Implementation of BIM 5d in The Implementation Plan of The Trans Sumatra - Jambi Toll Road with Civil 3d and Naviswork

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ABSTRACT

Significant contributions to technological advancement are helpful in various aspects of work. In Circular Letter 11/SE/Db/2021, it is emphasized that the use of Building Information Modelling (BIM) must be applied in the planning stage of highway construction. 3D and 5D modeling can be done using Autodesk Civil 3D, while 4D modeling can be facilitated through Autodesk Navisworks. This study takes the Trans Sumatra Jambi Toll Road Project as an object of study with the aim of modeling toll roads using BIM-based Autodesk Civil 3D, analyzing the estimated costs from the modeling results, and visualizing the progress plan of mainroad work at a certain time through Autodesk Navisworks. Secondary data includes DED, BoQ and HSP. Modeling was performed on Autodesk Civil 3D including modeling of excavations and embankments as well as road pavement and drainage structures, Clash detection using Autodesk Naviswork, volume of work integrated using Microsoft Project and time simulation using Autodesk Naviswork. The results of the study show that from the modeling that has been carried out, the estimated cost of mainroad work has a deviation of -3.24% from the BoQ document. Data comparison shows that volume and cost estimates from Autodesk Civil 3D BIM are lower than conventional methods. Simulations of mainroad work in Autodesk Naviswork provide integrated construction visualization, time tracking, and cost estimation to support project decisions.

Keywords: construction visualization, cost estimation, mainroad work, integrated simulation

1. INTRODUCTION

Today, technological developments in the construction industry have made a great contribution in various aspects of work. The Ministry of Public Works and Public Housing (PUPR) has released a policy that encourages the implementation of BIM. This is stated in Circular Letter Number 11/SE/Db/2021 from the Directorate General of Highways, which states that in order to support the transformation towards PUPR 4.0, BIM will be applied in the process of technical planning, construction implementation, and maintenance of road and bridge infrastructure.

The application of Building Information Modeling (BIM) in construction projects includes three-dimensional (3D) visual representation, time scheduling (4D), cost estimation (5D), to building operational management and maintenance (7D), as well as enabling multidisciplinary data integration that includes architectural, structural, utility, and landscape design. Each BIM dimension signifies the phase of project development, from 3D visualization and collaboration aspects, scheduling (4D), volume and cost calculation (5D), building viability (6D), to operational management (7D) [1].

There is BIM supporting software, namely Autodesk Civil 3D which can be used for 3D modeling design and through 3D models, analysis of the acquisition of work volume (5D) can be carried out. In addition, there is Autodesk Naviswork software that can be used to manage interference and collision detection and support for simulation and time analysis (4D).

The 4D and 5D dimensions are an important part of the seven BIM dimensions that support the success of construction planning. Precision in calculating volume, cost, and time is indispensable for project planning to be more efficient and on target. In this study, the main road structure is taken which the calculation of volume, budget, cost and time still uses conventional methods as the main reference and is accompanied by BIM modeling which is used as a project visualization for project owners.

Based on this, the main goal of this research is to apply BIM 4D and 5D dimensions as the main reference. The results achieved in understanding the role of BIM 4D are obtained through simulation and tracking of work progress at a certain time which refers to project payment in the form of a Monthly Certificate. Meanwhile, the role of BIM 5D is known by analyzing volume differences and cost estimates compared to conventional project calculations.

2. THEORY AND METHODS

2.1 Theory

The results show that the use of Civil 3D in toll road projects results in a more accurate calculation of earthwork volume than conventional methods, with a difference of 4.375% [2]. Similarly, study reveals that Autodesk Civil 3D produces smaller volume estimates for excavation and spoil compared to conventional calculations [3]. However, current research highlights a clear gap in comprehensive studies that directly compare quantity takeoff accuracy and progress tracking effectiveness between conventional methods and BIM in large-scale toll road projects, especially in Indonesia [4]. This research aims to address this gap by applying Autodesk Civil 3D for quantity takeoff and Autodesk Naviswork for construction time simulation on main road construction, thereby enhancing precision and integration in project delivery.

