International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 03 | March - 2023 Impact Factor: 7.185 ISSN: 2582-3930

Implementation of Lean Scheduling in Real Estate Industry: A Review

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Abstract:

It is observed that every construction project is unable to perform as per planned objectives as it faces variances in terms of cost, time, quality, safety, specifications, liable to various constraints pertaining to it. Conventional Scheduling techniques that uses push approach has to perform each activity right, the first time-every time in order to make the forthcoming activities follow the schedule. In this study we have introduced Pull Scheduling approach to overcome the delays resulting from wastes in a real estate project. Waste's typical cost as Construction businesses have started using Lean Construction to reduce waste and boost productivity. The proportion of project costs that do not include performance costs ranges from 5.38% to 14.70%. In order to implement lean concepts, which place a strong emphasis on waste minimization and efficiency improvement, building sites in India must first detect waste and its underlying causes. Lean Scheduling (LS) was employed to address efficiency and waste problems and to adapt to the challenges of the construction industry as a future project management philosophy. A comprehensive literature review is carried out to determine real time issues faced in real estate industry using a pilot questionnaire survey and overcoming those challenges using lean tools. Finally, a method for choosing the most fitting lean resources by pull scheduling was suggested. The key contribution of this study is to reinforce the decision-making capacity of the builders in their choice of the most suitable construction-coordinated method on real estate project.

Keywords: *Lean Construction Techniques, Pull Scheduling, Just-In-Time, Indian Real Estate Industry, Lean Thinking, Lean Concepts, Value stream mapping, Construction waste.*

Introduction

Background information for the research is provided in this portion of the thesis. The first chapter examines the challenge of controlling contractual delays in the construction industry as well as the problem of timetable predictability. The rationale then explains the motivation for the study. The purpose, goals, and restrictions are then discussed. Before the introduction is concluded with a presentation of the thesis's content, the research plan is offered.

In this research, stable workflow on a construction site is improved using lean concepts. The real estate industry is crucial to India's economy, contributing between 6 and 8% of GDP now and 13% by 2025, according to projections. By 2030, it is expected that the Indian real estate industry would have grown to $1 trillion, placing it third worldwide. It presently employs more than 50 million people, making it the third largest employer in the country (after agricultural and industrial).

The effect of the COVID pandemic has dealt a powerful blow to the rate of real estate recovery on a variety of counts. This high-powered panel discussion with leading industry experts would concentrate primarily on real estate sales and marketing at the present time.

With the ultimate goal of achieving on-time project delivery, the study conducted here aims to provide project management of real estate development projects with a more streamlined process of work coordination than the conventional critical path method (CPM) approach and the more contemporary LPS approach.

This guide offers a summary of the key Lean tools and practices that have been shown to provide real benefits for construction project success and delivery. For each instrument, it is not an exhaustive, step-by-step manual with comprehensive instructions. Instead to explain what it is, where and when to implement it and the associated advantages, each instrument is incorporated and adequate detail is given.

To help solve a particular problem or to make an upgrade, any of the methods from this guide can be used independently. However, once they are used as part of a lean end-to-end project management plan and improvement framework for construction firms to utilize their resources to its full value.

Lean Theory is centred on the ideas of lean manufacturing. Henry Ford first introduced the assembly line idea, which completely changed the auto manufacturing sector. developed by Toyota. Ohno pioneered the ideas of lean production management. In addition to researching ways to alter "muda," Taiichi Ohno, the founder of the Toyota Manufacturing Company, has been concentrating on expanding the narrow focus of craft production to include the whole production industry.

Lean Construction (LC) is an alternative method of project management since it establishes clear objectives for the execution phase. It concurrently creates goods and systems in order to maximize customer performance at the project level, and it exercises output control across the whole product life cycle, from conception through manufacturing. Abdul-Razek claims that the LC's key concept is to minimize or remove waste, which is expressed by non-worthy added activity, and boost value added activity quality. LC include just-in-time procedures, pull-led scheduling, decrease in job uncertainty efficiency, changes in flow flexibility, waste avoidance, organizational simplifying and incorporating benchmarking. Proof from the application of lean thinking has demonstrated that the use of lean concepts in building has proved multiple benefits. These advantages include improving efficiency, improving reliability, and improving consistency, improving customer service, improved predictability, shortening timelines, minimizing duplication, lower cost, improving construction build-ability, and improving safety.

Criteria for Evaluation of Project Success

Through effective scheduling and its tracking project can be completed on time within budgeted cost. Project success depends on various criteria and main criteria are listed below.
There are six criteria to evaluate project success.

