CHAPTER 37

Comparative Study of Lean Tools to Reduce Wastage and Increase Efficiency in Residential Building

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ABSTRACT

This research assesses the comparative effectiveness of three construction methods—Conventional Method, Just-in-Time (JIT), and the Last Planner System (LPS)—in curbing waste and improving efficiency of manpower in residential construction projects. Based on a 1225 sq ft project site located in Satara district, Maharashtra, the study targets external plaster work in three bungalows, each adopting a different approach. The results indicate that the JIT approach performs far better than the rest, with minimal wastage of materials in cement and sand at 4.92% and 2.35% respectively. Furthermore, JIT showed the greatest labor efficiency, with masons at 85.7% and helpers at 66.67% for plaster work (actual work done as per lean construction method Vs theoretical value) and also proved to be the cheapest method with the total cost of the project at ₹66,300. The research focuses on the capability of lean tools, especially JIT, to maximize resource efficiency, reduce environmental footprint, and increase customer satisfaction through enhanced project performance. The research places a strong focus on the relevance of ongoing process improvement in reaching sustainable construction methods.

Keywords: Lean construction; Just-in-time; Last planner system; Waste reduction; Efficiency improvement.

1.0 Introduction

1.1 General

Lean construction is a strategic approach aimed at enhancing process quality and efficiency while minimizing waste in construction projects. By implementing lean principles, organizations can continuously improve processes throughout a project, applying lessons learned to subsequent endeavors. This approach reduces resource usage and construction time, subsequently lowering costs. Over time, cumulative improvements lead to better project outcomes. Lean construction enables teams to identify process inefficiencies and take proactive measures to enhance productivity and client satisfaction while minimizing environmental impact.

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Waste in construction projects, such as idle time, unnecessary transportation, and excessive material usage, can hinder progress and inflate costs without adding value to the client. Lean construction mitigates these issues by optimizing processes to reduce waiting times and improve personnel productivity, ultimately enhancing profitability. The concept of Kaizen, originating from Japan, emphasizes continuous improvement by systematically identifying and eliminating waste. Lean construction views improvement initiatives as investments that add value to customers. Importantly, employees directly involved in processes play a crucial role in driving continuous improvement, fostering a culture of proactive waste reduction.

Implementing sustainable building practices, such as renewable materials and energy-efficient designs, aligns with lean principles by minimizing environmental impact. Techniques like the 5S (sort, set, shine, standardize, shine) methodology improve workplace organization, enhancing safety and efficiency by reducing material wastage and ensuring quick accessibility to essential tools and resources. Reducing waste correlates with lower project costs, directly benefiting clients. Continuous process improvements enhance communication, minimize misunderstandings, and ensure timely project completion. Lean construction improves overall client satisfaction by delivering high-quality outcomes within set timelines.

1.2 Background

Lean production originated from Henry Ford's early 20th-century assembly line innovation, which streamlined labor processes to boost productivity and minimize errors. The Toyota Production System advanced this concept in the 1970s by focusing on customer value addition alongside waste reduction. Toyota's success, with peak profits exceeding $15 billion, showcased the impact of lean manufacturing on profitability and global competitiveness. TOYOTA PRODUCTION SYSTEM is a structured approach emphasizing waste reduction and process consistency. Its four guiding principles include continuous improvement, just-in-time production, standardized work, and respect for people. This system has inspired industries globally to enhance quality and productivity while maintaining high employee engagement. In the 1990s, industry leaders such as W. Edwards Deming and Taiichi Ohno popularized lean manufacturing beyond production environments, expanding its application to customer service and product development. This evolution reflects the adaptability of lean principles in achieving strategic goals, such as cost reduction and quality improvement across various industries.

1.3 Need for study

Residential construction in rural and suburban regions faces significant challenges, including time and financial constraints, resource inefficiencies, and quality concerns. This study addresses these issues by implementing lean construction techniques to identify and eliminate waste in processes such as material handling, movement, and inefficient workflows. By fostering a culture of continuous improvement, we aim to optimize resource utilization, reduce costs, and enhance client satisfaction through timely and quality project delivery.

