THE DEVELOPMENT OF GREEN BIM BASED STANDARD OPERATING PROCEDURE ON SCHEMATIC DESIGN PHASE OF BUILDING PROJECTS TO IMPROVE DURATION PERFORMANCE FROM THE PERSPECTIVE OF ARCHITECTURE CONSULTANT

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ABSTRACT

Building Information Modeling (BIM) is one of the technologies that can help the building design process with green building concept and BIM can evaluate energy performance and ongoing assessments that are interpreted by Green BIM. This research aims to determine the activities, stakeholders and the role of Green BIM to improve duration performance on schematic design phase of building projects, which was developed with a Green BIM based Standard Operating Procedure. The methodology is based on secondary data and interview with the respondents who contribute in Architecture Consultant Office. The result is Standard Operating Procedure and illustrates the relationship between activities in each strategy on schematic design phase, the roles of stakeholders and the data exchange flow.

Keywords: BIM, Green Building, Schematic Design, SOP

Introduction

The project can succeed in achieving its targets if the construction process is well-planned. The construction process begins with planning and making effective decisions that form the basis of the design planning stage (Peckiene, Ustinovicius, 2017). With the increasing need to create sustainable and high-performance buildings, energy analysis on green building concept projects carried out at the initial design stage can provide an opportunity to make effective decisions at the beginning of the building's life cycle (Stumpf et al, 2011).

Being one of the fastest growing countries in Southeast Asia, industry practitioners AEC (Architecture, Engineering, Construction) in Indonesia currently face a high increase in demand for construction projects. With the increasing number of construction projects, especially building projects, if it is not supported by the ability of workers to complete the work it will lead to longer processing time and less effective workmanship (Indraprahasta, Widjanarso, 2015). The technological needs of the construction industry, especially architectural consultants, are inevitable because coordination between stakeholders involved in a construction project is a necessity and the need for energy analysis in the early stages of green building design (Rayendra, Soemardi, 2014, Krygiel, Nies, 2008).

BIM can change how designers work and have the ability to help direct the industry in a more sustainable direction by providing easier access to support the green building approach and can accelerate the time of submitting project documents (Krygiel, Nies, 2008, Arayici et al, 2012). BIM can provide data for energy performance evaluations and ongoing assessments that are interpreted by Green BIM. Green BIM includes Building Energy Modeling that is connected with project energy performance to identify choices in optimizing building energy efficiency during the life cycle (Maltese et al, 2016).

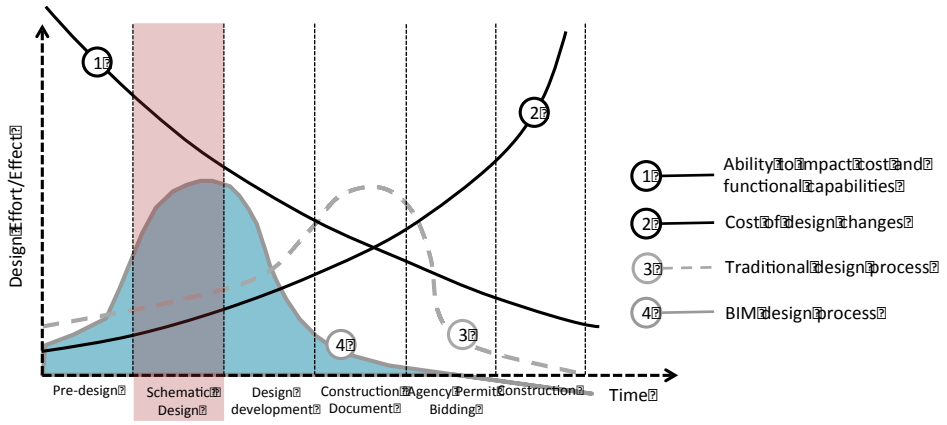

Figure 1. MacLeamy time-effort curve (BIM ASIG, 2009)

The MacLeamy curve describes the performance that is most needed when the schematic design stage is different from the conventional method which requires more performance at the construction document stage. Developing ideas at the beginning of the design phase will be cheaper compared to other costs in the building, more effective in changing decisions and conducting energy analysis to get the best design alternatives in the early stages of design (Krygiel, Nies, 2008). In the process of implementing BIM not only requires learning new software applications, but also how to rediscover workflows, how to train workers and assign responsibilities, and change the way construction is modeled (Bernstein, Pittman, 2004, Eastman et al, 2008). Based on the BIM Guidelines for National & Global Standards (NBS) (2013), a procedure for the construction industry is needed to be able to implement BIM in supporting collaborative design practices and help the construction industry be more integrated in the entire construction process. However, the lack of involvement of the government's role has caused the construction industry to experience difficulties in implementing BIM technology (Zahrizan et al, 2013).

