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Implementation Of Building Information Modelling 6D On The Building Of Asrama Haji Pondok Gede Considering Quantity Take Off And Lighting

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Abstract

The development in the world of construction in Indonesia in recent years has increased significantly, but currently most of the construction in Indonesia still uses conventional methods such as those used in the Asrama Haji Pondok Gede building. One of the weaknesses of conventional methods is the estimation of time that takes longer than the Building Information Modeling (BIM) method so that in this research, the Pondok Gede Hajj Dormitory building modeling from the previous conventional method will be implemented into Building Information Modeling (BIM) by considering scheduling and sustainability. The results of data collection carried out are primary data by making observations and secondary data in the form of conventional working drawings and Budget Plan Cost. Both types of data were then analyzed using Autocad and Microsoft Excel software which were then processed using Revit and Dialux software. After the processing process through Revit is complete, the results of Architectural and Structural modeling and Quantity Take Off calculations are obtained. Then the results of Dialux processing obtained lighting modeling results in the form of intensity of the number of luminaires. According to the modeling results by revving, the sample volume of the k1 column on the 2nd floor between the BIM and the upward field had no discrepancies, whereas between conventional and discrepancies there was a discrepancy of 9.53%. Then in Dialux modeling, the results obtained for all rooms have an average lux value that is in accordance with the Occupational Safety and Health Administration (OSHA) and National Environmental Quality Standards (NEQS), except for the 2nd floor room with an average lux value obtained exceeding OSHA standards of around 285 lux.

Keywords—*Building Information Modelling (BIM), Autodesk Revit, Quantity Take Off, Dialux, Luminaire.*

I. INTRODUCTION

Indonesia, as a developing Country in Southeast Asia, needs to increase economic growth by focusing on infrastructure development. Nowadays, most infrastructure development still uses conventional, expensive, inefficient methods in cost, quality, and time. More efficiently modernizing and adoption of construction methods are essential to both economic growth and development of Indonesia's construction sectors [1]. Conventional methods in project development tend to be less integrated because of the lack of complete and up-to-date sources of information. The lack of integration results in loss of information and value at each phase of the project [2]. In the construction industry, advanced technology, such as Building Information Modelling (BIM), is needed for effectiveness and

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efficiency. BIM is a method of AEC (Architecture, Engineering, and Construction) that collects information from all aspects of the building and describes it in 3D [3]. In Indonesia, through PERMEN PUPR NO 22/PRT/M/2018, the state building is not as modest as it covers more than 2000 m2 and is obliged to apply Building Information Modelling (BIM). The output from the design is based on BIM, such as architectural, structural, utility (mechanical and electrical), landscaping, execution volume and the cost budget plan [4]. BIM methods involve various sectors in the construction industry. A BIM project includes not only a geometric model as the most visible part but also a complete and comprehensive data base that includes the material used in the building as well as its mechanical properties and physical characteristics [5]. BIM has an influence on all aspects involved in construction projects, ranging from the early stages in shaping (architecture), the various stages of structural studies (structural design, analysis, and technical picture production), materials calculations and budgets, the building planning process (defines geometric models for each stage of construction), to the use and management of buildings (management and maintenance) at the next stage [6].

With 6d dimensions in BIM, information in project models, including geometry, material properties, spatial layout, solar path, and wind patterns, is integrated for more efficient planning. It can help meet the energy - efficient building needs in the construction industry to reduce the impact of global warming [7]. Lighting is a key factor in creating a safe, comfortable, and affecting our ability to look at objects with accuracy in both time and speed [8]. Standard lighting in the workplace not only increases productivity (10%-50%) and reduces errors (30%-60%), but it can also reduce eye fatigue (1,783 millisecond) with an increase in light intensity of 1 lux. Therefore, measuring up in space lighting is essential to the well-being and performance of employees [9].

With many benefits, therefore, from applying the Buliding Information Modelling (BIM) applications in a construction project. The current project, whether it is a private project or XXX-X-XXXX-XXXX-X/XX/$XX.00 ©20XX IEEE a government project, would not fall behind in applying the concept to the project in Indonesia [10]. The research object in this study is the Asrama Haji building located in Pondok Gede, East Jakarta. The Asrama Haji is a 4-story building designed by PT. Atelier Enam Arsitek during the planning phase. The aim is to expedite the modeling process, minimize errors, maximize the use of information, and optimize time, quality, and cost efficiency in the construction process.

