# The Application of Automatic Monitoring Platform(AMP)


Ye Li [1], Zheng Zhang [2, *], Aoran Mo [3,] Yaoheng Shu [3]

[1] Faculty of Geosciences and Environmental Engineering, Southwest Jiaotong University, China – liye_swjtu@163.com
[2] Chengdu Tianyouzhice Safety Technology Co., Ltd, Chengdu, China, – zzeverlasting@qq.com
[3] Chengdu Hancheng Technology Co., Ltd., Chengdu, – 328143633@qq.com



**KEY WORDS:** automatic monitoring, tunnel monitoring, AMP, urban metro



**ABSTRACT:**

In the deformation monitoring project of the first phase of Chengdu Metro Line 9 underpassed the Chengdu-Guizhou-Special (High-speed Railway) Airport Road Tunnel, the Automatic Monitoring Platform(AMP) is used to realize continuous monitoring of unattended and remote control of the project. The AMP supports multiple users to enter the database at the same time, and can remotely control and configure the system from anywhere.It has the following functions: data screening and verification, data adjustment processing, measurement area meteorological analysis, data transmission, etc. It also can achieve accurate and intuitive results display, so that tunnel deformation monitoring has the convenience and timeliness under the premise of ensuring accuracy, and improve the efficiency of deformation monitoring and reduce costs.


## 1. PROJECT OVERVIEW

### 1.1 General Instructions

The two-line shield tunnel of the Sanyuan Station-Taipingsi Station of Chengdu Metro Line 9 is underpassed the Chengdu-Guizhou-Special (High-speed Railway) Airport Road Tunnel， that is the first "small-angle, small-clearance, long-distance" shield tunnel project under the high-speed rail. In this project, the shield tunnel is slanted into a noble passenger line at an angle of 21°, the minimum distance from the top of the shield tunnel to the Airport Road Tunnel is only 10.15m, and the mileage of the Chengdu-Guizhou-Special affected by the underpass project is K12+909~K13+006. In order to ensure the safe operation of the high-speed railway and the normal construction of the subway shield, it is necessary to carry out strict deformation monitoring of the Airport Road Tunnel.

FIG. 1 is a schematic diagram showing the plane distribution of the tunnel point, wherein J1, J2, J3, and J4 are reference points, which are disposed on the tunnel wall that is not affected by the shield. Sections 1~Section 13 are monitoring sections. Each monitoring section set on three monitoring points, and fixed points are installed on the monitoring points, which are located on both sides of the tunnel wall and in the center of the tunnel bottom. The spacing between adjacent sections is about 10 meters. The reference network for tunnel deformation monitoring is an independent network, and an independent coordinate system is often used in the work.

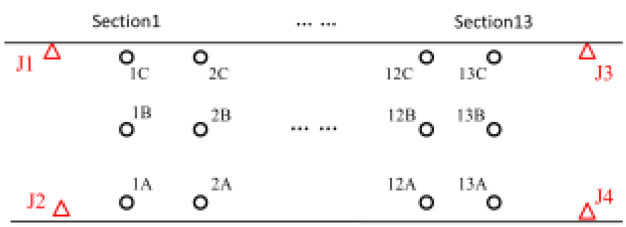


Figure 1. Diagram of point plane distribution in tunnel

Due to the strict construction conditions of high-speed rail, the entry into the high-speed rail tunnel can only be arranged at the "skylight point"——between 0 am and 5 am——of the railway. And it takes about 1 hour to walk from the tunnel entrance to the monitoring location. Therefore, the monitoring range is long and the number of monitoring points is large, but the monitoring time is tight, and it is difficult to complete high-density and all-weather measurement tasks by manual monitoring. However, monitoring with Automated Measurement Platform (AMP) does not require worrying about these issues.

## 2. STRUCTURE AND APPLICATION OF AMP

### 2.1 System Structure

The AMP consists of three subsystems: data acquisition system, communication system and control system.

**2.1.1 Data Acquisition System:** The system includes sensors such as the Leica series of measuring robots and temperature barometers. The measuring robot can realize functions such as automatic search, automatic sighting, automatic measurement, etc., and can work according to the instructions issued by the control system to collect the three-dimensional coordinates of the monitoring points; the temperature barometer can obtain the working site meteorological parameters in real time, and is used for the correction of the measurement data.

