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Comparative Analysis of Bill of Quantity Results with Revit, Tekla Structures and Excel Software in the Sei Mangkei Fat Trap Refinery II Construction Project

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ABSTRACT

This study aims to compare the results of Bill of Quantity (BOQ) calculations using three different approaches: Microsoft Excel, Autodesk Revit, and Tekla Structures, applied to the Fat Trap Refinery II Sei Mangkei construction project. The analysis focuses on the volume and weight of structural elements, based on secondary project data. Validation was carried out by modelling a beam approximately 50 meters long with dimensions of 300 mm × 600 mm, which showed that Autodesk Revit produced results closest to manual calculations. Microsoft Excel remains a dependable method, especially when used by meticulous planners, as it allows full control over the calculation process. Tekla Structures showed greater deviation but offers advantages in anticipating long-term risks. Based on the findings, Autodesk Revit is recommended as the most suitable method for modern projects that require precision and efficiency, while Excel remains relevant for users who prioritize manual oversight. This research is expected to serve as a reference for selecting the appropriate BOQ calculation method according to the characteristics and needs of construction projects.

Keywords: Bill of Quantity, Building Information Modelling, Tekla Structure, Autodesk Revit, and Project management.

1. Introduction

In every project construction, cost calculation is one of the most critical aspects of construction, requiring precision and efficiency. in a way precise and efficient. One of the documents important in estimate calculation cost is *Bill of Quantity* (*BOQ*), which contains details about quantity from each construction item. Accuracy in compilation *BOQ* is very influential to budget, material procurement, and smoothness implementation project.

In traditional procurement systems, the BOQ is used as the primary tool for estimating costs and as a tender document that enables a fair and competitive bidding process among contractors. With the BOQ,

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all tenderers have a uniform basis for determining the price of the work, which in turn ensures transparency and equity in the procurement process [1]. Now, The BOQ is no longer limited to the initial project phase, but now extends to the pre-contract and post-contract stages, supporting cost estimation, tender evaluation, price negotiations, and the preparation of final financial reports.[2]

The Building Information Modeling (BIM) concept involves constructing a virtual model before physical implementation to reduce uncertainty, enhance safety, resolve potential construction issues, and analyze potential impacts. Implementing BIM in project planning integrates outputs from various software platforms simultaneously, significantly improving project planning efficiency [3]

One of software *BIM* a lot used is *Tekla Structures,* which is specifically special designed for modelling structure with detail and precision height. *Tekla Structure* capable count various work items such as concrete volume, quantity reinforcement, as well as amount connection bolt in a way Automatically. This software also supports the creation of sectional drawings and dynamic model revisions during project execution. In the context of *BOQ preparation*, *Tekla Structures* allows the extraction of quantity data and material specifications directly from the 3D model, thus minimizing the potential for errors that often occur in manual calculations. *Tekla Structures* is commonly used on projects with complex structures, such as high-rise buildings, bridges, and industrial facilities [4].

According to Autodesk (2022), *Revit is a Building Information Modeling (BIM)* software that allows users to design, visualize, and simulate building projects in a collaborative environment, thereby improving interdisciplinary coordination and improving project outcomes. *Revit* enables architects, engineers, and contractors to create accurate and detailed 3D models, run simulations, and manage project information in an integrated manner [5]. *Revit* can generate *BOQs* in real-time, following design changes that occur throughout the planning process, thus ensuring that the data used in cost estimates is always up to date [6].

However, BIM implementation cannot be done instantly. It requires specialized training for the workforce, hardware upgrades, investment in software such as Tekla Structures or Autodesk Revit, and changes in the work culture within the organization. These factors are often the main challenges in the transition from conventional methods/Microsoft Excel to BIM [7].

In construction projects, the use of *Microsoft Excel* remains the most common approach for quantity calculations, particularly in Indonesia. This approach generally relies on two-dimensional (2D) drawings as the basis for calculating the volume of each element or section. Despite its widespread use, this method is considered less effective and efficient due to its time-consuming process and high risk of calculation errors. These risks primarily arise from discrepancies between the working drawings and the volume calculation results. This is reinforced by research conducted by Tasya Putri Artanti, I Ketut Sucita, and Erlina Yanuarini (2022), which states that modeling that frequently changes according to field conditions can increase project costs and tends to be more time-consuming and use resources inefficiently [8].

