

Evaluation Implementation of Green Construction of Garut City Plaza Mall Project

Ratu Mafas Sukmalaras^{1*}, Anton Soekiman², Tia Sugiri², Dody Kusmana², and Andini Radisya Pratiwi²

¹ Master of Civil Engineering Study Program, Sangga Buana University YPKP, Bandung Indonesia

² Postgraduate of Civil Engineering Lecturer, Sangga Buana University YPKP, Bandung, Indonesia

*Corresponding author: ratusukmalaras25@gmail.com

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Abstract: Construction projects in Indonesia are continuously, but many adversely affect the environment. Green Construction presents a solution to mitigate these impacts, aiming to harmonize environmental sustainability with present and future human needs. Evaluating the implementation of Green Construction in projects is crucial. This study employed the 2015 Green Construction Assessment Model by W.I. Ervianto to assess Green Construction achievements and conducted interviews to identify implementation obstacles in the City Plaza Garut Mall Building Development project. The research revealed that the Green Construction achievement score in the Garut City Plaza Mall Building project was 16.15 out of 21.92, equivalent to 74% of its potential. Although this is the highest Green Construction score achieved in Indonesia, opportunities for improvement persist. Several aspects require optimization. This study underscores the necessity of enhancing Green Construction implementation in construction projects to attain a sustainable balance between environmental conservation and human necessities.

Keywords: *Green Construction; environmental sustainability; assessment model; Garut City Plaza; implementation obstacles*

1. Introduction

At present the development of construction projects in Indonesia continues/increases, both construction projects carried out by the government and the private sector. Especially in Garut City at this time a lot of construction is being carried out both by the government to meet the needs of its people and those carried out by the private sector to invest in Garut City.

As a tourist destination, Garut City is inseparable from the development of construction projects to provide benefits, especially for regional income. providing many opportunities for all the potential that exists in Garut City, PT. Jakarta Inti Land as Investor and PT. Total Bangun Persada as the main contractor appointed to build the Garut City Plaza Mall Building project.

However, in the current development of construction projects, especially for multi-storey buildings, it is necessary to pay attention to aspects that have an impact on the environment. In general, the implementation of construction projects can cause negative impacts on the environment in the project area. Along with the development of technology and the implementation of sustainable development, building construction is the easiest object for implementing sustainable construction processes because it is easier to control the activity process

and to reduce environmental issues which can be a negative impact from the construction of construction projects. According to Ervianto [1], Green Construction can be defined as the process of planning and implementing construction projects that refer to contract documents to reduce negative impacts on the environment. The primary objective is to strike a harmony between the preservation of the environment and the fulfillment of human needs, both in the present and for generations to come.

In the planning and implementation stages, it plays an important role in the process of construction project activities. Green Construction is a good innovation to reduce negative impacts that may occur during construction projects. The negative impacts obtained in the implementation of the construction process can vary, such as air pollution, noise produced by equipment that operates day and night without paying attention to the rest time of the surrounding residents, stagnant water in the surrounding residents' settlements, in addition to the delivery of building materials that are otherwise not. When planning properly, it will disrupt traffic activities and the implementation of construction projects will still have many negative impacts. In order to create a Green Construction concept that can reduce the negative impacts of implementing construction projects, awareness from various parties is needed, namely from project owners, consultant planners, and especially contractors as construction project implementers. The concept of green construction has benefits for its implementation, but its implementation has not yet been fully achieved and there are still obstacles and challenges. The readiness and understanding of construction actors, especially contractors as implementers in the field, is a challenge and obstacle in implementing green construction. It requires understanding and support for the principles of green construction which are crucial elements in assessing green construction in Indonesia [2].

Therefore, it is necessary to evaluate the implementers (contractors) in implementing construction projects to find out the achievements that have been implemented in the field and the factors that become obstacles and challenges in implementing the Green Construction concept in order to reduce the negative impacts of implementing construction projects. Especially in the city of Garut, where the development of mall building construction projects is starting to develop, research of this kind has never been carried out and it is hoped that future construction projects can apply the green construction concept which can reduce the negative impacts of implementing construction projects.

