LOGIC
Journal of Engineering Design and Technology
Vol. 24 No.2 July 2024 ; p. 69 - 78

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

COMPARATIVE ANALYSIS OF BILL OF QUANTITY STRUCTURE GEDUNG LAYANAN TERPADU RSUD BANGKINANG CITY USING CONVENTIONAL METHOD AND TEKLA STRUCTURE APPLICATION

Bayu Baskoro[1*)], Zainuri[2)], Shanti Wahyuni Megasari[3)]

1) Program Studi Teknik Sipil, Fakultas Teknik, Universitas Lancang Kuning, Jl. Yos Sudarso km. 8 Rumbai, Pekanbaru, Telp. (0761) 52324

Corresponding email *) : bybskr@gmail.com

Abstract. In accordance with PUPR Ministerial Regulation No. 22 of 2018, the use of Building Information Modeling (BIM) must be applied to non simple state buildings with criteria for a building area of more than 2000 m2 and more than 2 floors. Gedung Layanan Terpadu RSUD Kota Bangkinang has an area of 5,040 m^2 and has 4 floors but the calculations still use conventional methods. The aim of this study was to analyze the comparison of the bill of quantity (BOQ) of the Gedung Layanan Terpadu RSUD Bangkinang City using conventional methods and the Tekla Structure application. The integrated services building consists of 4 floors, starting from the basement floor, 1st floor, 2nd floor, 3rd floor and roof floor. The research method used was to carry out manual calculations using Microsoft Excel based on the working plans and modeling the building structure using the Tekla Structure application. From the results of the study it can be concluded that the volume of concrete using the conventional method was 3,193.5 m^3 while the calculation using the Tekla Structure application was obtained 3,175.5 m^3 where there was a difference of 18 m^3 or in a percentage of 0,56 % less than the conventional method. For iron volume, there is a difference in iron volume of 2,687.23 kg or 0,45 % less using the Tekla Structure application compared to conventional methods. The conclusion from this study is that the calculation of the bill of quantity using the conventional method is greater than using the Tekla Structure application.

Keywords : BIM, BOQ, Conventional, Tekla Structure

1. INTRODUCTION

Building is a physical form created by construction work that blend into place. These buildings are partially or completely above ground or in water, and serve as places where people carry out various activities, such as residential, religious, business, social, and cultural [1]. In the United States, BIM technology began to be used in various industries since 2003, and developed rapidly in the field of construction since 2007. However, in Indonesia, only a few companies implement it across all sectors. After BIM was used in Indonesia for several

years, its use was considered not optimal despite the increasing development [2]. Building Information Modeling (BIM) is able to guarantee the integration of data or information such as synchronizing data between various stakeholders, automatic drawing generation, reports, design analysis, scheduling simulations, minimizing data redundancies, data loss and mistranslation of data into information [3].

Tekla BIM software has several benefits including precision and clarity of detail, automation of output and efficient and saving management costs [4]. The conventional calculation method in construction work is a method of calculating the volume of work that uses conventional software in the construction field such as Microsoft Excel for cost calculation, AutoCAD to make working drawings, Microsoft Project to create work schedules and SAP 2000 for structural analysis calculations. Unlike BIM, conventional methods are not integrated between one application and another [5]. Construction project management will generally include physical construction, cost, and time, material management as well as labor management [6]. Bill of quantity or volume of a job is to calculate the amount of volume of work in one unit. Volume is also referred to as cubication of work. The volume of work is calculated based on the bestek drawings of the building to be made. All parts or elements of construction present in the drawing must be calculated completely and meticulously to obtain an accurate and complete calculation of the volume of work [7].

The Ministry of PUPR as the Ministry in charge of Building made PUPR Minister Regulation No. 22 of 2018 concerning the Construction of State Buildings, it is stated that the use of Building Information Modelling (BIM) must be applied to non-simple buildings with criteria for an area above 2000 m² and above 2 floors [8]. One of the applications of Building Information Modelling (BIM) in the field of structure is Tekla Structure. This application can be used in making project structure drawings, structural analysis, project management, project control, and calculating work volume. This application itself can calculate the volume of work with better accuracy compared to conventional methods. The selection of the Integrated Service Building project at Bangkinang City Hospital is because this project still uses conventional methods which should have met the criteria required by PUPR Minister Regulation No. 22 of 2018 to perform calculations using BIM. With these considerations in mind, research is needed with the concept of Building Information Modeling using the Tekla Structure application to recalculate the structural aspect. The purpose of this study is to analyze the comparison of bill of quantity (BOQ) of the Integrated Service Building of Bangkinang City Hospital using conventional methods and Tekla Structure applications. According to Yuska, M. Y. I., (2021), in research comparing the conventional method and Tekla Structure application in calculating the structural cost of a hospital building, the aim was to compare the structural cost calculation of hospital construction. The results showed a 14.24% lower cost compared to the conventional method using Tekla Structure. This is because with BIM, modeling and data are integrated, and human errors or incorrect data input, which often occur in the conventional method, can be reduced [9].

