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Study of roadside packing to go with gob-side entry retaining technology on crisp surrounding and blasting face in the Xinzhuang mine

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ABSTRACT
In order to improve the recycle rate of coal resources, extend the service-life of the mine, and alleviate the tensions of excavation-replacement in the Xinzhuang mine, this paper presents a high-water material for roadside packing to go with gob-side entry-retaining technology on crisp surrounding rock and blasting working face. Based on the conditions in the field, the authors analyzed the utility of the filling structures of the 12011 machine roadway. On the basis of the engineering analogy method and laboratory experiments, the authors determined the ZKD new high-water material ratio of each component and the filling process parameters. The results show that when four conditions are met—rectangular packing is used; water cement ratio of the new high-water material is 1.8:1; the Φ 18 mm × L 3400 mm anchor bolt is imbedded in the filling body; and supplementary support, which consists of anchor bolt, wire rope, and steel beam, is applied—the average contraction rate of the roadway section is 13.38%, achieving a satisfactory effect. Compared with gob-side entry driving, it can improve the indirect profit by 9.86 million yuan; compared with digging a new roadway, it can increase the profit by 5688.5 yuan per metre.
KEYWORDS: gob-side entry retaining; high-water materials; observation of mine pressure; contraction rate of section

With the increase of mining service-life, the Xinzhuang coal mine now faces the problem of running out of coal mine resources, and the pressure of excavation-replacement is becoming increasingly great. In order to reasonably exploit existing coal resources, improve the mining rate of coal resources, extend the service-life of the mine, and alleviate tensions of excavation-replacement in the Xinzhuang coal mine, this paper presents a high-water material for roadside packing to go with gob-side entry retaining technology on crisp surrounding rock and blasting working face. This is based on the features of blast mining technology, a crisp and dry coal seam, and the fact that blasting vibration may cause the roadway wall to cave into the Xinzhuang coal mine at the three (3) 12011 working face.

To date, the new high-water rapid-hardening material for roadside packing to go with gob-side entry-retaining technology has been applied in different coal mines with satisfactory results. Tao Yi coal mine, Heng Jian coal mine, and Guo Er Zhuang coal mine of Handan Mine Group and Qiu Ji coal mine and Wang Lou coal mine of Lin Yi Mine Group are examples of this. It is worth mentioning that although the technology implemented in the aforementioned coal mines has unique characteristics, there are still significant differences between these mines and Xinzhuang coal mine. The working face implements a blasting excavation process, and coal seam is crisp and dry; the blasting vibration may cause the roadway wall to cave into Xinzhuang coal mine. These features bring great difficulties to the implementation of gob-side entry retaining technology in Xinzhuang coal mine.

1. SURVEY OF GEOLOGICAL AND PRODUCTION CONDITIONS ON 12011 MACHINE ROADWAY

Xinzhuang coal mine three (3) coal 12011 machine roadway is located in the west wing of three (3) 12th mining area. The elevation of this roadway is between 246.5 m and 162.6 m below base level, and the strike length is approximately 525 m. Three (3) coal seam is revealed in this region, and the thickness is 1.2 m to 1.8 m, with the average thickness being 1.3 m. The average dip angle is 9°, and hardness ratio f is 1.5. The stratification and joint is developmental and the immediate roof is mudstone, which has a thickness of 3 m to 3.5 m. The fissures are developed and hardness ratio f is 2. The floor is mudstone with a thickness of 3.15 m. It is gray and black, containing plant fossils. The fissures are developed, and hardness

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ratio f is 2. There exists about 0.5 m carbonaceous mudstone, soft and broken, under the coal floor. The section of 12011 roadway is rectangular; it has a net width of 4000 mm and clear height of 2600 mm.

2. FILLING MATERIAL

As necessitated by roof activities, at the beginning, the activity of the roof is mainly based on rotation and subsidence where the load is small, and the utility of the filling structure is primarily to balance the weight of the immediate roof. When the working face continues to move forward, the immediate roof and a range of old roof collapses and breaks up. In order to reduce the time of the presence of the old roof and the deformation of the surrounding rock, it is required that the filling structure has enough support resistance. When the support structure of old roof rock mass breaks up, the roof activity comes to an end, and the filling structure is there to maintain the stability of the structure.

Therefore, it is required that the filling structure is to be of high strength in the early stages, and increasing resistance as time passes. It is to be stable and reliable with high load bearing capability. ZKD new high-water filling material is better at meeting these requirements. This material consists of two components, A and B. Component A, based on special cement clinker, is made from suspension concentrate and a compound super-retarding agent. Component B is mixed with lime, gypsum, and compound accelerator. Both component A and B can be used at mass ratio of 1:1. According to the standard tests in the laboratory, the basic properties of the new high-water material are shown in Table 1.

