Scientific Research Publishing

Journal of Building Construction and Planning Research, 2026, 14(1), 1-20
https://www.scirp.org/journal/jbcpr
ISSN Online: 2328-4897
ISSN Print: 2328-4889

Integrating Building Information Modelling (BIM) with Construction Project Management for Enhanced Project Delivery and Risk Mitigation

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How to cite this paper: Rana, J., Kabir, A.A.B., Deshani Abeykoon, A.M. and Fahim, A.R. (2026) Integrating Building Information Modelling (BIM) with Construction Project Management for Enhanced Project Delivery and Risk Mitigation. *Journal of Building Construction and Planning Research*, **14**, 1-20.
https://doi.org/10.4236/jbcpr.2026.141001

Received: November 26, 2025
Accepted: January 10, 2026
Published: January 13, 2026

Abstract

Building information modelling is a collaborative process for creating and managing a digital representation of a project's physical and functional characteristics. This is widely applicable for construction project management before the start of the project. This is the application of three-dimensional modelling to include the data regarding the building. This will be included throughout the entire life cycle.

Keywords

Building Information Modelling (BIM), Construction Project Management, Risk Mitigation, Safety Management, Project Delivery, Cost Control, Project Scheduling

1. Introduction

1.1. Background of the Study

With the worldwide building sector changing, one of the major changes has been the emphasis on safety management to turn the working environment into an accident-free one. The relevance of safety in construction projects may be highlighted by taking a peek at the collapse of a scaffolding structure in 2019, causing fatal injuries to many. This is just one of the many incidents to reiterate the point that construction sites are one of the most dangerous settings around the globe.

According to the estimations made by the International Labor Organization (ILO), an estimated 60,000 deaths have been documented across the globe on construction sites [1]. This statistic shows that on average, 1 fatality occurs every 9 minutes per day. In light of such context, "Building Information Modelling (BIM)" technology represents an important opportunity to revolutionize the construction industry. BIM is more holistic than common models of the built environment since it incorporates risk identification and management in the design and construction phases of a project. It is far beyond just creating rich, interactive models, but rather a step towards a change from reactive safety management to a proactive one.

By the use of safety measures in every stage of the project life cycle, BIM assures that the sources of danger are not only identified, but also controlled in advance. All in all, BIM can support a comprehensive approach to safety with a focus on a preventive model and early interventions. The illustrated figure below shows the frequency and severity of accidents before vs. after BIM employment (**Figure 1**, **Table 1**).

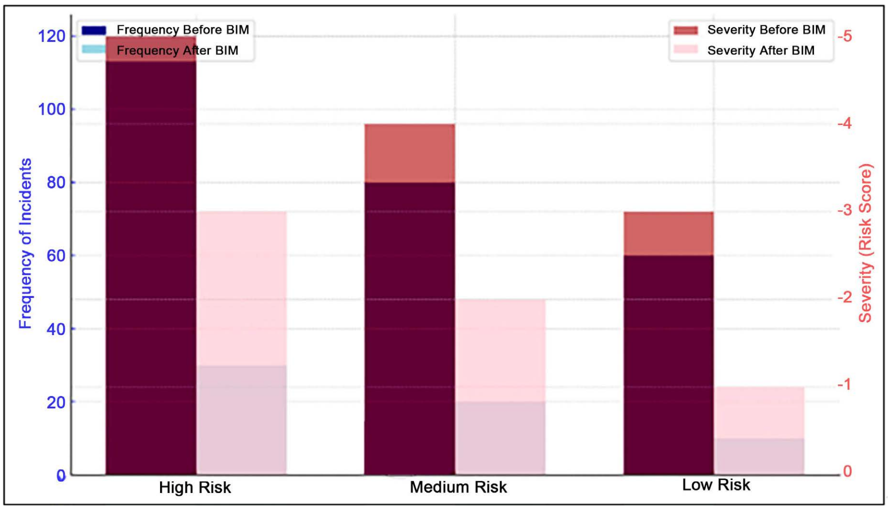


Figure 1. BIM implementation reduces the frequency and severity of accidents (source: Salzano *et al.*, 2024 [1]).

Table 1. Comparison of BIM and key technologies in safety management.

Technology	Uses in Safety Management	Limitations	Benefits of BIM	Source of Parameters
Machine Learning	Predictive analysis of injury types and occurrences	Limited by data quality and integration into real-time site operations	Enhances predictive safety measures, integrates with real-time monitoring for more effective prevention	Derived from industry standards and recent studies on ML in construction safety (1)

Continued

4D BIM	Reference models for safety planning	Complexity in implementation, high upfront costs	Facilitates dynamic simulation of construction processes and proactive risk management	Based on construction management literature and case studies (2)
Digital Twins	Real-time monitoring of construction progress	Focuses mainly on progress tracking rather than risk management	Provides a holistic view, supports proactive interventions and continuous adaptation to on-site changes	Compiled from digital twin technology applications in construction (3)
OHS Methodologies	Rule-based control and design validation	Often project-specific and not adaptable to varying project needs	Standardizes safety protocols, integrates design and operational safety measures more seamlessly	Sourced from OHS regulatory frameworks and safety management guidelines (4)

Source: Salzano *et al.*, 2024 [1].

1.2. Aim and Objectives

Aim

The present research goes into the depth of the effectiveness of BIM in construction project management for the enhancement of safety and the timely delivery of the project.

Objectives

- To analyse the significance of BIM in the reduction of risks in construction projects.
- To assess BIM's contribution to project cost control.
- To evaluate the effectiveness of BIM in the management of construction timelines.
- To demonstrate that BIM is superior to traditional project management methods for the delivery of the project.

