Application of wall monitoring technique for backfill grouting in inclined concrete shaft

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ABSTRACT: Grouting water plugging after main inclined shaft of Dafosi coal mine engineering instance, to ensure the safety of the shaft wall in the process of grouting, for the purpose of borehole wall monitoring scheme is proposed. Using strain monitoring technique, the wellbore hydrological and engineering geological conditions of surrounding rock in different location arrangement of monitoring stations, through the analysis of the monitoring instrument in the process of grouting wall stress change and the status of the casing deformation, and real-time monitoring and adjusting the grouting pressure, through the data analysis of shaft wall deformation law mastered the grouting process, grouting engineering provides the accurate monitoring data security and safety technology, therefore, study the application of monitoring technology in the wall after grouting has a very positive role.

INTRODUCTION

As a new field of engineering technology, grouting technology has more than one hundred years history (Weng(2014) &Zhang(2011) &Wang(2004)). Its theoretical research and development is very rapid, but especially under the condition of dynamic water wall post grouting technique for slope (tunnel, tunnel and other concrete structures) wall after grouting water plugging, governance, the damage is not yet mature, the application of research of monitoring technology in the backfill grouting is not much, so the monitoring technology in the application of backfill grouting, the study has a very positive role and can provide certain reference for design and construction (Xie(2004) &Qian(2013) &Yang(2011) &Wang(2006)).

Dafosi mine is in the southern of Binchang mining. Area 86.3km^2, Geological reserves 1249.92Mt, Recoverable reserves 765.68Mt. Production capacity is 6.00Mt/a, 92.5a service. The main shaft angle is 14 degrees, plagioclase 916m; vice inclined shaft angle of 20 degrees, length 647m. The main and auxiliary inclined wellbore both appear serious gushing phenomena in crossing the aquifer, while the shaft has arching concrete into the mine, but shaft backfill gushing still in large area through the reserved hole pipe, construction joint, crack. After analyzing the reason of gushing, backfill grouting method is used to block gushing channel behind wellbore wall, then adopt the method of shallow hole grouting to fill the void behind the wall and low pressure intermittent filling grouting construction technology to achieve the effect of plugging.

Slope through the formation of the geologic conditions are complex. In the process of grouting, monitor the strain of wellbore in order to prevent the damage caused by large pressure. Choose the wellbore hydrological and engineering geological conditions of surrounding rock in different location to arrange monitoring stations. By monitoring the strain condition in grouting, can provides the basis for other similar conditions of reasonable pressure control in backfill grouting.

Principle of borehole wall monitoring technology

The principle and processing method for calculation of stress

The calculation formula of the concrete stress σ_c for:

$$\sigma_c = E_c \varepsilon_c \qquad (2)$$

where $\varepsilon_c=\Phi(f)$ function, by the strain gauge calibration data are given，με ;E_c=Embedding of the strain gauge concrete elastic modulus, GPa .

Because ε_c is Φ(f) function and the zero stress at the time of the initial frequency of f0 two parties, therefore the determine of initial frequency f_0 is very important for the accuracy of calculation of concrete stress.

Strain measuring instrument

Using GHB-3 steel string concrete strain gauge produced by Dandongsanda testing instrument factory, its main technical indicators shown in table 1.

Table 1. Steel string strain gage technique parameters.

Related parameters	value
Model No.	GHB-3 type steel string strain gage
Working mode	Double coil continuous oscillation
Coil resistance	Excitation 30Ω; Induction 30Ω
Resolution	0.7με/Hz
Don't repeat rate	<1.0%F·S
Return difference	<1.0%F·S
Comprehensive error	<1.5%F·S
Long term stability	1.0%F·S
Working temperature	-30 ～ 70°C
Length	150mm
Weight	0.5Kg

Strain gauges are buried in concrete brickwork by gouging in depth of 200mm, filling and compacting with concrete lining wall with the strength of cement mortar, the data line keep outside the hole, then start backfill grouting monitoring when the concrete reach 7 days strength.

