Research on mechanical properties of fiber reinforced lytag concrete

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Abstract

In order to analyze the mechanical properties of fiber reinforced lytag concrete, some different ceramic and different fiber content ratio concrete had been made, this paper analyzed their mechanical properties according to the orthogonal experiment method, and draw the following conclusions: the amount of fiber is the main factor affecting the compressive strength of lytag concrete and the main factor affecting the dry volume density is the dosage of ceramsite.

Keywords

lytag concrete; polypropylene fiber; orthogonal experiment; volume density.

1. Introduction

Fly ash is a kind of industrial waste with large emission. It is a good choice to make use of fly ash to produce fly ash ceramsite, and to produce lytag concrete. Fly ash ceramsite is a lightweight aggregate made by solid fly ash, some cementing materials and water. The process is that first to mix these raw materials into balls, then burning expanding and curing, finally to form the little solid particles [1]. The use of ceramsite as a lightweight aggregate can greatly reduce the use of natural resources, and has very good social and economic benefits[2]. Ceramsite concrete has many advantages such as light weight, heat resistance and thermal insulation, but its strength is low, its brittleness is high and its crack resistance is poor. These shortcomings have been restricting the extensive application of ceramsite concrete in modern engineering. In this paper, the author will add polypropylene fiber into the ordinary ceramsite concrete and discuss the strength of the fiber to the lytag concrete.

2. Experiment

2.1 overview

lytag concrete is made of flyash ceramsite , cement, sand, water and other materials, its density is about 850kg/m3 to 1950kg/m3. It not only has the heat preservation, sound insulation and anti crack function, But its mass is also much lighter than the ordinary concrete, Therefore, the lightweight aggregate concrete has been widely used in the field of structural engineering [3].

2.2 Main material properties.

(1) cement

Cement is the important cementitious material in concrete. And P.O42.5 cement is selected because it has a good compatibility with ceramsiteis[4].

(2) sand

The sand is medium sand, and the physical properties are shown in table 1.

Tab 1 Physical properties of sand

sediment percentage (by mass%)	clay lump (bymass%)	fineness modulus	grain composition	apparent density (kg/m^3)	Stacking density (kg/m^3)	porosity(%)
3.96	0	2.8	Ⅱ	2580	1670	34.5

(3) fly ash ceramsite

The ceramsite is made up of fly ash and a small amount of solid fuel (such as coal gangue, etc.). Its properties are shown in table 2.

Tab 2 Basic properties of fly ash ceramsite

Type	Boiling mass loss(%)	Softening coefficient	Water absorption(%)	cylinder compressive strength(MPa)	apparent density (kg/m^3)	Stacking density(kg/m^3)
L C	0.7	0.83	12	7.75	1644	989

(4) Polypropylene fiber

Polypropylene fiber can prevent or reduce the initial cracks of cement concrete, which can be used as a "secondary reinforcement". Its basic properties[4] are shown in table 3.

Tab 3 Basic properties of polypropylene fiber

Material	moisture absorption (%)	Fiber shape	Fiber specification (mm)	density (g/cm^3)	Fracture extension length(%)	Cross section shape
Polypropylene fiber	<0.1	Fascicular monofilament	3, 6 9, 12	0.91	5-20	Y-shaped

2.3 Test block making

Considering the different ceramsite amount and different fiber specifications and amount, in this experiment, 12 groups of test blocks with specifications of 150mm x 150mm x 150mm are made, and 9 of them are effectively .

The process of blocks making is as follows:

(1) Weigh the mass of ceramsite, then immerse them for 24 hours, then weigh them again and measure the water absorption rate, the purpose is to strictly control the water consumption of concrete.

(2) Mix the cement, sand and pre wetted ceramsite , polypropylene fiber and stir them. Then make the test blocks with 150mm×150mm×150mm mold, vibrate them adequately.

(3) Soak the blocks for water maintenance

The process is shown as fig1.

