Analysis of the influence of ring beams and constructional columns of masonry buildings

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Abstract

2008 Wenchuan County in Sichuan 8 earthquake in masonry structures causing heavy casualties and property losses, through post-disaster survey analysis, structural system is unreasonable, inadequate ring beams and constructional columns and other structural measures is caused by the serious consequences the main reason. In order to clearly know the role of ring beams and constructional columns in masonry houses by China Academy of Building Research PKPM software masonry structure modeled analysis, it had established four models: 1) ring beams and constructional columns (Models 1); 2) there is no ring beam structure column (model 2); 3) there is no ring beam structure column (model 3); 4) no ring beams and constructional columns (model 4). In these four cases, housing pressurized computing, seismic calculation and partial pressure results were compared. Finally, the conclusion showed that the ring beams and constructional columns to be set in order to effectively restrained masonry, thereby increasing the shear, tensile strength and spatial integrity.

Keywords

Ring beams,structural column,masonry structure,compression,Seismic Calculation.

1. Introduction

1976 Tangshan earthquake, the vast majority of masonry buildings damaged or collapsed, but there are still a few houses cracked but not down, such as Xinhua Road, Tangshan, the eight layer of Xinhua Hotel main building [1]. To sum up the experience is not difficult to find, the good seismic performance is not only concerned with reasonable structure and layout, and good circle beam and structural column restraint measures. Since then, a series of experimental studies have been carried out on this kind of confined masonry in structural engineering, which has further deepened the understanding of the failure mechanism, mechanical properties and deformation properties of such structures. On this basis, structural measures of ring beams and constructional columns into the design specification of 89 earthquake in China, and has withstood the test of several earthquakes. Since then, the kind of confined masonry has replaced the traditional masonry, which has become a new seismic structural system.

2008 Wenchuan County of Sichuan Province magnitude 8 earthquake masonry structure caused heavy casualties and property losses, through disaster survey analysis found that inadequate measures of structure system is unreasonable, circle beam and structural column structure is main cause of the serious consequences. Therefore, China Academy of Building Research of PKPM software is used in this paper analyses the modeling of masonry structure established four models: 1) circle beam and structural column (model 1); 2) ring beams are no structural columns (model 2); 3) no ring beam constructional column (model 3); 4) without circle beam and structural column (model 4), in the four cases, for housing compression calculation, seismic calculation and local bearing calculation results were compared and analyzed.

2. Calculating formula

2.1 Compression calculation [2].

Bearing capacity of compression members shall conform to the requirements of the following type:

$$N \le \varphi f A \tag{1}$$

In Formula (1):N—Axial force design value;

φ—Influence coefficient of eccentric distance e with high thickness ratio β and axial force on the bearing capacity of compression members;

f—Design value of compressive strength of masonry;

A—Sectional area.

Note: for members with rectangular section, when the axial eccentric to the direction of the force of section length is greater than the length of one side of the other direction, in addition to according to the calculation of eccentric compression, but also to deal with smaller length direction, according to axial compression were checked.

2.2 Partial pressure calculation.

$$N_l \le \gamma f A_l \tag{2}$$

In Formula (2):N_l—Axial force design value of the local pressure on the area;

γ—Local masonry compressive strength increased coefficient;

f—The compressive strength design of masonry, the local compression area is less than 0.3m^2, cannot take into account the effect of the intensity adjustment coefficient gamma γ_a;

A_l—Local pressure area.

2.3 Seismic calculation[3].

1. Under normal circumstances, should be under-checking:

$$V \le f_{vE} A / \gamma_{RE} \tag{3}$$

In Formula (3):V—Consider the effect of the combination of seismic shear wall design value;

f_{vE}—Masonry along the stepped section failure seismic shear strength design value;

A—Wall cross-sectional area;

γ_{RE}—Seismic bearing capacity adjustment factor.

