The Development of Building materials Embodied Greenhouse gases Assessment System (SUSB-BEGAS) for Supporting the Green Building Certification System (G-SEED) in Korea

Sungwoo Shin
School of Architecture & Architectural Eng. Hanyang University, Ansan, Republic of Korea
swshin@hanyang.ac.kr

Seungjun Roh
Department of Sustainable Architectural Eng. Hanyang University, Seoul, Republic of Korea
sjroh@outlook.com

Sungho Tae
School of Architecture & Architectural Eng. Hanyang University, Ansan, Republic of Korea
jnb55@hanyang.ac.kr

ABSTRACT: This study aims to develop Building materials Embodied Greenhouse gases Assessment System (SUSB-BEGAS) for supporting green building certification system (G-SEED) in Korea. For this purpose, main building materials which met the cut-off level of ISO 14040 were drew based on the bill of quantities and selected the targets of evaluation for this study by reflecting the opinions of technical committee of green building certification standard. In addition, the Korea National LCI DB, LCI DB of Korea Ministry of Land, Infrastructure and Transport, and carbon footprint labelling certificate of Korea Environmental Industry & Technology Institute were adopted as the database of this study for reflecting the social features of Korea. As a result, Building materials Embodied Greenhouse gases Assessment System (SUSB-BEGAS) at the web environment applicable have been developed at the green building certification system (G-SEED).

1 INSTRUCTION

As the global environment problem attributable to greenhouse gas has emerged as the main issue of the international society, efforts to reduce greenhouse gas have been accelerated on the construction industry, the main industry generating greenhouse gas. As a part of this, environmentally advanced countries such as USA, UK and Japan have competitively created and complemented the items of evaluating the greenhouse gas emission throughout the life cycle of the building within the environment friendly building certification system (Finnveden et al. 2009, Li.2006).

In this regard, Korea has gradually expanded and executed the building energy consumption total emission system, building greenhouse gas and energy goal management system according to international agenda. However, this is the greenhouse reduction policy focusing on the energy consumed in the operation process of building and has a limit that it fails to reflect the greenhouse gas emission of building materials which takes about 32% of life cycle greenhouse gas emission of building (Ko et al. 2007, Lee. 2010, Roh & Tae. 2011). There is a drive in green building certification system(Green Standard for Energy and Environmental Design, hereinafter G-SEED) to create items of greenhouse emission evaluation for the building materials in order to consider environmental loads of various cycles(material production, construction, operation, maintenance, dismantle disposal) that building embodies. However, there are no sufficient technology to evaluate the greenhouse gas emission of building materials and studies that can connect this to G-SEED (Tae & Shin. 2009).

This study aims to develop Building materials Embodied Greenhouse gases Assessment System (hereinafter SUSB-BEGAS) for supporting G-SEED in Korea.

For this purpose, the environment-friendly building certification system mainly used at global were analyzed to explore items of greenhouse gas emission evaluation of building materials. In addition, by drawing the main building materials focusing on the greenhouse gas emission that meets the cut-off level of ISO 14040 based on the bills of quantities of actual apartment houses

and office building and reflecting the opinions of technical committee of green building certification standard, we selected the targets of evaluation for this study. In addition, the Korea National LCI DB, national DB of building material environmental feature information, and carbon-footprint labelling certificate of Korea Environmental Industry & Technology Institutewere adopted as the database of this study for reflecting the social features of Korea. Based on the database constructed as above, web-based SUSB-BEGAS have been developedat the G-SEED.

2 CONSIDERATION OF BUILDING MATERIAL GREENHOUSE GAS ASSESSMENT

2.1 *Overview*

With the most commonly used environment-friendly building certification systems at home and abroad such as LEED (USA), BREEAM (UK), CASBEE (Japan) and Korean G-SEED (before amendment), items of greenhouse gas evaluation of building materials applicable at each system were compared and analyzed as shown in the Table 1.

