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DEVELOPMENT OF GREEN CONSTRUCTION ASSESSMENT MODEL FOR BUILDING PROJECT

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The construction sector as one of the parties using natural resources in the form of manufacturing or natural material needs to evaluate the activity of the construction process. Indonesia as a developing country requires various types of infrastructure, one of which is building construction. Various studies show that the impact of the construction process produces a large number of wastes and causes a decrease in the number of non-renewable materials. One of approaches to organize those impacts is by applying the principle of green construction. In Indonesia, this principle has not been clearly defined the meaning and the size that will be used. The purpose of this research is to develop green construction assessment model for building construction in Indonesia to improve the performance of contractor in the construction process. The scoring model is developed hierarchically composed of aspect, factor, and green construction indicator using additive model. The test model was carried out in three different project characteristics, reflecting the combination of planned green construction and green contractors. The result of green construction assessment model is able to represent the fact that occurred in the construction process.

Keywords: Model assessment, Green construction, Building construction, Indonesia.

1 INTRODUCTION

In recent years, environmental issues in construction sector have been the major part of discussion by many parties in many countries. As one of many sectors that consumes natural resources, the construction is considered as an important part of the production process that contributes directly and indirectly to global warming phenomenon. Waste reduction in construction process is deemed as an important goal, as it leads to the reduction use of natural resources (Oladiran, 2009). A study by Anink (1996) suggested that construction process consisting phases from material extraction, transportation to the construction project site, construction process, building operation, building maintenance, and to building demolition consumed 50% of the entire removal of natural material and emitted wastes by 50% of all wastes. In US wastes generated by construction activity can significantly degrade the quality of the environment (Hendrickson and Horvath, 2000). To reduce the negative impact on the environment, the implementation of environmental management based on commitment and clear objective is a key factor to achieve success in reducing the negative environmental

impact that comes from construction activity (Christini, Fetsko, and Hendrickson, 2004). Approach to reduce negative impact to environment is commonly known as sustainable construction of green construction.

The purpose of sustainable construction is to construct building based on ecological considerations, using natural resources efficiently and environmentally during the operational of the building. Du Plessis (2002) stated that part of sustainable construction is green construction that is a holistic process aiming to restore and maintain the balance between the natural and unnatural environment. The definition of green construction encompasses the planning and implementation of the construction process to minimize the negative impact of the construction process on the environment for a balance of the environmental ability and human needs for present and future generations.

2 GREEN CONSTRUCTION CONCEPT IN INDONESIA

Environmental issues are typically considered as additional burden to construction projects, especially for those in the developing countries. Therefore, in Indonesia these issues were often got the least attention or even neglected. With the ever increasing public pressure for more environmentally accountable process for creating sustainable built environment, the Indonesian Construction Industry Development Board has started to response to these issues more seriously, among other by proposing a strategic action plan, called the Indonesian Construction 2030. One of the strategic objective of the plan is the promotion of sustainable construction for wastes reduction and ease of maintenance of the building after construction (LPJKN, 2007). To anticipate the negative impact of wastes and emissions caused by the construction process, the Indonesian construction industry has adopted the so-called "green concept". This green concept was initially brought into Indonesia through a Singapore government-owned project in Indonesia in 2007. In this project, knowledge of the green principles was transferred from Singaporean consultant design and supervision engineering firm to Indonesian contractors. In other instances, several green projects were initiated in Jakarta and several other cities in Java island, including the office building for the Ministry of Public Works. This particular building was planned and designed to get Platinum award by GBCI. The application of green concept for construction projects was then expanded to projects outside Java island. At the same time, other initiative was also introduced to promote green concept. The Green Building Council of Indonesia (GBCI) is an independent non-profit organization that focuses on effort to promote and monitor the application of green concept for building projects in Indonesia. GBCI has developed Greenship rating system to assess and rate the environmental impacts of a building. Based on this rating system, GBCI will award buildings according to how well a building can meet its green criteria. This rating system, however, is predominantly focuses on design and operation & maintenance of building, whereas the construction aspects are very limited. Only 4.44% of all criteria for green building is dedicated to assess the construction. Therefore, in order to accommodate more environmental issues in construction, other assessment model is considered important. Green construction assessment model is thought to help promoting green concept in the industry by assisting the contractors applying good green construction practices.

3 GREEN CONSTRUCTION ASSESSMENT MODEL

The green construction assessment model was developed based on input from experts and practitioners in the industry. The process encompassed three main stages. The first stage is to formulate green construction indicator by soliciting input from respondent with various background and expertise. This step was then followed by examining the suitability of green construction indicators, by taking feedback and confirmation from respondents and other related parties, and formulation of weighing factor for the indicators. The second stage was the development of green construction assessment model. This model was formulated in a hierarchical form. The last stage was to validate the model by applying it on existing building construction projects.

