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Integration Research and Design of the Bridge Maintenance Management System*

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Abstract

Bridge maintenance quality has a direct bearing on the normal use of road function and service level. Based on analysis of the requirements including bridge maintenance data management, bridge safety state comprehensive evaluation, intelligent aided decision analysis and information sharing, the bridge maintenance& management intelligent aided decision support system (BMMS) is designed. The system structure, function module, comprehensive evaluation and intelligent aided decision-making module are given, and BMIADSS based on intelligent decision-making management is developed. This paper provides strong support for the full implementation of bridge maintenance and management informatization.

Key words:Bridge engineering maintenance, management systems, information systems, decision-making

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1. Introduction

The bridge management is to coordinate and control the whole process about bridge, aiming at making sure that the bridge management department can make use of the limited resources reasonably and provide services for the users as good as possible. The bridge maintenance management system, developed on the basis of the bridge structural engineering, mechanism of disease detection and geographic information systems, offers economic and technical convenience for the supervision and maintenance of the bridge.

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The U.S. Federal Highway Administration started the research on the promotion of the bridge management system in 1987.

Based on the work such as database development and the detection of the classification, rating, sorting and the service life prediction of the maintenance operations, they developed a bridge management system-PONTIS. Japan's Ministry of Construction published the bridge inspection manual in 1988. Civil Engineering Institute developed the bridge maintenance management system in 1998 for the integration of the related materials in the periods of construction, detection as well as maintenance, and simplified data delivery by means of Internet in the meanwhile.

The research of domestic bridge maintenance management system dates from the late 80s of last century. The bridge maintenance management departments of various provinces developed the required bridge maintenance management systems according to their own specific conditions of bridge development. With the continuous expansion of the road network and the bridge construction scale, how to realize the sharing of the bridge maintenance information and its regional management is urgent to be solved.

The Bridge Maintenance & Management Intelligent Aided Decision Support System(BMIADSS) is a research topic based on this environment. The database of the system includes the users' database, the information management system database and the intelligent aided decision system database. The integration of the basic data information of the large-span bridges, the detection information of the manual inspection and the healthy detection information is good for analyzing the reasons of the structural diseases, finding out the defects of the components and the changes of related environment timely and handling the technical conditions of the bridge systematically.

2. Bridge Maintenance Management System design

Bridge Maintenance Management System differs with special requirements of departments, which has unique requirement. Bridge Maintenance Management System includes nonseparable major operating modules such as bridge database management, systems management, integrated assessment subsystem management, forecasting and auxiliary decision-making subsystem.,etc. Although the modules are mutually independent, all capable of serving the purpose of enabling connection between systems by using the same keycode (such as the bridge number) to series-connect or switch from each other. The framework for system design is shown in Figure 1.

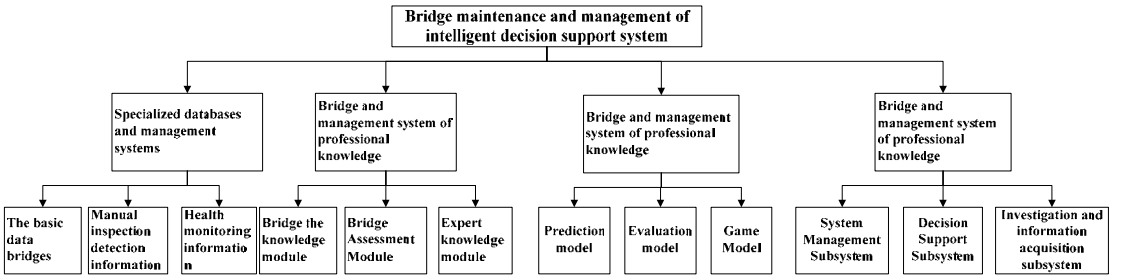

Fig.1 The frame diagram of BMIADSS system

2.2.Bridge Database Management Subsystem Design

Bridge data management subsystem is the system's main module which contains five major information sub-modules--the card information on bridge sub-module, manual inspection test records, condition monitoring records, bridge maintenance records, engineering drawings management. Each function module should have the programming function on data maintenance (to add, modify, delete), data query, statistical analysis, data processing and application.,etc.