2. METHODS

The research method used is to do manual calculations using Microsoft Excel based on working drawings of plans and modeling building structures using the Tekla Structure application which then the results of the two methods are compared to analyze the comparison of bill of quantity calculations at the Integrated Service Building of Bangkinang City Hospital. The conventional calculation method in construction work is a method of calculating the volume of work that uses conventional software in the construction field such as Microsoft Excel for cost calculation, AutoCAD to make working drawings, Microsoft Project to create work schedules and SAP 2000 for structural analysis calculations. Unlike BIM, conventional methods are not integrated between one application and another [5]. The Tekla Structure method enables the creation of accurate digital virtual models of buildings. Once completed, the resulting model contains the precise data and geometry required to complete the construction, fabrication, and procurement processes necessary to finish the building [3].

2.1.BIM Modeling

Before calculating the volume of structural work, 3D modeling was carried out using the Tekla Structure application, from which data on the volume of work in question was obtained. Here are the steps to find a volume using the Tekla Structure application:

a. Before modeling a Tekla Structure application, the first thing to do is to create a license for the application. The license obtained is in the form of a student version license by creating an account on the official Tekla Campus website and uploading the latest transcript as a condition for obtaining a license.
b. After obtaining the license, download and install the Tekla Structure application. Open the application so that the interface appears.

c. Grid settings are done by specifying the number, type and size of the x and y coordinates and setting them in the property pane on the right side of the application. The figure below shown the grid based on measurement between main structure. After setting up the grid, the interface will appear as shown in figure 1.

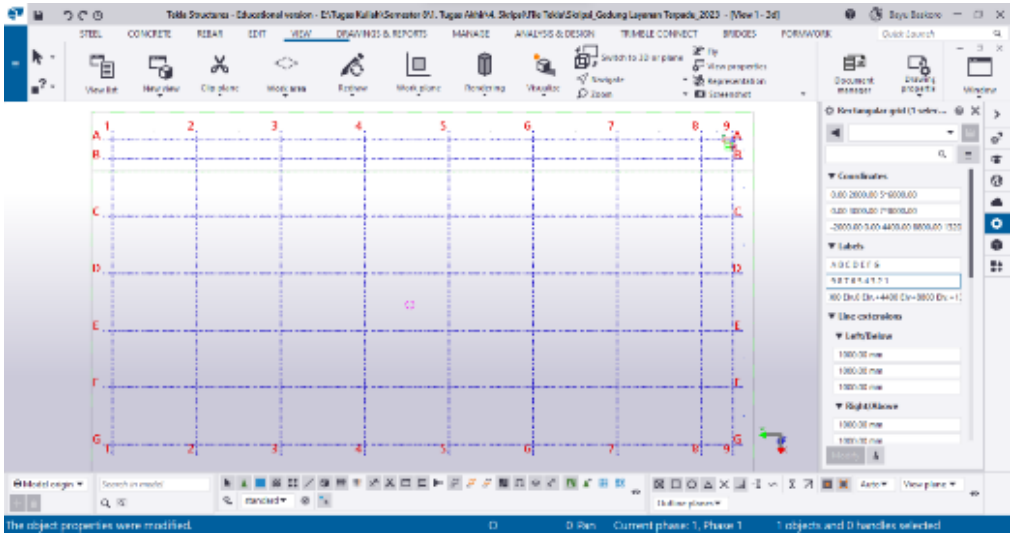

Figure 1. X and Y Axis Interface

d. Create a building axle line in the form of a Z-axis grid line for the vertical side of the building.

e. Create beam, tie beam and column modeling based on specified dimensions. The figure below shown the detail of beam, column and tie beam, by creating one detail work than it can be copied to each grid. It can be seen in figure 2.

