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A review of the bending properties of hybrid ceramic-copper-plated steel fiber light aggregate concrete after fire

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Abstract

Based on the synthesis of various literature at home and abroad, the bending performance of light aggregate mixed fiber concrete was studied, especially the impact of ceramic fiber, steel fiber and copper plating fiber on the flexural performance of concrete after mixing 1 or 2 kinds of concrete, and the influence of fire and mixed fiber content added to concrete on the flexural performance of concrete was summarized, hoping to help relevant scholars.

Keywords

Light aggregate, Hybrid fiber concrete, Under fire, Bending resistant.

1. Introduction

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2. Bending resistance of light aggregate concrete after fire

Wang Hualiang[4]et al. designed two steel fiber light aggregate concrete with steel fiber content of 0% and 1%, respectively. The load-deflection curve was obtained by three-point bending fracture test with four temperature changes of 25, 200, 400 and 600 °C, and the fracture energy of steel fiber light aggregate concrete before and after high temperature was studied. The results show that the 1% volume steel fiber content can greatly improve the ductility and deformation ability of light aggregate concrete, thereby significantly improving the fracture performance.

Zhang Xiaohui[5] added steel fiber and polypropylene fiber to light aggregate concrete at 0.3% and 0.6% total fiber volume ratio, and studied the fracture performance of fiber light aggregate concrete after high temperature by three-point loading cut beam method at five temperatures of 25°C, 200°C, 400°C, 600°C and 800°C. The results show that the maximum bending force of concrete increases first and then decreases after high temperature, and the fiber can slightly increase the maximum bending force of concrete. The change law of fracture toughness is similar to the maximum bending force, while the fracture energy shows different change rules.

The reinforcement effect of 0.6% steel fiber is the most obvious, and with the increase of temperature, the reinforcement effect of fiber gradually decreases.

Wu Xi[7] studied the flexural strength of self-compacting light aggregate concrete after high temperature action at 200 °C, 400 °C, 450 °C, 500 °C and 600 °C by measuring the flexural strength of self-compacting light aggregate concrete specimens with strength C40 and C50 at 200 °C, 400 °C, 450 °C, 500 °C and 600 °C, and compared with the flexural strength of ordinary concrete, light aggregate concrete and self-compacting concrete of the same strength. The results show that the residual resistance of self-compacting light aggregate concrete is at the same strength grade

The folding strength loss is slightly smaller than that of ordinary concrete, self-compacting concrete and light aggregate concrete, and self-compacting light aggregate concrete has superiority in residual mechanical properties.

Liu Yunpeng[6] studied the effect of high temperature fibers on the flexural properties of light aggregate concrete by adding basalt fibers and polypropylene fibers into light aggregate concrete. The results show that basalt fiber has obvious effect on enhancing the flexural strength of light aggregate concrete. When the amount of polypropylene fiber in the mixed fiber was 0.15%, the mixed fiber and polypropylene fiber had the same effect on the failure morphological characteristics of light aggregate concrete specimens, and the mixed fiber did not have an obvious effect on the flexural strength enhancement of light aggregate concrete.

Hani Alanazi[1] et al. prepared ultra-high-performance coagulation (UHPC) with light aggregate (LWA) instead of silica sand, and studied its resistance to high temperatures by evaluating the flexural strength of the specimen using SEM. The results show that the flexural strength of UHPC increases with the increase of LWA at ambient temperature, but decreases with the increase of temperature. The incorporation of LWA into UHPC mixtures has a greater negative effect on flexural strength than the effect of LWA on other properties. Replacing silica sand with 5%, 10% and 15% LWA reduced flexural strength by 21%, 22% and 37%, respectively.

Farshad Dabbaghi[2] et al. prepared lightweight concrete with a mixture of expanded clay (LECA) as a lightweight coarse aggregate to study its flexural properties at ambient temperature and after exposure to temperatures of 250, 500 and 750°C compared to ordinary concrete. The results show that the bending tensile strength of ordinary concrete and light aggregate concrete is a decreasing function of temperature, but temperature has little effect on light aggregate concrete.

Mehran Shahpari[3] et al. studied the effect of carbon nanotubes (CNTs) on the flexural properties of structural lightweight aggregate concrete (LWC) after high temperature by four-point bending test. The results show that the flexural performance of LWCs containing carbon nanotubes is improved compared with that of structural LWCs without carbon nanotubes in different temperature ranges from ambient temperature to 800 °C.

