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Study of Seismic Behavior of Steel Plate Shear Walls with Vertical and Inclined Stiffeners

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ABSTRACT: Steel shear wall is one of the most common systems which are suitable to provide strength and stability against seismic lateral loads. In this system, vertical boundary elements around the shear wall, in addition to being part of the lateral load-resisting system, are responsible for bearing the weight of the structure during and after the earthquake. Therefore, in designing this system the boundary elements are desired to remain elastic after the complete yield of the web plate. Also, to provide uniform stress along the length and height of the wall, vertical and horizontal boundary elements must have high flexural stiffness. To reach this goal, the code provisions sometimes lead to the selection of non-economic sections for the beams and columns attached to the wall. In this study, To reduce the demand for vertical boundary elements attached to the wall and to make the design economical, vertical and inclined stiffeners are predicted inside the wall. These stiffeners redirect the plastic deformations mainly into the wall and away from the columns. To evaluate and compare the behavior of the proposed model, 30 finite element models were studied under lateral monotonic and cyclic loading. The results show that the addition of stiffeners, in addition to increasing the stiffness and lateral resistance of the system, increases the ductility of the lateral load resisting system and reduces the required flexural stiffness of horizontal boundary elements.

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1- Introduction

Steel plate shear walls are among the lateral load- resisting systems, which are formed of a steel plate and surrounding frames [1]. The behavior of this type of system is such that the tensile fields are formed in the middle parts of the steel sheet first, then the plate panel- enters the nonlinear region, along with the plasticization of the plate [2], which will consequently spread throughout the plate and results in stress concentration at the wall corners.

In 2020, Farzampour and his colleagues [3] studied the effects of boundary conditions of the infill plate on the overall performance of steel shear walls with circular openings. And they concluded that any increase in dimensions leads to a decrease in final strength, stiffness, ductility, and energy absorption compared to the effective height of the wall.

In 2022, Y. Du, Y. Shao et al.[4] presented a method for strengthening damaged shear walls, in which diagonal stiffeners are used to strengthen the damaged shear wall. Experimental tests showed that the remaining deformation of the midframe steel sheets can be removed by installing additional ribs along with increasing the tension of the steel sheet.

In this research, the behavior of steel shear wall with a special arrangement of vertical and inclined stiffeners has been investigated. To compare the performance of the proposed system, the seismic behavior of structures including 3-story and 5-story structures with conventional samples have been compared. For this purpose, two separate models were modeled with and without stiffeners. In the proposed model, inclined and vertical stiffeners are added to the shear wall so that the stiffeners of the first floor are modeled obliquely and the stiffeners of the second and third floors are modeled vertically.

2- Methodology

To investigate the behavior of the steel shear wall with the proposed stiffeners, finite element models have been used for analysis and investigation.

2- 1- Specifications of the proposed model

In this research, vertical and inclined stiffeners have been used to improve the seismic behavior of the shear wall. In the proposed steel shear wall, it is expected that the addition of the stiffeners, shown in Figure 1, will affect the orientation of the tensile fields resulting from out-of-plane buckling of the wall sheet and reduce the amount of plastic strains at the beam-to-column junction. affect the demand created in the

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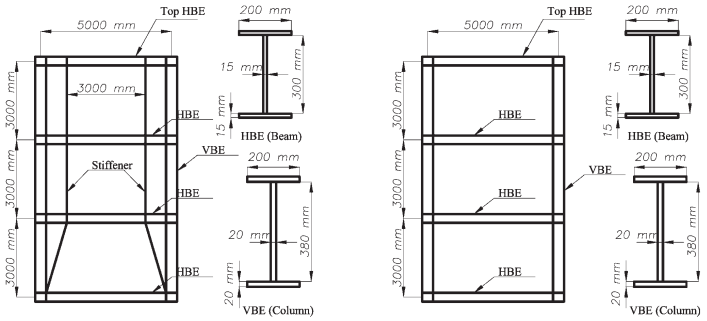

Fig. 1. Steel plate shear wall a) Shear wall sample without stiffener b) Shear wall sample with the proposed stiffener

