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THE STUDY ON THE GREEN CONSTRUCTION IMPLEMENTATION FOR BUILDING CONSTRUCTION IN BANDUNG

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ABSTRACT

In the early 1990s, the implementation of sustainable construction becomes more important. One part of the sustainable construction is green construction that is not only environmentally friendly construction but also efficient and effective in the use of tools, materials, labor, methods, and money regardless of the design stage based on the green design concept or not. Based on these beneficial opportunities, anyone that has conducted the green construction concept for the first time will tend to do it again on the next construction. So, it is interesting to find out the benefits in applying the green construction concept. The purpose of this study is to describe and analyze the perception of contractors on benefits in implementing the green construction concept and its correlation in building construction in Bandung. The research was carried out by determining the variables and indicators for both implementation and benefits of the green construction application. The data collection was taken by questionnaires and the results were processed by using the descriptive correlation method. The result showed five green construction implementation indicators correlated and met all three aspects of green construction benefits based on the respondents' perception. These five indicators were then analyzed by regression analysis to determine the significance level of indicators that influenced the green construction benefits. The most dominant indicator was only one and the indicators sorted all waste materials by type into organic waste, inorganic waste, and hazardous-solid-toxic waste material (X2.2). The coefficient from regression analysis showed that every time independent variables X2.2 increased by one, then the benefits for environmental aspect (Y1) increased by 0.496, social aspect (Y2) increased increasing by 0.193, and economic aspect (Y3) increased by 0.374.

*Keywords***:** Building construction; Friendly construction; Green design; Implementation of green construction; Sustainable construction

1. INTRODUCTION

Indonesia as a developing country has begun the construction on a massive scale from the west end, Sabang, to the east end, Merauke. It can be seen from the numerous number of project constructions, both building construction and building infrastructure. Project construction is a success if the basic requirements are achieved, such as cost effective, timely, and appropriate quality. But as time goes by, these requirements should be supported by a sustainable construction. Sustainable construction concept has been known widely since the beginning of 1990 in the Earth Summit. The concept of sustainable construction from the Earth Summit consists of three aspects: economic, social, and environmental.

Sustainable construction according to US Green Building Council can be divided into several stages in sequence those are green pre-design, green design, green procurement, green construction, and green occupancy. Green construction is not only environmentally friendly construction but also efficient and effective in the use of tools,

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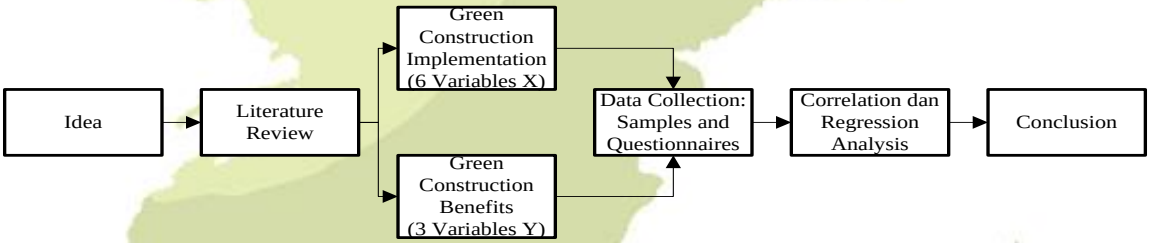
materials, labor, methods, and money regardless of the design stage is based on the green design concept or not. Based on these benefit opportunities, anyone that have conducted the green construction concept for the first time would tend to do it again in the next construction. So it is interesting to find out the benefits in applying the green construction concept. The purpose of this study is to describe and analyze the perception of contractors on benefits in implementing the green construction concept and its correlation in building construction in Bandung

2. RESEARCH METHOD

To achieve the purpose of this study, a combination of research methods has been used. It was based on the literature review and data collection technique. The framework of study is presented in Figure 1.



Figures 1. Framework of Study

2.1. Research Variable

Research variable is a value of people, objects, or activities adopted by researchers to be learned and to make a conclusion from it (Sugiyono, 2003). Based on the relationship between variables, it can be divided into two types, independent variable and dependent variable. In this study, the independent variable refers to the variables for the application of green construction called as the variable x (input). While the dependent variable refers to the benefit of the application of green construction then called as the variable y (output).

