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The Strategic Synergy of Lean Construction and BIM: Adoption Factors and Impact on the Performance and Sustainability of the Construction Industry

The Strategic Synergy of Lean Construction and BIM: Adoption Factors and Impact on the Performance and Sustainability of the Construction Industry

Andrezza Maria Moura Calheiros de Novaes - Bachelor of Science in Business Administration - CESMAC

Summary

The construction industry, which historically faces problems of low productivity and high waste, is seeking to improve its performance and adopt sustainable practices. Research suggests analyzing the synergy between Lean Construction (LC) and Building Information Modeling (BIM) to reveal their principles, obstacles, and performance improvements. LC seeks to maximize customer value and eliminate waste (muda) by considering production as an uninterrupted flow. On the other hand, BIM transforms 2D drawings into 3D information systems that can be read by machines, increasing efficiency. By integrating LC with BIM, leveraging its use with *Last Planner System (LPS)* and *Agile Design Management (ADM) tools,* significant improvements in workflow and productivity are achieved, optimizing resource usability and promoting sustainable construction. This implementation becomes complicated because it encounters cultural barriers within the organization, such as resistance to change and a lack of knowledge of the *Lean methodology.* It is concluded that the systemic and inclusive *(bottom-up)* adoption of LC and BIM is a promising path to ensure the long-term competitiveness and sustainable growth of the industry.

Keywords: *Lean Construction* (LC); BIM *(Building Information Modeling);* Sustainable Construction.

Abstract

The construction industry, which historically faces problems of low productivity and high waste, is seeking to improve its performance and adopt sustainable practices. This research suggests the synergy between Lean Construction (LC) and Building Information Modeling (BIM) to reveal its principles, obstacles, and performance improvements. LC seeks to maximize customer value and eliminate waste (muda) by considering production as uninterrupted flow. On the other hand, BIM transforms 2D drawings into 3D information systems that can be read by machines, increasing efficiency. By integrating LC with BIM, leveraging its use with Last Planner System (LPS) and Agile Design Management (ADM) tools, it provides significant improvements in workflow and productivity, optimizing resource usability and promoting sustainable construction. This implementation becomes complicated because it encounters cultural barriers within the organization, such as resistance to change and a lack of knowledge of the Lean methodology. It is concluded that the systemic and inclusive (bottom-up) adoption of LC and BIM is a promising path to ensure long-term competitiveness and sustainable growth of the industry.

Keywords: Lean Construction (LC); BIM (Building Information Modeling); SustainableConstruction.

Introduction

The construction industry plays an important role in the economy of several countries.

generating a large amount of money and promoting economic growth. However,

This industry is historically known for exhibiting negative characteristics, such as low

Productivity issues, high levels of waste and rework, and poor process standardization are all drawbacks.

(SIMU and LIDELOW, 2019). The current pressure, driven by the demand for higher quality and

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Efficiency, as well as the need to adhere to sustainable development, is forcing the sector to...
to seek methodologies capable of improving their performance. On the other hand, development
Sustainable production requires the efficient use of resources, reduced energy consumption, and optimization of
available labor (OGUNBIYI *et al,* 2014; ARAÚJO *et al,* 2023; CAMPOS and AZEVEDO,
2021; SIMU and LIDELOW, 2019).

In this quest for improvement, *Lean Construction* (LC), also known as Lean Construction, is a key element.
Lean, it emerges as a management methodology that can help develop more streamlined processes.
Sustainable and efficient. In the pursuit of improvements, *Lean Construction* (LC), also known as
Lean construction emerges as a management methodology that can help develop processes.
more sustainable and efficient. In adopting new management philosophies, *Building Information*
Building Information Modeling (BIM) represents a profound paradigm shift, transforming systems of
2D drawing-based documents in readable 3D object-based information systems
by machine, a significant advance for automation and improved productivity. The goal
The main goal of LC is to maximize value for the customer by minimizing activities that do not add value.
(OGUNBIYI *et al,* 2014; LUNA *et al,* 2025; CAMPOS and AZEVEDO, 2021; ARAYICI *et al,* 2011;
LOVE *et al,* 2011).

The adoption of technologies such as BIM and management approaches such as LC is considered
a relevant path for construction companies to gain a competitive advantage
sustainable (SIMU and LIDELOW, 2019; LUNA *et al,* 2025). However, Luna (2011) points out that the
The sector tends to show skepticism towards "management fads" that don't offer a solution.
A clear strategic competitive advantage. The effective adoption of these innovations requires management.
careful implementation of the change, overcoming resistance and, above all, ensuring that the operational strategy
be aligned with the company's business strategy (SIMU and LIDELOW, 2019; SEGERSTEDT,
et *al,* 2010). Arayici (2011) states that an inclusive and well-structured implementation strategy
It allows you to achieve this alignment.

This study examines the complementary relationship between the *Lean Construction* methodology.
and BIM technology, evaluating the necessary adoption strategies and operational benefits and
environmental benefits obtained through this synergy. In this way, the aim is to expose the fundamentals and the barriers.
implementation and the performance gains that this integration offers to the
construction industry.

