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Test of compressive strength of rubber ceramsite concrete modified by basalt fiber

Bu Changming[1,2], Zhu Dongxu[1,2], Liu Lei[1,2], Lu Xinyu[1,2], Sun Yi[1,2,*], Tan Baolin[1,2], Wang Faxiang[3]

[1]School of Civil Engineering and Architecture, Chongqing University of Science & Technology, Chongqing, 401331, China
[2]Chongqing Key Laboratory of Energy Engineering Mechanics & Disaster Prevention and Mitigation, Chongqing, 401331, China
[3]Chongqing Chengwei Light Quality Wall Board Co. Ltd, Chongqing, China
[*]Corresponding author: sunyi@cqust.edu.cn

Abstract: *In order to solve the problem of black pollution in the 21st century, a new type of rubber ceramsite concrete was prepared by crushing the waste rubber tire into granules and adding it into the ceramsite concrete. The basalt fiber was used to modify the rubber for reducing the weakening of the concrete mechanical property caused by the addition of rubber. In this paper, the compressive strength of concrete specimens at 3 and 28 days was measured to discuss the modification effect of single fiber. The results show that the compressive strength of concrete can be improved by adding basalt fiber, and it increases with the increase of adding content. With the increase of rubber replacement rate, the strength of concrete increases first and then decreases, which proves that adding proper amount of rubber can reduce the reduction of concrete strength. The length of basalt fiber also affects the compressive strength of specimens. Basalt fibers of 12 mm length work better than fibers of 9 and 18 mm.*

Keywords: *rubber ceramsite concrete, compressive strength, basalt fiber*

1. Introduction

Black pollution is a major ecological problem that human beings face after entering the 21st century. The high iteration rate of the automobile industry leads to a large number of waste cars being piled up and unable to be properly recycled, especially rubber products, an important part of automobiles [1-3,7,14].

Rubber products that are very difficult to degrade, including car tires and car interiors, will have a bad impact on the environment. At the beginning of the century, some scholars discussed the feasibility of crushing waste rubber products into aggregate and mixing it into concrete. However, the test results show that the concrete specimen mixed with rubber cannot be used in practical engineering, because the mixing of rubber greatly reduces the strength of concrete [2-3]. Based on this situation, various attempts have been made by scholars to improve the weakening effect of rubber aggregate on mechanical properties of concrete [4-7].

Ceramsite concrete is a new lightweight concrete material which is mainly used in the field of prefabricated building wallboard. Ceramsite concrete is light in weight and has good heat and fire resistance [5]. As a wall panel material for prefabricated buildings, it also has low requirements on strength. Based on the above characteristics, it is worth to study the change of the properties of ceramsite concrete by adding rubber particles. [3,6-7].

Basalt fiber is a new kind of green inorganic fiber [8-10]. The basalt fiber made from basalt melting and wire drawing has the strength comparable to steel fiber, but the production cost is only 1/6 of carbon fiber, so its high quality and low price make it have a wide market prospect. There are few studies on basalt fiber in the academic research field, but combined with the existing research results show that basalt fiber can significantly strengthen the connection between the aggregate inside concrete, strengthen the interface transition zone of concrete, improve mechanical properties including compressive strength [11-12].

In this paper, 10 mesh rubber particles were used as fine aggregate to replace river sand in traditional ceramsite concrete. The compressive strength changes under three incorporation ratios were investigated.

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The influence of different length and dosage of basalt fiber on its compressive strength was compared.

2. Test Overview

2.1 Test raw material

Cement: cement using chongqing Huanxin Yanjing Cement Co., LTD. Production of composite Portland cement P.C42.5R, in line with the national "General Portland cement" (GB175-2007) in Portland cement requirements.

Ceramicite: clay ceramicite produced by Chongqing Caishan Ceramicite Factory is adopted, and its specific performance indicators are shown in Table 1.

Rubber: adopt 10-mesh rubber granules produced by Chengdu Sitong Rubber and Plastic Co., LTD. See Table 2 for specific performance indicators.

Basalt fiber: the basalt fiber produced by Haining Anjie Material Co., Ltd. is used, and its specific performance indicators are shown in Table 3.