1. Time performance: Project completed within estimated time is considered as successful project
2. Cost performance: Project completed within estimated cost of construction is considered as successful project.
3. Safety: A project is deemed successful if it respects the health and safety rights of any involved workers and offers safe working conditions.
4. Quality performance: If a project meets or surpasses the established criteria of workmanship and quality in every regard and proves client pleasure, it is considered successful.
5. Satisfaction of stakeholders: A project is regarded as successful if it satisfies the objectives of its stakeholders.
6. Fewest conflicts possible: A project is considered successful if it is completed with no or few disputes during the project's life cycle.

Critical Literature Review

The critical literature review in this chapter is split into two sections that should be as follows.

1. Real Estate Scenario of India

The literature review on the real estate scenario of India are as follows:

Ramaswamy and Satyanarayana et al., (2009) formulated Indian technique for quantifying waste Sites of Building. Waste has been categorized into Equipment, low standard, labor and machinery with inefficiency. The inefficiency of the workforce and the Furthermore, equipment was listed as waiting, idle, Transport, excess manufacturing, and excess processing Movement. Movement. With the exception of performance-related costs, the average cost of waste as a percentage of project costs ranged from 5.38% to 14.70%. of the building projects examined.**[33]**

In Real Estate the Sub Sectors are:

1. Public Area Development primarily focuses on citywide infrastructure upgrades. This may help us create markets, rehabilitate waterways, build out infrastructure for recreation and sport, etc. The creation of public spaces is a key area of concentration for the Government of India's Smart Cities Mission, which intends to create 100 smart cities.
2. Given the size of India's metropolitan population and the growing middle class, residential real estate is a significant demand generator. The government has also created the Housing for All Scheme with the aim of constructing 20 million affordable houses by 2022 to fulfil the housing requirements of the lower classes.
3. With the advent of Real Estate Investment Trusts, the commercial real estate market in India has become one of the most efficiently structured sectors in the Asia-Pacific region (REITs). Government programmes like Make in India and other changes like the implementation of the Real Estate Regulatory Authority (RERA) and GST have significantly strengthened the industry.
4. The State Industrial Development Corporation or another relevant government body or statutory authority often promotes industrial parks or zones. These parks and zones serve as important industrial production centers and, depending on the park type, may be segmented into certain sectors. Typically, the government provides the common infrastructure for these parks.

The percentage of opportunities in real estate projects in India is shown in Figure 2.1.

Figure 2.1: Percentage of Opportunities in Real Estate Projects

(Source: https://indiainvestmentgrid.gov.in)

Mode of Implementation 373 on EPC 71 PPP 86 Other. Ownership of Real Estate Projects in Government is around 26347 Cr Worth. And in Private 34770 Cr Worth. In Year 2020.

On EPC Mode 39794.59 Cr. Worth 7534.04 Cr. Worth PPP 5836.72 Cr. Worth Others in this Year 2020.

The percentage of cost in real estate projects in India is shown in Figure 2.2.

Figure 2.2: Percentage of Cost for Real Estate Projects

(Source: https://indiainvestmentgrid.gov.in)

2. Lean Construction Management

These are the key findings from the literature review on Lean construction management:

Verutti, Josselyn. (2019) *"Best Practices for Lean Scheduling and Coordination in Commercial Construction",* In order to identify some of the best practise for quality information flow, Lean Principles, general scheduling, pull planning, and implementation of lean construction in a company, this project dissects the Last Planner System, one of the key components of lean scheduling and coordination, using a case study with a prominent commercial general contractor in the California Bay Area. [51]

Jadhav, Sonali A., and D. I. Mittapuli. (2018) *"Application of Lean Construction in Commercial Building.",* As demonstrated by a block-making scenario in Hinjawadi Area of Pune District, Maharashtra, the advantages of employing lean construction are as follows :

- Strength: Using the new block design and 20 MM aggregate in the new block design helped to increase the block's strength from 5.2 MPa to 5.8 MPa.

- Cost: After using the new block design, the price per block has decreased by one rupee. The usage of 20 MM aggregate is to blame, and as a result, the cement content has decreased. The previous block costs Rs. 19.5 in materials, whereas the new block costs Rs. 16.05.
- Waste: The durability of the block's exterior age is the primary factor in changing the old design. The exterior age is not stable in the previous design since it is just 30 MM X 170 MM in size. In the revised design, the 30 MM width is increased to 50 MM, allowing for the use of 20 MM aggregate while still giving the block stability. [15]

George et al., (2016) *"IMPLEMENTING LEAN CONSTRUCTION EFFECTIVELY IN A YEAR IN A CONSTRUCTION",* The administration of manufacturing, quality, safety, and customisation were all integrated. As a result of better service control, both internal and external clients are more confident in the project's success.

