Developing a Design Supporting System in the Real-Time Manner for Low-Energy Building Design Based on BIM

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Abstract. This study intends to introduce a method for designing a low-energy building based on building information modeling (BIM) and a BIM-based application. The proposed application aims to generate an analysis report of energy-saving performance of design alternatives automatically in a real-time manner, during the architectural design process. The research focuses mainly on developing an automatic generation application for that report, using BIM concepts. The proposed technology (EBIM) is a type of design-supporting system that minimizes the time and labor needed for energy analysis and generates the optimized design alternative by automatic generation of the analysis report.

Keywords: Building information modeling · Low-energy building · Design supporting system · Real time evaluation · Architectural design

1 Introduction

Energy scarcity is a worldwide problem to which the architectural industry is not immune. Buildings are at the center of this problem, as they represent 40 % of the global energy consumption. Several governments, including the South Korean government, have established regulations for saving energy, such as the implementation of energy efficiency ratings and green building certifications. The architectural design process is one of the most vital stages of saving energy because most of a building's energy performance is fixed during that phase [1–3].

The aim of this study was to develop a method for designing a low-energy building based on building information modeling (BIM) and a BIM-based application that can generate an analysis report of the energy-saving performance of design alternatives automatically, in a real-time manner, during the architectural design process. The main focus of this research was on developing an automatic generation application for that report using BIM concepts. The proposed technology (EBIM) is a design support system that minimizes the time and labor needed for energy analysis and generates the optimized design alternative by automatically generating the analysis report. EBIM can supply an energy-saving plan and data for the energy efficiency class verification of the design alternatives, thereby enabling the architect to review and make modifications during the design phase itself. To create the EBIM, we performed several tasks, such as a user interface design, the survey and classification of the building materials, development of the standard families for external walls and windows and doors, crafting of algorithms

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for energy performance analysis, and creation of the automatic generation module for the analysis report.

2 Implementation of EBIM

The process of architectural design involves several attempts to evaluate the energy-saving performance. [4, 5] However, there is scant research related to automatic reporting systems for energy performance analysis and architectural design. As previously stated, the aim of this research was to develop the analysis report generator of the energy-saving performance of design alternatives automatically and in real time.

Figure 1 shows the system structure of EBIM. It is a kind of plug-in module activated in Revit architecture 2014 (After Revit), one of the world's most popular BIM authoring tools. Thus, EBIM can be executed at any point during the architectural design process. EBIM consists of EBIM_Evaluator and EBIM_Reporter. EBIM_Evaluator is responsible for the energy performance evaluation of the designed alternative. Revit delivers the geometrical information of the design alternatives to EBIM_Evaluator and it calculates the energy consumption performance using a material database, which is used in both EBIM_Evaluator and BIM family library. After the calculations are done, EBIM_Evaluator delivers the evaluation result to EBIM_Reporter and it generates automatically the report of the evaluation result, which follows the format of the certificate report common to the architectural practice in Korea.

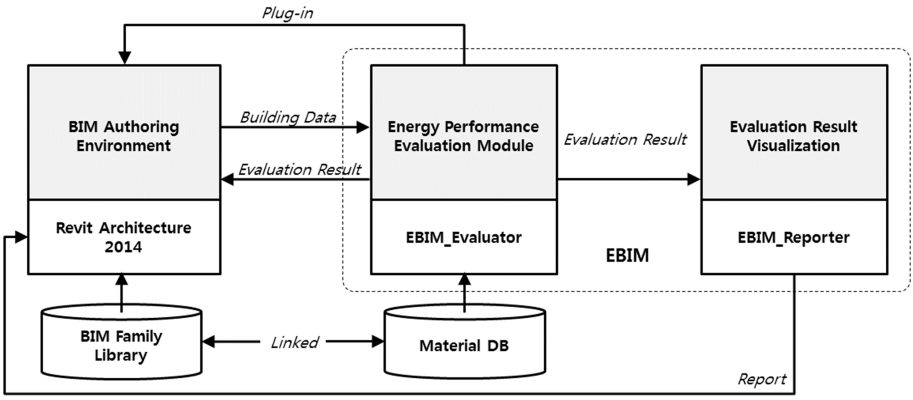

Fig. 1. The system structure of EBIM

Figure 2 shows the execution of EBIM for the automatic generation of the energy performance evaluation report. Executing EBIM then yields four kinds of real-time energy performance reports: (1) average heat transmission ratio, (2) wall area calculation table, (3) performance reports by door type, and (4) performance reports by wall type. These can be used as official documents for the eco-friendly building certification report as well as the design feedback for the improvement of the eco-friendly performance in the designed alternative.