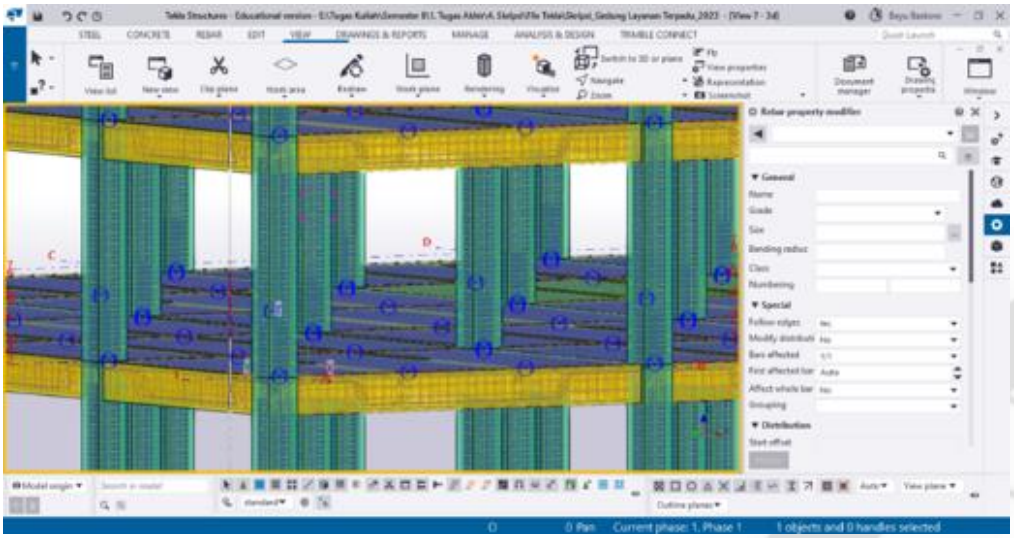

Figure 2. Beam, Tie Beam and Column Modelling View

f. Creating modeling of floor slabs based on specified dimensions. The figure below shown layout of concrete floor slab with the grid. It can be seen in figure 3.

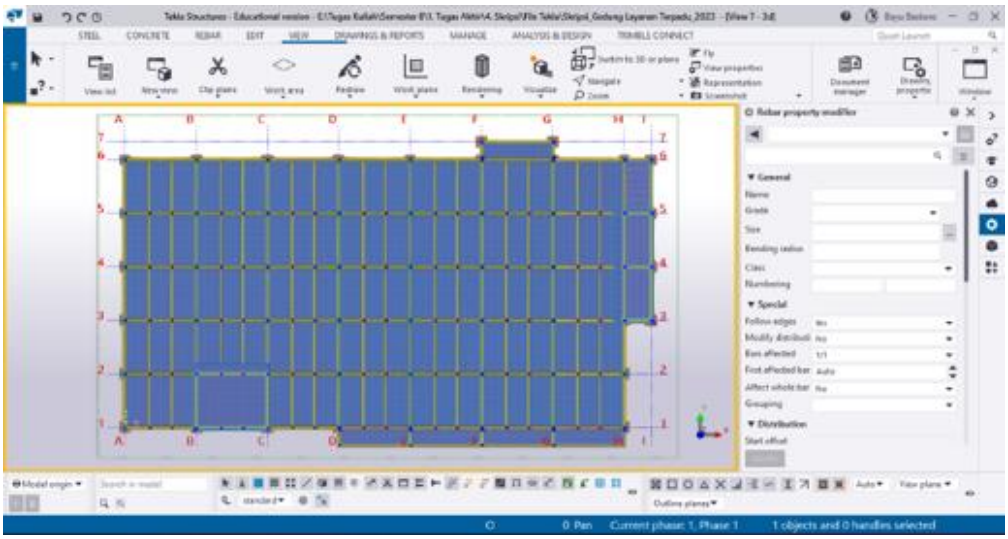

Figure 3. Floor Slab Modeling View

g. Make repeats on each element in detail and according to the reinforcement specified per element. The figure below shown reinforcement detail inside the concrete column, pedestal column, tie beam, pile cap and bored pile. It can be seen in figure 4.

