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Field Monitoring Research on the Backfilling Performance of Gangue-Gypsum Paste in Strip Coal Pillars in Coal Mines

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Abstract

The surface movement observation is used to evaluate the filling effect in the past, but its cycle is often longer, cost is higher and amount of labour is larger. To this point, we monitor amount of compression, force, hydration degree of filling body by means of the field monitoring system of paste backfill in the goaf that is developed by ourselves, and evaluate the filling effect. The monitoring results show that the filling body can control overlying strata movement very well because amount of compression is only 104.3mm, compression ratio is only about 5%, which is far less than the theoratic value (10%). Great degree of bending deformation can't occur in the overlying strata, because stress is only 5.1 MPa. Hydration temperation of filling body reach 54℃ and the minimum temperature is still about 50℃after 20 days, which has an influence on the early strength of filling body. Hydration reaction is the most intense on the second day. The field monitoring results has important significance for the spreading of paste filling in coal mine.

Keywords

Gangue backfill paste; field monitoring; stress of filling body; deformation; hydration degree.

1. Introduction

According to incomplete statistics on key coal mines nationwide, China currently has 13.764 billion tons of coal under the "three underground" pressure, 9.468 billion tons of coal under buildings, 2.391 billion tons of coal under railways, and 1.905 billion tons of coal under water bodies, with a further increasing trend [1-3]. According to statistical data from Shandong Province, the amount of coal under buildings in Shandong Province reaches 4.4 billion tons, accounting for 53% of the recoverable reserves. There are 3600 villages in Jining City with thick coal seams, and 564 of them needed to be relocated before 2012. The first mining area of Longgu and Zhaolou mines requires the relocation of 12 and 11 villages in one go.

For a long time, coal mining under buildings in China has mainly adopted methods such as village relocation, strip mining, overburden separation grouting, and paste filling. However, due to the continuous increase in the cost of village relocation [4,5], low resource recovery rate of strip mining, and relatively poor grouting effect of overlying strata separation, its application is gradually decreasing [6-9]. Although paste filling increases the cost per ton of coal, it has a good effect on controlling surface subsidence and will become the main technical approach for China to solve the "three down and one up" coal pressure and achieve green mining [10,11]. However, there are not many reports on the post monitoring of the filling material yet. Therefore, this article mainly relies on the data monitored by the independently developed goaf paste filling online monitoring system to provide a fair evaluation of the stability and filling effect of the filling body.

2. Composition of monitoring system

The online monitoring system for goaf paste filling is built on the hardware platform of "KJ216 Coal Mine Dynamic Monitoring System", and the system composition is shown in Figure 1. The main function of this system is to monitor the compression, stress, and hydration temperature of the filling material in the goaf for a long time.

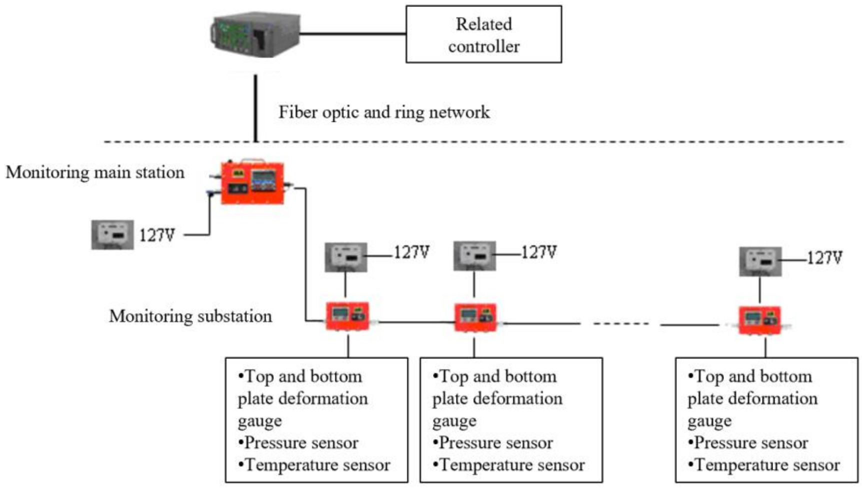

Figure 1. Monitoring system arrangement

The system has been successfully applied in the 2351 paste filling working face of Daizhuang Coal Mine of Zibo Mining Group. The specific engineering geological conditions are as follows: The 2351 paste filling working face of Daizhuang Coal Mine is a strip coal pillar recovery working face in the 2300 mining area, which is the remaining coal pillars mined out on one and two sides. The ground elevation is+36.8~+40.7m, and the bottom plate elevation of the working face is -280.68~-435.5m. Located in the northwest part of the west wing of the -410 level tape mountain. The net coal pillar of the belt groove on the northeast side and 2302 working face is 5.0m, the net coal pillar of the track groove on the southwest side and 2303 working face is 5.0m, and the net coal pillar of the cut eye and 1339 working face is 30m. Located 150m south of the -485 auxiliary horizontal water tank, this is the first paste filling mining face of the mine, and most of the coal seams on the three adjacent sides of the face have already been mined. The 2351 filling working face has a length of 100m, a strike length of 1074m, and a coal seam dip angle of 0-13 °, with an average of 5 °. The mining height ranges from 1.80 to 3.10m, with an average of 2.65m. The coal seam structure is simple.

