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Analysis of the Application of Bridge Rapid Inspection and Evaluation Technology

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Abstract: Rapid bridge inspection and evaluation mainly uses information technology to test the quality of bridge infrastructure and structures, integrates the test results with the existing management system, completes the bridge status assessment, establishes information management files to provide bridge disease problem inspection and analysis, and provides support for the application of disposal measures. This paper briefly discusses the necessity of applying rapid inspection and evaluation technology and analyzes the bridge's rapid inspection and evaluation content, inspection system, and application process. We look forward to the future application prospects of this technology and supporting those in this field.

Keywords: Bridge; Rapid inspection; Evaluation; Informatization

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1. Introduction

Bridges are important hubs in the highway transportation system and are responsible for logistics transportation, daily travel, and other tasks. Bridge operation safety issues have become increasingly prominent with the gradual deepening of infrastructure construction. If the management is poor, safety hazards may occur. The application of rapid inspection and evaluation technology to determine the use status of the bridge can provide timely analysis of changes in bridge strength, stiffness, etc., determine whether there are safety risks in the bridge, and promote the in-depth development of bridge management work.

2. The necessity of applying bridge rapid inspection and evaluation technology

Following the completion of the bridge project construction, it enters the service stage. As the use time increases, some bridges enter the fatigue period, and the probability of various bridge diseases is high. In the bridge project management process, implementing bridge safety inspection and management is an important prerequisite for ensuring the safety of infrastructure and public property. The safety of bridge operations must be given top priority whenever the bridge is put into use because the bridge may be affected by various

factors such as climate, oxidation, corrosion, and aging. At the same time, under long-term static load, the bridge structure may be damaged, which affects the structural stiffness and strength, shortens the life of the bridge, and seriously impacts driving safety. Currently, there are relatively many bridges. During the bridge maintenance stage, some departments have insufficient maintenance personnel, resulting in heavy maintenance tasks. Therefore, introducing information equipment and technology to complete bridge rapid inspection and evaluation can ensure the quality of work and improve bridge maintenance efficiency.

Countries including the United States, Denmark, Spain, the United Kingdom, and other countries have relatively complete technical development related to bridge rapid inspection and evaluation, and the above countries have their inspection systems in this field. However, there is a big difference between the application of foreign inspection and evaluation technology and the domestic technology system, so it is challenging to promote and apply the technology. In in-depth research on rapid inspection and evaluation technology in domestic bridges, the research direction is biased towards equipment automation and semi-automation, integrated means have not been formed, and the detection system function is relatively simple. In the field of inspection and evaluation, application systems, application platforms, etc., exist, but most of the development subjects are in the Internet industry. Certain problems in practical applications still affect the efficient development of bridge inspection and evaluation work [1]. Some testing platforms are incompatible with provincial maintenance platforms, and unification in management has not yet been achieved. In response to the above problems, to improve the quality and efficiency of bridge inspection, it is necessary to introduce information-based inspection technology, conduct an in-depth analysis of the inspection links, and use electronic and intelligent means to break through the information barriers of the bridge field management system. Therefore, applying bridge rapid inspection and evaluation technology is necessary.

3. Application of bridge rapid inspection and evaluation technology

3.1. Bridge rapid inspection and assessment content

Combined with the technical application needs in the field of rapid bridge inspection, the contents of this study mainly include the following aspects:

(1) Applying bridge rapid inspection and evaluation technology to create a daily inspection management system and a routine inspection management system to implement the routine management of each bridge.

(2) Applying rapid inspection and evaluation technology to build an information-based archive system to achieve the goal of “one bridge, one file” management and provide support for specific management work.

(3) Applying bridge rapid inspection and evaluation technology to analyze the causes of bridge diseases and formulate targeted assistance measures to create a decision-making management system.

(4) Applying rapid inspection and evaluation technology to build a bridge maintenance management system.

