International Journal Of Humanities Education And Social Sciences ***(IJHESS)*** *E-ISSN:* **2808-1765**
Volume 4, Number 3, December, *Page. 1324 – 1333*
Email : editorijhess@gmail.com

Comparative Analysis of Building Structure Work Cost Estimation with BIM Construction Approach (Case Study: Construction Project of Main Lecture Building of P4T Flagship Program of Empat Lawang Regency)

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Abstract

Volume estimation and Bill of Quantities (BOQ) are crucial processes in construction planning. Currently, volume and BOQ calculations are still done manually by calculating the volume of each component in the working drawings. This process is time-consuming and prone to human error. One way to improve efficiency is to implement Building Information Modeling (BIM) in volume estimation and BOQ calculation to enhance work effectiveness. Autodesk Revit is one software that can assist in 3D modeling and accurate volume calculation. This research discusses how BIM can aid in the design volume calculation process and BOQ planning for the Main Lecture Hall building within the Integrated Agricultural Research and Development Center (P4T). Compared to conventional methods, the results show that implementing BIM on this project has provided significant benefits in terms of efficiency, increased calculation accuracy, material usage, and cost savings. With an optimization of concrete material usage by approximately 1,35% and reinforcement volume by approximately 2.11%, and a cost reduction of 0,985%, BIM has proven to provide significant added value to the project.

Keywords : BIM, Volume, Budget Plan, Comparison, Efficiencies

INTRODUCTION

Minister of PUPR Basoeki Hadimoeljono (2015) said that the Indonesian government is encouraging food self-sufficiency by prioritizing the agricultural sector. Currently, Empat Lawang Regency is creating a concept for the Integrated Agricultural Research and Development Center (P4T) area with an area of 60 hectares with the aim of producing integrated research, development, assessment, and application (Litbangjirap) in the agricultural sector with the concept of community empowerment (Cahyono et al. 2018). The construction of the P4T Main Lecture Room Building is one of the main construction project programs from the development stage of the P4T area concept in Empat Lawang Regency (Rahadi, Yuliwati, and Supiyatiti n.d.). Estimation is one of the main processes in a construction project that aims to answer the question of how much funds are needed to carry out a construction activity (Smith, Merna, and Jobling 2014). Cost is a key factor in construction management. In general, the costs required in a construction project are large. Cost and time control must be carried out in a balanced manner to achieve project success (Aggor 2017). In calculating the budget cost of a construction project, a detailed analysis of the materials used and the time required for the implementation of construction activities is needed (Brook 2016). Inaccuracies that occur in the calculation process will have negative consequences for the parties involved (stakeholders) in it (Næss 2016). The delivery of unclear information and data that is not properly archived in a project plan is the root of many problems that often occur in the construction world (Sacks et al. 2018). The delivery of information through a two-dimensional (2D) model where the explanation and description of the work drawing object is less detailed, and the use of different software that is not integrated with each other is one of the main factors in the problems that often arise when construction work is carried out, making calculations in planning less accurate according to conditions in the field (Aziz 2013). Building Information Modeling (BIM) is a technological innovation that is revolutionizing the construction industry by providing very detailed and accurate 3D building

models. This model includes all the information needed for project planning, implementation, and management, so that it can improve construction efficiency and quality (Marizan et al., 2020). BIM can detect clash detectors so that it can save material usage and shorten work time in the field. BIM-based software also has plugins that make it easy for software users to import data directly between applications so that it is easier to communicate and collaborate between all sub-jobs in a project (Yudi & Apriani, 2020).

There are many benefits generated by conducting research driven by BIM-based education, including helping participants involved to quickly understand the core aspects of the work so that they can use what they learn better (Chen, Lu, and Wang 2020). The use of the BIM method in calculating the RAB has many advantages when compared to using conventional methods, because BIM can provide calculations with a high level of accuracy so that it can reduce errors due to human error, and can optimize the use of materials and resources in the field (Khosakitchalert, Yabuki, and Fukuda 2019).