Bridge card information consists both bridge data and bridge opening information. Bridge information includes information on its identity and geometric properties which could be modified by lining, naming and numbering of the bridge's basic information from the "data dictionary" of the Maintenance Management System. Corresponding to each bridge, each opening information such as opening number, structure of the upper and lower part and so on could be added.

Bridge opening is designated as the basic operation unit for manual inspection test records, condition monitoring records, as well as maintenance records. The sub-modules of condition monitoring and manual inspection records function maintenance operations management upon the specific components of certain bridge opening. Frequent inspection is a summary based on designating a certain opening of the bridge as the smallest operating unit to conduct a general inspection.

Engineering drawing data module is used to manage information on bridge design drawings. Its downloadable function enables customers of different interests to understand the bridge's designing information.

2.3.System Management Module Design

System management module includes user management, privilege management, opening type management, data backup, data recovery and other sub-modules. It provides the following security policies to secure the conservation of data from the Bridge Management System: (l) Management on system user--different types of users use different accounts; (2) Privilege Management--operators are divided into different levels according to the system requirements, and each level has its own software with corresponding functions;(3)database backup and recovery--setting scheduled backups of system databases, which anables the system to aquire the regularly backuped files for recovery in case of unexpected occurrence.The results is shown in Figure3,4.

2.1.system database design

The collection and input of data as well as the establishment of database is a crucial aspect in Bridge Maintenance Management System, and the quality of data acquisition has a direct impact on the overall system performance., therefore, database establishment must be paid much attention to. Bridge

Maintenance Management System Database, which adopts SQLSERVER or Oracle as the tool of development and management, consists of three parts-- (l)Basic information and data of the bridge, used to display bridge identification information and geometric information.(2)Business data for maintenance and management, including frequent inspections, regular inspections, maintenance record data, assessment data and so on, which all serve as the query to browse, direct source of report output, as well as evaluation for performance and the decision for maintenance programs. (3)The GIS data of bridge, used to display the bridge's geographic information and data.