This research takes a case study on the Fat Trap Refinery II Sei Mangkei Construction project, an oil processing industry project that has high complexity in civil and structural works. This project was chosen because it requires high accuracy in calculating concrete volume, reinforcement requirements, and

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other supporting materials. By comparing BOQ results from Excel, Revit, and Tekla Structures, this research is expected to answer the important question: which method is the most efficient, accurate, and appropriate for modern construction projects in Indonesia.

While previous studies have often compared BIM to conventional methods in general building projects, there is a lack of comparative research focusing specifically on the calculation logic differences between Autodesk Revit and Tekla Structures for complex refinery infrastructure. This study fills that gap by providing a direct comparison of these two major BIM platforms. Furthermore, the inclusion of a 50-meter test beam validation provides a unique benchmark to isolate and analysed how each software automates reinforcement detailing. Notably, instead of applying an external waste factor, this research evaluates how material allowances are inherently accounted for through Tekla Structures' automation of physical hooks, bends, and overlaps—a technical depth that has not been explicitly addressed in prior BOQ comparative literature.

2. Method

This research uses a case study approach with the object of the Fat Trap Refinery II Sei Mangkei Construction project. The selection of this project is based on the complexity of reinforced concrete structures that require high accuracy in calculating material quantities, so it is suitable to compare the effectiveness of conventional methods and *Building Information Modeling* (BIM) based methods. The research method used is descriptive-comparative, namely by comparing the results of *Bill of Quantity* (BOQ) calculations from three different approaches: *Microsoft Excel, Autodesk Revit,* and *Tekla Structures.*

The research stages used are as follows:

1. Secondary data collection in the form of project working drawings, technical specifications, and other supporting documents.
2. The data is then used as a basis for calculating quantities using conventional methods using *Microsoft Excel.*
3. At this stage, the volume and weight of the material are calculated manually based on the 2D drawing, then summarized in the form of a BOQ table.
4. Next, the same data was modeled in three dimensions using *Autodesk Revit* and *Tekla Structures.*
5. In *Revit,* the process is carried out by creating a complete structural model (columns, beams, slabs, foundations, and walls), then extracting quantities through the *schedule feature.*
6. Meanwhile, in *Tekla Structures,* modeling is done with more detailed structural details, including reinforcement placement, so that quantities are obtained through the *report feature.*
7. BOQ comparison uses the following formula [7, 8]:

$$Difference(\%) = \frac{Q_{BIM} - Q_{excel}}{Q_{excel}} x100\% \quad (1)$$

where Q_{BIM} denotes the material quantity extracted from BIM software (Autodesk Revit or Tekla Structures) and Q_{excel} defines the material quantity calculated using the conventional manual method (Microsoft Excel). To ensure the accuracy of the results, validation was carried out through modeling of a

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test beam measuring 0.3 × 0.6 × 50 m. This beam was calculated manually using the volume formula and reinforcement requirements according to the SNI 2847:2019 standard, then compared with the automatic results from Revit and Tekla Structures. This validation aims to measure the deviation of the calculation results of each method against the manual calculation, so that the accuracy level of the three methods can be determined.

Data analysis was carried out by comparing the quantitative results of the three methods on 4 parameters, namely: (1) Volume of Reinforced Concrete (RC), (2) Volume of Lean Concrete (LC), (3) Volume of Compacted Sand (CS), and (4) Total Weight of reinforcement per diameter. These parameters were chosen as they constitute the critical cost-drivers and material categories in industrial refinery foundations, allowing for a thorough evaluation of software performance across varying geometric complexities. The comparison results were then analyzed to evaluate the advantages, disadvantages, and relative deviations of each method. Consequently, this research produces not only a quantitative description but also provides practical recommendations regarding the most appropriate BOQ calculation method for modern construction projects in Indonesia. The research flowchart for this study is illustrated in Figure 1.

