CHOICE OF FILLING MATERIALS AND TECHNIQUES IN XINQIAO PYRITE MINE①

Zhang Qinli, Wang Xinmin
College of Resource, Environment and Civil Engineering, Central South University of Technology, Changsha 410083
Chen Jiasheng
Xinqiao Pyrite Mine, Tongling 244131

ABSTRACT The suitable filling materials and cemented rockfill techniques were discussed in detail on the basis of the mechanical features measurement of cemented samples in Xinqiao Pyrite Mine. The ratios of filling materials and the suggested pouring technique of cemented rockfill had been proved reasonably by the field experiment, from which, the main conclusions were obtained as follows: (1) Cemented rockfill is better than cemented sand fill for Xinqiao Mine; (2) The recommended composition ratios of cemented rockfill are 1∶15 for cement-sand, 2~3∶1 for rock-sand, and 1.8~2.0 for water-cement, respectively.

Key words stirring technique pouring technique compressive strength cemented rockfill

1 INTRODUCTION

Xinqiao Pyrite Mine, situated in Tongling City, Anhui Province, one of the most important copper bases in China, is a large deposit with more than 170 Mt sulphide ore reserve. The orebody No. 1 inclines to NE at 12°. Its width is 23 m averagely. Both orebody and surrounding rock are stable, but its direct roof is broken rock with a thickness of 1~8 m[1]. Sublevel open stoping with delayed filling is used. Without enough tailings, the alternative filling materials are sand extracted from Yangtze River and limestone fragments[2]. This paper will deal with the choice of suitable filling material and determine its composition and mixing method.

2 EXPERIMENTAL DESIGN

According to resources of filling materials and referring to current advanced filling techniques, three cemented filling techniques were adopted in the experiment, i. e:

(1) Cemented sand fill, which aims at examining whether cemented sand is appropriated as filling material.

(2) Stirring techniques of rock fragments and cement-sand grout.

(3) Pouring techniques of cement-sand grout to rock fragments.

In the experiment, sand and rock fragments (Their physical characteristics are summarized in Table 1) act as different filling aggregate and portland cement No. 425 as cementing material. The samples (sand fill: 100 mm × 100 mm × 100 mm, rockfill: 200 mm × 200 mm × 200 mm) were seperately made in terms of different filling techniques (strirring or pouring) and following parameters:

(1) Cement-sand ratio is 1∶5, 1∶10, or 1∶15; (2) Slurry concentration is 70%; (3) Water-cement ratio is 1.8~2.0; (4) Rock-sand ratio is 3∶1, 2∶1, 7∶3, respectively.

The finished samples were cured under moisture condition for 28 d or 56 d and then measured their compressive strength (σ_c), tensile strength (σ_t) and elastic moduli (E). The experimental arrangement and results are listed in Table 2.

① Supported by the Key Program of Chemical Ministry of China

Received Oct. 7, 1996; accepted Apr. 30, 1997

Table 1 Physical characteristics of filling materials[3]

Material	Density/ $t \cdot m^{-3}$	Porosity/ %	Grade range/ mm	Seepage factor/ $cm \cdot h^{-1}$
Sand	1.51	45.50	0.05~ 2	8~ 4
Rock	1.41	48.00	5~ 30	
Cement	1.30	56.60		

Table 2 Experimental arrangement and results

No.	Cement-sand ratio	Rock-sand ratio	Slurry conc. or water-cement ratio	Mixing method	σ_c/ MPa		σ_t/ MPa		E / 10^2MPa
					28d	56d	28d	56d	
1	1∶ 10	sand	70%	hydraulic haulage	0.26	0.55	–	0.22	1.87
2	1∶ 5	sand	70%	hydraulic haulage	1.56	2.08	0.33	0.75	1.56
3	1∶ 10	2∶ 1	1.8	pouring	5.25	5.70	0.62	1.15	7.50
4	1∶ 15	3∶ 1	1.8	stirring	4.59	5.54	0.45	0.65	6.25
5	1∶ 10	3∶ 1	1.8	stirring	4.50	5.90	0.50	0.65	11.5
6	1∶ 15	2∶ 1	1.8	stirring	3.65	4.35	0.55	–	4.88
7	1∶ 15	7∶ 3	1.8	pouring	3.70	5.05	0.57	0.55	8.00
8	1∶ 15	7∶ 3	1.8	pouring	5.05	6.60	0.65	0.65	5.00
9	1∶ 10	2∶ 1	1.9	pouring	5.25	6.05	0.90	0.90	4.50
10	1∶ 10	3∶ 1	1.9	pouring	4.84	5.45	.065	0.70	3.70

3 ANALYSIS AND DISCUSION

From the experimental results as listed in Table 2, it may be found that:

(1) The σ_c and σ_t of cemented sand fill are directly proportional to cement content. The σ_c of 56d is only 0.55MPa when cement-sand ratio is 1∶ 10, but comes to 2.08MPa at 1∶ 5. Its σ_t of 56 d increases also doubly at the same time to 0.75MPa (see No. 1, 2 in Table 2).