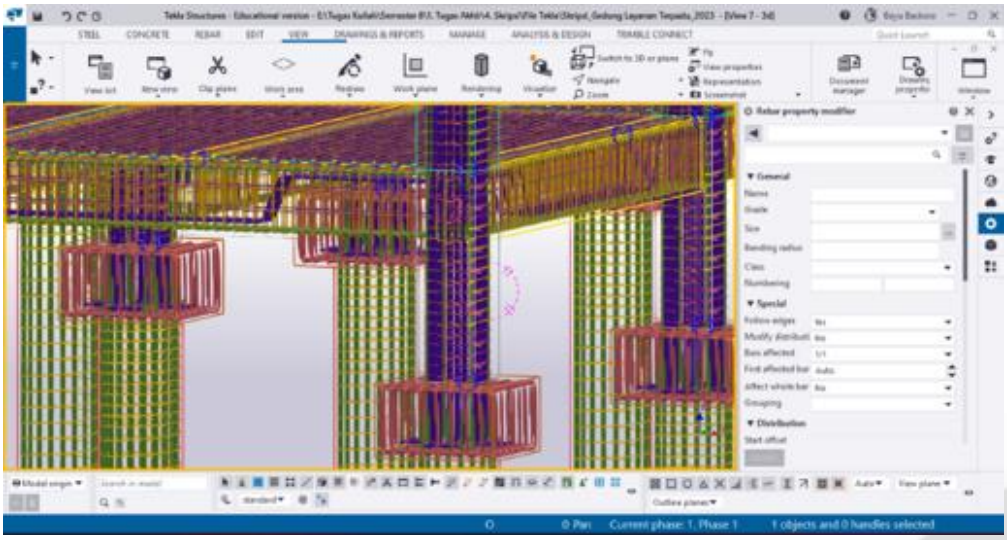

Figure 4. Floor Slab Modeling View

h. Create modeling output on the organizer menu on the manage menu tab of the application.

2.2. Volume Calculation

From the modeling carried out, it can directly calculate the volume using the Tekla Structure application, the results of the calculation will be compared with the bill of quantity using conventional methods. The calculation of the volume of work (bill of quantity) has several ways of calculation that are not the same as each other. One of the formulas for calculating the volume of work items in the conventional method is:

a. Volume for the length of the work item (m')
   (m') = Length
b. Volume for work item area (m^2)
   (m^2) = Length × Width (1)
c. Volume for cubication of work (m^3)

(m^3) = Length × Width × Height (2)

d. Volume for volume (ls, units, pieces)
In accordance with the agreement to Two sides

The flow chart in the study can be seen in figure 5.

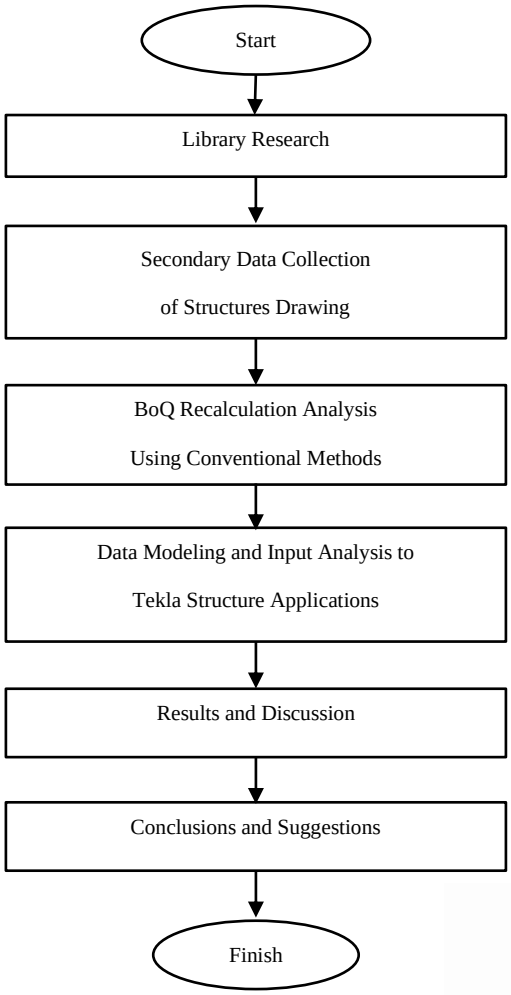

Figure 5. Research Flow Chart

3. RESULTS AND DISCUSSION

3.1 Bill of Quantity Comparison Analysis

After obtaining the bill of quantity results from both calculation methods using conventional methods and BIM methods with the Tekla Structure application, a comparative analysis of bill of quantity against each method will be carried out. The following is the result of the comparison of the bill of quantity of concrete work and ironing work at the Gedung Layanan Terpadu RSUD Bangkinang City.

Table 1. Comparative Analysis of Bill of Quantity Structur of Gedung Layanan Terpadu Basement Floor

