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CHALLENGES IN LEAN CONSTRUCTION: INSIGHTS FROM THE INDIAN CONSTRUCTION SECTOR

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ABSTRACT

The construction industry has very strategic and vital role in development of the country. Currently, the construction sector experiences rapid growth. However, the sector faces project delay, cost overrun challenges. Lean principles offer a systematic approach to address these inefficiencies by minimizing waste and optimizing resources with maximize values. This study investigates the challenges of implementation of lean principles in the construction industry through comprising literature review and quantitative survey was conducted among industry professionals to gather insights on the key factors hindering lean adoption. The analysis included multi linear regression techniques to understand the relationship between key variables and to identify significant factors impacting lean implementation and a fishbone diagram was developed to visualize the root causes. The finding highlights that people, management and knowledge are the major factors hinder the adoption of lean practices. The study also emphasizes the importance of top management support, comprehensive training programs, and active involvement of employees in overcoming these challenges. Practical solutions such as the Last Planner System, Kaizen, Just-In-Time practices, and BIM are proposed to enhance lean adoption.

***Keywords**: Lean Construction (Lc), Multi Linear Regression, Fishbone Diagram,*

1. INTRODUCTION

Indian construction industry is playing pivotal role in driving economic growth of the country and national development. Construction sector contributes around 13% to the gross domestic product (GDP) by 2025.[13] However, despite its size, the construction industry faces several challenges such as project delay, cost overrun, waste generation, scarcity of resources. Lean, a philosophy developed by Toyota in Japan in the 1980s, is based on the Toyota Production System (TPS) principles, and has shown significant success in the manufacturing sector.[2][3] This success has motivated its application in construction to address recurring challenges.[1] Lean construction (LC) offers numerous benefits, including cost savings, improved productivity, quality, safety, sustainability, and enhanced collaboration. Lean tools like last planner system, Value Stream Mapping, 5S, Kaizen, and Just-In-Time have proven effective in reducing waste and optimizing processes.[3][7] However, its implementation faces barriers like lack of awareness, resource constraints, resistance to change, and fragmented industry practices.[1][7]

In India, the construction sector struggles with complexity, sustainability and efficiency due to issues such as unskilled labour, poor management, and fragmented operations.[7] Leading firms have started embracing LC, recognizing it as an investment rather than a cost.[1][8] To address these issues, Strategy plays a crucial role in aligning organizational activities with overarching goals, LC thinking focus to change the organisation management, processes and peoples.[6][7] The innovative managerial and technical strategies have been adopted with Lean Construction. Lean construction practices have developed quite well over the last few decades and have lived up to their potential in many different countries, LC focuses on waste reduction, value enhancement for customers, and fostering continuous improvement within the construction industry.[4][6][9] LC enhances stakeholder relationships by fostering improved coordination and communication throughout all project phases.[5] It aims to boost efficiency and productivity, streamline management, and minimize waste.[5][8][9] By

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optimizing resource utilization and simplifying processes, LC ensures projects are completed within defined time and cost constraints.[4]

In this research systematically identify the primary factors hindering the implementation of Lean principles in the Indian construction industry. Data collection involved a structured questionnaire survey distributed to key stakeholders. The analysis highlighted critical barriers, such as people related, management and knowledge related. To delve deeper into these barriers, a root cause analysis was conducted. The outcomes of the analysis were visually represented using fishbone diagram, providing a clear and concise graphical representation of the interconnected challenges and their root causes. These visual tools not only emphasized the severity and frequency of each barrier but also served as a strategic guide for developing effective solutions.

2. LITERATURE REVIEW

Lean Construction (LC) originated in the early 1990s when researchers and practitioners in the UK began applying lean thinking to the construction sector.[1] The term “lean construction” gained attention in 1993.[1][7][11] The Indian construction sector faces challenges such as inefficiency, excessive waste, and poor quality.[2][3] Implementing LC can help overcome these issues, improving efficiency and quality while supporting the sector's role in economic growth.[2] Understanding the barriers to LC adoption can aid stakeholders in promoting its wider implementation. LC’s focus on waste reduction and sustainability can enhance environmental performance in the industry. Furthermore, adopting LC practices can boost the competitiveness of Indian construction companies in the global market by improving efficiency and quality.[11]

LC has gained widespread acceptance in the construction industry over the years, with researchers and practitioners continuously refining lean principles, tools, and techniques to enhance construction performance and efficiency.[1][9] A significant barrier to successful implementation lies in the incorrect application of LC tools, as highlighted by various case studies.[9] Koskela et al. (2003) suggest that a lack of innovation in the construction sector is a significant barrier, emphasizing the need for increased investment in research and development (R&D).[2][1] His work laid the foundation for future research and development in LC.[1] Despite its proven success in several developed countries, the adoption of Lean Construction in India remains limited. This is largely due to a wide array of barriers stemming from organizational, cultural, technical, financial, and knowledge-related challenges.

A number of technical factors must be taken into account while implementing Lean technologies in order to optimize their efficacy are mention in Table 1.

