EXPERIMENTAL STUDY AND NUMERICAL SIMULATION OF LOAD-BEARING CAPACITY OF REINFORCED GROUTED CONCRETE BLOCK MASONRY WALLS UNDER ECCENTRIC COMPRESSION

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ABSTRACT
Sixteen reinforced grouted concrete block masonry walls with varying eccentricity have been tested under eccentric compression. The load-bearing capacity, the load-deformation relationship, the failure process, and the complete load-strain process of the longitudinal reinforcement have been obtained. The nonlinear Finite Element Analysis software ANSYS is used to investigate the mechanical behaviour of reinforced grouted concrete block masonry walls under eccentric compression. The load-bearing capacity resulting from tests have been compared to the values recommended in the Chinese Code for Design of Masonry Structures GB 50003 [1]. It was shown that the plane-section assumption is valid and that the recommended method of the bearing capacity from GB 50003 is conservative.

KEYWORDS: block masonry, out-of-plane, reinforced, eccentric compression, bearing capacity

INTRODUCTION
Due to the wide use of the reinforced grouted concrete block masonry structures in China, more attention is paid on the performance of walls under eccentric compression. Particularly, when the room is with large space and large span or there is a beam with vertical loading on the exterior wall, out-of-plane eccentric compressive load on the reinforced grouted concrete block wall could be considerably obvious. Experimental and theoretical studies have not yet commenced in China, therefore the method recommended in Chinese Code for design of masonry structure GB 50003 [1] for load-bearing capacity of reinforced grouted block masonry wall under eccentric compression has to be in accordance with the method for unreinforced masonry.

In this paper, 16 reinforced grouted concrete block masonry walls have been tested under eccentric load. The load-bearing capacity, the load-deformation relationship, the failure process and mode have been studied; the applicability of the simplified method provided by Chinese Code [1] has been verified by results from tests. Finally, taking the advantage of the Finite Element (FE) analysis, the deficiency of test data can be made for, thus the influential factors including eccentricity and height-thickness ratio on load-bearing capacity of reinforced block masonry walls under eccentric compression was investigated. The results from this paper provide a basis for establishing an applicable method of calculation of the load-bearing capacity for reinforced grouted concrete block walls under eccentric loading.

SPECIMEN DESIGN AND MATERIAL PROPERTIES

In order to analyze the influence of different parameters including eccentricity, height-thickness ratio of wall, material strength of masonry, strength of grouted concrete and longitudinal reinforcement on the load-bearing capacity of reinforced masonry wall, 16 specimens were designed and fabricated. Specimen dimensions and reinforcement arrangement are illustrated in Figure 1, the design parameters of walls are shown in Table 1.

Table 1: Design Parameters of Specimens

Specimen Number	Block Strength Grade	Mortar Strength Grade	Grout Strength Grade	Eccentricity (mm)	Longitudinal Reinforcement	Specimen Dimension Height×Width×Thickness (mm)
Q1,Q2,Q3	MU15	Mb15	Cb30	40	4ø 12	1000×590×190
Q4,Q10,Q11	MU15	Mb15	Cb30	20	4ø 12	1000×590×190
Q5,Q6	MU15	Mb15	Cb30	0	4ø 12	1000×590×190
Q7,Q8,Q9	MU15	Mb15	Cb30	60	4ø 12	1000×590×190
Q12,Q13	MU10	Mb10	Cb20	30	4ø 12	1000×590×190
*Q14,*Q15,*Q16	MU15	Mb15	Cb30	40	——	600×590×190

Note: 1. MU15, MU10: the mean compressive strength for concrete hollow block are 15 MPa, 10 MPa ;

2. Mb15, Mb10: the mean compressive strength for 70.7mm cube mortar are 15 MPa, 10 MPa;

3. Cb30, Cb20: the characteristic compressive strength for 150mm cube grout are 30 MPa, 20 MPa;

4. The concrete strength grade of top and bottom beam is C30 (the characteristic compressive strength for 150mm cube concrete is 30 MPa);