This research was conducted by discussing how the BIM method helps the process of calculating the work volume design and RAB planning in a construction project when compared to conventional methods. The object of the research to be used is the Main Lecture Room Building in the Integrated Agricultural Research and Development Center (P4T) Area of Empat Lawang Regency.

RESEARCH METHODS

Project Data and Location

The project is located in the Integrated Agricultural Research and Development Center (P4T) Area, Tebing Tinggi District, Empat Lawang Regency. Overall, the P4T area itself has a total value of around Rp154,071,599,000.00 consisting of land clearing, construction of regional roads, and 19 supporting buildings in it.

The study discusses one of the main buildings in the P4T area, namely the Main Lecture Building which consists of 2 floors with a total building area of approximately 1,032 m2, with a building value of approximately Rp 5,649,510,000.00. This building was built to meet academic needs in the P4T Area.

Project Location

This research was conducted in a Main Lecture Hall Building located in the Integrated Agricultural Research and Development Center (P4T) Area, Jalan Poros, Tebing Tinggi District, Empat Lawang Regency.

Figure 1. Project Location

Research Procedures

This study focuses on a comparative analysis of the calculation of the estimated cost of building construction work between conventional methods compared to using the BIM method in a construction project, so that through this concept an analysis can be carried out to determine the optimum total cost plan for a building structure work reviewed with both methods. The main objective of this study is to calculate the volume using the 3D modeling method, then make a cost estimate quickly, accurately,

efficiently, and error-free using Autodesk Revit 2024 software, and finally make a comparative study between manual calculation estimates and BIM-based estimates. The object of research that will be used is the Main Lecture Room Building in the Integrated Agricultural Research and Development Center (P4T) Area.

