Green Building Premium Cost Analysis in Indonesia Using Work Breakdown Structure Method

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Abstract. The concept of green building in the construction industry is indispensable for mitigating environmental issues such as waste, pollution, and carbon emissions. There are some countries that have Green Building rating tools. Indonesia particularly is the country which has Greenship rating tools but the number of Green Building is relatively low. Development of building construction is depended on building investors or owner initiation, so this research is conducted to get the building aspects that have significant effect on the attractiveness using The Green Building Concept. The method in this research is work breakdown structure method that detailing the green building activities. The particular activities will be processed to get the cost elements for the green building achievement that it was targeted to improve better than conventional building. The final result of the study was a very significant work package on green building construction in the city of Indonesia case study.

1. Introduction
Economic growth development is supported by infrastructure development in some countries to meet the social and environment needs. Annual average amount of investment in infrastructure is up to US $4.6 trillion of the total construction in the world. Infrastructure construction contribute up to 8-10% total of Gross Domestic Products (GDP) in the world [1]. Furthermore, sustainable development has to be applied so that balancing the supply and demand in the countries could be achieved. Infrastructure development has the positive impact toward the economic aspect, but it has the negative impact to the environment aspect. In addition, increasing number of GDP will increase the number of high-risk building and Green House Gas (GHG) emission that it indicates the environment quality. Increasing the number of building activities in construction and operational, have impact on increasing number of world carbon emission. In 2007, carbon emissions in the world reach 29.65 billion ton or equivalent to 40% of total green house gas emission in the world. Then, the value is predicted increase up to 42.4 billion ton in 2035 [2, 3]. On the other hand, the condition is aggravated by exploitation of natural resources up to 30% to meet building construction and operational needs [4, 5]. At the end, all of the resources will produce the waste that it has recorded about 25-40% waste production sources in the world.

Indonesia as a particular development country in the world as the forth country with high number in building construction growth during 2009 to 2011 [6]. Furthermore, Indonesia have to control the
development strategy to meet sustainability infrastructure. Indonesia is committed in world carbon emission reduction program, that is about 29% in 2030. There are some strategies in Indonesia to support the emission reduction program such as land use planning, energy and water efficiency program, effectiveness of natural resources, and preventive program in regional development towards climate change. In building development, Indonesia has Green Building Concept Program which it was a mandatory from the government policies. In fact, the number of green building in Indonesia is grown very slowly if it is compared to the other countries as described in Table 1. Indonesia is the lowest in growth number of green building toward the countries which have local green building rating tools. United state as the highest number of green building with LEED rating tools that was developed since 1998. After that, Hongkong with BEAM Plus rating tools reached 1,500 building certification since 2005 until 2014. In South East Asia, Singapore and Malaysia is still aboved Indonesia with more significant growth number than Indonesia which had Greenship as green building rating tools.

Table 1. Average Number of World Green Building Growth [3, 5-8]

| Country Name | Year       | Number of Building | Avg. Growth Number (per year) |
|--------------|------------|--------------------|-------------------------------|
| US           | 1998-2012  | 13,000             | 867                           |
| Hongkong     | 2005-2014  | 1,500              | 150                           |
| Singapore    | 2005-2015  | 1,101              | 100                           |
| Germany      | 2009-2016  | 490                | 61                            |
| India        | 2001-2015  | 754                | 54                            |
| Malaysia     | 2009-2015  | 335                | 48                            |
| Japan        | 2001-2015  | 450                | 30                            |
| South Korea  | 2008-2012  | 53                 | 11                            |
| Israel       | 2005-2013  | 45                 | 5                             |
| Indonesia    | 2009-2015  | 23                 | 3                             |

Four main foundations in green building concept are mitigating the negative impacts of buildings activities on the environment, enhancing indoor health and comfort, payback period of the green features investation, and the effectiveness of green building concept in building life cycle. In Indonesia, based on the previous survey which the main reason of low interest in green building concept is higher cost of building features to achieve green concept [9]. Furthermore, there needs advance research identifying the cost component of green building. Work Breakdown Structure (WBS) approach is one of the systems that are needed in order to visually the work in order to complete a project. So, the final result of the breakdown is the work packet which could define the cost component [10]. This research is focus on defining the work packet and cost component of green features for green building concept development. Cost components which increased the total cost of building development could be reduced with the other alternatives in the planning phases without eliminates the function.

