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Utilization of BIM for Construction Cost Estimation of the Girder Bridge Structure in the IKN Project (Karang Joang–KKT Kariangau Segment)

Irna Hendriyani[1], Reno Pratiwi[1], Risa Aghix Primastyo Utomo[1]

[1]Departement of Civil Engineering, Balikpapan University

✉ irna.hendriyani@uniba-bpn.ac.id

The implementation of Building Information Modeling (BIM) is increasingly important for improving the efficiency and accuracy of quantity takeoff and cost estimation in large-scale infrastructure projects. This study evaluates 5D BIM using Allplan Engineering for girder bridge structural work (pilecap, pier, and pierhead) in the IKN Toll Road project, Karang Joang–KKT Kariangau Segment, and compares the results with Quantity Surveyor (QS) data and manual recalculation based on Detailed Engineering Design (DED) drawings. Using a comparative quantitative approach, the study developed a 3D model from DED data and performed BIM-based quantity extraction and cost estimation using unit prices from the project Budget Plan (RAB). The results show close agreement across methods, with total differences below 1% for both reinforcement and concrete quantities and costs. Compared with QS, BIM results are 0.17% lower for reinforcement and 0.17% higher for concrete; compared with manual recalculation, differences range from approximately 0.17% to 0.23%. Item-level discrepancies are most evident in Pierhead PH1 (up to 2.72% for concrete) and Pier P1 (up to 3.02% for reinforcement). Overall, 5D BIM in Allplan Engineering provides reliable and traceable outputs for quantity takeoff and cost estimation and supports faster updates during design revisions in national-scale infrastructure projects.

Keywords: Building Information Modeling (BIM); 5D BIM; Allplan Engineering; quantity takeoff (QTO); cost estimation; girder bridge; IKN Toll Road.

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Introduction

Technology in the construction sector offers significant benefits across various aspects of work, including modeling, planning, cost and volume estimation, sustainable development, and facility management (Prastya, Celvin Adi Prastya; Hendriyani, Irna; Pratiwi Reno, 2025). Currently, many companies have integrated automation through software, notably through the implementation of Building Information Modeling (BIM). BIM is a 3D modeling technology capable of representing all information within a construction project, including methods, materials, management, and work sequences. The implementation of BIM consists of several stages, commonly referred to as dimensions, which represent the level of execution relative to the construction phases. These dimensions include 3D (visualization and collaboration), 4D (scheduling), 5D (cost estimation and volume takeoff), 6D (sustainability), and 7D (facility management). To support the BIM concept, specialized software is required, such as Allplan Engineering. This software can be utilized to design construction models in 3D for structural, architectural, and Mechanical, Electrical, and Plumbing (MEP) works. Through 3D modeling, 2D working drawings and cost estimation analyses for each construction component can be generated. While previous BIM studies (Suasira, I Wayan; Tapayasa, I Made; Santiana, I Made Anom; Wibawa, I Gede Satra, 2021) and (Diantoro, Bayu Rahmad; Hendriyani, Irna; Pratiwi, Reno, 2024) utilized Tekla and Autodesk Revit, this study conducts a BIM analysis using Allplan Engineering.

Among the seven BIM dimensions, cost estimation planning is critical in construction planning. 5D BIM serves as an alternative solution to achieve the necessary precision. High accuracy in construction cost estimation is essential for achieving planning efficiency. Research by Farhana and Abma (Farhana, Amalina; Abma, Vendie, 2022) indicates that using the 5D BIM concept for cost estimation results in a deviation of approximately ±7% or less compared to the initial Budget Plan (RAB). This approach is particularly relevant for the development of Indonesia's New Capital (IKN) currently underway in East Kalimantan. One of the ongoing projects is the IKN Toll Road 3A, Karang Joang – KKT Kariangau Segment, located in North Balikpapan. The contract value for this project is IDR 3,335,421,077,000.00 (including 11% VAT). The project comprises several structures, including a 9.94 km main road, 2,975 m of slab-on-pile, a 415 m girder bridge, five overpasses, and one

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junction. This study focuses on the structural work of Girder Bridge 1, which includes sub-items such as foundations (pile caps), columns (piers), floor slabs, girders, bore piles, abutments, and barriers, with an estimated structural concrete cost of IDR 47,081,022,901.66.

In construction project management, three primary aspects must be prioritized: time efficiency, cost control and cost minimization, and quality standards compliance (Salsabila & Abma, 2023). In practice, cost estimation for bridge projects faces various technical and managerial challenges. Conventional estimation methods still rely on the interpretation of 2D drawings and manual calculations by planning consultants. This situation is prone to human error, information duplication, and discrepancies between the design model and field conditions. Furthermore, design changes during execution often necessitate major revisions to the Budget Plan (RAB), leading to delays and cost overruns. The lack of integration between technical disciplines—such as structural, architectural, and MEP—often causes overlapping work volumes or material specification mismatches.

Based on this background, this research implements the 5D BIM concept using Allplan Engineering software to evaluate the output of BIM-based cost estimation (5D BIM) in supporting structural work cost estimation. The analysis provides a comparison between BIM-based cost estimation and manual recalculation based on design drawings. It is expected that this study will enhance the effectiveness and efficiency of Girder Bridge construction in the IKN Toll Road project, Karang Joang – KKT Kariangau Segment.