2 . Wall in the middle of a substantially uniform constructional column and constructional column section is not less than 240mmX240mm (when the wall thickness of 190mm, can also be used to 240mmX190mm), structural column spacing is no more than 4m, can be included in the section of the wall structure in the central column of wall shear effect to improve and press type checking:

$$V \le \frac{1}{\gamma_{RE}}\left[\eta_c f_{vE}(A - A_c) + \xi_c f_t A_c + 0.08 f_{yc} A_{sc} + \xi_s f_{yh} A_{sh}\right] \tag{4}$$

In Formula (4):A_c—The cross-sectional area of the central column of the structure (on the transverse and inner walls, 0.15A,A_c>0.15A; external longitudinal wall, A_c>0.25A, take 0.25A);

f_t—Design value of axial tensile strength of concrete in the middle part of the structural column;

A_{sc}—The total area of the longitudinal section of the structure column in the middle of the middle, the reinforcement ratio should not be less than 0.6%, and the ratio of 1.4% is greater than 1.4%;

f_{yh}、f_{yc}—The design values of the tensile strength of the longitudinal reinforcement of the wall and the structural column are respectively;

ξ_c—The middle part of the structure of the column to participate in the work coefficient, center set a time to take 0.5, more than a time to take 0.4;

η_c—Wall constraint correction coefficient, generally take 1, the structure of the column spacing is not greater than 3.0m 1.1;

A_{sh}—The longitudinal reinforcement area of the vertical section of the wall is not less than 0.07% and not more than 0.17%, and the ratio of reinforcement ratio is less than 0.07% when the horizontal longitudinal reinforcement is less than 0.

3. Model building

To Chengdu for a six story masonry structure housing as an example (planar graphs as shown in Figure 1), the establishment of the four models: 1) circle beam and structural column (model 1); 2) ring beams are no structural columns (model 2); 3) no ring beam constructional column (model 3); 4) without circle beam and structural column (model 4), to the bottom shear method for static calculations and extract the calculation results were compared and analyzed, thus clear ring beam and structural column in masonry structure housing the role in [4, 5].

Structure of the total length of 31.2m, the total width of 11.7m. Using solid brick masonry, one to six layers of brick strength grade is MU10, mortar strength grade is M5, masonry construction quality control level is B. The seismic fortification intensity is 7 degrees, the basic seismic acceleration value is 0.1g, the site class is II, the design earthquake is grouped into third groups, the basic wind pressure is 0.3kn/m^2, the ground roughness category is C.