5. The specimen with an asterisk has no top beam, bottom beam and vertical reinforcement in concrete grout.

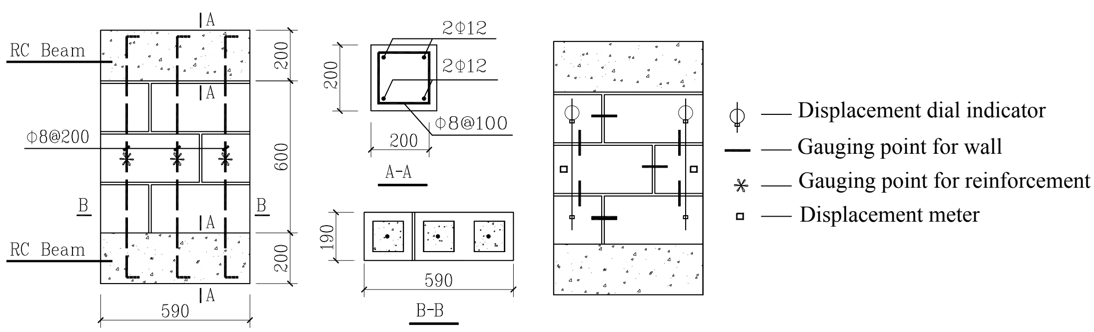

Figure 1: Design Details and Locations of Gauging Point for specimen

Strains on wall surfaces and in the embedded longitudinal reinforcement were measured through displacement dial indicators with gauge length of 400 mm and strain gauges, respectively. For large eccentricity on specimens, set displacement meter at the middle height of the wall to measure the out-of-plane displacement. Reinforcement strain gauging points, arrangement of strain gages and instrumentation on the wall surface are shown in Figure 1.

The monotonic compressive loading eccentrically was applied to specimens using a hydraulic pressure machine of 5000kN capacity with four columns and screen display by a set of knife-hinge on the top and bottom beam. Design parameters of specimens are shown in Table 1.

EXPERIMENTAL PHENOMENA

Despite of the different parameters between 16 specimens, the failure process and phenomena of all specimens indicated that the failure type of the wall mainly depends on eccentricity.

For specimens under concentric compression (e=0 mm), the concrete block in triaxial state of stress was not only bearing vertical compression, but also affected by the extrusion action from concrete grout in the hollow. When the principal tensile stress exceeded the concrete tensile strength, longitudinal cracks appeared, and then cracks propagated and joined the vertical mortar crack to become through vertical cracks on the wall surface. The crack patterns of the specimen under concentric compression are shown in Figure 2.

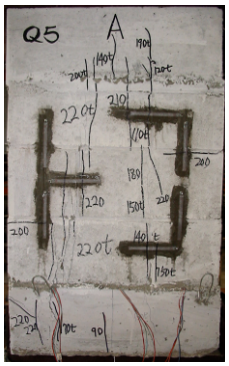

Figure 2: Wall Q5 (e=0 mm)