Table 1 Barriers of Lean Implementation

Knowledge related barriers	Inadequate lean awareness [1][2][5][8][12] Lack of motivation for employees to learn about LC (employee involvement) [2][1][13] Lack of knowledge about LC concepts (approaches) [4][2][5] Lack of employee training and continuous improvement in LC [1][2][8][11][13] lean tools are too complex [4][12]
People related barriers	Employee resistance to change [4][1][5][13] Unskilled labour and the site foreman’s low level of education [4][5][1][13] High employee turnover [1] Lack of client focus [2][1][13] Lack of LC professional [5][11][12]
Management related barriers	Lack of backing and dedication from top management [2][4][8][10][11][13] Centralized decision-making, avoiding delegation [1] Poor planning and inadequate pre-planning [2][4][10] Organizational structures and culture [2][4][12] Lack of long-term commitments [4][11][13]

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	Lack of supportive government laws, policies and regulations to help implement LC [4][10][11] Inadequate performance measurement system [4][2]
Communication and coordination related barriers	Lack of stakeholder interaction and transparency [4][8][10] Dependence on many stakeholders [2][4] Strict procurement requirements and approval [1] Inaccurate and incomplete designs, failure to apply constructability principles [4][11]
Financial related barriers	Increased costs or implementation costs [2][8] Additional labour cost [1] Lack of funding for implementation of LC [4][8][10] Poor professional pay, lack of incentives, and lack of desire [11] High inflation rates [1]
Resource related barriers	Scarcity of materials suitable for LC [4][5] Inadequate equipment to implement LC methods [4] Poor infrastructure in transportation and communications [1][13] Inadequate trash identification and management [1] Uncertainty in the supply chain [4]

3. METHODOLOGY

This research follows a systematically identify and analyse the critical factors hinders the implementation of Lean Construction in the Indian construction sector. The study begins with a comprehensive literature review that examines previous research, industry reports, and case studies to identify key barriers and enablers affecting Lean Construction adoption. Based on these findings, six major categories of influencing factors were established: Knowledge, People, Management, Communication and Coordination, Finance, and Resources. Each of these categories includes various sub-factors that collectively impact the successful execution of Lean principles are mentioned in table 1. From the literature review, a structured questionnaire survey was designed to collect empirical data.

The questionnaire was carefully formulated to capture the perceptions and experiences of industry professionals regarding the identified factors. The collected data statistical analysis using multiple linear regression (MLR).

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

y is the dependent variable
$X_1, X_2, \cdots X_n X_1, X_2, \cdots X_n$ are the independent variables
β_0 is the intercept
$\beta_1, \beta_2, \cdots \beta_n \beta_1, \beta_2, \cdots \beta_n$ are the slopes

MLR technique was chosen due to its ability to assess the relationship between multiple independent variables and a dependent variable. MLR enables the quantification of each factor's impact by determining its statistical significance and coefficient values. By analysing p-values, the model identifies the most critical determinants of the adoption of lean construction. Factors with higher regression coefficients and lower p-values are identified as having a significant impact, thereby providing clear guidance on where improvements are most necessary.

The findings from this research provide valuable insights for policymakers, construction firms, and practitioners, enabling them to develop targeted strategies to overcome barriers and optimize Lean Construction implementation in India.

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4. DATA ANALYSIS

The data collected for this study was obtained through a structured questionnaire survey distributed among industry stakeholders in the Indian construction sector. The survey aimed to identify the factors influencing the implementation of Lean principles, considering years of experience as the dependent variable and multiple influencing factors as independent variables.

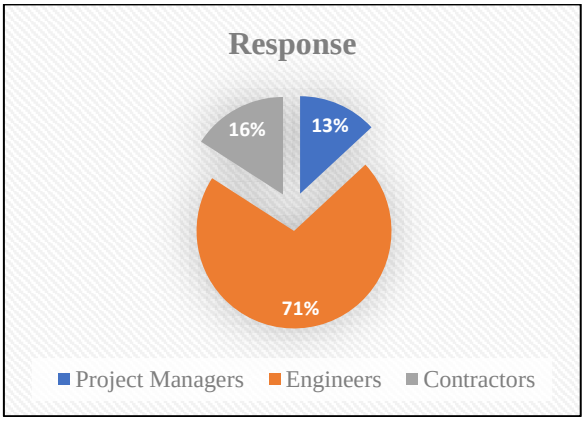

Fig. 1 Survey Responses

The survey was distributed among 150 construction professionals, including engineers, project managers, contractors, academicians, and architects to ensure a diverse representation of industry perspectives. Out of the total distributed surveys, 107 valid responses were received, resulting in a response rate of 71.3%. Among the respondents, 13% (14 respondents) were project managers, senior managers, or other senior professionals, bringing strategic and managerial insights into Lean Construction practices. The majority of respondents, 71% (76 respondents), were engineers and academicians with 1 to 10 years of experience, providing valuable input on technical and operational aspects of lean implementation. The remaining 16% of the respondents comprised local contractors, builders, and architects, contributing practical, on-site perspectives on the challenges and opportunities in adopting Lean principles in the construction industry. This diverse representation enhances the reliability of the study by capturing perspective from different roles within the industry.