Table 1: Basic properties of the new high-water material.

initial setting time (min)	uniaxial compressive strength (MPa)			
	2 h	24 h	7 d	28 d
3–20	≥2.0	4.2	8–9	10–11

The experimental results show that the compressive strength of the filling body, which consists of new high-water filling material, is generally more than 20% when the anchor bolt is placed in the filling body. The longitudinal and lateral deformation of the filling body can reach up to 7% and 10% respectively when there is no anchor bolt in the filling body. The whole anti-deformation capacity of the filling body can be increased by 6% to 28%. The placement of the anchor bolts can significantly improve the overall strength and stability of the filling body.

3. FIELD APPLICATION

3.1 Field filling technology

Combined with geological conditions in the Xinzhuang mine and based on engineering analogy methodology, this paper adopts the American MTS 815 rock mechanics test system to measure rock samples derived from different rock strata. These samples were compared to standard test specimens of new high-water material that have different proportions, taking the cost, equipment selection, operation flexibility, and requirements of the roadway support resistance into consideration. The water cement ratio was determined as 1.8:1, and under this condition, the average compressive strengths of the new high-water filling material are 1.7 MPa, 3.8 MPa, 4.9 MPa, and 5.9 MPa at the time of 6 h, 1 day, 3 days, and 7 days.

According to the production status of blasting mining face in three (3) coal 12011 roadway, the pumping station is planted at the corner of the roadway in three (3) coal 12 mining area. The schematic diagram of equipment layout in the filling chamber is shown in Figure 1. As is shown, materials are transported by a hydraulic injection pump that is specified for coal mine operations. The filling pipe is composed of a high-pressure hose with a diameter of 40 mm and seamless tube with an inner diameter of 40 mm. There are two feeding pipes: one for material A and one for material B that separately convey the materials from the pumping station to the filling point. To make the filling technology more convenient and reliable, a high-pressure hose is used between the filling pump and the tube, and between the filling pipe and the external tee mixer. The mixing pipe utilizes the high-pressure hose, with the inner diameter being 55 mm. A quick coupling was used between the rubber hose and steel pipe.

Considering the characteristics of the surrounding rock and the requirements for retaining roadway section in the Xinzhuang mine, it is determined that the filling body should be entirely arranged in the goaf, and the rectangular filling bag should be used with a size of 2400 mm × 3000 mm × 2600 mm. Its height and width can be adjusted according to the actual conditions. The diameter of the feed hole is 100 mm, and the length of the feed tube is less than 550 mm. There are six anchor holes in the filling bag, with the diameter being 25 mm, and the length of anchor bolt that is exposed on both ends being 150 mm.

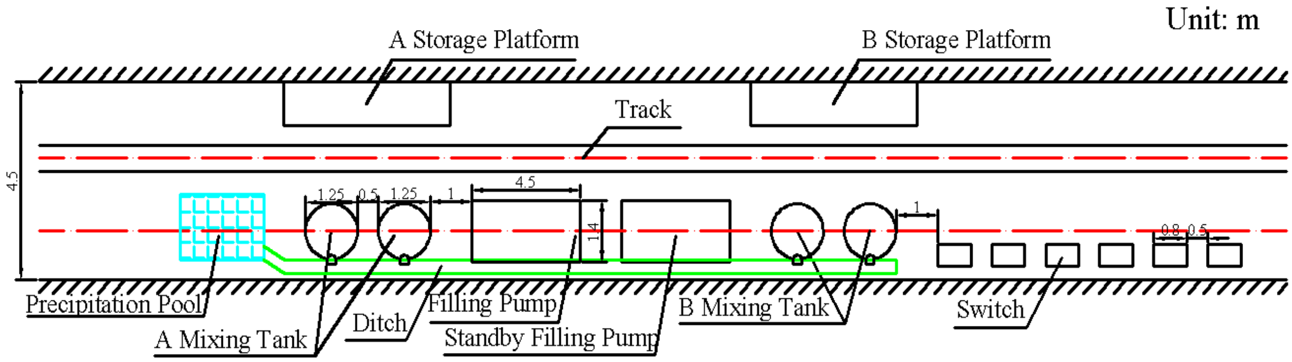

Figure 1: Schematic diagram of equipment layout in filling chamber.

