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BIM-based Property Management by Linking Maintenance with Financial Data for Commercial Building Projects

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Abstract: For a commercial building, property managers play an important role in maximizing the benefit by reducing cost and increasing revenue in the operation and maintenance phase of the building. However, most of property managers are spending their time in monitoring facility managers who have little impact on cost reduction and maximization of operating profit. The industry practitioners have difficutlty in increasing the efficiency of thier work due to this work environment. In addition, both property managers(PMr) and facility managers(FMr) are dependent on the paper drawings and manuals, which can worsen the inefficiency and human errors are inevitable. This study aims to contribute to improvement of the current practice by developing a novel algorithm that autmatically links the facility information with 3D model, which can provide an efficient property management for commercial buildings.

Key words: property management, asset data, automation linkage system, BIM(Building Information Modeling), Dynamo

1. INTRODUCTION

In recent years in South Korea, the importance of management in the operation and maintenance phase of facilities, which consumes a lot of cost, has been increasing. In fact, The Ministry of Land, Infrastructure and Transport of the Republic of Korea reported that the planning and design stage accounted for 0.4%, the construction stage 16%, the operation stage 83.2%, and the disposal stage 0.4% of the LCC(Life-Cycle Cost) ratio [1]. The person in charge of operation and maintenance(PMr and FMr) is performing various tasks such as energy management, building maintenance, and asset flow management in order to reduce maintenance costs and increase the value of the building at this stage. In this regard, many parts of work have been digitized, and further changes for automation are continuing [2,3,4].

However, according to the current work method confirmed through an interview with practitioners, a lot of time is invested in simple and repetitive tasks that have a low impact on the improvement of asset value compared to the time invested. A lot of time is invested in the overall management work related to the maintenance and repair work that occurred in the facility management stage and the task of counting the expenses incurred during the work. It can be seen that this problem occurs because PMr and FMr have to process the vast amount of facility management work documents and categorize them by expenditure details [5]. In addition, the problem of rework due to human error occurring in this process cannot be ignored.

In this regard, various methods such as operation and maintenance related data server and BIM-based program development and utilization have been proposed to solve problems such as inefficiency and low accuracy of the existing paper document-based manual work[6,7,8]. Nevertheless, the current maintenance management and expense counting tasks are being performed directly by the person in charge based on paper documents. This problem occurs because many of the proposed methods are not compatible with the existing work format or have poor accessibility in that they require the use of additional tools compared to the existing work.

Therefore, this study aims to propose a basic method that can automatically aggregate and classify expenses incurred in the facility management stage without using additional tools compared to the existing work. Through this study, it is intended to confirm the possibility of automation of maintenance work in commercial buildings in Korean society and to contribute to the introduction of an effective automation system.

2. RESEARCH BACKGROUND

Prior to this study, prior research related to maintenance work and asset management work, and related market trends were first identified. The details are as follows.

2.1. Literature review

Kasprzak and Dubler [9] proposed an integrated framework of a system for information exchange between a building information model and actual facility maintenance. Applicability to actual work was confirmed through case study. In addition, similar studies have been conducted [6], but in most studies, the definition of the aggregation method and flow of assets linked to the 3D model was insufficient.

Love et al. [2] proposed a BIM-based interworking system between maintenance information and building asset information to integrate overall FM data and asset information beyond simple maintenance information. Although this study contributed to asset information management in the maintenance stage, there is a limitation in that actual data were not reflected. In this regard, Patacas et al. [7] proposed a method of establishing a joint network for FM business based on BIM and data server. By sharing various information related to FM business through BIM and central data server, it contributed to the active communication of all FM business participants. However, the definition of the recognition of the asset flow generated by each task is insufficient.

Yoon and Cha [8] presented an effective maintenance process and data management plan through practical data analysis. Through systematic process analysis, practice was actively reflected and the applicability to actual work was verified. However, it was still insufficient to present a plan to identify and manage the flow of assets for each process.

Heaton et al. [10] recognized the importance of identifying the linkage between FM data and asset management data, and proposed a BIM-based asset management methodology. Through this, it contributed to the effective integration of FM data and asset data, which were not integrated in previous studies. However, the verification based on practical data was insufficient, and there is a limitation in the absence of suggestions for the manager's work method.

