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Lean Tools Application to Minimize Construction Waste and Improve Site Productivity: A Case Study on 5S System and Last Planner System

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Abstract

Persistent challenges in the construction industry include wastage of materials, budget overruns, schedule delays, and low labour productivity, where it is reported that more than 30 percent of construction works are non-value adding activities. The purpose of this research is to examine the performance of two major lean construction practices, namely, 5S System and Last Planner System (LPS), in reducing wastage in construction sites and enhancing productivity for a residential-commercial building project in Ahmedabad, Gujarat. A mixed methodological design approach was employed in this study where a field study was carried out for 15 days and two questionnaires were administered among 82 construction professionals in various designations such as Project Manager, Planning Engineer, Site Engineer, Supervisor, and Contractor. The Relative Importance Index (RII) was used for analysing data collected through this study. The 5S System had an overall RII of 0.869, resulting in an approximate reduction of between 8–12% in material waste and between 10–18% increase in labour efficiency. The Last Planner System was more efficient with an overall RII of 0.890, leading to a reduction of between 12–20% in project delay and between 15–22% increase in productivity. The percent plan complete increased from 60% to 85% after the use of LPS. Some of the major challenges associated with lean implementation include lack of awareness, inadequate training, and lack of acceptance towards change.

Keywords— Lean Construction; 5S System; Last Planner System; Relative Importance Index; Construction Waste; Site Productivity

INTRODUCTION

The construction industry is among the most resource-consuming industries in the world due to high levels of inefficiency, which makes it important in economic development and infrastructure construction. It involves many problems such as cost overruns, schedule overruns, material wastages, and poor labour productivity. Research shows that the amount of non-productive processes accounts for 25-35%, while material wastage is up to 5%-15% of project cost and labour inefficiency is responsible for up to 20%-30% loss in productivity. Cost overruns can be up to 10%-25% of project cost, while schedule

overruns involve 15%-30% more than the schedule. Reworking and errors can account for 5%-12% of project cost, while idle time is up to 20%-25%.

In India, the fast pace of urbanization and development has led to a higher incidence of construction work along with an increase in the generation of construction waste. Traditional construction techniques usually make use of disjointed planning, inadequate coordination between stakeholders, and a reactionary approach — thus leading to the existence of numerous activities on-site which do not add any value to the project at all. The concept of lean construction, which is derived from the Toyota Production System, provides a solution towards eliminating such wastes and improving efficiencies of operations with the help of concepts like the Last Planner System, 5S, Value Stream Mapping, JIT, and Kaizen.

These are the four important areas where there are research gaps in current literature, which are to be studied and addressed within this research paper: (1) existing literature considers lean techniques separately but fails to address their impact when considered together; (2) the empirical research on linking the use of lean techniques to productivity gains in Indian construction projects is scarce; (3) there is practically no study on the application of lean techniques within Indian construction projects in Gujarat; and (4) implementation models for Indian construction projects are also missing. These gaps have been studied by using questionnaire survey amongst 82 construction professionals and a 15-day case study at Orchid Gold Project, Ahmedabad.

LITERATURE REVIEW

A. Waste Identification and Classification

According to various studies, wastages in construction projects primarily arise because of delays, reworks, idle time for labour and machines, and delays in material arrivals. Poor planning and coordination were identified by authors like Patil and Kohar as the key reasons behind value-added activities. Nonetheless, most of the literature emphasizes only the identification of wastage based on surveys.

B. Last Planner System for Planning Reliability

The Last Planner System has proven to be very effective in improving planning reliability via master scheduling, look-ahead planning, weekly work planning, and PPC monitoring. Abdul and Vinod Chavan conducted studies that showed improved workflow and reduced idle time. Nevertheless, there is little study material on its use in high-rise building construction in Gujarat.

C. 5S System for Site Management

The 5S System is an approach for improving the management of the workplace. It was discovered by Yashneil and Jahal Chudasama that 5S helps reduce idle time as well as improves site control. However, there is little information on 5S application at Indian construction sites.

