An evaluation of existing environmental buildings' rating systems and suggested sustainable material selection assessment criteria

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Abstract

Environmental ranking systems for buildings' sustainability and green design are widely used all around the world. Ranking systems are used as planning guidelines to implement sustainability into buildings in the design stage. Although sustainability ranking systems may have their pitfalls, these systems have shed the light on sustainability and has led to businesses investing in green design. Many rating systems are available to assess buildings in terms of sustainability, where a set of criteria are assessed using a quantitative approach and a score is provided, the question that arises is are these systems reliable? Different rating systems are available, among these systems are Leadership in Energy and Environmental Design (LEED) in the USA, Building Research Establishment's Environmental Assessment Method (BREEAM) in the United Kingdom, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) that has been developed for the Japanese market, Green Globes that has been implemented in Canada, Sustainable Building Tool (SBTool) as an international toolkit and framework for rating the sustainable performance of buildings and projects. All rating systems are designed towards assessment of the building impact on the environment. All assessment methods have limitations which questions the usefulness of these methods and advocates the need for a better sustainability assessment system. This paper is an attempt to highlight the pitfalls of current environmental ranking systems and to raise awareness towards the need for a system which addresses sustainable material and system selection in project planning stage individually rather than assessment of the building in terms of sustainability as a whole. Suggested criteria for an effective sustainable system

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evaluation tool include (1) resource management, (2) cost efficiency, (3) technical aspects, (4) environmental impact, and (5) design for human. Multi criteria decision making tools is suggested as an evaluation criteria for different sustainable materials and systems.
Keywords: building sustainability, critique of environmental rating systems, criteria for sustainable material selection.

1 Introduction

Existing environmental building assessment methods evaluate the project design against different categories. These rating systems are subjective in their evaluation with no guidelines on how to assess a specific system in terms of sustainability. Common categories among varying building types are (1) Location and Transportation, (2) Sustainable Sites, (3) Water Efficiency, (4) Energy and Atmosphere, (5) Indoor Environmental Quality, (6) Innovation, (7) Regional Priority.

All building professionals use existing environmental rating methods when they seek guidelines on certification to "build green". There is a need to evaluate existing rating methods to examine if existing rating methods are effective in enhancing sustainability in buildings.

2 Evaluation of existing environmental assessment methods

Existing environmental assessment methods are addressed in terms of their effectivity, their limited cost assessment, their regional variability, their complexity, generalization, and missing criteria, their mixed quantitative and qualitative criteria, their weighting of different criteria equally, which offsets important criteria by unimportant ones, their subjectivity in meaurement scale, and their ineffective use for existing building evaluation.

2.1 Implementation of existing environmental assessment methods as design guidelines

Sustainability implementation into buildings is an early decision during early planning phase which takes place before the design phase. Existing rating systems follow a set of guidelines to fulfill the certification of building requirement. Designer innovation and new technologies creativity are not incorporated into the design as engineers and decision-makers are faced with the dilema of evaluating different materials and systems during the design stage to implement sustainability into their building. It is more useful to have a decision making tool that helps in the evaluation of building material specific rather than evaluation of a building as a whole. It is more effective to incorporate sustainability at early pre project planning stage and have it's reflection in the conceptual design by evaluating alternative sustainable systems that can enhance building's sustainability rather than trying to fulfill certification guidelings at late design phase. Although some environmental building tools are advertised to be used to assess sustainability of existing buildings such as LEED and BREEAM, the remedial work that a building undergoes to become sustainable is difficult, time consuming and costly. Furthermore, energy consumption, waste, and pollution that is produced in replacing existing systems with new more environmentally friendly ones are things to consider when refurbishing a building to become more sustainable. Therefore existing environmental rating systems of buildings maintenance are doubtful in their effectiveness.

2.2 Lifecycle cost analysis instead of initial cost as a criteria of evaluation

Success of a project is determined by whether is meets a set of constraints. These project constraints are time, cost, quality and safety for a pre defined scope of work. Cost is a major success driving factor in projects. Some environmental rating systems such as LEED do not include lifecycle cost analysis in their evaluation framework [1]. Lifecycle cost analysis that need to be evaluated in buildings includes (1) initial cost of systems to select from during the design phase, (2) ongoing cost, which is related to maintenance and building running cost, and (3) recovery cost, which is related to demolition cost, and material waste reduction. As a result, a new evaluation system which incorporates cost is needed.

