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The Effect of Flange Thickness on the Behavior of Flanged-Section Shear Walls

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Abstract

This paper investigates the effect of flange thickness on nonlinear behavior of flanged shear walls. Four T shape flanged shear walls are studied and analyzed using finite element method. The total volume of each model is similar, such that when thickness decreases in the model, the length of wing increases. The results indicate that in the presence of lateral loads, the thickness has a significant effect on the shear absorption, ductility, displacement and crack pattern of the flanged shear walls. Numerical results show that shear walls with thick flanges behave more efficient than walls with thin flanges. For instance, lateral strength resisted by shear walls with thin flanges is 1250 kN which is 14 percent decrease compared with thick flanged wall. Moreover, nonlinear behavior of flanged shear wall with thick flanges shows that strength and ductility are equivalent. Finally, the analyses indicate that while flange is in pressure, the global behavior is much more improved compared with condition which is in tension.

Keywords: Flanged shear wall, Nonlinear behavior, Lateral load, Finite element

1. INTRODUCTION

In the recent decade, shear walls in the medium and high-rise reinforced concrete buildings for the sake of interaction with the lateral forces, used by many of the engineers. However past studies on the behavior and situation of the shear wall indicated that shear walls with flange has better behavior. And this is due to interaction of flange and wall web. The effect of flanged shear wall in the control of

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displacement and simultaneous is similar to the performance in the tension and pressure declared advantages of flanged shear walls.

The effect of this kind of system (flanged section) is similar to the T-shaped beam that results in increasing the ductility of shear wall. For instance I-shaped shear wall was studied by the Vecchio and Palermo (2002), investigated under the cyclic displacement. They tested the effects of flange and axial load. Finally they understand that existence of the flange in improvement of structural behaviour is very useful. Another kind of flanged shear wall that study by the Kheyroddin and Mortezaei (2004) is T-shaped shear walls. Results of this study show that T-shaped shear wall has a better behavior in pressure and tension and controlling of displacement in compared with the rectangular wall. This research indicated that flanged walls improve the seismic behavior. In the other research they, investigated the effect of tensional stiffener in the flanged shear walls, with the NONLACS2 software (1996), that developed by the Kheyroddin(1996). Thomson and Wallace (1995) also with several tests on the T-shaped shear wall understand that, when flange wall is in the tension, has less ductility compare with the shear wall under pressure. The Authors (Khatami and Kheyroddin 2010) investigated flanged section shear walls with pushover analysis. In the research, T shape shear wall had better behaviour in static nonlinear analysis.

Mortezaei and Khatami (2009) also presented a paper about flanged section shear wall in the irregular buildings of the reinforced concrete. They introduced different kind, shapes of this building, and finally concluded that Z-shape shear wall has the better behaviour in the irregular building. Mohammad (2002) studied afterwards a numerical study on a hybrid shear wall system under cyclic load by finite element. The recent work has been done by laboratory. Flange of T shape shear wall, for the sake of interaction with the boundary element performed such as cantilever beam. Effect of long of flanged walls under the seismic loads is the main purpose of this paper, in this paper of analyses nonlinear are performed. Figure1 shows one model of T-shape flanged section shear wall.

Figure 1: Flanged section shear wall.

2. MODEL Analysis

Four T shape shear walls are selected for investigating the influence of length and thickness of flange on the nonlinear behavior.

Shear walls were analysed by finite element program. All of T shape shear walls had a web with thickness of 100 mm and height of 2000 mm. Displacement of the flanged of T shape shear wall figure and their size selected in such situation that surface of section in all of the walls is equal. With increasing of flange length, width increased. Because volume of usable concrete can be remain constant. Shear walls are under lateral load that applied on the upper slab. Dimensions of web and flange are in Table1.

Table 1. Dimensions of web and flange

Kind of shear wall	Web dimension(mm)	Flanged dimension(mm)
2500TSW	3000*2000*100	2500*2000*125
2700TSW	3000*2000*100	2700*2000*115
2900TSW	3000*2000*100	2900*2000*105
3100TSW	3000*2000*100	3100*2000*100

Both models made in the finite element program. Walls have been modelled and meshed by rectangular mesh. Each of meshes is eight-node element (Figure2).

