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Application of Last Planner System as Lean Construction Technique

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ABSTRACT
Construction projects generally face delays and other time-related uncertainties. They involve various risk factors that impact time objectives and may lead to time-overrun. Delays usually trigger due to weak communication, unclear project requirements, and regular misunderstandings in the construction industry. Collaboration problems are one of the significant factors influencing the low-productivity and efficiency in the construction industry. The continuous deterioration of profit margins because of project delays and increased competition, construction contractors have to minimize waste for maximize profit. Lean construction philosophy helps to eliminate waste. Due to the triumph of lean production system in the manufacturing sector, the construction industry has adapted lean procedures to minimize waste and increase profit.

Key words : Construction Management, Cost Management, Last Planner System,Lean Construction, Schedule Management,

1. INTRODUCTION

Lean construction (LC) is an idea based on the ideas of lean production. It is about the managing the construction procedures to profitably deliver the customers' needs. Lean construction presently is in initial stage of development.

LC is a "way to design production systems to minimize waste of materials, time, and effort to generate the maximum possible amount of value". Primarily, Lean approach introduced in manufacturing sector[1]. Since early 1990's, the construction research group has been analyzing the possibility of using the principles of lean production in construction industry. Although various approaches have been formed to improve efficiency and efficacy of construction procedures, lean construction methods offer the promise to minimize the rework[2].

LC breaks the large construction project into small parts of activities by clearly defining the start and end date of completion for each activity with an assigned person to monitor the all the activities to complete according to schedule. The lean principles can be used efficiently and effectively in construction by concentrating on the whole process. This means all stakeholders must be involved, committed, and work to overcome hurdles that may occur due to traditional contractual arrangements [3].

Lean principles can apply to 1) Designing phase 2) Procurement phase 3) Production Planning phase 4) Logistics and 5) Construction phases. The nature of the operation, planning, and execution are the key categories that emphasize the differences between manufacturing and construction [4].Because of these fundamental differences among construction and production processes, the application of lean production cannot be directly used to manage the construction processes and a modern tool is required.

LC along with its tools like Just in Time, Pull Approach, Continuous Improvement, Total Quality engagement, Last Planner System, etc. has popularized in developing countries. It was found that there is need for behavioral changes and training for effective use of lean tools. Most of the LC tools chosen for the project are either ready to use or are suggested with some alterations.

The uncertainness in the production system leads to variable and complex production environment and results in waste, inefficiency, and productivity loss [5].

This study advocates that the usage of proper and flexible production procedures is the initial step to keep the stable production environment.

In a series of research experiments since 1994, Howell and Ballard established LPS of production control to make planning processes (flow) more reliable.LPS makes comprehensive plans by individuals who executes the work and reviews the plan near its execution, for collaborative planning, to remove limitations in the project as team and

