Sustainable Civil Building Management and Engineering Journal Vol: 1, No 3, 2024, Page: 1-12

Analysis of Quantity Take Off Deviation Using BIM Method (Case Study of Construction of a Satpol PP Building)

Muhammad Reza Nur Fadlilah*, Fajar Sri Handayani, Muji Rifai

Civil Engineering Study Program, Faculty of Engineering, Sebelas Maret University

DOI: https://doi.org/10.47134/scbmej.v1i3.2828
*Correspondence: Muhammad Reza Nur Fadlilah
Email: muhrezaanur@gmail.com

Received: 01-05-2024
Accepted: 15-06-2024
Published: 31-07-2024

Abstract: Quantity Take Off (QTO) is in important process in the construction industry that calculates and estimates the amount of material needed to complete a construction project. This process includes detail analysis of design plans and technical specification to identify and calculate quantities. QTO results are used to create cost budgets, create project plans, and plan material procurement. This research explains the Building Information Modeling (BIM) application which uses Autodesk Revit software to calculate Quantity Take Off volume. The aim is to find out the difference between volume calculations using conventional methods and volume calculations using the BIM method and Quantity Take Off volumes in architectural work and structural work. A comparative analysis of conventional methods and the use of Autodesk Revit provide an overview of the efficiency and effectiveness of implementing BIM software in the Bantul Satpol PP Building Construction Project with a focus on structural an architectural work investigation studies. This research uses a case study methodology which includes a quantity survey using Building Information Modeling (BIM) techniques using Autodesk Revit and Microsoft Excel software. This research method includes preparatory steps, data collection techniques, 3D modeling, and data analysis based on volume the use of BIM software and conventional methods. Based on the survey results, the difference in volume calculations for architectural work is 9,68% and for structural work is 9,00%, this shows that volume calculations using the BIM method are smaller than using conventional methods.

Keywords: Autodesk Revit, Building Information Modelling, Quantity Take Off

Introduction

During this era of rapid technological development, advancements in the construction industry are occurring rapidly. One significant innovation is the use of digital technology, especially in Building Information Modelling (BIM) applications (Ergen, 2024; Tanko, 2024; Valinejadshoubi, 2024). BIM is a method that allows infrastructure development to be carried out more quickly and efficiently (C. G. P. H. Saputra, 2024; H. Saputra, 2024; Sholichan, 2024). One of the software that uses BIM is Autodesk Revit, which allows users to design buildings in 3D, 4D, and 5D. This includes modelling architectural, structural, and MEP construction, as well as integrating planning, design, execution, control, and maintenance information. Utilizing Revit, stakeholders such as owners, consultants, and contractors can work together effectively.

Implementation of the BIM concept in Indonesia has not been utilized to its full potential (Apriadi, 2024; Ren, 2024; Wardito, 2024). Workload miscalculation can cause great losses. However, several BIM-based Quantity Take Off (QTO) software programs have been developed. This improves estimation efficiency and reduces human error in construction projects. Quantity Take Off requires high expertise and accuracy (Forth, 2023; Huang, 2023; Sampaio, 2023b). If errors occur such as incorrect data entry of dimension measurement, it can reduce efficiency and incur huge losses (Hage, 2023; Sampaio, 2023a; Sierra, 2023). In Indonesia, volume calculations are carried out conventionally by quantity surveyors using calculation methods based on Autocad drawings and Microsoft Excel (Dwi Novita & Pangestuti, 2021).

According to a study entitled "Study of the Use of Cubicost for Quantity Take Off Work in the Tender Process", the BIM method using Cubicost TRB can reduce work time by 58% compared to conventional methods (Anindya & Gondokusumo, 2020). This research aims to produce an efficient Quantity Take Off and reduce material waste in the Bantul Satpol PP Building Construction project, Yogyakarta. By using the BIM method, a more efficient Quantity Take Off calculation can provide a clear picture to the public minimize material waste and estimate costs more accurately in structural work.