Fundamentals of Lean *Construction*

The Lean Construction philosophy redefines production by integrating the components of
Transformations and flows within a unified system. From this perspective, production is viewed as...
a continuous flow of materials and information, which includes transformations, inspections,

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movements and delays. According to Segerstedt (2010), the fundamental distinction of LC lies in recognition that transformations are the activities that actually add value to the product. Finally, flow activities, such as inspections or delays, consume resources without generating value. for the customer. Consequently, the fundamental principle of LC is to achieve excellence through complete elimination of waste, which is defined as any consumption of human or human resources. materials that do not result in value (OGUNBIYI *et al,* 2014; LUNA *et al,* 2025; CASTILLO *et al,* 2015).

Table 1 – Basic Types of Waste in Lean Construction

Waste Category	Description
Defects	Errors that need to be corrected. Refers to quality problems, such as the need for rework or repair work.
Overproduction	Producing more or accomplishing more than is necessary. This includes the overproduction of waste.
Inventory	Excess inventory, because inventory is not considered valuable and is seen as waste. This includes the loss of materials.
Unnecessary Processing	Unnecessary steps in processing or in the production chain. Includes inefficient and unnecessarily complex processes.
Transport	Unnecessary transportation of materials or transportation that takes too long. In construction, this includes excessive handling of materials.
Unnecessary Movement	Purposeless movement of employees. In construction, this includes excessive movement for work purposes.
Wait	Waiting time for employees to wait for equipment to finish working or for a previous task to be completed. This includes waiting periods for materials and labor, as well as schedule delays and work interruptions.
Failing to meet customer needs: Goods and services that do not satisfy customer needs.	

Source: Author, (2025).

Campos and Azevedo (2021) highlight that in the civil construction environment, several Activities fall into the category of waste, with the most frequent sources of loss being... rework, inefficient execution, and long waiting periods for materials were identified. labor. In addition to these, the *Lean* philosophy identifies other categories of waste, such as excess. production, unnecessary inventory, unnecessary processes in the supply chain production, transportation time and aimless movement, defects, and goods or services that They do not meet customer needs (OGUNBIYI *et al,* 2014; CASTILLO *et al,* 2015). For According to Ogunbiyi (2014), the focus of LC is to diagnose and systematically address these losses in order to increase overall efficiency.

Adopting LC is driving the company to migrate from a traditionally focused strategy. from resource efficiency to an operations strategy focused on flow efficiency. While resource efficiency optimizes the cost and delivery of the individual project, efficiency of The flow aims to maximize overall production, prioritizing standardization and perceived value. by the customer (SIMU and LIDELOW, 2019). According to Ferng and Price (2005), it is important to note that This philosophy complements other methodologies: *Lean* works to streamline workflow.

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"faster" by eliminating waste, while *Six Sigma* seeks to make work "better" by...
Focusing on reducing variation and eliminating defects. The success of LC therefore lies in its
The ability to integrate flow speed with process quality.

In short, LC establishes itself as a production management system that requires a
A change of perspective, treating projects as a continuous flow to be improved, and not as...
isolated events. Instead of simply accepting the losses inherent to the construction site, the
The methodology offers a path to continuous improvement *(Kaizen),* ensuring that efforts are...
focus only on activities that add value (OGUNBIYI *et al,* 2014; CASTILLO *et al,*
(2015). This shift in focus is necessary for organizations to be able to maintain their
competitiveness and long-term sustainability (SIMU and LIDELOW, 2019).

Adoption of Building Information Modeling (BIM) Technology and Barriers to Implementation

The introduction of *Building Information Modeling (BIM)* into architectural and design practice.
Engineering represents a profound reconfiguration of the work system, altering the...
Fundamental documentation of two-dimensional projects for three-dimensional information systems.
which are machine-interpretable and object-based (LOVE *et al,* 2011). For Luna (2025),
This technology is a factor of great importance, as it improves communication and coordination between
stakeholders , allowing for the early detection of conflicts and thus increasing efficiency and
productivity in the sector. However, the implementation of BIM requires substantial modifications in
almost every level of the construction process, from restructuring the workflow to...
Responsibility management (ARAYICI *et al,* 2011).

Arayici (2011) points out that practical experience demonstrates that the successful adoption of
Technologies like BIM are most effective when a *bottom-up* approach is adopted.
(top), in contrast to the *top-down approach.* Although the *bottom-up* approach may be more
Slow, it proves more efficient in managing change, as it ensures staff engagement and
It mitigates resistance by gradually building knowledge and the ability to use the tool.
Support from senior management also proves to be a very important factor, even if the
Even if the initial understanding of management isn't merely visionary, it demonstrates the company's commitment.
in order to gain a lasting competitive advantage. Implementation must also consider the environment.
sociocultural, recognizing that change involves people and processes, and not just technology.
(ARAYICI *et al,* 2011).

