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Summary of Research on the Durability of Basalt Fiber Concrete

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Abstract: The research status of the impermeability, frost resistance, erosion resistance and carbonation resistance of basalt fiber concrete at home and abroad have been summarized in recent years. The analysis results show that reasonable basalt fiber content can significantly improve the durability of ordinary concrete, among which the most significant effect is in improving the impermeability, frost resistance and erosion resistance of concrete, but there are few studies on the carbonation resistance of basalt fiber concrete. In the future, the following four aspects should be paid attention to: When studying the impermeability and frost resistance of basalt fiber concrete, the stress state of concrete under the action of load should be considered at the same time; To strengthen the research on the anti-erosion performance of basalt fiber concrete under the coupling effect of various factors; Strengthen the carbonation resistance of basalt fiber concrete research, can effectively solve the structural concrete due to the decrease of alkalinity and the loss of the reinforcement protection problem; The failure mechanism of basalt fiber concrete under the action of multiple factors is deeply discussed.

Keywords: Basalt fiber concrete; The permeability resistance; Frost resistance; Salinity resistance; The carbonation resistance

1. Introduction

In the 19th century, the Englishman Joseph Aspdin invented cement, which resulted in cement concrete [1]. After continuous development, cement concrete concrete has become the most used artificial building material in the world. The pace of research on various properties of concrete has never stopped. Basalt fiber(abbreviated as: BF), is a continuous fiber that is quickly drawn by using platinum-rhodium alloy drawing slip plate after crushing natural basalt rock material and melting it at high temperature [2]. Basalt fiber reinforced concrete (abbreviated as: BFRC) is a composite building material formed by mixing a certain amount of fiber as a reinforcing material in ordinary concrete or cement mortar.

The BF component is mainly silicate mineral material, which has good compatibility with concrete. After adding fiber, the performance of concrete in all aspects can be improved to a certain extent. With the continuous development of the construction industry, the application of basalt fiber in the construction field is also expanding. Its durability will also be a hot issue that experts and scholars pay attention to. This article will mainly analyze the research status and development trend of BFRC's impermeability, frost resistance, salt erosion resistance and carbonization resistance.

2. Research Status of BFRC Impermeability

As one of the basic properties of concrete material durability, impermeability is its own ability to resist the infiltration of gas and liquid from the outside. In actual engineering cases, common disease problems such as alkali aggregate reaction and corrosion of steel reinforcement in concrete are caused by the infiltration of moisture in the external environment, which causes the failure and damage of the concrete structure. Therefore, the research on the impermeability of concrete plays an important role in its durability.

Yang Qibin [3] and Chen Feng used the electric flux method to test the permeability of basalt fiber concrete. The test results show that the total electric flux is constantly changing when the basalt content changes from 0-1.6kg/m3. When the impermeability of concrete reaches the best, the reasonable amount of fiber is 1.2kg/m3. The experimental research of Zhao Chaohui [4] howed that: compared with ordinary concrete, the incorporation of BF can inhibit the cracking of concrete, thereby enhancing its impermeability. He Junyong [5] and Tian Cheng-yu carried out a comparative test study on the impermeability of basalt fiber and polypropylene fiber. The experimental study showed that basalt fiber has better impermeability effect than polypropylene fiber. Bai Yujin [6] used the water seepage height method to conduct research. The research results show that: BF can improve the impermeability of concrete very well, and the water seepage height gradually decreases with the length of the fiber. When the length of BF is 18mm and the content is 0.05%, the impermeability effect of concrete is the best.

Combined with the research of experts and scholars, the incorporation of BF can improve the permeability of concrete mainly for the following reasons: First, the incorporation of fibers can effectively prevent the water separation process on the surface of the concrete, and strengthen the cementitious material and coarse and fine aggregates. The combination of materials makes the concrete matrix have excellent uniformity, inhibits the uneven shrinkage of the concrete during the hydration process, and reduces the cracks in the concrete. Second, when adding fibers to concrete, they are evenly sprinkled during the mixing process. Therefore, the fibers are uniformly distributed inside the concrete. The uniform distribution of fibers has a certain crack resistance effect, reducing the number of cracks and preventing the length and width of cracks from propagating, and effectively preventing the cracks that have been produced from appearing through. The phenomenon. Third, the fiber is filled in the concrete matrix. Because of its small diameter, the capillary pores in the concrete are filled, the tension of the capillary action is reduced, and the moisture is not easy to migrate, thereby improving the impermeability of the concrete. However, it is not that the higher the fiber content, the better. When the fiber content is too much, the interior of the concrete matrix tends to gather together due to the concentrated fiber distribution, which will form pores. If the matrix has too many pores, the concrete impermeability will be caused. reduce.