No	Description	Unit	Volume		Deviation	Percentage
			Conventional	Tekla Structure		
(1)	(2)	(3)	(4)	(5)	(6) = (4) - (5)	(7) = (6)/(4)×100
I	Structural Work					
1	Basement Structure Work					
	a Bored Pile Foundation Work P1 dia. 80 cm					
	1) Concrete Work F'c = 25 MPa	m³	407,15	405,00	2,15	0,53%
	2) Reinforcement Work	kg	46.033,76	44.744,00	1.289,76	2,80%
	b Foundation Work Pile Cap P1 size 120×120×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	54,43	54,00	0,43	0,79%
	2) Reinforcement Work	kg	7.679,53	7.776,00	-96,47	1,26%
	c Pedestal Column Work size 200×60×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	38,88	37,80	1,08	2,78%
	2) Reinforcement Work	kg	13.227,18	13.480,00	-252,82	1,91%
	d S1 Tie Beam Work Elv. -6.40 size 40×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	181,66	181,60	0,06	0,04%
	2) Reinforcement Work	kg	41.385,70	41.181,00	204,70	0,49%
	e S2 Tie Beam Work Elv. -6.40 size 30×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	70,56	70,60	-0,04	0,06%
	2) Reinforcement Work	kg	13.596,24	13.819,00	-222,76	-1,64%
	f K1 Column Work Elv. -6.40 - ± 0.00 size 60×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	124,42	124,20	0,22	0,17%
	2) Reinforcement Work	kg	32.627,04	31.914,00	713,04	-2,19%
	g Concrete Floor Work Elv. -6.40 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	117,19	117,90	-0,71	-0,61%
	2) Reinforcement Work	kg	16.468,93	16.600,00	-131,07	0,80%
	Total Volume of Basement Floor Concrete	m³	994,29	991,10	3,19	0,32%
	Total Volume of Basement Floor Reinforcement	kg	171.018,39	169.514,00	1.504,39	0,88%

The results of the bill of quantity comparison on the basement floor Gedung Layanan Terpadu structural work which can be seen in table 1 show that there is a difference of 3.19 m³ or in percentage of 0.32% in concrete work where conventional calculations obtained results of 994.29 m³ while the volume of concrete using the Tekla structure application obtained results of 991.10 m³. In iron work there is a difference of 0.88% or 1,504.39 kg. There was a significant difference in pile cap iron work where a difference of 2.8% was obtained, while in concrete work the largest difference was in pedestal column work with a difference of 2.78%.

Table 2. Comparative Analysis of Bill of Quantity Structure of Gedung Layanan Terpadu 1st Floor

No	Description	Unit	Volume		Deviation	Percentage
			Conventional	Tekla Structure		
(1)	(2)	(3)	(4)	(5)	(6) = (4) - (5)	(7) = (6)/(4)×100
I	Structural Work					
2	First Floor Structure Work					
	a B1 Beam Work size 40×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	181,66	181,60	0,06	0,04%
	2) Reinforcement Work	kg	41.385,70	41.181,00	204,70	0,49%
	b B2 Beam Work size 30×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	70,56	70,60	-0,04	0,06%
	2) Reinforcement Work	kg	13.596,24	13.819,00	-222,76	-1,64%
	c Concrete Floor Work Elv. ±0.00 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	208,97	204,90	4,07	1,95%
	2) Reinforcement Work	kg	28.463,56	27.840,00	623,56	2,19%
	d K1 Column Work ± 0.00 - +4.40 size 60×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	85,54	86,40	-0,86	1,01%
	2) Reinforcement Work	kg	23.808,92	24.102,00	-293,08	-1,23%
	e Kp Column Work ± 0.00 - +3.70 size12×12 cm					
	1) Concrete Work F'c = 25 MPa	m³	6,34	5,80	0,54	8,52%
	2) Reinforcement Work	kg	537,14	532,40	4,74	0,88%
	Total Volume of First Floor Concrete	m³	553,07	549,30	3,77	0,68%
	Total Volume of First Floor Reinforcement	kg	107.791,57	107.474,40	317,17	0,29%

From table 2, it can be seen that the results of the bill of quantity comparison on the structural work of the 1st floor Gedung Layanan Terpadu show that there is a difference of 3.77 m³ or in a percentage of 0.68% smaller using the Tekla Structure application. In the iron work, there was a difference of 0.29% or 317.17 kg

smaller using the Tekla Structure application. In the calculation of the 1st floor bill of quantity, there is a significant difference in the floor plate work with a difference of 623.56 kg or in percentage of 2.19%.

Table 3. Comparative Analysis of Bill of Quantity Structure of Gedung Layanan Terpadu 2nd Floor

No	Description	Unit	Volume		Deviation	Percentage
			Conventional	Tekla Structure		
(1)	(2)	(3)	(4)	(5)	(6) = (4) - (5)	(7) = (6)/(4)×100
I	Structural Work					
3	Second Floor Structure Work					
	a B1 Beam Work size 40×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	181,66	181,60	0,06	0,04%
	2) Reinforcement Work	kg	41.385,70	41.181,00	204,70	0,49%
	b B2 Beam Work size 30×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	70,56	70,60	-0,04	0,06%
	2) Reinforcement Work	kg	13.596,24	13.819,00	-222,76	-1,64%
	c Concrete Floor Work Elv. +4.40 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	208,97	204,90	4,07	1,95%
	2) Reinforcement Work	kg	28.463,56	27.840,00	623,56	2,19%
	d K1 Column Work +4.40 - +8.80 size 60×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	85,54	86,40	-0,86	1,01%
	2) Reinforcement Work	kg	23.808,92	24.102,00	-293,08	-1,23%
	e Kp Column Work +4.40 - +8.10 size 12×12 cm					
	1) Concrete Work F'c = 25 MPa	m³	5,43	5,80	-0,37	6,72%
	2) Reinforcement Work	kg	460,40	423,20	37,20	8,08%
Total Volume of Second Floor Concrete		m³	552,17	549,30	2,87	0,52%
Total Volume of Second Floor Reinforcement		kg	107.714,83	107.365,20	349,63	0,32%

