GREEN STANDARD FOR ENERGY AND ENVIRONMENTAL DESIGN

The Development of an Assessment System Based on a Green BIM Template

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Abstract. To construct a building that meets the requirements of certification in terms of environmental friendliness, there must be a process that considers the certification criteria from the initial design phase. However, there are numerous complicated task performance procedures to analyse many required items in detail as well as perceive and apply the data requirements efficiently. Currently, Building Information Modeling (BIM) is gaining attention as a solution for environmental problems in architecture. BIM shows precisely how a virtual building is modelled in the real world, thereby providing an objective information and analysis through a simulation. However, the result values of BIM library or modelling may turn out differently as a result of the work environment of designers or users that is not standardized. Therefore, this study applies the modelled and extracted BIM data using the template and library established in the BIM add-in planning and design phase to review in advance the Green Standard for Energy and Environmental Design (G-SEED) assessment by item and manual input of users with the BIM-based (add-in) G-SEED assessment system, thereby providing support to enable users to establish specific strategies in designing green buildings.

Keywords. GBT; G-SEED; BIM System; BIM Add-in; Apartment.

1. Introduction

Buildings have performed a leading role in the global environment, such as energy depletion and environmental pollution; thus, concerns have been raised as regards the need for green buildings in advanced countries where the Convention on Climate Change is adopted.

In Korea, the Korea Institute of Civil Engineering and Building Technology has discussed building energy use and reduction of CO2 emissions actively, with a series of perceptions on the environment; through the discussions, it has strived to find a certification system to reduce environmental load on buildings and improve environmental quality level(KICT 2015).

Since 2002, the Ministries of Environment and Construction and Transportation (currently named the Ministry of Land, Infrastructure and Transport) have implemented the government-led Green Building Certification System. Systems related to green housing that have redundant certification criteria and subject were integrated and unified in February 2013 by the Building Act and Housing Act, resulting in the official launching of the Green Standard for Energy and Environmental Design (G-SEED). This has become the judgment criteria for environmental friendliness of buildings, as designers now produce G-SEED-based environmental designs to design green buildings (Kim 2014).

However, there are numerous complicated task performance procedures for the designer to analyse many required items in detail from the initial design phase as well as perceive and apply the data requirements efficiently.

Thus, to promote G-SEED-based green buildings, it is necessary to develop a new application technique that can provide more efficient support for detailed items of certification.

Building Information Modeling (BIM)-based G-SEED assessment system can be used to cope actively with the above concern. The G-SEED Certification Assessment BIM System (GCS) is a system that provides an environment in which information that can assess the criteria of G-SEED through Green BIM Template (GBT), including environmental quality level data, is extracted within the Autodesk Revit® environment automatically, and the final certification grade can be determined.

Therefore, this study will establish green building data through GBT so that designers can implement prompt and objective green building from the initial design phase, and propose a BIM system that can confirm the green building certification scores and grades in GCS based on the above.

2. Theoretical Discussions

The focus of green buildings is to minimise environmental loads in designing, constructing, and maintaining buildings, and to find ways to maximize social and economic benefits (Kim et al. 2008). There are various concepts of green buildings, but the common idea is that green buildings can only be achieved by understanding and approaching integrated building performance and environmental data. Buildings have different conditions, and thus there is a need for an adequate design technique in line with the balance of all kinds of environmental analysis data based on specialized understanding and knowledge of energy efficiency (Kim 2015).

2.1. KOREAN AND OVERSEAS GREEN BUILDING CERTIFICATION ASSESSMENT PROGRAMS

Table 1 shows the assessment programs developed in Korea and overseas as regard green building certification.

The GBT-based G-SEED assessment system in Korea performs assessment by linking BIM-based data to Microsoft Access and provides the results on Microsoft Excel; such system is inconvenient for users to establish and assess the BIM model compared with that in the United States and Japan. To contribute to the promotion of green building, it is necessary to provide an efficient assessment system for users, such as the BIM authoring tool add-in assessment system similar to the cases overseas.

Table 1. Assessment programs for green building certification in Korea and Overseas.

