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"Research Note"

AN EXPERIMENTAL STUDY ON THE BEHAVIOR OF INFILLED STEEL FRAMES UNDER REVERSED-CYCLING LOADING[*]

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Abstract– In this study, the behavior of nine steel frames having various infill properties under reversed-cycling loading were investigated experimentally. The steel frame systems consist of a single story with span/height ratios of 1, ½ and 2. The selected infill properties are no infill, brick-wall infill and brick-wall + plaster infill. The reversed-cycling loading was applied to test the specimens laterally to simulate the seismic load. Then, the displacements occurring at the specimens were measured. Strength envelopes, rigidity decreases and energy dissipation properties of the infilled frames were determined and the results obtained are compared.

Keywords– Steel frames with infill walls, seismic behavior of infilled steel frames

1. INTRODUCTION

Infill walls change the behavior of frames considerably under lateral loads and affect mainly the strength, rigidity, energy dissipation, etc. characteristics. Studies on the structural behavior and response of masonry infilled frames extend to as early as the 1950s [1]. Findings pertaining to infilled frames from the 1950s to the late 1980s are presented in a state of the art report prepared by Moghaddam *et al*. [2]. In general, researchers employed two different testing schemes in their investigations; the first one was an in-plane, diagonal and compressive loading of a single frame unit and the second was an in-plane racking test in which the frame had been subjected to a top lateral load [1]. Holmes [3], Stafford Smith [4-6], Mainstone and Weeks [7], Dawe and Seah [8], Flangan *et al*. [9], Mander *et al*. [10], and Dukuze *et al*. [11] have studied the behavior of masonry infilled steel frames under lateral loads [12].

In this study, nine single story steel frames (with 1/3 scale) having various infill wall properties were tested under lateral reversed-cycling loading, simulating seismic action [13-15]. The frames were constructed with various span/height (l/h) ratios and different infill wall properties. The properties of the produced test specimens were the following:

1) Frame systems with infill wall span/height ratio (l/h = 1), a-frame system with no infill – N110 (l/h=1), b- frame system with brick-wall infill – N111 (l/h=1), c- frame system with brick-wall + plaster infill – N112 (l/h=1). 2) Frame systems with infill wall span/height ratio (l/h=2), a- frame system with no infill – N110 (l/h=2), b- frame system with brick-wall infill – N111 (l/h=2), c- frame system with brick-wall + plaster infill – N112 (l/h=2). 3) Frame systems with infill wall span/height ratio (l/h=1/2) , a-frame system with no infill – N110 (l/h = 1/2), b-frame system with brick-wall infill – N111 (l/h=1/2), c-frame system with brick-wall + plaster infill –N112 (l/h=1/2).

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2. PRESENTATION OF TEST MECHANISM AND TEST TECHNIQUE

U profiles, manufactured by the bending of cold steel plates, were used for the preparation of steel frames and infill walls with various properties were constructed inside the steel frames. For a brick-wall infill, laterally placed hollow brick blocks were used. The brick-wall+plaster infilled specimens had 17.5 mm plaster on both sides of the wall. The physical and geometrical properties of the prepared test specimens are given in Table 1.

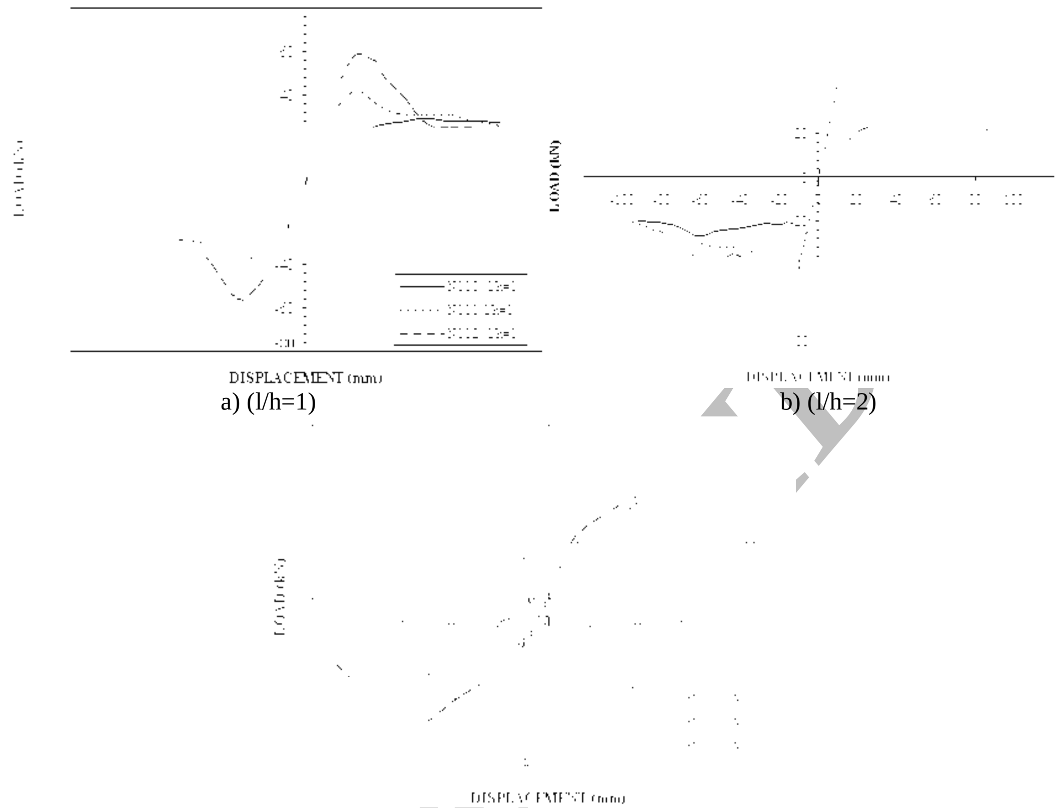
Table 1. Physical and geometrical characteristics of test specimens and experimental results

