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Comparison of green building standards in the united states and china

Yi-Wei Ding[1], Sungho Tae[2*] and Seungjun Roh[3]
[1]Student, Department of Architectural Engineering, Hanyang University, Ansan City, South Korea
[2]Professor, Department of Architecture & Architectural Engineering, Hanyang University, Ansan City, South Korea
[3]Assistant Professor, School of Architecture, Kumoh National Institute of Technology, Gumi, South Korea

***Corresponding author:** jnb55@hanyang.ac.kr

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A B S T R A C T

With the development of green buildings in China, the LEED green building rating standards are becoming familiar to the public and industry. This work analyzes the interpretation of the LEED evaluation system as applied to China. It includes a comparative analysis of the LEED and green building evaluation standards in the 2014 version, and analyzes the limitations in implementation in China. In reference to the successful experience of LEED, suggestions for improving Chinese green building evaluation standards are made.

Keywords: green building; LEED; evaluation standards; comparison; analysis

Introduction

The enormous pressures on energy, resources, and the environment have made green buildings an important issue of international concern [1]. In 2014, China's total building energy consumption was 814 million ton of standard coal equivalent(TCE), accounting for 19.12% of the country's total energy consumption [2]. In 2001, China began to conduct exploratory research into the application of green building standards [3]. Particularly during the 11th Five-Year Plan period [4], the development of green building technology and standards has resulted in positive progress in policy and standard construction systems, technology research and development, demonstration, and promotion. Under this background, various evaluation systems of green buildings have emerged. After more than 13 years of exploration, China's green building evaluation system has been improved many times and is now relatively complete: *Assessment Standards for Green Buildings* (ASGB) GB/T50378-2014 [5].

This paper provides a detailed analysis of four components: evaluation object, index weight, evaluation methods, and certification status of the latest version of the green building evaluation system in China and LEED in the United States. It explains theirl characteristics and puts forward constructive suggestions for improvement.

Theoretical Basis

Green building

A green building is one that saves resources (energy saving, land saving, water saving, and materials saving) as much as possible, protects the environment and reduces pollution, provides people with healthy, applicable and efficient use of space, and coexists with nature as harmoniously as possible.

Green Building Evaluation System

The green building evaluation system is a set of index systems applied to the Life-cycle assessment [6] of green buildings to evaluate whether a building conforms to green standards. It also has a normative guiding role in the development of green buildings as well as their design and construction management.

Assessment Standards for Green Buildings, ASGB

Since 2001, China has started the exploration of green buildings on the basis of building energy conservation work and has drawn on the advanced experience of foreign countries. In April 2014, the Ministry of Housing and Urban-Rural Development (MHURD) issued ASGB, which is an evaluation standard for implementing national technical and economic policies, saving resources, protecting the environment, standardizing the evaluation of green buildings, and promoting sustainable development [7].

U.S. Leadership in Energy and Environmental Design, LEED

LEED is an evaluation standard developed by the United States Green Building Council (USGBC) for green buildings in the United States. It is the most widely used green building rating system in the world. Available for virtually all buildings, community, and home project types, LEED provides a framework to create healthy, highly efficient, and cost-saving green buildings. LEED certification is a globally recognized symbol of sustainability achievement.

Comparison between ASGB and LEED

Evaluation Object

Due to the late development of green buildings in China, there are only two items in the series for the green building evaluation system, as shown in Table 1.

Based on continuous improvement and development over the years, LEED has constructed a number of system for evaluating different building types and different uses. Each item in its series has a corresponding evaluation object as shown in Table 2.

Table 1. ASGB member system and building types

Evaluation system	Type of projects
Design Evaluation	Residential building and public building
Operation Evaluation	Residential building and public building

Table 2. LEED member system and building types

Evaluation System	Types of projects
LEED BDl+C Building Design and Construction	New construction or major renovations; includes New Construction, Core & Shell, Schools, Retail, Hospitality, Data Centers, Warehouses & Distribution Centers, and Healthcare.
LEED ID+C Interior Design and Construction	Complete interior fit-out projects; includes Commercial Interiors, Retail and Hospitality.
LEED O+M Building Operations and Maintenance	Existing Buildings, Schools, Retail, Hospitality, Data Centers and Warehouses & Distribution Centers.
LEED ND Neighborhood Development	New land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix.
Homes	Single family homes, low-rise multi-family (one to three stories) or mid-rise multi-family (four to six stories); includes Homes and Multifamily Lowrise and Multifamily Midrise.
LEED Zero	Available for all LEED projects certified under the BD+C or O+M rating systems, or registered to pursue LEED O+M certification. LEED Zero is for projects with net zero goals in carbon and/or resources.

When China uses ASGB to evaluate different buildings, it simply divides the evaluation objectives into residential buildings and public buildings, and then divides the LCA into two stages: design and operation. In Table 2, we can see that LEED has different evaluation criteria for different buildings, and not only refers to the different weights of the indicators, but also the different evaluation criteria in the setting of the indicators. This is obviously more effective than ASGB. Compared with the diversification of the LEED system in the United States, ASGB in China lacks detail, which is the reason why the practicability of ASGB is far lower than that of LEED.

Index Weight

The indexes of ASGB are composed of seven Categories: Land Saving and Outdoor Environment, Energy Saving and Energy Utilization, Water Saving and Water Resource Utilization, Material Saving and Material Resource Utilization, Indoor Environment Quality, Construction Management, and Operation Management. Each category includes prerequisite items and scoring items. In addition, it also includes Bonus Items, which are Promotion and Innovation.

The indicators in different LEED evaluation systems are slightly different. In this paper, we evaluate LEED V4. DB+C is used as an example for comparison [8]. LEED BD+C includes seven categories: Integration Process, Location and Transportation, Sustainable Site, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. In addition, it also includes the Bonus Items Innovation and Regional priority, as shown in Table 3.

