Quantity Take-off Using Building Information Modeling on Superstructure Works

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Abstract — Technological advancements in the construction industry have encouraged the adoption of Building Information Modeling (BIM) as a digital approach in project implementation. This study discusses the implementation of BIM in calculating work volumes (Quantity Takeoff/QTO) and project scheduling by considering labor fluctuations through resource leveling analysis. The objective of this research is to compare QTO results between BIM and conventional methods, as well as to analyze labor requirements and project duration. This research uses a case study method on the superstructure phase of a building project. The comparison results show a difference in work volumes between the BIM and conventional methods, namely 8.98% for reinforcement work, 13.23% for concrete casting, and 8.57% for formwork. Based on these findings, this study provides a quantitative overview of the differences between the conventional and BIM-based methods in terms of work volume. Further studies are recommended using more diverse case objects and a broader scope of construction work.
Keywords: Building Information Modelling; quantity take off; superstructure.

I. INTRODUCTION

Technological advancements in the construction sector have rapidly accelerated, creating new opportunities for integrating digital tools. One such innovation increasingly adopted in Indonesia is Building Information Modeling (BIM). BIM plays a significant role in the construction industry as a technological approach that enhances the management and execution of construction activities.

QTO can be carried out using BIM-based technology, which generates work volume outputs directly from the 3D model created within the software. One of the most widely used BIM tools in Indonesia is Autodesk Revit, while other emerging alternatives include Tekla, Cubicost, and various similar platforms. BIM-generated models offer both visual representation and automated QTO calculations performed by the software. When design changes occur, the model can be updated accordingly, and the QTO results are automatically adjusted. This automation significantly reduces the time required for recalculating volumes during design revisions.

This study represents a form of adaptation to technological developments within the construction industry. The emergence of BIM-based QTO provides the industry with alternative methods for determining project costs. Therefore, it is essential to conduct research that identifies the most suitable QTO method for construction implementation. Such studies are necessary to align construction practices with technological advancements. Choosing the appropriate method enables more accurate and realistic cost estimation. The objective of this research is to identify the differences in QTO results and cost estimates between BIM-based and conventional methods. In this study, BIM is utilized to generate work volumes, specifically focusing on the superstructure works.

II. LITERATURE REVIEW

2.1 Autodesk Revit

Autodesk Revit is a Building Information Modeling (BIM) application developed to support structural calculation and engineering processes, while also providing integrated features for detailers, fabricators, manufacturers, and contractors. Revit not only enhances visualization and design capabilities, but also incorporates technical aspects such as structural logic, cost estimation, and project management. This application is capable of integrating architectural, structural, and MEP elements in the BIM analysis and modeling process (Eastman et al., 2008).

The use of Revit allows for easier software integration and supports automatic clash detection, thereby helping to prevent potential conflicts between building elements. Overall, Revit accelerates workflow processes and enhances accuracy in both construction planning and execution (Marizan, 2019). The name Revit, derived from 'revise instantly', highlights its ability to automatically update designs in real time. This function is crucial for complex construction projects, where modifications to one part influence the entire building system due to the high level of interconnectivity (M.Alimin et al., 2023). Drawing sheets generated in BIM are not standalone entities; rather, they are integrated components of a synchronized system that ensures consistency across the entire model (Pamungkas, 2022).

2.2 Quantity Take Off (QTO)

Quantity Take Off (QTO) is the process of measuring the volume or quantity of work as the basis for preparing the Bill of Quantities (BOQ) (Utama et al., 2008). This calculation encompasses various types of construction work, including preparatory work, substructure, superstructure, architectural, and MEP (Mechanical, Electrical, and Plumbing) components. In Indonesia, the QTO method is generally still performed manually based on AutoCAD drawings and supported by Microsoft Excel, with the Standard Method of Measurement (SMM) as the primary reference. The QTO process requires a high level of accuracy and consistency to ensure the reliability of project cost estimations (Laorent et al., 2019).

Conventional QTO calculations are typically carried out manually by measuring the dimensions of each construction element, such as area, volume, length, and other unit measures. This process is prone to various errors, including misreading dimensions, inaccurate data input, arithmetic mistakes, rounding errors, and other forms of human error (Ferial et al., 2022). Such inaccuracies can directly impact the accuracy of cost estimates and the execution of construction projects (Sastraadmadja, 1984).

III. METHOD

The study titled "Quantity Take Off with Building Information Modeling on Superstructure Works" employs a non-experimental quantitative research design with a descriptive approach. Descriptive research aims to gather information based on actual conditions without testing hypotheses or drawing general conclusions. This study uses quantitative descriptive analysis, aligning with the research objective that requires numerical calculations to address the formulated problems. An intrinsic case study design is deemed most appropriate, as the data processing focuses on a specific data source that serves as the central focus of the research.

This study adopts a case study approach focusing on the construction project of the Faculty of Law Building at Jenderal Achmad Yani University, located in Cimahi City, West Java. The building consists of three floors and functions as an educational facility under the management of Yayasan Kartika Eka Paksi. The digital modeling process was carried out using Autodesk Revit 2024 (student license) to generate integrated building information. This case study was selected due to its relevance as an academic facility and the availability of sufficient project data to support the Quantity Takeoff analysis.