2.2. Related market trends

The global proptech market started to grow after 2013, and various programs for FM/PM began to be developed. In this regard, various tools have been developed to manage maintenance information and predict the replacement period in the future. Since then, the amount of investment in proptech has exceeded $13 billion, and real estate has been combined with IT. In this regard, smart phone apps were started to be used to efficiently manage buildings and easily reflect relevant information [11]. However, there are few cases of large-scale building applications, and there is a

limitation in that the focus is on functions related to the real estate industry rather than facility management.

2.3. Preliminary findings

The problems viewed through prior research on the recognition and management of asset flow in the current maintenance stage and the identification of related market trends are as follows. 1) Lack of understanding and presentation of existing work methods, 2) Separation of facility maintenance work and real estate work, 3) Reluctance to change work methods and difficulties in practical application.

In order to solve this problem, it is necessary to understand the existing asset management business first. In addition, in order to reduce the objection to change in the work method, it is necessary to propose a method based on the existing tool rather than the use of a new tool. Therefore, this study aims to identify the current method of asset management in South Korea, and to propose a basic level maintenance-asset data linkage method that can be applied to the relevant business without the use of additional tools.

3. RESEARCH SCOPE AND METHODOLOGY

This study focuses on developing a system that adds a function to create maintenance information in the BIM program, and classifies the created maintenance information by accounting account so that it is automatically extracted within the BIM model.

The final goal of this study is to develop a system that automatically links FM data with asset management, and the system development method is shown in Figure 1.

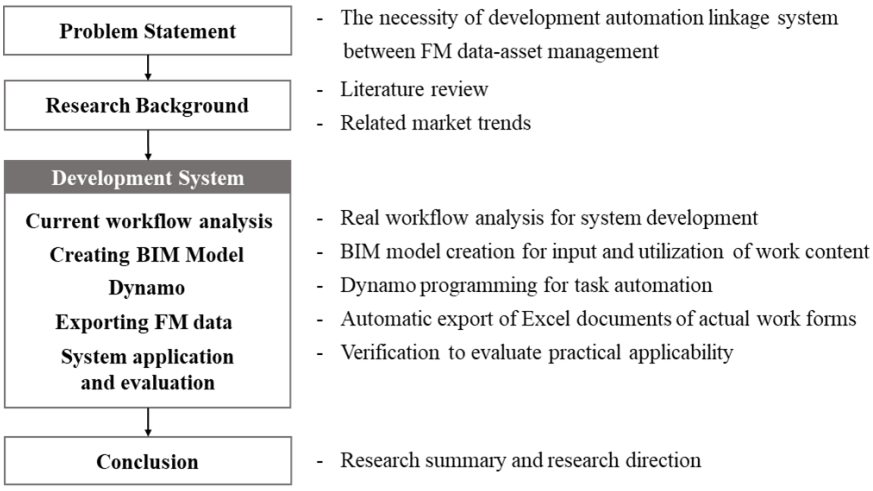


Figure 1. Research Methodology

This study analyzed related prior research and market trends after raising the problem, and proceeded to develop the system in five stages. In the system development stage, the first step is to identify the actual work flow and then create a BIM model based on it. After that, it is programmed using Dynamo for task automation. Through this, based on the BIM Model, the report in Excel format was automatically extracted according to the actual work form. Finally, a virtual example building was selected and the system was applied and evaluated.

4. AUTOMATION LINKAGE SYSTEM BETWEEN FM DATA AND ASSET DATA

The system proposed in this study is developed in five steps: Current workflow analysis, BIM model creation, Dynamo programming, Exporting Excel data, and System apply and evaluate. The details of each step are as follows.

4.1. Current workflow analysis

Prior to system development, the current asset management work flow was identified. FM Worker delivers the contents to PMr in the form of FM report after performing maintenance work. PMr issues a report after checking the contents and reflecting them on Cashflow by hand. At this time, the items prepared in the FM report include the work date, content, person in charge, cost per area, detailed content, and account, and the account can be said to be the purpose and content of the work. Table 1 shows the types of accounts for classification and management.

