

## Research Article

### The Data Management System of Tunnel Monitoring

<sup>1</sup>Hongliang Deng, <sup>2</sup>Kaijiang Chen, <sup>1</sup>Qihua Deng, <sup>1</sup>Tingting Ni and <sup>1</sup>Mingyan Zhu

<sup>1</sup>The College of Architecture and Civil Engineering, Beijing

University of Technology, Beijing 100124, China

<sup>2</sup>China Railway 22ND Construction Bureau Co. Ltd, Beijing 100043, China

**Abstract:** In this study, the author has developed a data management system of tunnel monitoring by using ACCESS database and made a new exploration in the field of tunnel monitoring data management. This study introduces the principles, the methods and the functions of this system. The system sets data input, data management, data applications and other functions all in one. It has made a good connection between the visual interface of front desk and the ACCESS database for monitoring information storage. What's more, it has realized functions of data entering, storage, querying, generating tense curve and space state diagrams, regression analysis and reports generating. The successful application in the engineering practice proves the validity and reliability of this system and it also provides a new way for tunnel monitoring data analysis.

**Keywords:** ACCESS database, management system, measurement data analysis, tunneling monitoring

#### INTRODUCTION

At present, new Austrian tunnelling method for construction is becoming more and more popular. One of the main characteristics of new Austrian tunnelling method is that it uses many means of measurement to monitor tunnel's surrounding rock after excavation dynamically. Such monitoring can be used to guide tunnel's structure design and construction. So the tunnel construction monitoring plays an important role in the tunnel construction. However, lacking of practical and efficient monitoring data analysis and processing technology, monitoring work is difficult to play its real role in tunnel construction (Yong, 2003; Zhengming, 2006). At present, monitoring working is far from our expected effect.

To manage and use monitoring data in a better way, Beijing University of Technology monitoring group of Shanghai-Kunming dedicated passenger railway 12<sup>th</sup> Section to develop a tunnel monitoring data management system which has a friendly user interface. This tunnel monitoring data management system combines the characteristics of monitoring with the requirements for which the surrounding rock and supporting structure stability analysis asked data management. This system contains lots of functions, such as monitoring data entering, storage, inquiring, alarm, regression analysis and reports generating. This system promotes the monitoring work effectively and meets the needs of the tunnel construction control.

#### OVERALL DESIGN OF THIS SYSTEM

This system is made up of 6 subsystems, namely: Data inputting system, Data querying system, Batching data modifying system, Data pre-treatment system, Data post-processing system and Reports generating. The functions of each subsystem are shown as follows:

**Data inputting system:** This system is responsible for everyday's data inputting to the database. There are two ways for entering: a single data entering and batch data entering.

**Data querying system:** You can query data as you like by inputting different requirements. It is quick and convenient for you to query by using this subsystem. But modifying is not allowed.

**Batch data modifying system:** This subsystem is used for database management and it can be used to inquiry monitoring data, inspect, modify batch data and change data format, etc.

**The data pre-treatment system:** This subsystem can test the data's topological relationships; analyze the data's accuracy; complete data's statistics analysis. By calculating, this system can transfer original coordinate data to the needed one which is used in monitoring.

**Corresponding Author:** Hongliang Deng, the College of Architecture and Civil Engineering, Beijing University of Technology, Beijing 100124, China

This work is licensed under a Creative Commons Attribution 4.0 International License (URL: <http://creativecommons.org/licenses/by/4.0/>).

**Data post-processing inspection system:** It is used to check the data stored in the database whether there is a repeat.

**Report generation system:** The subsystem is used to generate reports which are in accordance with the prescribed format. The reports include daily, weekly, monthly and other temporary reports.

**System function designing:**

**Single data entering:** This function is designed for you to entry single monitoring data including the initial monitoring values of each tunnel section and everyday’s gathering data. When you use this function, you must entry all the detail it allowed. The information needs to be input including tunnel name the section mileage, the measured point, the collecting time, date and the distance from the surveying section to the working face. If there is a damage point, you need to input the stationing time and the modified value.

