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Effectiveness of Quantity Take Off In Self Managed Projects Through Building Information Modeling (BIM) Integration

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Abstract
The Quantity Take Off (QTO) process plays a vital role in preparing construction cost estimates. However, conventional methods, which are still widely used in Indonesia particularly in Self Managed projects often result in volume deviations and require longer processing time. This study investigates the application of Building Information Modeling (BIM) using Autodesk Revit for QTO in the construction of an eight-story hospital project carried out through self-management. This project is under construction. A quantitative experimental method was employed by comparing the QTO results of concrete and reinforcement in major structural elements from both approaches. The findings indicate that the average deviation for concrete volume was 1.21%, while the average deviation for steel reinforcement was 1.75%. The highest concrete deviation occurred in shear walls (3.70%) due to differences in volume calculation for openings and elevation variations, whereas the highest reinforcement deviations were found in columns (2.72%) and beams (2.63%) as the conventional approach tends to simplify reinforcement details such as lengths, splices, and bends. The study concludes that BIMbased QTO is not only technically more reliable but also addresses the limitations of human resources in Self Managed projects. Therefore, adopting BIM is strongly recommended as a digital transformation strategy for more efficient quantity management in infrastructure projects in Indonesia.

Keywords: Quantity Take Off , BIM, Revit, Volume Estimation, Self Managed Projects, Digital Construction.

Abstrak
Proses Quantity Take Off (QTO) memiliki peran penting dalam penyusunan estimasi biaya konstruksi. Namun, metode konvensional yang masih dominan digunakan di Indonesia, khususnya pada proyek swakelola, sering menimbulkan deviasi volume serta membutuhkan waktu pengerjaan lebih lama. Penelitian ini mengeksplorasi penerapan Building Information Modeling (BIM) dengan perangkat Autodesk Revit dalam proses QTO pada proyek pembangunan rumah sakit delapan lantai secara swakelola. Proyek ini dalam tahap Pembangunan. Metode penelitian yang digunakan adalah eksperimen kuantitatif dengan membandingkan hasil QTO beton dan tulangan pada elemen struktural utama dari kedua pendekatan. Hasil analisis menunjukkan ratarata deviasi volume beton sebesar 1,21% dan ratarata deviasi tulangan baja sebesar 1,75%. Deviasi terbesar untuk beton terjadi pada elemen dinding geser (3,70%) akibat perbedaan pendekatan penghitungan bukaan serta variasi elevasi, sementara deviasi terbesar pada tulangan terdapat pada elemen kolom (2,72%) dan balok (2,63%) karena metode manual cenderung menyederhanakan detail panjang, sambungan, dan tekukan tulangan. Penelitian ini menyimpulkan bahwa penerapan QTO berbasis BIM tidak hanya lebih unggul dari sisi teknis, tetapi juga mampu mengatasi keterbatasan sumber daya manusia pada proyek swakelola. Dengan demikian, adopsi BIM direkomendasikan sebagai strategi transformasi digital dalam pengelolaan kuantitas proyek infrastruktur di Indonesia secara lebih efisien.

Kata Kunci: Quantity Take Off , BIM, Revit, Estimasi Volume, Proyek Swakelola, Digital Construction.

INTRODUCTION

Time efficiency in Self Managed construction projects with limited human resources (HR) is a significant challenge in achieving effective project management. One of the stages that frequently experiences delays is the Quantity Take Off (QTO) process, which forms the basis for cost estimation and material planning (AbdelHamid & Abdelhaleem, 2023), (Sholeh et al., 2020). The conventional QTO process, which relies on manual methods, often requires a long time, is prone to errors, and does not adequately support fast and accurate decision making. Therefore, there is an urgent need for innovations in the QTO process that can enhance time efficiency and reduce waste, particularly in Self Managed projects with limited manpower. The application of digital technologies such as Building Information Modeling (BIM) has become increasingly essential to accelerate and improve the accuracy of work volume calculations, while optimizing the use of available resources (Luo et al., 2022).In this context, one of the most widely used BIM software is Autodesk Revit, which can automatically generate material quantities from a developed 3D model. With BIM, all projectrelated information including material quantities, dimensions, and other details can be accessed in real time and utilized to streamline the QTO process (Rizki et al., 2023). Consequently, this research aims to develop strategies for implementing BIM in the QTO process to improve time efficiency in Self Managed construction projects with limited labor resources.

