Research on the influence of manufactured sand gradation on concrete performance

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Abstract: Based on experiments of C30 concrete with manufactured sand, this paper studied on the workability and compressive strength of the manufactured sand concrete with 7 different fineness modulus and different weight fractions (0%, 2%, 4%, 6%, 8%, 10%) of stone powder. The results show that the fineness modulus and the stone powder content in the gradation parameters of manufactured sand have great effects on the concrete performance. When the fineness modulus of manufactured sand is about 2.8, the workability and compressive strength of concrete can be improved. As the content of stone powder increases, the workability and compressive strength of concrete firstly increase and then decrease, and the optimal weight fraction of stone powder is about 6%. The research results can provide reference for the production and application of gneiss manufactured sand.

1 Introduction

With the rapid development of national urbanization and infrastructure construction, as the main raw material of concrete, the amount of natural sand is huge. Natural sand resources are constantly exhausted. The contradiction between market supply and demand is increasingly prominent. The price of natural sand is gradually rising. In order to meet the needs of engineering construction and protect the ecological environment, manufactured sand has gradually replaced natural sand with its characteristics of stable and controllable quality, moderate price and wide application range.

At present, experts and scholars in related industries have carried out some researches on the characteristics and engineering application of manufactured, and they have obtained some beneficial results. For example, Song and Cheng [1-2] selected 6 kinds of manufactured sand with different litholigy and studied the influence of manufactured sand litholigy on workability and strength of glue sand and concrete; Guo Dan and Yu Ping [3-4] carried out tests on glue sand and concrete with different grain content of manufactured sand, and proposed a reasonable gradation range of manufactured sand; Ai Chang-fa [5] analyzed the basic physical properties of manufactured sand and believed that the grain composition of manufactured sand was the main factor affecting the performance of concrete; Xu Zhi-hua [6] study on the influence law of MB value of microfines in manufactured sand on performances of concrete.

Existing research results show that the lithology, grain composition and MB value of manufactured sand had a greater influence on the performance of concrete. At the same time, the compatibility problem also appears in the mixing process of manufactured sand and different building materials, and the research results of manufactured sand for gneiss in Anhui area are few, which is difficult to meet the engineering practice needs of manufactured sand concrete. In order to further broaden the application range of manufactured sand, this paper takes the manufactured sand of gneiss in Anhui as the research object, carries out concrete tests, and explores the influence of the fineness modulus and stone powder content in the gradation parameters of manufactured sand on the concrete performance.

2 Test materials and methods

2.1 Test materials

(1) Cement

The cement used in the test was P.O42.5 grade produced by Anhui Huaining Conch Co., Ltd., with a specific surface area of 354 m^2/kg and a density of 3100 kg/m^3.

(2) Fine aggregate

The fine aggregate used in the experiment was gneiss manufactured sand produced in a gravel mill in Anhui Province. Two types of manufactured sand are selected: 7 types of manufactured sand with different fineness modulus in the actual production process, and the grain composition is shown in Table 1. The grain composition of manufactured sand is adjusted according to the different stone powder content, and the grain composition is shown in Table 2.

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Table 1 Grain composition of manufactured sand with different fineness modulus

Gradation Types	Weight Fraction of Grain Composition（%）								Fineness Modulus
	4.75	2.36	1.18	0.6	0.3	0.15	0.075	Stone Powder	
JX1	0	11.2	19	20.3	16.9	12.9	8.5	11.2	2.4
JX2	0	11.3	22.1	20.9	16.6	11.4	8.5	9.2	2.5
JX3	0	13.9	20.9	21.1	16.4	11.3	7.9	8.5	2.6
JX4	0	14.8	21.9	21.2	16.9	12.0	6.3	7.8	2.7
JX5	0	16.3	22.7	21.7	16.3	9.8	6.3	6.9	2.8
JX6	0	17.5	24.3	21.2	15.3	9.2	5.7	6.8	2.9
JX7	0	20.0	24.2	21.3	15.4	9.1	5.8	4.2	3.0

Table 2 Grain composition of manufactured sand with different stone powder content