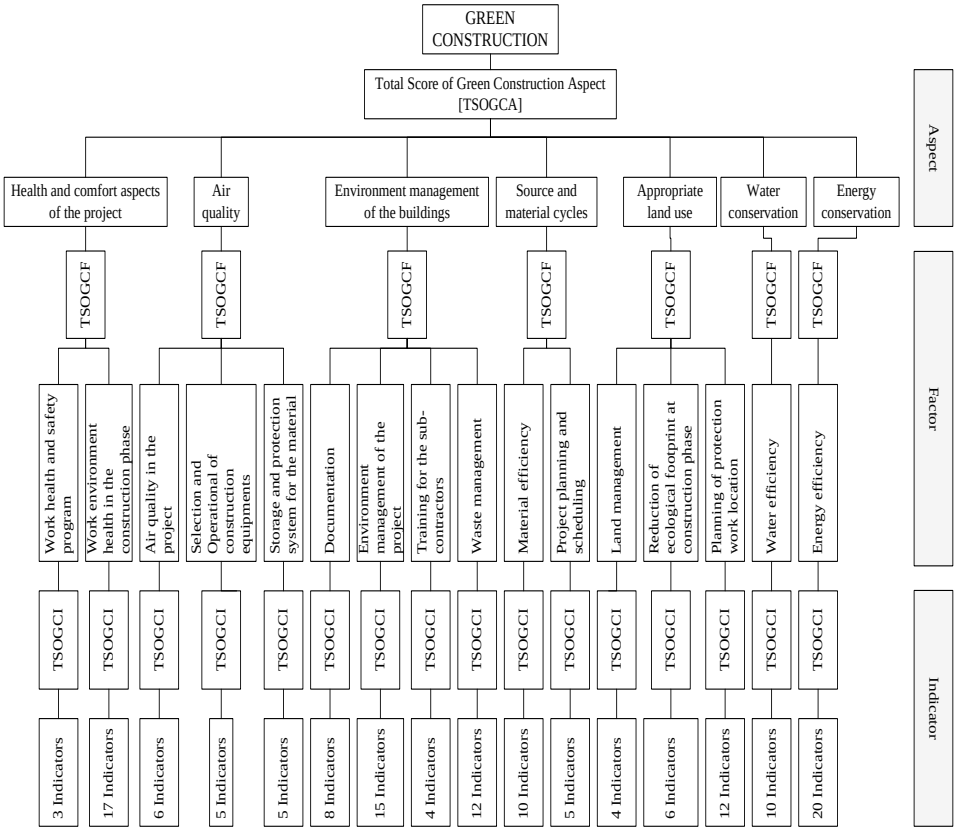

Figure 1. Hierarchical Assessment Model of Green Construction.

The scoring model is developed into four level hierarchies. Level 0 is green construction. Level 1 describes the green construction aspect consisting of seven aspects, namely: energy conservation, water conservation, appropriate land use, resource and material cycles, building environmental management, air quality, and health and comfort of the project. Level 2 describes green construction factors

developed based on the model proposed by Glavinich (2008), Kibert (2008), and practices by one leading national contractor. Level 2 consists of 16 factors, namely: planning and scheduling of construction project, source and material cycle, job site protection plan, management of wastes construction, storage and protection of material, workplace health of construction phase, health and safety programs, selection and operational construction equipment, documentation, training for subcontractor, reduction of ecological footprint of construction phase, air quality of construction phase, water efficiency, land management, and energy efficiency, environmental management of construction phase. Level 3 describes green construction indicators, which consists of 142 indicators. Hierarchical assessment model of green construction is shown in Figure 1.

The respondents in this research were divided into three groups: (a) the contractors, (b) other related parties from the site of green project in Jakarta and Denpasar, and (c) respondents from academia, government agencies green building assessment agency. Respondents from the contractor group were questioned to determine the indicators to be included in the model, whereas the second group was asked to determine the suitability and practicability of using the proposed indicators. Weighing for indicators was determined based on suggestion and feedback from the third group.

3.1 Green Construction Assessment

Green construction assessment process starts from level 3, going up hierarchically to level 2 and 1. At level 3 assessment is performed by providing values 1 or 0, depending whether such indicator is implemented or not in the project. The formula in the calculation Green Construction Value follows the equation (1) through (7).

3.1.1 *Green construction indicator*

Green Construction Indicator Value (GCIV) can be calculated as follows:

$$\text{GCIV} = (I_{i=0\ or\ 1}).(PW_{j=0.4\ or\ 0.6}) \quad (1)$$

where:

i is respondent's answer (*i* value of 1 if it is implemented in the project and 0 if it has not been implemented in the project), and PW is Priority Weight, *j* value of 0.6 for the first priority indicator and j is worth 0.4 for second priority indicator.

$$\text{Total GCIV} = \sum_{i-1}^{j} GC_i \quad (2)$$

3.1.2 *Green construction factor*

Green Construction Indicator Value will be the input of the green construction assessment factor level. Green Construction Factor Value (GCFV) is obtained by multiplying the GCIV with the weight of each factor. The output of this assessment will be the input for the green construction assessment aspect. GCFV can be calculated using equation 3.

