



RESEARCHES ON PERFORMANCE-BASED SEISMIC OF BRICK MASONRY STRUCTURES WITH FRAME-SHEAR WALL AT THE BOTTOM

Kai-fu Zhou¹ and Rong-rong Gu²

ABSTRACT

The idea of performance-based seismic design is introduced and the seismic capability of brick masonry structures with frame-shear wall at the bottom is analysed in this paper. By dynamic time history analysis, this paper studies the elasto-plastic response of brick masonry structures with frame-shear wall at the bottom under different earthquake intensity. The force and deformation characteristics of this type structures are studied. By an example, the performance-based seismic design method of brick masonry structures with frame-shear wall at the bottom is introduced and some conclusions are listed.

Key words: brick masonry structures with frame-shear wall at the bottom; performance-based; seismic capability

INTRODUCTION

The theory of performance-based seismic is first proposed by America scholars (Bertero et al., 1996). The basic idea of this theory is to ensure that the designed buildings can satisfy all preconcerted performance demands. The performance targets include many contents and should be confirmed by structure type, structure functions, personnel security, deformation limit, equipment and fitment etc. The displacement-based seismic design is a direct way to reflect the seismic performance of structure. The performance/displacement-based seismic design method is adopted by some seismic codes of many countries (Xiao gu jun jie, 2000; Bertero R. et al., 1996; SEAOC Vision 2000). In our country, many scholars (Li et al., 2001) have played a lot of researches on the performance-based seismic theory and suggested that current seismic codes should be improved to performance-based seismic theory in order to fit the international development and trend of seismic design thoughts.

Masonry structures with frame-shear wall at the bottom are widely used in the frontage buildings in our country. This type structure is composed by two different resistant properties, viz. frame-shear wall at the bottom and masonry of upper structure. So the elasto-plastic seismic response of the masonry structures with frame-shear wall at the bottom presents some specific characteristics (Zheng and Xue, 2004). The asymmetrical stiffness of this type structure is disadvantageous to seismic

¹ Engineer, College of Engineering, Yangzhou Univ., Yangzhou, China, lqgj@263.net

² Graduate student, College of Engineering, Yangzhou Univ., Yangzhou, China, gurr99@126.com

capability (Su, 2002; Yang and Zou, 2003). This type structure is allowed in our current 《Code for seismic design of building》 (GB50011-2001), but some restricted conditions are also listed. With consideration performance-based seismic idea, the force and deformation characteristics of masonry structure with concrete frame-shear wall at lower two stories are studied in this paper, and the seismic capability of this type buildings are discussed.

THE FORCE AND DEFORMATION CHARACTERISTICS OF MASONRY STRUCTURE WITH CONCRETE FRAME-SHEAR WALL AT LOWER TWO STORIES

The elements of bottom structure are frame-shear wall and the lateral stiffness is relatively small, but the upper structure is masonry structure and the lateral stiffness is great. The structure collocation is contrary to normal building, so the lateral stiffness presents asymmetrical phenomenon. And the brick is a kind of brittle material, which has bad tension intensity, blend intensity, shear intensity, as a result, the seismic performance of structure is weak.

Because of the force, deformation and seismic performance difference of frame-shear wall floors and masonry floors, the weak stories of structure are much related to the number of shear wall. To avoid the weak story in the upper masonry floors, the number of shear wall should be reasonable in order to make the interstory displacement comparatively well-proportioned. The weak stories are should controlled at lower two stories and the deformation of the weak stories should not be excess. The number of shear-wall is related to many factors, such as lateral stiffness ratio, the space of shear-wall, the displacement ratio of frame shear-wall story and conjoint masonry floor, the location form of shear-wall etc.

PERFORMANCE-BASED SEISMIC DESIGN METHOD

The lateral stiffness ratio of the third story to the second story is definitely prescribed in our current 《Code for seismic design of building》. It is denoted that the lateral stiffness ratio of the third story to the second story should be not more than 2.0 in 6,7 degree earthquake fortification zone, while in 8 degree zone the limit value is 1.5. And all limit value should not less than 1.0. Because the lateral stiffness of masonry floor is quite larger than frame floor, the frame floors at the bottom should increase some shear-wall to satisfy the stiffness limit value in the current seismic code. And the limit load-carrying capacity and lateral stiffness of lower two stories are also improved.

According to design regulations or current design code, in general, structures should satisfy the following rules. First, resist minor seismic level of earthquake ground motions without damage; second, resist moderate earthquakes without structural damage, but may experience some non-structural damage; finally, resist major earthquakes without collapse, and but possibly with some structural and/or non-structural damage. Under the performance-based seismic idea, the elasto-plastic responses of this type structure are analyzed under different earthquake intensities in this paper. The force and deformation characteristics of this type structure are expounded by time history analysis.

