Research progress of basalt fiber cement-based composites

Abstract: Basalt fiber cement-based composite is a new building material, which has attracted much attention in the research field in recent years. The development status of basalt fiber at home and abroad and the research progress in mechanics and durability are summarized. The results show that the tensile strength, impact resistance and durability of the composites can be effectively improved by adding appropriate basalt fibers. It has a wide application prospect in the fields of roads and bridges, building structures and ships. Through the research and application of this material in various applications, the development and research direction of basalt fiber reinforced cement-based composites are prospected.

Key words: basalt fiber, cement-based, mechanical properties, durability

1. Introduction

Since the 20th century, cement-based materials have developed rapidly, and become the most widely used engineering materials in the world[1]. Cement-based materials are the most widely used engineering materials in the construction industry. Due to the differences in the properties of the components, there will be a large number of cracks with different sizes in the interior and surface. It is precisely because of these cracks that the tensile, compressive and flexural mechanical properties of concrete will be reduced, which is also the main reason for the brittle failure of concrete. Fiber concrete is a cement-based composite material[2-3] which takes concrete as the base material and discontinuous short fiber or continuous long fiber as the reinforcing material. Adding fibers with high tensile strength, high elongation and good corrosion resistance into concrete matrix can effectively improve the working performance of concrete materials, especially the crack resistance, which can effectively delay the crack propagation in the matrix. Since the appearance of fiber reinforced concrete, it has been widely used in engineering field.

At present, several commonly used fiber reinforced concrete are basalt fiber reinforced concrete, steel fiber reinforced concrete, carbon fiber reinforced concrete, glass fiber reinforced concrete and synthetic fiber reinforced concrete, covering all fields of civil engineering. After fiber composite, the mechanical properties and durability of concrete materials are obviously improved. However, there are many kinds

of fibers, and different kinds of fibers have different performances in strengthening, toughening and economy. Basalt fiber is widely used in engineering because of its good natural compatibility with cement-based materials. Adding basalt fiber into concrete reasonably is helpful to improve the properties of concrete materials, and basalt fiber has incomparable advantages in economy.

Basalt Fiber BF, carbon fiber, aramid fiber and ultra-high molecular polyethylene fiber are also called four high-performance fibers. The fiber is made of volcanic rocks, which are melted at 1450-1500℃ and drawn through bushing. The color is generally brown and some are golden. Basalt fiber has the characteristics of heat insulation and fire prevention, and its composite fire insulation material has good high temperature resistance, which is mainly used in fire fighting, metallurgy, petrochemical and other fields. Basalt fiber has good thermal stability, high strength, sound absorption and sound insulation, and stable friction coefficient, and can be used in the fields of automobiles and buildings, such as friction reinforcing materials for automobiles, high-temperature filter materials and interior materials. In recent years, researchers at home and abroad have done a lot of exploration and research on the crack resistance mechanism, mechanical properties and engineering practice of basalt fiber reinforced cement-based composites. Based on this, this paper summarizes the research progress of basalt fiber and its reinforced cement-based composites.

2. Research background and significance

Fiber cement matrix composites (FCMC) are composite materials which are made of cement paste, cement mortar or concrete as the base material and discontinuous short fibers or continuous long fibers as the reinforcement. It can be traced back to more than 1000 years ago. The ancient Romans mixed horsehair with lime to make statues. At the beginning of the 20th century, Austria invented asbestos cement board and established the first asbestos cement products factory in the world. From 60s to 1970s, steel fiber and glass fiber were used to reinforce cement-based materials. Then, with the advent of high-performance fiber and the improvement of cement matrix, fiber-reinforced cement-based composites have entered a new stage. In 1954, the former Soviet Union successfully developed basalt fiber as a new material for the first time. Before 2002, basalt fiber was mainly used in military industry. Later, scholars from all over the world conducted a lot of research on this material. China was also listed as a 863 high-tech project in China in 2002, and basalt fiber was successfully developed in 2005. Basalt fiber has good physical and mechanical properties, such as large elastic modulus, strong

corrosion resistance, high tensile strength, good chemical stability, and natural compatibility. Reasonable addition of basalt fiber to concrete is helpful to improve the compressive strength, flexural strength and splitting tensile strength of concrete materials, as well as the impermeability and drying shrinkage deformation ability.

Nowadays, the research on basalt has been going on. Most of the existing buildings in China are made of concrete, and the data show that at least 50% of them have been put into use for 20 years. Due to technical problems and improper management in the design and construction process, reinforcement, repair and maintenance will become the focus of the future construction field[4]. With the development of civil buildings and various structures in today's society towards super-high-rise and long-span structures, the requirements for material properties are getting higher and higher, and the research results show that the high-strength performance of basalt fiber concrete can just meet this demand, and the influence of different dosage on its strength is also different[5].