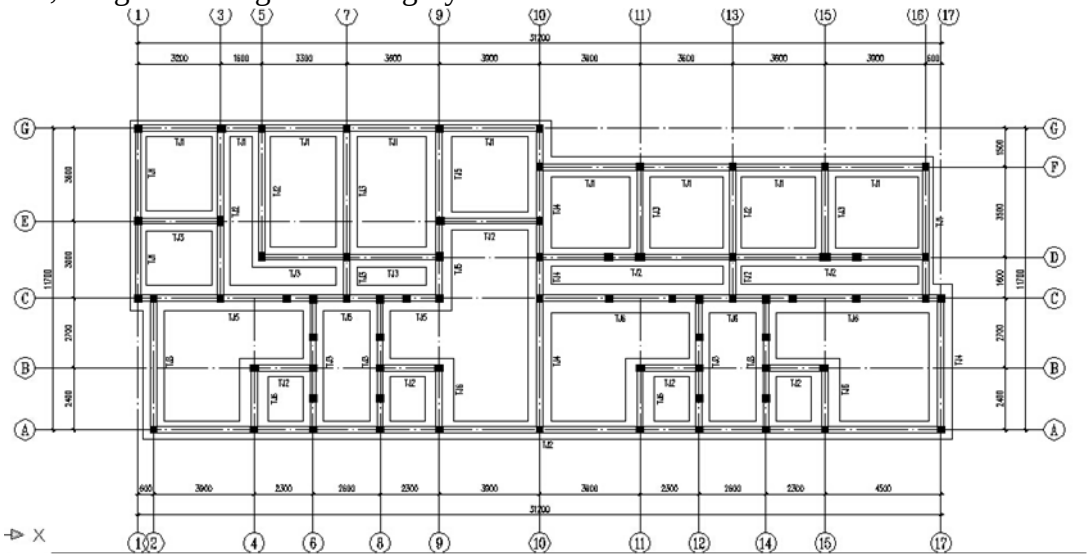
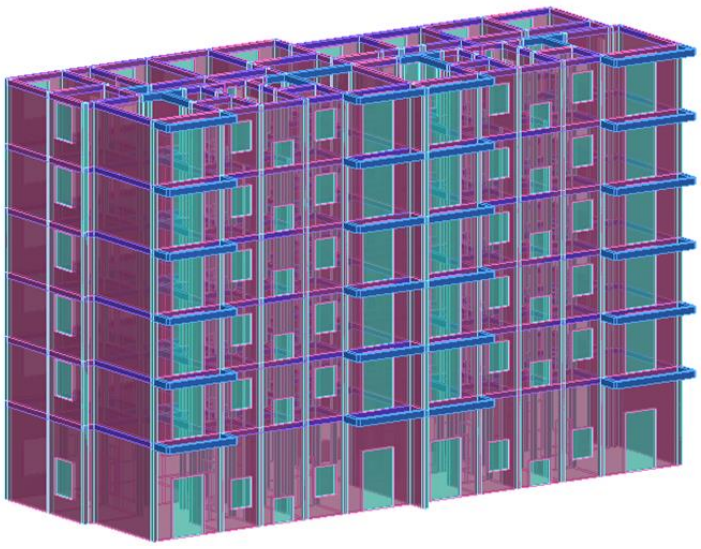
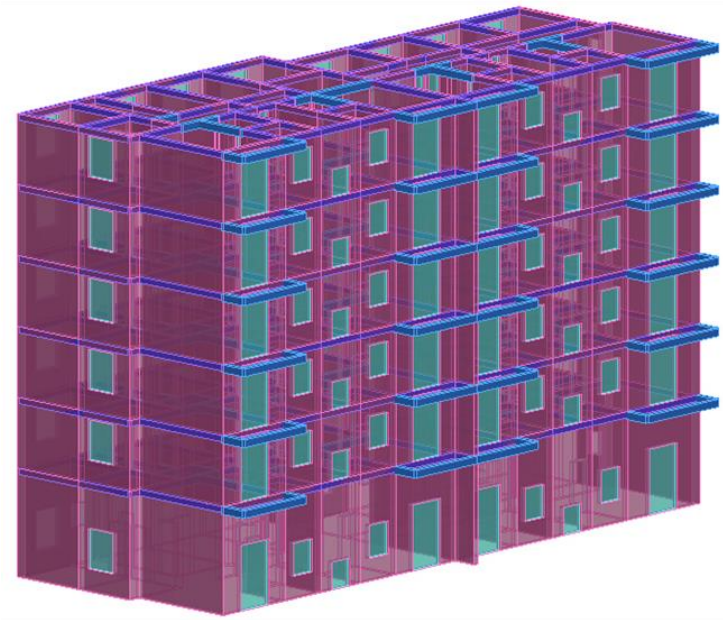