1.3. Research Questions

1) In what ways does BIM participate in cost control and scheduling of construction projects?

2) What is the significance of BIM in improving safety in construction projects?

1.4. Rationale

The aspects of "Building Information Modelling (BIM)" in improving construction projects have been opened up through this research study. Some projects may face uncertainties and rising costs that may come along with it, as a result of a lack of sufficient data. Henceforth, this study proposes to find out how BIM's integration in construction works assists in scheduling, cost control, and quality delivery.

1.5. Significance

This research study is relevant because it may provide an understanding of the effects of integrating BIM on project performance. This information can assist managers and engineers in the future with budgeting, decreasing downtime, and mitigating risks earlier. This may also assist with utilizing digital tools for understanding collaborative working and decision-making. This research will demonstrate an understanding of the value of the integrated BIM, which can assist the industry in accomplishing more intelligent and sustainable approaches to construction.

2. Literature Review

2.1. BIM in Ensuring the Safety of Construction Projects

A challenge concerning risk management is that it can tend to change over time. For example, in mega construction projects, the risks associated with the construction of Heathrow Terminal 5 were identified only after the project was completed. However, the risks associated with Dubai International Airport were determined throughout the process of project execution. This is one of the many dimensions of how risks evolve, with the BIM tool being increasingly employed for managing such risks.

The BIM assists in establishing a connection between the Projects Department and the Facility Management Department. It will start with the planning of the project, where it presents a perspective view of the building, with all relevant details. The next part will be in the construction, and at this time, it will show the engineers what the building will look like and identify the detailing of the structure with coordinates to minimize or even eradicate oversights.

At the conclusion of the project, a digital version of the BIM will be provided to the FM department. The version consists of all the information about the building, including the lights, when they were made, how they were installed, and much more. This level of detail will facilitate the fit-out process for the tenant, with changes being simple and smooth. Later on, the sales group can use the digital BIM to lease restaurants and stores, as tenants will have a visual indication of what they will be getting and how their fit-out will all accommodate together (**Figure 2**, **Figure 3**).

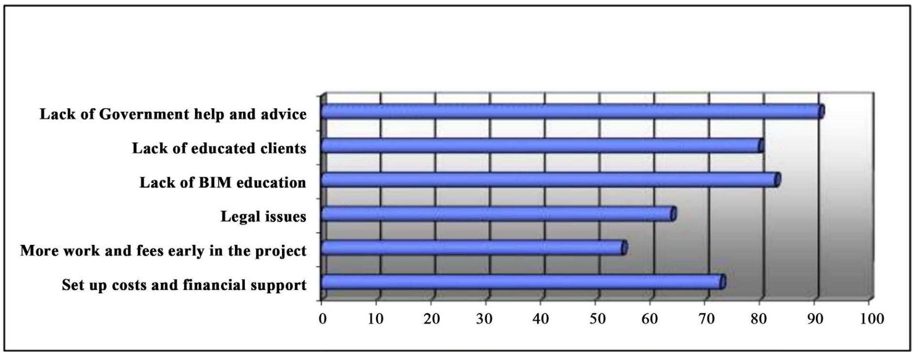


Figure 2. Concerns related to BIM implementation (source: Alzoubi, 2022 [2]).

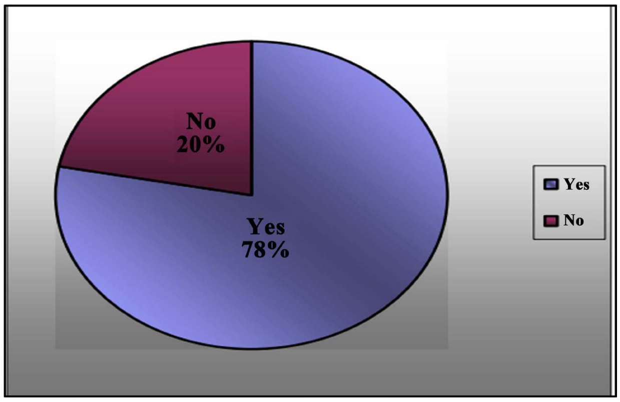


Figure 3. Consent of professionals to BIM implementation (adopted from: Anas Bataw, 2013 [3]).

Another study by [4] integrates risk management with the BIM framework for enhanced project delivery. Due to the importance of risk identification at different stages of the project and its complexity, risk identification would be labor-intensive, as well as subject to human error. Whether a decision tree and neural networks are implemented, the connection established between the planning of risks and risks incurred during project implementation always seems to be weak in relation. This is true, even in the case of contractors still using two-dimensional (2-D) maps for planning, risk identification, and information assemblage during project undertaking. It is widely accepted in the field that BIM advances the possibilities for enhancing risk management. For example, the capacity to calculate quantities quickly and estimate costs more accurately has improved project management. More importantly, BIM allows users to gather information in different phases of projects.

Many projects employ a risk plan during the beginning, but it becomes obsolete with time, due to the changes being made to construction projects. This requires the upgradation of the risk plan according to the transitions being made in construction projects. [4] propose a model using BIM that updates the risk plan based on the latest modifications, enabled by linking implementation data with the 3D model. Using this method stimulates identifying risks in less time and initiating prompt responses.

