Experimental Study on Cemented Tailings Backfill in a Copper Mine

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Abstract. A certain copper mine has entered deep mining. In order to solve the numerous production technical problems faced by deep mining and the shortcomings of the original filling system in the mine, the filling system will be transformed and a high concentration tailings cemented filling system will be established. The filling system is designed using the underground mixing station self-flow filling process, advanced vertical sand bin fluidized slurry making device, and a mixing station is constructed underground, fully utilized the original filling facilities of the mine. In order to control the ground pressure during deep mining, provide high-quality filling materials, and ensure safe and efficient mining operations, on-site inspections were conducted on the existing filling equipment and pipeline system. A trial mining site filling tailings ratio test was designed, with a filling slurry concentration of 67% and ratios of 1:12, 1:8, and 1:6. It was concluded that the current system's expected sand release amounts of 120m^3/h, 80m^3/h, and 60m^3/h are basically accurate, and the sand release concentration is controllable. The preparation system for cementitious filling water slurry has a normal preparation capacity of 12m^3/h (concentration of 55-61%) is accurate, the control process is stable and easy to be controlled.

Keywords: filling system, tailings sand, cement sand ratio, conveying capacity

1 Introduction

A copper mine has entered deep mining, and its cementitious filling design adopts the underground mixing station self-flow filling process. The system adopts advanced vertical sand bin fluidized slurry making device, and a mixing station is built underground, fully utilizing the original filling facilities of the mine. In order to control the ground pressure during deep mining, provide high-quality filling materials, create favorable mining conditions for the transformation of deep mining methods, and ensure safe and efficient mining operations, on-site inspections were conducted on the existing filling equipment and pipeline system. It was found that there were problems such as excessive sand discharge pipe diameter, reinforcement of some slurry pipelines, and the addition of soft rubber pipes in the feeding pipes of the mining area. Therefore, it is necessary

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to verify the main parameters of the cemented filling experiment in the mine, and analyze the existing data and test results to obtain reasonable filling parameters.

2 Proportioning Test Design

Due to the small conveying capacity of the existing cement slurry conveying system, according to the measured data, the conveying capacity is about 12m^3/h at a concentration of 55%[1]. Therefore, during the proportioning experiment, the cement slurry conveying is set as a constant, and sand is mixed according to the needs of the cement slurry quantity and ratio[2,3].

According to the drainage situation of the experimental mining site, the filling test of the mining site is conducted three times, with an interval of 2 days each time. The lime sand ratio is 1:12, 1:8, and 1:6, respectively[4,5]. The sand mixing dates (variables) are as shown in Table 1.

Table 1. Sand Preparation (Variable) Table

Filling frequency	filling date	filling time,h	Cement slurry concentration, %	Cement slurry usage, m^3/h	Dry cement usage, t/h	Cement sand ratio	tailings flow rate (65%), m^3/h	Filling volume, m^3
1	The first day	2	55	12	10.54	1:12	116	256
2	The second day	2	55	12	10.54	1:8	77	179
3	The third day	2	55	12	10.54	1:6	58	140

Before each filling experiment, it is necessary to ensure that there is no accumulated water in the experimental mining area, especially for the underground and release system, there should be no accumulated water, the underground sand release system is as shown in Figure 1.

Fig. 1. Underground sand release system

3 Experiment Process

3.1 Test requirements.

The safety measures for filling shall be carried out according to the original regulations. Due to the linkage between surface slurry production, sand storage, and mining areas, communication lines between the three areas need to be installed and ensured to be smooth.

Cement slurry production.
Follow the instructions of the underground sand bin to start and stop the cement slurry production operation, ensuring uniform, safe, and high concentration preparation and transportation.

Filling stope.
The filling pit should be in contact with the sand bin at any time to ensure that the washing machine and pipe washing water do not enter the pit. Before each filling, the accumulated water in the pit should be drained to ensure that the slurry does not overflow.

