ISSN: 2710-0170

Experimental Study on Durability of Hybrid Fiber Lightweight Aggregate Concrete

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Abstract

In order to study the influence of hybrid fiber on the frost resistance of lightweight aggregate concrete, the impermeability and frost resistance of six kinds of fiber lightweight aggregate concrete (ceramic fiber and steel ceramic fiber) were tested. The research shows that adding proper amount of hybrid fiber into lightweight aggregate concrete can improve the impermeability of lightweight aggregate concrete, reduce the mass loss rate of concrete and improve the compressive strength loss rate after freezing and thawing, and play a favorable role in enhancing the durability of lightweight aggregate concrete; When the amount of hybrid fiber is too much, it will lead to the increase of harmful pores in the concrete matrix, which is not conducive to the impermeability of lightweight aggregate concrete.

Keywords

Hybrid Fiber; Lightweight Aggregate Concrete; Durability.

1. Introduction

With the continuous development of society, the requirements for green buildings are gradually raised. Lightweight aggregate concrete has a history of 100 years, and has light weight, thermal insulation and other characteristics. It is of great significance to the development of civil engineering. At home and abroad, the research on the theory and practical application of fiber reinforced concrete has been carried out, but the research on the durability of hybrid fiber lightweight aggregate is less. The addition of fiber to lightweight aggregate concrete can effectively improve the mechanical properties and durability. At present, there is less research on ceramic fiber lightweight aggregate concrete and less research on the mixing of steel fiber and ceramic fiber. Therefore, in this paper, steel fiber and ceramic fiber are selected to study the impermeability and frost resistance, and the influence of different fiber content on the durability of lightweight aggregate concrete is analyzed.

2. Test Overview

2.1. Raw Material

Table 1. Fiber parameters

Fiber type	Length /mm	diameter /mm	Aspect ratio	Tensile strength /MPa
Copper plated steel fiber	6	0.22	27	3000
Ceramic fiber	6	0.003	2000	2400
Basalt fiber	6	0.022	261	1385

Light aggregate: round fly ash ceramsite (particle size 5-16mm), bulk density 1013kg / M ^{3}, The cylinder pressure strength is 11mpa. Fiber: copper coated steel fiber, ceramic fiber and

ISSN: 2710-0170

basalt fiber. See Table 1 for detailed fiber parameters. Cement: Ordinary portland cement (P.O 42.5). Fine aggregate: natural river sand with fineness modulus of 2.76. Other cementitious materials: micro silica fume and class II fly ash. Admixture: polycarboxylic acid superplasticizer.

2.2. Mix Design and Test Grouping

LC40 is used as the strength grade of concrete base and the water-binder ratio of concrete is determined to be 0.39 according to Technical Specifications for Light Aggregate Concrete. The final mix ratio is shown in Table 2 and the test grouping is shown in Table 3.

Table 2. Mix proportion design of lightweight aggregate concrete (kg·m-3)

Strength	Ceramic Grains	Cement	Water	Sand	Fly Ash	Silica Ash	Water Reducer
LC40	572	357	200	739.2	102	51	3.06

Table 3. Test grouping (kg·m-3)

Number	Ceramic Fiber	Steel Fiber
A	0	0
C1	1.3	0
C2	3.9	0
S1C1	1.3	40
S1C3	3.9	40
S2C1	1.3	50
S2C2	3.9	50

2.3. Specimen Preparation and Test Method

The specimen size for freeze-thaw cycle test is 100mm × 100mm × 100 mm, 175 mm for impermeability test × 185mm × 150mm. The initial value of water pressure for impermeability test was adjusted to 0.1 MPa, and the pressure was increased by 0.1 MPa every 8 hours. The test was terminated immediately when three of the specimens in a group seeped through the surface, and the water pressure value was recorded at the same time. The number of freeze-thaw cycles in the freeze-thaw test is 25 times and the freezing time is no less than 4h. The strength loss rate and mass loss rate of light aggregate concrete are calculated by weighing before and after the freeze-thaw test.

