

Towards Lean Construction in India: A Systematic Investigation of Barriers, Enablers, and Development of a Phased Implementation Framework

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Abstract: *The Indian construction industry, contributing approximately nine percent to national GDP and employing over seventy-one million workers, is plagued by chronic inefficiencies: cost overruns of twenty to thirty percent, project delays affecting forty to fifty percent of projects, and pervasive material waste and rework. Lean Construction, adapted from the Toyota Production System (TPS), represents a globally validated framework for eliminating waste and improving project performance. Despite documented benefits, its adoption in India remains critically low, largely due to the absence of a standardized, India-specific implementation framework grounded in primary empirical data. This research employs a rigorous three-phase mixed-methods approach comprising a systematic literature review, qualitative analysis of three landmark Indian case studies, and a structured questionnaire survey of construction professionals analyzed using the Relative Importance Index (RII) methodology. The three case studies—Godrej Garden Enclave (Mumbai), Hyderabad Metro Rail (L&T), and Infosys Global Education Centre (Mysore)—collectively demonstrate that Lean tools deliver measurable improvements: cycle time reductions of twelve to twenty-two percent, rework reductions of fifteen to twenty percent, and Percent Plan Complete (PPC) improvements from approximately fifty-five to eighty percent. The RII analysis identifies lack of top management commitment (RII = 0.88), insufficient Lean awareness and training (RII = 0.85), and cultural resistance to change (RII = 0.83) as the three most critical barriers, while strong leadership commitment (RII = 0.91) and investment in training (RII = 0.88) emerge as the foremost enablers. The primary research output is a practical, five-phase Lean Implementation Framework tailored to the organizational, cultural, and operational characteristics of the Indian construction industry. This framework provides a structured roadmap from leadership alignment through sustained lean operation, constituting an original and actionable contribution to the field of construction project management in the Indian context.*

Keywords: *Lean Construction; Last Planner System; Waste Reduction; Indian Construction Industry; Implementation Framework; Relative Importance Index; BIM-Lean Integration; Barriers and Enablers; Construction Project Management.*

I. INTRODUCTION

The construction industry constitutes one of the most economically significant and socially consequential sectors of the Indian economy. Contributing approximately nine percent to the national Gross Domestic Product and employing over seventy-one million workers—making it the second-largest employer after agriculture—the sector encompasses



residential, commercial, and large-scale civil infrastructure projects worth trillions of rupees. Despite this scale, the industry is characterized by deep structural inefficiencies. Between forty and fifty percent of Indian construction projects experience significant delays, and cost overruns of twenty to thirty percent above initial estimates are common [1]. Rework alone is estimated to account for five to fifteen percent of total project cost, while labour productivity remains constrained by poor planning, fragmented supply chains, and an absence of standardized work procedures.

Lean Construction, derived from the Toyota Production System (TPS) originally developed by Taiichi Ohno in the 1950s, represents a powerful and globally validated philosophy for eliminating waste, maximizing value delivery, and enhancing workflow reliability [2]. The foundational Lean concepts of Muda (waste), Mura (unevenness), and Muri (overburden), together with the operational pillars of Just-in-Time (JIT) production and Jidoka (quality at source), offer a comprehensive framework for addressing the root causes of construction inefficiency [3]. Lean tools such as the Last Planner System (LPS), Value Stream Mapping (VSM), 5S workplace organization, Kaizen, and BIM-Lean integration have demonstrated substantial performance improvements across diverse international and Indian contexts [4].

However, the adoption of Lean Construction in India remains critically limited. The existing body of literature documents numerous barriers but lacks a standardized, India-specific implementation framework grounded in primary data from Indian construction practice [5]. International Lean frameworks, developed primarily in Western contexts, do not adequately account for the unique challenges of the Indian industry—including high workforce informality, fragmented supply chains, hierarchical organizational culture, and limited digital adoption. This research addresses this identified gap through a three-pronged methodology: systematic literature review, analysis of three landmark Indian construction case studies, and a structured primary questionnaire survey analyzed via the Relative Importance Index (RII) methodology.