(2) All of rockfill samples have high compressive strength when stirring technique is adopted no matter what cement-sand ratio is (1∶ 15 or 1∶ 10). In these samples, sand content exerts obvious effect on σ_c. If sand content is reduced to 25% (No. 4, 5) from 33% (No. 6), their σ_c of 58 d may rise by 20%.

(3) Both compressive and tensile strength of rockfill samples made in accordance with pouring technique are high (say test No. 7, 8, 9, 10), and the variance of sand content influences on σ_c adversely to that of stirring technology. When sand is reduced from 33% (No. 9) to 25% (No. 10), for example, its σ_c of 56 d is lowered from 6.05MPa to 5.45MPa.

(4) Under the condition of the same cement-sand ratio, such as 1∶ 10, the compressive resistance of cemented rockfill is 10 times of that of cemented sand fill.

In brief, the experimental results indicate that the cemented rockfill is superior to the cemented sand fill. Because the rock fragments grip one another and form a "tight frame", whose space (48%, see Table 1) is filled completely by sand-cement grout (sand 30%, cemented 6.26% ~ 16.7%) and strengthened bearing capacity of the samples. In cemented sand fill, however, the space of sand (46.5%) can not be filled completely by a little amount of cement (6.25% ~ 16.7%) so that the fill can not bear much pressure and easily be damaged by shearing force.

Fig. 1 indicates the damage types of two kinds of fill. Cemented sand sample is damaged and collapses by shearing force when ultimate strength arrives, but cemented rockfill sample can still retain high residual strength and continue to bear a part of load after damage, which is very important to fill.

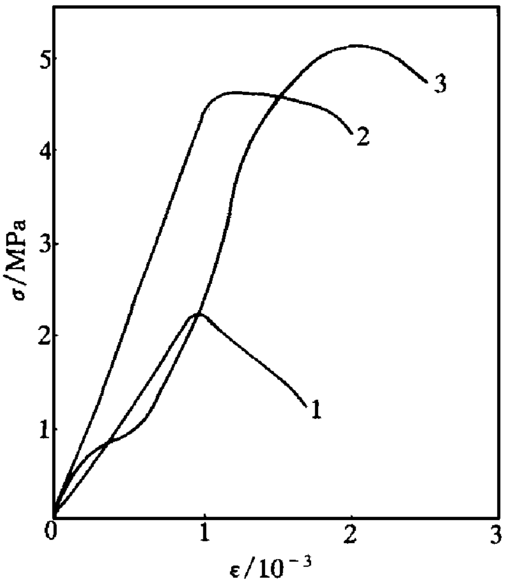

Fig. 1 Stress-strain curves of samples
1 —cemented sand fill; 2 —cemented rockfill;
3 —concrete sample

4 FIELD EXPERIMENT

In terms of the fill parameters and technique recommened above, the cemented rockfill system has been developed and its field experiment has been carried out in the mine[4]. Limestone fragments (about 150 mm in dia) are conveyed to fill the worked-out stope through the rock pass, main belt conveyor fixed at − 168 m level belt heading and movable branch conveyor at − 180 m level crosscut, where they are mixed with cement-sand grout flowing through the filling hole and pipe. Two of them are alternately filled untill the space is filled up. The result of field experiment listed in Table 3 has proved that the fill materials and their ratios recommended are reasonable, the cemented rockfill technique is successful, and fill quality and economic benefit are high. Cemented rock fill cost is about 71.23 RMB Yuan per cubic meters (RMB Yuan/ m^3), 54.03 RMB Yuan/ m^3 lower than that of cemented sand fill. Calculated by 92 500 m^3 of annual fill quantity, cemented rockfill may save fill cost about 5 million RMB Yuan as compared with cemented sand fill.

Table 3 Result of cemented rockfill field experiment

Item	Value	Item	Value
Fill volume/ m^3	300	Cement-rock ratio	1∶16
Rock quantity/ t	3 700	Rock-sand ratio	3∶1
Sand quantity/ t	1 150	Fill cost /RMB Yuan	71.23
Cement consumption/ t	220	Compressive strength/ MPa	3.3

5 CONCLUSIONS

On the basis of the analysis of experimental results, the main conclusion derived from the researcheres are as follows.

(1) Cemented rockfill is superior to cemented sand fill.

(2) The recommended composition of cemented rockfill is as follows:

Cement-sand ratio is 1∶15,

rock-sand ratio is 2~ 3∶1,

Water-cement ratio is 1.8~ 2.0.

(3) Pouring technique is suggested for its convenient management.

REFERENCES

1 Wang Xinmin. Technology for Chemical Mines, (in Chinese), 1994, (1): 12− 15.

2 Fang Shihong. Technology for Chemical Mines, (in Chinese), 1995, (3): 22− 26.

3 Peng Xucheng. Scientific and researching Papers of filling method, (in Chinese). Changsha: Central South University of Technology Press, 1992: 101−105.

4 Wang Xinmin, Zhang Qinli, Chen Jiaheng. The Chinese Journal of Nonferrous Metals, (in Chinese), 1997, 7(2): 10− 13.

(Edited by He Xuefeng)