This research was carried out to solve two major problems, there are identifying the green building rating tools that affect to total building cost and evaluating the green building features need based on building certification classification. Therefore, this research observed new green building only because there was premium cost data record. In Indonesia, there are 12 new green building and 8 existing green building. The new building is valued until final assessment before operational and maintenance phase, beside that the existing building is valued with the retrofitting cost of conventional building.
toward green building. Observations were constrained by building function as office buildings in Jakarta with Greenship Certification.

2. Green Building

Introduction of green building concept was begun after the world oil crisis in 1970. Green building movement and revitalization was made over decades that focused on climate change issues, natural resources conservation, and urban development [11]. Furthermore, definition of green building is friendly environment concepts on building that design, build, and operate are conducted to minimize the negative impact on environment. Ensuring the green standard in some regions was on the track, some regions in the world made the green building rating tools. The first founded of green building rating tools is Building Research Establishment Environmental Assessment Method (BREEAM) in United Kingdom in 1990 [12]. Rating tools are not only provided to meet the environment needs but also the cost effectively in adopting sustainable solutions [13]. There are several aspects that are assessed in green building certification process in several rating tools in the world such as site development, transport, energy conservation, water efficiency, material resources, indoor health and comfort, building management, pollution, waste, innovations, regional priority, and economic.

In Indonesia, there are Greenship rating tools as the local standard for green building certification. Greenship has six aspects in building assessment such as Appropriate Site Development (ASD), Energy Efficiency & Conservation, Water Conservation, Material Resources & Cycle, Indoor Health & Comfort, and Building & Environment Management [3]. Table 2 describes the aspects compilation on green building rating tools in the world. There are twelve aspects that were decided in some countries assessment according to the regional needs. Indonesia adopts six aspects on green building rating tools that are named Greenship. Greenship is under coordination of World Green Building Council, so that the point of assessment is not too different to LEED rating tools. Based on the average weighting score of the world green building rating tools aspect, Energy Conservation has the highest score. After that, the second position of the highest score achievement of green building rating tools are Indoor Health & Comfort and Site Development.

Table 2. World Green Building Rating Tools & Weighting Score [3, 6, 14, 15]

| Rating Tools          | BREEAM 2013 | LEED 2009 | CASBEE 4/04 | HK-Beam 2003 | Green Star 2005 | Green Mark 4.1 2009 | IS Standard 5281 | Green Building Index 2009 | DGNB 2011 | Greenship Ver. 1.2 Average |
|-----------------------|-------------|-----------|-------------|--------------|-----------------|---------------------|-------------------|--------------------------|-----------|---------------------------|
| Found Year            | 1990        | 1993      | 2001        | 2002         | 2003            | 2005                | 2005              | 2009                     | 2009      | 2009                      |
| Site Development       | 4.5%        | 23.6%     | 16.7%       | 13.9%        | 7.0%            | 22.1%               | 9.8%              | 22.5%                    | 16.8%     | 14.4%                     |
| Transport             | 8.1%        | 9.0%      | 1.7%        |              |                 |                     |                   |                          |           |                           |
| Energy Conservation   | 27.0%       | 31.8%     | 16.7%       | 41.7%        | 25.0%           | 61.1%               | 32.1%             | 35.0%                    | 25.7%     | 28.6%                     |
| Water Efficiency      | 8.1%        | 9.1%      | 8.3%        | 6.7%         | 14.0%           | 8.9%                | 15.7%             | 10.0%                    | 20.8%     | 10.6%                     |
| Material Resources    | 10.8%       | 12.7%     | 8.3%        | 12.8%        | 13.0%           | 7.5%                | 11.0%             | 13.9%                    | 9.6%      | 9.6%                      |
| Indoor Health & Comfort| 9.0%       | 13.6%     | 16.7%       | 25.0%        | 15.0%           | 4.2%                | 15.3%             | 21.0%                    | 22.5%     | 9.9%                      |
| Building Management   | 19.8%       | 16.7%     | 9.0%        | 7.8%         | 16.0%           | 10.0%               | 12.9%             |                          |           |                           |
| Pollution             | 4.5%        | 16.7%     | 8.0%        |              |                 |                     |                   |                          |           |                           |
| Waste                 | 6.3%        |           | 1.4%        |              |                 |                     |                   |                          |           |                           |
| Innovation/Green Features| 1.8%     | 5.5%      | 3.7%        | 8.6%         | 7.0%            | 22.5%               |                   |                          |           |                           |
| Regional Priority     | 3.6%        |           |             |              |                 |                     |                   |                          |           |                           |
| Economic              |             |           |             |              |                 |                     |                   |                          | 22.5%     | 2.0%                      |

