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Damping Ratio Evaluation of Steel Plate Concrete Shear Wall

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1. Introduction

In the existing research result of Akiyama et al.[1], the characteristics of dynamic behavior of the Steel Plate Concrete (SC) structure are similar to those of the Reinforced Concrete (RC) structure before surface steel plate is yielded. Therefore, the damping ratio for SC structure is recommended as 5% in JEAG-4618[2] like the same value of JEAC-4601[3], but this value is conditioned under elastic behavior of structure. This means that the damping ratio of 5% is just applied for the elastic seismic analysis, but for the inelastic behavior the hysteretic damping is naturally adopted by nonlinear seismic analysis based on JEAC-4601.

The seismic analysis based on the code requirements of Korea and the USA is performed by considering the elastic behavior of structure, and the damping ratio is to apply the energy dissipation of structure such as concrete cracking, material yielding, and connection behavior. Therefore, the damping ratio for expecting nonlinear behavior of the SC structure should be appropriately recommended through the tests regarding dynamic and cyclic behaviors.

In this research, a series of free vibration tests are performed to comparatively evaluate the damping ratio of the SC wall structure. Two types of specimens such as bending governing specimen and shear governing specimen are designed for the SC and the RC shear walls respectively, therefore total four types of structures are involved in the experimental test. The cyclic test results are also used for the evaluation of structural damping ratio. From the entire test results, the significant differences of the damping ratio between the SC and the RC shear walls are not observed.

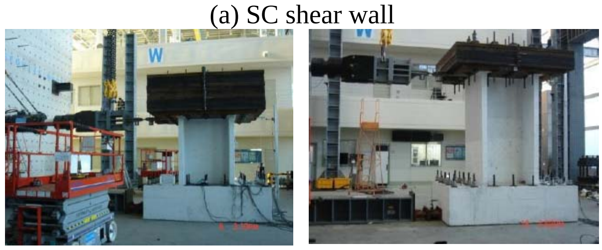
Consequently, it can be concluded that the damping ratio of the SC structure for Safe Shutdown Earthquake (SSE) level seismic analysis is the similar value with that of the RC structure.

2. Test Methods and Results

2.1 Free Vibration Tests and Results

Free vibration test method considering step relaxation is adopted for the measurement of vibration decaying data. For this test, a notched plate is used as a pulling lug of which the notch size is decided based on the static tensile test result to verify the loading level. Base slab of specimen is fixed to laboratory floor using the pretension anchors, and the steel frame is also supported laterally to prevent the lateral movement as shown in Fig. 1. Impact hammer excitation test is also carried out to measure the natural frequency before each loading step is started.

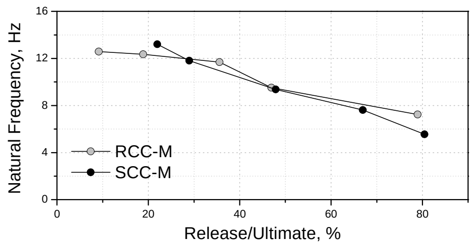
(a) SC shear wall



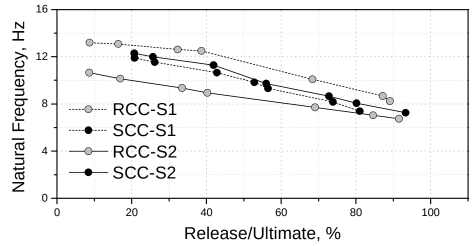
(b) RC shear wall

Fig. 1. Test setup for free vibration test

Bandwidth of natural frequencies is similarly placed to bending behavior specimens between 6 and 13 Hz for both SC and RC shear walls and shear behavior specimens between 7.5 and 13 Hz for both SC and RC shear walls as shown in Fig. 2.



