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Application Strategy of Digital Comprehensive Management and Maintenance System for Bridges

Shengzhong Xiang, Linlong Wang*, Manman Feng, Jian Cao

China Merchants Chongqing Highway Engineering Testing Center CO., LTD., Chongqing 400060, China

Corresponding author: Linlong Wang, azwzcq@163.com

Abstract: Effective application of digital integrated management and maintenance systems is essential for successful operation and maintenance management of bridge projects. This article analyzes the application strategy of such systems. It provides an overview of comprehensive digital management and maintenance of bridges, an analysis of the basic components of the integrated management and maintenance system, and its application strategies. This study aims to offer guidance for the application of the system and to improve the quality of modern bridge engineering management and maintenance work.

Keywords: Bridge engineering; Digital integrated management and maintenance system; Component modules

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1. Introduction

To effectively manage and maintain modern bridge projects, relevant units and staff need to have a clear understanding of the digital integrated management and maintenance system and its basic components. This will facilitate the application of various modules in the system. By doing so, the system's advantages can be fully utilized and modern bridges can be comprehensively managed and maintained.

2. Basic overview of bridge digital comprehensive management and maintenance

2.1. Concept

Digital integrated management and maintenance of bridges is the comprehensive management and maintenance of bridge engineering structures through digital technology and digital systems [1]. The main tasks of bridge maintenance workers typically include daily inspections, monitoring, testing, evaluation, and repair. With the advancements in digital and information technology and the development of China's bridge engineering industry, this system has been widely adopted for a more comprehensive management and maintenance of bridge projects.

2.2. Application significance

The digital comprehensive management and maintenance system has far-reaching significance in modern bridge projects. At present, the main significance of this system is as follows: (1) It can store all basic information about bridge projects and provide scientific references for subsequent operation and maintenance work [2]. (2) The daily inspections of bridge projects can be scientifically managed to ensure the effectiveness of inspections and corresponding problems can be detected promptly. (3) The maintenance and repair of bridge projects can be managed to ensure the quality and economy of maintenance and repair. (4) Scientific monitoring and evaluation of bridge projects can be carried out to identify major defects or problems [3]. (5) The health of the overall bridge project can be monitored so problems can be discovered and solved promptly. (6) It guides the decision-making process in the operation and maintenance work of bridge projects. With these advantages, this system has been widely used in modern bridge projects [4].

3. Basic components of the digital comprehensive management and maintenance system

3.1. Information storage module

The information storage module is used to input and store all basic information in the bridge project, including its overview, facade layout drawings and photos, specific location information, structural, technical information, administrative identification information, archival information, large-scale maintenance information, accident information, regular inspection information, etc. The information is stored visually using a BIM model so that the bridge engineering data and the dynamic information are continuous and synchronized [5]. **Figure 1** is a schematic diagram of the basic composition of the information storage module.

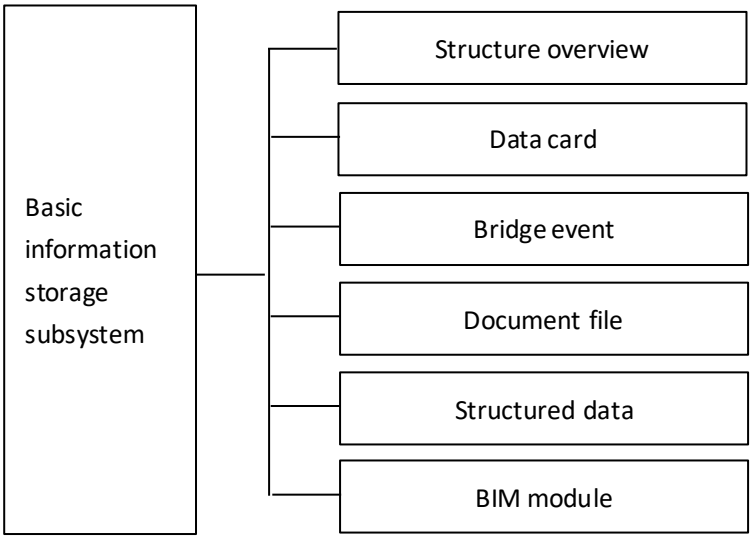

Figure 1. Schematic diagram of the basic composition of the information storage module

3.2. Daily inspection module

The daily inspection module is used to formulate daily inspection plans for bridge projects, collect on-site data on bridge projects, and automatically export and collect them. It can also provide support for real-time trajectory positioning and inspection playback of staff [6]. This module has five main functions: managing inspection tasks, monitoring inspection staff, summarizing inspection records, summarizing the defects found during inspections, and analyzing inspection results.