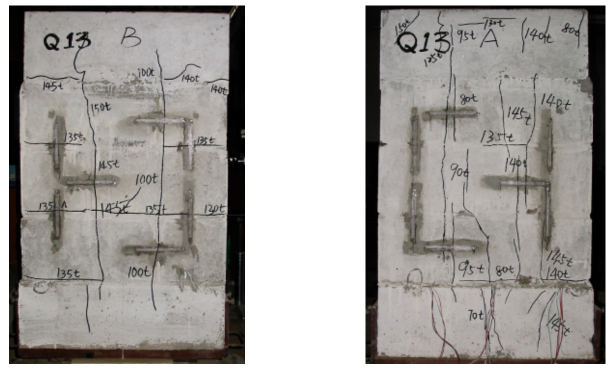

Figure 3: Wall Q13 (e=30 mm) :
a) Tensile Face; b) Compressive Face

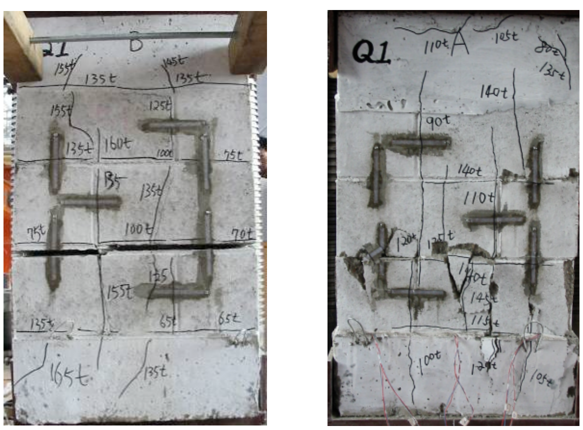

Figure 4: Wall Q1（e=40 mm）:
a) Tensile Face; b) Compressive Face

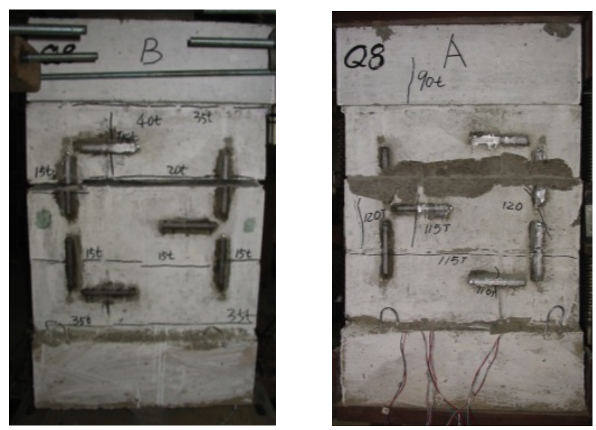

Figure 5: Wall Q8（e=60 mm）:
a) Tensile Face; b) Compressive Face

For specimens with 20 mm eccentricity, the eccentric side of the masonry walls was always under compression, the other side revealed uncertain stress condition at the beginning. With the increasing load, the stress of this side ultimately turned into tension, and then tended to slow increase. For failure stage, it appeared that the compressive side of block walls with through vertical cracks was crushed. Failure characteristics are similar to specimens under concentric compression, but there were non-continuous horizontal cracks at mortar layer appearing on the side away from eccentricity.

With the increase of eccentricity (e=30 mm~40 mm), the side of walls away from eccentricity was under tensile state, and appeared continuous and increasing horizontal cracks. Failure phenomena showed that the vertical crack propagation on the eccentric side of wall decreased with the increasing eccentricity and visible bending failure appeared. Distributions of wall cracks are shown in Figure 3 and Figure 4.

For specimens of 60 mm eccentricity, horizontal mortar joint of tensile side first cracked at the load of 150kN. With the increase of load, the width of horizontal mortar joint cracks developed, and even the grouted concrete located at tensile zone was damaged under tension. At the same time, the compressive zone did not crack. During the later stage of load-bearing capacity, high compressive stress and bending deformation led to the peeling of mortar and block at horizontal mortar joint, and grouted concrete located at the compressive zone also became crushed. Distribution of wall cracks is shown in Figure 5. After failure, the dissection of all specimens showed excellent bonding properties among block, grouted concrete, and longitudinal reinforcement. Basically, there was no separation between grouted concrete and block or between reinforcement and grouted concrete for all specimens. Therefore, no matter the specimen is under concentric or eccentric compression, blocks, grouted concrete and reinforcement in the grouted concrete column can cooperate very well.

TEST RESULTS OF MATERIAL MECHANICAL PROPERTIES

Block, mortar, concrete and reinforcement samples were taken and tested to determine mechanical properties at the time of specimen fabrication. Average yield strength of longitudinal reinforcement is 300.4MPa, average ultimate strength is 449.6MPa. The average compressive strength of block, mortar and concrete is presented in Table 2.