The working principle of concrete strain gauge

The steel slight oscillation in strain sensors, the relationship of its natural frequency of vibration f and axial stress σ as follows:

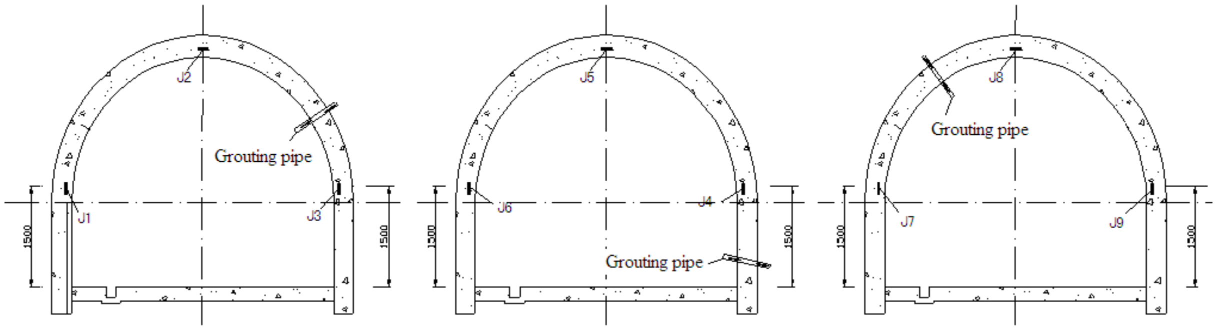
$$f=\frac{2}{2L}\sqrt{\frac{\sigma}{\rho}} \qquad (1)$$

where L=steel effective length, mm;ρ=steel volume density, Kg/m^3; σ=axial stress, MPa.

Monitoring method

Monitoring points arrangement

Main incline shaft were selected in the inclined length 201 m, 252 m, 319 m, a total of three monitoring sections, each monitoring section has three monitoring stations, respectively located in the roof and two side of the wall. As shown in figure 1.



The profile of Monitoring Section in the inclined length of 319 m

The profile of Monitoring Section in the inclined length of 252 m

The profile of Monitoring Section in the inclined length of 201 m

Figure 1 Main slope monitoring profile

The strain data acquisition

By the research of sensor technology Dandongsanda produced GPC-6 multichannel steel string frequency readout instrument, its main technical indicators shown in table 1.

Data collection was conducted in the vicinity of grouting working face, through the instrument readings will strain gauge change display and saving.

Table 2. Data acquisition instrument technology parameter table

Technical parameters	value
The use of temperature	0 ～ 50˚C
Input channel	1～ 6
Sampling period	0.8 seconds / Channel
Data storage	The 2000 frequency number
The scope of work	800～3000Hz
Frequency measurement resolution	0.1Hz
The modulus of resolution	0.1F; F-Modulus.Modulus = frequency value of the square/1000
Display mode	Frequency, modulus five digit display
Rechargeable batteries	Continuous work full of electricity for 8 hours
Volume	260×160×135mm
Weight	2.8kg

Casing deformation monitoring

Grouting Monitoring

Monitoring of borehole strain in the grouting process, every 2 minutes of observation and record at a time of grouting location, process and climate conditions have also made the corresponding record, and test the safety of grouting pressure based on monitoring data.

In the grouting process, by analyzing the monitoring data of borehole stress and changes of sidewall safety condition to provides accurate monitoring data for the entire grouting engineering, so the grouting station can make timely adjustment of grouting pressure.

Monitoring results

The monitoring data of the inclined length 319m is shown in Figure 2.

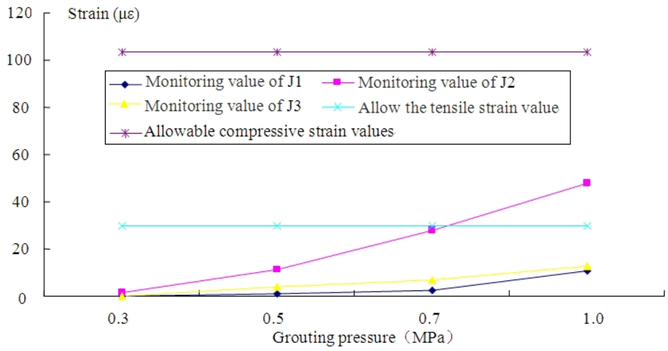


Figure 2 The monitoring curve of the relationship between the grouting pressure and strain in the inclined length of 319 m

J1 point of tension, Δεmax=10.933με <permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

J2 point of pressure, Δεmax＝47.890με< permissible value calculation 103.3με, with the grouting pressure and the increasing duration, the value of compressive deformation is also increase but not close to the permissible value.

J3 point of tension, Δεmax=12.703με <permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

The monitoring data of the inclined length 252m is shown in Figure 3.