2. Literature Review

2.1 Construction Projects

Construction projects are a series of activities that are usually carried out only once and have a short-term duration [3]. Construction project involves a series of interrelated activities aimed at achieving certain goals (building/construction) within specified time, cost and quality constraints. Construction projects always require resources such as labor, building materials, equipment (machines), implementation procedures (methods), costs, information, and time.

2.2 Characteristics of construction projects

The characteristics of construction projects [4] can be seen in three dimensions, namely:

1. Unique, construction projects are considered unique because there are never activities that are the same (not identical), are limited by time, and always involve different groups of workers.
2. Required resources (resources), in a construction project, there are various kinds of resources needed. Some of the main resources include:
 - a. Workforce Involve workers, experts, and the project team who have relevant skills and expertise to carry out construction tasks.
 - b. Materials, including building materials such as bricks, concrete, wood, steel, and so on used in the physical development of construction projects.

- c. Equipment/tools, Involving special machines and equipment used for construction activities, such as heavy equipment (excavators, trucks, graders), soil compactors, measuring devices, and so on.
- d. Finance/cost, Involving the budget and financial resources needed to finance construction projects, including procurement of funds, financing, and project financial management.
- e. Work method Refers to the plans, procedures and strategies used in carrying out construction projects, including project planning, work schedules, risk management and quality control.

3. Organization

Project organizations have different objectives and involve several people who have different skills and uncertainties. Types of construction projects can be divided into two categories based on the type of building [5], namely buildings (covering houses, offices, factories and the like) and civil buildings (covering roads, bridges, dams and infrastructure).

2.3 Activity Phase in a Construction

Construction activity is an activity that requires a long time with various problems that need to be overcome. In addition, development activities have sequences that are interrelated. The final stage of development activities is the operation of the building, so that the operational stages of development projects can be explained as follows.

1. Feasibility Study Stage
The purpose of the initial study phase is to ensure to the client that the construction project plan can be realized from conceptual, financial (budget and funding sources) and environmental aspects.
2. Explanation Stage (Briefing)
The explanation stage is intended to ensure that the client can describe the characteristics of the project and an acceptable budget, so that the planning consultant can accurately understand the client's wishes and make an estimate of the required budget.
3. Stage Design (Design)
The planning step aims to complete the project by preparing the layout, design, construction techniques and cost estimates which must be approved by the project manager and relevant authorities, preparing the required implementation information, such as plans and specifications, and completing procurement or tender documents.
4. Stage of Procurement/Tender
The sourcing/proposal stage has to appoint one contractor to lead and several contractors as subcontractors to carry out the field construction process.
5. Implementation Stage (Construction)
The implementation stage aims to carry out the building construction desired by the client and the design from the planner within the agreed time and quality required.
6. Stages of Maintenance and Preparation for Use (Maintenance and Start Up)
At the maintenance stage, the goal is to ensure that the building has been completed in accordance with the contract documents and that all facilities are operating properly. In addition, information on construction and use instructions are provided, as well as trained personnel for the use of the available areas.

2.4 Green Construction

Green construction is the process of planning and organizing development projects that follow contract documents to reduce environmental impacts arising from construction activities [6].

2.5 Model Green Construction Assessment (MAGC)

Model Green Construction Assessment (MAGC) for Building Projects in Indonesia Version 1.2 – 2015 by Wullfram I. Ervianto. Research conducted by Wullfram I. Ervianto produced a Green Construction Assessment Model which can be used as a tool to evaluate the extent to which green construction concepts are applied to building construction projects in Indonesia. This research assumes that with the existence of a green construction assessment model, activities in the construction process can be measured to what extent the green construction concept is implemented. Green construction assessment has been tested in several construction projects in various cities in Indonesia. In formulating assessments for green buildings, various aspects related to the environment, such as energy, water and waste, are considered in the development process. The Ervianto model was developed through a quantitative approach based on data collected through a series of questionnaires given by various parties involved in the construction [7-10].

