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QUANTITY TAKE-OFF COMPARISON OF CONVENTIONAL AND BIM-BASED CUBICOST METHODS: A CASE STUDY OF SMPN 2 MEGALUH

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Abstract

Quantity Take-Off (QTO) is an essential process in construction projects as it directly influences cost estimation and project planning. Conventional quantity calculation methods often require more time and are prone to errors due to the manual interpretation of construction drawings. This study aims to compare the Quantity Take-Off results obtained using the conventional method and the Building Information Modeling (BIM) approach through Cubicost software in the construction project of SMPN 2 Megaluh. The BIM model was developed based on architectural, structural, and mechanical-electrical drawings using the Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME) modules. The quantities generated by Cubicost were then compared with those obtained through conventional calculations. The results indicate that most work categories produced relatively small deviations, demonstrating a good level of agreement between the two methods. The largest deviations in the TAS module were observed in ceiling works (15.93%) and earthworks (15.71%), while several work categories produced identical results. Quantity differences in the TRB and TME modules were generally influenced by modeling details, drawing interpretation, and calculation procedures. Overall, the BIM-based approach using Cubicost proved to be more efficient, integrated, and consistent in generating Quantity Take-Off data, making it a reliable alternative to conventional methods for construction quantity estimation.

Keywords: Building Information Modeling (BIM), Quantity Take-Off, Cubicost, Construction Estimation, Quantity Comparison.

INTRODUCTION

Quantity Take-Off (QTO) is the process of identifying and calculating work quantities based on construction drawings or building models used in construction projects. The information generated from this process consists of work volumes that serve as the basis for material planning, cost estimation, and project implementation. Tigauw et al. (2023) explained that Quantity Material Take-Off in construction projects is commonly performed using two-dimensional drawings, making the accuracy of volume calculations an important aspect of project planning and execution. Therefore, accurate quantity calculations are essential to ensure that the resulting work volumes reflect actual project requirements. In construction practice, Quantity Take-Off is still widely performed using conventional methods based on two-dimensional drawings. This approach requires estimators to manually identify building elements, interpret drawings, and calculate work quantities. As a result, the accuracy of the calculations depends heavily on the estimator's interpretation and calculation process. Differences in interpretation and overlooked work elements may lead to variations in quantity results. Ihsan and Wacano (2024) reported that different quantity calculation methods can produce different results even when they are based on the same project documents.

The rapid development of digital technology in the construction industry has encouraged the adoption of Building Information Modeling (BIM) as an approach for managing project information. According to Eastman et al. (2018), BIM is a digital representation of a building that facilitates information management throughout the project life cycle. In the context of Quantity Take-Off, BIM enables quantity information to be extracted directly from three-dimensional models. One BIM-based software application used for this purpose is Cubicost, which provides several modules, including Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME). Bilqis and Safri (2023) and Aulia and Safri (2024) demonstrated the application of Cubicost in supporting quantity take-off calculations for different types of construction works. Based on previous studies, the application of Cubicost for Quantity Take-Off has generally been conducted separately for individual modules or specific types of work. Bilqis and Safri (2023) focused on the use of the TAS module, while Aulia and Safri (2024) examined the implementation of the TME module for mechanical works. Other studies have also primarily investigated reinforcement quantity calculations using the TRB module independently. However, studies integrating all three main Cubicost modules, namely Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME), within a single construction project remain limited. Therefore, this study provides a more comprehensive evaluation of the differences between conventional and BIM-based Quantity Take-Off results by simultaneously utilizing the three primary Cubicost modules in the same project. Despite the increasing use of BIM in quantity calculations, differences between conventional and BIM-based results may still occur due to factors such as drawing interpretation, reinforcement detailing, and the representation of building service components. Therefore, this study aims to compare Quantity Take-Off results obtained using conventional methods and BIM-based Cubicost on the SMPN 2 Megaluh project. The analysis focuses on the TAS, TRB, and TME modules to determine volume deviations and identify factors contributing to differences in calculation results.

