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ACCURACY ASSESSMENT OF BIM-BASED AUTODESK REVIT FOR CONCRETE AND REINFORCEMENT QUANTITY TAKE-OFF IN BRIDGE STRUCTURES

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Abstract

The development of Building Information Modeling (BIM) technology has accelerated digital transformation in the construction industry, particularly in improving the efficiency and accuracy of quantity estimation processes. However, Quantity Take-Off (QTO) calculations for bridge structures are still commonly performed using conventional methods, which are susceptible to human error and require considerable time. This study aims to evaluate the accuracy of BIM-based Autodesk Revit in estimating concrete and reinforcement quantities by comparing its results with conventional calculations on the Station VII B Bridge Project in Dumai City. A quantitative comparative approach was employed through three-dimensional modeling using Autodesk Revit 2024 and conventional quantity calculations based on Detailed Engineering Design (DED) documents. The resulting quantities were analyzed using Average Error and Root Mean Square Error (RMSE) to assess the level of agreement between the two methods. The results indicate that concrete quantity estimation recorded an Average Error of 1.455% with an RMSE value of 0.712 m^3, while reinforcement quantity estimation showed an Average Error of 1.765% and an RMSE value of 0.016 m^3. These findings demonstrate that Autodesk Revit is capable of producing quantity estimates that are highly consistent with conventional calculations while providing greater efficiency and reducing the potential for manual calculation errors. Therefore, Autodesk Revit can be considered a reliable alternative for Quantity Take-Off applications in bridge construction projects.

Keywords: Building Information Modeling (BIM), Autodesk Revit, Quantity Take-Off, Bridge Structure, Reinforcement.

INTRODUCTION

Accurate material quantity estimation is an essential aspect of construction project planning and control. Quantity information serves as the basis for cost estimation, material procurement, resource allocation, and project execution management. According to (Saputra et al., 2024), the Quantity Take-Off (QTO) process is a critical stage in construction projects because it serves as the foundation for cost estimation, material procurement, and material control. Furthermore, (Tigauw et al., 2023) stated that Quantity Material Take-Off is a crucial step in determining construction project cost estimates. Therefore, the accuracy of quantity calculations is highly important, as estimation errors may lead to cost overruns, project delays, and reduced efficiency and quality of construction activities.

Although conventional Quantity Take-Off (QTO) methods are still widely used in construction projects, they have several limitations that may affect the accuracy of material quantity estimation. The calculation process relies on the interpretation of two-dimensional drawings and manual data processing, making it susceptible to data entry errors, measurement inaccuracies, and human error (Stefanus Lutfiansyah, 2025). In addition, the lack of integration between design, cost, and scheduling information may reduce the efficiency and consistency of quantity calculations (Kusumaningroem & Gondokusumo, 2023). These challenges become more significant in reinforced concrete bridge structures with complex geometries and reinforcement details. According to (Taghaddos et al., 2024) , the demand for a more efficient and integrated quantity estimation process has encouraged the adoption of Building Information Modeling (BIM). Furthermore, (Johari & Hakim, 2026) reported that different estimation methods may produce different quantity results, highlighting the importance of evaluating the consistency and reliability of Quantity Take-Off methods in bridge construction projects. Building Information Modeling (BIM) offers a transformative solution to traditional workflows through the creation of three-dimensional digital models that consolidate all geometric data and material specifications into a single information system. Autodesk Revit is a leading BIM software widely adopted in the industry, designed to support workflows from design development to documentation, while also providing capabilities to display quantity data automatically. According to (Novita, Rizki Dwi Pangestuti, 2021), using Revit effectively minimizes human errors commonly found in manual methods, as all calculations are derived from a detailed and accurately built model. This is supported by (Fadillah & Nofriadi, 2022), who state that BIM-based calculations produce results that are simpler, more comprehensive, and detailed, where any design modification is instantly updated across all related data. Moreover, (Sadad et al., 2022) explain that the visualization and coordination features offered by Revit are highly effective for complex bridge structures, as they significantly reduce the risk of data inconsistencies frequently encountered in manual calculation approaches.

