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Exploring Strategies, Benefits, and Challenges for Combined Lean-BIM Implementation

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This study explores the activities, benefits, and challenges associated with combined implementation of Lean Construction (Lean) and Building Information Modeling (BIM) at project-level by conducting a traditional literature review using a representative sample of 37 journal articles. Such activities were categorized by project phase, i.e., planning, design, and construction, to understand the nuances of Lean-BIM throughout the project delivery process. Benefits were categorized by the Lean principles such as waste reduction, flow improvement, and value generation. Challenges were categorized by the different aspects of implementation such as cultural, technical, and organizational. The results show that during project planning, Lean-BIM strengthens visualization, scheduling, and constraint identification; during design, enhances collaboration, model-based coordination, and accuracy; during construction, enables reduced rework, efficient resource management, and effective communication between office and site operations. By identifying the key activities, benefits, and challenges associated with Lean-BIM integration, this study contributes to understanding of components that support planning for a Lean-BIM combined implementation.

Keywords: Lean Construction, Building Information Modeling, Project Planning

Introduction

The construction industry faces persistent challenges such as time overruns, cost escalation, poor communication, and inefficient coordination across project phases. (Likita et al., 2022). To address these problems, Lean Construction (Lean) and Building Information Modeling (BIM) have emerged as two major process and product improvement avenues. Lean focuses on optimizing value while minimizing waste through principles such as continuous flow, collaboration, and reliable planning (Moradi & Sormunen, 2024). BIM, on the other hand, enhances visualization, data integration, and coordination by creating a shared digital representation of the project (Guerriero et al., 2017). While both Lean and BIM have proven benefits independently, the growing need for greater efficiency and integration has encouraged researchers and practitioners to explore their combined application on construction projects (Koseoglu et al., 2018). Over the past decade, numerous studies have examined how Lean and BIM complement each other in planning, design, and construction (Bayhan et al., 2023). Still, most available research treats the two as separate avenues focusing on organization-level integration rather than project-level, despite construction being a project-based industry (Likita et al., 2022). This creates a lack of understanding in how Lean-BIM can be combined in day-to-day project workflows. As construction projects increasingly become complex and depend on multidisciplinary teams' collaboration, the Lean-BIM combined implementation offers an opportunity to enhance workflow reliability and establish transparency in communication throughout its delivery process (Guerriero et al., 2017). Research-driven, industry-sponsored guides exist that support the project-level planning for Lean (Messner et al., 2018) and BIM (Messner et al., 2021) implementation but as separate processes. Using both can seem daunting for a team that maybe new to either one or both. Where Lean requires the need for facilitator leadership and other "soft" skills that will allow motivation and encouragement to change a team's mindset towards new working methods, BIM when not properly planned, implemented, and monitored, makes a process more difficult and unstable (Liu et al., 2023). Further, each stakeholder benefits differently from Lean-BIM integrations (Dodge Construction Network, 2021, and 2023 a, b, c). Therefore, project teams need a single point resource, ideally a guided planning process to plan and manage project-level Lean-BIM combined implementation. As a first step, towards building this process, this study used a systematic literature review approach to explore Lean-BIM integration at the project level based on their interaction across the planning, design, and construction phases and to identify what strategies, benefits, and challenges are associated with the combined implementation of Lean-BIM at the project level. The information about key activities, benefits, and challenges associated with Lean-BIM integration from this study contributes to the understanding of components that can potentially support planning for a Lean-BIM combined implementation.