The stages in this research include the following steps:

1. Conduct studies and formulate aspects, factors and indicators of green construction from various sources. The result of this stage is the development of a data collection instrument in the form of a questionnaire which will be used to collect opinions from respondents including contractors, the community around the project, and experts.
 2. Grouping indicators into priority groups I and II using questionnaire data with contractor respondents.
 3. Process the data obtained from the questionnaire distributed to the community around the project location using the G-rescoring method, to ensure that the selected green construction indicators have a positive impact on the impact recipients.
 4. Ensure that green construction indicators are able to have a positive impact on the surrounding community by conducting a two-average similarity test (T-test) on the data obtained from steps 2 and 3.
 5. Determine the weight for each aspect, factor, and indicator using the Analytical Hierarchy Process (AHP) method using data obtained from questionnaires distributed to expert groups
 1. Validation of the representative model through a similarity test of two means on the data obtained using a questionnaire given to two different groups of respondents consisting of simple questions to test whether the model is able to represent facts in the field or not.
 6. Test the model for the 4 project criteria to determine whether the model can be used to assess the construction process
 7. Collect data from questionnaires given to contractors to find out green construction indicators that have been implemented and obstacles that occur in implementing indicators on projects
- The Green construction Assessment Model developed by W. I Ervianto consists of four hierarchical levels, namely:
- a. The Indicator Level is a factor that provides direction in planning and implementing the construction process to reduce negative impacts on the environment, so that a balance is achieved between the capabilities of the environment and the needs of human life for the present and the future.
 - b. Factor Level pertains to a circumstance that shapes the planning and execution of construction processes to reduce adverse environmental effects, thus establishing an equilibrium between environmental capacities and the current and future requirements of human life.
 - c. The aspect level involves the viewpoint employed during the planning and execution of construction processes to minimize adverse environmental effects, ultimately leading to an equilibrium between environmental capacities and the current and future requirements of human life.
 - d. Green Construction Concept Level
- The arrangement of the four hierarchies consists of indicator level, factor level, aspect level and green construction concept level. The hierarchy consists of 7 (seven) assessment aspects, 16 (sixteen) assessment factors and 142 Green Construction assessment indicators.

2.6 The maximum value of the green construction assessment model

To attain the highest score in the assessment, all green construction criteria need to be satisfied during its execution, denoted as the Green Construction Ideal (NGC Ideal) with a score of 21.92.

