Application of Big Data Technology in Bridge Construction Safety Control

Zhimei Wang¹, Jinlan Tan⁰,* Xu Wang² and Dongping Hu¹

¹School of Civil Engineering, Chongqing Metropolitan College of Science and Technology, Chongqing, China
²Chongqing University, Chongqing, China

*Corresponding author e-mail: tanjinlan@cmcst.edu.cn

Abstract. In the process of urbanization in China, bridges play a very important role, but there are many problems in the construction of bridges, which need to be effectively controlled, among which safety control is very necessary. Under the background of the rapid development of information technology and big data technology in the new era, the bridge construction safety control also needs to be applied to these technologies in depth. This paper explores the elements of safety control in bridge construction, puts forward the necessity of applying big data technology in the safety control of bridge construction, analyzes the contents of big data and the framework of big data platform, and makes a deep study on the early warning system.

Keywords: Big Data, Bridge Construction, Safety Control

1. Introduction
In the process of China's modernization, big data technology of information technology has shown a strong development trend, which provides a powerful impetus for the development of China's economy. At the same time, in the process of China's modernization, the road bridge project is also very important, and it is an important part of the construction of modern traffic hub. Therefore, only paying attention to the construction quality of bridge engineering, and regularly understanding the wear phenomenon in the process of using the bridge, and repairing and maintaining it can minimize the adverse impact of bridge damage on the development of Chinese cities and economic development. Therefore, this paper explores the application of big data technology in bridge construction safety control.

2. The Elements of Bridge Construction Safety Control and the Necessity of Applying Big Data Technology

2.1. Safety Control Elements of Bridge Construction
According to the in-depth analysis and Research on various risks involved in the bridge construction process, it can be found that it is mainly divided into construction personnel technical factors, construction equipment factors, construction scheme factors and construction organization factors.

**Table 1.** Construction risk factors

| Construction risk                          | Proportion | Risk severity |
|-------------------------------------------|------------|--------------|
| Personnel technical risk                   | 30%        | high         |
| Risk of mechanical equipment              | 20%        | middle       |
| Design risk                                | 10%        | low          |
| Construction organization risk             | 40%        | high         |

As shown in Table 1, the technical factors of construction personnel account for 30% of the construction risk, and the risk degree is relatively high. Especially some special operators have played a key role in the overall safety construction. They must have the qualification certificate to carry out construction on site. Some ordinary operators need to pass the site safety test before they can carry out construction, and strictly abide by the requirements of construction in the construction process to ensure their own safety and equipment safety.

Construction machinery and equipment elements account for 20% of the total risk, and the risk level is medium, mainly in the construction process, some equipment with qualified inspection and relatively good reputation should be selected. The construction scheme factors account for 10% of the total risk, and the risk level is relatively low [1]. Most of the design schemes are issued by the research institute or design institute, approved by experts and finally delivered to the construction unit. Therefore, the overall proportion of risk factors of the original design scheme is relatively low. Construction organization and management elements account for 40% of the total risk, and the risk level is relatively high, so we need to pay great attention to the construction organization risk. It is mainly the organization, structure, management system and other aspects of some construction units. Before construction, it needs to organize and formulate and research the reality, and at the same time, it also has a direct impact on the overall safety risk during the construction process.

2.2. Necessity of Application of Big Data Technology in Bridge Construction Safety Control

The scale of bridge construction in China is expanding rapidly, and the emphasis of bridge construction in China will be changed from the early stage to the later maintenance and maintenance, which puts forward higher requirements for the current safety control of bridge construction. Especially with the increase of bridge age, its own performance gradually degenerates, and the damage and disease appear. In order to adapt to this trend, China has gradually standardized the construction and maintenance contents of bridge projects.

Big data technology has its own strong advantages, especially the bridge data expression format is diverse. It has high dimension characteristics, involving many formats such as text and pictures, and also includes different data such as bridge type, bridge stress and bridge span, which can meet the requirements of modern bridge construction [2]. Especially in the context of the rapid development of Internet technology, the integration of Internet technology and bridge safety construction system has become an important trend in the new period.

According to the application of big data in western developed countries, great achievements have been made in bridge safety control, including real-time online monitoring system, massive historical engineering data mining technology, and bridge scheme and decision based on visualization technology. Different technologies are based on big data, through the effective analysis of massive data, can obtain useful information, and provide reference for the safety construction management of bridge engineering, including understanding the hidden dangers in the construction process, and proposing construction scheme decision [3]. Therefore, the application of bridge safety control system based on big data in China still has a great development prospect. In the general architecture of big data processing, it mainly includes control node, data node and other aspects. Each data node belongs to the master-slave relationship, while each data node can be used as standby to complete the
distributed processing of bridge engineering safety construction data. This greatly improves the level and efficiency of construction safety control of China bridge engineering, and can solve the traditional bridge inspection and maintenance to solve the problem And the shortcomings in information storage.

