Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.6, May : 2024

EXPLORING THE ADOPTION OF LEAN CONSTRUCTION TECHNIQUES IN THE CONSTRUCTION INDUSTRY.

Deepa Singh, M.Tech. Scholar in the Department of Civil Engineering, Faculty of Engineering & Technology :: deepasingh77020@gmail.com
Satish Parihar, Associate Professor of Civil Engineering, Faculty of Engineering & Technology
Vaibhav Dubey, Assistant Professor of Civil Engineering, Faculty of Engineering & Technology

Abstract
The incorporation of Lean construction methodologies presents a promising opportunity to improve the efficacy, sustainability, and cost-efficiency of the construction sector. This study delves into their deployment by identifying both hindrances and enablers while scrutinizing their impact on project performance. Through literature review, case studies, and expert interviews, this investigation offers valuable perspectives concerning strategies for implementation as well as advantages and obstacles that may arise. Ultimately, these discoveries provide significant direction for stakeholders seeking to integrate Lean principles into their activities.
In this research paper, we have studied the about the implementation of the Last Planner System (LPS) in the construction industry, there are so many method for the lean construction tools and its is very hard to apply every lean construction tools for only one research work. Here first we have analyse the process of the work without using the lean construction tools that is Last Planner System and after that using the Last Planner System in the second analysis. Here we will also apply the Last Planner system in the 1325 square feet area under construction project for completing the plaster work at ground floor and beam work at the first floor.
Keywords: Lean construction, Last Planner System, Construction Industry, Project performance, Management.

1.Background.

The origins of lean construction can be traced to the manufacturing sector, specifically the Toyota Production System (TPS) that Taiichi Ohno and Eiji Toyoda developed in post-World War II Japan. TPS underscored waste elimination, continuous improvement, and respect for personnel [1]. These principles were then adapted and integrated into construction practices, leading to the emergence of lean construction methodologies.
In the 1990s, innovative building companies began testing out lean principles in their projects. One notable instance was the implementation of the Last Planner System (LPS), which Glenn Ballard and Greg Howell created at the University of California, Berkeley. LPS centers around collaborative planning and reliable workflow management to minimize delays while enhancing project outcomes [2]. Early adopters of LPS reported significant enhancements in project delivery times as well as cost savings.

2.Lean Construction Tools

Lean Construction employs a range of tools and techniques to optimize processes, eliminate waste, and enhance efficiency in construction projects [2]. As an innovative approach to construction management and project delivery, Lean Construction prioritizes efficiency and value creation while minimizing waste throughout the construction process. Inspired by lean manufacturing principles pioneered by Toyota, Lean Construction emphasizes identifying and delivering what customers truly value. It achieves this through streamlining processes, eliminating all forms of waste, fostering collaboration among project stakeholders, and promoting continuous improvement [3]. Techniques such as pull planning, visual management, and just-in-time delivery are employed to optimize workflows; reduce batch sizes; ensure timely delivery of materials and resources. By embracing

these principles fully, Lean Construction aims to enhance project outcomes by maximizing efficiency while reducing costs; improving quality; ultimately delivering greater value for its clients.

2.1.Significance of exploring Lean Construction adoption

Exploring Lean Construction adoption is significant for several reasons:

Increased Efficiency: The Lean Construction principles endeavor to eradicate superfluousness, simplify procedures, and enhance efficacy across the entire construction project lifespan. Through embracing these streamlined practices, construction enterprises can curtail project durations, diminish expenses, and augment overall proficiency [4].

Improved Quality: Lean Construction prioritizes the delivery of superior outcomes by concentrating on value-added activities and sustaining improvement. Through early detection and rectification of inefficiencies and errors in the construction process, Lean methodologies can guarantee that projects meet or surpass quality standards.

