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Research on Reinforcement of Masonry Structure by Super High Performance Concrete Instead of Cement Mortar

Yang Chen

College of Architectural Engineering, North China University of Science and Technology, Tangshan 063200, China

Abstract

In our country, there are many historical buildings made of low strength cement mortar and lime. Masonry structure is a kind of structure with a long history of use in our country. Most of the masonry materials of masonry structure are brittle materials, such as tensile, shear and bending resistance, and the seismic capacity and toughness of the buildings are poor. Through the research and analysis of the relevant research literature, this paper summarizes how to strengthen the masonry structure, and puts forward the idea and rough test steps of using ultra-high performance concrete instead of cement mortar to strengthen masonry.

Keywords

Masonry structure; High performance concrete; Seismic

1. Introduction

Masonry structure is a structure constructed of brick masonry, stone masonry and block masonry, also known as masonry structure. Due to the high compressive strength of the masonry and the low tensile strength, the masonry structural members are mainly subjected to axial or small eccentric pressure, and are rarely pulled or bent. Generally, walls and columns of civil and industrial buildings the foundation can be made of masonry structure.

The main advantages of the masonry structure are: 1 easy to take materials locally. The bricks are mainly fired with clay; the raw materials of the stone are natural stone masonry structures; the blocks can be made of industrial waste - slag, with convenient source and low price. 2 Brick, stone or block masonry has good fire resistance and good durability. 3 Masonry does not require stencils and special construction equipment to save wood. The newly masonry masonry can withstand a certain load and can be continuously constructed. In cold regions, winter can be built by freezing method without special insulation measures. 4 Brick wall and block wall can be insulated and insulated, and the energy saving effect is obvious. Therefore, it is a better load-bearing structure and a better retaining structure. 5 When using blocks or large plates as the wall, it can reduce the structural weight, speed up the construction progress, and carry out industrial production and construction.

The disadvantages of the masonry structure are: 1 Compared with steel and concrete, the strength of the masonry is relatively low, so the cross-sectional dimension of the component is large, the amount of material is large, and it is self-important. 2 Masonry masonry is basically a manual method, and the construction labor is large. 3 The masonry has low tensile and shear strength, so the earthquake resistance is poor, and it is limited in use; the compressive strength of brick and stone cannot be fully exerted; the bending resistance is low. 4 Clay bricks need to be made of clay, occupying too much farmland in some areas and affecting agricultural production.

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2. Research significance

Masonry structure is the oldest building structure. China's masonry structure has a long history and a brilliant record. In history, there is the world-famous Great Wall, which is one of the world's greatest masonry projects built with "Qin Brick Hanwa" more than 2,000 years ago; Dengqi, Henan Province, built in the Northern Wei Dynasty The tower of the Yueyue Temple is a brick-built tower with a height of 40 meters. It is built on the Anji Bridge in Zhao County, Hebei Province. It has a net span of 37.37 meters, a total length of 50.82 meters, a width of about 9 meters and an arch height of 7.2 meters. The world's first open-air stone arch bridge, which has been selected by the American Civil Engineering Society as the 12th civil engineering milestone in the world; and the Dujiangyan water conservancy project built by Li Bing and his son, who is still irrigating today; all of which are worthwhile We are proud and inherited.

3. Present situation of research on the reinforcement of masonry

Zhongbang Huang[1] has obtained the following research results: after the cement mortar surface layer is reinforced with brick walls, the shear resistance of the original brick wall is generally doubled. After reinforcing the brick wall with the steel mesh cement mortar surface layer, the shear resistance can be more than 2 times higher than the original brick wall (refer to the 24cm thick M, mortar brick wall). Increasing the reinforcement mesh is not as effective as improving the shear resistance of the brick wall, but it can change the brittle fracture property of the wall to make it have a certain ductility, and the elongation coefficient is about 1.8. The steel bars in the steel mesh wall have less tensile stress during the elastic working stage of the brick wall, and some are still under pressure. Only when the mortar is in the plastic stage after cracking, the stress of the steel increases rapidly, and a small amount of steel may reach yield. The cement mortar has a certain elastoplasticity under the joint action of steel bars and brick walls. Its plastic strain value has a greater increase than the elastic phase. Generally, the stiffness of the reinforcement and the unreinforced test piece have elastoplastic deformation properties, and the surface layer is more obvious with the steel mesh. The brick wall is strengthened by cement mortar or steel mesh cement mortar surface layer, and the rigidity can be increased by 1 to 3 times.

In the experimental study, Wei Zhao and Chenjun Zhang [2] concluded that the cracking load (limit load) of the carbon fiber reinforced wall is significantly higher than that of the unreinforced wall; the deformation capacity of the reinforced wall is also significantly improved. The cracking displacement of the wall has increased significantly. When the carbon fiber cloth is used to reinforce the brick wall, the larger the width of the cloth, the more obvious the reinforcing effect. The carbon fiber cloth improves the stress state of the wall through the tension rod mechanism in the truss model, thereby improving the shear capacity of the member; on the other hand, by limiting the crack development of the wall, the crack resistance of the member is also improved.