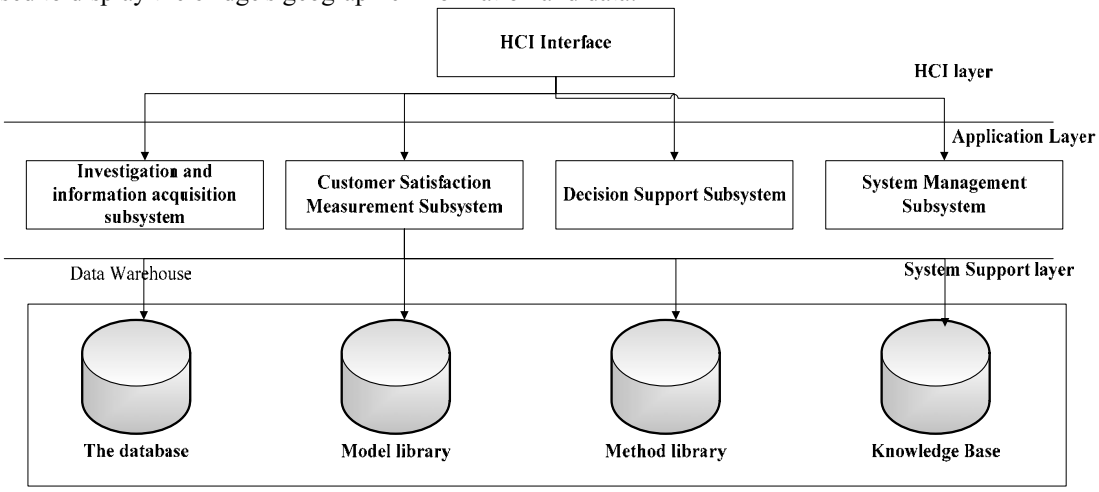

Fig.3 Bridge Maintenance Management Intelligent Integrated Evaluation System

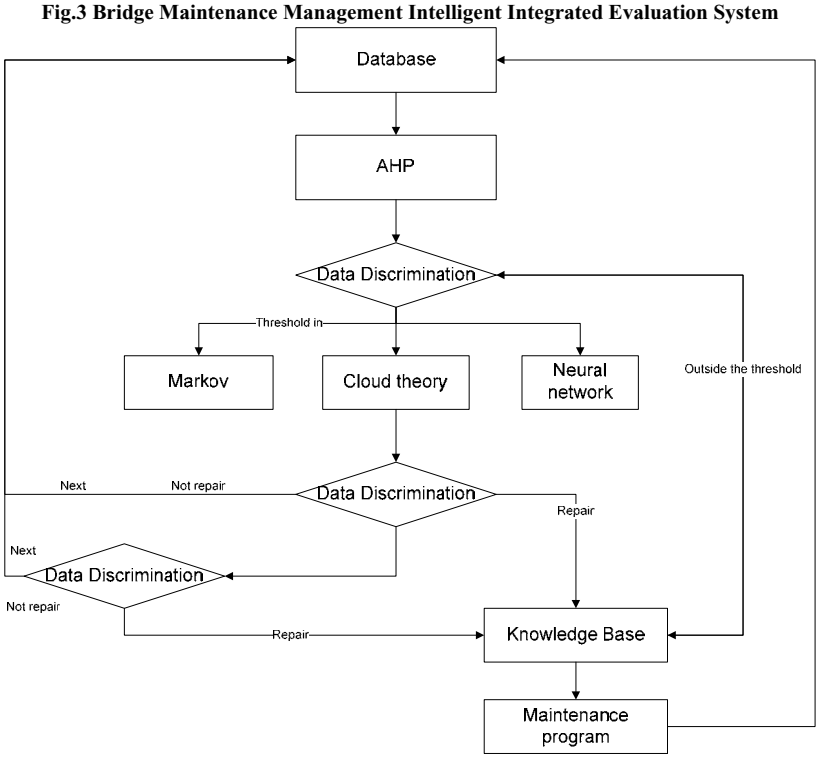

Fig.4 Management platform structure

3. System achievement and analysis of monitor main point

In order to explain in detail the specific process of system application and the validity of its actual application, we take the Xihoumen Bridge as a example to explain how the system implement the bridge's monitor and maintain works. Xihoumen Bridge is the second cross-sea bridge from Ning Bo to Zhou Shan after Jintang Bridge, and it is a extra long sea-cross bridge which uses the most difficult techniques in Zhou Shan-mainland connecting engineering. It is total 5.452kilometers long, the bridge is 2.588 kilometers long and it is two-span continuous steel box girder suspension bridge, split pairs of box section steel box girder, the steel box girder is 36 meters width and 3.5 metres high, the two boxes is connected by box-beams and I-beams. The suspension bridge program which connects Ce Zi island and Jin Tang island and whose main span is 485 metres+1650 metres+578 metres Is the world's largest long-span steel box girder suspension bridge, yet it is the second large long-span bridge in the world, and it is largest long-span bridge in the world, its designed navigable Level is 30 thousand tons, navigable clear height is 49.5 meters and navigable clear width is 630 metres.

In the past, Bridge Maintenance Management System is a stand-alone environment to run, but the actual bridge management needs of different management departments to complete. The system uses object-oriented programming techniques (OOP),. ARCGIS technology and client / server architecture (C / S) to conducted a software design and development, it achieves bridge maintenance data sharing and regional management functions and has a practical application. Figures 5 and 6 respectively show the use of the system and query interface.

