A Study of the Campus Facilities Maintenance System with Building Information Modeling Application

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Abstract –

As the scale of construction increasing and the structure being more complicated, it is necessary to use the computer information technology to promote the industrial efficiency and tend with information management. The application of Building Information Modeling (BIM) has become the trend. As there are different benefits in each phase of construction life cycle by using different BIM functions and there will produce different system efficiency by different participants when applying BIM technique; to make management of the facility maintenance at the period of using in effect, it is necessary to consider the management of facility maintenance at the planning phase and to make it easier to manage and reduce costs. In current, the most of BIM application and research are focusing on how to aid the design and construction phases. There are rarely researches focusing on the facility using and maintenance after construction.

This research will build a phototype management system database of the school educational facilities maintenance by using BIM technique, to allow managers can realize the historic fixing records, material categories and other related information. This system also can remind the facility's service life will near and need to be changed automatically. Based on the illustration of this research, this system can make facilities maintenance more effective.

Keywords–

Building Information Modeling (BIM); Campus Facilities ; Facilities Maintenance System

1 Introduction

According to the construction record from the Construction and Planning Agency Ministry of the Interior in 2005, school buildings are the biggest amount of the public building project. Most of the school buildings have been used more than ten years. School buildings are not only the place for teaching and learning but also the important space to teachers and students. So, the maintenance management is good or not will make a big influence during the school building using age for supplying a safety environment of student learning and facility teaching effectiveness.

Due to combining the development of science and technology and multi-domain knowledge, the application of Building Information Modeling, so called BIM, has become the trend. As using BIM in different state of construction life cycle have different benefits, it may increase the cost and work at the early state, but to the whole construction life cycle, it can reduce management cost and increase the efficiency, especially to the more later states which are able to reuse the information already set up for more benefits. The maintenance management in this research goal is belong to the later state, so this research focuses on how to continue the information which was set up before.

School building maintenance management is important, because the school building are the space for common use of the public. Maintenance management often makes many kinds of problems such as people and things, these problems even affect the safety of teachers and students, so the urgent need to establish a complete management system. In addition, it has a very close relationship between the level of school education and school building environment. In order to enhance the quality of school education quality, it is urgent to establish the relative facilities maintenance management.

2 Literature Review

2.1 Building facilities maintenance management

International Facility Management Association defined facilities management is that facilities management is a combination of business administration, architecture, activity and engineering science knowledge or principles, and make the crew and organization in facilities and real workplace can have coordination. In addition, Liu Mingguo in 1987 defined construction and maintenance management as "For building, it is to make action to be act, the corresponding protections have well warning, and always keep in mind and maintain the function can handle all the problem[1]."

Building facilities maintenance management can be divided in two parts basically, one is "operation management", its goal is providing user can use the building function. The other is "maintenance management" its goal is using all kinds of methods to recover or maintain the facilities functions. The maintenance management, a part of operation management, plays the rule of auxiliary. Therefore, facilities management focuses on construction life cycle management, to make each facility to achieve its highest value, also to ensure the normal operation of all facilities within the building environment[2].

2.1.1 Existing facilities maintenance management

The concept of facilities management originated in the United States in 1970[2], in recent years the international community has gradually attached importance to the facilities management. However, the current facilities maintenance management methods have been different by compared with the past. The maintenance management system in the past, considered the engineering ontology and the cost but not consider the process of assets management, such as budget planning management, administrative execution process and the situation of using. By comparison, asset maintenance management system is wider procedure than before, it is including every state of construction including design, construction, operation, resource management, finance, marketing and system operating; therefore, many advanced countries in Europe and the United States have already used the methods of business management in government department maintenance and management funds and use this method to improve efficiency, productivity, and service quality of users[1]. The different between facilities management and operating methods is shown on table 1.

Table 1. The different facilities management and operating methods between now and the past

	Past method	Current method
Budget preparation	Focusing on the most important cost. Overall, including bridge, road weights and other component cost estimates .	According to the demand, the specific construction program and detailed program information.
Cost Estimate	Estimate the cost of per area	Estimate the cost of each component per unit.
Plan selection	Based on subjective judgment, people complain and the experience in past	Based on objective information (pavement, estimated cost sorting scheme)
Current facility situation	Didn't use facility status indicators, geometric and historical data	Using facility status indicators, geometric and historical data
Facilities assessment	Not evaluated	Based on the objective information assessment program, describe the current conditional ability to determine the maintenance behavior
Facilities planning	Didn't have budget plan	Analyzing planning, scheduling, resource allocation and budget and other objective information rapidly

2.1.2 Building life cycle

In general, a building life cycle contains the six stages, including planning, design, contracting, construction, operation maintenance and final removal[2]. Every stage information is interrelated and complicated, and closely related with facilities functions. However, the traditional building or facility

management system model, often lack the complete life cycle of the information file, and cause many related documents lose due to the long-term savings, then affect the implementation of building maintenance operations [3].