Various studies have been conducted to verify the validity and reliability of volume data generated by Autodesk Revit when compared to traditional manual calculations. (Simatupang et al., 2024) compared both methods and found a difference of approximately 6% in reinforcement volume, noting that BIM results were more precise by eliminating redundant measurements and computational errors. In a study focusing on skewed bridges, (Tigauw et al., 2023) reported a result deviation of 5.13%, attributed to differing calculation assumptions and varying interpretations of technical drawings in conventional methods. Meanwhile, (Gabriel et al., 2025) observed a very minimal difference of only 0.60%, indicating that values produced by BIM closely reflect actual conditions. Additionally, (Faozan, 2025) and (Adji & Fransisco, 2025) confirmed that despite minor variations due to differing calculation principles, results from Autodesk Revit maintain a high level of accuracy and have proven capable of accelerating the planning phase compared to conventional techniques. Similarly, (Kusuma & Enda, 2026) reported average error values of 0.157% for concrete quantities and 1.559% for reinforcement quantities in a reinforced concrete bridge project, demonstrating a high level of agreement between BIM-based and conventional quantity estimation methods while highlighting the influence of structural geometry and reinforcement detailing on quantity deviations.

While BIM implementation has been extensively studied and proven effective in building construction, research specifically examining its application in bridge structures remains limited. This is particularly true for studies analyzing the accuracy of reinforcement quantity calculations, which involve far more complex geometric forms. Unlike standard buildings, bridge structures consist of interconnected elements that require a high level of detail in modeling. (Johari & Hakim, 2026) emphasize that applying different calculation methods can yield varying quantity values, making the evaluation of result consistency a crucial requirement. Based on this context, the present study is developed with the objective of analyzing and comparing reinforcement quantity results obtained through conventional methods and the BIM approach using Autodesk Revit. The findings aim to provide a clear overview of the magnitude of differences, the level of accuracy, and the reliability of this software as an effective and trustworthy estimation tool for bridge construction projects.

METHOD

This study was carried out on the Station VII B Bridge project in Dumai City using a quantitative comparative approach. The method was applied to compare the Quantity Take-Off (QTO) results of concrete and reinforcement works obtained from conventional calculations and Building Information Modeling (BIM) using Autodesk Revit. According to (Fadillah & Nofriadi, 2022), a comparative approach is useful for identifying differences in material quantity estimates generated by different calculation methods. The research process began with the collection and examination of project documents, including structural drawings, reinforcement details, and available quantity data for concrete and reinforcement works. Based on these documents, a three-dimensional structural model was developed in Autodesk Revit. The Quantity Take-Off outputs generated from the BIM model, consisting of concrete volumes and reinforcement quantities, were subsequently analyzed and compared with the results obtained through the conventional method. The analyzed bridge components consisted of abutments, base slabs, wing walls, deck slabs and parapets, and pile foundations. Quantity Take-Off results generated from Autodesk Revit were compared with conventional calculations to evaluate the accuracy and consistency of BIM-based estimation.

Conventional Quantity Take-Off Analysis

The conventional Quantity Take-Off (QTO) procedure was conducted using two-dimensional (2D) design drawings obtained from the Detailed Engineering Design (DED) documents as the primary source of information. Quantity calculations were performed manually by extracting dimensional data from the engineering drawings for each structural component. The quantities of concrete and reinforcement were then determined using the relevant mathematical formulas based on the geometric dimensions and reinforcement specifications provided in the design documents.

1. Calculating Gross Concrete Volume

$$V\ (Ki) = n\ \times (A\ \times L) \tag{1}$$

Where:
VKi = Gross concrete volume for bridge component i (m3)
n = Number in one type of bridge component i
A = Area of bridge component i (m2)
L = Length of bridge component i (m)

2. Calculating the volume of reinforcement

$$V_{\mathrm{T.i}} = \frac{W\ \mathrm{T.i}}{\rho\ \mathrm{steel}} \tag{2}$$

Where:
V(T.i) = Reinforcement volume for bridge component i (m3)
W(T.i) = Weight of reinforcement of a bridge component (Kg)
ρ steel = Density of reinforcement steel (7850 Kg/m3)

3. Calculating Net Concrete Volume

$$V\ (B.i) = V(K.i) - V\ (T.i) \tag{3}$$

Where:
V(B.i) = Net concrete volume for the bridge component (m3)
V(Ki) = Gross concrete volume for bridge component I (m3)
V(T.i) = Reinforcement volume for bridge component I (m3)

BIM-Based Quantity Take-Off Analysis

Quantity Take-Off (QTO) data using the BIM approach were obtained through three-dimensional modeling in Autodesk Revit. The procedure consisted of the following stages:

1. Development of the 3D Structural Model

   Two-dimensional (2D) design drawings obtained from the Detailed Engineering Design (DED) documents were used as the basis for developing a three-dimensional (3D) model of the bridge components, including the abutment, wing wall, slab, and approach slab, using Autodesk Revit.

