

The Study of Effectiveness in Using Building Information Modelling (BIM) in the Planning Phase in an Industrial Building

Heri Wijayanto¹, Jason Lim²Master Student of Civil Engineering, Tarumanagara University, Jakarta, Indonesia¹Lecturer of Master Civil Engineering, Tarumanagara University, Jakarta, Indonesia²

ABSTRACT: In a project, there are problems often occur caused by design changes during construction that affects the additional work. As the development of the era, innovations emerge in every field, especially in a planning method, which is Building Information Modelling (BIM). Therefore, this study conducts the study of effectiveness in using the Building Information Modelling in the planning phase in an industrial building. The research is processed firstly by collecting data related to the construction projects of factory industry including man-hour data, investment value, human resources requirements, time planning, number of design drawings, and contract value. The results of this study are BIM method can complete the work shorter with fewer HR needs compared to the conventional method. The use of BIM method can reduce the potential of additional works by **1.24%-1,68% of the contract value due to design adjustments**. However, the investment in applying BIM method is higher than the conventional method.

KEYWORDS: Building Information Modelling (BIM), Planning, Industry

I. INTRODUCTION

The construction industry in Indonesia is one of the industries that have experienced rapid progression as evidenced by the increasing number of infrastructure development. It encourages many construction service providers to increase the quality of the project more effectively and efficiently. In the competition of construction service, construction service providers are required to finish the construction project in a short time with good quality and lower cost. To realize it, a good concept is needed to cover all parts of construction starting from planning, engineering, procurement, and implementation in the field.

In a project, there are problems often occur caused by design changes due to adjustment during the construction process. Those can affect additional cost, long time delays, so that the resources used ineffectively and inefficiently can disrupt activities during the construction process.

As the development of the era, innovations emerge in every field, especially the construction that keeps progressing with the discovery of various methods in planning, and one of them is Building Information Modelling (BIM) concept. Autodesk as a company producing CAD application (Computer Aided Design) creates applications that support BIM. There are Autodesk Revit, Autodesk Inventor and Autodesk Navisworks that start to be mostly used by practitioners and Engineers.

II. RELATED WORK

The use of Building Information Modelling in the planning phase can lessen adverse impacts on the project because of good ability in calculating the project cost. BIM provides solutions for matters before it can effect on the high project

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

cost. It can be realized through cooperation and coordination of all project staff; therefore, it is crucial to have a good cooperation.

The study conducted by HergunselMemet (2011), it examined the benefits of using Building Information Modelling method for a construction manager and project scheduling BIM-based. According to Hergunsel, there are many uses of Building Information Modelling for each project presented in the table below:

Table 1. The Use of BIM (Building Information Modelling).

PLAN	DESIGN	CONSTRUCT	OPERATE
Existing Conditions Modeling			
Cost Estimation			
Phase Planning			
Site Analysis			
Programming			
	Design Reviews		
	Code Validation		
	LEED Evaluation		
	Other eng. Analysis		
	Mechanical Analysis		
	Lighting Analysis		
	Structural Analysis		
	Energy Analysis		
	Design Authoring		
		3D Coordination	
		3D Control and Planning	
		Digital Fabrication	
		Construction System Design	
		Site Utilization Planning	
			Record Model
			Disaster Planning
			Space Mgmt/Tracking
			Asset Management
			Building System Analysis
			Maintenance Scheduling

Primary BIM Uses
 Secondary BIM Uses

The conclusion of this study is that Building Information Modelling is worthy for the construction industry. BIM is useful for such coordination, construction scheduling, and prefabrication in which it makes the construction project more efficient. In other words, BIM provides cost-saving and time and produces better quality construction product. Various BIM method tools can be used to implement BIM in construction projects. Overall, Building Information Modelling is a good way, yet the BIM method still needs development for better use.

