

A Methodology of Building Code Checking System for Building Permission based on openBIM

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Abstract

The purpose of this study is to suggest methodology of building code checking system for building permission based on open BIM¹. To achieve this purpose, the authors have suggested an open BIM-based building code checking process and developed a building code checking system called KBim Assess-Lite. According to this process, prevent various problem which may occur in developing the automated design quality checking system.

Keywords –

Automated Code Checking System; Building Code; Building Information Modeling (BIM); Design Quality; Industry Foundation Classes (IFC)

1 Introduction

Architectural information is managed throughout the life cycle of a building. Building information modeling (BIM) serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward [1]. BIM technology has been utilized increasingly in quantitative ways in the architecture, engineering, and construction disciplines. However, owing to increasing requirements for an improvement in qualitative factors in BIM-based design projects, it has become necessary to develop a checking and evaluation process for improvement of BIM-based design quality [2]. The delivery of the BIM data is mandatory in advanced countries, and these countries are promoting the automated checking for BIM quality, including compliance with the building code. For example, Singapore has developed a BIM-based automated regulation checking process through the software

FORNAX and has built a construction administration system, CORENET. The SMARTcodes project in the USA has structuralized the regulations of the International Code Council (ICC) and developed automatic code compliance checking systems [3]. In particular, code checks through and automated code checking system can reduce errors, time, and the inefficient use of human resources through objective verification. The purpose of this study is to suggest methodology of building code checking system for design quality checking based on BIM. In this study, the scope of applied design quality checking is confined to Korean building codes. The methodology of this study to achieve this purpose is as follows.

1. The authors have suggested an open BIM-based design quality checking process, called in KBIM e-Submission process. The architects create open BIM data using guideline and BIM library that was developed this study. The BIM data is checked through building code checking system called KBim Assess-Lite.
2. The authors developed a logic rule-based management system called KBim Logic. This system translates Korea building code (natural language) into computer-executable rule set files. Following the logic-rule based mechanism, the building code sentences are converted into intermediate script language called KBim Code.
3. The authors developed a building code checking system called KBim Assess-Lite. This system can assess quality of the IFC-based open BIM data. Major aspect of the BIM model quality is conformance of the building code (KBim code).

According to this process, prevent various problem which may occur in developing the automated design quality checking system. Consequently, the architects can achieve the set up goals much easier and faster through the developed automated design quality checking system.

¹ Open BIM is a universal approach to the collaborative design, realization and operation of buildings based on open standards and workflows. Open BIM is an initiative of buildingSMART and several leading software vendors use the open buildingSMART data model.

2 Background

Building code checking is the most actively applied quality checking research. It is reviewed through national laws and is based on each country's regulations. It is processed through building code checking system developed using the IFC related information. Research of last four years were analyzed into the vertex. In the research of João Poças Martins et al., the system LicA was developed to examine the plumbing facilities and plumbing equipment of the provisions of Portugal. This paper presented a development plan, developed the LicAXML format to save the Pset and developed additional attribute information using the IFC format to another LicAXML for IFC compatible BIM software such as Revit MEP [4]. In the research of Sijie Zhang, a review was conducted for the safety regulations applicable to BIM model of construction process. Review of the potential risks arising from the construction process does not take into account of the design stage. Scaffolding was installed through automation and safety devices in order to solve this problem [5]. In the research of Sager Malsane et al., study of the IFC schema was performed to propose measures to increase the potential of the UK regulatory review through the localization of specific terms in the United Kingdom. This research attempted to improve interoperability by the reconstruction of IFC structure and applied model [6]. Inhan Kim et al. conducted a building code checking research of safety regulations targeting super-tall buildings. Using Application Program Interface (API) of Solibri Model Checker (SMC), the development of the ruleset in code checking system and the development of an evacuation elevator and safety evacuation zone sector utilizing the IFC Pset [7]. Junho Choi derived entries based on the building permission regulation check-list and proceeded with building code checking using Pset of the IFC. Case of determining whether or not to use entries in the living room space were randomly checked by defining the Pset [8]. Hyeonsu Lee et al. researched on analysing the human-readable language sentence in form of building codes objects and properties of building regulations, the associated functional conversion classification as well as the classification items as pseudo code of the previous stage of the system functions. This paper shows the possibility of utilizing building code checking from a variety of programs by establishing a web-based database based on the derived the entries and transformed codes [9].

The delivery of BIM data is mandatory in advanced countries, and these countries promote automated building code checking. For example, Singapore has developed a BIM-based automated code checking process through the software FORNAX and has built a construction administration system, CORENET [10].