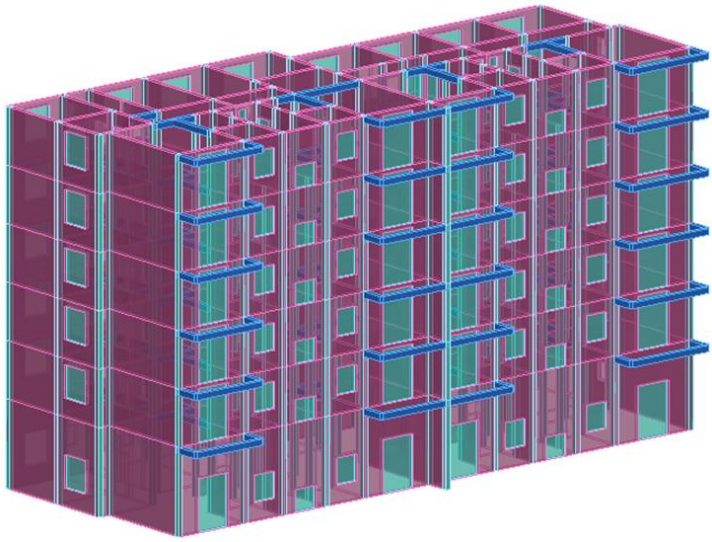
Fig.1 plan view



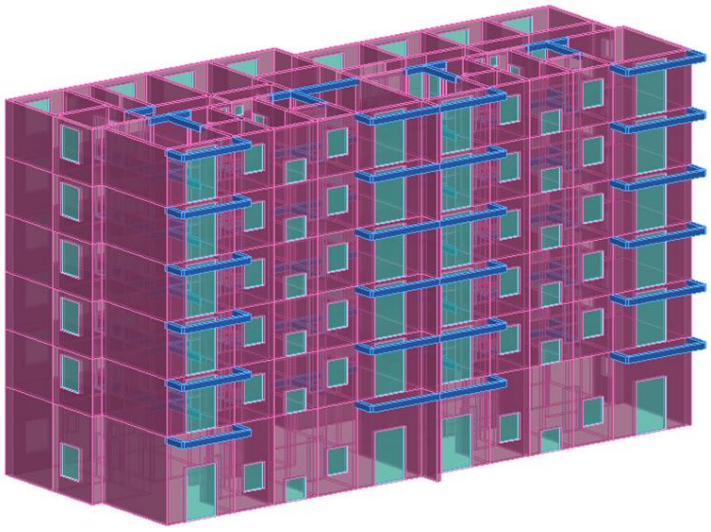
(a) with ring beams and constructional columns (model 1)



(b) there is no structural column beam (model 2)



(c) no beam structural columns (model 3)



(d) no ring beams and constructional columns (model 4)

Fig. 2 Three-dimensional model

4. Static calculation results

4.1 Compression calculation result.

Through the establishment of the previous model and related design parameters are set, by PKPM software masonry information and computing, four models of each layer of the wall of the compression (resistance and load effect ratio diagram to calculate the bearing capacity, when less than 1, said the calculation), for convenient data processing and analysis. In each model of each layer were taken six shear walls are compared and analyzed.

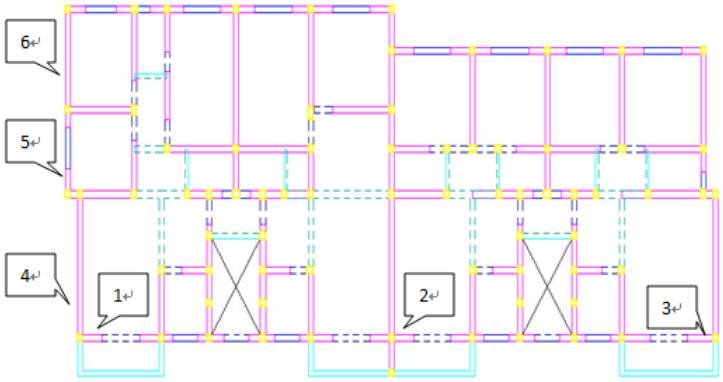


Fig. 3 Wall limb diagram

Table 1 Compression calculation results (ratio of resistance to load effect)

