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AN EXPERIMENTAL RESEARCH ON FRAMED LOW-RISE SHEAR WALL WITH VERTICAL SEAMS

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In this paper, the experimental research on framed low-rise shear wall with vertical seams and conventional R.C. low-rise shear wall was conducted. The seismic behavior, load-bearing capacity and ultimate deformation of framed R.C. low-rise shear wall with vertical seams are discussed. The results show framed monolithic wall panel with vertical seams can significantly improve the ultimate deformation capacity and energy-dissipating capacity of monolithic wall, and the wall with vertical seams is characterized by its great rigidity and deformation stability.

KEYWORDS

Low-rise; Vertical seam; Aseismic beharious; Load-bearing capacity; Ultimate deformation.

1. Foreword

Since the sides way rigidity of its frame on first story in multi-story brick building without aseismic shear wall is less than that of the intercalation of a top multi-story brick building ,under the action of earthquake the intercalated displacement is frequently much greater in the frame on first story so that the portion forming the frame on first story damages severely.

In order to improve the aseismic behavior of multi-story brick building with frame on first story, in accordance with the experiences on earthquake damage, it is suggested that a certain number of aseismic wall are built on first story and the sidesway rigity of the structure are built remitted to distribute along a height relatively and uniformly.

In practical engineering, a height-to-width ratio of reinforced concrete earthquake wall is often less than 1.0, known as a low-rise shear wall.

A shear of the low-rise aseismic wall is primary, its failure mode is a shear failure[1-5]. To improve the aseismic behavior of the low-rise shear wall the literature[6] suggests that the low-rise shear wall be of vertical seams in high-rise steel framed structure and a low-rise wall panel become a set of wallboard column, making a state of shear failure be the state of bend and shear failures so as to improve the deformation capacity and energy-dissipating capacity of wall body, while making its rigidity and load-bearing capacity decrease much. The literature[7] suggests that the slot be cut in concrete wallboard and the reinforcement bar penetrate through the longitudinal and transverse wallboard, an initial rigidity and load-bearing capacity decline less compared with that of a monolithic wall, however, its failure mode is still shear failure, even if its deformation capacity and energy-dissipating capacity increase than before, but are much poorer than the wall with vertical seams. Therefore, it is still a subject worthy of depth study that the behavior of low-rise shear wall is improved so as to make it be of greater deformation capacity and energy-dissipating capacity, and have greater rigidity and load-bearing capacity simultaneously. This paper mainly make an experimental research and theoretic exploration of improved aseismic behavior of the framed low-rise shear wall.

2. Model Design

In order to understand the behavior of monolithic low-rise shear shear wall and low-rise shear wall with vertical seams, five tests pieces are fabricated among which one is a monolithic wall, four are the walls with vertical seams. To study the effect of variation of high-to-width ratio of wallboard column in the wall with vertical seams on the seismic behavior of wall body, it is known that the wall with vertical seams is divided into two kinds, in which one or two vertical seams are cut at the middle of the wall, all the horizontal steel bars are broken at the vertical seams cut in the test pieces with vertical seams, and two concealed columns are rovided for on both sides of the vertical seams. There are two treatment methods at the vertical seams of the wall with vertical seams: one method is that two prefabricated cement grout lath of 15mm thickness then concerning; the other is that concretes are poured immediately to make be a monolithic concrete wallboard merely broken at horizontal steel bars. The frame sizes and reinforcements of five test pieces equal one another, as shown in Tables 1 and 2, and Fig. 1 in detail.

