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Seismic Performance Evaluation of Coupled Steel Plate Shear Wall in 3-Story Structures

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ABSTRACT

In the last several decades, coupled steel plate shear wall have become recognized as efficient lateral load resisting systems for high-rise structures, increasingly. Coupled steel plate shear walls give considerable lateral stiffness and strength as well as providing an architecturally practical structural system. In this paper, in order to observe the seismic performance of coupled steel plate shear wall, models of previous study was verified, and coupled shear wall with steel plate was carried out with various parametric analysis studies. Parametric analysis was performed with various width of bay. As a result, model that aspect ratio of steel plate was close to 1 was the most structurally safe.

1. INTRODUCTION

Steel braced frame and reinforced concrete walls have been used as the primary lateral load resisting system of high-rise structures (Driver 1997). However, steel plate shear wall can be used as a substitute for the conventional lateral load resisting system. Steel plate shear wall system offers excellent ductility and high energy dissipation capacity, and it has an advantage of reducing weight of structures by using thin plates. Therefore, it is an effective system to reduce the seismic load (Park 2004). The steel plate shear walls had been researched in U.S, Japan and Canada, primarily as seismic resisting system. However, design method of steel plate shear wall was even not established in Korea. Compared with the advantage of the steel plate shear wall system, it seems to the lack of awareness of the application construction field and the lack of research results in Korea. So, in the study, the lateral resisting performance of steel plate shear wall verified, and it was analyzed the behavior of structural system with strength of coupled steel plate shear wall and various parameters. In order to observe the seismic performance of coupled steel plate shear wall, parametric analysis

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was performed with variable of bay width of entire structures. Through the analysis, it was considered that stress distribution, strength change, aspect ratio and energy dissipation capacity can be obtained.

2. VERIFICATION OF ANALYTICAL MODEL

2.1 Summary of Verification Model

In order to consider the seismic performance of coupled steel plate shear wall, the model performed by (Choi 2005) was firstly quoted. The preceding research was conducted to the experiment that 1/3 scale of the 3 story with steel plate shear wall was applied cyclic loading, and analytical research was performed using ABAQUS6.4. However, in this study, the validity of analytical model was verified using non-linear element analysis program ANSYS.

The element used to verify was used 'Beam 189' element on column and beam; it was appropriate element that the transform on bending moments, axis-tension and torsion explained. The steel plate element was used 'Shell 181' that can accurately be predicted non-linear material behavior. Columns were connected to the node from the cross section center to flange end, and beam elements were modeled along the centerline of the beam. Also, the steel plate and beam elements were connected to an infinite rigid component. The properties applied in model was shown in Table 1, and it was used the same model as in previous research.

Table 1. Properties of verification model

Member	Grade	Section(mm)	Yield Stress(MPa)
Plate	SS400	2200x1000	235
Beam	SM490	H-150x100x12x20	325
Top beam		H-250x150x12x20	
Column	SM490	H-150x150x22x22	325

In order to consider constraints of the upper and lower plates, all nodes that were configured in the upper and lower plates was replaced with one node which represents the node. Therefore, one master node on the upper and lower plates was formed, respectively. Also, steel plates were divided 4x9 elements, and in order that beams and columns have to share the node points, beams and columns were divided 18 elements, 8 elements, respectively as shown in Fig. 1.

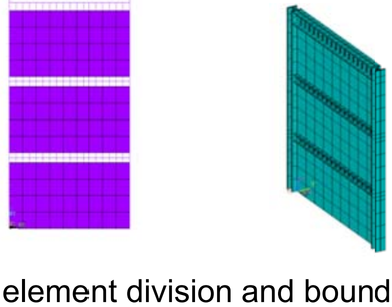


Fig.1 The element division and boundary condition

2.2 The Results of Verification Model Analysis

After completing all analysis, it was compared with yield point, displacement and maximum load of the preceding research. The error of the initial stiffness, as shown in Fig. 2, is no difference. Therefore, it was noted that the validity of this analysis was excellent, and as a result, it was deemed very appropriate that the variable analysis of coupled steel plate shear wall was to be used.