2.3 Limitations in regional variabilities implementation of existing rating methods

Most environmental building assessment methods were developed for local use and do not allow for national or regional variations [2]. Many variations accorss different regions exist such as climate conditions, pollutants, local building material and building methods, construction and maintenance equipment, labor work force, cultural and social differences, availability of resources, and legislations and regulations. Implementation of a specific rating system such as LEED or BREEAM in other countries is difficult because customising the system with a set of pre-designed environmental criteria that are prepared for worldwide use without further adjustments is impossible. According to the Green Building Challenge website [3], “SBTool is a generic framework for rating the sustainable performance of buildings and projects. It may also be thought of as a toolkit that assists local organizations to develop local SBTool rating systems”. However, a major drawback of the SBTool is that individual country teams established scoring weights subjectively when evaluating their buildings. The level of complexity and difficulty of SBTool is another issue in adapting this system.

2.4 Complexity, generalization, and missing criteria of existing models

Environmental rating systems are faced with the challenge of capturing all aspects of environmental evaluation criteria. As a result, environmental building assessment methods tend to be as comprehensive as possible with a large number of criteria to evaluate. This approach has led to complex systems which require analysis of large quantities of detailed information. Accordingly, existing environmentatl rating systems tend to be general to capture most environmental criteria for evaluation purposes. Existing environmental rating methods do not encompass many green building aspects, for instance LEED does not address land use, ecology of a building, and efficient systems for waste disposal [1]. Consequently, the usefulness in providing a clear direction for evaluation is jeopordized. It is a challenge to balance the completeness of the rating system and its simplicity. Identification of criteria to evaluate materials or systems in term of sustainability is dependent upon the problem the evaluation team is faced with. Brainstorming criteria that are important to sustainability on a project by project basis is an important step towards effective sustainability assessment.

2.5 Mixed evaluation of quantitative and qualitative criteria

Existing environmental rating systems combine both quantitative and qualitative assessment criteria for sustainability. Some criteria are measureable such as (1) energy and atmosphere, such as power savings, green power usage and carbon offset, toxic gases emissions such as CO_2 emission and renewable energy production, (2) indoor environmental quality in with respect to indoor air quality performance in terms of smoke measurements thermal temperature, interior lighting and daylight levels, (3) performance sustainable site including pollution prevention strategie, (4) water consumption. Other criteria are non measurable such as (1) location, (2) ease of transportation, (3) health, welbeing and increased comfort, (4) Innovation, (5) sustainable management strategies, (6) waste and recycling strategies. Rating buildings using a scoring tool that combines both quantitative and qualitative measurements is an undermining of the importance of qualitative criteria. Assessment of criteria influencing building sustainability requires a more advanced assessment technique which captures criteria subjectivity which influences building's sustainability.

2.6 Consistent weighting for different criteria

Different criteria contribute towards building sustainability with varying levels of importance. Existing environmental rating systems assume that all criteria have equal importance towards sustainability. Furthermore, there is no scientific reasoning or theoretical basis for deriving the weighting factors. Cole states that "the main concern is the absence of an agreed theoretical and non-subjective basis for deriving weighting factors. There is not enough consideration of a weighting system attached to the existing environmental building assessment methods" [4]. Some existing rating systems such as LEED provides a default weighting system and encourages users to change the weights based on regional differences [1]. Todd *et al.* [5] states that "since the default weighting system can be altered, it may manipulate the results to improve the overall scores in order to satisfy specific purposes". Although different criteria have varying weights towards fulfilling the sustainability objective on a project by project basis, the overall performance score in existing environmental rating systems is obtained by a simple aggregation of all the points awarded to each criterion. There is a need for an assessment method in which decision makers assess the criteria importance based on their belief on criteria importance.

2.7 Subjectivity in measurement scales

In existing environmental rating systems, building performance in terms of achieving sustainability objectives is measured using a scoring technique. Measurement scale of existing rating systems is subjective and might vary depending on the evaluator that performs the assessment. There is a need for a consistent measurement scales where assessment is based on clear guidelines that ensure consistency across different assessed projects. There is a need for a new assessment method which is more detailed and focuses on material selection at early preliminary pre project planning stage where stakeholders focus on the selection criteria and assign weights of these criteria to come up with a method to assess material in terms of different aspects.