D. Obstacles to Implementing Lean Practices in India

Lack of training, reluctance to change, poor understanding, and inadequate site management pose significant obstacles to implementing lean practices in India. The work of Nifla and Raavin Raaj demonstrates the importance of management buy-in in achieving success in implementing lean practices. There are very few implementation-focused case studies on lean practices.

E. Recent Trends – Lean 5.0

Lean 5.0 represents a novel idea that integrates human knowledge and artificial intelligence to create a predictive control system. According to Khoshkonesh, this approach enhances planning effectiveness, minimizes the need for rework, and improves forecast accuracy. Nevertheless, this innovation may only be relevant to technological settings and cannot yet apply to current Indian construction practices.

F. Contributions of This Study

This study seeks to address the above shortcomings by conducting an assessment of the joint impact of the 5S approach and the Last Planner approach, employing both questionnaire surveys and a case study at a construction site. Two sets of questionnaires were conducted using Google Forms among construction experts in Ahmedabad, with 82 valid responses analyzed through the Relative Importance Index (RII). Additionally, a 15-day case study was undertaken on Tower A of Orchid Gold Project in Ahmedabad, a mixed-use high-rise construction.

METHODOLOGY

A. Research Design

The proposed methodology in this study is a mixed method research design approach, which involves both quantitative research analysis of the questionnaires and qualitative field research of the on-site case studies. The research process will be divided into three major stages: (1) review of literature and selection of lean tools; (2) collection of primary data from questionnaire surveys and on-site case studies; and (3) data analysis by using the RII approach and PPC. Two lean tools have been selected in this study: 5S system for waste reduction and Last Planner System for improved planning reliability.

B. Design of Questionnaires

Two standardized questionnaires were prepared and sent out using Google Forms and personal site visits. Questionnaire 1 (5S System) included eight items namely, Sort, Set in Order, Shine, Standardize, Sustain, Effect on Performance, Barriers, and Overall Effectiveness. Questionnaire 2 (LPS) included: Master Planning, Phase Planning, Look-ahead Planning, Weekly Work Plan, Performance Measurement, Effect on Productivity, Barriers, and Overall Effectiveness. Both questionnaires were scored based on a 5-point Likert Scale ranging from “Strongly Disagree” (1 point) to “Strongly Agree” (5 points). Both were also validated by Planning Engineer on 23rd February 2026.

C. Case Study

A case study lasting 15 days was carried out at Tower A, Orchid Gold Project, Ahmedabad, a multi-story building consisting of a mix of commercial and residential units, chosen due to its complicated nature regarding coordination, waste generation, and production control. Tasks involved were observing the daily activities and waste in the construction site, documenting existing conditions in the site for the purpose of 5S audit, comparing planned against actual activities for LPS analysis, scheduling weekly work planning sessions, monitoring slab cycles, and identifying constraints.

RESULTS AND DISCUSSION

Results of the current research were gathered from two main sources, namely questionnaire survey analysis and a 15-day on-site case study. All 82 responses in the questionnaire were analyzed using the RII technique. It is observed that all RII calculations lie between 0.80 and 1.00, indicating Very High importance ratings in all categories for both techniques.

A. 5S System — Section-wise RII

Table I presents the RII scores for each 5S section. The overall 5S RII was recorded at 0.869, confirming very high perceived effectiveness among construction professionals.

Table I: Section-wise RII Results — 5S System

5S System all Questionary Overall RII Result – 0.869		
Section	**Description**	**RII**
A - Sort (Seiri)	Removing unnecessary items to clear space and stop search time	0.927
B - Set in Order (Seiton)	Creating labelled home for every item to eliminate motion waste	0.850
C - Shine (Seiso)	Daily cleaning to prevent defects and inspect equipment	0.831
D - Standardize (Seiketon)	Creating consistent rules and visual aids for the site	0.863
E - Sustain (Shitsuke)	Building discipline and making 5S a habit	0.882
F - Impact of Performance	Impact of 5S on construction site performance	0.877
G - Barriers	Barriers to 5S implementation on construction sites	0.845
H - Overall Effectiveness	Overall effectiveness of 5S in reducing waste and improving productivity	0.915

