An Overview of Sustainable Assessment Tools of BREEAM, LEEDv4 and GB

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Abstract

Purpose / Context - Sustainability has become an important issue in building construction sector. The tools of sustainable building assessment have been developed to evaluate the environmental impacts of buildings around the world. Chinese green building assessment tool (GB) was established later than other tools from developed countries. Therefore, the aim of this paper is to improve the evaluation method in Chinese green building assessment .Two famous assessment tools of BREEAM (2011) from the UK and LEEDv4 from the US are taken as examples for comparison analysis.

Methodology / Approach – The method of this research is to investigate the similarities and differences of assessment criteria and indicators among three assessment tools by conducting a comparison with other countries' green building standards.

Results –The results have found that when compared with major sustainable development categories, there is no obvious difference. However, in sub-criteria of each category, when compared with BREEAM and LEED, GB tool does not take more items into consideration and lacks more quantitative criteria, such as classifying building types, transport in sustainable site and energy efficient operation. Since each assessment tool has its own specialty to satisfy its local condition, GB assessment tool will follow the local standards and strategies to improve the deficiency of the original evaluation criteria.

Originality – This research provides constructive suggestions of the essential sustainable criteria for the future development of Chinese green building assessment.

Keywords - Sustainability, Green building, Sustainable green building assessment

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1. Introduction

Global warming and climate change have become important issues in the world, and immediate actions should be taken to avoid serious consequences for future generations (IPCC,2011). The research has shown that building sector accounts for a great amount of energy and resource consumption, leading to the damage of our environment (Emmanel, 2004). This may come from the absence of lacking environmental assessment tools capable of evaluating our built environment. Worldwide governments or environment-related institutions have gone into the development of such systems to assess the performance of buildings. Therefore, there has been great development of sustainable building environmental assessment tools since 1990s. Many tools have gained considerable success in the application of evaluation of green buildings (Cole, 2004; Seo et al.,2006). For example, In England, the Building Research Establishment Assessment Method (BREEAM) was the first tool developed for sustainable building design. Subsequently, Leadership in Energy and Environmental Design (LEED) in the USA in 1996, and Comprehensive Assessment System for Building Environment Efficiency (CASBEE) in Japan in 2002 have also been developed.

In China, due to the country's fast-paced urban development since 1980s, construction-related environmental problems have been increasing rapidly, leading to great damage of ecology and human's health. Based on nation's statistical data, the share of building energy consumption in total energy consumption in China rose from 10% in 1978 to 30% in 2006, and continues to maintain growth (Han et al., 2006). In recent years, the data shows that building energy consumption accounts for 46.7% of the total society energy consumption and 60% of carbon emissions in cities comes from maintaining building's function (Zhang, 2010). In consequence, environmental issues related to building construction have been paid more and more attention to. Due to the lack of building assessment in China, the first assessment system of Chinese green building (GB/T50378) was established in 2006, providing the standard of evaluation of sustainable buildings. However, the development of assessment system is not complete and needs ongoing improvement.
The aim of this paper is first to investigate the essential evaluation criteria among LEED, BREEAM and Chinese green building (GB) from literature review. Further, different criteria will be compared and analyzed, providing constructive suggestions for future improvement of Chinese green building assessment.

2. Environmental Assessment Method

Environmental assessment methods have been developed to suit different territory. However, understanding various assessment features is the first step.

2.1 BREEAM

BREEAM was the first assessment tool developed in the UK in1990. The latest version of BREEAM discussed in this paper is the method developed in 2011 (BREEAM, 2016). Main sustainable categories include management, health and wellbeing, energy, transport, materials, water, waste, land use and ecology, pollution and innovation. Assessed buildings include various types, such as residence, retail, industry unit, office, court, school, healthcare, prison and so on. Besides, BREEAM utilized a fixed weighting systems shown in Table 1 developed through the national consultative process (Sev, 2011). The assessment involves the comparison of main issues related to predictable practices and performance level. Afterwards, credits are given in ten categories. Each category has its specific criteria, with weighted credits that can be cumulative and added together to produce '*a single overall score on a scale of Pass, Good, Very Good, Excellent and Outstanding*' (BREEAM, 2016).