There was greater contact among employees as a result of having access to all of the team's data in a single database and the ability to perform quick analyses, which exposed their demands and provided answers to work-related issues. [10]

Table 2.1: Implemented Lean Practices [10]

Lean Practice	Decision making	Implemented tool and practice
Production System Design	Execution sequence definition	A network of activity-to-activity linkages in priority
	A review of workflows	Balance line for the apartment building
	Execution strategy explanation	Project's line of balance (long term plan)
	Defining the production resources' capacity	Spreadsheet showing manufacturing resources' capacity
Last Planner System	Look ahead (roll over) planning	12 weeks ahead planning
		List of constraints
		IRR (Index of Relative Constraints)
	Commitment planning	Advanced Weekly Work Plan

		Standing meeting
		Causes for remonstrance.
		Percentage of Plan Completion (PPC)
		Percentage of Plan Completed with Quality (PPCQ)
		Percentage of Plan Completed with Safety (PPCS)
Visual Management	Location of temporary facilities on construction site	Magnetic Post It Board at construction site
	Transparency of information about team competence.	Issue register Board in site office with PPC
	Transparency of information from drawings.	Line of Balance and Look ahead plan and Schedule Sheet on site.

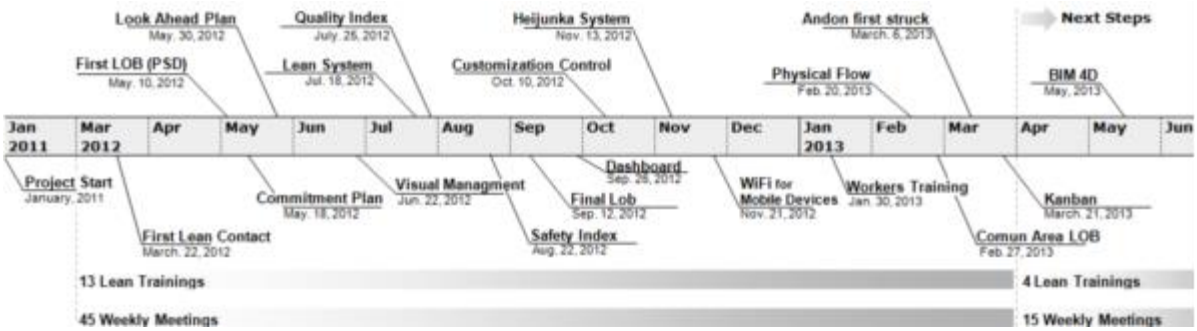

Figure 2.3: timeline of implementations along the year [10]

Lean Construction Institute (2013) *"Last Planner ® System."* The Last Planner System encourages dialogue between trade foremen and project management at the proper levels of detail and prior to the emergence of pressing problems. These discussions raise the likelihood that work will go dependably and acknowledge the importance of peer pressure and interpersonal interactions in the process. [1]

Using Just-In-Time (JIT) delivery, value stream mapping (VSM), and pull planning, among other lean construction concepts, LPS is a planning, monitoring, and control system.

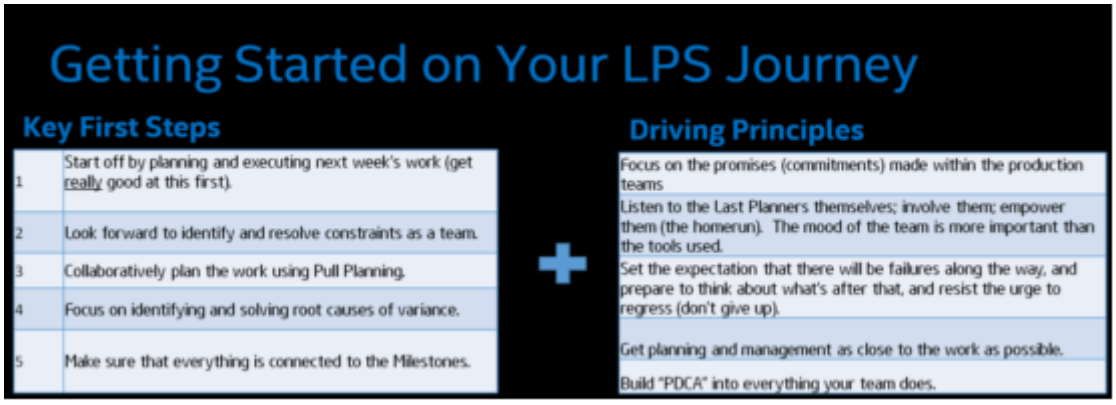

Figure 2.4: Implementing LPS [1]