Sand bin.
As the filling command center for this project, we carefully control the sand concentration and amount according to the ratio requirements, timely understand the process and process conditions, grasp the entire filling process (with a ratio table attached), and collect data records for the day.

3.2 Sample and measure the concentration at the outlet of the slurry pipeline in the mining area at a rate of 30 minutes per time. Prepare slurry strength test blocks according to experimental standards, and conduct uniaxial compressive strength tests on 7d/28d test blocks[6-8], as shown in Figure 2.

Fig. 2. Pouring of cement tailings sand test blocks

3.3 The mine conducted three cementitious filling experiments every two days, with slurry concentrations of 65% and 67%, ash sand ratios of 1:12, 1:8, and 1:6, respectively. The curing period was 7 and 28 days, respectively. After reaching the curing period, uniaxial compressive strength tests were conducted on the filling specimens, and the results are as shown in Table 2.

Table 2. Uniaxial compressive strength test results of filling material/MPa

No.	Slurry concentration /%	Cement-sand ratio	Uniaxial compressive strength, 7d/Mpa	Uniaxial compressive strength, 28d/Mpa
1	65	1：12	0.11	0.24
2		1：8	0.16	0.33
3		1:6	0.26	0.47
4	67	1：12	0.15	0.31
5		1：8	0.19	0.42
6		1:6	0.32	0.58

By fitting the results of the uniaxial compressive strength test of the filling material [9-11], the relationship curve between the strength of the filling material and the ratio of cement to sand, as well as the uniaxial compressive strength, can be obtained, as shown in Figure 3 and Figure 4.

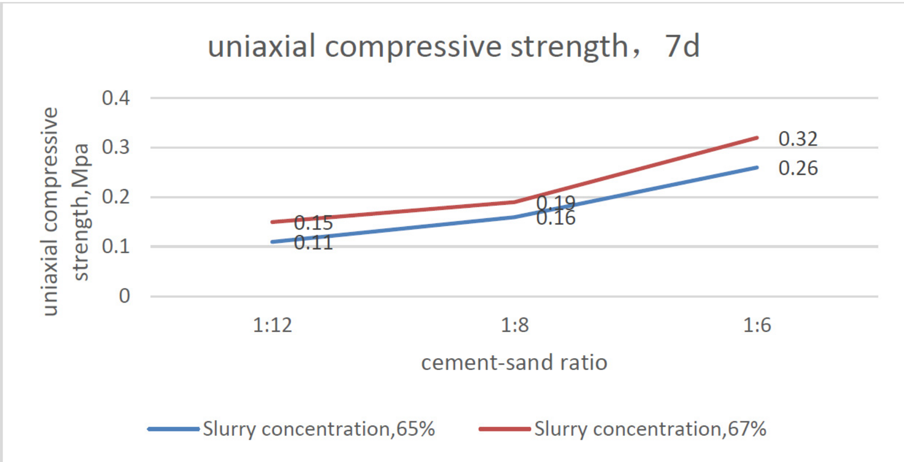

Fig. 3. Relationship curve between uniaxial compressive strength of filling body and sand cement ratio, 7d