2.8 Limited innovation in existing building evaluation

Although many existing environmental rating systems recognize innovation as a measurement in their building rating (BREAM and LEED), having guidelines to follow where a set of criteria are specified to get a building certified has caused limitation on design implementation of new technologies and creative sustainable designs. Also, the timing of implementing existing rating systems is at a late design stage which is a barrier towards design ingenuity and creativity.

2.9 Ineffective energy use of existing building evaluation

Certification awards takes place before the energy savings are proven, as a result energy efficiency of certified buildings is questionable. There is a need to examine and verify the energy usage level of certified buildings during their operation and usage and compare it to typical buildings. Another argument is that once a building is ranked satisfactory using existing environmental ranking systems, the operation of the building by the owner becomes questionable. Environmental ranking systems do not monitor the operation of buildings to ensure the energy efficiency of these buildings.

Certification of buildings in terms of sustainability is expensive, time consuming and requires applying for certification by a third party non-governmental organization. One might argue that the money spent in certification could be used in enhancing building sustainability. It is time for governments to mandate green rules and regulations without the need for a certification entity.

After reviewing existing environmental rating methods, it is clear that implementation of a scoring method with a set of criteria is ineffective. The suggested method of evaluation is subject to material selection among different available alternatives rather than evaluating the building as a whole in terms of sustainability. Decision makers evaluate different materials and systems to select from in terms of sustainability. The focus should be towards providing guidelines on criteria that decision makers need to address in their assessment of alternative materials and systems.

3 Suggested criteria for sustainability evaluation

Kohler [6] states that "a sustainable building has three dimensions: ecological, cultural, and economic sustainability". Ding and Langston [7] developed a multi-dimensional model to measure sustainability. The model determines a sustainability index, and can be used to compare options for a given problem and to benchmark projects against each other. The sustainability index developed by Ding and Langston is composed of four main criteria which include (1) maximize wealth and investment return, (2) maximize utility including social benefit, (3) minimize resources including all inputs over the full life cycle, and can be expressed in terms of energy (embodied and operational), (4) minimize impact in terms of loss of habitat [7].

After studying criteria that impact sustainability, suggested criteria that decision makers need to address in their selection of material towards building sustainability enhancement is composed of five aspects; (1) resources management, (2) cost efficiency, (3) technical aspects, (4) environmental impact, and (5) design for human aspects. Figure 1 represents the building sustainability enhancement criteria. An importance of each aspect towards sustainability in general can be assigned on a project by project basis where decision makers make the call on assessment of each criteria importance level. The framework for each criteria is further detailed into sub criteria where decision makers assess the importance of each sub criteria towards the main criteria effectiveness. It is important to understand that the criteria and sub criteria suggested in this study can be further detailed or minimized according to the material or the system decision makers are assessing. This study is not intended to limit decision makers to a set of pre-defined model as the case of existing rating systems. Main criteria and sub criteria are further discussed in the following discussion.

Figure 1: Building sustainability enhancement criteria.

3.1 Resources management

Resources management during planning and material extraction is an early sustainability assessment criterion; it is composed of efficient use of resources which includes efficient energy used in the planning and material extraction, efficient use of planning material that includes the decision on the selection of non-toxic and local material for project usage, efficient use of water to extract material, efficient use of land that includes planning for sustainable land and management techniques and vertical expansion to maximize land use, and efficient use of labor and equipment during the extraction of material used in construction. Figure 2 shows a hierarchy structure of resource management criteria and sub-criteria.

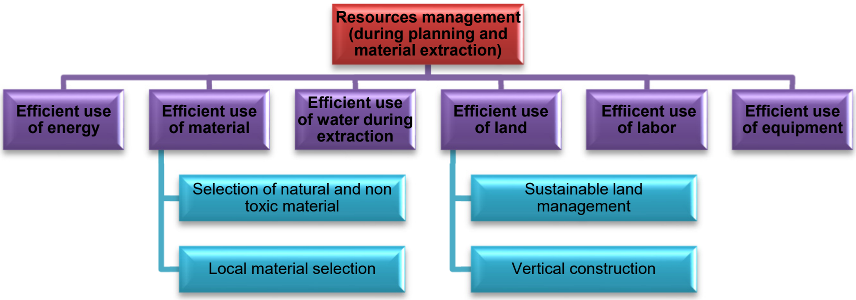

Figure 2: Hierarchy structure of resource management criteria and sub-criteria.