Sacks, R., et al., (2007) *"Lean Management Model for Construction of High-Rise."* The conventional construction planning approach of working your way up from floor to floor fails when clients make choices in an arbitrary order. Due to the lengthy cycle periods for delivering finished units and therefore large levels of work in progress, the developer, contractor, subcontractors, and clients are frequently unhappy with the process. As a result of applying lean construction ideas to this problem, pull scheduling, reduced batch sizes, and some degree of multi-skilling have all been introduced into the management model. The key advantages anticipated include a better capacity to supply personalised residences, increased cash flow, and shortened cycle times for delivering units. [39]

Aditi Javdekar et. al., (2007) *"A Case Study on Applying Lean Construction to Concrete Construction Projects."* Lean construction was studied, both at the operation and project levels, and its use in concrete construction projects. Real-world concrete building projects were studied in partnership with a concrete contractor, and issue areas causing delays and other wastes were found. [40]

Raghavan, N. et al., (2014) *"IMPLEMENTING LEAN CONCEPTS ON INDIAN CONSTRUCTION SITES : ORGANISATIONAL ASPECTS AND LESSONS",* IIT Madras, had started a meticulously planned programme for teaching and implementing with classroom and webinar-based instruction, reporting in preset forms, monitoring via site visits, and periodic evaluations, lean construction principles are applied to nine sample projects with a range of features. Sites were urged to implement a number of additional Lean technologies alongside the LPS, with tight faculty support. [34]

Tiwari, Saurabh, and Partha Sarathy. (2012) *"PULL PLANNING AS A MECHANISM TO DELIVER CONSTRUCTION DESIGN."* The project team was able to create a work plan by using the pull planning approach, which helped them reach their ultimate objective of presenting a constructible set of design drawings to the permitting agency on time. [50]

Pull Planning Shortfalls:

1. In order to create the collaborative environment required for this form of project delivery, the owner is essential.

2. Maintain discipline and follow the pull strategy at all times. Only if production work is being created from the plan does it provide value.

Remon Fayek et. al., (2013) *"Applying Lean Thinking in Construction and Performance Improvement."* The Last Planner System technique showed that it may enhance construction management procedures in a variety of ways, making it a major and increasingly popular application of lean construction concepts and methods. [2]

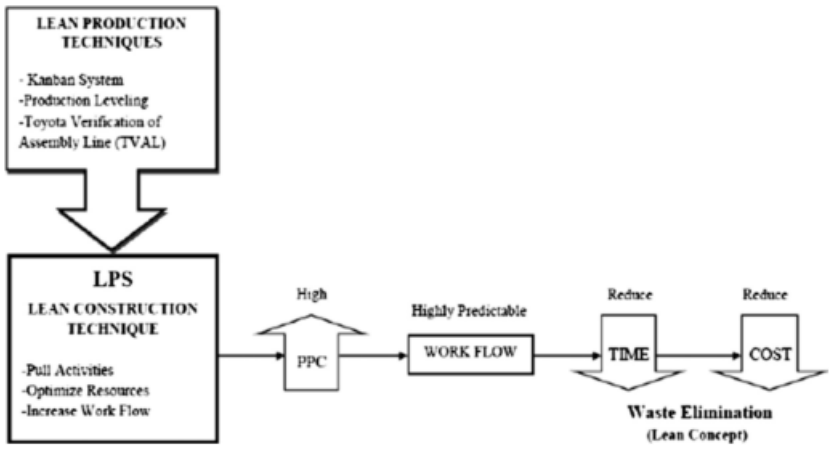

Figure 2.5. How Last Planner System achieves lean concept. [2]

Usama, Hamed et. al., (2013) *"Implementation of Lean Construction Techniques for Minimizing the Risks Effect on Project Construction Time."* Lean construction is applied in this study's execution of an industrial project in Egypt using the most recent planner system. Two metrics are used to assess the effects of implementing new technology: percent expected time-overrun (PET) and percent plan completed (PC) (PPC).14]

