RETHINKING CONSTRUCTION MANAGEMENT PRACTICES TO ATTAIN SUSTAINABLE DEVELOPMENT GOALS

(VOLUME - 1)

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Scripown Publications
New Delhi

Chief Editor: *Mohd Asim*
Edition: *1st*

Publication Year: *2023*

Pages: *201*

ISBN: *978-93-94375-70-3*

Price: *₹1200/-*

Scripown Publications
2nd Floor, 304 and 305, Pocket - 4,
Sector - 22, Rohini, North West Delhi,
Delhi, 110086, India

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STUDY AND APPLICATION OF LEAN CONCEPT IN CONSTRUCTION

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Abstract

Lean construction (LC) is an effective way of managing the construction process and accomplishing project objectives through reducing waste. The objective of this article is to give a basic understanding of lean construction techniques and identify the barriers in its application. In this study the author applies the lean thinking concept in an ongoing residential building project located at Lucknow. Few tasks has been identified at the site and detailed analysis of the tasked carried out to identify lean activities. The results show that the concept has a potential in saving not only cost and time but also improving quality of construction even when applied in smaller tasks.

Keywords: Lean Construction, Barriers, Waste reduction, Cost and time saving.

1. Introduction

Lean construction is defined as the process of planning a production system that reduces waste in terms of time, money, and resources in order to maximize value and fulfil customer expectations.

Toyota was the first to bring the Lean principles in automotive industry. Lean principles have slowly comes into the construction industry because of its approach to waste elimination. Lean construction is termed as a way to design production system to minimize of materials, time, cost and effort in order to get the maximum amount of value to deliver costumer needs. With the continuous decline in profit margins and increased competition in construction projects, construction contractors are continuing to search for ways of eliminating waste and increasing profit (Mastroianni and Abdel Hamid 2003). Although numerous approaches have been developed to improve efficiency and effectiveness of construction processes, lean construction techniques offer the promise to minimize, if not completely eliminate, non-value-adding work. Since the early 1990's, the construction research community has been analyzing the possibility of applying the principles of lean production to construction. Koskela (1992) introduced the idea of understanding construction as production. The International Group for Lean Construction (IGLC) has made significant contributions to the formulation of theoretical foundation for lean construction by abstracting the core concepts of lean production and applying them to the management of construction processes.

The Lean construction technique uses certain lean techniques to study the activities in the existing process and evaluate the improvement after implementing betterment ideas.

1.1. Benefits of implementing lean construction

In India, lean construction has already improved sustainability and reduced negative environmental impacts significantly (Dixit *et al*., 2017). Home builders using lean construction techniques reduced accident rates by 58 percent compared to those not using active lean construction, proving that the implementation of lean construction improves construction safety. Lean construction enables successful collaboration with advanced technology and delivers significant gains in terms of schedule, quality, safety, and productivity in building projects.

Reducing Waste

There are multiple types of waste, including waste of goods, time, energy, and money. Lean construction aims to reduce waste to the greatest extent possible. Instead of throwing away wasted resources, lean construction aims to reduce the project's waste of physical materials in order to save money. Construction sites are frequently disorganised and inefficient, with various parts of the crew working on different projects at the same time. Lean

construction aims to simplify all of the procedures associated with any individual building project so that employees may build both quickly and efficiently. On the building site, this saves time, energy, and money.

Jobs are Finished Faster

Any construction site that is efficient saves time and money. The sooner you complete a job, the sooner you can sign on a new customer. Once you've mastered lean construction, you'll be able to execute work faster than you did previously. Manufacturing housing is an example of a highly efficient process. This is how modular homes are manufactured swiftly and at a lower cost than regular housing. For a construction business, faster jobs mean more jobs each year. This means that you will be able to take on significantly more business. Time is money, as the adage goes. This is especially true in the construction sector, where clients want you to respond swiftly while maintaining high quality standards.

Saves on Total Labour Costs

When staff are paid on an hourly basis, it is desirable for a construction business to get as much done in each hour as feasible. When operations are simple and efficient, they require less time and stretch the hourly salary slightly farther. When a project is done effectively, it takes less time to accomplish a task, which puts you ahead of schedule. If a task runs beyond schedule for any length of time, you are paying hourly salaries and losing money for each additional hour without increasing the quantity of money coming in. When the process is inefficient, labour expenses are squandered.