3. Research Status of BFRC Freezing Resistance

In the cold environment, concrete is prone to frost damage during service in the outside world, causing the surface of the concrete to peel off and cracks inside. As the freezing damage continues to increase, it will pose a serious threat to the durability of concrete. When the concrete is in a saturated state and continues to undergo freeze-thaw cycles, it is prone to freeze-thaw damage. At present, four aspects are summarized for the failure mechanism of concrete at home and abroad: osmotic pressure theory, hydrostatic pressure theory, water migration mechanism and ice crystal growth theory [7].

The main reasons that fibers improve the frost resistance of concrete include : First, the fibers have better tensile properties. The fibers are distributed in a three-dimensional network in the concrete in a random direction, which can share a part of the tensile stress for the concrete, thereby effectively preventing The generation of cracks; second, the incorporation of fibers can improve the compactness of concrete to a certain extent, reduce the pores in the concrete structure, thereby enhancing the resistance to water penetration; third, the incorporation of fibers makes the concrete The water separation and segregation on the surface are effectively suppressed; fourth, the addition of fibers increases the air content of the concrete, which can reduce the hydrostatic pressure inside the concrete.

A lot of research results have been made in the research on BFRC's frost resistance. Zhang Yi-ping [8] and Xu Jia-wen conducted experiments on the frost resistance of concrete with different amounts of BFRC. The research results show that although the incorporation of BF improves the frost resistance of concrete, it is not that the more fibers added, the effect will be The better, there is a critical value for the selection of the blending amount. When the fiber content is 2kg/m3, the anti-freezing effect is the best. Zhao Bing-bing [9] and others selected 100mm standard cube specimens and adopted the slow freezing method. Experimental studies have shown that when basalt and polypropylene fiber are blended alone, after 50 freeze-thaw cycles, only basalt is blended. In the vicinity of 0.9%, the strength loss is small; the frost resistance of concrete is the best when mixed with 1:1. When the freeze-thaw cycle is 100 times, the minimum strength loss for concrete is a group of 0.3% mixed with 2:1 fiber. After 150 freeze-thaw cycles, the best effect is achieved when only 0.6% of basalt fiber is blended; the best effect is achieved when the blend of 1:1 fiber is 0.3%. In general, mixed fibers have a more obvious effect on improving the frost resistance of concrete than single fibers. Yang Yi [10] et al. conducted a freeze-thaw cycle test with a mixture of steel fiber and basalt fiber. The test results show that when the frost resistance of concrete reaches the best, the content of steel fiber and basalt fiber are at 1.5%, 0.05%.

The research of the above-mentioned scholars can fully demonstrate that mixing basalt fiber in concrete can improve the frost resistance of concrete. However, the more fiber is not the better, too much fiber will easily accumulate in the concrete and cause uneven dispersion. It is easy to form pores. To a certain extent, excessive blending of fibers will reduce its impermeability. Therefore, choosing a reasonable fiber content is very important for concrete.

4. Research Status of BFRC Resistance to Corrosion

In my country, the main types of concrete structures that are eroded by salt include chloride and sulfate, and sulfate erosion is the most significant. Sulfate erosion is caused by the chemical reaction between SO42- in the salt and the internal cement stone to cause damage to the concrete structure [11]. The most common types of sulfate erosion are crystalline physical damage, gypsum crystalline erosion, and ettringite (AFt). Crystal type destruction, carbothite (TSA) crystal type destruction, magnesium sulfate double erosion type [12-15].

Crystalline physical destruction mechanism. When the concrete structure is in a sulfate environment, because the sulfate in the internal pores of the concrete is saturated, the sulfate does not completely react with the internal components of the concrete, and sulfate crystals will precipitate, causing the volume of the concrete structure to expand (about it is 4.5 times of the original size), forming a crack, thereby generating erosion.

Gypsum crystal type erosion and ettringite (AFt) crystal type destruction mechanism. When the sulfate concentration is high, the sulfate solution will react with the internal components of the concrete to produce gypsum. The volume of gypsum is about 1.24 times that of calcium hydroxide, which will cause expansion and cracking, which will eventually lead to structural damage. The destruction of ettringite (AFt) crystal form is due to the pre-reaction of sulfate in the cement stone with Ca(OH)2 to form CaSO4, which further reacts with solid calcium aluminate hydrate to form a new substance, AFt. AFt easily combines with water, causing volume expansion (about 1.5 times the original), forming AFt crystals [16], which is a needle-like crystal with great internal stress, which is easy to cause cracks on the concrete surface.

