COMPARATIVE ANALYSIS OF COLUMN AND BEAMS VOLUMES OF CONVENTIONAL STRUCTURES WITH OUTPUT FROM AUTODESK REVIT AND PLAN TIME WITH WORK REALIZATION USING NAVISWORK (Case Study: Construction of the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital Building)

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ABSTRACT

The government issued regulations related to BIM (Building Information Modeling) in July 2021. The PUPR Ministry issued circular no. 11/SE/Db/2021 which requires the implementation of BIM. There are BIM supporting applications, namely Autodesk Revit and Autodesk Naviswork. This research takes a case study of the construction of the Prof. Mother and Child Hospital Building. Dr. I.G.N.G Ngoerah Denpasar, whose BoQ calculations still use conventional or manual methods. Therefore, this research was carried out to find out the comparison of the Building Information Modeling and conventional concepts. Secondary data includes work drawings, BoQ, schedule and AHSP. Based on the research that has been carried out, the results of the comparison of the volume of columns and beams of the Autodesk Revit output structure are the total volume of 852,921.74 kg of steel and 2,456.72 m3 of concrete with a comparison of the volume of concrete between conventional and output from Autodesk Revit 1:0.946 and the volume ratio of 1:0.976 with a total cost of conventional RAB of IDR 19,313,295,875.58 and RAB from Autodesk Revit of IDR 18,760,742,153.46 with a ratio of conventional RAB to output from Autodesk Revit of 1:0.971. deviation of -2.95% where the RAB from Autodesk Revit is IDR 552,553,722.12 less. The results of the plan time display with realization produce 12 work items that are being worked on and 30% work realization is achieved on day 119

Keywords: BIM, Autodesk Revit, Autodesk Naviswork, Volume, RAB

1. INTRODUCTION

In efforts to achieve digital transformation in the construction industry, the use of technological innovation is an absolute necessity. The goal is to enhance project execution quality and accelerate development. This is expected to improve national competitiveness in the era of Industry 4.0 [1].

In Indonesia, the government has taken various steps to address challenges in infrastructure development by issuing regulations related to the implementation of Building Information Modelling (BIM) in the construction industry. The Ministry of Public Works and Housing (PUPR) has issued regulations supporting the use of BIM in accordance with Law No. 2 of 2017 concerning Construction Services. The use of BIM covers various aspects, from

architectural drawings, structural drawings, utility drawings, to landscape drawings, as well as detailed volumes of work execution and cost budget plans (Pantiga & Soekiman, 2021).
There is a BIM supporting software known as Autodesk Revit. Autodesk Revit functions to design architecture, structure, and MEP (Mechanical, Electrical, Plumbing) systems, supporting 3D (working drawings) and 5D BIM implementation (quantitative material take-off analysis) [2].

Additionally, there is an application supporting Project Scheduling called Autodesk Navisworks Manage. This application enables the integration of multidisciplinary design data from various BIM applications into a single integrated project model. Furthermore, Autodesk Navisworks functions to support project scheduling with 4D scheduling simulation (Simulation Scheduling) [3].

With various regulations and advantages of BIM, it is necessary to reconsider the calculation methods used in preparing the Bill Of Quantity (BoQ), which still employ conventional methods involving manual item-by-item calculations. This requires precision, especially in concrete and reinforcement calculations, which are significant cost factors. Similarly, scheduling needs the latest innovation with Navisworks Application, which can display scheduled work sequences according to the real progress of the building, providing visual information to the owner.

Based on these considerations, this research is conducted to compare Building Information Modeling concepts with conventional methods, assessing the modeling results to review work volume, costs, and time. This study takes the case of the Construction of the Prof. Dr. I.G.N.G. Ngoerah Maternity and Pediatric Hospital in Denpasar, where BoQ calculations still utilize conventional or manual methods."

2. THEORY AND METHODS

2.1 Theory

Previous research

Previous research similar to this was also conducted by Laorent [4] titled "Quantity Take Off Analysis Using Autodesk Revit". The study was conducted at the location of Petra Christian University Building P1 in Surabaya. The results of this research show the advantages of Revit in performing quantity take-offs effectively and efficiently in terms of time, as it can calculate volumes more quickly. However, a drawback of Revit in modeling is that it requires a significant amount of time and meticulousness to achieve accurate results.