This study will be conducted in accordance with relevant legal frameworks governing construction practices in Indonesia. Government Regulation of Indonesia No. 16 of 2021 concerning amendments to Government Regulation No. 30 of 2000 on Indonesian National Standards (SNI) serves as a crucial legal foundation regulating technical aspects in the construction process (Presiden Republik Indonesia, 2021). In addition, the Ministry of Public Works and Housing (PUPR) Regulation No. 22 of 2018 on Guidelines for the Implementation of Sustainable Construction provides a regulatory framework that encourages innovation and the use of technologies that support efficiency and sustainability in construction projects (PUPR, 2018). Furthermore, Circular Letter (SE) of the Directorate General of Highways No. 11 of 2021 provides technical guidance on the application of

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information technology in infrastructure projects, including BIM, which is relevant to this study (Jenderal, et al., 2021). At the international level, ISO 19650 standards for information management in BIM also serve as a key reference to ensure data quality and consistency in BIM implementation for construction projects.

This study investigates the application of Building Information Modeling (BIM) using Autodesk Revit for QTO by analyzing a completed eight-story hospital construction project, which was executed through self-management. The project's completion data is utilized as the basis for comparing the efficiency and accuracy of QTO results between the two approaches. The problemsolving approach of this research is aimed at developing and applying strategies for BIM implementation in the QTO process of Self Managed construction projects with limited labor resources. The methodological framework will be based on the use of BIM technology to automate material quantity calculations within a 3D model, with the expectation of expediting material estimation, minimizing manual errors, and improving calculation accuracy and transparency. The research stages will begin with modeling the construction project using Revit to generate material quantity data automatically. This data will then be used to evaluate time efficiency in the QTO stage by calculating the reduction in time required for quantity measurement and verification compared to manual methods. The study will focus on developing a BIM implementation model capable of delivering automated and accurate quantity calculations, thereby minimizing work time while reducing the potential for manual errors.

METHODS

This research employed a quantitative experimental method to provide an indepth understanding of the BIM implementation process and its comparison with conventional methods. In general, the methodology consisted of four main stages designed to achieve the stated objectives. The process began with data collection, followed by the development of a 3D model. Once the 3D model was completed, the next stage involved utilizing the 5D model to generate the Bill of Quantity (BoQ) and conduct the Quantity Take Off (QTO). These stages are described in detail as follows:

Data Collection

The initial stage of the research began with the collection of both primary and secondary data. Primary data included technical project documents such as working drawings (shop drawings), technical specifications, and the Bill of Quantities (BoQ) obtained from an actual project. Secondary data were gathered through a literature review of relevant regulations and technical guidelines, including the Government Regulation of the Republic of Indonesia No. 16 of 2021 on the Implementation of Law No. 28 of 2002 concerning Buildings, the Ministry of Public Works and Housing (PUPR) Regulation No. 22 of 2018 on Guidelines for the Development of State Buildings, and Circular Letter of the Director General of Highways No. 11 of 2021 concerning the implementation of BIMbased construction. All these data served as the foundation for the subsequent stage, namely the development of the BIMbased digital model.

3D Modeling with Autodesk Revit

The second stage involves developing a threedimensional (3D) model of the case study project using Autodesk Revit, one of the widely used BIM platforms in the construction industry. This process includes modeling primary structural elements such as foundations, columns, beams, shear walls, and slabs for secondary structures, using parameters that can be digitally measured. The 3D model not only serves as a visual representation of the project design but also contains both quantitative and qualitative information that supports subsequent analysis. A key advantage of using Revit at this stage is its ability to integrate geometric elements with nongeometric data within a single, unified environment, enabling the automation of quantity extraction processes.