Division	VE-Toolkit for LEED	Revit Extension for CASBEE	GBT based G-SEED Evaluation System
National	Unite State	Japan	Korea
Organization	USGBC	JSBC	Hanyang Univ.
Years	2009	2010	2014
Feature	- Revit Add-In System (BIM Application) - 10 items among 72 items of evaluation system - Select building type and environmental element	- Revit Add-In System (BIM Application) - 12 items among 92 items of evaluation system - Use a separate evaluation tool	- BIM platform data evaluated in conjunction with Microsoft Access and Microsoft Excel provide results
Image			

2.2. ANALYSIS OF G-SEED'S ASSESSMENT ITEMS

This study applied apartment buildings, which are general buildings and have received the most assessment since the implementation of the green building certification system, as the assessment standard. This study analysed the BIM-based assessment possibility of 41 assessment items, excluding those in remodelling and dwelling performance, out of total 54 items of the G-SEED apartment assessment certification criteria announced in June 2013.

The analysis results showed that there were 17 out of 41 items that can be built with BIM data among design data necessary in the G-SEED assessment items. As shown in table 2, 11 of 17 items that are assessed automatically using BIM data are built with the BIM system. Items, such as 7.3.1 light-weight impact sound insulation and 7.3.2 heavy-weight impact sound insulation, require users to enter the value of floor impact sound pressure level, and thus are excluded from the automatic input method (Kim 2014).

Table 2. Information classification system for G-SEED items.

Assessment List	Classification	Information	Using
1.1.1 Ecological value	shape	area	part
1.2.1 Daylight interference prevention plan	shape	distance	part
1.3.1 Community center and facility plan	shape	area	whole
3.1.1 Floor plan for life-style change	shape	length	whole
3.2.1 Living furniture use prevention plan	shape	area	whole
3.3.1 Separate collection of recyclable material	attribute	separate collection container	whole
3.4.1 Certified green product use for valid resource recycling	attribute	eco-friendly certified product	whole
3.4.2 Carbon emission footprint of material	attribute	material's carbon emission quantity	whole
4.1.1 Rainwater load reduction plan	shape	area	part
4.2.2 Rainwater use	shape	area	part
6.1.1 Connected green axis plan	shape	area	part
6.1.2 Natural soil green area rate	shape	area	whole
6.2.1 Ecological area rate	shape	area	part
7.1.2 Natural ventilation plan	shape	area	whole
7.3.1 Light floor impact sound prevention	attribute	Light weight sound	whole
7.3.2 Heavy floor impact sound prevention	attribute	weight sound	whole
7.3.3 Noise protection between units	shape, attribute	wall thickness	whole

Thus, 9 of total 41 items, composing of 22%, can be assessed with the BIM-based automatic input method. Thirty-two items, excluding nine items of the BIM-based automatic input method, require users to enter the scores manually based on direct assessment criteria.

2.3. BIM-BASED DATA BUILDING METHOD

The BIM model is a 3D modelling technique and a design tool with object information. Thus, it is necessary to build a library that includes an object information. To assess the items of G-SEED, this study established a library of the key elements of a building, such as walls, floors, and windows that include relevant information, as shown in table 3, and conducted BIM modelling using the library to extract the data of the BIM model (Hong and Lee 2013).

To extract information from the BIM model, a list (txt), which is a data extraction method for BIM authoring tool, was used. As shown in table 3, the list is a table of data extracted from the elements of the building modelled with the BIM authoring tool. The data that changed in the process of revising the modelling are updated on the list automatically; this process bears the benefit of being able to extract data by reflecting the changes (Kim 2015).

3. Building Process of G-SEED Certification Assessment BIM System

As regards green building, the government is mandatorily implementing and expanding policies while also promoting adoption of BIM to support them; however, there is still not enough practical and specific system to make assessments. Evaluating and simulating environmental performance requires input of environmental data on building information as well as detailed additional tasks of modelling data. However, there is no system to guide users through the process.

Table 3. BIM based database (library, schedule).