Fig.5 System user interface

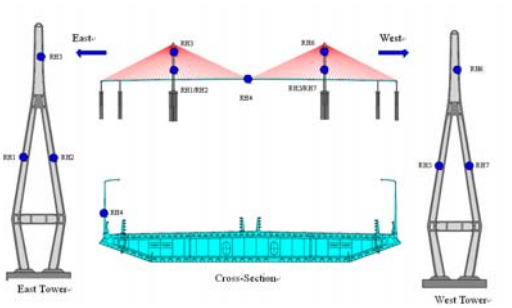

Fig.6 Real-time monitoring point at Xihoumen bridge

According to the monitoring and Bridge Maintenance Management System design requirements, considering the required relevant factors of laying the monitoring points, bridge type, monitoring content and sensor characteristics of its own etc. the monitor point fabric of Xihoumen Bridge should take the following principles: (1) structural deformation of the main control point of space; (2) maximum stress distribution and position or component of amplitude changes; (3) stress concentration and the position or component which can be clearly measured; (4) the main control points of the external wind loads; (5) The control points which can monitor overall structure temperature; (7)the laid of part of the sensors should be properly redundancy. Xihoumen Bridge laid a total of 208 real-time monitoring sensors (including temperature and hygrometer and rain gauge), the laid monitoring points see Figure 6.

By the analysis of monitoring the bridge operation we can see that the bridge is prone to defects suspension system components, and the component disease type is simple, the main diseases are corrosion and broken wires. According to the monitoring requirements of the Maintenance Management System, choose the system maintenance and management measures selected function key real-time for

the status of the bridge damage points, when select the maintenance measures, consider the terms of the budget and construction requirements, by Optimizing to enable maintenance effect to be achieved the maximum.

4. 4 Conclusion

(1) Database management system can complete the basic information about the bridge, inspection record, maintenance and reinforcement history, the input of the image information, etc, provide a variety of information queries and tab and other functions, and the recorded data automatically generates the documentations needed by the bridge comprehensive evaluation.

(2) Comprehensive evaluation system transplants the bridge experts' experiences and knowledges into the computer, and just enter the basic elements of a bridge, environmental conditions, traffic volume and data obtained from bridge inspection, system can use percentile methods to evaluate the the soundness of the all given bridge components.

(3)Using the object-oriented programming (OOP), ARCGIS technology and client / server architecture (C/S) developed BMIADSS, meets the needs of information sharing and regional management of modern bridge maintenance and management. In this paper,the writer used developed BMIADSS to realize Xihoumen Bridge conservation and management and monitoring, the system has great practicability and can serve as a supporting decision-making tools of bridge conservation and management department.

Acknowledgements

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References

[1] Mosbeh R. Kaloop and Hui Li .Monitoring of Bridge Deformation Using GPS Technique.KSCE Journal of Civil Engineering.(2009),13(6): 423-431.

[2] Yung Seok Shin, Jang Ho Park, and Dong-Ho Ha.Optimal Design of a Steel Box Girder Bridge Considering Life Cycle Cost.KSCE Journal of Civil Engineering (2009) 13(6):433-440. [DOI 10.1007/s12205-009-0433-9]

[3] WANG Chun sheng; CHEN Wei zhen; CHEN Ai rong.Damage safety assessment and maintenance management strategy of bridges[J]. Journal of Traffic and Transportation Engineering, 2002, 2(4):21-28.

[4] GAO Zhaohui ZHANG Ning LU Saijie.Modern Bridge Maintenance Management System Based on Web-GIS Technology[J].Computer and Communications,2006, 24(2): 42-44.

[5] ZENG Qing-ping.In-serve behaviors of CBMS in maintenance management of highway bridge[J].Technology & Economy in Areas of Communications, 2006(5): 71-72.

[6] LYER S R, SINHA S K, SCHOKKER A J.Ultrasonic C-Scan Imaging of Post-Tensioned Concrete Bridge Structures for Detection of Corrosion and Voids [J].Computer-Aided Civil & Infrastructure Engineering, 2005, 20 (2): 79-94·

[7] GATTULLI V,CHIARAMONTE L.Condition Assessment by Visual Inspection for a Bridge Management System[J].Computer-Aided Civil & Infrastructure Engineering, 2005, 20(2): 95-107.

[8] LU Sai-jie; QIAN Zhen-dong; GAO Zhao-hui. The Research & Development of Bridge Maintenance Management System[J].Journal of University of Science and Technology of Suzhou, 2004, 17(4): 55-59.

[9] LI Chang-zhu. Development and Application of CBMS2000[J].Journal of Highway and Transportation Research and Development, 2003, 20(3): 84-90.

[10] XU Lie-ping. The research and development of bridge maintenance management system[D].Chongqing Jiaotong University, 2008.