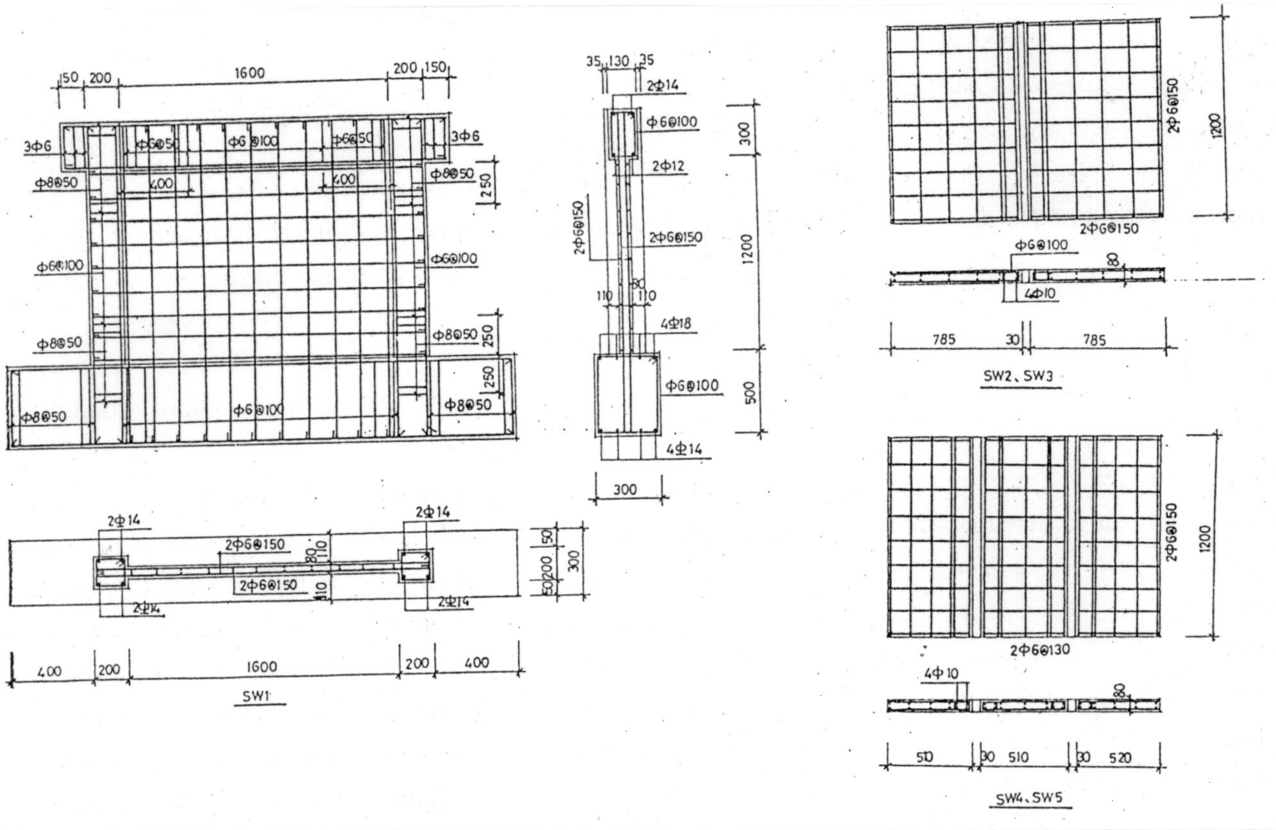

Fig. 1 reinforcing bars and size of SW1 ~ SW5

Size of tests **Table 1**

specimen	seams number	treat ment methods of seam	wall post b × n (mm)	beam b × n (mm)	height of wallboardH_0 (mm)	width of wallboard L_0 (mm)	height-to width radio of wallboard	enclosed column	thickness of wallboard
SW1	None	-------	200 × 200	130 × 350	1200	1600	0.75	80 × 120	80
SW2	1	pourred	200 × 200	130 × 350	1200	800	1.50	80 × 120	80
SW3	1	two grout lath	200 × 200	130 × 350	1200	800	1.50	80 × 120	80
SW4	2	pourred	200 × 200	130 × 350	1200	520	2.30	80 × 120	80
SW5	2	two grout lath	200 × 200	130 × 350	1200	520	2.30	80 × 120	80

Reinforcing of tests **Table 2**

specimen	reinforcing bars of column	steel ration of column	reinforcing bars of enclosed column	steel ration of enclose clumn	cross reinforcing bars of wall	cross steel ration of wall	vertical reinforcing bar of wall	vertical steel ration of wall
SW1	4 Φ 14	0.0154	4 φ 10	0.0327	2 φ 6@150	0.0055	2 φ 6@150	0.0055
SW2	4 Φ 14	0.0154	4 φ 10	0.0327	2 φ 6@150	0.0055	2 φ 6@150	0.0064
SW3	4 Φ 14	0.0154	4 φ 10	0.0327	2 φ 6@150	0.0055	2 φ 6@150	0.0064
SW4	4 Φ 14	0.015	4 φ 10	0.0327	2 φ 6@150	0.0055	2 φ 6@150	0.0055
SW5	4 Φ 14	0.0154	4 φ 10	0.0327	2 φ 6@150	0.0055	2 φ 6@150	0.0064

3. Results of model test

Under the coaction of vertical and horizontal loads, each member of reinforced concrete wall experiences a concrete cracking, steel bar yield and failure of4 these three processes. A lagging curve of five models tests is as shown in Fig. 2 .