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1.4 Research objective

- To identify the most suitable lean construction methods applicable to residential projects in rural and semi-urban areas.
- To evaluate and contrast particular lean construction tools according to how they affect cost savings, efficiency gains, and waste reduction.
- To identify the optimal lean construction tool for residential buildings that maximizes efficiency and cost-effectiveness while reducing waste.

2.0 Literature Review

The incorporation of Lean Construction methods has come to be recognized as an innovative way of optimizing efficiency, waste minimization, and optimal use of resources in the construction sector. Several studies have illustrated how the application of Lean principles enhances project performance through minimizing inefficiencies and continuous improvement. Nowotarski *et al.* (2019) highlighted the application of the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) cycle in wall masonry during the construction of the Pixel office buildings in Poznań. This approach led to a 50% reduction in waste and a significant increase in productivity, showcasing the scalability of Lean methods to other construction processes. Similarly, Jose *et al.* (2018) emphasized the role of the Last Planner System (LPS) in reducing construction waste and improving resource management. By minimizing workflow variability and optimizing process coordination, they demonstrated how Lean design results in better efficiency and balanced trade-offs between time and cost, ultimately streamlining project execution and reducing delays.

Further reinforcing the effectiveness of Lean methodologies, Kulgude *et al.* (2019) examined the impact of various Lean tools, such as the Production Display Method, Relative Importance Index (RII), Visual Management Production, and LPS, on material waste reduction and project duration. Their findings underscored the importance of RII in maximizing time management and material efficiency, reaffirming Lean's role in enhancing construction productivity. Likewise, Awad *et al.* (2021) explored Lean Construction principles in multi-story residential buildings in Pune, identifying key causes of waste through surveys, case studies, and literature reviews. They developed a Lean-based managerial framework to differentiate waste types and demonstrated that Lean methods are more effective than traditional project management approaches in improving efficiency, sustainability, and resource optimization.

The limitations of conventional project management methods have also been scrutinized in the context of dynamic construction environments. More *et al.* (2017) analyzed the shortcomings of the Critical Path Method (CPM) and proposed LPS as a superior alternative due to its advantages in coordination, planning, and stakeholder communication. They emphasized that training, risk assessment, and management support are critical for successful LPS adoption, leading to enhanced collaboration and improved project efficiency. Similarly,

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Porwal *et al.* (2012) examined the challenges of implementing LPS for production control in construction projects. Despite its potential to stabilize workflow and improve plan reliability, they identified obstacles such as inadequate training, resistance to change, and leadership gaps. The study highlighted the need for structured training programs and strong leadership to overcome these barriers and enhance project performance.

In addition to improving efficiency, Lean Construction has been linked to sustainability and resource optimization. Waite *et al.* (2020) explored the relationship between Lean principles and sustainable practices, reviewing the current state of Lean adoption in construction alongside the influence of emerging technologies. While Lean's sustainability benefits are well-established in manufacturing, their application in construction is still developing. The findings suggested that Lean methods can enhance both sustainability and productivity, though further research is needed to maximize their effectiveness in the construction industry. Fauzan *et al.* (2019) also examined Lean Construction practices, focusing on methodologies such as Just-in-Time (JIT), LPS, Six Sigma, and 5S (sort, set, shine, standardize, shine) management in the Australian construction industry. Their survey of construction professionals in Sydney revealed a strong correlation between Lean adoption and improved project performance. They emphasized the importance of performance monitoring, management commitment, and standardized housekeeping practices to enhance Lean implementation, reinforcing its impact on waste reduction and overall project success. When taken as a whole, these studies demonstrate how adaptable Lean Construction methods are in tackling the difficulties the construction sector faces. Lean concepts have been successful in increasing productivity and resource use in a variety of contexts, from time management and waste reduction to sustainability and continuous improvement. These results provide a solid basis for more research into Lean techniques and how they could enhance performance in residential building projects

3.0 Research Methodology

This study employed observational methods and systematic data collection to assess waste management in construction activities, specifically plastering and flooring. Direct on-site observation enabled the identification of inefficiencies, material management issues, and best practices. Primary data was gathered through interviews with site supervisors and project managers, along with surveys and documentation of waste generated during activities. Secondary data focused on implementing Just in Time (JIT) and the Last Planner System (LPS) at a 1225 sqft site in Satara district, Maharashtra. Three bungalows were analyzed: conventional methods for Bungalow A, JIT for Bungalow B, and LPS for Bungalow C.