This research has identified previous studies about developing the Building Information Modeling (BIM) implementation procedure. After successfully identifying previous studies, this research tried to update by combining the factors in the implementation of the green BIM in terms of the design process, human resources, technology and the application of green BIM that influenced communication flow at the design design stage. The design phase that will review more depth is schematic design stage for the building project which is viewed from the point of architectural consultants view. This research is expected to be able to become new knowledge about the implementation strategy of Green Building Information Modeling on schematic design stage and expected to be an encouragement for stakeholders to implement Building Information Modeling in Indonesia.

Research Objectives

The objectives of this research are :

a. To identify main activity that can improve duration performance on schematic design phase of building projects with green building concept (RQ1)
b. To identify stakeholder who contribute at the activity on schematic design phase of building projects with green building concept (RQ2)
c. To identify the role of green BIM that can improve duration performance on schematic design phase of building projects (RQ3)
d. To develop Standard Operating Procedure of implementation green BIM on schematic design phase of building projects (RQ4)

Literature Review

Green Building

Green buildings refer to structures and use processes that are environmentally responsible and resources that are efficient on building lifecycles starting from site determination, design, construction, operation, maintenance and demolition renovation. Green Building is a concept to make a building sustainable and has certain conditions such as location, planning and design systems, renovation and operation, which refers to the principle of saving energy and must have a positive impact on the environment, economy and social (Sudarwani, 2016). For the green building rating system in Indonesia, the Green Building Council Indonesia issued a rating system called Greenship (GBCIndonesia.org). Greenship is divided into 6 categories, namely as follows:

1. Appropriate Land Use - Appropriate Site Development (ASD)
2. Energy Efficiency and Conservation - Energy Efficiency & Conservation (EEC)
3. Water - Water Conservation (WAC) Conservation
4. Source & Material Cycle - Material Resources & Cycle (MRC)
5. Air Quality & Indoor Air Comfort - Indoor Air Health & Comfort (IHC)
6. Building Environment Management - Building & Environmental Management (BEM)

Building Information Modeling (BIM)

BIM is a process and information that produces a methodology for managing building design and important data from projects carried out in digital form throughout the building planning and construction cycle (Teemu Lehtinen, 2011, NBIMS, 2014). BIM makes it possible for planners, engineers and contractors to visualize the entire scope of the building project in three-dimensional form and can enhance collaboration between the people who carry out the project. Using a collaborative approach, between designers and contractors can plan output accurately and in detail from the location needed for the construction of the project until the project is completed (Korman et al, 2010). In addition, BIM focuses on developing, using and transferring digital information models from building projects that aim to improve design at the design planning stage to project operations (BIM: Project Execution Planning Guide, 2011).

Green BIM

Green BIM is an integration between Green Building and BIM technology. From environmental, social and economic orientation, BIM Technology can have an impact on green building in the project life cycle. At the design stage, economic and environmental considerations can be included when designers use BIM to assess the costs, risks and energy consumption of various models as a means of achieving green building goals. Data sources available in BIM Technology when used by stakeholders to assess sustainability aspects that include zero carbon approaches in construction, optimize energy use, optimize environmental performance, efficiency in managing waste, increase in indoor climate in building life cycles that lead to what called green BIM (Soltani, 2016).

Schematic Design Stage

At Schematic Design Stage, the designer makes appropriate draft concept that can meet the requirements of the design planning program, the designer arranges the patterns and compositions of the mass shown in the drawings, while the functional values are shown in the diagrams. Qualitative and quantitative aspects such as the estimated floor area, information on the use of materials, construction systems, costs, and the duration of the construction are presented in the written reports and drawings (iai- jakarta.org). According to Radeta Effendi's research (2016), there are 9 (nine) strategies used for BIM implementation at the Schematic Design Stage (Figure 2).