3. Bending resistance of ceramic fiber concrete after fire

Xiao Xian[8] made a laminated ceramic fiber concrete specimen by arranging ceramic fibers in a layered cloth manner. The effects of ceramic fiber volume content and number of layers on the flexural impact resistance of the specimen were studied. The results show that the optimal volume content of ceramic fiber is 0. 2%, the optimal number of laying layers of ceramic fiber is 2 layers; When the volume of ceramic fiber is fixed, the more layers of ceramic fiber, the better the bending impact performance of the specimen. When the number of ceramic fiber layers is fixed, with the increase of the volume content of ceramic fiber, the bending impact energy consumption of the specimen first increases and then decreases.

Guo Kaixuan[11] In the flexural test, three strong concrete specimens C20, C30 and C40 were designed, and the influence of ceramic fiber on the flexural strength of concrete was explored by comparing plain concrete and laminated ceramic fiber concrete specimens. Experiments show that layered ceramic fiber concrete is superior to plain concrete in terms of flexural and bending impact resistance, but ceramic fiber has limited improvement in improving the ductility of concrete, mainly because ceramic fiber is flexible fiber and has a small diameter. However, it is precisely because the ceramic fiber is extremely fine, a reasonable amount can fully contact the ceramic fiber with the particles of the cementitious material and the particles of the aggregate, greatly reducing the source of micro-cracks inside the concrete, inhibiting the generation of cracks inside the concrete, and improving the cracks in the concrete Ceramic fiber is greatly improved.

Ma Yiping[15] studied the mechanical properties of ceramic fiber reinforced ordinary Portland cementitious composites, and found that when ceramic fibers with a length of 5mm and a content of 5% (mass fraction) were added to cement mortar, the bending enhancement effect could reach about 40%. If silica ash is added to reduce the particle size of the matrix, the bending enhancement effect can be increased to nearly 100%; Under the humid heat aging condition of 70 °C, the bending enhancement effect of ceramic fiber cement mortar can be maintained for a long time, and its impact resistance and toughening effect can also be maintained.

4. Bending resistance of fire-plated copper-plated steel fiber concrete

Li Ji[19] added 0.5%, 1.0% and 1.5% copper-plated steel fibers to high-strength concrete, respectively, and discussed the effects of copper-plated steel fibers on the compressive strength and flexural strength of high-strength concrete under different dosages. It is found that with the increase of steel fiber content, the compressive strength and flexural strength are improved, and the increase in compressive strength is more significant.

Zhang Guiguo[20] selected seven kinds of steel fibers commonly used in engineering, and made high-strength concrete into longbow type, short bow type, large corrugated type, small corrugated type, shear corrugated type, dumbbell type and copper-plated microwire, and subjected them to compressive and splitting experiments, and analyzed the influence of seven steel fibers on the strength of concrete through the test results. The results show that the compressive strength and splitting strength of concrete of seven varieties of steel fiber concrete have been improved to a certain extent, but the degree of compressive strength improvement is smaller, while the splitting strength is increased more, and the result is that the surface dumbbell fiber and copper-plated microwire have a relatively good effect on the compressive strength and flexural strength of concrete, but the size specification of dumbbell fiber is larger, and the effect of copper-plated steel fiber is the best in comprehensive consideration.

Due to the frequent fire phenomenon in high-rise buildings, Wang Guan[18] et al. designed and experimented to make 5 high-strength concrete columns for fire resistance test, and the main fire methods of the specimen were fire on four sides and fire on three sides, and the temperature change and performance of the specimen observation point were observed. The test results show that high-strength concrete columns are prone to bursting at high temperature. Under the condition of fire on three sides, the uneven expansion of high-strength (fiber) concrete column material and uneven deterioration of performance will lead to the bending of the column to the unfired surface. Under axial constraint conditions, when the high-strength (fiber) concrete column is subjected to thermal expansion, additional axial forces will appear in the column, which has a certain impact on the initial bursting time of the high-strength concrete column.