As construction being completed and after the completion of operation, it is going into a long period of using, and the equipment also began to enter the operation period. As being used, facilities and equipment are getting older, the frequency of failure is increasing, the reliability and safety are reduced, and the energy consumption increased. Therefore, timely maintenance is very important. In Japan, due to operating the research about systematic building energy and analysis of building facilities using management planning in long-term, the foundation is very completely. The following is description of expenditure items and cost distribution, it shows the percentage of the total cost of the Japanese building in its life cycle which maintenance and management costs 51.1%, accounting for half of the total cost in the life cycle, and it is the 3-4 times higher than construction and facilities. It shows the importance of maintenance management in the life cycle of the building[4].

Table 2. The cost distribution of the building life cycle

Project	Project name	Percentage of costs
Design planning cost	Construction planning fees, local survey fees, land use fees, land consolidation fees, design fees, evaluation fees, real estate acquisition tax, special land tax, registration free tax, opening royalties	0.4%
Construction cost	Business expenses, business management fees, environmental countermeasures, opening fee, real estate acquisition tax, registration tax, business tax	15.8%
Maintenance and management cost	Building management, equipment management, sanitation management, cleaning management, security, garrison, repair update, management fee	51.1%
Management cost	Electricity, gas charges, fuel costs, water charges, sewage charges	32.3%
Fixed management cost	Fixed assets tax, city plan tax, property tax, damage insurance premium, boundary fee, general expenses, loan interest	0.4%

2.2 Building Information Modeling

Building Information Modeling, referred to BIM, is defined as the life cycle of construction facilities (including buildings, bridges, roads, tunnels, etc.) creating and maintaining the technology and concept of the digital information of construction facilities and its engineering application. And The American Institute of Architects further defines the building information model as a "model technology that combines engineering project information databases". BIM technology is a simulation in the computer virtual space as a real project, to assist in the construction of life-cycle planning, design, construction, operation, maintenance of the management and engineering operations of the new technology, new methods and new concepts, rather than a new tool which is often misunderstood. It uses digital information to simulate the real information which buildings have. In BIM, Information is not only a three-dimensional geometric information, but also contains a lot of non-geometric information[5]. This technical concept has now been widely adopted by the world, and The United States, Britain, South Korea, China are also actively developing BIM national standards.

BIM focuses on the sustainable used of construction life cycle, it can be used to show the entire life cycle of the process and related information, including geometric, spatial relationships, geographic information systems, the nature and quantity of various building elements (like supplier details) etc. Due to searching BIM can provide all kinds of appropriate information, assist decision makers to make the best decisions. At the same time, compared to the traditional way of the traditional 2D, it can significantly reduce every types of errors of the overall project. The advantage of BIM is 3D visualization presentation, information immediacy, horizontal cross-professional integration and vertical cross - stage collaborative management, geometric information link and three - dimensional spatial information integration…etc[3]. Its goal is reducing the design changes, repeated construction and other phenomena, and thus to reduce the wasting cost, shorten the duration and improve quality. BIM technology is also progressing and developing rapidly. BIM Project Execution Planning Guide, which published by the

American Building SMART Alliance in 2009 and 2010, summarized 25 kinds of applications in the BIM project planning, design, construction and application phase, it also shows that BIM can be used widely and multiple in the life cycle[5].

2.2.1 Building Information Model Exchange Standard

In current, the standards of exchanging information are quite much, its goal is to enhance the efficiency of the construction of industrial data exchange and promote the smooth flow of work and accelerate the automation of operations. The following are common BIM information exchange standards :

1. Industry Foundation Classes (IFC)

Industry Alliance for Interoperability, referred to IAI, has proposed a set of Industry Foundation Classes. It is an open data format for information exchanging, sharing and using in entire construction management. By using the standard definition of doors, windows, walls, lamps, furniture and other real objects and the abstract concept of space and structure, it can deal with the contents of the information by the form of an object database. So that all participants can use the information which is generated by different software in different stages, and able to circulate, apply and integrate to each other[6].

