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Site Monitoring of Gangue Backfill Paste Performance of Filling Replacement Mining the Strip Coal Pillar

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ABSTRACT

Normally, the filling effect is evaluated by means of surface movement observation with longer period, higher cost and more labor. To this point, on-line monitoring system of filling body performance is developed. We assess filling effect through monitoring filling body compression, force of filling body and hydration process. The monitoring results show that the compression and force of filling body located at the middle of working face is larger than that located at both ends. The compression of filling body located at the middle of working face is 104.3mm and its compression ratio is 3.85%. The force of filling body located at the middle of working face is 5.1MPa. The monitoring results show that the aggregate gradation, density and anti-compression properties of gangue backfill paste are good. The range of overburden strata affected by mining is small. The filling body can control the movement of overburden strata effectively. The maximum temperature of filling body is 54℃. The practical temperature of filling body is far above the curing temperature (20℃) in mixing proportion test, which will benefit the early strength of gangue backfill paste. This is very important for shortening solidification time and increasing productivity of filling working face.

KEYWORDS: gangue backfill paste; on-line monitoring; stress of filling body; amount of compression; hydration process

INTRODUCTION

According to incomplete statistics of key coal mines across the country, the amount of coal seam under water, railway and building are 137.64×10^8t with a further trend of increasing, including 94.68×10^8t under building, 23.91×10^8t under railway and 19.05×10^8t under water[1]. According to the statistical information of Shandong Province in China, the amount of coal seam under building is 44×10^8t, which equals 53% of recoverable reserves. Only in Jining, there are 3600 villages that are above thick coal seam is 3600 and the number of village that have to relocate is 564 before 2012. If you mine the first mining area of Longgu and Zhaolou Coal Mine, the number of village that have to relocate in each coal mine is 12 and 11 at once. For a long time, the methods of mining coal seam under water, railway and building include village moving, strip mining, grouting separated strata zone in overburden and filling mining and so on. Because of the rising cost of village moving, low resources recovery of strip mining and poor surface subsidence control effect of grouting separated strata zone in overburden, the range of these three methods decreases[2-4]. Though the per ton coal cost of filling mining increases, its surface subsidence control effect is good. Filling mining will become the main technical measures of releasing the coal resources under water, railway and building especially in central and eastern China and realizing green mining[5]. Late monitoring of filling body has seldomly been reported before. The paper takes working face of filling replacement mining strip coal pillar as an example and studies the backfill performance and filling effect by means of on-line monitoring system of filling body performance designed by ourselves.

ON-LINE MONITORING SYSTEM OF BACKFILL PERFORMANCE IN MINED-OUT GOB

On-line monitoring system of backfill performance in mined-out gob is based on hardware platform of KJ216 top dynamic monitoring system[6-10]. System component is shown in Figure 1. Monitor of filling body compression, earth pressure meter and temperature sensor are mounted in the filling body after working face. Monitor of filling body compression is shown in Figure 2. Shown Figure 3, temperature sensor is set in earth pressure meter. Realized long-term real-time monitoring of compression, stress and hydration process of filling body in mined-out gob during mining. Based on monitoring results, evaluated the filling effect comprehensively.

