Research on the Influence of a new kind of Admixture on the Property of Shotcrete

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Abstract—A new kind of admixture for the shotcrete was proposed, its main ingredient is silica fume (61.3%) and bentonite (38.3%), plus a small amount of polyacrylic acid (0.4%). The influences of the admixture on the liquidity of shotcrete were studied, it is results that: 1) with the increase of the cement content, the workability of the shotcrete improves significantly; 2) with the increase of admixture dose, the bleeding rate significantly decreases; 3) after adding admixture, the anti-segregation capabilities are mostly above 95%. Even if the shotcrete with admixture added in has high fluidity, it also has good anti-segregation capability; 4) the shotcrete before adding admixture has much dust around while the dust is obviously decreased after adding admixture.

Keywords-concrete admixture; shotcrete; roadway support

I. INTRODUCTION

In the early 20th century, Germany developed shotcrete mortar and applied it for roadway support [1-2]. The practice proved that compared with cast-in-place concrete, shotcrete has an advantage of simple and easy construction which avoids the jobs of form erecting, pouring and form removal. At present, shotcrete technology has been widely used in metallurgy, coal and water conservancy industry as well as various underground works for supporting the chambers and road ways [3-5].But, high rebound rate and instability of shotcrete are the long-standing problems with the development of shotcrete. [6]. Though the wet shotcrete method basically solves the problem of the high dust concentration in the air, since wet shotcrete normally requires liquid quick-setting agent, under the working of air pressure, residue of the liquid quick-setting agent is still easily observed in the air, which remains harmful to the workers' body [7-9].

There are several methods to solve the above mentioned problems. First, add more quick-setting agent so as to make the shotcrete sprayed on the rock surface cure rapidly and have no falling any more. But the quick-setting agent prevents the falling of shotcrete and reduces the loss of shotcrete only after the spray, and it doesn't solve the problem of shotcrete loss caused by the rebounded material in the course of spray. Second, add admixtures. Academy of Metallurgical Science has developed a kind of admixture, but this admixture is actually a kind of admixture, which are powders by grinding inorganic minerals. It can't reduce the loss rate of the rebound significantly, let alone to reduce the dust content in the air [10].

Therefore, a kind of specialized admixture for shotcrete is badly to be developed to improve the viscosity of the shotcrete, reduce the loss of rebound and the dust in the working space during the spraying process of the shotcrete and meanwhile thicken the thickness of every spray layer. This paper proposes a new kind of admixture for the shotcrete, and focuses on the study of the influence rules of the admixture on the liquidity of shotcrete.

II. MATERIALS

A Cement

The cement used in this study is a Chinese standard (GB175-2007) 425# Portland cement [19]. Its density is 3100 kg/m3.

B Aggregate

Coarse aggregate, with a specific gravity of 2.69 and a maximum size of 15 mm, was used. The fine aggregate was washed sand having a specific gravity of 2.65 and a fineness modulus of 2.92.

C Admixture

An especial self-made admixture was applied in this study. Its main ingredient is silica fume (61.3%) and bentonite (38.3%), plus a small amount of polyacrylic acid (0.4%).

III. TESTING EQUIPMENT

- A standard tester for consistency and setting time of the cement (Vicat Apparatus).
- A funnel of cement mortar consistency: produced by Hebei Guanghua Weiye Construction Instrument Factory, with a capacity of 1725 ml.
- Multi-function rock mechanics test (RMT) machine: A series of RMT systems was developed [11-12]. The machine has a unique multi-function design and control technology; it can conduct many types of tests such as uniaxial compression,

triaxial compression, tension, shear and fatigue tests. Its maximum load is 1 MN, and its maximum confining pressure is 50 MPa.

IV. RESULTS AND DISCUSSION

A The influence of the admixture on influence rules of the admixture on the liquidity of shotcrete

Slump and slump flow are used to describe the liquidity of shotcrete in the tests. The results of the influences of the cement content on the liquidity of shotcrete are shown in Table 4.

TABLE I INFLUENCES OF DIFFERENT CEMENT CONTENTS OF THE ADMIXTURE ON THE LIQUIDITY OF SHOTCRETE

Water-cement ratio	Cement/kg	Admixture/%	Slump/mm	Slump flow/mm	Bleeding rate/%	Air content/%
0.5	380	0.5	198	360	5.1	4.1
0.5	400	0.5	220	450	2.1	3.1
0.5	430	0.5	250	480	0	3
0.5	450	0.5	240	590	0	>10

It can be seen from Table 1 that with the increase of the cement content, the workability of the shotcrete improves significantly. As the water-cement ratio is invariant, so the quantity of mixing water is increased accordingly when increasing the cement content. As the water demand of the shotcrete mixed with admixtures will increase obviously, the increase of cement content will also increase the water consumption. Therefore, the increase of the mixing water will not lead to the bleeding and dissociation of the shotcrete, but will make the shotcrete maintain moderate cohesiveness. The increase of the cement content makes the new mixed shotcrete have moderate cohesiveness and liquidity. The application of the admixture improves the water-retaining property of the new mixed shotcrete.