Building Information Modeling

BIM (Building Information Modeling) is an information technology used in the AEC (Architecture, Engineering, and Construction) industry. It begins with the creation of a 3D digital model containing all information about the building [5]. When BIM is implemented, the model must encompass all building information used for collaboration, estimation, and decision-making related to design, construction, costs, and building[6].

Autodesk Revit

Autodesk Revit has functions for designing architecture, structures, as well as MEP (Mechanical, Electrical, and Plumbing). Using this software, users can design buildings and structures by modeling components in 3D. Additionally, the software allows users to generate 2D construction drawings and perform material quantity take-off analysis (5D) for each task [2]

Autodesk Naviswork

Autodesk Naviswork adalah sebuah aplikasi yang mendukung simulasi schedulling (5D). Navisworks berguna untuk review model secara keseluruhan dari sebuah plant. Navisworks banyak digunakan untuk meriview hasil pekerjaan [7].

Bill Of Quantitiy (BoQ)

Bill Of Quantity (BOQ) is a document used in tenders that contains descriptions and quantities of work. The BOQ document is an integral part of the bidding process, outlining provisions and specifications of the products that must be met. Therefore, in the tender process, contractors have the opportunity to negotiate [8].

Work Time Schedule

The schedule determination plan for each project task, known as the time schedule, is developed to establish time constraints for completing a project. With a time schedule, a project manager can grasp an overview of the work durations and relationships between job segments. This aims to prevent delays in the construction process. The authors employ Bar Charts, S-curves, and Network Diagrams in the time schedule used [9].

Quantity Take Off Material

Quantity take off is a method used to compile a complete list of materials needed for a construction project, including cost estimates for each material. This is a fundamental element of quantity take off in the construction context, but it is important to explore other components of this type of quantity take off. The initial process of quantity take off involves creating a comprehensive list of all materials required for the project, encompassing various types such as wood, concrete, asphalt, and steel. Additionally, quantity take off also includes all prefabricated elements necessary for the construction project [10].

2.2 Research Methods

Comparative Analysis of Column and Beam Volume in Structure Using Conventional Methods versus Outputs from Autodesk Revit and Planned Time versus Actual Work using Naviswork. (Study on the Construction of the Prof. Dr. I.G.N.G Ngoerah Mother and Child Hospital Building in Denpasar). The research systematics are displayed in the flowchart below with the following procedural explanations.

The problem identification begins with the government issuing regulations on the mandatory use of BIM and the often inaccurate conventional calculations. Next, a literature review is conducted to find relevant previous writings to support the background of this study, and to evaluate the strengths and weaknesses of previous studies.

The research object in this final project is the Construction Project of the Prof. Dr. I.G.N.G Ngoerah Mother and Child Hospital Building in Denpasar with a contract value of IDR 171,000,000,000. This building consists of five floors with an area of 21,341 m². The data collected are secondary data obtained from the project and also from the PUPR Department, including the time schedule, working drawings, AHSP, and BoQ.

After that, modeling is done in Autodesk Revit, including reinforced concrete structure modeling, followed by clash checks in Naviswork, and scheduling simulation. This provides information in the form of volume, drawings, and sectional details as well as scheduling simulation, which will be compared with conventional methods, followed by suggestions, conclusions, and completion.

