International Journal of Mining Science and Technology 27 (2017) 669–673

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Coal and gas outburst prevention using new high water content cement slurry for injection into the coal seam

Zhou Peiling, Zhang Yinghua, Huang Zhi'an *, Gao Yukun, Wang Hui, Luo Qiang

State Key Laboratory of High-Efficient Mining and Safety of Metal Mines, University of Science and Technology Beijing, Ministry of Education, Beijing 100083, China

ARTICLE INFO

Article history:
Received 1 October 2016
Received in revised form 9 December 2016
Accepted 18 January 2017
Available online 19 May 2017

Keywords:
Gas outburst
Setting liquid
Reinforce coal
High-water solidified materials
Rapid setting and early strength cement
Retarder

ABSTRACT

As coal and gas outburst is one of the most serious mine disasters, it is very important to at least control it if not prevent it from occurring. Injecting cement slurry or grouting into the coal seam can strengthen the seam, increase its rigidity coefficient (*f*), and reduce the volumetric expansion due to gas energy release. This paper reports the results of laboratory experiments on cement-based high water content slurry having different water-cement ratios (W/C) to be used for coal injection. The results show that as the W/C increases, the mobility of the slurry and its setting time increase. The compressive strength and rupture strength, however, are reduced. Furthermore, high W/C grout shows early strength after 7 days, which can be 80% of its 14-day compressive strength. To achieve rapid setting and early strength, the addition of Na_2SiO_3 has proven to give the best result, when the concentration of the additive is 3%. The initial and final setting times are 13 and 21 min shorter than samples without Na_2SiO_3, while the compressive strength is more than double. As a retarder, the initial setting time can be extended to 83 min when tartaric acid of 0.4% concentration is added. Through the orthogonal experiment, the optimum recipe of the new high water content slurry has been determined to be: W/C = 2, tartaric acid = 0.2%, Na_2SiO_3 = 3%, and 12% bentonite. Reinforcement by injection simulation experiments show that the grouting radius of the new slurry mix is 250 mm when the applied grouting pressure is 60 kPa, 7-day rupture strength and compressive strength are 5.2 and 6.4 MPa, respectively, and are 37% and 88% higher than ordinary cement grout. It can be concluded that the newly developed slurry mix is more effective than the ordinary mix for reinforcing coal and controlling gas outburst.

1. Introduction

Gas outburst is one of the natural disasters that threaten the safety of coal mine [1,2]. Forming coal sample simulation results show that, the stress and gas pressure are the source of gas outburst, and the strength of coal is the resistance, thus, gas outburst can be prevented by enhancing the strength of the coal seam [3–5].

To reinforce coal, grout injection into coal, which can infiltrate into the pores of the coal, is carried out [6]. The studies of grout setting slurry by domestic and foreign scholars show that cement grout has positive effects on the control of gas outbursts. The use of grout injection leads to lower seam permeability and greater consolidation strength [7–9]. High water content grout is a new type of cement slurry, whose water cement ratio can be as high as 3:1, thus enabling good flow and permeation resulting in high strength coal [10–12]. Elimination of gas outburst using high water content cement slutty has been demonstrated by experiments by Zhang et al. [13,14]. Once the cement slurry has cured, the strength coefficient *f* of the coal seam was significantly increased, and ΔP decreased from 35.5 to 2 [15,16]. Nevertheless, the performance of the new slurry is still not ideal. Thus by exploring the use of additives to the basic mix of high water content cement slurry, it is possible to improve the efficiency of the application and enhance the coal strength for gas outbursts control and prevention.

2. Mechanism of coal reinforcement and gas outburst elimination

When injecting grout slurry into coal, the slurry will infiltrate into the pores of the coal while pushing the gas out; partially adsorbed gas is driven out of the grouted coal seam. On the other hand, the coal seam becomes cemented together, which closes the passage to future gas desorption. At the same time, the water prolapsed by the solidification process will occupy small pores, thus closing gas desorption passage with capillary force. This will

* Corresponding author.
E-mail address: huang_za@qq.com (Z. Huang).

http://dx.doi.org/10.1016/j.ijmst.2017.05.003
2095-2686/

prevent free gas from release by adsorption, thus reducing the amount of free gas and decreasing gas desorption rate [13,14,17].