3.3. Maintenance and repair module

The maintenance and repair module stores various data related to bridge engineering maintenance. With the help of the two systems of maintenance and repair process and predetermined quota management, this module can track the entire maintenance and repair process of bridge engineering in real time [7]. **Figure 2** is a schematic diagram of the basic maintenance process of bridge engineering.

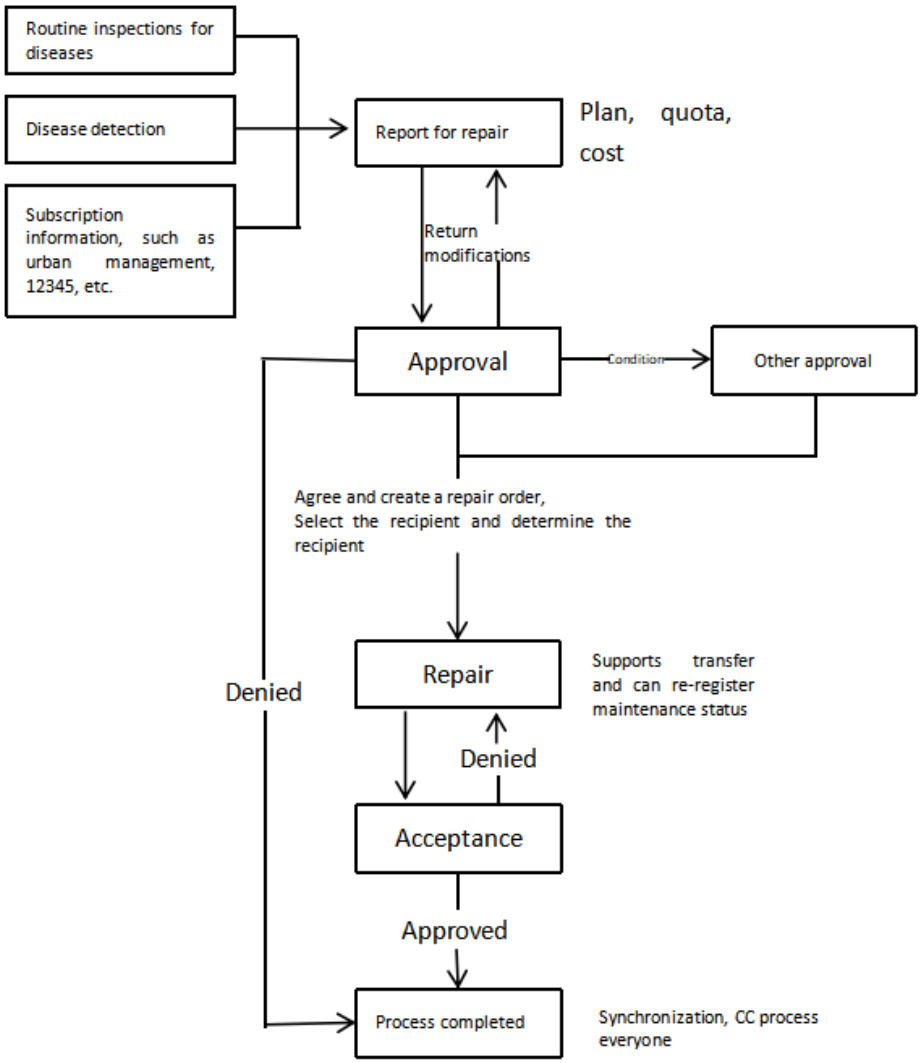

Figure 2. Schematic diagram of the basic process of bridge engineering maintenance and repair

3.4. Detection and evaluation module

The detection and evaluation module is used for routine inspections, special inspections, and material inspections. It performs data collection, automated technical status scoring, registration and export records, and automated inspection report preparation for bridge projects. This module usually has four main functions: detection overview, detection records, defect detection, and detection result analysis.

