



A Comprehensive Investigation of Lean Construction Management Practices for Improving Project Performance and Operational Efficiency

Shaikh Mohd Rahil Mohd Afzal¹, Manisha Jamgade²

¹Research Scholar, Department of Civil Engineering, Pillai HOC College of Engineering & Technology, Rasayani, University of Mumbai, Maharashtra, India

²Associate Professor, Department of Civil Engineering, Pillai HOC College of Engineering & Technology, Rasayani, University of Mumbai, Maharashtra, India

Abstract

Lean construction seeks to improve construction project delivery by coordinating production flow, reducing non-value-adding activities, and increasing the reliability of work commitments. This paper investigates the management practices through which lean principles can improve time, cost, quality, and operational efficiency, with particular attention to implementation constraints in Indian residential construction. An analytical narrative review of verified peer-reviewed publications is integrated with a secondary interpretation of a 2020 Indian construction thesis describing a ₹23-crore, 18-month housing project and a questionnaire administered to 30 construction professionals. The analysis distinguishes published empirical findings from the descriptive case context and proposes a transparent performance-measurement framework covering Percent Plan Complete, cycle-time variation, rework, material waste, and constraint-removal reliability. The literature identifies organizational commitment, lean knowledge, communication, and planning reliability as recurring determinants of implementation. A recent Indian multicriteria study assigns priority weights of 0.361 to managerial barriers and 0.309 to inadequate resources; these are published results, not estimates from the source thesis. The study contributes an integrated management framework and a practical indicator set for evaluating lean implementation without claiming unobserved productivity gains. Future field studies should collect baseline and follow-up observations to validate causal improvements.

Keywords: lean construction, project management, operational efficiency; Last Planner System, value stream mapping, construction waste

1. Introduction

Construction projects are production systems in which labor, materials, equipment, design information, and subcontractor activities must be coordinated under uncertainty. Fragmentation between design and site execution can create waiting, unnecessary transport, rework, and unreliable handoffs. Conventional schedule monitoring records deviations after they occur; lean management adds a production-control perspective that attempts to make assignments executable before work starts (Koskela, 1992; Moradi & Sormunen, 2023).

Lean construction should not be equated with indiscriminate resource reduction. Its central proposition is that customer value increases when non-value-adding activities are identified and workflow is stabilized. This requires cooperation across organizational boundaries, consistent information exchange, and the systematic removal of constraints. Planning and control therefore become organizational routines rather than isolated scheduling exercises (Agrawal et al., 2024).

The Indian context presents a useful setting because construction projects vary considerably in contractor capabilities, workforce skills, procurement arrangements, and project governance. A 2020 dissertation on a residential development in Bhayli, Vadodara, reported an 18-month turnkey project with 360 EWS residential flats and 24 shops and surveyed 30 construction professionals across four sites (Sadhaliya, 2020). That dissertation offers contextual evidence about perceived factors affecting cost, time, and quality, but does not by itself establish the general effectiveness of any lean intervention.

The purpose of this paper is to organize the available evidence into a decision-oriented management framework and to distinguish demonstrable findings from proposed indicators. Its contribution is analytical: it aligns lean practices with observable project outcomes, assesses barriers to adoption, and outlines a defensible monitoring design suitable for residential construction projects.

2. Research Aim and Objectives

The aim is to investigate how lean construction management practices can support project performance and operational efficiency. The objectives are to

- (i) synthesize verified literature on lean practices and implementation barriers;
- (ii) identify mechanisms connecting planning, workflow, and waste to project outcomes;
- (iii) reinterpret a documented Indian housing project as contextual secondary evidence;
- (iv) develop a reproducible measurement framework; and (v) formulate implementation and validation recommendations.

3. Literature Review

3.1 Conceptual foundations

Koskela (1992) challenged a purely transformation-based view of construction and emphasized the management of flow and value. Under a transformation-only model, each activity may appear locally efficient while the overall process remains disrupted by queues, waiting, and mismatched handoffs. A flow-oriented approach asks whether resources and information reach the next operation at the required time and quality.