2.2. BIM in the Scheduling of Projects

Construction Schedule Management (CSM) entails activities such as planning, coordinating, and controlling the tasks necessary for a project to be completed on time, within budget, and meeting the quality expectations of the parties involved. It has been identified that poor planning and scheduling are considered to be major contributors, causing cost performance issues. In addition, lack of planning and scheduling conflicts also ranked among the top reasons for project delays. The current methods related to the CSM are still primarily based on the manual method and are often slow and incorrect due to human error. In spite of being software processes available, they almost always require labor-intensive manual input. Recently, BIM and Natural Language Processing (NLP) have been two rising technologies in the Architecture, Engineering, and Construction (AEC) environment. Both of these technologies have been disruptive in project management as they help in the efficient delivery of work (**Figure 4**).

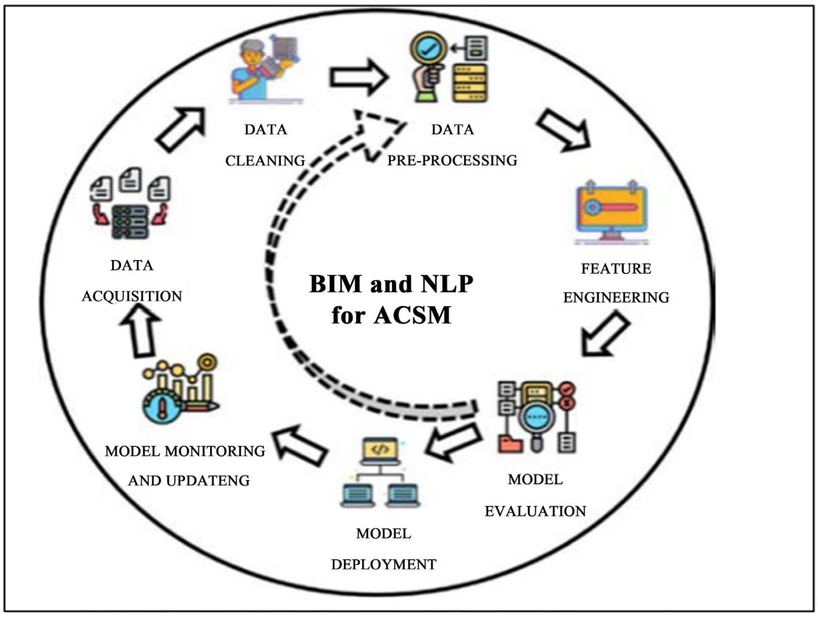


Figure 4. NLP-based data processing generalised workflow (source: Singh *et al.* [5]).

BIM presents a digital representation of a building's physical and functional characteristics. It can also generate schedules based on embedded data in the model, reducing reliance on project planners and helping to create more precise schedule outcomes. The combination of BIM and NLP in CSM could help mitigate some of the barriers to mainstream automated planning and scheduling. BIM has the potential to function as a centralized warehouse for construction knowledge that allows scheduling algorithms to be more flexible. Meanwhile, NLP can automate learning construction knowledge from present records and minimize dependence on manually authored work templates [5]. Furthermore, through the combination of the skills of BIM and NLP, automated dynamic work templates could be generated, which would allow for better scheduling and optimization of a construction project.

According to a paper by [5], "Construction scheduling" is a complicated task due to the links and contradictions of project task activities. Therefore, it is necessary to implement optimization algorithms based on populations, specifically "evolutionary algorithms", to determine the optimal resolutions. Nonetheless, once the problem includes 3 or more objectives, it will become less efficient in optimization, and trade-offs between the conflicting objectives need to be made to reach an ideal Pareto Frontier score. In recent years, there have been attempts to combine BIM with "Multi-Objective Optimization (MOO)" algorithms as a solution to building design and construction issues (**Table 2**).

Table 2. Conventional methods of construction scheduling optimization (CSO).

Methodology	Advantages	Disadvantages
Mathematical Approach	Guaranteed optimality	Can consider only small-scale problems
	Considered a deterministic approach	Requires a strong mathematical background
		Not viable enough to perform smooth simultaneous optimization
		Deals with only one objective
Heuristic Approach	Require less computational work	Problem-specific solutions that cannot be applied to all conditions
	Simple in application	Solutions may be far from optimal
		Geared towards single-project scheduling
Meta-Heuristic Approach	Flexible and robust to problem size	More repetition is required
	Easy to program and implement	Fails to converge sometimes when the initial search point is not selected carefully
	Optimal or near-optimal solutions	Lacks a theoretical basis
	Often a global optimizer	Stochastic, which may yield a different solution every repetition
	Can perform a many-objective optimization	Requires multiple search parameters
	Require a relatively shorter time	Needs specific problem information
	Considered problem-independent	

Source: Essam *et al.*, 2023.

Construction projects rely on one primary goal, which is to organize tasks in the most efficient manner possible while keeping track of time and resources. BIM technologies have made developing "building construction schedule optimization models" substantially easier through visualization and processing of data to achieve a more satisfactory quality. With these BIM software platforms, all parameters that would typically require manual assessment have immediate availability.

2.3. Role of BIM in Cost Control

Construction projects are time-consuming and require resources and funds. Cost control is a vital process that is necessary to achieve the success of the project and add value to it. The primary goal of the given research is to understand how it is possible to integrate BIM with VE (value engineering), demonstrating the advantages of this integration [6]. The proposed study was founded on the analytic hierarchy process (AHP) and the entropy technique to compute the weight and coefficient.

The framework was validated with the help of a case study approach to a high-rise building project in China, and how BIM can be combined with VE. The information was gathered by reviewing documents, interview techniques, and a questionnaire survey that focused on the participants of the project. The results demonstrate that BIM implementation in VE promotes the design change and the extraction of information, including the costs. This method resulted in a cost and time saving of 10 percent on the project. In addition to this, the general quality and performance of the project have been improved. The results indicate the importance of the integration between BIM and VE in the improvement of building project functionality and performance throughout the construction phase (**Table 3**).