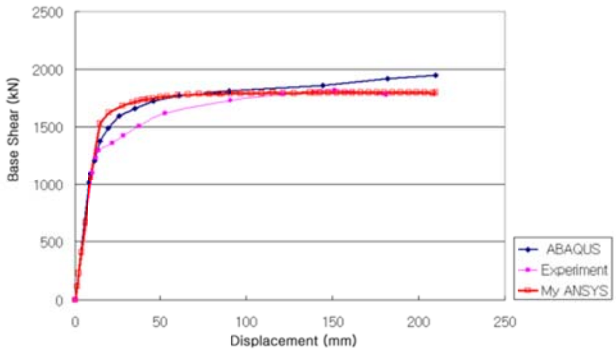


Fig.2 Comparison the curve of base shear-displacement with the preceding research

Table 2. Results of verification model

Type	Yield point (kN)	δ_y (mm)	Max Load (kN)
Experiment result	1653	15.5	1798
ANSYS	1528.8	14.9	1796
Error (%)	1.6%	4.02%	0.11%

3. SEISMIC PERFORMANCE OF COUPLED STEEL PLATE SHEAR WALL

3.1 Variable Analysis

The steel plate shear wall consisting of two openings is called coupled steel plate shear wall. It was considered that the stiffness and behavior of the coupled steel plate shear wall were affected by steel plate aspect ratio. The aspect ratio of 'D-SPSW-3N', 'D-SPSW-3M', 'D-SPSW-3W' were 0.7, 1.2, 1.5, respectively. And, the sizes of steel plate were 3050x3960mm, 4750x3960mm, 6100x3960mm, respectively.

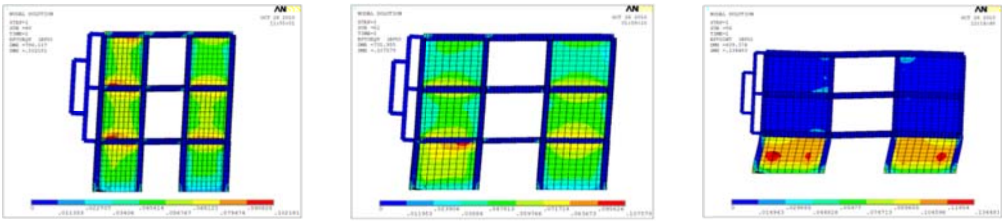
3.2 The Results of Analysis

As a result of analysis, 'D-SPSW-3M' was appeared the biggest strength among the systems, and 'D-SPSW-3W' with the aspect ratio 1.5 was appeared the lowest strength, as shown in Table 3.

Table 3. Results of variable analysis

Type	Initial yield load (kN)	Yield load (kN)	Displacement(mm)
D-SPSW-3N	5770	7250	3.17
D-SPSW-3M	7200	8480	2.93
D-SPSW-3W	6730	7660	2.94

As shown in Fig. 3, the stress distribution of 'D-SPSW-3N' was occurred the most stress concentration in 2nd floor and 3rd floor steel bottom. However, the stress concentration of 'D-SPSW-3M' was found in 1floor minutely. When comparing with 'D-SPSW-3N', the strength and stiffness of 'D-SPSW-3M' were also excellent, and the fracture pattern was almost not found in the connection. Therefore, 'D-SPSW-3N' was considered as the excellent model. As shown in Fig. 4, 'D-SPSW-3M' was also showed the most ductility and energy dissipation capacity.



a) D-SPSW-3N b) D-SPSW-3M c) D-SPSW-3W
Fig.3 The stress concentration of models

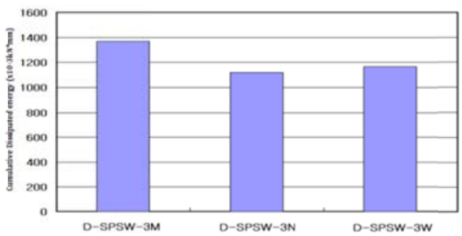


Fig.4 Comparison the energy dissertation capacity

4. CONCLUSIONS

As a result, the lower aspect ratio model was showed that the connections destroyed, and the higher aspect ratio model was showed the weakness that excessive stress concentration occurred on steel of the 1st floor. Therefore, 'D-SPSW-3N' with aspect ratio close to 1 was showed the result that it was the most structurally sound.

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