3. Monitoring plan

The original plan is to arrange three measuring lines, each measuring line is arranged with three measuring points, and the spacing between the three measuring lines is 50m. The three measuring points are located at the upper, middle and lower parts of the working face, and the spacing between the measuring points is 30m. In the actual installation process, the original design plan is adjusted according to the specific conditions of the top and bottom plates. The first batch of equipment failed because the impact of high temperature, high pressure and hydration on the site was not taken into account during the first installation, so the original three measuring lines were increased to four. The roof condition of the working face during installation was not absolute 50m, but flexible treatment according to the actual situation. The final installation scheme is shown in Figure 2.

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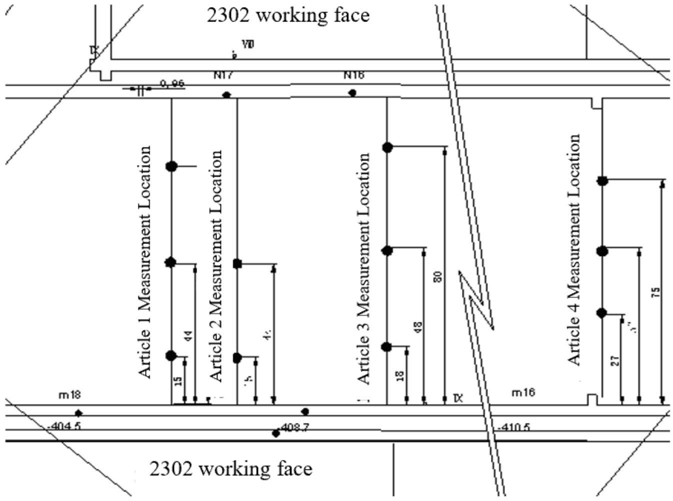

Figure 2. Monitoring location

4. Analysis of monitoring results

From August 8, 2010 to May 20, 2011, a large amount of data was obtained through long-term online monitoring of the filling material, and some of the data is now taken for analysis.

4.1. Compression amount of filling material

Taking the relationship curve between the compression amount of the paste and the cumulative pushing distance of the working face, which is plotted based on the data monitored by the 107L # (32 units) and 108L # (12 units) roof subsidence monitoring instruments located in the middle of the third measuring line (see Figure 3), as an example for analysis.

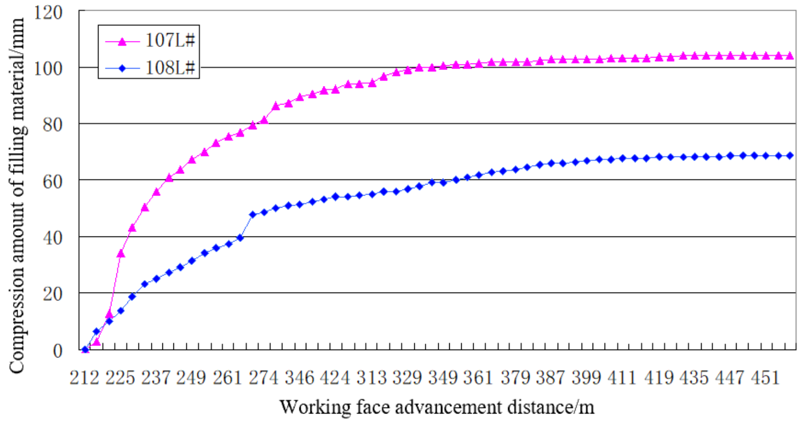

Figure 3. Curve between amount of compression and face advanced distance

From Figure 3, it can be seen that the compression amount of the paste gradually increases with the advancement of the working face and tends to stabilize. The compression amount of the paste in the middle of the working face is greater than that at the upper and lower ends of the working face. This is consistent with the movement pattern of the overlying rock layers. The maximum compression of the final filling material is basically maintained at around 104.3mm, with a compression rate of 3.85%, which is much lower than the theoretical expected amount of 10%. It can be seen that the filling material has a good effect on controlling the movement of overlying rock layers.