Table 3. Saving of costs due to the implementation of BIM and VE in ten thousand RMB (USD).

Building Components	Original Cost	Cost after VE and BIM	Difference
Civil engineering	7766.46 (1143.07)	6575.20 (967.74)	1191.26 (175.33)
Installation project	3069.31 (451.74)	3069.31 (451.74)	0
Decoration engineering	2175.17 (320.14)	1865.82 (274.61)	309.35 (45.53)
Total	13,010.94 (1914.95)	11,510.33 (1694.09)	1500.61 (220.86)

Source: Li *et al.*, 2021 [6].

[7] presents innovative 5D-BIM for tackling costs in construction works. The adoption of BIM 5D into construction project management is a revolutionary innovation compared to the traditional ways of estimating costs. What it mainly takes to its credit is that it brings about a cooperative culture whereby the different parties involved can work together on a common platform. This, in turn, enhances their participation in the decision-making processes. BIM 5D is one of the causes behind the time and budget optimization, as well as the smooth running of the project. Besides, one of the major strengths of BIM 5D is its capability to show the project development in 3D at the pre-construction phase. This feature plays a crucial role in foreseeing and solving project management problems, as well as making construction operations easier (**Table 4**).

Table 4. Pearson correlation test between 5 factors concerning "BIM 5D cost management".

How well does cost control using 5D BIM capture potential cost savings?	What is the level of accuracy in using 5D BIM technology in Cost Management?	What is the level of time-saving in exporting smart sheets according to 5D methodology?	What is the level of training and adoption of BIM 5D in your organization?	In your opinion, how do you foresee the future of cost management in the AEC industry? Will BIM 5D become the standard? Why or why not?
How well does cost control using 5D BIM capture potential cost savings? Sign. (2-tailed)	1		87	

Continued

What is the level of accuracy in using 5D BIM relation technology in Cost Management?	0.599** 0 0.84	1 0.86			
What is the level of time-saving in exporting relation smart sheets according to 5D methodology?	0.466** 0 0.87	0.684** 0 0.86	1 0.96		
What is the level of training and adoption of relation BIM 5D in your organization?	0.088 0.42 0.87	0.058 0.594 0.86	0.096 0.086 0.96	1 0.96	
In your opinion, how do you foresee the future of relation cost management in the AEC industry? Will BIM 5D become the standard? Why or why not?	0.294** 0.006 0.87	0.374** 0 0.86	0.169 0.099 0.96	0.012 0.905 0.96	1 0.96

Source: Safaa Eldin *et al.*, 2024 [7].

Depending on the results from the above table, a significant positive correlation of "0.599" is obtained, where p-value < 0.001. This signifies a strong relationship in the employment of BIM 5D for cost conservancies in construction.

There are multiple advantages to using BIM-based cost estimation over traditional cost estimating processes.

- Detailed 3D model information allows BIM to provide accurate measurements of building components, providing precision in cost determination over traditional approaches.
- It automates many tasks that require manual practice. This selectivity provides savings in time and effort for estimation and faster turnaround time for project budgets and proposals.
- Cost estimations based on BIM can readily coexist with the design process. For example, if a change is made to the BIM model, the cost estimate will be updated automatically.
- BIM models provide an image of the building design, which gives stakeholders a way to better understand the project scope.

3. Methodology

3.1. Research Design

Qualitative research design is employed for this study. According to [8], this method allows the use of the exact words of the participants, which thereby leads to minimization of fabrication in conclusion. Since this study makes use of secondary literary sources, quoting the original authors' work is necessary for the research work's credibility. Henceforth, the chosen design is best suited. This research centers on gathering and examining data obtained from already published research rather than collecting through interviews or surveys. The design enables the analysis of different authors' points of view, obtained from diverse secondary literature. Thus, it can be concluded that the application of this approach will be a support for the researcher in the process of discovering the advantages that BIM has in the construction industry (**Table 5**).

Table 5. Reasons for conducting qualitative research.

Reason	Focus Area	Key Points
Necessity	Addressing complex social phenomena	Explores the complexities of human behaviors and interactions Makes sense of complex social contexts Prevents oversimplification and misinterpretation of social realities
Importance	Generating rich insights and human-centered understanding	Provides a human-centered understanding of the world Leverages methods like in-depth and focus group interviews, as well as participant observation Useful for developing theories, informing policy, and making sure interventions are culturally sensitive and socially responsible
Relevance	Connecting research to real-world issues	Applicable to real-world issues Grounded in lived experiences, reflecting the complexities and responsive to the needs of the modern world Relevant for social scientists, policymakers, and stakeholders interested in understanding and making the world a better place
Urgency	Responding to rapid social change	Addresses the need for timely and relevant insights in a rapidly changing world Social phenomena are evolving due to political, economic, social, technological, environmental, and legal (PESTEL) forces Contributes to decision-making, interventions, or solutions, and overall well-being

Source: Lim, 2025 [9].

Reliable platforms with a huge amount of secondary literature, like Google Scholar, Science Direct, Research Gate, etc., will be used. The searches will be aimed at terms related to cost control, scheduling, and risk assessment via BIM. The utilization of this design allows the researcher to gather comprehensive details for developing valid and meaningful results. The qualitative research design is proper as it aims to comprehend the different facets of concepts and experiences, not just to quantify them. Given that this study is exploring existing knowledge based on the literature and not the data acquired via firsthand processes, the quantitative method would not make sense. In addition, qualitative research provides rich detail in describing concepts and the relationships between BIM and construction project management, supporting the exploratory purpose of the study (**Figure 5**).