Building Information Modeling

BIM is one of the important technologies in the architecture, engineering, and construction (AEC) sector [5]. This technology allows the simulation of the entire development project information into a three-dimensional model [6]. The implementation of BIM proves to improve team collaboration, profitability, cost efficiency, better time management, as well as strengthen relationships with clients.[7]

Autodesk Civil 3D

Autodesk Civil 3D is a software developed by Autodesk, Inc. from the United States, which was developed as an evolution of AutoCAD Land Desktop in the early 2000s. The software supports infrastructure planning through 3D modeling and is equipped with a Quantity Takeoff (QTO) component for 5D-based cost estimation analysis [8]. Autodesk Civil 3D features *object-based modeling*, which allows the representation of infrastructure design elements such as alignments, longitudinal profiles, and corridors in the form of parametric entities that are interconnected and able to respond dynamically to change [9].

Autodesk Naviswork

Autodesk Naviswork is a *software* that supports scheduling (4D) simulations. Autodesk Navisworks is used as a cross-disciplinary integration platform for conflict detection, scheduling, cost estimation, and project visualization, to minimize the risk of design errors and improve field execution efficiency [10]. Its ability to support cross-disciplinary integration in construction projects, Autodesk Naviswork is widely used in the design of engineering projects, such as plants, piping systems, electrical, instrumentation, civil structures, and architecture [11].

Construction Work Volume

Calculating the volume or quantity of construction work is the process of determining the number of work items based on design drawings or field conditions. This process is important as a basis for compiling bid prices, calculating payments for work that has been done, and evaluating the progress and cost control of the project.[12]

Estimated Construction Costs

Christensen & Dysert (1997) assert that the estimated cost of a construction project is an estimate of the expenses arising from a project, taking into account the scope, location, and completion schedule that has been set. The estimated cost of a construction project must be prepared before the project is implemented to determine the costs incurred by a construction project [13]. Based on the completeness of the data and the stages of the project, the estimated cost is divided into 3, namely Preliminary Estimate, Semi Detail Estimate and Definitive Estimate [14].

Construction Work Time

Construction work time is the duration required to complete all project construction activities according to the schedule and targets that have been set [15]. Construction project scheduling is a systematic process of allocating time for each activity to ensure efficient and timely completion of the project. According to Presidential Regulation No. 54 of 2010 Article 120, delays in project completion can be subject to a fine of 1/1000 of the contract value per day of delay. Effective scheduling is essential in the construction world, as delays in project completion can have an impact on increased costs and potential fines for contractors [16].

2.2 Methods

The identification of problems starts with the government issuing regulations on the use of BIM and development projects that still use conventional methods as the main reference. Furthermore, a literature study is carried out to search for relevant writings that have been made before to understand the context of the research, identify relevant theoretical frameworks, and find methods or approaches that have been previously used by other researchers as well as evaluate the weaknesses and advantages of previous studies.

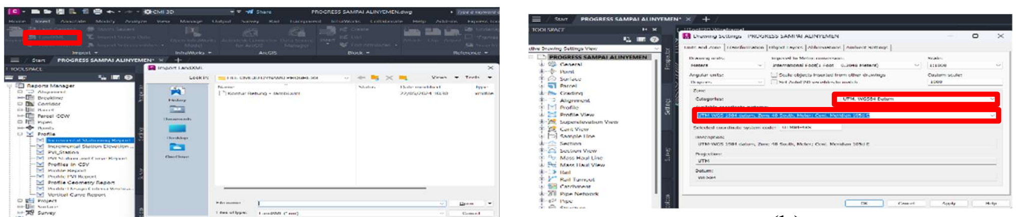
This research focuses on the Trans Sumatra Toll Road Betung–Jambi Section 1A, a 31.58 km project with a contract value of Rp3.5 trillion. Secondary data, including DED, BoQ, and HSP, are utilized. The design is modeled using Autodesk Civil 3D 2025 (horizontal/vertical alignment and cross sections) and exported to Naviswork 2025 for clash detection. Quantity takeoff is strictly based on DED drawings, while schedule re-simulation is performed according to technical construction analysis. Quantity data is integrated with Microsoft Project for scheduling, which is visualized in Naviswork 2025 to track progress and cost, providing direct comparison with conventional methods for final recommendations.ry out tracking progress work and the cost used. Then suggestions and conclusions and done.