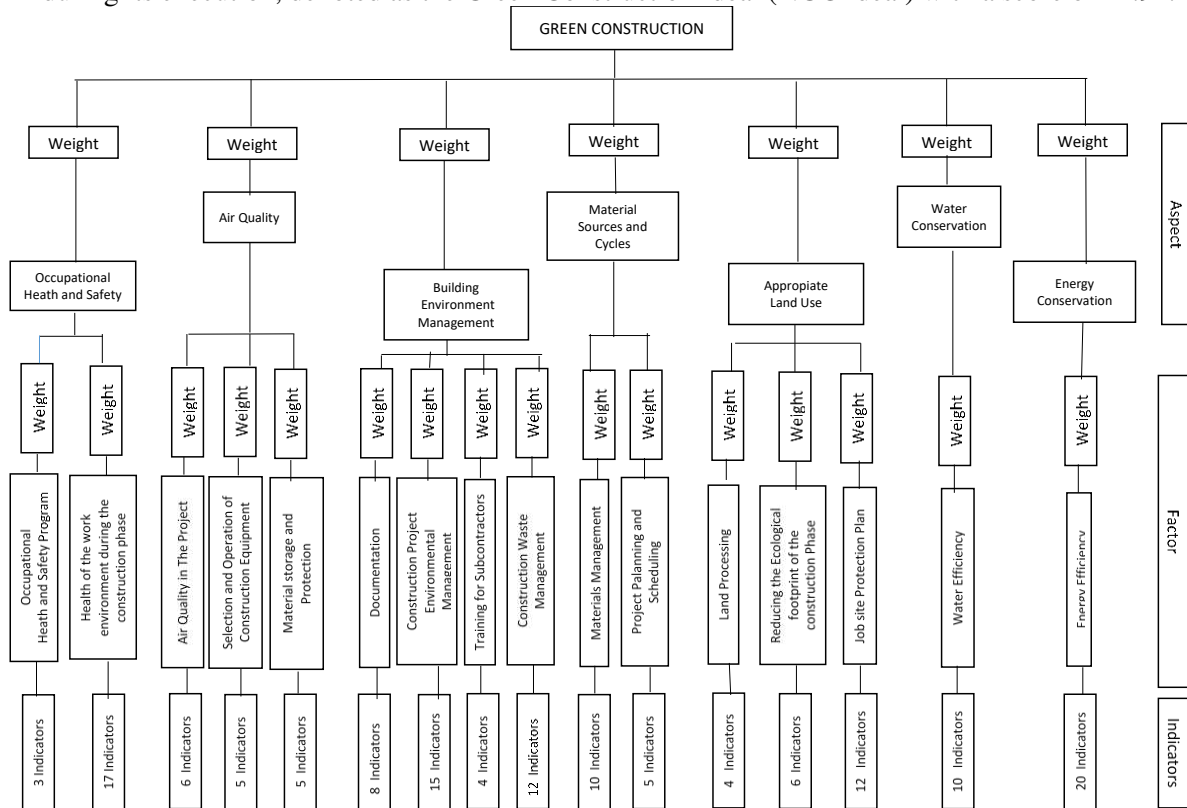


Fig. 1. Structure of Assessment Green Construction Model.

3. Method

3.1 Object of research

Application of Green Construction in the Construction of the City Plaza Garut Mall Building

3.2 Methodology

Primary data was obtained from direct field visits and interviews to carry out green construction assessments using the Green Construction Assessment Model, while secondary data was obtained through literature studies by collecting implementation work methods, SOP (Standard Operating Procedures), and work instructions obtained from contractors. PT. Total Bangun Persada.

3.3 Data Analysis

Data analysis carried out in this study used a descriptive analysis approach. In data analysis, researchers collected and calculated indicator values for research objects using Microsoft Excel. The purpose of this analysis is to get an NGC (Green Construction Value) value. The NGC value is then compared with the Ideal NGC and Best NGC as a reference to determine the extent to which the contractor has achieved green construction indicators in the project. The research results will be presented in a table, diagram, and radar to visualize the achievement value of green construction. Apart from that, the factors that become obstacles and challenges in implementing green construction will be explained, and suggestions will be given for achieving maximum green construction achievement values.