The results of the bill of quantity comparison on the 2nd floor of the Gedung Layanan Terpadu structural work which can be seen in table 3 show that there is a difference of 2.87 m³ or in a percentage of 0.52% smaller using the Tekla Structure application. In the iron work, there was a difference of 0.32% or 349.63 kg smaller using the Tekla Structure application. In the calculation of the 2nd floor bill of quantity, the smallest difference is in the concrete work for B1 blocks with a difference of 0.04%.

Table 4. Comparative Analysis of Bill of Quantity Structure of Gedung Layanan Terpadu 3rd Floor

No	Description	Unit	Volume		Deviation	Percentage
			Conventional	Tekla Structure		
(1)	(2)	(3)	(4)	(5)	(6) = (4) - (5)	(7) = (6)/(4)×100
I	Structural Work					
4	Third Floor Structure Work					
	a B1 Beam Work size 40×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	192,84	191,40	1,44	0,74%
	2) Reinforcement Work	kg	43.528,31	43.627,00	-98,69	-0,23%
	b B2 Beam Work size 30×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	70,56	70,60	-0,04	0,06%
	2) Reinforcement Work	kg	13.596,24	13.819,00	-222,76	-1,64%
	c Concrete Floor Work Elv. +8.80 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	208,97	204,90	4,07	1,95%
	2) Reinforcement Work	kg	29.252,68	29.082,00	170,68	0,58%
	d K1 Column Work +8.80 - +13.20 size 60×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	85,54	86,40	-0,86	1,01%
	2) Reinforcement Work	kg	23.808,92	24.102,00	-293,08	-1,23%
	e Kp Column Work +8.80 - +12.50 size 12×12 cm					
	1) Concrete Work F'c = 25 MPa	m³	5,86	6,20	-0,34	5,79%
	2) Reinforcement Work	kg	496,51	483,40	13,11	2,64%
Total Volume of Third Floor Concrete		m³	563,77	559,50	4,27	0,76%
Total Volume of Third Floor Reinforcement		kg	110.682,66	111. 113,40	-430,74	-0,39%

From table 4, it can be seen that the comparison of bill of quantity on the 3rd floor of the Gedung Layanan Terpadu structure work shows that there is a difference of 4.27 m³ or in a percentage of 0.76% smaller using the Tekla Structure application. In iron work, there is a difference of 0.39% or 430.74 kg greater using the application of Tekla Structure. The largest difference occurred in the volume of iron work column K1 with a difference of

293.08 kg or in a percentage of 1.23% greater using the application of Tekla Structure compared to conventional methods.

Table 5. Comparative Analysis of Bill of Quantity Structure of Gedung Layanan Terpadu Rooftop Floor

No	Description	Unit	Volume		Deviation	Percentage
			Conventional	Tekla Structure		
(1)	(2)	(3)	(4)	(5)	(6) = (4) - (5)	(7) = (6)/(4)×100
I	Structural Work					
5	Rooftop Floor Structure Work					
	a B1 Beam Work size 40×70 cm					
	1) Concrete Work F'c = 25 MPa	m³	209,92	208,40	1,52	0,72%
	2) Reinforcement Work	kg	47.383,72	46.572,00	811,72	1,71%
	b B2 Beam Work size 30×60 cm					
	1) Concrete Work F'c = 25 MPa	m³	70,56	70,60	-0,04	0,06%
	2) Reinforcement Work	kg	13.596,24	13.819,00	-222,76	-1,64%
	c Concrete Floor Work Ely. +13.20 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	220,15	219,40	0,75	0,34%
	2) Reinforcement Work	kg	29.548,60	29.227,00	321,60	1,09%
	d Concrete Floor Work Ely. +15.70 thk = 12 cm					
	1) Concrete Work F'c = 25 MPa	m³	16,62	14,50	2,12	12,76%
	2) Reinforcement Work	kg	1.992,53	2.034,70	-42,17	2,12%
	e K1 Column Work +13.20 - +13.70					
	1) Concrete Work F'c = 25 MPa	m³	3,96	4,40	-0,44	11,11%
	2) Reinforcement Work	kg	571,54	532,10	39,44	6,90%
	f K1 Column Work +13.20 - +15.70					
	1) Concrete Work F'c = 25 MPa	m³	9,00	9,00	0 ,00	0,00%
	2) Reinforcement Work	kg	1.529,93	1.491,00	38,93	-2,54%
Total Volume of Rooftop Floor Concrete		m³	530,20	526,30	3,90	0,74%
Total Volume of Rooftop Floor Reinforcement		kg	94.622,57	93.675,80	946,77	1,00%