3. New high-water content solidified grout to eliminate outburst

The key to the method of reinforcing coal and eliminating gas outburst is the development of a high water content slurry that is capable of setting and solidification. To conform to the special environment of a coal mine and the requirements of grouting, the setting slurry must have low viscosity to enable good fluidity and penetration into small pores. High water content grout is a new type of special cement grout mix, which is made up of component A and component B. The component A is sulphate-aluminate cement clinker and the component B is gesso and lime. Powder forms of components A and B mixed together with water, result in rapidly setting material through physical and chemical reactions [18].

3.1. Experimental materials

The experimental materials mainly including: sulphate-aluminate cement clinker, deflocculant, retarder, rapid setting and early strength cement, and coal powder. And the retarder refers to calcium lignosulfonate and tartaric acid, and the early strength cement refers to sodium silicate, triethanolamine, sodium chloride and sodium aluminate.

3.2. Methods and instruments

The experimental tests carried out include material mobility, viscosity, syneresis rate, stability, setting time, compressive strength, and tensile strength. The main instruments used are NJ-160B cement paste mixer, NDJ-5S digital rotary viscometer, setting time standards detector, 40 mm × 40 mm × 160 mm testing module, digital hydraulic pressure testing machine, and HBY-40B standard curing box.

3.3. Results and discussion

First, the effect of water cement ratio (W/C) on the properties of high water content material is examined. The W/C can be as high as 3:1, which benefits mobility, but affects early strength. The

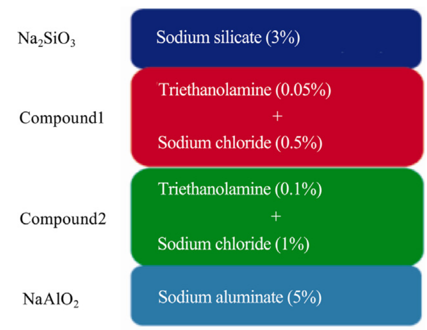

Fig. 2. Specific additives and their concentration for rapid setting and early strength development.

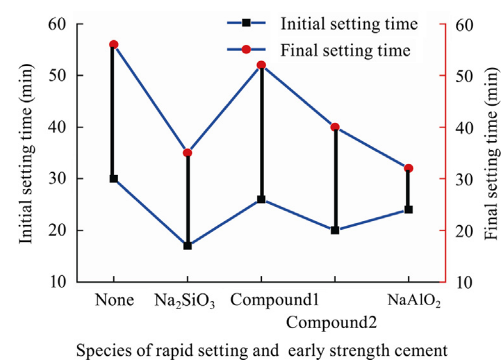

Fig. 3. Effect of additives on setting time.

Table 1
Effect of W/C on viscosity and setting time.

W/C	Viscosity (mPa·s)		Setting time (min)	
	Component A	Component B	Initial setting time	Final setting time
1.0	817	502	17	24
1.5	60	464	25	50
2	15	316	30	56
2.5	12	86	43	70
3.0	15	50	100	240

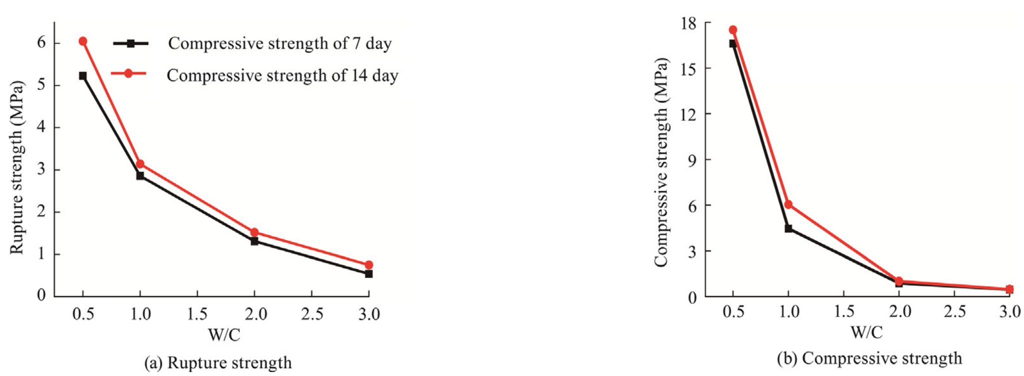

Fig. 1. Strength of 7-day and 14-day under different W/C.