Table 1 BREEAM environmental weightings

Category	Weightings%	Credits available
Management	12	10
Health and wellbeing	15	14
Energy	19	21
Transport	8	10
Water	6	6
Materials	12.5	12
Waste	7.5	7
Land use and ecology	10	10
Pollution	10	12
Innovation	10	10

2.2 LEED

The first LEED assessment was developed in the US. in 1998. LEED is a voluntary certification program developed through a process involving major stakeholders to provide a framework for evaluating building performance and meeting sustainability goals (Zimmerman, 2007). The method has been modified and improved for several times. The basic assessment category with credits shown in Table 2 includes location and transportation, sustainable site, indoor environmental quality, water efficiency, energy and atmosphere, materials and resources, innovation and regional priorities. LEED uses a simple additive method (1 for 1) with all criteria weighted equally, not using a complicated weighting system. In this research, the latest assessment version of LEED v4 is taken into consideration (LEED, 2016).

Besides, the classification of assessed buildings includes building design and construction (BD+C), interior design and construction (ID+C), operations and maintenance (O+M), neighborhood and development (ND) and homes. Buildings cover many types, such as residence, school, retail, commercial building, multifunction building, healthcare and so on. With regards to certified ratings, there are four levels: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points), Platinum (80+ points).

Table 2 LEED credits

Category	Possible points
Location and transportation	16
Sustainable sites	16
Water efficiency	11
Energy and atmosphere	33
Materials and resources	13
Indoor environmental quality	16
Innovation in design	6
Regional priority	4

2. 3 GB/T50378

The China Building Science Research Institute developed a two-stage green building rating system, the Chinese Green Building Label-3, or called 3-Star Rating in 2006 (GB, 2006). The rating system is managed by The Ministry of Housing and Urban-Rural Development (MOHURD) and building certified by the China Green Label Office at the China Green Technology Center. In the first stage, the building may earn a Green Design Building Label, so the project can be marketed as a green building to potential tenants. Second, the building may earn a Green Building Operation Label. The rating tool assigns a score based on the predicted performance of the building, using a simple adaptive approach, the same as LEED, with all criteria weighted equally. MOHURD-authorized universities rate 1-Star- and 2-Star building applications or local governments, while 3-Star building applications are rated by MOHURD. Sustainable categories also include construction and operation management, land efficiency and outdoor environment, energy savings & energy utilization, material saving & utilization of material resources, indoor environmental quality. Assessed building types including residential and public buildings are considered.

3. Results and Dicussion

3.1 Types of assessed buildings

Table 3 indicates types of assessed buildings from three assessment tools. Public buildings and residential buildings are two major types. GB tool lacks detail classification of assessed buildings but the latest version of more assessed building types is still under development. BREEAM includes nine types of buildings, among which eight types belong to public buildings and one type residential building. LEED contains five main categories, in which various types of buildings are taken into account. Basically, assessment tools are focused on buildings but in LEED, the category of neighborhood development involves larger scale of planning such as well-connected community.

Table 3 Classification of assessed buildings in three assessment tools

Comparision items	BREEAM	LEED	GB
Assessed building	Public buildings: retail,industry unit, office, court,school, healthcare, prison,multi-function building, unusual building Residential buildings	Interior design [1],building design & construction [2], building operation and maintenance [3],homes [4], neighborhood development [5]	Public buildings and residentail buildings

[1] Commercial interiors, retail and hospitality; [2] new construction, core & shell, schools, retail, hospitality, data centers, warehouses & distribution centers, and healthcare; [3] existing buildings, schools, retail, hospitality, data centers, and warehouses; [4] single family homes, low-rise multi-family (one to three stories), or mid-rise multi-family (four to six stories); [5] plan and built project

3.2 Category of different tools

3.2.1 The basic contents of category

Table 4 shows there is no great difference in the most of the categories. However, compared with assessment tools of LEED and GB, BREEAM includes categories in a more detail manner. For example, categories of land use, pollution and transport are included in sustainable site selection in LEED, and land saving and outdoor environment in GB. The category of “Waste” is highlighted in BREEAM because BREEAM regards waste treatment very essential at the end of building’s life; however, LEED and GB cover waste issue in categories of materials and resources, and material saving and resources use. The category of “Regional priority” , which BREEAM and GB lack, is a special indicator in LEED, which addresses geographically specific environmental priorities. Besides, BREEAM and LEED take the category of “Innovation” in the assessment, which provides design teams and projects the opportunity to achieve exceptional performance above the requirements.GB tool in China does not include this category, which may hinder creativity and inspiration of designers.