The SMARTcodes project in the USA has structuralized the regulations of the International Code Council (ICC) and developed an automatic building code checking system [11]. In particular, legality checking through an automated legality checking system can reduce errors, time, and inefficient use of human resources. Therefore, it is necessary to develop a building code checking system for design quality improvement based on open BIM in Korea, as an improvement over the conventional 2D drawings and documents.

3 Open BIM-based building code checking process

The Construction industry involves compiling a multitude of data from various sources working within different disciplines in a process that includes a variety of design stages. This process support collaboration between numerous participants. Architect can BIM data checking before Seumter (building administration permission services in Korea) submission through KBim Assess-Lite. Architect can pre-checking for Seumter building permission through BIM quality center verification process. Approver can Korean building code checking through KBim Assess in the Seumter environment [12].

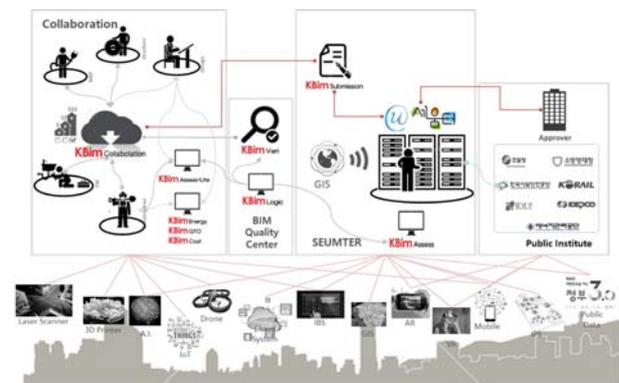


Figure 1. Open BIM-based design quality checking process

3.1 Design phase

3.1.1 Design Collaboration system

KBim Collaboration was developed to assist building design project management and communication in BIM and web-based environments. The purpose is to facilitate information transfers and seamless communication between different stakeholders and to prompt data sharing in an open BIM environment. This system thrives on optimizing essential features for BIM-based design collaboration by providing desirable industry features: [Project Information Management],

[Design Management], [Online Meeting], and [Project File Management]. These management tool functions were derived through a comprehensive analysis of the industry's needs (through a Delphi survey and expert interviews) to understand and overcome the limits of existing BIM collaboration systems.

In utilizing KBim Collaboration, the project participants are free to work across different BIM applications with the supported international open standard formats, Industry Foundation Classes (IFC), and BIM Collaboration Format (BCF). It is possible to extract required project management information from the IFC model and to communicate in BCF regarding design coordination.

Furthermore, KBim Collaboration serves as a platform for integrating other KBim-applications, such as KBim Submission, KBim D-Generator, and KBim Assess-Lite. The system automatically delivers all necessary and suited data for each application, including project information, BIM model files, drawings, and other project documents.

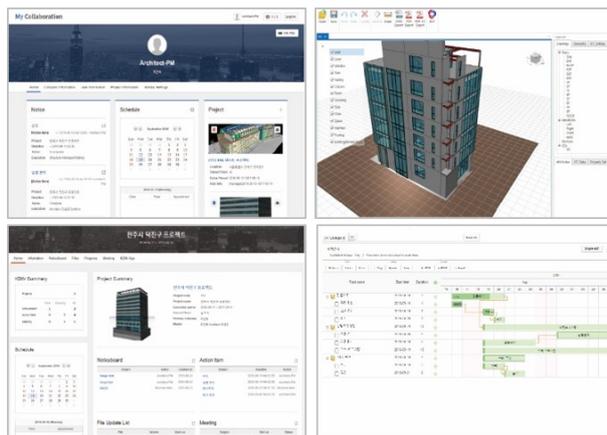


Figure 2. KBim Collaboration

3.1.2 BIM quality self-assessment

KBim Assess-Lite is a public-access version of KBim Assess software that supports BIM model checking for individual users. It operates as a rule-based model quality checker for IFC-based BIM models. KBim Assess-Lite aims to provide a convenient tool for building project participants to review their BIM models for building code compatibilities and general errors from the early design phase until submissions for project approvals.

Key functions include:

- IFC-based BIM model quality assessment by the rule-based checking methodology
- Provides text description of relevant building clauses from the Korean Building Act, its enforcement decree, and associated

regulations.

