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Life Cycle Assessment Applied to Green Building Certification in South Korea

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Abstract

The purpose of this study is to apply life cycle assessment (LCA) methodology for green building certification in South Korea. The method of environmental assessment in the field of building materials was examined using United States' LEED, and the United Kingdom's BREEAM building certification systems. Life cycle data and assessment methods were established on major categories of materials thorough theoretical consideration on life cycle assessment.

Building materials, assembly methods, and building use considerations were used to develop an assessment model to evaluate the environmental performance of a building. Numeric values for use in the developed model were established for concrete, rebar, gypsum board, steel, cement brick, glass, and insulation materials to potentially reduce greenhouse gas (GHG) emissions by 95% or more. An assessment method and LCA database were established. The model will be used to show that the choice of building materials can affect the GHG emissions during the construction phase of a building.

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1. Introduction

As environmental issues have emerged as a global agenda, studies to reduce the burden on the environment have been actively made at the national level in South Korea. Also in the construction industry, the opinion that suggests quantitatively evaluating the environmental load coming from construction materials and buildings in advance by life cycle assessment method has been advanced. Therefore, each country is developing building life cycle assessment techniques that are tailored to the individual country situation and can evaluate the environmental impact of construction materials and buildings, and in recent years, a tendency to revise the certification criteria is seen to

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apply the LCA results to the green building certification system. However, in South Korea's green building certification system G-SEED, the eco-friendly evaluation of buildings based on life cycle assessment has not been applied, and the score has only been given by whether or not to use the product which acquired an environmental product declaration (EPD) in materials and recyclable content. Such evaluation methods have the limitation that it is difficult to determine quantitatively the effect that the selection of eco-friendly building materials brings to the environmental performance of buildings. Therefore, the approach where building materials, construction assemblies and environmental impact assessment results of buildings are organically linked to each other and evaluated in the certification system is required. Thus, this study has a goal of suggesting a LCA method for buildings in Korea's G-SEED through the integrated assessment model. For this, the building life cycle assessment methods and the certification standards which are being reflected in international green building certification systems (LEED, CASBEE, and BREEAM) were analyzed. Also an integrated assessment model that can be linked to a green building certification system in construction material level, construction assembly level and building level based on the analyzed evaluation method was established, and the evaluation method and database which are required in each level have been established.

2. Analysis of Environment Assessment Method for Green Building Certification System

Recently, when it comes to the international green building certification systems, the LCA certification standard of buildings has been introduced and revised to reduce the environmental burden of buildings in the country. Therefore, representative international green building certification systems were analyzed as shown in Table 1 for the introduction of LCA in the construction sector of G-SEED. Major Green building certification systems are the LEED of US, the BREEAM of UK and the CASBEE of Japan. In LEED V4 which was recently revised, an assessment of the life cycle can be done by choosing one of Materials and Resources category Building Life-Cycle Impact items. The assessment method is to evaluate three certification systems including a global warming aspect using a LCA tool which gives a score based upon a reduction of more than 10% compared to the standard building. Also, the item gives an assumed improved score when using the EPD material. In BREEAM, the evaluation of building materials is being applied in detail since the initial version and the environmental performance assessment and information on building materials has been shared using its town building material information site called Green Guide. Also, the LCA programs such as ENVEST 2 and IMPACT have been used. By linking the evaluation results with the BREEAM, the environmental performance evaluation results of buildings have been reflected in the green building certification system. The CASBEE in Japan is a comprehensive performance assessment tool of buildings for the realization of the

Table 1. Overview of domestic and international green building certification system LCA.

Item	US LEEDV4	JAPAN CASBEE	UK BREEAM2014	KOREA G-SEED
Evaluation Item	MRc1. Building life-cycle impact reduction	Resources and Materials	Mat 01 Life Cycle Impacts	-
Scope of Evaluation	Cradle to Grave with Options	Cradle to Gate	Cradle to Grave with Options	-
Scoring	Up to 3 points	BEE	Up to 6 points	-
LCI DB	Ecoinvent	In-house DB	DB by individual company UK Trade associations Ecoinvent	-
Building Material Evaluation	EPD	ECO MARK, Eco friendly Products	Green Guide, EPD	EDP, GR Mark, Carbon Labeling, etc.
Evaluation Program	any LCA program	In-house Spread sheet	Mat Calculator or any LCA program	-
Standard Building	Set	Set	Set	-
Impact Category	GWP,ODP,AP,EP,	$LCCO_2$	11 kinds including GWP	-

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building that has a small environmental load during the entire life cycle and assesses the environmental performance of buildings by using the score of the environmental quality and performance and the environmental load of buildings. CASEBEE is a type where the user inputs directly without using an external program and has conducted a quantitative assessment on $LCCO_2$ by comparing and with the standard building through the CO_2 database and calculation method of the CASBEE itself. According to the analyzed life cycle assessment method above in international green building certification systems, the eco-friendly evaluation of building materials and buildings are based on different evaluation systems and standards. Thus, it is a situation that the environmental load evaluation results are not organically linked to each other.

