CHAPTER 16

Application of Lean Tools in Precast Manufacturing

Urvi Karmarkar[1], Mrunmayee Paranjape[1],
Aniruddha Pawar[1], Kaustubh Rajeev[1] and Sagar Malsane[2]

ABSTRACT

To meet the fast-paced demand for quicker, cheaper, and green solutions, the construction industry is undergoing rapid transformation. There are several advantages of the precast concrete construction method that includes improved quality, increased durability, and lower construction time. However, its complex manufacturing process requires major resources and coordination to optimize and reduce waste. Lean manufacturing, known for its reduced waste and improved workflows, is useful for these obstacles. The primary objective of this research paper is to identify the waste generated in the precast industry and to explore how lean tools can be applied to increase the efficiency in workflow, reduce waste, and enhance the delivery process in the precast industry. This research paper maps the entire process of the precast manufacturing to identify the non-value-added activities and optimize them. It also helps in identifying the types & sources of waste and develop a framework to enhance the productivity at site. The research methodology includes detailed literature review, live case study, empirical data collection, waste analysis, implementation of lean tools, and a thorough evaluation of results. Through site visits & interviews, it captures the current production inefficiencies & explores how lean principle & tools can be applied. Through the site visit observations, it was observed that the entire process could be optimized using the value stream mapping technique to optimize and eliminate non-value added but necessary & non-value-added activities. Two tools TAKT & KANBAN are analysed &are used to minimize the waste & increase the efficiency. The study concludes with recommendations for continuous improvement, to meet the growing demand for precast elements.

Keywords: Lean tools; Precast manufacturing; Waste reduction; KANBAN; Takt; Value stream mapping.

1.0 Introduction

1.1 Background

The construction industry has evolved significantly, driven by the need for faster,

[1]*School of Construction, NICMAR University, Pune, Maharashtra, India*
[2]*Corresponding author; School of Real Estate and Facilities Management, NICMAR University, Pune, Maharashtra, India (E-mail: smalsane@nicmar.ac.in)*

DOI: 10.17492/JPI/NICMAR/2507016 *ISBN: 978-93-49790-54-4*

cost-effective, and sustainable building methods. One major innovation is precast concrete, where concrete elements are manufactured in a controlled factory environment and later assembled on-site. This approach improves quality, speeds up construction, and enhances durability. However, precast manufacturing remains complex, requiring careful coordination, efficient resource use, and strict quality control. Challenges such as material waste, project delays, and logistical inefficiencies can impact costs and timelines, especially in large projects. Poor coordination between factories and on-site teams often leads to further setbacks. To address these issues, Lean Construction offers a practical solution by reducing waste, optimizing resources, and improving workflow efficiency.

Originally developed in the automotive industry, Lean principles focus on eliminating unnecessary processes, improving coordination, and fostering continuous improvement. When applied to precast manufacturing, Lean methods help streamline operations, minimize delays, and reduce waste, making production more efficient and cost-effective. Techniques such as better inventory management, workflow optimization, and improved scheduling can significantly enhance productivity. By integrating Lean principles with precast manufacturing, companies can deliver high-quality products faster and at lower costs, meeting the growing demands of urbanization and infrastructure development. This study explores how Lean strategies can transform precast manufacturing, creating a more efficient and sustainable construction process.

1.2 Research problem

This research examines inefficiencies in precast manufacturing and explores how Lean tools can reduce waste, improve production flow, and enhance project delivery. Key issues include excess inventory, delays in production and transport, defects causing rework, and installation time constraints. Lean methods like VSM, Takt Time, and Kanban offer solutions.

1.3 Research objective

This research aims to identify waste in precast manufacturing and explore how Lean tools can improve efficiency and delivery. It focuses on pinpointing key waste sources, assessing Lean methods like VSM, Takt Time, and Kanban, and developing a framework to boost productivity in precast production and installation.

2.0 Proposed Methodology

This study uses a mixed-method approach, combining literature review, case study, and empirical data collection to assess the impact of lean tools in precast manufacturing. A case study at a precast factory in Maharashtra was conducted, focusing on workflow inefficiencies and lean implementation.