3.2 Control of the stability of the filling body

According to field observation, the average dip angle of three (3) coal 12011 working face is 9°; however, parts of the area have a larger angle. There is a step between the roof and the floor with a height of 1.3 m. The filling body was placed along the angular surface with a large angle. In order to prevent the lateral deformation of the filling body, which leads to instability affected by the load from the goaf side or affected by the force from the side of the working face and the roof, an anchor bolt was placed in the filling body. The anchor bolt has two thread ends of sizes Φ 18 mm × L 3400 mm. After the shaping of the filling body and dismantling the basic template with dimensions of 2400 mm × 200 mm × 30 mm and dismantling the front template with dimensions of 3200 mm × 200 mm × 30 mm, the anchor bolt was fixed with light steel tape, which is suitable for roadway support at both ends. The nut and tray has dimensions of 300 mm × 250 mm × 50 mm. This too, enhances the strength and stability of the filling body. Results from the field application showed that the resistance of the anchor bolt improved the overall strength and stability of the filling body significantly, and the effect of reinforcement became obvious. Figure 2 is a schematic diagram of the roadway beside the filling support.

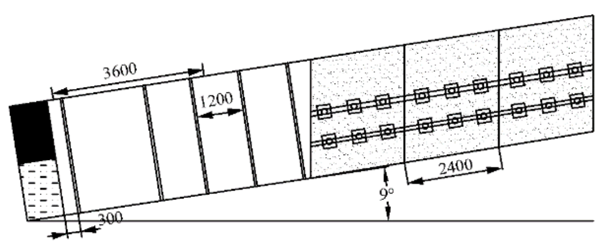

Figure 2: Schematic diagram of roadway beside the filling support.

3.3 Reinforce support of gob-side entry retaining

The crisp surrounding rock in three (3) coal 12011 machine roadway and the significant roof caving resulted from the tunneling process resulted in an ultrahigh roadway segment of 30 m length by 3.4 m to 6.0 m height. Because the roadway was subjected to a blasting vibration influence before implementation of the gob-side entry retaining, the degree of surrounding rock fracture in this part was further increased, and the ultrahigh segment became the most difficult area in gob-side entry retaining. In view of this situation, the reinforced support of the roof of roadway and the east side of the coal wall was decided to be implemented before the working face, 50 m in front of the retained roadway. In the original position between the two rows of anchor bolts, 2 anchor cables were added in the middle of the east side of the roadway, and the anchor cable used the steel strand with dimensions Φ 18 mm × L 5000 mm. The row spacing was 1.4 m and the column spacing was 1.5 m. At the same time, the flange beam was used to connect the anchor cable along the vertical direction, to form the structure that consisted of cables and beams to limit wall caving. At the bottom, from the 3.0 m baseboard, at an oblique upward angle of 5° to 10°, one steel strand cable was set, the size of which was Φ 18 mm × L 5000 mm. Two parts of it were fixed with the tray, the dimensions of which were 350 mm × 350 mm × 10 mm. Then, depending on the distance between the anchor cable hole and roadway floor, two or three anchors were set under the anchor cable. To ensure enough supporting force and the integrity of the coal wall, the spacing of anchors was not more than 800 mm. The spacing between the anchor bolt and the anchor cable was not more than 1000 mm, and the spacing between adjacent two rows of reinforce support was not more than 1.6 m.

4. ANALYSIS ON THE EFFECT OF MINE PRESSURE OBSERVATION AND GOB-SIDE ENTRY RETAINING

For this study, many measured control points were set. On these points, single cross wiring method was used to measure the surface displacement of the

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roadway. Beside the roof and bottom of filling body there were set control points forming a baseline along the vertical direction. On the middle of the filling body, a transverse steel pole was installed in advance. Its exposed end was fixed, then a tape measure was used to measure the distance between the two base points and the variable length of the exposed end. The change of displacement over time of the roadway at various locations is shown in Table 2.

From Table 2, it was concluded that the maximum and the average displacement of roof and floor were 239 mm and 222 mm. The maximum and the average displacement of the roadway's sides were 255 mm and 212 mm. The maximum and the average displacement of the filling body were 136 mm and 100.5 mm. The maximum contraction percentage of roadway section was 14.49%, and the average contraction percentage of roadway section was 13.38%. The effect is better and can meet the requirements of secondary use.