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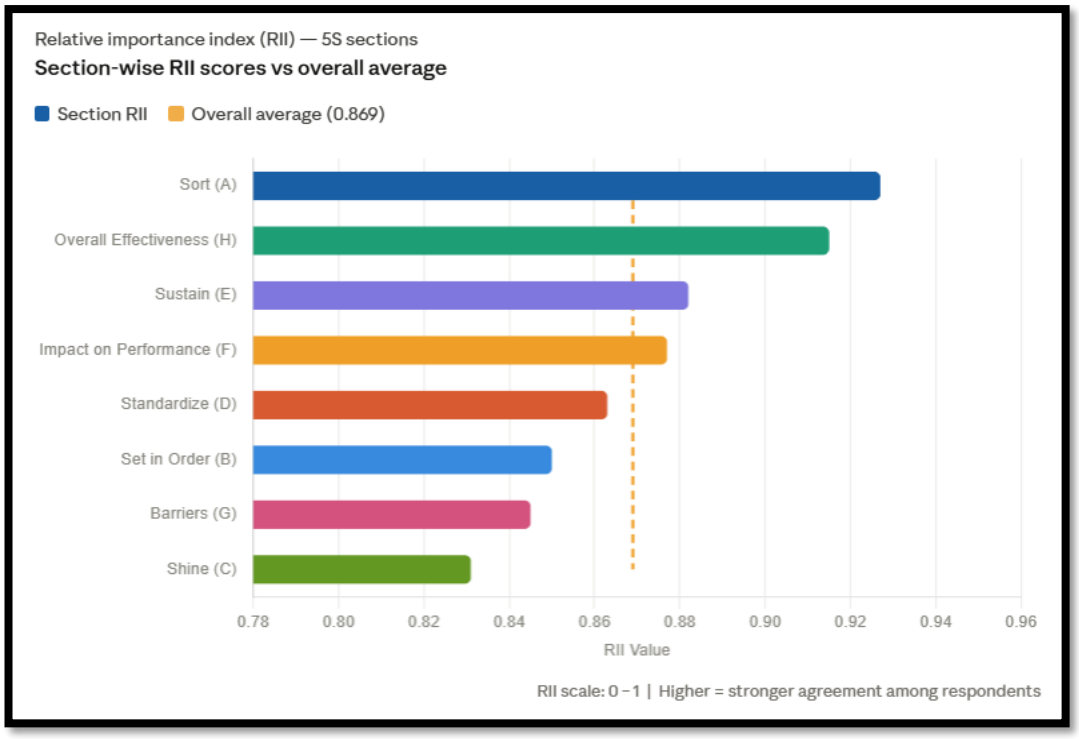

Figure I: 5S Questionnaire Section-wise RII Score vs Overall Average

Section A – Sort obtained the highest RII score of 0.927, signifying a high level of consensus regarding the removal of unnecessary materials as the most significant waste reduction measure, which is supported by the work of Kohar and Biswas, who emphasized the presence of unnecessary materials as one of the most important activities that do not add value to the process. Section H – Overall Effectiveness received an RII score of 0.915, which verifies the level of effectiveness of 5S as a practical technique. Section C – Shine obtained the lowest RII score of 0.831, signifying that cleaning on a daily basis was considered less significant than organization.

B. 5S System — Designation-wise RII

Table II presents 5S RII scores broken down by professional designation.

Table II: Designation-wise RII Results — 5S System

Designation	Project Manager	Planning Engineer	Site Engineer	Supervisor	Contractor
Overall	**0.884**	**0.866**	**0.879**	**0.844**	**0.840**
Section A	0.920	0.950	0.918	0.956	0.900
Section B	0.853	0.858	0.868	0.770	0.817
Section C	0.853	0.829	0.838	0.800	0.817
Section D	0.900	0.850	0.877	0.833	0.825
Section E	0.880	0.846	0.908	0.852	0.850
Section F	0.900	0.888	0.873	0.856	0.888
Section G	0.880	0.854	0.852	0.830	0.783
Section H	0.920	0.888	0.927	0.922	0.888

