Leica Geosystems TruStory
Monitoring Rail Tracks during Construction of Noise Barriers/HK

As one of the busiest and most crowded rapid transit system in the world, MTR (Mass Transit Railway, Hong Kong) operates high frequency train services from early morning until midnight. Due to the noise of the trains, areas where trains operate outdoors, like Tai Wai, suffer significantly from noise pollution. Serving as the busest interchange station in New Territories, connecting Ma On Shan Line to East Rail Line, Tai Wai Station and Depot are also one of the busiest hubs for train operation. As resdents move into the newly built residential buildings above Tai Wai Depot, the noise pollution problem is expected to affect an increased number of people.

In order to alleviate the noise pollution problem, noise barriers have been built along the tracks since 2009. However, before any works started, safety had to be ensured. Since the barriers were built very close to the existing tracks, deformation due to digging and various works for the construction of the barriers might have seriously affected the position of the tracks and subsequently train operation. Therefore, an automatic deformation monitoring system was implemented so that relevant preventive actions could be performed if an unpredicted deformation was detected by the real time monitoring system.

Monitoring System Setup

The monitoring systems consists of six total stations TCA2003, two computers, 23 reference prisms and over hundreds of monitoring

Objective

Deformation monitoring due construction works close to existing railway tracks

Customer/Institution

MTR (Mass Transit Railway, Hong Kong)

Date

2009 – ongoing

Location

Project Summary

Instruments

Leica TCA2003 Total Station
Leica Geosystems Monitoring prisms

Software

Leica GeoMoS Monitor / Analyzer
Web viewer for displaying data and reports

Communication

Cables
Uninterrupted Power Supley (UPS)

Challenge

- Real-time deformation monitoring throughout the construction
- Maintenance of the prisms and total stations in restricted MTR zones

Benefits

- Continuous and remote monitoring
- The safety of millions of MTR passengers can be ensured round the clock

Control Center of the Monitoring System

prisms. The total stations were sub-divided into two groups and located in Zone 1 and 2 of the construction site. Each location for the total stations was selected under various conditions, including solid foundations, safe distance from tracks and high-voltage overhead lines, and a clear sight to every monitoring and reference prism.
The monitoring prisms were installed at the upper and lower levels of overhead line masts to check tilting and also on the railway sleepers. The reference prisms were distributed around the total stations so that each total station could measure to approximately six prisms and compute the stability and orientation of the total stations.
An uninterrupted power supply (UPS) was provided to each total station to ensure the system could overcome any temporary power shortage.

The total stations were connected to two computers and the UPS in the workstation via signal cables and power cables respectively. The two computers were located in a workstation equipped with Leica GeoMoS software which is responsible for the control of the sensors, collection and analysis of data and the. In addition, both computers were connected to a web server via broadband internet, so that users can access the sys-tem remotely.

Leica TCA2003 Total Station can achieve an accuracy of ± 0.5″ in angle and 1 mm ± 1 ppm in distance. To achieve good visibility for the total stations, clean and not fogged prims in the correct position with a constant light condition with a dark background and no atmospheric disturbance were needed.

Data Acquisition

The operation of the automatic deformation monitoring systems started two weeks before the construction works commenced as so-called reference or null epoch data had to be collected. Throughout the construction, the deformation monitoring measurements were taken continuously in automatic two-hour cycles using the Leica GeoMoS software. All monitoring results were uploaded to the Internet for instant browsing and were closely monitored by surveyors. Any deviated data would immediately be investigated by surveyors to check the accuracy.

Messaging System

One of the main purposes of setting up an automatic deformation monitoring system was to inform the responsible staff of a situation when irregularities occurred in the construction site. After the monitoring positions of the optical prisms are measured, they are compared with the set limit levels. If any monitoring data reached or exceeded one of the three limit levels, the messaging system would immediately be activated. The designated personnel of MTR and the Contractor would be notified by e-mail. The surveyors in charge would then investigate the reasons behind the notification and confirm whether the message was due to faulty equipment, human error or construction activities. Additional respective measures may be taken according to the severity of the message, ranging from increasing the monitoring frequency to immediate cessation of all foundation and excavation works.

Reporting

All monitoring data was displayed in graphs showing and every 24 hours a report was generated.

Maintaining Stability

Notwithstanding the high precision of the surveying instruments and careful planning, every component in the system must perform sturdily to provide reliable data. However, maintaining the stability of such a complex system is never an easy task. First and foremost, maintenance of the equipment was carried out annually and wear outs and damages were fixed during this maintenance period. Since most of the instruments were installed along the tracks and masts, which belong to the restricted zone, working group meetings with MTRC were arranged to discuss the permitted working hours and site possession. Other than hardware maintenance, calibration of instruments was another important element to maintain stability. The system was tested prior to installation of the instruments to ensure that they were working and configured properly. From time to time, during the course of monitoring, the positions of the back sight prisms on the total station masts and the selected monitoring target prisms were checked by manual survey to verify that the automatic measurements had been made correctly, as the prisms might have been displaced either accidentally or naturally. The automatic measurements could be corrected using data from manual system checks when necessary. At the same time, all optical prisms were regularly cleaned and checked for stability, orientation and firm attachments. In cases of obstruction to the sight line of the total stations, prisms were relocated to other stable locations. They would also be re-installed if they were found loose. Moreover, not only would the instruments be examined for damage or defects on regular basis, but surveyors also assessed the system for any possible future damage caused by other construction activities or improvement works carried out by MTRC.

Advantages

Continuous Measurements: The most important reason of implementing an automated system was its non-stop measurements taking. In the past, when measurements were taken by manual survey, data collected could be fragmented as it was impossible for surveyors to work all day resulting in incomplete analysis and the process was not cost-effective. With the automatic deformation monitoring system, comprehensive reports could be generated solely by computers and an efficient messaging system enables deformation to be detected at all times.

Remote Monitoring: A considerably short period of time available for track possession was another significant constraint for works in an operational railway system. With surveyors monitoring the system anywhere via the Internet, the system could be operated without interfering with train services. Surveyors and other staff did not have to travel to the site to check for any irregularities and reports could be seen in just a few clicks.

User-Friendliness: To increase the efficiency of the system, a user-friendly web interface was used to display the monitoring results to the customer.

High Precision: As surveying has always been renowned for its high accuracy, surveyors strived to produce measurements as accurate as possible. However, human measurements can never be as accurate as those of machines, especially in a dark environment. To provide a highly precise monitor-ing system, the automatic deformation monitoring system minimizes the use of human labour with the replacement of newly developed total stations, which ensures extremely reliable measurements.

Conclusion

The success of the monitoring system has shown that safety can be ensured with the help of advanced technology, especially for works carried out in a train system which carries millions of passengers every day. Such a flexible yet efficient system has demonstrated that safety can be maintained round the clock and does not necessarily come with interference to our daily lives.

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