The research questions for this study are formulated as follows: (1) how is the volume analysis and cost estimation conducted using the Building Information Modeling (BIM) concept for the Girder Bridge construction in the IKN Project, Karang Joang – KKT Kariangau Segment? (2) what is the variance in volume and cost analysis between the BIM method and the manual recalculation method for the Girder Bridge construction in the IKN Project, Karang Joang – KKT Kariangau Segment?

The objectives of this research are (1) to analyze the volume and cost estimation using the Building Information Modeling (BIM) concept for the structural work of the Girder Bridge in the IKN Project, Karang Joang – KKT Kariangau Segment. (2) to analyze the variance in volume and cost between the BIM method and the manual recalculation method for the Girder Bridge construction in the IKN Project, Karang Joang – KKT Kariangau Segment.

Research Methodology

This study was conducted to evaluate the implementation of the Building Information Modeling (BIM) concept using Allplan Engineering software in supporting the preparation of the Budget Plan (RAB) for construction projects. The methods employed in this research include a literature study, data collection, BIM-based modeling, and cost estimation analysis (5D BIM).

Literature Study

This stage aims to identify theories, concepts, and previous research findings relevant to BIM implementation for volume takeoff and cost estimation in infrastructure projects. The analyzed sources include scientific articles, research reports, and Allplan Engineering software manuals. Primary references are derived from prior studies, including Suasira et al. (2021), Diantoro et al. (2024), and Prastya et al. (2025), which explored the effectiveness of BIM in construction cost estimation. Based on the literature findings, the study framework and data requirements were determined to support the modeling and cost estimation process.

Data Collection

The data collected pertains to the IKN Toll Road Project, Karang Joang – KKT Kariangau Segment, North Balikpapan, East Kalimantan. The data consist of the structural work Budget Plan (RAB) and the Detailed Engineering Design (DED). Additionally, supporting information such as technical specifications and unit price analysis (Analisa Harga Satuan Pekerjaan/AHSP) based on actual project documents was gathered. These data serve as the primary inputs for BIM modeling and subsequent volume and cost estimation.

Modeling and BIM-Based Cost Estimation (5D BIM)

Based on the DED and technical drawings, the bridge structure was remodeled using Allplan Engineering 2021. The modeling process followed architectural and structural templates in accordance with technical standards for reinforced concrete structures. This process produced a 3D model integrated with material quantity data (concrete and reinforcement volumes), which was subsequently used to generate BIM-based cost estimation outputs using the 5D BIM approach. The outputs from this stage provide BIM-based quantities and cost estimates to be evaluated against conventional estimation methods.

Volume and Cost Estimation Analysis (Comparison)

The BIM-based volume and cost estimation results were compared with the Quantity Surveyor (QS) analysis and manual recalculation based on design drawings. The QS analysis refers to data processed by the project's QS team. This comparison was conducted to assess the variance in volume and cost between methods and to evaluate the accuracy of BIM-based estimation relative to QS and manual recalculation.

Comparative Analysis and Data Validation

The calculation results from the three methods (BIM, QS, and manual recalculation) were analyzed using a comparative approach. Differences among methods were calculated as percentage deviations for both reinforcement and concrete volumes, as well as the resulting cost estimates. Validation was conducted to ensure that the BIM-based quantities and cost outputs remained consistent with the DED, technical specifications, and other project documentation, and—where applicable—field conditions.

Results Interpretation and BIM Efficiency Evaluation

The final stage involves interpreting the results to evaluate the efficiency and accuracy of BIM implementation in cost estimation. The evaluation focuses on the benefits of BIM in terms of time effectiveness, quantity precision, and the ease of revising the Budget Plan (RAB) when design changes occur.

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The research was conducted at the IKN Toll Road Project, Karang Joang – KKT Kariangau Segment, North Balikpapan District, Balikpapan City, East Kalimantan Province. The geographical location is illustrated in Figure 1.

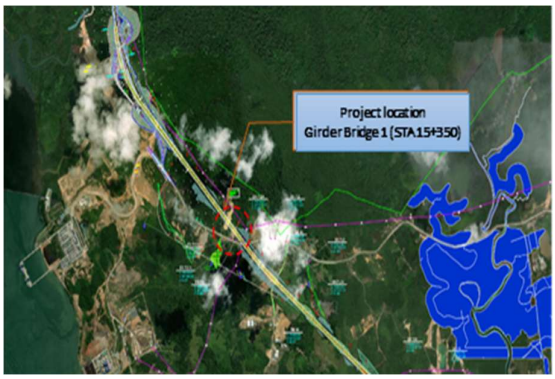

Figure 1 Project location

Results

Project Information

This study evaluates 5D BIM implementation for quantity takeoff and cost estimation in the IKN Toll Road project, Karang Joang – KKT Kariangau Segment, located in Balikpapan City, East Kalimantan. The analysis focuses on the girder bridge structural work (pilecap, pier, and pierhead) using three approaches: QS data, BIM outputs from Allplan Engineering, and manual recalculation based on DED drawings.

Quantity Takeoff Results

QS-Based Quantities

QS quantities were obtained from official project documentation. For example, the concrete volume for Pier P1 reported in QS records is 69.12 m³ (Figure 2). The QS recapitulation of concrete volumes for pilecap, pier, and pierhead work is presented in Table 1, with a total concrete volume of 3,816.13 m³. The QS recapitulation of reinforcement quantities is presented in Table 2, with a total reinforcement quantity of 396,726.31 kg (Figure 3 provides an example of the reinforcement record from project documents).

