Experimental study on material performance of separation grouting for prevention of rock burst

IOP Conf. Series: Materials Science and Engineering **587** (2019) 012009 doi:10.1088/1757-899X/587/1/012009

Experimental study on material performance of separation grouting for prevention of rock burst

Zhangliang Chen*, Junwei Shi, Binbin Zheng

School of Management Science And Engineering, Shandong Institute of Business And Technology, Yantai, China

*Corresponding author and e-mail: Zhangliang Chen, chenzhl_yt@126.com

Abstract. The purpose of this study is to obtain the optimal proportion of the full tailings cement filling, reduce the filling cost of the mine and ensure the stability of the empty area. Taking the whole tailings cemented backing block as the research object, the uniaxial compressive strength of the test block as the index, the filling body is investigated comprehensively. The influencing factors of strength were studied by orthogonal experiment, and the sensitivity and significance of the influence factors of the filling body strength were analyzed by using the range and variance analysis methods. The results show that, when cement content is increased, paste setting time is shorten and paste strength is enhanced; proper quantity of fly ash can improve the liquidity of paste, while degree of segregation and bleeding rate of paste are increased with the increase of fly ash; When cement ratio is 20% and the rate of fly ash: coal gangue is 1: 4 and the concentration of the paste is 75%, the pumpability and strength of paste is the best.

1. Introduction

Impact rock pressure refers to the dynamic phenomenon of sudden strong damage caused by the elastic deformation energy released by the rock mass around the mine roadway or working face. The occurrence of impact ground pressure is often accompanied by the throwing of coal rock mass. Huge sounds and impacts such as air waves [1], impact ground pressure has the characteristics of "strong disturbance" and "strong aging", which is a typical power disaster in coal mining. At present, fly ash tends to be cement clinker in construction engineering. Other auxiliary active materials are used together to produce cement and formulated concrete, but there are few applications in coal mining cementation filling method. Therefore, the author proposes green cement filling material based on fly ash-gangue. The research uses a fly ash-cement-desulfurization gypsum composite gelling system with fly ash as the main component, the original fly ash and the crushed coal gangue as the aggregate, and the orthogonal test design method is used for material mix ratio. Optimized design, strive to maximize the use of fly ash, desulfurization gypsum and other industrial waste to replace cement for cementation filling, for the preparation and promotion of high-quality low-cost cementation filling materials to make a useful exploration.

2. Experimental study on optimization of proportion of vermiculite cement filling materials

At present, the most effective way to control the surface subsidence of coal mining is filling and overburden grouting. In terms of filling and mining, the investment cost of filling pipeline system,

filling equipment and filling materials is too high [2]. Therefore, the overburden grouting technology is getting more and more attention, especially at the current stage of China's coal industry. Under the grim situation of overall profit decline. The separation grouting technology also has two problems to be solved: First, due to the influence of mining, the overburden movement is a dynamic process, and the height and width of the separation layer are constantly changing with the mining. Therefore, The location and timing of layer grouting are difficult to grasp. Once the mining is separated, the grouting work cannot be continued. This reduces the total grouting and does not achieve the desired effect in controlling surface deformation [3]. Second, the grouting material is generally made of fly ash. The mortar mixed with water, and the cementing ability of fly ash is weak. Once the mortar loses water in the layer, the consolidated fly ash is difficult to ensure sufficient strength to limit the movement of the overburden and control the deformation of the surface. Third, the water-cement ratio of the leaved grouting material is generally 2:1, and the water content is about 70%. After the fly ash in the separated zone is dehydrated, so much water will enter the stop face through the crack zone. The working surface environment has an adverse effect and even the danger of flooding.

2.1. Project overview

Study area is selected Hua Feng mine 1410 working face, the mining as deep as 1140m, coal seam thickness of the overlying thick conglomerate of 400 ~ 800 meters. Under the influence of mining activities, the thick conglomerate layer (about 800m)fracture movement makes the frequency and intensity of rock bursts occurred in rising, which threaten to the safety of the miners. The working face is located in the mid-eastern of the field, and coal group second segment before the first mining area of a -1100m level, the high limit and the low limit were -840m and -920m respectively, and working face from west to east on mining, for 1409 fully-mechanized caving goaf, next to un-mined 1411 working face. The main mining coal seam in 4# in this area for the structure is relatively simple thick coal seam, thickness in 5.6 ~ 6.9 m, 6.2 m on average [4]. The main mining coal seam in 4# has serious impact tendency, which has been in more than one face repeatedly impact ground pressure. Thick conglomerate layer of covering above the mining field (about 800m) integrity is stronger. The movement of thick conglomerate and multilayer cantilever beam, which will produce the markings in the surface subsidence, and has enormous influence on farmland, riverbed and buildings.