3.5. Health monitoring module

The main application function of the health monitoring module is to monitor the bridge project's status, manage the monitoring instruments and the obtained data, and conduct real-time viewing and processing of early warnings on bridge project quality and safety issues [8]. This module can perform real-time monitoring of

individual bridge engineering structures or intelligent monitoring of network-level bridge engineering groups.

3.6. Assisted decision-making module

The main function of the assisted decision-making module is to assist decision-making in the management and maintenance of bridge projects to improve the operational safety of the projects and extend their service life. Through other modules in the management system, daily inspection management, maintenance and repair management, inspection and evaluation management, and health monitoring management of bridge projects can be carried out. The integrated data obtained by other modules can facilitate making decisions that are scientific, rational, and targeted [9]. The main functions of this module include the following: managing early warning events, managing key bridge projects, managing the planning model of bridge project structures, managing the maintenance funds in bridge projects, budget management, and managing the medium and long-term repair and maintenance specifications of bridge projects.

4. Analysis of application strategies of bridge digital comprehensive management and maintenance system

4.1. Information management strategy

One of the main tasks in the management and maintenance of bridge projects is the management of basic data. This function is realized through the basic information management module. The staff needs to input the static and dynamic data of the bridge engineering structure into the module. With the support of the BIM model, the data can be collected and classified accordingly. This makes the management and maintenance of bridge projects much easier, achieving the effect of "one bridge, one stage." In addition, integrating the management and maintenance work files and GIS location information can further facilitate the process.

4.2. Integrated management of maintenance data

This digital system can efficiently integrate bridge engineering maintenance data through finer-grained data association. First, this system can establish correlations between various data types. During the maintenance process, the system will code the units, components, and other structures in the bridge project and select the appropriate maintenance services based on the item's characteristics and its correlation with other parts. This prevents "information islands" caused by fragmented data. Through the mutual integration of inspection, monitoring, and maintenance data, each component of the bridge project can be managed comprehensively. These data include basic conditions, physical examination records, disposal methods, incidence frequency data, etc [10]. Secondly, the system can achieve a high degree of integration of various business data. For example, integrating data from bridge engineering health monitoring, inspection and evaluation, and real-time monitoring systems can significantly improve the ability to handle various emergencies. Furthermore, through the early warning function of the early warning mechanism, the system establishes integrated monitoring data to discern correlations between different warning events. Such an approach provides robust support for the integrated management of bridge engineering maintenance data, thus streamlining maintenance efforts effectively.

4.3. Informatized supervision strategy for bridge maintenance work

The main purpose of the informatized supervision of bridge maintenance work is to improve the supervision of bridge maintenance. To achieve this goal, many informatized supervision functions are embedded in the system, including real-time tracking of staff trajectories, fixed location check-in, work delegation, statistics of task completion, export of task completion status, etc. to ensure that this work runs through the entire integrated

management and maintenance workflow of bridge engineering, personnel can also enhance its informatized supervision effectiveness by employing methods such as pre-planning, process tracking, and post-feedback.

4.4. Information standardization strategy for daily inspection work

The digital system incorporates various types of bridge engineering defect databases and maintenance decision libraries. This makes selecting operational actions much more convenient. It guides personnel to systematically register and input maintenance data into the integrated management system according to standards and specifications. During routine inspections and maintenance of bridge engineering, leveraging the embedded ERP workflow system within this system allows for closed-loop management of all maintenance tasks, including defect identification, formulation of repair plans, and defect resolution. This enables personnel to dynamically monitor real-time information on specific defects throughout the entire maintenance management process, facilitating comprehensive tracking of the entire bridge engineering maintenance workflow.

