Analysis of Concrete and Reinforcement Quantity Comparison between BIM and Conventional Methods in High-Rise Building Projects

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Abstract

In the construction industry, precise quantity estimation plays a crucial role in ensuring cost efficiency and reducing material waste. However, conventional methods based on 2D drawings often lead to inaccuracies and inconsistencies. This study presents a comparative analysis of quantity estimation results between Building Information Modeling (BIM) and conventional methods in calculating concrete volume and reinforcement weight in a six-story reinforced concrete office building project. BIM-based estimation was carried out using Autodesk Revit, utilizing its 3D modeling and Schedule/Quantities features. Meanwhile, the conventional method relied on 2D construction drawings and cost estimation documents commonly used in manual planning. The results showed that the total concrete volume using BIM was 488.52 m³, which is 0.22% lower than the conventional method at 489.60 m³. On the other hand, BIM estimated reinforcement weight at 181,682.58 kg, 0.67% lower than the conventional estimate of 182,912.42 kg. These differences are attributed to the digital modeling accuracy of structural elements, reduced potential for human error, and BIM's ability to generate more consistent quantities. These findings affirm that BIM improves efficiency and reliability in structural material estimation. Therefore, implementing BIM in quantity estimation processes can be an effective strategy for cost control and minimizing construction material waste.

Keywords: Building Information Modeling, Revit, Quantity Take-Off, Reinforcement

1. INTRODUCTION

Conventional construction methods are still widely applied in building projects; however, this approach often encounters various issues such as schedule delays, rework, and inaccurate material quantity estimation. These problems not only create inefficiencies in the construction process but also lead to cost overruns and reduced productivity. Dependence on 2D drawings and manual calculations is one of the main causes of low estimation accuracy, which hinders the effectiveness of overall project management (1).

As a solution, technological innovations such as Building Information Modeling (BIM) have begun to be adopted in the construction industry, and their implementation has significantly increased worldwide (2). BIM is an essential technology in the modern architecture, engineering, and construction (AEC) industry. It enables the creation of accurate digital models containing geometric and construction data. (3). These models support all project stages, from planning to operation, and offer better control and analysis than manual methods (4). BIM allows material quantity take-off within minutes (5), and excels in producing efficient technical and shop drawings (6).

1.1. Building Information Modelling (BIM)

BIM is an integrated approach to documenting construction projects across all stages, from design and planning to construction and building operation. BIM supports not only visualization of construction processes but also volume and cost estimation, work scheduling, and multidisciplinary coordination (7). One of its major benefits is the alignment of systems such as mechanical, electrical, and plumbing (MEP) within a single coordinated model. By detecting clashes before physical construction begins, BIM reduces errors on-site, resulting in time efficiency and cost savings. Moreover, BIM facilitates efficient data sharing, information management, and the implementation of sustainable building principles (8).

Autodesk Revit is a widely used BIM-based software in the AEC industry, supporting comprehensive BIM implementation (1). Its key features include integrated 3D visual modeling across disciplines (architecture, structure, MEP), automatic conversion between 2D and 3D views, and real-time updates to views and quantity schedules when changes occur in the model. Revit also supports phased design development and the reuse and customization of building components (families), enhancing planning and documentation accuracy (9).

1.2. Quantity Take Off (QTO)

QTO refers to the process of calculating the volume or quantity of construction elements from drawings or digital models as the basis for project cost estimation. Traditionally, QTO is performed manually by measuring elements from 2D drawings such as plans, elevations, and sections. This method is prone to errors, especially in complex conditions such as element intersections. Furthermore, coordination issues between disciplines in 2D documents often lead to inconsistencies and potential clashes, causing cascading errors in quantity estimation (10).

BIM includes built-in features for material and cost estimation. Quantities can be extracted automatically and are instantly updated when the model is modified. This system allows for faster, more consistent, and more accurate volume calculation than manual methods (11). BIM-based QTO reduces input errors, increases data transparency across disciplines, and simplifies quantity updates when design changes occur. Thus, it supports better decision-making in the early project phases and improves efficiency in cost estimation and resource management (12).

This study aims to compare concrete and reinforcement quantity estimates obtained from a 3D BIM model using Autodesk Revit with those from conventional calculation methods. The research object is the Bank BTN Soekarno Hatta Office Building project in Bandung, Indonesia, selected for its complete conventional calculation data and supporting documents, as well as its representation of common on-site conditions where BIM adoption is still limited.

