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PROMOTION OF SUSTAINABLE CONSTRUCTION TECHNIQUES IN EXISTING BUILDING ASSESSMENT METHODS: A COMPARATIVE ANALYSIS OF GBTOOL, BREEAM, LEED AND SBAT

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ABSTRACT

Progress towards sustainable development in construction may be partly indicated by implementation of good construction practice in building developments. The evaluation of construction practice is often conducted using building environmental assessment methods.

Assigning credits for implementation of sustainable construction measures in the building assessment is an important incentive for their implementation in the construction process. However, it is argued that the recognition of sustainable construction techniques in existing building assessment methods is not sufficient.

The purpose of this paper is to examine sustainable construction techniques that are included in building assessment frameworks, and the underlying principles that should govern the development and implementation of such techniques. Existing building assessment methods, such as GBTool, BREEAM, LEED, and SBAT, are analysed with regard to their contribution to promoting the implementation of sustainable construction techniques.

The methodology comprised an extensive literature review in the field of sustainable construction and a detailed analysis of the chosen building assessment methods.

KEYWORDS

Building Assessment Methods, Sustainable Construction, Sustainable Construction Techniques

1. INTRODUCTION

This paper investigates the promotion of sustainable construction practice and techniques in existing building assessment methods. The concept of sustainable construction is introduced, followed by a definition of sustainable construction practice. Subsequently, the social, economic and environmental implications of sustainable construction practice are presented. This is followed by definition of sustainable construction strategies and techniques.

Building assessment methods (i.e. GBTool, BREEAM, LEED, and SBAT) are examined to see to what extent these methods incorporate construction techniques and strategies that enhance sustainability of a construction project.

Finally, a discussion of findings and general conclusions with recommendations are provided.

2. DEFINITION OF SUSTAINABLE CONSTRUCTION PRACTICE

The concept of sustainable construction was introduced when it became apparent that in order to secure future growth in the construction industry its development ought to be based on the premises of sustainability (sustainable development). The Rio Declaration on Environment and Development (UN, 1992) defines sustainable development as one that equitably meets developmental and environmental needs of present and future generations (Principle 3 of Rio Declaration on Environment and Development). Thus, sustainable construction embraces socio-economic, cultural, biophysical, technical and process-orientated aspects of construction practice and activities (Hill and Bowen, 1997).

Sustainable construction may be understood as a process that incorporates the entire life-cycle of a construction development (i.e. urban planning and project design, manufacturing, construction, operation and decommissioning) (Hill *et al.*, 2001). Hence, sustainable construction practice aims at addressing social, economic, technical and environmental aspects of construction activities at each stage of the construction process.

Therefore, the best means of achieving sustainable construction is through implementing sustainable construction practice. Construction practice organises the entire construction process and determines what approaches and techniques are employed. Sustainable practice allows the implementation of sustainability principles in construction decision-making. Dimson (1996) argues that sustainable construction practice is a critical factor in addressing the environmental crisis and provides commercial builders with a competitive business advantage.

As sustainability calls for *"a more integrated, people centred, participatory approach to ecological concerns"* (Rampele, 1991; 7), social aspects in construction have received considerable attention. In order to be sustainable, construction practice needs to include participation of interested and affected parties in the decision-making process during project planning and design, as well as during its operational phase. Moreover, sustainable practice must take on social responsibility and focus on the empowerment of local communities through skill training, as well as respond to their needs (Hill and Bowen, 1997).

This social dimension of sustainable construction is directly linked with the economic issues that are involved in a construction development. Sustainable construction practice needs to contribute to the local economy through creation of employment, use of local resources and empowerment of emerging contractors by promoting small medium and micro enterprises. Sustainable construction also gains competitive advantage to building developers and promotes eco-efficiency. Implementation of strategies that are resource efficient reduces the life-cycle costs of the construction development and contributes to the conservation of natural resources.

Another aspect is the environmental dimension of sustainable construction, which requires implementation of an ecological design (it accounts for climatic conditions and ecology of the construction site), conservation of natural resources, and most importantly, mitigation of environmental impacts at each stage of the development life-cycle.

