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Feasibility Study of UHPC Reinforced Masonry Structure

Yang Chen [a], Shaojie Wang [b]

North China University of Science and Technology, Tangshan 063210, China
[a]2393868000@qq.com, btslgwsj@126.com

Abstract:*With the increase of service life of masonry structure and the damage of masonry structure caused by external environment, the structure will be difficult to meet the design requirements. It is necessary to repair and reinforce the existing structure or replace the original structure with a new type of composite structure. ultra-high performance concrete (UHPC) is a kind of high strength, high ductility, high durability material, which has the advantages of almost impermeability, almost no carbonization, and almost zero chloride ion penetration and sulfate penetration. UHPC has been widely used in the field of concrete structure reinforcement, whether the masonry structure can be better strengthened has become the research content of this paper. Basic mechanics of UHPC materials at home and abroad By systematically combing and summarizing the research progress of performance and reinforcement design, the feasibility of UHPC reinforced masonry structure is obtained.*

Keywords:UHPC; Mechanical properties; Reinforcement; Feasibility .

1. INTRODUCTION

At present, the masonry structure in the buildings of our country occupies a very large proportion, most of which can not meet the requirements of seismic intensity because of the aging of the structure or the lack of its own design strength. In order to ensure the safety of people's life and property, it is necessary to strengthen the existing masonry to improve its seismic capacity.

Masonry structure (masonry structure) is the structure of walls and columns made of blocks and mortar as the main bearing members of buildings. It includes brick structure, stone structure and block structure of other materials. The masonry structure has the advantages of good durability, good fire resistance, good heat insulation, good energy saving effect, convenient construction, simple technology, double function of load bearing and enclosure, etc. However, the masonry structure has large weight, low tensile, shear, bending resistance, poor seismic performance, and the amount of masonry work Heavy, low production efficiency and other shortcomings, in recent years has been abandoned by human beings. In the 1976 Tangshan earthquake, the masonry structure was seriously damaged. According to the analysis of the researchers, the biggest characteristic of the most damaged masonry buildings in the earthquake is the absence of ring beams, which greatly reduces the integrity and seismic resistance of the masonry structure.

2. BACKGROUND AND SIGNIFICANCE OF THE STUDY

At present, most of the masonry reinforcement methods on the market are reinforced concrete external layer reinforcement method, reinforced cement mortar external layer reinforcement method, additional buttress column reinforcement method, additional beam cushion reinforcement method, partial demolition of masonry, masonry crack repair and so on. Ultra-high performance concrete (UHPC) is a kind of material with high strength, high ductility and high durability. It has the characteristics of almost impermeability, almost no carbonation, chloride ion permeation and sulfate permeation almost zero [1]. At the same time, it has the advantages of simple preparation, high strength and good ductility. It is leading in engineering construction Domain has a good application prospect. High UHPC price, especially suitable for engineering reinforcement and transformation field. The Federal Institute of Technology (EPFL) of Lausanne, Switzerland, has issued the SIA 2052UHPFRC Swiss Standard, which proposes a reinforcement design method for concrete structures without involving the reinforcement of masonry structures. The existing building area of our country is nearly 60 billion square meters, and a large number of early existing buildings have problems such as insufficient safety and poor seismic performance, which can no longer meet the needs of modern development. Masonry buildings account for a large proportion of existing buildings. Application of Research UHPC in Reinforcement of Masonry Structure Building reinforcement and reconstruction provide strong technical support, with remarkable social and economic benefits.

3. UHPC RESEARCH STATUS

Ultra-high performance concrete (UHPC) is a kind of cement matrix composite material with the best gradation of composition material particles; water-binder ratio less than 0.25, containing a high proportion of fine short steel fiber reinforced material; compressive strength is not less than 150 MPa; toughness in tensile state, and tensile strength is not less than 5 MPa after cracking (France requires 7 MPa). The interior has a non-connected through-hole structure with high resistance to gas and liquid immersion. Compared with traditional concrete and high performance concrete (HPC), the durability can be greatly improved. The cement stone and aggregate of ultra-high performance concrete have strong co-ordination Same function. When the cement stone and aggregate properties of ultra-high performance concrete match, ultra-high performance concrete has the best performance.