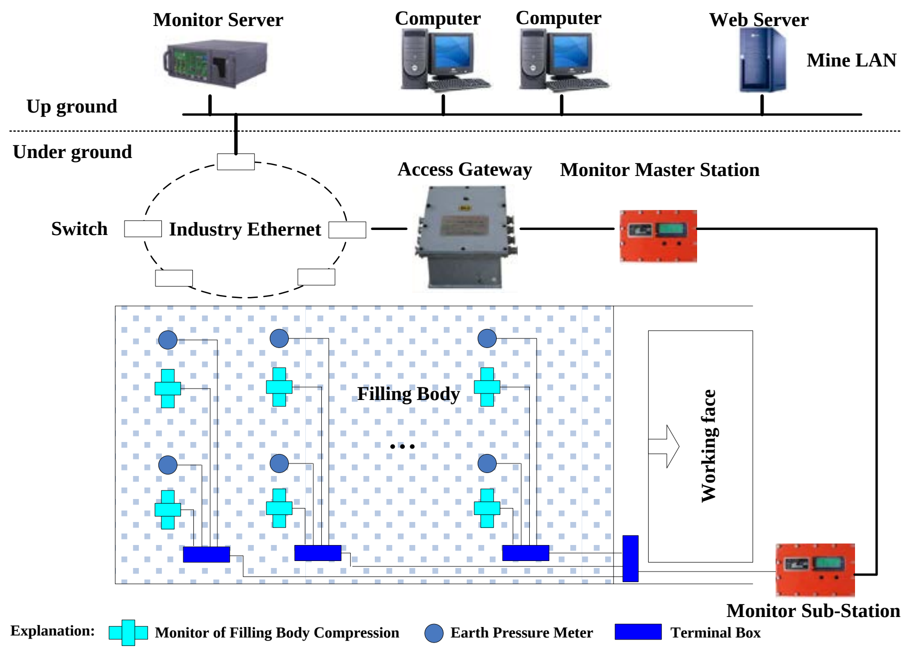

Figure 1: On-line monitoring system of filling body performance

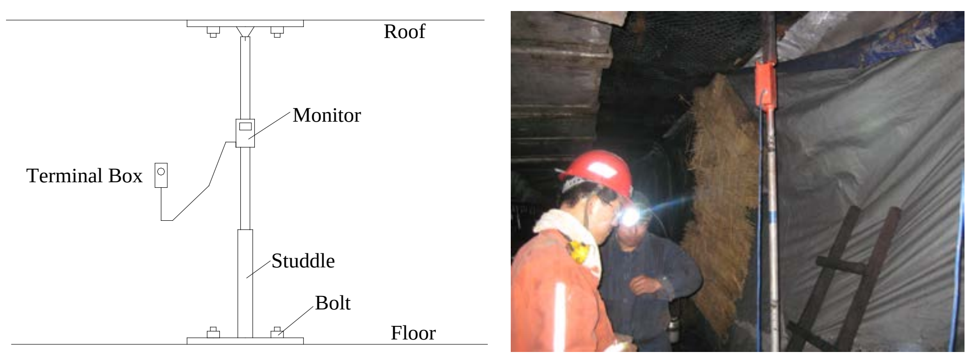

Figure 2: Monitor of filling body compression

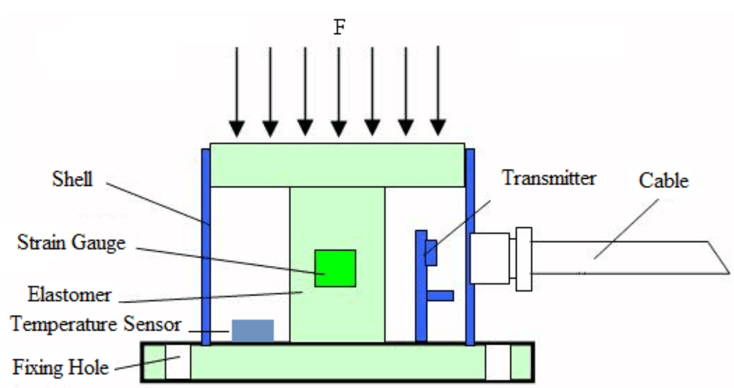

Figure 3: Earth pressure meter and temperature sensor

ENGINEERING GEOLOGICAL CONDITION

2351 paste filling working face in Daizhuang Coal Mine of Shandong Energy Zibo Mining Group Corporation limited is a working face of filling replacement mining strip coal pillar. The following are specific engineering geological conditions: 2351 paste filling working face is a strip coal pillar that both sides have been mined. The ground elevation is from +36.8m to +40.7m, and the floor elevation is from -280.68m to -435.5m. 2351 paste filling working face is located in the northwest of belt dip of the west wing of -410m level. The width of coal pillar between the belt crossheading of 2351 paste filling working face and the mined-out gob area of 2302 working face is 5m. The width of coal pillar between the track crossheading of 2351 paste filling working face and the mined-out gob area of 2303 working face is 5m. The width of coal pillar between the open-off cut of2351 paste filling working face and the mined-out gob area of 1339 working face is 30m. The distance between the working face and the sump of -485m auxiliary level is 150m. 2351 paste filling working face is the first paste filling working face in Daizhuang Coal Mine, and peripheral most NO. 3_{up} coal seam of 2351 paste filling working face has been mined. The inclined length of 2351 paste filling working face is 100m, and its strike length is 1074m. The dip angle of coal seam is from 0° to 13°, the average is 5°. The working face height is from 1.80m to 3.10m, the average is 2.65m. Coal structure is simple.

MONITORING SCHEME

