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Computer-Aided System for High-Performance Fiber Concrete Compressive Strength and Temperature Evolution Test

Xia Li*
College of Architectural Engineering
Kunming University, Kunming, 650214, China

Xinggang Shen
College of Architectural Engineering
Kunming University, Kunming, 650214, China

Abstract:Based on the computer-aided system, the microstructure scanning electron microscope test and compressive strength test of high-performance concrete after high temperature are carried out to study the relationship between the microstructure of high-performance concrete and its macro-mechanical properties. The test results show that the changes in the microstructure of concrete are consistent with its macro-mechanical properties. As the temperature increases, the concrete aggregates gradually become looser, cracks gradually increase, crack widths become larger and inter-connected, and the macro-mechanical properties decrease accordingly. After the synthetic fibers are melted, they leave pores in the matrix that can reduce the internal vapor pressure of the concrete, thereby reducing the damage to the concrete caused by high temperature by 7.4%.

Keywords: Computer Aided System, High Performance Fiber Concrete, Compressive Strength, Temperature Evolution Test

1. INTRODUCTION

The cement industry consumes a lot of energy and seriously pollutes the environment. On the premise of ensuring the quality and performance of the concrete, it is of great significance to reduce the amount of cement in the concrete. Blast furnace slag is a waste material in the production of iron and steel industry. After being ground to an appropriate fineness, it can be used as an admixture of concrete to replace cement in equal amounts to prepare high performance concrete with good performance and stable quality. Compared with ordinary concrete, high-performance concrete is more prone to bursting at high temperatures. The addition of fiber can better solve the high-temperature burst problem of high-performance concrete and improve the high-temperature performance of concrete. In this study, by adding fibers to high-performance concrete with micro-slag powder, the high-temperature compressive strength test of micro-slag fiber concrete was carried out, and the temperature, the content of micro-slag powder, the volume ratio of steel fiber, the content of polypropylene fiber, and the strength grade of concrete were discussed. The influence of factors on the compressive strength of slag fiber reinforced concrete after high temperature provides a reference for the fire-resistant design of slag fiber reinforced concrete structure and post-disaster repair and reinforcement.

High performance concrete (highperformanceconcrete, HPC) is widely used in super high-rise buildings, bridges and other engineering structures. Because HPC has high compactness, it is more likely to burst under fire conditions, which seriously affects the durability of the structure. Peng Gifei et al. tested the compressive strength of ultra-high performance concrete after high temperature. With the increase of temperature, the residual strength of ultra-high performance concrete generally showed a downward trend, and the strength rebounded at a certain temperature. Sun Wei et al. tested the residual mechanical properties of high-strength HPC after high temperature, and the results showed that the residual strength of HPC after high temperature decreased significantly. Jin Xin et al. tested the splitting tensile strength of C40HPC specimens (at different temperatures and the same constant temperature time). Under the same constant temperature time, with the increase of temperature, the splitting tensile strength of the specimens generally showed a downward trend. Zhang Yan et al. analyzed the change law of the compressive strength of machine-made sand C40 concrete cubes after high temperature of 300, 500, 700 ℃, and the results showed that the compressive strength decreased rapidly after high temperature of 300 ℃ and 500 ℃, and the strength loss after high temperature of 700 ℃ Basically the same as natural sand concrete. With the deepening and popularization of HPC research and engineering application in recent years, the high performance of ordinary strength concrete has become a direction of HPC technology development, but the high temperature performance of ordinary strength HPC mixed with machine-made sand is rare.

