Double-Arch Tunnel Monitoring Measurement Data Processing And Numerical Analysis

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Abstract

Monitoring measuration as one of the core contents about NATM(New Austrian Tunnelling Method). Data have studied and analyzed to guide subsequent construction.Deformation of the wall rocks and stress of the supporting structures have been note. This paper take Xiamen jinbang tunnel as an example,this paper introduces the specific projects of tunnel monitoring measurement,through regression analysis the monitoring data of vault crown settlement where grade Ⅴ wall rock typical blocks, the result can predict accurately the follow up tunnel deformation of similar blocks.

Keywords

Regression analysis, Double-arch, Monitoring Measuration, Vault crown settlement.

1. Introduction

At present, in the domestic urban tunnel construction, construction monitoring technology has been mature. But in terms of safety and risk management, including its theory, methods, standards, measures and countermeasures, Monitoring technology is still at the advancing stage and have not form methods and technologies systematic. Compared with abroad also has a lage gap to catch up. Engineering construction monitoring should be as the important part of the safety and risk management. The result of monitoring information to provide evidence for adjusting constrution method or various parameters in the project construction. Finally, achieve the goal of “dynamic design and information construction” [1-2].

2. Engineering Overview

Jinbang tunnel is location in Xiamen city railway sation on the west side.The tunnel length of 227 meters, where gallery 37 meters, double-arch tunnel 190 meters, the maximum depth of 45 meters, the tunnel single-hole clear width 9.5m, net height 5.0 m. The tunnel using the end wall portal.

This rock classification includes Ⅲ, Ⅳ and Ⅴ. with different levels of surrounding rock interlaced connection,among of the length of Ⅲ surrounding rock is 80 meters, Ⅳ surrounding rock is 20 meters and the length of Ⅴ surrounding rock is 127 meters. The tunnel project is given priority to with residual soil and weathered granite,partly there are solitary weathered stone which present rock structure planes and repose of shape . Groundwater and surface water is abundant. An average of 130 days a year during the raining season,affected by typhoon,it’s often meet heavy rains strong winds more than six grade. Ⅲ grade wall rock using the pilot tunnel construction technology and Ⅳ, Ⅴ grade wall rock using the three pilot hole construction.

3. Monitoring Projects and Instruments

Scope of Chinese current highway tunnel construction in composite lining of tunnel lining and spray seedlings will site monitoring measurement during the construction project as a whole is divided into

two categories, necessary project and selective items. Necessary project includes the whole observation, circumference displacement, and crown settlement, selective project includes foundation settlement of surrounding structures, surrounding rock pressure and internal force of steel arch frame project. According to the surrounding rock situation monitoring cross section, the field monitoring cross section distance and frequency as shown in table 1 and table 2 [3-4].

Table1: monitoring cross section distance

Rock Classification	Ⅲ	Ⅳ	Ⅴ
Spacing (m)	20	15	10

Table2: monitoring frequency

Excavation Time	0-15d	16d-30d	31-60d	60d-end
Frequency	2 times / day	1 times/day	2 times/week	1 times/ month

Monitoring instruments are mainly convergence gauge, level, total station and frequency instrument, where convergence gauge, level and frequency instrument below-contact measurement, greater interference by the tunnel construction, total station is a non-contact measurement, interference by the tunnel construction small.

4. Monitoring Data

This paper selects Ⅴ Grade wall Rock tenders in typical middle drift and left-right hole vault subsidence monitoring data for data processing, draw the middle drift and left-right hole vault settlement Statistical tables displacement over time, table 3 - table 5.

Table 3: ZPZ K1+190 section of the middle drift vault settlement monitoring data

Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)
0.5	0.6	7.0	5.6	20.0	8.7
1.0	1.2	8.0	5.9	21.0	9.1
1.5	2.1	9.0	6.3	22.0	8.8
2.0	2.8	10.0	6.5	23.0	9.1
2.5	3.0	11.0	6.9	24.0	8.9
3.0	3.1	12.0	7.2	25.0	8.9
3.5	3.2	13.0	7.5	26.0	9.2
4.0	3.5	14.0	8.2	27.0	9.1
4.5	3.7	15.0	8.8	28.0	9.4
5.0	3.8	16.0	9.3	29.0	9.3
5.5	4.5	17.0	8.9	30.0	9.5
6.0	5.0	18.0	9.2		
6.5	5.3	19.0	8.7		

Table 4: ZPZ K1+190 section of the left hole vault settlement monitoring data

Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)
0.5	0.5	7.0	7.3	20.0	11.4
1.0	1.2	8.0	7.9	21.0	11.5
1.5	1.6	9.0	8.3	22.0	11.2
2.0	2.1	10.0	8.8	23.0	11.8
2.5	2.5	11.0	9.2	24.0	11.4

3.0	2.9	12.0	9.4	25.0	11.6
3.5	3.5	13.0	9.9	26.0	11.1
4.0	3.8	14.0	10.4	27.0	11.2
4.5	4.2	15.0	10.7	28.0	11.4
5.0	4.6	16.0	10.9	29.0	11.8
5.5	5.3	17.0	11.3	30.0	11.5
6.0	6.0	18.0	11.5		
6.5	6.5	19.0	11.9		

Table 5: ZPZ K1+190 section of the right hole vault settlement monitoring data

Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)	Time (d)	Vault settlement (mm)
0.5	0.7	7.0	7.3	20.0	11.2
1.0	1.1	8.0	7.8	21.0	11.5
1.5	1.7	9.0	8.2	22.0	11.2
2.0	2.1	10.0	8.7	23.0	11.4
2.5	2.6	11.0	9.1	24.0	11.4
3.0	2. 7	12.0	9.3	25.0	11.6
3.5	3.2	13.0	9.8	26.0	11.1
4.0	3.6	14.0	10.8	27.0	11.2
4.5	4.1	15.0	10.7	28.0	11.4
5.0	4.4	16.0	10.9	29.0	11.1
5.5	5.1	17.0	11.4	30.0	11.5
6.0	6.0	18.0	11.5		
6.5	6.6	19.0	11.5		