Background of Lean-BIM Combined Implementation

The construction industry is a project-based industry and hence the maximum value is generated when Lean-BIM integrations are employed by teams specific to a project (Aburumman et al., 2023). Since each construction project and the team delivering it is unique, the reasons for using Lean, BIM, or both combined is also driven by it (Likita et al., 2025). Lean enables continuous improvement on the project by reducing waste and creating value, while BIM enables better visualization, coordination, and collaboration through digital models (Moradi & Sormunen, 2024). Therefore, when implemented in combination, their benefits and challenges are both amplified, but also leading to a more complex yet rewarding project delivery process (Likita et al., 2025). In the planning phase, integrating the Last Planner System® with 4D BIM improves reliability and transparency. Combining planning data with 4D visualization project teams can identify constraints early, plan tasks efficiently, and keep everyone on the same page (Sbiti et al., 2021). Lean-BIM combined implementation makes planning meetings more visual and collaborative. Teams can clearly see activity sequences, detect conflicts before execution, and align daily work plans with long-term schedules. BIM helps visualize what Lean is trying to control in the workflow. When the two come together, the schedule becomes more realistic, and work can flow with fewer interruptions (Andújar-Montoya et al., 2020). In the design phase, Alnajjar et al. (2025) highlights the link between the Lean method, Value Stream Mapping (VSM) and a building information model's clash-detection capability. Michaud et al. (2019) show that using VSM helps identify non-value-adding steps in the design process and model coordination helps visualize corresponding issues and resolve them early in the design phase. In that manner, Lean-BIM combined implementation reduces rework and saves time. When the design team uses VSM along with model coordination, they can see which processes are taking longer or where information is stagnant or redundant. Overall, Lean helps the team focus on what adds value, while BIM makes those processes visible and measurable (Yang, 2019). In the construction phase, integrating visual management tools with model-based common data environments (CDEs) has improved coordination between site and management teams (Aburumman et al., 2023) and help track progress, monitor issues, and enhance team communication (Bayhan et al., 2023; Nascimentoetal al., 2017). Visual management renders information easy to understand and remember. When connected to BIM, they display real-time data about site progress, material delivery, and task completion. This reduces confusion and helps supervisors make reliable and prompt data-driven decisions. Using a CDE, all teams can simultaneously access most current project information and visualize it using the model, minimizing errors and allowing faster decision-making (Nascimento et al., 2018).

Benefits and Challenges of Lean and BIM Integration

Most researchers found improvements in project time, cost control, and collaboration. For example, in the Dezhou case study on disassembly and reuse, Lean-BIM combined implementation reduced waste and shortened project duration (Hei et al., 2024). Similarly, a study conducted by Karatas and Budak (2023) observed a significant increase in labor efficiency and enhanced teamwork when Lean-BIM were implemented together. Herrera et al. (2021) compared team interactions in a traditional project with a Lean-BIM project and found stronger communication networks in the later. Another study conducted by Gökhan et al. (2021), combining Lean-BIM implementation noted faster decision-making and fewer coordination conflicts due to shared project information. Additionally, Moradi & Sormunen (2024), emphasized sustainability and long-term value resulting from Lean-BIM integration enhancing resource efficiency and waste reduction. This combined approach also contributes to improved facility performance and supports more sustainable project outcomes over time (Sepasgozar et al., 2020). Overall, projects achieve better results across quality, time, cost, and safety performance with Lean-BIM combined implementation. While Lean-BIM combined implementation offers many benefits, literature also identifies several recurring challenges. One major issue is the lack of skilled professionals who understand both systems (Ahuja et al., 2018). Prior research show that many project teams are familiar with either Lean or BIM individually, but lack the combined expertise needed to integrate both effectively. This creates gaps during implementation. (Likita et al., 2022). Another common challenge is resistance to change and the absence of clear digital workflows (Zhan et al., 2022). System Dynamics Outlook on BIM and Lean Interaction, and the Compatibility of BIM Maturity Models with Lean and IPD, highlight that without standard frameworks or leadership support, integration often depends on individual effort rather than a structured process (Rashidian et al., 2022). Cost is also a concern; high software and training expenses discourage smaller firms from adopting BIM or Lean on a full scale (Weerasinghe et al., 2024). Overall, the main barriers are more organizational than technical. Thus, successful implementation depends on leadership commitment, clear communication, and continuous training, indicating that construction companies who encourage collaboration and knowledge sharing tend to achieve better integration results (Demirdöğen et al., 2021; Herrera et al., 2021).

Methodology

This study adopted a traditional literature review approach to explore Lean-BIM implementations at the project level. Databases, Google Scholar and Engineering Village were selected because together they provide broad coverage of peer-reviewed engineering and interdisciplinary literature relevant to this study. Engineering Village offers curated access to key engineering databases, while Google Scholar complements this with wider coverage. Preliminary scoping indicated that the majority of relevant records indexed in other databases such as Scopus and Web of Science were already captured through these sources. Therefore, adding other databases was unlikely to substantially increase retrieval while increasing duplication. Initially 134 journal articles between 2010 and 2024 were extracted but due to a rise in the number of publications noted starting 2018 related to Lean-BIM combined implementations, 37 articles published between 2018 and 2024 were selected based on inclusion and exclusion criteria. Such criteria focused on only articles that had full text availability through the California State University-Fresno’s library system and were strictly based on project-level Lean-BIM combined implementation. Each paper was reviewed using a consistent data extraction approach to identify five key activities, five key challenges, and five key benefits. A count of five was used to ensure that each group was represented equally as many papers reported more than five items in each category. This created a large pool of raw statements, which were rewritten for standardization, and grouped using a thematic approach. Activities were grouped by similarity and then organized by planning, design, and construction phase. Benefits were grouped based on meaning and mapped to Lean principles: Waste Reduction, Flow Improvement, and Value Generation. Challenges were grouped by recurring themes and categorized as technical, organizational, and cultural. This thematic grouping enabled summarizing the information from all 37 articles into three tables. This strategy treated the selected statements as a manageable sample of the larger set of activities, benefits, and challenges described in each study, while keeping contributions from all 37 papers comparable. This approach ensured accuracy, transparency, and consistency throughout the literature review.