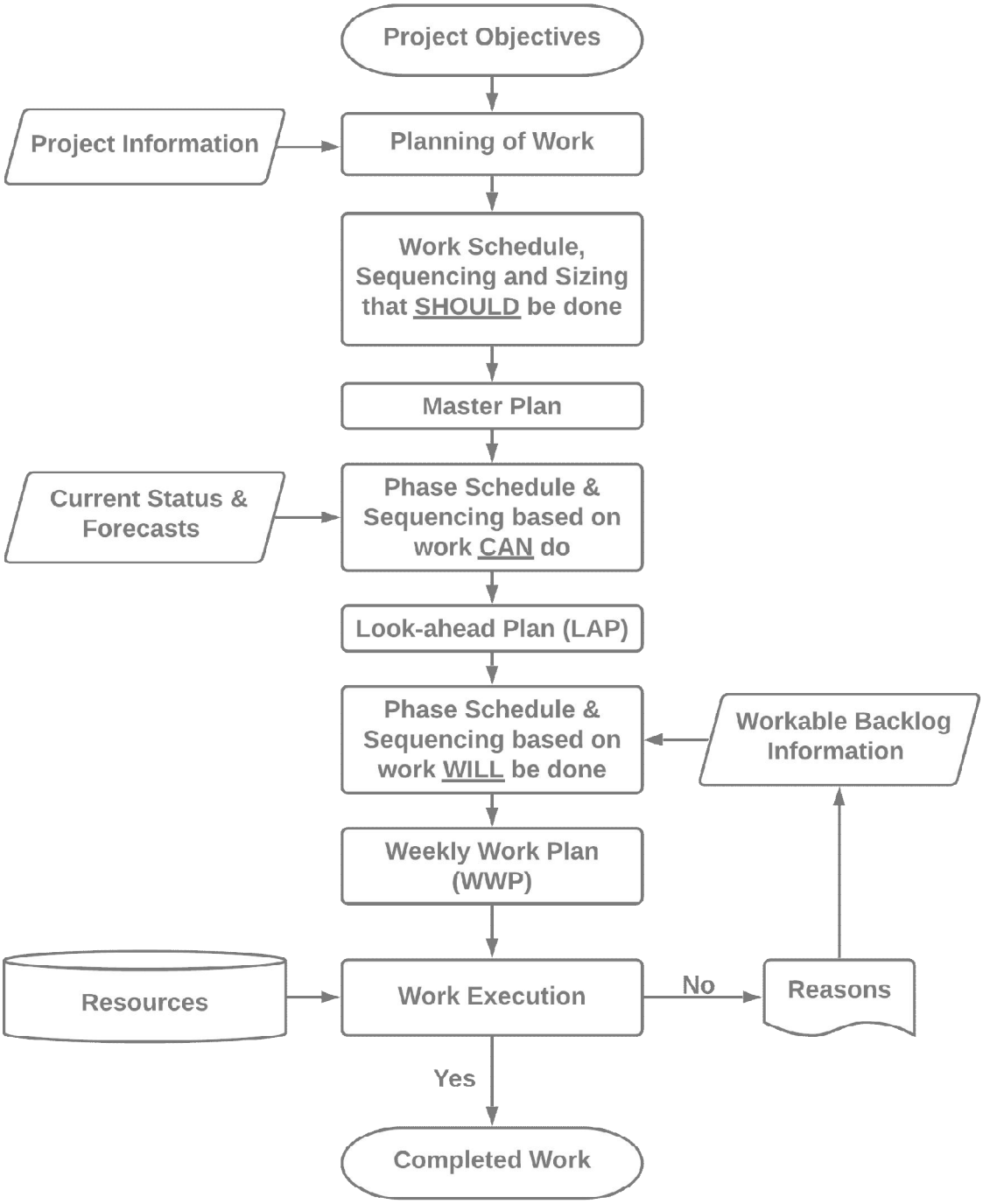

Figure 1: LPS Flow Chart

verify that promises made can be executed correctly, completely, timely and without ambiguity [6].

Lean construction's response to the construction industry production variability is to create a practical solution, the Last Planner System (LPS). LPS have generated a complex web of integrated tools and solutions that in turn has created a problem of how to implement it [7][8].

LPS is a planning, monitoring and control structure that follows LC principles such as, value stream mapping (VSM), just-in-time (JIT) delivery and pull scheduling.Last planner system planning process consists of creating master schedule, a look ahead schedule, and a weekly work plan by front-end planning using LC techniques.Weekly work planning is also known as "commitment planning" because, at this stage, precise resource assignments essential to be made so that work can be performed[9] [10].

Theroles of LPS as productive unit and workflow management and completing quality responsibilities.It also makes easier to get into the roots of the problem, and to take timely decisions about the adjustments required within the operation, so that execute measures conveniently, thus by increasing efficiency [11].

Components of LPS are Phase Scheduling; Look Ahead Planning; Constraint Analysis; Weekly Work Planning; Daily Huddle Meetings; First Run Studies; Percentage Plan Complete; Reasons for Non-Compliance and Feedback; Five-Whys - Root Cause Analysis [12].

The main aim of this study is focused on using the last planner system (LPS) tool in lean construction framework. This approach is said to save construction time and subsequently the costs involved in the project.

2. METHODOLOGY

Steps involved in LPS are as show in Figure 1 are Preparation of Master Plan; Preparation of Phase scheduling; The Look Ahead Planning; Constraint analysis; Weekly work plan (WWC); Daily huddle meetings; Percentage of work completed (PPC); Reasons for Non-Compliance and Feedback.

