Study of the application of the green construction concept on the integrated college building project of Teuku Umar University

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Abstract. Green construction is a sustainable concept in construction projects. The implementation stage plays an important role in the construction sector, because it has an impact on the environment. This study aims to determine the percentage of the application of the most dominant factors and constraints in the application of the green construction concept in project implementation. This research was conducted during the implementation of the Teuku Umar University Integrated Lecture Building project. The implementation phase of this research begins with a survey, to find out the construction implementation process, followed by interviews with workers, consultants, contractors. The results of the interviews were analysed using the Delphi method. The results show that Green construction in the implementation of the Teuku Umar University Integrated Lecture Building project has not been widely applied, with a weight value of only 10.2%. Constraints in the application of green construction based on the results of the questionnaire following the iteration obtained four obstacles, namely the lack of detailed rules regarding green construction, lack of socialization from the government regarding saving energy sources that support construction, lack of knowledge from contractors about green construction, and the lack of knowledge and experience of contractors, green construction consultant.

Keywords: Green Construction, Integrated Lecture Building, Delphi Method

1. Introduction
Global warming is a phenomenal issue today and is one of the challenges for the world's population, including in Indonesia. Global warming is caused by various factors including infrastructure. One of them is the existence of buildings that have a major contribution to global warming which has an impact on the environment. Construction design starts from general planning, pre-feasibility study, feasibility study, technical planning, review of soil conditions, construction implementation, maintenance operations, post-project evaluation, and building demolition that have an impact on the environment. In the various stages of implementation, there are several ways to implement insightful green construction that meets building requirements and has significantly measurable performance in saving energy, water, maintaining air circulation, and other resources, through the application of green building principles following functions and classifications.
Green construction is part of sustainable construction which is a holistic process that aims to restore and maintain a balance between the natural and artificial environment [1]. Green construction is defined as planning and implementation of the construction process to minimize the negative impact of the construction process on the environment so that there is a balance between the ability of the environment and the needs of human life for present and future generations [2,3]. By implementing green construction, many benefits can be obtained, namely lower operating costs, more comfortable because of the maintained temperature and humidity, good air circulation system, easy and cheap replacement of materials, and relatively low maintenance costs.

Green construction is increasingly attracting the attention of construction industry players in Indonesia. The most popular reference concept for implementing green construction is issued by the US Green Building Council, namely Leadership in Energy and Environmental Design (LEED). This concept can eliminate the confusion of understanding that the implementation of green construction is expensive, difficult, and not feasible in business. In Meulaboh until now there has not been a single integrated project using the LEED concept so that the key to its successful implementation is in the form of good socialization to construction actors. In many countries, the construction of a building has taken an ecological approach (the relationship between living things and the environment), and this has turned out to be an added value of the property's product. However, in developing countries such as Indonesia, especially the city of Meulaboh, it still requires a long educational process in looking for indicators of implementing green construction in building construction projects [4].

The government has regulated the process of implementing building planning that is oriented towards green buildings through the Minister of Public Works Regulation No. 2 of 2015 concerning Green Buildings [1], some requirements must be met, one of which is the practice of green construction in its construction. The green construction process is carried out through the application of green construction implementation methods, optimizing the use of equipment, implementing construction waste management, implementing water conservation in construction implementation [5]. However, there is a need for a study in applying the concept of Green Construction in the implementation of the Project.

The purpose of this study is to find out and examine how the application of the green construction concept and the obstacles encountered in the construction project of an integrated lecture building at the Teuku Umar University campus, West Aceh Regency.

The factors that greatly affect the application of green construction in construction projects are high investment costs, time-consuming application procedures, limited availability of green products, technical implementation difficulties, lack of information about green buildings, complicated planning, lack of expertise, low demand market [6].