Table 2: Average Compressive Strength of Specimen Materials

Specimen Number	Average Compressive Strength / Eccentricity e (mm)	Block f_1(MPa)	Mortar f_2 (MPa)	Grouted Concrete $f_{cu,m}$ (MPa)	Block Masonry f_m(MPa)	Grouted Masonry $f_{g,m}$(MPa)
Q1,Q2,Q3	40	15.3	13.4	43.46	10.03	20.98
Q4	20	15.3	14.94	43.46	10.42	21.37
Q5,Q6	0	15.3	14.94	43.46	10.42	21.37
Q7,Q8,Q9	60	15.3	14.94	41.4	10.42	20.85
Q10,Q11	20	15.3	13.4	41.4	10.03	20.46
Q12,Q13	30	18.41	10.89	30.91	11.05	19.04
*Q14,*Q15,*Q16	40	15.3	12.74	41.75	9.86	20.38

Note: 1. Average compressive strength of un-grouted block masonry: $f_m = 0.46 f_1^{0.9}(1+0.07f_2)$;

2. Average compressive strength of grouted block masonry: $f_{gm} = f_m + 0.63 \times 0.45 \times f_{cu,m}$;

3. The specimen with an asterisk has no top beam, bottom beam and vertical reinforcement in concrete grout.

TEST RESULTS AND ANALYSIS OF WALL LOAD-BEARING CAPACITY

Method recommended in Chinese Code for design of masonry structure GB 50003 [1] for load-bearing capacity of reinforced grouted block masonry wall under eccentric compression is in accordance with the method for un-reinforced masonry, and is given by Equation (1),

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

where N is axial load; f is compressive strength of grouted concrete block masonry, A is cross-sectional area; φ represents the influence coefficient based on the height-thickness ratio (β) and eccentricity (e) on load-bearing capacity, can be defined as,

$$\varphi = \frac{1}{1+12\left(\frac{e}{h}+\beta\sqrt{\frac{\eta}{12}}\right)^2} \tag{2}$$

where $\beta = \frac{H_0}{h}$, H_0 is calculated height of wall; h is thickness of wall; η is the coefficient depending on compressive strength of mortar f_2, when $f_2 \geq 5$MPa, η =0.0015; when f_2=2.5MPa, η =0.002; and when f_2=0, η =0.009.

Table 3: Comparison of the Load-Bearing Capacity

Specimen Number		β	Eccentricity (mm)	Test Results N_1(kN)	φ	Calculated Results N_2(kN)	N_1/N_2	FE Results N_3(kN)	$\frac{N_3-N_1}{N_1}$
URM	Q14	3.16	40	1470	0.581	1326.9	1.11	1557	5.92%
	Q15	3.16	40	1580	0.581	1326.9	1.19	1557	-1.46%
	Q16	3.16	40	1220	0.581	1326.9	0.92	1557	27.62%
RM	Q1	5.26	40	1650	0.536	1259.9	1.31	1736	5.19%
	Q2	5.26	40	1476	0.536	1259.9	1.17	1736	17.59%
	Q3	5.26	40	1778	0.536	1259.9	1.41	1736	-2.38%
	Q4	5.26	20	2188	0.757	1813.8	1.21	2205	0.80%
	Q5	5.26	0	2340	0.961	2302.0	1.02	2700	15.38%
	Q6	5.26	0	2580	0.961	2302.0	1.12	2690	4.26%
	Q7	5.26	60	1120	0.373	872.6	1.28	1259	12.37%
	Q8	5.26	60	1230	0.373	872.6	1.41	1259	2.32%
	Q9	5.26	60	1329	0.373	872.6	1.52	1259	-5.30%
	Q10	5.26	20	1980	0.757	1736.7	1.14	2127	7.42%
	Q11	5.26	20	2199	0.757	1736.7	1.27	2127	-3.27%
	Q12	5.26	30	1624	0.641	1367.5	1.19	1720	5.91%
	Q13	5.26	30	1560	0.641	1367.5	1.14	1720	10.26%
Mean				——	——	——	1.245		6.41%

Note: Bi-directional eccentric condition happened to specimen Q16 so that the test value was low.

