Current Status of Research on Masonry Structures Reinforced by Ultra-high Performance Concrete

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Abstract

In this paper, the current status of research on UHPC and masonry structure reinforcement in their respective fields is introduced, and the progress of UHPC in masonry structure reinforcement is summarized and prospected.

Keywords

Ultra-high performance concrete, Masonry structure, Reinforce.

1. Introduction

In the course of concrete development, the shortcomings of self-weight and low tensile strength always exist, which requires further study of concrete. Until 1994, Larrard et al.[1] first proposed the concept of "ultra-high performance concrete (UHPC)". Since the emergence of UHPC, the research heat has been increasing, and the number, scope and area of application have been expanding. Unlike ultra-high performance concrete, masonry structure appeared earlier and has been widely implemented. Masonry buildings account for a large proportion of the existing building area of nearly 60 billion square meters in China. Reinforcement of masonry structure is an important issue in current theory and practice.

The main defects of existing masonry structures are low mortar strength, poor seismic structure, complex construction technology of common reinforcement methods and poor reinforcement effect. UHPC is a kind of material with high strength, ductility and durability. It has a good application prospect in the field of Engineering construction. Studying the application of UHPC in masonry structure reinforcement can provide strong technical support for existing building reinforcement and transformation, and has significant social and economic benefits.

2. Current Status of Research

2.1 Current Status of Research on Ultra-high Performance Concrete

2.1.1 Raw Materials and their Proportion of Mixture

Zhengyu Huang et al.[2] used homemade low-temperature rice husk ash and boron sludge acid leaching residue to replace 25% and 50% silica ash respectively in the proportion of 1:2. It is concluded that the autogenous shrinkage and dry shrinkage of UHPC at the early stage decrease with the increase of substitution amount, and the fluidity increases first and then decreases. At the same time, the setting time of UHPC was prolonged and the compressive strength of UHPC changed little. Rice husk ash will make the initial setting time of UHPC change little, the final setting time shorten, and the compressive strength slightly increase

Qingjun Ding et al.[3] studied the influence of different kinds and gradations of fine aggregate on the working, mechanical and shrinkage properties of ultra-high performance concrete. The UHPC

prepared from quartz sand has the best working and mechanical properties, and machine-made sand is the worst, while river sand is slightly lower than quartz sand.

Ya Lu et al.[4] used copper tailings raw ore instead of natural river sand and ground copper tailings powder instead of cement or mineral admixture to prepare economical ultra-high performance concrete by conventional process. The bending and tensile properties of UHPC prepared separately were improved. The compressive strength of UHPC decreases when added together. The substitution of copper tailings can reduce the preparation cost of UHPC.

Xingwen Liang et al.[5] studied the effect of long and short steel fibers on the flexural mechanical properties of ultra-high performance concrete. It is concluded that the bending strength of UHPC is mainly affected by long fibers, but less by short fibers. The optimum volume fraction of long and short fibers is 2 vol% and 1 vol%.

Ran Hai et al.[6] discussed the influence of hybrid effect between steel fibers and polyvinyl alcohol fibers on their compressive strength, flexural-compressive ratio and tensile-compressive ratio. The results show that the compressive strength decreases significantly with the increase of the content of polyvinyl alcohol fiber, and the gain ratio of flexural-compressive ratio and tension-compressive ratio of super high performance steel-polyvinyl alcohol hybrid fiber concrete to super high performance steel fiber concrete increases with the increase of the content of steel fiber.

2.1.2 Mechanical Property

Xiaojun Ke et al.[7] found through experiments that UHPC has good compressive deformation performance. The strength of UHPC increases with the increase of peak strain, which is higher than that of ordinary concrete, but its ultimate strain is lower than that of ordinary concrete, which indicates that the increase of concrete strength will reduce the deformation capacity.

Juanhong Liu et al.[8] concluded through experiments that the porosity of ultra-high performance concrete is about 5%, which is uniformly distributed, with small early shrinkage, and has good anti-perme ability and anti-rust ability. Therefore, the durability of UHPC is better than that of ordinary concrete.

Haibin Xu et al.[9,10] studied the bending and shear resistance of UHPC beams through experiments, it was concluded that: ① UHOC carrying HRB500 can significantly improve the ultimate bearing capacity of UHPC beams; ② UHPC shear capacity decreases with the increase of shear span ratio, and increases with the increase of preload and stirrup ratio.

2.2 Current Status of Research on Reinforcement Methods for Masonry Structures

Because most of the masonry structure is old, so the masonry structure reinforcement should be comprehensive consideration of many factors, can not damage the foundation of the original structure, convenient for construction, after strengthening the structure has obvious bearing capacity improvement. Common masonry structural reinforcement methods are:

Steel mesh - cement mortar reinforcement method

Qingfeng Xu et al.[11] used the brick masonry removed from the old wall to build 8 pieces of brick wall, with a size of 1500mm×900mm×200mm, and carried out the test by controlling the number of cement mortar layers in different walls and whether cutting seam replacement was set. The results show that the reinforced cement mortar is an effective method, and the compressive bearing capacity increases by 121%-134%, and the horizontal bearing capacity increases by 25%-612%.