(5) Conducting in-depth research on the application compatibility of rapid inspection and evaluation technology to minimize the limitations of technology application.

3.2. Development of information inspection system

3.2.1. Development of inspection system

Bridge inspection work includes daily inspections and frequent inspections. Rapid inspection and evaluation technology is applied to conduct an in-depth analysis of the inspection process, and the inspection work is

completed in an information-based manner. The specific process is to use on-site equipment to collect various information during the inspection phase, complete the collection and management of bridge diseases, upload the relevant information to the assessment system, and integrate it with the regular inspection information of the bridge. After analysis, we can understand the various aspects of the bridge during the operation period, check parameter information, and develop a new system. The collection terminal functions are as follows: Firstly, the user module has a login function. Since the bridge detection location may be relatively remote, the user module can be set to offline mode so that the collection platform can be used offline to prevent remote mountainous areas where system applications are limited. Secondly, there are data updating and uploading, including data synchronization and clearing functions. The various inspection parameter information of the bridge during the operation period can be obtained through analysis. Thirdly, there is a project status list, with specific functions including project name, number, owner information, etc., covering the bridge project construction time, usage status, etc. Through this module, the management information can be seen at a glance. Fourthly, the bridge status information module specifically includes the bridge number (route), bridge name, detection time (start and end), and other related information, relying on this module to master the basic information of the bridge and the detection status. Fifthly, it can collect disease and operation information of the bridge, use detection technology to complete daily inspections of the bridge structure, check all routine contents and analyze whether there are abnormal conditions, and determine the damage to the bridge structure. Sixthly, abnormal information can be obtained, the inspection site information is uploaded by taking photos and marking the abnormal locations. Seventhly, there is an abnormal status warning, for abnormal problems in the inspection system, and an alarm button can be set on the mobile terminal. If an abnormal situation is encountered, the information will be communicated to the management department in a timely manner. Lastly, it has a disease information list and upload status. In the inspection system application stage, after relevant personnel obtains daily inspection information and routine information collection, if there are information recording errors, they can be corrected on-site. The development route of the inspection system is aimed at the information inspection system, relying on the user login port to create modules such as data clearing, data synchronization, project list, log out, project list and bridge list, abnormal information collection, information assessment, and data upload association, assisting the smooth progress of bridge inspection work [2].

3.2.2. Development of a file management system

During the development of bridge management work, some management units have relatively large archives. The paper archives have large storage space and are difficult to manage. It is challenging to find information during the archives use stage. In response to this situation, to implement the informatization of bridge management and create the management goal of “one bridge, one file,” the bridge management department can organize archive materials according to the needs of archives information management, form an electronic archive, and provide input for the information management of bridge archive. The functions of the information file management system include the standardized management of basic information, completing the splitting of standardized BIM (Building Information Modelling) components, and entering the electronic version of the bridge’s paper information into it to form an electronic management file, which is convenient for the bridge management department personnel to query and retrieve. The development route of this management system is as follows:

(1) Standardizing management of basic bridge information, covering standardized component information of bridge information cards.

(2) Entering bridge paper material attachments, developing an entry interface for archival data,

formulating a standardized management process, and completing statistics on bridge technical information and entering the current paper version into it.

(3) Conducting an in-depth study of the later electronic management needs of bridge archive information, building a rapid inspection and evaluation management system, and electronically converting bridge management and maintenance materials before entering them. Among them, specific information includes emergencies, bridge maintenance, special inspections, routine inspections, periodic inspections, daily inspections, and reinforcement maintenance.

(4) Combined with the existing management system of bridge projects, developing file retrieval, file query, and other management modules, and granting different levels of permissions based on different management levels.

During the development of the bridge archives information management system, according to the application requirements of the management system, management modules such as standardization of basic information, electronicization of paper materials, and electronicization of later data were set up to assist managers in querying and retrieving archive information, creating a "one bridge, one file" management system.