Obviously, the above-mentioned method is a simplified mode to estimate the load-bearing capacity for reinforced grouted block masonry walls under out-of-plane vertical load. The method is based on the following assumptions: 1) ignore the contribution of the longitudinal reinforcement on the load-bearing capacity; 2) the influence coefficient φ based on height-thickness ratio and eccentricity on load-bearing capacity borrowed the formula for un-reinforced masonry. In order to verify the applicability, calculated results according to Equation (1) were compared with experimental results, as shown in Table 3. It is worth mentioning that the cast-in-place RC beams at top and bottom be regarded as a block layer of the specimen for calculating height-thickness ratio β.

The results showed that test values of load-bearing capacity were greater than the calculated values according to the method recommended in Chinese Code [1]. Based on above-mentioned results, following viewpoints can be drawn：1) the adoption of influence coefficient φ in Chinese Code for design of masonry structure [1] is based on the research results of un-reinforced masonry. However, grouted concrete and reinforcement enhances the integrity and stability of reinforced grouted concrete block walls. This enhancement improves the ability of walls for resisting out-of-plane bending, and the performance of walls is between masonry and concrete structure. Thus, the decreasing effect on load-bearing capacity related to the influence coefficient φ was overestimated in Equation (2); 2) ignore the contribution of longitudinal reinforcement on the load-bearing capacity of the wall.

It can also be acquired from results in Table 3 that with the increasing eccentricity, the load-bearing capacity decreases, and the ratio of test and calculated result increases. Based on above-mentioned results, this article considers that the connecting effect between grouted concrete and reinforcement, and the bending capacity of longitudinal reinforcement makes the decrease of load-bearing capacity caused by eccentricity less obvious than un-reinforced masonry. Therefore, the error caused by calculating formula recommended from Chinese Code [1] increases with the increase of eccentricity.

STRAIN OF LONGITUDINAL REINFORCEMENT

Figure 6 is load-strain curve of reinforcement for specimens with varying eccentricity. As shown in Fig. 6, longitudinal reinforcement for wall Q5 (e=0 mm) and wall Q6 (e=0 mm) yielded in concentric compression tests, whereas reinforcement did not basically reach the yield strength for walls subjected out-of-plane eccentric compression load.

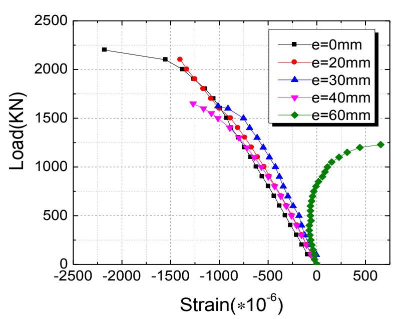

Figure 6:Load-strain Curve of Reinforcement

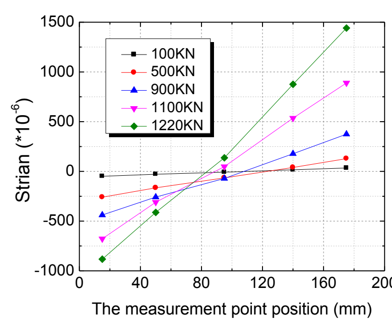

Figure 7: Cross-section Strain for wall Q16

The longitudinal reinforcement with ultimate strain of 1000 to 1500 micro-strain was in compression for specimens with eccentricity of 20 to 40 mm, the average stress was about 72% of yield strength. With the increase of eccentricity, the utilization of capacity for reinforcement decreased. It can also be found in Fig.6 that the longitudinal reinforcement was under compression when load was less than 800 kN, and then reinforcement gradually became under tension with the increase of load for the specimens with eccentricity of 60 mm. The section depth of compressive zone reduced with increasing compression, and the compressive section depth was less than half of wall thickness for the specimens with eccentricity of 60 mm, the longitudinal reinforcement located in central position of wall would bear tension. Hence, the strain stage of the longitudinal reinforcement appeared a transformation from compression to tension. At last, the tension strain of reinforcement did not reach the yield strength when the specimen failed (average ultimate strain is 656 micro-strain). Though longitudinal reinforcement did not yield, it served as a vertical connection that assured the integrity of the wall to avoid collapse after the crush of specimen at failure stage, and provided some bending capacity.