Variables for the application of green construction were defined as a measurement for green construction implementation. Some sources used as the variables for the application of green construction included Glavinich (2008), Kibert (2013), and the guidelines of PT Pembangunan Perumahan. Variables for the green construction implementation divided into 6 (six) variables that can be seen in Table 1.

Table 1. Variables and Indicators for Green Construction Implementation

Code	Variable and its Indicator
X1	Maintaining the cleanliness of the project site.
X1.1	Washing vehicle's wheel that coming out of the project site.
X1.2	Cleaning the dust by using water.
X1.3	Installing the safety net on the entire project to reduce dust.
X1.4	Disposing of construction waste in the trash that should be provided.
X1.5	Not throwing cigarette butts carelessly.
X1.6	Using restroom.
X2	Waste Management.
X2.1	Maintaining the quality of the construction material to avoid the repair work.
X2.2	Sorting all the waste by type into organic waste, inorganic waste, and hazardous-solid-toxic waste material.

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Code	Variable and its Indicator
X2.3	Providing storage location for materials so that it is not damaged before use.
X2.4	Performing an action to increase the material's quality; later not easily damaged after use.
X3	Using environmentally friendly material.
X3.1	Conducting a review of the material and providing the results of the review to the owner to use environmentally friendly material.
X3.2	Using environmentally friendly materials produced and sold in the local area.
X4	Maintenance and use of environmentally friendly equipment.
X4.1	Using renewable fuel for motorized equipment.
X4.2	Conducting a periodic maintenance for equipment.
X4.3	Ensuring the oil does not contaminate soil and water while maintaining the motorized equipment.
X4.4	Providing training to equipment operators.
X4.5	Cleaning equipment after work.
X4.6	Using assistive equipment that can be used repeatedly.
X5	Energy conservation.
X5.1	Supervision of electrical energy consumption.
X5.2	Using natural ventilation instead of air conditioning and natural lighting during the day for lighting in the room.
X5.3	Using automatic sensors for lights and air-conditioning.
X5.4	Using energy saving lamps.
X5.5	Using a laptop to do the job at site office.
X6	Water resources conservation.
X6.1	Monitoring of water usage.
X6.2	Rainwater harvesting.
X6.3	Using automatic faucets in the rest room.
X6.4	Using the shower in the rest room.

Variables for benefits of the green construction have been defined as the measurement for the advantages obtained after applying the green construction on the construction projects. Some sources that can be used as the variables for the benefits of green construction implementation included Ahn (2013), Okadiri (2012), and Sinulingga (2012). Variable for the benefits of green construction was divided into 3 (three) as seen in Table 2.

Table 2. Variables and Indicators for the Benefits of Green Construction

Code	Variable and its Indicator
Y1	Benefits based on environmental aspect.
Y1.1	The project location is clean, tidy, and the air is not dusty.
Y1.2	The air at the project site becomes fresher (not smell bad due to the garbage).
Y1.3	The water requirement from rainwater is sufficient for project
Y1.4	Groundwater qualified for drinking water based on his physical condition.
Y2	Benefits based on social aspect.
Y2.1	Minimizing some health problems for workers.
Y2.2	Habits and workers' awareness to protect the environment.
Y2.3	Communities around the project can live comfortably during the project.
Y3	Benefits based on economic aspect.
Y3.1	Operational cost savings of electricity.

Code	Variable and its Indicator
Y3.2	Operational cost savings of water.
Y3.3	Cost savings mobilization and waste disposal equipment.
Y3.4	The project is completed more quickly.
Y3.5	The cost savings of repair work due to disability can be minimized.

2.2. Data Collection Technique

The data in this research were collected through a survey by questionnaire. Three parts of the questionnaire in this research included personal profile section, perception towards green construction implementation in the study area, and perception towards green construction benefits in the study area. The measurement scale used the Likert scale, a measurement method used to measure the attitudes, opinions and perceptions of a person or a group of social phenomenon. The scale was from 0 to 4.

The observations of the perception of implementation rate and the perception of benefits rate of the application of green construction involved 17 respondents in this study. The observation was done by distributing the questionnaire to the participants in Bandung. The participant criterion was a contractor working on a building construction project with minimum floor height of five.