2.2 *LEED v4-draft*

Among the evaluation items of USA LEED, evaluation items of life cycle greenhouse gas emission of building material was included in Materials and Resources. As it was newly created (LEED v4-draft, 2012) as the No. 1 evaluation item (M.R. Credit 1. Building Life-Cycle Impact Reduction) in the material and resource part with the type of extra point (LEED v3, 2009) from existing innovation design item, it was analyzed to add weight to the influence of greenhouse gas emission evaluation of the building materials in the certification system. It could be evaluated through 'Option 4. Whole-Building Life-Cycle Assessment' of M.R. Credit 1, and found out that up to 3 point score would be given for the environmental load reduction over 10 % compared to the standard building through life cycle evaluation program of building materials designated by LEED including Athena Eco Calculator for Assemblies, BEES.

Table 1. Comparison and analysis of environment-friendly building certification system

Classification	LEED v4-draft	BREEAM 2009	CASBEE 2010	G-SEED (before amendment)
Country	USA	UK	Japan	Korea
Announcement	2012	2011	2010	2011
Target	New buildings	New buildings	New buildings	All buildings
By	USGBC	BRE	Japanese Ministry of Land, Infrastructure, Transport and Tourism	Korea Ministry of Environment& Korea Ministry of Land, Infrastructure and Transport
Evaluation item classification system	Sector(7) Evaluation item(56)	Sector(10) Evaluation item(50)	Sector(2) Evaluation item(55)	Sector(9) Evaluation item(52)
Building materialLCA evaluation item	Materials and Resources	Materials	Resources and Materials	-
Environment impact evaluation item	GWP, ODP, AP, EP, POCP, ERS	7 in addition to AD, OD, HTox Water, HTox Air, POCP, Ecotox	$LCCO_2$	-
Building materialLCA evaluation method	LEED LCA Credit Calculator evaluation based on EcoCalculator	Green guide to specification evaluation based on green guide	Self-evaluation through spread sheet(Excel)	-
Building material LCA score	Up to 3 points	Up to 5 points	BEE index	-

2.3 *BREEAM*

In UK BREEAM, the greenhouse gas emission evaluation items of building materials corresponds to Materials Part and the life cycle evaluation of building is conducted through 'Mat.1 : Life Cycle Impacts (Major Building Elements)' certification items. Evaluation targets are the main members of building types and separated into method of applying green guide database, constructed at BRE, and that of utilizing the life cycle assessment program designated at BRE. Green guide database evaluation method was analyzed to give up to 5 points after carrying out rating through summary rating per 290 major building elements. On the other hand, the evaluation method of utilizing life cycle assessment program was analyzed to give up to 5 points if presenting to the examiner the documentary evidence proving confirmation of environmental load reduction of materials compared to standard building and using Envest2, Eco-Quantum.

2.4 *CASBEE*

Japan CASBEE is the evaluation system that introduces the index concept by separating the building environment efficiency (BEE). It is separated into the numerator of BEE, Q (Quality : building quality performance) and denominator L(Loadings : external environmental load of building). Greenhouse gas emission of building materials is evaluated at L2(resource and material) and life cycle CO_2 emission of building is evaluated through 'L2.2.2 Continuing Use of Existing Structural Frame etc'. Materials for evaluation are 5 main materials including concrete, blast furnace cement concrete, steel frame, rebar and woods. It was analyzed to evaluate the life cycle CO emission of the building through spread sheet (Excel) provided and material input quantity per unit area, CO_2 database.

2.5 *G-SEED (Before Amendment)*

Korean G-SEED (before amendment) is classified into 9 categories such as land use, transportation, energy, material, resource, water resource, prevention of environmental pollution, maintenance, ecosystem and interior environment according to feature of building. Total points are calculated with weighted value and achievement rate for each item of 50 items, but the evaluation items of greenhouse gas emission of building materials was not created.

3 SELECTION OF EVALUATION TARGETS OF SUSB-BEGAS

3.1 *Overview*

To deduce main building materials emitting greenhouse gas to be applied for target of evaluation at SUSB-BEGAS, the bills of quantities of many apartment houses and office buildings constructed in Korea were analyzed, and the main building materials of greenhouse gas emission were deduced according to cut-off level specified in ISO 14040. In addition, by reflecting the opinions of technical committee of green building certification standard, a total of 4 elevation targets were selected including ready-mixed concrete, rebar, steel frame and cement.