Thematic Summarization of Activities, Benefits, and Challenges

The identification process for key Lean-BIM activities reported across the 37 articles, began by extracting five raw statements from each paper and then rewritten in a common language–based format to remove wording variations and ensure comparability. After standardization, similar activities were grouped to identify recurring patterns and eliminate duplicates or unclear items. These consolidated activity groups were then organized by project phase to show Lean-BIM combined implementation opportunities. An example shown in Table 1 demonstrates this process: several raw activities related to Kanban use and BIM-based change tracking were merged into two standardized activity statements and categorized under the Construction phase, showing how Lean tools and BIM functions align at the field execution level.

Table 1. Example of Common Language–Based Grouping of Lean–BIM Activities

Activities (Raw Extract)	Common Sentences	Keywords
1. Teams used a Kanban board on-site to display daily schedules, identify obstacles, and initiate Kaizen actions. 2. They attached digital Kanban cards to BIM objects through a simple app.	Physical and digital Kanban boards linked to BIM provided real-time production control and visibility of progress.	Kanban / Visual Board / Real-time Tracking

The identification of key benefits associated with Lean–BIM implementation, started with the extraction of five raw benefit statements from the 37 articles, resulting in a total of 165 entries. Then rewritten using a common language followed by grouping similar and comparable wording. After standardization, duplicates were removed and remaining grouped consistent with recurring patterns in the literature. This process reduced the full dataset to 19 benefit themes. Finally, these themes were organized under the three core Lean principles: Waste Reduction, Flow Improvement, and Value Generation to show how Lean–BIM integration supports efficiency, smoother workflows, better coordination, and improved decision-making. Table 2 illustrates an example of this consolidation process by showing how several raw benefit statements were merged into a single grouped theme based on shared intent and key concepts.

Table 2. Example of Lean–BIM Benefits Grouping

Benefits (Raw Extract)	Common Benefit (Grouped Theme)	Keywords
1. The extended conceptual model standardizes task-status attributes and prerequisite handling in IFC, improving data exchange and querying in BIM tools.	Data standardization & analytics are enabled through extended BIM models and Big Data applications, which improve data exchange, support	Data Standardization and Analytics

2. Enables data-driven insights through Big Data Analytics to optimize resource flows and predictive planning.	querying, and provide insights for optimizing resource flows and predictive planning.

To identify the key challenges associated with Lean–BIM integration, five challenge statements were extracted raw from the 37 articles, resulting in a total of 175 raw challenges. Using a common language-based grouping method, all raw challenge statements were rewritten in clear and consistent wording so they could be compared effectively. Similar challenges were then grouped to identify repeated patterns across studies, while duplicates, unclear statements, and challenges unrelated to Lean–BIM were removed. Through this thematic consolidation process, the 175 raw challenges were reduced to 33 common challenge sentences that captured the core issues reported across the literature. These 33 challenges were then organized into three major categories: Technical, Organizational, and Cultural, to highlight the underlying causes of integration barriers. As illustrated in Table 3, individual challenge statements, such as supply-chain uncertainties or unreliable building data, were merged into broader grouped themes and assigned to the appropriate category, making the dataset ready for further analysis.

Table 3. Example of Lean–BIM Challenges Grouping

Challenges (Raw Extract)	**Common Benefit (Grouped Theme)**	**Keywords**
1. Supply-chain delays disrupt Just-in-Time practices 2. Uncertainties in the supply chain, like unclear demand for salvaged materials and storage logistics, complicate pull-based deconstruction planning	Supply-chain uncertainties disrupt Lean pull-based planning and JIT workflows	Supply-chain Delays

Results and Discussion

For the 37 studies where the country of origin could be clearly identified, the evidence is spread across six continents. Asia (including Turkey, Lebanon, India, and China) accounts for 12 studies, followed by South America with 8 studies and both Europe and North America with 6 studies each. Africa and Oceania are each represented by 3 studies, mainly from Egypt and Australia. This continental distribution shows that most published Lean–BIM research in the sample comes from Asian and South American contexts, with additional but smaller contributions from Europe, North America, and Africa. A total of 175 activities, 176 challenges, and 165 benefits associated with Lean-BIM combined implementation were extracted and grouped. The activities were categorized by project phase, i.e., planning, design, and construction, to understand the nuances of Lean-BIM interaction throughout the project delivery process. Benefits were categorized by the Lean principles such as waste reduction, flow improvement, value generation. Challenges were categorized by the different aspects of implementation such as cultural, technical, and organizational. The results are presented phase-wise and mapped against the core Lean principles of waste reduction, flow improvement, and value generation.