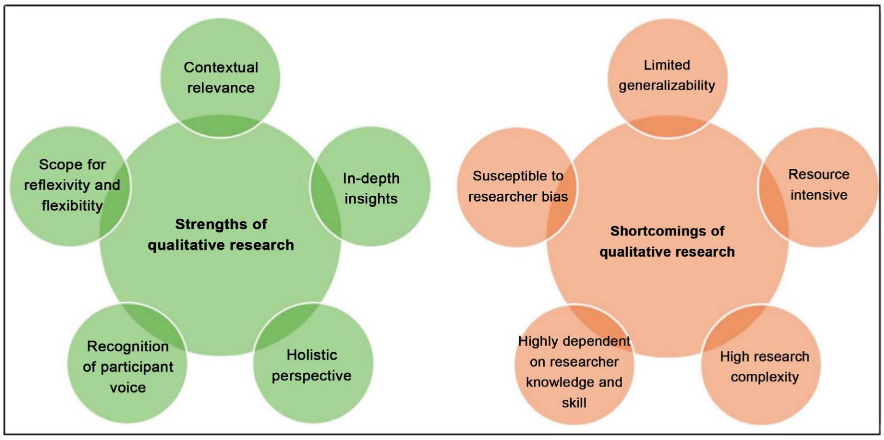


Figure 5. Benefits and drawbacks of qualitative study (source: Lim, 2025 [9]).

3.2. Research Approach

The best-suited approach for this study is inductive. This method relies on three primary steps, where the first one starts with the process of observations of the studied phenomenon [10]. Thereafter, it searches for relevant patterns and ideas within those observations. The third step involves developing new ideas or theories, depending on the observed data. Given that this study will also gather observations as secondary published data, this choice of methodology is the best approach to adopt.

The researcher will look into different scholarly articles related to scheduling, cost control, and risk reduction to get the desired conclusions. Subsequently, the themes and the relationship between BIM and Project Management, in general, will be brought to light. The identified patterns will lead to the creation of new concepts or paradigms that will articulate the effect of BIM integration on construction performance management.

A deductive approach would not be appropriate since this study does not seek to test a hypothesis or empirically verify the existing theory using statistical data. The study desires to develop understanding from qualitative evidence rather than test a hypothesis. Thus, the inductive approach allows flexibility and greater interpretive meaning of the literature (**Figure 6**).

3.3. Data Collection

Data will be collected via a second-hand method through credible platforms such as Google Scholar, IEEE, Science Direct, and others. Main sources from which information will be obtained include scholarly articles, peer-reviewed journals

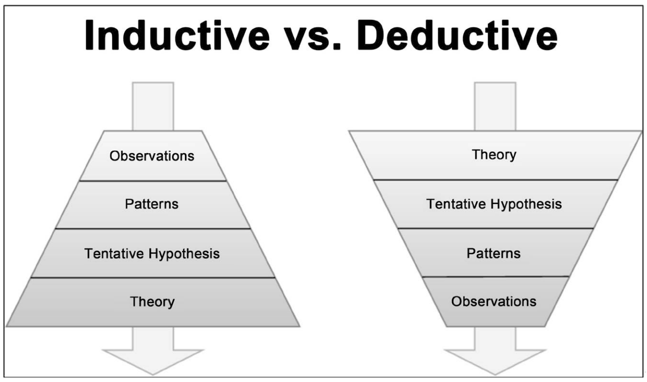


Figure 6. Notable differences between inductive reasoning vs. deductive reasoning (source: Molléri and Petersen, 2024 [11]).

and case studies, among others. This approach is much cheaper and easier to obtain than primary sources, and there is no responsibility for data quality, as it is just reported from the study's findings. However, [12] cautions that the backdrop of secondary studies should always be scrutinized afresh to validate the results.

The very first step in the search for literary sources is that the researcher is on the lookout for corresponding keywords. Among others, they can comprise "BIM in project risk analysis", "BIM in project cost control", etc. Only the resources dated within the last five years, *i.e.*, 2021-2025, will be considered in order to draw the most recent information. The entire information thus acquired is subjected to critical analysis to find answers to the research questions. One of the most obvious advantages of secondary data collection is that the researcher is free to focus on analysis and can thus provide more insightful recommendations. Additionally, it opens the door to a wide range of studies from different parts of the world, which helps to understand how BIM is used globally for construction management. A comparison of these selected studies will result in balanced conclusions about BIM integration in project management.

3.4. Ethical Considerations

Ethical behavior, including sound peer review, clear open methods, and accountability to accepted guidelines, helps contribute to a person's trust in research. When research is driven by an ethical framework, it reduces the likelihood of bias or fabrication and enhances the credibility of the results [13]. For example, employing ethics results in data being reported honestly and fully disclosing any conflicts of interest. This all adds to the credibility and trustworthiness of research.

Since this work does not rely on primary data collection, there is no concept of obtaining "informed consent" from participants. Regardless, there are concerns around intellectual property for the work of other researchers. Avoiding this, the study utilizes in-text citations to credit original authors, along with a detailed reference list at the bottom of the study. This also leads to the avoidance of plagiarism issues.

The researcher has ensured that all the information gathered from journals and articles is reported as it is, without any fabrication. Every step of collecting data is made transparent to avoid issues of bias and falsified report publications. In addition, only publicly accessible or open-access materials are utilized to adhere to copyright law. The investigator will not include any confidential or restricted information from private entities. The researcher ensured that the information taken from the other studies was properly understood and not altered to suit personal viewpoints. Due consideration has been taken to facilitate impartiality and demonstrate diverse perspectives of the authors.

All in all, adhering to the aforementioned ethical guidelines assisted in upholding academic integrity.