Gradation Types	Weight Fraction of Grain Composition（%）							
	4.75	2.36	1.18	0.6	0.3	0.15	0.075	Stone Powder
JF1	0	17.5	24.4	23.3	17.5	10.5	6.8	0
JF2	0	17.2	23.9	22.8	17.2	10.3	6.6	2
JF3	0	16.8	23.4	22.4	16.8	10.1	6.5	4
JF4	0	16.5	22.9	21.9	16.5	9.9	6.4	6
JF5	0	16.1	22.4	21.5	16.1	9.7	6.2	8
JF6	0	15.8	21.8	21.0	15.8	9.5	6.1	10

(3) Coarse aggregate

The coarse aggregate used in the test was 5-10mm, 10-20mm and 16-31.5mm gneiss gravel produced by a gravel factory in Anhui Province, and the mixing ratio was 1:5:4.

(4) water reducing agent

The polycarboxylic acid superplasticizer was used in the experiment, with a water reduction rate of 30% and a dosage of 1.1%.

2.2 Test methods

Manufactured sand with 7 different fineness modulus and different stone powder content was used in the test, and C30 concrete was configured respectively. Under the condition of the same water consumption and water reducing agent, the workability and compressive strength of concrete were measured according to *Test Methods for Cement and Concrete for Highway Engineering* [7]. C30 concrete mix ratio parameters is shown in Table 3

Table 3 C30 concrete mix ratio parameters（kg/m3）

Cement	Manufactured Sand	Gravel			Water	Water Reducing Agent
		5-10mm	10-20mm	16-31.5mm		
395	783	108	541	432	161	4.13

3 Test results and analysis

3.1 Influence of fineness modulus on concrete performance

The relation curve between fineness modulus and slump and expansion of concrete is shown in Fig. 1. As can be seen from the figure, when the fineness modulus of manufactured sand is 2.4-2.8, the slump and expansion of concrete increase with the increase of the fineness modulus, and the workability of concrete gradually gets better without the phenomenon of segregation and weeping. When the fineness modulus of manufactured sand exceeds 2.8, the concrete slump decreases, but the concrete expansion decreases first and then increases. This is because the workability and water retention of concrete become worse, and the phenomenon of segregation and bleeding gradually appears. The results show that the concrete works better when the fineness modulus of manufactured sand is about 2.8.

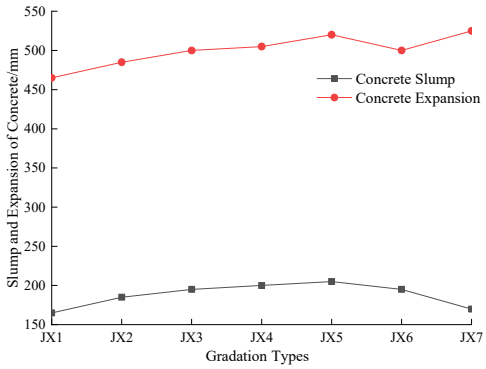

Fig. 1. The relation curve between the fineness modulus and the slump and expansion of concrete

3.2 Influence of stone powder content on concrete performance

The relationship curve between stone powder content and concrete slump and expansion is shown in Fig. 2. It can be seen from the figure that, with the increase of stone powder content, the concrete slump increases first and then decreases, while the concrete expansion decreases first and then increases and then decreases. When the content of stone powder is 0%, the fluidity of concrete aggregate is poor, and the phenomenon of segregation and bleeding occurs, which leads to large degree of expansion. When the stone powder content increased to 6%, the phenomenon of concrete segregation and bleeding disappeared, and its working performance reached the best state. In addition, when the content of stone powder is more than 6%, the concrete slump and expansion are reduced, the workability is worse, the mixing material is thickened, and the concrete performance is reduced.