2.2. Material composition of the model

Similar materials mainly include two aspects of raw materials, padding (or the aggregate) and cement. Normally, Padding uses river sand, mica powder, talc, etc., and cement includes gypsum, paraffin, calcium carbonate, cement, etc. For simulation of the overlying stratum movement, the experiment of similar material cement is plaster, meanwhile, adding calcium carbonate to increase its strength. The padding is river sand, and scatters mica powder between each layer that play a part in layering [5]. The difference with mock object and ratio, can be realized by different ratio of similar materials [6].

The choice of filling materials must follow two principles: first, the source is extensive; second, the cost is lower. In this test, the fly ash of the power plant of Xinzhuang Coal Mine was selected as the fine aggregate, the specific surface area was 750 m2/kg, the residual amount of 0.045mm square hole sieve (the original gray scale) was 58%, and the standard consistency water demand ratio was 135%. Desulfurization gypsum and 325 ordinary Portland cement clinker are mixed as a composite cementitious material in a ratio of 2:1; the coarse aggregate is a secondary crushed coal gangue in Xinzhuang Coal Mine, the water absorption rate is 6%, and the crushing index is 13.2%. The determination of the particle size grading of coal gangue was carried out by randomly sampling the vermiculite (particle size $\leqslant$ 25 mm) before the secondary crushing and mixing in the Xinzhuang Coal Mine. The test selected 10 square holes with a hole diameter of 25mm, 20mm, 16mm, 13.2mm, 9.5mm, 5mm, 1mm, 0.3mm, 0.1mm, 0.075mm, etc., to screen the coal gangue, and record each time. Screening allowance, and calculate the percentage of sieves with different particle size.

2.3. Similar models production and excavation

The experiment in Huafeng coal mine, xinwen mining bureau 1410 working face.conditions of enclosing,rock for the prototype, making a two-dimensional model. Model constituted by the coal seam,floor,and overlying strata. This experiment adopts similitude simulation test-bed systems, consisted of frame system, loading system and test systems. Framework specification for 2m*0.2m*2m, based on similar criteria,and geosim is 1:200.According to the overburden failure theory, model height should be greater than half of the mining areas. According to the analysis of the geological data, model runs up to 17 layers, and height of 1.46 m, and scattering mica powder between each layer that play a part in layering.Top model adopts hydraulic system through the joist steel of the uniform load(Q = 15.22 MP,r=0.025MN/m^3). Coal seam excavation along the tunneling of the coal floor, every time moves the 5cm, equivalent to the actual propulsion 10m at a time. According to similar principles and total of excavation of 15cm a day, equivalent to the actual mining 30m.Model ends retain the 40m boundary pillar in order to eliminate the influence of boundary conditions.

3. Grouting method for sac-type separated layer grouting material for controlling surface subsidence

3.1. Filling material grouting process

(1) Preparation for construction: the site is leveled, and the positions of several grouting holes are staked, and the spacing between adjacent grouting holes is 10~30m;

(2) drilling: drilling the grouting hole to a design depth, the opening diameter of the grouting hole is 240~300mm, and the inclination of the grouting hole is less than 1%;

(3) Grouting pipe and bag making: the length of the grouting pipe is larger than the designed depth of the hole 400~600mm; the upper end of the grouting pipe is provided with a grouting pipe elbow, and the grouting pipe elbow is connected with the high-pressure rubber a plurality of grouting holes in the shape of a plum blossom are arranged at a distance of 300 to 400 mm from the lower end of the grouting pipe, and a rubber valve plug is used at the lower end of the grouting pipe to seal the bottom; the diameter of the bag is 500~ 600mm, the length is 600~700mm more than the drilling design depth;