3.2 *Deduction of Main building materials*

To deduce the main building materials emitting greenhouse gas among the building materials used for building, we evaluated the greenhouse gas emission of building materials used for construction works based on the bills of quantities of many apartment buildings and office buildings, and identified the building materials with over 95% accumulated greenhouse gas emission according to the cut-off level of ISO 14040(Lee et al. 2009, Shin et al 2011). At this time, top 6 greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) including CO_2 emission were set as the gases for evaluation and converted to carbon dioxide equivalent (CO_{2eq}) by reflecting Global Warming Potential (GWP) of IPCC. As a result, 7 building materials such as ready-mixed concrete, rebar, steel frame, paint, glass, concrete product and insulators were found to take over 95% of greenhouse gas emission in the apartment houses and office buildings. In this regard, this study deduced above 7 building materials and a total of 7 main building materials including

cement which had relatively high basic unit of greenhouse gas emission, and in case of RC structure, 6 building materials except steel frame were selected as the main greenhouse gas emission materials.

3.3 *Selection of building materials for Evaluation*

To review suitability and to determine applicability of main 7 building materials emitting greenhouse gas including ready-mixed concrete, rebar, steel frame, paint, glass, concrete products and insulation materials deduced above, we have reviewed and consulted with the material and resource subcommittee of technical committee of green building certification standard. In addition, as shown in table 2 above, in consideration of the efficiency and reality of building drawings calculated according to evaluation period of G-SEED per project stage (project approval stage: preliminary certification, completion stage: certification), this study restricted the target building materials for evaluation into 4 types such as ready-mixed concrete, rebar, steel frame (only if SRC structure or S structure), and cement (Nam et al. 2011).

Table 2. Evaluation period of G-SEED per project stage

Construction Process	Basic Design	Deliberation	Project Approval	Detailed Drawing	Starting and Construction	Completion
G-SEED Certification Period	-	-	Preliminary certification	-	-	Certification
Drawings	Layout, Plane	-	Construction drawing	Bills of quantities	Work log	Details of completion

4 DEVELOPMENT OF SUSB-BEGAS

4.1 *Overview*

This study developed web-based SUSB-BEGAS reflecting the G-SEED based on the database and evaluation technique established above.

4.2 *Targets and Scope of Evaluation*

Evaluation targets of SUSB-BEGAS are set to 4 types of building materials (read-mix concrete, cement, bar steel, sectional steel for reinforced concrete) which could be easily applied at the evaluation stages (preliminary certification, certification) of Korean G-SEED. Evaluation scope of greenhouse gas was set to 6 types of greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) emission set at IPCC, and expressed as carbon dioxide equivalent (CO_{2eq}) in consideration of GWP for each gas.

4.3 *Basic Unit Database of Greenhouse Gas Emission*

Main database of SUSB-BEGAS were Korea national LCI DB, constructed by the Korea Ministry of Knowledge and Economy, and Korea Ministry of Environment in reflection of the environmental features of Korea, national DB on environmental information of building materials constructed by Ministry of Land, Infrastructure and Transport in greenhouse gas basic unit of general building materials. On the other hand, in case of G-SEED certification, when the information on building material used to the building is disclosed, if carbon footprint labelling product by Korea Environmental Industry & Technology Institute was actually used in the building, it was constructed to apply greenhouse gas won unit of the carbon footprint labelling. Table 3 shows the LCI Database of ready-mixed concrete, rebar, sectional bar and cement.