Enhanced Collaboration: Lean Construction advocates for cooperation and communication amongst all parties involved in a project, such as proprietors, architects, builders, and sub-contractors. By cultivating an environment that prioritizes collaboration and the pursuit of shared objectives, Lean methodologies can effectively reduce disputes, enhance decision-making processes and ultimately produce superior project results.

Reduced Waste: Construction endeavors frequently produce substantial amounts of waste in relation to materials, time, and resources. However, the implementation of Lean Construction techniques such as Just-In-Time delivery and pull scheduling can effectively reduce wastage by guaranteeing that all materials and resources are utilized efficiently and exclusively when required.

2.2.Principles of Lean Construction

The principles of Lean Construction serve as the bedrock for improving efficiency, eradicating waste, and optimizing project outcomes. At its essence, Lean Construction focuses on comprehending and delivering value through the client's perspective. This approach directs efforts towards activities that directly contribute to meeting client needs while minimizing or eliminating those that do not. By identifying and systematically eliminating various forms of waste throughout the construction process, such as overproduction, waiting times, and defects, Lean Construction promotes continuous improvement [4]. This commitment to Kaizen fosters a culture of innovation and efficiency where stakeholders are empowered to seek out opportunities for optimization. Pull planning and scheduling techniques ensure that work is initiated based on actual demand fostering a collaborative environment where all project participants are encouraged to communicate openly and work together towards shared goals [5]. Respect for people is paramount in this approach recognizing the expertise and contributions of all individuals involved in the project empowering them to drive positive change. Visual management techniques along with lean supply chain management practices further enhance transparency, coordination, and efficiency. Ultimately it is effective leadership underpinning these principles which enable construction projects to achieve higher levels of productivity quality along with client satisfaction [6].

3.Type of the Lean Construction Tools

Lean construction encompasses a plethora of methodologies, principles, and techniques that are designed to optimize productivity, minimize inefficiencies, and foster cooperation in construction ventures. Several typical examples of lean construction tools include:

1. Last Planner System (LPS)
2. Value Stream Mapping (VSM)
3. Target Value Design (TVD)
4. 5S Methodology
5. Just-In-Time (JIT)
6. Kaizen
7. Poka-Yoke

8. Lean Supply Chain Management
9. Continuous Flow Production

3.1.Last Planner System (LPS)

This is a collective scheduling methodology that encompasses the input of all parties involved in order to establish dependable work blueprints. It serves to enhance communication, coordination, and responsibility amongst members of the project team.

3.2.Value Stream Mapping (VSM)

The Visual Stream Mapping (VSM) technique is utilized as an instrument to scrutinize and enhance the movement of materials and information across the construction process. This method enables the distinction of activities that contribute value versus those that do not, facilitating waste reduction and operational efficiency improvement.

3.3.5S Methodology

This approach concentrates on arranging the workplace to optimize productivity and minimize inefficiencies. The 5S's denote Sort, Set in Order, Shine, Standardize, and Sustain - principles that are utilized to enhance workplace organization, hygiene, and uniformity.

3.4.Kaizen

Kaizen, a Japanese term denoting "continuous improvement," pertains to the process of effecting small and gradual changes in order to enhance efficiency and quality. It underscores the importance of involving all members of staff in identifying and implementing improvements.

3.5.Just-In-Time (JIT)

Just-in-Time (JIT) is a strategic approach that strives to deliver construction materials and resources precisely when they are required, thereby minimizing inventory and storage expenses while diminishing the waste linked with surplus materials.

3.6.Poka-Yoke

Poka-yoke pertains to error-proofing methods that avert the occurrence of flaws or inaccuracies whilst undertaking the construction process. This encompasses leveraging visual cues, checklists, and tangible obstructions to guarantee that tasks are executed flawlessly at their initial attempt.

3.7.Target Value Design (TVD)

The TVD approach is a strategic methodology that prioritizes the harmonization of project objectives with the resources and financial limitations at hand, right from the outset. This entails fostering a collaborative partnership between proprietors, designers, and contractors to guarantee that project aspirations are within reach while adhering to predetermined constraints.