4.5. Intelligent management strategy for bridge inspection and monitoring

Through applying the aforementioned functional module, the bridge project's inspection and monitoring data can be intelligently managed. The staff can use handheld terminals to inspect and monitor bridge engineering structures, thereby achieving real-time and accurate acquisition of various data. Through the one-click upload and one-click export functions on the handheld terminal, the acquired data can be uploaded to the daily inspection module and detection and evaluation module easily. After obtaining the corresponding inspection and monitoring data, these two modules will process them and automatically generate daily inspection reports, technical condition assessments, bridge engineering inspection reports, etc., and send them to the transportation company. This approach greatly reduces labor and time costs.

Moreover, with the integrated AR video monitoring system within this digital platform, rational planning can be made for inspection routes and defect identification techniques during bridge engineering inspections and monitoring. This addresses the online querying and office needs of the personnel involved, thereby minimizing geographical constraints on their maintenance work. This work mode also significantly enhances the efficiency of bridge engineering inspections and increases their frequency. The advantages of this system is far more notable, particularly in extreme conditions, facilitating bridge engineering inspections even under challenging circumstances.

4.6. Real-time information assessment strategy for bridge status

Real-time information-based assessment of the bridge's condition is a crucial aspect of managing bridge engineering through this digital system. The system combines data from routine inspections, maintenance, and periodic checks to calculate a technical condition index, facilitating timely evaluation of the bridge's state.

By adopting this approach, bridge maintenance units can not only devise scientifically informed operational and maintenance plans but also gather valuable technical data for overall management. This, in turn, greatly supports the ongoing comprehensive maintenance of bridge engineering projects. Moreover, the integration of deep learning and machine learning technologies enables the digital system to develop precise predictive models for assessing the technical condition of bridges. As a result, it provides a solid foundation for making well-founded decisions regarding future operations, maintenance, and management strategies.

5. Conclusion

The digital comprehensive management and maintenance system is the forefront and widely adopted

management tool in modern bridge engineering operations and maintenance. Its strategic application not only simplifies the maintenance workflow of bridge engineering but also significantly enhances work efficiency, quality, and cost-effectiveness. Therefore, it is crucial for relevant units and personnel to fully grasp the system's components and functionalities. By aligning these with the actual maintenance needs of bridge engineering, the system can be applied effectively. This ensures the system's technological advantages are fully leveraged, leading to improved efficiency and quality in bridge engineering maintenance.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Xu L, Dai W, Sun L, et al., 2023, Development of Bridge Maintenance and Management and Maintenance System Based on BIM. Engineering and Construction, 37(2): 412–415 + 432.

[2] Pan S, Gong X, 2022, Application Analysis of Structural Health Monitoring System in Bridge Maintenance. Transportation Manager World, 2022(36): 129–131.

[3] Hou N, 2022, Research on urban road bridge inspection and maintenance management information system. Science and Fortune, 14(16): 184–186.

[4] Chen Y, Wang Q, Li H, et al., 2022, Research on the Overall Design and Management Function of Urban Bridge Group Maintenance System. New Industrialization, 12(5): 253–256.

[5] Yang Y, 2022, A Brief Discussion on Applying Structural Health Monitoring System in Bridge Maintenance. Urban Roads, Bridges and Flood Control, 2022(1): 145–147 + 170.

[6] Li C, Su X, 2023, Research Status and Development of Intelligent Bridge Maintenance Management and Maintenance System. Urban Intelligence, 2023(23): 105–106.

[7] Cheng Y, Zhou Q, 2023, Review of the Development of Bridge Management and Maintenance Systems. Engineering and Construction, 37(3): 825–826 + 830.

[8] Dai W, Sun L, 2022, Research and Development Practice of BIM Information System for Suspension Bridge Maintenance of Maanshan Yangtze River Bridge. Modern Transportation and Metallurgical Materials, 2(4): 19–24.

[9] Liao C, Li F, Yu X, et al., 2022, Design and Implement Intelligent Decision-Making Expert System in Bridge Monitoring. Modern Electronic Technology, 45(1): 110–113.

[10] Yi T, Zheng X, Yang D, et al., 2023, Lightweight Design Method for Structural Health Monitoring System of Small and Medium-Span Bridges. Journal of Vibration Engineering, 36(2): 458–466.