Floors		Wall-1	Wall-2	Wall-3	Wall-4	Wall-5	Wall-6
First	Model-1	2.18	1.84	1.68	1.90	4.42	2.57
	Mode-l2	0.76	1.15	0.79	1.43	1.30	1.80
	Model-3	2.18	1.84	1.68	1.90	4.42	2.57
	Model-4	0.76	1.15	0.79	1.43	1.30	1.80
Second	Model-1	2.77	2.38	2.15	2.44	5.62	3.25
	Mode-l2	0.97	1.49	1.02	1.83	1.66	2.29
	Model-3	2.77	2.38	2.15	2.44	5.62	3.25
	Model-4	0.97	1.49	1.02	1.83	1.66	2.29
Third	Model-1	3.42	2.94	2.67	2.99	6.84	3.97
	Mode-l2	1.20	1.84	1.26	2.25	2.02	2.80
	Model-3	3.42	2.94	2.67	2.99	6.84	3.97
	Model-4	1.20	1.84	1.26	2.25	2.02	2.80
Fourth	Model-1	4.49	3.86	3.50	3.87	8.74	5.10
	Mode-l2	1.58	2.42	1.65	2.91	2.58	3.59
	Model-3	4.49	3.86	3.50	3.87	8.74	5.10
	Model-4	1.58	2.42	1.65	2.91	2.58	3.59
Fifth	Model-1	6.52	5.61	5.09	5.47	12.10	7.13
	Mode-l2	2.29	3.52	2.40	4.11	3.57	5.02
	Model-3	6.52	5.61	5.09	5.47	12.10	7.13
	Model-4	2.29	3.52	2.40	4.11	3.57	5.02
Sixth	Model-1	11.93	10.27	9.32	9.34	19.64	11.85
	Mode-l2	4.18	6.45	4.39	7.01	5.79	8.35
	Model-3	11.93	10.27	9.32	9.34	19.64	11.85
	Model-4	4.18	6.45	4.39	7.01	5.79	8.35

Comparative analysis can be found by Table 1: 1) four models with the increase of layers, the resistance and load effect ratio are increased, this is because with the increase of layers, the reason of

the decrease of dead load; 2 (1) model with ring beams and constructional columns) and model 3 (no ring beam structure column) the resistance and load effect ratio in all floors and all the wall all the same size, model 2 (there are no structural columns and ring beam model (4) without the ring beams and constructional columns) resistance and load effect ratio in all floors and walls all the size of the same, which indicates that the ring has no effect on the structure of the bearing capacity; 3) model 3 (no beam structural columns) the resistance and load effect ratio in all floors are greater than 4 (no model, which indicates that the ring beams and constructional columns) constructional columns for bearing structure Force has a significant contribution. 4) for the model 4 (no circle beam and structural column) multiple compression bearing capacity can not satisfy the requirement, by setting up reasonable constructional column model 3 (no ring beam constructional column), the compression bearing capacity has been increased more.

4.2 Local pressure calculation results.

Refers to the local pressure on the surface of the components, only part of area under stress state. In masonry structure, when the beam is directly placed on a brick wall, due to the beam and the brick walls are two completely different materials, often need to local bearing capacity of checking, to avoid damage due to the lack of local pressure, which leads to the component.

Through the establishment of the previous model and related design parameters are set, by PKPM software masonry information and computing, four models of local bearing calculation results. After statistical analysis after the floors of each model does not meet the local bearing number.

Table 2 Local pressure does not meet the number (unit: spot)

Floors	First	Second	Third	Fourth	Fifth	Sixth
Model-1	0	0	0	0	0	0
Mode-l2	2	0	0	0	0	0
Model-3	0	0	0	0	0	0
Model-4	24	24	24	26	11	1

In Table 2 can be found: 1) through the reasonable constructional column (model 3), the local bearing are met; 2) by setting the beam (model 2) although for partial pressure have a certain improvement, but in layer there are still two does not meet the requirements of local bearing capacity of checking; 3) with increasing numbers of stories, the local pressure does not meet the number showed decreasing trend. This is because with the increase in the number of floors, the representative gravity load value decreases.

4.3 4.3. Seismic calculation results.