2. Quantity Take-Off Data Extraction

   Upon completion of the modeling process, the *Schedule/Quantities* feature in Autodesk Revit was utilized to automatically generate quantity information. The extracted data included concrete volumes and reinforcement quantities for each modeled structural component.

3. Data Compilation and Analysis

   The Quantity Take-Off results generated from Autodesk Revit were compiled and subsequently used as the basis for comparison with the quantities obtained through the conventional calculation method.

Comparison of BIM and Conventional Analysis

A comparative analysis was conducted to examine the variation between the Quantity Take-Off (QTO) results generated by the conventional method and those obtained through Building Information Modeling (BIM). Percentage Error and Root Mean Square Error (RMSE) were utilized as quantitative indicators to measure the degree of deviation and assess the consistency of the estimation results. The mathematical expressions applied in the calculation of Percentage Error and RMSE are provided as follows.

$$Error\ (\%) = \frac{|V.k - V.r|}{V.k}\ \mathrm{x}\ 100\% \tag{4}$$

Where:

Vkonvensional = quantity or volume obtained through the conventional calculation method (m^3)
Vrevit = quantity or volume generated from the BIM model using Autodesk Revit (m^3)

$$RSME = \sqrt{\sum \frac{(y,-y)^2}{n}} \quad (5)$$

Where:
Y' = Conventional QTO
Y = BIM QTO
N = Sample Size

RESULTS AND DISCUSSION

The study utilized Autodesk Revit 2024 and presented the Quantity Take-Off results for the abutment, wing wall, slab, and approach slab components of the bridge.

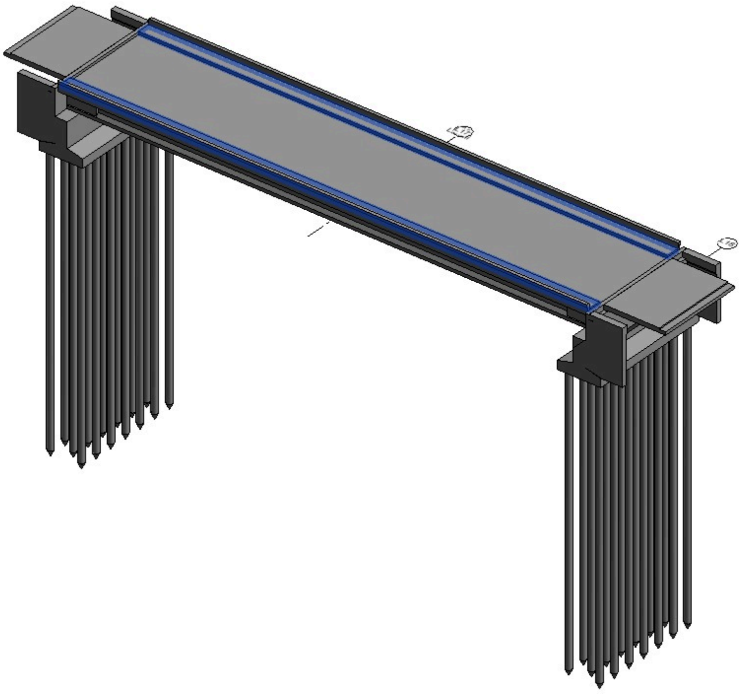

Figure 1. 3D Modeling of Bridge

The Quantity Take-Off (QTO) results obtained from the BIM-based approach and the conventional method were subsequently compared to evaluate the differences between the two estimation techniques. The comparison revealed that only minor variations were observed in several calculated quantities. Detailed comparison results between the BIM and conventional methods are presented in Table 1, Table 2, and Table 3.

