Leica Geosystems TruStory

Jiangyin Bridge, China: Monitoring with GPS RTK technology

Jiangyin Bridge's GPS monitoring reference station

In recent years, GPS RTK technology has being used by more and more bridge operation and management facilities in dynamic bridge displacement monitoring. Also GPS is playing an increasingly important role in high precision positioning projects, such as structural health status and ground motion monitoring. In 1999, the world's first GPS-based bridge monitoring project was deployed by Leica Geosystems on the Tsing Ma Bridge, Hong Kong. After that, Leica Geosystems' software and hardware have been deployed to monitor bridge structural health of numerous bridges including the Shandong Yellow River Bridge and the Jiangyin Bridge, earning Leica Geosystems a high regard in this field.

At the beginning of 2005, Leica Geosystems released Leica Spider 2.0, a new generation GPS reference station software based on the master-auxiliary centralized network RTK concept. This system has been scrutinized and installed widely around the world. Compared with the traditional real time RTK monitoring solutions, this technology is far superior.

Company

Jiangyin Yangtze River Highway Bridge Administration - PRC CHINA

Challenge

to provide a cost effective and innovative solution for delivering 3D positioning information at 20 Hz from 8 GPS Monitoring stations to an advanced analysis application software developped by the engineering company in charge of the whole structural monitoring project.

Date

installation finalized on March 2005

Project Summary

Instruments

Leica GPS GRX1200 Classic Reference Station, Leica GPS AX1202 Geodetic Antenna, Leica GPS AT504 choke ring antenna

Software

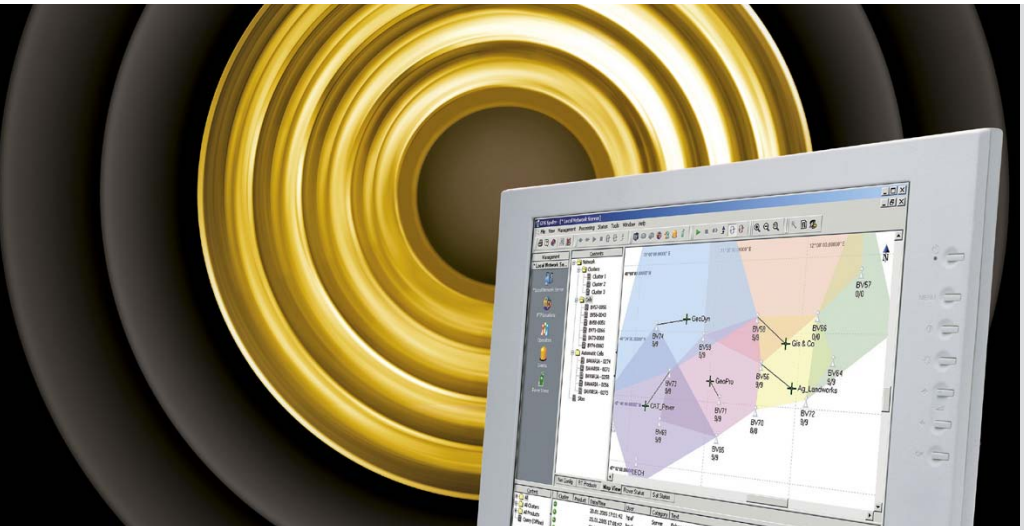
Leica GPS Spider v2.0 software including positioning option

Field

Design of the GPS monitoring network, installation of the GPS stations including monuments, accessories and cabling. Measurement of control points to define a local transformation from WGS84 to the bridge coordinate system.

Office:

Installation of Leica GPS Spider software, connection to the communication network, con-figuration, interface to the analysis software, training, support and maintenance jointly with Mr Li and his team of EuroAsia - the Leica Geosystems partner - Nanjing China.



GPS Spider Reference Station Software

Leica Geosystems' latest advanced centralized RTK concept

Leica Geosystems continues to be the world leader in GPS surveying with the fast and reliable long range network RTK operation capabilities using legendary SmartTrack and SmartCheck technology. The Leica GPS Spider reference station and GPS monitoring software has high flexibility, powerful functionality, modularized architecture, and high security. The software incorporates centralized RTK functionality enabling it to efficiently and conveniently distribute RTK correction data for an entire network from a single each data center. The Positioning module of Leica GPS Spider enables high precision real-time and post processed multiple baseline monitoring with high sampling rate (20Hz), advanced processing algorithms and reduced communication infrastructure for the monitoring of buildings, bridges and other structures.

No.1 bridge of China - The Jiangyin Yangtze River Highway Bridge

The Jiangyin Yangtze River Highway Bridge is the first super-large steel box-girder suspension bridge that spans more than one kilometer in China. It is the longest steel box-girder suspension bridge in China, the fourth longest in the whole World. It services a superhighway which is the national key trunk route crossing the Yangtze River. The Jiangyin Yangtze River Highway Bridge is the second suspension bridge that was constructed over the Yangtze River. It lies between Jiangyin and Jingjiang of Jiangsu Province, at the lower reaches of Yangtze River. Construction began on November 22nd, 1994, and the bridge was finally opened to traffic on September 28th, 1999. The total length of the bridge and main span of Jiangyin Bridge is 3,071 m and 1,385 m, respectively. The north and south towers are 190 m high.
On March 2001, Jiangyin Bridge passed 'check and acceptance' of the national construction project. The Bridge Monitoring Center was built at one side of the bridge (Jingjiang), equipped with Communication System, Closed Circuit Television, Information Management System, Message Sign System, Emergency Call System, Broadcast System, etc.