Key data points included theoretical vs. actual material and manpower usage, material wastage, manpower efficiency, and cost savings. A Fishbone diagram analysis identified root causes of inefficiencies. For JIT, issues included poor material quality, over ordering, and delayed deliveries. In LPS, challenges involved poor planning, miscommunication, and resource

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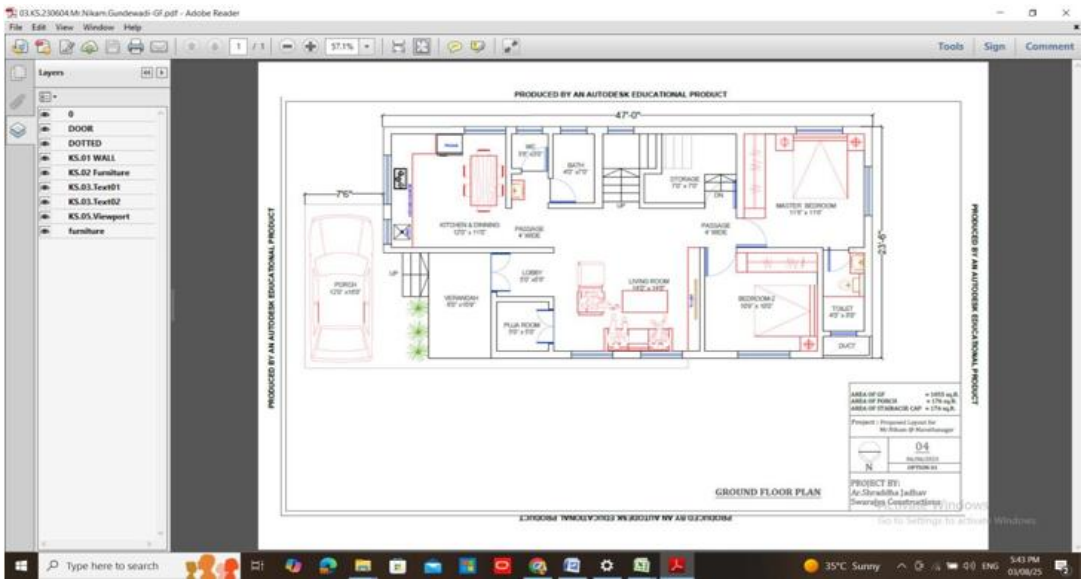
misallocation. Addressing these factors highlighted the potential of Lean tools to improve efficiency and reduce waste.

Figure 1: Plan Building



Source: Compiled by author

4.0 Data Analysis

4.1 Site details

At actual site 1225 sqft located at CHITALI, Satara district in Maharashtra 415506. External plastering was executed using three distinct methods: the Conventional Method, JIT, and the LPS. The study focuses on comparing three lean construction methodologies—Conventional Method, JIT, **"**and the LPS—to identify their effectiveness in reducing waste and increasing efficiency in residential building projects.

Table 1: Material Wastage Analysis

Method	Theoretical Cement (Bags)	Actual Cement (Bags)	Cement Wastage (%)	Theoretical Sand (Bags)	Actual Sand (Bags)	Sand Wastage (%)
Conventional	30.5	35	14.75	170	185	8.82
Just-in-Time (JIT)	30.5	32	4.92	170	174	2.35
Last Planner (LPS)	30.5	34	11.48	170	180	5.88

Source: compiled by author

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The research was conducted on a 1225 sq ft construction site located in Satara district, Maharashtra, where external plaster work was carried out using all three methods. The JIT method's minimal wastage underscores its efficiency in managing materials by ensuring delivery aligns with daily requirements, reducing the risk of overstocking and deterioration.