DOI: 10.17492/JPI/NICMAR/2507016 *ISBN: 978-93-49790-54-4*

2.1 Data collection

2.1.1 Literature review

A detailed review of lean principles, waste elimination, and process optimization in construction was conducted. Key lean tools—VSM, Takt Time, and Kanban—were analyzed for their applicability in precast workflows**.**

2.1.2 Production time observations

Direct observations and historical production data were collected to assess current inefficiencies**.**

Production Monitoring: Recorded cycle times for precast elements.

Interviews: Discussions with plant managers, engineers, and workers identified delays, rework causes, and customer demand trends.

2.2 Lean tool implementation

2.2.1 Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a lean management tool used to visualize and analyse the flow of materials, information, and processes required to deliver a product or service. It helps identify inefficiencies, waste, and areas for improvement, making it particularly useful in construction management and strategic planning.

Key elements of VSM are – Customer requirements, Process steps, Material flow, Information flow, Lead time, Cycle time, Value added and non-value-added activities. In precast manufacturing a Current State Map identified non-value-added activities affecting production flow. After optimization, a Future State Map reduced lead time by 33%**,** enhancing process efficiency.

2.2.2 Takt time

The Takt System is a lean production tool that aligns the production pace with customer demand. In precast manufacturing, the use of the Takt system helps in setting a steady rhythm or "takt time" for production processes, ensuring that each production stage is synchronized with the overall workflow. *Takt time formula:*

Takt Time= Available Working Time / Customer Demand

In precast manufacturing, Takt Time was calculated based on customer demand and available production hours**.** Adjustments like reducing handling time, automation in reinforcement bending, and optimized curing methods helped align production pace.