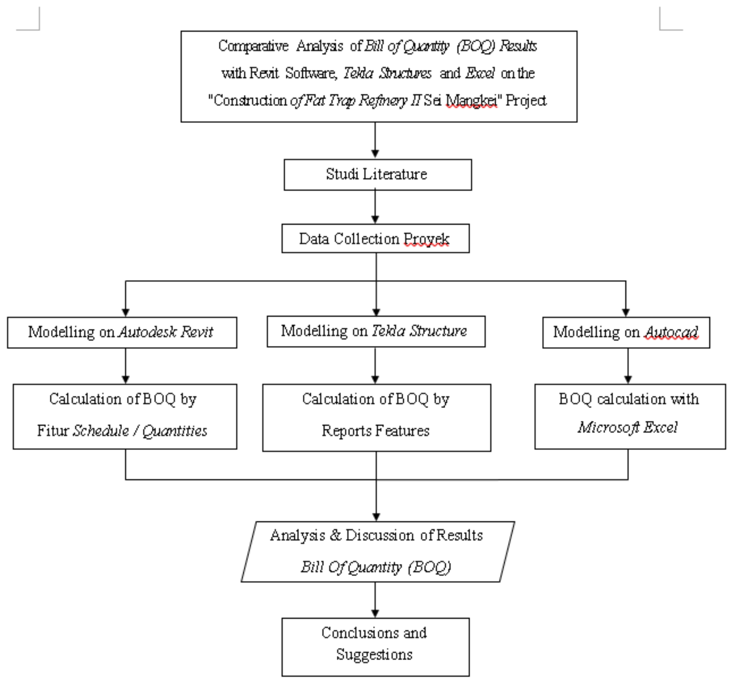

Figure 1. Research Flowchart

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3. Result and Discussion

3.1 Modelling

This Study produce comparison quantitative between three method Bill of Quantity (BOQ) calculations, namely Microsoft Excel, Autodesk Revit, and Tekla Structures, which are applied to the project construction of the Fat Trap Refinery II Sei Mangkei. Analysis focused on the parameters of reinforced concrete (RC), lean concrete (LC), compacted sand (CS), and total weight reinforcement per diameter. In addition, it is carried out validation through modelling test beam for measure deviation to manual calculation.

1. Tekla and Revit Modeling Results

Before automating BOQ in Tekla and Revit software, 3D modeling needs to be done.

Figure 2 is 3D Modelling images with Tekla Structures software.

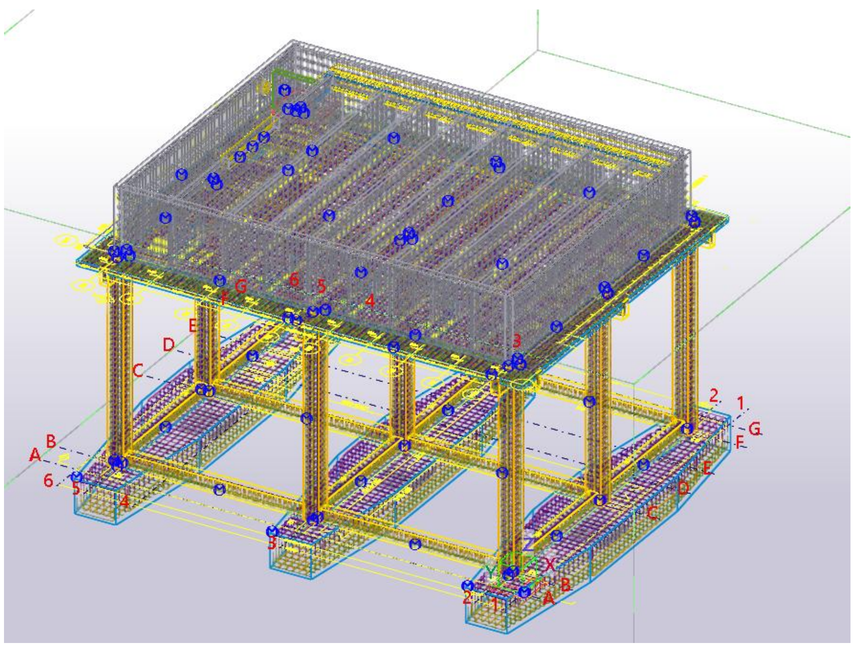

Figure 2. 3D modelling with *Tekla Structure*

Source: Output Program Tekla Structure 2024

Figure 3 is a 3D modeling image using Autodesk Revit software.