3. Study on the Necessity of Green Construction of Highway Bridges
The big data of bridge has many characteristics, such as diversification, mass and rapidity. Different bridges have a full life cycle. The data that can be queried involves professional data information such as design and construction, maintenance and detection. It can rely on advanced information system to establish big data analysis system.

3.1. Bridge Construction Data
In the bridge safety construction, the initial file includes the drawings and materials produced during the design process and the test report, and also includes bidding documents, as built drawings, financial statements and other aspects generated during the construction process. These data will be used as an important reference for bridge safety construction and later maintenance. With the gradual completion and use of bridges, the data will not be used Broken get updated.

3.2. Bridge Monitoring Data
There are many large bridge components in China, which have high cost of manual maintenance and many difficulties. Therefore, the bridge health monitoring system is installed in the bridge construction, involving acquisition system, transmission system, data evaluation system and alarm system. The monitoring data of transmission system mainly include environmental data, load data, bridge response data, etc. The data of these health monitoring systems are affected by the number of sensors and sampling frequency. The amount of data generated every day is relatively large, and the analysis, storage and call of these massive data is relatively difficult. In the new period, the bridge safety construction monitoring system can be built by using big data technology, then data real-time can be carried out, and more analysis and evaluation and alarm can be added. Especially with the improvement of data mining technology, more effective data will be excavated from these data [4].

3.3. Bridge Maintenance Data
According to the regulations of highway and Bridge Assessment in China, there are corresponding requirements for maintenance and inspection of bridges. During the whole life cycle, it is necessary to carry out regular inspection and inspection, including routine inspection and special inspection every month. The inspection items of each bridge mainly include the main beam, support and other contents. The average amount of test data is very large. The data of maintenance not only need to analyze the performance trend, but also can carry out the comparison of the same kind of bridges, including the maintenance mode and frequency, which must be presented in the best way, so as to grasp the state of the bridge in an all-round way [5].

3.4. Bridge Analysis Data
The analysis data of bridge is mainly based on some drawing data, materials, attribute data, etc. produced by the bridge design and construction, and some stress adjustment, strain data and parameter indexes for bridge completion. When the bridge is operated for a long time, some data will be generated from the deterioration of its own performance, which provides an important reference for the modification of bridge model and the presentation of the bridge state. In order to recover the data of the bridge, the corresponding design model must be analyzed and the corresponding bridge indexes must be provided when the bridge is reinforced safely in the later stage, so as to help the bridge recover performance. In addition, linear data and settlement monitoring data of some bridges are important information data to evaluate the operation status of bridges [6].

4. Big Data Platform Architecture
The bridge big data platform is a combination of network transmission composed of distributed platform to realize data interconnection. The overall architecture of big data platform involves hardware, software, network, data, logic, application and other levels, as shown in Figure 1. The whole big data platform has the characteristics of unified open and free, and can realize the information of users in the platform to provide query statistics and other functions.

![Diagram of big data platform](image)

**Figure 1.** Overall framework of big data platform

First, micro cloud platform. As an important source of data of bridge big data platform, micro cloud platform involves many functions such as data storage, analysis, integration and display. The sources of these information are very wide, involving the non-structural and structural data of bridges, including road conditions, earthquakes, typhoons, weather, and other real-time data collected and transmitted. The flexibility of micro cloud platform is relatively high, and each micro cloud platform includes application layer, software layer, hardware layer, logic layer, network layer, etc. In the case of bridge security, it can be composed of multiple or single servers to share data resources and provide corresponding services for the whole platform. Wechat platform has the same position in application, software performance of storage medium and hardware, which affect the overall application performance [7].

Second, hardware layer. Hardware layer mainly involves data acquisition, network transmission and data storage server.

Third, software layer. Software layer design to data entry, geographic information data analysis, evaluation and alarm and information statistics software. Software layer is an important relief to connect the data layer with the application layer. It can operate the original data. Some relatively complex algorithms are needed to meet the requirements of bridge safety construction safety. Meanwhile, the application time throughput and the direct connection of resource utilization of software system affect the overall calculation effect [8].