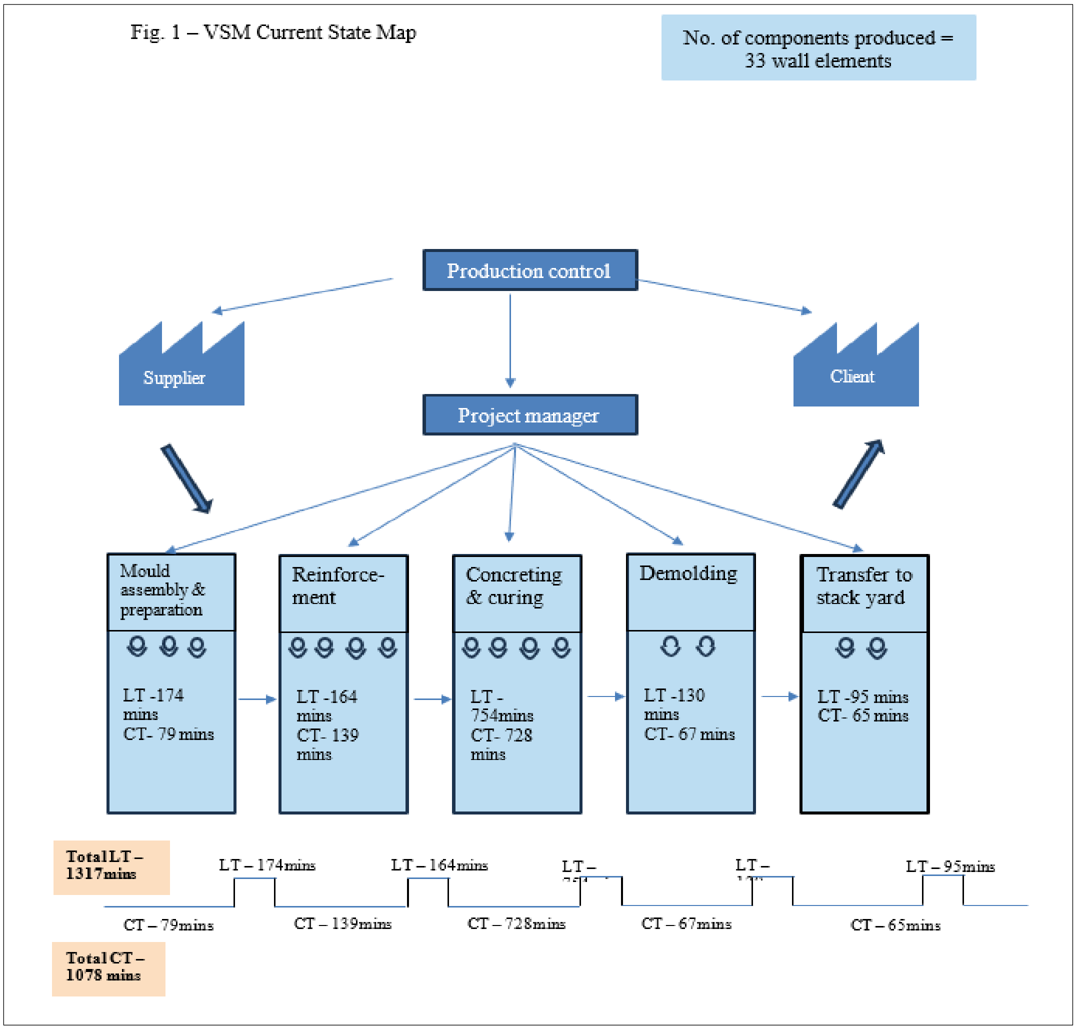
2.2.3 Kanban

The Kanban System is another lean tool that is utilized to manage the inventory of precast materials and to ensure a continuous, uninterrupted flow of production. Kanban operates

DOI: 10.17492/JPI/NICMAR/2507016 ISBN: 978-93-49790-54-4

on a pull system, where production is driven by real-time demand rather than forecasted projections, thus avoiding overproduction and excess inventory. In precast manufacturing, Kanban streamlined inventory management and communication**,** reducing waste and delays through a pull-based system that prevented overproduction and shortages.

Figure 1: VSM Current State Map



2.3 Data analysis

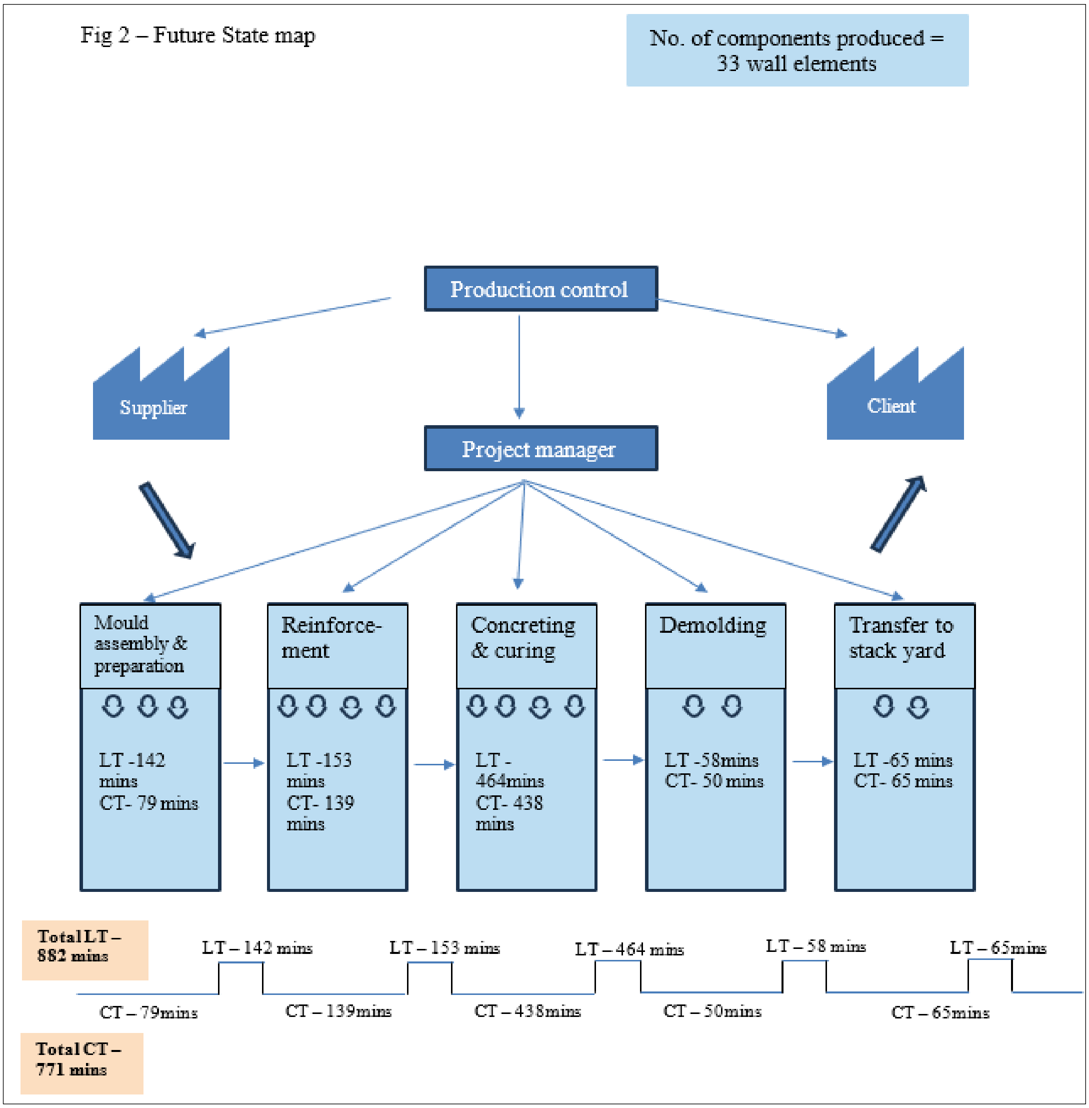
The impact of VSM, Takt Time, and Kanban was measured by comparing pre- and post-implementation data. Key improvements included:

DOI: 10.17492/JPI/NICMAR/2507016 *ISBN: 978-93-49790-54-4*

- Higher productivity and reduced waiting times.
- Optimized material flow, minimizing inventory waste.
- Improved workflow synchronization between teams.

These lean tools successfully enhanced efficiency and reduced waste in precast manufacturing.

Figure 2: VSM Future State Map



3.0 Literature review

Lean production is a methodology focused on maximizing value while minimizing waste. Originating from the Toyota Production System, it emphasizes continuous improvement, efficiency, and responsiveness, optimizing operations while reducing costs and improving quality. By eliminating waste and streamlining workflows, lean principles foster productivity and sustainability. The construction industry, despite its significant contribution to global GDP, suffers from inefficiencies, delays, and cost overruns. Studies indicate that improving productivity could save the global economy $1.6 trillion annually (Prasad, 2021). Given low profit margins and rising competition, contractors have increasingly adopted lean construction techniques to eliminate non-value-adding activities (Salem, 2005).

Lean Construction: Definitions & Core Principles: Lean construction applies lean production principles to design, project management, and execution, shifting the industry from traditional fragmented approaches to a systematic production mindset. Leading researchers and institutions define it as a production-based approach to project delivery, focusing on eliminating waste, improving flow, and maximizing value. A key aspect of lean philosophy is eliminating eight types of waste (DOWNTIME): Defects, Overproduction, Waiting, Non-Utilized Talent, Transportation, Inventory, Motion, Extra Processing (Prasad, 2021). By systematically addressing these inefficiencies, organizations can enhance quality, reduce costs, and streamline operations.

Application in Precast Manufacturing: Research highlights lean's role in optimizing precast workflows, reducing cycle times, and improving production flow. VSM helps identify bottlenecks, improve process synchronization, and enhance efficiency (Sirajudeen, 2021). Kanban reduces inventory waste and ensures a steady material supply, preventing overproduction. (Karthik, 2020) Takt-based scheduling enhances workflow predictability and coordination, minimizing idle time. (Kozlovská, 2021). Despite lean's potential, adoption in construction remains slow, hindered by organizational resistance and lack of awareness (Prasad, 2021). However, research validates its applicability in precast manufacturing, ensuring smoother operations, cost efficiency, and waste reduction.