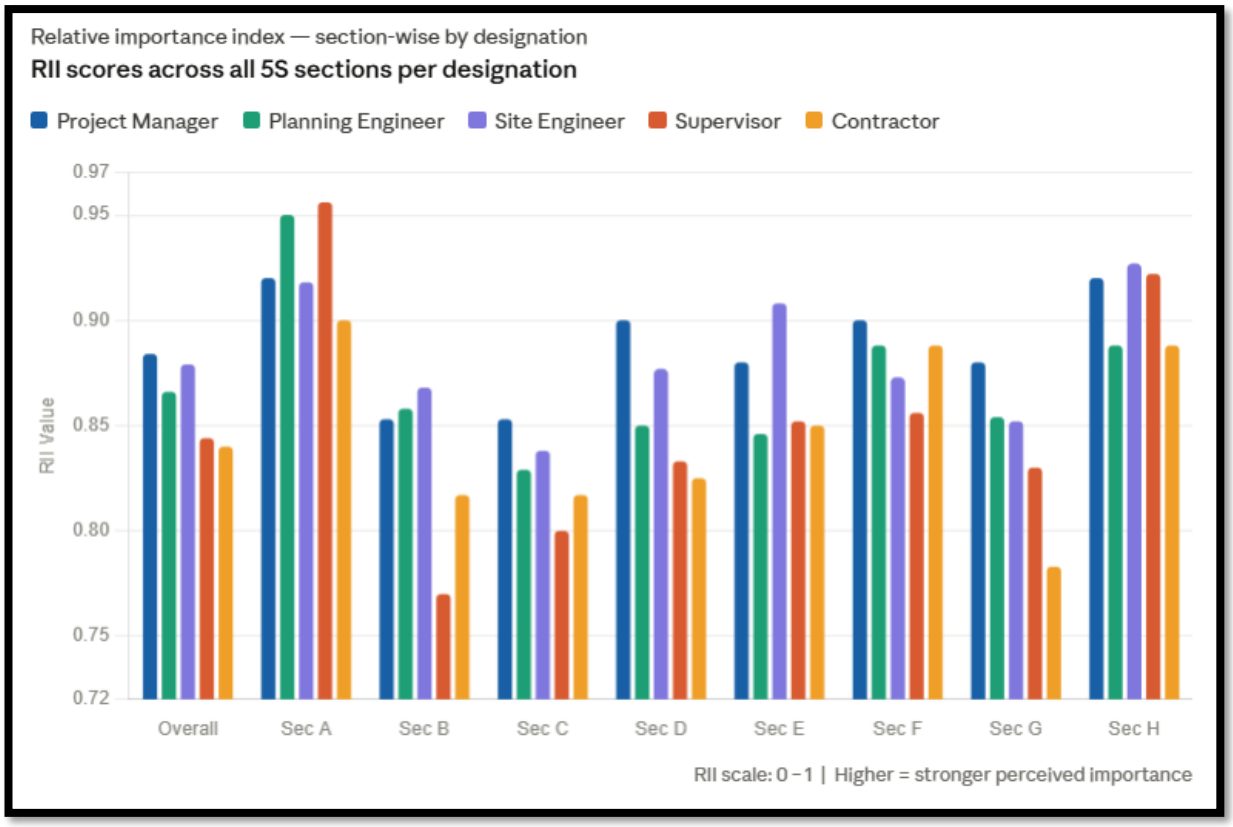

Table II: RII Score All 5S Section Per Designation

Project Managers had the highest RII score of 0.884, showing higher strategic understanding of 5S. Contractors had the least RII scores of 0.840, showing lesser knowledge of 5S in comparison – like observed by Raavin Raaj & Praveen Kumar. Section A – Sort achieved the highest mean score among all sections in each and every designation; the score was highest for Supervisors, i.e., 0.956. Section B – Set in order exhibited the maximum variance; the score was lowest for Supervisors, i.e., 0.770, while it was 0.868 for Site Engineers.

C. Last Planner System — Section-wise RII

Table III presents LPS section-wise RII scores. The overall LPS RII of 0.890 is marginally higher than 5S (0.869), indicating planning-related lean interventions are perceived as slightly more impactful.