The results of the bill of quantity comparison on the structural work of the rooftop floor Integrated Service Building which can be seen in table 4.21 show that there is a difference of 3.9 m³ or in a percentage of 0.74% smaller using the Tekla Structure application. In the iron work, there was a difference of 0.56% or 946.77 kg smaller using the Tekla Structure application. The following is a recapitulation of the results of the total difference in bill of quantity comparison in the structure of the Gedung Layanan Terpadu RSUD Bangkinang City which can be seen in table 5.

Table 6. Total Difference Analysis Bill of Quantity Comparison of Gedung Layanan Terpadu Structures

Description	Unit	Volume		Deviation	Percentage
		Conventional	Tekla Structure		
Total Volume of Basement Floor Concrete	m³	994,29	991,10	3,19	0,32%
Total Volume of Basement Floor Reinforcement	kg	171.018,39	169.514,00	1504,39	0,88%
Total Volume of First Floor Concrete	m³	553,07	549,30	3,77	0,68%
Total Volume of First Floor Reinforcement	kg	107.791,57	107.474,40	317,17	0,29%
Total Volume of Second Floor Concrete	m³	552,17	549,30	2,87	0,52%
Total Volume of Second Floor Reinforcement	kg	107.714,83	107.365,20	349,63	0,32%
Total Volume of Third Floor Concrete	m³	563,77	559,50	4,27	0,76%
Total Volume of Third Floor Reinforcement	kg	110.682,66	111.113,40	-430,74	-0,39%
Total Volume of Rooftop Floor Concrete	m³	530,20	526,30	3,90	0,74%
Total Volume of Rooftop Floor Reinforcement	kg	94.622,57	93.675,80	946,77	1,00%
Total Volume of Concrete	m³	3.193,50	3.175,50	18,00	0,56%
Total Volume of Reinforcement	kg	591.830,03	589.142,80	2687,23	0,45%

From table 6 it can be seen that for concrete work using conventional methods it produces a concrete volume of 3,193.5 m^3 and calculations using the Tekla Structure application produce a concrete volume of 3,175.5 m^3 obtained the difference for concrete work is 18 m^3 or in percentage of 0.56% greater in conventional calculations compared to using the Tekla Structure application. For the results of ironing work, conventional methods produce iron volumes of 591,830.03 kg while calculations using the Tekla Structure application obtained

results of 589,142.8 kg obtained a ratio of 2,687.23 kg or in percentage of 0.45% greater in conventional calculations than using the Tekla Structure application. The largest difference occurred in the calculation of concrete volume on the 3rd floor with a difference of 0.76% while the smallest difference was found in the volume of concrete on the 2nd floor with a difference of 0.52% smaller using the application of Tekla Structure compared to conventional methods.

3.1 Discussion

From the results of the comparison analysis above, there are several work items that have significant differences, this is because in the calculation process using the Tekla structure application, there are some items that do not produce perfect details, for example in bored pile ironing, in conventional calculations, bored pile ironing can be calculated in close detail using the provisions in SNI 03-2847, where the calculation for overlap or bending, can adjust to the applicable provisions, while in the calculation of the tekla structure application, how to apply the iron form is limited to the provisions of the application itself and there are some items that cannot follow the provisions of SNI 03-2847, causing this ironing calculation to be greater than conventional methods.

From table 6 it can be seen that for concrete work at the Gedung Layanan Terpadu RSUD Bangkinang City using conventional methods produces a concrete volume of 3,193.5 m^3 while calculations using the Tekla Structure application produce a concrete volume of 3,175.5 m^3 so that the comparison of the two methods for concrete work is 18 m^3 or in a percentage of 0.56% greater in conventional calculations compared to using applications Tekla structure. This is because calculations using the Tekla structure application produce more detailed volumes than the results of conventional methods whose calculations are still done manually and only based on working drawings [10].