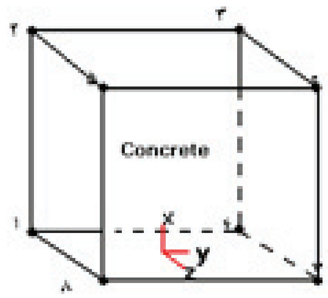


Figure 2. Eight-node element

The two input strength parameters, ultimate uniaxial tensile and compressive strength, were needed to define a failure surface for the concrete. The ratio for the concrete was assumed to be 0.2. The shear transfer coefficient of closed crack is 0.9 and open crack is 0.25.

For the compressive uniaxial stress- strain relationship of concrete used stress-strain curve in figure 3.

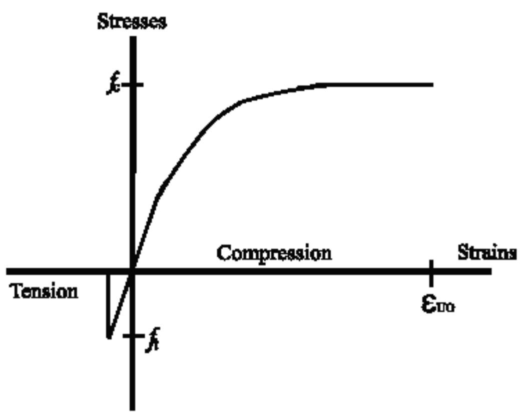


Figure 3. Stress-strain curve

In order to investigate the accuracy of the nonlinear finite element program, results of I shaped shear wall were compared by finite element program. The capability of finite element program to reliably is high. The results of finite element program compared with experimental results to verify key aspects of the numerical model. There is curve load-displacement that shows results of finite element program are good (figure 4).

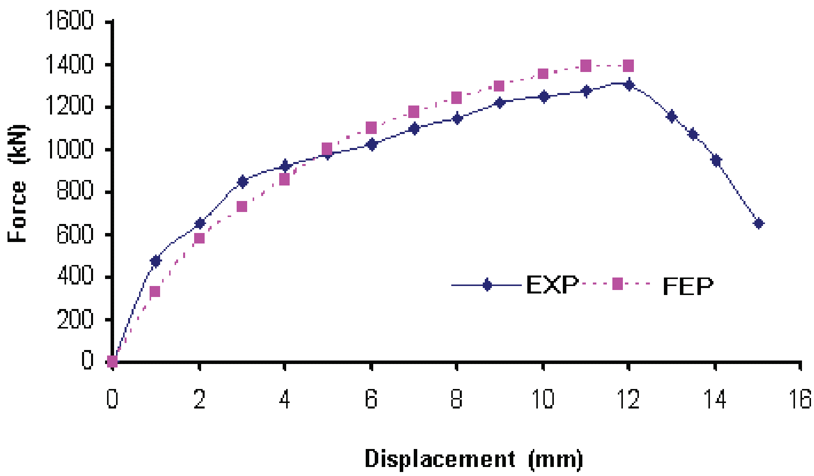


Figure 4. Comparison of experimental and finite element

From examination of plot in the Figure 4 it is obvious that in experimental analysis ultimate lateral strength is 1298 kN. This value is 1370 kN in finite element analysis which is 6 percent increase compared with results of experimental. In this paper, four different finite element models were generated to analytically predict the response of them under lateral load. Concrete of shear wall models were meshed with cube rectangular elements of dimension 20 mm. Figure 5 shows the reference model.

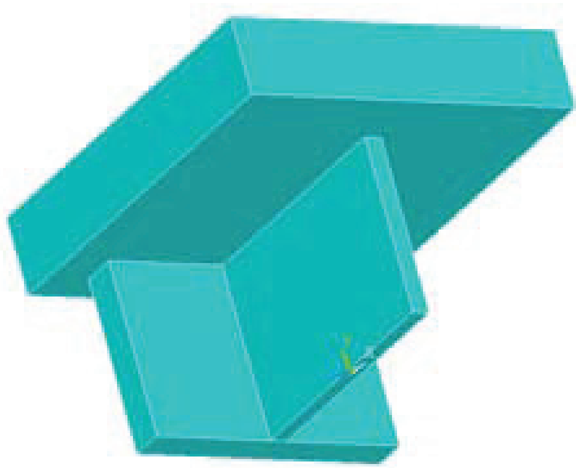


Figure 5. Model of analysis

1000 kN of Lateral load applied through the slab which located on the top of shear wall. In addition, 2400 kN of horizontal load were selected for better behavior of models.