III. LITERATURE REVIEW

Building Information Modelling (BIM)

Building Information Modelling (BIM) is a process for creating and managing a building's data during the project lifecycle, BIM uses 3D, real-time, and dynamic building modelling software to increase productivity in building design and construction. The production process of BIM encompasses building geometry, spatial relationship, geographic information, and the quantity and quality of building components.

BIM can be used to show all the building's lifecycle including the construction process until the building's operation. The quantity and quality of a material can be informed easily; the scope of work can be divided, separated, and determined. The installation system and detail of the sequential circuit can be displayed on a scale with a group detail.

Advantages of BIM Method

Advantages of BIM service according to Soemardi (2014) [8] as follows:

1. Minimizing Reworks design by improving collaboration between the owner, consultant, and contractor,
2. High quality and accuracy of documentation of the construction process,
3. BIM technology is used to entire building's lifecycle, including operational facilities and maintenance building,

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

4. High-quality products and minimizing the possibility of conflict,
5. Reducing project cost, and improving construction management.

The use of BIM method can improve the collaborative effort of a project implementer, architect, and engineer. A construction leader can provide constructability, sequencing, value and engineering reports in the planning phase. In the end, the final result of the BIM process itself is used for maintenance or maintenance as an asbuild drawing of a building. This is one of the important things why using BIM.

IV. RESEARCH METHODOLOGY

This study was conducted on the design plan of the palm oil mill industry located in West Kalimantan and used data related to the use of BIM method. The collected data in this study used secondary data collected. Among the data collected, there were:

1. Man-hour data and Schedule planning
2. Data on the investment value in software-hardware procurement, and
3. Data on contract value for construction of factory industry.

The next step was making a comparison for each data between BIM method and the conventional method, conducting an analysis of cost loss due to project delays, analysing the potential of additional works. Then, the conclusion was drawn from the result of the analysis.

V. ANALYSIS AND RESULT

Comparative Analysis of Man-hour

Analysis of man-hour is conducted by comparing the Man-hour requirement of BIM method and the conventional method in the design planning phase. To be able to conduct an equal comparison, the comparison is done between factory construction projects with the same capacity.

The following is the summary of the man-hour data in the planning phase of BIM method and the conventional data presented in Table 2.

Table 2. Summary of Man-hour requirement of BIM method and the conventional method

NO	Scope of work	BIM		Conventional	
		Hour	Crew	Hour	Crew
1	Mechanical	5200	7	8320	8
2	Civil structural and architectural	2960	3	3200	4
3	Electrical	2400	3	3200	4
	Total	10560	13	14720	16

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

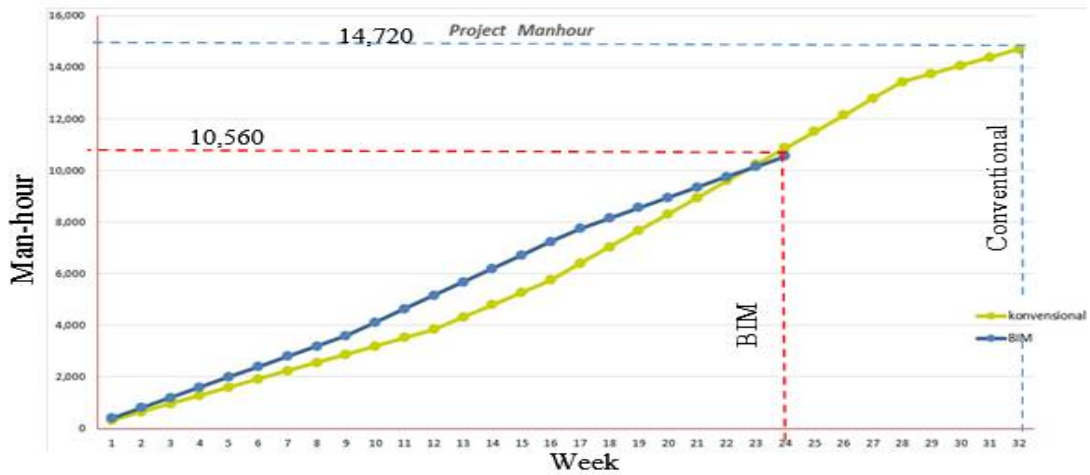


Figure 2. Graph of Man-hour Project

Figure 2 presents the Man-hour requirement in the design phase of BIM method and the conventional method. BIM Method completes the design phase at week 23, while the conventional method is at week 32.