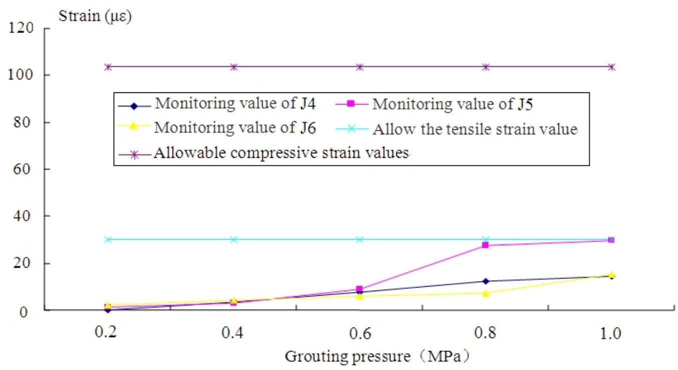


Figure 3 The monitoring curve of the relationship between the grouting pressure and strain in the inclined length of 252 m

J4 point of tension, Δεmax=14.384με <permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

J5 point of pressure, Δεmax＝29.437με< permissible value calculation 103.3με, with the grouting pressure and the increasing duration, the value of compressive deformation is also increase but not close to the permissible value.

J6 point of tension, Δεmax=15.035με <permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

The monitoring data of the inclined length 201m is shown in Figure 4.

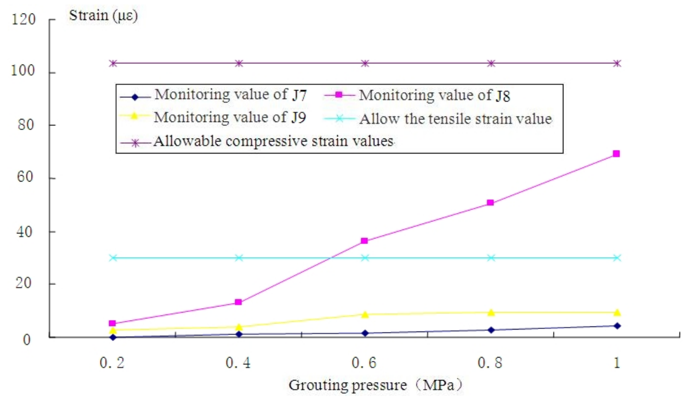


Figure 4 The monitoring curve of the relationship between the grouting pressure and strain in the inclined length of 201 m

J7 point of tension, Δεmax=4.211με <permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

J8 point of pressure, Δεmax＝69.192με<permissible value calculation 103.3με, with the grouting pressure and the increasing duration, the value of compressive deformation is also increase but not close to the permissible value.

J9 point of tension, Δεmax=9.614με<permissible value calculation 30με, with the grouting pressure and the increasing duration, the value of tensile deformation is also increase but not close to the permissible value.

Grouting monitoring conclusion

(1)The grouting pressure is safety, the shaft deformation is generally small, the shaft without damage. The maximum compressive strain value is 69.192με, the pressure less than the allowable strain value 103.3με; the maximum tensile strain is 15.035με, less than the allowable tensile strain 30με. The allowable compressive strain value according to the concrete designed with stand pressure calculation, ε=σ/E， the wall' Concrete design pressure is 3.1MPa，the elastic model of concrete is 30GPa。

(2)The monitoring sites structure of the wall concrete is not damage before the grouting;

(3)The strain gage performance is good after been embedded.

Analysis of shaft wall deformation

According to the monitoring of the shaft wall strain data and the engineering situation can be draw: with the grouting pressure and the increasing duration.

(1)The vault have the trend of movement to the middle, this because the part of vault produced the cavity when brickwork, grouting slurry concentration effect makes vault had a trend to move towards the centre;

(2)The side of the rock way has the movement trend to the surrounding rock, this because that the sides has been more dense after brickwork, so when is grouting, the sides under the arch of wellbore effect has the movement to the surrounding rock;

(3)Although the floor has not been monitored, but in the course of construction when grouting pressure reaches 1.5MPa the floor has drum phenomenon, this because that the thickness of floor has only 200mm when brickwork, when the pressure is too high, the deformation will be larger even occur rapture.

Conclusions

(1)Backfill grouting has certain influence for the deformation of the retaining structure, but the deformation is small, with increasing of the grouting pressure, the roof and floor move in the middle of the wellbore, on the contrary, both sides of the wall bulge outward.The success of the wall deformation monitoring can be a reference in the future.

(2)Wall after grouting pressure is generally calculated by theory, but also should be adjusted by combining real-time deformation monitoring data to ensure the shaft safety.

(3)With the development of information technology, the use of advanced wireless communications and digital visual technology to realize the ground 3 d video wall deformation monitoring is the research direction in the future.

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