Table 3. Comparison of the Index Weight in ASGB and LEED

Category	LEED BD +C	ASGB	Category
Integrative process	●		
Location and transportation	●	●	Land Saving and Outdoor Environment
Sustainable sites	●		
Water efficiency	●	●	Water Saving and Water Resource Utilization
Energy and atmosphere	●	●	Energy Saving and Energy Utilization
Materials and resources	●	●	Material Saving and Material Resource Utilization
Indoor environmental quality	●	●	Indoor Environment Quality
Innovation	●	●	Promotion and Innovation
Regional priority	●		
		●	Construction Management
		●	Operation Management

From Table 3, it is evident that the two systems are similar in terms of the framework. This is because LEED is the most widely used green building evaluation system. ASGB was built with LEED as a template at the beginning of its formation. LEED lacks a separate evaluation of construction management and operation management and therefore integrates construction management into other evaluation items. Operational management is an independent evaluation manual. In addition, regional priority is a bonus item to make full use of local resources to avoid unnecessary damage to the environment due to material transportation.

Evaluation Methods

ASGB determines the grade of a green building according to the total score, which is divided into three grades: one-star, two-star, or three-star. All three grades of green buildings should meet the requirements of all the prerequisite items in the standard, and the scoring items of each index should not total less than 40 points. When the total score of a green building reaches 50, 60, or 80 points respectively, the green building grade is one-star, two-star, or three-star, respectively. This is calculated by the following formula:

$$\sum Q = W_1 Q_1 + W_2 Q_2 + W_3 Q_3 + W_4 Q_4 + W_5 Q_5 + W_6 Q_6 + W_7 Q_7 + Q_8$$

First, the score Q_i (i = 1, 2, 3, 4, 5, 6, 7) is obtained according to the degree of the scoring item under various indicators. Second, Q_8 is the Promotion and Innovation score. Each $Q_{i\ is}$ multiplied by its weight W_i (Table 4), and the Bonus Items score is added to the final evaluation score of the building.

Table 4. Index Weight in ASGB

Evaluation Type		Land saving and outdoor environment W_1	Energy saving and energy utilization W_2	Water saving and water resource utilization W_3	Material saving and material resource utilization W_4	Indoor environment quality W_5	Construction management W_6	Operation management W_7
Design Evaluation	Residential building	0.21	0.24	0.20	0.17	0.18	-	-
	Public building	0.16	0.28	0.18	0.19	0.19	-	-
Operation Evaluation	Residential building	0.17	0.19	0.16	0.14	0.14	0.10	0.10
	Public buildings	0.13	0.23	0.14	0.15	0.15	0.10	0.10

Taking the LEED BD+C system as an example, the full marks of the system are 110, and the index weight is shown in Table 5. The Integration Process is a comprehensive evaluation that includes characteristics such as energy consumption model analysis, lighting and thermal comfort analysis, and operation plan [9]. When scoring, each index is scored first, and then the total score of each index is the final score. According to the final score of the building, LEED V4 has four certification levels: Certified is 40 to 49 points, Silver is 50 to 59 points, Gold is 60 and Platinum is more than 80 points.

Table 5. Index Weight in LEED V4.

New construction	Integrative process	Location and transportation	Sustainable sites	Water efficiency	Energy and atmosphere	Materials and resources	Indoor environmental quality	Innovation	Regional priority	Total score
Point	1	16	10	11	33	13	16	6	4	110

The examination method of LEED is relatively scientific and reasonable. The design stage is only used for control and guidance and does not include the effect of certification. Finally, the certification level is determined by examination when the construction is completed, which is conducive to ensuring the actual effect of green building projects.

Certification Status in China

First, since 2001, China has been developing green buildings. After 15 years, according to the Chinese Green Building Evaluation Label [10], by the end of September 2016, China had 4515 green building projects and the building area was 523.17 million square meters. Among them, there were 1865 certification projects that were one star, accounting for 41%, while three-star certification projects only totaled 847. Green building projects are also concentrated in coastal cities such as Jiangsu, Guangdong and Shanghai [11].

According to the USGBC statistics [12], as of May 2016, LEED projects covered 162 countries worldwide with nearly 80,000 registered projects and 32,500 certification projects. LEED certification in China began in 2003 [13]. In 2006, the Shanghai Intel Flight Exhibition Hall became the first LEED-CI gold-grade project in China [14]. Since then, LEED has developed rapidly in China. According to the GBCI website, as of December 2017, 1211 LEED projects in China have been certified [15].

Discussion

Various Types

Promoting the diversification of green building evaluation standards can not only provide more choices for assessors, but also ensure the pertinence and professionalism of green building evaluation standards. There are only two types of evaluation targets in China's green building evaluation standard. As such, it cannot be scientifically and comprehensively analyzed and divided into different types to realize diversification of green building evaluation standards.

Quantitative Standard

The quantitative scoring provisions can improve implementation of the efficiency of green building evaluation standards. For example, in the evaluation index of materials and energy, if the utilization rate of green building materials is 5%, it receives 3 points, but if it reaches 7%, it can receive 4 points. This evaluation method can improve the accuracy of the final green building evaluation results while ensuring standardization of the evaluation process.

Conclusion

In order to promote the healthy and long-term development of green buildings in China and improve the current assessment system, the following points should be improved. An assessment system of green buildings should be formulated based on China's national conditions, climate, and geographical characteristics. Furthermore, as scientific research and engineering of green buildings exist simultaneously, the evaluation system should not only be comprehensive and deep in scientific research, but also convenient and practical in terms of engineering.

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