Table 1: Performance parameters of ceramsite

Particle diameter (mm)	Density grade	bulk density (kg/m^3)	water content (%)	apparent density (kg/m^3)	water absorption (%)
0-10	500	476	16.63	758.97	5.53

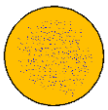
Table 2: Performance parameters of rubber

Particle diameter (mm)	mean grain size (mm)	bulk density (kg/m^3)	ash content (%)	apparent density (kg/m^3)	water absorption (%)
1-3	1	1120	1<	1052	3<

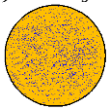
Table 3: Performance parameters of basalt fiber

Operating Temp (℃)	sintering temperature (℃)	Linear Density (μm)	elasticity modulus (GPa)	Density (kg/m^3)	tensile strength (MPa)
-269-650	1050	7-15	91-110	2630-2650	3000-4800

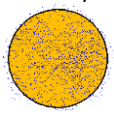
(a) Absolutely dry



(b) Air drying



(c) Saturated surface dryness



(d) Moist

Figure 1: Four moisture states of aggregate

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2.2 Test method

According to GB/T50081-2019, the compressive strength was respectively cured for 3 and 28 days in a constant temperature curing box at (20±2) ℃. The standard test method was used to measure the compressive strength. The sample size was 100 mm ×100 mm ×100 mm, 3 pieces in each group, 9 groups in total. Take the average of the calculated results.

$$f_c = \frac{F}{A} \quad (1)$$

Among them, f_c – Compressive strength of the sample (MPa);

F – Specimen failure load (N);

A – Specimen compression area (mm^2).

2.3 Test mix

According to the application technique of lightweight aggregate concrete standard and the early stage of the trial test, select the optimal ratio of qualifying examination for the next test are shown in table 4, the serial number of the sample using A - a - B - b - C - c form, which represents A basalt fiber dosage, a specific number of basalt fiber dosage, B for basalt fiber length, b is the length of the specific number, C is the rubber content, and c is the specific value of rubber content. The result analysis simplified the grouping into a- b - c form. Basalt fiber as admixture, according to the volume percentage of direct incorporation. Rubber particles were replaced, and river sand was replaced proportionally with equal volume.

2.4 Preparation of sample

Conventional ceramsite concrete is prepared in accordance with the technical Standard for Lightweight aggregate Concrete application (JGJ/T 12-2019). Among them, there are related definitions of ceramsite, namely, all-dry state, air-dry state, saturated surface dry state and wet state, as shown in Figure 1. On the basis of research and trial mix, the best state of dry ceramsite on saturated surface was selected as coarse aggregate. The dry state of saturated surface refers to that both inside and outside of the ceramsite are saturated and there is no clear water on the external surface. In this state, the ceramsite has little influence on the overall water-cement ratio during mixing. Rubber particles are sealed in advance, and taken out for use directly during the test[13]. Basalt fibers are dried in advance to avoid agglomeration caused by bonding moisture. In the process of mixing, the fibers are scattered into the mixing barrel in batches, and the fibers are found to be bonded and separated manually before being put in, paying special attention to the long fibers. After mixing, the working performance including slump was measured while the mold was installed. Rubber particles have high hydrophobicity, bleeding phenomenon is more serious, so the molding process should be rapid [14].

Table 4: Mix proportion (kg / m3)

Materials / ID	ceramsite	cement	water	rubber	fly ash	dosage	length
A-0.2-B-9-C-10	774.64	369	150	18.5	81	0.2%	9
A-0.4-B-9-C-10	774.64	369	150	18.5	81	0.4%	9
A-0.6-B-9-C-10	774.64	369	150	18.5	81	0.6%	9
A-0.2-B-9-C-20	774.64	369	150	37.1	81	0.2%	9
A-0.2-B-12-C-30	774.64	369	150	55.7	81	0.2%	12
A-0.2-B-18-C-30	774.64	369	150	55.7	81	0.2%	18
A-0.2-B-9-C-30	774.64	369	150	55.7	81	0.2%	9
A-0-B-0-C-10	774.64	369	150	18.5	81	0	0
A-0-B-0-C-0	774.64	369	150	0	81	0	0

3. Results analysis

After specimen curing for 3d and 28d, the compressive strength test was carried out. The test results

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showed that the compressive strength of the rubber ceramsite concrete specimen improved significantly with the increase of fiber content under the condition that the length of basalt fiber remained unchanged, as shown in Figure 2.