Methodology

This research was conducted within the scope of the Satpol PP Building Construction Project in Complex II of Bantul Regional Government Office, Lingkar Timur Mading St., Trirenggo, Bantul, D.I Yogyakarta, which has a building area of 984 m2, and a land area of approximately 2.618 m2 and is built with various type rooms. However, this research is limited to only some structures of the Satpol PP Building Construction Project.

Figure 1. Research project location

This research uses quantitative research methods. This research aims to determine the difference between existing (conventional) volume calculations and Quantity Take Off volumes carried out using Autodesk Revit software. The methods of this research include data collection, 3D BIM modeling of structural and architectural works, calculation of Quantity Take Off based on the resulting volume, and comparative analysis of Quantity Take Off between using BIM software and existing (conventional) methods.

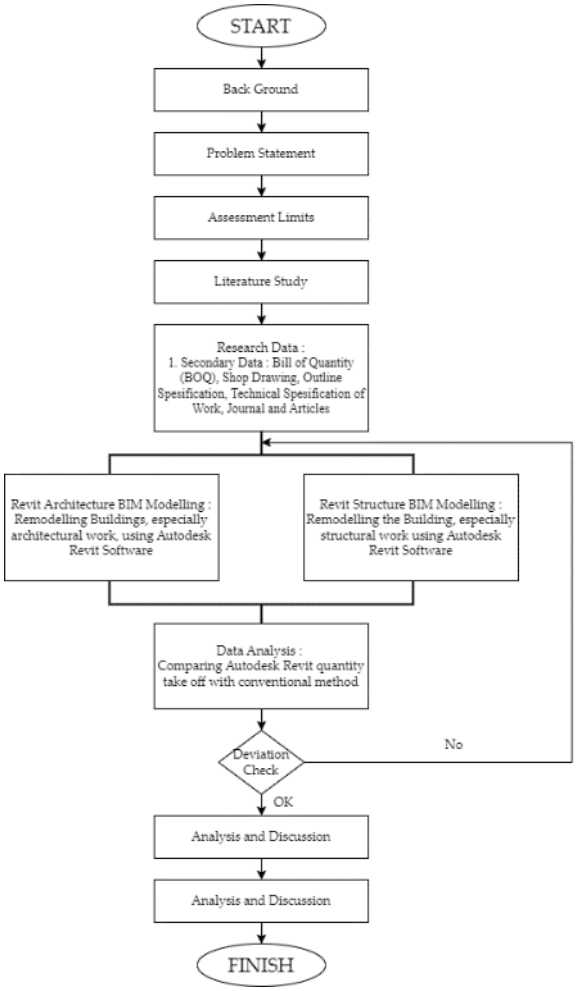

Figure 2. Research flowchart

Result and Discussion

3D Modeling of Architectural Works

Data analysis in architectural work is a vital process for understanding user needs and preferences and optimizing building design. The data analysed may include information on user demographics, functional needs, aesthetic preference, and environmental sustainability. In addition, data analysis can also help in resource use optimization, efficient project management, and evaluation of the environmental impact of the selected design. In this study, the author used Autodesk Revit software using the Building Information Modeling (BIM) method to process the data collected on the project. Following in Figure 3. Is the result of 3D modelling of architectural work carried out using 2022 version of Autodesk Revit software.

Figure 3. Results of 3D modeling of archotectural work with Autodesk Revit 2022 version software

Quantity Take Off in Architectural Work

Quantity take off in architectural work is an important stage in the cost estimation and project planning process. It involves an in-depth analysis of construction plans and technical drawings to identify and calculate the quantity of building materials required, such as bricks, timber, concrete, and glass. Using the data generated from quantity take off project managers and estimators can produce accurate cost estimates, manage budgets more efficiently, and plan the right resources to complete architectural project successfully. The quantity take off data obtained from the 2022 version of Autodesk Revit software is then entered into Ms. Excel software to analyse the estimated quantity take off materials needed in architectural work. The following table is a recapitulation of the quantity take off calculation for architectural works as shown in Table 1.

