Application and Prospect of New Masonry Infilled Wall

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Abstract. As a new wall material, autoclaved aerated concrete (AAC) can realize the self-insulation system of "single material" wall in different climate regions in China. At the same time, it has obvious advantages in engineering construction, such as saving resources, easy processing, and good fire resistance. Therefore, AAC can be used as the preferred wall material for infilled walls of frame structures and load-bearing walls of residential multi-story buildings. In this paper, firstly, the main characteristics of AAC blocks are briefly explained. Then, the seismic performance of Reinforced Concrete frame of AAC, the impact of hole characteristics on its mechanical properties, and its compressive properties are analyzed and explored. It is expected that AAC blocks will be widely used and developed in the process of filling construction in the future.

Keywords: AAC, anti-seismic property, Mechanical property, compressive property, New masonry infilled wall.

1. Introduction

With the promotion of assembly structure and the rapid development of new energy-saving filled walls, new building industrialization is becoming a trend in the development of Chinese construction industry, and the research of new masonry filled walls is indispensable. As a new wall material, Autoclaved aerated concrete (AAC) is the only single material that can meet the requirement of 50% energy saving. AAC, as a new type of wall material, is the only single material that can meet the 50% energy saving requirement. It has the advantages of high strength, high quality, light weight and easy processing of the frame-filled wall. It not only retains the characteristics of the traditional brick and stone structure, such as wide range of materials, low cost and convenient construction, but also has the characteristics of the reinforced concrete structure with high strength and good ductility. The use of AAC instead of traditional clay bricks can achieve the purpose of saving and effectively utilizing resources, protecting land and comprehensively managing the environment [1].

AAC is a kind of porous silicate products made of silicon material and calcium material as the main material, adding gas agent, by casting molding, static cutting, autoclaved curing and other technological processes. The mass of AAC blocks is generally 400 ~ 700kg/m^3, which only accounts for 1/4 ~ 1/3 of the mass of mortar bricks and clay bricks, and is also lower than the aggregate weight of ordinary lightweight aggregate concrete. The thermal conductivity of AAC blocks is only 1/5 ~ 1/4 of that of clay bricks, and it has good self-insulation characteristics. When applied to an entire building, it can reduce mass by 40%. At present, most AAC blocks are used as filling walls for frame structures. The main reason is that their absolute strength is low, but their strength utilization is high. The strength utilization rate of ordinary solid brick is generally 30%~40%, while the strength utilization rate of AAC block is generally about 70% [2-4]. In addition, the use of high height and large volume of the block can reduce the number of ash joints, improve the insulation of the wall.

This paper combines the existing experimental data to analyze and evaluate the basic performance of masonry filled walls with AAC as the main material, in order to further draw the application direction and prospect of new masonry filled wall in practical engineering. Since AAC material is different from traditional reinforced concrete, on the basis of changing the material, the bigger change is the difference in its engineering performance. Therefore, on the basis of sustainable development and green environmental protection, it is essential and extremely important to expand the research on all aspects of the new masonry filled wall. With the progress of science and technology, the future research and application of masonry filled wall is a hot direction. Therefore, it is necessary to summarize the existing experimental results and point out the shortcomings, which is also the significance of this paper.

2. The Main Analysis of New Masonry Infilled Wall

2.1. New masonry infilled wall RC frame construction

2.1.1 Seismic performance of RC frame structure with new masonry filled wall

Various tests and studies show that the infilled wall is widely used in construction projects in China because of its flexible layout and simple construction. As a non-structural component, it only plays the role of enclosure and partition. The Reinforced Concrete (RC) can effectively improve the lateral stiffness and horizontal bearing capacity of the RC frame structure, and also affect the deformation ability of the RC frame structure, so that the RC frame structure has better seismic performance than the non-frame structure.

However, the filled wall also has some disadvantages. Due to the constraint effect and stiffness effect of the filled wall the plane stiffness of RC frame structure cannot be uniform, symmetric and dispersed. In this case, the stiffness of RC frame structure deviates from the center of mass greatly, which often produces torsion or stress concentration phenomenon under the action of earthquake. In addition, due to the vertical stiffness mutation of RC frame structure due to the frame filled wall, the RC frame structure has a weak layer and eventually produces earthquake damage [5].

