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Experimental Study on Super-high Strength Concrete of Sea Sand Basalt Fiber

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Abstract: Ultra-high strength concrete has the characteristics of high strength, good durability and more economical, and gradually meets the requirements of the new era, so it is of great significance to study ultra-high strength concrete. In this paper, ultra-high strength concrete is prepared by removing coarse aggregate from ordinary Portland cement superfine and highly active mineral admixture polycarboxylic acid high performance water reducer. The compressive, flexural strength and flexural ratio of ultra-high strength concrete with different mix ratios and the optimum ratio of ultra-high strength concrete of sea sand basalt fiber are obtained based on orthogonal test, so as to realize the safe use of undisturbed sea sand.

Keywords: Orthogonal test, Ultra-high strength concrete, Optimal mix ratio, Undisturbed sea sand.

1. Introduction

Nowadays, the application of ultra-high strength concrete is more and more extensive. In this paper, sea sand in a sea area of Shenzhen is used as aggregate to replace quartz sand, so as to realize the in-situ use of sea sand resources. The mechanical and durability properties of sea sand concrete are improved by adding ultra-fine and highly active mineral admixtures and admixtures, so as to make rational and efficient use of sea sand resources. At the same time, it is of great significance for the sustainable development of our country and the application and promotion of sea sand.

2. Test

2.1. Test materials

(1) Anhui conch P · II52.5 Portland cement: the initial setting time is 115 min, the final setting time is 174 min.

(2) Micro silicon powder produced by Anmei Industrial Company: the content of SiO_2 reached 90.6 %, bulk density 218.

(3) The water slag powder produced by Wuhan Longze Material Company: the density is 2.94

(4) 6mm chopped basalt fiber from Shanghai Chenqi Company: average diameter 17μm, tensile strength 4100MPa, elastic modulus 100GPa, density 2.947

(5) Sea sand in a sea area of Shenzhen: It belongs to the medium sand in Zone II, with an apparent density of 2500 and a shell content of 6.5 %.

(6) PCA-Q8081 water reducer produced by Shanghai Yunzhe New Material Technology Co., Ltd. : the water reduction rate is 16 %.

2.1.1. Effect of water-binder ratio and sand-binder ratio

In this paper, the sand-binder ratio is fixed at 0.9, and the micro-silica powder, water slag powder, and cement account for 15 %, 15 %, and 70 % of the binder, respectively. It is determined that when the water-binder ratio is 0.14, 3.5 % of the water reducing agent is added.

As shown in Figure 1, with the increase of water-binder ratio, the fluidity continues to increase and is positively correlated. Li Chuanxi [1] studies have shown that reducing the water-binder ratio can improve the strength, but after experimental analysis, when the water-binder ratio is too low, the strength does not increase significantly but decreases. Zheng Yufei [2] studies have found that when the water-binder ratio is reduced from 0.21 to 0.13, the content of bound water is gradually reduced from 11.24 % to 7.32 %, a decrease of more than 30 %, and the content of chemically bound water after hardening of concrete is proportional to the water-binder ratio.

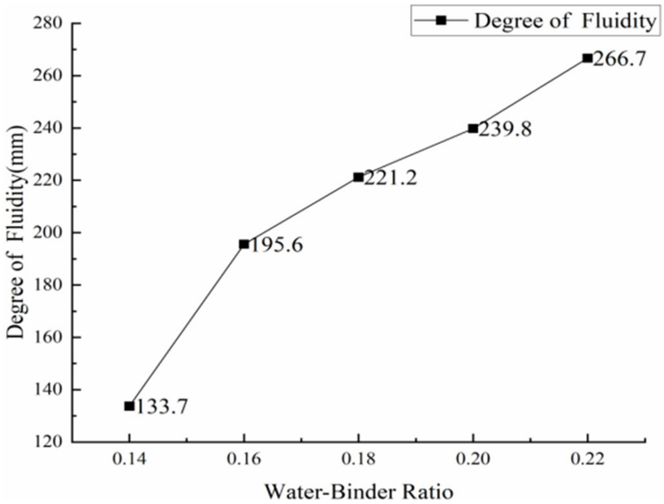

Figure 1. Effect of water-gel ratio on flow

As shown in Figs.2 and 3, when the water-binder ratio increases, the compressive strength and flexural strength show a trend of increasing first and then decreasing gradually. According to the research, when the water-binder ratio is 0.16, the compressive strength and flexural strength reach the extreme values of 122.1 MPa and 21.3 MPa, respectively. When the water-binder ratio is reduced, the less bound water inside the test block, the less capillary pores it occupies inside the test block, and the stronger the compactness of the concrete, so the water-binder ratio is set to 0.16.