3. Life Cycle Assessment Applied to G-SEED

In this study, an integrated assessment model was proposed for the LCD introduction in G-SEED of Korea. The integrated assessment model means the evaluation system where environmental performances of buildings are organically linked as the environmental performance of building materials is reflected through the construction assembly level evaluation and is evaluated in the certification system. Accordingly, the evaluation method and database that are required in each level were established by categorizing construction or building material level, building assembly level, building level and certification system. For example, see Fig. 1.The eco-friendly evaluation scope of buildings can be largely divided into the environmental effect due to the energy source which is used during the life cycle of the building and the inherent environmental effect due to building materials. At this point, mainly to consider the environmental impact of buildings according to the user's building material choice, only the inherent environmental effect was set in the scope of the integrated assessment model. It is possible to efficiently select building materials through introducing the building assembly level assessment of the integrated assessment model, and it can be evaluated by reflecting the environmental characteristics of building materials instantly. It is possible to obtain the target certification rating and to apply in the design phase through the feedback of the assembly level.

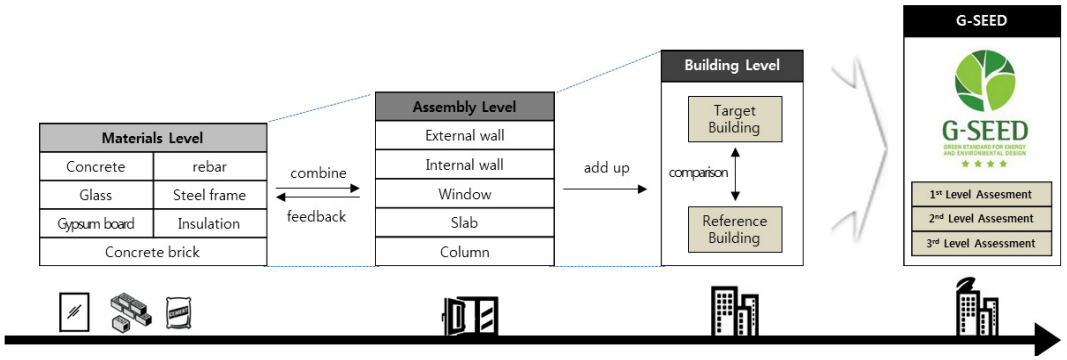

Fig. 1. Integrated Assessment Model for G-SEED

3.1. Building material level

In case that all the building materials used in construction need to be evaluated with existing evaluation methods, information for each step of the building life cycle should be established and the consumption of time, cost and resources is involved. Thus, the main building materials such as concrete, iron, steel, glass, insulation, drywall, and concrete products which can be evaluated on the environmental impact of a building, more than 95% by the exclusion criteria rule of the ISO 14040 were selected and evaluated. Also, when entering the building scenario of each life cycle step such as fuel efficiency, lifetime, and transportation distance, which can be assessed based upon

the environmental impacts of six major building materials which are global warming (GWP), resource depletion (ADP), eutrophication (EP), acidification (AP) and ozone layer depletion (ODP).

3.2. Building assembly level

The building assembly level evaluation is possible by combining environmental characteristics through the built database of building materials. That is, when applying other types of building materials even with the same assembly, it is expected that the evaluation results would be different depending on the assembly due to differences in the environmental characteristics of the material. In Korea, there is no case where the building assembly level is specified. Therefore, the assemblies which are suitable for a building type in Korea were classified into exterior walls, interior wall, slab, windows, pillars, etc. through studies and analysis of international cases. It is possible that the designer can efficiently evaluate the environmental impact at the assembly level and control it to obtain the certification score with the selection of building materials through the assembly level assessment feedback.