Max Point 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% 100%

3. Premium Cost

Several benefits using green building concept are not only in environment aspect but also in social and economic aspects. Using sustainable concept in building enhances building performance especially in building life cycle such as procurement, installation, operational, waste disposal, and recycle process.
[16]. In fact, starting the high-performance property development is not easy because it requires relatively higher ability especially in financing and knowledge than conventional building. Additional cost is required for green building concept implementation named premium cost. Premium cost is a cost used to implementation green features so that building efficiency could be reached in operational and maintenance phase [17].

In California, green building implementation required premium cost up to 1.84% or more expensive US $43 per sqm than conventional building cost. The average premium costs data are collected from 33 buildings in California as an office building function [18]. On the other hand, green building in Australia required up to 3-5% premium cost for a 5-star new green building development. Based on the country standard in Australia, minimum building achievement is equal to 4 stars [19]. In addition, the green building premium cost to meet a BREEAM Excellent rating was up to 6% for green features. The previous research about green building explained that green building concept has a higher initial cost, longer in design, and using non-standard materials or system. Beside that, green building concept has a benefit in long-term cost such as energy, water, and resources savings in operational and maintenance phase.

4. Work Breakdown Structure

Work Breakdown Structure (WBS) approach is a visual form of work that could be used to describe the project scope [10]. The main purpose of WBS is to effectively decompose the project requirement from planning until monitoring and controlling phase. In addition, WBS could be the material of lesson learned for the next project as historical information. WBS helps in detailing the project deliverable and activities that are broken down as manageable parts in resources and costs estimation, scheduling, and controlling each phase of a project. WBS is effective in bigger project or involves the complicated elements of construction. Decomposition process in WBS is a process of subdividing a project requirement into smaller component by all of the project team. Comprehensive WBS could be reached if the team work has good experience, communication, and high integrity.

WBS process is started with define the project scope. Project scope is broken down into particular activity that is named work packages. Graphical illustration of WBS helps the project stakeholder to divide the project scope based on management component levels and deliverables. After that, the deliverables in a bigger project is divided by planning package of progressive elaboration. The entire work package is under a control account for monitoring and controlling the process is in line with the project objectives and achievements. Work package is the smallest level of deliverables in WBS, but the number of work package depends on the characteristics of a project. Otherwise, the project manager needs is used to get the accurate estimating and effective project monitoring [20].

5. Research Methodology

This research was conducted in three stages. At the first stage, an identification aspects of green building rating tools that contributed to building premium cost, was conducted by qualitative approach used in depth interview. There are eight aspects of green building rating tools that was tested such as Appropriate Site Development, Energy Efficiency & Conservation, Water Conservation, Material Resources & Cycle, Indoor Health & Comfort, Building Environment & Management, Innovation, and Building Life Cycle. Based on the literature, 272 indicators of green building aspects or independent variables have a potential impact on green building premium costs. Beside that, there are 40 indicators of dependent variables that building cost component was changed because of green building concept. Five people is selected as an expert in this research that had greenship professional certificate issued from Green Building Council Indonesia. Three experts work in consultant firm and two others work in Developer Company with more 10 years of experience. 118 of 272 independent variable indicators were chosen by the experts.

