

# Systematic Review of 5D BIM Implementation in Construction Projects

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## Abstract.

*This study presents a systematic literature review on the implementation of 5D Building Information Modeling (BIM) in construction projects, focusing on the integration between scheduling (4D) and cost estimation (5D). The literature search focused on peer-reviewed articles and supporting academic sources published between 2019 and 2025, yielding a set of relevant studies. The analyzed data include project types, software used (Revit, Navisworks/Synchro, CostX), data exchange formats (IFC/CSV), and the relationship among the Work Breakdown Structure (WBS), Quantity Take-Off (QTO), and cost account code (COA). The synthesis shows that 5D BIM improves cost accuracy through model-linked QTO, accelerates estimation workflows, and shortens the time required to identify the impacts of design changes on both cost and schedule. The main obstacles to 5D BIM adoption include the loss of information attributes during cross-software data exchanges, inconsistencies in WBS/COA standards across project stakeholders, and limitations in user competency. Supporting factors for effective implementation include an open BIM approach, a Common Data Environment (CDE), standardized cost libraries, and structured training governance. The study also highlights replicable practices such as early WBS alignment for 4D–5D synchronization, rule-based QTO validation, and linking work progress to payment mechanisms. These findings are expected to contribute to the development of 5D BIM guidelines and educational curricula, particularly for small- to medium-scale contractors.*

**Keywords:** 5d bim; cde; ifc; integration 4d–5d and interoperability.

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## I. INTRODUCTION

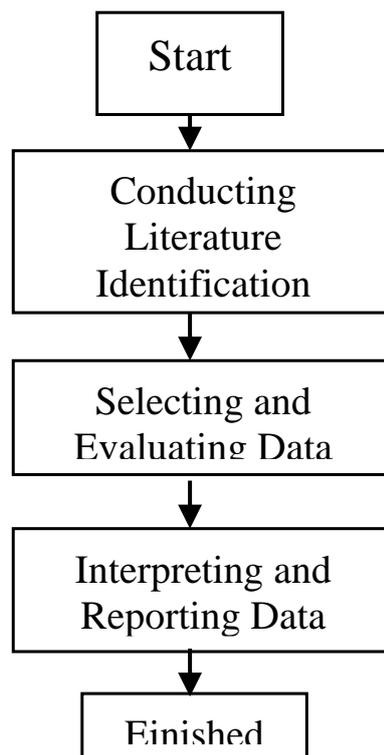
Digitalization in the construction industry has encouraged the use of Building Information Modeling (BIM) technology to the extent of 5D, which is the relationship between three-dimensional models and time simulations (4D) with cost estimates and control. In the implementation of building construction projects, a common challenge is the lack of correlation between schedule and cost, so that changes in the schedule do not immediately reflect changes in cost calculations and cash flow curves. This results in an increased risk of cost deviation, delays in detecting problems, and reduced accountability when design changes occur during the construction process. Based on various studies, it is known that when quantity take-off (QTO) is directly linked to model elements and aligned with the Work Breakdown Structure (WBS), the estimation process can be more consistent and easier to check because changes to specific parts can be traced to specific model components. [1], [2]. On the other hand, academic evidence also highlights structural barriers that hinder the utilization of these benefits. Loss of attributes during export and import between systems, inconsistencies in the structure of the WBS and Chart of Accounts, and widespread uncertainty about the competence of the project team often reduce the level of confidence in 5D results [3], [4].

This context is relevant to construction projects in Indonesia, especially for small to medium-sized contractors and educational environments, where initial investment, availability of training, and process standardization are often key factors in determining the success of adoption. This review begins with the need to summarize scattered evidence into a structured understanding of what is effective, the obstacles, and the factors that enable effective implementation of 5D in construction projects. The contributions used cover three main aspects. First, the creation of a 5D benefit map based on commonly reported quantitative indicators, such as increased cost accuracy, reduced estimation time, reduced cost variance, and increased speed of change impact detection [1], [5], [6]. Second, a review of the main obstacles and supporting factors ranging from interoperability and data management to competency development, including the role of open

BIM/IFC and CDE as important requirements for cross-device integration [2], [7], [8]. Third, writing best practices that can be reapplied and are relevant to building projects and learning at the university level, while identifying research gaps related to return on investment in small-scale projects and the sustainability of cost attributes in IFC [9], [10], [11].