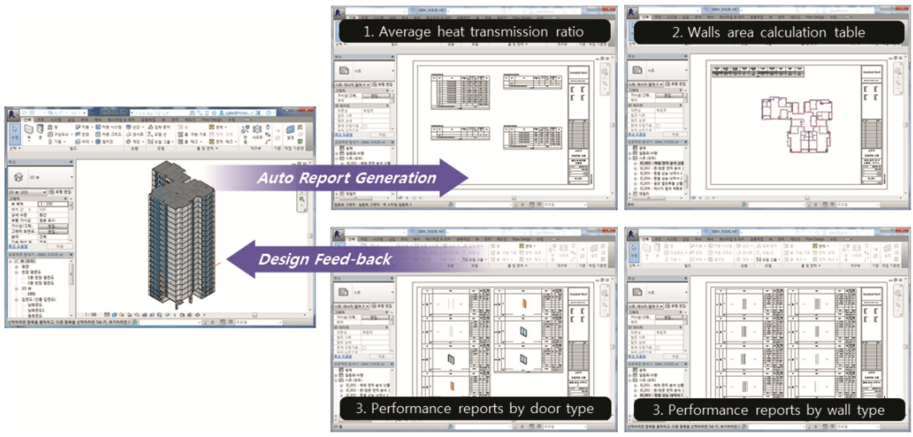

Fig. 2. Execution of EBIM for automatically generating an energy performance evaluation report

Figure 3 shows the eco-friendly architectural design process for EBIM. Conventionally, the energy performance evaluation of a design alternative is executed at the end stage of the design process, making it difficult to change the design alternatives that have already been finalized. However, it is easier to improve the energy performance and modify the design alternative because the architect can check the energy performance at an early stage of the design process. [6] With EBIM, architects can evaluate the energy performance of the alternatives at any stage of the design process, and they can make real-time decisions regarding the details of the design according to the results of the evaluation.

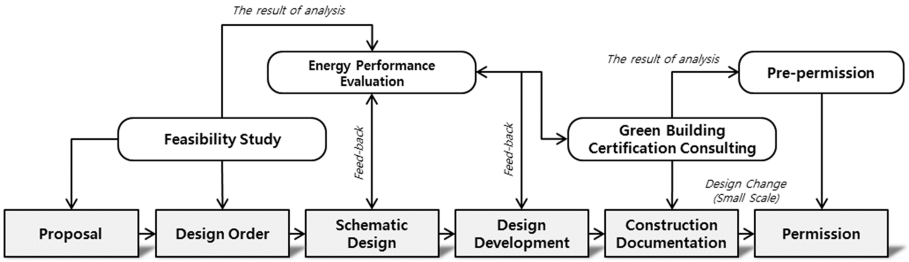

Fig. 3. Eco-friendly architectural design process using EBIM

3 Conclusion and Discussion

This study resulted in a proposed technology that can undertake the real-time evaluation of the energy performance of design alternatives. This technology is a BIM-based evaluation system, EBIM, which calculates the energy performance as well as the result report of alternatives during the design phase. This research mainly focused on the feasibility of this idea by developing the prototype for this system. Moreover, we

proposed an innovative design process with the proposed system that corresponds with the changes to Korea's national regulations and eco-friendly design certification. This process can prevent the need for large-scale design changes in order to obtain environmental certification and allow the owner to make an optimized decision according to the results of the analysis of the energy requirement at the design stage. In another study, we will refine the functions of the EBIM and apply this technology to the diverse domains of the architectural practice.

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