PERCEPTION ANALYSIS OF GREEN CONSTRUCTION IMPLEMENTATION ON CONSTRUCTION PROJECTS FOR CONTRACTORS IN BANDA ACEH CITY

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Abstract: Along with the increasing use of natural resources, and the large number of construction waste dumping in the environment, environmental damage is increasingly visible. Many areas, especially Banda Aceh City, have experienced land and air degradation due to the pattern of life and the number of people. Currently, the construction project has a new concept, namely green construction, which is believed to be able to improve the environment caused by various developments by reducing the occurrence of environmental damage. The research objective was to analyze the perception of the application of green construction in construction projects in the city of Banda Aceh in determining the most dominant factors and the relationship between the factors of implementing green construction (X) on costs (Y). The research location was in the city of Banda Aceh. Secondary data, namely contractor company data. Primary data were 34 questionnaires. The results of data analysis using SPSS include a validity test, reliability test, frequency analysis, and Pearson product-moment correlation test. Based on the research results, it was found that the most dominant green construction factor was the application of energy conservation in construction (X5) of 95.1%, the application of energy conservation (X10) of 92.8%, and the use of construction materials (X8) of 92.5%. The largest correlation coefficient value was obtained in energy conservation (X10) of 0.882.
Keywords: Green construction; Construction projects; Project environment; Implementation

Abstrak: Seiring meningkatnya pemakaian sumber daya alam dan banyaknya pembuangan limbah konstruksi di lingkungan, kerusakan lingkungan semakin terlihat. Telah banyak daerah-daerah khususnya Kota Banda Aceh mengalami degradasi lahan dan udara karena pola hidup dan jumlah manusia. Saat ini proyek konstruksi mempunyai sebuah konsep baru yaitu *green construction* yang dipercaya mampu memperbaiki lingkungan yang diakibatkan oleh berbagai pembangunan dengan mereduksi terjadinya kerusakan lingkungan. Tujuan penelitian untuk menganalisis persepsi penerapan *green construction* pada proyek konstruksi di Kota Banda Aceh dalam menentukan faktor-faktor yang paling dominan dan hubungan antara faktor-faktor penerapan green construction (X) terhadap biaya (Y). Lokasi penelitian di Kota Banda Aceh. Data sekunder yaitu data perusahaan kontraktor. Data primer sebanyak 34 kuesioner. Hasil analisis data menggunakan SPSS meliputi uji validitas, uji reliabilitas, analisis frekuensi, dan uji korelasi *pearson product moment*. Berdasarkan hasil

penelitian, diperoleh bahwa faktor *green construction* yang paling dominan adalah penerapan konservasi energi pada pelaksanaan konstruksi (X5) sebesar 95,1%, penerapan konservasi energi (X10) sebesar 92,8%, dan penggunaan material konstruksi (X8) sebesar 92,5%. Nilai koefisien korelasi terbesar didapat pada konservasi energi (X10) sebesar 0,882.

Kata kunci: *Green construction*; Proyek konstruksi; Lingkungan proyek; Penerapan

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Introduction

Climate change and global warming are big problems that are currently being faced by all of humanity. The amount of greenhouse gases in the atmosphere has increased recently, leading to climate change and global warming of the Earth (IPCC, 2013). The National Oceanic and Atmospheric Administration (NOAA, 2019) stated that CO_2 levels jumped from 407 to 409 ppm in January 2019.

The construction project sector is one of the industrial sectors that has the most significant impact on the environment by emitting large amounts of emissions into the atmosphere (Horvath, 2006). Construction projects are responsible for around 40% of CO_2 emissions (Lassio, 2016). The goal of the World Green Building Council (WorldGBC, 2018) is to reduce CO_2 emissions caused by the building and construction sector and achieve a net-zero emission building by 2050.

As the use of natural resources increases and the amount of construction waste disposal in the environment increases, the environmental damage becomes increasingly visible. There have been many areas, especially the city of Banda Aceh, which has experienced land and air degradation due to lifestyles and the increasing number of people. Global warming has become a world issue and has attracted attention in many circles of the surrounding community. Many parties have conveyed various efforts and socialization to minimize this global warming. Thus, construction companies must prepare themselves to improve the quality of work so that products produced using environmentally friendly concepts are not difficult to compete. According to Wu et al. (2014), current construction projects have a new concept, namely green construction, which is believed to be able to improve the environment caused by various developments by reducing environmental damage by using sustainable materials and sustainable technology.