Table 2**:** Summary of roadway section contraction percentage.

survey section	roof and floor		roadway's sides		filling body		contraction rate of section
	the displacement (mm)	the average displacement rate (mm/d)	the displacement (mm)	the average displacement rate (mm/d)	the displacement (mm)	the average displacement rate (mm/d)	
16#	222	6.94	229	7.16	100	3.12	13.77%
17#	207	6.27	243	7.36	109	3.30	13.55%
18#	214	6.48	255	7.5	136	4	14.08%
39#	230	6.97	227	7.09	112	3.5	14.02%
40#	214	6.11	241	7.09	103	3.12	13.76%
41#	228	6.33	251	7.17	101	2.97	14.49%
58#	202	6.73	174	5.8	92	3.07	11.78%
59#	224	7.22	188	6.06	96	3.10	12.91%
60#	239	7.47	208	6.5	96	3	13.91%
83#	217	7	167	5.06	96	2.91	12.17%
84#	235	7.34	178	5.23	85	2.5	13.09%
85#	228	6.91	185	5.29	83	2.37	12.99%
average	222	6.81	212	6.44	100.5	3.08	13.38%

Compared with digging a new roadway, gob-side entry retaining can increase the profits by 5688.5 yuan per meter; as opposed to gob-side entry driving, gob-side entry retaining reduces the excavation work significantly, cuts down the work time, alleviates tensions of excavation-replacement, prevents fire disaster, extends the service-life of mines, and improves indirect profits by 9.86 million yuan. To summarize, it results in substantial economic as well as social benefits.

5. CONCLUSION

This study adopted the new mine-fill whose water cement ratio is 1.8:1. The size (length × width × height) of rectangular filling bag was 2400 mm × 3000 mm × 2600 mm, and the size of anchor bolts which were imbedded in the filling body were Φ 18 mm × L3400 mm. Moreover, the supplementary support, which consisted of anchor bolts, wire rope, and steel beams, was used to ensure the stability of the lateral supporting force in the roadway, which had a crisp and dry coal seam. It was impacted by blasting work, and had ultrahigh height, with the size of wire rope being Φ 18 mm × L 5000 mm. These measures restricted the displacement of the coal wall, and improved overall strength and stability of the filling body.

The result of the mine pressure observation survey showed that the maximum of roadway section contraction percentage was 14.49%, and the average roadway section contraction percentage was 13.38%. The effect of gob-side entry retaining netted marked improvement and demonstrably met the requirements of secondary use.

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7. REFERENCES

Bai J. (2006).Surrounding Rock Control of Entry Driven along Goaf. Xuzhou, 171p

Bai J., Zhou H., Hou C., Tu X., and Yue D. (2004).Development of support technology beside roadway in goaf-side entry retaining for next sublevel. Journal of China University of Mining and Technology. Volume 33, pp.183-186

Bu T., Feng G., and Jia K.(2010).Gateway Side Backfilling Support Technology of Goaf Side Gateway in Fully Mechanized High Cutting Longwall Mining Face. Coal Science and Technology. Volume 38, pp.41-44

Chen Y., Bai J., and WANG X. (2012). Support technology research and application inside roadway of gob-side entry retaining. Journal of China Coal Society. Volume 37, pp.903-910

He T. (2012).The breaking place prediction of face end main roof flap top in the gob-side entry retaining. Journal of China Coal Society. Volume 25, pp.28-31

Hua X.，Ma J., and Xu T. (2005).Study on controlling mechanism of surrounding rock of gob-side entry with combination of roadside reinforced cable supporting and roadway bolt supporting and its application. Chinese Journal of Rock Mechanics and Engineering. Volume 24, pp.2107-2112

Hua X., Zhao S., and Zhu H. (2006) .Research on combined support technique of gob-side entry retaining. Rock and Soil Mechanics. Volume 27, pp.2225-2228

Ju F., Sun Q., and Huang P. (2014).Study on technology of gob-side entry retaining in thin seam surrounded by soft roof and floor. Journal of Mining and Safety Engineering. Volume 31, pp.914-919

Li J., Feng G., and Ning S. (2009).The technology and application of roadside supporting for gob-side entry retaining in full-mechanized mining. China Mining Magazine. Volume 18, pp.77-79

Qian M., Shi W., and Xu J. (2010).Mining pressure and strata control. Xuzhou, 374p

Tang J., Hu H., and Tu X.（2010）.Experimental on roadside packing gob-side entry retaining for ordinary concrete. Journal of China Coal Society. Volume 35, pp.1426-1429

Xie W., Da J., and Feng G. (2004).Mechanism of controlling surrounding rock around gob-side entry retaining in top-coal caving mining face. Journal of Central South University (Science and Technology), Volume 35, pp. 657-661

Xu J., Zhu W., and Li X. (2006).Study of the Technology of Partial-Filling to Control Coal Mining Subsidence. Journal of Mining and Safety Engineering, Volume 2, pp.6-11

Zhang D., Miao X., and Mao X. (2001).Simulation on Roof Activities of Gob-Side Entry Retaining in Fully-Mechanized Top-Coal Caving Faces. Journal of China University of Mining and Technology. Volume 30, pp.261-264