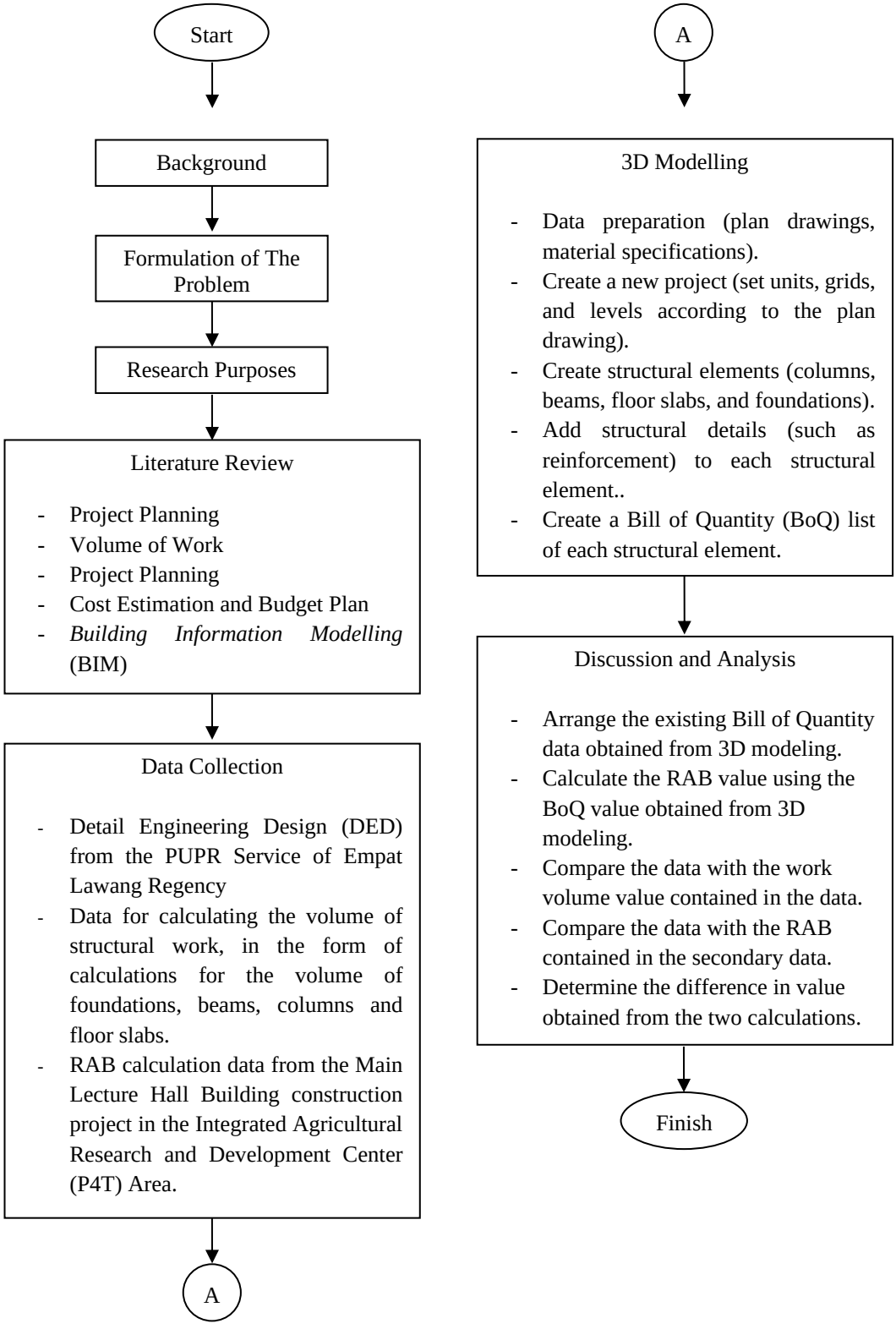

Figure 2. Research Methodology Flowchart

RESULT AND DISCUSSION

Building Modeling

Modeling is done using a BIM-based application, namely Autodesk Revit 2024 Software. Create a Grid, according to the position of the columns and beams used in the modeling.

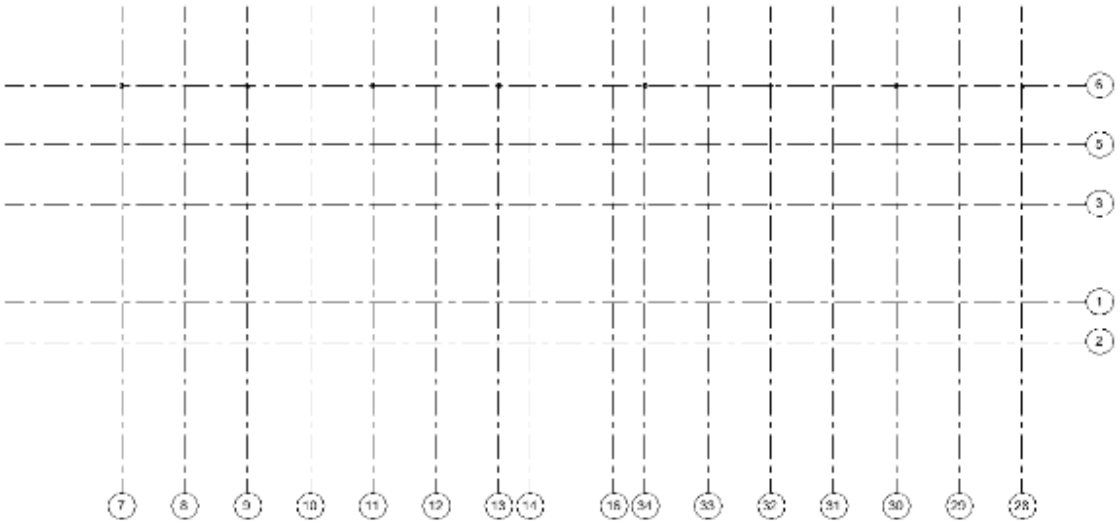

Figure 3. Grid view

Create a building structure level according to the elevation of each floor.