**Batch data import:** This function makes it very convenient for you to import batch data. This system allows the batch data from GTS to be input to the system directly. What you need to do is to make the data be the given format one. Then you should click on the button and choose the right data document, right data sheet. Finally, you get the batch data in your database.

**QUERYING**

We all know that tunnel monitoring has a great amount of data, so how to find one historical data quickly and accurately is most important. In order to facilitate querying, this subsystem designs three keys: the initial value inquiring, the history data querying (according to the point), historical data querying (according to the tunnel). According to the point and the tunnel, there are two ways for querying from lateral and longitudinal respectively. Its corresponding functions are shown as follows:

**The initial value inquiring:** To complete this querying, you should input two inquiring conditions which are the section mileage and the surveying point name. Then the querying result will be shown on the interface.

**Historical data querying (according to the point):** This querying method is a tool for you to get the whole information of one point for a period of time. To achieve this goal, you should input some necessary requirements including: the tunnel’s name, the surveying section, the point and the starting and finishing time of monitoring. Then you will see an interface like Fig. 1. From this querying result, you can

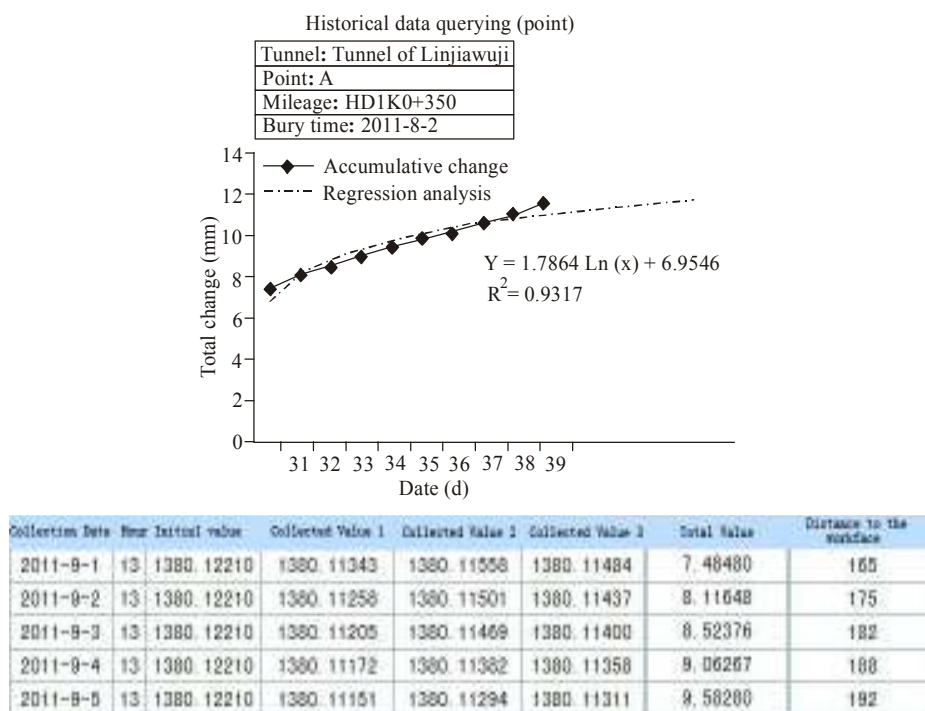


Fig. 1: Interface of historical data querying (according to the point)

get not only a data table but also a curve graph about accumulative total variation and time.

**Historical data querying (according to the tunnel):** For this method, you should input the tunnel's name and date. What you can get is all the information of the tunnel on that date.

**Report generation:** In this part, you can generate daily, weekly and monthly reports including many kinds of forms and graphics which are needed in the tunnel's monitoring daily work.

**The generation of daily reports:** Daily reports are used to instruct next day's construction on-site. Firstly, click on the right button; secondly, choose the date and the tunnel's name; thirdly, put the generated report and the report post-processing software into the same folder; finally, open the post-processing software and select importing daily data. After 4 steps you will get a report in allowed format.