Table 1 Concrete Volumes for Pilecap, Pier, and Pierhead Works (QS Data)

No.	Work Item	Unit	Volume
1	Pilecap P1, P2, P3, P4	m^3	2,183.89
2	Pier 1	m^3	69.12
3	Pier 2	m^3	96.00
3	Pier 3	m^3	92.80
5	Pier 4	m^3	99.20
6	Pierhead 1	m^3	241.86
7	Pierhead 2, 3, 4	m^3	1,033.26
Total			**3,816.13**

Table 2 Recapitulation of Reinforcement Quantity for Girder Bridge Structure Based on QS Analysis

No.	Work Item	unit	Volume
1	Pilecap P1, P2, P3, P4	kg	21,410.59
2	Pier 1	kg	23,897.04
3	Pier 2	kg	36,587.58
3	Pier 3	kg	35,741.55
5	Pier 4	kg	37,592.57
6	Pierhead 1	kg	68,679.60
7	Pierhead 2, 3, 4	kg	172,817.37
Total			**396,726.31**

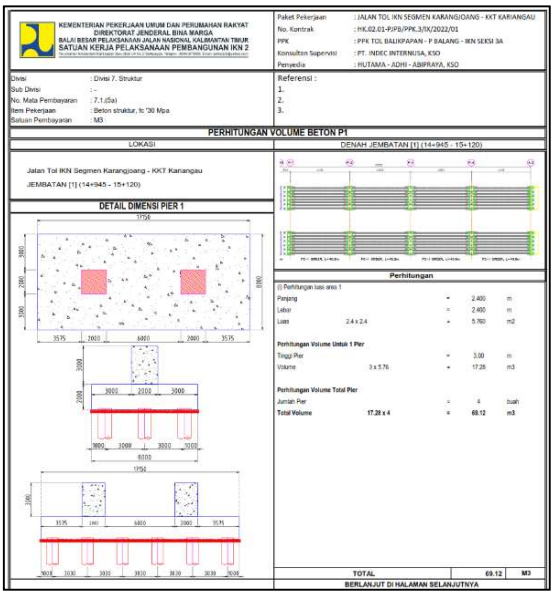

Figure 2 Pier 1 concrete volume data from the QS (Project Document Source)

Manual Recalculation Quantities

Manual recalculation was conducted using DED drawings following the conventional consultant approach. The recapitulation of concrete volume from recalculation is presented in Table 3, with a total of 3,816.13 m³ for the evaluated work items. The recapitulation of reinforcement quantity from recalculation is shown in Table 4, yielding a total reinforcement quantity of 395,816.98 kg.

BIM-Based Quantities (Allplan Engineering)

The bridge structure was remodeled using Allplan Engineering, and quantities were extracted from the BIM model. The concrete volume recapitulation is shown in Figure 4, while reinforcement quantity recapitulation is shown in Figure 5.

Cost Estimation Results (Basis: Budget Plan/RAB)

Cost estimation in this study used unit prices from the project's Budget Plan (RAB) applicable to the Karang Joang – KKT Kariangau Segment (Figure 6). Using identical unit prices across methods ensures that cost differences arise from quantity differences only.

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QS Cost Estimation

The QS-based cost recapitulation for bridge girder structure work is presented in Table 5. The total cost is IDR 21,289,228,148.64, consisting of IDR 13,088,533,545.00 for concrete work and IDR 8,200,694,603.64 for reinforcement work.

BIM Cost Estimation (Allplan Engineering)

The BIM-based cost estimation results are presented in Table 6. The total cost is IDR 21,297,158,541.80, consisting of IDR 13,110,314,615.00 for concrete work and IDR 8,186,843,926.80 for reinforcement work.

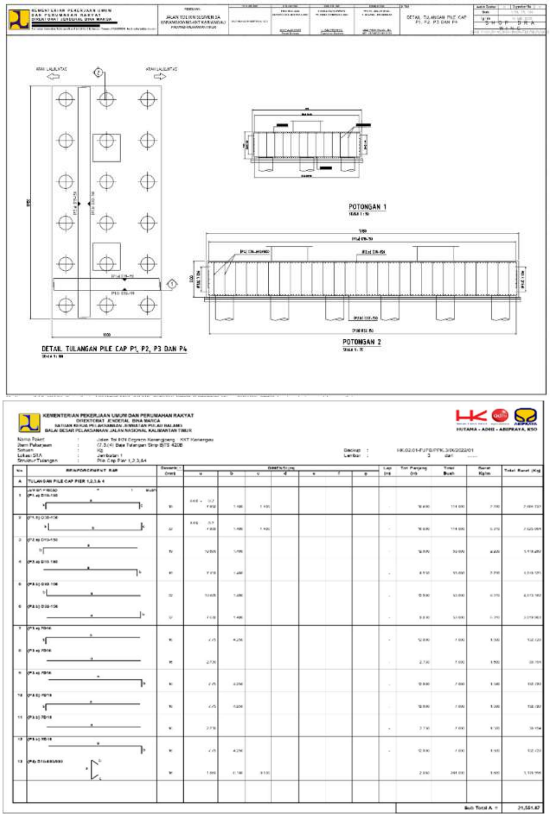


Figure 3 . Pilecap reinforcement quantity record (Project Document Source).