The second stage is evaluation of the variables that affected to green building premium cost using questioner as an instrument. The questioner is distributed to 47 respondents with related stakeholder with a green building development background, including developer and consultant bodies with 10
years of experience. The instrument used closed questionnaire with Guttman Scaling, so the respondents have just chosen “Yes/ No.” For instrument validation, Coefficient of Reproducibility is calculated from

\[ C_r = 1 - \frac{e}{n} \]  \hspace{1cm} (1)

where \( e \) = total errors and \( n \) = the number of responses. The number of responses (n) are equal to the number of respondents (N) multiplied by the number of variables (k). The coefficient of reproducibility measures how well the respondents responses from his position within the statement. \( C_r \) should be at least 0.90 [21]. After that, completed the validation process, Coefficient of Scalability is given by

\[ C_s = 1 - \frac{e}{c(n-T_n)} \]  \hspace{1cm} (2)

where \( e \) = total errors, \( c \) = probability the true answer or it equal to 0.5; \( n \) = the number of responses, and \( T_n \) = the number of choices [22]. The level of acceptance \( C_s \) may be 0.60. If the amount of \( C_r \) is less than 0.90 or \( C_s \) is less than 0.60, the most influential variable on decreasing the total errors is deleted from the analysis. Beside that, the characteristics of respondent can be used to improve the amount of \( C_r \) and \( C_s \). It is reasonable to eliminate the highest error on person’s data because the different characteristics of respondent can make low accuracy data [23].

The next test on questionnaire instrument is reliability measurements. Kuder-Richardson Formula 20 or KR-20 is a measurement reliability to check the consistency results of binary variables. KR-20 is used because the indicators of green building rating tools have varying difficulty for implementation. This is the formula of KR-20

\[ r_i = \frac{k}{(k-1)} \left( \frac{S_t^2 - \sum p_i q_i}{S_t^2} \right) \]  \hspace{1cm} (3)

where \( k \) = sample size for the test, \( S_t^2 \) = variance of the whole test (standard deviation square), \( \sum p_i q_i \) = sum the product of \( p q \) for all \( n \) items, \( p \) = proportion of people passing the item, and \( q \) = proportion of people failing the item or \( 1-p \). True item Range scores of reliability are from -1 to 1, where -1 is low reliability and 1 is perfect reliability [24].

Data analysis from questioner is simplified to get the conclusion of green building rating tools that affected to green building premium cost. This research used descriptive statistics to describe the basic features of the data. The descriptive statistic that used for nominal data is the frequency distribution with proportion percentages[25]. To calculate the percentage of frequency distribution could be defined as

\[ P = \frac{f}{n} \times 100\% \]  \hspace{1cm} (4)

Where \( f \) = frequency of the chosen answer, \( n \) = the number of responses. After that, the percentage of the frequency data distribution is interpreted into the category such as 0 - 1% = no impact, 2% - 25% = very little impact, 26% - 49% = little impact, 50% = middle impact, 51% - 75% = big impact, 76% - 99% = very big impact, and 100% = totally impact [26]. The green building aspects which have score greater than 50%, are chosen as the indicator of the green building premium cost components. In the last stage, this research conducted visualization of green building scope that has impact to the premium costs used WBS. The scope of project is broken down based on the data which were collected using in depth interview to the building owner or building management corporate. The WBS describes the cost components percentage and the work packages in the initial building development process. The sample of building data to develop the WBS consists of 2 buildings with platinum
certification, 2 buildings with gold certification, and a building with silver certification. Total 5 of 12 new green building that was certified by Green Building Council Indonesia, was analysed used average percentage premium cost in WBS visualization.

6. Result and Discussion
There are eight independent variables and one dependent variable in this research. Independent variables are consisted of appropriate site development (X1), energy efficiency and conservation (X2), water conservation (X3), material resources and cycle (X4), indoor health and comfort (X5), building environment and management (X6), innovation (X7), and building life cycle (X8). On the other hand, increasing factor of the green building rating (Y) is the dependent variable in this research. Based on the instrument validation, 40 of 118 independent sub variables and 13 of 40 dependent sub variables have been chosen as the critical factors of rating tools that affects the green building premium cost. Table 3 describes the process of Coefficient of Reproducibility (Cr) and Coefficient of Scalability (Cs) Calculation using Eq. (1) and Eq. (2). All of the Cr scores are bigger than 0.90 and Cs scores are bigger than 0.60, so the questionnaire instrument is valid.