To be able to implement green construction in construction projects, some obstacles often occur in the field [7,8], namely:

1. Technology Problems
   Technological problems, where contractors are still constrained by, The use of alternative fuels, Recycling technology, Limited availability of environmentally friendly equipment in terms of noise levels, Implementation of prefabricated components, Sport of renewable materials;

2. Active Role of Project Owner
   The project owner must be active in requiring the use of wood that can be accounted for from its origin, requiring the creation of a system for groundwater infiltration, provisions for filtering water to be channelled into the city roll, provisions for not cutting down trees except those during the construction period, requiring responsible use of water responsible for both sources from PDAM and groundwater, Monitoring the waste generated, Monitoring noise, vibration, and groundwater conditions caused by project activities, Monitoring air quality during the project to create clean air,

3. Regulatory Limitations
   Limited regulations related to standardization related to lighting that is suitable for construction activities both indoors and outdoors, Provisions for the use of low-emissions construction equipment and alternative fuels.
4. Source of Funding
   Intervene sources of funding in terms of upgrading various low-emissions and fuel-efficient equipment.

5. Awareness Factor
   The awareness factor includes socialization of saving water, energy, using light sensors for lighting, and not using hazardous materials such as mercury, Styrofoam, and other substances that are not environmentally friendly.

Several studies have conducted research related to green construction, namely:
   In a study entitled "A Study of Green Construction Factors in Building Construction Projects in Badung Regency" [9]. This study aims to determine the level of application of green construction in construction projects and what factors are the most dominant obstacles in implementing green construction in construction projects in Badung Regency, Bali. The data was obtained using a questionnaire obtained from 48 respondents who were taken from construction companies that were carrying out construction projects in the 2012-2014 implementation year and were eligible for improvement in Badung Regency, Bali.
   Dewi and Diputra [6], in a study entitled "Analysis of Constraints in the Implementation of Green Construction and Strategies to Overcome It". This study aims to identify obstacles in the application of green construction and determine strategies to overcome these obstacles in Indonesia, especially in the province of Bali. Data was collected through a questionnaire using the Delphi technique which involved experts in the field of green construction. Data analysis was carried out using descriptive analysis to reach a consensus or agreement among the respondents.
   In a study entitled "Analysis of Criteria for Application of Green Construction in Construction Projects in Surabaya" [10]. This study aims to determine how far the knowledge of construction actors regarding the application of green construction in industrial construction and to find out the most important criteria according to construction actors in implementing green construction in construction, especially those in Surabaya.

2. Methods
   This study uses primary data, all data obtained from the results of the distribution of questionnaires addressed to contractors and consultants on the project. The questionnaire was made into 3 parts, namely round 1 questionnaire, round 2 questionnaires, and round 3 questionnaires. Data processing for round 1 and round 2 used the Delphi method, in round 1 it was carried out to determine the mean value, median value, and mode value. In the second round determine the obstacles in implementing green construction. After completing the 1st and 2nd rounds, then proceed with the third round, using the pairwise comparison survey method or paired matrix survey which aims to find the relationship between the constraints in implementing green construction. In the third round, the questionnaire was given to experts who know the application of green construction, to be able to determine the value of vaxo to be sought from the variables in the second round of questionnaires by linking constraint one to constraint two and so on.

3. Results and Discussion

3.1 Results of Analysis of the Implementation of Green Construction Based on Planning
   The results of the analysis are based on the planning stages in terms of the building design of the Integrated Lecture Building, Teuku Umar University Campus. The results obtained, the design of the Integrated Lecture Building on the Teuku Umar University Campus has been able to apply the concept of green construction, shown in the pattern of the position of the building that follows the sun seen from the position of the building facing west. Maximum use of lighting, indicated by the presence of an open middle void and the number of windows in the space. The lamps are designed in such a way using energy-saving lamps, namely LED downlights.
In the design of frames and walls, it is possible to apply the concept of green construction, using manufactured materials, and avoiding materials from nature such as wood. Likewise with the wall material, using lightweight brick, namely foam brick.

3.2 Results of Analysis of the Application of Green construction based on Existing conditions

Based on the results of the analysis of the application of green construction in the field, the concept of green building is not applied. Judging by the distance of material transport reaching +10 km from the project site. In terms of time management, it consumes a lot of energy because the distance is too far from the project site. Resulting in the absence of cost efficiency and time efficiency because the transportation distance is too far.

The results of the survey in the field, the water source used in the implementation of the construction is bore wells. The use of water is calculated based on the needs during the construction of the building. Judging from the performance of workers at the project site, water management for the need for repeated water use is not efficient. At the project location, there is also a rainwater reservoir with a large capacity to be used as a backup water source. This shows the efficiency of water use can be implemented properly.