Gross Concrete Volume

Table 1. Gross Concrete Volume

Component Element	Conventional Method (m³)	Revit Method (m³)	Difference (m³)
Abutment	138.140	138.140	0.000
Base Slab	24.010	24.010	0.000
Wing wall	15.807	16.806	0.999
Deck Slab and Parapet	116.866	116.866	0.000
Pile Foundation	176.715	177.955	1.240

Summary of Reinforcement Volume

Table 2. Reinforced Volume

Component Element	Conventional Method (m³)	Revit Method (m³)	Difference (m³)
Abutment	1.570	1.598	0.028
Base Slab	0.377	0.357	0.020
Wing wall	0.267	0.264	0.003
Deck Slab and Parapet	1.880	1.889	0.009
Pile Foundation	2.921	2.924	0.003

Summary of Net Concrete Volume

Table 3. Net Concrete Volume

Component Element	Conventional Method (m³)	Revit Method (m³)	Difference (m³)
Abutment	136.570	136.542	0.028
Base Slab	23.633	23.653	0.020
Wing wall	15.540	16.542	1.002
Deck Slab and Parapet	114.986	114.977	0.009
Pile Foundation	173.794	175.031	1.237

Based on the Quantity Take-Off (QTO) results obtained from both approaches, a deviation analysis was conducted to assess the level of agreement between the conventional method and the BIM-based Autodesk Revit method. The evaluation was performed using Percentage Error and Root Mean Square Error (RMSE), and the results are presented in Table 4.

Table 4. Accuracy Test Analysis

Component Element	Net Concrete Difference (m³)	Reinforcement Difference (m³)	Concrete Error (%)	Reinforcement Error (%)
Abutment	0.028	0.028	0.021	1.810
Base Slab	0.020	0.020	0.084	5.282
Wing wall	1.002	0.003	6.448	1.147
Deck Slab and Parapet	0.009	0.009	0.008	0.475
Pile Foundation	1.237	0.003	0.712	0.110
Total	2.297	0.064	7.273	8.824

The comparison results indicate that the largest deviation in net concrete volume occurred in the wing wall component, with an error value of 6.448%. This difference may be attributed to the geometric complexity of the wing wall, which requires more detailed dimensional interpretation in conventional calculations. In contrast, Autodesk Revit automatically generates quantities based on the three-dimensional model, reducing the potential for measurement and calculation inconsistencies. Meanwhile, the abutment, base slab, and deck slab components exhibited very small deviations, indicating a high level of agreement between the BIM-based and conventional methods. These findings suggest that the accuracy of Quantity Take-Off results is influenced not only by the calculation method but also by the geometric characteristics of the structural components being analyzed. Similar observations were reported by (Kusuma & Enda, 2026), who found that quantity deviations in reinforced concrete bridge structures were strongly influenced by component geometry, particularly in elements with non-prismatic shapes and varying reinforcement configurations.

For reinforcement quantities, the differences between the two methods were generally insignificant. The highest reinforcement error was observed in the base slab component at 5.282%, while the remaining components showed deviations below 2%. These differences may be associated with variations in reinforcement detailing interpretation, bar arrangement assumptions, and modeling precision during the BIM development process. Nevertheless, the overall discrepancies remained relatively small, demonstrating that Autodesk Revit is capable of producing reinforcement quantity estimates that are highly consistent with conventional calculations.

Table 5. Average Error and RMSE Values

Quantity Take-Off (QTO) Parameters	QTO	
	Concrete	Reinforcement
Average Error (%)	1.455	1.765
RMSE (m3)	0.712	0.016

To assess the overall accuracy level, two statistical indicators were applied: Average Error and Root Mean Square Error (RMSE), as presented in Table 5. The analysis reveals that concrete work recorded an Average Error of 1.455% and an RMSE value of 0.712 m³, whereas reinforcement work showed an Average Error of 1.765% and an RMSE of 0.016 m³. These figures confirm that the Quantity Take-Off outcomes produced by Autodesk Revit align very closely with those from the conventional method, with reinforcement calculations demonstrating a notably smaller absolute deviation compared to concrete volume estimates.

In general, utilizing Autodesk Revit for the Quantity Take-Off process has proven effective in delivering volume calculations that are highly consistent with traditional results, while simultaneously enhancing work efficiency and precision in material quantification. Accordingly, Autodesk Revit serves as a reliable and efficient alternative for determining both concrete and reinforcement quantities in bridge construction projects. For a more detailed illustration, the comparative results of volume calculations for each structural component, obtained through both conventional methods and the BIM approach using Autodesk Revit, are shown in Figures 2 and 3.