**2.1.2 Communication System:** The main hardware of the communication system is the 4G wireless communication DTU, which can wirelessly transmit the data collected by the acquisition system to the control system, receive the instructions of the control system and communicate it to the data acquisition system..

**2.1.3** Communication System: It mainly includes software for the PC and APP for the PE, which can support multiple users to log in at the same time. The staff can realize functions such as man-machine interaction and remote control through the operation control system, and the system can also provide real-time feedback on abnormal data information while performing real-time data transmission, data storage and analysis.

## 2.2 Practical Application

**2.2.1 Installation of Equipment:** The fixing bracket is installed on the tunnel wall and a measuring robot (LeicaTM 30) is placed as a measuring station, and the measuring station maintains a view with all measuring points. Place a temperature barometer next to the TM30. The TM50 and temperature barometer are connected to the 4G communication DTU via a serial cable.

**2.2.2 Learning of Measuring Points:** Before the monitoring, the measurement learning is first performed, that is, the staff needs to adjust the parameters of the robot, and then manually observe each measurement point, obtain the horizontal angle and zenith distance data of each point, and save the initial value.

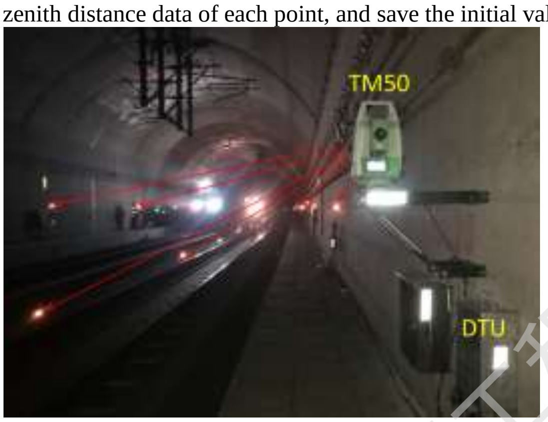


Figure 2. Learning of Measuring Points

**2.2.3 Configuration of Task:** The staff performs task configuration on the client software, including information such as instrument number, measurement mode selection, number of measurement returns, maximum number of search points, start observation time, observation interval, warning value, and project notes. The system will start on its own according to the starting observation time. According to the selected measurement mode (resection, full circle observation), the measured points will be observed. After the first stage of monitoring, the next period will be automatically calculated according to the observation interval. The observation start time is automatically monitored continuously for multiple periods.


Figure 3. Configuration of Task on the Software

**2.2.4 Automatic Measurement:** After completing the configuration task, the system can automatically measured according to the measurement program, an automatic measuring process real-time display of the current status of the measurement, the observed data and the like, can also be viewed in a plan view of the current station to all distribution points, as shown in Figue.4 to Figue.6. At the same time, the software can also handle some abnormal conditions in the automatic measurement process. For example, when the target is occluded during the observation process, the software can automatically perform the supplementary measurement; when the observation result exceeds the set tolerance, the software can display the data in different colors and control The measuring robot performs some or all retests as required.

