Research on the Green Evaluation System of Large Public Buildings

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Abstract. This paper introduces green construction from the entry point of a public building in Chongqing and analyzes its development status in China. The important role of green construction evaluation is a key issue in green construction. Nowadays, China does not yet have a compact evaluation model and system that fits the national conditions, which is scientific, and gives full play to evaluation, standardization, and guidance of green construction. Through the evaluation of three green construction evaluation models of China’s construction engineering green construction evaluation standards, British Building Research Establishment Environmental Assessment Method (BREAM), and Leadership in Energy and Environmental Design (LEED), the separate analysis and comparison of different systems are made. The results could provide supports for green construction evaluation models and systems and also promote the long-term development of green construction in China.

1. Introduction
Since the implementation of the first edition of the national standard "Green Building Evaluation Standards" (GB/T 50378—2006), the green buildings in China have developed for more than 10 years, from scratch to more, from individual cities to the whole country [1-4]. Nowadays, the major cities in China make efforts or even enforce to operate the green building standards. From 2008 to 2012, there were only 724 projects that received green building evaluation marks across the country. By the end of 2017, the total number of projects that received green building evaluation marks across the country exceeded 10,000, with a construction area of over one billion square meters.

The construction companies in China created a set of "Green Building Evaluation Criteria" based on the national conditions, which are suitable for the actual development in the country. However, we can find that in the construction process, there are still some traditional problems hindering the construction industry's gradual transition to energy conservation. The main reason is the lack of a systematic public building evaluation system. At present, most of the green building evaluation systems in China present a general overview of the design requirements of buildings. Such rules easily bring the other designers in a state of confusion, which is not conducive to the overall development of the construction industry. At the same time, the green building evaluation standards are just in the early stage of release, so there are often big loopholes in the relevant implementation process. As a result, part of the management work just stays on the surface, which in turn causes the contradiction...
between the design plan and the actual construction process. In addition, in the process of building design, the construction companies pay more attention to their own economic benefits rather than the influences of green buildings. Therefore, in the actual application process, the scientificity of the design plan cannot be guaranteed, which affects the construction quality of the office [5-8]. In this sense, a reliable and comprehensive green evaluation system of public buildings should be proposed as scientific guidance for construction.

Take a public building in Chongqing as an example. The project is located in the south of plot F40-1-1 in Konggang New Town, Chongqing, which belongs to administrative building land. The land is surrounded by municipal roads, with Tongmao Avenue on the south side, Chunhua Avenue on the east side, Chuntong Road on the west side, and Gongyuan Beiyi Road on the north side. The site location is very advantageous. The land area of the project is 24129.00 square meters, and the building area is 44760.26 square meters. The total building area of the application review part reaches 44760.26 square meters. The above ground area is 32853.86 square meters, and the underground area is 11906.40 square meters with the project building density of 26.40%, the plot ratio of 1.36, and the green area ratio of 35.17%. The project has 6 floors above ground with a height of 30.50 meters. The 6 floors above the ground are the comprehensive archives building. The main function of the first floor is the exhibition hall. The second floor is mainly used as the exhibition hall and archives service room. The main function of the third floor is the urban construction archive room. The main function of the first floor is the archives warehouse, and the sixth floor is mainly used for the technical and business rooms of the archives, which belongs to a class of high-rise public buildings. There is one underground floor with 4.5 meters high, where 271 small cars (including 33 electric car charging parking spaces) can be parked in the underground garage. In order to ensure that the project can be implemented in accordance with the relevant requirements of green public buildings, it is necessary to analyze the green evaluation system of public buildings at home and abroad [9-12]. The following of this paper analyzes the green evaluation system of public buildings in China, Britain, and the US. Comparison is made to provide effective suggestions for the development of green evaluation system in China.

2. China’s Construction Engineering Green Construction Evaluation Standard

The evaluation object of "Green Construction Evaluation Standard for Construction Engineering" (GB/T 50640—2010) is the construction process of construction engineering. This evaluation system sets the basic conditions to be met by "green construction projects" and major accidents that cannot occur. The control items, general items, and preferred items of the evaluation elements refer to the mandatory indicators of green construction, the indicators that require moderate standards and are evaluated according to actual conditions, and the indicators that are difficult and demanding. The evaluation score of each element \( F = \frac{\text{general item score}}{\text{general item total score}} \times 100 + \text{preferred item score} \). The weights of the five elements are 0.3, 0.2, 0.2, 0.2, and 0.1, respectively. The stage evaluation score \( G = \sum (\text{element evaluation score} F \times \text{weight index}) / \text{Number of evaluations} \). The weights of the three stages are 0.3, 0.5, 0.2, and the total evaluation score of the project is calculated as \( W = \sum \text{stage evaluation score} G \times \text{weight index} \).