No.	The types of account
1	Cleaning Expenses
2	HVAC Repair / Maintenance
3	Electrical Repair / Maintenance
4	Elevator Repair / Maintenance
5	BAS Repairs/ Maintenance
6	Security & Life Safety
7	General Building Repair / Maintenance
8	Parking Expenses

Table 1. The types of account

Currently, there are a total of 8 accounts ranging from simple cleaning expenses to parking expenses, and the expenses are managed by classifying the work that occurs by account.

4.2. Creating BIM Model

This is the stage of creating a BIM model that can be used for FM/PM work and allocating parameters so that FM workers can write related work progress. The work-related parameters created on the model were limited to the accounting account information in Table 1, the information used for the actual work identified earlier.

Parameters were created so that the date, content, person in charge, cost per area, detailed content, and accounting account can be created for each space. The generated parameters were assigned to each space, and characteristics were selected so that each parameter could be managed for each space after the parameter was created. Based on this, after allocating the parameters created for each space, it was made available in the model properties window and list.

The Room function can be used so that maintenance work information can be created separately for each rental space, and through this, it is possible to selectively manage FM data without missing information for each desired space.

4.3. Dynamo Programming

An automatic Excel extraction method was devised by using Dynamo, an add-in program in Revit, to document the maintenance tasks entered by the FM worker confirmed in real time on the 3D model. The dynamo programming stage consists of 3 stages in total: ① Revit Data Categories selection stage, ② Data import stage in Revit Categories, ③ Excel export stage, and the flow is shown in Figure 2.

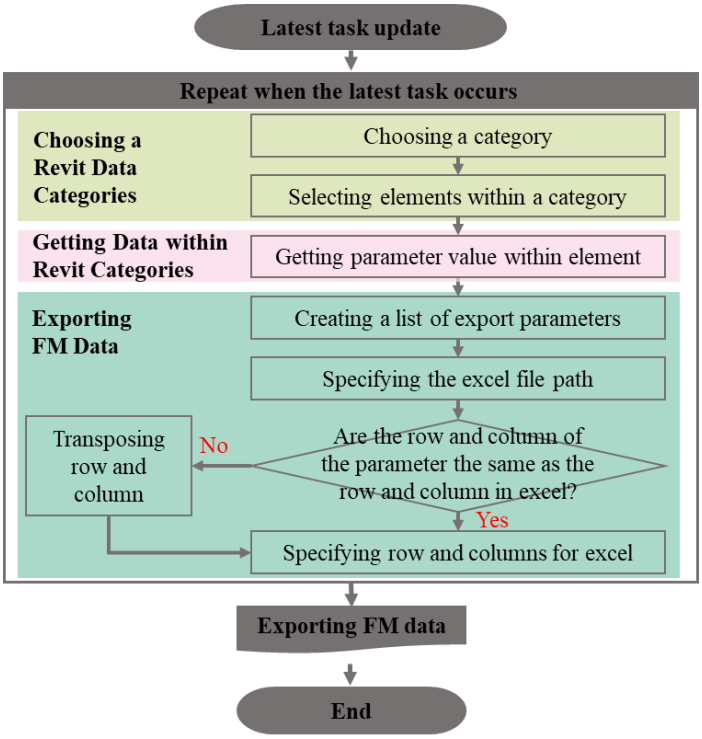


Figure 2. Dynamo programming algorithm

In the first step, Revit Data Categories selection step, select the category to associate with the Revit Model using the Categories selection node. After that, select the elements (equipment, wall, space, room, etc.) you want to import within the corresponding category. In the next step, Import Data in Revit Categories, use the Get Parameter Value node to select and import only the parameters you want to extract to Excel among the parameter values in the selected element. In the final step, Excel Export, use the List node to create a parameter list to be output to Excel, and then specify the Excel output file path through the File Path node. After that, it is checked whether the row and column of the parameter are the same as the row and column in Excel that you want to extract. If you have completed this task, you can finally output the Excel document by specifying the row and column of the Excel output value.