3.3 The Results of The Analysis of Constraints on The Application of Green Construction

The results of the questionnaire analysis are inputted by determining the mean, median, mode, and standard deviation values to produce the branch level. The results of the assessment can be seen in Table 1.

| Constraints To Implementing Green Construction | Mean | Median | Modus | SD  | Rating | %   |
|-----------------------------------------------|------|--------|-------|-----|--------|-----|
| 1 Lack of detailed regulations regarding green construction in Indonesia | 3.90 | 4.00   | 4.00  | 0.31| High   | 100 | 3.90 |
| 2 There is no comprehensive guideline in implementing green construction | 2.95 | 3.50   | 4.00  | 1.32| Medium | 95  | 2.95 |
| 3 Lack of support from the government in implementing green construction | 3.95 | 4.00   | 4.00  | 0.89| High   | 100 | 3.95 |
| 4 Lack of socialization from the government regarding saving resources | 3.80 | 4.00   | 4.00  | 0.83| High   | 100 | 3.80 |
| 5 Green construction financing and maintenance are perceived as expensive by the project owner | 3.40 | 4.00   | 4.00  | 0.88| High   | 96  | 3.40 |
| 6 The perceived financial risk is too great for the project owner | 3.35 | 4.00   | 4.00  | 0.88| High   | 100 | 3.35 |
| 7 It is difficult to get a certificate that can ensure that the materials used are environmentally friendly | 2.95 | 3.50   | 1.00  | 1.64| Medium | 95  | 2.95 |
There is still a lack of alternative materials and implementation methods in implementing green construction.

Lack of experts in government regarding green construction

Lack of knowledge, experience, and contractors regarding green construction

Lack of knowledge and expertise of consultants regarding green construction

Resistance attitude to implement green construction

Lack of awareness of the benefits of green construction

Feel unnecessary

The table above is the result of round 1 and round 2. Three obstacles have a moderate rating, namely the problem of not having a guideline, difficulty to get a certificate, and lack of alternatives. Data that has a moderate rating is not used as a constraint, but this data is discarded and a high data rating is taken.

There are eleven obstacles in the questionnaire analysis of the Delphi survey round 2.

Based on the results of the Delphi 2 questionnaire analysis, it is found that there are obstacles in implementing green construction as shown in Table 2.

Table 2. Obstacles in Implementing Green Construction

| No | Factor                                                                 |
|----|------------------------------------------------------------------------|
| 1  | Lack of detailed regulations regarding green construction in Indonesia |
| 2  | Lack of support from the government in implementing green construction |
| 3  | Lack of socialization from the government regarding saving resources    |
| 4  | Green construction financing and maintenance are perceived as expensive by the project owner |
| 5  | The perceived financial risk is too great for the project owner        |
| 6  | Lack of experts in government regarding green construction              |
| 7  | Lack of knowledge, experience, and contractors regarding green construction |
| 8  | Lack of knowledge and expertise of consultants regarding green construction |
| 9  | Resistance attitude to implement green construction                    |
| 10 | Lack of awareness of the benefits of green construction                 |
| 11 | Feel unnecessary                                                        |

The table above shows the obstacles in the application of green construction that have a high rating so that these constraints will be used as variables for the Structural Self-Interaction Matrix.

The next step is to fill out a paired matrix questionnaire or a pair-wise comparison survey. The results of this paired matrix questionnaire can be seen in Table 3 below. The results of this questionnaire are
then made a structural self-interaction matrix in which each matrix cell is connected with the following notation:

| Obstacle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|---|---|---|---|---|---|---|---|---|----|----|
| 1        | X | X | V | V | O | X | X | X | A | X  |    |
| 2        | X | O | O | X | X | V | V | O |   |    |    |
| 3        | X | X | O | X | X | X | X | V |   |    |    |
| 4        | X | X | X | X | O | X | O |   |    |    |    |
| 5        | O | X | X | O | A | O |   |    |    |    |    |
| 6        | O | O | V | O | O |   |    |    |    |    |    |
| 7        | X | X | X | V |   |    |    |    |    |    |    |
| 8        | X | X | V |   |    |    |    |    |    |    |    |
| 9        | X | A |   |    |    |    |    |    |    |    |    |
| 10       | X |   |    |    |    |    |    |    |    |    |    |
| 11       |   |   |    |    |    |    |    |    |    |    |    |