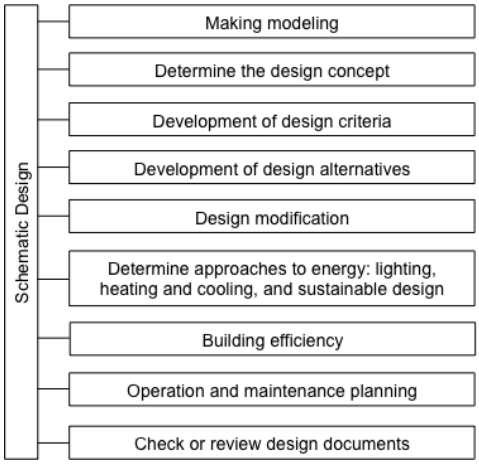

Figure 2. 9 (nine) strategies on Schematic Design Stage (Effendi, 2016)

Methodology

Data collection carried out in this study was interview. Interviews were conducted in an unstructured way to the experts who were used as sources of information using the activity variable questionnaire instruments obtained from literature studies. The results of this survey are primary data that is processed and analyzed qualitatively.

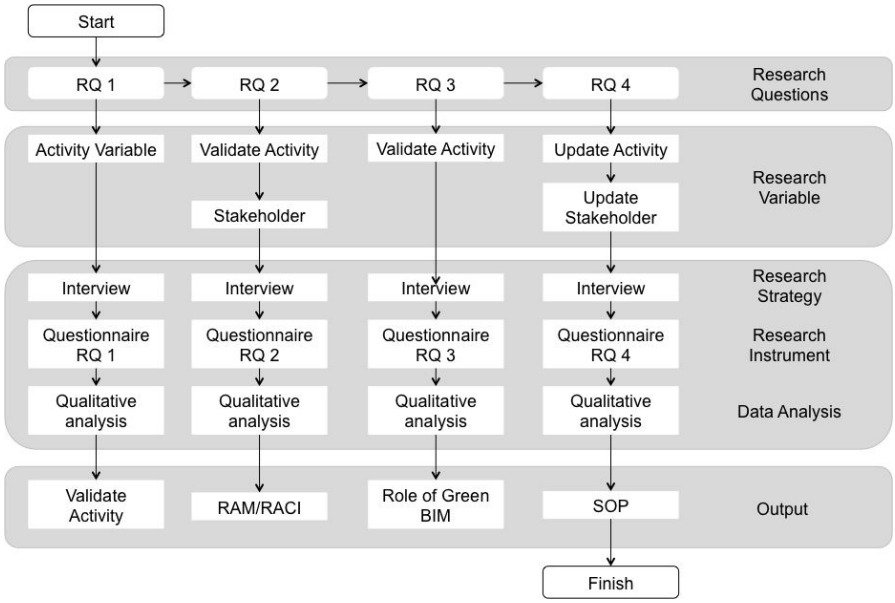

Figure 3. The research flow diagram

Result and Discussion

a. To answer RQ1

Based on the literature study, it is known that there are 9 strategies and 44 main activity variables carried out at the schematic design stage. To answer RQ1, unstructured interviews were conducted to obtain expert validation regarding the findings of the main activity variables identified based on the literature study. There were 8 expert interviewed to answer RQ1, the experts have an experience more than 3 years working in Architecture Consultant PT.X and other Architecture Consultant with the minimum position is architect. From the results of interview, it was found that there were several variables that were not appropriate and carried out variable renewal into 42 main activity variables. The following is the result of validation from the experts (Table 1).