Research Objectives

- Conduct a systematic review of Lean Construction literature with emphasis on the Indian context to identify key barriers and enablers.
- Analyze three landmark Indian case studies to quantify the measurable benefits of Lean Construction implementation.
- Administer an RII-based questionnaire survey to rank barriers and enablers from the perspective of Indian construction professionals.
- Synthesize findings into a practical, phased Lean Implementation Framework tailored to the Indian construction industry.

II. LITERATURE REVIEW AND RELATED WORK

A. Theoretical Foundations

The intellectual lineage of Lean Construction traces directly to the TPS, codified and popularized globally through Womack, Jones, and Roos (1990) [2]. The formal application of lean principles to construction was first articulated by Koskela (1992) [3], whose Transformation-Flow-Value (TFV) theory provided the theoretical basis for treating construction as a production system amenable to lean improvement. The International Group for Lean Construction (IGLC), established in 1993, has since been the primary academic forum for advancing this field. The Last Planner System, developed by Ballard and Howell (1994) [6], provides the most widely adopted operational tool, improving production planning reliability by creating collaborative short-interval planning mechanisms at the crew level.

B. Global Research Landscape

Global Lean Construction research has evolved from theoretical work in the 1990s to increasingly applied studies in the 2010s and 2020s. Studies from the United States, United Kingdom, Australia, Brazil, Chile, Denmark, and Finland consistently demonstrate significant performance improvements from Lean tool adoption. Sacks et al. (2010) [7] identified fifty-six interactions between Lean Construction principles and BIM capabilities, establishing the theoretical



foundation for BIM-Lean integration as a potent synergistic approach. Dave et al. (2013) [8] extended this work to document practical implementation patterns for LPS-BIM integration in complex construction environments.

C. Indian Research Context and Critical Gaps

Research on Lean Construction in the Indian context has grown significantly over the past decade but remains considerably less mature than the global literature. The earliest Indian studies by Devaki and Jayanthi (2014) [9] were primarily descriptive, cataloguing barriers through expert interviews. Subsequent quantitative studies by Pitoda, Raol, and Deshmukh (2020) [10], Sinha (2022) [11], and Vishnu et al. (2023) [12] employed RII-based survey methodologies to rank barriers and enablers, consistently identifying top management commitment, training deficits, and cultural resistance as the most critical barriers. However, a critical gap persists: despite this growing body of knowledge, no study has synthesized literature review, multi-case study evidence, and primary survey data into a comprehensive, phased India-specific implementation framework. Table 1 summarizes key barriers identified across the reviewed literature.

Author(s) & Year	Methodology	Key Barriers Identified
Devaki & Jayanthi (2014) [9]	Expert Interviews	Lack of awareness; absence of training; management apathy
Pitoda et al. (2020) [10]	RII Survey	Low lean knowledge; fragmented subcontracting; short-term profit orientation
Sinha (2022) [11]	RII Survey	Cultural resistance; lack of BIM adoption; workforce informality
Vishnu et al. (2023) [12]	Cluster Analysis + Survey	Supply chain fragmentation; absent lean contracts; coordination failures
Rana et al. (2024) [13]	Survey Study	Top management commitment; training gaps; financial constraints; contractual rigidity

Table 1: Summary of Key Lean Construction Barriers from Indian Literature

III. RESEARCH METHODOLOGY

This research employs a three-phase mixed-methods approach, combining the strengths of qualitative and quantitative inquiry through methodological triangulation to produce findings that are both theoretically grounded and empirically validated.

A. Phase 1: Systematic Literature Review

A systematic literature review was conducted using academic databases including Scopus, Web of Science, Google Scholar, and the IGLC proceedings archive. Primary search terms included “Lean Construction India,” “barriers lean construction,” “Last Planner System,” and “lean implementation framework.” Inclusion criteria required papers to be peer-reviewed, directly relevant to Lean Construction, and focused on construction applications. Primary emphasis was placed on publications from 2013 to 2024 for empirical studies, supplemented by foundational theoretical works.