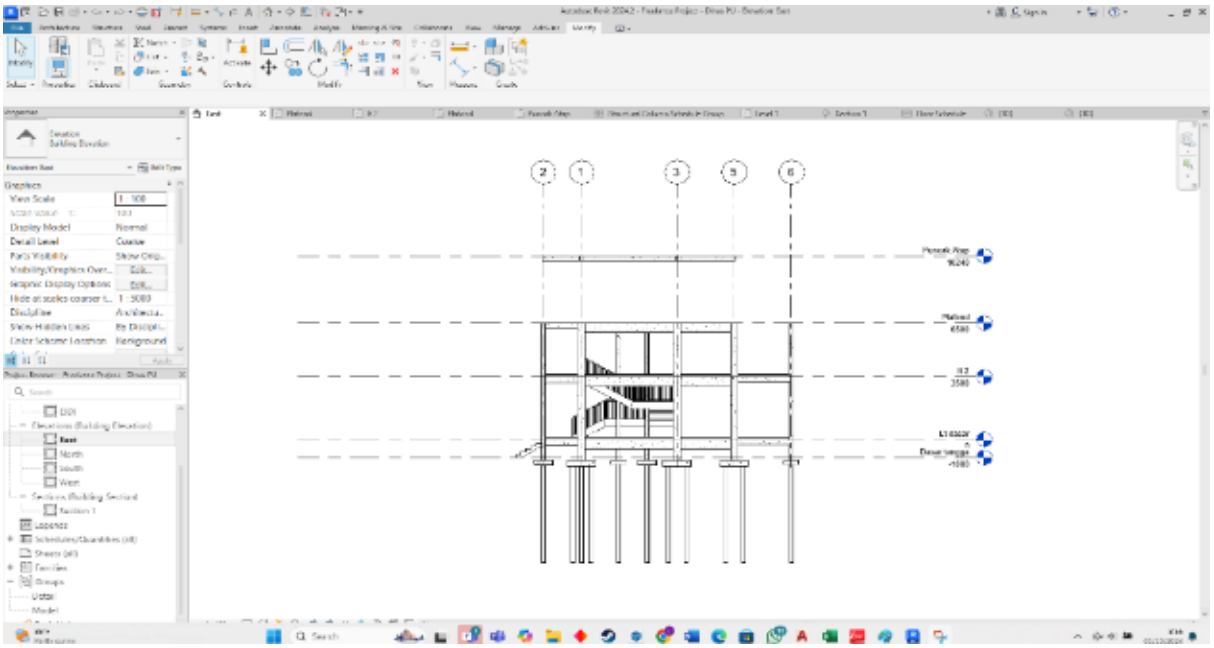

Figure 3. Building Level

Create column modeling according to the size of each column.

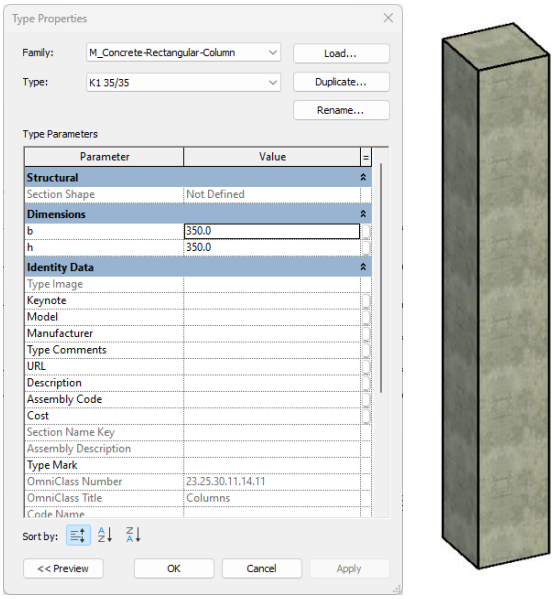

Figure 4. Column Modeling

Create beam and sloof models according to the size of each structure.