Table 1. Validated activity on schematic design stage

No	Strategy	Code	Activity	Reference
X_1	Make modeling that can be accessed by all stakeholders	X1.1	Make a site model according to existing conditions	Habib, Setiadi (2014) Arayici et al (2011)
		X1.2	Implement RTRW regulations on the model	Interview result
		X1.3	Implement green building criteria on the site	Interview result
		X1.4	Determine site zoning	Habib, Setiadi (2014)
		X1.5	Determine the position of mass composition	Rayendra, Soemardi (2014) Arayici et al (2011)
		X1.6	Determine the circulation parh on the site	Rayendra, Soemardi (2014)
X_2	Determine the design concept	X2.1	Knowing the needs of building space	Habib, Setiadi (2014)
		X2.2	Making mass compositions	Rayendra, Soemardi (2014)
		X2.3	Make alternative mass compositions	Zhikun et al (2015) Arayici et al (2011)
		X2.4	Determine the area and floor of the building	Rayendra, Soemardi (2014)
		X2.5	Determine zoning space	Interview result
		X2.6	Determine the main design concept	Rayendra, Soemardi (2014)
X_3	Development of design criteria	X3.1	Adjust the green building design criteria with the main design concept	Rayendra, Soemardi (2014)
		X3.2	Forming mass compositions into buildings	Rayendra, Soemardi (2014)
		X3.3	Make a circulation path connected to the buildings	Rayendra, Soemardi (2014)
		X3.4	Arrange the building plan concept	Interview result
		X3.5	Check the suitability of the design	Arayici et al (2012)
X_4	Development of design alternatives	X4.1	Adjust the alternatives design with the main design concept	Rayendra, Soemardi (2014)
		X4.2	Forming alternative mass compositions into buildings	Zhikun et al (2015) Arayici et al (2011)
		X4.3	Make alternative of circulation path connected to the buildings	Arayici et al (2011)
		X4.4	Arrange the alternative of building plan concept	Interview result
		X4.5	Check the suitability of the alternative design	Arayici et al (2012)
		X4.6	Make alternative design visualizations	Eastman et al (2011)
X_5	Design modifications to reduce construction costs according to the budget	X5.1	Make a Bill of Quantity	Interview result
		X5.2	Arrange design information for sharing with other stakeholders	Arayici et al (2012)
		X5.3	Coordinate with other stakeholders	Alreshidi et al (2016)
		X5.4	Receive information from other stakeholders for design modifications	Arayici et al (2012)
		X5.5	Reviewing the design	Arayici et al (2012)
		X5.6	Make design modifications	Arayici et al (2012)
X_6	Determine approaches to energy, lighting, heating and cooling, and sustainable design	X6.1	Identify building energy consumption requirements	Eastman et al (2011)
		X6.2	Identify building lighting requirements	Eastman et al (2011)
		X6.3	Identify building temperature requirements	Eastman et al (2011)
X_7	Building	X7.1	Check building energy consumption	Eastman et al (2011)

No	Strategy	Code	Activity	Reference
	efficiency	X7.2	Check building lighting	Eastman et al (2011)
		X7.3	Check the temperature of the building	Eastman et al (2011)
		X7.4	Make a simulation of building energy performance	Eastman et al (2011)
X_8	Operation and maintenance planning	X8.1	Determine building utility systems	Interview result
		X8.2	Make a building utility concept scheme	Interview result
X_9	Check or review design documents	X9.1	Prepare the initial architectural design documents	Interview result
		X9.2	Check the completeness of the initial architectural design documents	Interview result
		X9.3	Check completeness of design documents from other stakeholders	BIM Project Execution Plan Template USF (2018)
		X9.4	Checking the suitability of design standards from other stakeholders	BIM Project Execution Plan Template USF (2018)

b. To answer RQ2

Discussions were conducted with the respondents about the role of stakeholders involved in each of the main activity variables previously collected based on literature studies. It aims to identify stakeholders involved in the main activity at the Schematic Design stage. There were 8 respondents to be interviewed to answer RQ2, the interviewees have an experience more than 3 years working in Architecture Consultant PT.X and other Architecture Consultant with the minimum position is architect. From the results of identification from respondents, there are several stakeholders who had roles in activities at the schematic design stage. Those roles are Principal, Principal Assistant, Project Architect, Architect, Drafter, MEP Consultant, Greenship Professional, Green Building Council Indonesia (GBCI) and City Planning Service. After known the stakeholder involved in the schematic design stage, then describe the tasks or roles of each activity using the Responsibility Assignment Matrix (RAM) method and RACI format as follow:

- R (Responsible) is the party that carries out the activity
- A (Accountable) is the party responsible for the results of the “R” activity
- C (Consult) is the party that provides consultation on activities carried out “R”
- I (Inform) is the party that receives the result of “R”

c. To answer RQ3

Discussions were conducted with the respondents about the role of green BIM. This aims to identify the role of green BIM which can affect work time at the Schematic Design stage. There were 6 respondents to be interviewed to answer RQ3, the interviewees have an experience working with BIM for minimum 1 year and have experience more than 3 years working in Architecture Consultant with the minimum position is architect. From the results of discussions, when working with green BIM the design system of the design will change even though the activity is the same as doing it with non-BIM. From the 9 strategies at the schematic design stage, the main activities that have an important role are alternative design development strategy; design modifications to reduce construction costs according to the budget strategy; and building efficiency strategy. That 3 (three) strategies are important because the workmanship system at green BIM is more integrated and supports visualization and energy analysis. In addition, green BIM is very helpful in coordinating between teams or other stakeholders for revision and examination of images, so it helps the stakeholder to work more efficiently and improve duration performance of working.

d. To answer RQ4

In carrying out the development of green BIM-based Standard Operating Procedure on the schematic design of building projects, by collecting the results of data analysis that has been done before and then arranged in the form of a joint flow chart procedure and communication flow. The final data analysis begins with identifying the main activities on the Schematic Design stage and integrating with additional activities in the implementation of the green BIM. After that, the parties involved in carrying out the activity are in the form of Responsible, Accountable, Consult, and Inform (RACI) diagrams then determined by the flow of communication and data flow at the Schematic Design stage.

There were 6 respondents to be interviewed to answer RQ4, the interviewees have an experience working with BIM for minimum 1 year and have experience more than 3 years working in Architecture Consultant with the minimum position is architect. From the result of discussions with the respondents, there are additional role functions, namely BIM Specialist who is a companion in using BIM when working with green BIM. The BIM Specialist helped the design team in modeling and drawing. After knowing the activities, stakeholders and the role of BIM, it can be developed a Green BIM procedure that can affect work at the building project Schematic Design stage. The procedure illustrates the relationship between activities in each strategy in the schematic design phase, the function of the roles and stakeholders involved and the data exchange flow.