Thus, this article is intended to be a concise yet practical reference for practitioners and educators who wish to integrate 4D–5D into a consistent workflow. Previous research has shown a gap between time-based 4D outputs and cost-oriented 5D modules. In many studies, changes in the sequence of work do not automatically translate into updates in quantity and unit prices. This misalignment triggers delays in detecting cost deviations and reduces the team's ability to perform value scenarios (what-if) in the planning phase. [1], [2], [5]. In the Indonesian context—particularly for small-to-medium contractors—the adoption of 5D is often hampered by the absence of a standard WBS/COA across work packages and organizational policy limitations in specifying 5D deliverables in contract documents. This article closes this gap by presenting a map of applicable benefits, obstacles, and enablers for building construction projects. [3], [4], [10]. Our practical contribution is to summarize best practices that can be directly replicated, such as single WBS harmonization, rule-based QTO, and progress-to-payment dashboards, and to offer a follow-up research agenda that measures ROI on small projects and strategies for preserving costing attributes in IFC [1], [2], [11].

## II. METHODS



**Fig 1.** Research Method Flowchart

### Literature Review Method

This study uses a systematic literature review approach with a focus on the implementation of 5D BIM in construction projects. The search was conducted in reputable journal databases and scientific portals, such as Science Direct, Taylor & Francis, MDPI, and Google Scholar, using a combination of keywords: “5D BIM”, “4D–5D integration”, “BIM-based cost estimation”, “model-based QTO”, and “IFC cost attributes”. The publication year range was limited to 2019–2025 to capture the latest developments. [1], [4], [11].

### **Data Selection Procedure**

Articles were included in the review if: 1) They discussed the application of 5D BIM in relevant construction or building infrastructure projects; 2) They explained the relationship between BIM models, QTO, 4D scheduling, and 5D cost estimation; 3) They presented identifiable performance indicators (e.g., cost accuracy, estimation time, cost deviation, or response to changes); 4) It has a sufficiently clear explanation of the method. Articles that only discuss BIM in general, focus only on 3D or 4D without cost relevance, or do not adequately explain procedures and data, were excluded from the synthesis. Selection was carried out by screening titles and abstracts, followed by full reading. From this process, 13 main articles were obtained as the basis for analysis.

### **Data Extraction and Synthesis**

The following were extracted from each selected article: project type, software and data format (Revit, Navisworks/Synchro, CostX, IFC, CSV), WBS and COA forms, model–QTO–schedule–cost linkage mechanisms, recorded benefits, obstacles encountered, and supporting factors. Given the variation in context and methods, a narrative synthesis approach was used, grouping the findings into four themes: (1) key benefits of 4D–5D integration, (2) technical and organizational obstacles, (3) supporting factors and the role of open BIM/CDE, and (4) replicable implementation practices. The structure and reporting requirements follow the JACEIT template, including the layout of table and figure titles and the IEEE citation style.

## **III. RESULT AND DISCUSSION**

### **Benefits of Applying BIM 5D in Construction Projects**

QTOs linked to model objects show improved cost accuracy built with adequate information standards, with quantities and costs calculated being influenced by changes in geometry or properties. In this scenario, initial estimates and iterative updates can be shortened because the process no longer relies on manually extracting important parts from two-dimensional drawings. Several studies have reported a reduction in estimation errors and better consistency between plans and budget realization after 5D is integrated with scheduling [1], [5]. In addition, the impact of detected changes becomes faster because the relationship between schedule activities and cost items has been established, so that shifts in duration or work sequence are automatically reflected in the cost curve and cash flow [2], [6]. 5D also facilitates the demonstration of the cost decision-making flow for design changes in an educational context, so that students can evaluate the trade-offs between quality, time, and cost more realistically.

