APPLICATION OF BIM IN BUILDING ENERGY EFFICIENCY RATING CERTIFICATION

CHANGJAE YEO, JUNGHO YU

Kwangwoon University
E-mail: yeocj89@kw.ac.kr, myazure@kw.ac.kr

Abstract- The enormous amount of design information and technical limitations of 2D methods in large construction projects have resulted in challenges with noncompliance, omissions and miswriting for existing 2D drawings-based construction information management. In Korea, it is mandatory to have objective information concerning energy for use in an Energy Performance Program (ECO2) for a Building Energy Efficiency Rating Evaluation. Currently, the Building Energy Efficiency Rating Evaluation utilizes 2D drawings where information is obtained and input manually, resulting in inefficiency and subjective judgment. This study aims to propose 'Methods for Applying BIM to Building Energy Efficiency Rating Certification work' in order to secure the accuracy and reliability of Energy Efficiency Rating Certification information and apply BIM to Korean Energy Efficiency Rating Certification work. It is expected that the methods proposed in this study can be applied to a Building Energy Efficiency Rating System in other countries that may face similar challenges.

Index Terms- IFC(International Foundation Classes) , BIM(Building Information Modeling), BEER(Building Energy Efficiency Rating)

I. INTRODUCTION

In large construction projects, the enormous amount of design information and technical limitations of 2D methods are causing challenges with noncompliance, omissions and miswriting for existing 2D drawings-based construction information management data. In addition, there are issues with reliability and accuracy of estimates, cost planning, construction planning, and material procurement planning obtained from inaccurate 2D-based design information. Hence, various BIM (Building Information Modeling)-based software applications are emerging as new paradigms for planning and design information management and facilitating a rapid change from 2D-based designs to BIM-based designs.

The use of BIM and associated technology is rapidly increasing throughout the world, and advanced European countries such as Finland, Norway, Sweden, Italy and Germany are institutionalizing requirements that 3D-based design drawings should be submitted in basic and execute stages in order to overcome the limitations of existing 2D drawings generated in planning and design stages. In Korea, it has been mandatory to apply BIM to public enterprises for Office for Public Procurement orders since 2016.

In addition, interest in energy conservation and green buildings has also increased, such that the Building Energy Efficiency Rating was established and then implemented in 2001. Currently, it is mandatory to have objective requirement information concerning energy by using the Energy Performance Program (ECO2) for Building Energy Efficiency Rating Evaluation. Currently, the Building Energy Efficiency Rating Evaluation utilizes 2D drawings where information is obtained and input manually, resulting in inefficiency and subjective judgment.

Recently, due to the introduction of BIM, there are studies for the design stage, and there is also 'mutual exchange of information' between energy performance-related information, establishment of 'data standards' between related software, and 3D-based energy performance analysis using BIM. However, studies that address practical approaches to work efficiency improvements for an energy performance-related certification system are insufficient. Hence, current practices for generating input information required for the Building Energy Efficiency Rating Evaluation can result in missing or miswriting, errors in input information, and issues with the accuracy and reliability of the results due to the application of subjective judgment in producing the data.

This study aims to propose a 'Methods for Applying BIM to Building Energy Efficiency Rating Certification work' in order to improve the accuracy and reliability of Energy Efficiency Rating Certification information and apply BIM to Korean Energy Efficiency Rating Certification work. As such, this study analyzes information required for work processes and the authentication request for the Korean Building Energy Efficiency Rating Certification System and separates information required for authentication requests into 'information generated and obtained from BIM' and 'information which has to be managed separately'. In addition, this study proposes ways to generate information required

for Building Energy Efficiency Rating Certification in BIM by defining information that should be considered for modeling.

In this study, analysis was performed based on the Korean Building Energy Efficiency Rating Certification System and the work here aims to support an Energy Performance Analysis Program based on a 2D methodology. It is expected that this study will improve the efficiency of existing work processes by partial automation via BIM instead of the existing 2D-based manual processes.

II. BUILDING ENERGY EFFICIENCY RATING IN KOREA

A. Introduction

The Building Energy Efficiency Rating Certification System is intended to benefit everyone associated with a building such as construction business objects, owner objects, management objects and building users. This is done by providing objective information on the energy performance of a building, the quality of the living environment, and by recognizing value for the building. In addition, it aims to induce investment in energy-saving technology and visualize economic effects by providing accurate information on reasonable energy-saving practices for the energy used in the building.