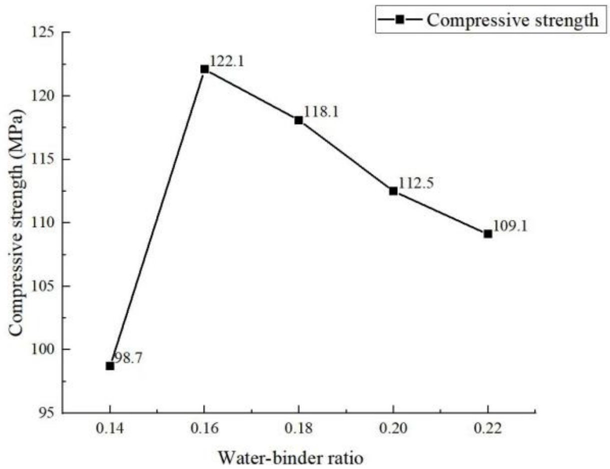

Figure 2. Effect of water-cement ratio on compressive strength of concrete

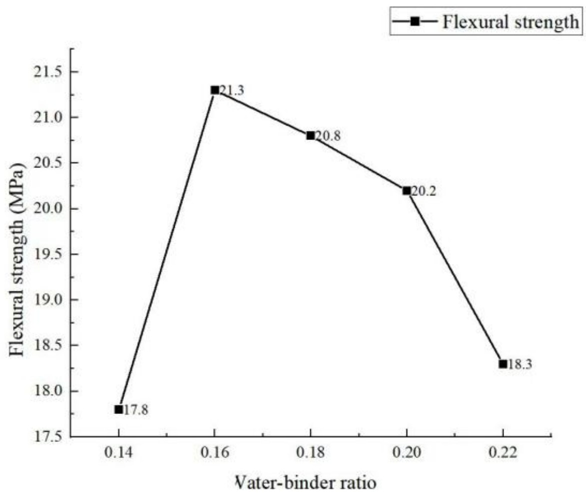

Figure 3. Effect of water-gel ratio on flexural strength of concrete

2.1.2. Effect of sand-binder ratio

In this paper, the water-binder ratio is 0.16, the water reducing agent is 3 % of the binder, and the proportion of cement and mineral admixtures is the same as that of the water-binder ratio test.

As can be seen from Figure 4, with the continuous improvement of the sand-binder ratio, the fluidity is slowly deteriorating, and the two are inversely correlated.

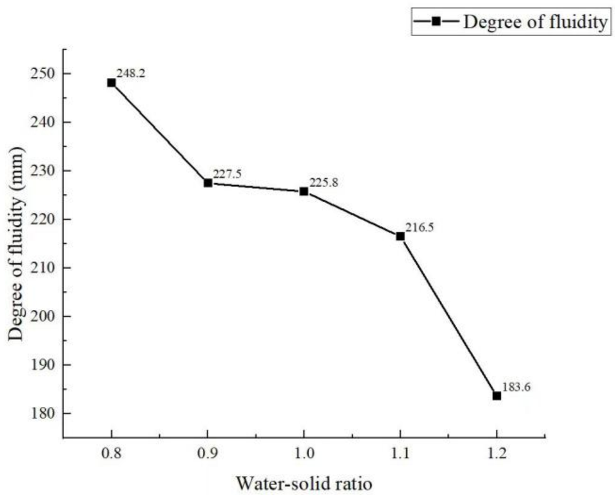

Figure 4. Effect of sand-gel ratio on flow

It can be seen from figure 5 and 6 that when the sand-binder ratio increases, the compressive strength increases first, then tends to be stable, and finally decreases, and the flexural strength increases first and then decreases. When the sand-binder ratio is 1.0, the compressive strength is 122.0 MPa and the flexural strength is 22.2 MPa. The sand-binder ratio selected in this paper is 1.0.