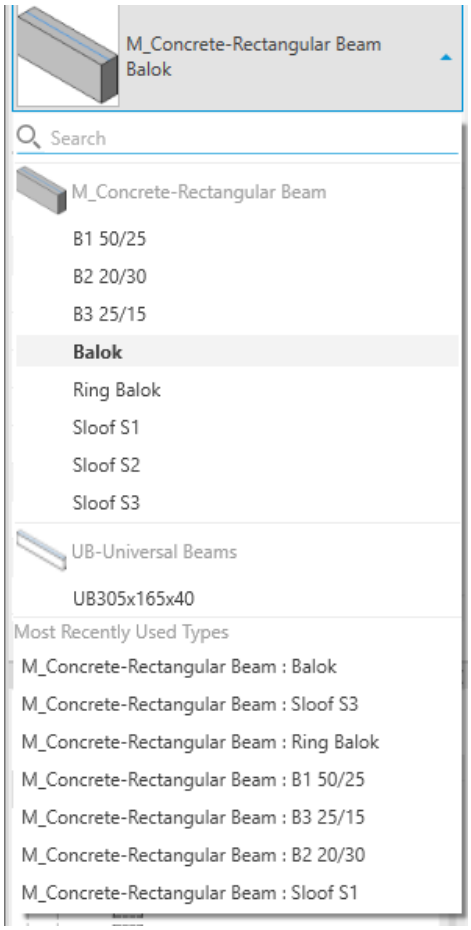

Figure 5. Beam and Sloof Modeling

Make floor slab modeling according to the planned dimensions.

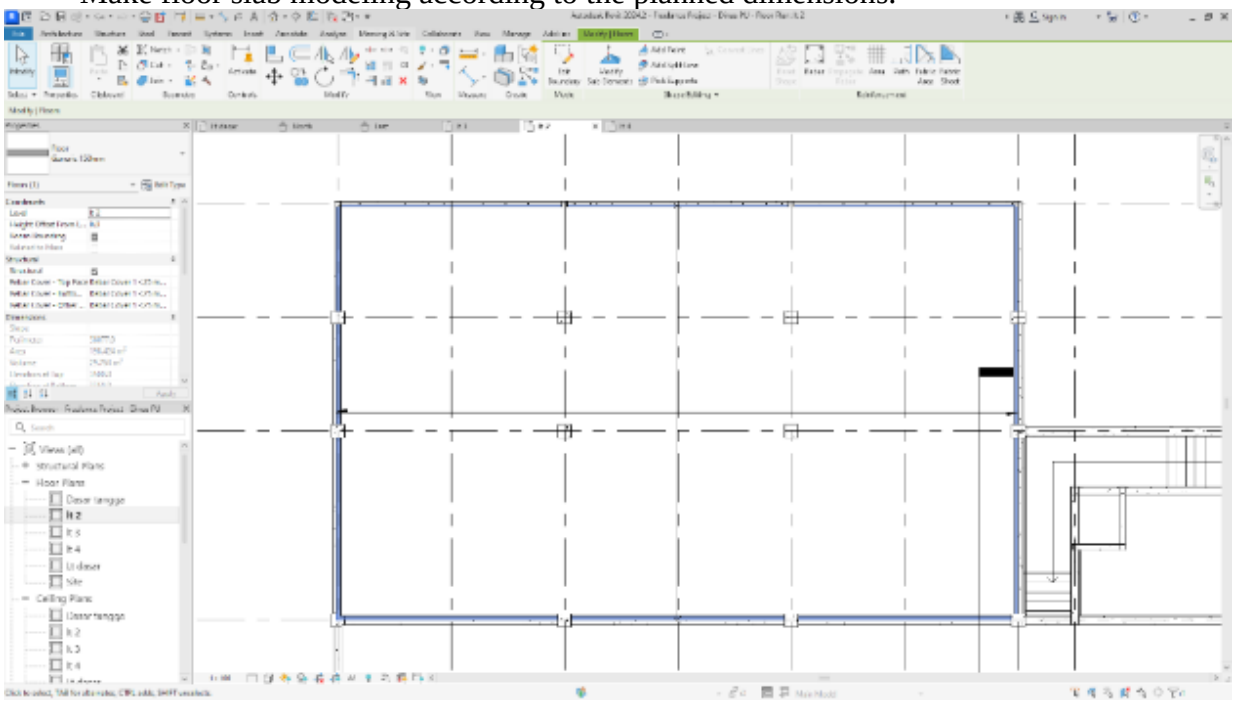

Figure 6. Floor Plate Modeling

Create mini pile foundation modeling according to the size of each foundation.