Table III: Section-wise RII Results — Last Planner System

Last Planner System All Questionary Overall RII Result – 0.890		
Section	**Description**	**RII**
A - Master Planning	Defines overall project milestones and contract completion dates	0.920
B - Phase Planning	Detailed planning for each stage to achieve milestones	0.901
C - Look-ahead Planning	3–6 week constraint-free task selection window	0.893
D - Weekly Work Plan	Reliable daily task commitments by foremen and contractors	0.887
E - Performance Measurement	Measuring PPC and analysing root causes of task failure	0.863
F - Impact on Productivity	Impact of LPS on construction site productivity	0.899
G - Barriers	Barriers to LPS implementation on construction sites	0.837
H - Overall Effectiveness	Overall effectiveness of LPS in improving site productivity	0.910

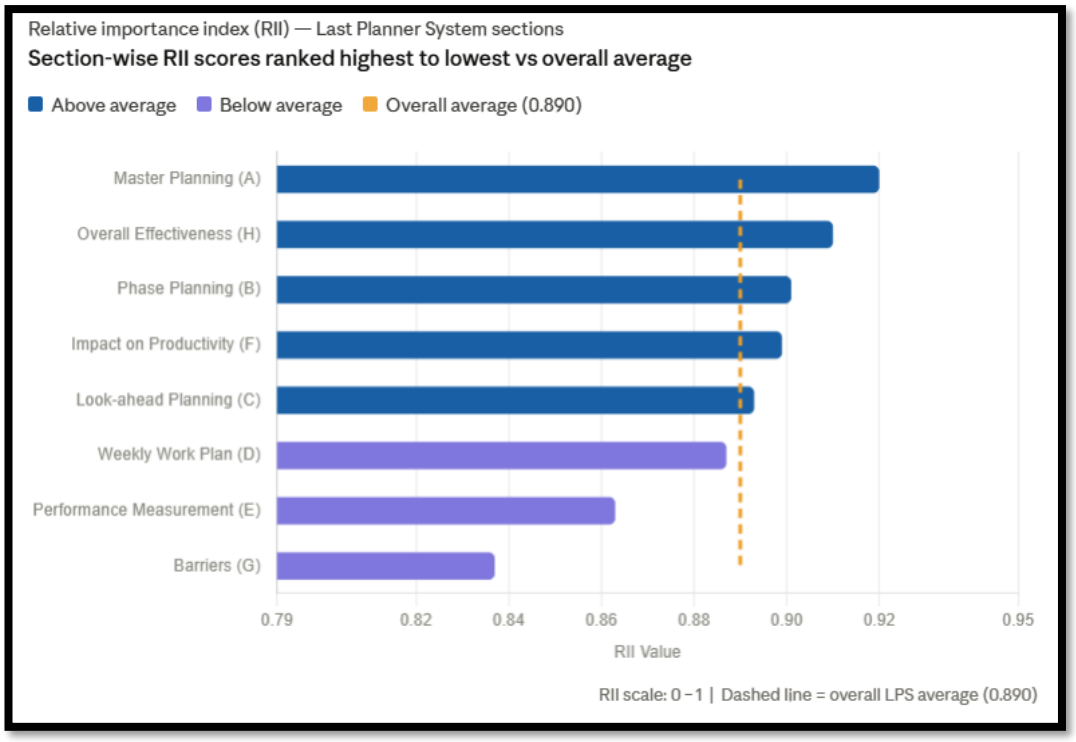

Figure III: Section-wise RII Score Ranked Highest to Lowest vs Overall Average

Section A –Master Planning had the highest RII value of 0.920, indicating that there is a high level of agreement that the establishment of milestones is essential for planning. Section E – Performance Measurement had a value of 0.863, which indicated that PPC monitoring is difficult to practice in real-life settings. Finally, Section G – Barriers had the lowest value of 0.837, showing that LPS is hindered by many factors in its implementation, such as a lack of awareness and resistance to planning.

D. Last Planner System — Designation-wise RII

Table IV presents LPS RII scores by professional designation.

