

## Large-scale Bridge Distortion Measuring Technique Discussion

Yue-Guang HE<sup>1, a, \*</sup>, Chun-Jie ZHAO<sup>1, b</sup>

<sup>1</sup>Changsha University of Science and Technology, School of Communication and Transportation Engineering, Changsha 410004, China

<sup>a</sup>hyg@csust.edu.cn, <sup>b</sup>zhaoluomi@126.com

\*Corresponding author

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**Abstract.** Deformation Measurement is a large measuring deformation monitoring of bridge and the bridge is structurally controlled an important part of long-term monitoring and diagnosis of health. The article comprehensively analysis contemporary advanced measuring equipment and new technology, such as GPS global positioning system, surveying robots and measuring digital close-range photogrammetry system, and then formulates advanced and reasonable surveying measurement, make up the corresponding data processing software to create real-time monitoring system and large bridges monitoring data analysis and management system, formed a complete bridge suitable for large deformation measurement theory and techniques to ensure the normal operation of large-scale bridge building and the quality is of great significance.

Large-scale bridge cost is very high; it has strategic significance in many ways, such as transportation, military, social life and so on. It can be predicted that, in the next 20 to 30 years, long-span bridge is still growth rapidly. Large-scale bridge is influenced by many aspects for the construction and operation. During the process of construction, bridge is a typical time-dependant structure, having a close relationship with construction technology. In addition, attack and corrosion of the environment, dynamic loading of vehicle and wind damage structure and reduce resistance and all of that affect the service life of bridge.

With the vigorous development of the transportation industry, bridge load tends to increase with new structure, new materials and new technology. The test technology of bridge engineering, constantly developing and improving is increasingly valued by people. Bridge monitoring can be divided into experiment monitoring and construction monitoring. In order to study the changes of the bridge, it must measure the variety and size of geometric quantities, for the characteristics of large-scale, for example, cable-stay bridge and suspension bridge, is large span, high tower and flexibly main span. Therefore, it is necessary that the bridge monitoring is used by geodesy and special engineering surveying instrument and methods [1].

### Construction Monitoring and Control Content of Large-scale Bridge Structures

The task of the bridge construction control is to ensure that the structure internal force and deformation are in the permitted range during the construction, to ensure that the status of bridge meets the design requirements. If not effective adjustment and control, it has different influence in the construction, appearance, reliability and economy because it is cumulative with theory and deviation during bridge construction. It has far-reaching significance that takes timely and effective monitoring and control of the bridge on the engineering quality and performance. Therefore, the construction control is to establish a center to have a system which have practical measurement, calculation analysis technology of monitoring and control technology. The system monitors main parameters in real time during each construction stage to guide and control construction, controlling construction internal force and deformation and also to ensure the linear and safety of the bridge.

Construction control includes four aspects: (1) the geometric deformation control (2) stress control (3) stability (4) safety control. Among them, it is critical to do the geometric deformation for the construction control and prediction. It is to control the deviation between the actual state and

forecast state of the bridge structure in the allowable range in order to meet the design requirements. Structure size is a basic requirement of the construction control. Through the construction monitoring, the final error on bridge structure should comply with Technical Specification for Construction of Highway Bridge and Culverts. The main purpose of geometric deformation control is to obtain the actual geometry structure deformation or displacement. The results of geometry parameters monitoring will directly feedback to the construction control system. Therefore, it requires not only accurate, also requires a consolidated date in a time [2].

### **The Content of Long-term Monitoring and Health Diagnosis of Bridge Structure**

Technology of bridge health diagnosis includes the load online real-time monitoring, geometric deformation monitoring, and structural reaction monitoring and state database of structure. The healthy monitoring system of bridge structure mainly includes high performance sensing element and the signal acquisition equipment, monitoring data of multi parameter and multi sensing element, data dynamic management method, structure damage identification in real-time, positioning and model modification, structure health diagnosis and safety early warning system for real time. The healthy monitoring system of bridge with full equipped is equal to a "all weather" doctor to guarantee the construction and operation of bridge [3].

The literature of 4 thinks, bridge engineering achievement in twentieth century is not only reflected in the development of prestress technology, construction of long-span bridges and the exploration of extra long-span bridges, but also reflected the people's ideas and efforts that structure of bridge is implemented intelligent control and monitor. In recent 20 years, research achievement of wind resistance and seismic performance, new material and new technology promote the development of long-span bridges. At the same time, along with people pay attention to the large bridge's safety, durability and normal function, bridge health monitoring and system have been made and developed.

### **Deformation Monitoring Method of Large-scale Bridge**

Deformation measurement is a method that using the method of measuring instruments and other specialized instruments to monitor and observe the phenomenon of deformation. The purpose of the deformation measurement is to obtain the date about subjects deformation process (including the amount of deformation and deformation rate) to monitor the surface and operations of the buildings.

Since 1950, people realize the importance of bridge safety monitoring. Early detection of the bridge is mainly for the long-term deformation of internal force about bridge structure, foundation settlement and so on. Its content is single and its technology is given priority to surveying method. With the development of advanced measuring instruments and technology, bridge monitoring technology has a great development.

### **Construction Monitoring Technology of Large Bridge**

Construction monitoring of large bridge, monitoring results of morphological parameters will directly feedback to the construction control system. At present, main instrument includes ranger finder, level, theodolite, total station electronic tacheometer and so on. It also uses a method as a means of monitoring that need three-dimensional geometry parameter of whole process tracking. The method adopts the total station instrument that range finder precision and angular accuracy conform to the specified value and combines with the fixed height of a target. It also uses many ways, such as precision level and the level ruler measurement, the line of sight level observation precision electronic inclinometer measurements and so on, to monitor elevation and deformation.