The research on the burst problem of high performance concrete has received attention since the 1980s, and the burst performance has become an important content of the research on the high temperature performance of high performance concrete. In 1984, HertzKD observed the explosion of concrete cylinders with a strength of 120-170MPa after being subjected to high temperature, and analyzed the reasons for this phenomenon. The research results show that when concrete cylindrical specimens are subjected to high temperature of 300～350℃, most of the specimens will be accompanied by bursting phenomenon. Sideris et al. studied the mechanical properties of high-performance concrete before and after high temperature, and the experimental results showed that the high-performance concrete burst when heated to the range of 380-580℃. At the same time, the study found that the addition of a proper amount of steel fiber to concrete will increase the initial temperature of concrete bursting, but it cannot suppress the bursting; in addition, the addition of silica fume and fly ash will increase the initial temperature of concrete bursting. F. H. Wittmann et al. found through experiments that: after high temperature, high-performance concrete bursts, but ordinary concrete does not, indicating that the fire resistance of high-strength concrete is worse than that of ordinary concrete. Clayton. Research by N et al. also showed that bursting of ordinary concrete is relatively rare after high temperature, while high-performance concrete is prone to bursting. Mixing an appropriate amount of polypropylene fiber into the concrete can achieve the effect of improving the bursting.

2. THE PROPOSED METHODOLOGY

2.1 The Compressive Strength of High Performance Fiber Concrete

The high-temperature furnace tested is a box-type resistance furnace, which is heated by silicon-carbon rods, with a maximum working temperature of 1200°C, and the temperature in the furnace can be automatically controlled. The heating system used in the test is: heating at a heating rate of 10°C/min. After reaching the target temperature and keeping the temperature for 2 hours, the high-temperature furnace automatically shuts down and stops heating, and the specimen is naturally cooled to normal temperature in the furnace. Then, referring to CECS13:89 "Test Method for Steel Fiber Concrete", the slag micropowder fiber concrete compressive test was carried out on the YA-3000 electro-hydraulic press. The high-temperature furnace for the cubic compressive strength and axial compressive strength test is a box type resistance. The furnace is heated by silicon-carbon rods, and the maximum working temperature is 1200°C. The temperature in the furnace can be automatically controlled. The heating system used in the test is: heating at a heating rate of 10°C/min. After reaching the target temperature and keeping the temperature for 2 hours, the high-temperature furnace automatically shuts down and stops heating, and the specimen is naturally cooled to normal temperature in the furnace.

Then, referring to CECS13: 89 "Test Method for Steel Fiber Concrete", the slag micropowder fiber concrete compressive test, cubic compressive strength and axial compressive strength were carried out on the YA-3000 electro-hydraulic press. , As the target temperature increases, the cubic compressive strength, axial compressive strength and relative compressive strength of the slag micropowder fiber concrete after high temperature continue to decrease, and the cubic compressive strength and axial compressive strength have similar changes with temperature. . Before 400℃, the compressive strength of the cube and the axial compressive strength decrease more slowly. After 400℃, the compressive strength of the cube and the axial compressive strength decrease more. The compressive strength at 600℃ is about 70% of normal temperature. The compressive strength at 800°C is about 50% of that at room temperature. The ratio of axial compressive strength of slag fiber concrete to cubic compressive strength is similar before 400℃, about 0.82; after 400℃, the ratio gradually increases, 0.86 at 600℃ and 0.95 at 800℃, indicating that as the temperature rises, the cubic compressive strength of the slag powder fiber concrete tends to be consistent with the axial compressive strength.

2.2 The Temperature Evolution Experiment of Fiber Concrete

For plain concrete without fiber and fiber concrete with mixed fiber, the addition of slag powder improves the cubic compressive strength and axial compressive strength of concrete after high temperature.

When the content of slag powder exceeds 40%, the increase is reduced. When the amount of slag powder is the same, the cubic compressive strength and axial compressive strength of fiber concrete are improved compared with plain concrete, indicating that the incorporation of hybrid fibers improves the internal interface characteristics of slag powder concrete, thereby improve the compressive performance of concrete after high temperature. For plain concrete, the ratio of axial compressive strength to cubic compressive strength varies widely, fluctuating from 0.77 to 0.98, with an average value of 0.88; for fiber concrete, the ratio of axial compressive strength to cubic compressive strength ranges from 0.69 to the change is 0.82, and the average is 0.76. It can be seen that with the increase of the slag content, the compressive strength of the plain concrete axis and the cube gradually become the same after high temperature; the incorporation of fibers has a significant improvement and reinforcement effect on the strength of the concrete, resulting in the fiber concrete axis and the cube the compressive strength ratios are all smaller than those of plain concrete.