Table 1. Recapitulation of quantity take off on architectural work from Revit

No	Job Description	Volume	
	1st Floor		
1	Lightweight Brick Wall Installation 7,5 cm	623,0	m^2
2	2 Side Installation of C Canal Frame GRC Caliboard Partition Walls 75	698,0	m^2

No	Job Description	Volume	
3	Granite Tile Flooring ex Asia Tile	1.719,0	m²
4	Toilet Floor Size 25 cm x 25 cm Anti Slip ex. Asia Tile	118,0	m²
5	Black Paste Stone Installation	109,0	m²
	2nd Floor		
1	7,5 cm Lightweight Brick Wall Installation	540,0	m²
2	2 Side Installation of C Canal Frame GRC Caliboard Partition Walls 75	597,0	m²
3	Granite Tile Flooring ex. Asia Tile	1.550,0	m²
4	Toilet Floor Size 25 cm x 25 cm Anti Slip ex. Asia Tile	116,0	m²
5	Black Paste Stone Installation	127,0	m²

Comparison of Architectural Work Volume

The quantity take off calculation that has been carried out using 2022 version of Autodesk Revit is then compared with the conventional method. The conventional method volume is obtained from the calculation of the project volume backup. The following table is a comparison using conventional methods and BIM methods where the difference in quantity take off value is obtained with an average of 9,68% on architectural work which can be seen in more detail Table 2. below.

Table 2. Comparison of quantity take off of architectural work conventional method with Revit method

No	Job Description	Conventional	Revit	Difference	Percentage
	1st Floor				
1	Lightweight Brick Wall Installation 7,5 cm	534,498	614,0	79,502	15%
2	2 Side Installation of C Canal Frame GRC Caliboard Partition Walls 75	278,08	322,0	43,92	16%
3	Granite Tile Floor 60 cm x 60 cm ex. Asia tile	384,98	430,0	45,02	12%
4	Toilet Floor Size 25 cm x 25 cm Anti Slip ex. Asia Tile	29,99	29,0	0,99	3%
5	Black Paste Stone Installation	86,00	87		1%
	2nd Floor				
1	Lightweight Brick Wall Installation 7,5 cm	391,146	286,0	42,854	11%
2	2 Side Installation of C Canal Frame GRC Caliboard Partition Walls 75	259,79	387,0	26,21	10%
3	Granite Tile Floor 60 cm x 60 cm ex. Asia tile	432,11	387,0	45,11	10%
4	Toilet Floor Size 25 cm x 25 cm Anti Slip ex. Asia Tile	33,83	29	4,83	14%
5	Black Paste Stone Installation	77,25	74	3,25	4%
	AVERAGE				**9,68 %**

3D Structural Work Modeling

3D modelling of structural works using Autodesk Revit makes it possible to create 3D representations of building elements that allow for more in-depth analysis. This modelling is done by drawing columns, beams, foundations, and floor slabs with the required data, namely Asbuilt drawings. In this study, the author used Autodesk Revit software using the Building Information Modeling (BIM) method to process the data collected on the project. The following in Figure 4. is the result of 3D modelling of structural work carried out using the 2022 version of Autodesk Revit software .

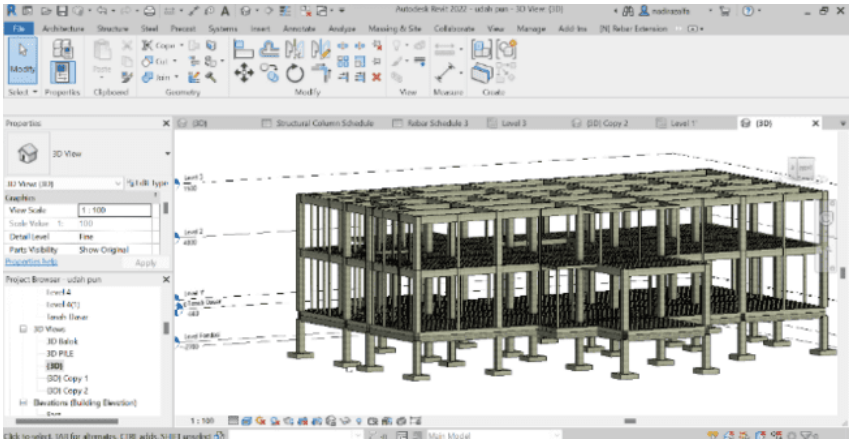

Figure 4. Results of 3D modeling of structural work with the 2022 version of Autodesk Revit software