PKPM software using the bottom shear method to calculate the seismic force, the total level of seismic force, the redistribution to the floor, and finally assigned to each wall. For seismic results, the PKPM software is also the ratio of the output to its resistance to the load effect. Similarly, a similar method is used to analyze the results of compression, and the six wall limbs (Figure 3) of each model are compared and analyzed, and the results are shown in table 3.

Table 3 Aseismic calculation results (ratio of resistance to load effect)

Floors		Wall-1	Wall-2	Wall-3	Wall-4	Wall-5	Wall-6
First	Model-1	1.70	2.19	1.68	2.11	2.49	2.25
	Mode-l2	1.41	1.39	1.40	1.42	1.61	1.50
	Model-3	1.70	2.19	1.68	2.11	2.49	2.25
	Model-4	1.41	1.39	1.40	1.42	1.61	1.50
Second	Model-1	1.72	2.25	1.70	2.21	1.86	2.35
	Mode-l2	1.45	1.42	1.43	1.44	1.29	1.55
	Model-3	1.72	2.25	1.70	2.21	1.86	2.35

	Model-4	1.45	1.42	1.43	1.44	1.29	1.55
Third	Model-1	1.81	2.41	1.79	2.36	2.00	2.52
	Mode-l2	1.52	1.49	1.51	1.50	1.36	1.61
	Model-3	1.81	2.41	1.79	2.36	2.00	2.52
	Model-4	1.52	1.49	1.51	1.50	1.36	1.61
Fourth	Model-1	2.03	2.76	2.00	2.70	2.28	2.87
	Mode-l2	1.71	1.66	1.69	1.66	1.52	1.79
	Model-3	2.03	2.76	2.00	2.70	2.28	2.87
	Model-4	1.71	1.66	1.69	1.66	1.52	1.79
Fifth	Model-1	2.54	3.56	2.49	3.47	2.94	3.64
	Mode-l2	2.13	2.08	2.10	2.04	1.90	2.19
	Model-3	2.54	3.56	2.49	3.47	2.94	3.64
	Model-4	2.13	2.08	2.10	2.04	1.90	2.19
Sixth	Model-1	4.05	5.99	3.97	5.77	4.82	5.76
	Mode-l2	3.45	3.40	3.40	3.15	3.00	3.29
	Model-3	4.05	5.99	3.97	5.77	4.82	5.76
	Model-4	3.45	3.40	3.40	3.15	3.00	3.29

By table 3 can be found: 1) the four models with the increase of layers, the resistance and load effect ratio are increased, this is because with the increase of layers, the floor is assigned to the interlayer shear decreases gradually; 2) model-1 with ring beams and constructional columns) and model-3 (no ring beam structure column) the resistance and load effect ratio in all floors and all the wall all the same size, model-2 (there are no structural columns and ring beam model-4 without the ring beams and constructional columns) resistance and load effect ratio in all floors and walls of all sizes are completely same, which shows no effect on beam seismic analysis of the structure, this is mainly because the beam in the in-plane stiffness of 0.

5. Conclusion

Through the calculation of the four models, and the calculation results of the comparative analysis, we can get the following points:

(1) in masonry structure, a reasonable set of constructional column can improve the structure of compression, local pressure and seismic performance, visible structural columns in the masonry structure in importance, so in masonry structure design, be sure to in accordance with the specifications set structural column at the specified location.

(2) in the masonry structure, only set the ring beam and did not set the constructional column approach is not desirable, because a separate set of ring beam is not the structure to form a whole, for compressed structure, local pressure and seismic performance of almost no contribution.

(3) in the masonry structure housing design, if a part of the local pressure check is not through, can be in the lower part of the structure through the additional column, you can check, and compared with the beam pad is more convenient construction.

(4) in order to improve the performance of the overall structure, must be in accordance with the specifications set structure column and ring beam, the two are combined into a whole and work together, only this can play to the constraint function, so as to improve the masonry shear, tensile strength, so as to ensure that the houses in the earthquake to work normally.

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