According to Ervianto (2015), green construction is a new strategy in the management of construction projects which has become a necessity in an urgent situation in human life and a place for life in environmental sustainability. This strategy is one of the stages in a series of stages in the construction project life

cycle. Currently, there is no information on the activities of contractors who carry out the green construction process, such as carrying out projects without damaging the environment, not causing health problems for workers, and people being disturbed because they live around the project site.

During construction, it usually has a direct impact on the surrounding environment. The construction industry is one of the most significant contributors to environmental problems due to improper construction activities (Afzan, 2016), which causes an increase in carbon emissions, climate change, resource scarcity, and the emergence of waste (Dadhich et al., 2015). Negative impacts on the environment around construction projects can be grouped into two parts: Physico-chemical and biological effects, which can cause biological damage, water pollution, air pollution, or reduction of groundwater reserves, and social impacts that can disrupt social interactions, environmental security and traffic disturbances.

Green construction implementation standards with green construction performance assessment based on the Minister of Public Works Regulation No. 2 of 2015 Article 24, the green building performance assessment at the construction implementation stage includes the suitability of the green construction process, green behavior practices, and green supply chains.

Setiawan (2017) mentions that a tool for assessing green buildings in Indonesia for new buildings is appropriate land use, energy efficiency and conservation, water conservation, material sources and cycles, air quality and room comfort, and building environmental management.

This study aims to analyze the contractor's perception of the factors of implementing green construction in construction projects in Banda Aceh City in order to obtain the most dominant factors of implementing green construction in construction projects, and to determine the relationship between the factors of implementing green construction (X) on project costs (Y). Where these factors are:

X1 = application of green construction implementation method
X2 = optimization of equipment usage
X3 = implementation of construction waste management
X4 = application of water conservation in construction implementation
X5 = application of energy conservation in construction implementation
X6 = implementation of occupational health and safety management system
X7 = implementation of environmentally friendly behavior
X8 = use of construction materials
X9 = supplier selection
X10 = energy conservation

The contribution of this research is expected as a measuring tool for contractors to be able to improve the implementation of better green construction, and the contribution to knowledge is to be able to add scientific studies in the application of green construction for the construction service industry, especially in developing countries, especially Indonesia.

Research methods

Data collection

The object of research is a contractor company as a respondent with qualifications of Large, Medium, and Small registered with the Construction Services Development Institute. The location of data collection was carried out in Banda Aceh City.

Questionnaire design

The questionnaire was summarized based on a literature study and designed in two parts: the respondents' characteristics and the factors of implementing green construction in Banda Aceh City. The measurement scale of the questionnaire uses a Likert scale. The details of the measurement are positive statements, namely *Very frequently* = 5, *Frequently* = 4, *Occasionally* = 3, *Rarely*= 2, and *Never =1.*

Questionnaire distribution

Filling out the questionnaire was done by distributing questionnaires to the respondents. If the respondent could not hold a meeting due to a fairly busy condition, the researcher left the questionnaire and then asked the respondent to fill out the questionnaire directly. It was taken after a few days or sent via email.

Determining population and sample

The target respondents in this study were respondents who have positions in the company's organizational structure, such as the main director, manager, or staff who understand green construction at a contractor company in Banda Aceh City. Based on the data obtained, the total population of contractors is 82 respondents. Determining the sample size with the provisions of Gay and Diehl, namely, the researcher takes a minimum of 30 samples of respondents with research that is testing the relationship between one or more variables (correlational research) (Sanusi, 2014).

Results

The results of the questionnaire based on respondents' opinions were then processed with validity tests, reliability tests, frequency analysis, and Pearson product moment correlation analysis.

Validity test

The validity test results use the test criteria with the decision of the validity of rcount with rtable with the decision if rcount > rtable means valid, and rcount < rtable means invalid. The value of N is associated with an error level or error level of 0.05 in both directions so that the rtable is 0.334.

Question items were divided into 107 question factors which are divided into 11 variables and 3 question categories. The results obtained were some of the validity tests of the rcount > 0.339, which means the question item was valid and rcount < 0.339 was not valid. Invalid items, there were 12 questions. Invalid questions will not be used for further testing.