Structural Work Quantity Take Off

Quantity take off in structural works is an important step in construction planning that involves calculation the amount of material required. It involves an in-depth analysis of construction plans and technical drawings to identify and calculate the amount of building materials required, such as columns, beams, foundations, floor slabs, and reinforcement. Using the data generated from quantity take off, project managers and estimators can produce accurate cost estimates, manage budgets more efficiently, and plan the right resources to complete structural projects successfully. The quantity take off data obtained from 2022 version of Autodesk Revit software is then entered into Ms. Excel software to analyze the estimated quantity take off material required in structural work. The following is a recapitulation of the quantity take off calculation for structural works as shown in Table 3.

Table 3. Recapitulation of quantity take off of structural work from Revit

No	Job Description	Volume	
	1st Floor		
1	Concrete Footplate fc 19,3 MPa, size 1250x1250, t=300, reinforcement. D16-15 SNI		
	Main Rebar D16-150	2120.44	kg
	Concrete fc 19,3 MPa	12.19	m^3
2	Structural Concrete Sloof f'c 19,3 MPa, size 200x300, reinforcement. 6D16, Stirrup Ø10-11/SNI		

No	Job Description	Volume	
	Main Rebar D16	2200.9	Kg
	Stirrup 10	803.5	Kg
	Concrete fc 19,3 MPa	13.49	m^3
3	Practical Concrete Sloof f'c 14,5 MPa, size 150x200, reinforcement. 4 Ø10 , Stirrup Ø6-15 SNI		
	Main Rebar D10	185.87	Kg
	Stirrup 6	100.08	Kg
	Concrete fc 14,5 MPa	2.27	m^3
4	Concrete Main Beam f'c 19,3 MPa, size 300x500, reinforcement. 10 D16, Stirrup Ø10-11/22 SNI		
	Main Rebar D16	4153.03	kg
	Stirrup 10	1339.76	Kg
	Concrete fc 19,3 MPa	33.47	m^3
5	Concrete Joist f'c 19,3 MPa, size 250x400, reinforcement. 8 D16, Stirrup Ø10-11/22 SNI		
	Main Rebar D16	1757.06	kg
	Stirrup 10	645.74	kg
	Concrete fc 19,3 MPa	13.8	m^3
6	Concrete Structural Column f'c 19,3 MPa, size 400x400, reinforcement. 10 D16, Stirrup Ø10-15 SNI		
	Main Rebar D16	4118.31	kg
	Stirrup 10	866.03	kg
	Concrete fc 19,3 MPa	25.79	m^3
7	Concrete Practical Column f'c 14,5 MPa, size 120x120, reinforcement. 4 Ø10, Stirrup Ø6-15 SNI		
	Main Rebar 10	562.74	kg
	Stirrup 6	98.67	kg
	Concrete fc 14,5 MPa	3.11	m^3
8	Floor Rebate Work 10cm Concrete fc 14,5 MPa	56.19	m^3
	2nd Floor		
1	Concrete Main Beam f'c 19,3 MPa, size 300x500, reinforcement. 10 D16, Stirrup Ø10-11/22 SNI		
	Main Rebar D16	4033.381	kg
	Stirrup 10	1196.26	Kg
	Concrete fc 19,3 MPa	29.07	m^3
2	Concrete Joist f'c 19,3 MPa, size 250x400, reinforcement. 6 D16 2 D19, Stirrup Ø10-11/22 SNI		
	Main Rebar D16	949.988	kg
	Stirrup 10	349.12	kg
	Concrete fc 19,3 MPa	7.5	m^3
3	Concrete Structural Column Qualifications f'c = 19,3 MPa, size 400x400, reinforcement. 12 D16, Stirrup Ø10-15 SNI		
	Main Rebar D16	1831.54	kg
	Stirrup 10	459.66	kg
	Concrete fc 19,3 MPa	13.44	m^3
4	Concrete Practical Column f'c 14,5 MPa, size 120x120, tul. 4 Ø10, Stirrup Ø6-15 SNI		
	Main Rebar 10	377.35	kg
	Stirrup 6	68.49	kg