$$\text{GCFC} = \sum_{i=1}^{j} (TotalGCIV_i \,.\, GCFW_i) \quad (3)$$

$$\text{Total GCFV} = \sum_{i-1}^{m} GCFV_i \quad (4)$$

3.1.3 *Green construction aspect*

The output of green construction factor value, then become the input for green construction assessment aspect. Green Construction Aspect Value of each aspect is obtained by multiplying the GCFV with the weight of each green construction aspect as shown in equation 5 and the calculation of the total GCAV as shown in equation 6.

$$\text{GCAV} = \sum_{i=1}^{j} (TotalGCFV_i \,.\, GCAW_i) \quad (5)$$

$$\text{Total GCAV} = \sum_{i=1}^{m} GCAV_i \quad (6)$$

3.1.4 *Green construction*

The final value of green construction is called Green Construction Value (GCV0, which is the sum of all green construction aspect values as shown in equation 7.

$$\text{GCV} = \sum_{i=}^{j} GCAV_i \quad (7)$$

3.2 Implementation of Green Construction Assessment Model

Green construction assessment model was applied at several projects in Indonesia with different characters: a) Projects planned based on green principles, b) Projects constructed by green contractor, c) Projects planned not using green principles, and d) Projects constructed by not green contractor.

Table 1. Project Classification Based on Design and Contractor.

	Green Design	**Not Green Design**
Green Contractor	Quadrant I	Quadrant II
	Condotel [15.44]	Offeice Building [16.04]
Not Green Contractor	Quadrant IV	Quadrant III
	Airport [15.43]	Hotel [10.68]
	Mental Hospital [16.83]	Hotel [9.34]

Quadrant I represents the project planned by using green principles and constructed by the contractor who had applied green principles. The GCV is relatively high which is 15.44 or 77.44% of the green indicators have been achieved. Other project with the same characteristic with the trial project had been awarded "Green Property Award 2010". It is indicated that the external parties give such recognition for the product and the activity of the contractor. Quadrant II is represented by the project with GCV 16.05 (≈73.16%). The contractor in this quadrant was the first contractor in Indonesia to implement green construction principles since 2007. Therefore, eventhough the project was not planned using green principles, it still produced high score of green construction. This achievement was a result of the contractor which is accustomed to execute the project by implementing green construction. Quadrant III is represented by two projects with GCV 10.68 (≈48.72%) and GCV 9.34 (≈42.61%). Both contractors had no experience in implementing project with green principles. Further inquiry

revealed that they did not even understand the terms and principles of green project. The tendency of low GCV is also affected by how they plan without accomodating green principles. In this case, there is no driving factor to engage in such activity which is leading to the achievement of green principles, both in planning and construction stages. Both projects are the representation of most projects in Indonesia. Quadrant IV is represented by two projects with GCV 15.43 (≈70.39%) for the project in Denpasar, Bali and GCV 16.83 (≈76.78%). The planning stage of both projects had implemented green principles (green design) and it was supported by green contract. However, contractors in those projects were not classified as green contractors. By implementing green principles planning and supported by green contract, the GCV is tend to be high. Both components are believed to be able to encourage contractors to implement green construction process eventhough they are not green contractors.

4 CONCLUSION

The dominant factors that contribute to green construction are water conservation, energy conservation, environmental health work of construction, health and safety programs and appropriate land use. These five factors are a priority to contractor in carrying out the construction process. The dominant factors of green construction is concentrated on a variety of environmental issues/problems, where these are new issues for the construction industry.

Green construction assessment model was able to represent the contractor activity in the construction process shown by the three project characters, where project that has not applied green principle and implemented by contractor who has not applied green principles will produce lower green construction scores than those of other two projects.

To encourage the implementation of green construction system, the assessment system can be used in two ways. The first way in the implementation of green construction through construction contract document approach green based. The second way is to educate related to green construction principle as outlined in the culture of contracting organization through leadership training coordinated by the contractor for all employees.

References

Anink, D. *et al.*, *The Handbook of Sustainable Building: Ecological Choice of Materials in Construction and Renovation*, James and James Science Publisher, London, 1996.

Christini, G., Fetsko, M., and Hendrickson, C., Environmental Management System and ISO 14001 Certification for Construction Firms, *Journal of Construction Engineering and Management*, 130(3), pp 330-336, May/June 2004.

Du Plessis, D., Chrisna, Editor, *Agenda 21 for Sustainable Construction in Developing Countries*, Pretoria: Capture Press, 2002.

Glavinich, T. E., *Contractor's Guide to Green Building Construction*, John Wiley, 2008.

Hendrickson, C dan Horvath, A., Resource use and environmental emissions of U.S. construction sectors, *Journal Construction Engineering Management*, 126 (1), pp 38-44, 2000.

Kibert, C., *Sustainable Construction*, John Wiley & Sons, Canada, 2008.

Lembaga Pengembangan Jasa Konstruksi Nasional, *Indonesian Construction 2030*, 2007.

Oladiran J.A., lnnovative waste management through the use of waste management plans on construction projects in Nigeria, *J. Arch. Engrg. and Des. Mgmt.*, vol. 5, hh. 165-176, 2009.