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A REVIEW OF DAYLIGHTING AND VISUAL COMFORT IN GREEN BUILDING RATING TOOLS

Fazidah Hanim Husain[1], Azhan Abdul Aziz[2], Mayamin Yuhaniz[3], Salahuddin Abdul Hakeem Abas[4] and Sabarinah Sheikh Ahmad[5]
[1-4]Department of Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, 32610 Seri Iskandar, Perak, Malaysia
[5]Department of Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Selangor Branch, Puncak Alam Campus, 42300 Puncak Alam, Selangor, Malaysia

Abstract

One of the main components of interior space is lighting. Daylight offers a high-quality indoor environment that provides the required illumination for visual comfort. Well-designed architecture allows natural light to be transmitted, provides view, reduces heat, and eliminates glare in order to provide a work atmosphere that is conducive. Lack of understanding at the early stage of design and poor site consideration will produce high-energy buildings that encourage the usage of electrical lighting. A report from the Building Sector Energy Efficiency Project (BSEEP) stated that energy waste increased 50% because of lack of passive design knowledge. Post occupancy evaluation of GBI rated buildings show glare and employee discomfort occurred in office environment. This research is conducted to identify the score reading and weightage of daylighting and visual comfort in green building rating tools. The study provides an overview on daylighting-related measures in the certification of the commonly used rating tools worldwide such as LEED, BREEAM, CASBEE, SB TOOL, GREENMARK, NZ GREEN STAR, and GBI specifically in office buildings which were comparatively assessed and analysed. This comparison allows researcher to identify the score reading of the daylight performance and visual comfort that fall under the category of Energy and IEQ to highlight the weightage and importance of daylight and visual comfort from the perspective of green building. The analysis shows that the score readings between the rating tools on both categories vary and are not homogeneous, but are based according to the locality, climate, and the region.

Keywords: *daylighting, visual comfort, passive design strategy, rating tools, energy efficiency, office*

1.0 INTRODUCTION

Daylighting is an effective and efficient strategy in achieving visual comfort and energy efficiency. Harvesting natural daylight is the most effective method, since it reduces the energy usage. The quality of daylight provides good color rendering and the light source is almost equivalent to human visual responses. Daylight offers a sense of brightness and gives significant impacts on human's psychology (Li & Lam, 2001).

Global energy consumption in the world has been growing gradually in recent years and this growth appears to continue in the near future (IEA, 2016). It is well known that the building industry contributes about 40 per cent of total energy consumption in developing countries (Zuo & Zhao, 2014). As a result, increasing energy efficiency in buildings is a major concern (Boyano, Hernandez & Wolf, 2013) and several strategies have been studied and proposed to improve this aspect (Gori et al., 2016). Indeed, numerous countries have established energy assessment procedures to determine the energy efficiency of buildings (Dall'O et al., 2013). Evaluating building performance from a wider perspective including taking into account the environmental, social, and economic effects of buildings is critical, considering that encouraging energy efficiency is one of the most important issues for governments (Mattoni et al., 2018).

In this paper, the category used for the evaluation of daylighting and visual comfort were discussed in seven commonly used instruments (LEED, BREEAM, CASBEE, SB TOOL, GREENMARK, NZ GREEN STAR AND GBI). The study focused on differences in score reading that concern office buildings. This preference was decided based on the belief that office buildings are characterised by some common or similar features around the world. This will provide a solid basis for the comparative analysis and evaluation attempted in this paper. In the scope of study discussed in this research, the form and scope of standard used to determine daylight and visual comfort related parameters, the weights score applied, and references to relative standards were checked and evaluated in a comparative way.

2.0 LITERATURE REVIEW

2.1 The Concept of Daylighting and Visual Comfort in Green Building Rating Tools

In order to satisfy the requirements for holistic performance assessments, evaluation and ranking systems were developed. First of all, it is useful to recognise the significant impacts on human and natural environments, such as environmental, economic, and social impacts when figuring out the different factors involved in the construction of sustainable outcomes (SB Tool, 2016). Figure 1 demonstrates the theoretical structure that is followed in the process, such as the relationship between requirements for daylight and visual comfort, design strategies or project components, with the performance factors linked to loadings, which in turn are linked to impacts.