In sum, the longitudinal reinforcement for the reinforced grouted concrete block walls with small eccentricity improves the load-bearing capacity. When the eccentricity is large, the effect decreases due to the limited resistance moment. Therefore, the calculation of load-bearing capacity should take the contribution of reinforcement into account according to the magnitude of eccentricity.

So to date, no clear argument of whether the assumption is practicable in calculating the load-bearing capacity for the walls under eccentric load is proposed. In order to provide theoretical basis, the out-of-plane plane-section assumption was verified by tests. Conclusions drawn from the test results are as follows: Specimens with different eccentricity basically accorded with the out-of-plane plane-section assumption. As an example, cross-sectional strain of wall Q16 remained plane in the whole process of loading, as shown in Figure 7. For specimens with large eccentricity (e=60 mm), when the load reached around 40% of the ultimate load, some strain gages located in tensile zone gradually happened to be broken while the rest strain gages showed that the strain still satisfied the plane-section assumption.

FINITE ELEMENT AND MODELING

FE analysis software ANSYS was adopted in this paper for its great advantages including saving calculating time, reasonable accuracy and stability. Because of the different material properties between block masonry, grouted concrete and reinforcement, in order to improve the precision of the FE analysis and calculation, grouted concrete, block masonry and reinforcement is modeled and meshed, according to the respective characteristics of shape and material properties.

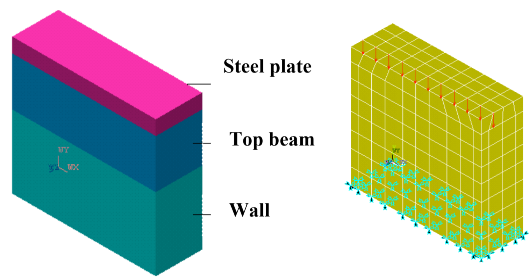

Figure 8: The FE Model

Although the reinforced block walls which is composed of block, grout, mortar and reinforcement is a kind of anisotropic material, current researches have indicated that the mechanical property of reinforced grouted block masonry is similar to RC structure [2]. Therefore, the reinforced grouted concrete block masonry walls can be regarded as assembled monolithic RC structure. For the above reasons, three dimensional eight nodes concrete element Solid65 was adopted to simulate the concrete grout and block masonry, and three dimensional bar element Link8 was adopted to simulate the reinforcement in FE analysis.

In order to avoid the local compressive failure on the loading surface, two steel plates were placed on the top and bottom surfaces of the specimen in tests. For FE analysis, two steel plates with large stiffness were also added to the top and bottom surfaces of the walls so that the FE model would not lose the load-bearing capacity due to the damage of local element during calculating.

With increasing mesh number, it will take too much calculating time, therefore FE model is simplified equivalently in this paper. According to the material mechanics, it is known that the critical force of a strut with length of L hinged at both ends is the same as that of a strut with length of L/2 fixed at one end and freed at the other end. Also, there is the same mid-span deflection for real model and simplified model. Therefore, based on above theory, a simplified model with height of 2/H was adopted to replace that of height H. The FE model of the walls is presented in the Figure 8.

CONSTITUTIVE RELATION FOR GROUT, MASONRY AND REINFORCEMENT

Based on Chinese Code for Design of Concrete Structures [3], the constitutive relation of grouted concrete is given as follows,

as $0 \le \varepsilon_c \le \varepsilon_0$, $$\sigma_c = f_c\left[1-\left(1-\frac{\varepsilon_c}{\varepsilon_0}\right)^n\right] \tag{3}$$

as $\varepsilon_0 \le \varepsilon_c \le \varepsilon_{cu}$, $$\sigma_c = f_c \tag{4}$$

$$n = 2 - \frac{1}{60}(f_{cu,k} - 50) \tag{5}$$

where $f_{cu,k}$ is the characteristic cube grout strength with dimension of 150 mm (in MPa); f_c is the prism grout strength (in MPa); $\varepsilon_0 = 0.002$; $\varepsilon_{cu} = 0.0033$.