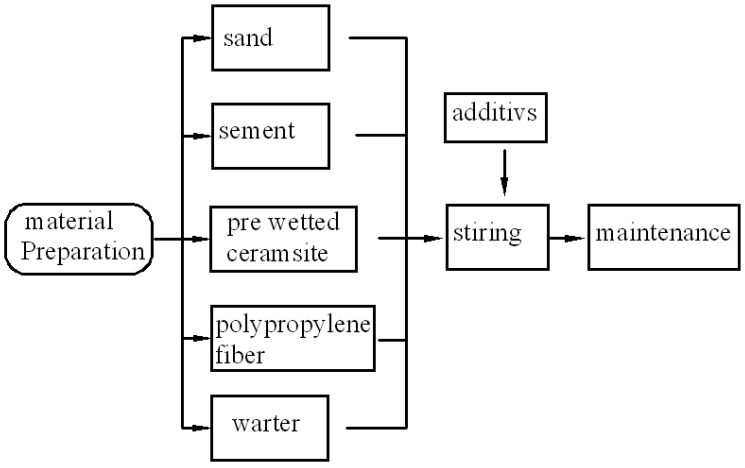

Fig. 1 process of blocks making

2.4 Test block making

In this experiment, the proposed strength grade of the ceramsite concrete is C40. And the orthogonal table L9 (34) is applied to the orthogonal experimental method. Set the "fiber specification", "fiber amount" and "the amount of ceramsite" as three variables, to discuss the influence of each of them on the mechanical properties of concrete block[5].

The specifications of each variable are shown in Table 4

Tab 4 specifications of each variable

specification	amount of ceramsite A (g)	fiber specification B (mm)	fiber amount C (g)
1	350	3	20
2	500	6	35
3	650	9	50

3. Experimental results and analysis

In order to analyze the mechanical properties of the test block, 9 groups of effective specimens were selected. Each group there are 2 blocks, named them separately as α and β. Loading until the test block is crushed , the results are shown in Fig 2 and Table 5 .

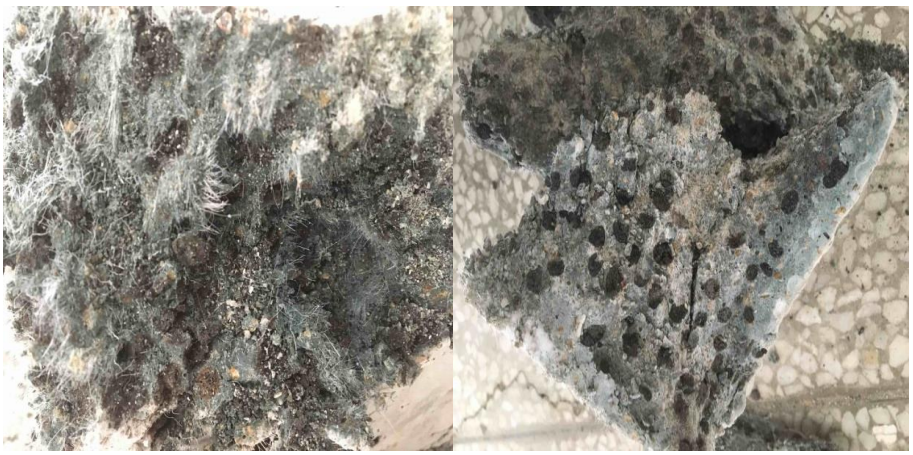

Fig. 2 the damage sketch about ceramsite concrete

Tab 5 results of the orthogonal experiment

number	amount of ceramsite A (g)	fiber specification B (mm)	fiber amount C (g)	Empty column	compressive strength of α (kN)	compressive strength of β (kN)	average value (kN)	dry mass of α (kg)	dry mass of β (kg)	average value (kg)
1	A1	B1	C1	D1	300	320	310	5.88	6.2	6.04
2	A1	B2	C2	D2	395	373	384	5.95	6.01	5.98
3	A1	B3	C3	D3	415	395	405	6.4	5.94	6.17
4	A2	B1	C2	D3	365	366	365.5	5.8	5.8	5.80
5	A2	B2	C3	D1	420	430	425	5.68	5.96	5.82
6	A2	B3	C1	D2	275	285	280	5.8	5.9	5.85
7	A3	B1	C3	D2	435	451	443	5.4	5.56	5.48
8	A3	B2	C1	D3	240	235	425	5.6	5.4	5.50
9	A3	B3	C2	D1	384	396	390	5.64	5.66	5.65

From table 5 we can see that if the ceramsite amount is constant, the compressive strength of concrete blocks increases with the increase of fiber dosage, while the dry bulk density increases with the decrease of ceramsite dosage.

The compressive strength of the 28 day age is

$$p = \frac{F}{A} \tag{1}$$

In the formula, F is the force, A is the bearing area, P is the compressive strength.