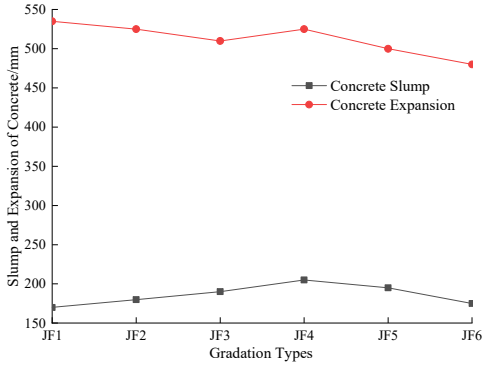

Fig. 2. The relation curve between the stone powder content and expansion of concrete

3.3 Influence of fineness modulus on compressive strength of concrete

Fig. 3 shows the relationship between the fineness modulus and the compressive strength of concrete. With the increase of fineness modulus, the concrete compressive strength first increases and then decreases. The concrete compressive strength of JX5 manufactured sand is the largest, and the corresponding fineness modulus is 2.8. The analysis shows that the grain composition of JX5 mechanized sand is close to the skeleton compacted structure, and fine particles can better fill the void between aggregate. When the fineness modulus of manufactured sand is too large, the content of coarse particles is more, the aggregate void can't be well filled, and it is easy to appear segregation and bleeding phenomenon, resulting in the loss of cement slurry and the decrease of the compressive strength of concrete. However, when the fineness modulus of manufactured sand is small, there are more fine particles filled between aggregate, which affects the bond strength of concrete.

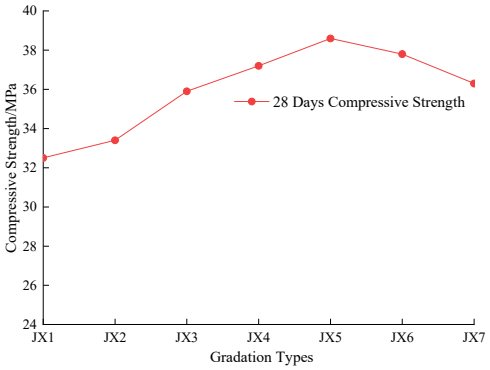

Fig. 3. The relation curve between fineness modulus and concrete compressive strength

3.4 Influence of stone powder content on compressive strength of concrete

The relation curve of stone powder content and concrete compressive strength is shown in Fig. 4. When the content of stone powder is 6%, the compressive strength of concrete reaches the maximum. With the increase of stone powder content, the compressive strength of concrete decreases. According to the experimental results of concrete workability performance with stone powder content, low stone powder content leads to poor water retention of concrete, and cement slurry loss occurs in the pouring process. The manufactured sand with higher stone powder content will increase the water demand of concrete. Under the condition of a certain water consumption, it may lead to insufficient hydration of cement, decrease the content of hydration products, and deteriorate the bond performance of concrete. Moreover, the increase of stone powder content will affect the skeleton structure of concrete and reduce the compressive strength of concrete.

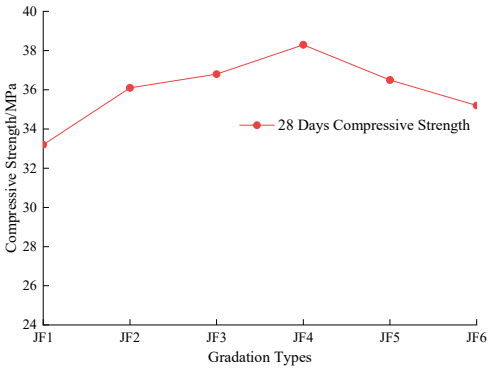

Fig.4. The relation between curve stone powder content and concrete compressive strength

4 Conclusion

Influenced by many factors, the research results of gneiss manufactured sand in Anhui are difficult to meet the needs of engineering practice. In order to further broaden the application range of manufactured sand, this paper takes the machine-made sand of gneiss in Anhui Province as the research object and carries out concrete

tests. This paper analyzes the workability and compressive strength of concrete, and explores the influence of fineness modulus and stone powder content in the grading parameters of manufactured sand on concrete performance. This paper draws the following conclusions

(1) Coarse particle content in manufactured sand can improve the skeleton structure of concrete, and an appropriate amount of fine particle content can enhance the water retention performance of concrete.

(2) The fineness modulus and stone powder content in the gradation parameters of manufactured sand have a great influence on the concrete performance. When C30 concrete is configured, the best fineness modulus of manufactured sand is about 2.8, and the best stone powder content is about 6%.

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