Chen Baochun, Ji Tao, Huang Qingwei and other [2] put forward that the compressive strength, steel fiber has a certain enhancement effect, but it is generally considered that there is a limit content, when the content exceeds this amount, the compressive strength does not rise and fall. Scholars from different countries have different views on this limit, from 2% to 4%.

He Feng and Huang Zhengyu of Hunan University carried out the experimental study on the influence of raw material quality and mix ratio on UHPC strength earlier, The UHPC of 52.5 grade cement, standard sand with particle size below 0.35 mm, wollastonite, fine quartz powder, superplasticizer and 13 mm of fine steel fiber should be; Without steel fibers, The UHPC; with compressive strength up to 229 MPa can be prepared by high temperature thermal maintenance process Adding 3% steel fiber and 200 OC high temperature curing, UHPC compressive strength is close to MPa.300.

UHPC mechanical properties are also affected by curing methods, material composition and fibers. Zhang Sheng et al .[4] studied the influence of standard curing, steam curing and hot water curing conditions on UHPC strength. The results showed that compared with standard curing, wet heat curing can effectively improve the interface bond between cement matrix and steel fiber, and the compressive strength and flexural strength of different ages under thermal curing are obviously higher than those after standard curing. therefore, in order to increase the pozzolanic reaction degree of ultrafine mineral admixtures and increase the strength of UHPC, the high temperature and pressurized curing system is a very important means.

4. UHPC REINFORCEMENT MATERIAL PERFORMANCE STUDY

4.1 UHPC durability

Durability is an important index to measure whether UHPC can be used as an effective reinforcement material. According to the Test Standard for durability Evaluation of concrete JGJ/T 193-2009,UHPC as a super high strength cement-based material, the items of durability evaluation include frost thawing resistance, water permeability, sulfate corrosion resistance, chloride ion permeability, carbonation resistance and early crack resistance. At present, the academic circles mainly evaluate the durability of UHPC from two aspects: freeze-thaw cycle resistance, durability coefficient (ratio of dynamic elastic modulus after freeze-thaw cycle to elastic modulus after freeze-thaw cycle) and durability coefficient According to the mass loss rate, the chloride permeation rate will seriously corrode the steel bar and greatly reduce its mechanical properties. The chloride permeation rate is often positively correlated with [5] corrosion rate of the steel bar.

The [6] of liu sifeng et al. soaked UHPC materials for 90 d, the maximum reduction rate of compressive strength of high pressure curing was only about 0.5%. instead, the compressive strength of standard curing and hot water curing was increased by 5%, showing excellent water resistance. the compactness was improved by morphological effect, active effect and micro- accumulation effect between admixtures with different particle sizes, which made UHPC have excellent carbonation resistance, freeze-thaw resistance and corrosion resistance.

The economical UHPC, of 75.9 MPa axial compressive strength was prepared by Dingsha et al After curing 28, the chloride diffusion coefficient is only 0.2×10-12, 1/19 of conventional C50 concrete under the same conditions; After 200 freeze-thaw cycles, A loss of 0.11 per cent in quality for economical UHPC, The dynamic modulus of elasticity is 97.9%, Frost resistance is far better than ordinary C50 concrete.

The main experimental variables [8] literature are cement type and silicon powder dosage, and silicon powder dosage is 0%~25% of cement quality. for more than 60 freeze-thaw cycles, the mass loss of all tested samples was

much lower than the mass loss limit, showing excellent freeze-thaw resistance; and although increasing the content of silica powder leads to higher permeability, the chloride permeability of all UHPC mixtures was "very low ".

Yang Juan [9] the test water pressure reached the limit water pressure of the equipment 4.0 MPa, and maintained for 7 days, no water seepage occurred in the specimen; the numerical value of the electric flux showed that the UHPC had super anti-chlorine ion permeation ability; but the shrinkage of the UHPC was large, especially the free shrinkage.

4.2 UHPC durability

According to the literature [10] the design theory of maximum packing density is used in ultra- high performance concrete to form a dense cementitious material with the best proportion of different particle size particles. Since the invention of concrete to the present proposal of ultra- high performance concrete, the compressive strength has gradually developed from 20~30 MPa to 150 MPa.200.