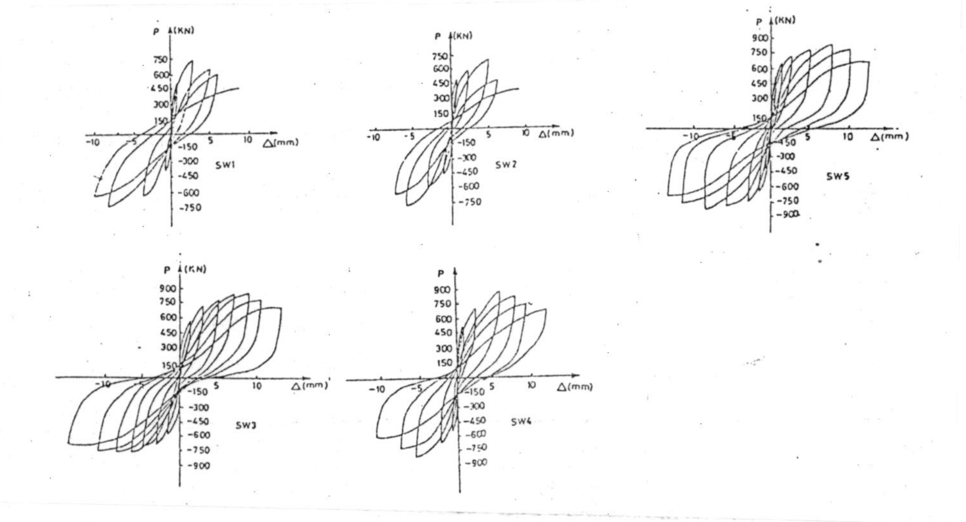

Fig. 2 lagging curre of tests

The measured values of elasticity ,cracking to yield and post-yield in specimens **Table 3**

specimen	direction	elasticity rigidity (KN/mm)	rigidity of cracking to yield (KN/mm)	post-yield rigidity (KN/mm)
SW1	**PUSH**	**951.0**	**204.0**	**104.0**
	DRAW	**1055.0**	**245.0**	**73.0**
SW2	**PUSH**	**1048.0**	**137.0**	**20.0**
	DRAW	**1006.0**	**153.0**	**59.0**
SW3	**PUSH**	**963.0**	**177.0**	**25.0**
	DRAW	**965.0**	**131.0**	**26.0**
SW4	**PUSH**	**1031.0**	**258.0**	**44.0**
	DRAW	**1132.0**	**151.0**	**18.0**
SW5	**PUSH**	**943.0**	**179.0**	**17.0**
	DRAW	**933.0**	**188.0**	**16.0**

3.1 Rigidity

The table 3 lists the rigidity measured values of elasticity, cracking, yield and post-yield. It can be seen in the table 3 that only horizontal reinforcement steel is broken, while the elastic rigidity of monolithic concrete SW2 and SW4 is equal to that of SW1, and the elastic rigidity of cement mortar boards SW3 and SW5 provided on two sides of the vertical seams is less than that of Sw1, consequently being 90 percent elastic rigidity of SW1. This proves that framed reinforcement concrete shear wall with the vertical seams has better elastic rigidity which is attributed to an intensive strained action of the frames mainly. Owing to no framed restraint of wallboard with vertical seams in steel frame designed by K. Muto under the action of earthquake the vertical seams rapidly propagate to the bottom and top of the wallboard forming a set of wallboard column, even if the vertical seams applied do not propagate to the top and bottom of the wallboard, on the contrary, as far as the framed wall with the vertical seams is concerned, as its cross section of a top beam is higher than that of conventional frame beam, in addition the hoping density of top beam increases in a corresponding portion of the vertical seams, therefore, the test specimens are damaged seriously, no any crack takes place on the top beam. So the ground floor of the frame brick house has much greater elastic rigidity on the bottom course of reinforced concrete wall.