Trust, Jitao Yao[3] clearly pointed out in the typical seismic strengthening technology and method of multi-story masonry structure wall: high-strength steel wire mesh squeezing polymer mortar method is the vertical crack direction or component cracking surface where cracks appear on both sides of the wall A crack repairing technique for laying high-strength steel mesh and applying 20~30mm thick polymer mortar. Pressure grouting combined with steel mesh cement mortar surface layer reinforcement method to remove the original damaged wall plaster layer, using special grouting equipment or process to inject crack repair special glue, cement latex mortar or high strength non-shrinkage grouting slurry under a certain pressure In the crack of the masonry; after the slurry solidifies, the two sides of the crack are re-bonded together, and the steel mesh with the diameter of 4 or p6 and the spacing of 200mm×200mm is fastened on the surface of the cracked wall, and fixed with the original member to improve the shear capacity of the wall. And for the purpose of ductility. The newly added reinforced concrete structural column and ring beam reinforcement method is to use the reinforced concrete structural column together with the ring beam reinforcement. After the structural column is strengthened, the shear strength is not improved much, but it works together with

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the ring beam, which greatly improves the wall. The ductility and deformability of the body have a significant effect on preventing sudden collapse of the structure.

Li Ming and Zhihao Wang[4] used steel mesh cement mortar to strengthen the brick wall, which can significantly increase the initial cracking load of the wall. Ultimate load and stiffness. The vertical pressure has a great influence on the initial cracking load and ultimate load of the wall. The smaller the displacement ductility ratio of the wall, the greater the stiffness. The double-sided reinforcement wall has the initial cracking load. The ultimate load and stiffness are higher than single-sided reinforcement, and the displacement ductility ratio is lower than that of single-sided reinforcement, but they are not multiples. The thicker the surface layer, the larger the initial cracking load and the ultimate load, but the displacement ductility ratio and stiffness do not change much.

Lin Lei and Liping Ye[5] made the conclusion through experiments that FRP reinforced masonry walls can significantly improve their shear capacity. FRP sticking to the masonry surface can not only directly participate in the wall shearing effect, but also improve the masonry's own shear resistance by indirect reinforcement, change the shear failure type, and improve the shear capacity of the masonry wall.

Xiangshun Zhang, Huiqin Wu, Shaomin Peng[6] concluded after the experiment that after CFRP reinforcement, the wall deformation capacity and shear strength were improved, which effectively improved the seismic performance of the new brick wall. When the height and width are relatively large, the bond between the wall and the ground beam is prone to damage. After the wall is cracked, CFRP can restrain the deformation of the wall by increasing the shear strength of the wall to improve the rigidity of the wall. Deterioration of wall stiffness is more severe than unreinforced walls.

Wei Song,Guohua Yuan, Lewei Zhou[7] concluded that the diagonal reinforcement reinforcement brickwork can effectively increase the stiffness of the wall and increase the horizontal ultimate bearing capacity of the wall and increase the integrity of the wall. The larger the diameter of the diagonal rib, the greater the stiffness of the wall and the slower the stiffness degradation. The amount of reinforcing reinforcement should not be too small, and the amount of reinforcing reinforcement is too small to restrict the deformation of the wall. Compared with the non-prestressed reinforcement, the prestressed reinforcement is more obvious than the latter. The magnitude of the pre-stress control value has a direct impact on the wall's shear performance.

Daitao Zhang[8] and other experiments on the vibration table of brick masonry building strengthened with steel mesh cement mortar. The research conclusions show that this reinforcement method will greatly improve the overall deformation resistance and bearing capacity of brick masonry buildings.

Juan Liao[9] and other experiments and applications of steel mesh reinforcement of the empty wall. The model test results show that the steel wall mesh cement mortar surface layer is used to strengthen the cracked empty wall to form the wall. The cracking load and the ultimate load are greatly improved compared with the original wall, and also exhibit good ductility. The stirrup spacing is an important factor affecting the bearing capacity of the composite wall. If the spacing of the stirrups is too large, the phenomenon that the reinforcing part is separated from the original wall body is easy to occur, and the bearing capacity of the original wall body is basically not improved: the spacing of the stirrups is too small, and the cross section of the original empty bucket wall is excessively weakened.

Sanqing Su [10] conducted an experimental study on the seismic performance of brick walls reinforced with steel mesh cement mortar. Through the experimental study of the low-cycle repeated load F of the brick wall reinforced with ordinary brick wall and reinforced concrete mortar, the effect and seismic performance of the brick wall strengthened with the splint wall are analyzed, and the splint wall of the un-cracked wall is given. Design calculation method for seismic reinforcement.