Quantity Calculation (5D Model)

The third stage involves the development of the 3D model into a five dimensional (5D) model, where the additional dimensions refer to cost estimation and work volume data. In the context of this research, the 5D model is utilized to perform the Quantity Take Off (QTO) process automatically. Autodesk Revit provides quantification features that enable users to generate work volume schedules based on parameters defined within the 3D model. This process produces outputs in the form of systematic and consistent quantity tables, while minimizing the risk of human error commonly found in conventional methods. The data obtained from this automated quantification process then serves as the primary reference for comparative analysis against the manual method.

Quantity Comparison

The final stage is the process of comparing the quantification results. The conventional method is carried out by manually calculating work volumes using Microsoft Excel, based on the interpretation of working drawings. The results of the manual calculation are organized in a table format identical to the Revit output, enabling systematic analysis of volume differences. The comparison is conducted to assess the accuracy, time efficiency, and potential cost savings of each method.

The following flowchart illustrates the systematic stages of the research, starting from the initial data collection of shop drawings and the Bill of Quantities (BoQ), followed by 3D modeling, then 5D modeling, manual volume calculation using Microsoft Excel, and automated BIMbased calculation through Autodesk Revit. Subsequently, a comparative analysis of the calculation results is performed to evaluate the efficiency of both methods, as well as to assess volume discrepancies and the potential for improving cost and time efficiency in Self Managed projects.

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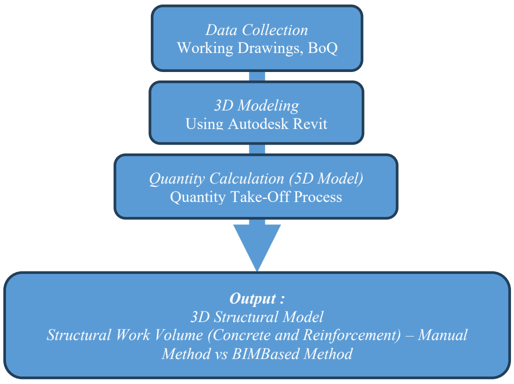

Picture 1. Flowchart Detailing a Process for Calculating Structural Work Volume
Source: BIM based approach

Literature Review

To strengthen the theoretical foundation and understand relevant approaches in implementing Building Information Modeling (BIM) for the Quantity Take Off (QTO) process, a review of previous studies related to this topic was conducted. The literature review includes an analysis of methodologies, findings, as well as the strengths and limitations of each study.

The selection of literature was based on its relevance to the use of BIM particularly Autodesk Revit its impact on QTO time efficiency, and its application to medium to largescale construction projects. Several studies also highlighted comparisons between manual and automated methods, as well as the benefits of BIM in terms of data transparency and quantity accuracy.

The following table presents a summary of ten literature sources used as references in this study, which also reinforces the urgency and direction for developing automated QTO methods in BIM based construction projects.

