Research on BIM based bridge Inspection and Safety Evaluation System

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Abstract. The appearance of BIM technology brings a new revolution to the bridge detection technology. This paper mainly introduces the content and advantages of the bridge detection and safety evaluation system based on BIM technology.

Keywords: Bridge detection; BIM; Safety evaluation system.

1. Introduction

As a lifeline project, the safety of bridge operation is very important. How to ensure the health inspection and safety monitoring of Bridges, especially long-span Bridges, is another hot topic in bridge research. In the process of operation, Bridges are repeatedly subjected to vehicle-borne, wind loads and other loads, as well as adverse factors such as climate, aging materials, fatigue and earthquake, which inevitably lead to natural aging and damage accumulation, and even sudden collapse in serious cases. On June 29, 2009, the West Bridge in Tieli City, Heilongjiang Province collapsed. According to the statistics of 24 bridge accidents, there were 3 accidents in 2009, 4 accidents in 2010, 6 accidents in 2011, and 8 accidents in 2012, with the bridge accidents increasing year by year[1-2]. Therefore, the health monitoring and safety monitoring of Bridges are becoming more and more important. Through monitoring, hidden structural hazards can be found in time and measures can be taken to effectively prevent sudden disasters. It can also provide data basis for the evaluation and verification of new theories and technologies of bridge structures[3-5].

After 20 years of active exploration, some achievements have been made in the field of bridge health monitoring[6-8]. However, it should be clearly recognized that there are still many unsatisfactory aspects in the current bridge health monitoring system due to the complexity and uncertainty of the bridge structure itself, as well as the limitations of many objective conditions: (1) the optimal arrangement of limited sensors and reasonable determination of the system scale; (2) The change of bridge structural performance is not sensitive to the structural fingerprint, and the damage identification is still in the theoretical research stage; (3) The real-time processing and analysis of a large number of original data lag behind, and the information obtained cannot meet the engineering requirements; (4) The evaluation method of structural health status is not perfect, and it is difficult to give reasonable conclusions and explanations; (5) The structural health status only considers the performance of the structure itself, but does not consider the health status of the auxiliary components; (6) There is no unified standard and specification for bridge structure supervision and monitoring, and the system is too different; (7) How to effectively combine with other related systems, especially with the traditional inspection and maintenance system.

The above shortcomings and limitations determine that the traditional visual inspection method cannot be directly and effectively applied to the health condition inspection of large Bridges. Therefore, a new method is needed to monitor the structural response of Bridges under various environmental and load factors in real time, and provide effective scientific basis for bridge maintenance and management, so as to significantly improve the overall management level of Bridges[9-12]. Thus, the integrated monitoring system can ensure the safe operation of the bridge to the maximum extent, diagnose the bridge disease and extend the service life of the bridge.

2. Traditional bridge detection and safety assessment technology

The traditional bridge inspection technology is to monitor, inspect and evaluate the structure safety of the bridge to be inspected by experienced engineers through visual inspection or using the information obtained from the measurement of portable inspection instruments[13]. This kind of artificial bridge inspection can be divided into regular inspection, regular inspection and special inspection according to time. However, in practical engineering application, the artificial bridge detection method has many limitations and deficiencies, which are mainly manifested in:

(1) Poor integrity. The actual detection is mainly carried out for a single component, and can only provide local detection and diagnosis information, and can not provide structural detection and safety evaluation information systematically.

(2) Professional assistance is not flexible enough. Because of the time and geographical relationship, the coordination of multiple traditional bridge technology majors is often limited to one department or one city, which cannot effectively mobilize relevant technical talents.

(3) Technical communication depends on drawings. Drawing is the main communication medium of sensor layout scheme at present, which requires the artificial use of spatial imagination to transform two-dimensional drawing into three-dimensional spatial entity, which may bring potential misunderstandings in communication and its visibility is weak.