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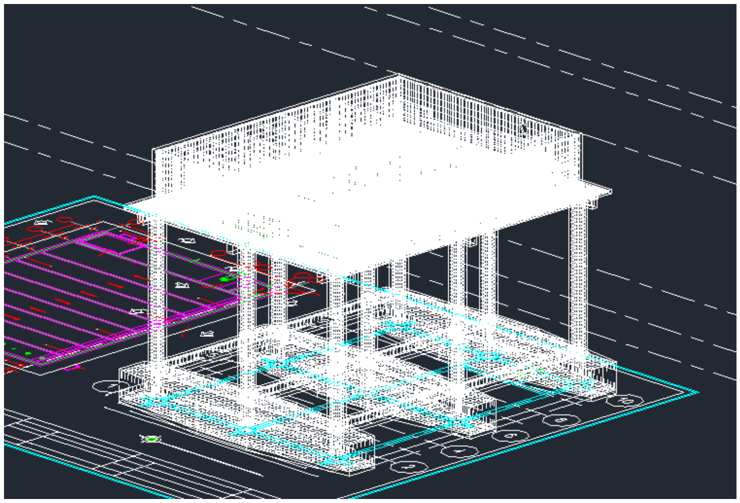

Figure 3. 3D modelling with *Tekla Structure*

Source: Output Program Autodesk Revit 2024

2. Comparison of BOQ Results

Recapitulation results show that Autodesk Revit produces yields quantity estimations that align most closely with the manual baseline established via Microsoft Excel. Tekla Structures tends to produce more deviation large, especially in weight reinforcement, however own superiority in modelling and anticipation details risk term long.

Table 1 shows the comprehensive Bill of Quantities (BOQ) results for the Sei Mangkei Fat Trap Refinery II project, comparing total reinforcement weight and various concrete volumes across the three study methods. The data reveals a consistent pattern where the quantities generated by Autodesk Revit and Tekla Structures closely approximate the manual Excel baseline for primary structural elements like reinforced concrete. This comparison serves as the foundation for evaluating how digital BIM platforms interpret 2D project data into 3D structural volumes.

Table 1 Summary of material weight and volume

PARAMETER	EXCEL (MANUAL)	REVIT (BIM)	TEKLA (BIM)
Total Reinforcement Weight (Tons)	11.89	11.78	12.45
Volume of RC (m^3)	153.53	152.94	153.77
Volume of LC (m^3)	3.8525	3.53	3.6165
Volume of CS (m^3)	7.71	7.06	7,233

Table 2 shows the percentage deviations of the BIM software outputs relative to the manual Microsoft Excel calculation, which is established as the baseline reference. A distinct pattern emerges in the reinforcement weight category, where Autodesk Revit shows a minimal negative deviation of -0.99%, while Tekla Structures shows a significant positive deviation of +4.64%. These variations highlight the different

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computational logics used by each platform, specifically regarding how they account for reinforcement detailing such as hooks and overlaps mandated by SNI 2847:2019.

Table 2 Deviation compared to *Excel*

PARAMETER	REVIT DEVIATION (%)	TEKLA DEVIATION (%)
Total Reinforcement Weight (kg)	-0.99%	+4.64%
Volume of RC(m^3)	-0.39%	+0.15%
Volume of LC (m^3)	-8.37%	-6.13%
Volume of CS (m^3)	-8.37%	-6.13%

Figure 4 shows a comparison graph of the total reinforcement weight results across the three calculation methods. The data reveals a consistent pattern where Autodesk Revit produces a result of 11.78 tons, which is the closest to the manual Excel baseline of 11.89 tons. This visual comparison highlights the minimal deviation in Revit's parametric logic while showing the higher +4.64% tonnage reported by Tekla Structures due to its automated fabrication detailing.