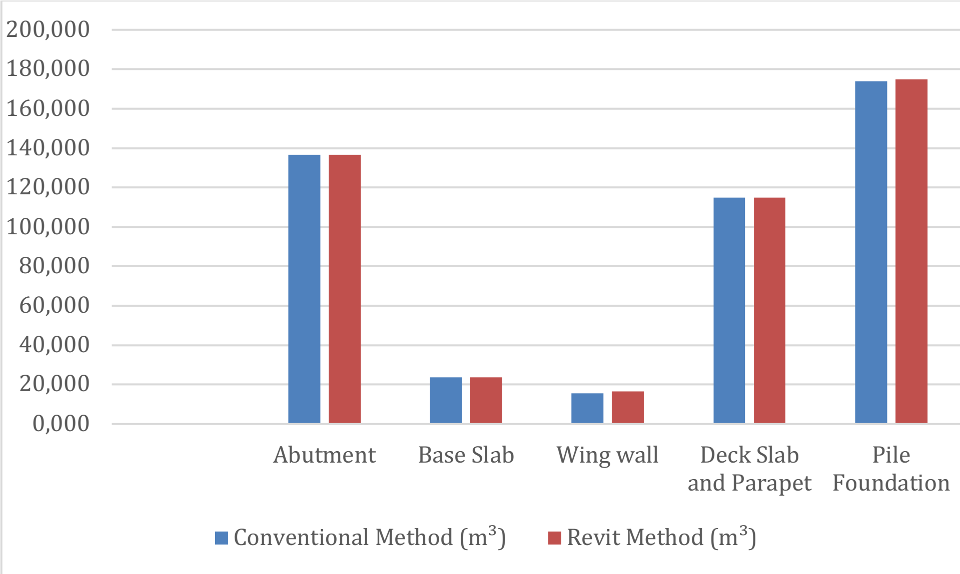

Figure 2. Concrete Volume

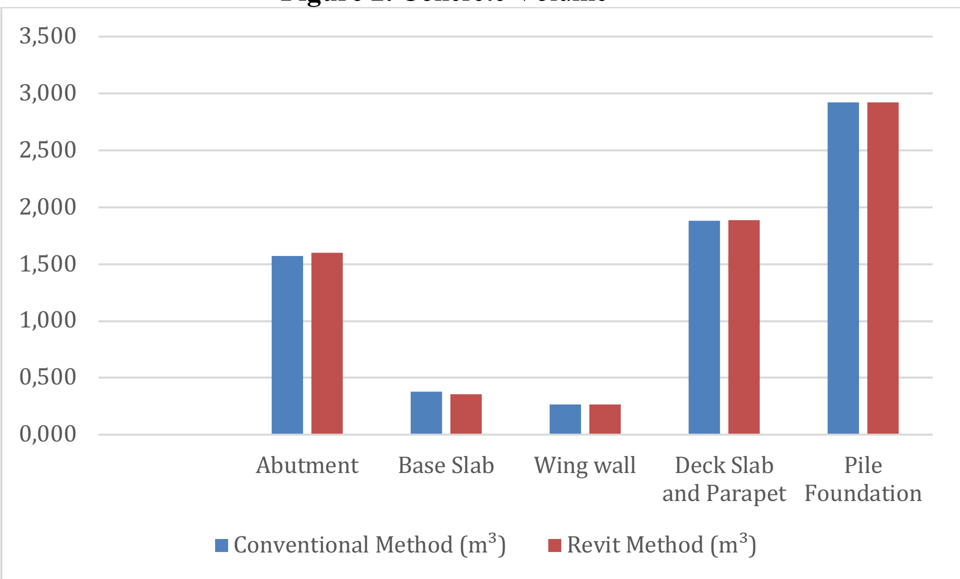

Figure 3. Reinforcement Volume

CONCLUSION

Based on the research findings, Autodesk Revit is capable of producing Quantity Take-Off (QTO) calculations for concrete and reinforcement volumes that are highly consistent with those obtained through conventional methods on the Station VII B Bridge Project in Dumai City. The analysis results indicate an Average Error of 1.455% and an RMSE value of 0.712 m^3 for concrete quantities, while reinforcement quantities recorded an Average Error of 1.765% and an RMSE value of 0.016 m^3. These results demonstrate that Autodesk Revit provides a high level of accuracy in estimating construction quantities.

In addition to improving accuracy, the BIM-based approach offers greater efficiency and consistency by reducing the potential for manual calculation errors and facilitating the quantity take-off process. Therefore, Autodesk Revit can be considered a reliable alternative for quantity estimation in bridge construction projects. For future studies, it is recommended to apply this approach to more complex bridge structures and larger-scale projects in order to further evaluate the effectiveness and reliability of BIM-based quantity take-off methods under different structural conditions.

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