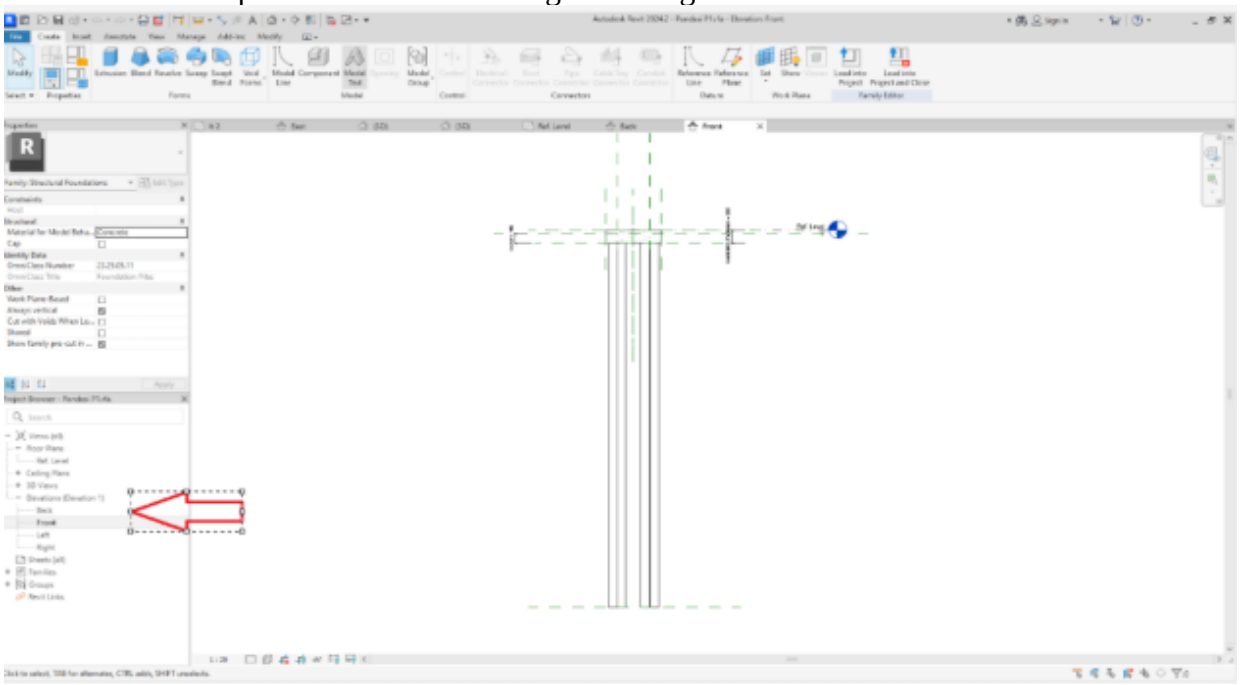

Figure 7. Foundation Modeling

Structural modeling results.