Table 3. Process of Cr and Cs Calculation for Instrument Validation

| Variables | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | Y |
|-----------|----|----|----|----|----|----|----|----|----|
| e         | 90 | 110| 36 | 32 | 88 | 84 | 20 | 22 | 174|
| N         | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 |
| k         | 20 | 24 | 9  | 9  | 21 | 23 | 6  | 9  | 40 |
| n         | 940| 1128| 423| 423| 987| 1081| 282| 423| 1880|
| Cr        | 0.9043 | 0.9025 | 0.9149 | 0.9243 | 0.9108 | 0.9223 | 0.9291 | 0.9480 | 0.9074|
| Tn        | 190 | 249 | 134 | 97 | 220 | 191 | 49  | 90  | 331|
| Cs        | 0.76 | 0.75 | 0.75 | 0.80 | 0.77 | 0.81 | 0.83 | 0.87 | 0.78|
| Subvar.   | 6  | 8  | 4  | 4  | 7  | 6  | 2  | 3  | 13 |

The next step is to calculate the reliability score using the formula of KR-20 on Eq. (3). The reliability test is conducted to 40 independent sub variables and 13 dependent sub variables. Total of 53 variables are the sample size validated in advanced. Sum the product of pq are accumulation of the proportion between the people who agree and disagree which the sub variable impacted to the green building premium cost. The result is described on Table 4 in which the instrument has high reliability with score 0.85 (between 0.71 and 0.90). After all of the validation and reliability test of the research instrument are eligible, this research continued to the frequency distribution calculation and description based on the categorization of the variables and they are followed with the evaluation using WBS.

Table 4. Process of KR-20 for Instrument Reliability Test

| Element | Value |
|---------|-------|
| K       | 53    |
| Σpiqi   | 11.71824 |
Table 4. (Continued)

| Element | Value  |
|---------|--------|
| $S_t^2$ | 73.89316 |
| Mean    | 32.97872 |
| KR-20   | 0.85760 |

6.1. Appropriate Site Development (ASD)

Appropriate Site Development is the first variable that is evaluated in Greenship rating tools. Based on the literature study, there are 20 sub variables in ASD. Six of twenty sub variables in ASD have the impact to green building premium costs. Beside that, all of the chosen sub variables have the high category in enhancing building cost because more than 28 of 47 respondents are agree with the sub variables. There are landscape area (37), building envelope (34), landscape design (32), storm water technology (31), basic green area (28), and storm water management (28) which Figure 1 presents the percentage value of ASD sub variable. The average amount of respondents choosing on sub variable is 32 which there are three sub variables with the highest impact on green building premium cost. The first is landscape area which the premium costs were used for roof garden, terrace garden, and wall garden. The second is building envelope which the premium costs were used for green roof and avoiding material with heat island effect. The third is landscape design which it is consisted of kind of the softscape and hardscape.

![Figure 1. Sub variables of appropriate site development](image)

6.2. Energy Efficiency and Conservation (EEC)

The second aspect or variable of green building is energy efficiency and conservation. Based on the respondent’s opinion, there are 8 of 24 EEC sub variables that have an impact to enhancing the green building premium cost. All of the chosen sub variables have the big impact category such as energy savings lamp (37), automatic/sensor system (36), ventilation system (36), lux sensor system (30), building envelope (28), CO$_2$ sensor (28), renewable energy sources (27), and thermal transmission (27) which Figure 2 describe the percentage value impact of EEC sub variable to green building premium cost. Three of eight sub variables have values above the average number of 32. The sub variable with the highest amount is energy saving lamps. Premium costs in this sub variable are used for lighting system which they are natural lighting system and artificial lighting. After that, the automatic sensor system on lamp is the second sub variable in EEC which above the average amount. The last one is ventilation system which the price is based on the technology used.
6.3. Water Conservation (WAC)

Water conservation is consisted of 9 sub variables. Based on the survey result, there are four of nine sub variables that are impacted to the green building premium cost. All of the chosen sub variables have greater than 50% weighting score such as water treatment for AC (41), recycling water (34), water controller in landscape area (31), and water treatment for alternative sources (28). Figure 3 shows the rank of achievement of WAC variable. The average value of water conservation sub variable is 34. There are two sub variables equal or above this average amount. The first is recycling water system which the premium cost is used for recycling water machines implementation. The next is water treatment for air conditioning which it is more advance than the recycling system because the water is recycled for air cooler or chiller.