II. LITERATURE REVIEW

A. Building Information Modelling (BIM)

The BIM (Building Information Modelling) is a collaborative process on a construction project where everyone shares information using digital design [11]. BIM covers the entire cycle of projects, from planning to management, and can increase its integration, quality, and efficiency [12]. The benefits include early detection of problems, increased collaboration, better visualization, time efficiency, better documentation, improved job quality, and more accurate material estimates [13]. BIM modeling goes beyond just representing 2D and 3D aspects. In addition to 3D modeling, BIM can provide outputs in 4D, 5D, 6D, and even up to 7D.

1. 3D modeling is the foundation, representing the physical and spatial aspects of a project using parametric object modeling.
2. 4D involves sequencing and scheduling, including materials, labor, area measurements, time, and more.
3. 5D includes cost estimation and part-lists, integrating cost-related data with the project model.
4. 6D considers environmental impact, encompassing energy analysis, and clash detection among other aspects.
5. 7D focuses on facility management, allowing for long-term maintenance and operations planning.

These dimensions (3D to 7D) enhance the capabilities of BIM by adding layers of information and functionality to the modeling process. This comprehensive approach not only aids in design and construction but also extends to the project's lifecycle and sustainability [14].

B. Autodesk Revit 2020

The Autodesk Revit software is a parametric 3D design platform used in the architectural design industry. These include Revit Architecture, Revit Structure, and Revit MEP, which cater to the various professional design needs. The Autodesk version Revit 2020 integrates these three software into one platform. Revit MEP-based technology BIM and is used for modeling mechanical, electrical, and plumbing systems. This is suitable for architectural specialization and enables rapid development [15]. Research by Eastman et al. (2011) identifies the Autodesk Revit as the most known BIM software and dominates the market in the BIM implementation of the architecture project. Revit has many strong users and reputations, affirming its role as a leader in the architectural design industry [16].

C. Quantity Take Off

Quantity take-off (QTO) is a crucial step in construction projects where detailed calculations of material and labor volumes are performed. Conventional QTO involves manual calculations, which can be time-consuming and prone to errors such as dimension misinterpretations and data input mistakes. It encompasses calculations of elements like area, volume, and length. Common errors in conventional methods include arithmetic mistakes, division errors, and more. Typically, conventional methods are performed using tools like Microsoft Excel and AutoCAD. In contrast, Building Information Modeling (BIM) employs BIM-based software to create 3D models, enabling more efficient and accurate calculations following conventional method rules. [17]. The conventional method of quantity take-off calculation can be done manually using Microsoft Excel and AutoCad based on shop drawing and technical specifications or by utilizing Bill of Quantity (BoQ) data prepared by the contractor [24]. In contrast, the BIM method employs BIM-based software, involving the creation of a 3D model that adheres to the rules of conventional calculations for comparison [18].

D. Dialux Evo 11.1

Dialux is a software that used the radiosity method to compute light distribution in 3D models, day and night [19]. These are used to set up artificial and natural lighting and are available free of charge with automatic and visual rendering features that are constantly renewed. The program continues to grow to meet the needs of the latest lighting technology [20]. The lighting conditions within each room vary, depending on the activities conducted in those spaces [25]. Each room has its own lighting standards, and the lighting analysis in this study was based on the Occupational Safety and Health Administration (OSHA) and National Environmental Quality Standards (NEQS) using Dialux software. The lighting standard for indoor spaces set by OSHA is 250 Lux, while according to NEQS, the standard is 300 Lux. Similar findings were also reported in a study by Putra, which concluded that production areas with routine work require an illumination level of around 300 lux [26].

III. RESEARCH METODE

A. Research Location

Define The location of this research is in East Jakarta, precisely in Building Asrama Haji Jl. Wisma H. No.12, RT.1/RW.1, Pinang Ranti, Kecamatan Makasar, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13560, Indonesia.

