ENHANCING MAINTENANCE MANAGEMENT USING BUILDING INFORMATION MODELING IN FACILITIES MANAGEMENT

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ABSTRACT: Facilities management (FM) usually is difficult and complicated work. The facility staffs usually use paper or information system to record the facilities maintenance work. However, it is not easy for facility staffs to refer the traditional 2D CAD-based information illustration in the facility maintenance. Moreover, the information of same facilities maintenance needs to repeat the record and cause inconvenience for facility staffs. To overcome these problems, the building information modeling (BIM) approach is applied and developed as 3D information models for managing and maintaining facilities in the study. With the integration of BIM model with related information of facilities maintenance, the facility staffs may improve the efficiency of maintenance and management work of facilities. This study proposes a BIM-based Facility Management (BIMFM) system for facility managers and staffs. The BIMFM is then applied in selected case study of a school maintenance project in Taiwan to verify our proposed methodology and demonstrate the effectiveness of tracking and managing the related maintenance information in the 3D environment. Finally, this study will present the benefits, limitations and conclusions of BIM application in facilities management, and also provide suggestions for future research

***Keywords**: Building Information Modeling, Facilities Maintenance Management, Information Technology*

1. INTRODUCTION

Facilities management (FM) represents one of the fastest growing sectors in real estate and construction. To benefit most, organizations need to understand that they must be informed clients in managing their facilities and properties. However, tracking and managing facility effectively are extremely difficult owing to the various facilities. Real time monitoring and control for maintenance management may be necessary and helpful to control and manage effectively the maintenance work in the building facilities. To enhance maintenance management performance, the building information modeling (BIM) approach is applied and developed as 3D information models for managing and maintaining facilities in the study. With the integration of BIM model with related information of facilities maintenance work, the facility maintainers may improve the efficiency of maintenance and management work of facilities. With the assistance of the BIM approach, facility-based maintenance management information enables information dissemination and information sharing in the 3D environment. Generally, facility managers and staffs require access to the facility location to handle inspection and maintenance work at any facility locations. Facility staffs generally use sheets of paper and/or field notes. Facility staffs generally handle various types of information, including 2D drawings information for inspection and maintenance. However, it is not easy for facility staffs to refer the traditional 2D CAD-based information illustration in the facility maintenance.

Information technology (IT) is important in successfully controlling and managing construction projects, particularly in enhancing communication and coordination among participants. Communication and coordination must be maintained to support resource and competency sharing among the involved participants. This paper proposes a new and practical methodology to capture and represent facility management information by

using Building Information Modeling (BIM) approach. This study addresses application of facility management in the maintenance phase and proposes a BIM-based Facility Management (BIMFM) system for facility managers and staffs. The BIMFM is then applied in selected cases study of a building project in Taiwan to verify our proposed methodology and demonstrate the effectiveness of tracking and managing the related maintenance information in the 3D environment. By developing BIMFM system, facility managers can track and manage the related maintenance record in the 3D environment.

2. RESEARCH OBJECTIVES

This study utilizes the BIM approach and web-based technology to enhance the maintenance progress and effectiveness in FM. Identifying, tracking, controlling, and managing facility assets and problems are critical tasks in FM. This study develops the BIMFM system for facility managers and staffs to enhance facility information tracking and sharing efficiency. Notably, this study integrates novel 3D facility assets model and the BIM approach to track and manage facility assets in a graphic form. The main function of the BIM approach in this study is 3D illustration and mapping of facility asset. The BIM approach retains facility information in a digital format, and facilitates easy updating and transfer of facility information in the 3D CAD environment. By using the 3D facility asset, project participants can obtain an overview of previous and current facility asset in a given facility and manage facilities. Furthermore, facility staffs can track and access the most recent information for any basic information, conditions, or maintenance during the maintenance phase. Maintenance information can be updated rapidly and made available via the web-based 3D CAD environment. This research is a pilot study to apply the BIMFM system for Taiwan building project, and discusses and analysis the entire maintenance management process.

3. LITERATYRE REVIEW

Designers always use 2D plane graphics to transfer the idea and need of design in the past times, but it is difficult to the unprofessional building designers to understand the design completely by 2D plane design graphics. Due to this kind of situation may cause the communication problems, the concept of using 3D entity model to present and transfer the idea and need of design appears gradually. Through 3D entity model to present the basic construction, ways, planes, facades and related details can help the unprofessional building designers to understand the building which was designed by architect, raise the convenience of communication and decrease the error of information transferring.