The next step is to create a reachability matrix by substituting the structural self-interaction cell matrix as given in Table 4.

| Obstacle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|---|---|---|---|---|---|---|---|---|----|----|
| 1        | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0  | 1  |
| 2        | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1  | 0  |
| 3        | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1  | 1  |
| 4        | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0  |    |
| 5        | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0  | 0  |
| 6        | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0  | 0  |
| 7        | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1  | 1  |
| 8        | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1  | 1  |
| 9        | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1  | 0  |
| 10       | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1  | 1  |
| 11       | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 1  |

The next stage is to form the final reachability matrix as shown in Table 5. The content of this matrix is intended to control the filling of the matrix with O notation where cells (i, j) and (j, i) each contain 0. For example, there is no relationship between constraints 1 and 2, in the initial reachability matrix, the input (1,2) is 0 and (2,1) is 0. However, in the structural self-interaction matrix, it is found that factor or constraint 1 causes factor or constraint 5, and factor or constraint 5 causes factor or constraint 2. So based on the rules of the Interpretive Structural analysis Model (ISM), it can be said that factor or constraint 1 causes factor or constraint 2. So that the final reachability matrix for cells (1,2) is 1.

So, from the results of the matrix calculation above, it shows that the obstacles that are very influential in the application of the green construction concept are the absence of comprehensive guidelines in implementing green construction, Lack of socialization from the government regarding resource savings, Difficult to get certificates that can ensure that the materials used are friendly. environment, there is still a lack of alternative materials and implementation methods in implementing green construction.
The results of the analysis show that the application of green construction for contractors is not very important due to the contractor's lack of knowledge and experience regarding green construction, and the lack of awareness of the benefits of green construction buildings. In the construction project of the Integrated Lecture Building, Teuku Umar University Campus, the percentage of green construction implementation is 10.2%. The percentage of application is seen from the results of the distribution of the second stage of the questionnaire with the number of percentage constraints reduced by those that are not obstacles so that there is the application of green construction according to the results of the distribution of the questionnaire.

4. Conclusion
From the research and study, it can be concluded that the application of green construction based on the planning stages in the Integrated Lecture Building Project for the Teuku Umar University Campus, has been implemented properly. These results are obtained based on calculations from questionnaires distributed to planning consultants.

There are eleven obstacles in implementing green construction while the main obstacles are lack of detailed rules, lack of support from the government, lack of socialization from the government, feeling expensive for maintenance, large financial risks, lack of experts, lack of consultant knowledge, lack of contractor knowledge, are less aware of the benefits of green construction, are resistant to implementing green construction, feel no need

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**Table 5. Final Reachability Matrix**

| Obstacle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Driving Power |
|----------|---|---|---|---|---|---|---|---|---|----|----|---------------|
| 1        | 1 | 1 | 1 | 1 | 1 | 0*| 1 | 1 | 1 | 0  | 1  | 9             |
| 2        | 1 | 1 | 1 | 1*| 1*| 1 | 1 | 1 | 1 | 0  | 1  | 10            |
| 3        | 1 | 1 | 1 | 1 | 1 | 1*| 1 | 1 | 1 | 1  | 1  | 11            |
| 4        | 0 | 1*| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1  | 10            |
| 5        | 0 | 1*| 1 | 1 | 1 | 0*| 1 | 1 | 1 | 0  | 0*| 7             |
| 6        | 0*| 1 | 1*| 1 | 0*| 1 | 0*| 0*| 1 | 0  | 0*| 5             |
| 7        | 1 | 1 | 1 | 1 | 1 | 0*| 1 | 1 | 1 | 1  | 1  | 10            |
| 8        | 1 | 1 | 1 | 1 | 1 | 0*| 1 | 1 | 1 | 1  | 1  | 10            |
| 9        | 1 | 0 | 1 | 1*| 1*| 1 | 1 | 1 | 1 | 1  | 0  | 9             |
| 10       | 0 | 0 | 1 | 1 | 1 | 0*| 1 | 1 | 1 | 1  | 1  | 7             |
| 11       | 1 | 0*| 0 | 1*| 0*| 0*| 0 | 0 | 0 | 1  | 1  | 4             |
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