Table 3. Status of LCI database application per building materials

Classification	Name	Basic unit	Unit	DB source	Remarks
Ready-mixed concrete	Ready-mixed concrete	346.000	kg-CO_{2eq}/m^3	Korea National LCI DB	Applicable for certification
	Ready-mixed concrete [Spec.:25-24-150]	835.000	kg-CO_{2eq}/m^3	Carbon footprint labelling	
	Ready-mixed concrete [Spec.:25-21-150]	201.000	kg-CO_{2eq}/m^3	Carbon footprint labelling	
	Pre-cast concrete [MPS build-up girder]	189.000	kg-CO_{2eq}/m^3	Carbonfootprint labelling	
Rebar	Steel making at electric furnace -Rebar	0.760	kg-CO_{2eq}/kg	Korea National LCI DB	
Sectional steel	H sectional steel	0.397	kg-CO_{2eq}/kg	LCI DB of Korea MLIT	
Cement	Cement	0.944	kg-CO_{2eq}/kg	Korea National LCI DB	

4.4 *Configuration of SUSB-BEGAS*

The main function of SUSB-BEGAS developed at this study is the evaluation of greenhouse gas, and was made up of 2 simple screens of information input and evaluation results for easy evaluation of greenhouse gas emission of building materials. It can be evaluated by separating into preliminary certification and certification according to the progress of G-SEED. Figure 1 shows the configuration of SUSB-BEGAS developed by this study.