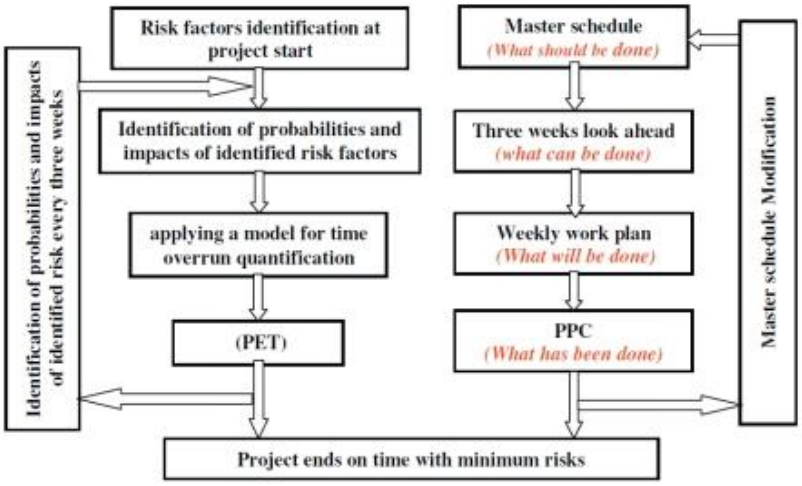

Figure 2.6. The suggested research methodology's steps.[14]

R. Jayanthi et. al., (2014) *"Barriers to Implementation of Lean Principles in Construction Industry."* The following have been recognised as the primary obstacles to using Lean principles in Indian real estate & construction industry:

Lack of awareness of the necessity to use lean construction

Uncertainty in the supply chain

The tendency to apply traditional management

Issues with culture and human attitudes (Mindset issues)

Lack of commitment from top management

Non-participation of management style for workforce [3]

M. Talat Birgonul et. al.,, (2017) *"A Construction Delay Analysis Approach Based on Lean Principles."* Suggesting delay analysis methodology and delay register example that can be referred for future work for risk management against delay. [4]

Table 2.2. Delay register example [4]

#	Delay Item	Delay Cause	Delay Amount	Responsible Party	Strategies for Similar Delays
1	Slow work progress	Inadequate resources	3 days	Contractor	Resource increase
2	Suspension of piling works	Default of piling subcontractor	12 days	Contractor	Changing the prequalification criteria for subcontractors
3	Prevention of site usage	Expropriation problems for the 31st and 32nd tower	5 days	Owner	Completion of expropriation prior to start of works
4	Administrative disturbance	Delay in getting permission from the local electricity authority	8 days	Third Party	Establishing better relationships with local authorities

Srinivas, K. (2020) *"Lean Construction in a Real Estate Project - A Case Study."* In this project, a building's cost is estimated according to the project's parameters, and the traditional methods are contrasted with lean construction methods, which can reduce costs while significantly improving quality with a focus on customer satisfaction. Without altering the specs, it has been found that lean construction may cut the project's overall cost by 6.91%. Concrete for footings and columns, stone dust, and reinforcing steel all have different amounts that have led to cost increases. Continual development made it possible to complete the project with greater client satisfaction. [42]

Raol, Parthrajsinh H et. al.,, (2021) *"Integration of BIM with Lean Principles in Indian Construction Industry."* The upcoming month's tasks were taken from the timetable and worked on in zones, such as column, slab, beam, and so on. The beginning stages of all three zones had significant obstacles, which led to significant weekly planning. BIM and lean services like 4D simulation along In order to decrease change orders and RFIs and provide more value to the client, Look Ahead planning was implemented. This included Quantity Take Off, Clash detection during look-ahead, and Weekly Work Planning. [35]

Patel Dhruv et. al., (2021) *"APPLICATION OF LEAN TOOLS IN CONSTRUCTION OF REAL ESTATE PROJECT." The Last Planner System is employed for Lean Construction Implementation because it satisfies the majority of the objectives in the work supplied from the literature.* [31]

Table 2.3. Comparison of various LCTs [31]

Lean Tools / Objectives	LPS	VM	DHM	FRS	5S	FSQS	6SIGMA	KANBAN	JIT	KAIZEN	PREFAB	BIM	VSM	PULL	TQM	HSM	BENCH MARK	STANDARD-IZATION
Reduce Planning Variabilities	✓								✓		✓	✓		✓	✓	✓	✓	✓
Reduce Design Variabilities		✓									✓	✓						✓
Reduce Process Variabilities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
Maintaining material Flow	✓				✓			✓	✓				✓	✓	✓			✓
Continues Improvements	✓	✓	✓	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓	
Better Visualization		✓		✓							✓	✓		✓				✓
Customer Focus	✓						✓				✓		✓	✓	✓			
Improving Workflow	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Defect analysis and Control	✓					✓	✓			✓		✓		✓	✓			✓
Improve communication	✓	✓										✓		✓	✓	✓	✓	✓
Improving working procedures	✓	✓	✓	✓	✓						✓	✓	✓	✓		✓	✓	
Improves Safety	✓	✓			✓	✓		✓		✓				✓	✓	✓		

7. Practices for Lean Construction

Lean construction practises (LCPs) have been identified through literature surveys conducted from 2000 to 2020, and those practises have been divided into four major groupings based on potential applications in the designing, planning, building construction and real estate projects. These four categories are :

1. Construction and Site Management Practices-(CMP)
2. Health and Safety Management Practices-(HSMP)
3. Design and Engineering Practices-(DEP)
4. Planning and Control Practices-(PCP)

The Details Lean Practices for DEP's, PCP's, CMP's, HSMP's are in show correspondingly in Tables 2.4, 2.5, 2.6, and 2.7.