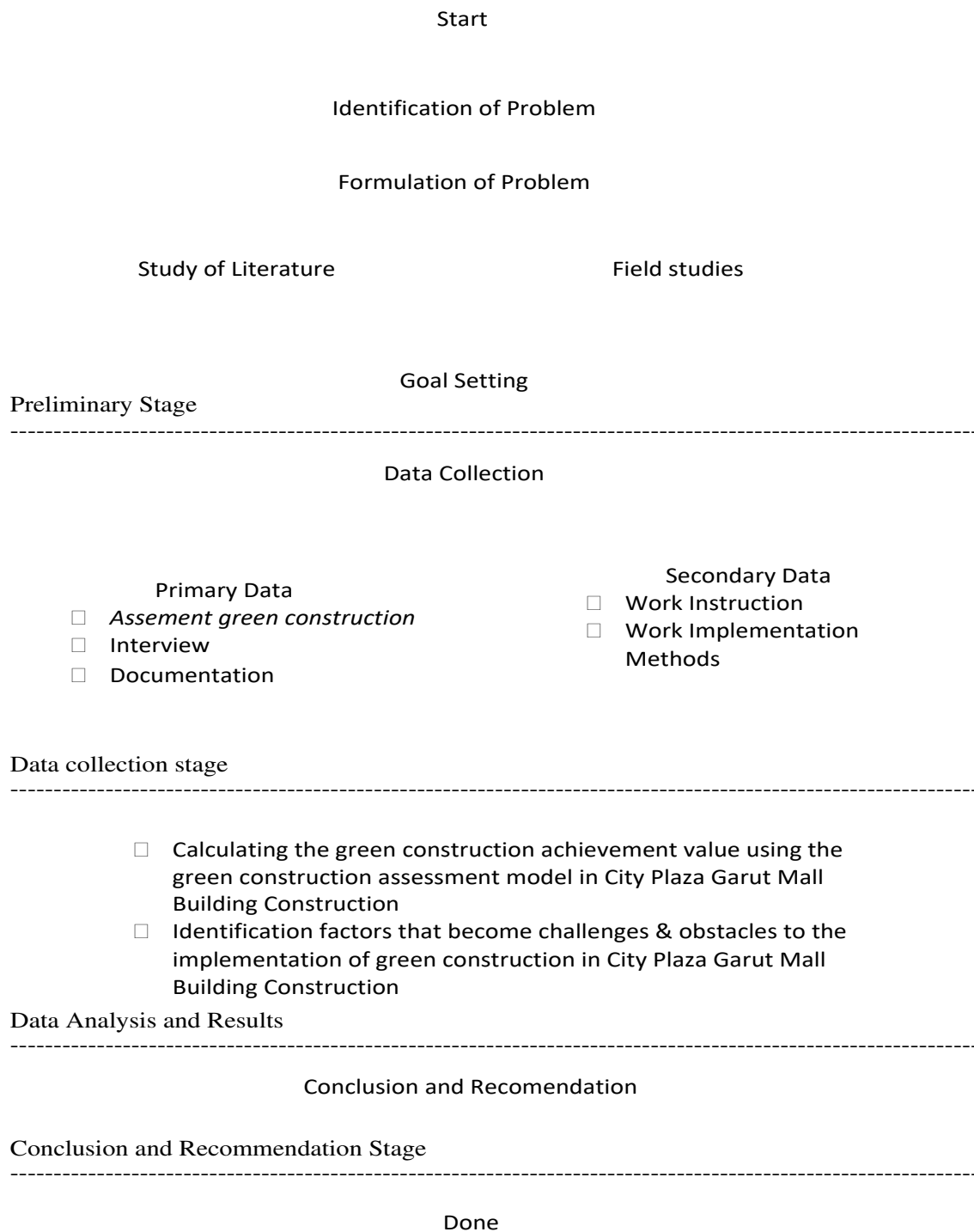


Fig. 2. Flowchart Research.

4. Result and Discussion

The Green Construction assessment using model version 1.2 in 2015 was carried out to determine the achievement of Green Construction Values in buildings in Indonesia, especially in the construction project for the City Plaza Garut Mall building in this research. In this research, the green construction assessment was carried out by direct observation in the field by filling in the assessment of all indicators in the green construction assessment by filling in the binary numbers 1 and 0 (value 1 if implemented and 0 if not implemented in the field), in addition to interviews

with related parties. in accordance with the position to find out what are the inhibiting factors in the implementation of green construction. Following the completion of a green construction assessment and the input of field data for the Garut City Plaza Mall building project, the subsequent step involves the computation of the Indicator Value, Factor Value, and Aspect Value. These three values are calculated through mathematical calculations using Microsoft Excel software, resulting in the Green Construction Value. Once the Green Construction Value is determined, the next phase involves comparing the field implementation results with the baseline Green Construction Value, which may encompass either the Ideal or the Best Green Construction Value.