Moradi and Sormunen (2023) analyzed 230 studies and identified lack of lean awareness, resistance to change, and insufficient top-management commitment as leading barriers. Their synthesis also emphasizes lean culture, practical tools, and management support as enabling conditions. These findings suggest that implementation should be evaluated as organizational change, not simply as adoption of a scheduling template.

A systematic review of lean practices identified 32 practices across design and engineering, planning and control, construction and site management, and health and safety; Last Planner System and just-in-time were among the most frequently implemented (Ogunbiyi et al., 2019). This diversity matters because the benefit of any individual tool depends on how it interacts with procurement, workforce capacity, and project coordination.

3.2 Planning reliability and Last Planner System

The Last Planner System (LPS) links milestone plans, lookahead planning, constraint screening, weekly commitments, and learning from plan failures. Percent Plan Complete (PPC) is commonly used as a reliability indicator, but a high PPC alone cannot establish that the project is ahead of schedule, economical, or free of rework. It should be considered alongside constraint clearance, task quality, and throughput (Lappalainen et al., 2023).

Agrawal et al. (2024) reviewed 112 studies of automated planning and control within LPS, identifying 50 automation functionalities across six stages. Their synthesis found that lookahead planning contained the largest

number of identified functionalities (19). Digital support can improve information availability and replanning, but automated dashboards cannot substitute for reliable site data and accountable commitments.

3.3 Value stream mapping, 5S, and waste control

Value Stream Mapping (VSM) documents the sequence of activities, handoffs, processing durations, and waiting periods for a defined production unit such as a floor slab. The current-state map identifies non-value-adding steps, while the future-state map proposes a feasible revised flow. The resulting comparison is a plan for improvement until it is tested with measured site observations.

5S workplace organization and visual management can reduce search and handling effort by improving the visibility and accessibility of materials and equipment. Just-in-time delivery may lower storage needs, but it can also increase exposure to supply interruptions if procurement reliability is weak. Lean implementation must therefore balance inventory reduction with schedule resilience (Moradi & Sormunen, 2023).

Michalski et al. (2022) reviewed the interface between lean construction and building information modeling (BIM). Their work supports treating digital models as potential coordination aids rather than automatic evidence of productivity improvement. Model quality, process ownership, and integration with field planning determine whether information can be converted into reliable work.

3.4 Evidence on barriers in India

Negi et al. (2024) examined lean implementation barriers in the Indian prefabrication sector, initially identifying 26 barriers and extracting ten common components through exploratory factor analysis. Their findings highlight insufficient understanding of lean construction, limited technical knowledge, and organizational challenges as important obstacles to effective implementation. A separate Indian construction study using the analytic hierarchy process reported that managerial and inadequate-resource barriers received weights of 0.361 and 0.309, respectively (Identifying Critical Challenges to Lean Construction Adoption, 2023). These findings indicate that management commitment, resource availability, workforce training, and effective coordination play significant roles in successful lean adoption. Therefore, improving organizational awareness, strengthening managerial support, and developing systematic implementation strategies are essential for enhancing lean construction practices in Indian construction projects. However, the reported values represent the specific methodologies and samples of the respective studies rather than universal sector-wide rates.

Table 1: Relevant Study and Literature

Study	Method & Validation	Relevant contribution
Moradi & Sormunen (2023)	230 studies	Barriers, enablers, and organizational implications
Negi et al. (2024)	Indian prefabrication survey	Barrier structure and lean awareness
Agrawal et al. (2024)	112 studies	LPS automation functions and planning stages
Michalski et al. (2022)	Systematic review	Lean and BIM integration
Lappalainen et al. (2023)	Quantitative review	PPC interpretation and measurement
Sadhaliya (2020)	30 respondents; Indian housing case	Contextual cost/time/quality factors

4. Materials and Methods

4.1 Research design and evidence boundaries

This manuscript employs a structured analytical narrative review supplemented by descriptive secondary case interpretation. Journal sources were selected for direct relevance to lean implementation, production planning, barriers, or performance measurement; the bibliography is not claimed to be an exhaustive systematic search. Reported sample sizes and numerical results are attributed to their original publications. No new questionnaire was administered and no project intervention was performed for this manuscript.