IV. RESULTS AND DISCUSSION

The DED (Detailed Engineering Design) drawings obtained were subsequently used to model both the structural elements and reinforcement components. The modeling process referred to the DED drawings and the standard details applied in the construction project. These standard details follow the provisions of SNI 2847:2019. This study specifically modeled the superstructure elements of the building, focusing on casting work, reinforcement work, and formwork. The modeling was carried out using Autodesk Revit 2024 with a student license. The result of the modeling process is presented in Figure 1.

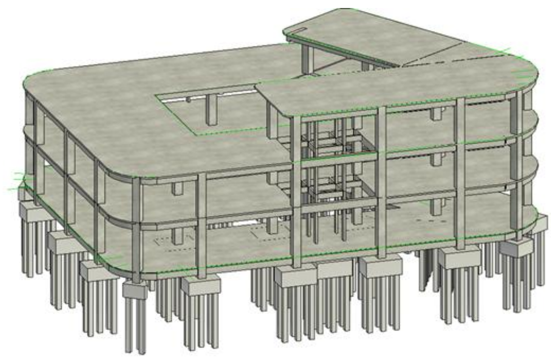

Figure 1. Revit modeling result

The data analysis results in this study indicate that the BIM method produces a smaller concrete volume compared to the conventional method. The volume of each type of work calculated using the BIM method is consistently lower than that of the conventional approach. Specifically, the BIM-based calculation for reinforcement work resulted in a volume that was 8.98% smaller than the conventional method. For casting work, the BIM method yielded a total volume that was 13.23%

lower than the conventional QTO method. Similarly, the formwork calculation using BIM showed a volume difference of 8.57% less compared to the conventional method.

These results reflect the overall comparison, encompassing all types of structural work (reinforcement, formwork, and concrete) across all structural elements (columns, beams, and slabs). However, when the comparison is broken down by individual elements and work types across each floor level, the differences in quantities vary. These variations can be attributed to discrepancies between the automated calculations generated by the software and the manual conventional method. Overall, the differences in Quantity Takeoff (QTO) between the BIM and conventional methods are influenced by several factors.

A. Element Cutting

Figure 2. Example of overlapping case

Calculations performed using Revit are automatically adjusted to account for overlapping elements. For instance, the volume of a beam is directly reduced when it intersects with a column, resulting in the software computing only the net length. Similarly, the height of the beam is automatically adjusted to accommodate the presence of a slab. Columns are also truncated by the slab thickness, ensuring that the slab volume is recorded based on its actual surface area.

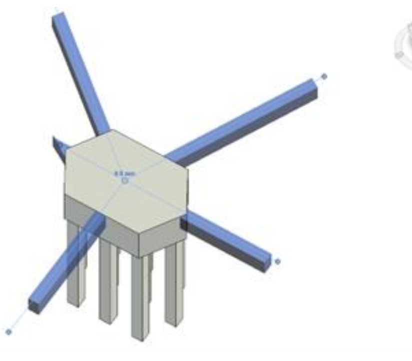

Figure 3. Example of overlapping case

This is evident in beam B3 on the second floor, where the volume discrepancy reaches 40.28%. The intersection of elements significantly affects the calculation results, especially for smaller elements like B3, where minor cuts result in a relatively large volume difference in percentage.

B. Differences in Stirrup Calculation Result

The difference in reinforcement calculation results between the conventional method and the BIM method occurs due to varying levels of accuracy in calculating the quantity of reinforcement, particularly stirrups. For instance, in the beam located at axis D-B/10 on the second floor, the conventional method results in 89 stirrups with a total weight of 112.41 kg. In contrast, the BIM method, through modeling in Revit, calculates 82 stirrups with a total weight of 96.32 kg. Overall, the reinforcement weight of the beam on that axis is recorded at 359.72 kg using the conventional method, while the BIM method yields a total reinforcement volume of 312.53 kg. The discrepancy in stirrup unit length calculations between the conventional method and the BIM-based method is attributed to the level of detail considered in representing the actual reinforcement shape. Revit calculates the stirrup length by accurately accounting for bends and the actual dimensions of the reinforcement, resulting in higher precision. Based on the case study shown in Figure 4, the stirrup length calculated using the conventional method is 2.05 meters, whereas Revit generates a length of 1.95 meters. This difference indicates that the BIM method can provide a more accurate estimation of reinforcement length and volume, which ultimately has a direct impact on the total rebar quantity calculations in the project.

The difference in volume between the BIM method and the conventional method has a direct impact on the cost required to complete the work. Cost estimation was conducted to determine the percentage difference between the two methods. The calculation was based on unit price data and standard work item cost analysis. The results indicate a cost difference of 5.42%, with the BIM method yielding a lower total cost of IDR 3,823,982,026.07 compared to the conventional method, which amounts to IDR 4,043,319,639.59.

V. CONCLUSION

The research conducted on the Faculty of Law Building project shows that Quantity Take-Off (QTO) calculations using the BIM method result in smaller structural work volumes compared to the conventional method, with differences of 13.23% for concrete, 8.98% for reinforcement, and 8.57% for formwork. The cost difference between the two methods amounts to IDR 217,825,853.73 or 5.42%, with the BIM method yielding a lower total cost.

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