2. METHODS

This research employs a comparative quantitative approach to analyze the differences in quantity results obtained from BIM and conventional estimation methods. The focus is on the volume and weight of primary structural elements, including beams, columns, and floor slabs.

2.1. Research Object

The object of this study is the Bank BTN Soekarno Hatta Office Building project located in Bandung, West Java. It is a six-story building constructed using reinforced concrete elements such as beams, columns, and floor slabs.

2.2. BIM Modeling with Autodesk Revit

The modeling process was carried out using Autodesk Revit 2025 to generate a 3D digital model of the building. The structural elements were modeled based on available architectural and structural drawings. The structure template was selected to match the modeling needs. Concrete volume and reinforcement weight data were extracted using the Schedule/Quantities feature. Reinforcement was modeled using the Rebar feature to obtain accurate weight estimations.

2.3. Comparative Analysis of Quantity

The analysis evaluated differences in volume and weight estimations between the two methods. Conventional data were sourced from the 2D construction drawings and Bill of Quantities, while BIM data were extracted from the digital model. Parameters compared included concrete volume (m³) and reinforcement weight (kg) for beams, columns, and slabs. Differences and percentage deviations were calculated using the following formulas:

$$\text{Difference} = Q_{\text{BIM}} - Q_{\text{Conv}} \quad \text{.................................} \quad (1)$$

$$\text{Percentage} = \frac{\text{Difference}}{Q_{\text{Conv}}} \times 100\% \quad \text{.................................} \quad (2)$$

Where:

Q_{BIM}	= Quantity obtained from the BIM method
Q_{Conv}	= Quantity obtained from the conventional method
Difference	= The absolute difference in quantity between BIM and conventional methods
Percentage	= The percentage deviation of the BIM quantity relative to the conventional quantity

3. Results and Discussion

3.1. Concrete Volume Output

The concrete volume estimation was performed for the main structural elements (beams, columns, and floor slabs) based on a 3D model created using Autodesk Revit. The quantities were calculated automatically using the Schedule/Quantities feature, providing more consistent and precise material estimates. The detailed concrete volume output for each structural element is presented in Table 1.

Table 1: Concrete Volume Output by Structural Element

No.	Structural Element	BIM Volume (m^3)
1	Beam B70/40	129.50
2	Beam B60/30	14.44
3	Beam B50/25	40.30
4	Beam B40/25	40.29
5	Beam BK40/25	1.38
6	Beam BS15/15	0.93
7	Column K65/65	106.22
8	Column K60/30	8.06
9	Column K35/35	5.05
10	Column K35/30	1.52
11	Floor Slab	140.84

As shown in Table 1, Beam B70/40 has the largest concrete volume among all beam types, amounting to 129.50 m^3, followed by Beam B40/25 with 40.29 m^3. For the columns, type K65/65 recorded the highest volume at 106.22 m^3. The floor slab contributes a volume of 140.84 m^3. The total concrete volume generated from the BIM model is 488.52 m^3, comprising 226.83 m^3 for beams, 120.86 m^3 for columns, and 140.84 m^3 for floor slabs.

3.2. Reinforcement Weight Output

The estimation of reinforcement weight was carried out by adding the Reinforcement Volume parameter for each structural element and multiplying the volume by the density of steel, which is 7,850 kg/m^3. This process resulted in the total reinforcement weight for beams, columns, and floor slabs. The reinforcement weight per structural element is shown in Table 2.

Table 2: Reinforcement Weight Output

No.	Structural Element	Reinforcement Weight (kg)
1	Beam B70/40	42768.3
2	Beam B60/30	5268.17
3	Beam B50/25	15018.66
4	Beam B40/25	17151.02
5	Beam BK40/25	634.84
6	Beam BS15/15	231.81
7	Column K65/65	39751.76
8	Column K60/30	3089.58
9	Column K35/35	500.35
10	Column K35/30	2424.62
11	Floor Slab	54843.47

As seen in Table 2, Beam B70/40 has the highest reinforcement weight among all beam types, totaling 42,768.30 kg, followed by Beam B40/25 at 17,151.02 kg. For the columns, type K65/65 recorded the highest reinforcement weight at 39,751.76 kg. The floor slab element contributes a reinforcement weight of 54,843.47 kg. The total reinforcement weight estimated using BIM is 181,682.58 kg, consisting of 81,072.80 kg for beams, 45,766.31 kg for columns, and 54,843.47 kg for floor slabs.

3.3. Comparison of Concrete Volume and Reinforcement Weight between BIM and Conventional Methods

Table 3 presents a comparative analysis of concrete volume estimation between the BIM and conventional methods for each structural element. The differences are presented clearly to facilitate quantitative analysis.