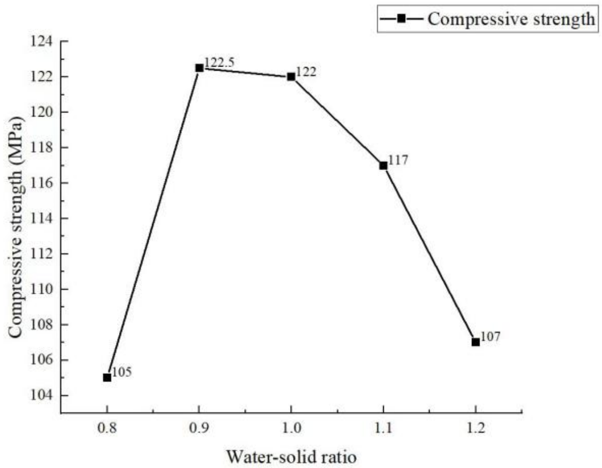

Figure 5. Effect of sand-gum ratio on compressive strength of concrete

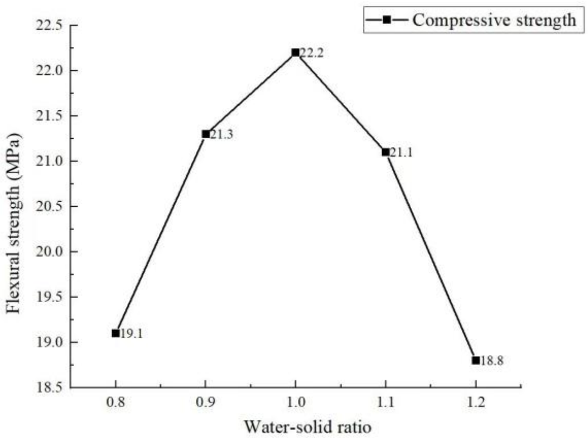

Figure 6. Effect of sand-gel ratio on flexural strength of concrete

2.2. Orthogonal test of concrete

When Fan Yunting [3] studied the preparation of RPC, it was found that RPC100 can be successfully prepared by replacing traditional steel fiber with 0.05 % 6mm short-cut BFRP, which not only has good toughness but also has excellent durability. In this paper, the orthogonal method is adopted, and the orthogonal design scheme of three factors and three levels is adopted. The orthogonal scheme can be satisfied by a total of 9 groups of experiments, and the orthogonal scheme design is neatly comparable: when the experimental data are analyzed, the orthogonal test is processed by mathematical statistics method, and the probability of each factor in each column of the orthogonal table is the same [4]. The orthogonal test scheme is shown in Table 1.

Table 1. Orthogonal text scheme

test number	factor		
	A Water slag powder content (%)	B Micro silicon powder content (%)	C fiber volume content (%)
1#	15	5	0.05
2#	15	10	0.10
3#	15	15	0.15
4#	20	5	0.10
5#	20	10	0.15
6#	20	15	0.05
7#	25	5	0.15
8#	25	10	0.05
9#	25	15	0.10

3. Test Results and Analysis

In the process of the experiment, the speed of the machine is 2.4kN / s.When the specimen is destroyed immediately and produces a huge roar, the test machine is quickly unloaded until it is 0kN. The whole process of applying load to failure lasts for about 1 ~ 2min. The sea sand ultra-high strength concrete mixed with superfine high active mineral admixture and basalt fiber shows good mechanical properties.

Table 2. Extreme Difference Analysis of Mechanical Properties

	K value and R value	A	B	C
compressive strength	K_1	117.1	117.8	123.1
	K_2	126.8	126.3	122.2
	K_3	124.2	124.0	122.8
	R	9.7	8.5	0.9
break off strength	K_1	22.5	21.5	21.1
	K_2	21.7	22.2	21.7
	K_3	21.2	21.8	22.7
	R	1.3	0.7	1.7
bend-press ratio	K_1	19.22	18.24	17.18
	K_2	17.14	17.57	17.74
	K_3	17.12	17.67	18.56
	R	2.10	0.67	1.38

It can be seen from Table 2 that the order of influence of factors on compressive strength is $A>B>C$; The order of influence of factors on flexural strength is $C>A>B$; the order of influence of factors on the folding pressure ratio is $A>C>B$.