TSA crystal type, magnesium sulfate double erosion type damage. TSA crystalline damage is a slow erosion damage, which directly causes the disintegration of the C-S-H gel, causing the cement stone to lose its strength and cohesion. This kind of erosion is somewhat hidden and more destructive.

Magnesium sulfate double-erosion type is a more harmful type, because both Mg2+ and SO42- in the erosion solution can cause corrosion of the concrete structure. The damage degree of this double-type composite salt corrosion is much greater than that of single salt. Magnesium sulfate and calcium hydroxide in cement react to produce magnesium hydroxide and gypsum. The gypsum or AFt generated immediately after the reaction causes the volume of the concrete structure to expand, transforming C-S-H into C-M-H, which makes the concrete brittle and reduces the strength, stiffness and cohesive force. If the corrosion is severe, the concrete will lose its cementing power and become a paste.

Wang Xuezhi [17] used two methods of single blending and blending, and blended fibers (basalt fiber and polypropylene fiber) with different content to conduct sulfate corrosion performance research. Through the 7d, 14d, 28d age fiber concrete to resist The compressive strength and corrosion resistance coefficient is used as an indicator. The study shows that for the 7d age, the single blending is 0.6%, 0.9% and 1:1, 1:2 fiber blending and the blending amount is 0.3%, 0.6%, 0.9% of the concrete , Its compressive strength and corrosion resistance coefficient have been significantly improved. At the age of 14 days, 0.3%, 0.6%, and 0.9% single-mixed basalt fiber can improve the corrosion resistance of concrete; the 2:1 mixed fiber series has the most obvious effect when the dosage is 0.3%. When the concrete is at the age of 28 days, the effect is obvious when the basalt fiber is mixed with 0.9% alone; the corrosion resistance coefficient of the mixed 1:2 fiber series is increased obviously at 0.3%. Compared with single blended fiber, the effect of blending is better than that of single blending. Li Yi[18] conducted experiments on basalt and polypropylene fibers under the sulfate-dry-wet cycle. The test results show that the incorporation of fibers can effectively improve the sulfate corrosion resistance. Compared with ordinary concrete, it has the same corrosion age. In the future, the sulfate ion content of fiber concrete is lower than that of ordinary concrete. Zhao Yanru[19] and Liu Fang-fang conducted research under the salt freeze cycle with a rapid freeze-thaw test. The study showed that compared with ordinary concrete, the salt-freeze resistance ability was significantly enhanced after fiber was incorporated.

Based on the previous research results, the types and mechanisms of salt attack on concrete are different, and the damage caused to concrete is also different. However, in general, the salt attack on concrete requires attention. The current research is mainly aimed at the research of materials, and the later research will pay more attention to the research of concrete structure components and apply them in actual engineering.

5. Research Status of BFRC Anti-Carbonization Performance

The corrosion principle of carbonization is that the carbon dioxide in the external environment of concrete invades into the matrix and the alkaline substances in the aggregate undergo a series of complex physical and chemical changes, which will corrode the steel bars in the concrete, change the internal pH of the matrix, and directly affect the strength and durability of the concrete. Sex. The addition of appropriate amount of fiber can effectively reduce the porosity inside the matrix, make the concrete have good compactness, and slow down the invasion and corrosion of carbon dioxide in the air. The concrete carbonization mainly produces carbonic acid and calcium carbonate[20] The specific reaction process is as follows:

$H2O+CO2 \rightarrow H2CO3$

$H2CO3+Ca(OH)2 \rightarrow CaCO3 \downarrow +2H2O$

Cheng Yunhong [21] have shown that concrete mixed with polypropylene fiber has better anti-carbonization effect than steel fiber concrete. The research of Wang Zhanhai [22] showed that the appropriate amount of steel fiber can improve the carbonization resistance of concrete. Wang Zhijie [23] and others conducted a rapid carbonization test study on sprayed fiber concrete. The research showed that the anti-carbonization performance of concrete was improved after fiber was added.

Based on the above research, the current fiber research is mainly focused on the carbonization resistance of polypropylene, steel fiber and glass fiber. What is the impact of the addition of basalt fiber on the carbonization resistance of concrete? How big needs further discussion and research.

6. Conclusion

From the current research status of basalt fiber reinforced concrete, mainly from a single environment factors on the influence of basalt fiber reinforced concrete durability analysis, and a large number of experiments show that the fiber in made in all aspects of the durability of concrete were improved significantly, especially in the concrete permeability resistance, frost resistance, erosion resistance, etc. Therefore, great progress has been made in the study of the durability of materials under the influence of a single factor.