Library Type	Library Attribute		
	ID data	measurement	materials
wall	· annotation · mark · pure resource code	· thickness	· material
		· area · width · volume	
	text	etc	
	· main material	· eco-friendly certified · carbon emission quantity	
	structure		
	· structure · structural use		
	ID data	measurement	materials
floor	· annotation · mark · pure resource code	· thickness	· material
		· area · slope · volume	
	text	etc	
	· main material	· eco-friendly certified · carbon emission quantity	
	structure		
	· structure		
	composition	measurement	materials
door	· shape · function · wall finish · construction type	· thickness · height · frame thickness	· frame materials · glass materials · door materials
	text	etc	
	· main materials · pure resource code	· eco-friendly certified · carbon emission quantity	
	composition	measurement	materials
window	· shape · function · wall finish · construction type	· thickness · height · frame thickness	· frame materials · glass materials · door materials
		· area · width · height	
	text	etc	
	· main materials · pure resource code	· eco-friendly certified · carbon emission quantity	

Schedule	(unit : ㎡)

<GBS_3.2.1 Validity of plan for inhibiting use of household furniture - room>	
A	**B**
kind of room	area
balcony	33
bathroom	27
dress room	12
entrance	16
kitchen	56
living room	121
room	150
room,closet	6

In this perspective, this study suggests that G-SEED certification assessment BIM system could serve as a system that can guide modelling using the BIM-based template GBT and manage the scores and grades constantly to obtain green building certification.

GBT is a method that interworks BIM data with G-SEED detailed items, and provides an environment to judge the environmental performance objectively. This increases convenience in building data according to the purposes of users by guiding the modelling, and also enables efficient data management.

GCS, which implements G-SEED certification assessment in the same environment based on the modelling that used GBT, is an environment that can show the results of the output data for the input data. By using this system, users will receive results according to the G-SEED certification items. This performs the role of helping users understand and implement integrated environmental data on green building.

3.1. G-SEED CERTIFICATION ASSESSMENT BIM SYSTEM SCENARIO

The G-SEED Certification Assessment BIM System using GBT consists of the data phase and BIM modelling phase of GBT(i), and BIM add-in implementation, evaluation and result phase of GBT(o), as shown in figure 1 (Jun et al. 2015).
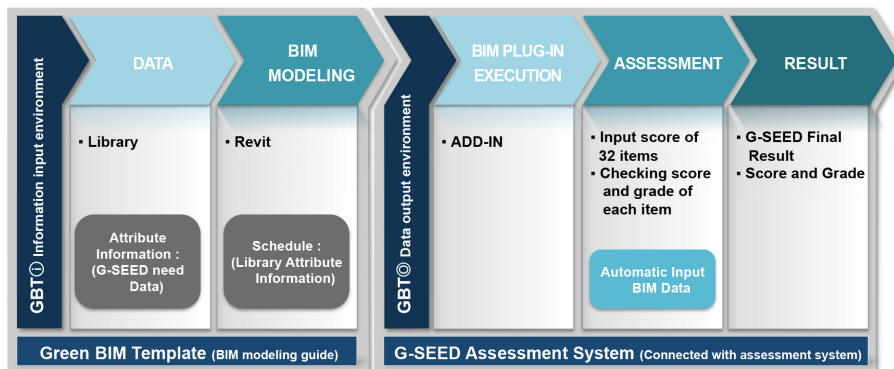

Figure 1. Scenario of GCS.

In the data phase, attribute data is set in the library provided for users to extract necessary data for evaluation, as the G-SEED evaluation criteria. In the BIM modelling phase, modelling is performed with the library, including attribute data, whereas modelling data, according to the attribute data on the list established to enable automatic input of data for evaluation, are extracted in the GBT(o) environment. The BIM add-in implementation, evaluation, and result phases conduct evaluation with the BIM authoring tool add-in system and provide the final results to users.

3.2. BIM ADD-IN DEVELOPMENTMENT PROCESS

This system was built in the form of Revit 2015 add-in using SDK basically provided by the BIM authoring tool Revit with the C# development language in Visual Studio 2015 developed by Microsoft.

The development process in figure 2 shows that Revit SDK is used in the C# project to create the C# source file, with reference to the DB according to UI and attribute data, thus coming up with nine items of automatic input and codes for the manual input and final results. The DB of the BIM authoring tool is DB of the BIM model according to the attribute data necessary for evaluating each item, and the logic according to the evaluation criteria for each item is coded, providing