2.3. Data Analysis Method

Method used in this study was a non-parametric statistical method used if the data was not normally distributed, or data level was nominal or ordinal as well as the number of respondent data tended to be very little.

The aim of descriptive analysis was to obtain the mean and deviation of the overall assessment that have been given by the respondents to variables in the questionnaires. The use of the mean and deviation was intended to obtain a qualitative picture of the green construction implementation and benefits rate by the respondents' perception.

Correlation analysis used the spearman rank correlation. The data source for spearman rank correlation was derived from a different source and the data type to be correlated included ordinal data, plus the data from the two variables that did not have to form a normal distribution. Thus, the spearman rank correlation worked with ordinal data or tiered or ranking, and free distribution. The correlation technique used was Spearman's correlation with the basis for a decision by significance tests indicating the probability level less than 0.05

Regression analysis was conducted to study how close relationship between one or several independent variables and a dependent variable was. In general, the form of the multiple regression models is written as follows:

$$Y = A + B_1.X_1 + B_2.X_2 + \ldots.. + B_n.X_n + e \quad (1)$$

where: Y = the dependent variable, A = intercept, B_1; B_2; B_n = the independent variable's coefficient, X_1; X_2; X_n = the independent variable, e = error.

Regression analysis was used in this research to create a subjective model from data collected. The whole statistical model analysis was performed using SPSS.

The regression model was then analyzed by the coefficient of determination analysis or R^2 test. The analysis of the coefficient of determination was used to observe the appropriateness of the variables affecting the dependent variable. This coefficient showed that the percentage shares of the total variable Y (variable related) can be

explained by variables. The closer the Y of the regression model to the data points, the higher the R square. This method is also known as the validation of prediction and the value of R square area was from zero to one.

3. RESULTS

3.1. The Green Construction Implementation Rate

The first aim of this descriptive analysis was to obtain a qualitative picture of the green construction benefits rate by the respondents' perception as seen in Table 3.

Table 3. Descriptive Analysis for Green Construction Implementation

Code	N	Sum	Mean		Std. Deviation	Variance	Green Construction Implementation Rate
	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	
X1.1	17	54.00	3.1765	.24608	1.01460	1.029	Very high
X1.2	17	43.00	2.5294	.22877	.94324	.890	High
X1.3	17	55.00	3.2353	.23529	.97014	.941	Very high
X1.4	17	42.00	2.4706	.15141	.62426	.390	High
X1.5	17	18.00	1.0588	.05882	.24254	.059	Fair
X1.6	17	21.00	1.2353	.10605	.43724	.191	Fair
X2.1	17	45.00	2.6471	.20901	.86177	.743	High
X2.2	17	28.00	1.6471	.25641	1.05719	1.118	Fair
X2.3	17	49.00	2.8824	.25556	1.05370	1.110	High
X2.4	17	39.00	2.2941	.14258	.58787	.346	High
X3.1	17	52.00	3.0588	.27747	1.14404	1.309	Very high
X3.2	17	35.00	2.0588	.15975	.65865	.434	High
X4.1	17	1.00	.0588	.05882	.24254	.059	Low
X4.2	17	53.00	3.1176	.24075	.99262	.985	Very high
X4.3	17	27.00	1.5882	.21107	.87026	.757	Fair
X4.4	17	58.00	3.4118	.22782	.93934	.882	Very High
X4.5	17	53.00	3.1176	.22496	.92752	.860	Very high
X4.6	17	60.00	3.5294	.12478	.51450	.265	Very high
X5.1	17	26.00	1.5294	.12478	.51450	.265	Fair
X5.2	17	44.00	2.5882	.22782	.93934	.882	High
X5.3	17	.00	.0000	.00000	.00000	.000	Very low
X5.4	17	44.00	2.5882	.25809	1.06412	1.132	High
X5.5	17	38.00	2.2353	.27825	1.14725	1.316	High
X6.1	17	26.00	1.5294	.12478	.51450	.265	Fair
X6.2	17	6.00	.3529	.19061	.78591	.618	Low
X6.3	17	1.00	.0588	.05882	.24254	.059	Low
X6.4	17	.00	.0000	.00000	.00000	.000	Very low

The highest implementation rate based respondents' perception was the indicator X4.6 (using assistive equipment repeatedly). This indicator was about the use of equipment that can be used repeatedly and had the highest implementation rate because the contractors as the respondents often used this equipment. The main reason for using this equipment was because it could help in the construction work and profitable.