2. Information Delivery Manual (IDM)

Information Delivery Manual is known as to realise the BIM value and achieve the information exchanging between different members and software products, It is necessary to establish an open data to exchange standard format IFC. Because of this kind of information exchange involved the variety of projects, the complexity of the project stage, the huge project life cycle time, and the exchange of information often only exchange for a specific project in a project or only for the participants in a few workflows and exchange by applying software, it is not necessary and impossible to use entire IFC contents when exchange information. So which contents are necessary to exchange in similar information exchanging is what IDM have to do. In this result, operating a specific project or a specific participant are defined the necessary content of exchange information for their respective work by IDM, and exchange them by using IFC standard format. Furthermore, Model View Definition is mainly method of transferring the general language of IDM into computer language of IFC[7].

3. International Dictionary Framework (IFD)

Because the global natural language is diverse and ambiguous, to ensure the information is consistent between the information providers and users from different countries, regional, language and cultural background, IFD gives every text and terminology the globally unique identifier (GUID) to make every information in IFC enable to connect with unique GUID. When providing a necessary information, it is able to get the unique content. So it is not important describing information in which language to users from different background[8].

3 Research Content

3.1 System Construction

To make the facilities management perfect, it is necessary to let information be electronic and manage it by using software, and it can enhance management ability in effect. It is the most commonly used way to store the database. Therefore, this study proposes the based framework of a database engine to manage a large number of IFC file. The system framework is shown in Figure 1. The stored information are include the IFC file from BIM software. As it having many format in the IFC file, this study uses IFC2x3, which can transfer this information into the data from database, and develop a man-machine interface by C # program language to provide users using the functions like operating, adding, researching, modifying more convince. In addition to the above functions, using the information of objects duration provided by database can set the reminding function automatically to make the system more complete.

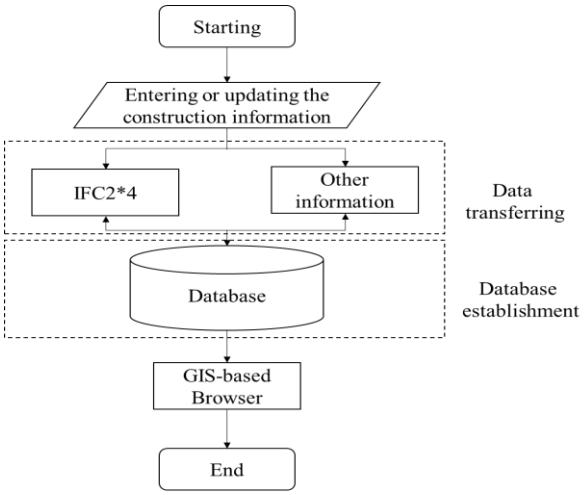

Figure 1. System framework flow

To the use of the object period, the use of the database has been established for comparison and remind the user in the jumping windows by C# program when closing the limited period of using, as the figure 2 shows.

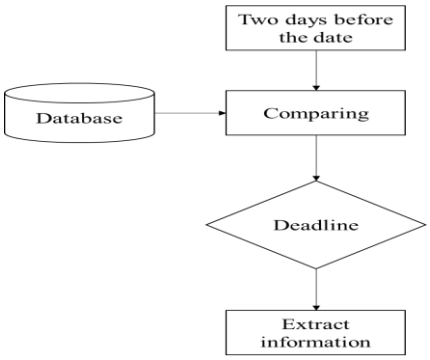

Figure 2. The flow of the automatic remind the object limited used duration.

3.2 System Function

The following figure 3 is the system function structure.

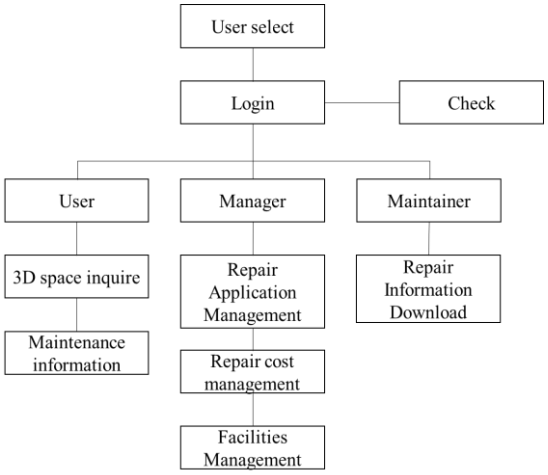

Figure 3. System function structure

3.2.1 Each Building Maintenance System

The building in this system can provide the relate base information by 3D model. User just need to click the item, and can get the information at the left hand side. Such as material, size, manufacture, produced date and the repair record…etc. As the figure 4 and 5 shown.