3.1. Analysis of 28-day compressive strength

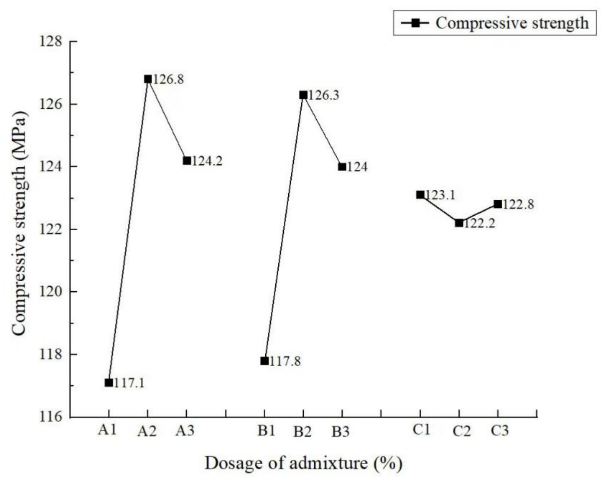

Figure 7. Relationship between different factors and compressive strength

It can be seen from Fig.7 that with the increase of the content of water slag powder and micro silicon powder, the compressive strength increases first and then decreases. With the increase of fiber content, the compressive strength decreases first and then increases. When the content of water slag powder is 20 %, the compressive strength is 126.8MPa.When the content of micro silicon powder is 10 %, the compressive strength is 126.3MPa.When the fiber yield is 0.05 %, the compressive strength is 123.1MPa.Therefore, the optimum content of water slag powder is 20 %, the optimum content of micro silicon powder is 10 %, and the optimum content of fiber is 0.05 %.

3.2. Analysis of 28-day flexural strength

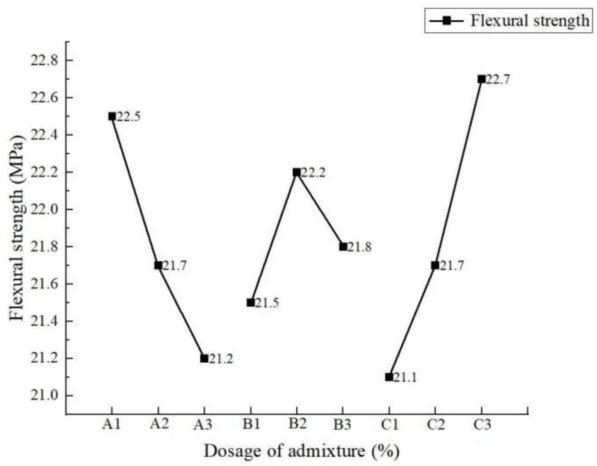

Figure 8. Relationship between different factors and flexural strength

It can be seen from Fig.8 that with the increase of water slag powder content, the flexural strength decreases gradually. With the increase of micro silicon powder content, the flexural strength increases first and then decreases. With the increase of fiber content, the flexural strength increases gradually. When the content of water slag powder is 15 %, the flexural strength is 22.5 MPa ; when the content of silica fume is 10 %, the flexural strength is 22.2 MPa ; when the fiber content is 0.15 %, the flexural strength is 22.7 MPa, so the best slag powder content is 15 %, the best micro silicon powder content is 10 %, and the best fiber yield is 0.15 %.

3.3. Analysis of 28-day compression ratio

Through Figure 9, it can be seen that with the increase of the content of water slag powder, the ratio of folding pressure gradually decreases ; with the increase of the content of micro silicon powder, the flexural pressure ratio decreases first and then increases gradually. With the increase of fiber content, the flexural-compression ratio increases gradually. When the content of water slag powder is 15 %, the ratio of folding pressure is 19.22 % ; when the content of micro silicon powder is 5 %, the ratio of folding pressure is 18.24 % ; when the content of fiber is 0.15 %, the ratio of folding pressure is 18.56 %, so the optimum content of water slag powder is 15 % ; the optimum content of micro silicon powder is 5 % ; the optimum content of fiber is 0.15 %.