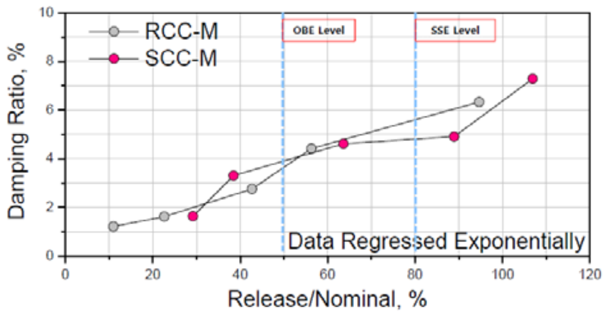
(a) Bending behavior specimens



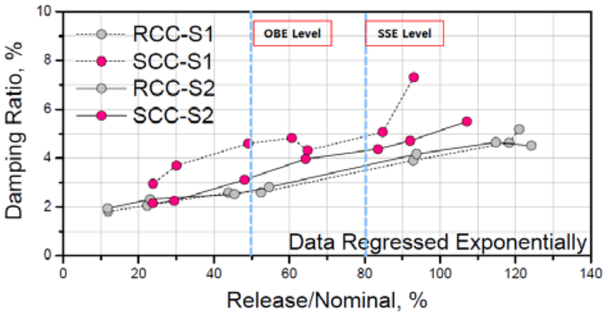
(b) Shear behavior specimens

Fig. 2. Measured natural frequencies

Logarithmic decrement, half-power bandwidth, and exponential curve fitting are applied for the evaluation of the damping ratios using free vibration test results, and the evaluation results of each SC shear wall is compared with those of the corresponding RC shear wall. Consequently, it is concluded that the damping ratios of the SC structure under SSE level have the same trend with those of the RC structure as shown in Fig. 3.



(a) Bending behavior



(b) Shear behavior

Fig. 3. Damping ratios from test data regression

2.2 Cyclic Tests and Damping Ratio Evaluation

Cyclic tests of eight (8) walls are carried out to verify the seismic performance of the SC structure as shown in Fig. 4, and a typical test result is also shown in Fig. 5.

Fig. 4. Test setup for cyclic test of SC shear wall

Fig. 6 represents results of structural damping ratio evaluation using the cyclic test data of the SC shear walls, and the results show that the damping ratios are steadily increased according to displacement increase. The result shows over 4.1% in the non-cracked concrete condition and the average value of 6.7% between concrete cracking and surface steel yielding.

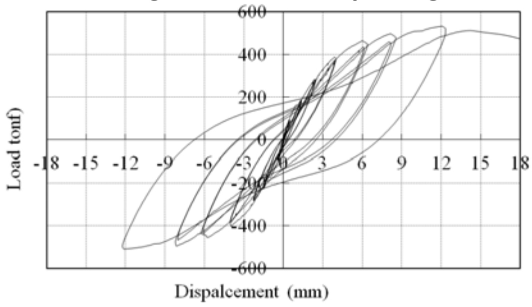


Fig. 5. Typical test result for cyclic test of SC shear Wall

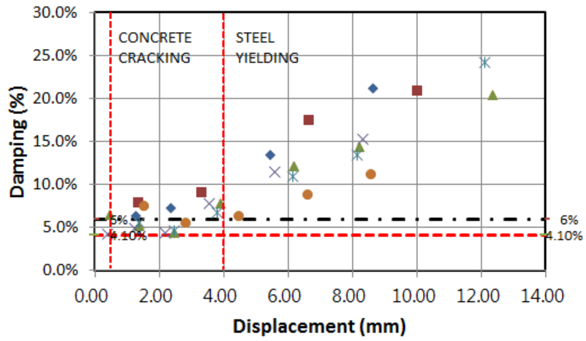


Fig. 6. Damping distribution dependent on lateral displacement of SC shear walls

3. Conclusions

In this study, a damping ratio of the SC structure is evaluated based on free vibration and cyclic test results.

According to the free vibration test results, the damping ratio characteristics of the SC structure are similar to those of the RC structure. In the cyclic test results, the damping values show over 4.1% in the non-cracked concrete condition and the average value of 6.7% between cracked concrete and surface steel yielding conditions. Therefore, it can be proposed to apply initial damping value of 4% for the non-cracked concrete condition or the nonlinear seismic analysis and the damping value of 6% before surface steel yielding.

Acknowledgement

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REFERENCES

[1] Hiroshi Akiyama et al., "1/10th Scale Model Test of Inner Concrete Structure Composed of Concrete Filled Steel Bearing Wall", 10th SMiRT, 1989, pp. 73-78

[2] Japan Electric Association, “Technical Guidelines for Aseismic Design of Steel Plate Reinforced Concrete Structures; Building and Structures", JEAG 4618, 2005.

[3] Japan Electric Association, “Technical Code for Seismic Design of Nuclear Power Plant", JEAC 4601, 2015.