3. RESULTS AND DISCUSSION

Autodesk Civil 3D Modeling Stages

The Stage Map to get the output of the volume of excavation work on heaps, road pavement structures, and drainage from Autodesk Civil 3D is as follows.

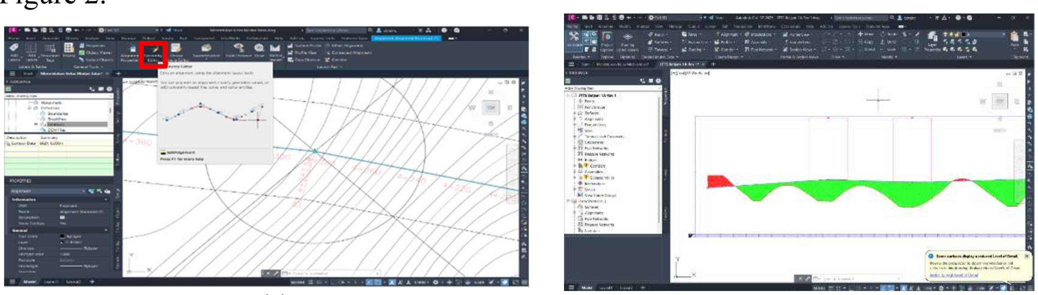
1. Input the contour of the project area and set the UTM coordinates according to the project area in Figure 1.



(a) (b)

Figure 1. Stages of Setting Region Contours and UTM Coordinates (a) Contour Input, (b) UTM Coordinate Setting

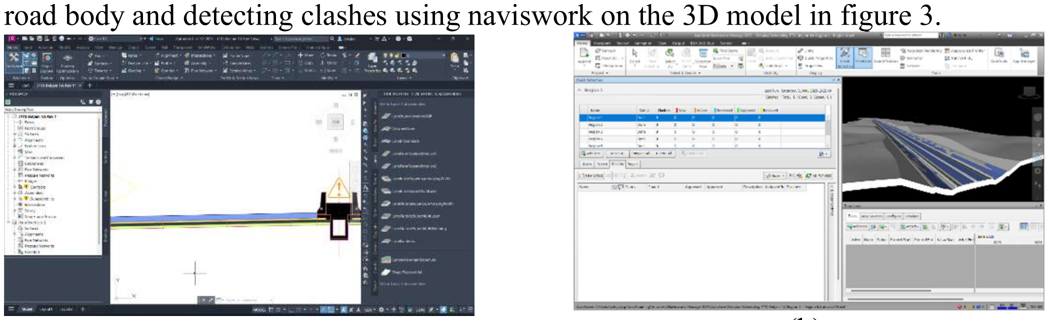
2. Modeling horizontal and vertical alignment according to the geometry of the DED data in Figure 2.



(a) (b)

Figure 2. Stages of 3D Modeling Street Model (a) Horizontal Alignment Modeling, (b) Vertical Alignment Modeling

3. Modeling the cross-sectional as an example of modeling the cross-sectional section of the road body and detecting clashes using naviswork on the 3D model in figure 3.



