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Analysis and comparison of lighting design criteria in green building certification systems —Guidelines for application in Serbian building practice

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ABSTRACT

Green building assessment is currently being introduced into Serbian building practice. Since there is no Serbian certification system which could support building assessment, and especially lighting design evaluation, this paper analyzes and compares the lighting design criteria of three international certification systems, LEED, BREEAM and CASBEE. Specific requirements for each considered criterion, as well as the grading structure and stringency of these systems, are also analyzed. Based on the conclusions of these analyses, a new set of criteria, some of which are original, are offered in order to be incorporated into the future Serbian certification system. Taking into account that the structure of the future system is unknown, the basic applied principle was simplicity for application and, therefore, a single requirement is defined for each criterion. Finally, a hierarchy within the new set of criteria is established for both indoor and outdoor lighting. Mandatory criteria are selected first, while the remaining criteria are divided into two groups based on their relevance. Although predominantly intended for the improvement of Serbian building practice, the proposed set of assessment criteria is general and can be used throughout the world.

Introduction

Procedures for the evaluation of buildings in terms of sustainability have been developed since the beginning of the last decade of the 20th century and as much as 600 methods of assessment exist today (Ebert et al., 2011). The scope of sustainability issues these methods address is various, ranging from a single issue, such as energy efficiency, to a wide range of issues belonging to all three pillars of sustainability (economy, ecology and society). The latter are comprehensive, complex and known as Green building assessment methods or Green building certification systems. They are considered to be objective, containing clear comparison tools for a holistic assessment of a building's sustainability, developed and structured in a way to give transparent building assessment results, followed by the issue of certificate which is suitable for the use in the building market. Constant development of the building market in the direction which encourages and promotes sustainable construction practice through an added value of certified buildings is giving an impetus to the further development of certification systems.

As one of the fundamental elements of building design and also one of the important issues when considering building sustainability, lighting design is being addressed in all of these systems (Liu et al., 2010). The treated aspects of lighting design are also similar within different systems. However, different structures of the systems and criteria definition put those aspects into different categories and define different thresholds and compulsory requirements for every criterion or compulsory criteria (depending on the structure of the certification system). There are only a few compulsory requirements addressing lighting design, and in some systems there are no such requests. Also, current grading is not stringent enough in assessing lighting design issues, which practically means that projects can achieve enough points for obtaining the certificate without improving lighting design in any way.

The research presented in this paper analyzes and compares criteria for the lighting design assessment in three international certification systems: LEED, BREEAM and CASBEE. These systems are chosen because they are distributed over three continents, thus covering the variety of different climatic and building practice conditions. LEED is the only system currently being used in Serbia on several projects, and its criteria and application is already known to a number of local experts. CASBEE is selected as a representative of Asian rating systems with quite a specific assessment methodology, while BREEAM is chosen as a representative of European rating systems.

Since Serbia has no official certification system and the whole sustainable construction practice and market is emerging, the comparison of different rating systems could give useful guidelines for the development of a national system. The aim of this research is to define the criteria by which lighting design could be assessed (not only taking them over from the considered certification systems) and to determine the compulsory criteria which must be addressed in green building lighting design in Serbian building practice. These criteria are expected to be incorporated into the future Serbian assessment method, without proposing their position in the new system's structure.

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Structure of the three compared systems

By definition, a certification system is: "…a way to evaluate the environmental performance of a building against an explicit set of criteria and typically consists of three major components:

1) a declared set of environmental *performance criteria* organized in a logical fashion—*the structure*,
2) the assignment of a number of possible points or credits for each performance issue that can be earned by meeting a given level of performance—*the scoring*, and
3) a means of showing the overall score of the environmental performance of a building or facility—*the output*" (Cole, 2003).

The selection of performance criteria expresses the range of sustainability issues a system can contribute to. The structure and procedures of certification systems are presented in Fig. 1.

In the three analyzed systems, all three components (structure, scoring and output) vary significantly. The major difference is that BREEAM and LEED scoring systems are both based on collecting credits (points) in different categories and summing them up to the total number (percentage) which determines the rating level, while CASBEE is based on the value of BEE (Building Environment Efficiency) indicator.