3.2. The Benefits of Green Construction Implementation Rate

Another aim of this descriptive analysis was to obtain a qualitative picture of the green construction benefits rate by the respondents' perception as seen in Table 4.

Table 4. Descriptive Analysis for Benefits of Green Construction Implementation

Code	N	Sum	Mean		Std. Deviation	Variance	Green Construction Benefit Rate
	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	
Y1.1	17	38.00	2.2353	.20164	.83137	.691	High
Y1.2	17	46.00	2.7059	.29412	1.21268	1.471	High
Y1.3	17	4.00	.2353	.18250	.75245	.566	Low
Y1.4	17	55.00	3.2353	.21911	.90342	.816	Very high
Y2.1	17	63.00	3.7059	.11391	.46967	.221	Very high
Y2.2	17	23.00	1.3529	.14706	.60634	.368	Fair
Y2.3	17	29.00	1.7059	.16638	.68599	.471	Fair
Y3.1	17	32.00	1.8824	.16896	.69663	.485	Fair
Y3.2	17	46.00	2.7059	.16638	.68599	.471	High
Y3.3	17	39.00	2.2941	.11391	.46967	.221	High
Y3.4	17	30.00	1.7647	.16109	.66421	.441	Fair
Y3.5	17	44.00	2.5882	.14997	.61835	.382	High

The benefits of green construction implementation rate were summarized into 3 variables (Y1, Y2, and Y3) only by using the mean of their indicator mean. So, the variables can represent each aspect in the correlation and regression analysis.

3.3. Correlation Analysis

Correlation analysis aimed to identify and found the relationship between the variables green construction implementation (X) and the variable benefits of green construction (Y). The correlation technique used was Spearman's correlation with the basis for a decision by significance tests that indicated the probability level less than 0.05. The probability level less than 0.05 must meet the three aspects of green construction benefits as the requirement of the implementation of green construction. The output of Spearman correlation used SPSS 23 software and has been summarized using the probability level less than 0.05 as seen in Table 5 below.

Table 5. The Result of Spearman's Correlation Analysis

Code	Variable Description	Indicator Description	Correlation Coefficient		
			Y1	Y2	Y3
X2.2	Waste Management.	Sorting all the wastes by type into organic waste, inorganic waste, and hazardous-solid-toxic waste material.	0.827	0.678	0.753
X2.4	Waste Management.	Performing an action in increasing the material's quality so that it is not easily damaged after use.	0.809	0.608	0.726
X4.2	Maintenance and use of environmentally friendly equipment.	Conducting a periodic maintenance for equipment.	0.702	0.498	0.552

Code	Variable Description	Indicator Description	Correlation Coefficient		
			Y1	Y2	Y3
X4.4	Maintenance and use of environmentally friendly equipment.	Providing a training to equipment operators.	0.535	0.590	0.559
X4.6	Maintenance and use of environmentally friendly equipment.	Using an assistive equipment that can be used repeatedly.	0.788	0.512	0.486

The result from Spearman correlation analysis was only five green construction implementation indicators that were correlated and met all three aspects of green construction benefits based on the respondents' perception. These five indicators were then analyzed by the regression analysis to determine the significance level of indicators that influenced the green construction benefits.

3.4. Regression Analysis

Regression analysis was conducted to study how close the relationship between one or several independent variables or indicators (X) and one dependent variable (Y) was. Based on the removed variable Table in the regression analysis, there was only one most dominant indicator (sig. was below 0.05) and the indicators sorted all the waste materials by type into organic waste, inorganic waste, and hazardous-solid-toxic waste material (X2.2) for every dependent variable Y. The result from the regression analysis is shown in Table 6 below.