Consequently, the sustainable approach within construction practice addresses a building as a system (sub-system of the built environment) and takes into account all interactions and relations between the system's elements. A building is perceived as an open system with the following relations (Building Research and Information, 1998):

- External relations of the designed system;
- Internal relations of the designed system;
- External-to-internal exchanges of energy and matter (system inputs); and
- Internal-to-external exchanges of energy and matter (system outputs).

In addition, sustainable construction practice shifts the focus of construction practitioners from product provision to service provision. Yashiro (2000) suggests that such service includes benefits from building functioning, performance and psychological perceptions embodied with buildings. Therefore, buildings are not the end-products of the construction process but devices for supplying service. This again necessitates implementation of a life-cycle management approach.

In summary, sustainable construction practice incorporates social, economic, technical and environmental aspects of construction development in a holistic manner and contributes to the implementation of sustainable construction objectives. However, the specific goals and targets can only be addressed through adequate strategies and methods, i.e. sustainable construction techniques.

2.1 Sustainable Construction Techniques

Sustainable construction techniques comprise particular methods of implementing strategies set by sustainable practice. These are low-energy and environmentally-sound (i.e. conserve rather than damage the environment) methods used during material (building product) manufacturing, construction works, as well as during the operational and demolition phases of a building's life-cycle.

As sustainable construction techniques provide practical solutions to implementing construction tasks, they are more technically and environmentally orientated. They contribute to the enhanced durability, reliability, functionality, quality and serviceabilty of construction developments (Hill and Bowen, 1997).

However, it is important that they also enhance the socio-economic dimension of a construction development. This can be achieved when the techniques are labour-intensive and can be performed by unskilled labour. A technique that illustrates this approach is the use of soil and caliche as building materials - inexpensive for materials costs, but emphasising labour in the construction method (Green Building Programme, 2002).

An example of a sustainable construction technique includes cogeneration in the management of waste. This technique allows the capture of emitted energy, which is converted into steam and used as additional energy to heat the building (Dimson, 1996). Other sustainable techniques could be neutralisation of concrete residue generated at construction site in order to protect the soil and groundwater resources (Dimson, 1996), or an evapotranspiration system for grey water recycling (Green Building Programme, 2002).

As the choice of a particular technique to be applied in the construction process is determined by a great range of factors (such as availability of resources, climate, location or building performance requirements, etc.), each construction development is implemented using specific construction methods. Furthermore, it is impractical to include a checklist of sustainable construction techniques in building assessment methods that would be relevant to each construction development being evaluated. Therefore, it is necessary to broaden a definition of sustainable construction techniques for the purpose of this paper.

In a broader view, sustainable construction techniques embrace all measures taken to comply with the principles of sustainable construction. Ueda and Yamamoto (1996) address such techniques *as "innovative approaches based on ingenuity and flexibility"*. These measures focus on the reduction in the use of raw, non-renewable materials and promote the use of secondary and renewable materials with low environmental impact. In addition, they aim at conserving energy, water and space.

One of the principles of sustainable construction practice is integration. This also applies to sustainable techniques, which need to be integrated to enhance efficiency and effectiveness of the building performance. It means that techniques used in the solid waste management must be integrated with the techniques applied in liquid waste management. Liquid waste management techniques (i.e. grey water recycling) need to be integrated with water-saving techniques (i.e. site irrigation). Likewise, passive building heating and ventilation systems must work in conjunction with mechanical HVAC systems.

Sustainable construction techniques can be only meaningfully implemented if they are guided by strategies of sustainable construction practice. The following strategies aim at reducing the overall building footprint (Environmental Building News, 2001):

Energy efficient buildings: low embodied energy, use of renewable energy sources (e.g. solar energy), energy-efficient mechanical equipment and appliances;
Water conservation: use of water-efficient appliances, water recycling, collection of rainwater,
Building recycling: utilisation of existing buildings and infrastructure for new developments;
Conservation of natural resources: reduction of construction waste, recycling and reuse of construction materials, simplification of building geometry to save materials, on-site waste segregation;
Protection of the site ecology: protection of wetlands and sensitive ecosystems during project planning and construction, mitigation of on-site impacts, minimisation of groundwater pollution during building operation;
Indoor quality: efficient air distribution systems, moisture control, optimal use of daylight;
Use of low-impact materials: use of materials with low environmental impacts during extraction and manufacturing, use of renewable and locally available materials, use of materials with low embodied energy; and
Durability and adaptability: use of durable materials, design for easy replacement and maintenance.