The graph shows that BIM method is higher than the conventional method at week 1 to 24, it indicates that the Human Resources (HR), structural, mechanical, and electrical civil, involved in this phase is started simultaneously, while the conventional method is carried out gradually starting from mechanical, then civil, and lastly electrical.

Hereby, it can be seen that the Man-hour requirement of BIM method is less than the conventional method; BIM method needs 10.560 hours whereas the conventional method is 14.720 hours to complete the design of factory construction planning. The result of the analysis is the BIM method can complete the work shorter with fewer HR needs.

Analysis of Work Hour's Requirement in the Planning Phase

Analysis of work hour's requirement in the planning phase uses the planning data of each scope of work of the design. BIM method works in parallel that directly coordinating with each scope of work, while the conventional method works sequentially or in series between the scopes of work with each other. The planning table of BIM method and the conventional method can be seen in Table 3.

Table 3. Planning table of BIM method and the conventional method

Scope of Works	Method	Weeks																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Mechanical																										
Boiler Station	K	■	■																							
	B	■	■																							
Power House	K			■	■	■	■																			
	B			■	■	■	■																			
Civil Structure																										
Boiler Station	K			■	■																					
	B	■	■																							
Power House	K					■	■	■	■																	
	B			■	■																					
Electrical																										
Boiler Station	K																	■	■							
	B								■	■																
Power House	K																			■	■	■	■			
	B										■	■	■													
K = Conventional method B = BIM method																										

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

In Table 3 it can be seen that the blue colour is for BIM method and the red colour is for the conventional method. For the conventional work, each design discipline is worked sequentially, as an example is the work of Boiler Station on the mechanical is finished in week 2, then it is proceeded with the work on civil at week 3 and finished in week 4, whereas the work on electrical can be carried out at week 17 and completed at week 18, the last of electrical is performed after civil construction is completed by 70%. Meanwhile, BIM method is carried out simultaneously, for instance, the work of Boiler Station on the mechanical and civil is carried out at week 1 and finished in week 2, and at week 9 the work on the electrical is started and completed at week 10. The work on mechanical and civil runs simultaneously in which it can correct each other if there is a design that collides or is incompatible with the structural and electrical civil work.

Comparative Analysis of Human Resource (HR) Needs

Comparison on HR is based on the number of HR needs of BIM method and the conventional method in the construction planning and the industrial process machinery of a palm oil processing plant. For the conventional method, it needs HR who has congenial disciplines such as civil engineer, mechanical engineer, and drafter. In this case, the HR needs of BIM method is similar to the conventional method, however, the BIM method has a BIM engineer. The duty of a BIM engineer is to make a drawing design using Autodesk Revit, and then it is reviewed by the engineering team using Autodesk Naviswork software.

A drafter of BIM method is in charge of changing or converting 3D images into 2D, adding component details and explanation notations on the 2D construction drawing meanwhile, in the conventional method, a drafter works the overall design of the concept drawings, detail drawings, and tender drawings. The data on the HR needs of each method can be seen in Table 4.

Table 4. The HR Needs of The Conventional Method

No	Method	HR (people)
1	BIM	13
2	Conventional	16

In Table 4, it shows the comparison of HR needs in the planning design phase in which it can be seen that the planning with BIM method needs fewer HR that is 13 people, while the conventional method needs 16 people so that the use of BIM method can reduce the drafter's needs in the scope of work.

Comparison of Total Design Detail

Comparison of design for BIM method and the conventional method based on the number of 2D construction drawings or designs printed on A3 sheets, each method has a different number of printed drawings. For the number of printed drawings, the planning result of BIM method and the conventional method can be seen in Table 5.