4.0 Data Analysis and Findings

4.1 Value stream mapping (VSM) analysis

A Current State Map of precast wall panel production revealed inefficiencies in mould assembly, reinforcement, concreting, demoulding, and transport. The total lead time was 1317 minutes, with major delays in curing and material handling.

After optimizing non-value-added activities, the Future State Map showed a 33% reduction in lead time (to 882 minutes) and improved cycle times, allowing more efficient production flow.

DOI: 10.17492/JPI/NICMAR/2507016 ISBN: 978-93-49790-54-4

4.2 Identified wastes and proposed solutions

Key wastes identified:

- Waiting: Delays due to long curing times.
- Transport: Congestion in deliveries caused inefficiencies.
- Inventory: Excess storage led to high holding costs.

Optimizations applied:

- Steam/membrane curing reduced waiting time.
- Night deliveries improved transport efficiency.
- Just-in-time (JIT) inventory management prevented overstocking.

4.3 Takt time implementation

Takt Time was used to synchronize production with customer demand, reducing bottlenecks and process delays. Key improvements:

- Handling & welding time reduced through automation.
- Optimized reinforcement cage movement cut transfer time.
- Faster curing techniques aligned cycle time with production goals.

Table 1: Takt Time Calculation

Activities	Current time	Takt Time
Mould assembly & preparation works	174/38 = 4.5mins	115/38 =3 mins
Reinforcement	164/38 = 4.31 min	118/38 = 3.1 min
Concreting & curing	754/38 = 20 min	715/38 = 19 min
Demoulding	130/38 = 3.42 min	82/38 = 2.15 min ~ 2 min
Transfer to stock yard	95/38 = 2.5 min	65/38 = 1.71 min ~ 2 min

4.4 Impact of Kanban

A lack of communication was a major challenge at the precast unit. Kanban boards improved coordination by visually tracking progress, ensuring even work distribution, and increasing transparency. Tasks were listed on a master plan, with sticky notes moving as production progressed, helping teams stay aligned.

The use of VSM, Takt Time, and Kanban streamlined processes, reduced waste, and improved efficiency. VSM identified bottlenecks, Takt Time synchronized production with demand, and Kanban optimized inventory management. Together, these tools enhanced productivity and workflow efficiency in precast manufacturing.

DOI: 10.17492/JPI/NICMAR/2507016 ISBN: 978-93-49790-54-4

Figure 1: KANBAN Board- Master Sheet

Master Plan				
No.	Task	To Do	In Progress	Done
1	Conceptualization and Planning	Wall panels 30 No.		Columns 10 No.
2	Pre-Production Setup	Wall panels 15 No.	Wall panels 15 No.	Columns 10 No.
3	Manufacturing of Precast Elements	Wall panels 30 No.	Columns 5 No.	Columns 5 No.
4	Storage and Inventory Management		Columns 10 No. Wall panels 30 No.	
5	Pre-Transportation Preparation	Columns 10 No. Wall panels 30 No.		
6	Transportation to Site	Columns 10 No. Wall panels 30 No.		
7	On-Site Handling	Columns 10 No. Wall panels 30 No.		

5.0 Conclusion and Recommendations

5.1 Conclusion

This research confirms that lean construction methods significantly improve productivity, reduce waste, and enhance efficiency in precast manufacturing. Derived from the Toyota Production System, lean principles were successfully adapted to optimize workflows and minimize non-value-added activities.

DOI: 10.17492/JPI/NICMAR/2507016 *ISBN: 978-93-49790-54-4*

Key findings include:

- Better resource utilization and cost savings through lean adoption.
- Takt Planning reduced bottlenecks and synchronized workflow.
- VSM identified inefficiencies, improving cycle times.
- Kanban optimized material flow and inventory control.

Challenges persist, particularly resistance to change, lack of training, and poor planning, limiting lean adoption. However, structured training, better organizational commitment, and process standardization can overcome these barriers, making lean a viable, long-term solution for the construction industry.