In the future, we should pay attention to the following four aspects:

When studying the impermeability and frost resistance of basalt fiber concrete, the stress state of concrete under load should be considered at the same time.

To strengthen the research on the anti-erosion performance of basalt fiber concrete under the coupling effect of multiple factors.

Strengthening the carbonization resistance research of basalt fiber concrete can effectively solve the problem that structural concrete loses its protective effect on reinforcement due to the decrease of alkalinity.

The damage and failure mechanism of basalt fiber concrete under the action of multiple factors is deeply discussed.

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References

[1] Yu Junbao, Hu Mengjie, Yang Dingyi. Discussion on the characteristics and application of fiber concrete. Jiangsu Building Materials. 2015, (06), 18.

[2] Czigany T., Poloskei K., Karger-Kocsis J. Fracture and failure behavior of basalt fiber mat-reinforced vinyl ester/epoxy hybrid resins as a function of resin composition and fiber surface treatment. Journal of Materials Science. 2005, (2), 128.

[3] Yang Qibin, Chen Feng. Test of impermeability of basalt fiber high performance concrete. Journal of Civil Engineering and Management. 2017, 34(2), 95-98.

[4] Zhao Chaohui. Experimental study on the durability of basalt fiber concrete. Forum for Science and Technology Association. 2011, (4), 74-76.

[5] He Junyong, Tian Chengyu. Research on the durability of basalt fiber hydraulic high performance concrete. Concrete and Cement Products. 2013, (5), 46-48.

[6] Bai Yujin. Research on the influence of basalt fiber on the durability of concrete. Building Materials. 2020, (2), 89.

[7] Hao Shuai. Research on frost resistance of fiber concrete in severe cold area. Jilin: Northeast Dianli University. 2018.

[8] Zhang Yiping, Xu Jiawen. Experimental study on the strength and frost resistance of self-compacting concrete with basalt fiber. New Building Materials. 2018, 25-28.

[9] Zhao Bingbing, He Jingjing, Wang Xuezhi, et al. Freezing resistance test of basalt-polypropylene hybrid fiber concrete. Journal of Liaoning Technical University (Natural Science Edition). 2015, 34(12), 1402-1407.

[10] Yang Yi, Ning Cuiping, Cheng Ruifang, etc. Experimental study on freeze-thaw cycle of concrete mixed with steel and basalt fiber. Journal of Water Resources and Water Engineering. 2017, 28(4), 182-186+192

[11] Adam Neville. The confused world of sulfate attack on concrete. Cement and Concrete Research. 2004, (8), 1275.

[12] Zhang Guanghui. Summary of research on sulfate corrosion of concrete structures. Concrete. 2012, (1), 49.

[13] Wu Danhong. Review of research on concrete resistance to sulfate erosion. Ecological Building Materials. 2014, (2), 40.

[14] Li Xiujuan. Research on the mechanism of sulfate erosion and the test method of sulfate erosion resistance. Hebei: Hebei Institute of Technology. 2004.

[15] Tang Haichang. Analysis of the durability of concrete under sulfate attack. Jiangsu: Nanjing University of Science and Technology. 2008.

[16] Liang Ruheng. Research on the sulfate corrosion resistance of ordinary C40 concrete. Guangdong Building Materials. 2008, (8), 51.

[17] Wang Xuezhi, He Jingjing, Zou Haofi, et al. Experimental study on sulfate corrosion of basalt-polypropylene hybrid fiber concrete. Concrete and Cement Products. 2014, (5), 50.

[18] Li Yi, Zhang Shuang. Sulfate corrosion resistance of hybrid fiber concrete under dry-wet cycle. Journal of Northeastern University (Natural Science Edition). 2016, 37(6), 895-898+903.

[19] Zhao Yanru, Liu Fangfang, Bai Jianwen, et al. Experimental study on the salt-freezing resistance of basalt fiber concrete. Concrete, 2019, (08), 68-71.

[20] Yang Jing. The carbonation mechanism of concrete and its influencing factors. Concrete. 1995, (6), 23.

[21] Cheng Yunhong, Wang Hongwei, Wang Yuan. Preliminary study on the anti-carbonation performance of fiber-reinforced concrete. Journal of Building Materials. 2010, 13(6), 792.

[22] Wang Zhanhai, Yang Dejian. Research on influencing factors and prediction model of carbonization depth of steel fiber concrete. Journal of Tianjin Urban Construction University. 2015, 21(4), 262-266.

[23] Wang Zhijie, Wang Qi, Sun Changsheng, et al. Research on carbonization depth prediction of fiber shotcrete based on rapid carbonization test. Concrete. 2014, (2), 21-24.