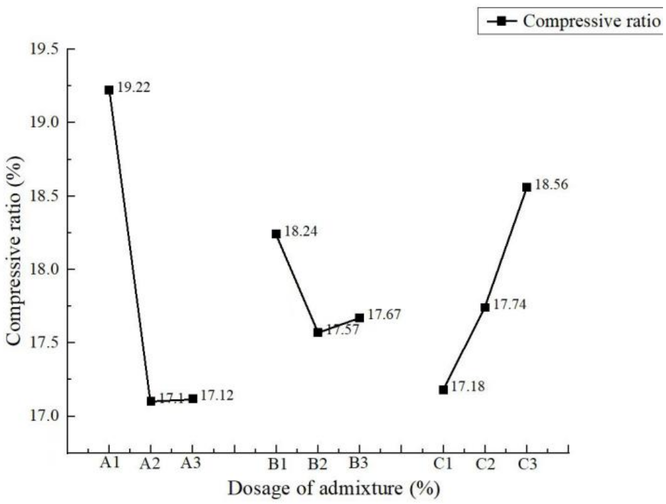

Figure 9. Relationship diagram between factors and flexural-compression ratio

3.4. Determination of optimal mix proportion

Table 3. Mixture ratio optimal

	performance index	Intuitive analysis of the optimal group	Order of influencing factors	Optimal group
Sea sand ultra-high strength	compressive strength	$A_2B_2C_3$	A＞B＞C	$A_2B_2C_1$
	break off strength	$A_1B_3C_3$	C＞A＞B	$A_1B_2C_3$
	bend-press ratio	$A_1B_3C_3$	A＞C＞B	$A_1B_1C_3$

According to Table 3, it can be concluded that factor A has the greatest influence on compressive strength and flexural-compressive ratio, while factor A has the second influence on flexural strength, and the horizontal factor is determined between A_1 and A_2. When the horizontal factor is A_1, the flexural strength is relatively good ; when the horizontal factor is A_2, the compressive strength is relatively good. Considering the requirements of mechanical properties, the economy of later use and the recycling of industrial waste such as water slag powder, the optimum content of A is determined to be 20 %. Similarly, in terms of B and C factors, when the horizontal factor is B_2, the compressive strength is higher, and the optimal content of B factor is finally determined to be 10 %. When the horizontal factor is C_3, the flexural strength is relatively large. However, with the continuous increase of the content of factor C, the flexural strength can be significantly enhanced, and the optimal content of factor C is determined to be 0.15 %. Therefore, the optimal group of sea sand ultra-high strength concrete is $A_2B_2C_3$.

4. Conclusion

This paper mainly studies the relationship between the compressive strength, flexural strength and flexural-compression ratio of sea sand concrete before super high by orthogonal test, water slag powder, micro silicon powder and basalt fiber, and finally determines the optimal mix ratio.

(1) For 28d compressive strength, with the increase of water slag powder content, the compressive strength increases first and then decreases, and the final content is 20 %. With the increase of micro silicon powder content, the compressive strength increases first and then decreases, and the final content is 10 %. With the increase of basalt fiber content, the compressive strength decreases first and then increases, and the final content is 20 %. For 28 d flexural strength, with the increase of water slag powder content, the flexural strength continues to decrease, and the final content is 15 %. With the increase of micro silicon powder content, the flexural strength increases first and then decreases, and the final content is 10 %. With the increase of basalt fiber content, the flexural strength continues to increase, and the final content is 0.15 %. For the 28d folding pressure ratio, with the increase of the amount of water slag powder, the folding pressure ratio first decreases and then tends to be gentle, and the final content is 15 %. With the increase of the amount of micro silicon powder, the folding pressure ratio first decreases and then increases, and the final content is 5 %. With the increase of basalt fiber content, the folding pressure ratio continues to increase, and the final content is 20 %.

(2) The final optimal mix ratio is that the content of water slag powder is 20 % of the binder, the content of micro-silica powder is 10 % of the binder, and the fiber is 0.15 % of the volume content.

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