Most of these strategies are based on technical solutions selected during building design, implemented during construction and used during operational phase. Thus, it is important to ensure that the principles of sustainability are applied at each phase of the building development. In addition, technical aspects of building's design, such as its configuration, orientation, location of windows, availability of environmental controls are as important as building environmental management systems, because all of them affect building performance. This is the reason why building environmental assessment methods should focus not only on the aspects of environmental management but also include the evaluation of technical strategies that affect building's environmental performance.

3. BUILDING ASSESSMENT METHODS

The majority of existing building assessment methods provides means for the evaluation of building performance with respect to environmental (green) criteria. The most popular building environmental assessment methods include Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED) and Green Building Tool (GBTool). Due to the fact that they evaluate mainly environmental performance of buildings, they have a limited scope of the building sustainability assessment. The South African CSIR has recently developed a Sustainable Building Assessment Tool (SBAT), which evaluates a building across social, economic and environmental assessment criteria.

The increasing application of building assessment tools has provided considerable theoretical and practical experience on their potential contribution to environmentally responsible building practice (Barker and Kaatz, 2001). Building assessment methods play the following roles:

1. Provide common and verifiable set of targets and criteria;
2. Serve as building design tools; and
3. Serve as product comparison tools (frameworks for evaluation of building impacts and efficiency of the building systems).

Building design tools are more technically orientated, as they assist the design team with decision making. They show whether particular design decisions result in a high or low score during building assessment. Thus, these tools will assess the strategies and measures implemented in the construction development to achieve desired outcomes.

On the other hand, the product comparison tools provide means for eco-labelling of building with outstanding environmental performance. As they focus on the environmental performance of the building the assessment criteria concentrate mostly on the consumption of natural resources. This is achieved through the analysis of system inputs and outputs and consequent efficiency of processes taking place within the building system.

However, it is important to emphasise that evaluation of buildings purely on the basis of their environmental performance is not enough to create significant positive change in construction practice. Building assessment methods must serve as guidelines for designers and provide ways to integrate technical and environmental sustainability aspects in a construction development (Baker and Kaatz, 2001).

Todd *et al*. (2001) argue that incorporation of prescriptive strategies in building assessment tools may enhance their role as a design guideline system. However, they are likely to become out-of-date as new strategies are being developed (Todd *et al*., 2001).

The following sections provide a short description of each building assessment tool examined in this paper.

3.1 Green Building Tool (GBTool)

GBTool is a product of Green Building Challenge (GBC), which is an international initiative that set up an agenda for environmental assessment of buildings (Building Research and Information, 2001). It is a very comprehensive assessment tool that focuses on the biophysical aspects of a building development. GBTool is a market-orientated tool for awarding eco-labels, as well as a design guideline tool. It was developed to assess such building types as commercial, multi-residential and schools.

GBTool provides a generic framework of building assessment that is customised by national teams, who participate in the GBC, to suit the regional and local conditions and the context of building assessment. Thus, the assessment is made relative to regional benchmarks (Larsson and Cole, 2001).

Unlike any other assessment methods, GBTool framework includes environmental sustainability indicators to address total consumption of energy, land and emissions of greenhouse gases (Larsson and Cole, 2001).

3.2 Building Research Establishment Environmental Assessment Method (BRREAM)

BREEAM, designed as an eco-labelling system, was developed by the British Research Establishment (BRE) and private sector researchers (Larsson and Cole, 2001). This tool provides a relatively comprehensive assessment of building performance.

BREEAM may be used to assess new and existing office buildings, residential and industrial units as well as retail superstores and supermarkets (Baldwin *et al*., 1998).

3.3 Leadership in Energy and Environmental Design (LEED)

LEED is a design supporting tool and product marketing tool launched by the US Green Building Council (USGBC) to rate commercial office buildings. It aims at stimulating green competition and transforming the marketplace. LEED may be used for the assessment of commercial, institutional and high-rise residential new constructions and major renovation (www.usgbc.org).