LITERATURE REVIEW

Quantity Take-Off (QTO) is the process of calculating construction work quantities used as the basis for material planning, cost control, and project execution. With the advancement of technology, QTO can be performed using Building Information Modeling (BIM). One of the BIM-based software applications used for this purpose is Cubicost, which consists of the Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME) modules. Several studies have demonstrated that BIM can improve the accuracy of Quantity Take-Off calculations. In architectural and structural works, Uzlifati (2022) reported that the concrete volume calculated using Cubicost TAS had a deviation of 4.38% compared to conventional calculations. Similarly, Wibisono et al. (2025) reported deviations of 6.99% using BIM and 8.88% using conventional methods in architectural quantity calculations. These findings indicate that BIM can provide quantity estimates that are closer to the planned quantities.

In addition to improving quantity accuracy, Cubicost has also been applied across different construction disciplines. For reinforcement works, Nugroho (2023) found that quantity estimations generated using Cubicost produced error values ranging from -11.15% to 5.58%. The results demonstrate that BIM-based modeling can support material quantity estimation with an acceptable level of accuracy. In mechanical works, Aulia (2024) utilized Cubicost TME to calculate material coefficients for building installation systems and obtained coefficient values ranging from 0.00088 to 0.59756 per meter. The study showed that Quantity Take-Off outputs generated from Cubicost improved calculation accuracy compared to manual methods. However, previous studies have generally focused on a single Cubicost module or a specific work category. Research on architectural and structural works primarily utilized the TAS module, while reinforcement and mechanical works were examined separately using the TRB and TME modules. Therefore, studies integrating the three main Cubicost modules, namely TAS, TRB, and TME, within a single construction project remain limited. This study addresses this gap by comparing Quantity Take-Off results obtained using conventional and BIM-based Cubicost methods through the simultaneous application of all three modules within the SMPN 2 Megaluh project.

METHOD

The BIM model was developed by the researcher based on the Detailed Engineering Design (DED) drawings of the SMPN 2 Megaluh project in AutoCAD format. All architectural, structural, and mechanical-electrical elements were modeled according to the dimensions and specifications provided in the DED drawings. Conventional quantity calculations were also performed using the same drawings, allowing the Quantity Take-Off results from both methods to be directly compared. The procedures for both the conventional and BIM-based Quantity Take-Off methods used in this study are described in the following sections.

Conventional Quantity Take-Off Analysis

The conventional Quantity Take-Off (QTO) procedure was conducted using two-dimensional (2D) construction drawings obtained from the project design documents as the primary source of information. The documents consisted of architectural, structural, and mechanical-electrical drawings used to determine the quantities of each work item manually. Quantity calculations were performed by identifying each building element, extracting dimensional data from the drawings, and calculating the corresponding volume, weight, or quantity based on the specifications provided in the project documents.

1. Calculating of Architectural and Structural Quantities
   For volume-based work items

$$Vc = L \times W \times H \tag{1}$$

Where:
Vc = Concrete volume (m^3)
L = Length of the element (m)
W = Width of the element (m)
H = Height of the element (m)

   For area-based work items

$$A = L \times H \tag{2}$$

Where:
A = Quantity area (m^2)
L = Length of the element (m)
H = Height of the element (m)

2. Calculating of Concrete Volume

$$Wr = Lr \times Uw \tag{3}$$

Where:
Wr = Reinforcement weight (kg)
Lr = Total reinforcement length (m)
Uw = Unit weight of reinforcement (kg/m)

3. Calculating of Electrical Installation Quantity

$$Qe = Le \tag{4}$$

Where:
Qe = Quantity of electrical installation work (m)
Le = Total length of electrical installation routes (m)

BIM-Based Quantity Take-Off Analysis

Quantity Take-Off (QTO) data using the Building Information Modeling (BIM) approach were obtained through Cubicost software. The modeling process was carried out based on architectural, structural, and mechanical-electrical drawings using the Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME) modules. The Quantity Take-Off procedure consisted of the following stages:

1. Development of the BIM Model
   Two-dimensional (2D) construction drawings consisting of architectural, structural, and mechanical-electrical drawings were used as the basis for model development in Cubicost. The modeling process was carried out using the Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME) modules according to the type of work being analyzed.
2. Quantity Take-Off Data Extraction
   After the modeling process was completed, Cubicost automatically generated Quantity Take-Off data through the calculation features available in each module. The extracted data included work volumes from TAS, reinforcement lengths and weights from TRB, and quantities of mechanical-electrical components from TME.
3. Data Compilation and Comparison
   The Quantity Take-Off results generated from Cubicost were compiled and subsequently compared with the quantities obtained through the conventional calculation method to identify differences in quantity results for each work category.