Table 4 Main contents of category

Comparison items		BREEAM	LEED	GB
Basic contents of category	Similar category	Land use and ecology	Sustainable site	Land saving and outdoor environment
		Pollution		
		Transport		
		Water	Water efficiency	Water saving and water resources use
		Energy	Energy and atmosphere	Energy saving and use
		Materials	Materials and resources	Material saving and resources use
		Health and well-being	Indoor environmental quality	Indoor environmental quality
	Different category	Waste	Innovation	Operational management
		Innovation	Regional priorities	

3.2.2 The contents of criteria

The major function of environmental assessment approaches is the examination of building performance. A list of criteria should be ranked to evaluate the degree to which the assessed buildings are environmentally friendly, meeting the goal of sustainability. Criteria from different methods are discussed in the following.

(1) Sustainable site:

The purpose of this category shown in Table 5 is to mitigate the pollution on construction site, including destruction of bioactivity and biodiversity. This category also aims to deliver a good level of communication, through access to public services and relevant facilities and adequate provision for pedestrians,drivers and cyclists (BREEAM, 2016; USGBC, 2016). In BREEAM, this category was divided into Land use and ecology and Transport, which can be equivalent to the Sustainable site category in LEED. In this regard, while BREEAM and LEED are similar in terms of criteria, LEED pays more attention to Brownfield redevelopment and Public transportation access (USGBC, 2016). Most of the criteria in GB are similar to BREEAM and LEED, but more categories in Transport are Pedestrian and cyclist safety and Car parking capacity.

Table 5 Sustainable site and ecology criteria

Sustainable site and ecology	BREEAM	LEED	GB
Construction site			
Site selection	●	●	●
Site protection	●	●	●
Ecological value			
Polluted land	●	●	●
Mitigation ecological impact	●	●	●
Enhance site ecology	●	●	●
Biodiversity protection	●	●	●
Transport			
Accessibility	●	●	●
Density development	●	●	●
Community connectivity	●	●	●
Pedestrian and cyclist safety	●	●	
Car parking capacity	●	●	

(2) Water efficiency:

Water resource is one of the most important environmental issues and water conservation has great impact on local water cycle balance. Therefore, assessment systems tries to manage action towards water use effectively. The goals are to reduce the water consumption and enhance the possibility of water recycling. BREEAM, LEED and GB approaches all focus on these related issues in Table 6. The criteria of " Recharge of ground water" in GB, which BREEAM and LEED do not list in the assessment criteria, enhances a balance between water cycle and ecology, moistening soil and enriching the ground water resource.

Table 6 Water efficiency criteria

Water efficiency	BREEAM	LEED	GB
Water consumption	●	●	●
Rain water harvesting	●	●	●
Grey water recycling	●	●	●
Innovative wastewater technology	●	●	●
Water fixture and conservation strategy	●	●	●
Irrigation system	●	●	●
Recharge of ground water			●

(3) Energy efficiency:

Energy consumption leads to environmental damage such as global warming, acidification effect, air pollution and so on. In consequence, energy efficiency has the largest proportion of credits distributed among the environmental categories.The categories of "Energy performance" and "Natural resources" are all regarded important in three assessment tools shown in Table 7.Energy consumption criteria in LEED accounts for the greatest proportion of credits [USGBC, 2016]. "Efficient operation" indicates the evaluation of energy consumption and CO_2 emissions. In LEED and BREEAM, it is necessary to use supplementary tools and guidance to estimate the amount of these environmental burdens, such as Standard Assessment Procedure (SAP), American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). However, GB assessment does not include the criteria of energy monitoring and CO_2 mitigation strategy. The reason may come from the fact that in China, technology for supporting energy monitoring was not broadly used and some strategies and regulations related to CO_2 reduction are still under development [Ye et al.,2013].

