A DEVELOPMENT OF KBIMS-BASED BUILDING DESIGN QUALITY EVALUATION AND PERFORMANCE REVIEW INTERFACE

PARK HYEJIN¹, GU HYEONGMO², LEE WOOJUN³, KIM INHAN⁴ and CHOO SEUNGYEON⁵
¹,²,³ Kyungpook National University, South Korea
¹,⁵ {gpwls3143|dadlchoo}@gmail.com ³ {wjee0306}@naver.com
⁴ Kyung Hee University, South Korea
⁴ ihkim@khu.ac.kr

Abstract. Recently, The South Korean national government and local governments in Korea are pursuing national R & D tasks that can be used in the design stage to expand the BIM technology to the public environment of the future city, such as the construction of the IT integrated architecture design environment and the convenient construction administrative system environment. Among these R & D researches, various studies are continuing to provide more convenient and accurate architectural services at the licensing stage in order to promote the introduction and practical use of BIM in the Korean construction industry. Typical examples are BIM-based building design quality evaluation and building performance review technology development. Therefore, the goal of this study is to introduce the case of developing the performance review interface according to the regulation and required performance criterion of BIM model using KBIMS and analyze the possibility of evaluating building design quality by applying this to a practical project.

Keywords. OpenBIM; Design Automation; Performance Review; Design Quality; Legal Review.

1. Background

Recently, BIM (Building Information Modeling) has been actively introduced in public construction projects in the US, European countries and major Asian countries. Already in 2006, the General Services Administration (GSA) in the United States made it mandatory to submit design drawings as IFC (Industry Foundation Classes) files when designing public buildings. Singapore’s Building & Construction Authority (BCA) has mandated the submission of BIM-based plans for all new buildings by 2015, and has extended it to the construction industry until now. The introduction of BIM is changing the construction process, and it is becoming easier and simpler to communicate and exchange information among project participants.

In particular, Singapore has developed a Web-based CORENETD system that examines the appropriateness of specific laws and applies for licenses and permits.
using the BIM model. In this way, developed countries are encouraging the delivery of BIM data based on the BIM standard. It also recognizes the importance of BIM quality and conducts some automation reviews. The study of design quality has been actively applied in the field of legal review that reflects various laws and regulations in Korea. These studies have developed a system of reviewing building codes using the linkage information of IFC, an open BIM data standard format. When conducting legality review through the BIM-based automated review system, it is possible to minimize the errors that can occur, and to make accurate and objective quality reviews such as reduction of manpower and cost reduction.

Figure 1. BIM Technology Level Graph By Country.

In Korea and abroad, various studies are carried out for quality control of BIM data. In the world, researches are being conducted to develop guidelines and review system of quality standards and apply them to practical applications. One of the most basic requirements for making a design into an authentic building that can be constructed in the real world is the legality of the design. This is one area of BIM data quality management. Therefore, there is a tendency to actively develop a system that can automatically check the quality of the BIM data base in Korea and overseas. In addition, since design standards are different for each country, a proper design quality review system should be established.

The purpose of this study is to provide a preliminary quality review environment in order to improve design quality based on BIM in Korea. Therefore, this study introduces the development of performance review interface according to the regulation and required performance standard of BIM model using KBIMS. We also analyze the possibility of evaluating building design quality by applying the interface in practice.
2. Status Analysis

2.1. ANALYSIS OF OVERSEAS RESEARCH

Among the quality review studies, there has been active researches on the legal review studies that reflect various legal standards. Many of these studies are based on IFC’s linkage information, which is an open BIM data standard format. Especially, the automatic regulatory review system is expected to shorten the amount of work and time required for reviewing the regulations at the design and licensing stage, which proved to be efficient in various cases. A typical case analysis is as follows.

**Singapore CORENET**

Singapore is a representative country for licensing and delivery through BIM. Since 1995, CORENET (Construction and Real Estate Network) service has been developed and used for the processing of licenses and permits. CORENET is composed of e-submission, e-submission, e-plancheck to support automatic review of plans, and e-info to manage all information throughout the construction industry. Of these, e-plancheck is a review system for compliance with the FORNAX-based building codes. Initially, it started as a 2D CAD-based review system, but it is now being developed for review through the delivery of IFC. Singapore has achieved a 75% reduction in license turnaround time and is expecting 10 times more efficient investment.