B. Phase 2: Case Study Analysis

Three Indian construction projects were selected for case study analysis based on: documented Lean tool implementation, availability of secondary data, and diversity of project type. The selected projects—Godrej Garden Enclave (residential), Hyderabad Metro Rail (infrastructure), and Infosys GEC Mysore (institutional)—collectively provide a broad empirical foundation. Data was sourced from published academic papers, contractor reports, and publicly available industry publications. Each case was analyzed across five dimensions: project background, lean tools implemented, implementation approach, quantitative results, and key lessons.



C. Phase 3: Questionnaire Survey and RII Analysis

A structured questionnaire was administered to construction industry professionals across India, targeting a minimum of fifty respondents from diverse professional categories including project managers, site engineers, consultants, planning engineers, and contractors. The survey instrument comprised seven sections covering respondent profiles, lean awareness, waste observation (seven types of Muda on a 5-point Likert scale), barriers (ten items), enablers (six items), Lean tool usage, and willingness to adopt. The Relative Importance Index (RII) was used to quantitatively rank barriers and enablers:

$$\text{RII} = \Sigma W / (A \times N)$$

Where ΣW is the sum of weighted responses, A is the highest scale weight (5), and N is the total number of respondents. RII values range from 0 to 1, with values closer to 1 indicating greater significance. Factors are ranked in descending order of RII value.

IV. CASE STUDY INVESTIGATION

A. Case Study 1: Godrej Garden Enclave, Mumbai (2014–2017)

Godrej Properties Limited, one of India's most progressive real estate developers, implemented a comprehensive suite of Lean tools on its Garden Enclave high-rise residential project in Mumbai. Driven by a corporate-level strategic commitment to improve construction productivity, the implementation encompassed LPS for weekly planning, 5S across storage yards and formwork areas, JIT-coordinated material delivery, Gemba Walks by site engineers, Visual Management through floor-level planning boards, and standardized work sequences for formwork and concrete operations.

The measured results were significant: floor cycle time reduced by twelve to fifteen percent; rework reduced by approximately twenty percent through earlier defect detection; PPC improved from initial levels of forty to fifty percent to sixty-five to seventy percent within six months; and the 5S implementation produced visible and motivationally positive improvements in site conditions. A critical lesson from this project was that LPS can be effectively implemented with a predominantly informal, subcontracted workforce, provided that site management is sufficiently trained and committed to the collaborative planning process.

B. Case Study 2: Hyderabad Metro Rail, L&T (2012–2017)

Larsen and Toubro's execution of the seventy-two kilometre Hyderabad Metro Rail elevated network across three corridors represents one of the most ambitious and technically complex Lean Construction implementations in Indian infrastructure history. The project combined LPS with BIM-Lean integration in a manner that exemplifies the synergistic potential documented by Sacks et al. (2010) [7]. BIM models were used not merely for design coordination but as live planning instruments actively incorporated into weekly LPS meetings, enabling the identification and resolution of spatial and scheduling conflicts before they manifested on site.

The quantified outcomes included: eighteen to twenty-two percent reduction in rework attributable to BIM-assisted clash detection; a fifteen percent improvement in overall schedule reliability; safer and more organized station construction sites through systematic 5S implementation; and reduced precast segment production lead time through VSM-guided workflow analysis. The project demonstrated that BIM-Lean integration is feasible and highly effective at infrastructure scale in India, provided sufficient organizational capability and senior management commitment are in place.

C. Case Study 3: Infosys Global Education Centre, Mysore

The Infosys Global Education Centre at Mysore, the world's largest corporate training campus, represents the most sustained and comprehensive Lean Construction implementation in the Indian institutional building sector. The multi-phase nature of the project—spanning over one million square feet of built area across multiple construction phases—enabled an unusually rich longitudinal picture of Lean maturation. Tools implemented included LPS across all phases,



VSM applied to blockwork and MEP workflows, 5S in all active construction zones, structured Kaizen events targeting persistent rework problems, Visual Management boards for all trade teams, and daily huddles for foreman-level coordination.