4.2 Secondary project context

The source dissertation describes a turnkey housing project at Bhayli, Vadodara, with a stated cost of ₹23 crore, planned duration of 18 months, and a scope including 360 EWS flats and 24 shops. Thirty construction professionals were surveyed across four project sites (FP 100, FP 112, FP 114, and FP 180). Identified management concerns included change orders, rework, inadequate supervision, poor coordination, ineffective scheduling, incomplete drawings, delayed material delivery, and low labor or equipment productivity (Sadhaliya, 2020).

Because the available dissertation presents perception charts and selected site observations, the analysis does not convert those responses into new inferential statistics or infer cost savings without verified expenditure records. The questionnaire sample is small and project-specific; representativeness beyond the studied sites is not established.

4.3 Performance Indicators

Table 2: Performance Indicators

Indicator	Operational definition	Required data
Percent Plan Complete (PPC)	Completed planned tasks / committed tasks $\times 100$	Weekly commitment register
Cycle-time reduction	(Baseline cycle – follow-up cycle) / baseline cycle $\times 100$	Repeated comparable slab cycles
Process cycle efficiency	Value-adding time / total lead time $\times 100$	Time-and-motion observations
Rework rate	Rework hours / total productive hours $\times 100$	Labor and quality logs
Material waste intensity	Discarded material / material issued $\times 100$	Issue, return, and disposal records
Constraint-removal rate	Constraints cleared by deadline / constraints identified $\times 100$	Lookahead constraint log

These equations define prospective metrics, not calculated outcomes. For comparative analysis, the same measurement rules, building types, floor complexity, and observation windows should be used before and after

implementation. Weather, crew size, design changes, and supply disruptions should be logged as potential confounders.

5. Analytical Results and Synthesis

5.1 Observed secondary evidence

The evidence supports three descriptive observations. First, the source housing project identifies a range of operational problems spanning design information, site coordination, supply, and workforce productivity (Sadhaliya, 2020). Second, published literature consistently treats organizational readiness and management commitment as prerequisites for successful lean implementation (Moradi & Sormunen, 2023; Negi et al., 2024).

Third, planning reliability and constraint management provide a plausible route from management practices to more stable workflow, although improvements must be established through longitudinal site measurements (Agrawal et al., 2024; Lappalainen et al., 2023).

5.2 Cross-study numerical evidence

Table 3: Cross-study numerical evidence

Published source	Reported quantity	Interpretation
Moradi & Sormunen (2023)	230 reviewed studies	Breadth of barriers/enablers synthesis
Agrawal et al. (2024)	112 studies; 50 functionalities	Scope of LPS automation review
Negi et al. (2024)	26 initially identified barriers	Candidate barriers in Indian prefabrication
Indian AHP study (2023)	0.361 managerial; 0.309 resources	Study-specific priority weights
Sadhaliya (2020)	30 surveyed professionals	Size of historical case questionnaire

The numerical values in Table 4 are deliberately not pooled into an overall lean-performance percentage because they measure different constructs.

The 230 and 112 values are numbers of reviewed publications, not sample sizes of construction workers and not percentages of improvement.