3. British Building Research Institute Environmental Assessment Act

The British Building Research Establishment Environmental Assessment Method (BREEAM) was founded in 1990 by the British Building Research Establishment (BRE). This system is the world’s first comprehensive evaluation system for green buildings. In order to adapt to the development of the times, the evaluation system has been continuously revised. It is currently applicable to buildings with multiple functions such as office buildings, commercial buildings, and industrial buildings. As one of the widely used green building evaluation methods in the world, BREEAM’s first-level scoring indicators include nine parts: management, energy, water resources, land use, ecology, materials, pollution, waste, transportation, health and comfort. Three aspects including design and construction, building performance (BPS), management and operation, are evaluated. Except for the above nine
items with a weight value less than 1, there are other innovative items without a weight value. The upper limit of the score is 10 points. BREEM’s evaluation distinguishes the stage of the project, the design and construction stage, the existing vacant buildings, and the buildings in use. It differentiates evaluations for different stages and calculates the total score. As an international evaluation system, the weighting index of each region in BREEM is comprehensively formulated based on the original standard system, local natural environment, climate environment, population density and other factors to achieve localization. For example, according to the actual situation in China, BREEM’s weight index has 6 values. Take Shanghai for example, it is located in Zone 5, the representative buildings of the Shanghai International Shipping Service Center have obtained BREEM’s outstanding or outstanding certification.

4. Leadership in Energy and Environmental Design

The Leadership in Energy and Environmental Design (LEED) is a green building evaluation system designed, developed and managed by the US Green Building Council (USGBC), which draws on the British BREEM evaluation system. LEED is well-known and influential internationally, and is also the most successful evaluation system for commercialization.

LEED V1.0 was released as an experimental version in 1998. After two years of practice, the improved LEED V2.0 was released in 2000 as the official version for green evaluation of buildings. In 2002, USGBC released LEEDV2.1, LEED V2.2 in 2005, LEED V2009 in 2009, and LEED V4 in 2013. The LEED V4 currently in use contains nine first-level evaluation indicators for a total of 110 points, which are: 1 point for integration progress, 16 points for location and transportation, 10 points for sustainable sites, 11 points for water-saving efficiency, 33 points for energy and atmosphere, and materials 13 points for resources, 16 points for indoor environmental quality, 6 points for innovation, and 4 points for regional priority. A total of multiple secondary evaluation indicators are designed under the nine primary evaluation indicators, including the minimum program requirements (MPR) and scoring indicators. MPR refers to the requirements that must be met to carry out the scoring work. LEED V4 does not have a set weight index, but the difference in the size of the score of each indicator reflects the degree of importance. The terms of the first-level evaluation index are strictly scored. And then they are summed up to obtain the total score. Finally, it determines the certification level using the following rules: 40 to 49 are certified; 50 to 59 are silver grade; 60 to 69 are gold grade, and 80~124 are platinum grade. The standard of LEED scoring indicators is in the form of a list, and all procedures are completed through the Internet to ensure its openness.

5. Comparison and Analysis

Green building evaluation models and systems, like BREEM and LEED, are involved in the construction phase of the building, which should be considered and implemented. Although the evaluation standard for green construction of building engineering is more developed for a certain period, there are still obvious shortcomings and drawbacks. There is a nonlinear and fuzzy relationship between the evaluation indicators at all levels and actual conditions of green construction. The method of using the index score to judge the level of green construction by uncomplicated mathematical operations has yet to be improved. Based on above sections, there are various evaluation models and systems related to green construction with different ideas. But they convey similar green concepts and have a positive effect on the development of green construction and green buildings.

In comparison with BREEM and LEED proposed in Britain and the US, respectively, the green building evaluation models and systems are still having a long way to go. First, the basic theory of the China’s model and system needs to be further constructed and confirmed. To some extent, the present items and factors for the evaluation should be adjusted and improved. Second, more cases should be used in the validation of China’s model and system. Compared with BREEM and LEED, the actual applications of China’s model and system are still limited. In this sense, the validation and confirmation of these evaluation rules are not sufficient. Third, a comprehensive survey should be conducted to investigate the green building evaluation models and systems all over the world. Except
for BREEAM and LEED, there are still other green building evaluation models and systems in different countries. To enhance the reliability of China’s green building evaluation models and systems, these experience and achievements should be referred to.

6. Conclusion
This paper takes a public building in Chongqing as the starting point, then compares the green evaluation systems of large public buildings in China and abroad (BREAM and LEED). Finally, the relationship between these systems is analyzed and compared. The development of the large-scale public building green evaluation system in China is still in a preliminary stage. Therefore, it is necessary that completeness and robustness of the evaluation system should be improved based on the study of relevant foreign experiences and achievements.

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