Table 5. The Number of Design Details

No	Method	The Number of Design Details (Sheets)
1	BIM	937
2	Conventional	855

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

Table 5 presents the number of the design details of the plant building planning in which BIM method has more than the conventional method that is 937 sheets, while the design details using the conventional method has 866 sheets. The result of the comparison of total design details can be seen in Figure 3.

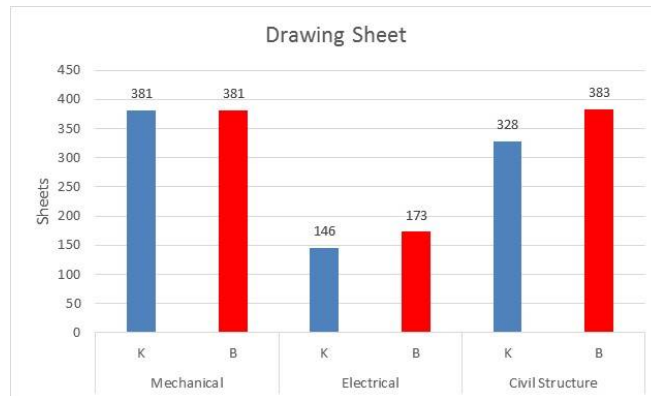


Figure 3. Graph of the Number of Sheets

In Figure 3, it shows that the number of the mechanical works of BIM method and the conventional method is 381 sheets; it is because of the mechanical design of the conventional method using Autodesk Inventor which is one of the BIM supporting software.

Figure 4 and 5 show the design planning view on the one part of a palm oil processing plant that is the guard post with BIM method and the conventional method. The guard house sizes 3m x 4m consisting of the main room and a toilet on the side.

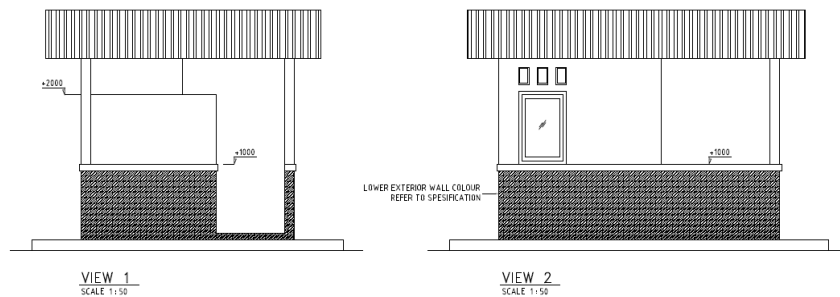


Figure 4. Guard House of the Conventional Method Display

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

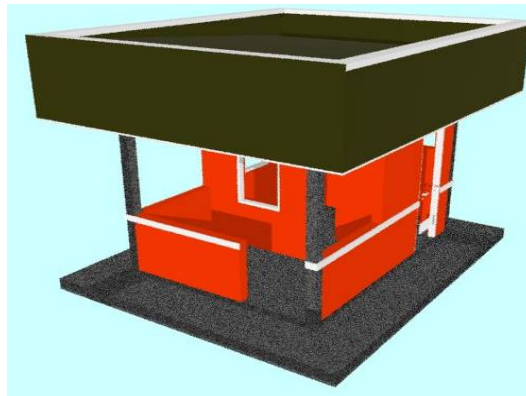


Figure 5. Guard House of BIM Method Display

Figure 4 and 5 present that BIM method display is more realistic or real and easier interpreted on the design or construction phase. For the detail drawing of the guard post of BIM method is similar with the conventional method which is displaying the appearances of the front, side and design of each part. The building drawings are equipped with notations, size dimensions, and material specifications used.

Analysis of investment in Software and Hardware Procurement

To find out the differences in the investment value of each method, an analysis of the value on the software and hardware of the BIM method and the conventional method is conducted. The investment cost of software and hardware procurement of BIM method and the conventional method is presented in Table 6.