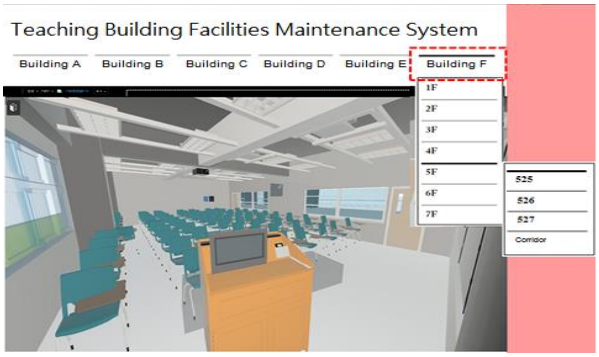

Figure 4. Click the classroom you want to check.

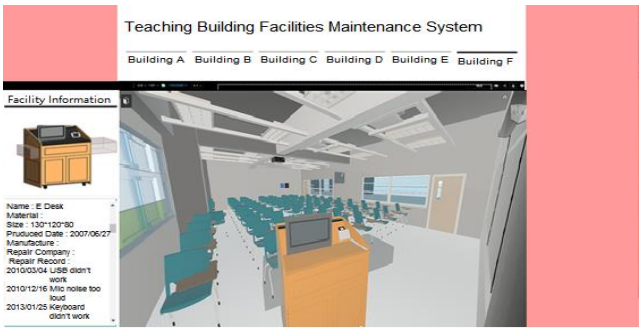

Figure 5. The information pop-up at the left hand side

Developed by C# program, the system will pop-up the window at the monitor bottom right corner to remind the user that today is the day before the deadline. As shown in figure 6 and 7.

Figure 6. Facility maintenance system automatic reminder function.

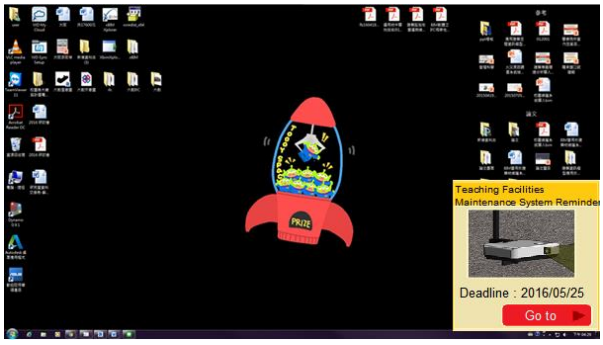

Figure 7. Auto remind function display position

4. Conclusion and Suggestion

Establishing the relevant maintenance system database, can let the staff to understand the maintenance of the past facilities, structure, material types and related records and other information and can automatically remind the facility that the item is about to expire. If combining building information model with maintenance management system in effect, it can make the staff record convenient and reduce the time of operation. It is not only can conform economy but also can replace the traditional disadvantages like paper records are easily defaced, missing and complicated login procedures and improve the efficiency of the overall maintenance of campus facilities. It also can achieve immediate, convenient and intelligent detection purposes, and then to achieve sustainable development goals.

References

[1] Wu Yi-Zhen and Xie Shang-xian. BIM opportunities and challenges in facility maintenance management. *Construction News Record*, No. 386, page 47-52, 2015.

[2] Li Meng-xing and Lin You-zheng. Application of BIM Model in Construction Stage of Construction Project. *Taiwan Highway Engineering*, Vol. 38, No. 3, page 45-54, 2012.

[3] Li Yi-qian, The *Application* of Building Information Modeling in Property Management, master paper, National Taipei University of Technology, 2010.

[4] Zhou Tian-ying, Cai Hui-ru, and Yan Lan Kun, New trend of 3D GIS Application: BIM (Building Information Model), *National Geographic Information System communication*, Vol. 73, page 45-51, 2010.

[5] Xu Rui-gai, Wu Yi-Zhen and Chen Yi-Zuo, Design and Implementation of Facilities Maintenance Management System with Open BIM Concept, *CECI Engineering Technology*, No. 138, page 46-55, 2015.

[6] Guo Zhe-yu, The Establishment of Electronic Building Construction Resume System, master paper, master paper, Chung Hua University, 2010.

[7] Xiao Le-dong, A study on the management strategy for the military camp maintenance, master paper, National Central University, 2004.

[8] Xie Bo-quan, Research for BIM in Architectural Lifecycle Process Application, China University of technology, 2011.

[9] Yen-Yu Hu, The Study of Building Information Modeling Applied in the Campus Maintenance System, Master paper, National Taipei University of Technology, 2016.