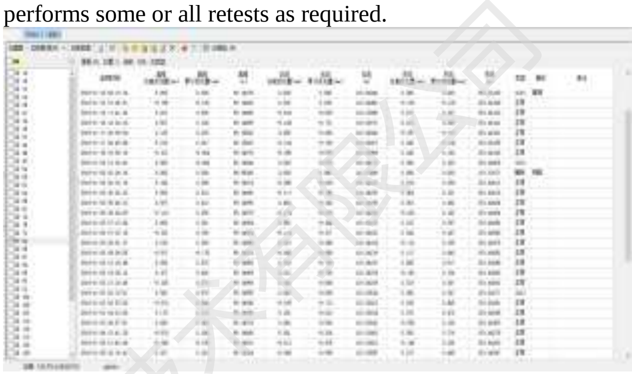

Figure 4. Real-time Monitoring Data Display

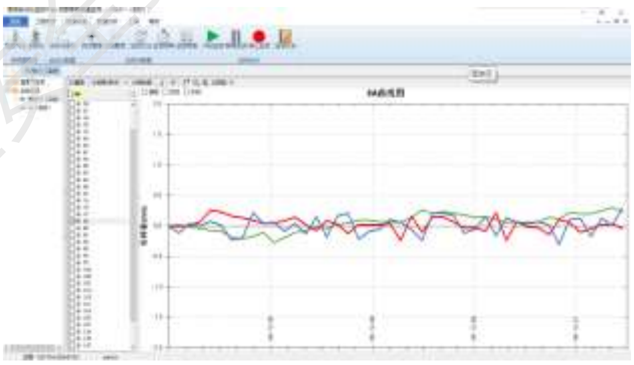

Figure 5. Displacement Curve of Monitoring Data

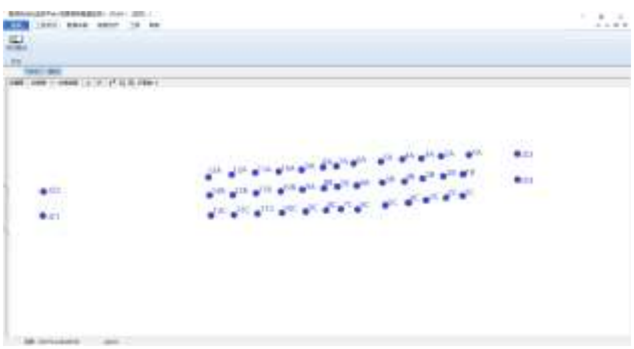

Figure 6. Schematic Diagram of the Actual Plane Distribution of the Measured Points

## 3. ANALYSIS OF RESULTS

According to the requirements, the maximum value of the horizontal displacement of the tunnel deformation monitoring should not exceed 3 mm, the maximum value of the vertical displacement should not exceed 2 mm, and the sedimentation rate should be controlled at 1.0 mm/d. Set 50% of the maximum value as the warning value, that is, horizontal displacement ±1.5mm, vertical displacement ±1.0mm; set 70% of the maximum value as the warning value, that is, horizontal displacement ±2.1mm, vertical displacement ±1.4mm. During the monitoring process, if any of the above values are exceeded, the monitoring system will send an alarm message to the relevant personnel.

The monitoring results show that the horizontal displacement of each monitoring point is always within the warning value; because the accuracy of the total station triangular elevation measurement is relatively low, there are a few vertical displacements in the monitoring results exceeding the warning value, but the vertical displacement after retesting is less than the warning value, the system will The overrun data is identified as a gross error for culling. In order to verify the accuracy of the monitoring system, the vertical displacement data obtained by the AMP system is compared with the on-site static level system measurement data. The monitoring results show that the AMP system monitoring data is reliable and can reflect the deformation of the tunnel in real time.

## 4. CONCLUSION

Practice has proved that the AMP can not only avoid artificially caused observation errors, reduce the input of artificial labor costs, but also carry out all-weather, high-precision real-time and dynamic remote telemetry under the special monitoring environment. The AMP can realize unattended continuous operation and high-precision automatic deformation monitoring in the true sense. And it has broad application prospects in various deformation monitoring fields.

## REFERENCES

Fan Ben. The research of automatci deformtaion montioring in subway tunnel construction based on georobot technology [J]. Geomatics & Spatial Information Technology, 2015, (1): 189～191. ( in Chinese)

Jiang Chen. On line control of measurement robot and its application in automatic monitoring of subway tunnel [D]. Xuzhou: China University of Mining and Technology, 2015. ( in Chinese)

Leica Geo Systems AG. Leica TPS1200_TS30_TM30_Geo-COM_Manual [Z]. Heerbrugg Swit Zerland

Liu Shaotang, Wang Guo, Pan Jiechen. Development of georobottunnel deformation monitoring system[J]. Engineering of Surveying and Mapping, 2016, 25(10) : 42～48. ( in Chinese)

Mei Wensheng, Zhang Zhenglu, Guo Jiming, et al. Software of georobot deformation monitoring system [J]. Geomatics and Information Science of Wuhan University, 2002, (2): 57～63. ( in Chinese)