Table 6. The Investment Cost of Software and Hardware Procurement of BIM Method

No	Method	Cost in Jakarta (IDR)
1	BIM	1.864.393.500
2	Conventional	495.745.500

Based on the comparison of the value of software and hardware procurement, the procurement value of BIM method is more expensive than the procurement value of the conventional method. The procurement value of BIM method is 1.864.373.500 IDR, while the procurement value of the conventional method is 495.745.500 IDR.

Analysis of Loss Due to Project Delays

To find out if project delays can cause losses to the palm oil industry, an analysis is conducted to calculate the corporate profit if the manufacturing industry is already operating and processing FFB with the factory capacity of 40 Ton/hour in accordance with the schedule planned.

Calculation of the analysis as follows:

$$\text{Rendemen} \times \text{Mill Capacity} \times \text{Processing Hours} \times \text{Processing Days in A Month} \times \text{price/ Ton CPO/Ton}$$

Price of CPO oil	: 8.600.000 IDR/ Ton. (2018, Source of GAPKI) [13]
Rendemen	: 25 %
Mill capacity	: 40 Ton per hour
Processing hour	: 20 hours per day
Processing day	: 25 Days per month

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

Operating cost of operating expenditures (opex) ± Rp 36.500.000.000,-/Year or 3.041.666.667 IDR/ Month = (25% x 40) x 20 hours x 25 days x 8.600.000 IDR /Ton obtained 43.000.000.000 IDR/ month.

Monthly Net Profit 43.000.000.000 IDR reduced 3.041.666.667 IDR, obtained 39.958.333.333 IDR. The net profit of FFB is carried out when it is processed by its palm oil plant with the capacity of 40 TPH that is 39.958.333.333 IDR every month.

If the palm oil plant is not ready yet to process FFB, then FFB is ready to be sold to other processing plants, it can reduce the company's profit.

Calculation of the analysis as follows:

$$\text{MillCapacity} \times \text{Processing Hours} \times \text{Processing Days in A Month} \times \text{FFB Price/Ton}$$

Price of FFB : 1.324.340 IDR/Ton. (2018, Source of GAPKI) [13]

= 40 x 20 hours x 25 days x 1.324.340 IDR /Ton obtained 26.486.800.000 IDR every month.

The calculation shows that when FFB is sold to other factories, the company only obtains a profit of 26.486.800.000 IDR every month.

From the analysis of the calculation if FFB is not processed but it is sold to other factories, then the company will acquire less profit. Sale of FFB to other factories is due to the delays in completing the work. This delay on every month can reduce the company's profit by 39.958.333.333 to 26.486.800.000 IDR with a difference of 13.471.533.333 IDR every month.

Analysis of Potential Changes of Employment Contract

To discover if the use of BIM method is a cost-effective, an analysis of an additional work cost is carried out. Here is the data on the contract value of the factory construction work for some projects.

In a construction project, it is undeniable that there are changes in the employment contract effecting reducing the additional work. In the table above there are changes in the employment contract affecting an addition of the additional work value. The value addition or additional work can be seen in Table 7.

Table 7. The Value Addition of Employment Contract

No	Project	Contract Value (IDR)	Value Addition (IDR)	Additional work (%)	Percentage of the causative factor From the Value Addition (%)		
					Design Changes	Weather	Additional Scope of Work
1	PI	250.119.728.235	7.753.711.575	3.1	40	40	20
2	TR	232.945.900.339	6.988.377.010	3	45	40	15
3	SG	315.444.206.178	8.832.437.773	2.8	60	30	10
4	PA	260.622.527.248	10.424.901.090	4	30	65	5
5	SR	135.988.460.720	4.895.584.586	3.6	40	60	0

Changes in the execution time of a work occurring in a construction project are mostly due to several factors, such as weather, design changes and additional scopes of work during the construction process.