3.2.3. Development of disease management system

In the stage of analyzing the causes of bridge diseases and applying treatment measures, it is necessary to conduct research on the past operation data of the bridge, summarize and analyze typical bridge diseases, develop a bridge problem analysis database and problem treatment measures library, and combine the effects of bridge inspection, maintenance, and reinforcement, etc. The data regularly updates the management system, and after continuous optimization, it improves the accuracy of disease analysis results and supports the formulation of bridge reinforcement and maintenance measures. The specific development content of the disease management system is as follows: firstly, a disease cause analysis database is established to analyze the causes of typical diseases on bridge structures; secondly, a disease treatment database is established and treatment measures are proposed for typical bridge diseases; thirdly, a disease cause analysis system is established to conduct in-depth analysis of the causes of disease through expert technology; lastly, a disease treatment effect evaluation management system is established to analyze the application effect of bridge disease treatment measures based on the evaluation results.

3.2.4. Development of maintenance management system

The development of the bridge maintenance project management system is mainly for the daily maintenance of bridges and special maintenance building management. The management content includes maintenance information, progress, special maintenance, maintenance acceptance, maintenance history, and other information management. The system development technical line is as follows. Daily maintenance and special maintenance management modules are developed with the bridge maintenance management objectives. Daily maintenance management information includes basic information, maintenance progress, maintenance acceptance, and other information management content; special maintenance includes basic information, project progress, and maintenance. Information management content such as historical databases eventually form a bridge maintenance management system for one bridge and one dam [3].

3.2.5. Development of compatibility optimization system

Currently, during the development of bridge management work, to unify and coordinate management and incorporate bridge data into the domestic highway bridge information management system, bridge information needs to be entered manually. The input workload for managers is large, and it is difficult to record data and

update relevant information with the development of bridge technology. Therefore, it is necessary to use the bridge rapid inspection and evaluation system to study its compatibility with domestic bridge management systems, focusing on system interfaces, management modules, etc., which can break down information barriers such as bridge data, inspection information, statistical reports, and maintenance management [4]. During system application, relevant information can be automatically filled in to generate forms, and data can be updated simultaneously, replacing the previous manual entry management model. The system development plan is as follows: the data in the rapid inspection and evaluation system, such as bridge data, is used to simultaneously update bridge structure, files, diseases, usage status, and other information. Bridge inspection data is updated, focusing on routine inspections, periodic inspections, basic status, and other data. Bridge maintenance data update is to synchronously update data in rapid inspection and evaluation, domestic highway bridges, and other systems [5].

3.3. Application scenarios of rapid inspection and evaluation technology

The application scenarios of bridge rapid inspection and evaluation technology are as follows: Firstly, the bridge management and maintenance departments can use the data in the maintenance system to adopt standardized and electronic management of bridge maintenance data to realize the informatization of maintenance work information management. For example, regularly checking the status of bridges, conducting inspections of bridge structures, grasping bridge reinforcement and maintenance information, and understanding the progress of bridge maintenance on-site work [6]. Relying on this technology, we can obtain bridge structure information, understand the usage status and future development trends of bridges in our jurisdiction, and provide support for making maintenance decisions. Secondly, bridge inspection units can apply this technology to manage inspection. For example, the inspection engineer uses a handheld terminal to check the overall condition of the bridge and enter the inspection results in electronic form, realizing paperless operation throughout the process. After the information is collected on-site and uploaded to the background database, bridge engineers can also use big data detection to conduct analysis. The analysis process has regional and line-based characteristics, and the analysis results are submitted to the owner to guide them in bridge maintenance work. The information compiler of the inspection unit enters the bridge profile information into the system through the background. The system can automatically complete the evaluation, output the inspection report, and form an original record. It has standardized characteristics and is easy to store and manage. After the system is applied, bridge inspection work can be implemented in a paperless operation, making it easier to control the progress of on-site inspections, understand bridge disease information, and manage historical bridge inspection data and maintenance data [7].