5. RESULT

The responses were analysed using multiple linear regression (MLR) to determine the relationship between experience levels and key barriers or enablers affecting Lean adoption in excel. The study provides insights into the factors influencing the successful implementation of Lean Construction. As shown in Table 2, knowledge has the most significant impact on Lean adoption, with a positive coefficient (β = 1.070) and a statistically significant p-value (0.020). A higher level of knowledge enables construction professionals to understand Lean tools, methodologies, and their benefits, reducing resistance and improving efficiency in project execution.

Table 2 Multi linear regression analysis output

Berrier	Coefficients (β)	Standard Error	P-value
Knowledge	1.070	0.451	0.020
People	-0.934	0.473	0.049
Management	0.760	0.415	0.069
Communication and coordination	0.180	0.403	0.656
Finance	0.415	0.527	0.433
Resource	-0.334	0.482	0.490

On the other hand, People-related factors exhibit a negative effect (β = -0.934) with a marginal p-value (0.049), indicating that workforce-related challenges, such as resistance to change, lack of skilled labour, and limited involvement of workers, pose obstacles to Lean implementation. Although the result is just outside the conventional significance threshold ($p < 0.05$). Similarly, Management practices show a positive coefficient (β =

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0.760) but a slightly higher p-value (0.069), meaning that while leadership and managerial commitment contribute to Lean adoption, their impact is not as strong as knowledge-related factors.

In contrast, the study finds that Communication and Coordination (β = 0.180, p = 0.656), Finance (β = 0.415, p = 0.433), and Resource (β = -0.334, p = 0.490) do not contributes statistically significant effects on Lean implementation. This suggests that, within the studied context, financial constraints and resource limitations may not be the primary challenges hindering Lean adoption.

The visualization of barriers through the Fishbone Diagram (Ishikawa Diagram) allows construction firms to prioritize key areas for improvement and develop data-driven strategies to enhance Lean adoption. The construction of the fishbone can branch off to as many levels as is needed to determine the causes of the underlying problem. The diagram consists of a central "spine" representing the primary problem or objective which is the challenges faced while adopting lean principle, with multiple "bones" branching out to categorize contributing factors. Fig. 2 shows the first level of the fishbone diagram representing critical factors that hinder the lean implementation.

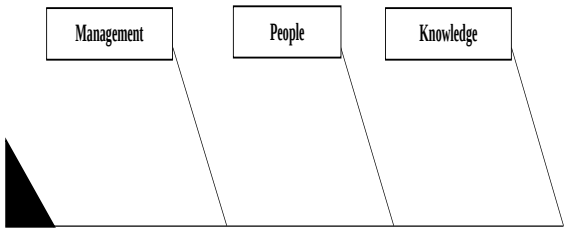

Fig. 2 Fishbone diagram

6. SUGGESTION

Knowledge-related barriers are among the major obstacles to implementing Lean Construction. Raising awareness of Lean concepts through organized training initiatives like Project-Based Learning (PBL), conferences for exchanging knowledge, and scholarly participation is crucial to addressing this. Understanding and adoption could be further enhanced by promoting employee participation and combining Lean techniques with software innovations. Challenges relating to the workforce constitute the second significant obstacle. Implementation challenges can also be facilitated by seeking advice from Lean Construction (LC) specialists and professionals. Top management needs to be urged to actively support Lean initiatives in order to address management-related issues. To ensure effective workflows, organizational structures should be modified to conform to Lean principles. To improve planning, control wastages, and improve quality, it is recommended to implement practical Lean tools like Kaizen, Just-In-Time (JIT) techniques, and the Last Planner System (LPS). Lean adaptation can also be reinforced by technology integration and Building Information Modelling (BIM). Concerns about budgetary limitations, communication, and resource management, seem less significant, indicating that in order to optimize the advantages of Lean Construction, efforts should be directed toward enhancing workforce preparedness, leadership commitment, and education. By removing these obstacles, industries experienced increasing project efficiency, quality, waste reduction, and resource utilization.

7. CONCLUSION

This study highlights key barriers affecting the implementation of Lean Construction in India's construction industry. The findings reveal that awareness and knowledge gaps are the most significant obstacles to Lean adoption. This emphasizes the need for structured training programs, widespread knowledge sharing, and continuous professional development to enhance awareness at all organizational levels. People-related challenges, particularly resistance to change and the shortage of skilled workers, also pose serious hurdles. To overcome this, companies need to engage employees, foster positive attitudes, and cultivate a culture of continuous improvement to build acceptance of Lean practices. the study finds that financial constraints, resource limitations, and communication gaps while often considered major challenges do not show statistically significant influence on Lean adoption in the Indian construction. This suggests that improving knowledge, skills, and leadership could have a far greater impact than addressing these perceived barriers. To accelerate Lean implementation, the study calls for stronger managerial leadership, policy support, collaboration across the industry, and academic-industry

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partnerships. By prioritizing education, workforce encourage, and proactive leadership, India's construction sector can move toward more efficient, waste-free, and sustainable project delivery.

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