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A Survey on Parameters Affecting the Lateral Behavior of Composite Shear Walls

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ABSTRACT: In this paper lateral behavior of composite shear walls is studied. The composite wall consists of a steel shear plate and a concrete cover connected together with a suitable mechanical means such as studs or bolts. The most important role for the steel plate of a composite shear wall is to increase stiffness and ductility while that of the concrete cover is to prevent buckling of the steel plate. The focal point in this study is to assess the variables affecting the lateral behavior of such walls, such as thickness of plate, thickness of concrete cover, spacing between the connectors and strength characteristics of concrete and steel. For modeling of the nonlinear behavior, material and geometric nonlinearities and large deformations are considered within the Abaqus software. According to the results of analysis, thickness of the steel plate proves to be the prime factor affecting lateral strength of the wall. On the other hand, lateral stiffness of the wall proves to be independent of the thickness of the concrete wall, spacing of the shear studs, and the compressive strength of the concrete cover. The study is distinguished from similar studies for the number of parameters studied and the extensive range of their values, detailed modeling of all components, and presenting the lateral behavior of the composite shear wall against the mentioned parameters.

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1- Introduction

Composite shear wall is a relatively new structural system as an extension of the steel plate shear walls. It is comprised of a thin steel plate covered on one or both sides by a reinforced concrete cover. The concrete cover is used to prevent the steel plate from premature buckling hence to make it more ductile and stronger against lateral forces. This is the only role of the concrete cover. In other words, no portion of the lateral force is assigned to the cover by terminating it just before the peripheral beams and columns.

In continuation of past studies on such systems [1-5], in this paper the one-sided non-linear lateral behavior of composite shear walls is studied. Several parameters are considered for this purpose. They are including the thickness and compressive strength of concrete, thickness of the steel plate, and spacing of the shear studs. Effects of each of the above parameters on the lateral stiffness, strength, and ductility of the system are investigated by changing their values within the conventional ranges.

2- Methodology

The non-linear modeling and pushover analysis of the specimens are performed using ABAQUS [6]. To verify the validity of the non-linear model, first the results of an available experimental study on a similar system are utilized. For this purpose, the experimental sample of Zhao and Astaneh-Asl [2] is selected. It is shown in Figure 1.

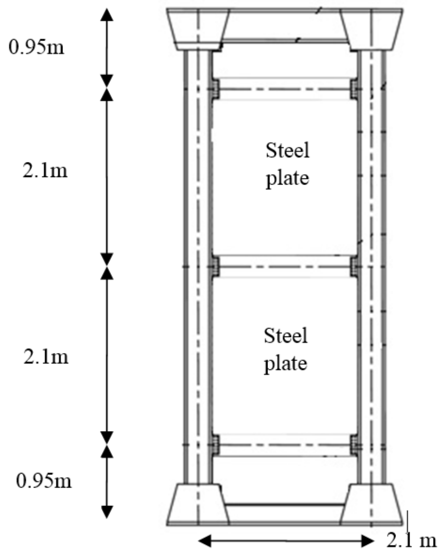

Figure 1. The experimental set-up of Zhao and Astaneh-Asl [2]

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Characteristics of the sample and the materials used in modeling of the mentioned wall are listed in Tables 1-3.

Table 1. Dimensions of the experimental wall (mm)

Column section	Beam section	Bolt diameter	Concrete cover			Plate thickness
			Rebar spacing	Rebar diameter	Thickness	
W12×120	W12×26	13	100	10	76	4.8

Table 2. Properties of concrete

Compressive strength (N/mm^2)	Tensile strength (N/mm^2)	Elastic modulus (N/mm^2)	Poisson's ratio
28	2.6	24,900	0.17

Table 3. Properties of steel

Element	Ultimate strength (N/mm^2)	Yield Strength (N/mm^2)	Elastic modulus (N/mm^2)	Poisson's ratio
Beam and column	500	345	200,000	0.3
Steel plate and rebars	370	248	140,000	0.3
Bolts	823	623	200,000	0.3

The beams and columns and the steel plate are modeled by shell elements. The concrete cover is modeled using the three dimensional solid elements. The reinforcing steel and the shear studs within the concrete cover are modeled by the wire element. The element dimensions are sufficed to be 100 mm. Number of the elements of the concrete cover, steel plate, beams, and columns is 1584, 874, 703, and 1512, respectively.

Figure 2 shows the force-displacement curve of the mentioned system by analysis and by experiment. A very good accuracy in the envelope behavior is observed.