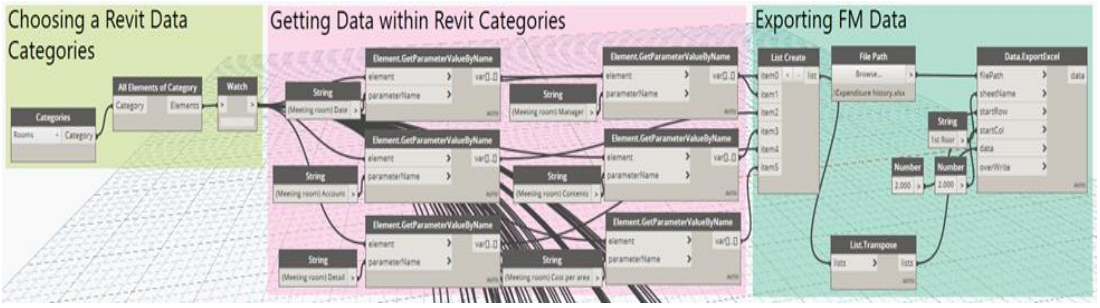


Figure 3. The contents of Dynamo

Some of the contents written in Dynamo are shown in Figure 3. For each color, the yellow green field contains the contents of Choosing a Revit Data Categories, the pink field is Getting Data within Revit Categories, and the turquoise field contains the contents of the Exporting FM data step.

4.4. Exporting FM data

When the latest work performance information is created in the BIM Model, PM Manager can use Dynamo to output the organized expenditure history Excel document without categorizing the documents by room or expenditure history. The sheet information in Excel and the rows and columns in the specified format are specified in Dynamo in advance, and Excel output is possible according to the setting values. Since the task of organizing the existing expenditure details was performed in Excel, it is possible to manage assets using the existing form without using the new form by setting the actual expenditure record management Excel file as a file path and re-specifying the rows and columns. point is characteristic.

4.5. System application and evaluation

The system developed through the above four steps was applied to the virtual model to evaluate the usability and effectiveness. The contents of parameter creation and assignment are shown in Figure 4, and spaces with various characteristics such as conference rooms, offices, toilets, and halls were created and utilized. Based on this, parameters were created and assigned.

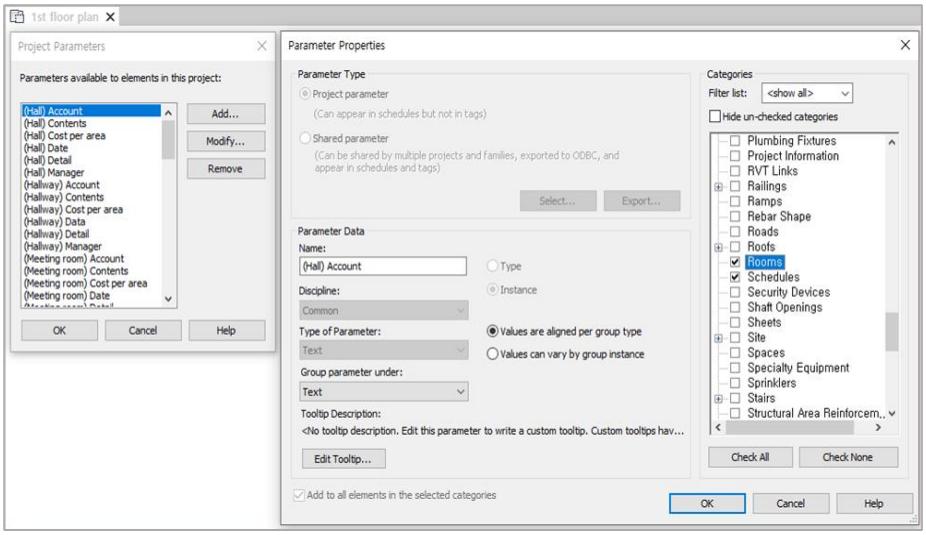
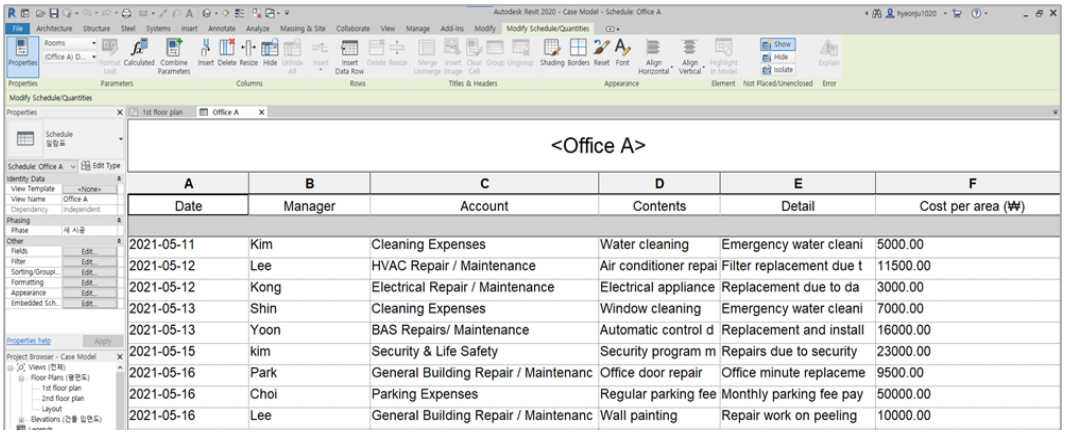