The monitoring scheme was originally planned to arrange three survey lines with three measuring points in each survey line. The survey line spacing is 50m. Three measuring points distribute at the upper, middle and lower of working face uniformly. Because we didn't consider the impact of hydration temperature beforehand, monitoring sensor went out of action after having been installed 48 hours. And then, we optimized equipments and adjusted original monitoring scheme according to field condition. Finally we distributed 4 survey lines with three of them effective. Concrete survey lines and measuring points arrangement are shown in Figure 4.

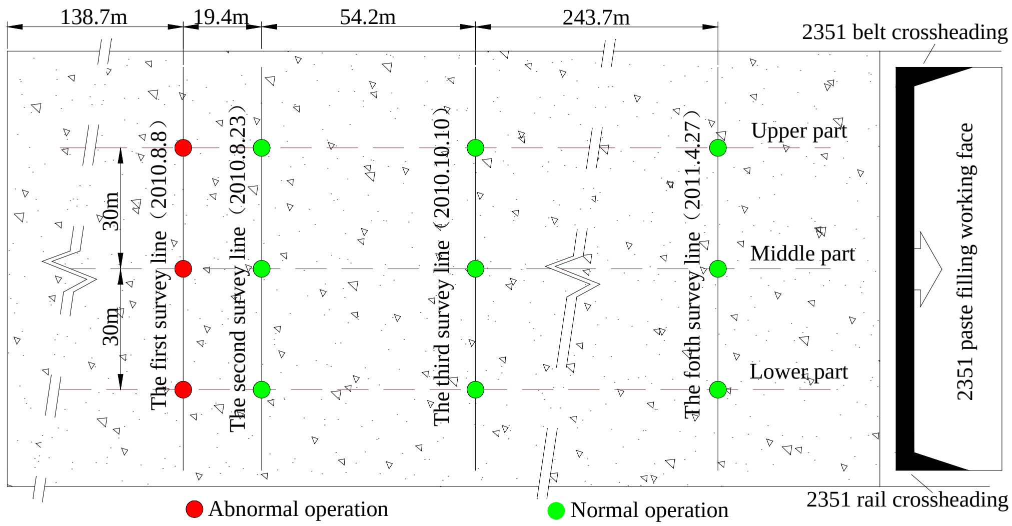

Figure 4: Survey lines and measuring points arrangement

ANALYSIS OF MONITORING RESULTS

Filling body of 2351 paste filling working face was monitored by means of on-line monitoring system of filling body performance from August 8th, 2010 to May 20th, 2011. A large number of measured data is acquired, now we take parts of measured data to analyze the filling body performance.

Filling body compression

Take the data monitored by 107L# and 108L# monitor of filling body compression that located at middle and lower of the third survey line for example, filling body compression is analyzed. Relationship between filling body compression and distance between measuring point and working face is shown in Figure 5.

As shown in Figure 5, filling body compression increases with the advancing of working face and tends to stabilize. The compression of filling body located at the middle of working face is larger than that located at both ends, which is consistent with the movement law of overburden strata. The maximum compression of filling body is 104.3mm, and its compression ratio is 3.85% which is far less than the theoretic value (10%). The monitoring results showed that the aggregate gradation, density and anti-compression properties of gangue backfill paste is good and it is very effective to control the movement of overburden strata.