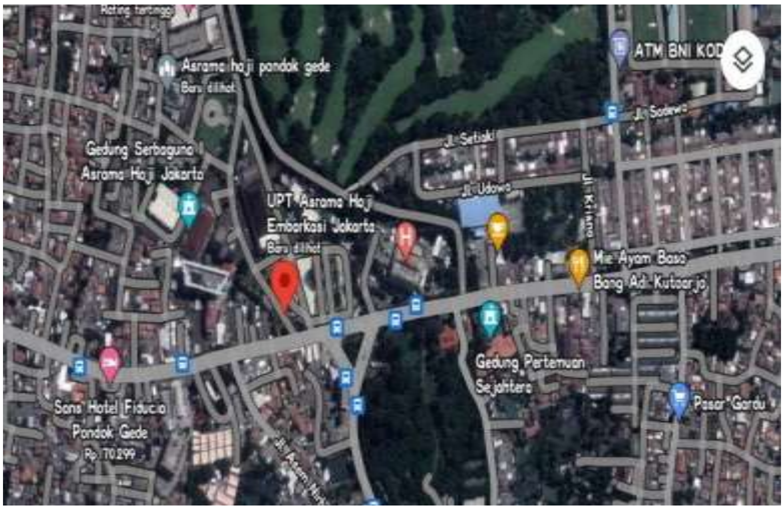

Fig. 1 Research Location

B. Data Collection

The data used on this research came from a company [27]. The data used is among other things:

1. Shop Drawing
2. Cost Budget Plan

C. Research Flow Chart

This research flow describes the stages of research starting from the beginning of the process until it is finished to produce conclusions [28]. The research flow chart can be seen in Figure 2.

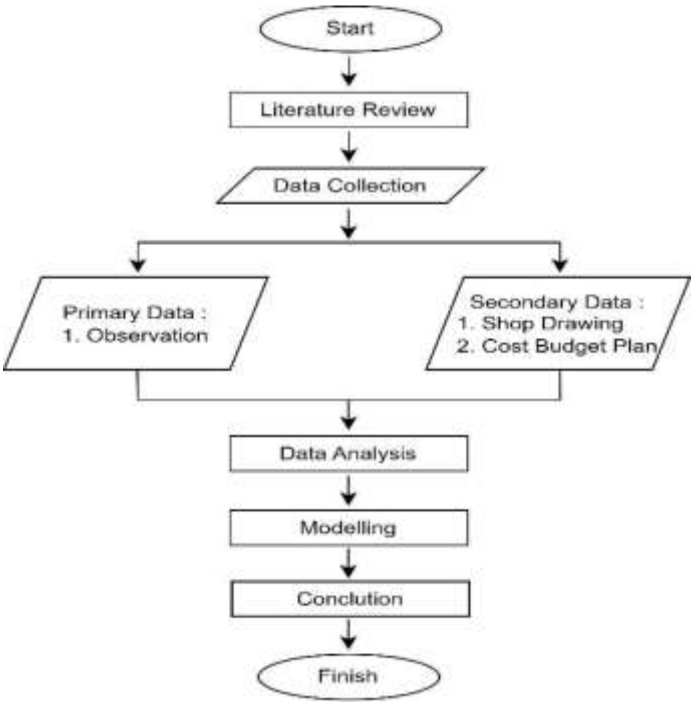

Fig. 2 Research Flow Chart

IV. RESULT AND DISCUSSION

The results and discussion of the implementation of the BIM concept in the Asrama Haji Pondok Gede building include modeling results and also the analysis of the volume quantity take-off comparison and lighting analysis in the building [29]. The results and discussion include the following:

A. Architectural Modelling

Fig. 3 Architectural Modelling

B. Structural Modelling

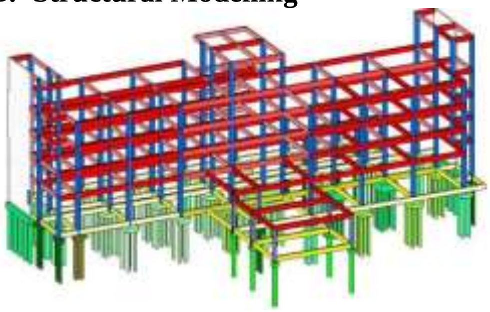

Fig. 4 Structural Modelling

C. Volume Quantity Take Off Analysis

The calculation of quantity take-off volume using Autodesk Revit 2020 software is conducted for several structural works [30]. The results of the quantity take-off volume calculations can be seen in the following Table 1.