Table 2: Manpower Efficiency

Method	Theoretical Masons	Actual Masons	Mason Efficiency (%)	Theoretical Helpers	Actual Helpers	Helper Efficiency (%)	Scaffolder Efficiency (%)
Conventional	12	16	75	12	19	63.16	100
Just-in-Time (JIT)	12	14	85.7	12	18	66.67	100
Last Planner (LPS)	12	15	80	12	19	63.2	100

Source: compiled by author

JIT's superior manpower efficiency can be attributed to its real-time tracking system and daily task breakdown, which minimized idle time and optimized workforce utilization. The JIT method's cost-effectiveness is evident in its ability to reduce material overuse and optimize labor, despite slightly higher transportation costs due to multiple deliveries. The reduced material wastage in JIT not only cuts costs but also lessens environmental impact by minimizing waste disposal requirements. This aligns with sustainable construction goals. The study conclusively identifies the JIT method as the most efficient and sustainable lean tool for external plastering in residential buildings. Its ability to significantly reduce material wastage, improve labor efficiency, and lower overall project costs makes it the optimal choice over conventional and LPS methods. Implementing JIT in residential construction projects could lead to better resource management, cost savings, and environmental sustainability.

Table 3: Cost Implications

Method	Manpower Cost (₹)	Material Cost (₹)	Transport Cost (₹)	Total Cost (₹)
Conventional	35,400	33,050	2,800	71,250
Just-in-Time (JIT)	32,600	30,800	2,900	66,300
Last Planner (LPS)	34,300	32,140	2,800	69,240

Source: compiled by author

5.0 Conclusion

The study unequivocally proves that lean building equipment, namely the Just-in-Time (JIT) system, offers higher efficiency and sustainability in house building projects. JIT, through synchronization of material supply with work needs on a daily basis, reduces wastage to the

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barest minimum, keeping cement wastage to 4.92% and sand wastage at 2.35%. Its hourly tracking facility and work division into daily tasks increase manpower effectiveness, with masons attaining 85.7% efficacy and helpers 66.67%, bettering the Conventional and LPS methods. Additionally, the cost analysis in total reinforces JIT as the most cost-effective method with a project cost of ₹66,300, illustrating its equilibrium between cost reduction and productivity. Apart from cost effectiveness, JIT's low environmental footprint via waste minimization is consistent with sustainable construction practices, making it the most appropriate for residential building projects. The research emphasizes continuous improvement, proper resource utilization, and active reduction of waste as key drivers towards high-quality construction results. The research promotes further application of lean principles, specifically JIT, across residential and other construction industries in order to optimize project efficiency, minimize environmental footprints, and maximize overall client satisfaction.

References

Abdullahi, C. M., & Tembo, M. (2023). Improving the efficiency and effectiveness of construction project planning and scheduling using lean principle. *International Journal of Construction Engineering and Management, 12*, 75–80.

Abo-Zaid, M. A., & Othman, A. A. E. (2018). Lean construction for reducing construction waste in the Egyptian construction industry. In *Proceedings of the 2nd International Conference for Sustainable Construction and Project Management* (pp. xx–xx). Aswan, Egypt.

Adhi, A. B., & Muslim, F. (2023). The analysis of stakeholder influence and role in implementing sustainable construction by observing the principles of lean construction on infrastructure projects in Indonesia. *International Journal of Innovation Management and Technology, 14*, 115–123.

Ajay, R., & Sridhar, M. B. (2016). Incorporation of 5S (sort, set, shine, standardize, shine) methodology in construction practices. *International Journal of Chemical Sciences, 14*, 127–134.

Awad, T., Guardiola, J., & Fraíz, D. (2021). Sustainable construction: Improving productivity through lean construction. *Sustainability, 13*(24), 13877. https://doi.org/10.3390/su132413877

Aziz, R. F., & Hafez, S. M. (2013). Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal, 52*(4), 679–695.

Chandrakar, V. K. S., & Jain, A. D. (2019). Efficient construction by implementation of lean management principles. *International Journal of Scientific Research in Civil Engineering, 3*(2), 20–25.

Conte, A. S. I. (1998). Last planner, look ahead, PPC: A driver to the site operations. In *Proceedings of the IGLC* (Vol. 98, No. 1).