There are various expressions of stress-strain curve for masonry under compression. A famous logarithmical expression put forward by a Soviet scholar Л. И. ОНИЩИК is as follows [4]:

$$\varepsilon = -\frac{1.1}{\zeta}\ln\left(1-\frac{\sigma}{1.1f_k}\right) \tag{6}$$

where σ is stress of masonry, ε is strain of masonry; ζ is elastic characteristic value which is relative with the mortar strength (in MPa); f_k is the characteristic compressive strength of masonry (in MPa). Reference [5] has made following transformation to Equation (6): take $\zeta = 460\sqrt{f_m}$ and substitute the characteristic compressive strength of masonry f_m (in MPa) for f_k. Therefore, the stress-strain relation of masonry under eccentric compressive load is as following,

$$\varepsilon = -\frac{1}{418\sqrt{f_m}}\ln\left(1-\frac{\sigma}{1.1f_k}\right) \tag{7}$$

Considering the local compression and non-uniform stress distribution for masonry under eccentric load, the compressive strength of masonry should be increased and the expression of masonry compressive strength is as following,

$$\sigma = 1.1(1 - e^{-418\varepsilon\sqrt{f_m}})\gamma f_m \quad (8)$$

where γ is the enhancing coefficient of masonry compressive strength derived from reference [6],

$$\gamma = 1 + \log_{10}\frac{h}{x} \quad (9)$$

where the value of γ is related with h (depth of section) and x (depth of compression zone).

In this paper, the stress-strain relation of reinforcement is ideal elastoplastic and uses a double broken line form, i.e. the stress of reinforcement σ_s is the product of the strain ε_s and elastic modulus E_s, which shall be not greater than that of yield strength f_y.

NUMERICAL SIMULATION RESULTS

To demonstrate the applicability of the FE analysis method in this paper, the simulation results of all specimens are presented and compared with test results. The comparison of the load-bearing capacity for all specimens between experiment and simulation are shown in Table 3.

As shown in Table 3, the experiment results are in good agreement with the FE results, with the error within about 10% except specimens Q2, Q5, Q7 and Q16. There was local compressive damage at the top or bottom of RC beam for specimens Q2, Q5 and Q7, and bi-directional eccentric compression for specimen Q16 in test. Consequently, the load-bearing capacity of above-mentioned specimens was lower.

ANALYSIS OF INFLUENTIAL FACTORS ON LOAD-BEARING CAPACITY

Many factors influence the load-bearing capacity of reinforced grouted concrete block masonry walls under eccentric load. The following parameters were selected for FE analysis in this paper:
1) Out-of-plane eccentricity：0 mm, 10 mm, 20 mm, 30 mm, 40 mm, 50 mm, 60 mm；
2) Height-thickness ratio: 5.26, 10.53, 15.79.

It can be concluded from the test phenomena and results that eccentricity is the main factor which dominates the failure mode and the load-bearing capacity. Therefore, FE model was built to analyze the wall load-bearing capacity under 7 different eccentricities. Meanwhile, the conditions of 3 different height-thickness ratios were selected. Results of calculation are shown in Table 4 and Figure 9. Based on the results of calculation, the out-of-plane load-bearing capacity decreases with the increase of eccentricity, and the decreasing extent for different height-thickness ratio are consistent, i.e. the variation tendency are same for 3 curves in Figure 9.

Chinese Code for Design of Masonry Structure [1] rules that the limit of eccentricity to be less than or equal to 0.6y, in which y stands for the distance from centroid of section to edge of eccentric side of section. Test phenomena and FE results also indicated that the tension side of section with large eccentric cracked horizontally under relative low cracking load. With the increase of eccentricity, section depth of compression zone gradually reduced, meanwhile, the stiffness of walls decreased, thus, the longitudinal bending was more obvious and caused the decrease of load-bearing capacity of walls. In addition, the material compressive strength was not efficiently utilized for large eccentricity.