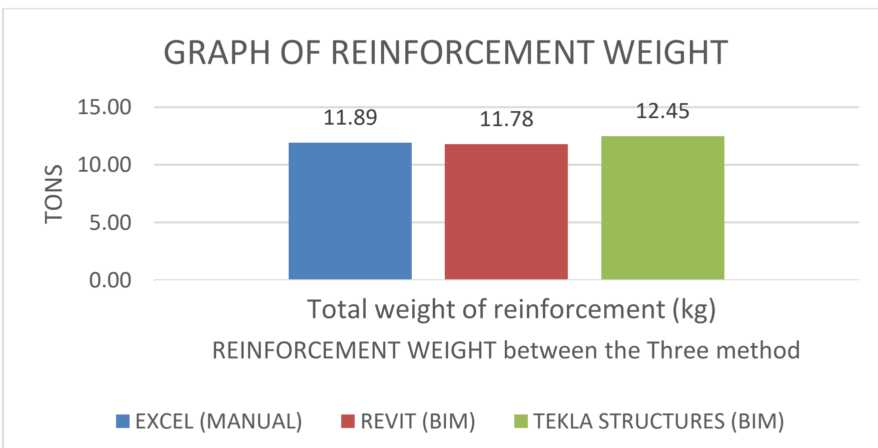

Figure 4. Reinforcement weight comparison graph

Figure 5 shows the comparison of the Reinforced Concrete (RC) volume extracted from the manual method and the two BIM platforms. A stable pattern is observed across all three methods, with the total volume ranging from 152.94 m^3 to 153.77 m^3. These results indicate that for standard structural volumes, both Revit and Tekla Structures provide highly reliable data that aligns closely with traditional manual take-offs.

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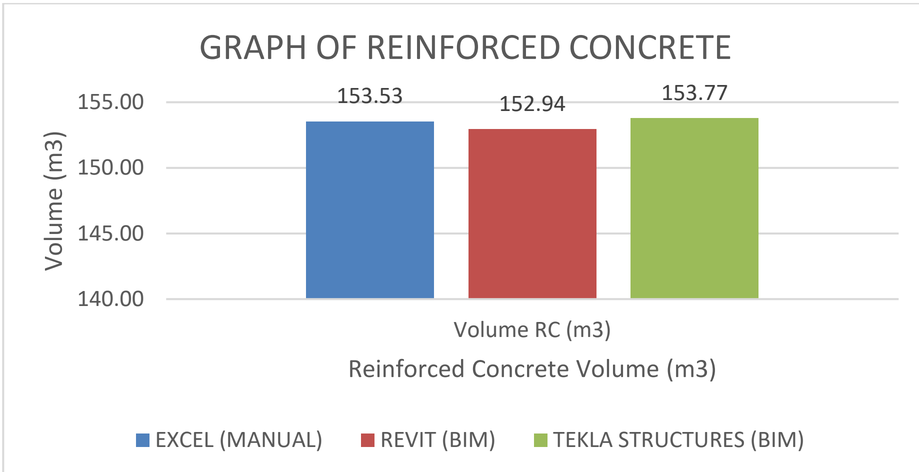

Figure 5. Reinforced concrete volume comparison graph

Figure 6 shows the comparative results for the volume of lean concrete (LC) calculated using the study's three approaches. The bar chart reveals a pattern of negative deviation in both BIM softwares, where the manual baseline of 3.85 m³ is notably higher than the Revit and Tekla outputs. This discrepancy of approximately -6% to -8% suggests that 3D modeling interprets the secondary concrete layers with higher geometric precision than simplified 2D manual formulas.

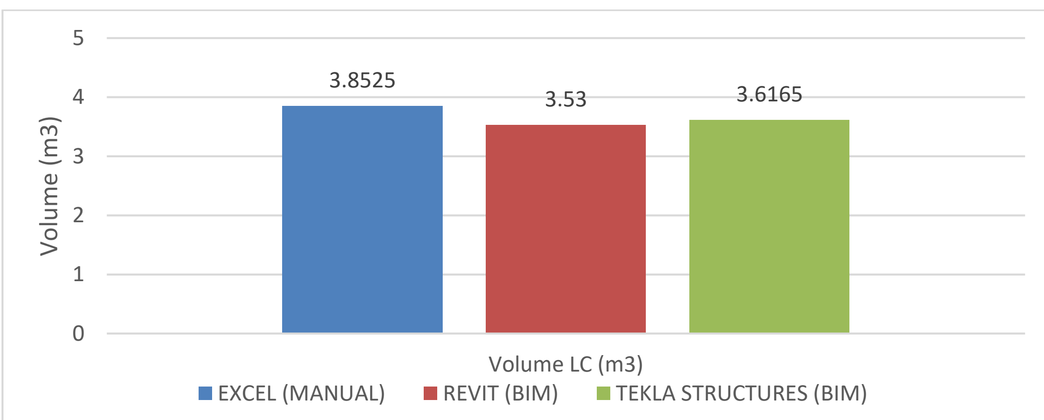

Figure 6. Lean concrete volume comparison graph

Figure 7 shows the volume comparison for compacted sand (CS) among the Microsoft Excel, Revit, and Tekla Structures methods. Similar to the lean concrete results, a pattern emerges where the digital models produce lower volume quantities compared to the 7.71 m³ manual calculation. This graphical representation underscores the impact of different calculation logics on auxiliary materials, which remain a significant factor in overall project cost estimation.