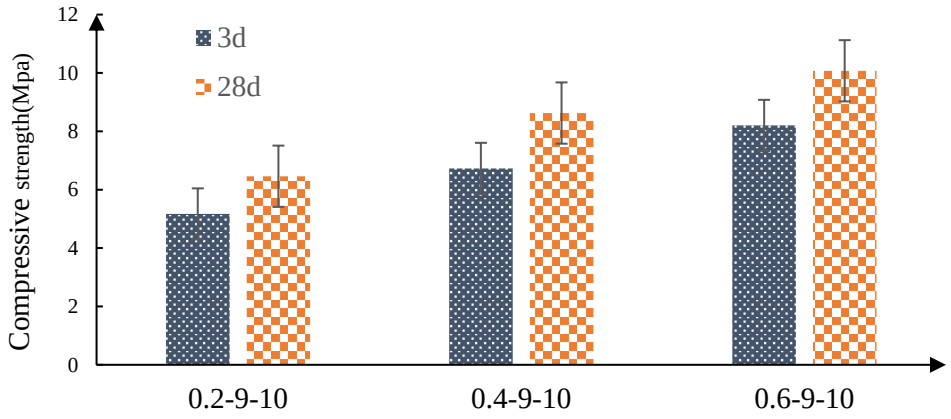

Figure 2: Diagram of compressive strength variation with fiber content

At the same time, Figure 3 shows the compressive strength curve following the change of fiber length when the fiber content remains unchanged. It can be observed that there is little difference in strength between the 9mm length combination and the 18mm length combination, but the 12mm length combination has a significant improvement. The three-day strength increases 19.9% compared with 9mm and 23.7% compared with 18mm. It can be considered that the compressive strength of basalt fiber length increases first and then decreases, and appropriate length is obviously beneficial to the improvement of compressive strength. Meanwhile, by comparing group A-0.2-B-9-C-10 and group A-0-B-0-C-10 in Figure 5, it can be considered that basalt fiber has an improvement effect on the compressive strength of rubber ceramsite concrete, and the compressive strength increases by 6.2%. A comparative analysis of the A-0-B-0-C-10 group and the A-0-B-0-C-0 group showed that the addition of rubber did significantly weaken the compressive strength of ceramsite concrete. In the three-day strength test, the compressive strength of the control group adding 10% rubber was 21.9% lower than that of the ordinary ceramsite concrete. This decrease gradually increased as the curing time went on, and reached 45.5% at 28 days.

Figure 4 shows the influence of different rubber content on compressive strength. A-0.2-B-9-C-10 group, A-0.2-B-9-C-20 group and A-0.2-B-9-C-30 group show the compressive strength variation curve under the influence of three different rubber content. It is observed that the compressive strength of ceramsite concrete will increase first and then decrease with the increase of rubber content. It is considered that appropriate replacement rate of river sand can reduce the weakening degree of the compressive strength of the specimen after adding rubber.