2.1.2 New masonry infilled wall RC frame structure wall filling material

The infilled wall may collapse under the action of earthquake, which may block the emergency escape passage or cause casualties. Therefore, the research and application of new infilled wall materials is imminent. At present, the research on the mechanical property changes and seismic performance evaluation of the wing-filled material in various stages under earthquake action is still scarce in our country, in most tests, the infilled wall frame made of traditional solid clay brick is still used as the research object, and the research results are cited. The study on the change of mechanical property index and the evaluation of seismic performance of new test materials such as AAC block, concrete hollow block and hollow block under the action of earthquake needs to be further carried out [6].

2.1.3 Anti-seismic performance of AAC masonry filled wall frame structure

It can be seen from the previous earthquake damage that the filled wall has a significant effect on the seismic performance of the main frame structure. large number of experimental studies and numerical analysis show that the connection between the filled wall and the main frame is one of the main factors affecting the seismic performance of the main structure.

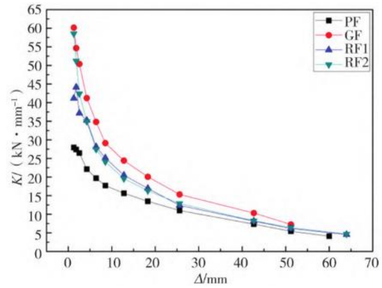
As for the influence caused by different connection methods, some main conclusions can be drawn based on the seismic performance analysis test of filled wall frame structure with different wall construction measures carried out by Zhou et al. [7]. The test is as follows: an out-of-plane monotonic static load test is carried out on a frame structure undergoing in-plane damage. The out-of-plane mechanical performance and failure characteristics of the filled wall under different wall-frame connection modes and wall structures are analyzed. Figure 1 shows the changes of each specimen in the experiment. By observing and analyzing the variation of specimen values, I can judge how to optimize each connection type and further improve the overall seismic effect of the in-plane and out-of-plane filled wall frame structure. The following are the main conclusions from this trial.

(1) Compared with empty frames, the addition of filled walls can improve the in-plane horizontal bearing capacity and initial stiffness of frame structures regardless of wall-frame rigid connection or

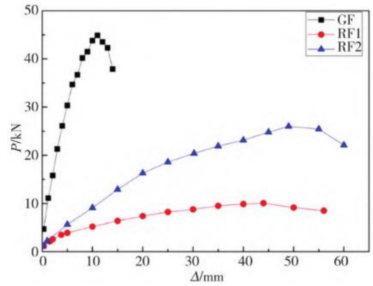
flexible connection, and the improvement effect of rigid connection scheme is more obvious. However, the rigid connection scheme is lower than the flexible connection specimen in other seismic performance indexes, such as stiffness degradation, displacement ductility and energy dissipation capacity.

(2) Under out-of-plane loads, the horizontal bearing capacity and initial stiffness of the wall-frame rigid connection frame structure are higher than those of the flexible connection structure, but the bearing capacity degrades rapidly after reaching the peak load. At the same time, the out-of-plane stiffness of the filled wall is in rapid degradation, which is not conducive to earthquake resistance. However, the flexible connected frame structure has stronger out-of-plane deformation ability and larger displacement ductility.

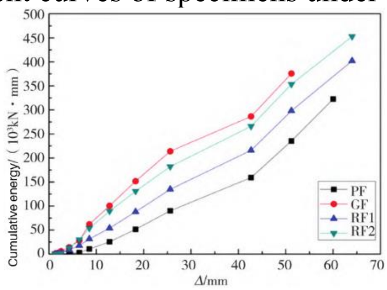
(3) The X-shaped diagonal bracing set in the filling wall plays the role of wall skeleton, which significantly improves the out-of-plane horizontal bearing capacity and displacement ductility of the filling wall of the flexible connected frame structure, and enhances the out-of-plane collapse resistance. Therefore, through comprehensive analysis, the filled wall frame with X type diagonal braces and flexible wall-frame connection is more conducive to the structural anti-seismic [8].