6.4. Material Resources and Cycle (MRC)

There are nine of basic sub variables of material resources and cycle criteria. Based on the questioner result, there are four of nine that have direct impact on green building premium cost. Only one variable has high impact on MRC aspect, there is certified friendly environment material. Figure 4 describe the frequencies of MRC sub variables. Beside that, there is only certified friendly environment material sub variable which the value is above the average of respondent. The average respondent value of this MRC variable is 25. Using certified materials in Indonesia is more expensive than non-certified. There are an assessment value of the raw material resources, process, and legality. For example, using the certified wood based on forest stewardship council which it is comen from legal logging, green process, and local material.
6.5. Indoor Health and Comfort (IHC)

Following the identification of indoor health and comfort sub variable, 7 of 21 sub variables was chosen by calculating the percentage of frequency distribution. The seven sub variables are insulation on building machine equipment (37), low VOC for wall material (34), humidity control (33), CO\textsubscript{2} control (32), indoor temperature (31), noise control (27), and adhesive control (26). Using insulation in some building equipment and machines are the highest impact to green building premium cost. The others sub variables have the highest impact to green building premium cost based on the respondents opinion using percentage of frequency distribution that is greater than 50%. Figure 5 describes all of the sub variables weighting score results for indoor health and comfort. The average value of respondent in indoor health and comfort sub variable is 32. There are insulation on building machine equipment, low VOC for wall material, humidity control system, and CO\textsubscript{2} control. The building developer spends the premium cost on the health and comfort control system.

6.6. Building Environment and Management (BEM)

Based on the literature review, for building environment and management aspects, there are 23 sub variables that calculated in green building assessment. The respondents in this research chose 6 of 23 sub variables that have impact to green building premium cost. All the six sub variables have big impact because the weighting score is greater than 50%. There are testing-commissioning periodically (37), dumpster (34), water flood controller (34), periodic testing of building installation (32), integration of building (28), and improvement action (26). Figure 6 describes the weighting scores of building environment and management sub variables. The category average amount of building environment and management is 32 consisted of testing-commissioning, dumpster, water flood controller, and periodic testing of building installation. In building environment and management, premium cost incurred to make building easy to maintain and to operate. Beside that it has to effective and efficient in building life cycle and friendly to the environment.
6.7. **Innovation (In)**

Innovation is one of the optional variables, because it is chosen based on literature study from other green building rating tools. There is not an innovation aspect in greenship, so for this study using innovation is the alternatives of variables that have potential impact to green building premium cost. There are two of six the biggest impact of innovation on green building premium cost such as environment improvement and cleaning self facade system. But, the biggest sub variables impact in innovation aspect toward green building premium cost is only environment improvement (Figure 7). The average value of innovation sub variable is 25. So, only one sub variable is above the average amount that is environment improvement. This sub variable is used for sustainability implementation to the building environment such as the internet of things, smart building, and others information technology use.

6.8. **Building Life Cycle (BLC)**

The second alternative variable in this research is building life cycle aspect. According to the literature study, there are 9 sub variables in building life cycle aspect. The respondents chose 3 of 9 indicators that have impact in green building premium cost. There are technology update, building operational, preventive, and maintenance cost, and building access. All of the sub variables have big impact to green building premium cost because the weighting scores are greater than 50%. Figure 8 describes the all sub variables achievement on building life cycle variable. The average value of respondent for all sub variables is 30. In green building concept especially building life cycle, the premium costs are affected by technology update to redesign or retrofit the building components.
6.9. Enhancing Green Achievement by Premium Cost