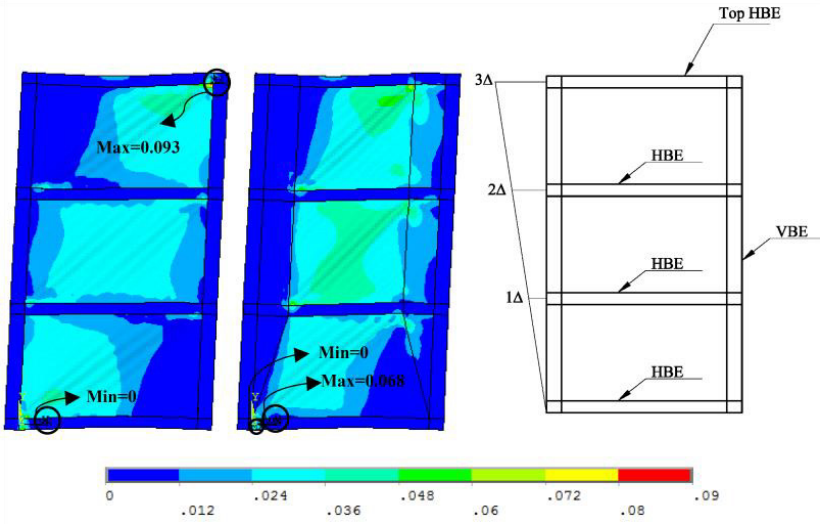

Fig. 2. Plastic strain values in two models with stiffener (3S-t2) and without stiffener (3NS-t2) in 5% drift

columns.

3- Results and Discussion

According to AISC-341[5], To create a uniform stress in the entire plate and also its uniform yield, the moment of inertia of the beam and column should be selected so that equations 1 and 2 are satisfied. In these equations, L is the center-to-center distance between the two columns. According to equation 2, the value of the moment of inertia required for the beam has a direct relationship with the fourth power of L, and with the increase of the length of the span, the moment of inertia increases significantly. In some cases, this issue may make the project uneconomical. In the proposed model, by placing vertical stiffeners, the free length of the beam is reduced, and instead of the distance between the columns, the distance between the stiffeners can be replaced by the length of the beam in relations 1 and 2. In this way, the moment of inertia required for the beam is significantly reduced.

$$1.\ I_c \geq \frac{0.0031 \times t_w \times h^4}{L}$$

$$2.\ I_b \geq \frac{0.0031 \times t_w \times L^4}{h}$$

Figure 2 shows the Von-Mises plastic strain in models 3NS-t2 (without stiffener) and 3S-t2 (with stiffener) under 5% drift. In models with stiffeners, if the variable L in equation 2 is replaced with the distance between the stiffeners, this equation is satisfied.

4- Conclusion

In this research, To reduce the minimum required moment of inertia for beams in steel shear walls, vertical and oblique stiffeners have been used. So by placing the suggested stiffeners, the minimum moment of inertia required for the beams is reduced.

In steel shear walls, To create uniform tension in the entire sheet and also its uniform yielding, limits for the moment of inertia of beams and columns have been placed in various regulations, including AISC, and this sometimes causes the design to become

uneconomical. so that relatively large sections are required for beams and columns. In the proposed model, due to the placement of stiffeners, the effective length of the beam is reduced, so the results show that To calculate the minimum moment of inertia required for the beam, instead of the total span length, the free length between the stiffeners can be used in the relationships. should be used, in which case the required moment of inertia for the beams is reduced.

References

[1] M. Azhari, Rasoul Mirghaderi, Design of steel structures, Arkan Danesh, 2018 (in persian).

[2] H. Valizadeh, H. Veladi, B.F. Azar, M.R. Sheidaii, The cyclic behavior of Butterfly-shaped Link Steel Plate Shear Walls with and without Buckling-restrainers, in: Structures, Elsevier, 2020, pp. 607-625.

[3] N. Paslar, A. Farzampour, F. Hatami, Investigation of the infill plate boundary condition effects on the overall performance of the steel plate shear walls with circular openings, in: Structures, Elsevier, 2020, pp. 824-836.

[4] Y. Du, Y. Shao, L. Zhong, Repairing damaged steel plate shear wall with additional ribs, in: Structures, Elsevier, 2022, pp. 222-234.

[5] S.C. Manual, American institute of steel construction, Inc., Thirteenth Edition, First Print, (2005).

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