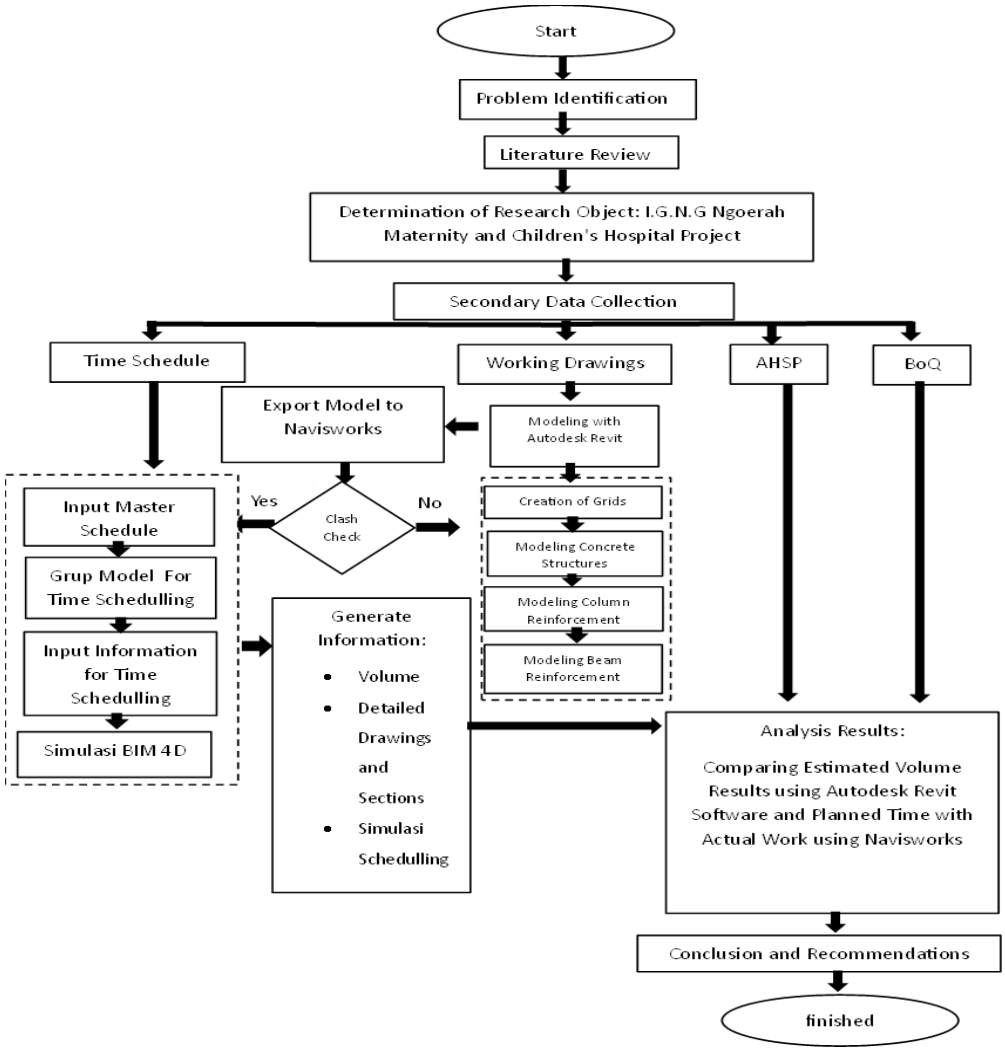

Figure 1 Flowchart

3. RESULTS AND DISCUSSION

Autodesk Revit Modeling Stages

The steps to obtain the work volume output and detailed drawings from Autodesk Revit are:

1. Adjust the number of grids and elevations to match the working drawings from AutoCAD.

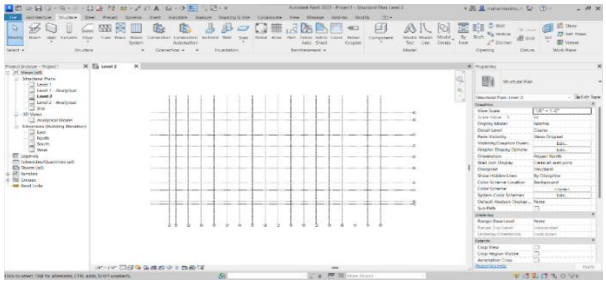

Figure 2 Grid Layout

2. Create the structural modeling of the foundation, columns, beams, and slabs.

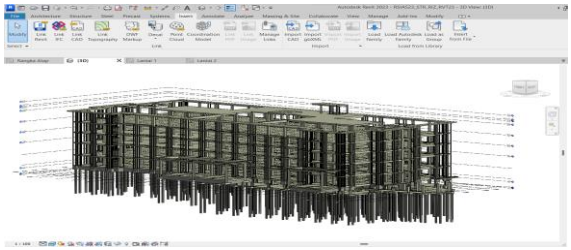

Figure 3 Structural Modeling

3. Create reinforcement details from the structural modeling that has been completed.

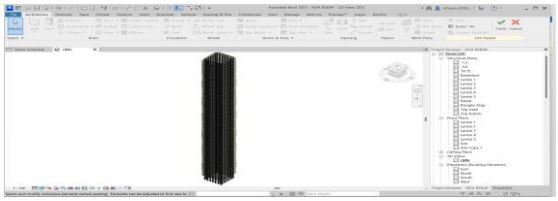

Figure 4 Reinforcement Modeling

4. Perform a clash check to identify any collisions between work items.

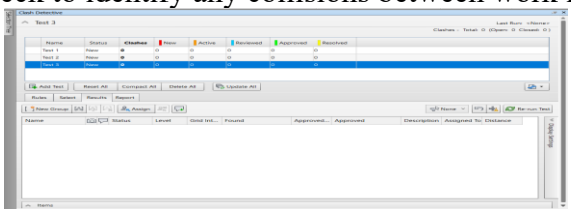

Figure 5 Clash Check

4D Modeling Stages in Autodesk Navisworks

The roadmap to obtain the work volume output and detailed drawings from Autodesk Naviswork is:

1. Import the 3D Revit model into the Autodesk Navisworks application.

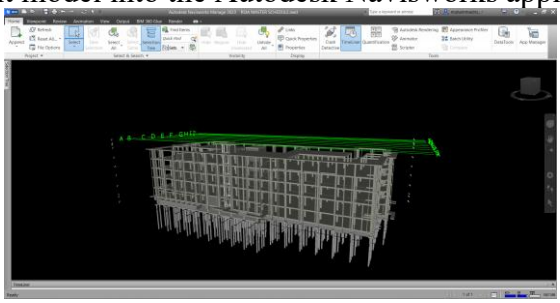

Figure 6 Import Model

2. Input the schedule file from Ms Project into Autodesk Navisworks.

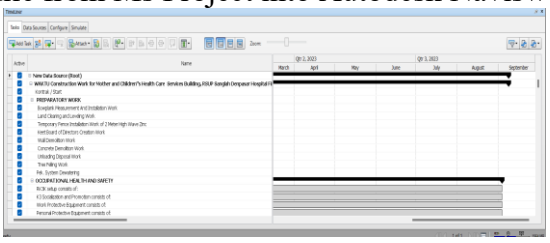

Figure 7 Input Schedule

3. Group the tasks to be used later in scheduling simulations.

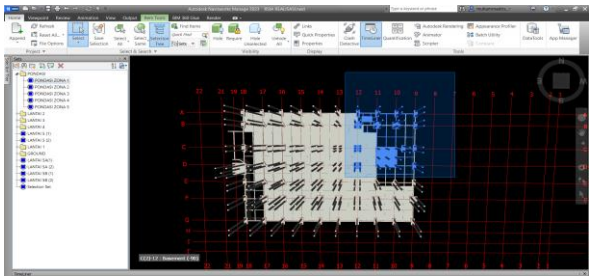

Figure 8 Grouping Attached

4. Select the simulate menu and then perform scheduling simulation.

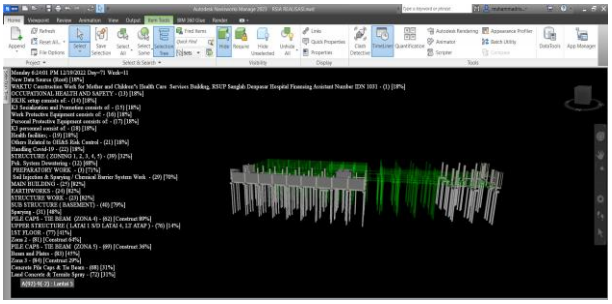

Figure 9 Scheduling Simulation

Comparison of Conventional Volume with Revit Volume

The comparison results were obtained by comparing the BoQ volume from the contract document with the volume generated from modeling using the BIM application, Revit. Data analysis was performed by comparing the BoQ volume from the contract document with the BoQ volume from modeling using BIM Revit for each work item. The deviation value was calculated based on the two obtained data sets, with the conventional value considered as 1. The comparison results are presented in Table 1 and Table 2.

Table 1 Summary of Concrete Work

Floor	Contract Volume (M3)	BIM Revit Volume (M3)	Deviation (%)
1	528,43	500,57	-5,27
2	566.13	536,50	-5,23
3	513,37	487,45	-5,42
4	516.16	487,89	-5,54
5	470,68	444,61	-5,54
Total	2.596,77	2.456,72	-5,39
Comparison	1	0,946	

In Table 1, it was found that the total concrete work for the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital building, based on the contract volume, is 2,596.77 m3, and using BIM, it is 2,456.72 m3. The comparison of the two data sets is 1:0.946, resulting in a deviation of -5.73%, which means the BIM calculation volume is smaller than the conventional one.