### **Commonly Encountered Obstacles**

Interoperability is a major obstacle that is consistently reported. Inconsistent exports and imports between systems have the potential to eliminate important attributes such as item codes, units, or unit prices, resulting in inconsistent calculations across tools. Disparities in WBS and COA structures among various parties cause mapping difficulties when data moves from modeling to scheduling and cost modules. Output quality varies due to uneven team competencies, ranging from QTO-oriented modeling to scheduling and estimation knowledge [3], [4], [7]. Organizational aspects such as a lack of acceptance of process changes and doubts regarding the initial implementation costs are also limiting factors, especially for small to medium-sized contractors working on construction projects.

### **Effective Supporting Factors**

Open BIM/IFC is an effective supporting factor, which includes its use to maintain data traceability and completeness when moving between applications, the application of a *Common Data Environment* with version management and change control, and the presence of a standardized cost library that binds item codes, units, and measurement rules. BIM *Execution Plan* and 4D–5D integration plans, which have clear governance from the planning phase, foster consistency in work between parties. ERP systems or financial modules that extend integration and physical progress data flow towards payments can be organized more reliably and *audit-ready* [8], [9]. Training and certification programs specific to the 4D–5D workflow have been shown to help close competency gaps, particularly in QTO-friendly modeling and consistent WBS structure mastery [10].

### Best Practices Recommendations for Application in Construction Projects

Best practices emphasize the importance of alignment from the outset. Joint WBS development as a single reference for scheduling, QTO, and cost determination enables seamless integration. Establishing modeling rules that accommodate QTO requirements reduces the need for downstream data cleaning, while rule-based checking helps identify inconsistencies before estimates are run. When scheduling is linked to cost items, changes in duration or sequence can be immediately recalculated for their impact on costs and cash flow, which are then presented on a progress-to-payment dashboard to accelerate decision-making [1], [2], [6]. To improve the reliability of results, an organizational level, strengthened governance, the use of CDE as a single source of truth, and the establishment of model quality control points at specific milestones are required. In education, a studio design that requires students to run the entire 4D–5D flow helps instill conceptual understanding as well as work habits that can be transferred to industry.

#### Study Summary and Key Findings

Table 1 presents a representative summary of relevant studies, including their focus, tools/formats, and key outputs associated with benefits, barriers, and enabling factors.

**Table 1.** Study Summary and Key Outputs

ID	Year	Focus	Tools/Format	Outcome/Key Findings
S1	2024	5D for estimation, cost control, payment	5D framework	5D integration supports more accurate estimation, control, and progress payments [1].
S2	2024	4D–5D for infrastructure (workflow & coordination)	BIM environment; case study	4D/5D workflow improves coordination and accelerates impact assessment of changes [2].
S3	2023	5D-BIM & governance for cost overrun	Governance framework	A conceptual governance framework to reduce cost deviations [3], [4].
S4	2024	Pre-tender cost estimation based on BIM	Case study	The application of 5D in the pre-tender stage improves calculation accuracy [5].
S5	2023	Deep learning + BIM properties	Applied study	Schematic cost predictions based on BIM properties improve initial accuracy [6].
S6	2024	Cost variance & 5D adoption	PLS-SEM	The impact of dynamic 5D adoption on contract variance factors [7].
S7	2024	Lifecycle cost control with BIM	Empirical review	BIM impacts building lifecycle cost control [8].
S8	2024	BIM + Value Engineering	Framework integration	BIM-VE synergy provides housing cost efficiency [9]
S9	2024	5D implementation in local projects	Indonesian study	5D for building structure volume and cost estimation [10].
S10	2023	BIM-based LCCA	Review	BIM-based LCCA mapping in cost management [11].
S11	2023	BIM as a time/cost-saving tool	Case study	Evidence of time and cost savings in residential typologies [12].
S12	2022	5D + machine learning for material costs	Prototype	5D integrated material cost classification [13].