(4) Long cycle and poor timeliness. The information connection between majors is fluid. Only after the previous major is completed can the next major be connected. Information cannot be shared in time. Bridges can be inspected on a cycle of several years. In the event of a major accident or serious natural disaster, immediate information cannot be provided to policy makers and the public.

(5) It requires a lot of manpower and material resources and is highly subjective. Although the timeliness of bridge detection and safety assessment is becoming more and more perfect, some response phenomena and damage development process are difficult to be evaluated quantitatively, which can only be done by experience.

As can be seen from the above, there are many defects in the implementation process of traditional bridge inspection and safety assessment technology, so new technology is needed. BIM based bridge health inspection and safety assessment technology may make up for the shortcomings of traditional technology and bring new development.

3. BIM based bridge health detection and safety evaluation technology

BIM, which is short for Building Information Modeling, emerged in the United States and has gradually been widely recognized and applied in developed countries. Different from the traditional bridge health detection technology, BIM based bridge health detection technology will take the bridge project information model data as the core for multi-professional collaborative detection, evaluation and management. Its technical core is mainly composed of three parts: bridge structure model information system, bridge detection information acquisition system and bridge structure safety evaluation and early warning information system.

3.1. Bridge structure model information system

The bridge information data system uses BIM modeling software to establish the project structure data information including the bridge and canal structure, construction and operation environment, as shown in Figure 1. Revit modeling software should be used for bridge building, structural and electromechanical information law. It provides visual communication and management basis for the optimization of bridge health detection scheme, data collection and bridge reinforcement in the later stage. The prospective simulation and optimization of the location, quantity and sensitivity index of sensors before the implementation of the detection and reinforcement scheme can not only provide more accurate and effective data information, but also accelerate the efficiency of communication and collaboration among different majors. It is also helpful for the intelligent detection and evaluation of future Bridges, especially in the detection blind areas of different types of Bridges.

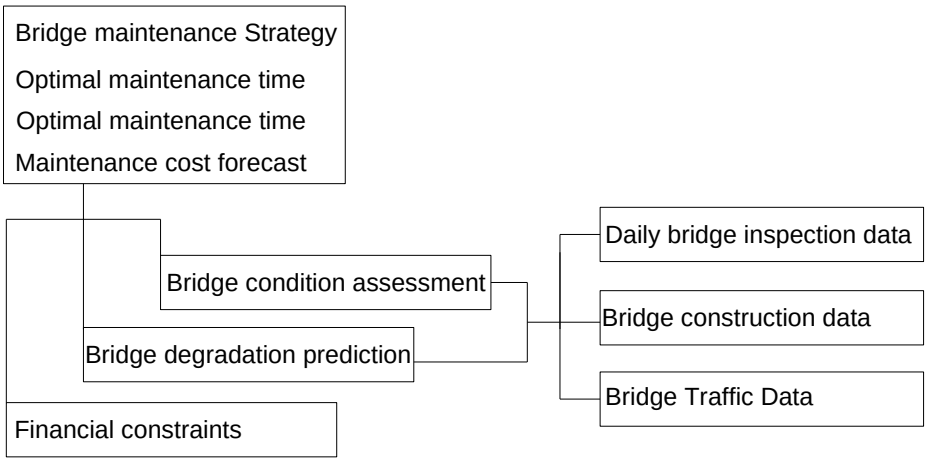

Figure 1. The basic framework of bridge management system

3.2. Bridge detection information data collection

The bridge health monitoring system is a comprehensive monitoring system which integrates structure monitoring, system identification and structure evaluation. A variety of advanced testing instruments and equipment are usually used to monitor various responses of Bridges under various external incentives, including traffic loads and environmental loads [14]. The building information data acquisition system generally collects the stress, displacement, load and other information of each detail of the bridge by the strain tester at each part of the bridge, and then realizes the remote transmission and data processing through the network interface connected with the computer. The stress-strain sensor can generally collect the following data according to different data collection and installation positions:

(1) Bridge structure data information: stress, displacement, deflection, pre-response, structural key node stress, beam deflection and vibration, bearing reaction, pile stress and other previews are consistent with the source document download HD without watermarking;

(2) Data information of bridge structure load and action: earthquake action, wind and rain load, collision between vehicles and ships, river scouring, displacement and settlement of pile foundation and cap, etc.