Table IV: Designation-wise RII Results — Last Planner System

Designation	Project Manager	Planning Engineer	Site Engineer
Overall	**0.933**	**0.885**	**0.888**
Section A	0.940	0.932	0.913
Section B	0.960	0.891	0.900
Section C	0.920	0.877	0.896
Section D	0.920	0.879	0.888
Section E	0.940	0.855	0.859
Section F	0.960	0.903	0.891
Section G	0.840	0.836	0.837
Section H	0.960	0.895	0.911

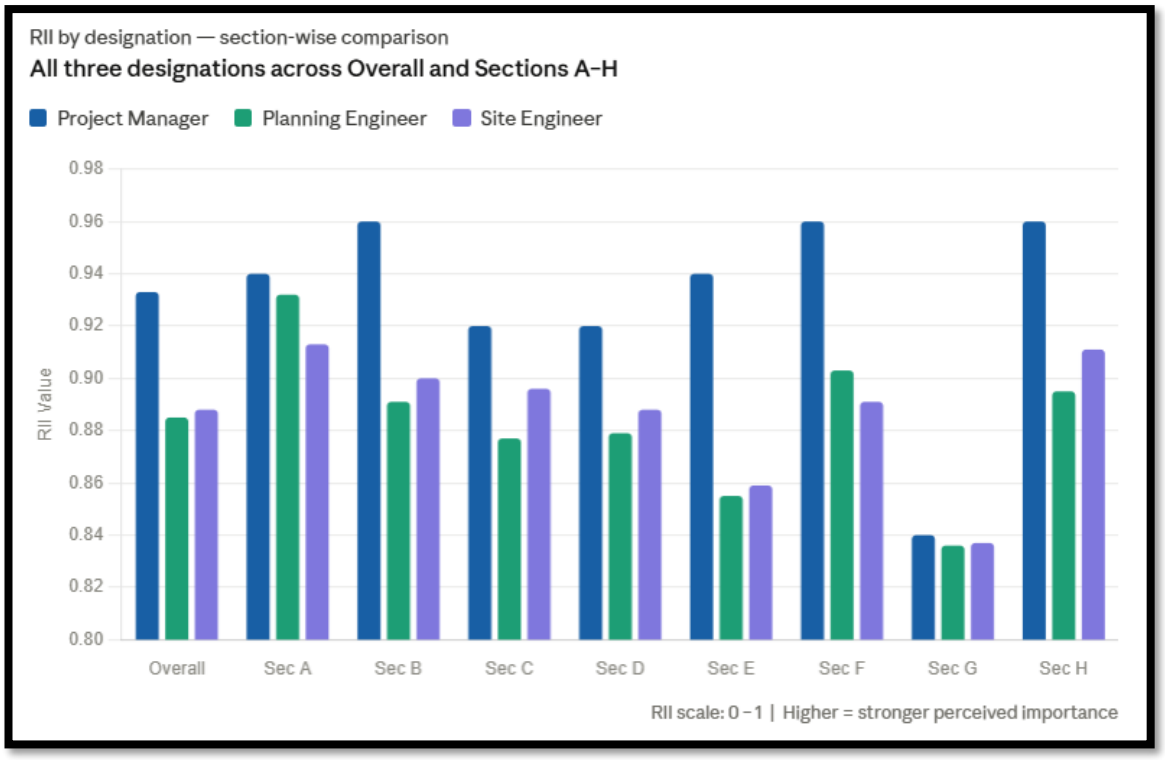

Figure IV: RII Score Across All LPS Section Per Designation

Project Managers reported the highest LPS RII at 0.933, which is much higher compared to Planning Engineers (0.885) and Site Engineers (0.888). Sections B, F, and H registered the maximum score for Project Managers at 0.960. However, what must be noted is that the barrier sections (G) scored quite similarly for all three categories, Project Managers – 0.840, Planning Engineers – 0.836, and Site Engineers – 0.837. This is indicative of an organizational problem rather than lack of awareness in any one particular category.

E. Comparative Analysis — 5S vs LPS

Table V presents a direct comparison of both lean tools.