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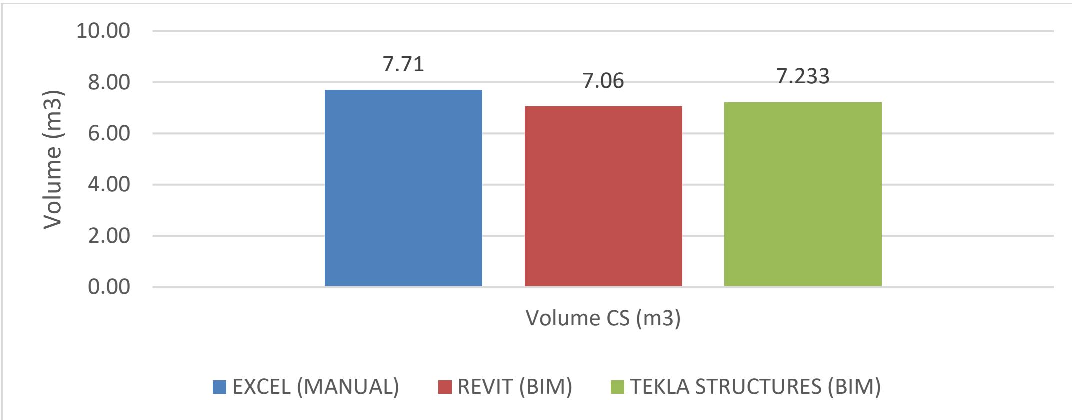

Figure 7. Compacted sand volume comparison graph

3.2 Validity Test

To ensure the accuracy and reliability of the calculation results across the different platforms, a validity test was performed on a specific structural element. A sample beam with a total length of approximately 50 meters and cross-sectional dimensions of 300 x 600 was selected as a benchmark, as it represents a typical reinforcement complexity within the project. The validation aims to quantify the extent to which BIM outputs from Autodesk Revit and Tekla Structures align with manual calculations performed according to SNI 2847:2019 standards. By comparing the concrete volume and reinforcement weight from all three methods, the relative deviation can be analyzed to determine which software provides the highest precision relative to the manual baseline.

Validation done with two approaches:

1. Manual calculations using volume formulas and reinforcement requirements based on SNI 2847:2019 standards.
2. Modelling test beams in Autodesk Revit and Tekla Structures for get results quantity in a way automat

The results obtained from the three methods were compared to analyze the deviations relative to manual calculations, specifically regarding concrete volume and reinforcement weight per diameter. This validation aims to measure the extent to which BIM software outputs align with manual calculations, which are established as the baseline reference. Furthermore, this approach helps identify potential discrepancies resulting from detailing configurations, connection lengths, and hook settings utilized within the software environment.

Figures 8 and 9 show the 3D reinforcement modelling of the 50-meter test beam in Autodesk Revit and Tekla Structures, respectively. The visualization reveals a consistent pattern in the placement of longitudinal and shear reinforcement, providing a clear spatial verification of the structural design before

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quantity extraction. These figures demonstrate that both BIM platforms can accurately represent complex rebar configurations, which is essential for the reliability of the subsequent comparative analysis.