**Norway DISK**

In recent years, DIBK (Direktoratet for byggkvalitet), which is responsible for the laws and architectural policies related to building permits in Norway, is carrying out various studies to utilize BIM for licensing and collaboration. The construction permit system for building permits can be applied to local governments through an online building license and application system.

**Finland LUPAPOSTE**

Finland has built a system called lupapiste to support the online construction administrative system. In May 2015, a built a nationwide online archive through the pilot system. This makes it possible to automatically check the past paper drawings manually by the system. To that end, Finland announced the Series 14 of COBIM 2012, the BIM model guide for building supervision, in March 2014.

As a result, the development of online administrative services in the field of architecture has been under way in various ways. Until now, research has focused mainly on changing the online submission system and environment of licensing documents. As a result of previous research, most countries have plans to focus on automation research for design quality and performance review using BIM technology in the future.

2.2. RESEARCH TRENDS IN KOREA

Currently, Korea has built a residential system through the intelligent construction administration project in 2009, and this system began spreading nationwide in 2011. The Ministry of Land, Transport and Maritime Affairs provides the legality review service at the building administrative system building and conducts the
legal review of the design. However, this is limited to the review based on 2D CAD drawings. The study of the automatic review of the design rules has been conducted over a long period of time. At the beginning, the legal review based on 2D CAD drawings was carried out. Currently, the study of legal review in 3D model is mainly proceeding. However, the review of 2D-based regulations has technical limitations in reviewing complicated and enormous laws and standards, and BIM-based legal review has been studied to a limited extent for evacuation, disaster prevention, and disabled persons.

Recently, The South Korean national government and local governments in Korea are pursuing national R&D tasks that can be used in the design stage to expand the BIM technology to the public environment of the future city, such as the construction of the IT integrated architecture design environment and the convenient construction administrative system environment. A key Representative of the R&D is the ‘Open BIM-based architectural design automation support technology and advanced maintenance management technology development’ which is being promoted by the National Institute of Land, Information and Nuclear Technology (KITA) as of March 2017. This R&D project is scheduled to be completed by December 2021. The contents of this R&D are largely classified into three categories: open BIM standard platform for implementation of IT integrated architecture design, development of application technology, development of automation technology and application technology for architectural design legality evaluation based on open BIM, with technology for building maintenance based on open BIM Development as the main goal. Among these R&D researches, various studies are continuing to provide more convenient and accurate architectural services at the licensing stage in order to promote the introduction and practical use of BIM in the Korean construction industry. Typical examples are BIM-based building design quality evaluation and building performance review technology development.

Figure 2. ‘Open BIM-based Architectural Design Legality Evaluation Automation Technology and Application Technology Development’ R&D.
Therefore, this study intends to introduce the R & D study introduced above in order to apply BIM to the present situation. It is expected that BIM technology will be spread and industrial growth engine will be obtained.

3. Methodology

3.1. PROCEDURES OF RESEARCH

First, BIM data visualization analysis method was developed by extracting object attribute information, quantity calculation, estimation information, model geometry information, and other information in KBIMS based on the BIM model. All legal text data were entered into logical rules for the development of an automatic performance review interface of a building. The performance of the building itself as described in this study includes environment, structure, evacuation, etc. The standard is based on the performance of the building according to the licenses and regulations, the design constructability, and the workability evaluation index. Therefore, the development of the automatic legal review interface for the BIM-based building performance review consists of four modules: visualization module, collaboration management module, report module, and legal result review module. The developed automated regulatory review interface was applied to practical projects to evaluate the quality of building design.