Da Silva Etges, B. M. B., & ten Caten, C. S. (2023). Lean supporting a framework for the construction innovation process. In *Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31)* (Vol. 81, pp. 91–100).

Dutta, B. N. (n.d.). *Estimating and costing in civil engineering* (27th ed.).

Formoso, C. T., Isatto, E. L., & Hirota, E. H. (1999, July). Method for waste control in the building industry. In *Proceedings of the 7th Annual Conference of the International Group for Lean Construction (IGLC)* (Vol. 7, pp. 325–332).

Gimenez, V., Diepenbruck, T. M., Rodegheri, P. M., Serra, S. M. B., & Anumba, C. J. (2022). Lean solutions for program development for construction daily report. In *Proceedings of the 30th Annual Conference of the International Group for Lean Construction* (pp. 727–737).

Hamzeh, F. R. (2011, July). The lean journey: Implementing the last planner system in construction. In *Proceedings of the 19th Annual Conference of the International Group for Lean Construction (IGLC)* (Vol. 19, pp. 13–15).

Hiwale, A., Wagh, A., Waghmare, V., Khairnar, D., Champanerkar, S., & Mane, P. (2018). Effectiveness of 5S (sort, set, shine, standardize, shine) implementation in lean construction (commercial building construction project). *International Journal for Research in Applied Science and Engineering Technology, 6*(6), 62–65.

Issa, U. H. (2013). Implementation of lean construction techniques for minimizing the risks effect on project construction time. *Alexandria Engineering Journal, 52*(4), 697–704.

Jagannathan, M., Kamma, R. C., Renganaidu, V., & Ramalingam, S. (2018, July). Enablers for sustainable lean construction in India. In *Proceedings of the 26th Annual Conference of the International Group for Lean Construction (IGLC)*, Chennai, India (pp. 18–22).

Jose, J. P. A., Prasanna, P. R., & Prakash, F. (2018). Lean design strategy of waste minimization in construction industries. *International Journal of Applied Engineering Research, 13*, 64593–64598.

DOI: 10.17492/JPI/NICMAR/2507037 *ISBN: 978-93-49790-54-4*

Karaz, M., & Teixeira, J. M. C. (2020). Waste management using lean construction and building information modelling: Systematic literature review. *[Publication Info Missing]*

Kulgude, R., Chavan, H. N., & Shelar, A. (2019). Use of lean construction technique for waste control at construction site. *International Journal of Innovations in Engineering Research and Technology*, 1–3.

Lee, S. H., Diekmann, J. E., Songer, A. D., & Brown, H. (1999, July). Identifying waste: Applications of construction process analysis. In *Proceedings of the 7th Annual Conference of the International Group for Lean Construction (IGLC)* (pp. 63–72).

Low, S. P., & Ang, G. K. (2003). Integrating JIT and 5-S concepts for construction site management: A case study. *International Journal of Construction Management, 3*(1), 31–47.

Marhani, M. A., Jaapar, A., Bari, N. A. A., & Zawawi, M. (2013). Sustainability through lean construction approach: A literature review. *Procedia - Social and Behavioral Sciences, 101*, 90–99.

Nowotarski, P., Paslawski, J., & Skwarek, J. (2019, September). Waste reduction by lean construction—Office building case study. In *IOP Conference Series: Materials Science and Engineering* (Vol. 603, No. 4, p. 042061). IOP Publishing.

Porwal, V., Fernández-Solís, J., Lavy, S., & Rybkowski, Z. K. (2010, July). Last planner system implementation challenges. In *Proceedings of the 18th Annual Conference of the International Group for Lean Construction (IGLC)* (Vol. 18, pp. 548–554).

Public Works Department, Government of Maharashtra. (2024). *District schedule of rates (DSR 2024–25)*.

Sundararajan, S., & Madhavi, T. C. (2023). Lean system-based tool for housing projects management in the pandemic period. *Buildings, 13*(10), 2507.

Torp, O., Knudsen, J. B., & Rønneberg, I. (2018, July). Factors affecting implementation of lean construction. In *Proceedings of the 26th Annual Conference of the International Group for Lean Construction (IGLC)* (Vol. 2, pp. 1261–1271).

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