3.2 Cost efficiency

As described earlier, a detailed cost analysis throughout the project life is needed, therefore cost efficiency criteria include (1) initial cost which is related to lifecycle cost analysis, selection of local material, and selection of local management techniques, (2) cost in use which is related to efficient practices to optimize the cost during the service life of the project and includes the added quality by selecting material with long expected service life, design for easy maintenance to minimize the maintenance cost, design to protect material from destructive natural forces such as sun, rain, and wind, maintenance management plan using innovation and technologies to ensure efficient energy usage, design for possible expansion and possible changes of building function, and design a building that could adapt a new fuel sources or renewable energy technologies for electrical system and Heat, Ventilation, and Air Conditioning (HVAC), and (3) recovery cost which includes strategies for building demolition and material recovery to minimize cost and maximize material reuse. Figure 3 represents a hierarchy structure for cost efficiency criterion.

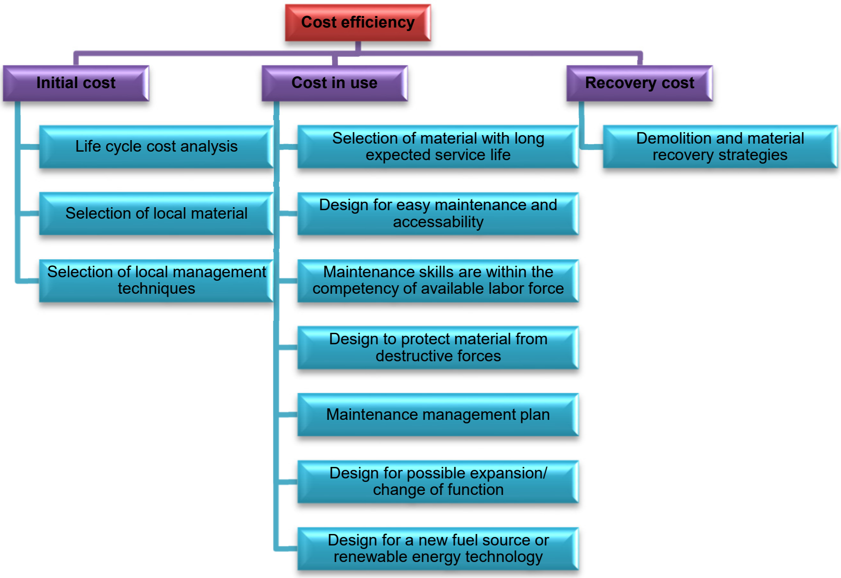

Figure 3: Hierarchy structure for cost efficiency criterion.

3.3 Technical aspects

Technical aspects are criteria related to sustainability practices including energy savings during construction and operation. Technical aspects include constructability practices to ensure that the design can be translated into physical building with easy construction practices, and energy usage during construction phase, Furthermore, technical aspects is related to the use of material and construction practices which adds quality to have a long life expectancy to minimize maintenance, During construction and implementation phase, implementation of material and construction practices that save energy such as insulation, the use of multi glazing in windows and other practices that save energy. The building can be natural disaster resistance using material and design that can resist natural forces such as fire, flood, earthquakes and other natural damaging forces. Figure 4 represent a hierarchical structure for technical aspects criteria that affect sustainability.

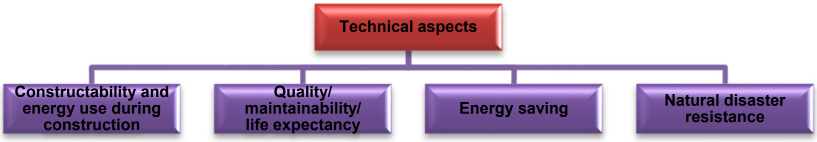

Figure 4: Hierarchical structure for technical aspects criteria.

3.4 Environmental impact

Environmental impact is subdivided into air impact, water impact, energy use, soil impact, and waste material management. Air impact is related to all toxic gases that are the result of implementing non sustainable practices and air pollution as a result of non-green energy and power consumption. Air impact is related to all toxic gases emission such as sulfur dioxide (So_x), nitrogen oxides (No_x), carbon mono oxide (CO), carbon dioxide (CO_2), and volatile organic compounds (VOCs). Water impact is related to optimization of the system by designing an efficient water system using water pressure control and other strategies such as designing an alert system to detect water leaks. Water conservation strategies is related to technologies and measures that could be implemented to allow water conservation such as water efficient plumbing fixtures and designing a low demand landscaping. Water reuse and recycling systems include plumbing to reuse non potable water for irrigation. Energy use is related to operational energy, localization of material, labor and equipment used for both construction and maintenance and energy saving strategies such as thermal insulations. Operational energy is the energy that is used to maintain the internal environment of a building. Designing a system that optimizes the operational energy is critical in selecting material and systems to enhance sustainability. Localization of material, labor and equipment used for both construction and maintenance of a building saves energy by reducing energy loss in transportation. Energy needed for operation can be reduced by implementing technical solutions such as building insulation. Soil pollution can be a problem during construction and during natural material extraction due to hazardous waste. Soil degradation and loss of fertile land is the result of soil pollution. Biodegradable construction material selection is a strategy towards minimizing negative soil impact. Another factor towards environmental impact is waste material management, which considers the design for reusable material, storage and disposal of waste material strategies to minimize waste negative impact. Figure 5 shows hierarchical structure for environmental impact criteria that influence sustainability.