Table 7 Energy efficiency criteria

Energy efficiency	BREEAM	LEED	GB
Energy performance			
Ventilation rate	●	●	●
Internal lighting	●	●	●
External lighting	●		
Hot water system	●	●	●
Heat transmission	●	●	●
Natural resources	●	●	●
Renewable energy technology	●	●	●
Efficient operation			
Energy monitoring	●	●	
Optimum performance and energy saving	●	●	●
CO_2 mitigations strategy	●	●	

(4) Material resource criteria:

Material resource is considered an important category in the most of the assessments due to its life cycle process from raw material extraction, transportation, manufacturing and disposal phase. Table 8 shows that BREEAM has more specific criteria in this category. The reason may come from the fact that BREEAM has developed a large material database, containing over 1500 specifications used in different types of buildings (BREEAM, 2016). This can help designers to select more sustainable materials in their design process. In LEED, reusability and maintenance of construction materials are paid much attention to. However, GB assessment has developed the criteria of "Hazardous substances of materials", which BREEAM and LEED do not include. In the 21st century, environmental pollution in China has already become serious in building construction sector, not only from the stage of construction but also from the stage of building's demolition ; thus, managing materials with hazardous substances becomes very crucial.

Table 8 Material criteria

Material	BREEAM	LEED	GB
Material with low environmental impact	●	●	●
Use of non-renewable-virgin materials	●	●	●
Reuse of structural materials	●	●	●
Use of non-structural materials	●	●	●
Insulation material	●	●	
Material efficiency over its life cycle	●	●	●
Hazardous substances of materials			●

(5) Indoor environmental criteria:

This category in BREEAM is called "health and wellbeing" and "indoor environmental quality" in LEED and GB. Indoor environmental quality is considered to be one of the major objectives in assessment tools. The goal is to reduce harmful impacts on human health, such as noise, lighting system, ventilation and thermal comfort. It can be found in Table 9 that BREEAM makes noise criteria more detail including sound insulation and absorption. Besides, GB includes most of the criteria but lacks criteria of CO_2 monitoring and visual comfort. CO_2 density is strongly related to human indoor comfort, affecting people's concentration when working. Visual comfort may not be the direct factor that affects human's health but in order to increase work efficiency and create a better living place, it is suggested that these two criteria should be contained in the GB assessment.

Table 9 Indoor environment criteria

Indoor environment	BREEAM	LEED	GB
Noise and acoustics			
Noise level	●	●	●
Sound insulation	●		
Sound absorption	●		
Lighting and illumination			
Lighting controllability	●	●	●
Glare measure and control	●	●	●
Daylight factor	●	●	●
Ventilation			
Ventilation system	●	●	●
Air purification supply	●	●	●
Air quality sensors-CO_2 control	●	●	
Thermal comfort			
Visual comfort	●	●	●
Temperature comfort	●	●	●
Humidity comfort	●	●	

3.3 Future green building development in China

In addition to green building assessment criteria discussed above, some essential issues related to the future development of green building in China should be concerned because these issues influence further development of green building assessment tool in China.

In spite of some national and local standards that have been existed already, a complete system on the design, construction, operation and evaluation of green building is not well-established. Although different areas have their own climate conditions in China, specific standards for different regions are required. In China, green building is still in the initial stage, and related policies, regulations and evaluation system are under development and need to be improved. Factors such as regional economic development level, resources usage, climate conditions and construction characteristics should be taken into consideration when green building standards and assessment tools are developed. As for evaluation systems, they should include quantitative standards with higher qualities, so research and application on quantitative and qualitative index must be enhanced. To promote green building development, the government must cultivate an independence

third-party certification agency to evaluate before implementing design proposal, under construction process and building materials and devices.

4. Conclusion

It is not so easy for any single assessment method to be suitable for every region in the world because each territory has its particular individual specifications in terms of geographical and cultural variations. However, by comparative study of different assessments, some information related to assessed criteria can be obtained to broaden and deepen the insufficiency of contents in each assessment. Above all, it can be found that main assessed categories from different assessment tools do not differ much. But when evaluation of building types is compared, it is necessary for GB tool to be more specific in classifying various types of buildings, thus developing a more scientific-based evaluation of green buildings. Besides, in sub-criteria of each category, when compared with BREEAM and LEED, GB tool does not take more items into consideration and lacks more quantitative criteria. But this will be improved until the latest version of GB tool is proposed. On the other hand, GB tool still has some environmentally-friendly criteria that LEED and BREEAM do not cover, such as recharge of ground water and hazardous substances of materials. Since the climate in different areas in China is different, GB standards and criteria should adjust to local conditions and provide different guidances to various situations. More works will be done in the future related to local sustainability factors and local environmental policy.

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