This assessment method allows for a comprehensive assessment of building environmental performance and uses a life-cycle approach. LEED comprises a checklist of credits that are linked to design strategies (Todd and Lindsey, 2000). Thus, it promotes integrated design and construction process (www.usgbc.org).

3.4 Sustainable Building Assessment Tool (SBAT)

SBAT is a tool that targets sustainability of construction developments. In order to address social, economic and environmental aspects of a development, SBAT compromises in terms of comprehensiveness of covering biophysical issues (Barker and Kaatz, 2001).

This building assessment tool was designed by the Sustainable Building Group of CSIR in South Africa. SBAT may be used as a decision-supporting tool and a brief to the design team (CSIR, 2001).

4. DISCUSSION OF FINDINGS

The selected building assessment tools have been compared according to appropriate environmental aspects of building assessment (e.g. ecological design, indoor air quality, energy conservation, water management, material and waste management, adaptability and flexibility). The comparative evaluation resulted in the findings discussed below.

GBTool, BREEAM, LEED and SBAT evaluate construction projects with respect to their environmental impacts at the global, regional and local scale. In doing so, these tools assess building performance focusing on the amount of consumed resources (i.e. energy, water, land and materials) as well as on environmental management systems implemented (i.e. environmental purchase policy, meeting consumption targets, monitoring of building operations). This part of the assessment does not allow for specification of sustainable construction techniques that have been applied in a particular project.

However, the second part of the building assessment is related to the use of specific materials, design strategies and application of innovative technologies. Incorporation of such measures in the building assessment allows to demonstrate to building designers applicability of specific techniques that enhance sustainability of construction projects.

It was found that LEED gives credits for certain aspects of a building development, such as sustainable site development, energy efficiency, water conservation, efficient use of materials and resources as well as indoor environmental quality. Thus it is much easier to account for sustainable techniques using LEEd assessment. GBTool and BREEAM are structured in a major part around environmental loadings (i.e. resource consumption and pollution emission), which represent issues that belong to the domain of environmental management. SBAT compromises the two approaches as it addresses issues of water management and energy use management, use of materials and buildings components, waste management strategies as well as site consideration in the environmental component of the assessment.

Accounting for the technical aspects of building design, GBTool, BREEAM, LEED and SBAT emphasise the importance of design that facilitates solar control (i.e. passive solar performance, minimisation of glare) as well as control of environmental conditions (e.g. temperature, humidity). While SBAT refers only to the quality and quantity of supplied air (i.e. adequate ventilation), GBTool and BREEAM also require specification of the location of air inlets and outlets aiming at reducing air recirculation. GBTool further focuses on the filtration systems used for ventilation. In addition, GBTool and BREEAM require description of ventilation, cooling and heating systems and associated distribution systems, whereas SBAT inquires about the use of passive ventilation, cooling and heating systems.

With regard to energy conservation, technical approaches mentioned in the building assessment systems vary significantly. GBTool requires description of measures taken to minimise operating energy consumption in a building and specification of fuel type used for generation of electricity as well as heating or cooling. BREEAM inquires about carbon dioxide net emissions and submetering for substantive energy uses. SBAT emphasises in this domain the use of passive environmental control systems for ventilation, heating and cooling, solar control and low energy appliances. Moreover, GBTool, LEED and SBAT highlight the importance of the use of renewable energy

The issue of water management is covered in a more homogenous manner by all assessment tools. All methods aim at reduction in the use of water. Thus, they inquire about water use metering and use of water-efficient appliances. GBTool, LEED and SBAT ask about harvesting of rainwater and use of grey water systems. SBAT requires specification of water efficient delivery devices. LEED is more proactive in this regard and requires specification of water efficient landscaping and innovative wastewater technologies. Water management includes the prevention and minimisation of runoff. SBAT refers to the implementation of techniques that would minimise runoff, whereas BREEAM also emphasises measures necessary to avoid contamination of watercourses due to on site treatment of oil interceptors and filtration. In addition, BREEAM and GBTool assign points for water, gas and refrigerant leakage detection systems.