Table 1. Results of the volume quantity take off calculation using the BIM method

No.	**Item**	**Volume (m^3)**
I	**Pile Cap Foundation**	
1	400mm diameter	45.24
2	500mm diameter	128.4
3	600mm diameter	27.09
4	Pile Cap 135 (PC135)	2.3
5	Pile Cap 235 (PC235)	8.88
6	Pile Cap 335 (PC335)	1.4
7	Pile Cap 435 (PC435)	16.43
8	Pile Cap 535 (PC535)	34.9
9	Pile Cap 535A (PC535A)	13.14
10	Pile Cap 835 (PC835)	13.57
11	Pile Cap 1853 (PC1835)	30.27
12	Pile Cap 635 (PC635)	19.31
II	**Tiebeam**	
1	TB1 300x600 mm	19.69
2	TB2 400x700 mm	62.3
3	TB3 300x700 mm	20.27
4	TB4 400x800 mm	12.16
III	**Column**	
1	K1 400x800 mm	202,69
2	K2 400x400 mm	5.25
IV	**Beam**	

1	B1 300x600 mm	90
2	B2 400x700 mm	212,90
3	B3 300x700 mm	31,29
4	B4 400x800 mm	51,07

To determine the comparison results of quantity take-off between the BIM method, conventional method, and on-site work, one specific task was selected as a calculation sample [31]. The selected sample is for the K1 column, measuring 400x800 mm, on the 2nd floor of the Asrama Haji Pondok Gede building.

<Structural Column K1 Quantity>

A	B	C	D
Type	Count	Length	Volume
K1 400 X 800 MM	32	3500	35.84 m³
Grand total: 32			35.84 m³

Fig. 5 The quantity take-off (QTO) volume for column work on the 2nd floor

The above picture illustrates the results of the quantity take-off calculation using BIM, where the naming of Column K1 in the calculation results is grouped together due to their identical dimensions [23] [32]. The Column K1 in the calculation results consists of columns K1, K2, K3, K4, and K5, each measuring 400 mm in length, 800 mm in width, and 3500 mm in height [33].

The conventional volume calculation is based on the Structural Budget Plan. In the Structural Budget Plan, the volume for each column can be determined [22] [34]. The calculation process is as follows:

1. Volume of column K1

Number of K1 columns = 2 pieces

Concrete volume = 2.3 m^3

Reinforced steel volume = 487.6 kg = 0.4876 m^3

V= 2.3 + 0.4876

V= 2.7876 m^3

V= 2.79 m^3

2. Volume of column K2

Number of K2 columns = 10 pieces

Concrete volume = 11.52 m^3

Reinforced steel volume = 2442.24 kg = 2.44224 m^3

V= 11.52 + 2.44224

V= 13.96224 m^3

V= 13.96 m^3

3. Volume of column K3

Number of K3 columns = 9 pieces

Concrete volume = 10.37 m^3

Reinforced steel volume = 2198.44 kg = 2.19844 m^3

V= 10.37 + 2.19844

V= 12.56844 m^3

V= 12.57 m^3

4. Volume of column K4

Number of K4 columns = 4 pieces

Concrete volume = 4.61 m^3

Reinforced steel volume = 1129.45 kg = 1.12945 m^3
V= 4.61 + 1.12945

V= 5.73945 m^3

V= 5.74 m^3

5. Volume of column K5
Number of K5 columns = 3 pieces

Concrete volume = 3.46 m^3

Reinforced steel volume = 909.98 kg = 0.90998 m^3
V= 3.46 + 0.90998

V= 4.36998 m^3

V= 4.37 m^3

6. Total column volume
ΣV= K1+K2+K3+K4+K5
ΣV= 2.79+13.96+12.57+5.74+4.37

ΣV= 39.43 m^3

So, the total volume of all the columns on the 2nd floor is 39.43 m^3.
To determine which method is more accurate between using the BIM method and the conventional method in quantity take-off calculations, calculations are also carried out in the field for the sampled work. Furthermore, the calculation for one of the sampled works, which has been measured, and the measurement results for the volume of column work K1 on the 2nd floor in the field are as follows.
Height (h) of column K1 = 3.5 meters
Length (l) of column K1 = 800 mm = 0.8 meters Width (w) of column K1 = 400 mm = 0.4 meters Number of column K1 = 32 pieces
V = l x w x h
V = 0.8 x 0.4 x 3.5
V = 1.12 m^3
After finding the volume of K1, it is then multiplied by the number of columns.
∑V = 1.12 x 32
∑V = 35.84 m^3
The results of the calculations using the BIM method, conventional method, and actual field measurements can be summarized in Table 2.