The structure plane and section is shown as in Fig.1 and the lateral stiffness ratio of the third story to the second story is 1.66. Earthquake fortification intensity is 7⁰(0.15g). The earthquake ground motion accelerations are 0.1g, 0.22g and 0.4g which correspond to minor earthquake, moderate earthquake and major earthquake. The thickness of reinforced concrete shear wall at lower two story is 200mm, frame column dimension 450×450mm, beam dimension 250×500mm(Y-direction) and 250×400mm(X- direction) of first story, 300×600mm(Y-direction) and 300mm×450mm(X- direction) of second story, concrete property C30. The thickness of brick masonry stories is 240mm, brick property MU10, mortar property M7.5.

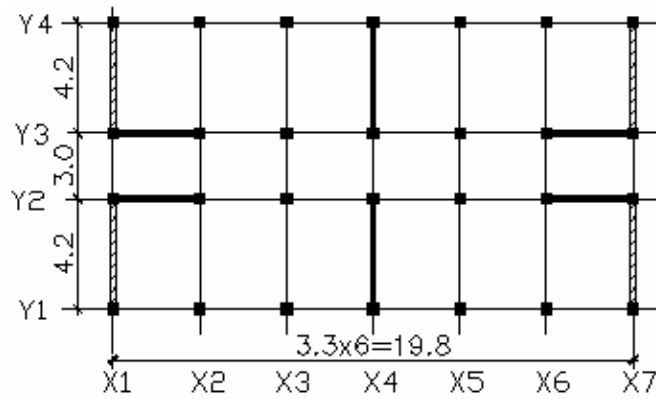


Figure 1. Plane of lower two stories.

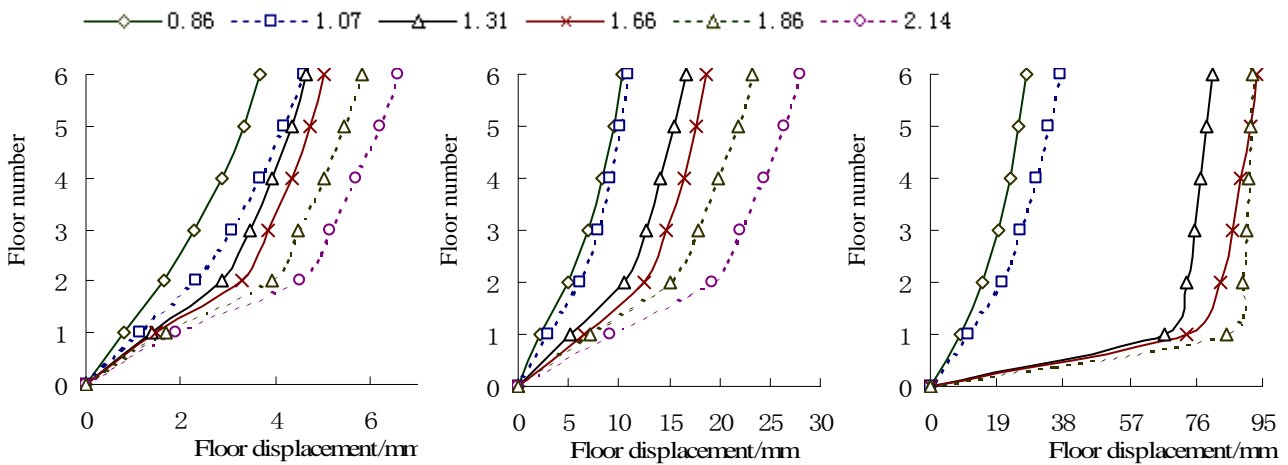
The shear-wall collocation of the lower two stories and its corresponding lateral stiffness ratios are shown as in Tab.1. The time history analysis is performed by CANNY (Li, 2002) program.

Table 1. The shear-wall collocation and its lateral Stiffness ratio

Shear-wall collocation	Lateral Stiffness ratio
X3,X5,Y1-Y2;X1,X4,X7,Y3-Y4; 200mm R/C shear-wall	0.86
Based on 0.86, eliminating X4,Y3-Y4 R/C shear-wall	1.07
Based on Fig.1, adding 2 piece R/C shear-wall	1.31
Shown as Fig.1	1.66
X3,X5,Y1-Y2 brick shear-wall; X1,X7,Y3-Y4 R/C shear-wall	1.86
Based on Fig.1 eliminating 4 piece brick shear-wall	2.14

ANALYSIS RESULTS

The maximum floor displacements are plotted in Fig.2 and the maximum interstory displacements are shown as in Fig.3. The maximum interstory displacement angles are listed in Tab.2.