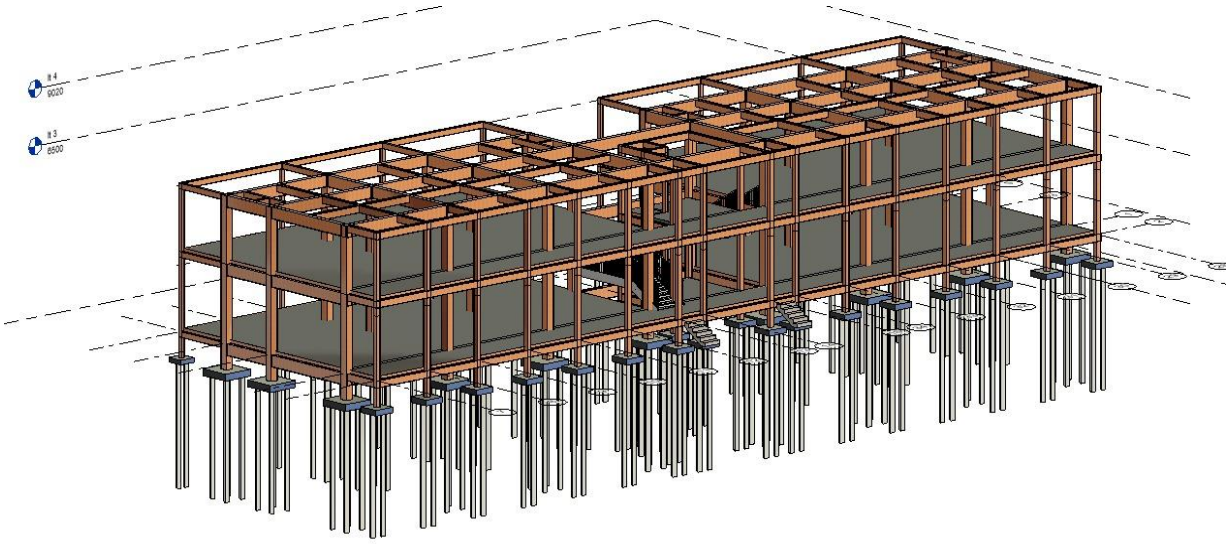

Figure 8. Structural Modeling Results

Comparison of Structural Volume Calculations

The following are the results of a comparison of the volume of structural work between manual calculations and modeling of the Main Lecture Hall Building in the Integrated Agricultural Research and Development Center (P4T) Area using Autodesk Revit 2024 software.

Table 1. Comparison of Structural Volume Calculations

A	**K 300 Concrete Work**	**Conventional**		**BIM**		**Deviation**	
		Volume	**Unit**	**Volume**	**Unit**	**m^3**	**(%)**
1	Foundation Work	29,29	m^3	29,65	m^3	-0,37	-1,25
2	Sloof Work	40,54	m^3	26,70	m^3	13,84	34,13
3	Beam Work	66,27	m^3	67,24	m^3	-0,97	-1,47
4	Column Work	27,28	m^3	29,61	m^3	-2,33	-8,52
5	Floor Slab Work	100,68	m^3	107,29	m^3	-6,61	-6,57
	Total Volume of Concrete	**264,06**	**m^3**	**260,50**	**m^3**	**3,56**	**1,35**
B	**Reinforcement Work**	**Conventional**		**BIM**		**Deviation**	
		Volume	**Unit**	**Volume**	**Unit**	**kg**	**(%)**
1	Foundation Work	2.920,89	kg	2.903,42	kg	17,47	0,60
2	Sloof Work	4.534,35	kg	3.701,45	kg	832,90	18,37
3	Beam Work	7.451,34	kg	7.448,16	kg	3,18	0,04
4	Column Work	3.959,87	kg	4.152,38	kg	-192,51	-4,86
5	Floor Slab Work	12.463,40	kg	12.463,40	kg	-	-

	Total Volume of Concrete	**31.329,86**	**kg**	**30.668,82**	**kg**	**661,04**	**2,11**

The table above presents a comparison of the volume of structural work between conventional methods and Building Information Modeling (BIM) on the Main Lecture Hall Building construction project in the Integrated Agricultural Research and Development Center (P4T) Area. The data presented includes the volume of concrete and reinforcement for the structural components of the foundation, sloof, beams, columns, and floor slabs.

The results of the calculation above show that the total volume of concrete in conventional calculations is 264.06 m3 and the total volume of reinforcement is 31,329.86 kg. While the calculation with BIM shows the total volume of concrete is 260.50 m3 and the total volume of reinforcement is 30,668.82 kg. From the results of the comparison, it shows a difference in the calculation of the concrete volume of 1.35% and the volume of reinforcement of 2.11%.

