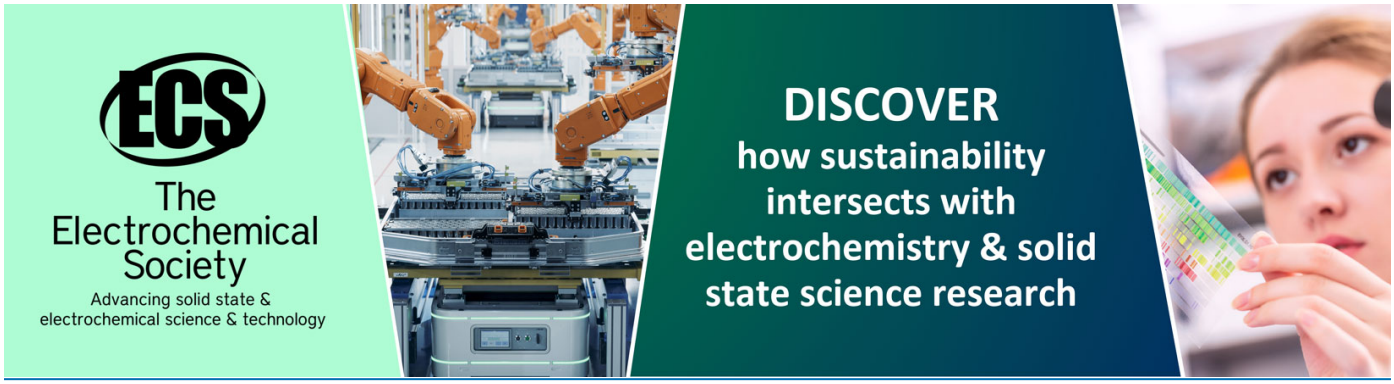
Green Construction Capability Model (GCCM) for Contracting Companies



Green Construction Capability Model (GCCM) for Contracting Companies

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Abstract. Construction project has been considered as one of the contributors to the environmental destruction, therefore green construction becomes the important issue in many countries including Indonesia. However, the success of green construction implementation depends on the capability of contractors, therefore model to assess the capability of contractors to build the projects based on green construction approach becomes important need to be developed. This study is aimed to develop a model to assess capability level of contractor to implement green construction. The model has adopted the concept of Capability Maturity Model (CMM). The model assesses the capability level of contractors based on 16 factors that are categorized into seven aspects of green construction. Those aspects are energy conservation, water conservation, safety and health, environment management, appropriate land use, air quality, sources and cycle of materials. While the capability of contractors to implement green construction is classified into five levels: initial, repeatable, defined, managed and optimizing. Finally, the assessment model named Green Construction Capability Model (GCCM) is proposed as a tool to assess the capability level of contractors to implement green construction.

1. Introduction

Indonesian Construction 2030 mentioned that construction in Indonesia as a developing country is still ongoing; therefore, Indonesia has grand design and grand strategy for construction. One of the proposed agenda in the grand design and grand strategy is the promotion of sustainable construction that aimed at materials saving, waste reduction and convenience building maintenance [1]. According to the definition from Ministry of Public Work Republic Indonesia, sustainable construction is efficient and environment friendly construction practices that provide economic, social and environmental benefits.

Environmental sustainability is considered as an important issue in construction industry because construction process is a process that produces waste. Li, Zhu [2] mentioned that the waste of construction process is considered relatively small compared to other industry, however due to increasing number of projects, the impact of construction process on environmental sustainability, as well as public health has a potential to become a serious problem. Discussion about sustainable construction cannot be separated from green construction that is considered as a part of sustainable construction. According to USEPA [3], green construction is construction process that considers environmental sustainability and efficient use of resources throughout the building's life cycle from site planning, construction, operation, maintenance, renovation to deconstruction.

Referring to the definition above, this study is focused on green construction at the construction stage, therefore the role of contractors to implement green construction during construction process

becomes the main focus of this study. In order to be success to carry out the construction process in a green way, the contractors need to understand their capability to implement green construction. Furthermore, by understanding their capability, contractors can develop the strategy to improve the factors those are weak and to maintain the factors those are strong.