5. Data Analysis

According versus displacement monitoring measurement data plotted versus time, can be more intuitive to see the wall rock vault settlement, ground settlement and horizontal convergence of changing circumstances, and preliminary judge whether the wall rock to stabilize or abnormal situation. Regression analysis methods currently used for data analysis of surrounding rock are exponential, logarithmic and hyperbolic functions of three linear regression curve. In this paper, take the three regression analysis method [5]. The Middle Drift Vault Settlement Data Analysis Carried out by the Origin software exponential function, logarithmic functions and hyperbolic functions regression analysis of regression equation and R-square, where x represents the cumulative time, y represents vault settlement value, and the rest represent the regression coefficients, regression curve see Figure 1, regression model and R-square in table 6-7 [6-7].

Table 6: regression model

regression	Exponential Function	Logarithmic Function	Hyperbolic Function
regression model	$y = y_0 + A_1 * e^{(-x/t)}$	$y = a + b * \ln(x + c)$	$y = (p_1 * x)/(p_2 + x)$

Table 7 regression model and R-square

Regression	Regression Equation	R-square
Exponential Function	$y = 9.795 - 9.5738 * e^{(x/-8.667)}$	0.9837
Logarithmic Function	$y = -1.6540 - 3.3779 * \ln(x + 1.3385)$	0.9692
Hyperbolic Function	$y = （12.7077 * x）/(9.0465 + x)$	0.9781

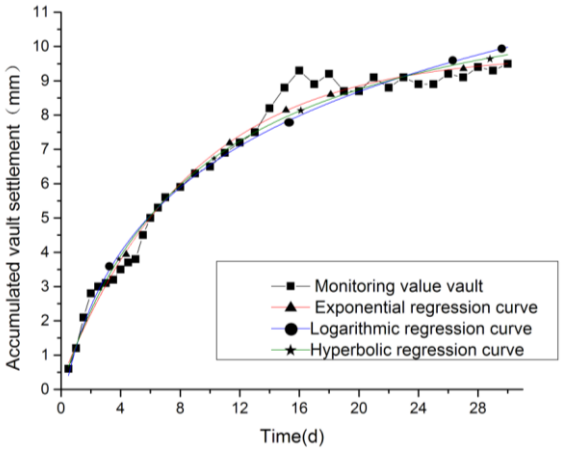

Fig1: The middle driff vault settlement regression curve

From the above Table 5, Table 6 and Figure 1 shows:

1. The maximum R-square exponential function, return the highest accuracy, select this equation representatives dome subsidence situation.

2. According to the regression equation for determining the final displacement section vault settlement is 9.49mm, the current total settlement 9.50mm.

3. At 0~12d and 18~30d during the logarithmic regression model curve and the observed value of the curve fit better, is more accurate. Monitoring in section 13 ~ -17d, the use of cumulative displacement logistic regression model obtained is small, due to too few observations, the regression coefficient model to determine the error is too large, it can give.

The Left-Right Hole Vault Settlement about Data Analysis

Since the left-right tunnel excavation, the Final settlement amount and the regularity are basically the same, this article only take left hole vault regression analysis. Carried out by the Origin software exponential function, logarithmic functions and hyperbolic functions regression analysis of regression equation and R-square, where x represents the cumulative time, y represents vault settlement value, and the rest represent the regression coefficients, regression curve see Figure 2, regression model and R-square in table 8.

Table 8: regression model and R-square

Regression Model	Regression Equation	R-square
Exponential Function	$y = 12.1935 - 13.1700 * e^{(x/7.6689)}$	0.9873
Logarithmic Function	$y = -2.6788 - 4.8350 * \ln(x + 1.6714)$	0.9594
Hyperbolic Function	$y = （16.8373 * x）/(10.4435 + x)$	0.9686

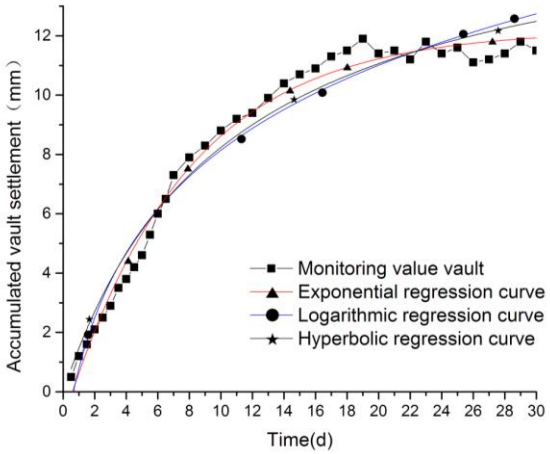

Fig2: The left hole vault settlement regression curve

From Table 7 and Figure 2 shows:

1. the maximum correlation coefficient exponential function, return the highest accuracy, select this equation representatives vault subsidence situation.

2. according to the regression equation for determining the final displacement section vault settlement is 11.93mm, the current total settlement 11.5mm.

3. at 0~7d and 22~30d curve value during the logistic regression model is slightly larger than the observed value of the curve. During the 8~21d monitoring section of the curve value logistic regression model is slightly smaller than the observed value of the curve.

6. Conclusion

In the process of tunnel construction, monitoring measurement and data regression analysis can be as an important means of tunnel dynamic construction, for monitoring results in larger deviation timely feedback, master the working state of the surrounding rock and supporting structure timely, and adjust the support parameters as to the results of the monitoring, finally achieve “dynamic construction and dynamic design”.

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