Comparison of RAB Calculations

The following are the results of the comparison of the RAB between manual calculations and modeling of the Main Lecture Hall Building in the Integrated Agricultural Research and Development Center (P4T) Area using Autodesk Revit 2024 software.

Table 2. RAB Calculation Calculation

NO	JOB DESCRIPTION	ORIGINAL DATA	MODELING DATA	DEVIATION	
		TOTAL PRICE (Rp)	TOTAL PRICE (Rp)	Rp	(%)
I	PREPARATORY WORK	Rp 174.804.056,00	Rp 174.804.056,00	-	
II	LANDWORK	Rp 15.709.499,49	Rp 15.709.499,49	-	-
III	FOUNDATION WORK	Rp 410.133.804,30	Rp 409.944.226,56	Rp 189.577,75	0,0462
IV	REINFORCED CONCRETE WORK	Rp 1.495.309.570,84	Rp 1.431.981.711,98	Rp50.395.098,87	3,370
V	WALL MASKING AND PLASTERING WORK	Rp 329.697.484,92	Rp 329.697.484,92	-	-
VI	ALUMINIUM DOOR WINDOW WORK AND FITTINGS	Rp 683.116.263,00	Rp 683.116.263,00	-	-
VII	ROOF WORK	Rp 335.818.769,14	Rp 335.818.769,14	-	-
VIII	CEILING WORK	Rp 365.802.350,00	Rp 365.802.350,00	-	-
IX	FLOORING WORK	Rp 538.561.573,23	Rp 538.561.573,23	-	-
X	SANITATION WORKS	Rp 79.637.286,56	Rp 79.637.286,56	-	-
XI	ELECTRICAL INSTALLATION WORK	Rp 270.108.509,10	Rp 270.108.509,10	-	-
XII	PAINTING JOB	Rp 177.651.449,74	Rp 177.651.449,74	-	-
XIII	PARKING LAND WORK	Rp 254.567.705,00	Rp 254.567.705,00	-	-
XIV	FINAL CLEANING WORK	Rp 5.000.000,00	Rp 5.000.000,00	-	-
TOTAL I - XIV		**Rp5.135.918.321,32**	**Rp5.085.333.644,71**	**Rp50.584.676,62**	**0,98491728**
PPN 10%		**Rp 513.591.832,13**	**Rp 508.533.364,47**	**Rp 5.058.467,66**	
TOTAL		**Rp5.649.510.153,45**	**Rp5.593.867.009,18**	**Rp55.643.144,28**	
ROUNDED		**Rp5.649.510.000,00**	**Rp5.593.867.000,00**	**Rp55.643.000,00**	

The table above presents a comparison of RAB calculations between conventional methods and Building Information Modeling (BIM) on the Main Lecture Hall Building construction project in the Integrated Agricultural Research and Development Center (P4T) Area.

The results of the calculation above show that the total RAB in conventional calculations is Rp 5,649,510,000.00, while the modeling data shows a total RAB value of Rp 5,593,643,000.00. The results of the comparison show a difference in the RAB calculation of Rp 55,643,000.00 or around 0.985%

CONCLUSION

A comparative analysis between BIM and conventional methods shows that BIM has made a significant contribution to the success of the Main Lecture Hall Building project. By reducing the use of concrete by 1,35% and reinforcement by 2.11%, BIM not only improves the accuracy of calculations but also saves project costs of Rp 55,643,000.00 or around 0.985%. This proves that BIM is an effective tool in managing modern construction projects. With its ability to improve efficiency, accuracy, and optimize costs, BIM can become a new standard in managing construction projects in the future.

The application of Building Information Modeling (BIM) in this project has provided various benefits, including increased calculation efficiency, optimization of material use, and cost savings of 0. 985%. These results show that BIM is a profitable investment in the construction industry. With its ability to increase efficiency, accuracy, and optimize costs, BIM can become a new standard in the management of construction projects in the future.

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