(4) the grouting tube and the pouch are tied, the lower hole: the pouch is first sleeved from the bottom to the outside of the grouting tube, the bottom of the pouch is fastened with a thin wire, and then the pouch is The bottom end of the bag is folded back 250~300mm, and then fastened with fine wire 19; from the bottom end of the bag, every 0.8~1.2m, the bag is tied with the rubber band or 18 wire. On the slurry pipe, at the uppermost end of the bag, the rubber collar is fastened to ensure that the plastic collar can slide relative to the grouting pipe, and the upper end of the grouting pipe protrudes above the ground by more than 500 mm; After the grouting hole is cleaned, the grouting pipe to which the pouch is attached is slowly placed into the grouting hole, and when the pouch reaches the design height, the lowering is stopped;

(5) Mixing and grouting: the cement, fly ash, admixture and mine drainage slurry stirred in the mixing tank enters the high pressure grouting pump, and the ground is pushed by the high pressure grouting pump a pumping pipe, the high pressure rubber hose, the grouting pipe elbow and the grouting pipe inject slurry into the bladder, during which time a pressure gauge of the high pressure grouting pump is used to ensure The grouting pressure is 0.4~0.6 MPa, and the flow rate of the grouting is controlled by the electromagnetic flowmeter on the ground pumping pipeline to be 50-65L/min; the bottom-up grouting is to be injected into the upper section of the pouch. After the slurry is designed to the amount of pulp, the next section can be grouted;

(6) Pulling the slurry pipe: after the bag grouting amount reaches the design requirement, and when the grouting amount and the grouting pressure are substantially the same as the design requirements, the bag bag has fully expanded to expand the bag, The grouting pipe is slowly pulled out, and the speed of pulling the grouting pipe is controlled at 0.5~0. 8m/min, and the grouting pressure is maintained at 0.4~0.6 MPa; after the grouting pipe is completely pulled out, Backfill the upper hole with sand and gravel, and compact the ground vibration;

(7) Flush the grouting tube and move to the next hole for the next cycle.

3.2. Advantages of grouting materials

(1) The time of grouting in the layer can be flexibly controlled. In the early stage of coal seam mining, the pocket-like grouting reinforcement can be carried out under the key layer which is easy to produce, which is not affected by the dynamic change of the separation space in the mining. .

(2) Different from the traditional separation grouting process, the bag-type separation layer grouting method of the present invention is actually a separation layer reinforcement process, which performs lateral extrusion and longitudinal reinforcement on the separation layer under the key layer. The soft rock layer in the separation zone has certain bending, shearing and compressive strength, and the traditional passive post-separation grouting is the active separation of the layer, which fundamentally limits the development of the separation layer and ensures that the key layer is not Will break, to achieve the purpose of controlling the surface subsidence.

(3) Through the isolation of the bladder, the slurry will not leak, spread to the working surface through the crack, and pollute the environment.

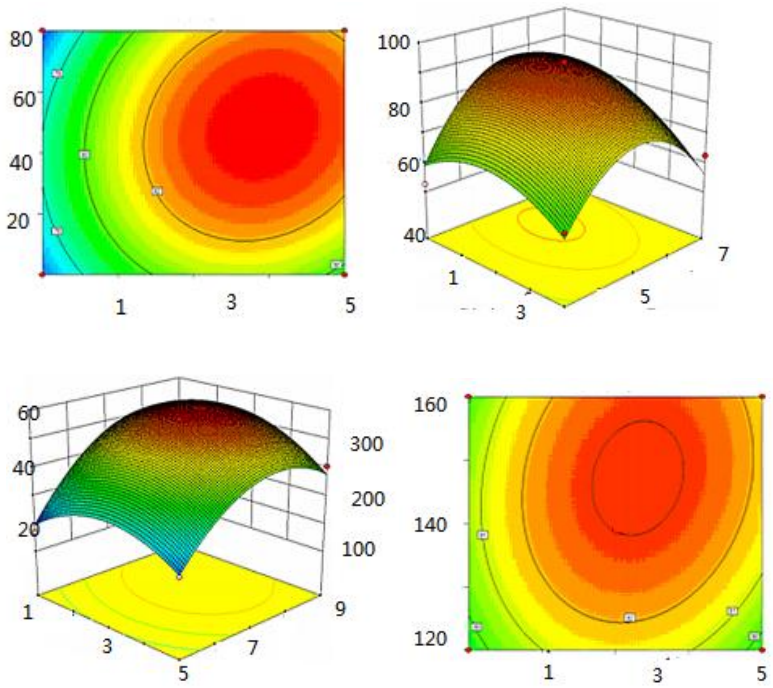

Figure 1. Response surfaces of A and B and C to any two significant influential factors