The micro-topography of HPC at 25°C and normal temperature. At room temperature, fly ash mixed into concrete can react with cement hydration product calcium hydroxide (C-H phase) to form C-S-H gel, which accelerates the hydration reaction of cement, C-S- The structure of H gel is complete and compact. The unhydrated fly ash is distributed in granular form, and its surface is covered by partial hydration products. The hydration products in the cement stone cement each other to form a continuous phase, and the overall structure is relatively uniform and dense. There is no obvious transition zone at the interface between the aggregate and the cement paste, which indicates that the cement hydration product and the aggregate surface are well bonded. Therefore, the strength of concrete is higher at room temperature.

The compressive strength of high-performance concrete decreases with the increase of temperature. It can be found that the aspect ratio of polypropylene fiber has an effect on the reduction of the compressive strength of high-performance concrete. It can be seen from the figure that when the temperature reaches 500℃, the compressive residual strength of each concrete is basically maintained at 75 %above. From the data in the figure, it can be considered that when the temperature is in the range of 500°C to 600°C, the compressive strength of concrete decreases.

2.3 The Computer Aided Analysis of Compressive Strength of Fiber Concrete

The split tensile strength of the test piece gradually decreases with the increase of temperature, and there is no strength rebound phenomenon. Among them, the split tensile strength of the L10 specimen is always greater than the split tensile strength of the L15 specimen; before 400°C, the split tensile strength of the L10 specimen decreases slowly, while the split tensile strength of the L15 specimen decreases more rapidly. The splitting strength of the pieces decreased significantly, and the splitting strength value was close. Compared with L15, the splitting strength loss rate of L10 increased slowly before 400°C; the splitting strength loss rate of L10 increased more rapidly after 400°C; among them, the splitting strength loss rate of L10 and L15 had the largest difference at 400°C. , Is 18.79%, and the difference is the smallest at 700 ℃, only 3.81%. At 800°C, the splitting tensile strength loss rate of L15 was 85.6%, and the splitting tensile strength loss rate of L10 was also as high as 79.3%, indicating that the crack resistance of C50HPC was lower at 800°C.

After blending with polypropylene fiber, the cubic compressive strength and axial compressive strength of the slag fiber concrete at high temperature increased slightly, and with the increase of the polypropylene fiber content, the compressive strength increased slightly; the slag powder concrete axial center the ratio of compressive strength to cubic compressive strength tends to be stable, about 0.813. The reason why the incorporation of polypropylene fiber increases the compressive strength of concrete after high temperature is that although the incorporation of polypropylene fiber will increase the air content of the concrete and reduce the compactness of the concrete, the pores left after the high temperature melting will increase the concrete The capillary pores increase the internal defects of the concrete matrix and adversely affect the strength; but the existence of these pores also accelerates the dissipation of moisture inside the concrete at high temperatures, and alleviates the thermal damage caused by the high temperature to the interior of the concrete. It is also beneficial to weaken the deterioration of strength caused by high temperature. Under the combined effect of these two contradictory factors, the polypropylene fiber in a certain dosage range can improve the compressive strength of the fiber slag powder concrete after high temperature.

3. CONCLUSIONS

This paper describes the current research status of high-temperature mechanical properties of concrete based on computer-aided systems and the excellent characteristics of fiber concrete, and reveals the research significance of high-temperature mechanical properties of fiber concrete. Through experiments, the law of fiber concrete strength changing with temperature is revealed, and the mechanism of the influence of temperature on the mechanical properties of fiber concrete is analyzed. Research shows that: when the temperature is lower than 200℃, the compressive strength of fiber concrete increases; after 200℃, the compressive strength begins to decrease.

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