3. Results and Analysis

3.1. Impermeability Test

Fig. 1 shows the hydraulic strength of each fiber lightweight aggregate concrete when it is permeable for 60d. It can be seen from Fig. 1 that less ceramic fibers have adverse effects on lightweight aggregate concrete. When c160d is permeable, the water pressure strength is reduced by 7.1% compared with the reference group. The reason is that ceramic fibers are hydrophilic, lightweight aggregate concrete and fibers have a good bonding matrix. When the content is low, the ceramic fiber dimension distribution is uneven, and the fiber and concrete matrix will produce weak links, which cannot suppress the generation of micro cracks. The hydraulic strength of hybrid fiber lightweight aggregate concrete is higher than that of reference group A and single fiber at 60d water permeability. The effect of s3c1 mixing method is the best. The water pressure strength of s3c1 is 21.4% higher than that of the reference group when it is permeable for 60 days. After mixing, the two fibers produce a synergistic effect, which effectively suppresses the early drying shrinkage of lightweight aggregate concrete, reduces the

ISSN: 2710-0170

generation of cracks and restricts the development of cracks, reduces the water permeability, and makes the concrete reach the "positive mixing effect", thus improving the impermeability of lightweight aggregate concrete

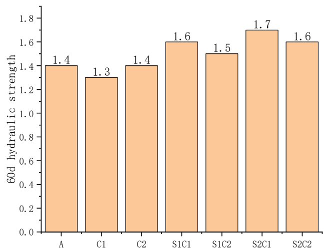

Fig 1. Hydraulic strength of fiber concrete at 60d permeability

3.2. Frost Resistance Test

3.2.1. Compressive Strength

Table 4. Compressive strength before and after freeze-thaw cycle

Numble	Strength before freezing and thawing	Strength after freezing and thawing	Loss rate
A	40.9	39.1	4.1
C1	37.2	35.9	3.5
C2	36.4	35.3	2.8
S1C1	40.8	39.9	2.2
S1C2	40.5	39.7	1.9
S2C1	42.5	41.4	2.5
S2C2	41.7	41.0	1.6

Table 3 shows the compressive strength of fiber concrete before and after freeze-thaw cycle. It can be seen from table 3 that the strength loss rate of each group of fiber concrete after the freeze-thaw cycle is lower than that of the reference group of concrete, which proves that the addition of fiber can improve the frost resistance of concrete. With the increase of ceramic fiber content, the strength loss rate becomes lower and lower, and the strength loss rate of s2c2 is the lowest. The reason is that the fiber can bridge the micro cracks in the concrete to prevent these micro cracks from developing into macro cracks, It is the synergistic effect of fiber mixing.

3.2.2. Mass Loss

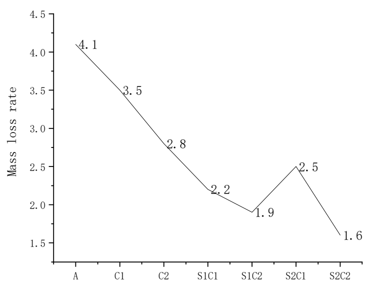

Fig 2. Mass loss rate of fiber concrete

Fig. 2 shows the mass loss rate of each group of fiber concrete under the action of freeze-thaw cycle. It can be seen from Fig. 2 that the mass loss rate of concrete after adding fiber is lower than that without fiber, and the overall trend is decreasing. However, the mass loss of s2c1 in hybrid fiber is higher. The reason is that there are less ceramic fibers and they are not uniformly dispersed in lightweight aggregate concrete. The mass loss of s2c2 is the smallest, because the hybrid fiber forms a space network structure in the cement matrix, optimizes the pore structure of hardened concrete, and plays a role of superposition reinforcement. At the same time, fiber can prevent the development of micro cracks, improve the compactness of lightweight aggregate concrete and improve the frost resistance of lightweight aggregate concrete.

4. Conclusion

1) Hybrid fiber can improve the impermeability of lightweight aggregate concrete better than ceramic fiber. C1 can reduce the impermeability of lightweight aggregate concrete, so it is not conducive to improve the impermeability of lightweight aggregate concrete.

2) With the increase of ceramic fiber, the strength loss of lightweight aggregate before and after freezing and thawing is smaller, and the mass loss rate of hybrid fiber to lightweight aggregate concrete is better than that of single ceramic fiber.

3) Adding fiber can reduce the mass loss rate of lightweight aggregate concrete, and s2c2 is the best. Hybrid fiber can obviously improve the frost resistance of concrete, but the mass loss rate of s2c1 in hybrid fiber is large, which is not conducive to improving the spalling of concrete caused by freezing and thawing.

Acknowledgments

Innovation and Entrepreneurship Training Program Project of North China University of Science and Technology College (X2021126).

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