BIM-Based Quantity Take-Off Analysis

Deviation analysis was conducted to determine the differences between the Quantity Take-Off results obtained from the conventional method and BIM-based Cubicost. The deviation percentage was calculated by comparing the quantities generated by both methods using Equation (4). Positive values indicate that the quantity obtained from BIM-based Cubicost is greater than the conventional calculation result, while negative values indicate that the BIM quantity is lower than the conventional result.

$$D = \frac{Q_{BIM} - Q_{Conv}}{Q_{Conv}} \times 100\% \quad (5)$$

Where:
D = Deviation percentage (%)
QBIM = Quantity obtained from BIM-based Cubicost
QConv = Quantity obtained from the conventional method

RESULTS AND DISCUSSION

The BIM model of the SMPN 2 Megaluh project was successfully developed using Cubicost as the basis for the Quantity Take-Off (QTO) process. The model included foundation works, tie beams, columns, beams, floor slabs, walls, roof structures, and other architectural elements in accordance with the project drawings.

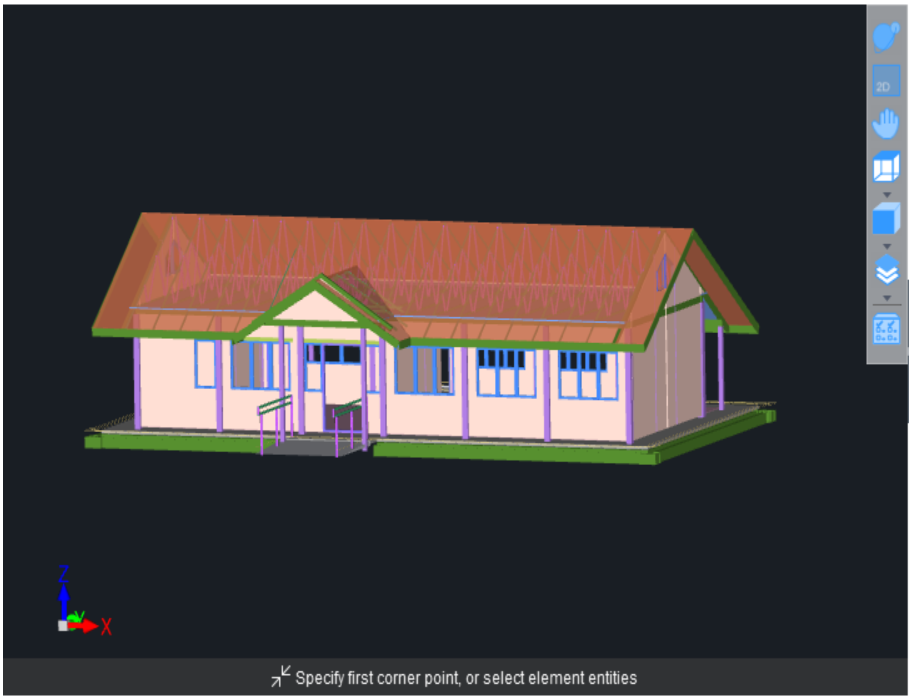

Figure 1. BIM Model of SMPN 2 Megaluh Building

The Quantity Take-Off results obtained from the conventional method and BIM-based Cubicost were subsequently compared to analyze quantity differences and deviation levels in architectural and structural works (TAS), reinforcement works (TRB), and mechanical-electrical works (TME). The comparison results are presented in the following tables.