Specimens	Frame span/ height (l/h)	Experimental maximum lateral load			Ultimate rigidity		Energy consumed at the end of the test	
		Load (kN)	(δ/H)	Initial Rigidity (kN/mm)	Rigidity (kN/mm)	(δ/H)	Cumulative Consumed Energy (kNmm)	Cumul. Σ(δ/H)
N110 (l/h=1) No infill (empty)	843/823	32,37	0,0994	1,46	0,40	0,0994	10878	0,422
N111 (l/h=1) Brick-wall infill	843/823	41,42	0,0247	10,75	0,23	0,1108	14877	0,437
N112 (l/h=1) Brick-wall+ plaster	843/823	56,92	0,0247	19,30	0,15	0,0986	17978	0,416
N110 (l/h=2) No infill (empty)	1643/823	27,15	0,0722	1,28	0,23	0,1115	13237	0,435
N111 (l/h=2) Brick-wall infill	1643/823	45,50	0,0241	13,20	0,33	0,1019	17406	0,437
N112 (l/h=2) Brick-wall+ plaster	1643/823	63,23	0,0243	25,80	0,33	0,1323	17886	0,439
N110 (l/h=1/2) No infill (empty)	843/1603	12,97	0,0510	0,46	0,14	0,0538	2991	0,285
N111 (l/h=1/2) Brick-wall infill	843/1603	23,64	0,0244	3,72	0,13	0,0560	5871	0,275
N112 (l/h=1/2) Brick-wall+ plaster	843/1603	28,60	0,0322	6,10	0,17	0,0552	7429	0,281

The prepared specimens were tested under lateral reversed-cycling loads and the necessary load and displacement data were recorded. The system has a rigid base plate that enables test specimens to be rigidly supported by using bolts. The lateral load was applied at the top of the frame. The displacements measurements were made by using LVDTs and the lateral displacements of the top edges of the steel frame were determined. Load measurements were made by using a load cell working in contact with a hydraulic jack. All of the tests were carried out under displacement control and performed by applying a 10 mm incremental displacement at each cycle. The purpose of selecting such a loading program was to generate a method to compare the results obtained from different specimens. This is because each of the frame systems has different structural characteristics. Therefore, each frame system could be evaluated according to lateral displacement and (δ/h) ratio with desired behavior characteristics and compared with other specimens. In order to see the complete lateral load-top displacement curve and evaluate the behavior of the steel frame at high displacement values, the ultimate applied drift ratio was higher than the code requirement.

3. RESULTS AND CONCLUSIONS

For each specimen, the strength envelope, rigidity deterioration and energy dissipation values were obtained. These results were then compared with each other in Table 1 and Fig. 1. In the table, the applied maximum lateral load and corresponding displacement were also listed. The following results are obtained during this experimental study.



a) (l/h=1) b) (l/h=2)

c) (l/h=1/2)

Fig. 1. Strength envelopes of frame systems having different infill wall span/ height

1. The infill walls, having various structural characteristics, considerably increase the lateral load bearing capacity, lateral rigidity and energy dissipation capacity of the steel frame system under lateral loading.
2. The ratio of the infill wall span/height (l/h) considerably affects the lateral load bearing capacity, lateral rigidity and energy dissipation capacity of the frame system under lateral loading.
3. While the ratio of the infill wall span/height (l/h)>1 increases the lateral load bearing capacity, the ratio of (l/h)<1 decreases it significantly.
4. It is clearly seen that plaster usage on brick walls considerably increases the lateral failure load, lateral rigidity and energy dissipation capacity of the infilled frame system. For this reason, special care should be given to using plaster in applications.

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