Previously, evaluation methods and procedures between apartment houses and non-apartment houses were different, but since revision on May 20, 2013, all of these buildings undergo a unified assessment program called ECO2. Primary energy consumption is evaluated with ten grades that cover heating, air-conditioning (except for homes that don't have air-conditioning equipment), hot-water supply, lighting and ventilation. According to the evaluated grade, incentives such as Special Exemptions to Local Taxes and relaxing Regulations of Construction can be provided. There are ten classifications for the authentication grades. Intervals for separating grades of residential buildings are 30～50 KWh/㎡·year from 60 KWh/㎡·year to 420 KWh/㎡·year and intervals separating grades of non-residential buildings are 60～90 kwh/㎡·year from 80 kwh/㎡·year to 700 kwh/㎡·year.

B. Work Status of Building Energy Efficiency Rating Certification in Korea

As the number of buildings targeting Building Energy Efficiency Rating Certification increases, it is necessary to improve work efficiency and reduce consulting expenses at the technical review stage, which is required for achieving the certification goals of each building. Currently, design books frequently change along with technical performance changes required in each field to obtain optimal design solutions according to the certification goals. In each process, however, input costs and personnel have to complete the work within a limited process period from planning to construction, and frequent design changes result in an increase of temporary evaluation work for the Building Energy Efficiency Rating that is done using 2D drawings. Subjective judgment is used to obtain and process information requested for the Building Energy Efficiency Rating Program. The data from 2D design books causes omissions, changes and errors in information. In addition, whenever designs are changed, the change in information required for Building Energy Efficiency Rating Evaluation is not automatically applied. It is currently necessary to continually check the 2D drawings directly and reenter data. In particular, the time necessary to calculate building areas depends on usage of the buildings and the work time increases as building size increases. This causes problems as costs and time increases for certification. Therefore, it is necessary to have the capability to automatically obtain requested information and manage such information using BIM data, which can respond to design changes that occur frequently due to input from various decision-makers such as business objects, designers and builders in the preliminary/real certification stage.

C. Analysis of Information for Building Energy Efficiency Rating Certification

The ECO2 Program is a Quasi-Steady State Analysis Program Evaluation developed for the Korean Buildings Energy Efficiency Rating Evaluation, and was developed based on DIN V 18599 and ISO13790 standards. The program developed for the Korean Buildings Energy-related Policy has a number of characteristics that modify weather data and the profile is impossible to use for quick and objective evaluation, and to input items required for energy performance analysis. The ECO2 Program analyzes energy consumption and primary energy consumption of heating, air-conditioning, hot-water supply, lighting and ventilation in compliance with ISO13790 and DIN V 18599 and evaluates primary energy consumption with ten grades. Information input and the calculation process for energy performance analysis are shown in <Picture 00>.

The user interface of the ECO2 Program is composed of eleven menus for building name, input zone, input surface, air conditioning treatment, heating equipment, heating supply system, heating distribution system, cooling equipment, cooling distribution system, renewable and cogeneration and heat transmittance.

III. A METHOD FOR APPLYING BIM

A. Analysis of Building Energy Efficiency Rating Certification Information for Applying BIM

Concerning BIM information that can be used as Building Energy Efficiency Rating Information, information related to existing BIM information from Building Energy Efficiency Rating Information was analyzed for construction parts with IFC 2x4. Analysis for equipment and electric parts was excluded from the scope of this study. <Table 1> provides the results from the analysis. In addition, parameters on the information where BIM models require input for energy analysis were defined, although they did not exist in IFC. The parameters were separated as building number, analysis target possibility, direct to air and outdoor windows. Energy analysis targets were added by checking the possibility of characteristics or targets according to the main categories.

B. BIM Modeling method for Building Energy Efficiency Rating Certification

For wall distinction in a BIM program, it is necessary to determine planning and analysis for the possibility of insulation and to distinguish walls targeting energy analysis through various settings. Although materials and thickness of the walls are same, it may be necessary to separate the walls according to determination of analysis possibilities (direct/indirect selection of outdoor air) during modeling.

Table 1 IFC Extraction Information Definition

Category			IFC Entity
Thermal Transmittance	Wall	Wall name	IfcWall
		Locate	IfcPropertysSingleValue
		Material Name	IfcMaterialLayer
		Depth	IfcMaterialLayer
	Roof	Roof name	IfcRoof
		Locate	IfcPropertysSingleValue
		Material Name	IfcMaterialLayer
		Depth	IfcMaterialLayer
	Slab	Slab name	IfcSlab
		Locate	IfcPropertysSingleValue
		Material Name	IfcMaterialLayer
		Depth	IfcMaterialLayer
	Window	Window Name	IfcWindow
		Locate	IfcPropertysSingleValue
	Door	Door Name	IfcDoor
		Locate	IfcPropertysSingleValue
Input Zone	Space Name		IfcSpace
	Space Area		IfcSpace
	Space height		IfcSpace
Input Surface	Wall	Cardinal Point	IfcAxis2Placement3D
		Surface Area	IfcWall
	Window	Surface Area	IfcWindow
	Door	Surface Area	IfcDoor
	Slab	Surface Area	IfcSlab
	Roof	Surface Area	IfcRoof