Liping Shao [11] carried out research on the bending and shearing performance of the steel mesh mortar reinforcement wall. The results show that the reinforced concrete mortar layer is very effective in strengthening the cracked wall after the earthquake, which can greatly improve the shear strength of the wall.

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Qian Gu, Bo Peng, Weiguo Liu, etal. [12] conducted a study on the seismic behavior of six brick walls and doors under the low-cycle reciprocating load, and explored the use of carbon fiber cloth for seismic reinforcement of unreinforced open-mouth wall panels. Destruction form, force characteristics and reinforcement effect, compare the influence of different carbon fiber cloth bonding methods on the seismic strengthening effect of the unreinforced open-hole masonry wall. According to this proposal, it is recommended to apply carbon fiber cloth around the hole in the window of the seismic window. An effective reinforcement method for anchoring carbon fiber cloth strips is added at the corners of the window holes, and an effective reinforcement method for attaching the carbon fiber cloth around the hole and affixing the carbon fiber cloth diagonally on the wide wall limbs is adopted for the wall of the opening door. At the same time, according to the experimental research results, the calculation model of the shear capacity of the open-wall masonry wall reinforced with carbon fiber cloth based on carbon fiber bracing mechanism is established. The calculated results agree well with the experimental results, indicating that the calculation model can reflect well. The force mechanism of carbon fiber cloth working together with unreinforced masonry wall can be used for engineering design.

Dagen Weng,Xilin Lu, Xiaotong Ren etal. [13] used the 240 standard brick wall under various compressive stresses, before the test and after the test cracking, the wall was reinforced with GFRP and the reinforced mesh mortar surface layer was used. The pseudo-static device horizontal loading method checks the effect of reinforcement. The test proves that for masonry with low mortar strength, GFRP reinforcement can effectively enhance the seismic integrity of the masonry, which is equivalent to the effect of improving mortar strength. To improve crack resistance and ultimate bearing capacity, the thickness of GFRP should meet its tensile strength. The ability is greater than the masonry's shear resistance. For the wall piece after the ultimate bearing capacity is broken, the GFRP reinforcement can restore the wall piece to the original maximum bearing capacity.

4. Ultra high performance concrete

The basic raw materials for ultra high performance concrete (UHPC) are: cement, silica fume, high efficiency or super high efficiency water reducer, aggregate (fine quartz sand with dmax ≤ 1 mm or ordinary grade sand and coarse aggregate), fiber (steel fiber) , PVA fiber). The typical water-to-binder ratio (w / b) is 0.15 to 0.20. Ultra High Performance Concrete (UHPC) is a cement-based composite material with the best gradation of the constituent material particles; it contains a relatively high proportion of fine short steel fiber reinforced materials; the compressive strength is not less than 150 MPa; Toughness, tensile strength is not less than 5MPa after cracking (7MPa in France); internal non-connecting pore structure, high resistance to gas and liquid immersion, compared with traditional concrete and high performance concrete (HPC) The durability can be greatly improved.

UHPC belongs to modern advanced materials, and innovates the composite mode of cement-based materials (concrete or mortar) and fiber, steel (reinforced steel or high-strength prestressed steel), which greatly improves the strength utilization efficiency of fiber and steel in concrete, making cement base The overall performance of structural materials has advanced by leaps and bounds. UHPC can be used to build a lightweight, high-strength and high-toughness structure that completely changes the state of the concrete structure "fat beam fat column"; its structure has durability and working life far beyond steel, aluminum, plastic and other structural materials.

Today, the technical approaches and materials used to formulate UHPC are diversified, but the basic principles followed do not change, ie the particle composition and mix ratio maximize the compactness. The ultra-high strength of UHPC determines that the water-to-binder ratio or the water-powder ratio is generally less than 0.25. For the preparation of high fluidity or self-compacting UHPC, the water-reducing agent is required to exert greater effectiveness, and a compatible water reducing agent is selected. Cement and silica fume are the keys to success.

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5. Summary

At present, the existing masonry reinforcement methods on the market are reinforced concrete plus layer reinforcement method, reinforced concrete mortar plus layer reinforcement method, additional buttress column reinforcement method, additional beam pad reinforcement method, partial masonry demolition, masonry crack repair, etc. The common features of these methods are complex construction, high cost and poor effect. Ultra-high performance concrete has the advantages of simple preparation, high strength and good ductility. If ultra-high performance concrete is used instead of cement mortar to plaster the masonry structure, It not only increases the strength of the wall, but also resists the shearing force of the wall under earthquake action by the strength of the ultra-high concrete. If the ductility of the ultra-high performance concrete meets the requirements of seismic deformation, it can even be used to replace the steel mesh.

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