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Table 1. Literature Study

No	Author & Year	Title	Main Findings
1	(Alathamneh, et al., 2024)	BIMbased quantity Take Off : Current state and future opportunities	From a total of 52 articles sourced from the Scopus® and Web of Science® databases, the benefits, challenges, and future opportunities of the BIMbased QTO approach were identified. (Alathamneh et al., 2024)
2	(Tresnandhini , et al., 2023)	Comparison of Building Information Modeling and Conventional Methods for Concrete and Rebar Quantity Take Off	The QTO process for concrete was approximately 49% faster, while rebar quantification was 20% faster, with a rebar deviation of around 0.67%.(Tresnandhini Kusumaningroem & Gondokusumo, 2023)
3	(Wiranti, et al., 2022)	Analisis Perhitungan Quantity Take Off Menggunakan Building Information Modeling (Bim) Pada Proyek Jalan Tol IndralayaPrabumulih	Using the BIMbased QTO method, the Cost Budget Plan (RAB) showed a difference of 0.03% higher compared to the conventional method. (Wiranti et al., 2022)
4	(Retno, et al. 2022)	Perbandingan Quantity Take Off (QTO) Material Berbasis Building Information Modeling (BIM) Terhadap Metode Konvensional pada Struktur Pelat	Concrete efficiency was 1.67% higher, while reinforcement usage was 3.32% lower compared to the manual method. (Retno Asih et al., 2022)
5	(Taghaddos, et al., 2019)	Automation of Construction Quantity Take Off Using Building Information Modeling	The BIM API generates accurate and consistent automatic quantity estimations. (Taghaddos et al., 2019)
6	(Wahab & Wang, 2021)	A Comparative Study of BIMbased and Traditional 2D Quantity Take Off Approaches	BIMbased QTO is more productive, collaborative, and accurate compared to conventional 2D manual methods. (Wahab & Wang, 2021)
7	(Khosakitchalert , et al., 2018)	The Accuracy Enhancement of Architectural Walls Quantity Take Off for Schematic BIM Models	Architectural wall QTO is more accurate in schematic BIM models. (Khosakitchalert et al., 2018)
8	(Fadlilah, et al., 2024)	Analysis of Quantity Take Off Deviation Using BIM Method (Case Study of Construction of a Satpol PP Building)	The deviation between BIM and conventional methods was 9.68% for architecture and 9.00% for structure. (Fadlilah et al., 2024)
9	(Pratama, et al., 2025)	Implementation of Building Information Modeling (BIM) for Bridge Abutment Cost Estimation Considering QTO Validity	BIM produced more accurate results, with a deviation of 7.73% for sand and concrete, and 9.39% for reinforcement steel compared to conventional methods.(Pratama et al., 2025)
10	(Saavedra, et al., 2025)	Comparative analysis of quantity Take Off concrete, steel bars and formwork in apartment buildings based on CAD and BIM methodologies	The advantages of BIM over CAD for QTO in construction projects provide valuable information for informed decisionmaking in future projects.(Saavedra et al., 2025)

Source: Data Results (2025)

RESULTS AND DISCUSSION

Project Overview with 3D Modeling

The case study in this research involves the construction of an eight-story hospital located in Sidoarjo Regency, East Java, with a total building area of 3,851.2 m². The hospital is designed to accommodate comprehensive healthcare functions, including inpatient wards, an emergency department, operating rooms, and other supporting units. Digital modeling was carried out using

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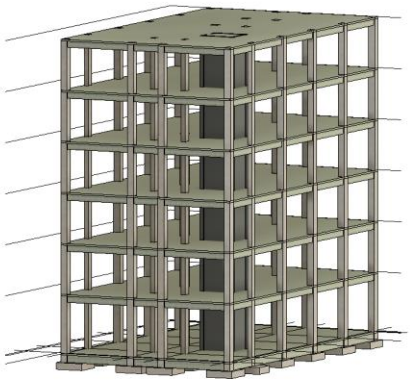
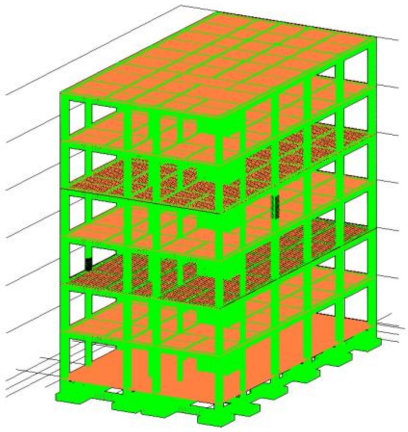
Autodesk Revit, focusing on the main structural elements such as foundations, columns, beams, floor slabs, and shear walls. Input data were obtained from the project's working drawings and Bill of Quantities (BoQ). The scope of modeling covered the entire structure from the ground floor to the roof. The purpose of the modeling was to support the automatic Quantity Take Off (QTO) process and to compare it with the conventional method, in order to evaluate the efficiency and accuracy of the volume estimation. The resulting model is presented in the following section.