3.8.Lean Supply Chain Management

This involves optimizing the flow of materials and information from suppliers to the construction site to minimize waste and improve efficiency. It may include strategies such as vendor-managed inventory and strategic partnerships with suppliers.

3.9.Continuous Flow Production:

The fundamental objective of this principle is to establish a consistent and foreseeable progression of work during the construction process, mitigating any potential hold-ups or disruptions. This entails arranging tasks in a sequential manner with the goal of minimizing idle periods and maximizing resource allocation.

4.Last Planner System

The Last Planner System (LPS) is a collaborative approach to scheduling and production planning that has found application in lean construction [7]. Its development can be attributed to Glenn Ballard and Greg Howell in the 1990s, with its popularity growing since then as it continues to demonstrate remarkable efficacy in enhancing project performance.

Note: Here we have also selected the 1325 square feet are undeer the construction in the Lucknow city (Near the Dubbaga). Here the foundation, beam, column and slab of the ground floor completed,

and some brick work is also completed. In this real project we will apply LPS to complete the project within given time. The Last Planner System comprises various critical components:

- **Master Schedule:** The master schedule outlines the overall project timeline and key milestones. It provides a high-level overview of the project's objectives and constraints [8].
- **Phase Planning:** The project is divided into phases or stages, each with its own set of tasks and activities. These phases are typically defined based on the project scope, schedule, and deliverables.
- **Pull Planning:** Pull planning sessions entail the participation of primary stakeholders, comprising the project proprietor, designers, contractors, and subcontractors. In these meetings, the team collectively strategizes for forthcoming stages by retrogressively working from the project's culmination date [9]. This approach facilitates identifying interdependencies, limitations and probable hazards.
- **Weekly Work Planning:** In order to ensure that tasks and activities for the upcoming week are properly detailed, a weekly work planning meeting is conducted. During these meetings, the identified work packages from pull planning sessions are broken down into smaller, more manageable tasks. This allows for a clearer understanding of what needs to be done and how it can be accomplished efficiently. The individuals or teams responsible for these tasks then commit to completing them within the specified time frame, ensuring that everything stays on track and progress is made accordingly. These meetings play a crucial role in ensuring that work is organized and executed effectively, leading to successful project completion.
- **Daily Huddle Meetings:** Daily huddle meetings are brief, stand-up meetings held at the beginning or end of each workday. These meetings provide an opportunity for team members to review progress, discuss any issues or obstacles, and coordinate activities for the day [10].
- **Continuous Improvement:** The Last Planner System emphasizes continuous improvement through feedback and reflection. Lessons learned from previous phases or projects are used to refine planning processes and identify opportunities for optimization.

4.2.Importance of the Last Planner System Over Other Lean Construction Tools.

The Last Planner System (LPS) holds significant importance over other lean construction tools due to its focus on collaborative planning, real-time adaptability, and improved communication among project stakeholders [11]. Here are several reasons why the Last Planner System stands out:

Collaborative Planning: LPS encourages the active involvement of all project stakeholders, including owners, designers, contractors, and subcontractors, in the planning process [12]. This collaborative approach ensures that all parties contribute their expertise and insights, leading to more realistic and achievable project plans.

Increased Accountability: By involving individuals responsible for executing the work in the planning process, LPS fosters a sense of ownership and accountability among team members. When individuals commit to completing specific tasks during pull planning sessions, they are more likely to follow through and deliver on their commitments [12-13].

Flexibility and Adaptability: LPS allows for greater flexibility and adaptability in project execution. Weekly work planning meetings and daily huddles enable teams to adjust their plans in real-time based on changing conditions, such as weather delays, material shortages, or unforeseen site conditions. This ability to quickly respond to changes helps to minimize disruptions and keep the project on track [14].