Lean–BIM activities were categorized across the planning, design, and construction phases. Each phase demonstrated unique integration patterns that link Lean and BIM to enhance reliability, coordination, and communication. Such key activities are summarized in Table 4 by phase.

Table 4. Key Activities Associated with Lean-BIM Integration

Phase	Activities	Integration Pattern	Outcome
Planning	Setting up joint BIM–Lean frameworks; conducting collaborative Last Planner sessions; creating visual process maps; applying Value Stream Mapping to identify constraints (Andújar-Montoya et al., 2020; Sbiti et al., 2021)	Last Planner System ↔ 4D BIM Scheduling	Improved plan reliability, visualization, and communication
Design	Running BIM-based clash detection; mapping workflows using VSM; holding design coordination meetings; automating model updates; standardizing BIM execution procedures (Michaud et al., 2019; Yang, 2019).	Value Stream Mapping ↔ BIM Clash Detection	Reduced design waste, minimized rework, and improved design coordination.
Construction	Using digital Obeya rooms; integrating visual management dashboards; linking field data to BIM models; applying BIM-based QA/QC and progress tracking (Nascimento et al., 2017, 2018).	Visual Management ↔ Shared BIM Models (CDEs)	Strengthened collaboration, ensured transparency, and supported real-time monitoring.

The benefits of Lean–BIM adoption align strongly with Lean's fundamental principles. Integrated practices improved waste reduction, workflow stability, and decision-making transparency across project phases. Such benefits are summarized by Lean principles in Table 5.

Table 5. Key Benefits Associated with Lean-BIM Integration

Lean Principle	Benefits	Mechanism/ Integration Type	Outcome
Waste Reduction	Decrease in rework and idle time (Yang, 2019); Lower material waste through accurate quantity take-offs (Hei et al., 2024); Less rework via early clash detection and prefabrication (Moradi & Sormunen, 2024).	Early clash detection and just-in-time prefabrication through BIM.	Up to 10 % cost and schedule reduction in multiple case studies.
Flow Improvement	Smoother information exchange between teams (Sbiti et al., 2021); Higher schedule reliability and planning accuracy (Bayhan et al., 2023); Improved workflow continuity and reduced bottlenecks (Guerriero et al., 2017).	Digital pull planning using shared 4D BIM environments and real-time visualization.	Continuous flow of tasks and improved PPC (plan percent complete) reliability.
Value Generation	Enhanced decision-making through data visualization (Demirdöğen et al., 2021); Greater transparency and	Collaborative dashboards, model-based	Data-driven decisions and long-term value

	collaboration between stakeholders (Moradi & Sormunen, 2024); Improved sustainability and long-term asset value (Sepasgozar et al., 2020).	coordination, and integration with Big Data analytics.	realization through better resource management.

The analysis identified technical, organizational, and cultural barriers that limit Lean–BIM adoption. While technical issues are frequent, most challenges arise from organizational and behavioral factors, such as lack of leadership support and resistance to change. Such challenges are summarized by category in Table 6.

Table 6. Key Challenges Associated with Lean-BIM Integration

Category	**Challenges**	**Root-cause/ Description**	**Impact**
Technical	Software tools not compatible or unable to share data smoothly (Rashidian et al., 2022; Zhan et al., 2022); Inconsistent model detail and lack of data standards (Rashidian et al., 2022; Sbiti et al., 2021); Difficulty linking Lean metrics with BIM data (Sbiti et al., 2021; Zhan et al., 2022).	BIM and Lean tools often work on different platforms and lack standard data formats.	Makes it hard to synchronize BIM information with Lean planning and performance tracking.
Organizational	Limited leadership support for Lean–BIM initiatives (Ahuja et al., 2018; Likita et al., 2022); Lack of trained professionals skilled in both Lean and BIM (Likita et al., 2022); Absence of a clear implementation framework (Ahuja et al., 2018; Bayhan et al., 2023).	Organizations often apply Lean or BIM separately without a unified strategy or proper training.	Disrupts workflow integration and reduces long-term sustainability of digital adoption.
Cultural	Resistance to changing traditional project management habits (Likita et al., 2022; Weerasinghe et al., 2024); Poor collaboration between design and construction teams (Bayhan et al., 2023; Herrera et al., 2021); Hesitancy to invest in new tools due to uncertainty of returns (Moradi & Sormunen, 2024; Weerasinghe et al., 2024).	Teams unfamiliar with Lean–BIM methods struggle to adapt to collaborative, data-driven workflows.	Slows down adoption, reduces team coordination, and limits integration success.