Table 2. Comparison of QTO volumes

No.	*Method*	*3*
1	BIM	35,84
2	Conventional	39,43
3	Actual Field	35,85

Volume (m)
From the above results, it can be concluded that there is no significant difference between the volume quantity take-off calculations taken from the structural column work sample between the BIM method and field measurements [35]. However, in the conventional calculation, there is a difference of 3.59 m3 or approximately 9.53%.

D. Lighting Analysis

Lighting modeling in this research was carried out using Dialux Evo 11.1 software. Modeling and lighting analysis were performed only on the 1st and 2nd floors [36]. The lighting modeling can be seen in Figure 6.

Fig. 6 Lighting Modelling

After creating the modeling, the next step is to perform lighting analysis. The analysis is conducted only in the rooms on the 1st and 2nd floors [37]. Based on the visualization results in each room on the 1st and 2nd floors, which were conducted every 4 hours from 8 AM to 8 PM, the lighting levels in each room can be categorized as shown in Table 3 below:

Table 3. The luminaire calculation results

No	Room	Luminaire		OSHA (120-	NEQS (300 lux)
		Highest	Avera		
A	1st Floor				
1	Longue and Lobby	500 lux	218		
2	Multipurpose Room	250 lux	167 lux		
3	Coffe Shop	1000 lux	250		
4	Office 1	300 lux	178		
5	Office 2	300 lux	176		
6	Office 3	300 lux	150		
7	Ablution Area	290 lux	229		
8	Accessible Toilet	250 lux	218		
9	Men's Toilet	400 lux	250		
10	Women's Toilet	400 lux	244		
11	Control Room	300 lux	121		
12	Transformer	300 lux	133		
13	Staircase	450 lux	120		
14	Generator Room	300 lux	165		
15	Warehouse	300 lux	158		
16	Kitchen	300 lux	157		
17	General Storage	300 lux	136		
18	Recreation Room	300 lux	131		
19	Purchasing Room	300 lux	130		
20	Trash Room	300 lux	157		
B	2nd Floor				
1	Bedoom	1000 lux	285		
2	Lobby	500 lux	222		
3	Office 1	300 lux	150		
4	Office 2	300 lux	150		
5	Control Room	300 lux	121		

Based on the research results conducted on the difference in sample calculations for the volume of column K1 on the 2nd floor using the conventional method, BIM method, and field measurements, the volume of column K1 was found to be 39.43 m^3, 35.84 m^3, and 35.84 m^3, respectively. Therefore, the volume calculation of column K1 on the 2nd floor between the BIM method and the conventional method with field$_3$ measurements shows a difference of 3.59 m or 9.53%. Thus, it can be concluded that calculations using the BIM method are more accurate.

The modeling in each room indicates that the number of luminaires produced is influenced by natural and artificial lighting. The highest intensity of natural light occurs when the sun is at the equator, with an average value of 500-1000 lux around openings, especially in the window areas. Natural light intensity decreases in the late afternoon around 4:00 PM to 300-500 lux and becomes stable in the evening around 8:00 PM with an average value of 175-300 lux. The selection and placement of luminaire components also affect the intensity of light generated inside the room. Based on calculations at four different times, namely 8:00 AM, 12:00 PM, 4:00 PM, and 8:00 PM, it can be concluded that if the average lux values meet the Occupational Safety and Health Administration (OSHA) criteria of 120-250 lux and the National Environmental Quality Standards (NEQS) criteria of 300 lux, then the indoor lighting intensity is considered adequate according to the applicable standards, except for the second- floor room with an average lux value that exceeds the OSHA standard at around 285 lux.

The table above shows the results of the lighting analysis conducted in several rooms on the 1st and 2nd floors. The analysis results indicate that all the rooms meet the lighting requirements according to OSHA and NEQS, except for the rooms on the 2nd floor. The analysis indicates that the lighting in the 2nd floor rooms does not meet the OSHA standards and may exceed them.

V. CONCLUSION

Based on the modeling results carried out at the Asrama Haji Pondok Gede building using the Building Information Modeling (BIM) method, which involves stages such as CAD import, grid creation, level creation, foundation creation, wall creation, floor creation, column creation, door placement, and window placement. After going through these stages, the results obtained are in the form of architectural and structural modeling. Furthermore, these modeling results can be used to perform quantity take off calculations and lighting modeling processes.

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