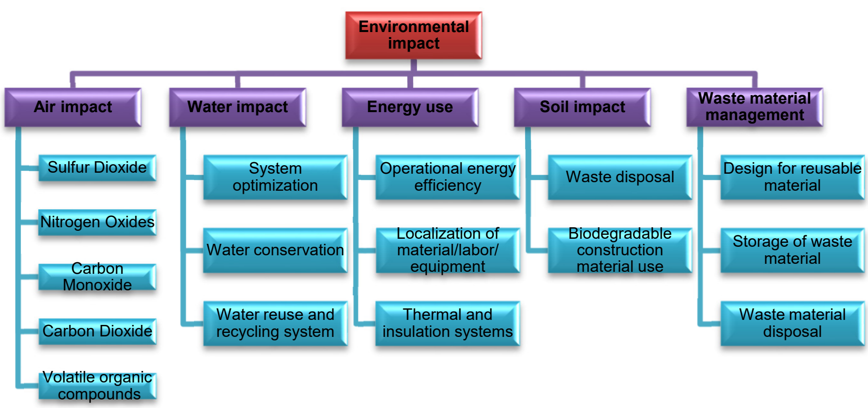

Figure 5: Hierarchical structure for environmental impact criteria.

3.5 Design for human aspects

Design for humans is concerned with indoor environmental quality. Design for humans is related to thermal comfort, daylight, natural ventilation, acoustic comfort, safety and risk prevention, functionality and possible expansion, and aesthetic. Thermal comfort is related to interior air temperature, humidity level, solar radiation, and air flow circulation systems. Daylight aspects of the design for humans include strategies that optimize urban design and building orientation, selection of the size, form and glazing treatment for windows, selection of shading for visual comfort and cooling, and selection of solar radiation system. Natural ventilation strategies are related to selection of the building layout and the selection of windows and doors orientation to enable natural ventilation. Acoustic comfort strategies are related to the selection of wall insulation, the selection of sound insulation, the selection of wall framing, and the selection of window framing. Safety and risk prevention aspect of design for humans is related to evaluation of strategies related to the labor force during construction, evaluation of strategies related to public safety during construction, and evaluation of strategies related to the end users' safety. Functionality and possible expansion strategies aspect of design for humans is related to design selection options that allow for possible future expansion and is related to the options of selecting durable material for the building to minimize maintenance. Aesthetic strategies selection is another aspect of the design for human to enhance the building indoor environmental quality and enhance sustainability. Figure 6 depicts hierarchical structure for design for human criteria.

4 Suggested model

Although international efforts have been conducted on measuring building sustainability using environmental scoring rating systems, an aggregated approach with different criteria including environmental impact is needed. Multi criteria that include resources management, cost efficiency, technical aspects, environmental impact, and design for human aspects is suggested as the criteria evaluated in selecting sustainable building material. Assessment of a building in terms of sustainability as a whole has its shortcomings, it is suggested to assess material or systems in terms of sustainability rather than assessing the building as a whole. In reality, decision making is based on a set of multi dimensions criteria which integrates different sustainability criteria. Different criteria contribute towards sustainability with varying degrees of importance, therefore criteria can be weighted by decision makers during the analysis.