Table 2 Reinforcement Work Summary

Floor	Contract Volume (M3)	BIM Revit Volume (M3)	Deviation (%)
1	133.279,27	133.822,39	-2,52
2	200.297,39	194.364,90	-2,96
3	187.244,31	183.879,96	-1,80
4	175.467,32	170.404,19	-2,89
5	173.764,99	170.450,30	-1,91
Total	874.053,28	852.921,75	-2,42
Comparison	1	0,976	

In Table 2, it was found that the total reinforcement work for the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital building, based on the contract volume, is 874,053.28 kg, and using BIM, it is 852,921.75 kg. The comparison of the two data sets is 1:0.976, resulting in a deviation of -2.42%, which means the BIM calculation volume is smaller than the conventional one.

The differences in the two work items are due to the following reasons: The overall difference in concrete volume is caused by the fact that the contract volume calculations are based on centerline dimensions without accounting for clashes, such as the intersections between beams and columns. The overall difference in reinforcement volume is due to the contract volume calculations not considering clashes or overlaps, such as the intersections between overlapping beams and column reinforcements.

Comparison of Contract BoQ with Revit BoQ

The comparison results were obtained by comparing the BoQ from the contract document with the BoQ generated from modeling using the BIM application, Revit. Data analysis was performed by comparing the BoQ from the contract document with the BoQ from modeling using BIM Revit for each work item. The deviation value was calculated based on the two obtained data sets, with the conventional value considered as 1. The comparison results are presented in Table 3.

Table 3 Comparison of Cost Estimation

Volume	Unit	Unit Price	Total Price
Konvensional			
2.596,77	M3	Rp1.108.151,85	Rp 2.877.615.479,52
874.053,28	KG	Rp 18.803,98	Rp 16.435.680.396,05
Total			Rp19,313,295,875.58
BIM			
2.456,72	M3	Rp1.108.151,85	Rp 2.722.478.812,93
852.921,75	KG	Rp 18.803,98	Rp 16.038.323.528.56
Total			Rp18,760,742,153.46
Difference			Rp552,553,722.12
Comparison			1:0,971
Deviation (%)			-2.95%

In Table 3, the total BoQ for the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital building, based on the contract BoQ, is Rp19,313,295,875.58, and using BIM it is Rp18,760,742,153.46. The comparison of the two data sets is 1:0.971, resulting in a deviation of -2.95%, which means the BIM calculation volume is smaller than the conventional one by Rp552,553,722.12.

Based on Table 3, the difference in BoQ is due to the volume calculations generated by Autodesk Revit being smaller compared to the volume generated in the contract documents.

Planned Time vs Actual Time Using Navisworks

The comparison of planned time with actual time was obtained using the planned time schedule and the actual time schedule from the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital building with the assistance of the BIM application, Navisworks.

The output from the Navisworks application will display the percentage of each task being completed in the progress, which is 30% according to the first payment phase. The data from the Navisworks output showing the percentage of completion is presented in Table 4 and Figure 10.

Table 4 30% Job Completion

30% JOB PERCENTAGE		
NO	JOB DESCRIPTION	Realization
1	2	3
1	*Structure* (Zoning 1,2,3,4,5)	99%
2	Upper *Structure*	99%
3	*Structure* (Zoning 6,7,8,9,10)	51%
4	5Th Floor	96%
5	Zona 2	95%
6	*Beam* and Plates	92%
7	Upper *Structure*	10%
8	2ND Floor	24%
9	Zona 1	78%
10	Beam and Plates	58%
11	Zona 2	23%
12	Column	83%

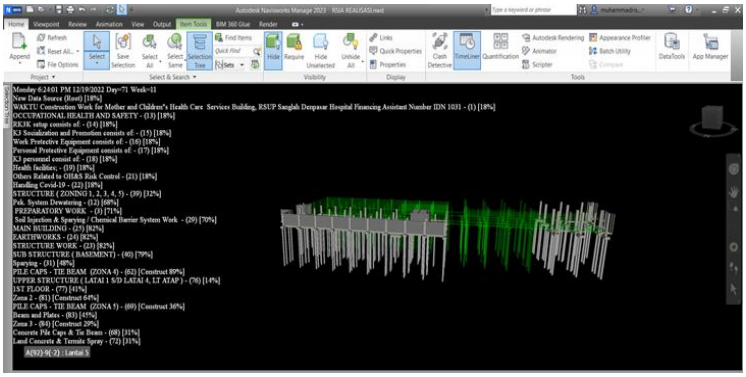

Figure 10 30% Completion Display

Based on Table 4 and Figure 10, the 30% progress output for the Prof. Dr. I.G.N.G Ngoerah Denpasar Mother and Child Hospital shows that 12 ongoing tasks have reached the 30% completion milestone, as indicated in Table 4. The completion of 30% of the work was achieved on day 119, specifically on December 12, 2022. In Figure 10, tasks currently in progress during the 30% progress phase are highlighted in green.