Table 7 presents the values of additional work occurring in the five projects is 2,8% to 4% of the contract value. Here are factors influencing the additional work in the project:

1. Design changes effects the additional work by 30% to 60% of the value of the additional work, design changes occur due to incapability between the drawings (mechanical and structural civil) discovered during the construction process.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 9, September 2018

2. Weather factors result in the additional work by 30% to 65% of the additional work. Activities which are most affected by the weather are excavation and structural civil work. The activity of excavation and embankment work is very hazardous and difficult to do during the rainy season.
3. Addition of work scope affects the additional work of 5% to 20% of the value of the additional work. It occurs because the owner adds the work in the form of building, machine, or processing system outside the employment contract during the construction process inflicting additional work.

The use of BIM method can eliminate the value of the additional work due to design changes since incompatible drawings of mechanical, architectural and electrical structural civil is 1,24% to 1,68 % of the initial contract value.

VI. CONCLUSION

Based on the explanation result and analysis of effectivity review the use of BIM in the planning phase of the industrial construction, thus it can be concluded as follows:

1. The use of BIM can increase the efficiency in the planning time and the HR requirement effecting on the cost-saving used in the project planning. The use of BIM method has the advantage of facilitating coordination in every planning phase to construction.
2. Based on the case study of the industrial building planning by comparing BIM method with the conventional method, BIM method can reduce the amount of the HR requirement by 18,76%. The use of BIM is able to identify incompatibility design in mechanical drawing, architectural and electrical civil in the planning phase, so it is able to depreciate the potential changes in the employment contract (Contract Change Order) caused design adjustments during the construction by 1,24 – 1,68% of the contract value.
3. The result of a visual comparison of the BIM method is more real or realistic than the conventional method. BIM method has more the number of produced design and more detail than the conventional method so that BIM method facilitates engineer in presenting planning design to the management or the owner.
4. The use of BIM can increase the efficiency in the planning time and the HR requirement effecting on the cost-saving used in the project planning. The use of BIM method has the advantage of facilitating coordination in every planning phase to construction.

REFERENCES

- [1] Autodesk, "Autodesk Revit Architecture". Manual handbook, 2017
- [2] Autodesk, "Building Information Modeling". Handbook, 2008
- [3] Azhar, S, "Trends, Benefits, Risks, and Challenges for the AEC Industry". BIM (Building Information Modeling) Leadership and Management in Engineering. ASCE, 2011
- [4] Dumairy, "Perekonomian Indonesia". Erlangga, Jakarta, 1996.
- [5] Journal of Building Information Modeling, The National Institute of Building Sciences building SMART alliance, Washington D.C.
- [6] Latief, Hasandan, Mulyani, "Kajianefektifitaspenggunaan BIM (Building Information Modeling) dalam mengurangi addendum proyek". Pascasarjana Universitas Bung Hatta, 2017.
- [7] Hergunsel, Mehmet F, "Benefits of Building Information Modeling For Construction Managers and Bim Based Scheduling". Thesis. Massachusetts Worcester Polytechnic Institute, 2011.
- [8] Soemardi, "Studiapilasiliteknologi Building Information Modeling untuk pra-konstruksi". Simposium Nasional RAPI XIII, Jakarta, 2014.
- [9] Sugiyono, "Memahami Penelitian Kualitatif". Alfabet, Bandung, 2005.
- [10] Undang-Undang Republik Indonesia. Undang- Undang Republik Indonesia Nomor 5 tahun 1984 Tentang Perindustrian. Jakarta
- [11] Walean, D., Mandagi, R., Tjakra, J., Malingkas, G, "Perencanaandan Pengendalian Jadwal dengan Menggunakan Program Microsoft Project 2010 (Studi Kasus: Proyek PT. Trakindo Utama)". Universitas Sam Ratulangi, Manado, 2012.
- [12] Winardi, "Kamus Ekonomi". MandarMaju, Bandung, 1998.
- [13] Gabungan Pengusaha Kelapa Sawit Indonesia. www.gapki.id, 2018