### **The Characteristics of the Large Bridge Safety Monitoring**

Large-scale bridge safety monitoring has an unique characteristics, such as (1) synchronization and real-time monitor several specific point;(2) for modal testing, each measuring point sampling 5

times for the interested frequency at least;(3) Field testing. Automatic engineering structure damage identification can only test on real structure. Test work under atmospheric conditions, the equipment must be able to withstand severe weather conditions, working all-weather in rain and fog day. System can withstand the distractions;(4) High precision measuring displacement(asked for 1~2 cm), large measurement range ( $\pm 1$  m) . It is often difficult to achieve these requirements for classic measurement method.

### **Method of Safety Monitoring of Large Bridges**

At present, there are three methods for large building vibration, geodesic method, the accelerometer test method and displacement sensor testing. Accelerometer measurement method is a kind of classical vibration test. But before measuring instrument must be zero, zero drift appears continuously during long-time observation. It also needs wires to connect the accelerometer with data center to increase the measurement noise. In order to obtain displacement of bridge, it needs to be accelerometer measurements after twice integral and it gets a great error. Displacement sensor testing method is a contact testing method; test equipment's end shall be installed on the fixed point outside the object. It is often used in measuring structure model, and in this way, it is difficult to test large buildings.

Geodetic method includes total station measuring method and GPS measurement method. With the development of science and technology of surveying and mapping, it becomes applicable for bridges safety.

### **GPS Bridge Safety Monitoring**

With the GPS receiver technology and software developed, especially the improvement of GPS satellite signal solution to improve precision accuracy, which can real-time, high dynamic, high precision displacement measurement. It provides the conditions for the real-time safety monitoring of large bridge. GPS sampling rate up to 10Hz, the precision of plane  $\pm 1$ cm, elevation  $\pm 2$ cm. Because main vibration frequency amplitude of the large span bridges are below 0.5 Hz, under random excitation in 10 cm in the vehicle and under the influence of the typhoon can reach meters level. The current GPS sampling rate can completely satisfy the requirement of vibration test.

### **GPS Multi Antenna Technology**

GPS monitoring technology can realize the real-time dynamic monitoring, which is very suitable for the overall rigid body, using local point instead of the whole bridge monitoring. However, the conventional GPS technology are some problems:(1)There are so many points that need a lot of expensive GPS receiver;(2)It is unable to guarantee safety to many equipment, such as GPS receiver, a solar power supply device, communication, computer and so on.

GPS monitoring system, using GPS multi-antenna sharing editor, only need install the antenna on each monitoring point. It does not need to install the GPS receiver. In other words, a receiver controls multiple antennas. Therefore, it reduces the cost of monitoring system greatly. The deformation monitoring system called GPS multi-antenna array deformation monitoring system, the system can save two-thirds of costs.

### **High Precision Measurement Robot**

The machine is called measuring robot that can be continuous and timely for multiple cooperative target with automatic identification, aiming, tracking, angle measurement, distance measurement and three dimensional coordinate measurement. This system can be continuous or timely for multiple cooperative targets with automatic recognition, aiming, tracking, angle measurement, distance measurement, and 3D coordinate measurement. It also can realize "the unattended", and can achieve sub-millimeter accuracy. Its characteristic is the high degree of automation, all-weather work, and high measurement accuracy. It is very suitable for deformation monitoring of building [6], such as bridge deck line and the deflection observation, horizontal displacement of the main girder, swing of high pillar observation and so on. But the bridge multi-point measurement using polling

mode, the single point positioning needs 3s, it needs 10s at least for multi measuring points. It is difficult to realize the real-time safety monitoring.

### **Digital Photogrammetry Method**

Photogrammetry is a kind of remote sensing data collection way, operation personnel can be far away from the measured object due to the conventional photogrammetric equipment specialized, expensive, long data processing cycle. On the other hand, the digital close shot photogrammetry system consists of image processing, 3D reconstruction, deflection analysis and drawing software. This system is also long cycle of date. It can be used for production monitoring, not to achieve real-time dynamic monitoring. Therefore, it is difficult to popularize application in bridge safety monitoring [7].

### **Conclusion**

(1) In order to avoid accident of large bridge, bridge health monitoring and vibration control technology have become an important way for disaster evolution research of bridge structure and safety rules guarantee. Because the large-span bridge is greatly influenced by environmental factors and safety coefficient is low, it must be continuous monitoring. Deformation monitoring is an important content of bridge health monitoring.

(2) At present, based on the large bridge safety monitoring requirement for high displacement precision, synchronization and real-time monitoring, the high accuracy measurement robot and digital photogrammetry method is difficult to realize.

(3) Measuring robot's characteristic is the high degree of automation, all-weather work, high measurement accuracy. It can be used for production monitoring, such as bridge deck line and the deflection observation, horizontal displacement of the main girder, swing of high pillar observation and so on.

(4) Compared with other displacement monitoring instrument, GPS has obvious advantages because of positioning accuracy, high speed, 10Hz sampling rate and precision of  $\pm 1\text{cm}$ . It can be used to monitor the long-span bridges continuously and real-timely.

(5) Switch antenna array of GPS monitoring system greatly reduce the number of GPS receiver, which can greatly reduce the monitoring cost, it is a great significance to build large-scale monitoring system.

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