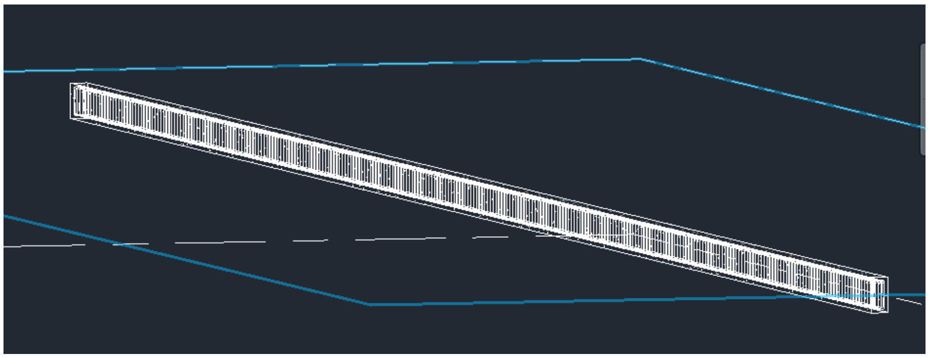

Figure 8: Modeling test model with *Autodesk Revit software*

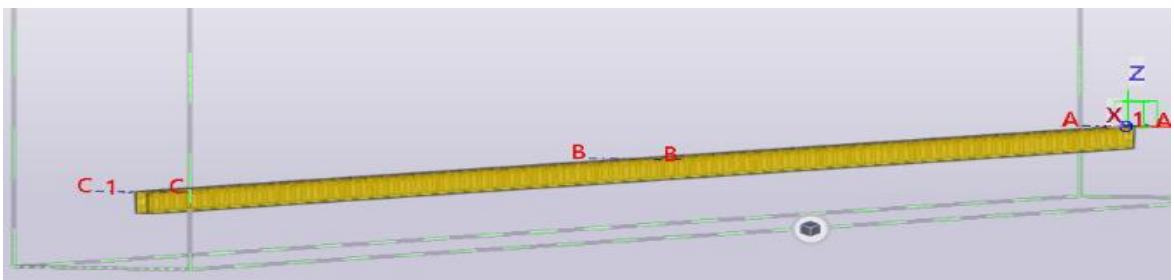

Figure 9: Modeling test model with *Tekla Structure software*

Table 3 shows the final validation results for the 50-meter test beam, comparing the numerical outputs of the manual calculation against the two BIM platforms. The data reveals a pattern of high precision, where the volume and weight deviations remain within an acceptable margin of less than 5% across all three methods. This successful validation confirms that the software settings are correctly calibrated and suitable for the full-scale analysis of the Sei Mangkei Fat Trap Refinery II project.

Table 3. Test Beam Validation

Comparison	Manual	*Tekla*	*Revit*
Volume	9.0 M^3	9.0 M^3	9.0 M^3
Reinforcement (D13)	249.98 Kg	261.5 kg	249.75 kg
Reinforcement (D10)	281.98 kg	286.4 kg	276.04 kg

- *Tekla Structure*

$$Percentage\ weight\ difference\ D13 = \frac{261.5-249.98}{249.98} x\ 100\% = 4.61\% \quad (2)$$

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$$Percentage\ weight\ difference\ D10 = \frac{286.4-281.98}{281.98} x\ 100\% = 1.57\% \quad (3)$$

- *Autodesk Revit*

$$Percentage\ weight\ difference\ D13 = \frac{249.75-249.98}{249.98} x\ 100\% = -0.09\% \quad (4)$$

$$Percentage\ weight\ differenceD10\ = \frac{276.04-281.98}{281.98} x\ 100\% = -2.106\% \quad (5)$$

The research results show that each method has its own characteristics and advantages. Microsoft Excel, as a conventional method, offers flexibility and full control over the calculation process, but it is highly dependent on user accuracy and prone to input errors. While the results are quite accurate, the process is time-consuming and inefficient for large-scale projects.

Autodesk Revit has been proven to produce quantity values closest to manual calculations, both in terms of concrete volume and reinforcement weight. The deviation shown by Revit compared to the manual method is very small, namely -0.99% for total reinforcement weight and -0.39% for RC volume. This indicates that Revit is very suitable for projects that require high efficiency and accuracy. Furthermore, the schedule feature in Revit allows for automatic and integrated quantity data extraction, thereby speeding up the estimation process and minimizing errors.

Tekla Structures showed a larger deviation of +4.64% for the total reinforcement weight compared to the manual baseline. However, this discrepancy is not a calculation error; rather, it highlights Tekla's advantage in modeling structural details, particularly in the high-precision placement of reinforcement and connections. While Microsoft Excel and Autodesk Revit primarily calculate the "theoretical net volume" based on center-to-center dimensions, Tekla Structures operates on a "fabrication-ready" logic.

This deviation is specifically rooted in the software's automated inclusion of physical detailing—such as 90° or 180° hook extensions, bend radii, and lap lengths (splices)—required for structural continuity according to SNI 2847:2019 standards. In the case of the 50-meter validation beam, these fabrication requirements accumulate into a significant tonnage difference that is often simplified or ignored in manual 2D takeoffs. By accounting for these real-world material needs, Tekla provides a more realistic "gross" quantity necessary for actual procurement. Consequently, Tekla is exceptionally well-suited for projects with complex structural requirements, such as industrial refinery facilities and high-rise buildings, where precise material ordering is critical to preventing on-site shortages.