2.1 Preparation of Master Plan

This is to obtain a general plan and identify all the work packages for the whole project showing the main activities, their duration, and sequence [13].

2.2 Preparation of Phase scheduling

After master plan of the project we prepare the Phase Scheduling of the project. It involves the division of the master plan into separate phases of the comprehensive development plan and sets out priorities that can be considered goals by the project team [14]. Phase planning covers the gap between master plan and look-ahead planning.

2.3The Look Ahead Planning

In the look ahead planning management focusing and give attention on what is supposed to happen at some time in the future, and to take actions in the present that cause that future work. Look-ahead schedules to get the attention of managers on what work is to be completed in the immediate future [15].

2.4Constraint Analysis

Do Constraint analysis for each step of look ahead planning. Constraints analysis requires suppliers of goods and services to actively manage their production and delivery and provides the coordinator with early warning of problems.

2.5Weekly Work Plan (WWP)

After the constraint analysis define weekly working plan of the project. Weekly work plans are the most detailed plans in the LPS. This is the plan taken from the contractor tasks for the next day or week via weekly meetings. Weekly meeting help to plan the work that will be done in the next week. The weekly work plan meeting covers the weekly plans, safety issue, quality issue, resources, construction methods, and any problems that occur in the field [16].

2.6Daily Huddle Meetings

After the Weekly meetings, a daily huddle meeting should be conducted. Meetings where team members quickly give the status of what they had been working on since the previous day's meeting. It will be contact every starting of the work [17].

2.7Percentage of Work Completed (PPC)

The percentage of work done shall be measured in accordance with the weekly schedule. The number of scheduled activities performed is divided by the total number of planned activities, calculated as a percentage.

2.8Reasons for Non-Compliance and Feedback

After the PPC, Identification of reasons Non-Compliance and Feedback for why planned works are not done and these are been evaluated. And there by reducing the time lag for the next step to avoid such unfinished works within time. This provides the initial data needed for analysis and improvement of PPC, and consequently for improving project performance.

3. CASE STUDY

To understand the effectiveness of Last planner system in Lean construction, the following live project has been selected. The selected project is in construction stage at Warangal. The details of this project are given in Table 1

Balaji infrastructure Pvt. Ltd is one of the best companies for the construction and infrastructure. It has undertaken one of the prestigious projects in ThiruvalluvarNagari.e construction of GMR Brindavan Apartments.

The premium project signifies a modern day having for inspirational living-offering apartments designed with your aspirations in mind and built with an electric ensemble of

Table 1: Details of the case study

Name of the project	GMR Brindavan
Construction company	Balaji Infrastructures Pvt. Ltd
Selected block	Amenities block
Location	ThiruvalluvarNagar, Thiruvanmiyur
Planned Cost of Work	Rs. 99,68,635/-
Planned Duration	200 Days
Actual cost of the work	Rs. 1,13,79,066/-
Actual time taken to execute the work	229 Days