Focus on Constraint Management: LPS emphasizes the proactive identification and management of constraints that may impede progress. By addressing constraints early in the planning process, teams can mitigate their impact on the project schedule and minimize delays. This focus on constraint management sets LPS apart from other lean construction tools that may not prioritize this aspect as explicitly [14].

Continuous Improvement: LPS fosters a culture of continuous improvement within the project team. Lessons learned from previous phases or projects are used to refine planning processes and identify

opportunities for optimization. This iterative approach enables teams to learn from their experiences and continually enhance their performance over time.

Alignment with Lean Principles: While other lean construction tools focus on specific aspects of the construction process, such as waste reduction or value stream mapping, LPS encompasses many lean principles, including respect for people, continuous improvement, and customer focus. By incorporating these principles into its methodology, LPS provides a comprehensive framework for improving project performance [15].

5.REASONS FOR INCOMPLETE OF WORK

The primary undertaking was hindered by the need to complete pre-essential work, which was deemed necessary due to the current stage of development. This resulted in inadequate completion of tasks, particularly those related to construction activities that were heavily reliant on the successful completion of primary tasks [16]. The causes for incomplete tasks were analyzed and compared with similar cases.

The major cause to unfinished the construction works are given below:

1. Material.
2. Pre-requite work.
3. Sanction (approval).
4. Supply of labor at time.
5. Re-work.
6. Unfinished Design Information.
7. Construction tools (Equipments).
8. Bad Weather Condition.
9. Late Request.
10. Change in the Priority.
11. Less Space for construction work.

6.PROCESS OF CONSTRUCTION WORK WITHOUT LPS

The process of the work is given below in the form of the graph without applying the LPS in the construction. This work is doing by utilizing 3 mistri and 10 labors at the construction site, and normal working hours is 8.

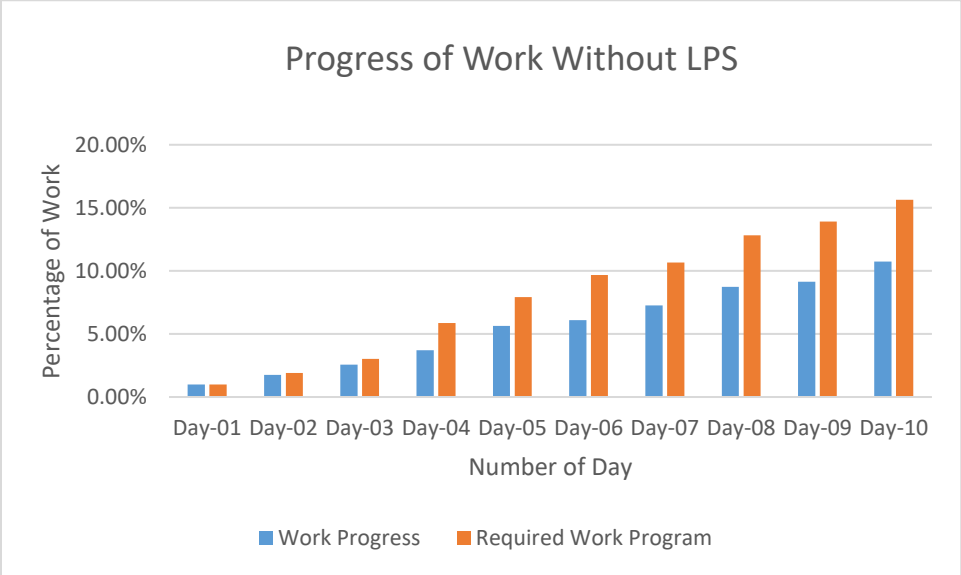

Figure-1: Progress of Work Without LPS.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.6, May : 2024

7.PROCESS OF CONSTRUCTION WORK WITH LPS(1)

The process of the work is given below in the form of the graph with applying the LPS in the construction. This work is doing by utilizing 3 mistri and 10 labors at the construction site, and working hours is increased to 8.30 Hours.