3.5. Research Limitations

The research has certain limitations that might affect the depth of the study. Since it relies solely on secondary data, it is largely dependent on the quality and accuracy of prior research rather than new findings. The researcher has no access to the data and hence cannot verify or control it. Therefore, the presence of any bias or mistake in the original sources can affect the outcomes. Additionally, due to limitations of time and resources, the review will be limited only to a certain number of articles. This may not fully represent the different aspects of BIM-CPM integration. The absence of primary data, like interviews with construction professionals, prohibits the inclusion of more real-world opinions. Sometimes, data collected via second-hand methods may not be related to the research questions posed in this study.

Besides, the changes in technology in the construction sector are very rapid. Since BIM tools and project management software receive updates regularly, the reviewed sources may become outdated. This restricts the accuracy of the results over a longer time. There might be some obstacles in using certain paid academic journals or company reports, posing hindrances in drawing some useful results from them. The research, however, provides a valuable presentation of the application of BIM in improving the effectiveness of construction projects, despite the discussed limitations.

4. Discussion

4.1. BIM's Position in Cost Control and Scheduling

A lot of construction projects today continue to grapple with cost excesses and time lag in operations. Thus, the construction progress monitoring sphere (CPM) requires automatic solutions to tackle these issues. [14] suggested a system that combines a BIM-planned model and laser scans on-site, because these scanners demonstrated enormous opportunities in the CPM field. The proposed system also employed color-coding to recognize the condition of each element according to its "recognition" and "scheduling" state and clear any occlusions when computing the recognized objects. Another automatic status of the project progress in relation to schedule (4D) and cost (5D) was also presented in the results. The outcome of the automated results was also compared to the manual calculation, with a low difference of 1.35% in the results. This system exhibits an extent of precise tracking of progress.

The suggested system creates a user interface through which the computation of the progress tracking of the "schedule" and "cost" can be quantified. The user interface approximates schedule and cost progress based on EV through the:

- Budgeted cost of work scheduled (BCWS);
- Budgeted cost of work performed (BCWP);
- Actual cost of work performed (ACWP).

Figure 7 presents the progress tracking outcomes based on the schedule and cost of concrete work in the case study. Total cost in unrecognized elements in BCWS, BCWP, and ACWP is also illustrated in the figure.

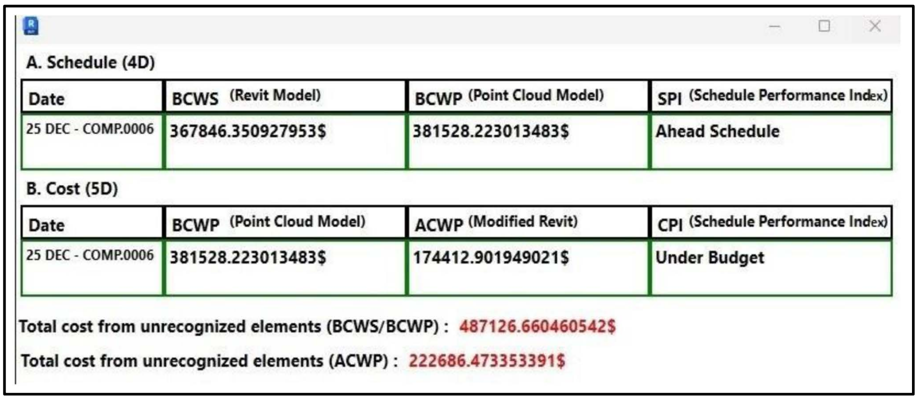


Figure 7. User interface calculation of SPI and CPI for the proposed system (source: El-Qasaby *et al.*, 2023 [14]).

[15] discusses how the construction industry has seen an impressive development due to disruptive technologies such as BIM and Artificial Intelligence (AI). The combination of BIM and AI in the cost management of a construction project has a lot of advantages. BIM makes the project requirement easier by providing a very detailed digital model of the project, and AI, on the other hand, smartly analyzes it along with its future forecasting functionalities. The BIM model is so comprehensive in terms of information that it becomes the input for AI algorithms. The AI then processes the data to uncover the patterns and relationships that are associated with the costs.

Moreover, the joining of these technologies renders the construction schedules less difficult and cheaper to handle. One of the primary advantages is better visualization and coordination. BIM allows for the creation of a highly detailed 3D model of the entire project. This data can be analyzed by AI algorithms to identify possible clashes or conflicts in the design and allow for resolving the issue in advance. Through this proactive measure, delays are minimized, and the project delivery will be of high quality (Table 6).

Table 6. BIM-AI merging to tackle schedule, cost, and safety management.

Sl. No.	Aspect	Building Information Modeling (BIM)	Artificial Intelligence (AI)	Integration Methods	Challenges	Future Directions
1	Construction Schedule Management	Utilizes 3D models and clash detection for visualizing construction processes	Employs AI algorithms for accurate project timeline predictions based on historical data	Real-time adjustments using predictive analytics	Data interoperability, varying standards	Enhanced interoperability, IoT integration, dynamic scheduling via AI
2	Cost Management	Provides precise quantity takeoffs and cost estimation through 3D models	Utilizes AI for cost analysis from diverse data sources, ensuring accurate forecasts	Integrates BIM data into AI algorithms for reliable budgeting	Cost data accuracy, integration complexity	Advanced cost data validation algorithms, blockchain for transparent tracking
3	Quality Management	Facilitates 3D visualization for clash detection and coordination among systems	Employs AI with image recognition and sensors to monitor construction quality	BIM 3D models serve as references for AI-driven quality control	Data accuracy, real-time monitoring complexity	AI-driven automated quality assurance, advanced real-time sensor technologies
4	Safety Management	Includes safety-related information, such as escape routes in 3D models	Utilizes AI to predict safety hazards and suggest preventive measures	BIM data on safety features enhances AI-driven risk assessment and safety protocols	Data security, privacy, AI reliability	Enhanced AI algorithms, privacy-preserving techniques, standardized safety data formats