No	Job Description	Volume	
	Concrete fc 14,5 MPa	2.22	m^3
5	2nd Floor Plate Work 12 cm thick Concrete f'c 19,3 MPa, Plywood Formwork		
	2 Layers Rebar D 10-150	7,286.58	kg
	Concrete fc 19,3 MPa	48.51	m^3

Structural Work Volume Comparison

The quantity take off calculation that has been carried out using the 2022 version of Autodesk Revit software is then compared with the conventional method. The conventional method volume is obtained from the calculation of the project volume backup. Following then is a comparison using conventional methods and BIM methods where the difference in quantity take off value is obtained with an average of 9,57% on structural work which can be seen in more detailed in Table 4. below.

Table 4. Comparison of quantity take off of structural work conventional methods with BIM methods

No	Job Description	Conventional	Revit	Difference	Percentage
	1st Floor				
1	Concrete Footplate fc 19,3 MPa, size. 1250x1250, t=30, reinforcement. D16-15 SNI				
	Main Rebar D16-150	1.883,99	2.120,44	236,45	13%
	Concrete fc 19,3 MPa	12,19	12,19	0	0%
2	Concrete Structural Sloof f'c 19,3 MPa, size 200x300 cm, reinforcement. 6D16, Stirrup Ø10-11/22 SNI				
	Main Rebar D16	2.611,89	2.200,9	410,99	16%
	Stirrup 10	747,45	803,5	56,05	7%
	Concrete fc 19,3 MPa	14,36	13,49	0,87	6%
3	Concrete Practical Sloof f'c 14,5 MPa, size 150x200 reinforcement. 4 Ø10, Stirrup Ø6-15cm SNI				
	Main Rebar 10	185,82	185,87	0,05	0%
	Stirrup 6	174,23	100,08	74,15	43%
	Concrete fc 14,5 MPa	2,21	2,27	0,06	3%
4	Concrete Main Beam f'c 19,3 MPa, size 300x500, reinforcement. 10 D16, Stirrup Ø10-11/22 SNI				
	Main Rebar D16	4.088,94	4.153,03	64,09	2%
	Stirrup 10	1.139,94	1.339,76	199,82	18%
	Concrete fc 19,3 MPa	31,74	33,47	1,73	5%
5	Concrete Joist f'c 19,3 MPa, size 250x400, reinforcement. 8 D16, Stirrup Ø10-11/22 SNI				

No	Job Description	Conventional	Revit	Difference	Percentage
	Main Rebar D16	2.022,11	1.757,06	265,05	13%
	Stirrup 10	551,43	645,74	94,31	17%
	Concrete fc 19,3 MPa	13,34	13,8	0,46	3%
6	Concrete Structural Column f'c 19,3 MPa, size 400x400, reinforcement. 10 D16, Stirrup Ø10-15 SNI				
	Main Rebar D16	4.536,2	4.118,31	417,89	9%
	Stirrup 10	913,45	866,03	47,42	5%
	Concrete fc 19,3 MPa	27,87	25,79	2,08	7%
7	Concrete Practical Column f'c 14,5 MPa, size 120x120, reinforcement. 4 Ø10, Stirrup Ø6-15 SNI				
	Main Rebar 10	592,02	562,74	29,28	5%
	Stirrup 6	87,62	98,67	11,05	13%
	Concrete fc 14,5 MPa	3,02	3,11	0,09	3%
8	1st Floor Concrete Rebate Work fc 14,5 MPa	46,18	46,83	0,65	1%
	2nd Floor				
1	Concrete Main Beam f'c 19,3 MPa, size 300x500, reinforcement. 10 D16, Stirrup Ø10-11/22 SNI				
	Main Rebar D16	4.152,24	4.033,381	118,86	3%
	Stirrup 10	1.174,61	1.196,26	21,65	2%
	Concrete fc 19,3 MPa	29,22	29,07	0,15	1%
2	Concrete Joist f'c 19,3 MPa, size 250x400, reinforcement. 6 D16 2 D19, Stirrup Ø10-11/22 SNI				
	Main Rebar D16	1.172,52	949,988	222,53	19%
	Stirrup 10	293,47	349,12	55,65	19%
	Concrete fc 19,3 MPa	5,68	7,5	1,82	32%
3	Concrete Structural Column f'c 19,3 MPa, size 400x400, reinforcement. 12 D16, Stirrup Ø10-15 SNI				
	Main Rebar D16	1.836,52	1.831,54	4,98	0%
	Stirrup 10	448,5	459,66	11,16	2%
	Concrete fc 19,3 MPa	13,44	13,44	0	0%
4	Concrete Practical Column f'c 14,5 MPa, size 120x120, reinforcement. 4 Ø10, Stirrup Ø6-15 SNI				
	Main Rebar 10	435,16	377,35	57,81	13%