Table 3 Recapitulation of concrete volume of bridge girder structure work based on recalculation

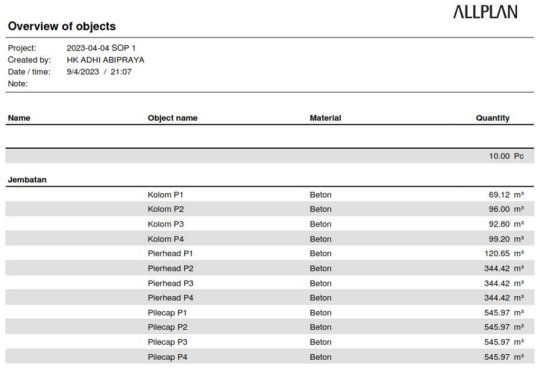
No.	Work Item	Unit	Volume
1	Pilecap P1, P2, P3, P4	m^3	2,183.89
2	Pier 1	m^3	69.12
3	Pier 2	m^3	96.00
3	Pier 3	m^3	92.80
5	Pier 4	m^3	99.20
6	Pierhead 1	m^3	241.86
7	Pierhead 2, 3, 4	m^3	1,033.26
Total		**m^3**	**3,816.13**

Manual Recalculation Cost Estimation

The manual recalculation cost results are presented in Table 7. The total cost is IDR 21,256,372,259.28, consisting of IDR 13,088,293,060.00 for concrete work and IDR 8,168,079,199.28 for reinforcement work.

Table 4 Calculation of reinforcement volume for bridge girder structure work based on recalculation

No.	Work Item	Unit	Volume
1	Pilecap P1, P2, P3, P4	kg	21,472.09
2	Pier 1	kg	23,915.17
3	Pier 2	kg	36,600.83
3	Pier 3	kg	35,630.08
5	Pier 4	kg	37,608.74
6	Pierhead 1	kg	68,441.35
7	Pierhead 2, 3, 4	kg	172,148.72
Total		**kg**	**395,816.98**

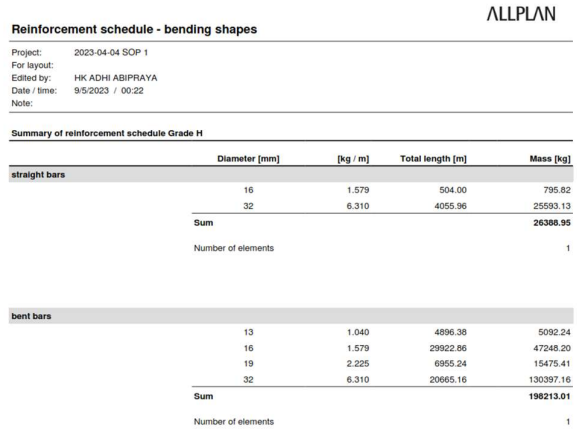

ALLPLAN

Overview of objects

Project: 2023-04-04 SOP 1
Created by: HK ADHI ABIPRAYA
Date / time: 9/4/2023 / 21:07
Note:

Name	Object name	Material	Quantity
			10.00 Pc
Jembatan			
	Kolom P1	Beton	69.12 m³
	Kolom P2	Beton	96.00 m³
	Kolom P3	Beton	92.80 m³
	Kolom P4	Beton	99.20 m³
	Pierhead P1	Beton	120.65 m³
	Pierhead P2	Beton	344.42 m³
	Pierhead P3	Beton	344.42 m³
	Pierhead P4	Beton	344.42 m³
	Pilecap P1	Beton	545.97 m³
	Pilecap P2	Beton	545.97 m³
	Pilecap P3	Beton	545.97 m³
	Pilecap P4	Beton	545.97 m³

Figure 4 Concrete Volume Recapitulation (Allplan Engineering Source)


ALLPLAN

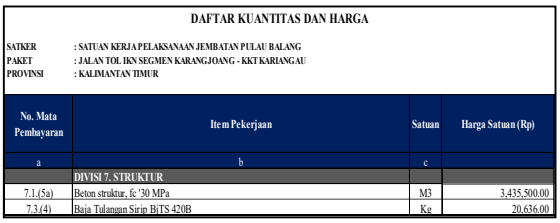
Reinforcement schedule - bending shapes

Project: 2023-04-04 SOP 1
For layout:
Edited by: HK ADHI ABIPRAYA
Date / time: 9/5/2023 / 00:22
Note:

Summary of reinforcement schedule Grade H

	Diameter [mm]	[kg / m]	Total length [m]	Mass [kg]
straight bars				
	16	1.579	504.00	795.82
	32	6.310	4055.96	25593.13
	Sum			26388.95
	Number of elements			1
bent bars				
	13	1.040	4896.38	5092.24
	16	1.579	29922.86	47248.20
	19	2.225	6955.24	15475.41
	32	6.310	20665.16	130397.16
	Sum			198213.01
	Number of elements			1

Figure 5 Recapitulation of reinforcement volume (Allplan Engineering Source)



DAFTAR KUANTITAS DAN HARGA

SATKER : SATUAN KERJA PELAKSANAAN JEMBATAN PULAU BALANG
PAKET : JALAN TOL IKN SEGMEN KARANGJOANG - KKT KARIANGAU
PROVINSI : KALIMANTAN TIMUR