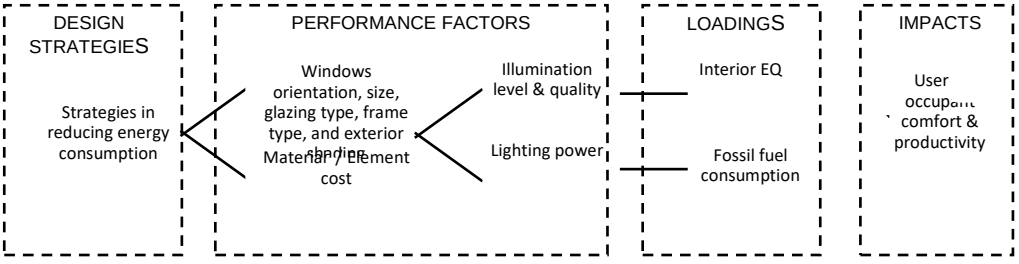

Figure 1: Building scale overview of relationships between design strategies, performance factors, loadings, and impacts.

(Source : SB Tool)

Natural energy is used directly as energy without the use of any mechanical force, as in the use of daylight. Many buildings have natural lighting as their basic energy saving measures. The passive design approach such as the positions (orientations) of openings can make an efficient use of daylight. The assessment of lighting and illumination is carried out regarding the efficient utilization of natural light (daylight use), measuring against the glare of direct sunlight during the day (glare counter measures), the balance and level of brightness (illuminance), and the control of brightness and positions of lights.

2.2 Green Building Rating Tools

The rating tools presented in this paper (LEED, BREEAM, CASBEE, SB TOOL, GREENMARK, GREEN STAR and GBI) vary in their theory, procedure, and structure. Therefore, the presence of their main features is an inseparable part of the analysis of the criteria in the assessments they perform related to visual comfort. In Table 1, these characteristics are presented.

3.0 RESULT & DISCUSSION

3.1 The Category of Daylighting and Visual Comfort in International Green Building Rating Tools

Based on Table 2, the measures used to assess daylight and visual comfort in each of the tools were formulated in a different way, depending on the general evaluation context, purpose, and process of each rating tool. Table 2 shows two main categories in rating tools that are related to daylighting and visual comfort.

Table 1: The overview of well-known green building rating tools

No	System	Founding Years	Duration of Years	Total Number of Project Certified	Total Area Certified (Building)	Body	Administration Body	Certification Levels and Points
1	LEED (US)	2000	19	70,000	279 million m2	Non-profit	US Green Building Council (USGBC) and Green Building Certification Institute (GBCI)	Platinum: 80+ Gold: 60-79 Silver: 50-59 Certified: 40-59
2	BREEAM (UK)	1990	29	8,000	40 million m2	Non-profit	BRE Trust	Outstanding: 85+ Excellent: 70-84 Very Good: 55-69 Good: 45-54 Pass: 30-44
3	CASBEE (Japan)	2001	18	300 (update to 2016)	n/a	Government Body	Japan Sustainable Building Consortium (JSBC)	Excellent (S) Very Good (A) Good (B+) Fairly Poor (B-) Poor (C)
4	SBTOOL	2007	12	n/a	n/a	Non-profit	International Initiative for a Sustainable Built Environment (ISBE)	Best Practice (4-5) Good Practice (2-3) Minimum Practice (0-1) Negative (-1)
5	GREEN MARK (Singapore)	2005	14	2,002	n/a	Government Body	Building and Construction Authority (BCA)	Platinum: 90-100 Gold Plus: 85-89 Gold: 75-84 Certified: 50-74
6	NZ GREEN	2003	16	726	40 million m2	Non-profit	The Green Building Council of	6 Star: 75+ 5 Star: 60-74