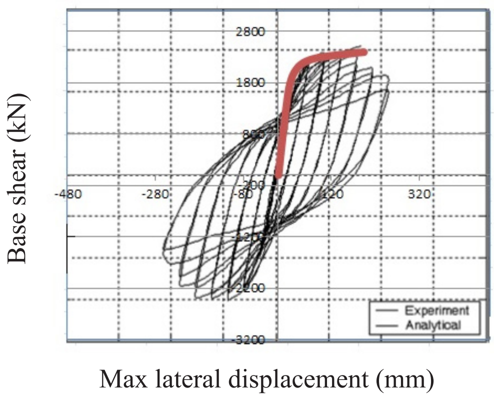

Figure 2. Comparison of the Lateral behavior of the test specimen of Zhao and Astaneh-Asl

3- Results and Discussion

Several characteristics of the system are selected for parametric study. Thickness of the steel plate is varied between 1- 6.5 mm, thickness of the concrete cover between 30-75 mm, spacing of the shear studs between 150-750 mm, and compressive strength of concrete is varied between 14-35 Mpa. In each case the non-linear modeling of the system is conducted similar to Sec. 3. The force-displacement cure is drawn for all of cases and variations of the lateral stiffness and strength and the ductility factor of the system are investigated. As an example, Figure 3 shows the results of analysis for a composite shear wall comprising of a steel plate with different thicknesses, a concrete cover being 75 mm thick, shear studs at a 300 mm spacing, and an ultimate strength for concrete being 28 Mpa.

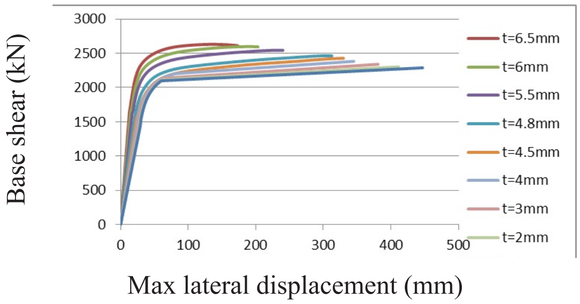

Figure 3. Lateral behavior of the composite shear wall for different thicknesses of the steel plate

4- Conclusions

The lateral behavior of composite shear walls was studied in this paper. Through a parametric pushover analysis, 9 values were taken for the thickness of the steel plate, 5 values for the thickness of the concrete cover, 5 values for shear studs spacing, and 5 values for the compressive strength of the concrete cover.

It was resulted that:

1. Lateral stiffness of the composite shear wall is practically a function of the thickness of the steel plate only.
2. Thickness of the steel plate is again a prime factor in determining the lateral ductility of the system.
3. Increase of the distance between the shear studs results in reduction of the lateral strength of the system.
4. There are certain bounds over which change of the values of the influencing parameters has also no effect on the values of the lateral characteristics of the system.

References

[1] M. Azhari, S.R. Mirghaderi, DESIGN OF STEEL STRUCTURES (LRFD-ASD), published by arkan-danesh, Volume 4: Seismic Design, 2013. (in Persian).

[2] T. Yamakaji, M. Yamada, Resisting Characteristics of Hybrid Center Core Shear Wall Systems, Steel Profile, 30 (2000) 30.

[3] Q. Zhao, A. Astaneh-Asl, Seismic behavior of composite shear wall systems and application of smart structures technology, Steel Structures, 7 (2007) 69-75.

[4] F. Hatami, A. Rahaei, Behavior of composite shear walls under seismic loading, Journal of Sharif University of Technology, No. 46, pp 21-31. (2009).

[5] M. Husem, S. Pul, E. Yozgat, S.E. Gorkem, Fracture of connections between steel and reinforced concrete shear walls under the cyclic loading, Iranian Journal of Science and Technology. Transactions of Civil Engineering, 36(C1) (2012) 97.

[6] A. Ayazi, H. Ahmadi, S. Shafaei, The effects of bolt spacing on composite shear wall behavior, World Academy of Science Engineering and Technology, 6 (2012) 10-27.

[7] D. Systèmes, Abaqus analysis user's manual, Simulia Corp. Providence, RI, USA, (2013).

[8] F. Behnamfar, E. Shakeri, A. Makhdoumi, A macromodel substitute for simple prediction of the lateral behaviour of composite shear walls, Bulletin of the New Zealand Society for Earthquake Engineering, 51(3):115-126,2018.

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