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Numerical finite element parametric study to investigate the performance of SPSW in RC frame

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ABSTRACT: Studies conducted on the performance of Steel Plate Shear Walls (SPSWs) indicate high stiffness, capacity, ductility and significant potential of energy absorption of this lateral seismic system. In this regard, using SPSWs in Reinforced Concrete (RC) structures has recently been considered by researchers. In this paper, two different connection types have been proposed and numerically investigated to connect SPSW to RC frame (RCF). In the first type connection, SPSW has been connected to RCF by a few studs through fish plates. However, in the second type, it has been connected to RCF by additional stirrups, which has been welded to the endplate. The behavior of connections has been evaluated using non-linear finite element analysis (NLFEA). A parametric study has been conducted on the thickness of SPSWs and the placement of studs and stirrups through the length of columns. Results of the specimens with different types of connections demonstrated that using both connection types leads to a prominent increase in stiffness and capacity comparing to the reference RCF. Investigating the placement of studs and stirrups showed that there is no need to use studs and stirrups in whole column height. Similar results can be obtained by connection in a length of 0.3 or 0.2 of the column clear height. The dual system behavior factor of special RCF with SPSW was estimated to be 8.

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1. INTRODUCTION

In recent decades application of SPSW as a lateral load resisting system is taken into consideration, especially in medium and high-rise buildings. Major experimental and analytical studies was toward SPSW in steel frame. However, the idea of using thin SPSW has been considered by Timler and Kulak in Alberta university for the first time, which was based on plate girder theory [1].

Recent researches show that composite SPSW and SPSW with and without stiffeners have sufficient stiffness for controlling lateral displacement, ductile failure mechanism and high energy absorption [2-7]

In this paper, two connection methods have been investigated numerically to connect infill plate to RCF. In the first connection method, SPSW has been connected to the beams and columns through embedded studs. However, in the second method of connection, additional stirrups transfer the loads between SPSW and RCF. This parametric study aims to investigate the effect of partial connection of SPSW to RCF on the capacity, stiffness, ductility and behavior factor of the system. In this regard, full connection has been compared to three different lengths of connection. Three different thicknesses have been investigated, as well.

2. FE MODELING AND VERIFICATION

To verify the finite element model (FEM), SPIW1, which is one of the experimental models of Choi and Park [8], is selected. The selected specimen is a three-story one-bay one-third scale RCF with thin SPSW. Geometrical details of experimental specimen have been illustrated in "Fig. 1".

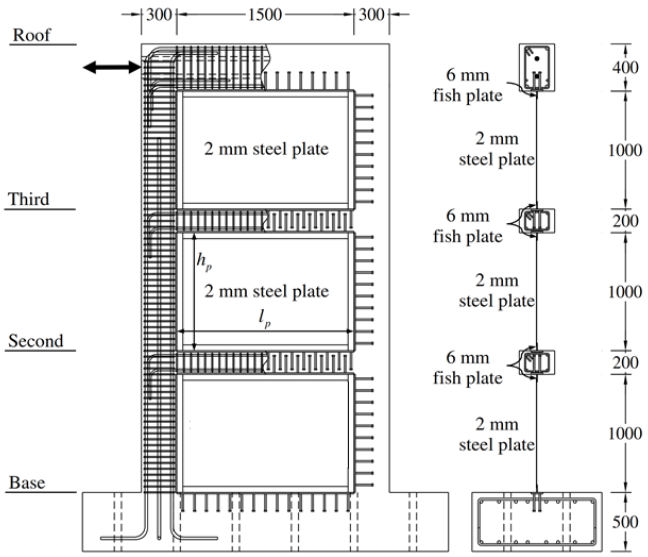

Fig. 1. Details of experimental specimen (mm) [8]

The load-story drift ratio curve for FE model has been compared to that of experimental specimen, in "Figure