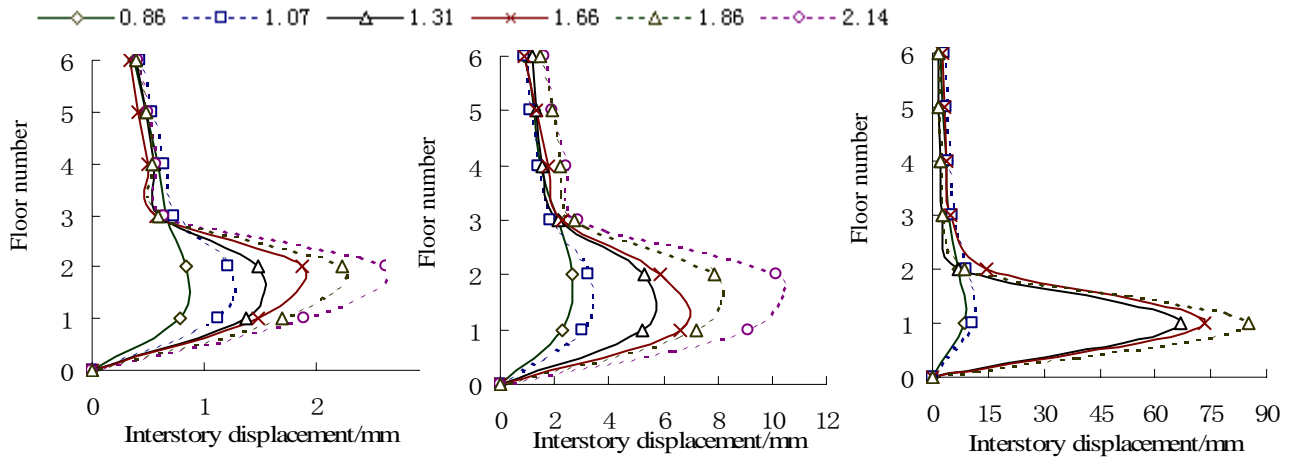


(a) Ground acceleration 0.1g

(b) Ground acceleration 0.22g

(c) Ground acceleration 0.4g

Figure 2. The curve of maximum floor displacements.



(a) Ground acceleration 0.1g (b) Ground acceleration 0.22g (c) Ground acceleration 0.4g
 Figure 3. The curve of maximum interstory displacements.

- (1) According to Fig.2 and Fig.3, it is shown that the floor displacements increase as the lateral stiffness ratio increases under different earthquake intensities. The floor displacements of six stiffness ratios are all lower at ground acceleration 0.1g . The structure is at elastic state and can satisfies the minor seismic level of earthquake ground motions without damage. The maximum interstory displacement angle reaches 1/413 at ground acceleration 0.122g, but this value is also less than the limit value of code 1/500. When the lateral stiffness ratios exceed 1.31, the displacement response of the lower two stories are too excessive.
- (2) The maximum intersory displacement responses entirely appear in the second floor at ground acceleration 0.1g and 0.22g. But the weak story appears in the first floor at ground acceleration 0.4g and the intersory displacement rapidly increases as the stiffness ratio increases.
- (3) The intersory displacement angles all go beyond the elastic limit 1/550 at ground acceleration 0.4g in Tab.2. The intersory displacement angles are more than elasto-plastic limit 1/100 when the lateral stiffness ratio exceeds 1.31.

Tab.2 The maximum interstory displacement angles of structure

Stiffness ratio	Floor	6	5	4	3	2	1
	Acceleration						
0.86	0.1g	1/7564	1/5892	1/4796	1/4248	1/5000	1/5359
	0.22g	1/3110	1/2274	1/1855	1/1319	1/1598	1/1841
	0.4g	1/1203	1/1053	1/777	1/616	1/608	1/488
1.07	0.1g	1/6618	1/5243	1/4393	1/3831	1/3478	1/3710
	0.22g	1/3288	1/2564	1/2046	1/1494	1/1307	1/1384
	0.4g	1/870	1/768	1/629	1/513	1/448	1/382
1.31	0.1g	1/7077	1/5903	1/5050	1/4662	1/2838	1/3036
	0.22g	1/2309	1/2167	1/1792	1/1319	1/790	1/808
	0.4g	1/1734	1/1503	1/1356	1/1131	1/586	1/62
1.66	0.1g	1/8244	1/6675	1/5633	1/4952	1/2248	1/2836
	0.22g	1/3177	1/2127	1/1611	1/1211	1/717	1/634
	0.4g	1/1069	1/915	1/735	1/606	1/286	1/57
1.86	0.1g	1/6973	1/5899	1/5254	1/4705	1/1886	1/2472
	0.22g	1/1873	1/1488	1/1257	1/1015	1/531	1/581
	0.4g	1/1158	1/1082	1/966	1/571	1/213	1/49
2.18	0.1g	1/6688	1/5656	1/4943	1/4403	1/1595	1/2216
	0.22g	1/1758	1/1482	1/1166	1/972	1/413	1/460

CONCLUSIONS

- (1) In the 7⁰ (0.22g) earthquake fortification zone, the prescripts of seismic codes for masonry structure with concrete frame-shear wall at lower two stories are appropriate. The structures designed by code criterion can satisfy the “three performance level” anti-seismic requirements.
- (2) In the 8⁰ (0.4g) earthquake fortification zone, the masonry structure with concrete frame-shear wall at lower two stories should be restrainedly used. If the building is must to be adopted, The lateral stiffness ratio of the third story to the second story should be strictly controlled. It is suggested that the lateral stiffness ratio should not be more than 1.3 and less than 1.0 in this paper.

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