Table 6. Coefficient from Regression Analysis for Dependent Variables Y1, Y2, Y3

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
For Y1										
(Constant)	1.286	.167		7.706	.000					
X2.2	.496	.086	.830	5.765	.000	.830	.830	.830	1.000	1.000
For Y2										
(Constant)	2.312	.111		20.88	.000					
X2.2	.193	.057	.657	3.375	.004	.657	.657	.657	1.000	1.000
For Y3										
(Constant)	1.632	.155		10.54	.000					
X2.2	.374	.080	.771	4.687	.000	.771	.771	.771	1.000	1.000

From Table 6, the dependent variables model for Y1, Y2, and Y3 can be determined as:
Y1 = 1.286 + 0.496 X2.2.
Y2 = 2.312 + 0.193 X2.2.
Y3 = 1.632 + 0.374 X2.2.

The coefficient from regression analysis showed that every time independent variable X2.2 increased by one, then the benefits for environmental aspect (Y1) increased by 0.496, social aspect (Y2) increased by 0.193, and economic aspect (Y3) increased by 0.374.

3.5. Coefficient of Determination Analysis

The analysis of the coefficient of determination was used to see the appropriateness of independent variable affecting the dependent variable.

Table 7. Model Summary

Dependent and Independent Variable		R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
Y1	X2.2	.830[a]	.689	.668	.36378	.689	33.230	1	15	.000
Y2	X2.2	.657[a]	.432	.394	.24123	.432	11.391	1	15	.004
Y3	X2.2	.771[a]	.594	.567	.33717	.594	21.965	1	15	.000

From Table 7 it can be seen that the model summary obtained r square at worth 0.689, 0.432, and 0.594. it indicated that the means of independent variables mentioned above were able to explain the variation of the dependent variable (benefits) amounted to 68.9% for environment aspect, 43.2% for social aspect, and 59.4% for economic aspect. While the rest was able to be explained by other factors not explained in the model.

4. DISCUSSION

Based on the correlation analysis, there were only two variables that had a close relationship to the benefits in applying green construction. Those two variables included waste management and the maintenance and use of environmentally friendly equipment. Four variables have been excluded because not having a close relationship to the benefits in applying green construction are maintaining the cleanliness of the project site, the use of environmentally friendly material, energy conservation, and water resources conservation.

4.1 Waste Management

Waste management is an action to reduce the excessive use of construction materials and improve the durability of the material. This action is not only environmentally friendly but also is economically profitable. It is a good from the social aspect as well. So, from the viewpoint of contractor, the waste management is an action that must be done to realize the sustainable construction - specifically the green construction.

4.2 The Maintenance and Use of Environmentally Friendly Equipment

Another variable is about the maintenance and the use of environmentally friendly equipment as an action to use assistive equipment repeatedly and maintenance the equipment purposely to be used longer. This action is also environmentally friendly, economically profitable, and from the social aspect is good from the viewpoint of contractor. This variable is an important part in realizing the sustainable construction.

4.3 The Excluded Variables

Other four variables have been excluded from the variables of green construction implementation for not being correlated to the benefits of the green construction implementation. This might occur because the other variables had some indicators that were not able to describe the unique situation or different condition from all building construction projects.

5. CONCLUSION

There are five correlated green construction implementation indicators that meet all the three aspects of green construction benefits. The indicators sort all the wastes by types into organic waste, inorganic waste, and hazardous-solid-toxic waste material (X2.2);

performing an action in increasing the material's quality so that it is not easily damaged after use (X2.4); conducting the periodic maintenance for equipment (X4.2); providing training to equipment operators (4.4); and using assistive equipment that can be used repeatedly (X4.6) based on the respondents' perception.

From those five indicators, only one as the most dominant indicator is to sorting all the waste materials by type into organic waste, inorganic waste, and hazardous-solid-toxic waste material (X2.2) for every dependent variable Y. Model for benefits of green construction variables is Y1 = 1.286 + 0.496 X2.2; Y2 = 2.312 + 0.193 X2.2; and Y3 = 1.632 + 0.374 X2.2. The X2.2's coefficient shows that every time independent variables X2.2 increases by one, then the benefits for environmental aspect (Y1) increases by 0.496, social aspect (Y2) increased by 0.193, and economic aspect (Y3) increased by 0.374.

The model summary obtained r square is worth 0.689, 0.432, and 0.594. That is means of independent variables or indicators (X2.2) only able to explain the variation of the dependent variable (benefits) amounted to 68.9% for environment aspect, 43.2% for social aspect, and 59.4% for economic aspect. While the rest were able to be explained by other factors that are not explained in the model.

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