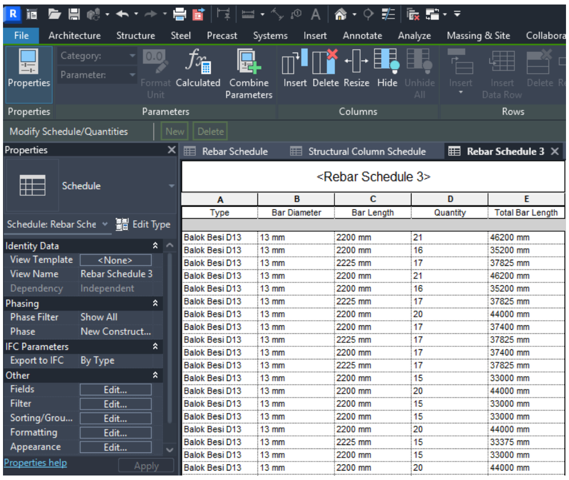
Picture 2. Concrete Structure Modeling
Source: Data Results (2025)



Picture 3. Reinforcement Structure Modeling
Source: Data Results (2025)

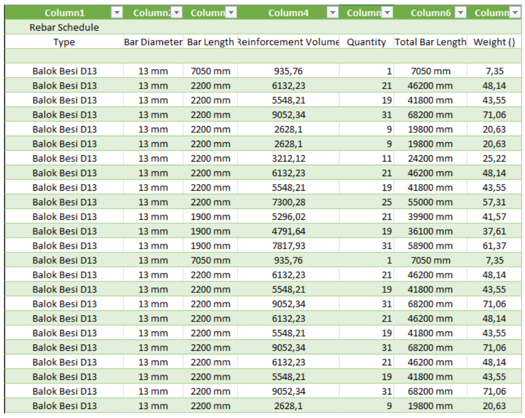
QTO Results Using BIM (Autodesk Revit)

After all the main structural elements including foundations, columns, beams, floor slabs, and shear walls were modeled using Autodesk Revit, the Quantity Take Off (QTO) process was performed through the Schedule feature available in the software. The QTO results were then exported to Excel format to facilitate analysis and comparison.



<Rebar Schedule 3>

A Type	B Bar Diameter	C Bar Length	D Quantity	E Total Bar Length
Balok Besi D13	13 mm	2200 mm	21	46200 mm
Balok Besi D13	13 mm	2200 mm	16	35200 mm
Balok Besi D13	13 mm	2225 mm	17	37825 mm
Balok Besi D13	13 mm	2200 mm	21	46200 mm
Balok Besi D13	13 mm	2200 mm	16	35200 mm
Balok Besi D13	13 mm	2225 mm	17	37825 mm
Balok Besi D13	13 mm	2200 mm	20	44000 mm
Balok Besi D13	13 mm	2200 mm	17	37400 mm
Balok Besi D13	13 mm	2225 mm	17	37825 mm
Balok Besi D13	13 mm	2200 mm	17	37400 mm
Balok Besi D13	13 mm	2225 mm	17	37825 mm
Balok Besi D13	13 mm	2200 mm	15	33000 mm
Balok Besi D13	13 mm	2200 mm	20	44000 mm
Balok Besi D13	13 mm	2200 mm	15	33000 mm
Balok Besi D13	13 mm	2200 mm	15	33000 mm
Balok Besi D13	13 mm	2200 mm	20	44000 mm
Balok Besi D13	13 mm	2225 mm	15	33375 mm
Balok Besi D13	13 mm	2200 mm	15	33000 mm
Balok Besi D13	13 mm	2200 mm	20	44000 mm