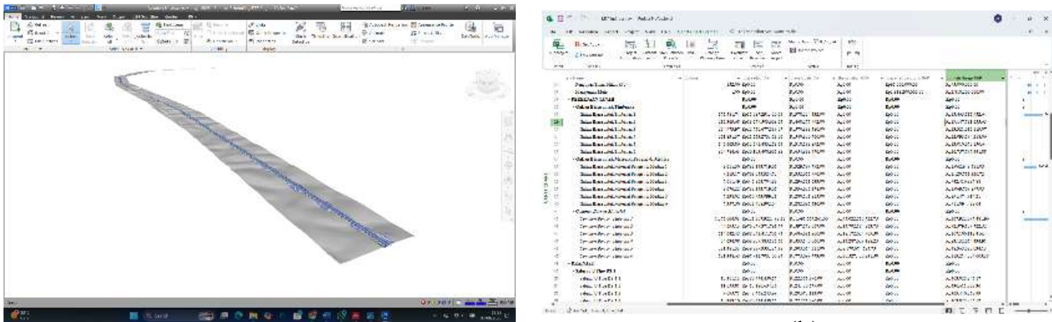
(a) (b)

Figure 3. Stages of 3D Modeling of Road Models and Clash Detection (a) Modeling of the Transverse Cross-Section of the Road Shoulder, (b) Checking Clash Detection 3D Model

Autodesk Naviswork 4D Modeling Stages

The Stage Map to get the output of the work volume and detail drawings from Autodesk Naviswork is

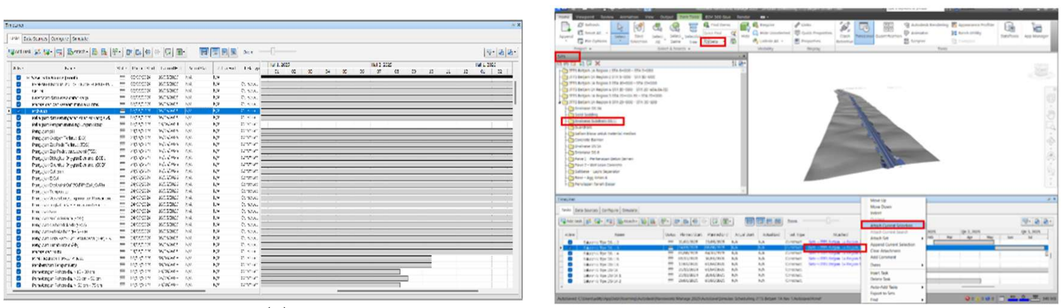
1. Integrate the Autodesk Civil 3D model with Autodesk Naviswork and integrate the time schedule with the quantity of work using the Microsoft project as shown in Figure 4.



(a) (b)

Figure 4. Stages of Naviswork 4D Modeling (a) Model 3D Integration with Naviswork, (b) Job Quantity Output Integration in Microsoft Project

2. Integrating Time Schedule with Work Quantity Using Microsoft Project Integrating Time Schedule with 3D models in naviswork as shown in Figure 5.



(a) (b)

Figure 5. Stages of 4D Naviswork Modeling (a) Integration of Time Schedule with Work Quantity, (b) Integration of 3D Model with Time Schedule

3. Select the simulate menu and then perform a scheduling simulation as shown in Figure 6.

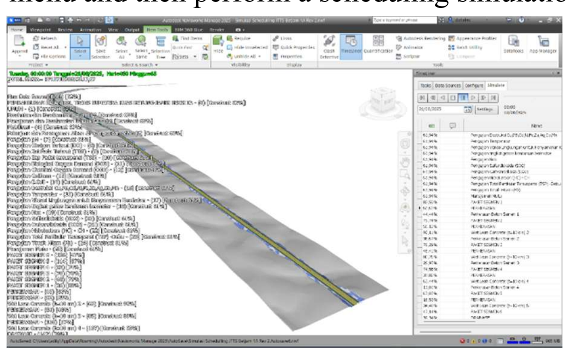


Figure 6. Schedulling Simulation for Job Progress Tracking

BoQ Work Cost Estimation Deviation with Autodesk Civil 3D BIM

The cost estimation results were obtained by multiplying the output of the volume of Bill of Quantity and Autodesk Civil 3D BIM by the project's Unit Price (HSP). By comparing the cost estimation results of these two methods, it can be seen that the cost differences that may arise due to differences in accuracy in volume calculations. The results of the analysis of the calculation of deviation calculations of the estimated volume and cost of earthworks, drainage, road pavement and other works can be seen in Table 1.