No. Mata Pembayaran	Item Pekerjaan	Satuan	Harga Satuan (Rp)
a	b	c	
	DIVISI 7. STRUKTUR		
7.1.(5a)	Beton struktur, fc' 30 MPa	M3	3,435,500.00
7.3.(4)	Baja Tulangan Sirip BjTS 420B	Kg	20,636.00

Figure 6 Unit Price List for Girder Bridge Work (Project Document Source)

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Table 5 Recapitulation of bridge girder structure work costs

No.	Item Details	Unit	Unit Price (IDR)	QS (*Quantity Surveyor*)		
				Volume	Amount	Total Price (IDR)
1	**Concrete**					
	Pilecap P1, P2, P3, P4	m^3	3,435,500.00	2,183.89	8.00	7,502,754,095.00
	Pier 1	m^3	3,435,500.00	69.12	4.00	237,461,760.00
	Pier 2	m^3	3,435,500.00	96.00	4.00	329,808,000.00
	Pier 3	m^3	3,435,500.00	92.80	4.00	318,814,400.00
	Pier 4	m^3	3,435,500.00	99.20	4.00	340,801,600.00
	Pierhead 1	m^3	3,435,500.00	235.45	2.00	808,888,475.00
	Pierhead 2, 3, 4	m^3	3,435,500.00	1,033.33	6.00	3,550,005,215.00
	Sub Total					**13,088,533,545.00**
2	**Reinforcement**					
	Pilecap P1, P2, P3, P4	kg	20,636.00	21,551.87	8.00	444,744,389.32
	Pier 1	kg	20,636.00	23,197.04	4.00	478,694,117.44
	Pier 2	kg	20,636.00	36,711.81	4.00	757,584,911.16
	Pier 3	kg	20,636.00	35,989.31	4.00	742,675,401.16
	Pier 4	kg	20,636.00	37,556.91	4.00	775,024,394.76
	Pierhead 1	kg	20,636.00	68,441.35	2.00	1,412,355,698.60
	Pierhead 2, 3, 4	kg	20,636.00	173,949.20	6.00	3,589,615,691.20
	Sub Total					**8,200,694,603.64**
	Total					**21,289,228,148.64**

(Quantity Surveyor Data Source)

Table 6 Recapitulation of bridge girder structure work costs with Allplan Engineering

No.	Item Details	Unit	Unit Price (IDR)	BIM (Builiding Information Modeling)		
				Volume	Amount	Total Price (IDR)
1	**Concrete**					
	Pilecap P1, P2, P3, P4	m^3	3,435,500.00	2,183.89	8.00	7,502,754,095.00
	Pier 1	m^3	3,435,500.00	69.12	4.00	237,461,760.00
	Pier 2	m^3	3,435,500.00	96.00	4.00	329,808,000.00
	Pier 3	m^3	3,435,500.00	92.80	4.00	318,814,400.00
	Pier 4	m^3	3,435,500.00	99.20	4.00	340,801,600.00
	Pierhead 1	m^3	3,435,500.00	241.86	2.00	830,910,030.00
	Pierhead 2, 3, 4	m^3	3,435,500.00	1,033.26	6.00	3,549,764,730.00
	Sub Total					**13,110,314,615.00**
2	**Reinforcement**					
	Pilecap P1, P2, P3, P4	kg	20,636.00	21,410.59	8.00	441,828,935.24
	Pier 1	kg	20,636.00	23,897.04	4.00	493,139,317.44
	Pier 2	kg	20,636.00	36,587.58	4.00	755,021,300.88
	Pier 3	kg	20,636.00	35,741.55	4.00	737,562,625.80
	Pier 4	kg	20,636.00	37,592.57	4.00	775,760,274.52
	Pierhead 1	kg	20,636.00	68,679.60	2.00	1,417,272,225.60
	Pierhead 2, 3, 4	kg	20,636.00	172,817.37	6.00	3,566,259,247.32
	Sub Total					**8,186,843,926.80**
	Total					**21,297,158,541.80**

(Allplan Engineering Source 2023)

Comparative Results

Reinforcement Quantity Comparison

The reinforcement quantity comparison across QS, BIM, and manual recalculation is summarized in Table 8 and visualized in Figure 7. The total reinforcement quantity based on BIM is 396,726.30 kg, which is 0.17% lower than the QS total (397,397.49 kg). Compared with manual recalculation (395,816.98 kg), the BIM total is 0.23% higher. Item-level deviations of BIM relative to QS range from −0.66% to 3.02%, while deviations relative to manual recalculation range from −0.29% to 0.39%.

Concrete Quantity Comparison

Table 9 shows that the total concrete volume for the bridge girder structure using the QS analysis is 3,809.79 m^3, while the BIM analysis is 3,816.13 m^3, or 6.34 m^3 **higher** than the QS analysis. The deviation from the BIM method relative to the QS analysis ranges from −0.01% to 2.72%. Meanwhile, the total concrete volume using the recalculation method is 3,809.72 m^3, or 0.17% **lower** than the BIM analysis. The deviation relative to the recalculation method ranges from 0 to 2.65%. Graphically, the total concrete volume for the three methods is shown in Figure 8.