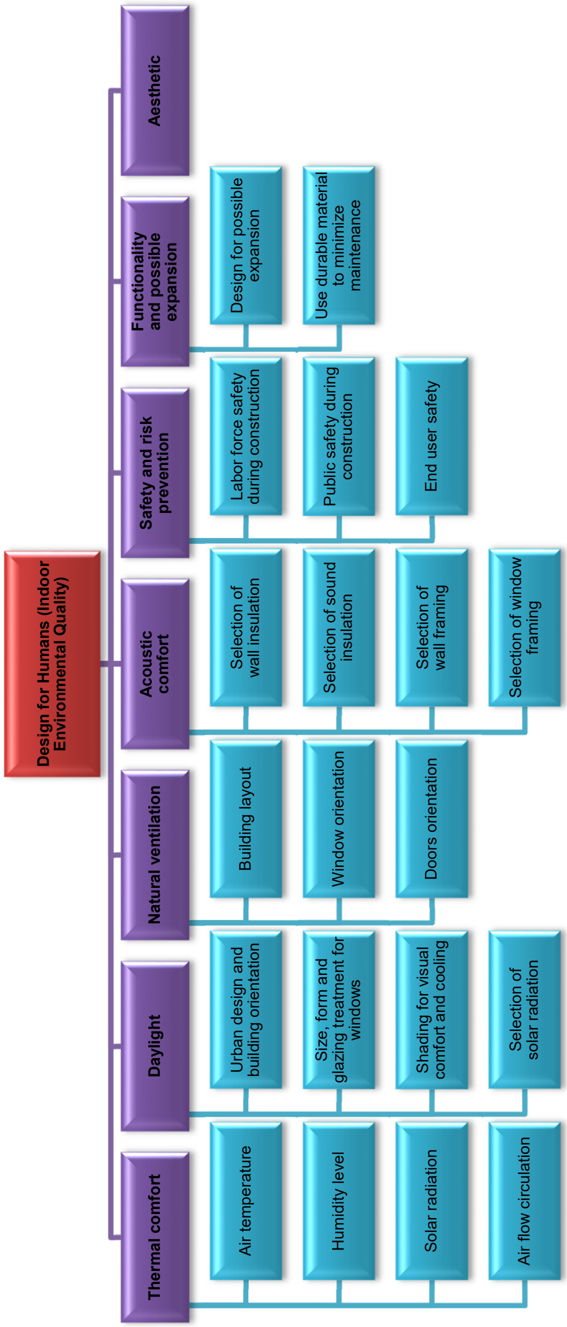

Figure 6: Hierarchical structure for design for human criteria.

5 Conclusion

Existing environmental building assessment methods have their limitations as illustrated in this paper reducing their effectiveness. There is a need for greater effort among the owner, the designer and other project stakeholders to implement sustainability into buildings. Major obstacles towards acceptance of existing environmental rating systems include implementation of existing environmental assessment methods as a design guidelines, lifecycle cost analysis instead of initial cost as a criteria of evaluation, limitations in regional variabilities implementation, complexity, generalization, and missing criteria of existing models, mixed evaluation of quantitative and qualitative criteria, consistent weighting for different criteria, subjectivity in measurement scales, limited innovation in existing building evaluation, ineffective energy use of existing building evaluation.

A multi criteria decision making method to evaluate material and systems rather than a rating system for the building as a whole is the suggested model of evaluation in this study where criteria for evaluation consists of resource management, cost efficiency, technical aspects, environmental impact and the design for humans are provided where decision makers can use these criteria and sub-criteria in brainstorming the criteria and sub-criteria that is important in the evaluation framework. Additionally, stakeholders will participate in assessing weights to reflect the degree of importance of criteria and sub-criteria at an early planning stage of the project.

References

[1] U.S. Green Building Council (USGBC), http://www.usgbc.org/, August, 2016.
[2] Ding, G.K.C., Sustainable construction – The role of environmental assessment tools, Journal of Environmental Management, Vol. 86, No. 3, pp. 451–464, 2008.
[3] International Initiative for Sustainable Built Environment, http://iisbe.org, August 2016.
[4] Cole, R.J., Emerging trends in building environment assessment methods, Building Research and Information, Vol. 26, No. 1, pp. 3–16, 1998
[5] Todd, J.A., Crawley, D., Geissler, S., and Lindsey, G. Comparative assessment of environmental performance tools and the role of the Green Building Challenge, Building Research and Information, Vol. 29, No. 5, pp. 324–335, 2001.
[6] Kohler, N., The relevance of Green Building Challenge: An Observer's Prespective, Building Research and Information, Vol. 27, No. 4/5, pp. 309–320, 1999.
[7] Ding, G.K., Langston, C., A methodology for assessing the sustainability of construction projects and facilities, Proceeding of Environmental and Economic Sustainability, ICEC Melbourne, 2002.