Figure 2: Departmental KANBAN Board

Conceptualization and Planning				
No.	Activity	To Do	In Progress	Done
1	Identify project requirements			Columns 10 No.
2	Design structural elements		Wall panels 30 No.	Columns 10 No.
3	Feasibility analysis		Wall panels 30 No.	Columns 10 No.
4	Develop shop drawings	Wall panels 30 No.	Columns 10 No.	
5	Approve designs	Columns 10 No. Wall panels 30 No.		
6	Plan logistics	Columns 10 No. Wall panels 30 No.		

DOI: 10.17492/JPI/NICMAR/2507016 ISBN: 978-93-49790-54-4

Pre-Production Setup				
No.	Activity	To Do	In Progress	Done
1	Procure raw materials		Wall panels 30 No.	Columns 10 No.
2	Prepare and calibrate molds		Wall panels 30 No.	Columns 10 No.
3	Set up quality control	Wall panels 30 No.	Columns 10 No.	
4	Train workers		Columns 10 No. Wall Panels 30 No.	
5	Arrange curing facilities	Columns 10 No. Wall Panels 30 No.		
6	Schedule production workflow	Columns 10 No. Wall Panels 30 No.		

5.2 Limitations

This study is limited by its focus on a single precast unit, making broader applicability uncertain. Resistance to change in the industry and lack of structured training hinder lean adoption. Additionally, the long-term impact of lean implementation requires further study.

5.3 Recommendations

- *Structured training:* Educate employees on lean methods at all levels.
- *Formal planning:* Standardize workflows using VSM and Kanban.
- *Takt planning:* Synchronize production with demand to minimize delays.
- *Change management:* Engage stakeholders and provide incentives for lean adoption.
- *Technology integration:* Use BIM, automation, and real-time tracking for efficiency.
- *Waste reduction:* Optimize material use and implement recycling models.
- *Policy support:* Government incentives to promote lean construction.
- *Performance monitoring:* Regular KPIs, audits, and assessments to track progress.

DOI: 10.17492/JPI/NICMAR/2507016 *ISBN: 978-93-49790-54-4*

By implementing these strategies, the construction sector can accelerate lean adoption, enhance efficiency, and achieve sustainable growth.

References

Damanellore Karthik, D. C. (2020). *Role of Kanban system in construction*. Department of Civil Engineering, N.B.K.R. Institute of Science and Technology, Vidyanagar, Andhra Pradesh.

Institute for Lean Construction Excellence (ILCE). (n.d.). *Institute for Lean Construction Excellence*. Retrieved 2025, from https://www.ilce.in/

Issa, U. H. (2013). Implementation of lean construction techniques for minimizing the risks effect on construction projects. *Alexandria Engineering Journal*, *52*(3), 697–704. https://doi.org/10.1016/j.aej.2013.04.004

Lean Construction Institute. (n.d.). *Lean Construction Institute*. Retrieved 2024, from https://leanconstruction.org/

Kozlovská, M., & Džuganová, K. (2021). *Influence of Takt Time planning on construction efficiency*. Department of Technology, Economics and Management in Civil Engineering, Faculty of Civil Engineering, Technical University of Kosice.

Kozlovská, M., & Džuganová, K. (n.d.). *Impact of Takt-Time planning on plastering work productivity: A case study*. Department of Technology, Economics and Management in Civil Engineering, Faculty of Civil Engineering, Technical University of Kosice.

Raghavan, N., & Kumar, S. (n.d.). *Implementing lean concepts on Indian construction sites: Organizational aspects*.

Salem, O., Solomon, J., Genaidy, A., & Luegring, M. (2005). Site implementation and assessment of lean construction techniques. *Lean Construction Journal*, *2005*(2), 1–21.

Prasad, K. V., & Prabhakar, D. (2021). A study on construction wastes and challenges for lean implementation in Indian projects. In *Proceedings of the Indian Lean Construction Conference (ILCC)*.

Sirajudeen, R. S., & Anbarasu, K. (2021). Application of lean manufacturing using value stream mapping (VSM) in precast component manufacturing: A case study. *College of Engineering Guindy, Anna University*, Chennai.

The International Group for Lean Construction. (n.d.). *The International Group for Lean Construction*. Retrieved 2024, from https://iglc.net/

DOI: 10.17492/JPI/NICMAR/2507016 ISBN: 978-93-49790-54-4