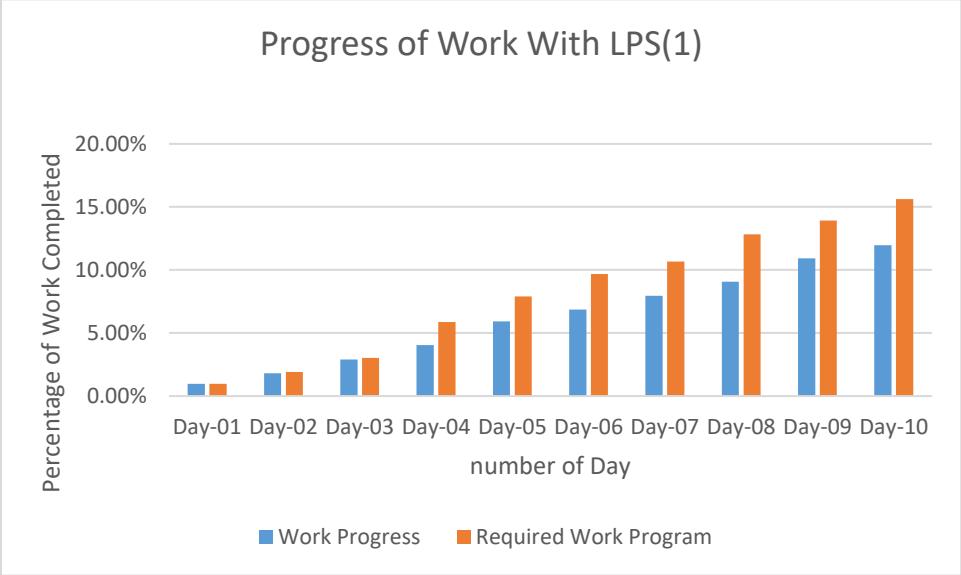

Figure-2: Progress of Work with LPS (1).

8.PROCESS OF CONSTRUCTION WORK WITH LPS(2)

The process of the work is given below in the form of the graph with applying the LPS in the construction. This work is doing by utilizing 3 mistri and 10 labors at the construction site, and working hours is increased to 9.00 Hours.

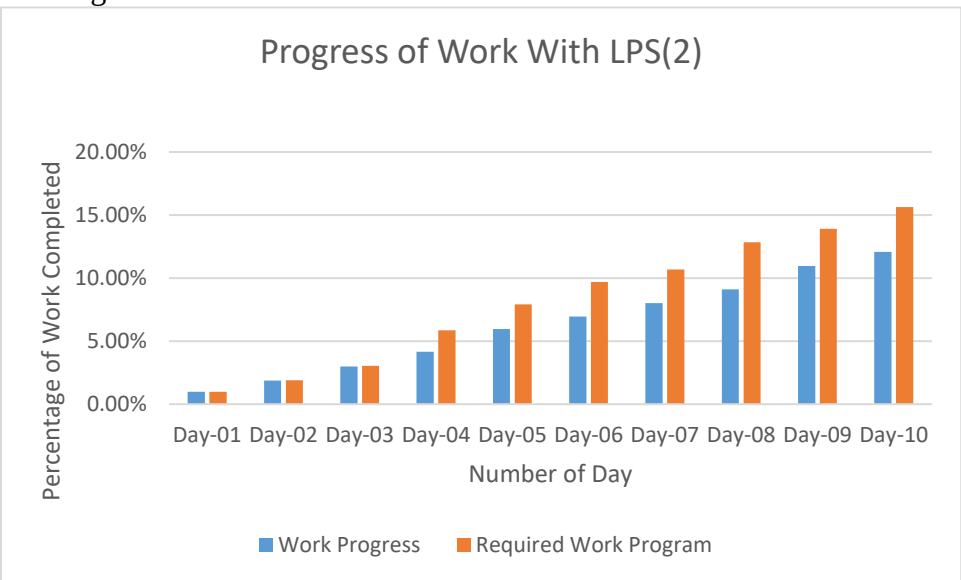

Figure-3: Progress of the Work with LPS(2).