Quantity Take-Off of Architectural and Structural Works

Table 1. TAS Quantity Result

No	Work Category	Conventional Method (m^3)	Cubicost TAS (m^3)	Difference	Deviasi %
1	Preliminary Works	66,1	66,1	0,00	0,00%
2	Earthworks	29,99	25,28	4,71	15,71%
3	Foundation Works	112.88	127.84	14.96	13.25%
4	Concrete Works	11.99	11.29	0.70	5.84%
5	Wall Works	544.11	544.64	0.53	0.10%
6	Door and Window Works	46.22	44.77	1.45	3.14%
7	Roof Structure and Roofing Works	568.96	543.92	25.04	4.40%
8	Ceiling Works	471.50	396.38	75.12	15.93%
9	Floor and Ceramic Works	156.88	158.97	2.09	1.33%
10	Painting and Wall Finishing Works	482.76	437.77	44.99	9.32%
11	Hardware and Accessories Works	198	198	0,00	0,00%
12	Other Works	20.55	20.05	0.50	2.43%

Summary of Reinforcement Quantities

Table 2. TRB Quantity Result

No	Work Category	Conventional Method (m^2)	Cubicost TAS (m^2)	Difference	Deviasi %
1	Foundation Reinforcement Works	573.65	633.85	60.20	10.49%
2	Concrete Reinforcement Works	1,695.42	1,786.39	90.97	5.37%

Summary of MEP Quantities

Table 3. TME Quantity Result

No	Work Category	Conventional Method (m')	Cubicost TAS (m')	Difference	Deviasi %
1	Electrical Installation Works	86.77	114.95	28.18	32,47%
2	Sanitary and Bathroom Accessories Works	28.97	29.69	0.72	2,49%

The comparison results indicate that there are differences in quantities between the conventional method and the BIM-based method using Cubicost. In the Take-off for Architecture and Structure (TAS) module, the largest deviation was found in ceiling works with a deviation of 15.93%, while the smallest deviation occurred in wall works with a deviation of 0.10%. These differences may be attributed to variations in quantity identification and the representation of building elements during the BIM modeling process compared to conventional calculations.

In the Take-off for Reinforcement Bar (TRB) module, the deviation in reinforcement quantities was 10.49% for foundation works and 5.37% for concrete structure works. These results indicate that BIM-based reinforcement modeling can identify reinforcement requirements in greater detail than conventional calculation methods. In the Take-off for Mechanical, Electrical, and Plumbing (TME) module, the highest deviation was observed in electrical installation works with a deviation of 32.47%, while sanitary works showed a deviation of 2.49%. These differences may be influenced by the level of detail incorporated into the MEP model as well as the automated quantity extraction process performed by Cubicost. To evaluate the overall level of variation between the conventional and BIM-based methods, an analysis of the average deviation was carried out for each Cubicost module. The average deviation values for the TAS, TRB, and TME modules are presented in Table 4.

Table 4. Average Deviation of Quantity Take-Off Results

No	Module	Average Deviation (%)
1	TAS	5.95%
2	TRB	7.93%
3	TME	17.48%
4	Overall Average	7.64%

Based on Table 4, the TAS module recorded the lowest average deviation of 5.95%, indicating a high level of consistency between the BIM-based and conventional quantity calculations. The TRB module produced an average deviation of 7.93%, while the TME module showed the highest average deviation of 17.48%. Overall, the average deviation of 7.64% suggests that the Quantity Take-Off results generated using Cubicost are generally comparable to those obtained through the conventional method. To further illustrate the comparison between the conventional and BIM-based Quantity Take-Off methods, the quantity results for each work category are presented in graphical form, as shown in the following figures.