Table 2.4: Design Engineering Practices-(DEPs)

DEPs	Description	Authors
Virtual Construction Design (VDC)	Simulations and a design platform for computer-aided modelling (CAD). Additionally, it may be utilised to spot design and specification flaws and guide an errorless design transition for production or manufacturing. It's also conceivable.	Franco Picchi et al., (2016) **[14]**
Design structure matrix (DSM)	Using to divide the designing process into a number of sections.	Johansen Walter et al., (2007) **[18]**
Prefabrication and Modularization	Components are manufactured at an off-site warehouse and sent to the prefabrication facility for installation. To facilitate mass prefabrication procedures of project components, areas are divided into repeated segments or modules of identical size.	Hermes et al., (2015) **[16]**
Detailed briefing	Review of client briefs and prompt design transition.	Seim et al., (2012) **[36]**
Big room workshop	Project managers utilize this conference room to explore and evaluate the project's general concept and functioning, handle issues, and develop novel design solutions.	Vaidyanathan et al., (2016) **[41]**
Integrated project delivery (IPD)	The project delivery approach calls for the signing of an agreement between the client and the project's principal planners, vendors, and other stakeholders.	Riached, Hraoul, Karam Hamzeh et al., (2014) **[32]**
Target Value Design (TVD)	A project-focused planning method built on customer-set budget and deadline targets.	Franco Picchi et al., (2016) **[14]**
Standardization	Usage of established measures, criteria, and requirements in the planning and execution of the project part.	Mourao and Elias et al., (2016) **[13]**
Concurrent Engineering	This entails cooperatively communicating information during the execution of numerous activities in a project in order to create practical architecture with high quality and	Sarhan et al., (2017) **[34]**

	efficiency.	

Table 2.5: Planning and Control Practices (PCPs)

PCPs	Description	Authors
"Last planner system (LPS)"	LPS is a more effective planning and management tool for monitoring the construction process. This involves the implementation of planning processes. (master, phase, forward, weekly).	Li et al., (2017) **[11]**
Work structuring and scheduling	Design is divided into sequential and independent tiny pieces in this way to reduce job uncertainty.	Murguia et al., (2016) **[27]**
Benchmarking	A rewarding plan is introduced to each portion of a team of employees during benchmarking, which serves as a strategic and motivating source for task teams.	Andersen et al., (2012) **[8]**
6 Sigma	To ensure ongoing process improvement, it is beneficial to analyse the construction process using mathematical perspective (i.e., the identification of obstacles, evaluation of outcomes, and analysis of variances).	Sarhan et al., (2017) **[34]**
Value Stream mapping (VSM)	Using this technique, non-value-added operations are mapped out in order to maximise value and provide it to the user during the course of development.	Murguia et al., (2016) **[27]**
Daily cluster or huddle meeting	All project managers assemble regularly for cluster or huddle meetings to discuss project issues and improve communication between project managers and site staff.	Sarhan et al., (2017) **[34]**
Pull Planning /Scheduling	The gathering of resources to make them accessible for manufacture in accordance with the project timeline or plan makes up the entire supply chain process.	Franco Picchi et al., (2016) **[14]**

Error proofing (Poka- yoke)	To stop mistakes from spreading unchecked throughout the building process, this is employed in the pre-compliance check.	Nikakhtar et al., (2015) **[28]**

Table 2.6: Practices for Construction and Site Management (CMPs)