the final results of total scores and grades for users through automatic input of nine items and manual input of 32 items. The proposed BIM add-in is an add-in system designed by users based on BIM and that can be applied immediately, thereby customized for users to perform G-SEED evaluation in a BIM authoring tool environment.
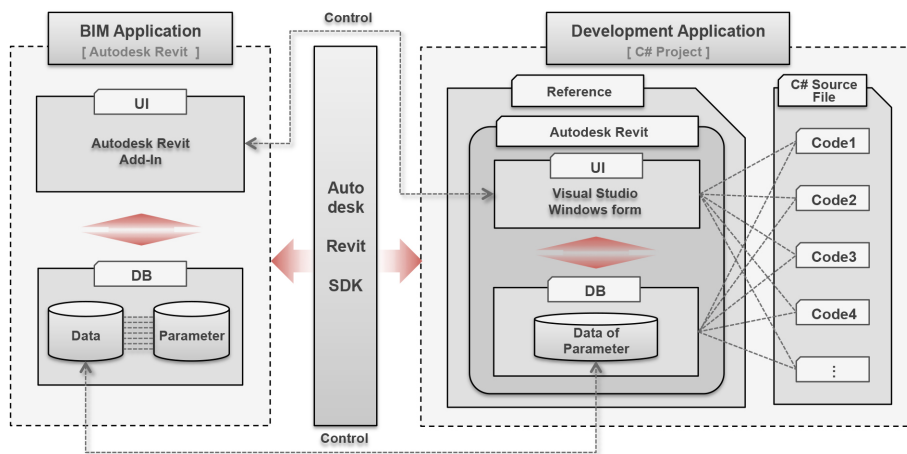

Figure 2. Development process of GCS .

4. G-SEED Certification Assessment BIM System Using GBT

This system must standardise the BIM library and information types and provide a consistent work environment for users to review the assessment result values and various alternatives quickly.

GBT is a green building information modelling template to obtain suitable outputs by building an environment that is linked to green building criteria automatically using BIM data.

4.1. FORMING GBT THAT IS A BIM-BASED TEMPLATE

figure 3 shows the structure of GBT and application of GBT(i) and GBT(o) to the BIM authoring tool. Users are provided with an installation file to run GBT.rte and GBT(o), which are template files of the BIM authoring tool in which GBT(i) is built. G-SEED assessment is carried out by modelling the library built in the GBT template and running GBT(o).

For automatic assessment in the GBT(o) environment, it is necessary to extract attribute data of the BIM model according to the assessment criteria. To assess nine items, mediating variables are set up to extract attribute data according to the assessment criteria in the nine libraries, as shown in table 4. Then, 14 list sheets are set up for the attribute data according to the mediating variables to be entered on GBT(o) automatically in a prompt and consistent manner. Users enter basic information in BIM add-in and enter the scores of 32 out of 41 items according to

the assessment criteria of the G-SEED manual. The nine items are assessed based on the attribute data, which is extracted automatically from the BIM model, and the scores of the 32 and 9 items are collected to come up with the final results of total scores and grades.
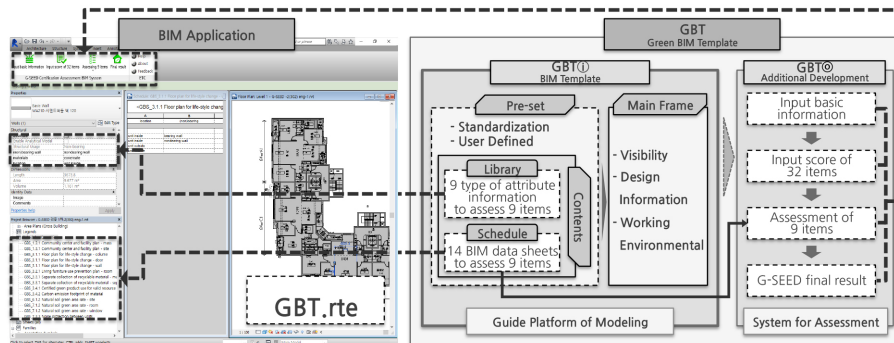

Figure 3. GBT structure and BIM authoring tool application.

4.2. BUILDING A LIBRARY FOR BIM-BASED CERTIFICATION ASSESSMENT

For BIM-based certification assessment, the library provided by the BIM authoring tool was used, and special facilities were added. An analysis of about 100 libraries built in the BIM authoring tool shows that the libraries consist of objects in the building, such as walls, doors, windows, components, pillars, roofs, ceilings, curtain wall system, curtain grid, and mullions. The libraries necessary to assess the nine items include topography, mass, pillars, walls, floors, doors, windows, rooms, and special facilities, as shown in table 4. Items, such as 3.4.1 and 3.4.2, are assessment of products that obtained green building and carbon labelling certifications, and thus must be used after the users choose and copy them according to library type.

