in the size of 30cm×16cm were added and placed to the walls on the both sides of the experiment specimen as shown in Fig. 3 (b), the W-SW-B experiment specimen where the two walls in the size of 45cm×12cm were added and placed to one side as a way to improve efficiency of using plane as shown in Fig. 6 (c), and the W-BW experiment specimen where frame plane was filled with masonry walls as shown in Fig. 3 (d).

3. Test results

In the W-N experiment specimen, cracks appeared first on the slab in the slab-wall joint part in the stage 4. As the experiment went on in the stages, the cracks in the joint part expanded and at the same time, the transverse cracks also appeared in large numbers on the wall. In the stage 6, the slab on the first floor also showed cracks, which proved that the experiment specimen reached the yielding point. The lateral load on the first floor that was loaded in case of yielding was 14.5kN in the (−) direction while the maximum load was 15.89kN in the (−) direction. These values are around 41% of 26.67kN that is the required strength of structure that was obtained based on calculation of the base side shear force, which demonstrated the need for strength enhancement in the lateral direction. Test results are shown Fig. 4.

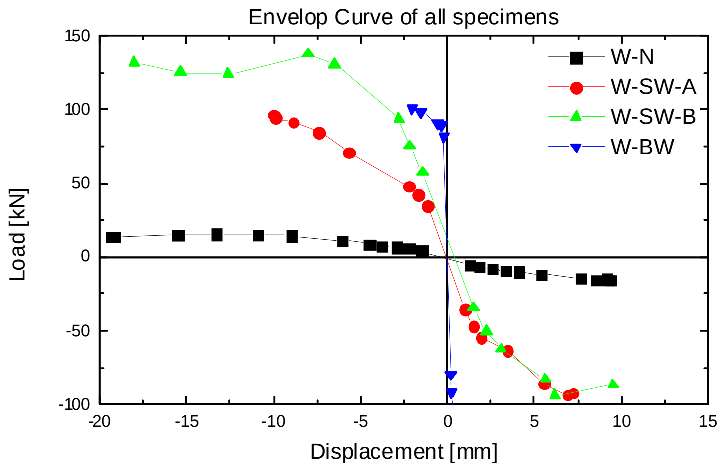


Fig. 4 Envelope curve of all specimens

4. CONCLUSIONS

The experiment brought us to the conclusions as follows.

1. The reference specimen showed the strength that was 41% less than the required strength. But all of the reinforcement experiment specimens were found to satisfy the required strength.

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