Reliability test

The value of the number of respondents (N) is associated with an error level of 5%, so the rtable is 0.339. The results of the reliability test can be seen in the following Table.

Table 1. Reliability test results

Case Processing Summary				***Reliability Statistics***	
		N	**%**	***Cronbach's Alpha***	**N *of Items***
Cases	*Valid*	34	100.0	.987	95
	Excluded[a]	0	0.0		
	Total	34	100.0		

From the results of processing the reliability test data, it is known that all questions on the questionnaire have been considered reliable because the criteria are 0.997 > 0.339.

Frequency analysis

Frequency analysis is used to calculate the frequency of respondent characteristic data and the level of influence of the variables on the application of green construction on construction projects in Banda Aceh City. This can be described as follows.

Table 2. Characteristics of respondents

Characteristics of respondents	**Contractor**	
	F	**%**
Respondent's position		
a. Director	10	29%
b. Deputy Director	0	0%
c. Experts	1	3%
d. Expert staff	13	38%
e. Engineering staff	0	0%

Characteristics of respondents	Contractor	
	F	%
f. Estimator	0	0%
g. Architect	1	3%
h. Quality controller	0	0%
i. Supervisor	0	0%
j. Project manager	4	12%
k. Field manager	3	9%
l. Manager of GSC	1	3%
m. Project management expert	1	3%
Company experience		
a. 0 - 2 years	1	3%
b. 3 - 4 years	5	15%
c. 5 - 7 years	1	3%
d. > 7 years	27	79%
Respondent experience		
a. 0 – 2 years	1	3%
b. 3 – 4 years	3	9%
c. 5 – 7 years	2	6%
d. >7 years	28	82%
Respondent's last education		
a. High School/Equivalent	1	3%
b. Diploma degree	3	9%
c. Bachelor	27	79%
d. Masters/PhD	3	9%
Respondents participated in green construction certification or seminars		
a. Yes, certification	1	3%
b. Yes, seminar	9	26%
c. No, certification	21	62%
d. No, seminar	13	38%
e. Select both "yes" options	12	35%
Sources to know about green construction		
a Internet	3	9%
b Organization	8	24%
c Seminars	13	38%
d Other	10	29%
Number of construction projects handled annually		
a 1 – 3	2	6%
b 4 – 6	2	6%
c 7 – 10	5	15%
d >10	25	74%
Average value of projects carried out each year		
a Rp. 1 M – Rp. 3 M	8	24%
b Rp. 3 M – Rp. 5 M	10	29%
c Rp. 5 M – Rp. 7 M	0	0%
d > Rp. 7 M	16	47%
Estimated project duration		

Characteristics of respondents	Contractor	
	F	%
0 – 6 months	11	32%
6 – 12 months	23	68%
12 – 18 months	0	0%
> 18 months	0	0%
Actual project completion time		
a 0 – 6 months	14	41%
b 6 – 12 months	20	59%
c 12 – 18 months	0	0%
d > 18 months	0	0%

Table 2 explains that the highest score based on the questionnaire is the position of expert staff by 38%, the most experienced in the company is >7 years by 79%, the experience of the most respondents is >7 years by 82%, with the most education being bachelor by 79%. Respondents who took part in certification were 3%, seminars were 26%, and attended both were 35%. The largest source of knowledge about green construction is seminars at 38%. The highest number of construction projects each year is > 10 projects, with a percentage of 74%, the average project value is > Rp. 7 M, the estimated project duration is 6 – 12 months by 68%, with the most actual project completion time being 6 – 12 months at 59%.

The level of implementation of green construction

The factors for the application of green construction, including the *very frequent* category, are the application of energy conservation in the construction implementation (X5) by 95.1%, the application of energy conservation (X10) by 92.8%, and the use of construction materials (X8) by 92.5%. For more details, see the table below.

Table 3. The level of implementation of green construction

	Percentage Interpretation of scores	Rank	Score Interpretation	Average Interpretation Score	Rank	Score Interpretation
A.	Green Construction Process					
X1	92.4%	4	Very frequently	87.6%	3	Very frequently
X2	80.8%	10	Frequently			
X3	83.4%	9	Very frequently			
X4	86.2%	7	Very frequently			
X5	95.1%	1	Very frequently			
B.	Green Behavior Practices					
X6	89.7%	5	Very frequently	89.6%	2	Very frequently
X7	89.5%	6	Very frequently			
C.	Green Supply Chain					
X8	92.5%	3	Very frequently	90.4%	1	Very frequently
X9	86.0%	8	Very frequently			
X10	92.8%	2	Frequently			

The most dominant green construction application factors in the top three in the *Very frequently* category were the application of energy conservation in construction implementation (X5) of 95.1%, the application of energy conservation (X10) of 92.8%, and use of construction materials (X8) of 92.5%.