Other essential aspects of building assessment include resource consumption and waste management. All building assessment tools promote use of materials and products with low embodied energy, and low emitting characteristics. Building materials should originate from local, renewable resources. In addition, all methods emphasise reduction, reuse and recycling strategies with regard to building components (e.g. reuse of existing facades, potential for future recyclability of building structures or use of recycled construction materials). GBTool, LEED and SBAT also inquire about strategies implemented to minimise construction waste.

SBAT covers the aspect of waste management in a great detail as it asks about onsite recycling of organic and inorganic waste as well as disposal of toxic waste. GBTool asks only about description of sanitary waste management systems. Yet, these issues not included in BREEAM.

Furthermore, GBTool and SBAT focus greatly on the adaptability and flexibility of building structures and systems, which determine quality of building service and sustainability of its performance. BREEAM does not refer to this aspect of building design strategies.

All examined building tools address design strategies to limit noise levels and measures taken to protect the vegetation during construction works. GBTool requires specification the extent of environmentally-sensitive construction procedures. Whereas, BREEAM refers to decontamination of land prior to construction works. LEED focuses on the measures that would reduce onsite disturbance and control erosion and sedimentation processes. SBAT, on the other hand, refers to the building and construction process designed to minimally impact the environment, which a vaguely specified requirement.

In addition to the above, LEED concentrates also on such technical issues as the reduction of light pollution and control of indoor chemical and pollutant source. SBAT incorporate building designs adapted for the disabled.

Summarising, due to its structure, LEED facilitates identification of potential sustainable strategies and encourages green design. This method also provides a reference guide that suggests strategies and techniques for achieving each assessment criterion. On the contrary, BREEAM is more adequate to assess building operational performance rather than the implementation of technical strategies in a construction process.

GBTool and SBAT are structured partially around environmental loadings and partially around prescriptive strategies. Both of them require specification and description of measures and system designs. This means that techniques used to achieve specific goals need to be indicated in the assessment.

5. CONCLUSIONS AND RECOMMENDATIONS

It may be concluded that none of the examined building assessment methods refers directly to specific techniques necessary to achieve particular strategy to enhance sustainability of a building system. While BREEAM and LEED are structured as checklists, GBTool and SBAT require to description and specification of technologies and measures to be applied to addressing particular aspects of building assessment.

It is argued that such an approach gives freedom to building designers and developers to choose various techniques that can lead to a desired endpoint. In this way, none of the technologies used in the building construction and operation will be perceived as an out-of-date practice. On the other hand, this leaves room for implementation of techniques that are cost-effective and not necessarily represent the state of art or the best environmental option.

Furthermore, the examined building assessment methods fail to address all stages of a building life-cycle. For instance, the building decommissioning stage is largely ignored by all examined methods. Yet, this stage also results in considerable environmental impacts and implementation of appropriate deconstruction techniques would considerably contribute to mitigation of potential impacts. It is important to remember that the choice of a particular technique also affects social and economic aspects of building sustainability. Greater emphasis should be placed on the construction stage of a building life-cycle.

It appears that LEED proves to be the most proactive building assessment methods that promotes implementation of sustainable construction techniques and approaches. The structure of its assessment framework facilitates design and planning decision-making with respect to the sustainable construction practice. LEED goes further than simple checklist assessment of building developments. It also suggests certain technical strategies and solutions that are effective in addressing particular assessment criterion.

GBTool and SBAT, on the other hand, require specification and description of technical solutions and building systems designs. This means that techniques used to achieve specific goals need to be indicated in the assessment. This is also a way of promoting new technical solutions which enhance sustainability of building developments.

BREEAM also focuses on technical aspects of building developments. However, greater emphasis is placed on the building performance and environmental management systems implemented. Thus, this building assessment method has a limited potential to promote sustainable construction techniques.

Therefore, in conclusion, although there is a strong tendency to contextualise and customise each building assessment, it is important to ensure that the choice of construction techniques is not guided only by the aspects of cost and practicality. The chosen techniques must have optimal potential to enhance the overall building sustainability with regard to social, economic and environmental issues involved in a particular building development. It is crucial that building assessment methods also provide means to address these issues.

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