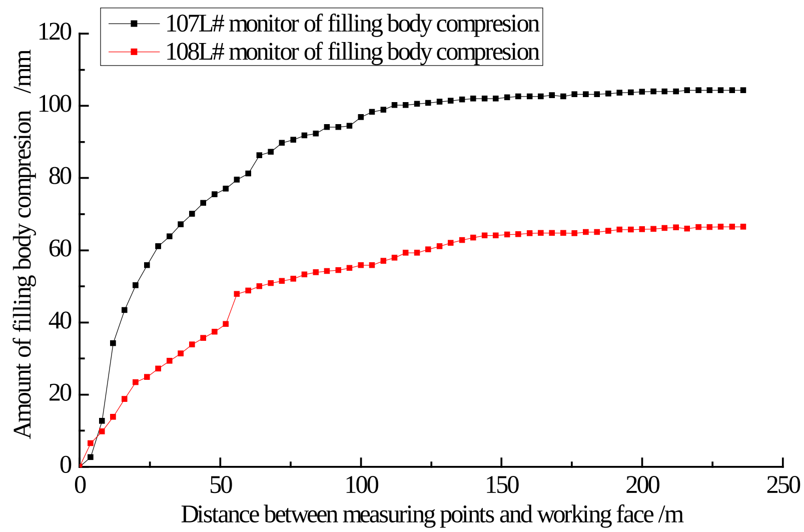

Figure 5: Relationship between filling body compression and distance between measuring point and working face

Force of filling body

Take the data monitored by 014Y# and 014Y# earth pressure meter that located at middle and lower of the third survey line for example, the force of filling body is analyzed. Relationship between force of filling body and distance between measuring point and working face is shown in Figure 6.

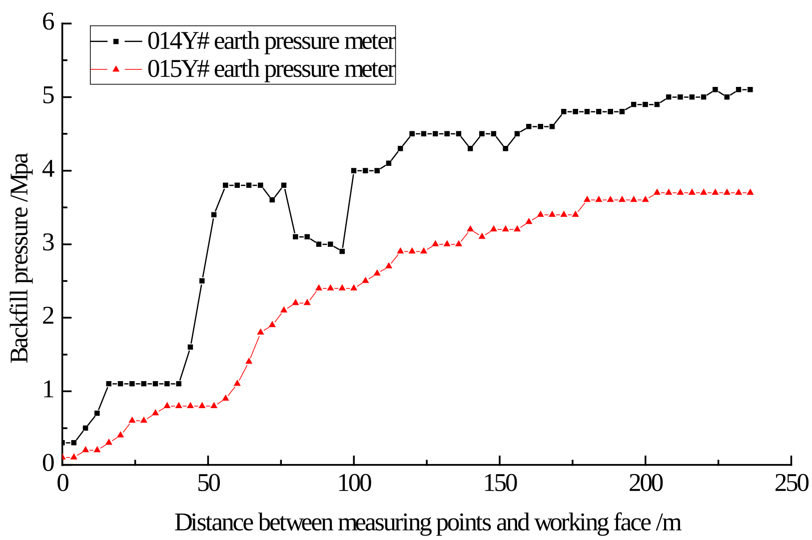

Figure 6: Relationship between force of filling body and distance between measuring point and working face

As shown in Figure 6, the force of filling body increases with the advancing of working face. The force of filling body located at the middle of working face is larger than that located at both ends, and the maximum force of filling body is 5.1MPa. The monitoring results showed that the range of overburden strata affected by mining is small. The filling body can control the movement of overburden strata effectively and keep long-term stability.

Hydration process of filling body

Filling body behind working face is a kind of concealed work. It is difficult to realize the monitoring of hydration process of filling body through analyzing composition. The hydration process of cement will produce hydration heat, which will inevitably increase the temperature of filling body in the confined space[11]. Based on this, the hydration process of filling body can be monitored by monitoring the temperature of filling body.