Currently, some developers conducted improvement the building quality to meet green buildings concept because the government has the mandatory policies in the building development in Indonesia country. So that, these dependent variables were tested for green building cost evaluation that affected to enhance the green building achievement in Indonesia. There are 40 sub variables that have potential in green achievement. There 13 of 40 sub variables can be enhanced to improve the green building achievement (Figure 9). But, only 7 of 13 sub variables have the big impact such as energy savings (36), storm water management (33), lightening (29), alternative water sources (27), building facade (25), bicycle facility (24), and water reduction (24). The average amount of respondent in this variable is 26. The sub variables which are above the average value of respondent are consisted of alternative water resources, lighting, storm water management, and energy savings. This four sub variables are the higher potential of building assessment improvement by premium cost than others.

![Figure 9. Sub variables of Enhancing Green Achievement](image)

7. WBS for Premium Cost Evaluation

The last stage of this research is the work breakdown structure evaluation, The following scenario for developing green building features for achieve the rating tools is divided in 8 aspects. The scope of green building premium work in green building development is based on the previously identified with questioner and in depth interview. Based on the sub variables on the previous description makes the WBS like on Figure 10.

In Figure 10, P means green building certified platinum, G means Gold rating achievement, and S means Silver rating achievement. The written value on table is the weighting score of case study premium cost in green building Indonesia. DKI Jakarta as the capital city of Indonesia has the highest number of new green building in Indonesia which the amounts of building certified by green building council Indonesia are six buildings. But, this paper only contains 5 green building premium cost data because of the access limitation. This research used 2 platinum building, 2 gold building, and a silver building as the building case study. The highest green building premium cost in platinum building is the material resources and cycle aspect (48.13%); on the other hand the highest premium cost on gold certification building is the energy efficiency and conservation (92.76%). Then, the silver building used premium cost to meet building environment and management aspect.

The highest focus of green building developer is energy savings, friendly environment material, and building environment and material. They spend their money for energy savings using energy saving lamps, intelligent lighting control, and building envelope design and simulation. In material resources and cycle, the fullest attention in application is prefabrication material and using local raw material in construction. And the last, the building environment and management aspect pays attention on garbage technology and the composter process.
Figure 10. Work Breakdown Structure Based on Green Building Premium Cost
8. Conclusion

According to literature study and expert validation, there are eight independent variables with 118 of 272 sub variables that affected on green building premium cost. On the other hand, there are 40 of 118 sub variables of dependent variable. This research was continued with identification the most impact factors of applying green rating tools based on respondents that they involved in green building development. The respondents chose 53 of 118 independent sub variables that have high impact on green building premium cost. The top six of critical factors affected green building premium cost are water treatment for AC (or indoor usage), certified material of friendly environment, periodically testing-commissioning, insulation usage in building machine room, energy saving lamps, and basic green area.

Evaluating the green building features needs were depend on building certification classification. Almost all of green building features are applied in platinum green building. The highest weighting score of premium cost to achieve platinum certified green building in Indonesia are building envelope (23.89%), regional materials (15.92%), and legal logging material (13.86%). On the other hand, gold certified green buildings have different achievement that they tend to pay attention on energy in the green building premium cost (21.435) with sub–indicators of intelligent lighting control system features (72.05%) and building envelope (20.54%). Different things happen in silver certified green building in Indonesia which the only one building, so case study data also still limited. However, based on the sample data obtained that the silver green building in Indonesia concerned on building environment and management (45.94%) with garbage and composter technology. In addition, the other application of green features is in energy efficiency and conservation (41.49%) with automatic or sensor system (35.11%).

This research weighting scores are based on case study of green building in Indonesia. The improvement of green building development especially in cost and green features analysis could be based on this case study. The mandatory policy from government of Indonesia was already presented as one of the requirement to get the building permit. Unfortunately, this concept doesn’t attractive because the premium cost is needed in the beginning of building development. Based on this paper result, there are some potential way to reduce the initial cost of green building such as defining the incentives rule which it was stated in government policy but not in details, modeling life cycle cost to get the effective of investment and incentives cycle, and greater technology competition are expected to breakthrough the enhancing of green building achievement especially to full fill the target in 2030.
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