The cracking , yield , maximum load and its displacements **Table 4**

specimen	direction	cracking load (KN)	cracking displacement (mm)	yield load (KN)	yield displacement (mm)	maximum load (KN)	displacement of maximum load (mm)	ultimate displacement (mm)
SW1	**Push**	**361.5**	**0.38**	**606.2**	**1.58**	**758.4**	**3.05**	**6.30**
	Draw	**368.8**	**0.34**	**643.1**	**1.50**	**759.2**	**3.10**	**7.10**
SW2	**Push**	**335.5**	**0.32**	**630.4**	**2.48**	**681.1**	**5.08**	**5.60**
	Draw	**352.1**	**0.35**	**676.2**	**2.47**	**884.0**	**6.00**	**-**
SW3	**Push**	**375.4**	**0.39**	**654.8**	**1.97**	**822.8**	**8.80**	**12.00**
	Draw	**385.9**	**0.40**	**620.8**	**2.20**	**797.2**	**9.00**	**14.00**
SW4	**Push**	**381.3**	**0.37**	**714.6**	**1.66**	**897.9**	**5.80**	**8.40**
	Draw	**373.4**	**0.33**	**753.3**	**2.85**	**805.4**	**5.70**	**8.80**
SW5	**Push**	**377.1**	**0.40**	**651.2**	**1.93**	**754.8**	**8.00**	**11.40**
	Draw	**382.7**	**0.41**	**668.3**	**1.93**	**753.0**	**7.20**	**11.00**

3.2 Displacement

Table 4 shows the maximum measured cracking load and yield load and corresponding displacement amplitude and ultimate displacement of a variety of specimens. It is seen from Table 4 the cracking load and displacement of five specimens are almost equal and their maximum loads do not decline. Since the grade of concrete strength of other four specimens is a little higher than that of SW1 except for the framed restraint. Though the horizontal steel bars of the other four are cracked at the vertical seams, for concealed columns are provided on the two sides of the vertical seams, so the vertical reinforcement ratio of the wallboard increases. The displacement and ultimate displacement corresponded by the wall with the vertical seams, in preset concrete mortar slab, are much greater than that of the monolithic wall. An ultimate displacement angle of the monolithic wall is 0.005, while the ultimate displacement angle of the cement mortar board wall with the vertical seams is 0.01. To see in a lagging curve of force and displacement, SW3 and SW5 not only have an obvious yield inten sification, descent segment, and more stable rigidity following the maximum load, but also the ultimate displace-ment and energy-dissipating capacity are relatively greater in comparison with SW1.

4. Conclusion

1. Framed low-rise reinforced concrete wall makes use of the vertical seams down to the beam bottom and prefabricated reinforced concrete slabs are placed at the vertical seams, the framed low-rise wall is divided into two or three wall panel units with a height-to-width ratio being more than 1.5, which greatly improve the seismic behavior of the framed low-rise wall, its elastic rigidity and ultimate load-bearing capacity declines ess than that of the monolithic low-rise wall, but its deformation capacity and engergy-dissipating capacity greatly increase.
2. Check of experimental results of two sets of wall bodies illustrates that the seismic behavior of the wall two blocks of cement mortar boards placed at the vertical seams, is superior to the aseismic behavior of the monolithic concreting wall with only breaking horizontal reinforcement steel. Consequently, at the vertical seams two blocks of prefabricated concrete boards should be placed as the partition boards which have a width equaling a thickness of the concrete wall, its thickness being 50mm, in addition a network of steel bars 6 should be made up so as to strengthen the rigidity of the partition broads.
3. The concealed columns should be installed on two sides of the vertical seams of the wall with the vertical seams and have given restriction in the formation and propagation of the concrete crack on the two sides of the vertical seams, while, can improve the load-bearing capacity and ultimate deformation capacity of the wall board unit. A cross section of the concealed column should be 1.5-2.0 times the wall thickness.
4. The longitudinal reinforcement and hooping in the framed column of the framed low-rise wall with the vertical seams have a great influence on the ultimate load-bearing capacity and deformation capacity, the longitudinal reinforcement of the framed column should not be lower than requirements for reinforcement steel and hooping in the framed column of without concrete shear wall.
5. The framed beam of the framed low-rise with the vertical seams will be additionally sheared in a corresponding portion of the vertical seams due to an action of the vertical seams, the density of the reinforcement steel should increase on the two sides of the vertical seams with 1.5 temes height of beam, and its spacing of the reinforcement steel should be less than 100mm.
6. So far as experimental results of one or two vertical seams are concerned, to improve the seismic behavior of the monolithic wall is fundamentally identical. It is suggested that the eight-to-width ratio of wall board unit in the wall with vertical seams be more than 1.5, while less than 2.5 in order to improve the seismic behavior, deformation capacity and energy-dissipating capacity.

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