Figure 4. The contents of parameter creation and assignment

Figure 5 shows the results of using the properties window and the table in the model. Based on the created and assigned parameters, the actual work contents were entered in the properties window and the list, respectively.

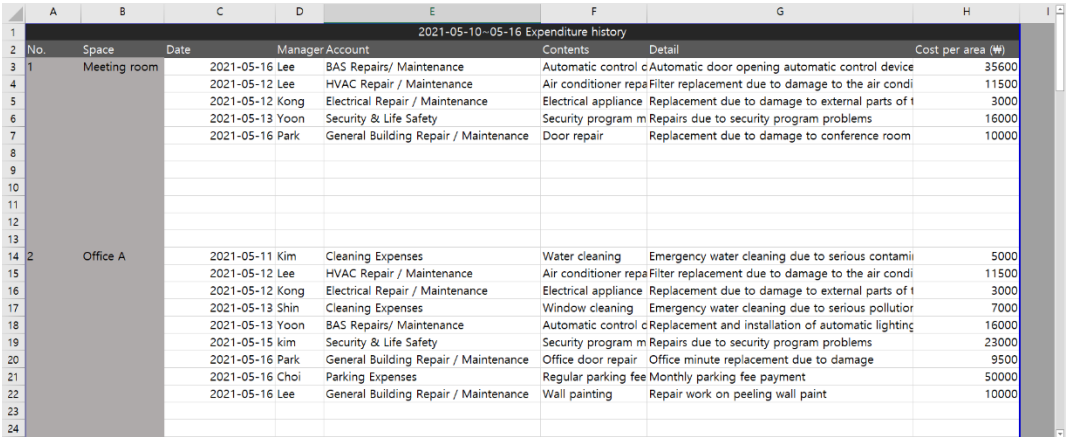


<Office A>

A	B	C	D	E	F
Date	Manager	Account	Contents	Detail	Cost per area (₩)
2021-05-11	Kim	Cleaning Expenses	Water cleaning	Emergency water cleani	5000.00
2021-05-12	Lee	HVAC Repair / Maintenance	Air conditioner repai	Filter replacement due t	11500.00
2021-05-12	Kong	Electrical Repair / Maintenance	Electrical appliance	Replacement due to da	3000.00
2021-05-13	Shin	Cleaning Expenses	Window cleaning	Emergency water cleani	7000.00
2021-05-13	Yoon	BAS Repairs/ Maintenance	Automatic control d	Replacement and install	16000.00
2021-05-15	kim	Security & Life Safety	Security program m	Repairs due to security	23000.00
2021-05-16	Park	General Building Repair / Maintenanc	Office door repair	Office minute replaceme	9500.00
2021-05-16	Choi	Parking Expenses	Regular parking fee	Monthly parking fee pay	50000.00
2021-05-16	Lee	General Building Repair / Maintenanc	Wall painting	Repair work on peeling	10000.00

Figure 5. Office A work table

In this process, it was confirmed that the latest FM business data could be entered in the FM task-related parameter item in the properties window, and it was confirmed that it could be resolved within the list if additional content description was needed. Through this, it was confirmed that if there is an existing BIM model used in the design and construction stage, it can be used in the FM data management stage through additional parameter creation and assignment. In addition, it was confirmed that the updated latest FM work contents can be automatically extracted in the existing managed Excel format.