CSMPs	Description	Authors
Gemba walk	Investigating a problem's roots is necessary in order to identify its cause and resolve it.	Franco Picchi et al., (2016) **[14]**
Total Preventive maintenance (TPM)	It is a handy security method used to safeguard the site director's facilities. This implies that operators maintain their facilities when they are using them.	Sarhan et al., (2017) **[34]**
Kan-ban system	This dated lean tool necessitates the usage of an inventory management schedule/card or a stock taking list at the project's location. This usually makes capturing and keeping inventory on construction project sites more efficient.	Sarhanet al., (2017) **[19]**
5S's of On-site Management	5S's: Sorting, straightening, shining, standardizing, and maintaining all site procedures and activities to ensure excellent construction site management.	Li et al., (2017) **[11]**
First run studies	This is the formulation of construction site activities that are necessary, especially when those involved have less information of the execution. It requires analysis for the avoidance of mistakes and identification of alternate methods.	Ogunbiyi (2014) **[29]**
Kaizen	This promotes continuous development on any construction site phase.	Sakka et al., (2016) **[12]**
Total quality management-(TQM)	TQM is a construction management approach that is used to find and investigate potential problems, create and implement new approaches, and evaluate results.	Sarhan et al, (2017) **[34]**
Just-in-time (J.I.T.)	JIT allows for the rapid delivery of materials, information, drawings, and other project-related requirements at the place of use.	Sarhan et al., (2017) **[34]**

Improved Visualization Management	VM, a method for providing precise instructions to team members in the field. On construction locations, it might specify where sign boards or post-its should be placed.	Sarhan et al., (2017) **[34]**
Conference Management	Preferred For organising meetings, seminars, and trainings on a project.	Li et. al.,, (2017) **[11]**

Table 2.7: Practices for Health and Safety Management (HSMPs)

HSMPs	Description	Authors
Safety and Quality- Fail Safe	By predicting the likely possibility of my mishap and taking preventative actions to prevent it, It aids in reducing disruption on the job location and, in some cases, helps guarantee that no employee is hurt at all while working there.	Ogunbiyi et al., (2014) **[29]**
Sustainable Enviroment Management (ESM)	This lean strategy is helpful in planning for safety and health through examination, identification, and control of likely risk. Planning and creating the required arrangements are often necessary to offer the greatest level of employee safety.	Sarhan et al., (2017) **[34]**
Improvement of Health & Safety Management (HSM)	Planning for the health and welfare of construction site workers is a component of this cutting-edge lean technology.	Sarhan et. Al,. (2017) **[34]**

Major Findings from Literature

The major finding from literature reviews are as follow:

1. The Last Planner System is used to implement lean construction because, according to the literature study, it accomplishes the majority of the goals.
2. The main purposes of all lean tools are to eliminate process variations, to continuously enhance workflow, and to increase productivity.**[7]**
3. More efficient cash flow, reducing cycle times for delivering homes, and increasing the capacity to supply customized housing are the key advantages of implementing a lean management approach.
4. To gauge the effects of implementing the new technology, two metrics are used: the percent expected time-overrun (PET) and the percent plan completed (PPC).
5. The major obstacles to implementing lean construction, according to reviewers, were those related to management, finances, education, technology, and attitudes.**[26]**
6. From the literature, Figure 2.7 depicts the flow of implementing lean methods, which are the required tools are shown graphically.