Ren Hongwei[16] studied the effects of different volumes of steel fiber yield on the compressive strength and flexural strength of concrete by using finite difference fraction value simulation and test methods, and set the steel fiber volume content to 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and

3.0%, respectively. The experimental results show that with the increase of steel fiber volume, the 7D and 28D compressive strength and 28D flexural strength of the specimen show a trend of first increasing and then decreasing, and the suitable volume content range is 2.0%~2.5%. The incorporation of an appropriate amount of steel fiber can increase the elastic modulus and residual strength of concrete, enhance the peak ductility of concrete, and improve the performance of concrete.

Hui Hongyi[17] carried out a design experiment on the performance trend of reinforced concrete at high temperature, and compared the stress magnitude of reinforced concrete with a volume content of 1% at 600°C and 20°C. The analysis of test results shows that the compressive strength and residual strength of steel fiber concrete are relatively high. The strength loss of steel fiber concrete is low, and its residual strength is high. Steel fibers are incorporated into cement concrete, which plays a good crack barrier effect, blocks the expansion of micro-cracks, and strengthens the strength and ductility of concrete.

5. Bending properties of ceramic-copper-plated steel fiber concrete after fire

Huo Junfang[13] believes that the fibers added to concrete can greatly improve the crack resistance and impact resistance of concrete by absorbing a large amount of energy, and the effect of fiber mixing on the flexural toughness of light aggregate concrete is studied by mixing steel fiber and polypropylene fiber. The test found that the toughness of light aggregate concrete with steel fiber light aggregate concrete with a certain volume rate of steel fiber increased with the increase of polypropylene fiber content, but the toughening effect was not obvious. With the incorporation of fibers, the failure form of light aggregate concrete changes, and the specimen is cracked but not scattered after the failure, showing integrity, and the failure of the specimen is manifested as a gradual decrease in bearing capacity or excessive bending deformation.

Liang Xiongxiong[10] conducted compressive strength and flexural strength tests through 12 groups of externally doped copper-plated steel fiber light aggregate concrete test blocks, and studied the effects of multi-scale copper-plated steel fiber and different light aggregate substitution rates on the mechanical properties of concrete. The test results show that with the increase of the substitution rate, the compressive strength and flexural strength of 6mm copper-plated steel fiber concrete decrease the most. Light aggregates with a 17mm copper-plated steel fiber with a replacement rate of 50% have the best compressive strength, and 17mm copper-plated steel fibers have the best flexural strength with a replacement rate of 30%.

Zeng Zhixing[14] mixed steel fibers into light aggregate concrete to become steel fiber light aggregate concrete. It concentrates the advantages of steel fiber concrete and light aggregate concrete, makes up for the shortcomings of low tensile strength and self-weight of ordinary concrete, and studies the mechanical properties of this new concrete material. The experimental results show that the tensile strength of steel fiber light aggregate concrete is significantly improved compared with ordinary light aggregate concrete, and the initial crack resistance and flexural limit strength are also greatly improved, and the increase of flexural toughness is particularly significant.

Zhang Meng [12] took different basalt fiber volume ratio (Vb), polypropylene fiber volume ratio (Vp) and ceramic substitution rate (Rc) as the influencing factors, and designed nine groups of mixed fiber light aggregate concrete by orthogonal test method, and carried out compressive strength, flexural strength and splitting tensile strength tests, and the test results showed that the increase of flexural strength of the three factors was greater than that of compressive strength and splitting tensile strength.

Chang Shanshan[9] obtained through research that the residual flexural strength effect of ceramic-copper-plated steel fiber concrete after fire is enhanced with the increase of copper-plated steel fiber. When the ceramic content is 3.9kg/m3 polypropylene and the polypropylene content is 1.4kg/m3, the specimen has residual flexural performance, indicating that the residual flexural strength of ceramic-copper-plated steel mixed fiber concrete after fire is enhanced with the increase of copper-plated steel fiber dimension;

6. Conclusion

Today, the study of hybrid fiber concrete is still an emerging field of concrete research. Although there is a certain consensus in this academic field on the various mechanical properties of hybrid fibers, researchers are still discussing more aspects, and there are still no specific specifications for the application of hybrid fiber concrete. Hybrid fiber concrete also has great prospects. Follow-up research should explore more about the bending performance of fiber and light aggregate concrete after fire, as well as the practical application of theoretical research and engineering.

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