The dry density is

$$\rho = \frac{m}{v} \tag{2}$$

In the formula， m is the mass, v is the volume, ρ is the density.

The results of the test blocks in each group are shown in Table 6

Tab 6. L9 (34) Calculation results of orthogonal experiment

number	Amount of ceramsite A (g)	Fiber specification B(mm)	Fiber amount C (g)	Empty column	Compressive strength f/MPa28d	Dry volume densityρ(kg/m3) 28d
1	A1	B1	C1	D1	13.778	1790
2	A1	B2	C2	D2	17.067	1770
3	A1	B3	C3	D3	18.000	1830
4	A2	B1	C2	D3	16.244	1720
5	A2	B2	C3	D1	18.889	1725
6	A2	B3	C1	D2	12.444	1730
7	A3	B1	C3	D2	19.689	1620
8	A3	B2	C1	D3	10.556	1635
9	A3	B3	C2	D1	17.333	1675

The extreme analysis method is used to analyze the data obtained from this group of orthogonal experiments [8]. The specific results are shown in Table 7 and table 8.

Table 7 results of extreme difference in compressive strength

Assessment index	f28/MPa			
factors	A	B	C	D
K1	48.845	49.711	36.778	50.000
K2	47.577	46.512	50.644	49.2
K2	47.578	47.777	56.578	44.8
K1	16.282	16.570	12.259	16.667
K2	15.859	15.504	16.881	16.400
K3	15.859	15.926	18.859	14.933
w	0.423	1.066	6.600	1.734

Table 8 calculation results of extreme difference in dry volume density

Assessment index	ρ28(kg/m^3)			
factors	A	B	C	D
K1	5390	5130	5155	5190
K2	5175	5130	5165	5120
K3	4930	5235	5175	5185
K1	1797	1710	1718	1730
K2	1725	1710	1721	1707
K3	1643	1745	1725	1728
w	154	35	7	23

As can be seen from table 7 and table 8:

(1) Among the factors of affecting the compressive strength, the maximum extreme difference is the amount of fiber, it shows that this factor has great influence on the 28d compressive strength of ceramsite concrete, which is the main factor among the three factors. The secondary one is the fiber length and the third one is the amount of fly ash ceramsite. The degree of influence can be intuitively expressed as: C > B > A;

(2) the degree of influence about dry density of lytag concrete is: A ＞B ＞C. Among them, the extreme difference of A is 154, which is far greater than that of other factors, So it can be seen that the amount of ceramsite is the most important factor.

In order to avoid the chance of the experimental results, the variance analysis results were analyzed [8]. The results are shown in Table 9 and table 10.

Tab 9 variance analysis of f28

Source of variance	quadratic sum	Freedom	mean square deviation	F-measure
Factor A	0.357	2	0.179	0.070
Factor B	1.731	2	0.866	0.331
Factor C	68.835	2	34.418	13.167
deviation E	5.227	2	2.614	
sum	76.15	8		

Tab10 variance analysis of ρ28

Source of variance	quadratic sum	Freedom	mean square deviation	F-measure
Factor A	35316.67	2	17158.34	34.74
Factor B	2450	2	1225	2.41
Factor C	66.67	2	33.4	0.07
deviation E	1016.66	2	508.33	
sum	38850	8		

By literature 7, the critical values of F are: F0.1(2,2)=9,F0.05(2,2)=19,F0.01(2,2)=99 [6]. The amount of fiber mainly affects the compressive strength, and the amount of ceramsite mainly affects the dry volume density, The results are in agreement with the results of the above difference analysis.

4. Conclusion

The result of the extreme difference analysis and variance analysis of the orthogonal test show that, Fiber amount is the main factor affecting the 28d strength of ceramsite concrete, and the amount of ceramsite is the main factor affecting the dry volume density of it. It shows that increasing the ceramsite amount will not significantly improve the strength of concrete, but the density will be relatively reduced, that is, its insulation performance will be improved.

(1) The compressive strength and dry volume density of ceramsite concrete can be significantly affected by the amount of fiber, fiber length and amount of ceramsite.

(2) In the concrete standard test block, it's not the more the fiber used, the greater the compressive strength. The compressive strength can reach the maximum value when the fiber content is about 50g.

(3) In the concrete standard test block, with the increase of the amount of ceramsite, the dry volume density and the strength will be reduced. When the amount of ceramsite reaches 650g and the fiber content is about 50g, the block can reach its smallest weight and highest strength value.

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