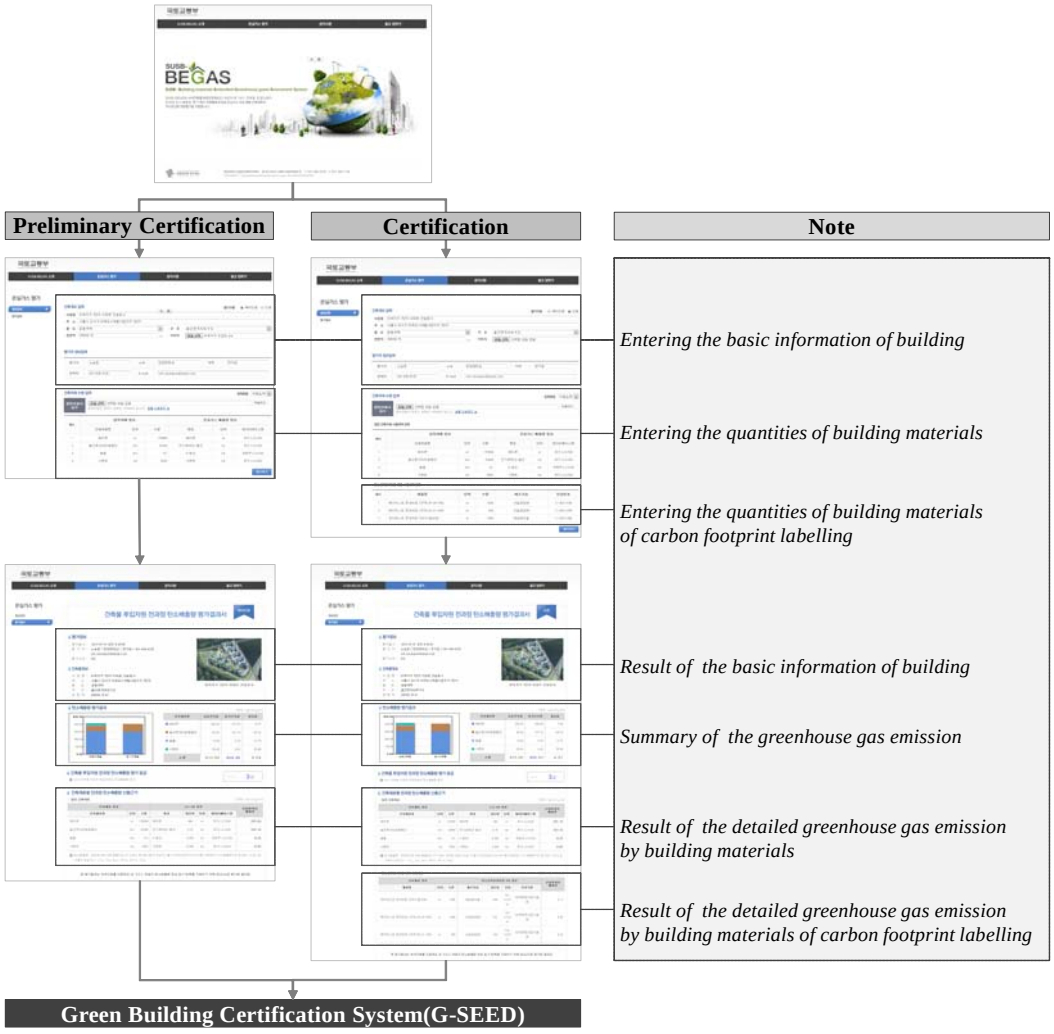

Figure 1. SUSB-BEGAS configuration

Preliminary certification is moved to the evaluation results by entering the basic information of building and quantities of building materials and through the evaluation button. Evaluation results of preliminary certification consist of basic information of building (evaluation information, building information), evaluation results of greenhouse gas emission, life cycle greenhouse gas emission evaluation rating, and grounds for calculation of life cycle greenhouse gas emission for each material. It can be printed or downloaded as Excel and evaluated as the evaluation results of life cycle greenhouse emission of building.

Certification is conducted in the same form as preliminary certification, and can be entered and applied for the building materials acquiring carbon footprint labelling carried out by Korea Environmental Industry & Technology Institute along with application for general building materials. Evaluation result is structured same as the preliminary certification, but the acquisition of carbon footprint labelling and evaluation results of building materials are additionally displayed on the bottom part so that it can be printed or downloaded as Excel, used as the life cycle greenhouse gas emission evaluation results of the building materials.

5 CONCLUSION

This study aims to develop SUSB-BEGAS for supporting G-SEED and obtained the following conclusions.

1. Compared and analyzed the greenhouse gas evaluation items of building materials applied in each environment-friendly certification systems on the main environment-friendly certification system of LEED, BREEAM, CASBEE and Korean G-SEED (before amendment).
2. Analyzed the bills of quantities of building, deduced the main building materials emitting the greenhouse gas, and selected the evaluation targets of ready-mixed concrete, rebar, steel frame and cement by reflecting the opinions of technical committee of green building certification standard.
3. Developed the web-based SUSB-BEGAS which could be easily reflected in G-SEED with 4 building materials shown above.

6 ACKNOWLEDGEMENT

This research was supported by a grant (13CHUD-C060439-03-000000) from High-tech urban development projects Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

REFERENCES

Finnveden, G.& Hauschild, M.Z. et al. 2009. Recent developments in life cycle assessment. *Journal of environmental management* 91(1): 1-21.

Ko, J.K.& Park, N.B. et al. 2007. *A Study on Greenhouse Gas Emission Characteristics of Local Governments in Gyeonggi-Do*. Suwon: Gyeonggi Research Institute.

Lee, K.H. & Tae, S.H. et al. 2009. Development of a life cycle assessment program for building (SUSB-LCA) in South Korea.*Renewable& Sustainable Energy Reviews* 13(6):1994-2002.

Lee, S.E. 2010. Technology and policy goals for zero energy buildings. *Architectural Institute of Korea* Special issue:52-8.

Li, Z. 2006, A new life cycle impact assessment approach for building,*Building and Environment*41(3): 1414-1422.

Nam, H.J., Moon, J.H. et al. 2011. An analysis of environmental factors and efficiency in the apartment housing project. *Architectural Institute of Korea*27(11):203-210.

Roh, S.J. & Tae, S.H. 2011. A Study on the development of building construction field CO_2 emission amounts evaluation management system. *SB11 Helsinki conference 1*:504-505.

Shin, S.W. & Tae, S.H. et al. 2011. The development of environmental load evaluation system of a standard Korean apartment house. *Renewable & Sustainable Energy Reviews* 15(1):1239-1249.

Tae, S.H. & Shin, S.W. 2009. Current work and future trends for sustainable buildings in South Korea. *Renewable & Sustainable Energy Reviews* 13(3):1910-1921.