Mix Proportion Experiment and Mechanical Properties of Hybrid Fiber Reinforced Concrete

Zeng Xiaoyun, Wang Yushan, Li Guangzhou, Jiang Xuecan

College of Water Conservcyan &Architectural Engineering, Shihezi University, Shihezi, China

Keywords: Hybrid Fiber, Concrete, Frost Resistance and Impermeability, Mix Proportion, Mechanical Properties

Abstract: as an Important Structural Material in Modern Engineering, Concrete Plays an Important Role in Related Fields. However, the Concrete Has the Shortcomings of Brittleness, Low Compressive Strength, and Serious Problems Such as Water Leakage and Cracking in the Use Process, Which Not Only Affects the Durability and Service Life of Concrete, But Also Increases the Later Maintenance Cost. in This Regard, This Paper Summarizes the Current Situation of Concrete Research, and Finds That There Are Many Researches on Steel Fiber Mixed with Concrete. Although It Will Improve the Durability to a Certain Extent, It Can Not Guarantee to Extend the Service Life of Concrete and Improve the Frost Resistance and Permeability Resistance. Based on This, through the Mix Proportion Test of Steel Fiber and Polypropylene Fiber, Further Analysis of Steel Fiber and Polypropylene Fiber Hybrid for Improving the Frost Resistance, Impermeability and Mechanical Properties, in Order to Fill the Academic Research Gap.

1. Introduction

1.1 Literature Review

As a building material, concrete is widely used in the construction industry, so as to enhance the resistance of the building to provide security for human settlements and travel safety. However, the concrete is easy to crack and has low tensile strength, which leads to water seepage and cracks in the use of concrete. In this regard, most scholars based on different perspectives to explore the anti freezing and anti permeability functions of mixed fresh concrete. Zhao Hua, He Rui, Peng Ting, et al. Prepared hybrid fiber concrete with excellent deformation performance by using materials such as high elastic modulus polyethylene fiber and low elastic modulus polypropylene coarse synthetic fiber, and analyzed its uniaxial tensile resistance characteristics. The results showed that there would be cracks at different stages, and the cracks would be improved after infiltration of silica fume(Zhao et al,2015). Deng Zongcai, Zhang Yongfang and Xu Haibin, etc. found that the addition of cellulose into concrete can effectively improve the anti cracking and anti permeability of concrete, and is superior to that of polypropylene fiber(Deng et al,2012). Wang Xuezhi, Zheng Shuwen, He Jingjing and others set up a comprehensive durability evaluation system of fiber-reinforced concrete from the perspective of concrete impermeability, and further proved the rationality of the durability evaluation model of fiber-reinforced concrete through the study of frost resistance and index fitting(Wang et al,2015). Huang Jie, Liu Xiaofan, Li Jixiang and others simply start from the shortcomings of ordinary concrete, through the experiment of adding fiber and anti permeability label method to the concrete anti permeability test, the most mixed fiber mix ratio is obtained(Huang et al,2012). To sum up, most scholars have their own opinions on the research of concrete fiber addition, and realize the improvement of concrete performance from different perspectives. Then, in order to enrich the experimental data, by using the research status of the above scholars for reference, the accuracy and performance of the data can be better reflected.

1.2 Research Purposes

As the most common building materials, concrete is used in tunnel building, high-rise building, road building and so on. However, problems such as cracking and leakage often occur in the use of

  DOI: 10.25236/acete.2019.036

concrete. The application of new materials and technologies can only maintain the function of joint filling for a while(Liu,2014). Moreover, the long-term crack repair of concrete will reduce the service life of building materials and further aggravate the instability of buildings. In addition, concrete is used to enhance the frost resistance. The foam board is added to the concrete interface to expand the thermal effect of the building, thereby preventing the concrete from cracking due to low temperature and reducing the concrete performance(Jiang,2019). However, at present, there is no good experimental research to verify the addition of fiber and other materials to concrete, so as to improve the frost resistance, impermeability and compressive strength of concrete. In this paper, by studying the current research status of hybrid fiber reinforced concrete, we further summarize the relationship between the frost resistance and seepage resistance of fiber and the mechanical properties of concrete. Through collecting all kinds of materials and mechanical materials needed for concrete to be mixed with fiber, and carrying out mix proportion test, it is found that different fiber content and different fiber have different effects on the frost resistance, seepage resistance and compressive resistance of concrete.