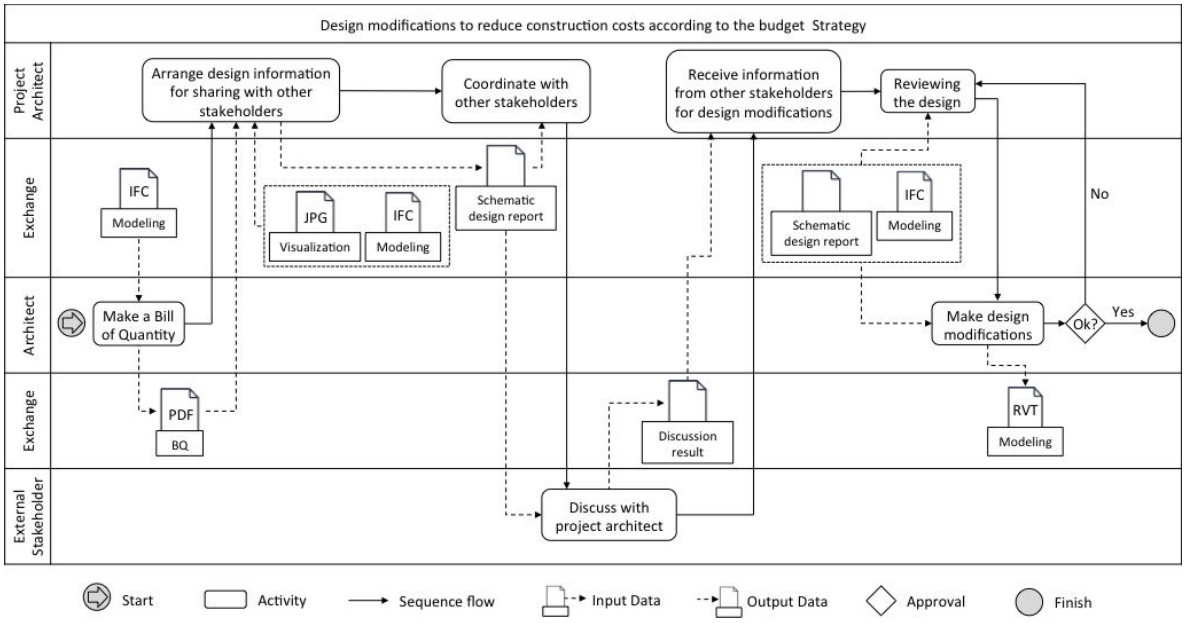

Figure 4. Example proposed process map

The proposed procedure is presented as a process map in Figure 4. The process map illustrates the procedure of working with green BIM based on the data from the respondent such as variable activities, responsible roles and the data exchange. Process map shows that each activity has an data exchange in the form of input and output data which is described in the "exchange" column, the data used varies depending on the activity carried out. The list of roles described in the map process is the role involved in each activity in the strategy and every strategy has a different role involved.

As shown in figure 4, the process map is the process of X_5 strategy (table 1) and the X_5 strategy is the one of important strategy on schematic design stage. By implementing BIM, the map process from X_5 strategy changes methods in exchange data and communication

to all stakeholders involved, the information shared is better and more efficient than conventional methods. This new method addresses all buildings or projects by including everything in the same model (Krygiel, Nies, 2008). The model produced by BIM can be used to create a visualization of designs (Eastman et al, 2011). The first activity of X_5 is the Architect make a Bill of Quantity with the BIM modeling as an input data and the output is the Bill of Quantity with PDF format. BIM can produce a more accurate and produced Bill of Quantity to estimate costs made based on its design modeling (Eastman et al, 2011).

After all the information has been prepared then produce a schematic design report as output data consisting of Bill of Quantity, visualization and modeling in the IFC format so that stakeholders who do not use BIM can still open documents. With one BIM Modeling and Bill of quantity, the Project Architect use the document for communication with owners, consultants, MEP and Greenship Professional. Coordination carried out to exchange data with the stakeholders involved can improve workflow and exchange information with BIM (BIM ASIG, 2009). The Project Architect disscus with owner to review schematic design report and choose one design from the alternatives. The choosen design will be discuss with MEP consultant and Greenship Professional to give an information to the project architect about the possibility in determine approaches to energy, lighting, heating and cooling, and sustainable design. The result of discussion was accepted and reviewed by Project Architect. With the format of PDF for the report and IFC for the modeling, it will be the input data for the architect to make design modification and have to get approval from Project Architect to finish the activity in this strategy. With the modified design modeling, it can help quantify the area of space and the amount of material, making it possible to estimate costs earlier and more accurately (Eastman et al, 2011).

Conclusion

The purpose of this paper is to determine the activities, stakeholders and the role of Green BIM to improve duration performance on schematic design stage. According to Radeta Effendi's research (2016), there are 9 (nine) strategies used for BIM implementation at the Schematic Design Stage. In each of these strategies identification of the activities needed to be able to develop the communication flow of the design process of the building project Schematic Design stage. This paper answer the 4 (four) research objective where the RQ1, RQ2, RQ3, and RQ4 carried out with interviewed to the respondents. The interviewees are the expert and the person who involve in architecture consultant and have an experiences working with BIM.

From the results of the interview it was found that there were several variables that were not appropriate and carried out variable renewal into 42 main activity variables. Each activity has a role responsible for working on the activity. Those roles are Principal, Principal Assistant, Project Architect, Architect, Drafter, MEP Consultant, Greenship Professional, Green Building Council Indonesia (GBCI) and City Planning Service. there are additional role functions after applying the green BIM, namely BIM Specialist. BIM Specialist is an BIM expert who help the designer team to working with green BIM.

When working with green BIM, all the activity is the same as doing it with non-BIM but the design system and the way of working will change. The workmanship system at green BIM is more integrated and supports visualization and energy analysis. In addition, green BIM is very helpful in coordinating between teams or other stakeholders for revision and examination of images. After knowing the activities, stakeholders and the role of green BIM, then developed a Green BIM Standard Operating Procedure with illustrates the relationship between activities in each strategy in the Schematic Design Phase, the function of the roles and stakeholders involved and the data exchange flow.

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