3.2. SCOPE AND ELEMENTS OF RESEARCH

The attribute information of the members included in the BIM data includes not only the name and the material but also additional attribute information applicable in various fields. In addition to basic attribute information, additional information should be defined in the BIM model. This attribute information is used as a basis of judgment in the quality review system. The preliminary quality review of items can be divided into the items containing the attribute value and the items that contain relation value. An item having an attribute value can be classified into an item having basic attribute information and an item containing additional attribute information (PSET). Items that contain need to be related can be classified into items containing object-object, space-object, space-space relationship. For
this purpose, we have been working on mapping IFC objects (Entity), Relations, and Properties. As the architectural design process progresses, various tasks are accompanied and complex information is generated. In order to examine the quality of such information, the definition of subject and information requirements must be selected first. This study is a study to derive information requirements for BIM - based prior quality review, and it defines the expressive structure of the IFC and the subject which is required to be reviewed in advance in the domestic license and regulations. In order to define the additional attributes of the BIM model, IFC provided additional property information through the development of the property set (PSET). In this study, IFC2x3 was applied.

The scope of the study was limited to “regulations on standards of evacuation and fire protection of buildings” for the purpose of establishing technical standards for evacuation and fire prevention of buildings and some contents related to evacuation in “Building Law” of domestic regulations. Therefore, IFC - based attribute system is applied to applicable laws through mapping for developing quality review automation system. In this study, a performance review interface is developed by first selecting the properties that can be reviewed and logically implemented.

4. Evaluation Method of Building Design Quality
4.1. EXTRACTING PROPERTY INFORMATION OF BIM MODEL

The requirement information extracted from the legal analysis can be extracted from the BIM data so that the legal review is possible. Among the request information, there is a frame for inputting information, so it is possible to input additional information when necessary in the modeling process. Basic information of buildings should be inputted by using the property information input window supported by the BIM authoring tool. For Autodesk’s Revit, you can add and create basic building information using a feature called a project parameter. When a project is created, the designer creates a property of the design quality evaluation factor and inputs related information of the building generated as the design progresses into the property. In this case, the information related to the building input is the information generated in the designing process due to the use of the building, the structure, the number of parking lots, among others, so management by the BIM authoring tool is required. In order to extract the property set of license information entered in BIM authoring tool with IFC, IFC Export function which is the add-on of Revit should be utilized. The IFC (Industry Foundation Classes) is a designated international standard for interoperability of information in the BIM model generated in various design environments. It is a format that can be used in various BIM software without prejudice to specific program format. buildingSMART The International Federation supports the Property Set to include the information that users require in IFC. Attribute information extraction for design review Define in Default User and Defined Parameter Sets. Therefore, IFC can be created by using the Default User and Defined Parameter Sets, and the performance can be classified and managed by type.
4.2. LOGICAL REGULATION OF LEGAL DATA

The legitimacy review of the design requires a process of verifying the information through interpretation of the legislation. At this stage, the information required for the review was extracted from the original text through legal analysis. The extracted request information is a natural language that can be recognized by a person and converted into a form that can be processed by a computer. The information extracted from the building codes can be divided into objects, attributes, parameters, and associations. In this case, the classification standard is based on the criteria of “BIM Application Guideline for Architecture” presented by the Ministry of Land, Transport and Maritime Affairs in 2010. According to the guide, objects are classified into architectural objects, spatial objects, and facility objects according to fields, and classified according to the attributes in the objects. The development of IFC data is mainly due to the development centered on the United States and the United Kingdom. Also, buildingSMART has developed and provided a customization of a kind of IFC specification through Pset. However, the use of non-standardized Pset causes problems of information compatibility in the legal review system, and objectivity and reliability is poor. In this study, the name of Pset used in legal review is defined as “Pset_KBIMS (title of this research) + □□□ (upper property name)” and the criteria of Pset name of property used for legal review is suggested. Even after the rule standard was added, the unity of data names was ensured.