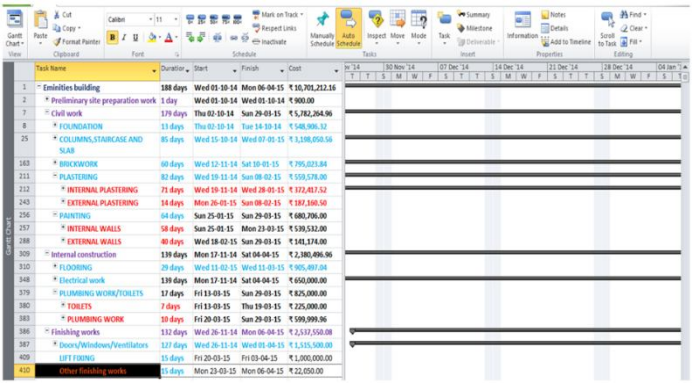

Figure 2: Phase Scheduling in M S Project

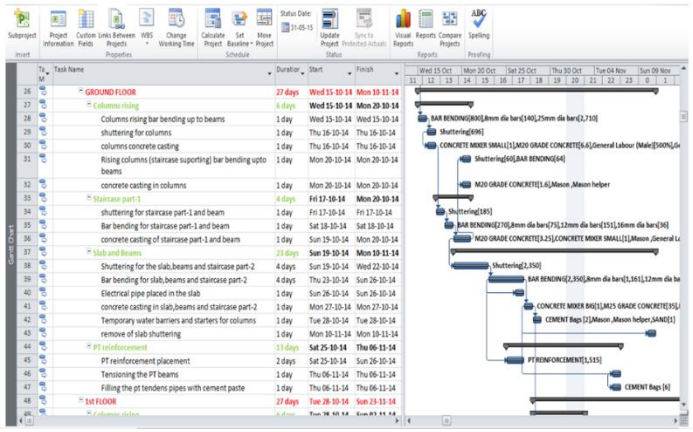

Figure 3: Look- Ahead Plan from MS Project

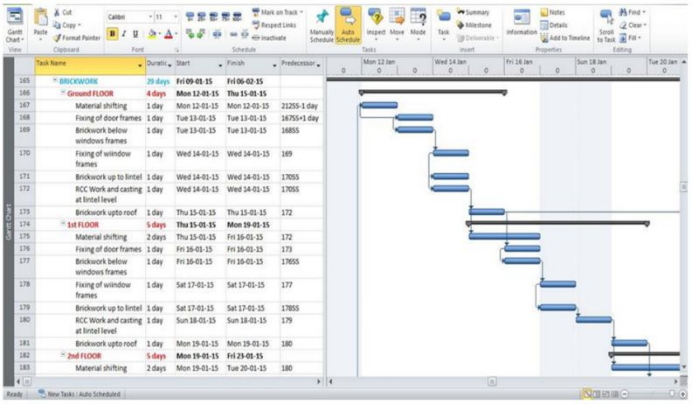

Figure 4: Weekly Work Plan from MS Project

innovative architecture, free flow of space, abundant natural light and all modern amenities expertly woven into safe and secure gated enclave.

In the GMR Brindavan construction project there are total 10 blocks, among them I had selected one block (amenities) for my thesis study which costs 1,13,79,066/-for completion of project. The total time taken for construction is 229 days.

3.1 Preparation of Master Plan

In Last planner system 1st step is the preparation of the Master plan. Master plan divided the projects into sub-projects. In this case study total building (construction project) is divided into some sub projects. This master plan is useful to clearly understanding the project.

3.2 Preparation of Phase scheduling

Phase scheduling divided the master plans (sub-projects) in to work packages. The sub-projects in the building (master plan) are further divided into work various phases as in Figure 2.

3.3 The Look Ahead Planning

Look-ahead plans are the outcomes of mid-term planning showing activities initially at the level of processes and subsequently at the level of operations. In the look ahead planning management focusing and give attention on what is supposed to happen at some time in the future, and to take actions in the present that cause that future work. Look-ahead schedules to focus supervisors' attention on what work is supposed to be done in the near future as given in Figure 3.

3.4 Constraint Analysis

In this step, for each activity of look ahead planning we do constraint analysis. By using these constraints, we can forecast the resources required for the work and compare with available resources, so that we can eliminate uncertainties. For example, casting the slab a look-ahead plan was prepared before a week. By constraint analysis, we got 400 bags of cement is required for casting. But we found that available inventory is 355 bags. This was early warning of problem to the coordinator.

3.5 Weekly Work Plan (WWP)

After the constraint analysis define weekly working plan of the project. Short-term planning results in weekly work plan. In this every week we prepare weekly work plan. These plans are useful to know what work will be done in that week or the next week. Weekly work plans are the most detailed plans in the LPS. Figure 4 shows one of the WWP of the case study.