Moreover, to extract attribute data complying with the assessment criteria for each item from the library, it is necessary to set additional mediating variables including the basic ones, as shown in table 3. To set the mediating variables, those that can be shared in multiple projects and libraries are created in the BIM authoring tool, and those necessary for each library are added to the projects, as shown in table 4. Here, the data of mediating variables are set as instance as attribute data varies according to whether there is non-bearing or bearing walls and the position of interior and exterior even if the same type of library is used.

The library with the mediating variables set up is built on GBT(i), and thus users can use the library to perform modelling and extract attribute data according to the mediating variables on a list, and enter the data on GBT(o) automatically to perform G-SEED assessment.

Table 4. BIM library and parameter.

Automatic Input Assessment List	Library	Parameter
1.3.1 Community center and facility plan	**site, mass**	facility name, area
3.1.1 Floor plan for life-style change	**column, wall, floor, door**	location(inside/outside), bearing/non-bearing, length
3.2.1 Living furniture use prevention plan	column, wall, floor, room	kind of room, area
3.3.1 Separate collection of recyclable material	mass, **special facility**	facility name, area, number of separate collection container
3.4.1 Certified green product use for valid resource recycling	column, wall, floor, door, **window**, etc	product name, certification, location
3.4.2 Carbon emission footprint of material	column, wall, floor, door, window, etc	product name, certification
6.1.2 Natural soil green area rate	site	name, area
7.1.2 Natural ventilation plan	column, wall, floor, window, **room**	kind of room, area, inside/outside, open/ shut, width, height, open area
7.3.3 Noise protection between units	wall	partition wall, wall material, width

4.3. G-SEED CERTIFICATION ASSESSMENT BIM SYSTEM USING GBT

Add-in of the BIM authoring tool of GBT(o) can be used in the BIM authoring tool when running the system installation file of GCS Setup.exe. The add-in of the BIM authoring tool is shown in figure 4.
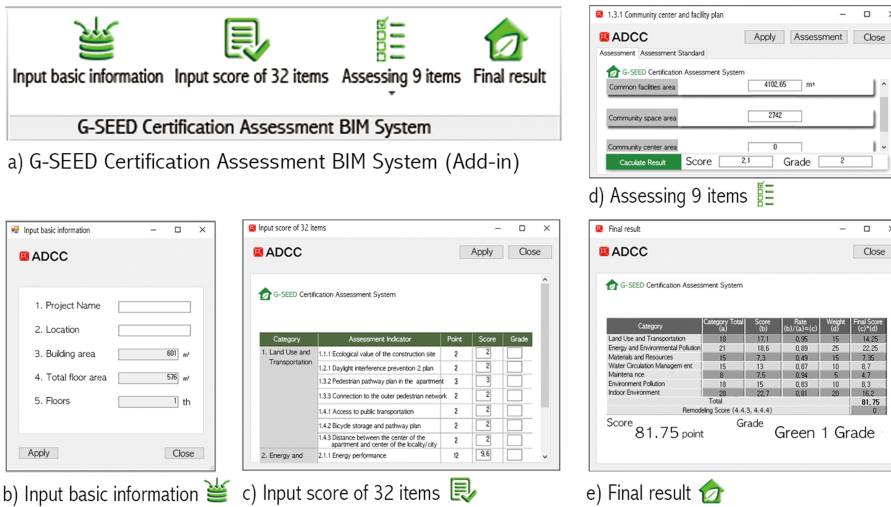

Figure 4. Interface of GCS.

5. Conclusion

The template for G-SEED certification assessment was established based on the results of this study, and the following conclusions can be drawn by proposing the BIM system.

First, there was a need for the library with necessary attribute data according

to the assessment criteria as well as the template that can extract attribute data promptly and consistently according to mediating variables for users to perform modelling for G-SEED assessment easily; the assessment was built with GBT.

Second, this study proposed the BIM authoring tool add-in system for users to perform assessment immediately after modelling in one BIM authoring tool and check the scores and grades promptly and objectively.

The limitations of this study are as follows. The developed BIM system can only assess in the unit of individual buildings. Thus, to assess multiple buildings within the complex, the final results could be drawn by calculating the assessment results of the buildings that exist in individual files manually.

Therefore, this study aims to provide users with a template that can assess multiple buildings in the complex in a single platform and support assessment items other than the nine items.

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