![Figure 4. Example of Mapping of BIM PropertySet and IFC Attribute Information.](image)

5. Development of Building Performance Review Interface

5.1. PERFORMANCE REVIEW INTERFACE DEVELOPMENT SCENARIO

In this study, BIM model data and quality review system generated according to the scenario (Fig. 5) are developed and an open BIM-based automated quality review interface can be constructed. In this study, the evaluation method of design quality based on open BIM is as follows.
(1) The designer conducts BIM modeling using design tools according to the application scenarios that reflect the evacuation regulations and requirements. At this time, KBIM-code is additionally defined as the attributes related to legal and fireproof examination as well as the geometrical expression. (2) Extract the BIM model into the open BIM standard file, IFC format. (3) The BIM data is composed of python-based KBIM-logic for legal review in accordance with legal standards such as evacuation and fire prevention. Therefore, KBIMS-code and KBIMS-logic are linked to each other and entered into KBim Assess-Lite. KBim Assess-Lite is a program that performs rule-based review on the quality of the open BIM model (IFC) generated by the BIM authoring tool. The purpose of this is to allow the user to review the legality of the BIM model being designed in the course of the architectural design process prior to the license application, and to prevent the trial and error of the BIM model. Therefore, the design quality evaluation and performance review interface to be developed in this study were created. These interfaces provide a more accurate and efficient quality review. (4) The quality review system applied in this study is divided into the section where the legal review section developed by using the SMC API and the examination result are stored as an XML file and the result can be confirmed in a separate interface. (5) The designer continually revises and reviews the design until the BIM model satisfies all of the requirements for the quality review criteria as the quality review process continues. On the client side, it is possible to perform a more accurate and rapid evaluation by applying the common BIM result (the evacuation regulation and the fire regulation standard in this study). The results of the quality review can be summarized as reports if necessary. In this study, it is possible to output the examination results as an Excel file and also to output the PDF report.

5.2. CONFIGURATION OF THE PERFORMANCE REVIEW INTERFACE
KBim Assess-Lite was constructed based on the attribute mapping system presented in this study. The BIM model was constructed according to the BIM model guide. The object to be analyzed in the BIM model will be created by reflecting the required attribute information, and it is determined whether the object conforms to the legal standard through the attribute information defined.
in the loaded model. The KBim Assess-Lite uses the license and enforcement checklists as a review basis, and the BIM model is reviewed to reflect the review list in the program. Fig. 6 shows the interface of KBim Assess-Lite.

The middle screen of Fig 6. shows the result of the legal review of the evacuation and fire prevention part based on the methodology built according to the actual created attribute mapping system. Therefore, the contents of relevant laws and regulations can be confirmed through the check list of laws. Based on the BIM model and the IFC-based property mapping system, rule sets are generated through algorithms in the law review system, and the performance of buildings can be reviewed. The BIM model used for the review was based on the BIM model guide, which was proposed to improve IFC data compatibility. The BIM model used in the statutory review system has the attribute information value of the same IFC data and is shown as conforming (T) and nonconforming (F) in the list of the examination results of the selected regulation item located at the bottom right as shown in Fig 6.

6. Conclusion

This study suggests the development of open BIM-based design quality evaluation and performance review system for legal review. BIM quality control can be more effective when interrelated in the fields of design, environment, and structure. However, since the practical use of BIM is low, integrated operation and development are insufficient. The results of this study are as follows. It is found that more than 70% of the automatic interface review technology for BIM-based building performance review is applicable to practical application. The logical structure for the review of automatic regulations was analyzed to be 50% practical. The practical efficiency of the design alternate automatic generation system was 25%. It verified the possibility based on the expert’s evaluation and review opinion on interface development. This study focused primarily on the field of evacuation and fire protection regulations. This can be done by reviewing the quality of the
various aspects through the extension of the regulations in the future study. In addition, since the range is limited, practical application is limited only by the items that can be analyzed in the automated regulation review system. In order to supplement this, it is necessary to extend the application scope and through various analysis and practical consultation. The development technology of this study can be applied to residential and commercial buildings that occupy about 71% of the general buildings, especially the four-year license. Therefore, the system development methodology developed in this study is one of the studies for application of BIM in the field, and it is expected that the application of BIM will be activated in future by reviewing various practical applicability.

This study suggests that it is necessary to continually update the DB regarding the new regulations. Research based on this should be complemented. Through continuous research, we hope to be applied to the future industrial technology environment as well as the information fusion with the national industrial promotion and other industries.

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