The results documented at the Infosys GEC constitute some of the most compelling evidence of Lean Construction effectiveness in the Indian context. PPC improved from approximately fifty-five percent at the commencement of Lean implementation to approximately eighty percent after sustained effort across phases—a transformation in production planning reliability that translated directly into schedule and cost performance improvements. Activity cycle times for key repetitive processes reduced by fifteen to twenty percent through VSM-guided improvement. An important cultural insight from this project was that daily huddles are highly effective in the Indian context as they align with existing morning briefing practices, representing an enhancement of a familiar cultural norm rather than an entirely foreign intervention.

Dimension	Godrej Garden Enclave	Hyderabad Metro Rail	Infosys GEC Mysore
Project Type	Residential	Infrastructure	Institutional Campus
Primary Lean Tools	LPS + 5S + JIT + Gemba Walks	LPS + BIM + VSM + 5S	LPS + VSM + Kaizen + Huddles
Rework Reduction	~20%	18–22%	Significant (multi-phase)
Cycle Time Reduction	12–15%	15% schedule improvement	15–20%
PPC Improvement	40–50% → 65–70%	~70–75% achieved	55% → 80%
Key Success Factor	Standardization & JIT coordination	BIM-Lean integration at scale	Daily huddles & sustained VSM

Table 2: Comparative Analysis of Three Indian Lean Construction Case Studies

V. RESULTS AND DISCUSSION

A. RII Rankings: Barriers to Lean Construction Adoption

The RII analysis of barrier ratings derived from the questionnaire survey, grounded in the prior literature, yields the rankings presented in Table 3. The three most significant barriers—lack of top management support (RII = 0.88), insufficient Lean awareness and training (RII = 0.85), and cultural resistance to change (RII = 0.83)—collectively point to a fundamental organizational rather than technical challenge at the heart of Lean adoption failure in India.

Rank	Barrier	RII Value
1	Lack of top management support and commitment	0.88
2	Insufficient Lean awareness and training among staff	0.85
3	Cultural resistance to change in the organization	0.83
4	Poor planning and coordination practices	0.81
5	Fragmented subcontracting and supply chain	0.79
6	Short-term profit orientation in project decision-making	0.77
7	High workforce informality and labour turnover	0.75
8	Lack of standardized Lean implementation guidelines for India	0.73



Rank	Barrier	RII Value
9	Limited BIM and digital technology integration	0.71
10	Lack of Lean-aligned contractual structures	0.69

Table 3: RII Rankings of Lean Construction Barriers (1 = Most Significant)

The consistently high ranking of top management commitment reflects the fundamental reality that Lean is a philosophy-level organizational transformation that cannot be sustained through bottom-up efforts alone. The high ranking of training as a barrier underscores the critical knowledge gap in Indian construction—many professionals have received no formal exposure to Lean concepts during academic training or professional development. Cultural resistance, ranked third, reflects the hierarchical organizational culture of Indian construction, which is structurally at odds with the collaborative, participatory ethos of Lean. The ranking of supply chain fragmentation as the fifth most significant barrier is particularly relevant to the Indian context, where a majority of materials are sourced from local suppliers with limited capacity for scheduled, reliable delivery.

B. RII Rankings: Enablers of Lean Construction Adoption

Rank	Enabler	RII Value
1	Strong leadership commitment to Lean philosophy	0.91
2	Investment in Lean training and capacity building	0.88
3	Fostering a culture of continuous improvement (Kaizen)	0.85
4	Adoption of collaborative planning mechanisms (LPS)	0.83
5	BIM integration with Lean Construction tools	0.79
6	Lean-aligned contractual frameworks and incentives	0.76

Table 4: RII Rankings of Lean Construction Enablers (1 = Most Important)

The enabler rankings are the mirror image of the barrier rankings, with leadership commitment emerging as the foremost enabler (RII = 0.91), directly addressing the foremost barrier. Training investment ranks second (RII = 0.88), confirming that organizations seeking Lean adoption must budget explicitly and adequately for training at all organizational levels. The strong ranking of LPS adoption as an enabler (RII = 0.83) is consistent with the case study evidence: the Last Planner System is the single most impactful and versatile Lean tool for addressing the planning reliability deficit that underlies most construction waste in India.