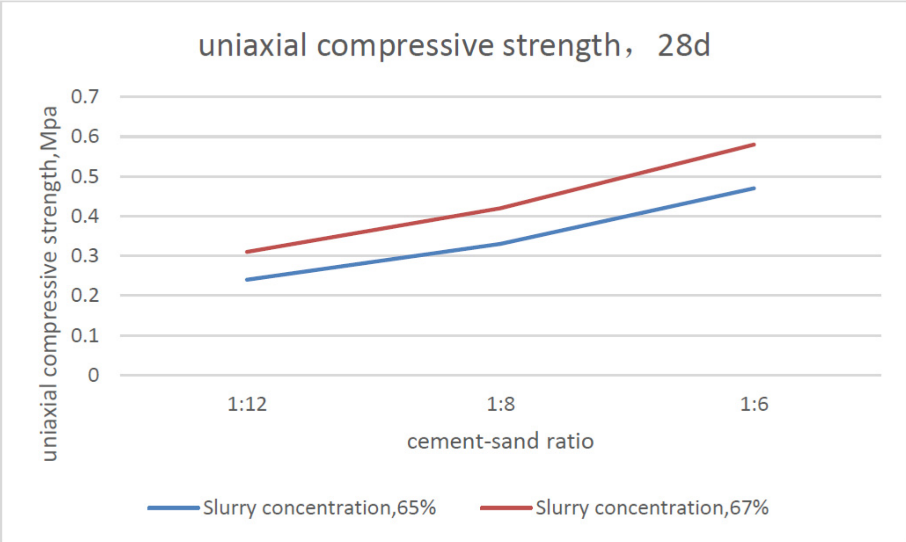

Fig. 4. Relationship curve between uniaxial compressive strength of filling body and sand cement ratio, 28d

4 Conclusion

A copper mine conducted three cementitious filling experiments every two days, with a lime sand ratio of 1:12, 1:8, and 1:6, respectively. The summary is as follows:

4.1 The cementitious filling process of this system is smooth and controllable. The control of manual sand release in this experiment is easy to grasp. The expected sand release amounts of 120m^3/h, 80m^3/h, and 60m^3/h are basically accurate, and the sand release concentration is controllable (65-67%). The tailings mortar in filling test is as shown in Figure 5.

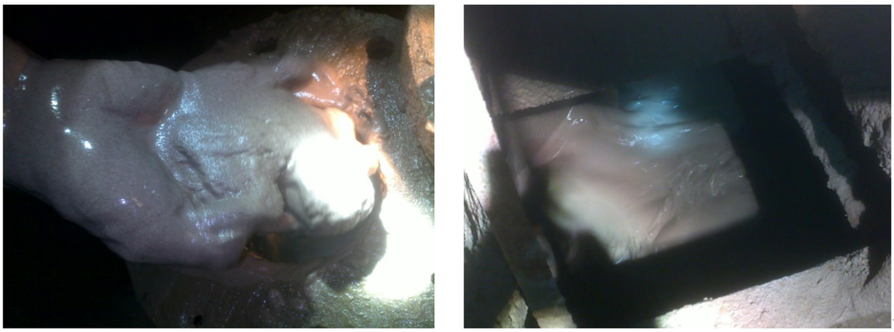

Fig. 5. Tailings mortar in filling test

4.2 The normal preparation capacity of the cementitious filling water slurry preparation system for this time is 12m^3/h (concentration 55-61%), which is accurate. The control process is stable and easy to grasp, and it is controllable and reliable as a constant "1" in future proportioning, making it suitable for use in this system.

4.3 In this experiment, samples were taken from the mining site and a testing module was made according to the "Cube Compressive Strength Test Standard", and the concentration of the filling slurry was measured. The proportion of times the average concentration of the measured slurry reaches 65-67% is relatively high (except for 8 meters on the 16th due to low sand storage). Due to the pressure test results requiring a long-term time process, there is currently no consensus. If there is any non-compliance, further analysis and treatment will be conducted, and the mining party will continue to complete the pressure testing work.

4.4 By analyzing the relationship between the concentration of filler slurry, sand cement ratio, and curing period and the uniaxial compressive strength of the filler, it can be concluded that the uniaxial compressive strength (7 days, 28 days) of the cemented filling body increases with the increase of filler slurry concentration. From the initial setting of the filler slurry to the curing period of 7 days, the uniaxial compressive strength of the test block gradually increases, and the growth rate during the 7-28 day curing period is higher than the growth rate from 0 to 7 days.

4.5 The copper mine filling system, as a non-cemented and cemented filling system, meets the level standards of the same industry and technology in China.

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