2. Research Status of Hybrid Fiber Concrete

During the hardening process of concrete, cracks will appear due to hydration heat and other reasons. At present, polypropylene fiber, steel fiber and glass fiber are widely used. Hybrid fiber concrete is to mix different sizes of fibers according to the specified proportion and then mix them into concrete, so that the advantages of different fibers can be brought into full play and the comprehensive performance of concrete can be improved. At present, the research results of hybrid fiber reinforced concrete based on fiber constitution and size are relatively discrete, and the experimental results can only partly reflect the effect of fiber on concrete. At the same time, there is no accurate explanation for the mixed fiber concrete and the single fiber concrete.

Although modern concrete technology has been developed rapidly to a certain extent, its strength and variety are increasing, but its service life has not been increased. Furthermore, it not only increases the function of maintenance, but also causes a lot of waste of resources. Therefore, it can be found that in order to shorten the construction period and present high-strength concrete, most construction companies neglect the durability and huge maintenance cost of concrete. In addition, steel fiber reinforced concrete has been unable to withstand the current huge traffic flow in China, resulting in different degrees of damage to the bridge deck and the ground, resulting in huge economic losses. Moreover, increasing the cost of steel fiber will not only increase the cost, but also is not conducive to effective concrete setting. Therefore, mixing polypropylene fiber with steel fiber can not only effectively change the concrete structure, but also give full play to the frost resistance, impermeability and mechanical properties of the two fibers.

3. Experiment on the Mixture Ratio of Frost Resistance and Permeability Resistance of Hybrid Fiber Concrete

3.1 Experiment of Anti Freezing and Anti Permeability

As a number of composite heterogeneous materials, concrete is made of cement, water, aggregate and other materials after mixing and solidification. There are many fine pores inside and on the surface of concrete, which is the permeability of liquid and gas when the concrete is subjected to the pressure difference between inside and outside. The ability to resist the penetration of liquid is called the impermeability of concrete. The frost resistance and impermeability of concrete is a measure of the durability of buildings. The better the frost resistance and impermeability is, the better the compactness is. The less the concrete is eroded by harmful media, the better the durability is. In this paper, through the study of the influence of hybrid fiber on the anti freezing, anti permeability and mechanical properties under different hybrid content, we can find out the materials that will contribute to the durability of the building in the future.

3.2 Experimental Materials and Mix Proportion Test

Cement: 42.5R ordinary portland cement produced by Dalian Xiaoye cement plant is selected; Coarse aggregate: crushed stone with a maximum particle size of 20 mm; Fine aggregate: river sand with fineness modulus of 2.9; Fiber: select Yixing Junwei Metal Fiber Co., Ltd. to produce bow shaped steel fiber (g) and CTA modified polypropylene fine fiber (P) and coarse fiber (H), The main physical properties of steel fiber are 30 mm in length, 0.5 mm in diameter, tensile strength $\geqslant$ 1150 MPa, The initial modulus of physical properties of modified polypropylene fiber is divided into fine fiber (P) > 3.5, length > 19, diameter 20.0, breaking strength > 400, density 0.91, and breaking elongation about 15-35%, Crude fiber > 4.2, length 30 ~ 50, diameter 1.0, breaking strength > 410, density 0.91, breaking elongation 15 ± 5%; water reducing agent: Sika superplasticizer; air entraining agent: Sika air entraining agent.

3.3 Test Piece Production and Test Method

The test pieces are made according to the test methods of steel fiber reinforced concrete (CECs 13:89) and the test procedures of cement concrete for Highway Engineering (JTJ 053-94). It is determined that the compressive strength and splitting tensile strength test pieces are 150 mm × 150 mm × 150 mm cubes, the flexural strength test pieces are 150 mm × 150 mm × 550 mm small beams, and the impermeability test pieces are 175 mm upper diameter, 185 mm lower diameter and 150 mm high circular beams Form tablethe forced mixer shall be used in the production of the test piece. In addition, the feeding sequence should first mix other addition materials except fiber, and then gradually put in any fiber materials needed to be added. When all fibers are put in, stir for about 1 minute to achieve material adhesion. In addition, the test of compressive strength, splitting tensile strength and flexural strength shall be carried out in accordance with the test method of steel fiber concrete(CECs 13:89), so as to carry out the test of impermeability 90 volume 11 of the Journal of building materials shall be tested in accordance with the method of impermeability height in the code for test of cement concrete in Highway Engineering(JTJ 053-94). The specific process can be divided into the following steps: add the water pressure to(1)20 ± 0.05) MPa for 24 hours, and then stop pressurizing. Split the fracture specimen and measure the water penetration height at the 10 average points of the concrete section, and use the arithmetic mean value data of the 10 measuring points as the water penetration height of the split specimen, then take the arithmetic mean value of the water penetration height of the 6 specimens as the average water penetration height of the group of specimens, and then measure the frost resistance and mechanical properties of the hybrid fiber.