This study is aimed at developing the model to assess capability level of contractors to implement green construction. The model is named Green Contractors Capability Model (GCCM) that is developed based on Capability Maturity Model (CMM).

2. Literature review

2.1. Green construction

Over the last decades, sustainability has been considered as an important issue in order to preserve our environment, therefore it becomes widely discussed among people around the world including people in construction industry. Li, Zhu [2] consider that construction process causes a serious impact on environmental sustainability. Khanna, Babu [4] introduced the concept of carrying capacity as a tool for sustainable development. Furthermore, they mentioned carrying capacity consists of two components: supportive capacity that is related to the level of natural resources consumption and assimilative capacity that is related to the environment pollution load. Related to the sustainable construction, the first aspect has to be considered is minimization of the use of materials in construction, while the second aspect is related to reduction of construction waste.

In Indonesia, the serious attention has been taken to an implementation of green construction as a part of sustainable construction. The implementation of green construction in Indonesia has been regulated by Building Law Number 28 of 2002, while the environmentally friendly buildings is regulated by the Regulation of the State Minister of Environment Number 08 of 2010. At the regional level, there is Regulation of the Governor of DKI Jakarta Number 38 of 2012 that regulates green buildings in Jakarta.

Considering the need of construction industry to implement green construction concept without exception construction industry in Indonesia, it was established that research that is specifically focused on green construction is very important to be carried out.

2.2. Capability Maturity Model

There are several models to assess the performance of companies available in the marketplace. Among these models, CMM provides comprehensive framework to measure and then to improve the performance of companies. CMM has been explained clearly and improved time by time; therefore it becomes one of the assessment models that is widely implemented in many business sectors.

Initially CMM was developed in 1991 by the Software Engineering Institute, Carnegie Mellon University. CMM for software is developed as a guidance for software companies to find a strategy to control and to improve the process of software development and maintenance [5]. Later on CMM has been well developed and evolved time by time. Initial model that was released in 1991 was CMM version 1.0 and then 2 years later was followed by CMM version 1.1. Four years later CMM version 1.2 draft C was released.

In construction field, CMM is spreading widely in several aspects of construction such as project management [6], contract change management [7], construction risk management [8], and supply chain management [9]. Although CMM has been adopted in several aspects of construction, so far the model of sustainable construction that is developed based on CMM has not been found. However, sustainable construction is the current and important issue that have been widely discussed among people in construction industry around the world.

3. Model development

The assessment model in this study is developed into two main stages. The first stage explores the indicators of green contractor that will be used to assess the green level of contractors. Then it's followed by the second stage to develop the assessment model based on capability maturity model. Figure 1 shows

a clear picture about the process of model development. Each stage of model development is explained in detail in the following sections.

3.1. Indicators of green construction

The indicators of green construction were adopted from green construction factors that have been developed by Ervianto, Soemardi [10]. This study explored factors of green construction in stages by following the hierarchy of green construction that divided into aspects and factors. Aspect is defined as point of view about minimizing negative impacts of construction process to the environment. While factor is a situation influencing planning and implementation of construction process in order to minimize negative impact to the environment.

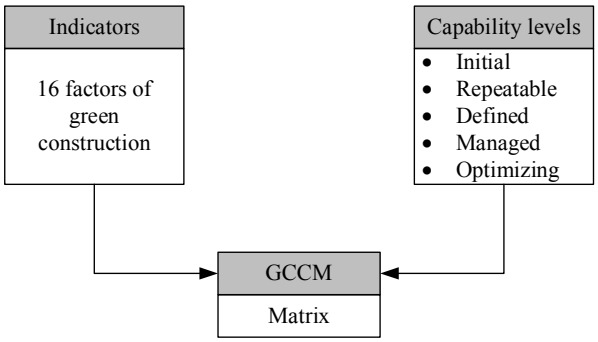

Figure 1. Model development

It started from identifying green construction aspects from literatures. In this stage, seven aspects of green construction have been identified from the documents that were published by two institutions in Indonesia: (a) Green Contractor Assessment Sheet of P.T. Pembangunan Perumahan (Persero) Tbk Indonesia, (b) the GREENSHIP 1.0 rating system of Green Building Council Indonesia. The description of those aspects in this study are explained as follows:

1. **Energy conservation**: to monitor and to record energy use in order to save energy consumption, and to control the use of energy sources that has an impact on the environment during the construction process.
2. **Water conservation:** to monitor and to record water usage in order to save water consumption, and to recycle water use during the construction process.
3. **Appropriate land use:** to maintain green environment by reducing/absorbing CO_2 and pollutants, also reducing the city's drainage load caused by construction process.
4. **Sources and life cycle of materials:** to resist the exploitation of non-renewable natural resources in order to extend materials life cycle through several ways such as (a) using recycle construction materials; (b) using fabrication materials that are produced in environmental friendly process; (c) using local materials to reduce energy consumption for the transportation process.
5. **Environment management**: to reduce construction waste and to encourage sorting of waste in order to facilitate waste recycling.
6. **Air quality**: to reduce air pollution caused by building materials and equipment during the construction process.
7. **Safety and health:** to reduce pollution of chemicals that are harmful to human health and to maintain clean and comfortable project environment.

After the seven aspects of green construction were identified, further literature review was carried out in order to identify factors at the lower level of green construction hierarchy as explained above. In this stage, 16 factors of green construction that can be classified under seven aspects have been identified from two previous documents, and the other two literatures [11, 12].

In order to ensure that the aspects and factors of green construction in this study are appropriate for contractors in Indonesia, they were reviewed by peoples who work for contractors in Indonesia such as: project managers, site managers and R&D staff. All of these factors were assessed for its importance and practical application. Based on the inputs from experts, the aspects and factors of green construction have been renamed and redefined. Finally, 16 factors that were classified into seven aspects are assigned as factors of green construction. All of these factors and their explanation are presented in Table 1.

Table 1. The factors of green construction

Factors	Explanations
Material planning and scheduling	Plans to use materials that environmentally friendly and sourced from around the project site and managing the schedule of materials utilization
Material selection	To select materials that can keep natural resources sustainability
Site protection plan	To protect construction site from air pollution, sound pollution, waste water and erosion
Construction waste management	To minimize construction waste through the programs of reduction, reuse and recycle of construction materials
Material storage and protection	To store materials properly in order to minimize damaged materials
Healthy construction work environment	To create a work environment that supports an efficient construction process
Occupational health and safety program	To ensure safety and health of workers during the construction process
Selection and operation of equipment	To manage schedule of equipment utilization in order to optimize their productivity, and to train the equipment operator in order to increase their working efficiency
Documentation	To document the use of materials, material waste and material content with the aim of ensuring their efficiency
Subcontractors training	To ensure that sub-contractors work without ignoring environmental sustainability
Reduction of ecological footprint	To ensure efficient use of natural resources for construction activities
Air quality in the project site	To maintain fresh air at the project site that is needed by all workers during the construction process
Water efficiency	To maintain a balance of water availability in the project site
Land management	To manage project facilities arrangement by considering the efficiency of construction process in the project site
Energy efficiency	To ensure energy saving in the project site mainly through the efficiency of electricity use
Project environmental management	To minimize both construction and non-construction waste in the project site

3.2. Green Construction Capability Model (GCCM)

This study adopts the principles of CMM to develop model to assess the capability level of contractors to implement green construction. The model is named Green Construction Capability Model (GCCM). GCCM consists of two main parts: indicators of green construction and capability levels to implement green construction. The 16 factors of green construction are used as indicators to assess capability level

of contractors to implement green construction. While the capability of contractors to implement green construction is classified into five capability levels, started from initial and then followed by repeatable, well defined, managed and finally optimized. These five levels are adopted from the initial CMM that also classified the process into five levels. The five capability levels that are used in this model together with their explanations are described as follows:

1. Initial
   The implementation of green construction is not well defined. The working environment is unstable therefore the implementation of green construction is unpredictable and only depends on the efforts of individuals involved in the process.
2. Repeatable
   Contractors have established the policies to implement green construction and procedure to implement those policies, therefore the implementation of green construction are planned and managed based on the experience in similar projects. The earlier successes of green construction implementation are allowed to be repeated.
3. Defined
   The process of green construction implementation has been established and integrated into a contractor's standards. The implementation of the green construction process is consistent and controllable.
4. Managed
   At this level, the outcomes of green construction are predictable because they are quantitatively measured and understood, therefore the deviations of the process can be identified and the corrective actions to restore the process to the correct path can be taken.
5. Optimizing
   Contractors at this level continuously improve the process of green construction based on the evaluation and feedback from the process. The contractors have a tool to evaluate their performance, therefore their weaknesses and strengths to implement green construction can be identified. At this level, contractors can proactively improve the process.

The GCCM is formatted in the form of matrix where 16 green construction indicators and five capability levels are arranged in the first column and first row. Each cell in column and row crossing represents level of achievement in every indicators of green construction. The matrix of GCCM can be seen in Table 2.

In order to apply the model for assessing capability level of contractor to implement green construction, the evaluators or respondents will assess the capability level of contractor by choosing one number in each factor. Then the quantitative data is analysed using statistical mean which is the arithmetic average of all numbers in a set of data. By using this model, mean that represents the capability level of contractors will range between 1 (lowest capability level) to 5 (highest capability level). The values of mean are used to determine the capability level of contractor in two different issues as follows:

1. Mean of each factor shows the capability level of contractors to implement each factor
2. Mean of all factors shows the capability level of contractor to implement green construction thoroughly

Furthermore, to provide a clear picture of contractor's capability level in each factor of green construction, mean of each factor is proposed to be presented in the format of radar diagram, as can be seen in Figure 2. This diagram clearly shows the factors of green construction, in which, contractor is still at the low level. This finding can be used by contractors to come up with strategies to improve their capability to implement green construction.

Table 2. Green Construction Capability Model (GCCM)

Aspects and Factors	Level				
Energy conservation					
Energy efficiency	1	2	3	4	5
Water conservation					
Water efficiency	1	2	3	4	5
Safety and health					
Healthy construction work environment	1	2	3	4	5
Occupational health and safety program	1	2	3	4	5
Environment management					
Construction waste management	1	2	3	4	5
Documentation	1	2	3	4	5
Subcontractors training	1	2	3	4	5
Project environmental management	1	2	3	4	5
Appropriate land use					
Site protection plan	1	2	3	4	5
Reduction of ecological footprint	1	2	3	4	5
Land management	1	2	3	4	5
Air quality					
Material storage and protection	1	2	3	4	5
Selection and operation of equipment	1	2	3	4	5
Air quality in the project site	1	2	3	4	5
Sources & cycle of materials					
Material planning and scheduling	1	2	3	4	5
Material selection	1	2	3	4	5

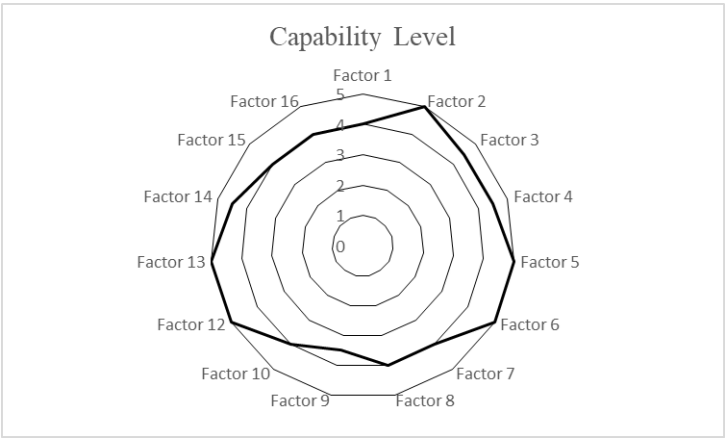

Figure 2. The example of GCCM output

4. The Implementation of GCCM

GCCM can be directed to assess contractors' capability to implement green construction for both internal and external purposes. The internal purpose is directed to contractor's self-assessment in order to understand the existing capability level to implement green construction. Then the results of self-assessment can be used by the contractors to develop strategy to move forward in implementation of

green construction. The self-assessment is proposed to be carried out regularly by the team of evaluators that are appointed by top management. The team should consist of representatives from various departments in the main office.