These findings align with research conducted by Tasya Putri Artanti, I Ketut Sucita, and Erlina Yanuarini (2022), which stated that there was a discrepancy between the reinforcement BOQ results using the conventional method and the BIM method. This was caused by data input errors in the manual method and the failure to calculate the radius or bend in the reinforcement. The more detailed differences in the number and length of reinforcement in the BIM method resulted in higher quantity results and in line with actual detailing standards. This research confirms that the BIM approach is more accurate in capturing real-world conditions and is more in line with modern construction practices.

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The validation of the test beams confirmed the finding that Revit had the smallest deviations from manual calculations, namely −0.09% for D13 and −2.11% for D10. Meanwhile, Tekla showed deviations of +4.61% for D13 and +1.57% for D10. These results indicate that Revit is more precise in quantity estimation, while Tekla is superior in detail modeling and connection configuration.

Overall, Autodesk Revit is recommended as the primary method for preparing BOQs for modern construction projects that demand precision and efficiency. Microsoft Excel remains relevant for manual control and verification, while Tekla Structures is suitable for projects requiring high structural detailing.

3.3 Technical Analysis of Software Calculation Logic

The quantitative discrepancies among the three methods are fundamentally rooted in their distinct computational logic and mathematical interpretation of geometry. Microsoft Excel represents a traditional 'theoretical' approach, relying on manual data entry that simplifies 3D geometry into 2D linear calculations, which inherently increases the risk of human error. In contrast, Autodesk Revit utilizes a 'parametric' logic, extracting quantities directly from the 3D geometry's metadata. Because Revit, like the manual method, primarily calculates the 'theoretical net volume' based on center-to-center dimensions, it achieves high precision and minimal deviation (approximately -0.99% for reinforcement) relative to the manual baseline.

Conversely, Tekla Structures operates on a 'fabrication-ready' logic, prioritizing the physical reality of construction over purely theoretical design. The observed +4.64% increase in reinforcement weight is not a calculation error but rather an automated inclusion of essential constructability requirements, such as rebar hook extensions, bend radius, and specific overlap lengths mandated by structural standards. While these attributes are frequently omitted in manual 2D takeoff or simplified in other BIM platforms, Tekla's high-precision modeling captures the 'gross' volume necessary for actual procurement. Consequently, the deviation in Tekla highlights its superior ability to account for real-world material requirements, providing a more reliable basis for industrial-scale fabrication and site implementation.

4. Conclusion

This study compares the Bill of Quantities (BOQ) calculations using Microsoft Excel, Autodesk Revit, and Tekla Structures on the Fat Trap Refinery II Sei Mangkei construction project. The analysis shows that Autodesk Revit produces quantities closest to manual calculations, with a difference of less than 1% in the total weight of reinforcement and concrete volume. Microsoft Excel remains relevant for manual control, while Tekla Structures shows a slightly larger difference, especially in the weight of reinforcement, reflecting a more detailed and conservative modeling approach.

Validation through test beam modeling strengthens the finding that BIM methods, particularly Revit, provide more accurate and realistic results than conventional methods. The difference in results in Tekla and Revit is largely due to more complete detailing configurations, such as rebar bend radii and lengths, which are not accounted for in manual methods. This is in line with previous research showing that the BIM method produces larger rebar volumes because its calculations are more detailed and adjust to standard rebar details [8].

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Reinforcement calculations also require special attention to various technical details such as hook lengths, connections, and bending configurations, which makes them quite complex in terms of calculations [9]. In conventional approaches, this process is highly dependent on the planner's accuracy and is prone to errors in input and interpretation of working drawings. This reinforces the urgency of using BIM-based methods that can accommodate these details automatically and more accurately in preparing the BOQ [10].

Considering efficiency, accuracy, and data integration, Autodesk Revit is recommended as the primary method for preparing BOQs for modern construction projects. Excel can still be used as a manual verification tool, while Tekla Structures is suitable for projects requiring high detailing and advanced technical documentation.

5. Acknowledgements

The research that produced this study was conducted by two people. The purpose of this study was to determine the most efficient and accurate Bill of Quantities (BOQ) calculation methodology for the Fat Trap Refinery II Sei Mangkei Construction Project by conducting a comprehensive, data-driven comparison.

6. Conflict of Interest

The authors of this work, whose names are stated below, attest to the absence of conflicts of interest.

Luviko Jose Andreas

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