- Execution criteria are defined and managed with code checklists of existing Korean building regulations and codes
- Checked results visualized in real-time 3D graphics
- Review reports can be outputted as MS Excel or .pdf files
- Modifiable execution criteria can be defined with user-customizable scripts



Figure 3. KBim Assess-Lite

3.1.3 Energy saving and automatic checking

KBim Energy is an automation program that generates energy performance evaluations from open BIM-based models. It is used in reference to energy-saving standards and the energy efficiency rating certification system of Korea for buildings with a total floor area of more than 3000m². The energy ratings from the automated analysis process are calculated according to ISO13790 to ensure transparency and reliability.

It provides a means for the rapid energy analysis of design alternatives; thus, it enables users to better determine energy requirement-compatible designs, enhances design workflow, and effectively reduces the amount of repetitive work. Energy Performance Index (EPI) output is also available for users from the web-based interface.

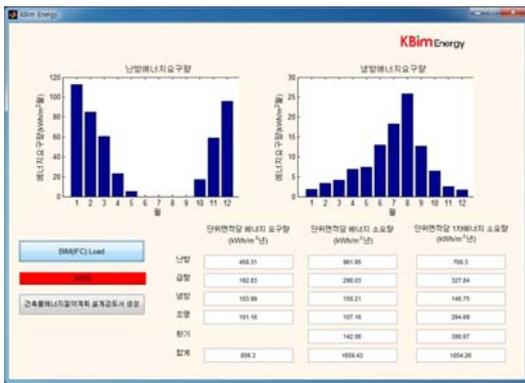


Figure 4. KBim Energy

3.2 Verification phase

3.2.1 BIM quality verification

KBim Veri is a BIM model quality assessment module for verifying KBim Assess regulatory compliance and before submitting the BIM model data to SEUMTER for project approval.

KBim Veri functions as a part of the BIM Quality Center service, which is a proposed web-based service for authenticating verified BIM models for SEUMTER submissions.

Key functions include:

- BIM model evaluation for file errors, such as invalid IFC version or wrong format.
- Preliminary checking of BIM models prior to KBim Assess on proper input of model objects and attributes necessary for automated code checking.
- Basic quality assessment of model objects' dimensions, location, type, and object relations.
- Reports generation of checked results



Figure 5. KBim Veri

3.2.2 Logical rule for building code

The KBim Logic application is a logic rule-based management system that governs the process of digitalizing the National Building Regulations and

Codes of Korea (natural language) into KBim Code. It is comprised of 1) a logic rule-based meta database of Korean building regulations and codes; 2) the KBim Code authoring tool; 3) and the KBim Code database, a comprehensive management tool, and system databases.

The logic rule-based meta database provides the classification of regulatory-specific objects and properties, sentence relations etc. Following the logic rule-based mechanism, the KBim Code authoring tool accesses the meta database for the generation and management of intermediate script language, KBim Code.

KBim Code is the intermediate script language codes of Korea Building Code sentences. It was established as a database to be reused and executed in accordance with the Building Act. KBim Code is generated and managed by KBim Logic, the logic rule-based management application. An exported series of KBim Code can be used in KBim Assess, an open BIM-based model checker for building permits in Korea.

Distinguishing features of KBim Code include the following: it is a software-independent and standardized approach to the rule-making process and it is officially maintained and managed by government authorities, guarantying reliability for public use as well as ensuring an up-to-date database.

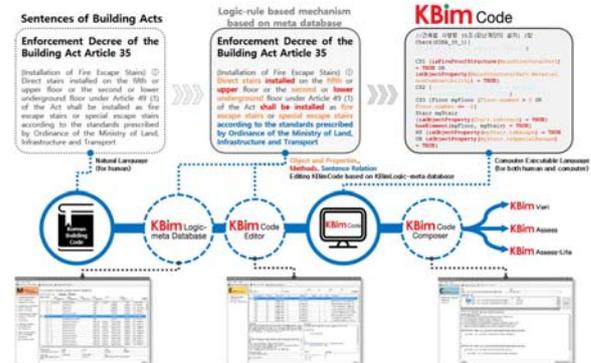


Figure 6. KBim Logic and Code

3.3 Submission phase

3.3.1 Automated submission system

The KBim Submission program facilitates the organization and management of building permits. It enables direct data linkage to SEUMTER (a Korean national e-submission system), therefore minimizing manual administrative work on project information throughout the design process. It revolutionizes the submission process by automating submission data entries in the SEUMTER system, providing an efficient management platform. Stepping away from traditional processes, 280 different categories of information (based on new builds) required for building permission

can now be automated, avoiding inaccuracy from manual input and the inefficiency of manual data collection.