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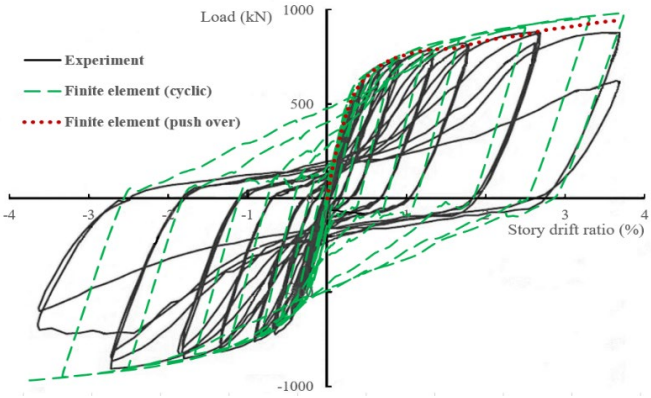

Fig. 2. Verification of experimental specimen

Table 1. Characteristics of investigated models (mm)

Connection Type	Thickness of SPSW	Abbreviation for different connection Types			
		Full column length connection	100 mm in two ends of column	200 mm in two ends of column	300 mm in two ends of column
Stud	t= 1.5	Stud-U-1.5	Stud-100-1.5	Stud-200-1.5	Stud-300-1.5
	t= 2.0	Stud-U-2.0	Stud-100-2.0	Stud-200-2.0	Stud-300-2.0
	t= 2.5	Stud-U-2.5	Stud-100-2.5	Stud-200-2.5	Stud-300-2.5
Stirrup	t= 1.5	Stir-U-1.5	Stir-100-1.5	Stir-200-1.5	Stir-300-1.5
	t= 2.0	Stir-U-2.0	Stir-100-2.0	Stir-200-2.0	Stir-300-2.0
	t= 2.5	Stir-U-2.5	Stir-100-2.5	Stir-200-2.5	Stir-300-2.5

2". As it is observed in this Figure, in both cyclic and push over analysis, there are a good agreement between analytical and experimental specimens. However, there are complete agreement in the linear parts of the experimental and analytical model in the both cyclic and push over analysis. Analytical maximum load carrying capacity over corresponding value of the experimental specimen is 1.05, which shows only 5% difference.

In this article for investigating the performance of SPSW in RCF, two connection methods have been used. Both methods are applicable to new structures. Under consideration, parameters are the thickness of the infill plate and length of connection between the RCF column and SPSW. For considering the thickness of the infill plate three values of 1.5, 2.0 and 2.5 have been considered. However, for considering different values for the second parameter, a full connection between RCF column and SPSW and 100, 200 and 300 mm connection in both sides of the column have been selected. In Table 1, characteristics of all specimens are presented.

3. RESULT AND DISCUSSION

Comparison of the load-displacement behaviors of specimens for all the thicknesses for both stud and stir connections in full and partially connected specimens illustrates proper compatibility in the same thicknesses.

In the stir specimens, the maximum load-carrying capacities for the specimens with 2.5 and 1.5 mm thickness of the infill plates show 11.63% increase and 12.73% decrease regarding the corresponding value of the specimen with 2 mm thickness, respectively. However, in the stud specimens, the maximum load-carrying capacities for the specimens with 2.5 and 1.5 mm thickness of the infill plate illustrate 13.82% increase and 14.76% decrease in comparison with corresponding value of the specimen with 2 mm thickness, respectively.

4. CONCLUSION

In this paper, performance of SPSW in RCF by two different connection methods has been investigated.

SPSW connected to RCF via studs and additional stirrups. Understudy parameters were the thickness of infill plate, which varied by values of 1.5, 2 and 3 mm, and the length of connection between RCF columns and SPSW. The results are:

- The specimens with additional stirrup show higher ductility and stiffness regarding to the corresponding stud specimens. The average ductility of the specimens are 1.76 and 1.34 times larger than the reference RCF, respectively. The elastic stiffness of mentioned specimens are 16.57 and 10.58 times larger than the reference RCF, respectively.

-The average behavior factor of RCF with SPSW has been estimated equal to 8.

- The related results of the both stir and stud specimens with 200 and 300 mm length of connection, between the infill plate and RCF columns, show good compatibility with the corresponding value of the full connected specimens. It shows that, the connection in 0.2 to 0.3 length of the columns can be substitute with full-length connection of the columns.

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