Pearson Product Moment Correlation Test

A correlation test was conducted to analyze the relationship and effect of green construction implementation on costs.

Table 4. Pearson product moment correlation test

	Correlation coefficient (r)	DC (%)	Relationship	t-count	t-table	Influence
A.	Green Construction Process					
X1	0.804	64.564	Very strong	7.636	2.034	Significant
X2	0.701	49.165	Strong	5.563	2.034	Significant
X3	0.822	67.588	Very strong	8.169	2.034	Significant
X4	0.779	60.672	Strong	7.026	2.034	Significant
X5	0.841	70.802	Very strong	8.809	2.034	Significant
B.	Green Behavior Practices					
X6	0.387	15.011	Low	2.377	2.034	Significant
X7	0.845	71.342	Very strong	8.925	2.034	Significant
C.	Green Supply Chain					
X8	0.850	72.242	Very strong	9.126	2.034	Significant
X9	0.799	63.824	Strong	7.514	2.034	Significant
X10	0.882	77.821	Very strong	10.596	2.034	Significant

Based on Table 4, it is found that the relationship between the X and Y variables is very strong, which is found in factors X1, X3, X5, X7, X8, X10. The largest correlation coefficient is found in the energy conservation factor (X10) of 0.882. At the same time, the effect of the application of green construction on the cost of all factors has a significant effect.

The results show that the overall interpretation of the factors of implementing green construction has a significant value that has a positive effect on costs on construction projects which can have a direct impact on cost savings.

Discussion

The most dominant green construction implementation factors in construction projects

The most dominant green construction implementation factors in the third-largest ranking are:

1. Application of energy conservation in construction (X5)

This factor has 8 indicators that are included in the green construction process category. One of the highest dominant factors in this factor is the use of

daylighting (natural lighting) for lighting purposes in the workspace (X.5.1) by 98.2% (Very frequently)

According to Karya (2019), electricity and fuel oil are the most widely used energy sources during the construction process. Karya (2019) also argues that the green construction process is a work method and technology that can maximise the value to be achieved by minimizing waste or waste disposal in the construction process.

The utilization of daylighting (natural lighting) for lighting purposes in the workspace can save artificial energy such as electricity by utilizing natural energy as the lighting in the room. The utilization of sunlight as alternative energy is very easy to find around the environment in Indonesia, especially in the city of Banda Aceh. Lighting can be adjusted with the room using glass windows facing the sun. Light adjustment can be added with a glass filter so that the heat energy is not too high in the room.

2. Energy conservation (X10)

This factor has 15 indicators that fall into the green supply chain category. One of the highest dominant factors in this indicator is double glazed windows for ventilation or lighting (X10.1) of 96.5% (Very frequently).

Energy conservation is the efficient and rational use of energy without reducing the energy needed. Efforts in energy conservation are applied at all stages of utilization, starting from the utilization of energy resources to the final utilization, using efficient technology, and cultivating an energy-saving lifestyle (ugm.ac.id 2005). The National Energy Policy (NEP) sets an energy conservation target of 1% per year in reducing energy intensity and reaching 17% by 2025 in final energy savings (duniaenergi.com 2019).

Electrical power savings can be selected by product design from the green supply, which has an energy conservation concept such as choosing a product with a double-glazed window design, this is done so that sunlight from outside can enter the room, which can reduce the use of electrical energy, so there is no energy wastage. However, the use of too much glass is not recommended because glass can create high emissions, so that it can damage the ozone, except using glass with a reflective glass type that reflects solar thermal energy.

3. Use of construction materials (X8)

This indicator has fifteen (15) supporting factors that fall into the green supply chain category. One of the highest dominant factors is the application of a concrete mixer truck transporting a maximum of 90% of the mixer capacity to avoid spilt concrete during the journey (X.8.5) and non-toxic/hazardous materials (X.8.14) with the same value of 98.2 % is very applicable.