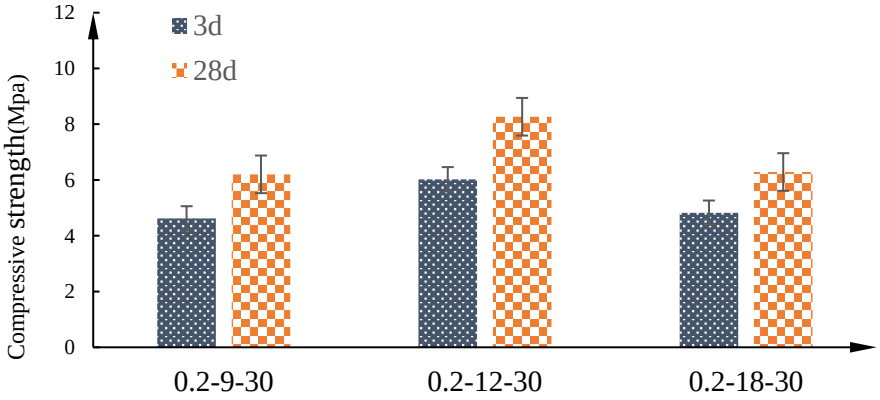

Figure 3: Diagram of compressive strength variation with fiber length

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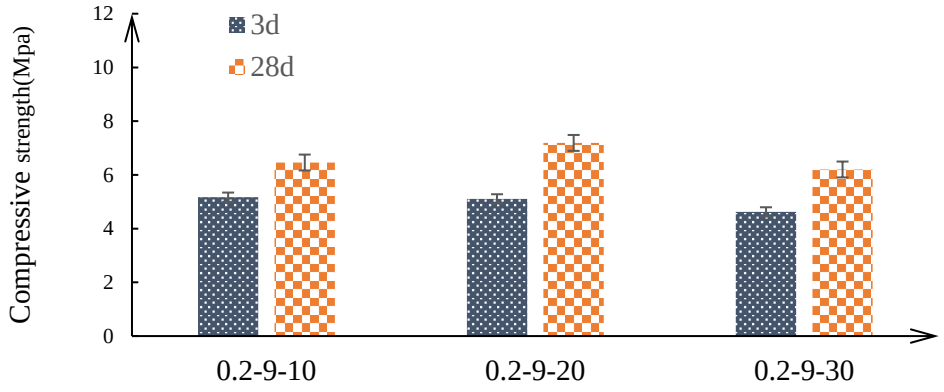

Figure 4: Diagram of compressive strength variation with rubber content

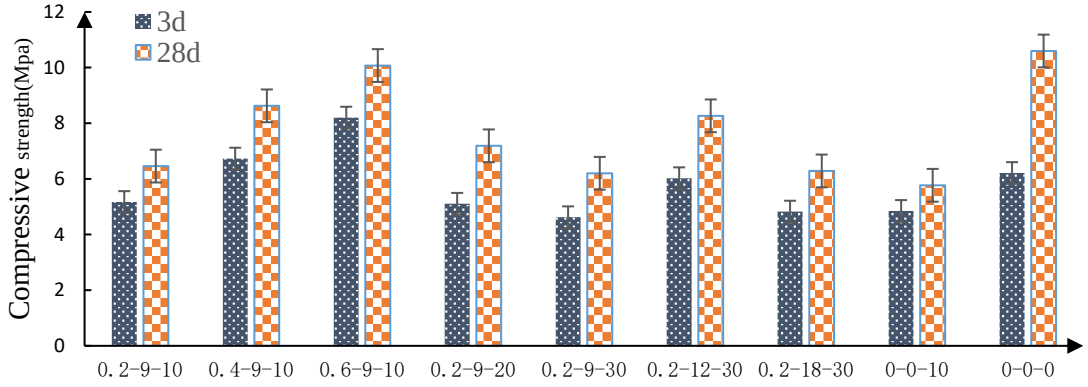

Figure 5: Diagram of multi-age compressive strength variation in each group

4. Conclusion

Basalt fiber rubber ceramsite concrete through 3 and 28 days of compressive strength test can be drawn the following conclusions:

(1) Basalt fiber can significantly improve the strength of rubber ceramsite concrete, and the improvement effect is the best when the content of 0.6%. Compared with ordinary rubber ceramsite concrete, the strength of 3 days and 28 days is increased by 65.4% and 74.6%.

(2) The length of basalt fiber will also affect the lifting effect of compressive strength, and the lifting effect of 12mm length is the best.

(3) With the increase of rubber content, the strength of rubber ceramsite concrete increases first and then decreases. Generally speaking, the combination of 20% content is better than that of 10% and 30% content.

(4) Reasonable mix of rubber and basalt fiber content, length combination can achieve the strength of ordinary ceramsite concrete.

To sum up, the selection of appropriate collocation scheme can help reduce the strength weakening of ceramsite concrete after adding rubber, and achieve a wider range of engineering applications.

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