The transition to *Lean* and BIM-enabled management is complex and faces barriers.
significant. Among the technical challenges are the need to overcome resistance to change, the
Proper training of professionals in BIM, and adaptation of existing workflows to
Processes guided by *Lean* philosophy and the guarantee of high-quality *hardware* and network resources.

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performance to run applications efficiently. Coordination difficulties and Interoperability between design disciplines, such as structural and mechanical engineering. Electrical and hydraulic engineering (MEP) also represent significant obstacles (ARAYICI *et al,* 2011).

Additionally, there are cultural and knowledge barriers that slow down adoption. Complete LC and BIM. Lack of knowledge of *Lean* methodology on the part of the technical staff. Poor communication between teams is a frequently reported difficulty (CAMPOS and AZEVEDO, 2021). The construction industry often adopts a skeptical stance towards managerial innovations that do not demonstrate a clear strategic advantage (LOVE *et al,* 2011). Thus, implementation requires continuous investment in training and reinventing workflows. work and a focus on data protection and user autonomy to sustain the gains of efficiencies achieved (ARAYICI *et al,* 2011).

Synergies and Performance Gains

The most notable performance gains in modern construction are achieved through A deliberate synergy between the principles of LC and digital modeling and management tools. This The integration between philosophy and technology maximizes customer value and improves workflow. Information within the project, resulting in faster operations and higher quality. (LUNA *et al,* 2025). According to Castillo (2015), the application of operations strategies focused on Flow, like *Lean Construction,* leads to statistically significant improvements in indicators of performance, such as workflow, productivity, production capacity and utilization of time. These concrete results demonstrate the effectiveness of the Lean approach in environments of project.

In the context of the design phase, which is notoriously complex due to problems of Coordination, three tools stand out for their impact and complementarity: the *Building Information Modeling (BIM),* the *Last Planner System* (LPS) and *Agile Design Management (ADM).* THE BIM, on the one hand, strengthens coordination and allows for the early detection of conflicts in the 3D model. (LUNA *et al,* 2025). On the other hand, LPS acts directly in production management, reducing the uncertainty and increasing workflow reliability. The ADM, with its ability to divide Breaking tasks down into smaller packages improves control and clarity in decision-making. The combination These three tools have the potential to cover approximately 88% of *design* functionalities. identified, which proves its ability to greatly optimize the process (LUNA *et al,* 2025).

Ogunbiyi (2014) points out that the benefits of implementing LC extend beyond immediate operational efficiency, achieving social, economic and environmental aspects, Establishing a strong connection with sustainable construction. By reducing waste and maximizing...

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In terms of value, LC contributes to optimizing the use of resources such as energy, water, and materials, and also for improving the environmental quality of projects. Other observed results include Improved corporate image, increased productivity, and enhanced compliance with... customer expectations.

For these gains to be sustainable, it is essential that construction companies replace adversarial contractual models with cooperative relationships *(partnering)* in the supply chain. supplies (SEGERSTEDT, et *al,* 2010). Cooperation is a very important element, because It facilitates the integration of skills and the joint resolution of problems, which eliminates waste. generated by distrust and competition. The implementation of a remuneration system. based on incentives, such as gain share/pain share arrangements , It strengthens this cooperative spirit, increasing the commitment of all those involved with the common project objectives (SEGERSTEDT, et *al,* 2010).

Conclusion

When faced with the available methodologies and technologies, organizations benefit. with the integration of *Lean Construction* and BIM, as it presents itself as a promising path and necessary for the construction industry to evolve in terms of performance, quality and Sustainability. The success of this transformation is linked to the adoption of an inclusive strategy. *(bottom-up),* which not only invests in technology, but also develops the capacity of teams and the promotion of effective management of complementary tools, such as BIM, LPS and ADM, to optimize the value stream. The proposed approach demonstrates that focusing on excellence in The process is just as important as focusing on the product.

Even if the operational benefits and productivity gains in pilot projects While significant, organizations still face important challenges to consolidation. of LC and BIM on a large scale. Cultural aspects such as resistance to change and lack of Lack of knowledge of *Lean* methodology creates insecurity and persists in encountering obstacles.

To eliminate these obstacles, it is necessary to invest in continuous training and planning. Operational strategies that prioritize value streams, in addition to leadership being willing to innovate in Transformation of internal culture. The lack of data that quantifies the improvement in productivity, Consumption of inputs and generation of waste is also an obstacle to a complete assessment and A compelling argument about the benefits of lean construction for businesses.

In conclusion, the decision to adopt an operations strategy, such as *Lean Construction,* Differentiating oneself from traditional industry practice is a choice that companies must make to ensure... Their long-term competitive position. Companies that focus on decision categories. Infrastructural aspects, such as continuous improvement and a long-term vision, develop skills that

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Companies that focus on specific decision categories find it more challenging to replicate their competitive edge.

Infrastructural aspects, such as continuous improvement and a long-term vision, develop skills that

These are more challenging to replicate the competition. Thus, the adoption of LC and BIM, when

Performed in a systematic way and focused on the flow strategy, it not only solves issues of

project, as it establishes new foundations for the company's sustainable growth.

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