Table 3: Concrete Volume Comparison between BIM and Conventional Methods

No.	Structural Element	Concrete Volume (m³)		Difference (m³)
		BIM	Conventional	
1	Beam B70/40	129.50	129.72	-0.22
2	Beam B60/30	14.44	14.44	0.00
3	Beam B50/25	40.30	37.25	3.05
4	Beam B40/25	40.29	42.64	-2.34
5	Beam BK40/25	1.38	1.37	0.01
6	Beam BS15/15	0.93	0.78	0.15
7	Column K65/65	106.22	106.96	-0.74
8	Column K60/30	8.06	8.45	-0.39
9	Column K35/35	5.05	5.40	-0.35
10	Column K35/30	1.52	1.74	-0.22
11	Floor Slab	140.84	140.86	-0.02
	Total	488.52	489.60	-1.08

As shown in Table 3, differences are expressed as positive or negative values to indicate whether the BIM estimate is higher or lower than the conventional estimate. For example, Beam B50/25 shows a positive deviation of +3.05 m³, indicating a higher BIM estimate. In contrast, Beam B70/40 has a negative deviation of −0.22 m³, suggesting a lower BIM estimate. A similar pattern is seen in Column K35/30 with a difference of −0.22 m³, while Column K65/65 shows a negative difference of -0.74 m³.

In total, the concrete volume estimated using BIM is 488.52 m³, compared to 489.60 m³ from the conventional method. The deviation can be calculated as follows:

$$\textit{Percentage Difference in Concrete} = \frac{Q_{\mathrm{BIM}} - Q_{\mathrm{Conv}}}{Q_{\mathrm{Conv}}} \times 100\%$$

$$= \frac{-1.08}{489.60} \times 100\%$$

$$= 0.22\%$$

This result indicates that the BIM method produced a slightly lower concrete volume estimate, with a deviation of -0.22%. The discrepancy may be due to the manual nature of the conventional method, which is more prone to input errors and rounding, resulting in slightly lower estimates compared to the automated BIM calculations.

Table 4: Reinforcement Weight Comparison between BIM and Conventional Methods

No.	Structural Element	Reinforcement Weight (Kg)		Difference (kg)
		BIM	Conventional	
1	Beam B70/40	42768.3	40495.40	2272.90
2	Beam B60/30	5268.17	5375.89	-107.72
3	Beam B50/25	15018.66	15046.34	-27.68
4	Beam B40/25	17151.02	19483.48	-2332.46
5	Beam BK40/25	634.84	688.29	-53.45
6	Beam BS15/15	231.81	200.52	31.29
7	Column K65/65	39751.76	39662.11	89.65
8	Column K60/30	3089.58	3507.57	-417.99
9	Column K35/35	500.35	516.34	-15.99
10	Column K35/30	2424.62	2487.99	-63.37
11	Floor Slab	54843.47	55448.49	-605.02
	Total	181682.58	182912.42	-1229.84

Table 4 shows a variety of differences across structural elements. For example, the reinforcement weight of Beam B70/40 estimated using BIM is 2,272.90 kg higher than that from the conventional method. Conversely, Beam B40/25 showed a lower estimate by 2,332.46 kg using BIM. Similar trends are observed in floor slabs and certain column types, where negative differences indicate lower BIM estimates.

Overall, the total reinforcement weight estimated using BIM is 181,682.58kg, compared to 182,912.42 kg using the conventional method, yielding a difference of -1229.84 kg. The percentage deviation is calculated as:

$$\textit{Percentage Difference in Reinforcement} = \frac{Q_{\text{BIM}} - Q_{\text{Conv}}}{Q_{\text{Conv}}} \times 100\%$$

$$= \frac{-1229.84}{182912.42} \times 100\%$$

$$= -0.67\%$$

This indicates that the BIM method resulted in a slightly lower reinforcement weight estimate, with a deviation of -0.67%. The result demonstrates BIM's potential for high accuracy in material quantification and supports its use for improving efficiency in project planning.

4. Conclusion

This study demonstrates that BIM using Autodesk Revit provides reliable quantity estimations for concrete and reinforcement compared to conventional methods. Across all structural elements (beams, columns, slabs), BIM showed a 0.22% lower concrete volume and 0.67% lower reinforcement weight compared to conventional estimates. These results highlight BIM's effectiveness in minimizing manual calculation errors and improving efficiency in high-rise building projects. Therefore, BIM can be considered a more consistent and reliable approach for quantity estimation and project planning.

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