Calculations using the Tekla Structure application can be said to be a shorter calculation process if you understand how to use it compared to conventional methods which require more time in interpreting work drawings and making them units of work volume needed. In addition, the use of BIM applications to calculate the volume of work is said to be very efficient, because the applications have been integrated with each other so that when there is a design change in planning, the calculation of work volume automatically follows the existing changes so that it eliminates the time required to identify differences due to changes [9].

4. CONCLUSION

The comparative analysis of the Bill of Quantity (BoQ) volume for the Gedung Layanan Terpadu RSUD Bangkinang City using conventional methods and the Tekla Structure application reveals several key insights:

1. Efficiency and Accuracy
   The Tekla Structure application demonstrates higher efficiency in terms of calculation speed and the ability to automatically adjust volumes with design changes. This integration reduces the time required for recalculations and enhances the accuracy of the BoQ by minimizing human error inherent in manual calculations.
2. Floor-by-Floor Analysis
   The differences in volume calculations varied across different floors. For example, the largest difference in concrete volume was observed on the 3rd floor, with a 0.76% discrepancy, while the smallest difference was on the 2nd floor at 0.52%. Similarly, reinforcement work volume differences varied, with significant differences observed in specific elements like the pile cap and pedestal column work.
3. Overall Implications
   Despite the differences, the overall volume calculations using both methods are relatively close, suggesting that either method can be reliable depending on the project's requirements. However, the use of the Tekla Structure application is recommended for its higher efficiency, ability to integrate design changes seamlessly, and potential to reduce manual calculation errors.

In conclusion, while conventional methods provide slightly higher volume calculations for both concrete and reinforcement work, the Tekla Structure application offers significant advantages in efficiency and integration, making it a preferable choice for modern construction projects. Further research with multiple case studies is suggested to validate these findings and enhance the robustness of the conclusions

5. REFERENCES

[1] Peraturan Pemerintah Pekerjaan Umum dan Perumahan Rakyat, 2018, Undang - Undang No. 28, Tentang Bangunan Gedung Negara, Jakarta.
[2] Fakhruddin, Parung, H., Tjaronge, M. W., Djamaluddin, R., Irmawaty, R., Amiruddin, A. A., Djamaluddin, A. R., Harianto, T., Muhiddin, A. B., Arsyad, A. and Nur, S. H., 2019, Sosialisasi Aplikasi Teknologi Building Information Modeling (BIM) pada Sektor Konstruksi Indonesia, Jurnal Fakultas Teknik Vol. 2 No.

2, pp. 112–119, ISSN: 2654-2781.
[3] Nugraha, D. B., 2020, Analisis Inventarisasi Pemodelan Komponen Superstructure Jembatan Cikujang Menggunakan BIM Tekla Structure, Journal of Chemical Information and Modeling, Vol. 53 No. 9,
[4] Minawati, R., Chandra, H. P. dan Nugraha, P., 2017, Manfaat Penggunaan Software Tekla Building Information Modeling (BIM) Pada Proyek Design-Build, Dimensi Utama Teknik Sipil, Vol. 4 No. 2, pp. 8–15, ISSN: 2656-3312
[5] Berlian, C. A., Adhi, R. P., Hidayat, A. dan Nugroho, H., 2016, Daya Manusia Antara Metode Building Information Modeling (BIM) dan Konvensional, Jurnal Karya Teknik Sipil, Vol. 5 No. 2, pp. 220-229, ISSN: 2597-2674.ISSN: 1689-1699.
[6] Putri, F. F., 2019, Evaluasi Anggaran Biaya Struktur dan Arsitektur Menggunakan Metode Building Information Modeling (BIM) (Studi Kasus: Gedung Integrated Laboratory For Science Policy And Communication IsDB Uneversitas Jember), Tugas Akhir, Program Studi S1 Teknik Sipil Universitas Jember, Jember.
[7] Siswanto, A. dan Salim, M., 2019, Manajemen Proyek, Pillar Nusantara, Semarang.
[8] Peraturan Pemerintah Pekerjaan Umum dan Perumahan Rakyat, 2018, Undang - Undang No. 22, Tentang Bangunan Gedung Negara, Jakarta.
[9] Yuska, M. Y. I., 2021, Perbandingan Penggunaan Metode Konvensional dan Aplikasi Tekla Structure Pada Perhitungan Anggaran Biaya Struktur Atas Gedung RSUD Selasi Pangkalan Kerinci, Tugas Akhir, Program Studi Teknik Sipil Universitas Lancang Kuning, Pekanbaru.
[10] Arianti, T. P., Sucita, I. K. dan Yanuarini, E., 2022, Perbandingan BoQ Tulangan Antara Metode Konvensional dengan BIM Apartemen "X", Vol. 21 No. 1, pp. 28-35, ISSN: 1412-2782.