When Jiangyin Bridge was completed on August 20th, 1999, Leica Geosystems was invited to perform the loading tests with TPS and GPS RTK by the bridge displacement measurement facility. On the day of the load tests, heavy rain prevented the use of TPS in the tests; however, Leica Geosystems' GPS RTK was able to complete the test smoothly. With Leica's advanced RTK technology, impressive test accuracies at the 1 cm level were achieved.
This loading test convincingly vindicated the superiority of GPS-based bridge monitoring. After this, the upgrade and modification of the superstructure health monitoring system of Jiangyin Yangtze River Highway Bridge was completed using the Leica Geosystems' GPS monitoring system that focused on the monitoring of the girder geometric form and the displacement of the bridge towers.

Installation of the brigde monitoring system on Jiangyin Yangtze River Highway Bridge.

Leica Geosystems' GPS bridge monitoring solution

The GPS bridge monitoring system consists of GPS sensors, communication links, processing, management and analysis software, and accessories. All of above components form an integrated system. In the design stage, the environmental situation has been considered as the predominant error source in the bridge environment. Multipath is caused by signals arriving at the antenna which have been reflected by nearby metal objects, ground or water surfaces. The error is different in each measuring site and cannot be eliminated by differential techniques. At the reference station site, the position of the antenna has been selected to avoid such reflections. Leica Geosystems' AT504 choke ring geodetic GPS antenna help to reduce the multipath effects. Leica Geosystems' advanced dual-frequency GPS reference stations comprising GRX1200 Classic, one AT504 Choke Ring antenna and several AX1202 antennas were proposed in the monitoring system. Leica GPS Spider software with the new positioning option was adopted as the software of this system.

A GPS reference station should be established in a stable area. As the start point of each baseline, the reference station must have precise coordinates within the local coordinate system. Only one reference station was installed on the roof of the Bridge Monitoring Center in this upgrade and modification. To show to maximum effect the distortions and dynamic characteristic of the bridge, 8 GPS monitoring points have been installed. These were placed at the two bridge towers, the maximum flexibility point of the main span, and at the four quartile points, at the 1/4,1/2 and 3/4 points of the bridge. Finally, based on the transformation parameters provided by the user, the system provides three dimensional dynamic displacement results within the bridge's coordinate system. Leica GPS Spider also provides an interface for other analysis software over serial and TCP/IP. Any analysis software that uses the standard NMEA format can be used. The architectural engineering partner of Leica Geosystems may provide this kind of solution. With real time bridge coordinates, third party analysis software may perform dynamic display of real time distortion curve, storage, statistical analysis and warning. Moreover, Leica GNSS QC quality test analysis software can be used to perform the quality analysis and research on the results. This is an indispensable tool for checking data and results in the design and operational stages.

The application advantages using the Leica Geosystems' centralized RTK software in the Jiangyin Bridge GPS Monitoring and some suggestions

The new advanced GPS Spider bridge monitoring solution with centralized RTK function developed by Leica Geosystems is superior to the traditional RTK solution. The communication requirements are greatly simplified with Leica GPS Spiders' centralized RTK concept. The receiver equipment can be remote controlled and monitored, and the status of the system can be obtained at anytime. With the standardized output interface, it can be easily connected with third party analysis software. Operating at a 20Hz measurement rate, the bridge monitoring system is able to detect high frequency vibrations.

Mr. Li of Leica Geosystems partner EuroAsia installing a GPS monitoring station

In order to enhance the reliability of the system, we suggest establishing two reference stations. Leica GPS Spider supports multiple reference stations to provide redundant checks. If the communication to one reference station breaks down, other reference stations can be used as backup for processing any combination of baseline. Leica GPS Spider can process the observations of L1 single-frequency GPS receiver and L1+L2 dual-frequency GPS receiver. Thus single-frequency GPS receiver also can be used for the bridge monitoring application.

GPS RTK technology will be applied widely to the digital, intelligent bridge construction

With GPS RTK technology, the geometric form of the bridge can be monitored in real time and in all weather conditions. The three dimensional displacement of the towers, main span and suspension cables can be measured directly. All of this characteristic information that reflects the bridge's health can be combined with structural models to analyze the internal forces affecting the main components of the bridge. The reliability of the bridge health monitoring and evaluation can be increased and the risk of potential damage to the structure bridge can be detected. Therefore, GPS monitoring can improve the efficiency and effectiveness of the maintenance work, provide the quantification information to the management and decision making of the traffic and structure safety of bridge, and make reliable assessment of the safety of the bridge. With the ongoing development and improvement of GPS hardware, processing algorithms and software GPS monitoring systems will be applied widely to the structural monitoring such as bridges, building and other structures. Meanwhile, the Jiangyin Bridge's structure health monitoring system will play an active role in the promotion and development of the digital and intelligent bridge engineering.

Benefits

- Leica GPS Spider software incorporates centralized RTK functionality tuned to support structural monitoring applications at 20 Hz handling single and dual frequency GPS receivers.
- The results are streamed in real time through different communication ports like serial, modem and TCP/IP under various format like the standard NMEA and the Leica extended format which facilitate the integration in third party analysis applications.
- The communication between each GPS monitoring station and the office center is reduced to only one duplex line.
- An advanced filtering technic has been developped and implemented to improved the performance of the results. The unique Quasi-Static initialisation method provides the fastest ambiguity resolution

The Jiangyin Yangtze River Highway Bridge is the longest steel boxgirder suspension bridge in China

Whether you monitor the movement of a volcanic slope, the structure of a long bridge or track the settlement of a dam; whether you measure, analyse and manage the structures of natural or man-made objects: the monitoring systems by Leica Geosystems provide you with the right solution for every application.

Our solutions provide reliable, precise data acquisition, advanced processing, sophisticated analysis and secure data transmission. Using standard interfaces, open architectures and scaleable platforms, the solutions are customizable to meet individual requirements - for permanent and temporary installations, for single sites and monitoring networks.

When it has to be right.

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