Table 2: Actual Schedule Executed in Work Progress

Task Name	Duration	Start	Finish
Amenities Building	**229 days**	**Wed 01-10-14**	**Sun 17-05-15**
Preliminary Site Preparation Work	1 day	Wed 01-10-14	Wed 01-10-14
Civil Work	225 days	Thu 02-10-14	Thu 14-05-15
Foundation	18 days	Thu 02-10-14	Sun 19-10-14
Columns, Staircase and Slab	101 days	Mon 20-10-14	Wed 28-01-15
Ground Floor	29 days	Mon 20-10-14	Mon 17-11-14
1st Floor	29 days	Wed 05-11-14	Wed 03-12-14
2nd Floor	29 days	Fri 21-11-14	Fri 19-12-14
3rd Floor	29 days	Sun 07-12-14	Sun 04-01-15
4th Floor	29 days	Tue 23-12-14	Tue 20-01-15
Water Tank	21 days	Thu 08-01-15	Wed 28-01-15
Head Room and Lift Room	16 days	Thu 08-01-15	Fri 23-01-15
Brickwork	29 days	Fri 09-01-15	Fri 06-02-15
Ground Floor	4 days	*Mon 12-01-15*	*Thu 15-01-15*
1st Floor	5 days	*Thu 15-01-15*	*Mon 19-01-15*
2nd Floor	5 days	*Mon 19-01-15*	*Fri 23-01-15*
3rd Floor	8 days	*Fri 23-01-15*	*Fri 30-01-15*
4th Floor	9 days	*Thu 29-01-15*	*Fri 06-02-15*
Head Room and Lift Room	4 days	*Fri 09-01-15*	*Mon 12-01-15*
Parapet Wall	8 days	*Fri 09-01-15*	*Fri 16-01-15*
Plastering	35 days	Sat 07-02-15	Fri 13-03-15
Flooring	25 days	Fri 27-02-15	Mon 23-03-15
Painting	60 days	Mon 16-03-15	Thu 14-05-15
Internal Construction	**105 days**	**Sat 31-01-15**	**Fri 15-05-15**
Electrical Work	105 days	Sat 31-01-15	Fri 15-05-15
Ground Floor	89 days	Sat 31-01-15	Wed 29-04-15
1st Floor	91 days	Sun 01-02-15	Sat 02-05-15
2nd Floor	93 days	Mon 02-02-15	Tue 05-05-15
3rd Floor	97 days	Tue 03-02-15	Sun 10-05-15
4th Floor	101 days	Wed 04-02-15	Fri 15-05-15
Plumbing Work/Toilets	17 days	Thu 16-04-15	Sat 02-05-15
Toilets	7 days	Thu 16-04-15	Wed 22-04-15
Plumbing Work	10 days	Thu 23-04-15	Sat 02-05-15
Finishing Works	**120 days**	**Sun 18-01-15**	**Sun 17-05-15**
Doors/Windows/Ventilators	79 days	Sun 18-01-15	Mon 06-04-15
Ground Floor	79 days	Sun 18-01-15	Mon 06-04-15
1st Floor	14 days	Sun 08-03-15	Sat 21-03-15
2nd Floor	16 days	Tue 10-03-15	Wed 25-03-15
3rd Floor	19 days	Thu 12-03-15	Mon 30-03-15
4th Floor/ Others	21 days	Sun 15-03-15	Sat 04-04-15
Lift Fixing	15 days	Tue 28-04-15	Tue 12-05-15

Table 3: Project Parameters of Case study

Name of the Blocks	Planned Parameters		Actual Parameters		LPS Parameters	
	Duration	**Cost**	**Duration**	**Cost**	**Duration**	**Cost**
Amenities	200 Days	Rs. 99,68,635	229 Days	Rs. 1,13,79,066	188 Days	Rs. 1,07,51,212