3.3. Building level

In the building level evaluation, the building can be quantitatively evaluated by summing the evaluation results of the assemblies which were combined into the major building materials. Therefore, the eco-friendly evaluation of buildings is implemented with the building assembly information which uses eco-friendly building material information which is linked depending on the integrated assessment model method. In this point, the eco-friendly evaluation of buildings can be compared and analyzed quantitatively for the level of the evaluation results by setting the standard building. The standard building is the result of the environmental impact assessment result of the same application and structure type and the same region where the national database in Korea is used.

3.4. Evaluation in certification system

Currently the G-SEED is being evaluated on whether or not the building material which acquired EDP, carbon footprint label, etc. is used, or it has been reflected in the certification system focusing on assessment items related to the energy consumption in the operation phases. It was analyzed assuming that the quantitative building assessment reflecting the environmentally friendly characteristics of building materials is insufficient. The step by step linkage plan which complies with the situation in Korea is needed to link the integrated assessment model to the G-SEED. The evaluation items for eco-friendly evaluation level were divided into scope of the evaluation, evaluation target, assessment tool and the step-by-step linkage model going up to the third step where all ranges are evaluated from the first step and the level of eco-friendly evaluation assessment is reflected is proposed as shown in Table 2.

Table 2. Evaluation method for each step in G-SEED

Item	Step1	Step2	Step3
Evaluation target	GWP	6 Environmental Impacts	6 Environmental Impacts
Scope of evaluation	Cradle to Gate	Cradle to Grave with Options	Cradle to Grave
Evaluation tool	Life Cycle Assessment Program (step 1)	Life Cycle Assessment Program (step 2)	Life Cycle Assessment Program (step 3)
Evaluation method	Simple grading	Detailed grading	Single indexation
Major material	3 kinds of major materials	7 kinds of major materials	7 kinds of major materials

DB	National LCI DB	Individual LCI DB National LCI DB	Individual LCI DB National LCI DB

The step-by-step linkage model to step 3 above where the level of assessment is reflected is proposed as shown in Table 2. Step 1 will be applied to the G-SEED 2015 amendment. Step 1 evaluates top three major building materials for the global warming in the material production phase. Also, it is graded by comparing with the value of the standard building. The second step is to evaluate the six environmental impacts for the entire process except for the operation step for seven major building materials. Step 2is rated according to the reduction ratio compared to the standard value by evaluating with the assembly level. Therefore, the designer can find the suitable scheme for the certification system with the assembly level assessment result without changing the building materials. Step 3 is targeting for the entire environmental impact assessment including six environmental impact assessments and takes the entire process including the use phase as the application scope. It evaluates the overall environmental friendliness of buildings by integrating the assembly level evaluations of buildings and the evaluation results are displayed in the unified index. The unified index is the weighted value considering the regional characteristics for the situation in Korea. Therefore, it's expected that it is possible to do a comparative evaluation of the environmental friendliness simply with the unified index. Also, it's a trend where the CAD support program based with 2D information has changed to the 3D BIM program including various information of the building. Therefore, it is possible to enable the BIM information to be linked using the life cycle assessment program (step 3). When using the BIM program, it's considered that the eco-friendly evaluation of buildings is possible just with the BIM modeling without the need to input or output the additionally required information for the life cycle assessment.

4. Conclusions

This study has the purpose of proposing the LCA method of assessing buildings in Korea's G-SEED certification system through the integrated assessment model, and the results follow. The integrated assessment model was proposed where it is possible to link each other by distinguishing the eco-friendly evaluation of buildings into building material level, building assembly level, building level and certification system.. The eco-friendly building evaluation method of the G-SEED for each step which is suitable for the situation of Korea and is easy to apply was proposed through the integrated assessment model. The evaluation method and database for each level were built and the target grade can be efficiently obtained for each step by letting the users apply the eco-friendly building materials which are suitable for the assembly. LCA items for each step as above can be applied to the material and resource items in G-SEED, and the database establishment is required to build the database and set up reference values on a variety of building materials for the future LCA.

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References

[1] S.J. Roh, S.H. Tae and S.W. Shin, Development of Building Materials Embodied Greenhouse Gases Assessment Criteria and System (BEGAS) in the Newly Revised Korea Green Building Certification System (G-SEED), Renewable and Sustainable Energy Reviews. 35 (2013) 410-421.

[2] S.J. Roh, S.H. Tae, T.H. Kim and R.H. Kim, A Study on the Comparison of Characterization of Environmental Impact of Major Building Material for Building Life Cycle Assessment. Journal of Architectural Institute of Korea (2013) 93-100.