Table V: Comparative RII — 5S System vs. Last Planner System

Parameter	5S System	Last Planner System
Overall RII	**0.869**	**0.890**
Highest Section RII	0.927 (Sort)	0.920 (Master Planning)
Lowest Section RII	0.831 (Shine)	0.837 (Barriers)
Barriers Section RII	0.845	0.837
Overall Effectiveness RII	0.915	0.910
Impact Section RII	0.877	0.899
Impact Level	Very High	Very High

LPS demonstrated a slightly higher Overall RII score (0.890 vs. 0.869), corroborated by the findings of Patil et al., which recognized that time-based wastes, directly targeted by LPS, were the most significant source of inefficiency in construction. However, the 5S method showed a higher Overall Effectiveness RII score (0.915 vs. 0.910), suggesting that participants view the 5S method as more effective in providing a broader scope of benefits. Barriers were the lowest-scoring category for both tools, highlighting that implementation difficulties are a widespread issue in construction in India.

F. Case Study — PPC and Site Performance Results

Table VI summarises key performance outcomes from LPS implementation at the Orchid Gold Project.

Table VI: Performance Measurement — PPC Before and After LPS

Performance Metric	Before LPDS	After LPS	Improvement
Percent Plan Complete (PPC)	60%	85%	25%
Labour Productivity	Baseline	Improved	20–25% gain
Workflow Delays	Frequent	Reduced	12–20% reduction
Team Coordination	Poor	Significantly Improved	Qualitative gain

The improvement in PPC from 60% to 85% is an improvement of 25 percentage points in planning accuracy — similar to the findings of Ashwin Amarshi Maru, who observed that the increase in PPC was the most prominent factor in improved planning efficiency as a result of LPS introduction. 5S System has been responsible for the estimated reduction in wastage of materials by 8-12%, while labour efficiency improved by 10-18%. The utilization of both systems concurrently has allowed for the reduction of wastages of 10-15%, improvement in labour efficiency of 15-20%, and reduction in project delays by 12-18%.

G. Discussion

The findings clearly indicate that both the **5S System** and the **Last Planner System** positively influence construction site performance.

Based on the survey results, the average RII of 5S is 0.869, and the average RII of LPS is 0.890, indicating that respondents view both lean tools as highly effective. The slightly higher value for LPS means that changes related to planning can have a more immediate impact on productivity on-site.

The case study analysis provides further evidence supporting this assertion. Effective workplace organization helped reduce wasteful movements and searching for materials, while planning ensured smoother coordination between teams and increased process reliability.

One key insight gained from the study is that using 5S and LPS together yielded better results than when each lean tool was used individually. In contrast, prior research focused on analyzing each tool separately, while this study shows that integrating waste elimination with reliable planning results in observable short-term improvements in terms of costs and time.

Additionally, the study uncovered critical barriers for implementation, such as lack of awareness about lean practices, inadequate training, resistance to change by workers, and lack of managerial commitment. These barriers correspond with barriers identified in other Indian construction projects.

CONCLUSION

The efficacy of 5S methodology and LPS was assessed for the purpose of minimizing waste and maximizing construction productivity through the RII of 82 construction professionals along with a 15-day on-site assessment of the implementation of these two methods at the Orchid Gold Project Ahmedabad. The application of 5S method was found to be highly effective, resulting in site organization improvements along with an 8%-12% reduction in material waste; Sort (RII = 0.927) and Overall Effectiveness (RII = 0.915) achieved the highest RII scores amongst sections. The application of LPS was also highly effective, PPC increased from 60% to 85%, 12%-20% delays were minimized, and the productivity improved by 15%-22%.

The designation-based assessment showed that Project Managers consistently scored both these approaches highest whereas the barriers to their implementation remained constant for all types of professional designations, thus highlighting organizational problems in contrast to individual skill deficiencies. In combination with each other, both these approaches resulted in a reduction of overall waste by 10%-15%, improvement in labor productivity by 15%-20%, and a reduction in delays of 12%-18%.

This study proposes a pragmatic framework for implementing lean in high-rise construction in India, which directly bridges the research gaps concerning Gujarat-based lean literature and the need for empirical evidence on the relationship between

lean tools and site outputs. Further research can take the following directions: expanding the current framework at a more macro scale; conducting financial benefit-cost analysis; and integrating BIM and artificial intelligence prediction models as proposed under the Lean 5.0 approach.

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