Making More Money, Producing Less Waste

Lean creating means more money and less waste for construction businesses and contractors. This provides construction companies a competitive advantage in an expanding market. Lean construction is a technology that can help any construction organization.

2. Literature Review

Brady *et al*. (2009) Construction employees are involved to the highest level possible. Inadequate preparation and training. A lack of role description. Inadequate information. Due to deadlines, there are time limits. Non-integrated producing supply chain. Nesensohn *et al*. (2012) it is noted that the introduction of Lean in construction project management usually requires both a change in organizational mindset and structure. It is also emphasised that effective Lean adoption needs an in-depth assessment of the organization's capacity to become leaner. Bajjou *et al*., (2017) Aziz and Hafez, (2013)

According to the studies, the fundamental and prominent difficulties in construction projects include cost overruns and schedule delays. Furthermore, the construction business suffers greatly from low quality, poor construction safety, and negative environmental consequence. Researchers have shown significant benefits from incorporating lean building into construction projects. Mohd Arif Marhani a, Aini Jaapara, Nor Azmi Ahmad Baria, and Mardhiah Zawawib (2013) Lean construction (LC) is effective in managing the construction process and reducing waste. The goals of this work are to convey basic understanding of LC and to identify the hurdles to its implementation.Devaki M.P (2014) observed that lean construction is an integration of ideas such as continuous improvement, flattened organizational structure, effective resource utilization, waste removal, and cooperative supply chain. The use of Lean Construction in India is now being debated based on the success of Lean Production in manufacturing and the growth of Lean Construction in nations like as Brazil, Denmark, and the United States. Piotr Nowotarski, Jerzy Paslawski, and Jakub Matyja (2016) the goal of this paper is to demonstrate how Lean Management may impact the total cost of a specified process of managing storage area on a building site. The paper is based on the authors' research on the construction of an office building in Poznan (Poland) city centre, where a proposed new management strategy was implemented and evaluated. Prasanna Venkatesan Ramani and Laxmana Kumara Lingan KSD (2019) lean construction is a strategy that tries to reduce waste in building while increasing productivity. The goal of this study is to discuss the usefulness of the Lean approach in project management. It is obvious that wastages were mostly caused by procedural flaws in project implementation. For example, poor stacking of structural steel members. Shakil Ahmed, Md. Mehrab Hossain, and Iffat Haq (2020) investigated the significance of directly or indirectly using the lean concept in construction management. The goals of this study are to examine the present level of awareness of lean construction practises, to identify and prioritise the possible advantages and barriers of implementing lean construction in the Bangladeshi construction sector.

2.1 Challenges to Implement Lean Construction

Managerial Issues

Every organization's senior management plays a critical role in the effective adoption of innovative ideas (Salem *et al*., 2005; Hudson 2007).The dedication to designing and implementing an effective strategy, as well as appropriately providing the essential resources and support to manage changes resulting from the implementation, is critical to the success of lean practice.

However, challenges found in some research appear to be management-related. A thorough research review discovered decision-making delays, a lack of top management support and commitment, poor project definition, material delivery delays, a lack of equipment, material scarcity, a lack of time for innovation, an unsuitable organizational structure, weak administration, a lack of supply chain integration, poor communication.