#### Quantitative Summary

Of the 13 articles reviewed, seven studies reported an increase in cost accuracy of over 10% after implementing 5D, while five studies reported a reduction in estimation time of 20–35% compared to conventional methods. Four studies documented a reduction in cost variance in structural and architectural work when a single WBS was used across 4D–5D. These figures show a consistent trend of benefits, despite the variety of project details and tools used. [1], [5], [6], [10], [11].

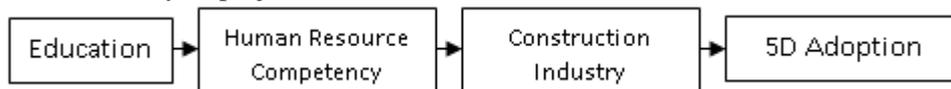
#### Application Examples

In an educational building project, the integration of 4D scheduling and 5D QTO enabled the simulation of changes in floor casting duration to be immediately reflected in the monthly cost curve. This practice cuts the lead time for analyzing the impact of changes from days to hours and reduces miscommunication between the planning team and the field team [1], [2], [10].

#### Implications of 5D BIM for Industry Education

The implementation of 5D not only affects project efficiency but also drives a paradigm shift in civil engineering education and the construction industry. In the context of education, the use of 5D encourages students to understand the relationship between the dimensions of a project—design, time, and cost—making

learning more contextual. BIM practicums that combine 4D–5D can shape analytical competencies and data-driven decision-making skills. From an industrial perspective, the adoption of 5D BIM has the potential to improve coordination between stakeholders. With the Common Data Environment (CDE), the entire project team has access to the latest cost and schedule data, minimizing duplication of work and information conflicts. In addition, the link between the cost estimation module and ERP makes the billing and reporting process more transparent and auditable. However, human resource readiness remains a major challenge. Many small to medium-sized companies do not yet have a workforce with sufficient skills to utilize 5D optimally. Therefore, cooperation between educational institutions, professional associations, and industry is needed to develop curricula and training based on 5D BIM competency standards. Education This collaboration between academia and industry is expected to accelerate digital transformation in Indonesia's construction sector, making 5D not only a technical tool but also a strategic means for improving the quality, efficiency, and sustainability of projects.



**Fig 2.** Diagram of the Relationship between Education, Industry, and BIM 5D Implementation

#### IV. CONCLUSION

Based on our data and review, we conclude that implementing 5D BIM in construction projects contributes to improved cost accuracy, reduced estimation time, and accelerated change-impact detection, provided there is strong synchronization between 4D and 5D and adequate data infrastructure support. The most prominent barriers, such as interoperability issues, inconsistent WBS/COA, and competency gaps, can be addressed through open BIM/IFC, CDE with clear governance, a standardized cost library, and training programs targeting the 4D–5D flow. At the practical level, early WBS harmonization, rules-based QTO validation, and progress-to-payment alignment result in a more accountable and audit-ready workflow.

Recommended further research includes measuring ROI for small-scale projects and testing cost-attribute preservation strategies within IFC-based workflows to more equitably achieve the benefits of 5D. This study confirms that the primary benefit of 5D is not only cost accuracy but also decision literacy—the ability of project actors to quickly understand the cost consequences of design and schedule changes. This is relevant to project owners who demand transparency and accountability. Contracts and tender documents should incorporate standardized 5D obligations (WBS structure, data format, audit trail) and adopt CDE as a single source of truth. Future research can focus on evaluating the impact of 5D BIM integration on economic and environmental project performance indicators. Approaches that combine 5D BIM with artificial intelligence (AI) and the Internet of Things (IoT) should also be explored to strengthen dynamic, predictive cost analysis for future projects.

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