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Table 7 Recapitulation of bridge girder structure work costs with recalculation

No.	Item Details	Unit	Unit Price (IDR)	Recapitulation		
				Volume	Amount	Total Price (IDR)
1	**Concrete**					
	Pilecap P1, P2, P3, P4	m^3	3,435,500.00	2,183.89	8.00	7,502,754,095.00
	Pier 1	m^3	3,435,500.00	69.12	4.00	237,461,760.00
	Pier 2	m^3	3,435,500.00	96.00	4.00	329,808,000.00
	Pier 3	m^3	3,435,500.00	92.80	4.00	318,814,400.00
	Pier 4	m^3	3,435,500.00	99.20	4.00	340,801,600.00
	Pierhead 1	m^3	3,435,500.00	235.45	2.00	808,888,475.00
	Pierhead 2, 3, 4	m^3	3,435,500.00	1,033.26	6.00	3,549,764,730.00
			Sub Total			**13,088,293,060.00**
2	**Reinforcement**					
	Pilecap P1, P2, P3, P4	kg	20,636.00	21,472.09	8.00	443,098,049.24
	Pier 1	kg	20,636.00	23,915.17	4.00	493,513,448.12
	Pier 2	kg	20,636.00	36,600.83	4.00	755,294,727.88
	Pier 3	kg	20,636.00	35,630.08	4.00	735,262,330.88
	Pier 4	kg	20,636.00	37,608.74	4.00	776,093,958.64
	Pierhead 1	kg	20,636.00	68,441.35	2.00	1,412,355,698.60
	Pierhead 2, 3, 4	kg	20,636.00	172,148.72	6.00	3,552,460,985.92
			Sub Total			**8,168,079,199.28**
			Total			**21,256,372,259.28**

Table 8 Recapitulation of reinforcement analysis on bridge girder structure work

No	Work Item	Reinforcement Volume (kg)			Difference			
		QS	BIM	Recalculation	BIM VS QS	% BIM VS QS	BIM VS Recalculation	% BIM VS Recalculation
1	Pilecap	21,551.87	21,410.59	21,472.09	-141.28	-0.66	-61.50	-0.29
2	P1	23,197.04	23,897.04	23,915.17	700.00	3.02	-18.13	-0.08
3	P2	36,711.81	36,587.58	36,600.83	-124.23	-0.34	-13.25	-0.04
4	P3	35,989.31	35,741.55	35,630.08	-247.76	-0.69	111.47	0.31
5	P4	37,556.91	37,592.57	37,608.74	35.66	0.09	-16.17	-0.04
6	PH 1	68,441.35	68,679.60	68,441.35	238.25	0.35	238.25	0.35
7	PH 2	173,949.20	172,817.37	172,148.72	-1,131.83	-0.65	668.65	0.39
	Amount	**397,397.49**	**396,726.30**	**395,816.98**	**-671.19**	**-0.17**	**909.32**	**0.23**

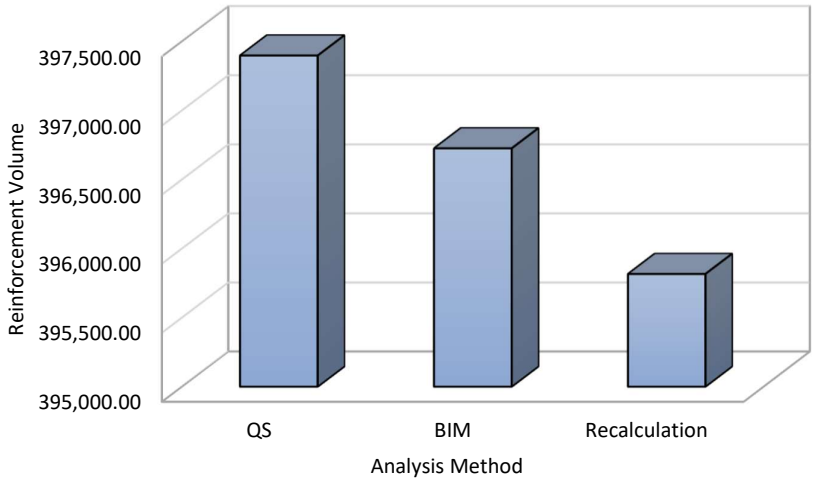

Figure 7 Reinforcement Volume Comparison Chart

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Table 9 Recapitulation of concrete volume analysis on bridge girder structure work

No	Work Item	Concrete Volume (m³)			Difference			
		QS	BIM	Recalculation	BIM VS QS	% BIM VS QS	BIM VS Recalculation	% BIM VS Recalculation
1	Pilecap	2,183.89	2,183.89	2,183.89	0.00	0.00	0.00	0.00
2	P1	69.12	69.12	69.12	0.00	0.00	0.00	0.00
3	P2	96.00	96.00	96.00	0.00	0.00	0.00	0.00
4	P3	92.80	92.80	92.80	0.00	0.00	0.00	0.00
5	P4	99.20	99.20	99.20	0.00	0.00	0.00	0.00
6	PH 1	235.45	241.86	235.45	6.41	2.72	6.41	2.65
7	PH 2	1,033.33	1,033.26	1,033.26	-0.07	-0.01	0.00	0.00
	Amount	**3,809.79**	**3,816.13**	**3,809.72**	**6.34**	**0.17**	**6.41**	**0.17**