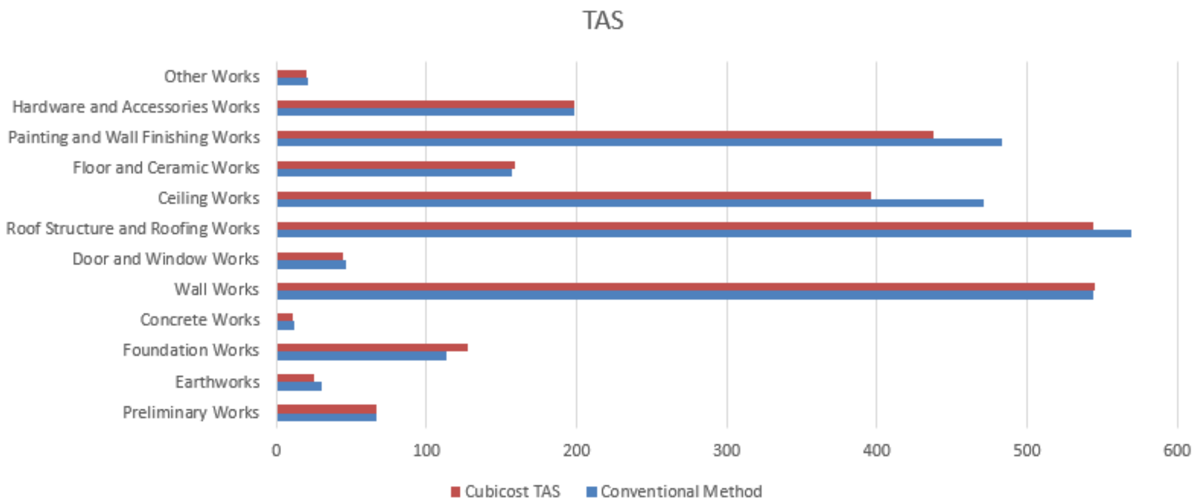

Figure 2. Comparison of Quantity Take-Off Results for TAS Work Categories

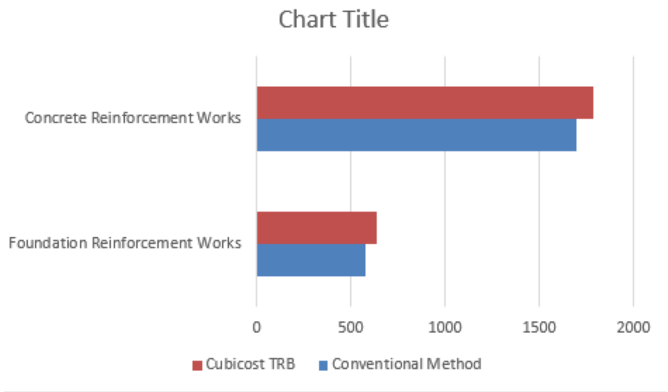

Figure 3. Comparison of Quantity Take-Off Results for TRB Work Categories

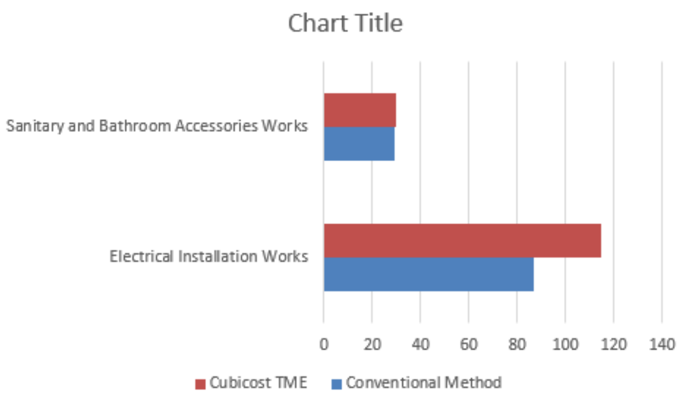

Figure 4. Comparison of Quantity Take-Off Results for TME Work Categories

CONCLUSION

Based on the results of this study, the Building Information Modeling (BIM) approach using Cubicost was able to generate Quantity Take-Off (QTO) data comparable to those obtained using the conventional method. The comparison results from the Take-off for Architecture and Structure (TAS), Take-off for Reinforcement Bar (TRB), and Take-off for Mechanical, Electrical, and Plumbing (TME) modules indicate that most work categories exhibited relatively small deviations, demonstrating a good level of agreement between the two approaches. For the TAS module, the largest deviations were observed in ceiling works (15.93%) and earthworks (15.71%), while several work categories, such as preliminary works and hardware and accessories works, produced identical quantity results. In the TRB and TME modules, quantity differences were generally influenced by modeling details, drawing interpretation, and calculation procedures adopted in each method. Overall, Cubicost proved capable of improving the efficiency of the Quantity Take-Off process through a more integrated, automated, and consistent calculation workflow. Therefore, Cubicost can be considered an effective and reliable alternative to conventional methods for construction quantity estimation. Future studies may expand the analysis by applying the TAS, TRB, and TME modules to different project types and scales to further evaluate their accuracy and reliability. In practice, the adoption of standardized BIM modeling procedures and consistent project documentation is recommended to reduce quantity deviations and improve the effectiveness of BIM-based Quantity Take-Off processes.

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