**Weekly report generation:** Except large amount of data tables, Weekly report also includes two kinds of curves. One is about accumulative total changes with the change of time and its trend line; another is the accumulative total variation with the distance of the surveying section to the working face. All of the graphs are automatically generated by the system. The report's generative process is: firstly, click on "custom weeks/months report" button; secondly, select the start-ending dates and tunnel name; thirdly, put the figures and post-processing software into the same folder named Data; finally, open the post-processing software choice "batch import and output PDF" button. The generating of Monthly reports is almost the same with the Weekly generating except for choosing a longer period of time.

**The data pre-treatment:** In this part, there are two buttons on the main interface. One is automatic calculation and the other is automatic filter.

**Automatic calculation:** This function is designed for original coordinate calculating. You can translate those original coordinate data into the monitoring data which can be used directly, such as the settlement of the vault, the settlement of the arch feet and the changes of the clearance.

**Automatic filtering:** This function can be used to check the everyday's data and it will eliminate the clearly wrong data automatically. After filtering, it will store the final data.

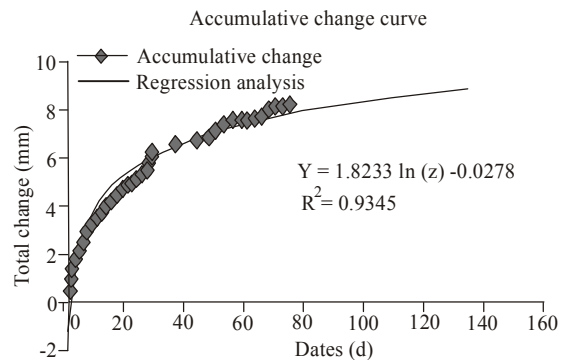


Fig. 2: Vault sinking of D1K937 + 027.5 section

## THE ENGINEERING APPLICATION

**Overview of the engineering:** This system has been used in Shanghai-Kunming dedicated passenger railway 12<sup>th</sup> Section's tunnel monitoring work. Through a period of time, this system gets a good effect. And it has played an important role in the stability judgment of supporting structure and surrounding rock. It also helps a lot in directing construction and predicting early warning.

The 12<sup>th</sup> Section is located at Panxian, Guizhou province. This Section is from DK924 + 135 to DK977 + 651.51 and it is 48.32 km long. This Section is located at Yunnan-guizhou plateau or in the transitional belt of Yunnan-guizhou plateau's edge. The bad geological structure contains karst, coal gas and goaf, landslide, collapse and dangerous rock slipped, rock falls, rock pile, debris flow, soft rock weathering pineapple.

**The practical application:** Take the D1K937 + 027.5 section of Gaojiatun tunnel as an example. Gaojiatun tunnel has adopted this system for monitoring. From the monitoring result, we can judge whether this system is useful in practical applications or not. Through a long period of time's monitoring, we input all the needed information of this section into the system's database. After filtering and calculation, we generate a weekly report of this section. Figure 2 is a curve of vault sinking which is generated by this system. It is one of the curves of this weekly report. We can find that this curve and its regression curve fit very well. The vault sinking's correlation coefficient is 0.9545. From this curve, we know that this system can reflect the changing trends of the surrounding rock truly.

## CONCLUSION

Tunnel monitoring data management system has realized the functions of automatic processing and

management. It helps to ensure the measurement data's integrity and veracity and improve the working efficiency. Because the tunnel monitoring data management system does well in guiding tunnel construction and in determining the supporting parameters, it also ensures the safety of the tunnel construction and speeds up the progress of tunnel projects. Through a period of time's application in engineering, it is clear that this system can expediently manage and analyze the tunnel monitoring data. It also proves that this system is reasonable, effective and has a high application value.

#### REFERENCES

- Yong, L., 2003. Development of highway tunnel monitoring data management system [J]. *Technol. Highway Transport*, 1: 54-57, (In Chinese).
- Zhengming, Z., 2006. Comprehensive management of quality detecting and monitoring in tunnel construction [J]. *Highway*, 10: 222-226, (In Chinese).