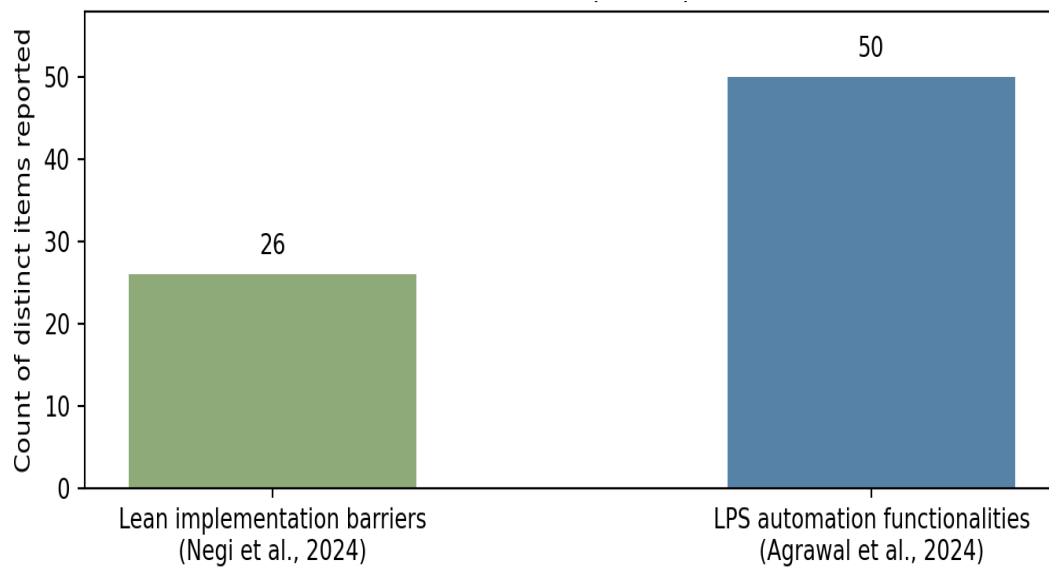


Figure 1: Distinct study-specific analytical counts

The 26 barriers and 50 automation functionalities are different types of items; their heights must not be interpreted as comparative effectiveness.



Figure 2: Proposed lean construction management evaluation pathway

This diagram is an original conceptual synthesis. The links are hypotheses for evaluation, not demonstrated causal effects.

Interpretation of graphical results. Figures 1 visualize the extent and type of secondary evidence, not measured productivity gains. Figure 2 organizes prospective management interventions and associated outcome measures.

5.3 Integrated management pathway

A coherent implementation sequence starts with executive sponsorship and a shared definition of customer value. A multidisciplinary planning team then maps a repeatable work package, identifies constraints before commitment, and uses visual controls to expose disruptions. Weekly learning meetings classify reasons for non-completion and assign corrective actions. Finally, cost, quality, cycle-time, and waste metrics are reviewed together so that local speed improvements do not conceal rework or inventory transfers. This pathway is a conceptual synthesis of the reviewed sources, not a tested intervention.

5.4 Evaluation Matrix

Table 4: Result of Evaluation Matrix

Management intervention	Mechanism	Result
Lookahead planning	Resolve prerequisites before task release	Constraint clearance and PPC
VSM	Identify waiting and handoff delays	Lead time and cycle efficiency
5S / visual management	Reduce searching and movement	Nonproductive labor time
Collaborative weekly planning	Improve trade coordination	Plan reliability and rework
Material flow control	Align delivery with actual demand	Waste intensity and stockouts

6. Discussion

The principal managerial implication is that lean construction is a coordination system rather than a menu of isolated tools. A VSM diagram may reveal waiting, but waiting will persist unless procurement decisions, approvals, and crew availability are addressed. Likewise, weekly plans may appear reliable if teams choose only easy tasks; therefore PPC should be assessed with production volume, schedule-critical work, and the quality of completed activities.

The reviewed Indian evidence indicates that managerial readiness deserves explicit attention. When training, responsibility allocation, and senior-level support are weak, tool deployment risks becoming ceremonial. Conversely, leadership alone is insufficient if the site lacks stable materials, qualified labor, accurate drawings, or usable progress data. The interaction between managerial and resource constraints argues for phased implementation rather than organization-wide rollout without pilots.

Operational efficiency should be evaluated through balanced indicators. Faster slab cycles are not necessarily improvements if achieved through excessive overtime, increased defects, or safety compromises. Similarly, reducing on-site inventory may increase disruption risk when delivery reliability is low. A balanced scorecard combining time, cost, quality, waste, and planning reliability is therefore more defensible than a single improvement percentage.

The distinction between analytical review and case-study experimentation is especially important. The source thesis contains historical data and VSM material, but this paper does not reproduce its claimed improvements as if they were independently verified. Its original contribution is a structured synthesis and a measurement protocol. Future empirical work could compare matched towers or repeated floors, collect at least several cycles before and after implementation, and report variability and contextual differences.

7. Practical Implementation Roadmap

Phase 1-Diagnosis: Define the work package and the customer-value criteria; collect baseline cycle times, rework records, delay causes, and material flows. Select a stable and repeatable activity such as RCC slab construction.