No	System	Founding Years	Duration of Years	Total Number of Project Certified	Total Area Certified (Building)	Body	Administration Body	Certification Levels and Points
	STAR (New Zealand)						Australia (GBCA) - Green Star	4 Star: 45-59
7	GBI (Malaysia)	2008	11	300	14 million m2	Non-profit	Malaysia Institute of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM)	Platinum: 86-100 Gold: 76-85 Silver: 66-75 Certified: 50-65

(Source: LEED, BREEAM, CASBEE, SB TOOL, GREEN MARK, NZ GREEN STAR & GBI)

Daylighting and Visual Comfort criteria were structured under the environmental section of Indoor Environmental Quality, Indoor Environment, and Health and Wellbeing. Meanwhile, the External Light (Daylight), Renewable Energy and Energy Efficiency criteria were grouped under the theme of Energy, which applies to the subject of Energy and Atmosphere, Energy, Energy and Resource Consumption, and Energy Efficiency. Each rating tool carries different names but belongs to the same section and has similar definitions of Daylighting and Visual Comfort.

3.2 The Score Breakdown of the Green Building Rating Tools Categories

An additional analysis is displayed in Table 3; the rating tools were split into 12 fundamental categories that deal with the key aspects of green buildings. Those areas are the same for all other protocols and the breakdown of credits and points with the total score is shown. Each rating tool carries a different total score and the percentage of IEQ and Energy are shown in Figure 2.

Table 2: The category of daylighting and visual comfort in international green building rating tools

No	LEED	BREEAM	CASBEE	SB TOOL	GREEN MARK	GREEN STAR	GBI
1		Management	Quality of Service	Service Quality		Management	
2	Indoor Environmental Quality	Health and Wellbeing	Indoor Environment	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality
3	Energy and Atmosphere	Energy	Energy	Energy and Resource Consumption	Energy Efficiency	Energy	Energy Efficiency

No	LEED	BREEAM	CASBEE	SB TOOL	GREEN MARK	GREEN STAR	GBI
4	Location and Transportation	Transport				Transport	
5	Water Efficiency	Water			Water Efficiency	Water	Water Efficiency
6	Material and Resources	Materials	Resource & Material			Materials	Material & Resources
7	Sustainable Sites	Land and Use Ecology	Outdoor Environment on Site	Site Regeneration and Development	Environmental Protection	Land Use and Ecology	Sustainable Site Planning & Management (SM)
8		Pollution				Emissions	
9		Waste		Social, Cultural and Perceptual Aspect			
10			Off-site Environment	Environmental Loadings			
11	Regional Priority						
12	Innovation	Innovation		Cost and Economics	Innovation	Other Green Features and Innovations	Innovation

(Source : Researcher Analysis)

Table 3 shows the score breakdown of the green building rating tools' categories and highlights two main categories of the study which are the Indoor Environmental Quality (IEQ) and Energy that represent Daylighting and Visual Comfort criteria and Energy Efficiency. From the score breakdown, we can see that the score values in LEED, Green Mark and GBI have a significant difference in IEQ and Energy Category. However, the score values in IEQ and E nergy category of BREEAM, SB Tool, and Green Star have only a slight difference. Meanwhile, CASBEE presents the same score reading of IEQ and Energy which is 2.

According to the study done by Giarmaa, Tsikaloudaki, and Aravantinos (2017) the points and credit for daylighting and visual comfort criteria differ between rating tools, including the parameters measured. BREEAM, LEED and CASBEE tends to provide holistic explanation and approach on the daylighting performance and IEQ evaluation breakdown since the establishments of the rating tools were more than fifteen years ago. Besides, the criteria index provided by each rating tool has a significant influence based on locality and climate. Tropical regions like Singapore and Malaysia have an abundance of daylight. Therefore, the daylight and visual comfort criteria index for IEQ is lower to be compared with other rating tools of other regions. The criteria index in rating tools for Temperate and Sub-Tropical regions tends to have higher points in IEQ because the climate's region has four seasons climate and minimal

sunlight. The rating tools of tropical regions provide higher reading scores under the Energy category to encourage building designers to produce climate responsive buildings that reduce energy usage.