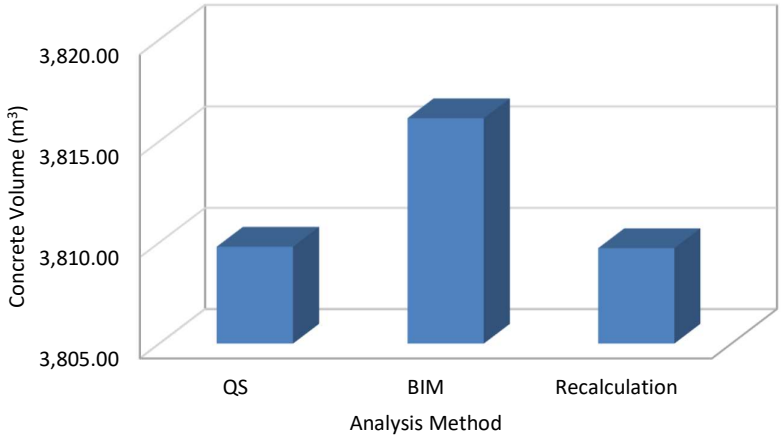

Figure 8 Concrete Volume Calculation Summary

Reinforcement Cost Comparison

Reinforcement cost comparison is summarized in Table 10 and visualized in Figure 9. BIM yields a reinforcement cost of IDR 8,186,843,926.80, which is 0.17% lower than QS (IDR 8,200,694,603.64). Compared with manual recalculation (IDR 8,168,079,199.28), BIM is 0.23% higher. Deviations follow the reinforcement quantity patterns.

Concrete Cost Comparison

Concrete cost comparison is summarized in Table 11 and visualized in Figure 10. BIM yields a concrete cost of IDR 13,110,314,615.00, which is 0.17% higher than QS (IDR 13,088,533,545.00). Compared with manual recalculation (IDR 13,088,293,060.00), BIM is also 0.17% higher.

Key Findings

BIM-based quantities and cost estimates generated using Allplan Engineering are highly consistent with QS documentation and manual recalculation. At the total level, differences remain below 1% for both reinforcement and concrete quantities and for the resulting costs under the same RAB unit price basis. The largest item-level differences are concentrated in Pierhead PH1 for concrete quantities and Pier P1 for reinforcement quantities.

Table 10 Analysis of the cost of reinforcing bridge girder structure work

Work Item	Reinforcement Price (IDR)			Difference			
	QS	BIM	Recalculation	BIM VS QS	% BIM VS QS	BIM VS Recalculation	% BIM VS Recalculation
Pilecap	444,744,389.32	441,828,935.24	443,098,049.24	-2,915,454.08	-0.66	-1,269,114.00	-0.29
P1	478,694,117.44	493,139,317.44	493,513,448.12	14,445,200.00	3.02	-374,130.68	-0.08
P2	757,584,911.16	755,021,300.88	755,294,727.88	-2,563,610.28	-0.34	-273,427.00	-0.04
P3	742,675,401.16	737,562,625.80	735,262,330.88	-5,112,775.36	-0.69	2,300,294.92	0.31
P4	775,024,394.76	775,760,274.52	776,093.958.64	735,879.76	0.09	-333,684.12	-0.04
PH 1	1,412,355,698.60	1,417,272,225.60	1,412,355,698.60	4,916,527.00	0.35	4,916,527.00	0.35
PH 2	3,589,615,691.20	3,566,259,247.32	3,552,460,985.92	-23,356,443.88	-0.65	13,798,261.40	0.39
Jumlah	**8,200,694,603.64**	**8,186,843,926.80**	**8,168,079,199.28**	**-13,850,676.84**	**-0.17**	**18,764,727.52**	**0.23**

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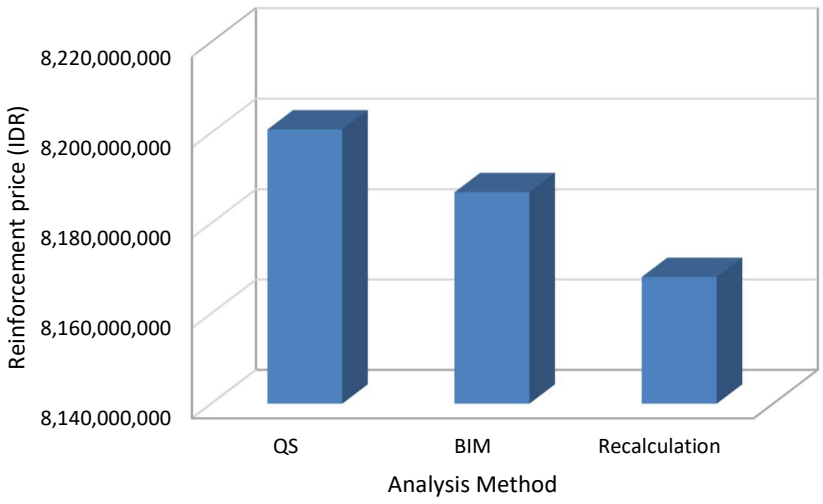

Figure 9 Recapitulation of Reinforcement Costs for Girder 1 Bridge Work

Table 11 Concrete cost analysis of bridge girder structure work

Work Item	Concrete Price (IDR)			Difference			
	QS	BIM	Recalculation	BIM VS QS	% BIM VS QS	BIM VS Recalculation	% BIM VS Recalculation
Pilecap	7,502,754,095.00	7,502,754,095.00	7,502,754,095.00	0.00	0.00	0.00	0.00
P1	237,461,760.00	237,461,760.00	237,461,760.00	0.00	0.00	0.00	0.00
P2	329,808,000.00	329,808,000.00	329,808,000.00	0.00	0.00	0.00	0.00
P3	318,814,400.00	318,814,400.00	318,814,400.00	0.00	0.00	0.00	0.00
P4	340,801,600.00	340,801,600.00	340,801,600.00	0.00	0.00	0.00	0.00
PH 1	808,888,475.00	830,910,030.00	808,888,475.00	22,021,555.00	2.72	22,021,555.00	2.65
PH 2	3,550,005,215.00	3,549,764,730.00	3,549,764,730.00	-240,485.00	-0.01	0.00	0.00
Jumlah	**13,088,533,545.00**	**13,110,314,615.00**	**13,088,293,060.00**	**21,781,070.00**	**0.17**	**22,021,555.00**	**0.17**