9.PROCESS OF CONSTRUCTION WORK WITH LPS (3)

The process of the work is given below in the form of the graph with applying the LPS in the construction. This work is doing by utilizing 3 mistri and 11 labors at the construction site, and working hours is normally 8.00 Hours. In this takes we increased 1 labor in the construction work to achieve the delay of the project.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.6, May : 2024

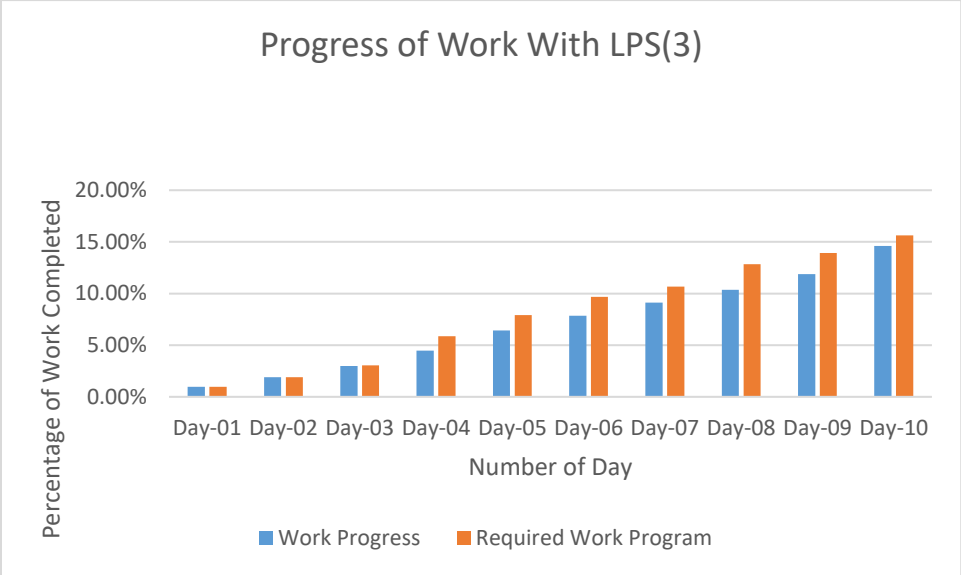

Figure-4: Progress of the Work with LPS(3).

10 PROCESS OF CONSTRUCTION WORK WITH LPS (4)

The process of the work is given below in the form of the graph with applying the LPS in the construction. This work is doing by utilizing 4 mistri and 12 labors at the construction site, and working hours is increased to 8.30 Hours. In this takes we increased 1 labor and 1 mistri in the construction work to achieve the delay of the project or complete it before the given time if it is possible.