4.1 Research Results

- a. *Achievements of NIGC (Green Construction Indicator Value), NFGC (Green Construction Factor Value) and NAGC (Green Construction Aspect Value)*

Based on the results of the implementation assessment and facts in the field, the input data for the green construction assessment obtained the indicator values for each green construction factor. The results of applied NIGC calculations and maximum NIGC can be seen in table 1 which is the recapitulation result of applied NIGC calculations and maximum NIGC.

Table 1. Recapitulation of results from maximum GCIV calculations and implementation GCIV.

No	Green Construction Factor	GCIV Maximum	GCIV Implementation	Percentage
F1	Occupational Health and Safety Program	1,6	1,2	75%
F2	Health of the work environment during the construction phase	9,6	9	94%
F3	Air quality in the project	3,2	3,2	100%
F4	Selection and operation of construction equipment	2,6	1,2	46%
F5	Material storage and protection	2,6	1,6	62%
F6	Documentation	4,4	2,4	55%
F7	Construction project environmental management	8	6,8	85%
F8	Training for subcontractors	2,2	1	45%
F9	Construction waste management	6,2	6,2	100%
F10	Materials management	5,6	4,4	79%
F11	Project planning and scheduling	3	3	100%
F12	Land processing	2,2	2,2	100%
F13	Reducing the ecological footprint of the construction phase	3	3	100%
F14	Job site protection plan	7	6,4	91%
F15	Water efficiency	4,8	1,8	38%
F16	Energy efficiency	10	8	80%

After the NIGC is obtained, the next step is to calculate the NFGC, and NAGC on the results of application in the field on the Garut City Plaza Mall Building project using mathematical formulas in Microsoft Excel. The calculation results for the two application values can be seen in table 2 as follows:

Table 2. Results of Implementation Assessment of GCFV & GCAV.

No	Green Construction Factor	GCIV	Factor Weight	GCFV	GCAV
F1	Occupational Health and Safety Program	1,2	0,48	0,58	0,28
F2	Health of the work environment during the construction phase	9	0,52	4,65	2,41
F3	Air quality in the project	3,2	0,46	1,46	0,67
F4	Selection and operation of construction equipment	1,2	0,23	0,27	0,06
F5	Material storage and protection	1,6	0,31	0,50	0,16
F6	Documentation	2,4	0,19	0,46	0,09
F7	Construction project environmental management	6,8	0,28	1,87	0,51
F8	Training for subcontractors	1	0,24	0,24	0,06
F9	Construction waste management	6,2	0,30	1,83	0,54
F10	Materials management	4,4	0,42	1,85	0,17
F11	Project planning and scheduling	3	0,58	1,74	0,16
F12	Land processing	2,2	0,38	0,84	0,32
F13	Reducing the ecological footprint of the construction phase	3	0,30	0,90	0,27
F14	Job site protection plan	6,4	0,32	2,04	0,65
F15	Water efficiency	1,8	1,00	1,80	1,80
F16	Energy efficiency	8	1,00	8,00	8,00

b. NGC Achievements (Green Construction Value)

After inputting data on the green construction assessment and calculating the application value and the maximum NIGC, NFGC, and NAGC, then the Green Construction value is calculated. The results of calculating the achievements of the Green Construction Value can be seen in table 3.

Table 3. Achievements of Green Construction Values.

No	Value Aspects Of Green Construction	Aspect Value Maximum	Aspect Value Implementation	Percentage
F1	Occupational Health and Safety Program	0,37	0,28	75%
F2	Health of the work environment during the construction phase	2,56	2,41	94%
A1	Occupational Health and Safety	2,94	2,69	92%
F3	Air quality in the project	0,67	0,67	100%
F4	Selection and operation of construction equipment	0,14	0,06	46%
F5	Material storage and protection	0,26	0,16	61%
A2	Air Quality	1,06	0,89	84%
F6	Documentation	0,16	0,09	54%
F7	Construction project environmental management	0,61	0,51	85%
F8	Training for subcontractors	0,12	0,06	46%
F9	Construction waste management	0,54	0,54	100%
A3	Building environment management	1,43	1,20	84%
F10	Materials management	0,22	0,17	78%
F11	Project planning and scheduling	0,16	0,16	100%