(3) The external environment data information of the bridge structure: the layout of sensors such as temperature, humidity, corrosion degree of concrete and rebar and corrosion gas concentration should be economical, reasonable and applicable, and the monitoring items and layout points should be analyzed and optimized in combination with the stress characteristics of the bridge. Special and important parts should be focused, monitoring equipment capacity and the number of sensors should also have moderate redundancy, to ensure the reliability of the system, and meet the system module system upgrade in the future. Sensor construction should minimize the damage to the bridge structure.

3.3. Bridge structure safety assessment and early warning information system

The bridge structure safety evaluation system is to make use of the established bridge structure damage identification mechanism and cloud database to preliminarily screen the data collected by the bridge detection system to obtain the required characteristic information of the bridge structure, and then conduct simulation analysis through the established BlM model, so as to realize the bridge structure safety evaluation. At the same time, a more intelligent early warning information system should be established for Bridges of different bridge types and geographical locations. At present, the system should include the following contents: (1) structural geometric form parameter assessment (2) Damage identification based on structural deformation (3) Damage identification based on structural internal force or stress (4) Damage identification based on structural vibration characteristic parameters (5) bridge structure working state assessment (6) bridge bearing capacity identification [15].

BIM based bridge structure safety assessment and early warning information system takes bridge BIM model as the main body (as shown in Figure 2). Various professional departments can communicate with each other directly through the network and mobile communication terminal, enabling engineers of different specialties distributed in different geographical locations to work collaboratively through the network. Avoiding the straight-line model where each department must be completed after the previous department helps to leverage the resources and talents of each department. At the same time, the visualization of BIM bridge detection can realize the optimization of sensor layout, construction and late maintenance scheme of the detection system.

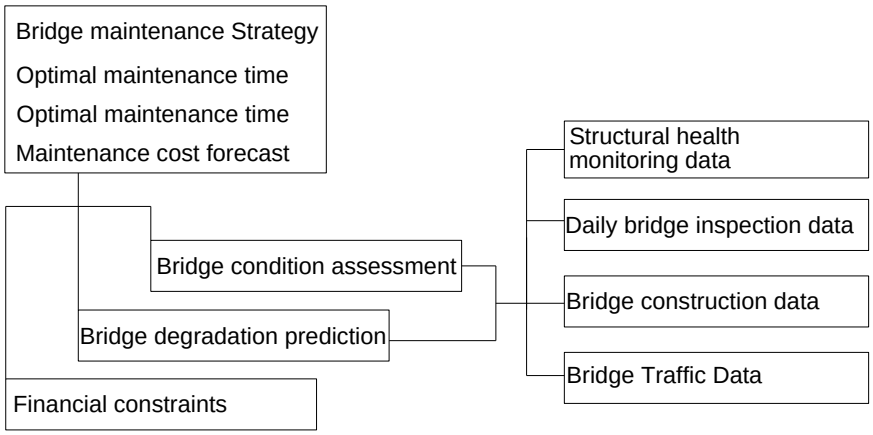

Figure 2. Basic framework of bridge maintenance management system after information fusion

4. Conclusion

The monitoring level of domestic bridge maintenance pipe lags behind and lacks advanced technology. It is still in the technical level of artificial bridge detection and security checking calculation, which needs to consume a lot of manpower, material resources, financial resources and time. Therefore, based on the establishment of bridge project information model, the BIM bridge safety detection and monitoring technology, which collects information data in bridge operation through network technology and wireless optical fiber and conducts data analysis, will be the inevitable trend of the development of bridge detection and monitoring management technology in the future.

Acknowledgments

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