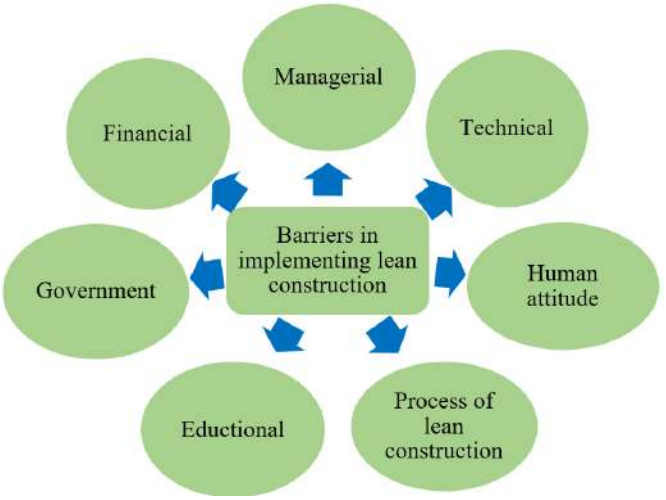

Fig 1: Challenges to adopt lean construction

Financial issues

Innovative solutions, such as lean construction, need some financial investment. Adequate financing is required to encourage workers, supply necessary equipment, and engage lean specialists to help both employers and employees in putting the concept into action. Financial concerns are among the most prevalent barriers to lean practice in diverse enterprises and nations. The nature of this barrier, however, differs per country. According to a study of papers published by Common *et al*., (2000), Olatunji (2008), and Mossman (2009), some of these barriers include corruption, insufficient project financing, inflation, implementation costs, and low professional earnings, a lack of incentives and motivation, and risk aversion. Unless sufficient efforts are made to overcome these challenges.

Governmental issues

Considering the massive economic contribution provided by the construction sector in several nations, it suffers multiple issues that appear to be tied to government policy. According to various research, some hurdles

evolved in some nations as a result of government attitudes towards the building sector. An in-depth examination of the study findings in Olatunji (2008) indicates impediments such as government bureaucracy, policy inconsistency, a lack of social services and infrastructure, material scarcity, and volatile commodity prices. Furthermore, some of the financial hurdles, such as inflation, professional wages, and illegal practises, may be tied to government difficulties.

Educational issues

Academics, researchers, practitioners, and bodies such as Lean construction institutes, Construction Lean Implementation Programme (CLIP), Construction Excellence (CE), and British Research Establishment have all made efforts to raise awareness, provide guidance, and knowledge about lean construction. Despite a huge amount of study articles, it appears that educational concerns are the most prevalent hurdles to lean practice. High-level illiteracy, a lack of training, a lack of holistic implementation, insufficient knowledge, a lack of project team skills, insufficient exposure to requirements for lean implementation, a lack of awareness programmes, difficulty understanding concepts, and a lack of information sharing are among the barriers identified. As a result, educational hurdles may constitute a significant threat to the sustainability of lean practice.

Human attitudinal issues

According to Howell (1999), one of the primary elements influencing the application of lean construction in diverse construction sectors is human mindset. According to Common *et al*., (2000) and Cue *et al*., (2001), cultural change, lack of team spirit, lack of self-criticism, lack of teamwork, lack of cooperation, poor housekeeping, poor leadership, leadership conflict, poor understanding of client's brief, misunderstandings about lean practice, over-enthusiasm, perceived as too complex and alien, and fear of unfamiliar practises are all factors.

Technical issues

Technical barriers could slow down the application of lean construction. These barriers are classified as technical because they have a direct influence on the use of specific lean construction principles and tools, such as confidence, simplicity, adaptability, and benchmarking.

3. Application of lean concept

In this study a live construction project is selected to apply the concept of lean construction. The project is situated at kursi road lucknow at Integral

University. The project is of constructing multistory residential block for faculties. The details of the project is given below.

4. Methodology and Result

For application of lean concept, an ongoing construction of residential project of 'faculty residential building' Integral University has been chosen. The relevant details of the project is given below.

Details of the project

Table 1

Name of the project	Faculty apartments construction project
Client	Integral University
Contractor	JR constructions and Interiors
Location	Integral University campus kursi road lucknow
Built up Area	5581 sq-ft
No. of floors	7
Total plastering area	9754.82 sq-m
Brick work at first floor	65000

In the above project two tasks i.e. plastering work and brickwork has been taken up for the study. The activities performed in the task has been analyzed and the activities which are lean have been identified. The cost analysis then have been performed to evaluate the benefits of removing the waste involved in the activity.

4.1. Plastering work

In the plastering, we have been identified that the sieving of sand is required at site before making the mortar. This activity has been identified as lean since the screened sand is already been available in the market at a reasonable rate. Moreover during the application of mortar manually, a lot of effort and material is wasted. This wastage can be minimized by using plastering machine which is also improved the quality of plastering.