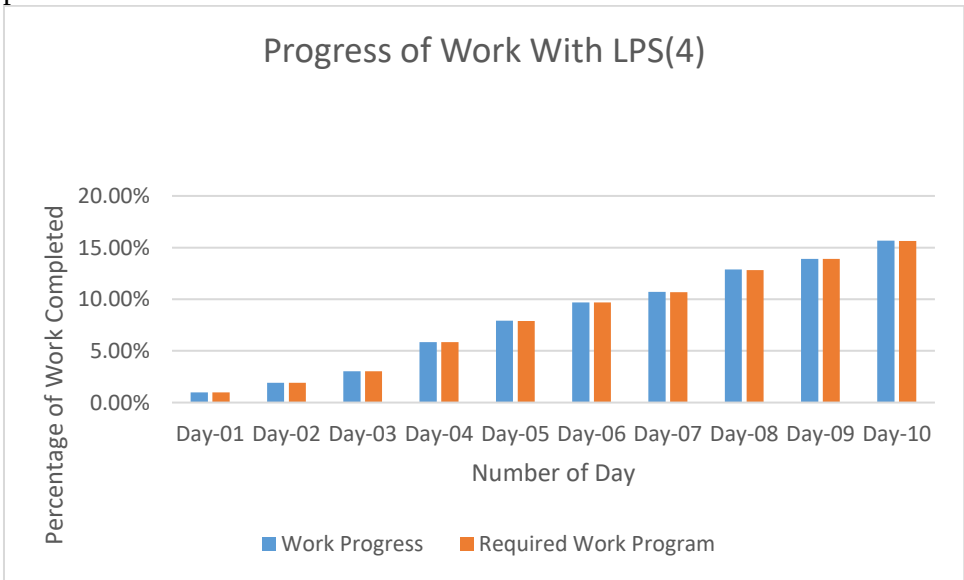

Figure-5: Progress of Work with LPS(4).

11.APPLICATION OF LPS IN REAL PROJECT

In this research work, we have selected the project of area 1325 square feet, and some work has been completed. The figure of the project in given below:

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.6, May : 2024

Figure-6: Working Project.

As we can see from the figure, some plaster work is remaining at the ground floor, and beam work at first floor remaining. So we will try to achieve the remaing work by using the Last Planner System because this work is delay about 17 to 18 day.

1.11.1.Plaster Work at Ground Floor

Here we will complete plaster work by using the Last Planner System. The details of work is given below in the form of the table:

Table-1: Plaster Work at Ground Floor

Serial Number	Wall Name	Wall Area	Planned Date For Complete Work	Actual Date For Complete Work	Material Required
01	Wall-1	10 ft by 15 ft	18 April 2024	23 April 2024	2 bags cement and 0.34 tone (1:4)
02	Wall-2	10 ft by 12ft	19 April 2024	22 April 2024	2 bags cement and 0.24 tone (1:4)
03	Wall-3	10 ft by 15 ft	18 April 2024	23 April 2024	2 bags cement and 0.34 tone (1:4)
04	Wall-4	10 ft by 12ft	19 April 2024	22 April 2024	2 bags cement and 0.24 tone (1:4)

1.11.2.Beam Work at First Floor

Here we will complete beam work at the first floor by using the Last Planner System. There are seven number of the beam at the first floor. The details of work is given below in the table-2:

Table-2: Beam Work at Ground Floor

Serial Number	Wall Name	Planned Date For Complete Work	Actual Date For Complete Work
01	Beam-01	20 April 2024	22 April 2024
02	Beam-02	20 April 2024	22 April 2024
03	Beam-03	20 April 2024	22 April 2024
04	Beam-04	20 April 2024	22 April 2024
05	Beam-05	20 April 2024	22 April 2024
06	Beam-06	20 April 2024	22 April 2024
07	Beam-07	20 April 2024	22 April 2024

12.CONCLUSION

From the above analysis of the application of Last Planner System (LPS) in the construction industry, we found some conclusion regarding it which is given below:

Upon examining the Last Planner System, it was observed that construction work can be delayed due to factors such as insufficient supply of materials, absence of labor and delayed approvals. To avoid such delays, we propose providing an additional three days' worth of construction materials at the site. Section 4.6 of this thesis highlights that a percentage of construction work is delayed due to lack of available labor and mistri workers arriving late on site in accordance with schedule start times. In order to mitigate such delays, working hours were increased by thirty minutes without compromising project timelines. This study identifies disparities between current practices for delivering construction work from scheduling and organizational perspectives within the industry by exploring modern practices across major regions in the sector. It also generates innovative insights into popular functions related to construction arrangements and management ideologies through the lens of the Last Planner System. When analyzing application of LPS in the construction industry using extended working hours exceeding 25% beyond normal limits resulted in decreased worker efficiency which made achieving required schedules unfeasible. Therefore, increasing worker numbers at sites would prove more effective as opposed to overworking existing staff members who are likely to become fatigued during operations resulting in suboptimal outcomes.