Table 1. Analysis of Calculation of Deviation of Estimated Work Costs

Analysis of Calculation of Deviation Calculation of Estimated Cost of Mainroad Work				
Bill Of Quantity Vs Bim Autodesk Civil 3d				
No	**Job Items**	**BIM Pricing (IDR)**	**BoQ Price (IDR)**	**Deviation (%)**
		(1)	**(2)**	**(3) = (1-2)/2**
1	Earthworks			
	Common Excavations For Deposits	123.317.264.017,96	127.648.241.693,75	-3,39%
	Ordinary excavation for filler material in the median	5.099.047.185,23	5.300.014.215,24	-3,79%
	Common Borrow Material	745.941.572.145,58	767.403.130.583,62	-2,80%
2	Drainage			
	Ds-1 Type U Channel	2.275.138.956,12	2.326.050.185,00	-2,19%
	U Channel Type Ds-1a	15.610.702.494,78	15.610.702.494,78	0,00%
	Pre-Printed U Channel, Type Ds-3A	18.689.394.040,84	18.903.254.267,28	-1,13%
	Concrete Sewer, Type Ds-8	15.203.057.259,96	15.821.265.471,46	-3,91%
3	Groundland Preparation			
	Preparation of the Basic Soil	16.302.257.485,67	17.513.098.234,29	-6,91%
4	Aggregate Foundation Layer			
	Class A Aggregate Foundation Layer	13.174.568.628,20	13.079.788.163,62	0,72%
	Separator Layer/Caping Layer	168.942.363.588,11	169.331.148.735,84	-0,23%
5	Pavement			
	Cement Concrete Pavement	580.824.934.038,05	610.829.204.547,76	-4,91%
	Wet Lean Concrete (T=10 Cm)	142.951.612.480,80	152.990.492.769,42	-6,56%
6	Other Jobs			
	Solid Sodding	22.423.865.754,00	22.739.986.113,49	-1,39%
	Type A Vehicle Guardrail	63.345.262.205,24	66.184.734.052,50	-4,29%
	Concrete Barrier, Type – A	165.202.057.529,99	165.202.057.529,99	0,00%
Total		2.099.303.097.810,5	2.170.883.169.058,	-3,24%

Based on Table 4.1, the total estimated cost of the main road work from the Quantity Take-Off (QTO) using Civil 3D is IDR 2,100,542,533,734.10, compared to IDR 2,170,883,169,058.04 in the BoQ document, showing a negative deviation of -3.24%. This lower Civil 3D estimate results from its precise 3D modeling that relies heavily on data and geometry accuracy, whereas BoQ includes corrective factors like waste, losses, and safety margins. Similar studies confirm that BIM-based estimates, such as those using Civil 3D, generally produce lower and more accurate cost results compared to conventional methods, with accuracy improvements ranging around 3–6% and cost savings reported up to 5.8%. Thes findings highlight BIM's capability to enhance cost estimation precision by reducing assumpt ions and manual errors typical in conventional processes.

