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Studding the Behavior of Semi- supported Steel Shear Wall against Monotonic and Cyclic Loads

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ABSTRACT: The formation of a plastic hinge at the bottom of steel shear wall columns can lead to a total collapse of the structure. To overcome this defect, Semi-supported Steel Shear Wall systems (SSSWs) are introduced. In these systems, boundary columns are separated from the mainframe columns with a specific distance and only tolerate the lateral seismic forces. So, even these columns experience plasticity, the mainframe does not experience any damages. Evaluating the behavior of SSSW is restricted to some limited laboratory studies. Since the experimental evaluation of the effects of factors such as wall web thickness, web stiffness (one or both side), and the shape of boundary element is too much expensive, in this paper the effect of the aforementioned parameters on elastic stiffness, energy absorption capacity, ultimate strength and ductility is evaluated by finite element simulation. First, the numerical model is verified and the other models have been produced based on the verification model. Based on numerical simulation the results show that changing the shape of boundary columns does not affect the linear and non-linear response of SSSWs. But using vertical and horizontal web stiffness in one or both sides of the shear wall plus using mid-span secondary column increases the elastic stiffness, energy absorption capacity, ultimate strength while decreases the ductility due to increasing the-out-of plane stiffness of the shear web plate. Moreover, increasing web panel thickness from 2 to 4 mm, increases the elastic stiffness, energy absorption capacity, ultimate strength, and ductility.

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1- Introduction

The use of steel shear walls as three-way and two-way sheets to resist lateral forces such as earthquakes and winds in buildings, especially high-rise buildings, has been considered. The system was harder than the toughest x-shaped braking systems to shear stiffness, and with the ability to create pop-ups anywhere, it has the potential to perform all bracing systems in this respect [1]. Also, use of the steel shear wall as an effective seismic lateral load system in efficient seismic Improvement to increase the lateral strength of the building stiffness against the Earthquake, considered in concrete and steel structures. This system has good stiffness to control the deformation of the structure as well as the ductile fracture mechanism and high energy dissipation. Ways to reinforce walls are to improve their buckling behavior by installing horizontal and vertical stiffener on one or both sides of the wall web, modifying the secondary column cross-section, and adding the middle secondary column. One of the strategies to improve the performance of the steel shear wall is to remove the vertical wall boundary element from the main columns of the building. For this purpose, with space to the main column (gravitational and lateral load system column), two secondary columns are run as vertical shear wall elements. Such a system is called a “Semi-supported Steel Shear wall” system or SSSWs [2, 3].

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2- Methodology

In this study, the laboratory model of Moharram and Habibnejad, whose information is provided in reference [4], was used to generate the Verification model. ABAQUS finite element software, under Pushover and cyclic loading, was used for numerical simulation and nonlinear analysis of the samples. The main purpose of this paper is to investigate the influence of various factors such as the type of boundary column cross-section in both UNP and IPE modes, the simultaneous use of stiffener on the wall web (one and two sides web) with the edge element, the effect of the presence of an additional vertical secondary column in the center of the shear panel on the behavior of SSSWs. As shown in Fig. 1,

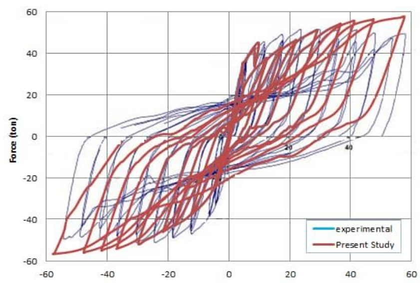

Fig. 1. Hysteresis curve of the laboratory model and the numerical model of the present paper

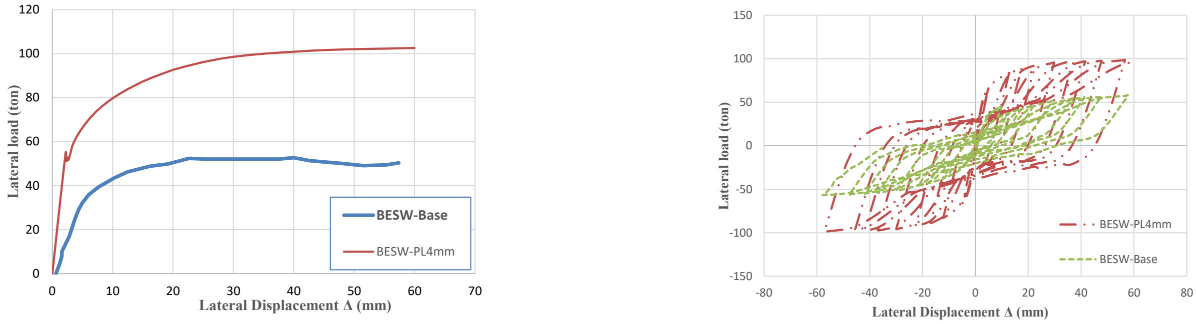

Fig. 2. The effect of web thickness on hysteresis (right) and pushover curves (left)