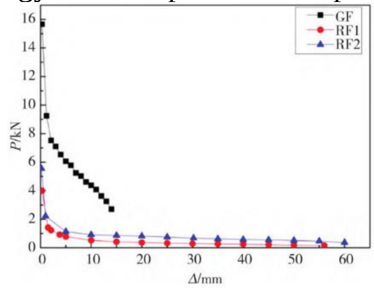
(a) Curves of stiffness degradation



(b) Load-displacement curves of specimens under out-of-plane loading



(c) Relation between energy con-sumption and displacement of each specimen



(d) External stiffness degradation curve of the test piece plane

Figure 1. The change of each specimen in the experiment [7]

2.2. Effect of pore characteristics on mechanical properties of AAC

The pores in AAC are mainly introduced by aerating agent. The formation of this type of hole goes through four stages: the gas generator reacts to form gas, gas forms bubbles under pressure, the slurry expands under the action of bubbles. In the next stage, the slurry becomes more viscous and rigid. The main factors affecting the pore structure of AAC are raw material and its mixture ratio, aluminum powder and process parameters. The calcium to silicon ratio determines the morphology and quantity of hydration products during autoclaving. When the ratio of calcium and silicon is low, the hydration products are few and the strength is low. On the contrary, if the ratio of calcium to silicon is too high, too much free calcium oxide will be produced, which will adversely affect the strength.

When the ratio of water to material is low, the consistency of slurry increases, resulting in insufficient gas production, which affects the uniformity of holes. When the water content is relatively large, the fluidity of slurry also increases, the gas development speed is fast, the formation of unsatisfactory pore structure, and even the collapse of mold may occur. In order to obtain AAC with uniform pore structure, it is very important to control the appropriate water-material ratio. The commonly used aerating agent for AAC blocks is aluminum powder. The smaller the particle size of aluminum powder, the larger the specific surface area, the faster the gas rate, and vice versa. The suitable particle size of aluminum powder is 60 ~ 75μm. In the new masonry filling wall RC frame structure, for example, the pores in the pore structure of AAC block are mostly macro pores, and the macro pores have a greater impact on the performance of AAC block. Through various studies at home and abroad, it has been shown that the indicators describing the pore structure morphology, such as specific pore volume, specific surface area, pore size distribution, porosity, pore size has a certain impact on the mechanical properties of AAC blocks. But at present, the research and test of pore structure are not complete and deep enough. It is necessary to carry out more detailed and scientific classification test and summary of hole structure in AAC block. Thus, the effect of pore structure on mechanical properties of AAC blocks is comprehended [9, 10].

2.3. Experiments on compressive properties of AAC

As one of the building materials with good application prospect, the compressive resistance of AAC is a very important mechanical property index. It is necessary to test the compressive properties of the test blocks under different conditions, so that the following statistics and summary are made according to the existing experimental results.

2.3.1 Material mechanical properties of AAC

There are many factors influencing the mechanical properties of AAC. In order to further clarify the influence law of its mechanical properties and material parameters on the mechanical properties of concrete test block, on the premise of determining the parameters of the specimen. The axial compressive strength test and cube compressive strength test of aerated concrete are carried out. At the same time, the adhesion of reinforcement is studied.

Cao [11] set up 24 aerated concrete test blocks in the experiment and conducted the following tests in groups, as shown in Table 1. (1) The influence of dry density on cube compressive strength and axial compressive strength: with the increase of concrete dry density, the cube compressive strength and axial compressive strength of aerated concrete both increases. The cubic compressive strength and axial compressive strength of aerated concrete are positively correlated with dry density. And the growth rate of cubic compressive strength is larger than that of axial compressive strength. (2) Influence of specimen height on cube compressive strength and axial compressive strength: With the increase of specimen height, the cube compressive strength and axial compressive strength of aerated concrete both decreases. And the influence law of specimen size height on the compressive strength of aerated concrete is different with different dry density. (3) Reinforcement adhesion: Reinforcement adhesion is an important mechanical index of AAC. In this experiment, the reinforcement adhesion test will be carried out on the reinforcement wrapped in cement and the reinforcement treated with conventional rust prevention. The experimental results show that both of them can meet the specification requirements. It is concluded that cement paste wrapping can be used as corrosion resistance of steel reinforcement.