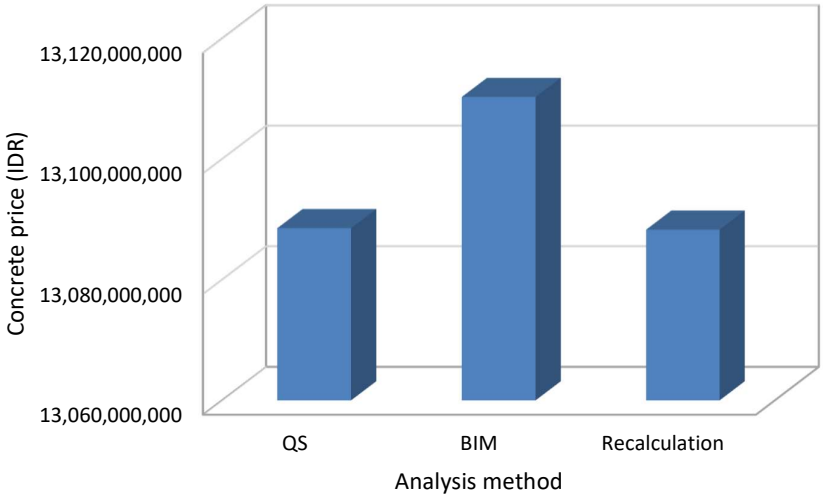

Figure 10 Concrete cost analysis diagram for bridge girder structure work

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Discussion

Agreement with Prior 5D BIM Studies

The small total variance (<1%) between BIM outputs and conventional methods supports prior evidence that 5D BIM can produce acceptable cost estimation accuracy. Farhana and Abma (2022) reported that 5D BIM may achieve deviations within approximately ±7% compared to conventional estimation; the present study demonstrates a tighter agreement for the evaluated work scope and documentation basis.

Interpreting Item-Level Deviations

Although totals are consistent, item-level deviations are not uniform. The largest deviation in concrete quantities occurs at Pierhead PH1, indicating that pierhead geometry may be more sensitive to modeling interpretation (e.g., segmentation of concrete components, rounding conventions, or differences between drawing-based measurement and model object definitions). For reinforcement, the highest deviation appears at Pier P1, which may reflect differences in reinforcement detailing interpretation or categorization between QS records and BIM extraction. This aligns with Suasira et al. (2021), emphasizing that BIM QTO accuracy depends on consistent modeling practices and sufficient level of detail.

Practical Benefits: Revision Speed and Data Integration

Beyond numerical accuracy, 5D BIM provides workflow advantages. Chan, Olawumi, and Alfred (2019) highlight that 5D BIM links geometric models with cost databases, enabling automatic cost updates when the model changes. This capability reduces repeated manual recalculation, improves traceability, and supports faster decision-making during design revisions—particularly relevant for large infrastructure projects.

Comparison with Studies Reporting Larger Variance

Compared with studies reporting larger discrepancies (e.g., Setiawan et al., 2025, with reinforcement and concrete volume variances up to 13.53% and 10.22%), the present results indicate that controlled scope, clear DED inputs, and consistent RAB unit price basis can contribute to strong agreement among BIM, QS, and manual recalculation.

Lifecycle Implications

BIM can also support downstream phases by storing geometry and material information in a unified database. As noted by Katke (2020), this supports operation and maintenance by enabling easier access to asset information. Therefore, the BIM model developed for the girder bridge case may provide benefits beyond planning, provided that updates are maintained consistently.

Conclusion

The conclusions of this study are as follows:

1. The results of the volume analysis for the girder bridge structural work (pilecap, pier, and pierhead) using the BIM concept show a reinforcement quantity of 396,726.30 kg and a concrete volume of 3,816.13 m^3. The estimated reinforcement cost is IDR 8,186,843,926.80, while the estimated concrete cost is IDR 13,110,314,615.00.
2. Compared with the QS analysis, the difference in reinforcement quantity obtained using the BIM concept is 671.19 kg (with a cost difference of IDR 13,850,676.84), indicating that BIM is 0.17% lower than QS for reinforcement. For concrete work, the BIM result differs from QS by 6.34 m^3 (with a cost difference of IDR 21,781,070.00), indicating that BIM is 0.17% higher than QS for concrete.
3. When compared with manual recalculation, the BIM results also show small differences, indicating that the BIM-based estimates are consistent with conventional calculations. Overall, the total variance between BIM, QS, and manual recalculation remains below 1% for both quantities and costs under the same unit price basis from the project Budget Plan (RAB).
4. These findings indicate that 5D BIM using Allplan Engineering can reliably support quantity takeoff and cost estimation for bridge structural work while providing practical advantages in updating quantities and revising the Budget Plan (RAB) when design changes occur.

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