4. Result Analysis

4.1 The Influence of Hybrid Fiber on the Frost and Seepage Resistance of Concrete

After adding fiber into concrete, the frost resistance and impermeability of concrete decreased slightly, but it can still meet the requirements of construction engineering. When the total content of hybrid fiber is 1.0%, with the increase of the content of steel fiber, the frost resistance and impermeability of hybrid fiber reinforced concrete is on the rise. In addition, after adding 0.02% air entraining agent, the frost resistance and impermeability of plain concrete and fiber concrete are improved in varying degrees.

At present, most people think that the elastic modulus of the fiber is higher than that of the initial set concrete. Therefore, the fiber increases the concrete plasticity and the tensile strength in the hardening process, inhibits the early shrinkage crack of concrete, and reduces the porosity. At the same time, due to the incorporation of fiber, the water loss area of concrete body becomes smaller, and the water migration is more difficult, so as to reduce the tension caused by water loss shrinkage of capillary and improve the frost resistance and impermeability of concrete.

On the whole, the effect of fiber incorporation on the frost and seepage resistance of concrete can be divided into adverse and favorable effects. The adverse effect is that the fiber occupies more concrete interface, takes up a lot of cement slurry space, reduces the fluidity of the concrete diagram,

decreases the compactness, and increases the porosity. In addition, the cement will cover more orthopedics and fibers, which is easy to form cracks, and can be used for many reasons, so as to improve the water permeability of concrete. The favorable effect is that fiber reinforced concrete will increase the content of steel fiber, and the overall frost resistance and seepage resistance trend of high mountains. This is because steel fiber is better than modified polypropylene fiber in preventing fracture. Concrete mixed with fiber can weaken the concentrated stress at the end of the crack, so as to prevent the development of crack extension and improve the frost resistance and impermeability.

4.2 Influence of Hybrid Fiber on Mechanical Properties of Concrete

Generally, it is considered that steel fiber has little effect on the compressive strength of concrete in high mountains, and polypropylene fiber with lower elastic modulus can only improve the impact resistance, but not the compressive strength. According to the relevant data, hybrid fiber concrete can improve the strength of concrete, such as tension compression, compression and flexural strength. According to the above experiments, when the content of hybrid fiber is 0.5% and 1.0%, the compressive strength of hybrid concrete will increase with the continuous incorporation of steel fiber. Among them, the overall content of 1.5% hybrid fiber can enhance the compressive strength more effectively, and the compressive strength of g5h10 and ag10h5 concrete is 206% and 8% higher than that of G10 concrete, two to three times higher than that of ordinary concrete. In general, the hybrid fibers with different sizes and properties can play different fiber sizes and performance effects, so as to achieve the purpose of strengthening the compressive strength.

Acknowledgement

The fifth division of xinjiang corps science and technology project”Study on seismic reinforcement of existing frame structures with dampers”

References

[1] Zhao H., He R., Peng T., et al.(2015), Mixed Synthetic Fiber Concrete Single-Axis Tensile Mechanical Properties and the Relationship between this Structure. Silicate Advisory, 40 (3),770-775.

[2] Deng Z.C., Zhang Y.F., Xu H.B., et al. (2012), Cellulose Fiber Concrete Early Cracking and Impermeable Properties test. South-North Water Transfer and Water Technology, 43 (6), 10-13.

[3] Wang X.Z., Zheng S.W., He J.J., et al.(2015), Fiber Concrete Durability Evaluation System based on Impermeability . Concrete and Cement Products, 46(1),46-51.

[4] Huang J., Liu X.F., Li J.X.(2012), Mixed Fiber Concrete Anti-Permeability Test Study . Journal of Wuhan Light Industry University, 38 (1),71-74.

[5] Liu W., Zhai Z.C.(2014), Study and Application of the Mechanical Characteristics of mixed Fiber Concrete in Deep Rock Alleys. Coal Technology, 33 (9), 148-151.

[6] Jiang Y.Q., Liu H.W., Li L., et al.(2019), Bridge Telescopic Device Anchoring Area mixed Fiber Concrete Mechanical Properties and Antifreeze Test Study . Journal of Wuhan University of Engineering, 41(04), 380-385.