Take the data monitored by 216M# temperature monitor that located at the fourth survey line for example, the hydration process of filling body is analyzed. Relationship between temperature of filling body and time is shown in Figure 7.

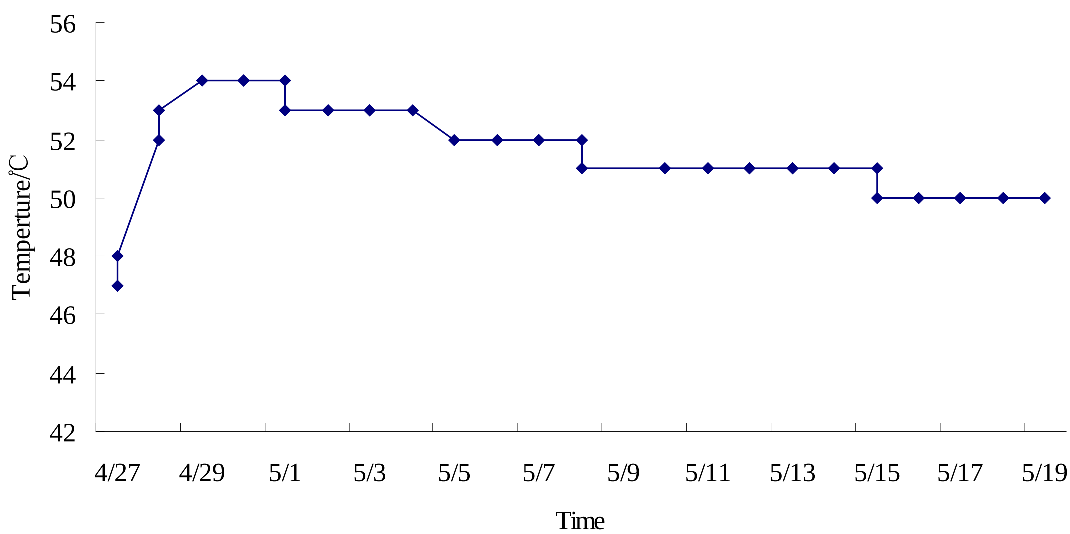

Figure 7: Relationship between temperature of the filling body and time

As shown in Figure 7, the temperature of filling body increases generally with time in the first two days, and the first day's temperature change rate is faster than the second day's. The maximum temperature of filling body is 54℃, the average is greater than 50℃. The monitoring results showed that the hydration reaction of gangue backfill paste occurs mainly in the first two days, and the first day's is most remarkable. The practical temperature of filling body is far above the curing temperature (20℃) in mixing proportion test, which will benefit the early strength of gangue backfill paste. It is very important for shortening solidification time and increasing productivity of filling working face.

CONCLUSION

The filling body of 2351 paste filling working face was monitored by means of on-line monitoring system of filling body performance designed by ourselves in real time. According to the monitoring results, some conclusions are drawn as following:

(1) The compression and force of filling body located at the middle of working face is larger than that located at both ends. The compression of filling body located at the middle of working face is 104.3mm and its compression ratio is 3.85%. The force of filling body located at the middle of working face is 5.1MPa. The monitoring results showed that the aggregate gradation, density and anti-compression properties of gangue backfill paste is good. The range of overburden strata affected by mining is small. The filling body can control the movement of overburden strata effectively and keep long-term stability.

(2) The temperature of filling body increases generally with time in the first two days, and the first day's temperature change rate is faster than the second day's. The monitoring results showed that the hydration reaction of gangue backfill paste occurs mainly in the first two days, and the first day's is most remarkable. The maximum temperature of filling body is 54℃, the average is greater than 50℃. The practical temperature of filling body is far above the curing temperature (20℃) in mixing proportion test, which will benefit the early strength of gangue backfill paste. It is very important for shortening solidification time and increasing productivity of filling working face.

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