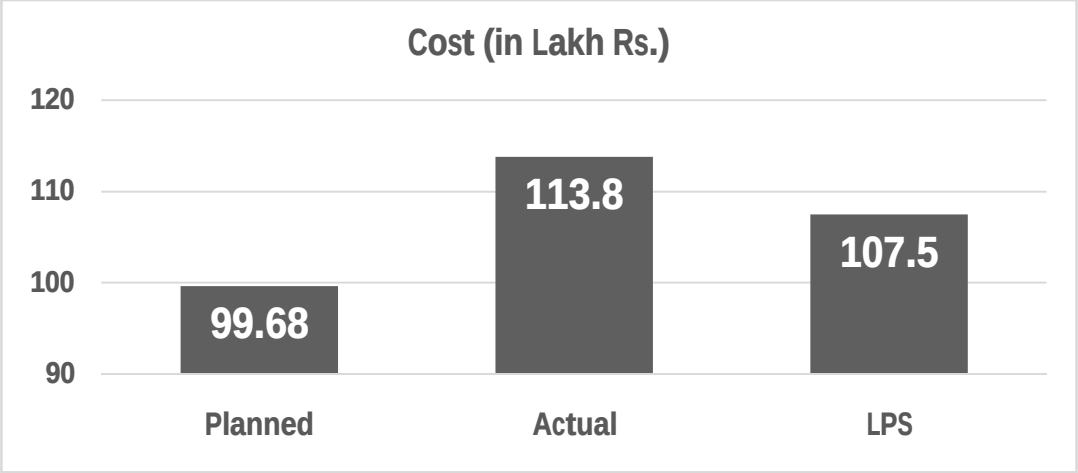

Figure 5: Cost Comparison

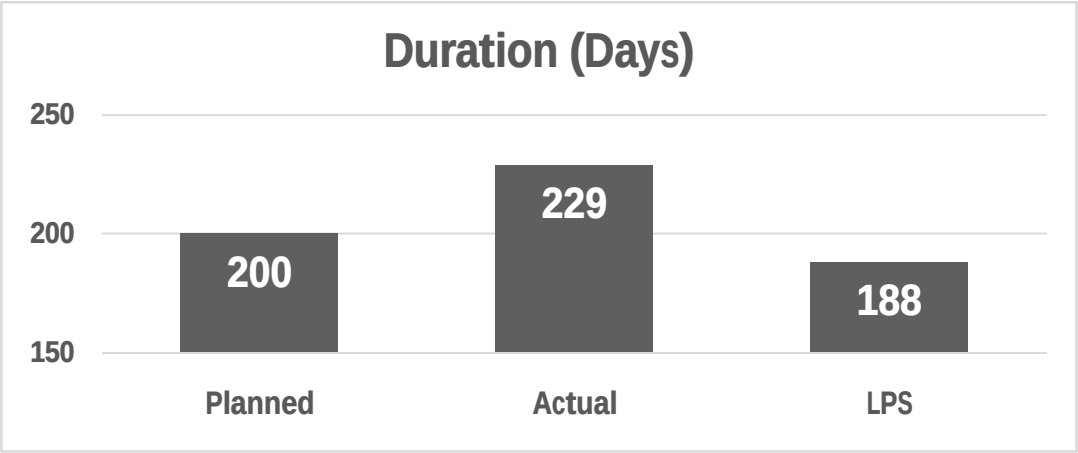

Figure 6: Schedule Comparison

3.6 Daily Huddle Meetings

After the Weekly meetings a daily huddle meeting were be conducted. In this team members quickly give the status of what they had been working on since the previous day's meeting. It will be contact every starting of the work.

3.7 Percentage of Work Completed (PPC)

Next step in LPS Percentage of work completed (PPC). Percentage of work completed is evaluated according to the weekly plan. PPC (percent plan complete) is the number of planned activities completed divided by the total number of planned activities, expressed as a percentage.

3.8 Reasons for Non-Compliance and Feedback

After the PPC, Identification of reasons Non-Compliance and Feedback for why planned works are not done and these are been evaluated. This feedback can be used to improve PPC value in next activities and execution of work plan without delays.

4. RESULTS AND DISCUSSION

Based on the case study the following results are determined. The various factors are tabulated in Table 3 which indicates the data representation. Figure 5 and Figure 6 depicts the cost and schedule parameter of project in each cases.

Actual cost of the project is Rs. 1,13,79,066 which is more of Rs. 7,82,577 than planned. If Last Planner system is applied, the actual cost is reducing to Rs. 1,07,51,212.

Application of LPS saves Rs. 6,27,854 with respective to actual cost and 41 days ahead of actual completion.

5. CONCLUSION

The purpose of using Last planner system for construction simulation is to assist project planners to better understand the construction process and predict the accurate future costs. This shows that the Last planner system can be used for this purpose and site is a key to implement the Last planner method.