Table 1. Dry density relationship [11]

Specimen number	Density degree	fc(I)/MPa	fc(II)/MPa	fc(I)/fc(II)	Average value
LA-1	B05	2.76	2.66	1.04	
LA-2	B05	2.58	2.66	0.97	1.01
LA-3	B05	2.74	2.66	1.03	
LB-1	B06	4.10	4.02	1.02	
LB-2	*B06*	3.74	4.02	0.93	1.01
LB-3	B06	4.34	4.02	1.08	
ZA-1	B05	2.20	2.14	1.04	
ZA-2	B05	2.10	2.14	0.97	1.01
ZA-3	B05	2.22	2.14	1.03	
ZB-1	B06	3.10	2.92	1.02	
ZB-2	B06	2.81	2.92	0.93	1.01
ZB-3	B06	2.97	2.92	1.08	

*Note: fc(I) is the experimental result; fc(II) is the theoretical calculation result.

2.3.2 Compressive properties of AAC under three-way stress and high impact forces

Concrete structures or members in buildings are often subjected to multidirectional stresses, and the performance of concrete materials under multidirectional stress states is studied, in general, by triaxial tests in which cylindrical specimens subjected to transverse loads are loaded axially. Triaxial tests are divided into conventional triaxial tests and true triaxial tests. For AAC materials, studying the performance of materials under multi-directional stress is helpful for the analysis of components or structures in the design. At the same time, the relationship of material stress under multidirectional stress is analyzed.

Analysis of the effect of the three-way stress condition on the compressive strength of AAC materials can be obtained according to the conventional triaxial test conducted by Hou [12] through AAC specimens:

(1) Under the three-way stress condition (conventional triaxial test), AAC materials can maintain a high residual strength despite the occurrence of a large axial strain; the material is loaded during the test until it reaches the ultimate breaking strength. The transverse strain is very small, and the relative axial strain can be neglected.

(2) With the increase of the enclosing pressure, the material's partial stress compressive strength first increases and then decreases, the partial stress has a maximum value in the experiment under a certain enclosing pressure, the increase of the early enclosing pressure can improve the compressive strength, after the enclosing pressure exceeds a certain value, the compressive strength will have a small decrease.

(3) AAC materials in the process of high-speed impact, the ultimate breaking strength increases with the increase in strain rate, but the ultimate breaking strain remains in a certain range.

Since AAC is a new material, it is necessary to know more about its compressive performance under complex stress conditions such as high impact force and multidirectional force. At present, the static compressive properties of AAC are rarely analyzed. Therefore, the compressive properties of AAC need further study.

3. Conclusion

ACC material is quite different from the traditional reinforced concrete, for it is changed on the basis of the material, and the bigger difference lies in the engineering performance. Based on the sustainable development and green environmental protection, it is indispensable and extremely important to expand the research on all aspects of the new masonry filled wall. With the progress of science and technology, the future research and application of masonry filled walls is a popular direction. Therefore, it is necessary to summarize the existing experimental results and put forward the shortcomings, which is also the significance of this paper.

In this paper, the seismic performance of RC frame with new masonry filled wall, the effect of pore characteristics on the mechanical properties of AAC and the effect of test on the compressive properties of AAC are studied, respectively. Finally, some major conclusions and prospects are made. In order to prevent possible engineering accidents, it is necessary to carefully analyze the mechanical properties of AAC, such as seismic resistance, so that AAC materials can be more widely and stably used in the future.

With the continuous production and application of new materials, the requirements for engineering projects should be gradually improved. In addition to ensuring the quality of new materials, but also to implement the material under various circumstances. The application of AAC blocks in filled wall construction can not only reduce the cost, but also effectively improve the performance of the building. As an important new material, AAC filled wall is of great significance when it is applied in the process of wall construction.

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