3.4. Achievements in technology application

Relying on the bridge rapid inspection and evaluation technology, the application effects are as follows: Firstly, the management of bridge account data is more standardized, using electronic data to improve the communication efficiency of management departments and controlling management costs. Secondly, relying on rapid inspection and evaluation technology to create different management systems, it is easier for managers to analyze the bridge structure and status, provide support for them to make maintenance decisions, rationally allocate maintenance funds, and improve the overall management level of the bridge [8]. Thirdly, the informatization of bridge maintenance work management helps improve the efficiency of maintenance management and control investments into the maintenance process, including personnel and costs. Fourthly, the bridge management on-site inspection work is informalized, and the error rate of management information

input is reduced, which can improve inspection efficiency and control costs. Fifthly, during the bridge information inspection, relevant personnel can divide work and cooperate at multiple points operations to avoid the gathering of people during the inspection period, which is very beneficial to the resumption of work and production. Sixthly, bridge inspection and evaluation reports are automatically generated, which greatly reduces the workload of internal operations and lowers the cost of management personnel. Lastly, bridge maintenance data and information can be archived electronically, controlling data storage space, reducing paper waste, and saving energy [9].

4. Future development prospects of bridge rapid inspection and assessment technology

In the future, with the support of national policies, information infrastructure will be established, a data application system will be constructed, and intelligent maintenance, handheld inspections, and digital monitoring of key bridges will be implemented [10]. It will be a trend to apply network and computer technology and rely on the bridge rapid inspection and evaluation system to deeply explore the information management and maintenance methods of bridge structures to increase the workload of the bridge maintenance department and expand the scope of technology application.

5. Conclusion

In summary, in the bridge management process, rapid inspection and evaluation technology should be applied to build infrastructure based on information technology, create a smart management model, digitally monitor the operating status of the bridge, and assist the management department in mastering data information, including bridge usage, repair, maintenance, etc., to achieve precise management of bridge maintenance and upkeep.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Sui S, 2021, Establishment and Application of Health Monitoring and Safety Assessment System for Cross-Railway Cable-Stayed Bridges. Urban Roads, Bridges and Flood Control, 2021(6): 195–198.

[2] Yu J, Wan W, Xiang B, et al., 2023, Research on Rapid Identification Methods of Disease Investigation and Damage Status of Small and Medium-Span Bridges. Heilongjiang Transportation Science and Technology, 46(10): 64–68.

[3] Huang X, 2021, Application of Bridge Inspection and Assessment Model Based on Disease Development. Chinese and Foreign Highways, 41(2): 97–101.

[4] Zou J, Zhang X, 2021, Detection and Evaluation Method of Extra Large Cable System Bridge Girder Bottom Inspection Vehicle. Industrial Safety and Environmental Protection, 57(11): 36–39.

[5] Zhang Z, Cui X, 2022, Inspection and Evaluation of In-Service Rail Transit Low-Tower Cable-Stayed Bridges. Urban Roads, Bridges and Flood Control, 2022(3): 144–146, 167.

[6] Duan X, 2023, Bridge Reliability Analysis Based on Visual Inspection Results. Construction Machinery, 2023(1): 41–45.

[7] Zhi T, 2023, Discussion on Bridge Appearance Inspection and Non-Destructive Testing Technology. Transportation

World, 2023(18): 178–180, 184.

[8] Wang C, 2023, Research on Bridge Detection and Safety Assessment Based on BIM. Heilongjiang Transportation Science and Technology, 46(8): 74–76.

[9] Zhou L, 2023, Analysis of Bridge Crane Inspection and Testing Technology and Safety Assessment Measures. Modern Industrial Economy and Informatization, 13(2): 214–215, 219.

[10] Liu X, 2023, Analysis of Bridge Safety Operation Assessment After Floods. Transportation Manager World, 2023(3): 143–145.