Tracking Progress Percentage of Work

Tracking the progress of the percentage of work is the process of monitoring and controlling the progress of a project or work both in terms of job completion and cost use. The output of the Naviswork Application is in the form of a scheduling simulation which can later be used as a reference to find out the amount of costs based on the amount of work and the percentage of work that has been completed on the construction of the main road. It took time to carry out the scheduling simulation, namely on the 450th day (15th monthly payment) whose output can be seen in Figure 7 and Table 2 which shows the description of progress

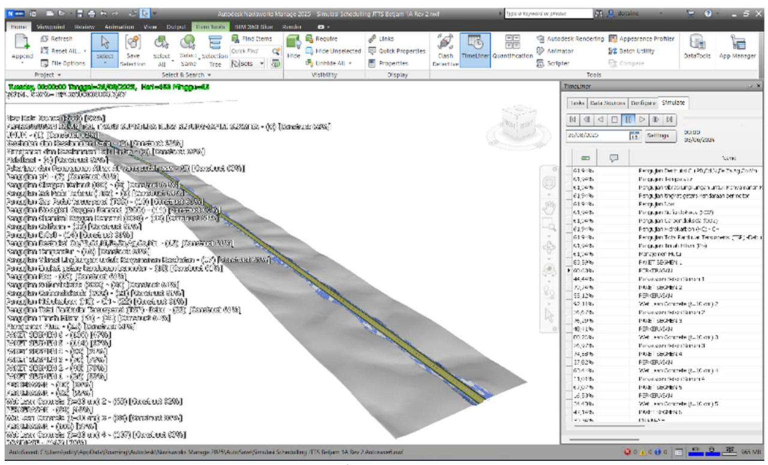


Figure 7. 450th Day Job Progress View

Table 2. Description of Work Progress on the 450th Day

Description of the Progress of the 300th Day of Work		
No	**Job Items**	**Realization (%)**
	(1)	**(2)**
1	Segment 1 STA 0+000 – STA 5+000	
	Cement Concrete Pavement	44,44%
2	Segment 2 STA 5+000 – STA 10+000	
	Wet Lean Concrete (t=10 cm)	92,11%
	Cement Concrete Pavement	36,67%
3	Segment 3 STA 10+000 – STA 15+000	
	Wet Lean Concrete (t=10 cm)	80,26%
	Cement Concrete Pavement	26,97%
4	Segment 4 STA 15+000 – STA 21+150	
	Wet Lean Concrete (t=10 cm)	63,44%
	Cement Concrete Pavement	11,01%
5	Segment 5 STA 21+150 - STA 25+000	
	Wet Lean Concrete (t=10 cm)	34,48%
6	Segment 6 STA 25+000 - STA 31+100	
	DS-1A Type U Channel	67,21%
	Pre-printed U Channel, DS Type 3A	56,52%

Description of the Progress of the 300th Day of Work		
No	**Job Items**	**Realization (%)**
	(1)	**(2)**
Overall Total Percentage of Work		63%
Estimated Cost Used		IDR1,371,030,813,217

In the 450th day work progress scheduling simulation, the 15th monthly payment is on August 26, 2025 and produces a total percentage of work of 63% with an estimated cost of Rp813,611,396,650. Produce as many as 10 items of work in progress with a percentage according to Table 2. In Figure 13, the green display describes the work in progress at the time of the 450th day of work progress and the percentage weight of the work progress generated in Autodesk Naviswork is calculated based on the time weight of the work itself.

4. CONCLUSIONS

The research on BIM 5D implementation for the Trans Sumatra–Jambi Toll Road using Civil 3D 2025 and Naviswork 2025 shows a cost deviation of -3.24% between field BoQ and BIM estimates, confirming BIM's tendency to produce smaller, more precise cost calculations. Naviswork's simulation provides an integrated view of time, physical progress, work scope, and costs, with tracking on day 450 showing 63% completion and costs of IDR 1.37 trillion. For practitioners and policymakers, adopting BIM 5D is strongly recommended to improve cost accuracy, enhance project transparency, and streamline decision-making processes in large-scale toll road projects. Comprehensive BIM use from planning through execution minimizes design errors, supports schedule revisions based on technical analysis, and enables real-time progress and cost control, leading to reduced risk of overruns and improved project outcomes

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