BIM is an emerging technique which was applied in construction engineering and building project for many years overseas. Most people think 3D BIM model is not different to 3D graphics software, but the most special of BIM is it contained the information of building and project, and the objects of the model have the objects oriented characteristic. Besides, the mainly function of BIM is to completely present and simulate a building project by 3D image. The process of using BIM in construction engineering makes the related people can communicate through 3D visible model to understand the requirement of engineering, and comprehend the difficult and barriers in engineering previously through the link of information between model and project. The above characteristic can reduce the cost and risks of the project, entrust the detail works to related professional person to do more accurate check and simulation of engineering, and combine all the detail works at the same time to achieve the purpose of specialization of specialized field. So, people can get the related information through 3D visible model and do not need to consult complicated graphics while engineering is under construction, and rise the convenience of communication and integrated of interfaces, reduce the error of engineering at the same time.

There are many previously research publications regard to BIM issues in construction. Tse (2005) presented the core barriers, these factors and recommends using BIM technology for construction industries [1]. Vanlande (2008) proposed an extension of the BIM technology to manage information during the entire lifecycle of an AEC project [2]. Goedert (2008) extended BIM technology into the construction process and to create a single repository of facility data for the owner [3]. Succar (2009) explored publicly available international

guidelines and introduced the BIM framework, a research and delivery foundation for industry stakeholders [4]. Kaner (2008) illustrated how BIM can help managers of structural engineering firms to avoid some of the pitfalls of replacing 2D CAD practices [5]. Umit and Jason (2010) proposed two design patterns as a foundation to formulate the design of information systems for BIM-based synchronous collaboration [6].

4. SYSTEM DEVELOPMENT

In this study, the BIM is interpreted as an information model in the BIMFM system. The primary purpose of this study is to extend BIM into the maintenance phase and to create a single repository of facility data for facilities maintenance. Furthermore, the application of utilizing BIMs to capture and store information of facilities thought to 3D BIM model including facing problem description of facilities, facilities maintenance information, and attaching documents in the BIMFM system. Tekla Structures was used to model the 3D CAD-based facility models and create BIMs files. Tekla Review was used to read BIM files for the 3D interface maps. The information integration with 3D CAD-based facility models was achieved using application programming interface (API) and C# programming language.

5. CASE STUDY

This case is applied in the Taiwan school maintenance work. The facility department hopes to enhance maintenance management performance using full advantage 3D CAD-based environment, and let facility staffs handle maintenance easily and effectively. Furthermore, the facility department hopes to develop the 3D CAD-based FM system to support facility-related information sharing among facility managers and staffs. Therefore, the contractor announced that all engineers would be encouraged to begin to use the BIMFM system integrated with BIM approach to apply maintenance management to manage facility-related data and information effectively in the 3D visual environment.

5.1 System implementation

■ The mode of schedule management of FM

This research checks the actual time of tasks whether consistent with the plan schedule of tasks using 3D with time factor (it is called 4D herein) models, and uses different colors to distinguish four types of maintenance condition in the BIM model. The four types of maintenance condition of facility are as follows: maintenance on schedule, completed maintenance, delayed maintenance, and no needs for maintenance. And colors of types are yellow, green, red and transparent, respectively. The facility staffs can clearly know what time need to maintain facilities which have planned in the schedule (see Fig. 1). If no facilities need to be maintained in selected date, the system would only show the facilities of completed maintenance and delayed maintenance. This mode helps facility staffs to visualize the actual progress state of facilities maintenance via BIM, and enhance efficiency and convenience of facilities maintenance.

■ The mode of result of FM

This research also uses different colors to help facility managers to easily and clearly understand the result of facilities maintenance (see Fig. 2). The following shows the meaning of the various colors:

- Green – The facility's maintenance work has been completed and the work is satisfactory.
- Red – The facility's maintenance work has been completed, but the result is not satisfactory.
- Blue – The facility's maintenance work has been completed and the work is satisfactory, but the schedule has been delayed.
- Yellow – The facility's maintenance work maintenance has not been completed.

■ Other functions of BIM software

In the BIM software, there have some functions can helpful to manage facilities such as creating report and browsing BIM model in the web. The "Create Report" function can create a report of facilities management information when the facilities models have been saved the information of maintenance (see Fig. 3). In the other part, facility managers can be published the BIM model to the web, and then the users can understand the state of facility through the web-based BIM model (see Fig. 2).