Fourth, the network layer can ensure the efficiency and security of data communication, including routing, connection, maintenance and termination of network layer. The communication network management can realize the balanced data layer of query time and capacity, mainly providing the data storage mode and structure, and is the center of the whole system. The central database under the data layer includes logical database, address database and data database, which can ensure the storage specification and unification.

Fifth, application layer. The application layer provides services directly to users, which makes it convenient for users to quickly check and apply the corresponding data and meet the needs of users.

**5. Bridge Safety Early Warning System Based On Big Data Technology**

5.1. Analysis of Functional Requirements

Combined with some common risk factors of bridge safety construction, the corresponding early warning system is built for it, which mainly involves human factors, equipment risks, management risks and other aspects. Therefore, the safety system needs to ensure the practicability and comprehensiveness of the data acquisition on site, guarantee the timeliness and accuracy of data
transmission, guarantee the reliability and compatibility of the data storage on site construction, and ensure the efficiency, accuracy and timeliness of risk prediction of data analysis.

5.2. Build Early Warning System
The construction data of bridge engineering has the characteristics of diversification and isomerization. To build the engineering data storage technology based on big data technology, the environment configuration and application requirements should be taken into account. When the actual architecture is carried out, the installation program needs to be downloaded, the corresponding model files should be installed, and the software will be configured and then applied.

5.3. Expand Core Module
After the construction of safety control system based on big data technology, we can understand the hidden danger of safety risks and illegal operation during the construction process and give early warning in time. However, in the early warning, we need to consider the confidentiality of data, and pay attention to the security of data. Many construction technology information involves patents in China's construction field, as well as important secrets. Therefore, the construction management and control system based on big data system needs to be continuously collected and upgraded and optimized. The core module is used to expand, configure the corresponding data encryption transmission protocol, and guarantee the confidentiality of data acquisition and data transmission. It can also guarantee the secret retrieval of engineering construction technology by combining with corresponding algorithms.

6. Conclusion
In the bridge safety construction, it involves a large amount of data, and the big data technology can meet the requirements of modern bridge construction in the new era. This paper analyzes the risk of the hidden danger of bridge construction safety, mainly including the risk of artificial technology, equipment risk and management risk, and explores the necessity of application of big data technology. Meanwhile, the construction of big data platform is analyzed. The construction data of bridge includes construction, monitoring, maintenance and analysis data. Big data platform mainly includes micro platform, hardware layer, software layer, data layer, logic layer, application layer, etc. At the same time, the paper focuses on the analysis of big data early warning system, builds the early warning system and expands the core module on the basis of functional analysis. With the development of bridge construction technology and the promotion of big data technology in the new era, it will be more widely used, which will provide technical support for the improvement of the level of bridge data security control in China.

References
[1] Jaiswal Amit Kumar, Tiwari Prayag, Garg Sahil, Hossain M. Shamim. Entity-aware capsule network for multi-class classification of big data: A deep learning approach. Future Generation Computer Systems, 2021,117.
[2] Mamta Mittal, Shailendra Singh, Dolly Sharma. Bioinformatics and RNA: A Practice-Based Approach. CRC Press: 2021-03-04.
[3] Kolla Bhanu Prakash, Janmenjoy Nayak, B tp Madhav, Sanjeevikumar Padmanaban, Valentina Emilia Balas. Big Data Analytics and Intelligent Techniques for Smart Cities. CRC Press: 2021-03-04.
[4] Ventura Roberto, Barabino Benedetto, Vetturi David, Maternini Giulio. Bridge Safety Analysis Based on the Function of Exceptional Vehicle Transit Speed. The Open Transportation Journal, 2020, 14.
[5] Homaei Farshad, Yazdani Mahdi. The probabilistic seismic assessment of aged concrete arch bridges: The role of soil-structure interaction. Structures, 2020, 28.
[6] Yu Han, Jie Li, Xiulan Cao, Ruoyu Jin. Structural Equation Modeling Approach to Studying the
Relationships among Safety Investment, Construction Employees’ Safety Cognition, and Behavioral Performance. Journal of Construction Engineering and Management, 2020, 146(7).

[7] Tazarv Mostafa, Shrestha Grshima, Saiidi M. Saiid. State-of-the-art review and design of grouted duct connections for precast bridge columns. Structures, 2021, 30.

[8] Xu Yan, Zeng Zeng, Wang Zhigang, Ge Jiping. Experimental studies of embedment length of precast bridge pier with socket connection to pile cap. Engineering Structures, 2021, 233.