No	Value Aspects Of Green Construction	Aspect Value Maximum	Aspect Value Implementation	Percentage
A4	Material sources and cycles	0,38	0,33	87%
F12	Land processing	0,32	0,32	100%
F13	Reducing the ecological footprint of the construction phase	0,27	0,27	100%
F14	Job site protection plan	0,71	0,65	92%
A5	Appropriate land use	1,3	1,24	95%
F15	Water efficiency	4,8	1,8	38%
A6	Water conservation	4,8	1,8	38%
F16	Energy efficiency	10	8	80%
A7	Energy Consevation	10	8	80%
	Green Construction Value	21,92	16,15	74%

Based on Table 3 above, the results of NGC value in the Garut City Plaza Mall building construction project were 16.15 or 74% of the maximum NGC (Green Construction Value).

4.2 Challenges and obstacles in the implementation of green construction

Following the green construction assessment and interviews, it was identified that various discoveries highlighted impediments that led to the inability to attain the desired green construction implementation in the Garut City Plaza Mall project.

1. In the Occupational Health and Safety Program Aspect (A1), indicators that are not implemented are:
 - a. Does not make a schedule for activities that generate emissions to reduce their impact on construction workers because an activity plan has not been prepared for their implementation
 - b. Does not provide facilities for smoking at a distance of ± 5 meters outside the work location, because outside the work location is a public city facility so it does not provide it
2. In the Air Quality Aspect (A2) the indicators that are not implemented are as follows:
 - a. Do not replace fossil fuels with alternative energy sources for construction equipment because they still use dex diesel fuel,
 - b. Does not provide training for equipment operators so that the specified productivity can be achieved, because the operator has an SIO (OPERATOR'S LICENSE),
 - c. Not prioritizing the use of public transportation for construction workers because the workers' bunks are located behind the project site so they do not use public transportation
 - d. Not storing certain materials that are prone to dust to be stored outside the construction project site because no materials are stored outside the project,
 - e. Not storing certain materials by gluing perfectly because there is no material stored by gluing
3. In the Building Environment Management Aspect (A3) the indicators that are not applied are:
 - a. Do not record related to the amount of residual material. Because there is no concrete or iron waste, the remaining material is not recorded.
 - b. Does not record the amount of recycled material content (recycle). Because there is no concrete or iron waste, the remaining material is not recorded.
 - c. Does not record the use of products from certified wood, because the record is carried out by the wood subcontractor
 - d. Not documenting the air quality program in construction projects because it has not been implemented by the vendor
 - e. Not providing training for construction workers on how to manage construction waste because this is not the domain of construction workers,