B The influence of the admixture on the bleeding performance of shotcrete

The bleeding performance of the shotcrete mixed with admixtures is pretty poor, which hardly bleed. This is another characteristic that differs from other shotcretes. The ratio of the fixed tests are: the tests on the relationships between different mixing amounts of admixtures and the bleeding rates under the conditions of the water-cement ratio being 0.5, the cement content being 400 kg/m3 , and the sand percentage being 0.4. The results of the tests are shown in Fig .1.

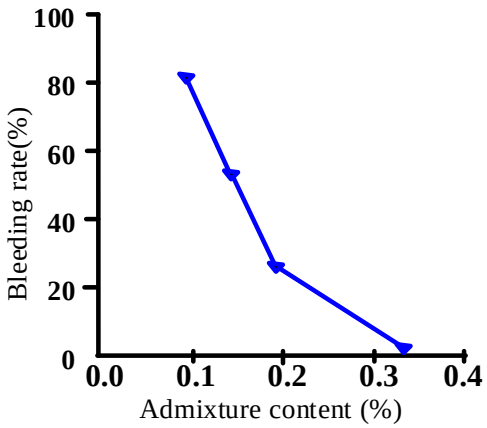

Figure 1. The relation curve of the mixing amounts of admixtures and the bleeding rates

As obviously shown in the data and curve above, under the condition of fixing shotcrete mixture proportion, with the increase of admixture dose, the bleeding rate significantly decreases. When water-cement ratio is 0.5, cement content is 400 kg/m ^{3} and the dose of admixture adds to 0.33%, the bleeding rate of shotcrete is 0, indicating that shotcrete with admixture mixed into has a good water conserving property which is beneficial to the development of shotcrete strength and the delay or decrease of inchoate cracks.

C *Influences on the anti-segregation capability of the influence of admixture on the property of shotcrete*

For influences on the anti-segregation capability of the influence of admixture on the property of shotcrete, see Table 2.

TABLE II INFLUENCES ON THE ANTI-SEGREGATION CAPABILITY OF THE INFLUENCE OF ADMIXTURE ON THE PROPERTY OF SHOTCRETE

Test Group Number	Water-Cement Ratio	Cement/kg	Sand Percentage/%	Admixture/%	Fluidity/mm	Anti-segregation/%
1	0.6	400	40	0.4	430	98.2
2	0.5	430	40	0.2	470	98.4
3	0.4	430	40	0.1	400	94.9

According to the analysis of test results, after adding admixture, the anti-segregation capabilities are mostly above 95%. Even if the shotcrete with admixture added in has high fluidity, it also has good anti-segregation capability.

D *Influences on the rebound rate of the influence of admixture on the property of shotcrete*

Fix the mixture proportion for tests: under the conditions that water-cement ratio is 0.5, cement content is 400 kg/m^3, sand percentage is 0.4 and that admixture dose is 13.05% of the cement content, scene conditions before and after adding admixture are shown in Fig. 2 and the test results of dust concentration are presented in Table 3. As seen in both Fig .2 and Table 3, the shotcrete before adding admixture has much dust around while the dust is obviously decreased after adding admixture, which indicates that the influence of admixture on the property of shotcrete and obviously has an effect on reducing the rebound rate.

TABLE III INFLUENCES ON THE REBOUND RATE OF THE INFLUENCE OF ADMIXTURE ON THE PROPERTY OF SHOTCRETE

Test Item	Before adding admixture	After adding admixture
Dust Concentration/(mg/m^3)	113	27
Rebound Rate/%	16.8	7.3

(a) Without adding admixture (b) After adding admixture

Figure 2. Effects of admixture on controlling dust

V. CONCLUSIONS

A new kind of admixture for the shotcrete was proposed. The influences of the admixture on the liquidity of shotcrete were studied and can be summarized as follows.

1) With the increase of the cement content, the workability of the shotcrete improves significantly.

2) With the increase of admixture dose, the bleeding rate significantly decreases.

3) After adding admixture, the anti-segregation capabilities are mostly above 95%. Even if the shotcrete

with admixture added in has high fluidity, it also has good anti-segregation capability.

4) the shotcrete before adding admixture has much dust around while the dust is obviously decreased after adding admixture, which indicates that the influence of admixture on the property of shotcrete and obviously has an effect on reducing the rebound rate.

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