	A	B	C	D	E	F	G	H	I
1	2021-05-10~05-16 Expenditure history								
2	No.	Space	Date	Manager	Account	Contents	Detail	Cost per area (₩)	
3	1	Meeting room	2021-05-16	Lee	BAS Repairs/ Maintenance	Automatic control c	Automatic door opening automatic control device	35600	
4			2021-05-12	Lee	HVAC Repair / Maintenance	Air conditioner repa	Filter replacement due to damage to the air condi	11500	
5			2021-05-12	Kong	Electrical Repair / Maintenance	Electrical appliance	Replacement due to damage to external parts of t	3000	
6			2021-05-13	Yoon	Security & Life Safety	Security program m	Repairs due to security program problems	16000	
7			2021-05-16	Park	General Building Repair / Maintenance	Door repair	Replacement due to damage to conference room	10000	
8									
9									
10									
11									
12									
13									
14	2	Office A	2021-05-11	Kim	Cleaning Expenses	Water cleaning	Emergency water cleaning due to serious contamii	5000	
15			2021-05-12	Lee	HVAC Repair / Maintenance	Air conditioner repa	Filter replacement due to damage to the air condi	11500	
16			2021-05-12	Kong	Electrical Repair / Maintenance	Electrical appliance	Replacement due to damage to external parts of t	3000	
17			2021-05-13	Shin	Cleaning Expenses	Window cleaning	Emergency water cleaning due to serious pollutior	7000	
18			2021-05-13	Yoon	BAS Repairs/ Maintenance	Automatic control c	Replacement and installation of automatic lighting	16000	
19			2021-05-15	kim	Security & Life Safety	Security program m	Repairs due to security program problems	23000	
20			2021-05-16	Park	General Building Repair / Maintenance	Office door repair	Office minute replacement due to damage	9500	
21			2021-05-16	Choi	Parking Expenses	Regular parking fee	Monthly parking fee payment	50000	
22			2021-05-16	Lee	General Building Repair / Maintenance	Wall painting	Repair work on peeling wall paint	10000	
23									
24									

Figure 6. Expense history of Excel file

The actual export document is shown in Figure 6, and it can be confirmed that the information extracted from the BIM model is matched to the Excel format used for the existing work. Through the System apply and evaluate stage of this study, it was confirmed that FM business data could be efficiently managed using the existing BIM model, and the possibility of application in actual work was confirmed.

5. CONCLUSION

The biggest problem with current asset management is that it takes too much time compared to its importance because the asset manager has to read the massive amount of facility management documents and categorize the expenditure details identified in the documents. To solve this problem, this study has developed a system that provides real-time based information system for PM managers by automatically linking BIM-based FM data with asset management tasks.

In this study, the 3D BIM model has been used to generate the necessary parameters in the maintenance stage. In addition, the related parameters have been created so that the pertinent information needed for asset aggregation can be identified and used in the BIM model. When FM work occurs, the participants can check and share all information via the BIM program, and the manager can automatically classify expenses based on the updated information and extract Excel documents.

This study has tried to overcome the existing inefficicency in FM work process by using BIM model, and tried to define the actual work flow. It is meaningful in that it proposes a system that can be used for actual asset management work by allowing the existing work process to be used as it is. Throughout this study, it is possible to automatically perform the work in managing the change order issues, checking the documents for facility management, and manually classifying the expenditure details in the BIM Model.

As a result, the accuracy when reflecting building information is increased compared to when performing work without applying the automatic linkage tool between FM data and asset

management, and it can contribute to increase work efficiency by eliminating the additional work of writing reports.

This study is limited to the process of checking cashflow among the current status of work confirmed previously. However, case studies through empirical analysis are essential in that FM data must lead to the issuance of reports tailored to the company's regular report format, as the actual asset management task includes periodic report publication. Therefore, in future research, it is essential to verify the applicability of the system in generating the ordinary reports using the BIM-linked databse proposed in the study.

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