There is concrete grout, horizontal cast-in-place belt and longitudinal reinforcement in reinforced block masonry, which plays a role in enhancing the overall capacity and stability of the wall in the process of being eccentrically compressive, however, the effect of improving the crack prevention on tensile face is poor. Therefore, this paper argues that the rule about eccentricity for reinforced grouted concrete block walls should be in accordance with unreinforced masonry, i.e. $e \le 0.6y \approx 60$ mm for block with a thickness of 190mm.

With the increase of height-thickness ratio of the wall, FE results indicated that the influence of longitudinal bending on decrease of load-bearing capacity of walls show obvious. Details are shown in Table 4 and Figure 10.

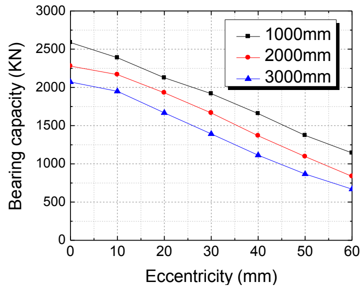

Figure 9: Bearing Capacity-Eccentricity Curve

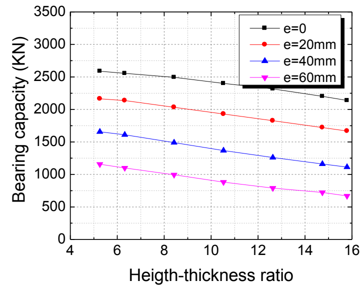

Figure 10: Bearing Capacity-Height thickness Curve

Table 4: FEA Results for Varying Eccentricity

Eccentricity e (mm)	Height×Width ×Thickness (mm)	β	Average Compressive Strength of Grouted Masonry f_{gm} (MPa)	Reinforcement	Results from Eqn.(1) N_1(kN)	FE Results N_2(kN)	N_2/N_1
0	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	2202 1967 1670	2587 2401 2138	1.175 1.221 1.280
10	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	1996 1702 1407	2400 2195 1949	1.202 1.290 1.385
20	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	1734 1437 1175	2163 1930 1667	1.247 1.343 1.419
30	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	1467 1200 979	1940 1665 1391	1.322 1.388 1.421
40	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	1226 1001 820	1662 1367 1114	1.356 1.366 1.359
50	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	1022 837 691	1389 1096 866	1.359 1.309 1.253
60	1000×590×190 2000×590×190 3000×590×190	5.26 10.53 15.79	20.463	3 ø 8	855 705 587	1157 881 669	1.353 1.250 1.140

5 CONCLUSIONS

By test and FE analysis of 16 reinforced grouted concrete block masonry walls under out-of-plane eccentric compressive load, following conclusions can be drawn:

1. When eccentricity is little, utilization of longitudinal reinforcement can be relatively sufficient. With the increase of eccentricity, reinforcement becomes under tensile from compressed, the influence of longitudinal reinforcement on load-bearing capacity is becoming weak and even ignorable.

2. Plane-section assumption is basically applicable for reinforced masonry walls under eccentric compression.

3. No matter the specimen is under concentric or eccentric compression, blocks masonry, grout and longitudinal reinforcement can cooperate well.

4. Test results of load-bearing capacity were greater than the calculated values according to the method recommended from Chinese Code. Moreover, the error increases with the increase of eccentricity. For reinforced block masonry walls, the value of φ in calculation of load-bearing capacity recommended from Chinese Code is relatively conservative due to the enhancement of integrity and stability caused by grouted concrete, longitudinal reinforcement, and the bonding capacity of longitudinal reinforcement.

5. With the increase of eccentricity and height-thickness ratio, load-bearing capacity of walls under eccentric compression decreases gradually, and out-of-plane eccentricity of reinforced block masonry with 190 mm thickness should be limited to less than or equal to 60 mm.

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