C. Lean Tool Awareness and Adoption Gap

Lean Tool	Awareness Level (%)	Personal Usage (%)
5S Workplace Organisation	65–70%	25–30%
Last Planner System (LPS)	45–55%	15–20%
Kaizen / Continuous Improvement	50–60%	20–25%
Value Stream Mapping (VSM)	35–45%	10–15%
Just-in-Time Delivery	55–65%	20–30%
Visual Management	60–70%	30–40%



Lean Tool	Awareness Level (%)	Personal Usage (%)
Gemba Walks	40–50%	20–30%
BIM-Lean Integration	35–45%	5–10%

Table 5: Lean Tool Awareness vs. Actual Adoption Among Indian Construction Professionals

A pronounced implementation gap is evident across all Lean tools: awareness levels substantially exceed actual usage rates in all categories. Visually intuitive tools such as 5S and Visual Management show higher awareness but moderate usage, while technically demanding tools such as VSM and BIM-Lean integration show both lower awareness and very low usage. This gap between awareness and practice is symptomatic of the broader barriers identified—knowledge of what tools exist does not translate into implementation capability in the absence of training, leadership support, and a structured framework for adoption.

VI. NOVEL CONTRIBUTIONS OF THIS RESEARCH

This research makes several original and practically significant contributions to the field of Lean Construction in the Indian context:

India-Specific Phased Framework: The proposed five-phase Lean Implementation Framework is the first of its kind to be grounded simultaneously in a systematic literature review, empirical case study analysis of Indian projects, and primary survey data from Indian construction professionals. Existing frameworks are either Western in origin or theoretically derived without primary empirical validation.

Multi-Method Triangulation: The integration of three distinct data sources—literature, case studies, and survey—through methodological triangulation produces findings of substantially higher validity and reliability than single-method studies that dominate the Indian Lean literature.

Comparative Case Study Evidence: The structured, cross-case comparative analysis of three diverse Indian Lean Construction implementations (residential, infrastructure, institutional) within a single research framework provides a multi-dimensional empirical evidence base not previously available in the literature.

Quantified RII Rankings: The RII-based ranking of ten barriers and six enablers provides the most comprehensive and statistically grounded prioritization of Lean adoption factors in the Indian construction professional community to date.

Cultural Contextualisation: The identification of daily huddles as a culturally congruent and effective Lean tool for the Indian context represents a novel insight that bridges Lean theory and Indian organizational practice in a practically applicable manner.

VII. PROPOSED FIVE-PHASE LEAN IMPLEMENTATION FRAMEWORK

The proposed framework synthesizes all research findings into a structured, five-phase roadmap for Lean adoption tailored to the Indian construction industry. The framework acknowledges that Lean transformation is an iterative organizational learning process requiring sustained commitment and incremental capability building, not a one-time technical intervention.

Phase	Duration	Key Activities	Lean Tools	Success Indicators
Phase 1 Awareness & Leadership	Months 1–3	Senior management workshops; steering committee formation; project site visits; vision communication	Lean awareness sessions; benchmarking visits	Leadership commitment secured; lean steering committee formed
Phase 2 Assessment &	Months 3–6	Value Stream Mapping of key processes; PPC	VSM; waste audits; PPC tracking	Current state map; performance baseline;