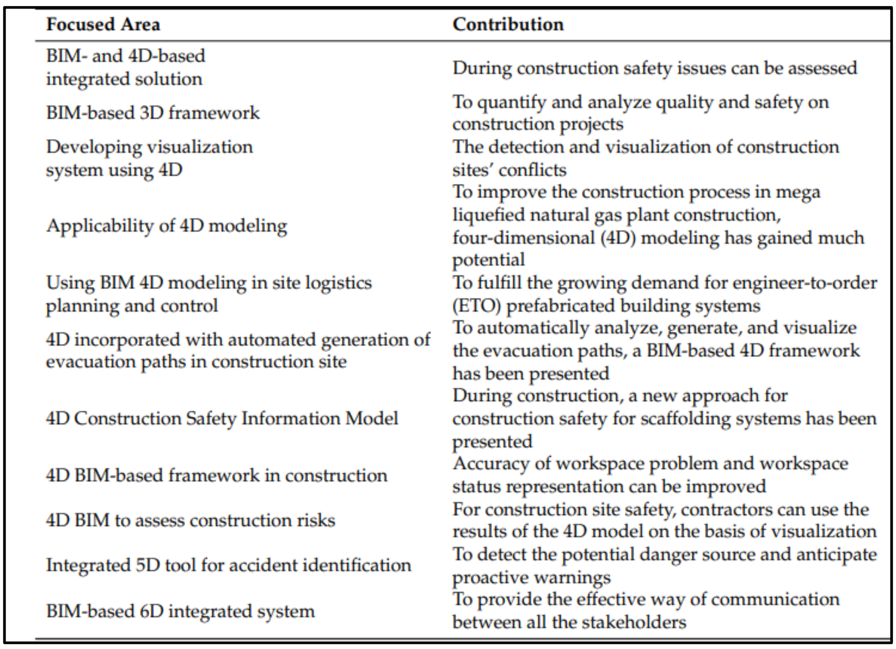
Source: Rane, 2023 [15].

4.2. BIM and Safety Enhancement

The Health and Safety Executive (HSE) in the UK recently found out that out of 138 work-related deaths in 2023/24, 51 of them were in construction (britsafe.org, 2025). Studies have indicated that the absence of digital "occupational safety and health (OSH)" information is one of the major factors that have led to the poor performance of OSH management in construction. It is crucial that the AECO (Architecture, Engineering, Construction, and Operation) industry realizes the best way it can use BIM to enhance the OSH processes.

According to recent academic literature, BIM can optimize the management of OSH, and the construction industry is beginning to implement these types of technologies. As the experience in the AECO sector suggests, the stakeholders in this sphere should cooperate more. The source of information deployed in projects entails hundreds of attributes and may not be structured, complicating the interpretation of the relevant information. BIM offers the necessary instruments to systematize this kind of information. Also, BIM helps showcase the risks during the design stage to enhance timely risk detection and reduction.

Crossrail in the UK used BIM-based clash detection in the project to prevent accidents on site caused by poorly coordinated installations [16]. The risk of worker injury due to unexpected site changes is reduced since the BIM identifies and solves problems that could cause injury during construction beforehand. Another major improvement is the 4D BIM simulation that combines planning and a 3D model. It allows construction teams to see every stage of a project before its implementation, identify the activities that have high risks, and take preventive measures. Moreover, the safest sequence of construction activities can be identified using these simulations to ensure that activities with a high level of risk are carried out carefully. Moreover, BIM enhances safety training through the creation of virtual reality (VR) and augmented reality (AR) platforms that allow workers to get used to the site conditions before they go to a risky area. Incorporating BIM resulted in a reduction of serious accidents by 70 percent, showing the effect BIM can have on situations that are hazardous [16] (**Figure 8**).



Focused Area	Contribution
BIM- and 4D-based integrated solution	During construction safety issues can be assessed
BIM-based 3D framework	To quantify and analyze quality and safety on construction projects
Developing visualization system using 4D	The detection and visualization of construction sites' conflicts
Applicability of 4D modeling	To improve the construction process in mega liquefied natural gas plant construction, four-dimensional (4D) modeling has gained much potential
Using BIM 4D modeling in site logistics planning and control	To fulfill the growing demand for engineer-to-order (ETO) prefabricated building systems
4D incorporated with automated generation of evacuation paths in construction site	To automatically analyze, generate, and visualize the evacuation paths, a BIM-based 4D framework has been presented
4D Construction Safety Information Model	During construction, a new approach for construction safety for scaffolding systems has been presented
4D BIM-based framework in construction	Accuracy of workspace problem and workspace status representation can be improved
4D BIM to assess construction risks	For construction site safety, contractors can use the results of the 4D model on the basis of visualization
Integrated 5D tool for accident identification	To detect the potential danger source and anticipate proactive warnings
BIM-based 6D integrated system	To provide the effective way of communication between all the stakeholders

Figure 8. Construction safety and BIM's contribution (source: Manzoor *et al.*, 2025 [16]).

4.3. Opportunities of BIM in Construction Project Management (CPM)

Project management has been based on traditional approaches, but with the emergence of BIM technology, there is a paradigm shift in the way projects are executed. The holistic nature of BIM allows the formation of a common digital architecture so that interested parties can cooperatively communicate with project information throughout the entire operating cycle. Starting with design coordination and clash detection, the possible contribution of BIM is extensive, including scheduling and cost estimation.