Table 3. The score breakdown of the Green Building Rating Tools categories

NO	CATEGORY	LEED	BREEAM	CASBEE	SB TOOL	GREEN MARK	GREEN STAR	GBI
1	Management	6	21	1.5	20	0	9	0
2	Indoor Environmental Quality (IEQ)	**9**	**23**	**2**	**18**	**8**	**16**	**21**
3	Energy	**25**	**27**	**2**	**10**	**67**	**22**	**35**
4	Transportation	5	11			2	8	0
5	Water	9	10			3	8	10
6	Materials	10	12	1.5		8	16	11
7	Land Use and Ecology	6	10	1.5	22	7	5	16
8	Pollution	4	12			2	10	0
9	Community	17	1	1.5	10	0	0	0
10	Climate Change Adaptation	2	1		19	0	0	0
11	Regional Priority	3	0			0	0	0
12	Innovation	4	6		4	3	7	7
	Total Score	**100**	**134**	**10**	**103**	**100**	**100**	**100**

(Source: Researcher Analysis)

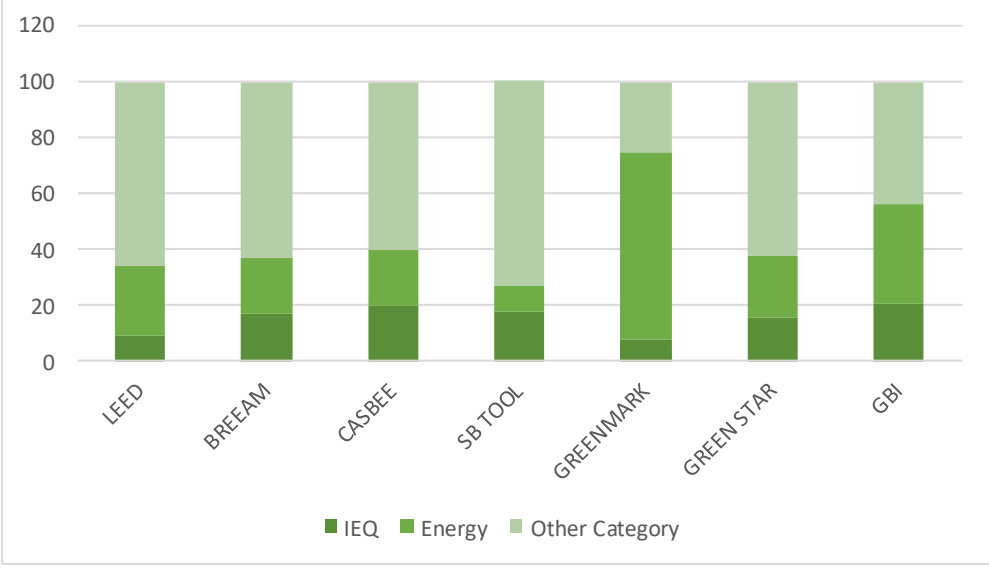

Figure 2. The percentage of IEQ and Energy category from the total score.

(Source: Researcher Analysis)

4.0 CONCLUSION

This paper has described the standards related to daylight and visual comfort in seven major green building rating tools. Details on their inclusion in the structure of the instruments, their score contribution to the category involved, and the final score of the protocol were presented, as well as the criteria used to determine these guidelines. Focus was imposed on

daylighting, for which the relevant data were provided in a more detailed and analytical manner. The analysis presented in this paper shows that the score readings between the rating tools vary in both categories and are not homogeneous and are based on locality, climate and location. The study, which describes the methods and techniques was analysed, making it easier to distinguish discrepancies and similarities between them, both at the level of their general context and with regard to the particular elements and criteria associated with the evaluation process.

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