- f. Not providing training for construction workers to maintain air quality at the project site, because there is no training related to maintaining air at the project site
 - g. Not serving food and using a minimum catering system to minimize the generation of waste, because efforts are only made so that workers are not allowed to bring food into the project location,
 - h. Do not use Veldples for drinking water, because Veldples have not been used in the project,
 - i. Do not make biopore holes to reduce erosion due to surface water, because there is already a DPT (soil retaining wall) and the soil's absorption capacity is good
4. In the Material Source and Cycle Aspect (A4), indicators that are not implemented are as follows:
- a. Does not use manufactured building materials that use environmentally friendly raw materials and production processes, because in the construction process only structural work is carried out so that the construction materials used do not use environmentally friendly manufacturing raw materials and production processes.
 - b. Do not use wood raw materials whose origins can be accounted for/certified, because they do not use certified wood because wood is only used for temporary buildings (temporary)
5. In the Appropriate Land Use Aspect (A5), the indicator that is not implemented is not measuring runoff water due to the construction process on locations around the project. This does not carry out water measurements because the groundwater level at the project site is under the building so it is safe.
6. In the aspect of water conservation (A6) indicators that are not implemented are as follows:
- a. Not collecting rainwater for reuse in various activities that do not require potable water not being implemented because there is no rainwater storage area due to the additional cost factor of making a storage tank.
 - b. Not making plans for the use of dewatering water, because there is no dewatering because the groundwater level is under the building so it is safe,
 - c. Do not make recharge wells in the form of absorption wells and/or biopore holes, because you do not use infiltration wells because the water disposal is already smooth,
 - d. Not Installing a piezo meter to monitor the groundwater level because there is already a water meter,
 - e. Not Utilizing dewatering water for activities in the field, because there is no dewatering
 - f. Do not use automatic faucets for sinks in project offices because automatic faucets are more expensive than manual faucets
 - g. Not using a shower for bathing construction workers due to using a bathtub and using a ladle for bathing.
7. In the Energy Efficiency Aspect (A7) the indicators that are not implemented are as follows:
- a. Not calculating the CO₂ reduction obtained from energy efficiency, because there is no PIC that has calculated the CO₂ reduction obtained from energy efficiency,
 - b. Not making a transportation schedule for construction workers and project employees, because there is no project transportation because the project bed is close to the project location, so project workers walk to the project location,
 - c. Not carrying out vibration measurements during the construction process, because the construction process uses a hydraulic method for erection so vibration measurements are not carried out,
 - d. Not ensuring that all vehicles and heavy equipment used in the project pass the exhaust emission test, because it is temporary,
 - e. Not using AC equipment with a minimum COP of 10% greater than the SNI 03-6390-2000 standard, because AC is rarely used because the air temperature in the Garut district area is already cool

5. Conclusion

The following is the conclusion of the research that was made, namely:

1. According to the outcomes of the green construction assessment for the Garut City Plaza Mall building project, the Green Construction Value attained reached 16.15 out of 21.92, signifying a 74% implementation rate with the utilization of 111 indicators. This achievement marked the Best Green 1. Construction Value, signifying progress in green building construction implementation in Indonesia. Previous research had only achieved a Green Construction value of 15.47, equivalent to 71.83% with the use of 102 indicators.
2. Several factors are obstacles in implementing the green construction concept in the construction project for the construction of the Mall City Plaza Garut building. There are 3 (three) factors from the 3 (three) aspects of green construction whose values still do not meet the requirements. or below 50% of the maximum value that must be applied, namely:
3. Water efficiency factor (water conservation aspect), where only 38% of its application. In this aspect, there are obstacles in its implementation which are influenced by internal factors of the implementing contractor, namely the creation of rainwater storage tanks, the use of automatic wash basin faucets and the use of showers for bathing construction workers. In this application it is influenced by cost efficiency factors which in this application require additional costs.
4. Factors Selection and operation of construction equipment (Aspects of Occupational Health and Safety), where only 46% of its application. In this aspect, there are obstacles in its implementation which are influenced by internal factors of the implementing contractor, namely that training has not been implemented for equipment operators to achieve the specified productivity, this is because there is no productivity planning for operators from the implementing contractor. Apart from that, the indicator of replacing fossil fuels with alternative energy sources has not been implemented due to the readiness of implementing contractors in terms of technology to replace alternative energy sources so that they still use fossil fuels.
5. Training Factor for subcontractors (Air Quality Aspects), of which only 46 % are implemented. This aspect is influenced by the readiness of the implementing contractor who has not been able to provide training for subcontractors on how to manage construction waste and maintain air quality at the project site.

Suggestion

Suggestions addressed to companies include:

1. To maximize the implementation of green construction, it is necessary to increase the readiness of implementing contractors in terms of technology which can replace fossil fuels with alternative fuels and how to recycle construction waste
2. The implementing contractor should provide outreach or training for workers and subcontractors related to waste management so that it will increase the abilities and skills of workers and minimize the generation of construction waste. In addition, training to maintain air quality for workers and subcontractors so that air pollution does not occur around the project site. Training for equipment operators is important to increase equipment productivity.

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