3. Results of Analysis

Shear walls were analyzed in each of four models. Results of analysis showed different responses in each models. First of model has 2500TSW. The analytical value of the first crack load is 232 kN. As shown in figure 6, the value at the failure is 1248 kN. This amount is maximum value between four models for failure. The displacement value at the ultimate force is 3.9 mm. Second model is 2700TSW. First of crack occur in 232 kN. So model is resisting and yielding in 668 kN. Load-displacement curve shows that the ultimate load is force of 1192 kN and in the 4 mm. In this model, ultimate load is 5 percent lower than the 2500TSW.

Flanged of 2900TSW has a long of 2900 mm. flanged of this model included 841 rectangular mesh. In this model, the load response is the yielding at 675 kN. Deflection of yielding is 0.9 mm. the ultimate load of 2900TSW is 1152 kN, which is %8 lower than the 2500TSW and 4 percent less than 2700TSW. Load-displacement curve in 2900TSW show that ultimate deflections occur in 4.2 mm. Fourth model is 3100TSW. This model has 1024 point and 961 rectangular mesh. This equal is maximising between all of models. First crack showed in 235 kN. Crack increase in tension area. Crack pattern of the flanged of shear wall show in figure 7. Load of yield is maximum. Amount of yield load is 680 kN, which is 5 kN higher than 2900TSW. So model is resisting until 1075 kN, which is minimum value between three models other.

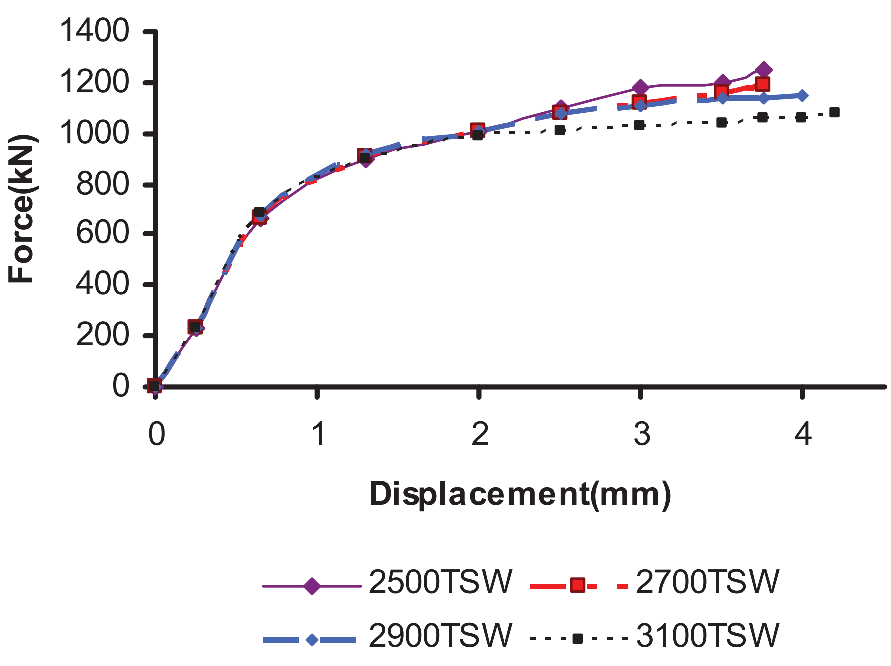


Figure 6. Load- displacement curve

Table 2. Result of analysis

Type of model	Δ y (mm)	Δ u (mm)	Pcr (kN)	Py (kN)	Pu (kN)	Pu/ Py	Ductility
2500TSW	0.85	3.9	232	663	1248	0.53	4.58
2700TSW	0.87	4	232	668	1192	0.56	4.59
2900TSW	0.9	4.05	235	675	1152	0.58	4.5
3100TSW	0.95	4.2	235	680	1075	0.63	4.42