The project planning process could be very much impacted by the workplace, which could lead to inferior choices and difficulty in carrying out the project. Still, the use of 5D BIM models, as [17] states, would make the whole construction process very easy, and it focuses right on the project timeline. It promotes the alignment of the design and construction schedules, which in turn would reduce project delays and provide the client with a clearer understanding of the whole construction process.

5D BIM models enable users to have a precise estimation of project cost by automated quantity takeoffs. For successful building projects, effective communication and collaboration are required. BIM functions as a tool that visually represents information, thereby reducing the chances of misinterpretation. BIM usage secures the centralization and proper handling of data, depicted through 3D models (**Figure 9**).

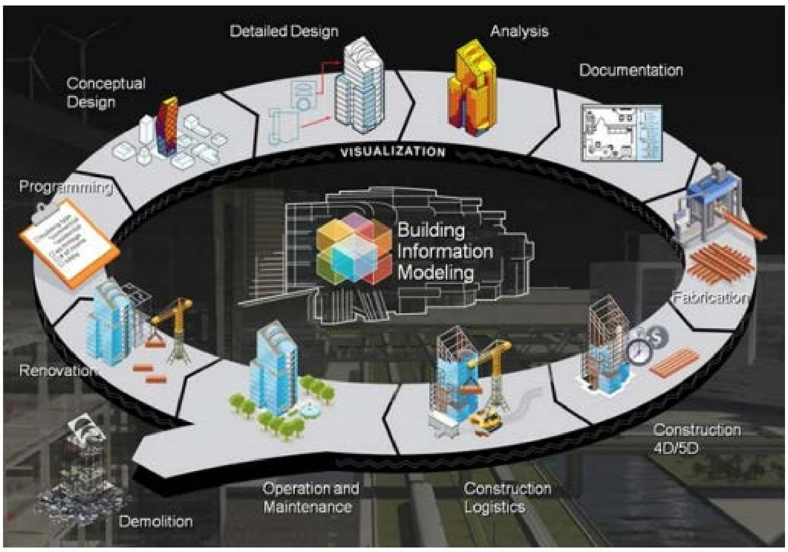


Figure 9. Operation and maintenance phases of a building's lifecycle using BIM (source: Tran *et al.*, 2024 [17]).

A study by [18] focuses on the utility of BIM 3D/4D/5D tools for building visualization in CPM. The BIM technology articulates the totality of the building. It enhances the growth of AEC. on the basis of data integration. Design output is even more visualised in case the designer uses BIM technology. It also introduces a database of visual models that is developed from the construction drawings. It is a big contrast to the traditional 2D drawing, including the AutoCAD tool. The

3D model has the capability to create different elevation views and section drawings easily. The approach enhances efficiency in design work and minimizes errors in design.

Based on the 3D representation, the BIM 4D system introduces time, and the 5D system introduces quantity consideration. This is a technology that incorporates the cost information and project work schedule into the model. The dynamic analysis is carried out by the project team through connecting the real situation on the site. The clash detection process was identified to have numerous problems, and the visualization modelling is the guiding tool in site plan work. Moreover, the BIM 5D tool assists a quantity surveyor to obtain the appropriate quantities of materials within a short period and enhance cost control.

5. Conclusions and Recommendations

5.1. Conclusions

The research focuses on the revolutionary impact of BIM on CPM in areas like safety, cost control, and scheduling. According to second-hand literature, operations enabled by BIM are far superior in terms of proactiveness and data usage when compared with conventional approaches. It allows the detection of risks at an early stage, facilitates communication among teams, and much more. Furthermore, integration of BIM with AI, NLP, and Value Engineering is helpful in decision-making and accuracy.

One of the main benefits of BIM is its capability to handle construction safety issues through the prediction of safety hazards in the design phase. 4D and 5D BIM technologies are used to create virtual scenarios of the site work, thus the chances of mishaps and injuries have been drastically lowered. In the same light, the use of BIM-powered budgeting and planning instruments has been the main reason for a great deal of time and money being saved. These incidents have resulted in the fast delivery of the project, and the general quality has improved.

The decision to employ a qualitative and inductive research approach in this study facilitated an extensive comprehension of the role of BIM from various academic perspectives. Being dependent on secondary data put forward convincing arguments that the use of BIM leads to the positive effects of cost minimization, planned schedules, and lowering of risks in construction projects. On the other hand, there were limitations recognized, among which were the constantly changing nature of technology and the lack of primary data. Meanwhile, compliance with ethics ensured that the academic integrity of this study was upheld at all costs.

BIM is a vital breakthrough for the construction sector, by which the industry has been able to transform project management from a reactive to a preventive and intelligent one.

5.2. Recommendations

- It is a must for construction firms to ensure that engineers, architects, and project managers receive frequent training in BIM to develop the required skills.

- Ensure that the use of BIM is combined with AI, 5D modelling, and other technologies for a more accurate schedule and budget control.
- Authorities must set up definite guidelines for the use of BIM and provide a reward system for those organizations that implement it in the safety and management aspects of the project.
- Spread awareness in developing nations regarding the potential benefits of employing BIM, related to overall project effectiveness.
- Future research work may collect firsthand information from construction projects that are in progress to have a better understanding of practical issues and BIM's performance in the real world.
- Collaborations should be formed between research centers and construction companies to create next-generation applications of BIM.

The use of pilot projects in public infrastructure can be a great way to show how effective BIM is, encouraging its implementation in the private sector.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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