学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Application of Information Technology to Maintenance Management of Civil Infrastructure with BIM Collaboration Platform

(BIM プラットフォームで連係した情報技術のインフラ維持管理マネジメントへの適用)

Civil infrastructure, such as steel structures, reinforced concrete structures constitutes the foundation of our society. To ensure safety and serviceability of infrastructure during design service life, long-term maintenance management should be thoroughly conducted. Maintenance management aims to make timely maintenance decisions and also implement the maintenance actions; and its efficiency depends on quick response to structural failures by making full use of information. Decisions related to maintenance require assistance from information usually available in many different types, scales, and formats. The various information originate from loosely coupled and dispersed resources that are strongly interdependent. Managers decide whether the infrastructure needs to be repaired by comprehensively considering especially the following three kinds of information: (1) historical document information, such as documents generated from design and construction and previous maintenance; (2) on-site monitoring and inspecting data; and (3) professional analysis results for understanding the structural durability, safety, economy, etc. A key factor adversely affecting civil infrastructure maintenance is a conventional method for information management. It is inefficient for information storage and retrieval due to paper-based form and unsystematic database, the discrete and non-visual storage of information makes it difficult to quickly obtain and locate information in the real world of infrastructure. There is an inefficient in the management of professional analysis information. Usually, managers need to spend a lot of time to consult experts one by one to obtain the results of different professional analyses because experts usually share only the analysis results to managers every time, instead of helping managers do professional analysis and obtain the analysis results independently,

This research focused on the management of maintenance information by using information technology with BIM collaboration platform. Three main tasks are completed:

(1) Firstly, an information platform was independently developed to integrate various information in modularity. This platform innovatively provides a visual 3D real-world model environment for the project by utilizing Building Information Modelling (BIM) and Geographic Information System (GIS). Modular information such as electronical document information and structural health monitoring data is linked to the corresponding location in the model and integrated in this platform. The professional analysis module is integrated in this platform and inserted by using browser and network technology, which can share professional analysis.

(2) Then, how to achieve the sharing of professional analysis from experts to non-experts was focused, which included sharing professional knowledge and analysis tools. This research proposed a method of professional analysis sharing based on knowledge management. Taking numerical simulation as

an example, experts use professional knowledge to create simulation prototypes through professional software, and then simplify the prototype into an application in form of an open parameter model, finally release the application to the professional analysis module in the developed information platform through network. Non-experts (maintenance managers) can run the application in the platform without restriction of professional software and professional knowledge.

(3) Finally, the numerical simulation was explored on the chloride ion concentration into tunnel concrete over time under external hydrostatic pressure, which has been studied as an example to form a simulation prototype. A theoretical diffusion-convection model describing the process of chloride ion penetration into concrete under external water pressure is described by considering multiple affecting factors, such as unsaturated flow, fluid-solid coupling, and chloride binding. A numerical model of unsaturated concrete is built to simulate the coupled process. Based on this model, the classic expression of effective diffusion coefficient is modified by considering a constrictivity factor, and the sensitivity analysis was carried out on five sets of parameters (i.e. effective diffusion coefficient, saturated permeability, van Genuchten parameters, initial saturation, and binding capacity parameters) aiming at evaluating the robustness of the model. The simulation results show that the multi-mechanism penetration model is computationally feasible, and the multiphysics coupling model can well reproduce the chloride ion transfer process in a microscopic perspective. Furthermore, the sensitivity analysis results indicate that the parameters governing moisture transport process are more sensitive to the prediction of the chloride ion penetration into undersea tunnel concrete. This simulation model shows high value in the research of chloride ion penetration into concrete structures under hydrostatic pressure.

In this research, firstly, theoretical studies were performed to define the conceptual framework and demonstrate the implementation on the subject matter. Then, information development technology helped to realize the development of the integrated information platform. Finally, case studies proved the successful application of the proposed approach.

The information management method proposed in this research overcomes the limitations of conventional method in maintenance information management of civil infrastructure and will greatly improve the efficiency of maintenance management.