Unique methodology of the CASBEE structure is derived from the new definition of building efficiency, and is based on the evaluation of building's environmental qualities and loads. In CASBEE, values for these two categories, The Building Environmental Quality and Performance (SQ) and Building Environmental Loads (SLR), range from 1 to 5. They are calculated by the following formulas:

$$SQ = \sum_{i=1}^{m} q_i \cdot K_{q_i} \tag{1}$$

$$SLR = \sum_{i=1}^{n} l_i \cdot K_{l_i} \tag{2}$$

where q_i and l_i represent the achieved levels of performance for *i*th criterion in categories of quality and loads, respectively, K_{q_i} and K_{l_i} the corresponding weighing coefficients, and m and n the number of criteria in each of these categories. These sums are then expressed as values of the numerator Q and the denominator L, which are between 0 and 100, using the following formulas:

$$Q = 25 * (SQ - 1) \tag{3}$$

$$L = 25 * (5 - SLR). \tag{4}$$

The Q/L ratio gives the BEE value. This value is represented by an x/y diagram and a radar chart, giving a clear representation of the building's achieved results in every assessed field. The BEE value also determines the building's rating level and labeling. In addition, the $LCCO_2$ (Life Cycle CO_2) indicator has been introduced in the 2008 revisions of CASBEE and is also given in the final results chart, as an independent indicator of the building's sustainability level (rated with 5 levels of green stars) (CASBEE, 2013).

Also, the major scoring difference between the CASBEE and BREEAM systems on one side and the LEED system on the other is that the former have a threshold for every building rating level within every criterion. Thus every rating level has its own structure of mandatory requirements (prerequisites) and higher standards are set for higher rating levels throughout all assessment issues. This prevents cases of high ratings derived from weights in just several criteria, leaving some issues unaddressed.

In the compared certification systems criteria that address lighting design are found scattered throughout different credit categories. Although all of the criteria are in the mutual correlation, they are assessed through different groups, as seen in Table 1. Compulsory criteria represent the most relevant criteria for a certain area. If a criterion is not compulsory, then the project team can decide if they will incorporate strategies to pursue it, depending on the overall planned scoring structure. In this way, some of the important issues regarding green buildings can be overlooked, especially if the scoring for that criterion is low, which represents a disadvantage of such a system.

Criteria and their requirements

This research is based on an analysis of the criteria relevant for lighting design in the selected certification systems. The analysis is conducted separately for each system, based on the description of the criteria and their procedures given in the reference guides.

The LEED system

Lighting design issues are addressed by criteria which belong to three different sections:

- Light pollution,
- Energy efficiency, and
- Indoor environmental quality.

Not taking into account the energy efficiency related credits (there are no separate criteria for lighting design in this section), environmental lighting design strategies can achieve up to 2 points (Core and Shell — CS), 3 points (New Construction — NC) and 5 points (Schools), which is only 2–5% of the overall weighing.

Credits from the Sustainable Sites credit category deal with the selection and development of a building site (USGBC, 2009). As one of the aspects of environmentally responsible site development, *light pollution* issues are addressed. In order to achieve the only possible point for this credit, the project team must treat both interior and exterior lighting.

Interior lighting is addressed by controlling the amount of light which leaves the building during the night, either by reducing the input power of all nonemergency luminaires with a direct line of sight to any openings by 50% from 11 p.m. to 5 a.m., or by shielding those openings with an automatic device for a resultant transmittance of less than 10%. No calculations are needed for the compliance with these measures, just the description and proof of the taken measures.

For exterior lighting, in order to achieve the mentioned point, the project must comply with the maximum lighting power allowance (USGBC, 2009) and must fulfill all the requirements for the light zone in which it is qualified (as defined in *Lighting for Exterior Environments* (IESNA, 1999)). The light zone requirements provide the exact levels of illuminance and the amount of luminaire light trespass (0–10% of the total fixture lumens (USGBC, 2009)). The project team must first determine the light zone and then provide calculations for the light

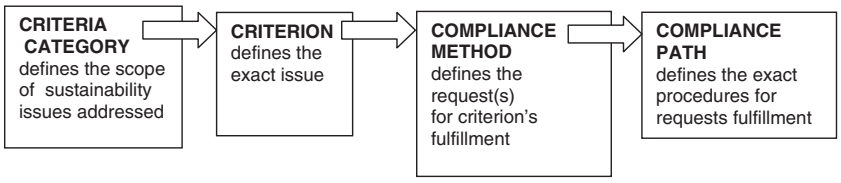

Fig. 1. Schematic representation of structure of certification systems.