According to the Ministry of Public Works and Public Housing (2015), the green supply chain in the green building construction process is obtained from

suppliers and sub-contractors who contribute by considering the life cycle principle in carrying out construction products from the supply. By considering the use of materials. In the implementation of construction, it must be carried out as optimally as possible so that the use of resources is more efficient and reduces construction waste in the form of residual materials.

The project team always strives for the use of construction materials in the application of concrete mixer trucks with a maximum of 90% of the mixer capacity in order to avoid spilt concrete during the trip, and there is no residual material on the road for cost, time, quality efficiency, and to avoid road damage caused by material waste. The team also assessed that non-toxic/hazardous materials were highly applied to avoid air pollution and even disease to facility users.

The influence of the factors of implementing green construction on project costs

The results show that the overall interpretation of the factors of implementing green construction has a significant value that positively affects construction project costs, which can directly impact cost savings. The value of the greatest influence is on the application of energy conservation (X10) which affects the cost of construction projects, namely the cost of fuel (Y3). The cost factor can be seen in terms of short-term and long-term green construction projects. There are several factors that can be categorized as short-term, such as fuel costs during project implementation, and long-term, such as operational costs, maintenance, and repairs in the building and the surrounding environment.

Contractors during project implementation spend more on fuel costs for vehicles and equipment used. Contractors as much as possible implement cost-effective fuel by using vehicles and equipment not too often by planning tasks in advance so that they can be completed at one time. Green and non-green construction projects both have a high or low-cost effect. According to Prasaji (2012), structural work with the green construction concept can save more project costs. Overall green construction costs are lower than non-green construction. Structural work can save construction costs by applying the use of hollow formwork because it can save the use of wood. Although structural work using precast floor slabs is more expensive than the application of conventional floor slabs / non-precast floor slabs, it provides the advantage of reducing the use of wood formwork such as floor slabs. According to (Ervianto 2012), the benefits of green construction include two things, namely environmental benefits and economic benefits, where the first benefit is energy saving, the second benefit is water savings, and the third benefit is the control of solid, liquid and gas waste**.**

Meanwhile, preparatory work on green construction may increase

construction costs. Still, it can positively impact the environment, such as lower air pollution, controlling noise levels, good construction waste management, and energy savings (Prasaji 2012). However, green construction projects are more concerned about protecting the surrounding environment in order to remain stable in the environmental life cycle. Thus, the effect of applying the cost factor in green construction is more beneficial because it has a long-term effect, especially in energy conservation which is more efficient because all equipment and vehicles that use fuel with the addition of biodiesel are in better condition, more efficient and reduce emissions in the environment that cause depletion of the ozone layer.

Conclusion

Based on the results of the study, the most dominant green construction application factors in the third-largest ranking were the application of energy conservation in the construction implementation (X5) of 95.1% (highly applied), the application of energy conservation (X10) of 92.8% (highly applied), and material usage (X8) of 92.5% (strongly applied). While the relationship between variable X and variable Y is very strong, which is found in factors X1, X3, X5, X7, X8, X10. All factors in the application of green construction have a significant value that positively affects construction project costs, which can directly impact cost savings.

Energy-saving or energy conservation is to reduce the amount of energy used during construction projects. Energy savings can be achieved by using energy efficiently, where the same benefits are obtained by using less energy or reducing excessive energy consumption (Ervianto, 2012). In its application in the field, most construction companies have used materials that are environmentally friendly, non-toxic, and can be used repeatedly. One example is the field that has been applied is the use of go green roofs as a substitute for asbestos and zinc.

In general, Indonesian people do not know the importance of green construction. It started from the concept, its benefits in the long term, and its application in the field. Socialization about green construction can be given to the people of Indonesia. This is done so that people know more about the importance of implementing green construction in the world of development in Indonesia. In the threat of climate change, increasing energy shortages and also health problems, in the implementation stage of construction projects, it is necessary to save energy, reduce waste and pollution, and improve occupational health and safety for environmental sustainability. Green construction prioritizes the balance of short-term benefits on long-term risks by carrying out activities that do not damage future health, safety, and welfare. (Tanubrata, 2016).

Recommendation

Based on the study results, the suggestions that can be given are as follows:

Further research on the same topic is needed by adding new methods and variables. There is an increase in the number of respondents, the more the number of respondents, the better the research results. It is necessary to conduct similar research in different locations so that the research results can be more comprehensive related to green construction.

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