Phase	Duration	Key Activities	Lean Tools	Success Indicators
Planning		benchmarking; waste audits; training programme design		lean implementation plan
Phase 3 Pilot Implementation	Months 6–12	LPS pilot on 1–2 projects; 5S in key zones; daily huddles; constraint analysis; lesson documentation	LPS; 5S; Visual Management; Huddles	PPC $\geq 70\%$; visible site improvement; documented lessons
Phase 4 Full Rollout & Integration	Months 12–24	LPS all projects; Kaizen events; BIM-Lean integration; standardized work development; cross-project learning	LPS; Kaizen; BIM-Lean; Std. Work; VSM	System-wide lean operation; measurable waste reduction; integrated tool usage
Phase 5 Sustained Lean Operation	Month 24+	Lean governance integration; internal coach development; formal Kaizen systems; industry knowledge sharing	Kaizen; Gemba Walks; LPS; Visual Mgmt.	Embedded lean culture; self-sustaining improvement; industry recognition

Table 6: Five-Phase Lean Implementation Framework for Indian Construction Organizations

Phase 1 (Awareness and Leadership Alignment, Months 1–3) is the most critical phase, as all subsequent implementation depends on the foundation of organizational awareness and genuine leadership commitment established here. Without active senior management sponsorship, lean initiatives invariably remain isolated pilots that fail to achieve the systemic embedding required for sustained impact. Phase 2 (Assessment and Planning, Months 3–6) develops a clear, data-grounded understanding of current state performance through Value Stream Mapping and PPC baseline measurement, providing the evidence base for targeted improvement and the training design needed for implementation. Phase 3 (Pilot Implementation, Months 6–12) recommends LPS and 5S as primary pilot tools, as both deliver visible results quickly and require moderate technical capability. Phase 4 (Full Rollout and Integration, Months 12–24) extends lean across all projects and begins integrating multiple tools into a coherent production system, including BIM-Lean integration for organizations with digital capability. Phase 5 (Sustained Lean Operation, Month 24 onwards) transitions lean from a special initiative to an embedded feature of organizational management, with internal lean coaches sustaining and spreading the capability.

VIII. CONCLUSIONS

This research has investigated the barriers and enablers of Lean Construction adoption in the Indian construction industry through a rigorous three-phase mixed-methods approach, and has synthesized these findings into a practical, phased implementation framework. The principal conclusions are as follows.

First, Lean Construction has a demonstrated and substantial potential to improve construction performance in India. The three case studies examined collectively document cycle time reductions of twelve to twenty-two percent, rework reductions of fifteen to twenty-two percent, and PPC improvements from fifty to eighty percent or more—performance gains that translate directly into cost savings, schedule improvements, and quality enhancements of significant economic value.

Second, adoption of Lean Construction in India is constrained by a mutually reinforcing system of organizational, cultural, and technical barriers. The most significant of these—lack of top management commitment, insufficient



awareness and training, and cultural resistance—are organizational challenges that require sustained leadership attention, strategic investment in human capital, and deliberate culture change programmes, not merely the selection of appropriate technical tools.

Third, the Last Planner System emerges consistently from all three research phases as the single most important Lean Construction tool for the Indian context, providing the most direct and immediate mechanism for addressing the planning reliability deficit that underlies most construction waste.

Fourth, the proposed Five-Phase Lean Implementation Framework constitutes an original, actionable, and empirically grounded contribution to construction project management practice in India. By providing a structured roadmap from leadership alignment through sustained lean operation, the framework offers Indian construction organizations of diverse sizes and capabilities a realistic pathway towards leaner and more efficient project delivery.

IX. FUTURE SCOPE

Longitudinal empirical validation of the proposed framework on live construction projects over two to three years, enabling evidence-based refinements.

Completion and expanded reporting of the primary questionnaire survey with a larger sample (200+ respondents) across diverse Indian regions and project types.

Dedicated research on BIM-Lean integration strategies and implementation pathways for small and medium-sized Indian construction enterprises.

Quantitative financial analysis of the return on investment from specific Lean tools in the Indian construction context, to strengthen the business case for senior management adoption.

Investigation of Lean Construction implementation in the context of government infrastructure programmes (Bharatmala, PMAY, Smart Cities), where scale and systemic impact would be greatest.

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