Saitao Zhang et al.[12] conducted a comparative test on the simulated seismic vibration closure of two brick masonry building models, one of which was reinforced with steel mesh cement mortar. The test results show that the load-bearing capacity and deformation capacity of the model house are improved after the reinforcement, and the load-bearing capacity of the reinforced specimen is 1.15 times higher than that of the unreinforced specimen, and the anti-deformation capacity is 46.73% higher.

Bonding fiber composite reinforcement method

Shui Tian et al.[13] through the existing level of paste and tic-tac-toe CFRP sheet reinforced masonry shear wall performance test data and the formula to calculate the shearing resistance of collecting and sorting, comprehensive consider data distribution and calculation factor, puts forward the calculation formula of coefficient of fiber composite material to participate in the work, the results better agreement with experimental values.

Krevaikas et al.[14] tested the compressive properties of four groups of Brick-column specimens by changing the number of layers, the way of FRP bonding, the types of fibers and the ratio of length to width of columns. The results show that the deformation capacity and bearing capacity of the strengthened brick columns increase linearly with the average restraint stress, and the strengthening properties are similar to those of FRP reinforced concrete.

Reinforced concrete slab wall reinforcement method

Fuwen Zhang et al.[15] used quasi-static low-cycle repeated loading of unreinforced brick walls and reinforced brick walls with slab walls to conduct comparative tests. It is concluded that slab wall reinforcement can significantly improve the seismic performance of the brick wall with holes, and the shear bearing capacity of the brick wall reinforced with single-side slab wall is less than the sum of the bearing capacity of the reinforced concrete wall and the brick wall, but its ultimate deformation capacity is similar to that of the reinforced concrete wall, and the displacement ductility coefficient is obviously greater than that of the reinforced concrete wall and the pure brick wall.

Wenzhong Zheng et al.[16] conducted axial compression tests on brick walls reinforced by six concrete slab walls with a height to width ratio of 0.8 and 1.1 and an axial compression ratio of 0.15, 0.25 and 0.35, and studied their axial compressive properties. The axial compression deformation of the reinforced brick wall is even, the concrete wall is crushed first, and the axial compression bearing capacity of the reinforced brick wall is obviously higher than that of the unreinforced brick wall.

2.3 Ultra-high performance concrete reinforced masonry structure

Sandong Wei et al.[17] used the bricks obtained in the central position of the historic protected building to prepare the mortar used in the original building, and made two pieces of low-strength brick wall specimens according to the original masonry method. One of them is subjected to pseudo-static loading to failure and then to single-side reinforcement, and the other one is subjected to single-side reinforcement directly, and then both of them are subjected to pseudo-static loading to failure. The test results show that the bearing capacity of unreinforced specimens is 41.4kN, and that of reinforced specimens is 134.0kN and 167.0kN respectively. UHPC reinforcement improves the bearing capacity and stiffness of the wall.

3. Prospect

At present, domestic buildings are nearly saturated, and the future trend is to reinforce buildings. Therefore, UHPC can be considered to reinforce building structures, and the research on UHPC in strengthening is worth further exploration. Nowadays, there are still brick houses in most areas, and the study of masonry structure reinforcement is directly related to the safety of people's lives and property. Ultra high performance concrete and masonry structure reinforcement methods and techniques in their respective fields have been increasingly perfect, the combination of the two can be using ultra high performance concrete reinforcement to masonry structure with reinforced UHPC mechanical performance and design method of composite masonry wall components, research applied to masonry wall reinforcement of UHPC products, the construction technology of UHPC reinforced masonry wall. We hope that relevant guidelines or codes can be issued as soon as possible in China. We believe that with the research and application of domestic scholars and engineering units, UHPC can gradually enter the ranks of masonry structure reinforcement, so that the field will get a fast and long-term development

4. Conclusion

(1) By searching for domestic and foreign scholars' research and analysis of UHPC's related properties, summarize and analyze from two aspects: the mix ratio of raw materials and the mechanical properties of UHPC.

The traditional raw materials of UHPC are: quartz sand, quartz powder, silica fume, cement, steel fiber, etc. At present, the research mainly starts from steel fiber and silica fume, and analyzes the properties of the prepared UHPC.

(2) Summarize the commonly used masonry structure reinforcement methods, and introduce and analyze the related research of each method.

Different reinforcement methods should be selected for different structures and different reasons of failure. While meeting the requirements of overall safety of the structure, other factors should be considered comprehensively to determine the most reasonable reinforcement scheme.

(3) Ultra-high performance concrete has been used in masonry structures, but the development process is still relatively slow.

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