Rebar Schedule

Type	Bar Diameter	Bar Length	Reinforcement Volume	Quantity	Total Bar Length	Weight ()
Balok Besi D13	13 mm	7050 mm	935,76	1	7050 mm	7,35
Balok Besi D13	13 mm	2200 mm	6132,23	21	46200 mm	48,14
Balok Besi D13	13 mm	2200 mm	5548,21	19	41800 mm	43,55
Balok Besi D13	13 mm	2200 mm	9052,34	31	68200 mm	71,06
Balok Besi D13	13 mm	2200 mm	2628,1	9	19800 mm	20,63
Balok Besi D13	13 mm	2200 mm	2628,1	9	19800 mm	20,63
Balok Besi D13	13 mm	2200 mm	3212,12	11	24200 mm	25,22
Balok Besi D13	13 mm	2200 mm	6132,23	21	46200 mm	48,14
Balok Besi D13	13 mm	2200 mm	5548,21	19	41800 mm	43,55
Balok Besi D13	13 mm	2200 mm	7300,28	25	55000 mm	57,31
Balok Besi D13	13 mm	1900 mm	5296,02	21	39900 mm	41,57
Balok Besi D13	13 mm	1900 mm	4791,64	19	36100 mm	37,61
Balok Besi D13	13 mm	1900 mm	7817,93	31	58900 mm	61,37
Balok Besi D13	13 mm	7050 mm	935,76	1	7050 mm	7,35
Balok Besi D13	13 mm	2200 mm	6132,23	21	46200 mm	48,14
Balok Besi D13	13 mm	2200 mm	5548,21	19	41800 mm	43,55
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Balok Besi D13	13 mm	2200 mm	9052,34	31	68200 mm	71,06
Balok Besi D13	13 mm	2200 mm	2628,1	9	19800 mm	20,63

Picture 4. Autodesk Revit QTO results exported to Excel
Source: Data Results (2025)

The figure above shows the exported QTO Schedule from Autodesk Revit in Excel format. The data include the volumes of concrete structural elements such as foundations, columns, beams, and floor slabs, which have been accurately modeled within the BIM environment. Each row in the Excel table represents an element with digitally measured dimensional parameters, thereby automatically generating the total work volume. This information serves as the basis for calculating material requirements and as a reference in the recapitulation process presented in the subsequent table, supporting the efficiency analysis of the BIM method compared to the conventional method.

Table 2. Autodesk Revit QTO Recap

No.	Type	Volume	Unit
1	Pilecap	90,45	m3
2	Column	269,64	m3
3	Beam	397,77	m3
4	Shear Wall	136,08	m3
5	Floor Plate	505,47	m3
6	Pilecap Reinforcement	29415,578	kg
7	Column Reinforcement	158800,52	kg
8	Beam Reinforcement	161277,9	kg
9	Shear Wall Reinforcement	17028,92	kg
10	Floor Plate Reinforcement	32260,6	kg

Source: Data Results (2025)

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ISSN : 2541 - 2884 [Print]

QTO Results Using the Conventional Method

To compare with the results from Autodesk Revit, manual calculations were performed using Microsoft Excel through the conventional method. The process involved interpreting 2D construction drawings and calculating volumes based on standard construction units and geometric formulas. The manual calculation results are presented in Table 3:

Table 3. Conventional Method QTO Recapitulation

No.	Type	Volume	Unit
1	Pilecap	90,45	m3
2	Column	274,5	m3
3	Beam	398,478	m3
4	Shear Wall	141,12	m3
5	Floor Plate	507,22	m3
6	Pilecap Reinforcement	29976,588	kg
7	Column Reinforcement	154477,629	kg
8	Beam Reinforcement	157040,9	kg
9	Shear Wall Reinforcement	17222,4	kg
10	Floor Plate Reinforcement	32372,29	kg

Source: Data Results (2025)

Comparison of QTO Results Using BIM and the Conventional Method

The comparison between the two quantification methods is presented in Table 4 and Table 5. The volume differences between the Revitbased method and the manual method were then calculated in percentage units to evaluate the level of deviation.