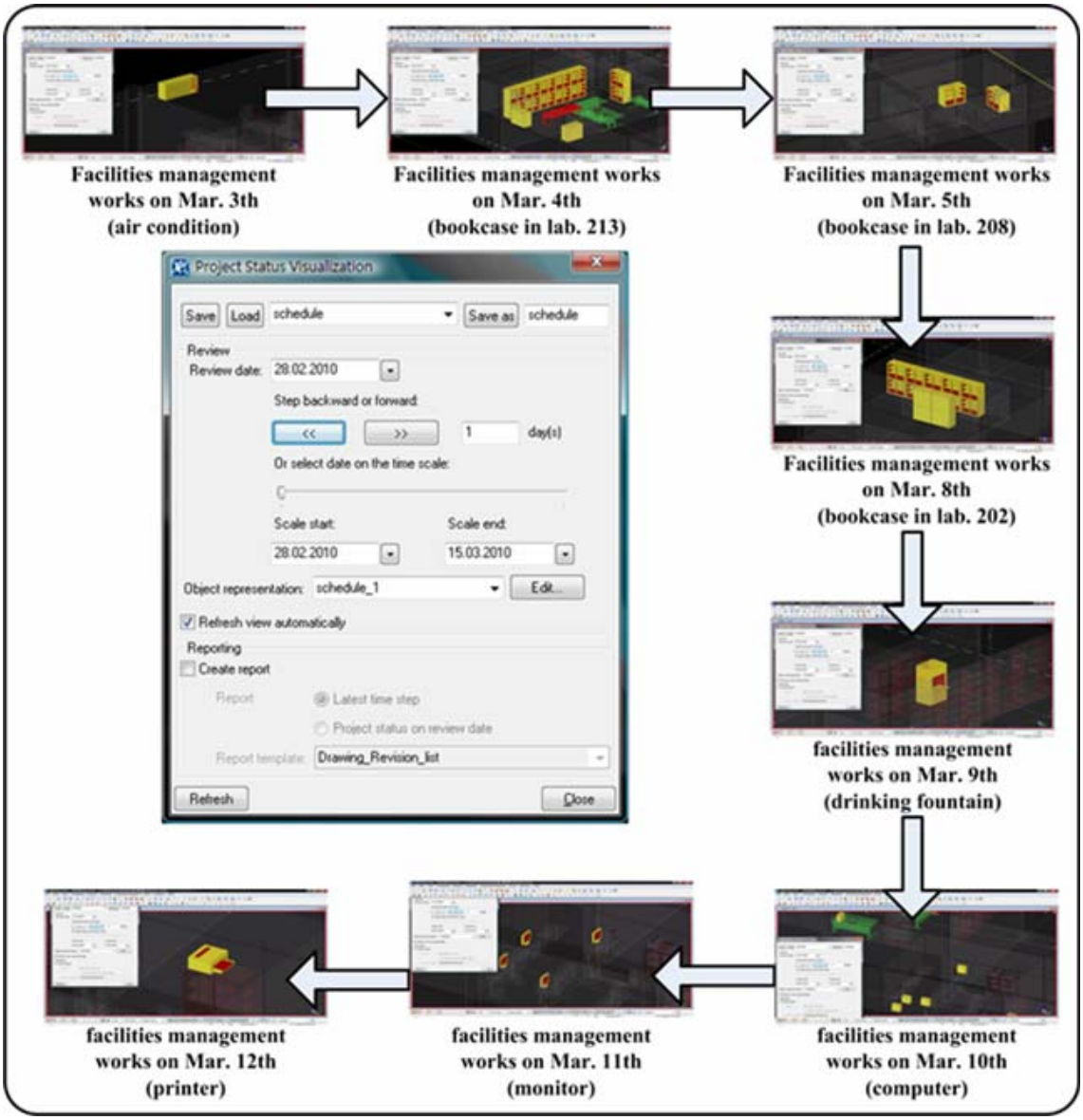

Fig. 1 Presenting the schedule of facilities management via 4D BIM model

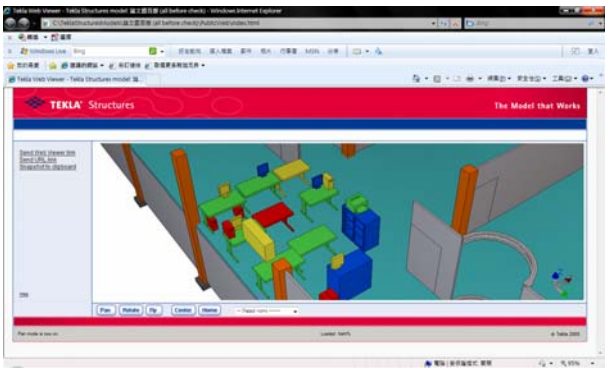

Fig. 2. Web-based the result of facilities maintenance in the case

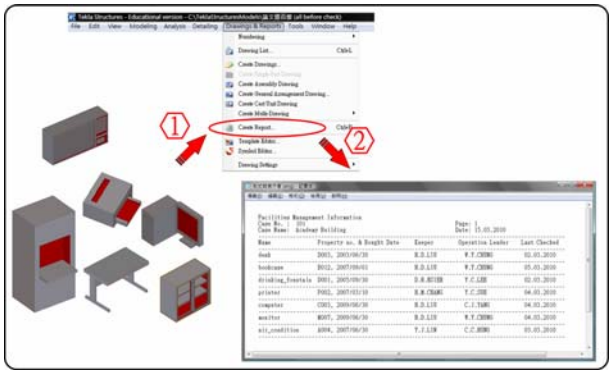

Fig. 3 Summary report of facilities management in the case

■ Facilities maintenance document management

This research makes an external program to integrate the facility maintenance document with the models of facility. The facility staffs only needs to link the facilities maintenance document with related model when the work of maintenance is completed, and then facility managers or staffs can quickly find the information and maintenance document using this external program. With the assist of external program, the users can more comprehensive understanding of the facility information and effectively enhance the integrity of the application of BIM in facilities management.

5.2 Discussion and Analysis

The differences between BIM imported mode and traditional mode as follows:

■ Application mode

In this study, the 3D visualization model assists the user to easily and quickly find the location of facility and increases work efficiency, and storing maintenance information using BIM model to improve the inconvenience of traditional mode such as carrying and looking up a lot of paper documents. Besides, the 4D model more immediately finds and handles the abnormal state compared with traditional mode, because the traditional mode is a passive reporting mode.

■ Progress monitoring:

Using BIM model to store the planning of facilities management can assist facility managers understanding the schedule of tasks, task time and maintenance staffs of task. The BIM imported mode not only enhanced efficiency and convenience of facilities management, but also reduced lacks of schedule management that are caused by human factors.

■ Quality inspection:

Using the BIM imported mode, the facility staffs can quickly find the location of facilities, monitor the state of facilities maintenance, and examine the related files of facility. Therefore, the BIM imported mode can be more helpful to facility managers when they need to make an appropriate action or decision compared with traditional mode.

In addition to the above differences, this research also to compare their information presenting, information recording and information searching as shown in Table 1.

Table 1 Comparing BIM approach with traditional facilities management method

	BIM Imported Mode	Traditional Mode	
		Management Information System	Paper Works
Information Presenting	● 3D visual model ● External related information files	● Screen display ● 2D CAD-based ● Related information files	● 2D figures ● Related paper report
Information Recording	● BIM-based model to save information ● Save in external related information files	● E-System to save information	● Paper works to save information
Information Searching	● Searching by combination functions of model and software ● Linking to external related information files ● Searching by standard report which was exported by BIM model and software	● Searching the information in the system	● Searching the information on paper reports