In order to get the final result of capability level, this study proposes two stages of assessment process, those are: preparation and execution. Figure 3 shows the whole process of self-assessment. The process begins with the formation of evaluation team by top management. The team starts their activity by holding preparatory meetings to design the most appropriate process of evaluation, to anticipate any potential problem and to find the solution. The meeting is also aimed to bring every evaluator to a common level of understanding about the assessment model.

Then the next stage is execution where assessment is conducted through filling out the matrix of GCCM and holding discussions or interviews with the project team in order to get clarification about the implementation of green construction. Furthermore, the results of GCCM analysis will be confirmed by several existing documents, such as: company standard of procedure, working instructions, manuals, etc.

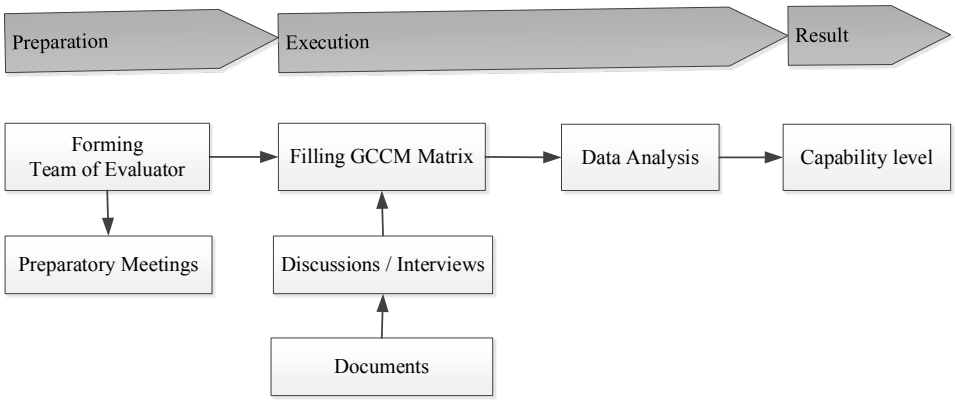

Figure 3. The procedure of GCCM implementation

In addition to the self-assessment, the assessment for external purpose is also needed. However the assessment by external parties has a different purpose and interest; usually it is aimed to judge the performance of contractors for various purposes such as contractor classification, contractors pre-qualification, etc. Example of the external parties that are concerned with this assessment are association of contractors, government agencies, prospective clients, etc. The similar procedure can be implemented for external purposes, only the evaluator team should be assigned by external party.

5. Conclusions

This paper is aimed at developing assessment model to measure capability of contractors to implement green construction that is named GCCM. The GCCM has been developed based on the concept of CMM. This model uses 16 factors of green construction as the indicators and classifies contractors into five capability levels. Finally the matrix that combines those two aspects is developed as the model. The model can be implemented for two purposes: self-assessment and external purposes. Self-assessment is directed for internal need of contractors in order to develop the appropriate strategy to improve their performance. While the external purpose is directed to the interest of external parties to determine the performance of contractors, especially that are related to green construction.

The indicators have been investigated from two standards that have been implemented in Indonesia and two literatures that were written based on the cases of other countries. Then they were reviewed by peoples who work in contractor companies in Indonesia in order to ensure that they are appropriate for contractors in Indonesia. Therefore, GCCM is influenced by the particular working circumstances of contractors in Indonesia, however this model can be used by contractors in other countries after being reviewed and may be modified according to the circumstances of contractors that will implement this model.

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