No	Job Description	Conventional	Revit	Difference	Percentage
	Stirrup 6	64,9	68,49	3,59	6%
	Concretefc 14,5 MPa	2,17	2,22	0,05	2%
5	2nd Floor Plate Work Thickness 12cm Concrete f'c 19,3 MPa, Plywood Formwork				
	2 Layer Rebar D 10-150	8.782,99	7.286,58	1.496,41	17%
	Concrete fc 19,3 MPa	53,63	48,51	5,12	10%
	AVERAGE				**9,00 %**

Conclusion

Based on the results of the research that has been carried out, conclusions can be drawn including volume from the Quantity Take Off on architectural works on the volume of 7,5 cm light brick wall installation of 1.048 m2, volume of GRC wall installation of 608 m2, volume of 60 cm x 60 cm tile floor of 817 m2, volume of 25 cm x 25 cm tile floor of 57 m2, and volume of black paste stone installation of 161 m2. The volume of Quantity Take Off in structural work on the casting volume is 251,69 m3 and the volume of the reinforcement is 35.558,20 kg. The percentage difference between the Quantity Take Off volume comparison of the two methods is 9,68% for architectural work volume and 9,00% for structural work volume.

References

Anindya, A. A., & Gondokusumo, O. (2020). Kajian Penggunaan Cubicost Untuk Pekerjaan Quantity Take Off Pada Proses Tender. Jurnal Muara Sains, Teknologi, Kedokteran Dan Ilmu Kesehatan, 4(1), 83. https://doi.org/10.24912/jmstkik.v4i1.6718

Apriadi, A. (2024). The application of building information modelling (BIM) for cost and time analysis: Bintang Bano Dam, West Sumbawa, Indonesia. *AIP Conference Proceedings*, *2927*(1). https://doi.org/10.1063/5.0192688

CRC Construction Innovation. (2007). Adopting BIM for facilities management Solutions for managing the Sydney Opera House.

Dwi Novita, R., & Pangestuti, E. K. (2021). Analisa Quantity Take Off Dan Rencana Anggaran Biaya Dengan Metode Building Information Modeling (Bim) Menggunakan Software Autodeks Revit 2019 (Studi Kasus: Gedung Lp3 Universitas Negeri Semarang) Quantity Take Off Analysis And Cost Budget Plan Using Building Information Modeling (Bim) Method Using Autodeks Revit 2019 Software (Case Study: Lp3 Building Of Universitas Negeri Semarang).

Ergen, F. (2024). Development of ontological algorithms for exact QTO of reinforced concrete construction items. *Structures*, *60*. https://doi.org/10.1016/j.istruc.2024.105907

Forth, K. (2023). Calculation of embodied GHG emissions in early building design stages using BIM and NLP-based semantic model healing. *Energy and Buildings*, *284*.

https://doi.org/10.1016/j.enbuild.2023.112837

Hage, S. (2023). Efficiency in the Preparation of Life Cycle Assessment. *Environmental Science and Engineering*, 143–155. https://doi.org/10.1007/978-3-031-43478-5_15

Huang, M. Q. (2023). A framework for integrating embodied carbon assessment and construction feasibility in prefabricated stations. *Tunnelling and Underground Space Technology*, *132*. https://doi.org/10.1016/j.tust.2022.104920

Ike Marbun Nur Rohmah. (2023). Analisis Perbandingan Perhitungan Volume Struktur Antara Building Information Modelling Dengan Metode Konvensional Pada Proyek Design & Build Penataan Kawasan Pura Besakih.