Based on the case study, the following are main findings and suggestions.

- Through the results of a real case study show that the imported of BIM is not only helpful and can bring lots of convenience in works of FM, but also can raise up the effective of the works of FM.
- The BIM imported mode not only provides the information of facilities transparency, but also enhances

the confidence of the user in the facilities, because the users can understand the state of facilities through the web-based BIM model.

- With the assist of external program, the BIM model of facility can link the related files of facility to help the users more comprehensive understanding of the facility information and effectively enhance the integrity of the application of BIM in FM.

This research encountered some difficulties and limitations in the process of case study, the details as follows:

- The information or files of FM cannot be completely stored in parameters of model of facility, so need to store detail information using other approaches.
- The related information of facilities maintenance is updated to the model of facility after the maintenance task finished. This situation may cause the defect of management, because the manager could not be confirmed the maintenance staffs whether truly arriving the place of facility in the BIM model.

In spite of the application of BIM in facilities management can bring many benefits, there have some problems need to solve. Thus this research suggests that the future research can further develop functions of FM to support BIM software.

6. CONCLUSIONS

The application of FM integrated with the BIM approach for building projects during the maintenance phase is discussed in this work. This study implements the novel BIMFM system for all facility staffs as a facility management platform. The BIMFM system provides insight into factors impacting FM activities, which in turn assists facility staffs in managing interface events to improve facility management performance. The BIMFM system allows facility staffs and managers to track and manage the most recent maintenance-related information, events, problem descriptions, and solutions in the 3D CAD-based models. The 3D CAD-based models illustrate facility events, problem descriptions, and solutions in 3D representations. Notably, BIM is a highly promising means of enhancing FM and identifying facility information relevant to both basic information and maintenance. Besides, BIM integrates 3D CAD-based models comprising building design by incorporating external factors, such as facility location, facility descriptions, and facility conditions, into a database that functions as the sole integrated source for all facility-related information.

Finally, the proposed BIMFM system is applied to a case study of a school building in Taiwan to verify its efficacy and demonstrate its FM effectiveness. Case study results demonstrate that the BIMFM system allows facility staffs effectively to identify, track, coordinate, and access facility maintenance work in the 3D environment. Overall, case study results indicate that the proposed BIMFM system is an effective and user-friendly platform for FM.

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