Phase 2-Readiness: Establish management sponsorship, clarify responsibilities, train planners and foremen, and create a constraint register. Confirm that drawings, procurement, access, safety permits, and equipment are available before committing work.

Phase 3-Pilot: Prepare a current-state map, run weekly collaborative planning, implement visual management and targeted 5S, and document every material or information handoff.

Phase 4-Evaluation: Compare like-for-like work cycles using the defined indicators. Report denominators, observation dates, missing data, and adverse outcomes. Investigate both successful and unsuccessful assignments.

Phase 5-Scaling: Standardize practices only when improvements persist and do not compromise quality or safety. Extend to additional trades with explicit adaptation to project conditions.

8. Limitations and Future Research

The manuscript relies on secondary literature and a historical dissertation; it does not contain newly collected field data. The Indian case survey includes 30 respondents and cannot support causal inference or broad national generalization. Differences in research design prevent pooling the cited numerical findings. The proposed framework is therefore a testable management model, not evidence of a specific percentage improvement. Future work should include prospective multi-project data collection, comparable baseline and follow-up periods, documented cost accounting, and independent quality and safety measures. Digital LPS and BIM integration can be evaluated as enabling interventions rather than assumed sources of efficiency.

9. Conclusion

Lean construction management offers a coherent approach to controlling workflow, improving planning reliability, and identifying avoidable waste. The literature suggests that implementation success depends on the combined presence of leadership commitment, lean knowledge, reliable resources, and effective collaboration. The secondary Indian housing case illustrates practical concerns about change orders, rework, coordination, drawings, delivery, and workforce productivity. This paper translates those concerns into a transparent management pathway and a set of measurable indicators. No new cost or productivity gains are claimed. The resulting framework provides a basis for a subsequent field-based evaluation of lean construction performance in residential projects.

References

1. Agrawal, A. K., Zou, Y., Chen, L., Abdelmegid, M. A., & González, V. A. (2024). Moving toward lean construction through automation of planning and control in last planner system: A systematic literature review. *Developments in the Built Environment*, 18, 100419. <https://doi.org/10.1016/j.dibe.2024.100419>
2. Identifying critical challenges to lean construction adoption. (2023). *Construction Innovation*, 24(1), 67–105. <https://doi.org/10.1108/CI-09-2022-0229> [Author details to verify before submission]
3. Koskela, L. (1992). Application of the new production philosophy to construction (CIFE Technical Report No. 72). Stanford University. <https://stacks.stanford.edu/file/druid:kh328xt3298/TR072.pdf>
4. Lappalainen, E., Reinbold, A., & Seppänen, O. (2023). Planned percentage completed in construction – A quantitative review of literature. *Proceedings of the International Group for Lean Construction*. <https://doi.org/10.24928/2023/0104>
5. Michalski, A., Głodziński, E., & Böde, K. (2022). Lean construction management techniques and BIM technology – Systematic literature review. *Procedia Computer Science*, 196, 1036–1043. <https://doi.org/10.1016/j.procs.2021.12.107>
6. Moradi, S., & Sormunen, P. (2023). Implementing lean construction: A literature study of barriers, enablers, and implications. *Buildings*, 13(2), 556. <https://doi.org/10.3390/buildings13020556>

7. Negi, P., Thakur, G., Singh, R., Gehlot, A., Thakur, A. K., Gupta, L. R., Priyadarshi, N., & Twala, B. (2024). Perception of lean construction implementation barriers in the Indian prefabrication sector. *Heliyon*, 10(16), e36458. <https://doi.org/10.1016/j.heliyon.2024.e36458>
8. Ogunbiyi, O., et al. (2019). Implementation of lean practices in the construction industry: A systematic review. *Energy and Buildings*. <https://www.sciencedirect.com/science/article/pii/S0360132318306760> [Full bibliographic metadata to verify]
9. Sadhaliya, A. J. (2020). Implementation of lean construction concept in Indian construction projects [Master's thesis, Birla Vishvakarma Mahavidyalaya]. User-provided thesis, 18IF805.