As we can see from table-1 and table-2, that if any construction project is delay due to any reason such as delay in material, lack of labour, rainfall, or any other reason. We can complete the project within given time by using the Last Planner System but the losses of the material or we can say it is little more costly as compared to thre normal project

REFERENCE

[1] Fiallo, M., and Revelo, V. (2002). Applying the last planner control system to a construction project: a case study in Quito, Ecuador. In Proceedings of the 10th Annual conference of the International Group for Lean Construction.

[2] González, V., Alarcón, L.F. and Mundaca, F. (2008a). Investigating the Relationship between Planning Reliability and Project Performance. Prod. Plan. Control, 19, (5),461-474

[3] Abdullah O. Alsehaimi 2009 “Last Planner System: Experiences From Pilot Implementation In The Middle East” https://www.researchgate.net/publication/45622275.

[4] Leal, M. and Alarcon, L.F. (2010). Quantifying Impacts of Last Planner™ Implementation in Industrial Mining Projects. In:, Walsh, K. & Alves, T., 18th Annual Conference of the International Group for Lean Construction. Haifa, Israel, 14-16 Jul 2010. pp 518-527.

[5] Ograbe Ahiakwo1, David Oloke2 2012 “Critical Review of Potential For Implementation Of Lean In The Nigerian Building Industry” Proceedings of the 20th Annual Conference of the International Group for Lean Construction.

[6] Mohd Arif Marhani 2012 “Lean Construction: Towards enhancing sustainable construction in Malaysia” ASIA Pacific International Conference on Environment-Behaviour Studies
[7] Mercure Le Sphinx Cairo Hotel, Giza, Egypt, 31 October 2 November 2012.
[8] Kalsaas, B. T. (2012). The last planner system style of planning: its basis in learning theory. Journal of Engineering, Project, and Production Management, 2(2), 88-100.
[9] Fullalove, L.H. 2013, 'Examples of Lean Techniques and Methodology Applied to UK Road Schemes' In:, Formoso, C.T. & Tzortzopoulos, P., 21th Annual Conference of the International Group for Lean Construction. Fortaleza, Brazil, 31-2 Aug 2013. pp 1057-1066
[10] McConaughy, T. & Shirkey, D. 2013, 'Subcontractor Collaboration and Breakdowns in Production: The Effects of Varied Lps Implementation ' In: Formoso, C.T. & Tzortzopoulos, P., 21th Annual Conference of the International Group for Lean Construction. Fortaleza, Brazil, 31-2 Aug 2013. pp 649-658
[11] Ograbe Ahiakwo1, David Oloke2, Subashini Suresh3 2013 “A Case Study of Last Planner System Implementation in Nigeria” Production Planning and Control page 699 to 707.
[12] Hackett, V. , Pasquire, C. , Stratton, R. & Knight, A. 2014, 'Use of a Pilot Study to Assess the Development of Virtual First Run Studies (VFRS)' In:, Kalsaas, B.T., Koskela, L. & Saurin, T.A., 22nd Annual Conference of the International Group for Lean Construction. Oslo, Norway, 25-27 Jun 2014. pp 1331-1341
[13] Khan, S. and Tzortzopoulos , P., (2014) Effects of the Interactions Between LPS and BIM on Workflow in Two Building Design Projects. In: Proceedings of the 22nd Annual Conference of the International Group for Lean Construction, Oslo, Norway, pp. 933-944. 4
[14] Ogunbiyi, O.E., (2014). Implementation of the lean approach in sustainable construction: a conceptual framework. PhD thesis , University of Central Lancashire.
[15] Nesensohn, C., Bryde, D. J., Ochieng, E., & Fearon, D. (2014). Maturity and maturity models in lean construction. Australasian Journal of Construction Economics and Building, 14(1), 45-59.
[16] Abdullah O. AlSehaimi 2014 “Improving construction management practice with the Last Planner System: a case study” www.emeraldinsight.com/0969-9988.htm.