4. CONCLUSIONS

Based on the discussion on the Analysis of Comparison of Column and Beam Structure Volumes between Conventional Method and Autodesk Revit Output, and the Comparison of

Planned Time Schedule with Actual Work using Navisworks, several conclusions can be drawn:

1. The comparison of concrete work volumes for beams and columns between the conventional method and Autodesk Revit output shows a ratio of 1:0.946 for all concrete works and 1:0.976 for all reinforcement works. There is a deviation of -4.71% for all concrete works and -2.42% for all reinforcement works.
2. The comparison of costs for beam and column structure works between the conventional method and Autodesk Revit output shows a ratio of 1:0.971, with a deviation of -2.95%, resulting in a cost difference of Rp552,553,722.12.
3. The display of time with realization at the 30% progress of work using Navisworks resulted in 12 ongoing tasks achieving 30% completion, with the 30% work realization achieved on day 119, specifically on December 12, 2022.

REFERENCES

[1] O. H. Simarmata, "Teknologi Canggih dalam Manajemen Proyek Teknik Sipil: Transformasi Digital di Lapangan," *Tugas Mahasiswa Sipil*, vol. 1, no. 1, 2023.

[2] S. CHINDRIKA KUMARA, "Penerapan Building Information Modeling (BIM) Menggunakan Software Autodesk Revit 2019 (Studi Kasus: Gedung B Fakultas Ekonomi dan Bisnis Universitas Lampung)," 2023.

[3] S. RACHMAWATI, "Implementasi Konsep Bim 4d Dalam Perencanaan Time Schedule Dengan Analsis Resources Levelling (Implementation Of 4d Bim Concept In Time Schedule Planning With Resources Levelling Analysis)(Studi Kasus: Proyek Pembangunan Gedung Fakultas Ilmu Kesehatan Universitas Hendral Soedirman, Purwokerto, Jawa Tengah)," 2022.

[4] D. Laorent, P. Nugraha, and J. Budiman, "Analisa quantity take-off dengan menggunakan autodesk revit," *Dimensi Utama Teknik Sipil*, vol. 6, no. 1, pp. 1–8, 2019.

[5] I. Putera, "Manfaat BIM Dalam Konstruksi Gedung: Suatu Kajian Pustaka," *Jurnal Ilmiah Teknik Sipil*, vol. 26, no. 1, pp. 43–52, 2022.

[6] Y. Arayici, T. Fernando, V. Munoz, and M. Bassanino, "Interoperability specification development for integrated BIM use in performance based design," *Autom Constr*, vol. 85, pp. 167–181, 2018.

[7] R. Ferial, B. Hidayat, R. C. Pesela, and D. Daoed, "Quantity take-off berbasis building information modeling (bim) studi kasus: gedung bappeda padang," *Jurnal Rekayasa Sipil*, vol. 17, no. 3, pp. 228–238, 2021.

[8] T. P. Artanti, I. K. Sucita, and E. Yanuarini, "PERBANDINGAN BOQ TULANGAN ANTARA METODE KONVENSIONAL DENGAN BIM APARTEMEN 'X,'" *Jurnal Poli-Teknologi*, vol. 21, no. 1, pp. 28–35, 2022.

[9] U. H. Umar and W. M. Putra, "Estimasi Waktu untuk Pengadaan Material Berdasarkan Time Schedule pada Proyek Pembangunan Ruko Kawasan SP Plaza Batu Aji," *Journal of Civil Engineering and Planning*, vol. 10, no. 10, 2020.

[10] M. Shick Alshabab, A. Vysotskiy, M. Petrichenko, and T. Khalil, "BIM-based quantity takeoff in autodesk revit and navisworks manage," in *International Scientific Conference on Energy, Environmental and Construction Engineering*, Springer, 2019, pp. 413–421.