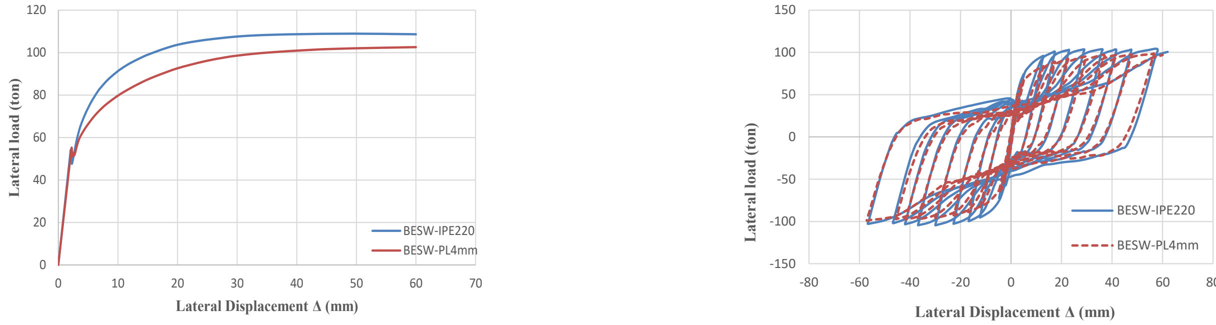

Fig. 3. The effect of boundary element section on hysteresis (right) and pushover curves (left)

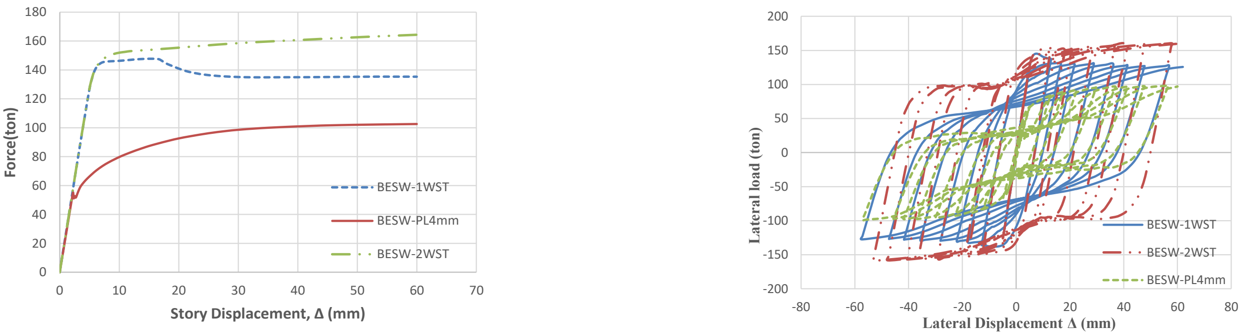

Fig. 4. The effect of stiffneres on hysteresis (right) and pushover curves (left)

the numerical model cycle diagram is in very good agreement with the reference laboratory results [4].

3- Results and Discussion

To investigate the effect of web thickness on linear and nonlinear wall behavior, two BESW-Base models (2 mm thickness verification model) and 4 mm thickness (BESW-PL4) models are considered. The two models were then loaded under Pushover loading up to 60 mm (displacement control) and Fig. 1(a) was obtained. Besides, by cyclic analysis of the specimens as a result of cyclic loading, the cyclic diagram is obtained in Fig. 2(b). In the following, the BESW-IPE220 model, 4 mm web thickness, and IPE220 secondary column section were considered and the results were compared with BESW-PL4mm with 2UNP120 secondary columns (see Fig. 3(a) and Fig. 3(b)). To investigate the effect of stiffeners, both BESW-1WST and BESW-2WST models are considered (see Fig. 4(a) and Fig. 4(b)). Also, to assess the effect of the additional middle column, both BESW-RMC and BESW-PL4mm models have been considered ((see Fig. 5(a) and Fig. 5(b)).

4- Conclusion

1. Increasing web thickness from 2 to 4 mm increases initial stiffness, ductility, and energy dissipation capacity. The power dissipation capacity for the 4 mm plate model was 97% higher than that of the 2 mm plate model.

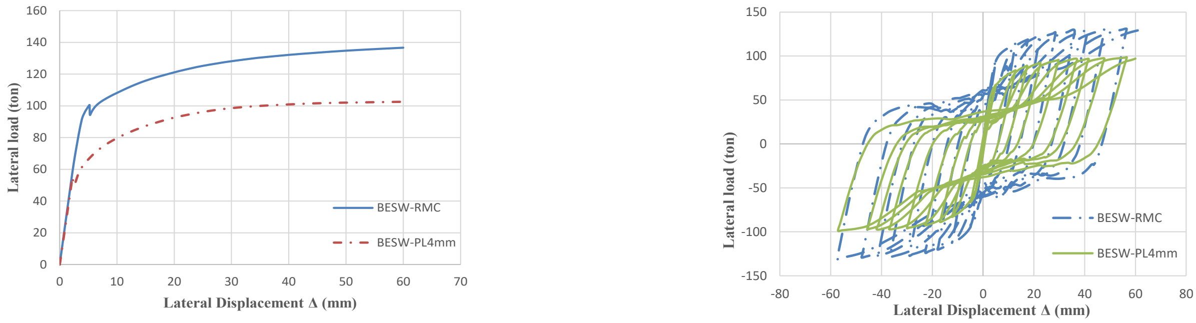

Fig. 5. The effect of adding middle column on hysteresis (right) and pushover curves (left)

2. Changing the profile type (without changing its area) has little effect on the performance of the SSSW system.

3. By installing stiffeners on one and both sides of the plate and the addition of the middle secondary column, the initial stiffness, ultimate strength, and energy dissipation increased, and the transient ductility decreased.

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