3.3. Grouting material performance evaluation

After the grouting is completed, part of the grouting material is taken for laboratory testing, and the setting time, slumping degree, stratification degree and bleeding rate are measured and recorded. Three sets of experiments are carried out and three tests are carried out in each set of tests. The size of the block and the test block is (150.0 × 150.0 × 150.0) mm3. After demoulding, it is cured in a constant temperature curing box with a curing temperature of 22 ° C and a humidity of 85%. After 28 days of maintenance, after the specified age, the large test piece is demolded, and the large sample module is cored and polished by using the test sample processing equipment (AHM-200) and cutting machine (DQ-4). Since the rock mechanics test specification stipulates that the standard rock sample is a cylindrical shape of 50mm*100mm, this time adopts a 50mm drill bit (inner diameter 50mm, that is, the core diameter is 50mm) to take the core, and finally the YAW-400 type pressure testing machine is used to measure the single. The axial compressive strength, the average of each set of experimental results is shown in Table 1.

Table 1 Grouting material performance evaluation form

Index / Number	Setting time/h	Slump/cm	Stratification/mm	Bleeding rate/%	Compressive strength/MPa	
					8h	28d
S1	3.1	23.7	15.0	1.9	0.67	3.84
S2	2.8	22.3	11.0	1.5	0.85	4.27
S3	2.5	21.6	13.0	1.4	0.84	5.1

4. Conclusions

This paper provides a bag-type separation layer grouting material for controlling surface subsidence, which is prepared from the following components by weight ratio: cement, fly ash, water and admixture, wherein the water-cement ratio is 0.7-0.8. Fly ash: cement is 0.8~0.9, and admixtures account for 3%~5% of the total. The bag type separation layer grouting material of the invention has good pumpability, low bleeding rate and stratification degree, short coagulation time, high strength and stability, less grouting amount, and total single grouting It is about 13m3 and the material cost is low. The invention also provides a preparation method and a grouting method for the above-mentioned bag type separation layer grouting material, the preparation method is simple in operation and low in cost; the grouting method can be flexibly controlled by the layer grouting time, and fundamentally Limit the development of the separation layer, ensure that the key layer will not break, and achieve the purpose of controlling the surface subsidence. Through the isolation of the capsular bag, the slurry will not leak and pollute the environment.

Acknowledgement

This research was financially supported by Study on Physical and Mechanical Properties of High Thickened Tailings during Upstream Dam Filling of National Natural Science Foundation Project(Grant NO.51804178), Teaching Reform Project of Shandong Business School: A Study on Hybrid Teaching Model and Evaluation System Based on Application-oriented Talent Cultivation (Grant NO. 1168G201701) and Shandong Natural Science Foundation: Research on enterprise informatization introduction mode and enterprise value increment oriented to supply and demand network(Grant NO. ZR2012GM003).

References

[1] F K CHENG, J P YAN, T Y FAN, et al. Research on optimizing operation parameters for leaching chlorophyll-a of landscape water based on orthogonal experiments[J]. Ecological Science, 2014, 33(6): 1085-1090. (In Chinese)

[2] L M DOU.J L XU,C P LU. The abscission grouting control rock burst risk mechanism's discussion[J]. Journal of China University of Mining and Technology,2004,33(2):145 – 149. (In Chinese)
[3] JAMES C N, CHENG Wenchieh. G rout efficiency of lifting structure in soft clay [J] . ASCE, 2009.
[4] J W SHI, Z J WEI , Q L LIU. Research on Proportion Optimizing of Paste Filling Material Based on Orthogonal Experiment in Coal Mine [J]. Journal of China University of Mining and Technology, 2011, 21(6): 112-115. (In Chinese)
[5] Palomo A, Fernandez-Jimenez A, Criado M. Microstructure development of alkali- activated fly ash cement: a descriptive model [J]. Cement and Concrete Research, 2005(35):1204-1209.
[6] Huynh L, Beattie D A, Fornasiero D, etal. Effect of Poly phosphate and Naphthalene Sulfonate form aldehyde Condensate on the Rheological Properties of Dewatered Tailings and Cemented Paste backfill[J]. Minerals Engineering, 2006, 9(1):28-36.