The study explored how Lean and BIM complement each other at the project level. Integration was visible across planning, design, and construction each phase demonstrating unique opportunities for improving efficiency and coordination. During the planning phase, combining the Last Planner System with 4D BIM scheduling enhanced plan reliability, visualization, and communication. The studies showed that visualizing workflow sequences helped teams identify constraints early, align commitments, and improve schedule predictability. In the design phase, integrating Value Stream Mapping with BIM clash detection reduced non-value-adding activities, improved coordination, and prevented rework by detecting design issues before execution. Meanwhile, in the construction phase, using visual management and shared BIM models strengthened collaboration between site and management teams, ensured transparency, and supported real-time monitoring through dashboards and digital Obeya rooms. Overall, Lean–BIM integration consistently contributes to waste reduction, flow improvement, and value generation. Projects reported fewer delays, improved information flow, and higher team productivity. The benefits also extended to better decision-making and long-term sustainability outcomes, as the combination of Lean's process control and BIM's data visualization created a more collaborative and reliable workflow environment. However, integration remains challenging in practice. The most recurring barriers were resistance to change, lack of training and leadership support, and limited understanding of both systems. Organizational readiness and culture played a more significant role than technology itself. Many firms still rely on traditional management structures and are hesitant to adopt new workflows, while others struggle with the high upfront cost and shortage of experienced professionals capable of managing both Lean and BIM simultaneously.

This research is limited to findings derived from a sample of 37 journal articles published between 2018 and 2024, when most Lean-BIM studies were evident and may not capture earlier developments or emerging approaches. The analysis was confined to project-level studies, excluding organizational and multi-project implementations. Most reviewed studies were case based, focusing on completed projects rather than real-time applications. In addition, review was limited to selection of five activities, five challenges, and five benefits from each article, so the themes reported here are based on a controlled sample of the available evidence, and some secondary or less-emphasized points in the original papers may not be represented. Consequently, this review did not include ongoing case studies where Lean–BIM integration is still in progress, where such cases could provide valuable insight into the adaptation process and evolving team dynamics over time. Differences in project type, scale, and digital maturity among the reviewed papers also limit direct comparison. Additionally, several studies lacked standardized performance metrics, making it difficult to quantitatively measure improvements.

Conclusion

This study explored how Lean Construction and Building Information Modeling (BIM) can be implemented together at the project level to improve efficiency, coordination, and value delivery. The results show that Lean–BIM combined implementation strengthens communication, enhances workflow visualization, and supports collaborative decision-making. Across all phases, Lean–BIM integration was found to improve project performance consistently. Most papers reported shorter delivery times, reduced material waste, and higher productivity. These benefits align closely with Lean principles of waste elimination, continuous flow, and value generation. Beyond efficiency, Lean–BIM practices also encourage collaboration and shared understanding among all project participants, which is essential for achieving sustainable project outcomes (Koseoglu et al., 2018). At the same time, the study revealed that the most common barriers are organizational and cultural rather than technical. Many firms struggle with limited digital literacy, a lack of leadership support, and resistance to change. This suggests that successful integration requires more than just technology; it requires strong management commitment, training, and a supportive culture that promotes teamwork and learning (Likita et al., 2022). The study highlights the need for future research to develop measurable performance indicators and practical frameworks to guide project teams in systematically implementing Lean–BIM. Future work could test the themes identified in this review through multi-case studies or surveys that link specific Lean–BIM practices to schedule, cost, safety, and sustainability outcomes. It could also apply the same approach to other regions, project types, and organization-level or multi-project programs to see whether the patterns found here still hold true. In addition, the activity, benefit, and challenge lists developed in this study can serve as a starting point for pilot Lean–BIM implementation guidelines in practice, with lessons from those pilots feeding into updated frameworks and tools. Overall, the conclusion emphasizes that Lean–BIM combined implementation is not only feasible but highly beneficial for the construction industry, and that it can help move project delivery toward a more transparent, coordinated, and value-driven process.

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