Table 2 Defined Parameter

Parameter Name	Category	Data Type
Building Number	Room Door Slab Wall Roof Window	Text
Room Number	Room Door Slab Wall Window	Text
Room Type	Room Slab	Text
Direct to air	Door Slab Wall Roof Window	Yes/No
Analysis Target Possibility	Door Slab Wall Roof Window	Yes/No
Outdoor Window	Window	Yes/No

As shown in <Picture 1>, in performing BIM modeling, regardless of indoor environmental conditions, heat-insulating plans, direct and indirect parts of outdoor air, if a target consists of a wall, '① consider it as a wall', and as a target of energy analysis according to indoor environmental conditions, heat-insulating plans, direct and indirect parts of outdoor air '② like case of wall distinction', the modeling has to be separated during modeling. For bottom plates and rooms, it is necessary to separate a room for modeling unless the indoor environmental conditions and air-conditioning system are integrated into a single zone due to the same conditions and system.

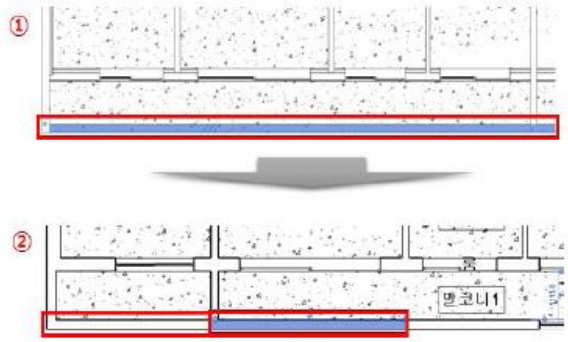


Fig. 1 Wall Modeling Consideration



Fig. 2 Slab Modeling Consideration

C. Modeling Process for Building Energy Efficiency Rating Certification

In BIM modeling, the process is to first add project parameters such as the same information, real information, and household information using a BIM authoring tool. Subsequently, modeling is done by separating walls and floor according to insulation plans that have to be performed. Additional data (distinguishing direct and indirect outdoor air, etc.) by each object then has to be input. Through this process, completed BIM models can be used for Building Energy Efficiency Rating Certification.

CONCLUSION

This study analyzed current processes in the Korean Building Energy Efficiency Rating Certification System based on existing 2D design and the information required for Building Energy Efficiency Rating authentication. The information required for Building Energy Efficiency Rating Certification was separated into information that can use existing BIM information, information that has to be generated and obtained in BIM, and information that cannot be used in BIM. In addition, information that has to be generated and managed in BIM was also defined and considerations on how to model this and apply BIM to Building Energy Efficiency Rating and Certification were proposed. In the future, it is necessary to develop systems that can utilize BIM information and manage information that is not currently managed in a BIM model. Additional studies are necessary to improve work efficiency with BIM application by applying the developed system to real practice. It is expected that the proposed methods in this study can be applied to a Building Energy Efficiency Rating System in other countries that have similar systems.

It is important to consider initial construction costs and also maintenance cost, operation cost, and end-of-life costs, which together are called the life cycle cost (LCC). LCC analysis is compulsory in Korea per various regulations and systems. Increasingly, the construction industry must deal with a large amount of information and building information modeling (BIM) is now being implemented to address this issue. Therefore, it is inevitable that the use of BIM in construction and LCC analysis in the pre-construction phase will inevitably need to be brought together. This research proposes an ontological approach to automatic BIM-based estimation of repair and replacement costs. This will overcome current problems in cost estimation of repair and replacement. Such estimates are currently done thru a manual process that lends toward inefficiency and subjectivity.

The proposed methodology of the study is as follows. First, analyze repair and replacement criteria currently applied overseas and in Korea. Second, define the route of extraction IFC (Industry Foundation Classes) data from the BIM model that describes each of the required elements for estimating repair and replacement costs. Finally, suggest a process of automation to estimate repair and replacement costs thru an Initial Construction Cost Estimation Ontology (ICCEO) that recommends the most adequate work item in order to map with cost information and the Repair and Replacement Cost Estimation Ontology (RRCEO) that refers to initial construction costs as recommended by ICCEO. Using the proposed process is more objective and accurate for obtaining estimated R&R costs. The use of IFC is more accurate and it is more consistent to infer appropriate R&R criteria and information based on ontology technology.

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