Table 4. Concrete QTO Deviation

No.	Type	Unit	Autodesk Revit	Conventional	Deviation
1	Pilecap	m3	90,45	90,45	0,00%
2	Column	m3	269,64	274,5	1,80%
3	Beam	m3	397,77	398,478	0,18%
4	Shear Wall	m3	136,08	141,12	3,70%
5	Floor Plate	m3	505,47	507,22	0,35%
				Average	**1,21%**

Source: Data Results (2025)

Table 5. Reinforcement QTO Deviation

No.	Type	Unit	Autodesk Revit	Conventional	Deviation
1	Pilecap	kg	29415,578	29976,588	1,91%
2	Column	kg	158800,52	154477,629	2,72%
3	Beam	kg	161277,9	157040,9	2,63%
4	Shear Wall	kg	17028,92	17222,4	1,14%
5	Floor Plate	kg	32260,6	32372,29	0,35%
				Average	**1,75%**

Source: Data Results (2025)

Based on the comparison of structural quantity results between the BIM method using Autodesk Revit and the conventional Excelbased method, varying deviations were found across different structural elements. As shown in Table 4, the average deviation for concrete works was 1.21%, while reinforcement works recorded an average deviation of 1.75% (Table 5). Although relatively small, these deviations highlight the differences in approach between the modelbased digital system (BIM) and the documentbased 2D conventional method.

The highest deviation in concrete work occurred in the shear wall element, with a value of 3.70%. This is attributed to the geometric complexity of shear walls, which often include openings for doors and varying elevations at the footing level. In the conventional method, the volume of shear walls is typically simplified, calculated by multiplying the average crosssectional area by the thickness, without considering details such as openings or actual elevation changes. Conversely, 3D modeling in Autodesk Revit automatically detects and deducts volumes affected by openings, while also accounting for actual shapes based on design parameters, thereby producing more precise and reliable data.

Meanwhile, in reinforcement works, the highest deviations were found in column reinforcement at 2.72% and beam reinforcement at 2.63%. These deviations generally stem from differences in calculation approaches between manual and digital methods. In the conventional approach, estimates of reinforcement quantity and length are made based on assumed distributions of main and additional bars, derived from 2D drawings and often rounded for practical purposes. By contrast, Autodesk Revit, through its Rebar Schedule feature, automatically quantifies each modeled reinforcement bar, including parameters such as lap splices, hooks, stirrups, and ties.

Additionally, Revit has the capability to detect overlaps and bending lengths that are often simplified or overlooked in conventional methods. This results in reinforcement quantities in Revit being more detailed and accurate. The variation in deviations among structural elements indicates that the level of geometric complexity and technical detailing significantly affects calculation accuracy, particularly when comparing the modelbased digital approach to the 2D documentbased manual approach. Therefore, these findings reaffirm that the use of BIM, particularly Autodesk Revit, can provide more precise quantity estimations, especially for largescale construction projects such as multistory hospitals.

CONCLUSION

This study demonstrates that the application of Building Information Modeling (BIM) using Autodesk Revit for the Quantity Take Off (QTO) process in an eight-story Self Managed hospital construction project provides results that are more efficient, accurate, and transparent compared to conventional methods. The research approach emphasizes the development of automated material quantity calculations through 3D modeling, which is particularly relevant for projects with limited workforce and tight

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schedules. Structural elements such as foundations, columns, beams, slabs, and shear walls were modeled in Autodesk Revit to generate automatic QTO data, later exported to Excel for analysis and comparison with manual calculations. The findings indicate an average deviation of 1.21% for concrete volume and 1.75% for reinforcement weight, both within acceptable technical tolerance limits. The highest deviation in concrete occurred in shear walls, mainly due to complex geometry and differing measurement methods between manual and Revit approaches. For reinforcement steel, the largest deviation was observed in columns and beams, largely caused by rounding in manual calculations, differences in reinforcement detailing, and potential default software parameters not fully aligned with sitespecific conditions. Overall, the implementation of Revit significantly accelerates material quantification, minimizes human error, and facilitates data verification, reinforcing the role of BIM as a strategic solution for enhancing the performance of Self Managed construction projects.

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