4. DISCUSSION OF RESULTS

Results of analysis showed that flange shear wall with different flange dimensions had various response by lateral load. For instance, ultimate lateral load is 1248 kN in 2500TSW, 14 percent higher than that 3100TSW. Also, ductility is 4.5 in 2900TSW, which is %5 lower than 3100TSW. Since thickness of models is difference, responses are too. All of models cracked in lateral load about 232 kN. So flange dimension doesn't have been effect in flange shear wall. The load-displacement curve for four models indicated that yield force is very low in model with high thick. That means, 2500TSW has 125 mm thickness, load of yielding is minimum. When thickness is decreasing in models, yielding force is increase. For example, increasing of 25 mm in thickness of flanged, 20 kN will decrease yield load and 1 mm yield displacement. But after yield, shear walls had been various behaviours. P_u/ P_y showed that in table 2. These relations indicate how percent shear wall could be resistance lateral load before yield. For example, in 2700TSW, shear wall has been resistance lateral about 670 kN which is %56 of the ultimate load (1192 kN). In this model, 524 kN load is carrying after yield. In the figure 7, amount of lateral load is showing before yield.

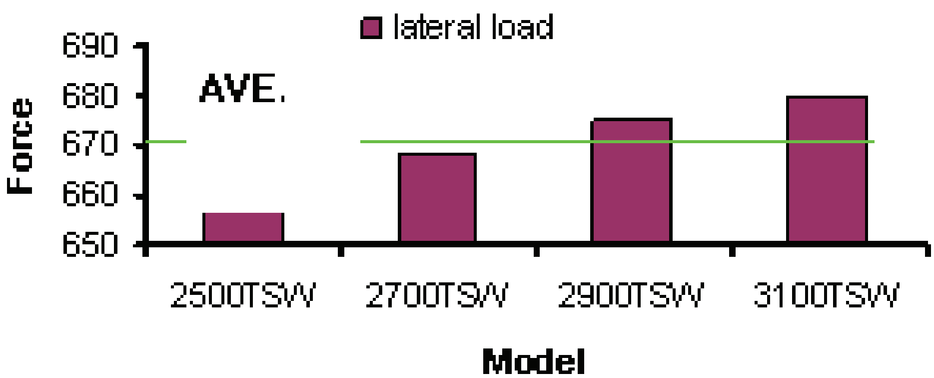
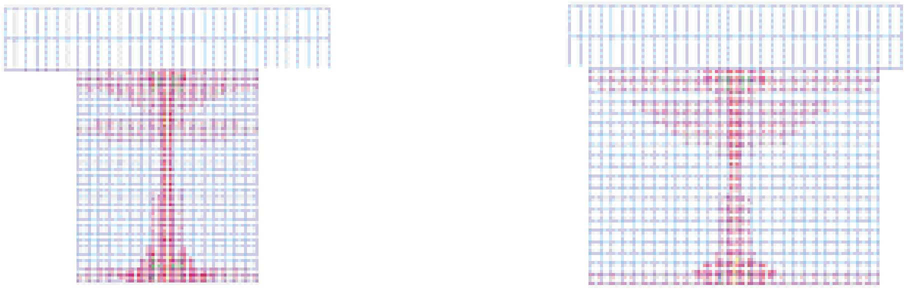


Figure 7. Lateral load before yield

Lateral load value of resistance before yield is maximum in 3100TSW model. This amount is %63 that %10 is higher than 2500TSW. But this is very important that how much shear wall has been carried by lateral load after yield. After yield, model of 2900TSW has been absorbed about 480 kN, which is %17 higher than 3100TSW and 18 percent less than 2500TSW. Figure 8 show cracks in 2700TSW. All of models cracked in tension area of flange. Investigation of cracks in flanged of shear wall showed that cracks in approach of web are more.

So cracks were increased by decrease of tension resistant. They developed in flange. But crack in 2500TSW was less. Since in this model thickness is more, concrete resistant.



(a) (b)

Figure 8. Cracks in a) 2700 TSW and b) 3100TSW model

5. CONCLUSION

The comparison of models indicates that finite element model used in this study is capable of predicting the nonlinear behavior of the models when these are different thickness. Results of analysis in four models and load- displacement of them indicated that 2500TSW had better behavior. It had been resisted about 1248 kN. This load is 5, 14 percent higher than other models. Also, ductility of this model showed a good agreement. For example, ductility in the 2500TSW model is 4.58 which is three percent higher than 3100TSW. The finite element models of four T shape shear wall in this study could increase shear absorb when were useful flange shear wall with more thickness. Results of analysis showed that 3100TSW had better strength after yield. This equal was 18% higher than 2500TSW. Crack pattern in all of models showed that increase of thickness could decrease crack in shear wall.

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