Karya, J., & Sipil, T. (2016). Perbandingan Efisiensi Waktu, Biaya, Dan Sumber Daya Manusia Antara Metode Building Information Modelling (Bim) Dan Konvensional (Studi Kasus: Perencanaan Gedung 20 Lantai) (Vol. 5, Issue 2). Halaman. http://ejournal-s1.undip.ac.id/index.php/jkts

Laorent, D., Nugraha, P., & Budiman, J. (2019). Analisa Quantity Take-Off Dengan Menggunakan Autodesk Revit. Dimensi Utama Teknik Sipil, 6(1), 1–8. https://doi.org/10.9744/duts.6.1.1-8

Luqman Alghifarry. (2017). S1-2017-330418-abstract.

Olsen, D., & Taylor, J. M. (2017). Quantity Take-Off Using Building Information Modeling (BIM), and Its Limiting Factors. Procedia Engineering, 196, 1098–1105. https://doi.org/10.1016/j.proeng.2017.08.067

Ren, S. (2024). An automatic design-feedback process for structural prefabricated components quantity take-off calculation using BIM. *Architectural Engineering and Design Management*, *20*(2), 287–302. https://doi.org/10.1080/17452007.2023.2272623

Risky Apriansyah. (2021). Lembar Pengesahan Implementasi Konsep Building Information Modelling (Bim) Dalam Estimasi Quantity Take Off Material Pekerjaan Struktural Implementation The Concept Of Building Information Modelling (BIM) In The Estimation Of Quantity Take Off Materials Of Structural Work.

Sampaio, A. Z. (2023a). BIM Manager Role in the Integration and Coordination of Construction Projects. *Buildings*, *13*(8). https://doi.org/10.3390/buildings13082101

Sampaio, A. Z. (2023b). The use of BIM-based tools to improve collaborative building projects. *Procedia Computer Science*, *219*, 2027–2034. https://doi.org/10.1016/j.procs.2023.01.504

Saputra, C. G. P. H. (2024). Application of 5D building information modeling using Cubicost in estimating construction structure work costs (Case study: Emergency Room and Hemodialysis Building at Waras Wiris Local General Hospital of Boyolali, Indonesia). *Engineering and Applied Science Research*, *51*(3), 276–285. https://doi.org/10.14456/easr.2024.27

Saputra, H. (2024). Comparative Analysis of Quantity Take-Off Material Between Conventional Method & BIM Nemetschek Allplan Method on Bridge. *Civil Engineering and Architecture*, *12*(4), 2622–2633. https://doi.org/10.13189/cea.2024.120410

Sholichan, A. (2024). Minimize the risk of time delay & cost overrun based on M-PERT & BIM 5D on structural work in stadium construction. *AIP Conference Proceedings*,

2710(1). https://doi.org/10.1063/5.0144140

Sierra, C. (2023). Building Information Modelling for Constructability and Asset Management of Large Rail Infrastructure. *2023 IEEE Engineering Informatics, EI 2023*. https://doi.org/10.1109/IEEECONF58110.2023.10520519

Tanko, B. L. (2024). BIM in the Malaysian construction industry: a scientometric review and case study. *Engineering, Construction and Architectural Management*, *31*(3), 1165–1186. https://doi.org/10.1108/ECAM-04-2021-0324

Valinejadshoubi, M. (2024). Automated system for high-accuracy quantity takeoff using BIM. *Automation in Construction*, *157*. https://doi.org/10.1016/j.autcon.2023.105155

Wardito, E. (2024). Increasing the value of jetty projects based on building information modelling 5D (BIM 5D). *AIP Conference Proceedings*, *2710*(1). https://doi.org/10.1063/5.0144139