The effects of fiber content, fiber length-diameter ratio UHPC workability, adhesion to matrix UHPC compressive and flexural tensile strength were compared with those of steel fibers with straight line type, end hook type and corrugated type within 20 mm. The increase of fiber content, compressive and flexural tensile strength gradually decreased, fiber content in 2. Between 5% and 3%, the compressive strength and flexural tensile strength are basically the same; the ratio of length to diameter of fiber to UHPC compressive strength .

4.3 UHPC tensile strength

Huang Xiang and others [12] concluded that the biggest drawback of masonry structure is low tensile capacity and high brittleness. However UHPC the tensile strength is increased to more than 30 MPa by adding short fine fibers, and the fracture energy can reach 1 500~40 000N/m, shows high tensile strength and high toughness.

4.4 UHPC fire resistance and high temperature resistance

The strength loss of high-strength concrete at high temperature is very great, because of its own internal disconnected pore structure and high resistance to gas and liquid penetration. In a period of high temperature, temperature changes are uneven, and heat cannot be dissipated, leading to concrete bursting. Experiments have shown that the compressive strength of concrete fluctuates between +5% and -8% at room temperature (20 °C) within 300 °C. When the temperature is higher than 300 ° C, the compressive strength drops almost linearly. When the temperature is 900 ° C, the compressive strength is less than 10% of the normal temperature compressive strength. However, Zheng Wenzhong et al. [13] found that adding PPF fiber with a volume content of 0.3% into UHPC had an obvious inhibitory effect on UHPC high-temperature bursting.

In reference [14], steel fiber with a volume content of 2% can inhibit the development of cracks at high temperature, improve the residual strength of UHPC after high temperature and reduce the strength loss rate.

To sum up, by changing the types of fibers and the volume mixing amount of fibers, the fire- resistance and high-temperature resistance performance of UHPC can be effectively improved, so that UHPC can show its ultra-high mechanical properties during the reinforcement process.

4.5 UHPC fatigue resistance

Fatigue resistance is the most important mechanical property of building materials that can maintain the life of building structures. Under the action of repeated loads, the life of structures will decrease with the cycle of repeated loads. Under natural conditions, the compressive fatigue deformation performance of concrete is reflected by measuring the relationship between cumulative fatigue deformation and loading cycle times of concrete under constant amplitude repeated load.

[15] The attenuation rate of residual compressive strength after fatigue of UHPC decreases with the increase of cycle life ratio, while the attenuation rate increases with the increase of cycle life ratio.

Reference [16] studied the influence of parameters such as steel fiber content, fatigue load level and loading mode in UHPC on its fatigue performance, and the results showed that increasing steel fiber content could significantly improve the fatigue performance of specimens.

5. UHPC AND MASONRY

As the masonry structure reinforcement material, UHPC must have good bonding performance and common stress characteristics with the masonry structure, so as to give full play to the ultra-high compressive performance of UHPC, so as to improve the ultimate bearing capacity of the reinforced structure.

Literature [17]-[18] adopts the bricks acquired in the original location of the historic preservation building, and the mortar used in the original building is prepared according to the retained data. Two low-strength brick wall specimens are made according to the original masonry method. The damaged specimens are cored with a coring machine, and it is found that UHPC is reliable to bond with the wall.

Zheng Qizhen et al. [19] used the black brick removed from the historic building wall 100 years ago to design 3 pieces of low-strength scale wall with mortar strength less than 1 MPa. After the test of specimen W3, samples were taken from the upper, lower, left and right sides of the wall and from the center of the drilling core. It was concluded that the UHPC material surface layer and the brick wall bonded well without cracks and slippage, the core sample was taken out with good integrity, and the UHPC material was tightly bonded to the block during the test.

6. SUMMARY

There are a lot of masonry structures in China. Some buildings have certain historical significance, while others do not have the conditions for demolition. Therefore, reinforcement is the best way to protect these buildings. The reinforcement methods proposed by scholars are also various, which have the effects of strengthening the structural system, enhancing the bearing capacity and enhancing the seismic action. As a kind of material with super high mechanical properties, UHPC has been widely studied and applied in recent years. Ultra-high performance concrete is widely used in the reinforcement of Bridges and other concrete structures. Through the review paper, there is also a very good synergy between UHPC and masonry, and the constitutive relationship between them is also similar. Therefore, UHPC has certain social value in the reinforcement of masonry structures.

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