Cost analysis of removing sieving of sand at site

- Total Requirement of sand for plastering:

  Total mortar required = 276 Cubic meter

  Total amount of sand required for plastering = 295.7 cubic meter
- Time required for sieving $1m^3$ of sand by two Labour =1 hr. 46min
- Total time required to sieve complete amount of sand = 522.4 hrs.
- Number of man hour saved considering 8 hrs. shift = 130.66 man hours

- Cost of these man hours as per minimum wage criteria = ₹ 45731
- Extra amount spend in purchasing sieved sand = ₹ 35484
- Cost saving if sieved sand for plastering is used at site = ₹ 45731 – ₹ 35484 = ₹ 10247

Cost implication of minimizing waste by introduction of plastering machine

Total labour cost when manually plastering is done = ₹ 1769524

Cost of plastering using machine

Machine cost = 4,50,0000

Productivity area in one day = 500 m^2

Number of working days when the plastering machine is used = 19.50 days

Total energy consumption by the machine = 56160 Units. (By calculation)

Hence the total cost of plastering including cost of capital of the machine for the period including operation and maintenance cost. The machine will require one operator and three helpers.

= cost of capital + fuel cost + operator and helper cost + maintenance cost

$[\frac{450000*0.149}{365} \times (19.50+35+5)] + [19.5*60*6*8 + 19.50+35+5)*1*973+ 19.5*3*350] + 2500$

= ₹147959

Saving in cost by using plastering machine = ₹ 1769524 - ₹ 147959 = ₹ 1602106

From the above calculation, it can be seen that use of plastering machine not only minimize the wastage in terms of material and effort, wastage of cost can also be minimized considerably. Moreover, the completion time of plastering done by machine can be matched with the manual labour if we increased the no masons and labour. But this will again increase the indirect cost also lead to disruption due to excessive labour at the site which may lead to unsafe condition at the site.

4.2. Brick Work

In brick masonry the bricks are stored bit far from the place of its application and labours are carried the bricks manually from the place of

storage to place of application at ground and higher floors. The time taken to transport the brick manually and by monkey lift has been calculated and subsequent reduction in time and cost has been calculated.

For first floor

Data received from the site

No of bricks used in the brickwork in first floor = 65000

No of bricks carried by monkey lift = 55

Time required to carry number of brick on first floor by monkey lift including carrying and placing and unloading bricks on monkey lift by a labour = 4 min 38 sec

Time required by a labour to complete one cycle of placing the brick at first floor

= 1 min 48 sec (108 seconds)

No of bricks carried by a labour in one cycle = 7

No of man-hours required if manual labours carried the bricks = 278.571hrs

Cost of labour incurred if only manual labours carried the bricks

= (278.57/8)*350 = ₹ 12187

No of labour required if monkey lift is used along with the manual labour = 91.26 hrs.

Cost of labour incurred if monkey lift is used along with the manual labour

= (91.26/8)*2*350 = ₹ 7985

Operating and maintenance cost of monkey lift for the period including idle period

= Rs. 3813

Total cost saving in using monkey lift = 12187- (7985+3813) = ₹ 389

Though this cost is not significant for carrying brick on first floor but for upper floor this amount will be increased significantly as manual labour timing for carrying the bricks will increase significantly.

No. of story	Cost saving
First story	₹389

Second story	₹4388
Third story	₹8315
Fourth story	₹12232
Fifth story	₹16172
Sixth story	₹20112
Total Saving	₹61608

So we can save 61608 rupees in brickwork by monkey lift as compare to manual work.

Conclusion

This paper presents and discusses the benefits of applying the lean thinking concept in a residential project in lucknow (India). With the help of literature review, the concept of lean construction has been presented. The concept and benefits of various lean tools and techniques such as value stream mapping, last planner system, Pareto analysis, integrated project delivery method, location based management system etc. has been studied and presented. At the construction project, plastering and brickwork task has been studied in details to identify the lean activities. The result shows that removing these lean activities completely or by replacing it by adopting latest construction practices resulted in saving significant cost and time. This study shows that the lean concept has the great potential in minimizing the waste in a construction projects hence saving the cost and time.

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