KBim Submission enables the extraction and evaluation of the data necessary for building permits directly from BIM models and fully supports open BIM. With IFC-based BIM models, users can manage the design-to-submission processes with ease due to the highly automated functionality of KBim Submission. The program also includes a standardized library of 399 types of materials for the systematic management of design drawings, specifications, and documentations applicable to building permit applications. Furthermore, the data submitted is automatically converted and linked to the SEUMTER internal database, eliminating the need for information re-entry.

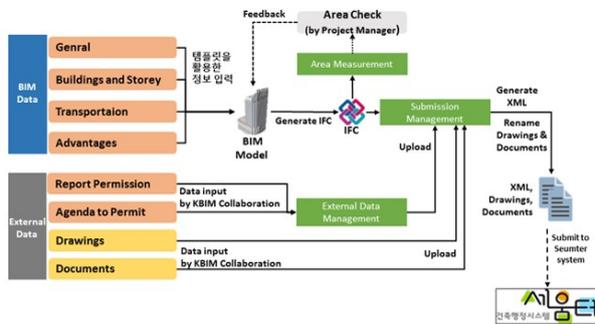


Figure 7. KBim Submission

3.3.2 2D drawing creation from IFC

The KBim D-Generator program automatically generates building permit submissions applicable to 2D drawings, such as plans, elevations, and sections, directly from the 3D IFC model. The generated drawings are interactive 2D drawings connected to the 3D model. Through the KBim D-Generator program, users can view both the 3D model and the generated drawings in parallel and access specific objects and information on the interactive drawings according to their needs.



Figure 8. KBim D-Generator

3.4 Permission phase

KBim Assess is a rule-based BIM model that checks software for screening eligible BIM-based projects prior to project approvals from SEUMTER. SEUMTER is the Korea national construction administrative online service, which includes e-submissions.

KBim Assess rejects any faulty or defective models that contain errors or insufficient data for the SEUMTER approval process. This pre-checking procedure saves time and manual efforts effectively for governmental officers. Unlike KBim Assess-Lite, which can be executed as a stand-alone application, KBim Assess operations depend on the SEUMTER system and execute checking only for the models provided by the system. It performs checking with the latest versions of the Korean building regulations, codes a logic rule-based meta database, and delivers results directly back to the SEUMTER system.

Key functions include:

- IFC-based BIM model quality assessment by a rule-based checking methodology
- Checking results visualized in real-time 3D graphics
- Interoperability with the SEUMTER system on BIM model downloads, results uploads to the SEUMTER server, and project data transfer.
- Connects to the Korean building regulations and codes database and executes the latest versions.

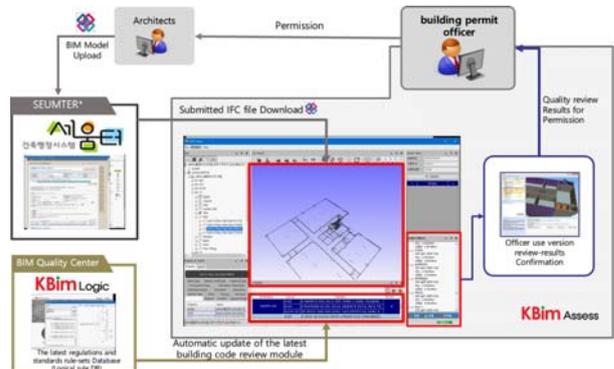


Figure 9. KBim Assess

4 Conclusion

OpenBIM-based automated code checking is recognized as the prominent future of BIM worldwide. It is expected to bring changes to the architecture and construction industry for the next 20 years. In Korea, in order to advance on the architectural and construction technology of the nation and strengthen the competitiveness of small and medium-sized design

firms, government funded the BIM-related project [13]. This project develop applied technology for building permission documentation through standardized data format, submission format, criteria and requirements for the benefit of BIM data exchange; and to develop an integrated collaborative project administrative system.

Prior to the KBIM e-Submission development, building permission process of Seumter relied greatly on 2D drawings with around 150 pieces of documents required in total from architectural, structural, MEP and etc. KBIM e-Submission process reduces 1/3 of the time required to generate required documentations for submissions by automating the drawing generating process, pre-checking BIM models with the latest building codes, allowing a sustainable platform for collaboration, and automating the code compliance assessment processes.

Acknowledgements

This research was supported by a grant (17AUDP-B127891-01) from Architecture & Urban Development Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

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