4.2. The force on the filling body

Taking the data obtained from the monitoring of pressure boxes 014Y # (32 units) and 015Y # (12 units) located in the middle of the third measuring line as an example for analysis. The relationship curve between the force on the paste and the advancement of the working face is shown in Figure 4.

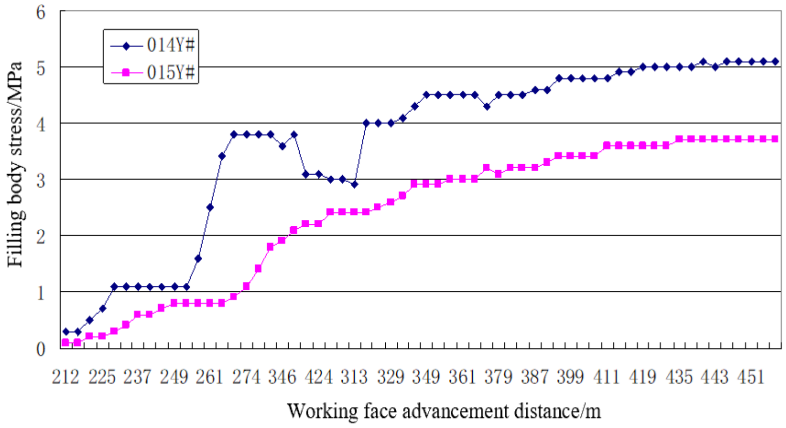

Figure 4. Curve between load of the filling body and face advanced distance

From Figure 4, it can be observed that as the working face advances, the force on the filling body gradually increases, which is consistent with the movement law of the overlying rock layer. It can also be found that the maximum pressure on the filling body is basically around 5.1 MPa, and the force on the upper and lower ends of the filling body is smaller than that in the middle of the filling body, indicating that the overall pressure is not high. The bending deformation of the upper overlying rock is very small, and the filling material has a good effect on controlling the movement of the overlying rock layer. The filling material can maintain its long-term stability.

4.3. Hydration process of filling material

It is difficult to monitor the hydration process of the filling material through component analysis, and one external manifestation of the hydration reaction is the change in the temperature of the filling material. This can be used to monitor the hydration process of the filling material. Taking the data monitored by the 216M # paste temperature monitor on the fourth measuring line as an example, the hydration process of the filling material is analyzed. The temperature variation curve of the filling material over time is shown in Figure 5.

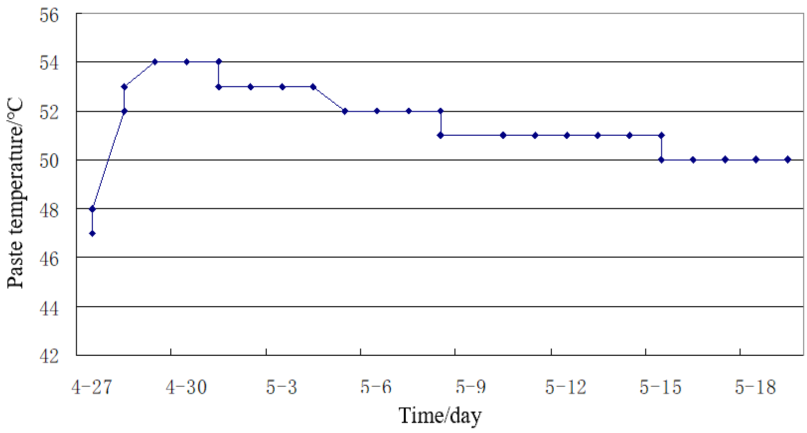

Figure 5. Curve between temperature of the filling body and time

From Figure 5, it can be observed that the temperature of the filling material rises rapidly in the initial stage, reaching a maximum temperature of 54℃ on the second day. The early hydration reaction of the filling material is relatively strong, and the hydration reaction is basically completed on the second day, indicating that the early strength of the filling material increases rapidly. This is of great significance for shortening the cycle time and improving the production capacity of the filling working face.

5. Conclusion

Long term monitoring of the goaf filling material was carried out using an independently developed online monitoring system, and the monitoring results showed that:

(1) The final compression amount of the filling body is 104.3mm, with a compression rate of about 4%, which effectively controls the movement of the overlying rock layers.

(2) The overall force on the filling body is not significant, with the maximum force maintained at around 5.1 MPa. The overlying rock layer only undergoes minor bending deformation, and the filling body can maintain long-term stability.

(3) The highest hydration temperature of the filling material reaches 54℃, and the hydration rate reaches its fastest on the second day. This shows that the strength of the filling material increases rapidly, which is of great benefit to improving the production capacity of the filling working face.

Acknowledgments

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