3. Related research at home and abroad

Wang Zezhu, Tian Zhenghong and others[6] in order to analyze the reinforcement effect of basalt powder and basalt fiber on concrete. The results show that the pore structure in concrete is deteriorated due to the inclusion of exogenous bubbles in basalt fiber, and basalt fiber will corrode in alkaline cement matrix, which will weaken the interface bonding between basalt fiber and cement matrix, and the toughening effect of basalt fiber will not be fully exerted. Adding basalt powder can improve the internal pore structure of concrete, especially adding basalt powder and basalt fiber. Basalt powder can reduce the corrosion degree of basalt fiber, enhance the interfacial adhesion between basalt fiber and cement matrix, and enhance the mechanical and frost resistance of concrete.

Chang Honglei[7] and other scholars studied the influence of fiber types and content on the crack resistance of plane thin-plate specimens, mainly basalt fiber concrete and polypropylene fiber concrete, and found that basalt fiber concrete can greatly improve the crack resistance of concrete materials, and it will increase with the increase of content.

In 2016, LuigiFenu, DanieleForni[8] and others studied the dynamic properties of basalt fiber cement mortar. The results show that the addition of basalt fiber significantly improves the static bending strength of mortar, while the dynamic tensile strength hardly increases (slightly increases). Under the dynamic load, the post-peak performance of basalt fiber mortar is improved.

In 2018, Muhammad Riaz Ahmad, Bing Chen[9] and others studied the influence of basalt fiber on the mechanical properties of composite magnesium phosphate cement (MPC) mortar. The experimental results show that the compressive strength and flexural strength of basalt fiber MPC mortar are improved with the increase of the content, and the compressive strength and flexural strength are improved to the greatest extent under the optimal content.

4. Study on mechanical properties of basalt fiber cement-based materials

Wu Zhaoxian[10] and others have studied the basic mechanical properties of basalt fiber reinforced concrete. The results show that the compressive strength of basalt fiber reinforced concrete is positively correlated with the fiber content under the package of cement paste, and the strength increase is more obvious in the early stage. When the dosage is 2.0 kg/m, the compressive strength of the specimen is increased by 17.23% and 15.09% at three days and seven days respectively, and the compressive strength at 28 days is increased by about 5.5%.

At present, the mechanical properties of basalt fiber reinforced cement-based composites mainly focus on the experimental study of compressive strength, flexural strength, bending and splitting tensile strength, and the variables are generally the length and content of fiber, or based on the consideration of engineering cost, the influence of mineral admixtures such as silica fume or fly ash on the mechanical properties of fiber reinforced cement-based composites is studied. When basalt fiber is used to reinforce concrete, adding basalt continuous fiber or discontinuous fiber into concrete in a reasonable amount and in a proper way can improve the comprehensive mechanical properties of concrete, such as compressive strength, tensile strength and impact resistance, and has the advantages of toughening and improving durability in engineering. Compared with ordinary concrete, basalt fiber reinforced concrete also has the properties of high temperature resistance, corrosion resistance, sound absorption and sound insulation.

5. Study on durability of basalt fiber reinforced concrete

5.1 Frost resistance

Li Zhen[11] studied the influence of different basalt fiber content (0.05%, 0.1%,

0.15%, 0.2% by volume) on the working performance, mechanical properties and durability of concrete under the action of salt freezing by indoor rapid freeze-thaw test. The research shows that the concrete with fiber content of 0.15%~0.2% has the best freeze-thaw erosion resistance. Under the same freeze-thaw conditions, the mass loss and the decline rate of relative dynamic elastic modulus of concrete with fiber are lower than that of PC, and the addition of fiber slows down the mass loss and the decline rate of relative dynamic elastic modulus of concrete, which has the effect of toughening and preventing cracks in concrete.

5.2 Corrosion resistance

Yao Yong et al. studied the corrosion resistance of basalt fiber at home and abroad by simulating seawater, acid and alkali environment. The results show that the seawater resistance of basalt fiber at home is better than that of foreign countries, and the acid resistance is similar, and the alkali resistance is different.

5.3 chloride ion erosion

By studying the influence of basalt fiber on the durability of concrete, Zhu Huajun found that with the addition of fiber, the pore structure in concrete was improved. The frost resistance of concrete is greatly enhanced. Compared with plain concrete, the early drying shrinkage of concrete mixed with basalt fiber is basically the same, and the drying shrinkage increases obviously when the age reaches about 14 days, and the drying shrinkage of the two kinds of concrete does not increase basically when the age reaches 60 days. By comparing the chloride ion permeability of plain concrete and basalt fiber concrete, it is concluded that basalt fiber concrete with fly ash has the strongest chloride ion permeability resistance.

6. outlook

Basalt fiber has many excellent properties such as high temperature resistance, tensile strength, chemical stability, thermal shock stability, acid and alkali resistance and so on. And China has independent intellectual property rights, advanced manufacturing technology and low cost. Although the application of basalt fiber in strengthening cement-based materials in China has achieved some research results, there are still many problems to be solved. The direction of microcracks in cement-based materials with fiber arrangement under load is observed by some microscopic means, and the reasons for different results are explained by combining theory with

experiment.

By changing the length, diameter, dosage, fiber arrangement angle and the relationship between specimen age and stress, the function of basalt fiber in the crack resistance of cement-based materials is discussed, and the best combination is determined, which lays a foundation for the application practice of basalt fiber in the crack resistance direction, and then promotes the development of basalt fiber cement-based materials in different engineering projects.

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