The last Planner System could be an appropriate tool to help solve problems which arise at site during execution, minimizes delays, optimize the resources, and reduced the project cost. Present study describes how a Last planner system is prepared and the case study demonstrates an application in which the Last planner system enabled the user to validate proposed construction estimation.

Last planner system was successful in reducing the construction complexities during execution of the project. In conclusion, the developed Last planner system is more accurate and simpler to use most with significant time and cost saving

REFERENCES

1. Ballard, G. (1997, July). **Lookahead planning: the missing link in production control.** In Proc. 5th Annl. Conf. Intl. Group for Lean Constr.
2. Salem, O., Solomon, J., Genaidy, A., &Minkarah, I. (2006). **Lean construction: From theory to implementation.** Journal of management in engineering, 22(4), 168-175.
3. Ala-Risku, T., & Kärkkäinen, M. (2006). **Material delivery problems in construction projects: A possible solution.** International Journal of Production Economics, 104(1), 19-29.
4. Seppänen, O., Ballard, G., & Pesonen, S. (2010). **The Combination of Last Planner System and Location-Based Management System.** Lean construction journal.
5. Moghadam, M., Alwisy, A., & Al-Hussein, M. (2012). **Integrated BIM/Lean base production line schedule model for modular construction manufacturing.** In Construction Research Congress 2012: Construction Challenges in a Flat World (pp. 1271-1280).
6. Gao, S., & Low, S. P. (2014). **Lean construction management.** From Lean Production to Lean Construction, 27-48.
7. AlSehaimi, A. O., Fazenda, P. T., & Koskela, L. (2014). **Improving construction management practice with the Last Planner System: a case study.** Engineering, Construction and Architectural Management.
8. Bajjou, M. S., & Chafi, A. (2018). **The potential effectiveness of lean construction principles in reducing construction process waste: an input-output model.** Journal of Mechanical Engineering and Sciences, 12(4), 4141-4160.
9. Sebastian, A. E. (2019, October). **Analysis Lean Construction Application to Reduce Material Waste at Bridge Construction Project.** In IOP Conference Series: Earth and Environmental Science (Vol. 328, No. 1, p. 012001). IOP Publishing.
10. Kapuganti, C. B., Balaji, K. V. G. D., & Santhosh Kumar, T. (2019). **Comparison of project monitoring and controlling methods: Earned value management (EVM) & earned duration management (EDM).** International Journal of Recent Technology and Engineering, 7(6), 549-555.
11. Shetty, P., & Rao, B. P. (2019). **Importance of lean concepts and its need in construction projects.** International Journal of Recent Technology and Engineering, 8(2), 2534-2541.
12. Parekh, V., Asnani, K., Bhatt, Y., & Mulchandani, R. (2020). **Comparison between Critical Path Method (CPM) and Last Planners System (LPS) for Planning and Scheduling METRO Rail Project of Ahmedabad.** In CIGOS 2019, Innovation for Sustainable Infrastructure (pp. 519-524). Springer, Singapore.
13. Abusalem, O. (2020). **Towards last planner system implementation in Gaza Strip, Palestine**. International Journal of Construction Management, 20(5), 367-384.
14. Aslam, M., Gao, Z., & Smith, G. (2020). **Development of Innovative Integrated Last Planner System (ILPS).** International Journal of Civil Engineering, 1-15.
15. Kumar, T. S., Balaji, K. V. G. D., Ram, N. T., Kapuganti, C. B., & Sowjanya, C. L. (2020). **Effect on CO_2 cured concrete exposed to sodium sulphate.** International Journal of Emerging Trends in Engineering Research, 8(7), 3670-3674.
16. Bhattacharya, A., & Neware, S. (2020). **Nagpur metro tracks construction monitoring system.** International Journal of Emerging Trends in Engineering Research, 8(5), 2209-2213.
17. Bagade, M., Hablani, R., &Dharmik, A. (2020). **Determining changes in green cover in urban areas.** International Journal of Emerging Trends in Engineering Research, 8(5), 2009-2014.