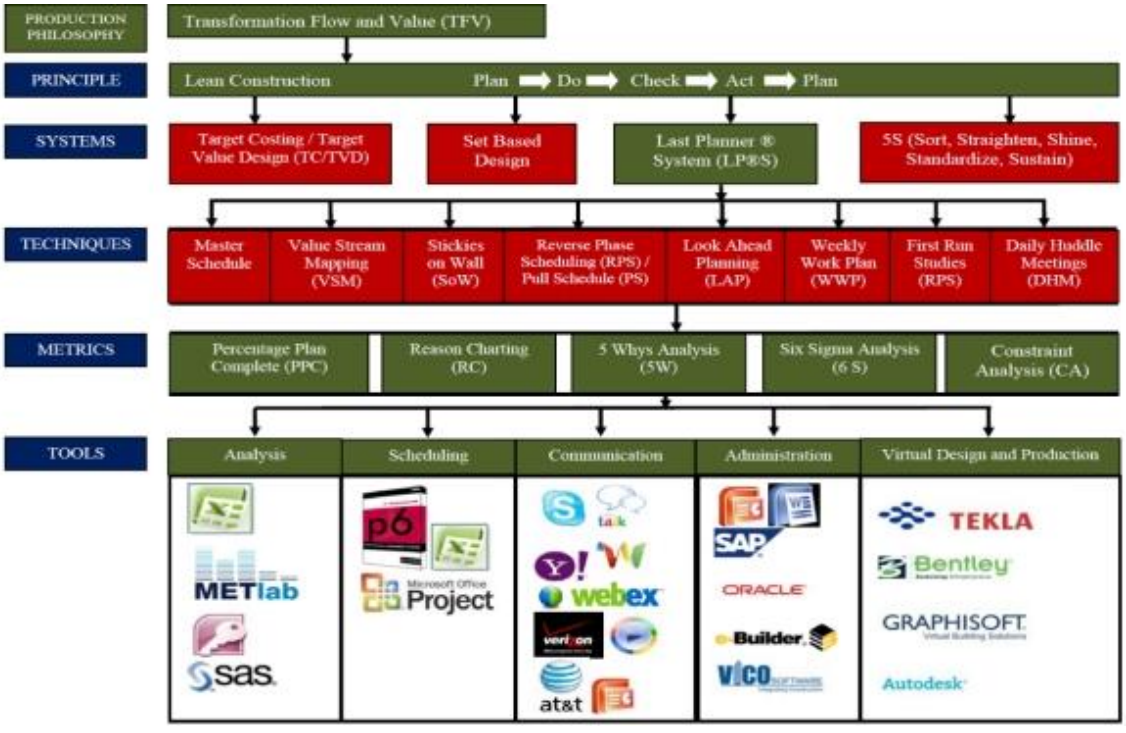

Figure 2.7: Lean Management in Construction: A Systemic View

(Source: Jose Fernández-Solís, Vishal Porwal (2009)

Conclusion:

The purpose of the entire analysis work was to learn the application of LEAN scheduling techniques in medium scale real estate industry. It is possible to identify various reasons for waste occurring during the project execution phase. The primary goal of this research is to improve the builders' ability to make decisions regarding the best construction-coordinated technique for a real estate project.

Using various literature from previous studies carried out on Lean Manufacturing, Real Estate Industry, Lean Tools and Techniques, Lean Scheduling, Last Planner system, a systematic approach to analyse a residential project under Lean scope can be carried out.

Following are the areas on which detailed roadmap was known after thorough review of these literature:

1. Understanding the process of lean manufacturing and necessity to identify wastes in construction industry.
2. Various types of waste prevailing in the real estate projects that cause variance in achieving project goals in terms of cost overrun and schedule delays.
3. Identifying various non value adding processes and activities that cause schedule delay in a real estate project.
4. Listing and detailed information collection about various Lean Construction Technique & Tools.
5. Identified the pertinence of LPS in Lean-Scheduling and to apply Pull Scheduling technique rather than conventional scheduling.
6. Finally, recognising Touchplan® as an efficient pull scheduling software.

References:

1. Anon. 2018. “Last Planner ® System.”
2. Aziz, Remon Fayek, and Sherif Mohamed Hafez. 2013. “Applying Lean Thinking in Construction and Performance Improvement.” *Alexandria Engineering Journal* 52(4):679–95. doi: 10.1016/j.aej.2013.04.008.
3. Devaki, M. P., and R. Jayanthi. 2014. “Barriers to Implementation of Lean Principles in Construction Industry.” *International Journal of Engineering Research & Technology (IJERT)* 3(5):1189–92.
4. Dikmen, Irem, M. Talat Birgonul, and H. Erol. 2017. “A Construction Delay Analysis Approach Based on Lean Principles.” (July). doi: 10.24928/2017/0175.

5. Dupin, Patrick Guy. 2021. "USING PULL AND FLOW SYSTEMS TO IMPROVE PRODUCTION STABILITY IN REAL ESTATE DEVELOPMENT PROJECTS." (July).
6. El Sakka, Fatima, et al., (2016) Integrating lean into modular construction: a detailed case study of company X. Proceedings of the 24th Annual Conference of the International Group for Lean Construction.
7. Fernandes, N. B. L. S., et al., (2016) Proposal for the structure of a Standardization manual for lean tools and processes in a construction site. 24th Annual Conference of the International Group for Lean Construction, International Group for Lean Construction, Boston.
8. Franco, Jéssica V., and Flávio A. Picchi. (2016) Lean design in building projects: Guiding principles and exploratory collection of good practices. Proceedings of the 24th annual conference of the International Group for Lean Construction, Boston, MA, USA.
9. Foon, Low, and Chong Heap. 2012. "A Comparative Approach of Japanese Project Management in Construction , Manufacturing and IT Industries." 57:193–200. doi: 10.1016/j.sbspro.2012.09.1174.
10. George, Barbosa, Andrade Fabíola, Biotto and Clarissa, and Mota Bruno. 2016. "IMPLEMENTING LEAN CONSTRUCTION EFFECTIVELY IN A YEAR IN A CONSTRUCTION." *SIIPRO, Lean and BIM Consultancy Pubication* (May).
11. Ghosh, Somik, Matt Reyes, Anthony Perrenoud, Van Vleet Oval, Van Vleet Oval, Van Vleet Oval, and Oklahoma City. 2017. "Increasing the Productivity of a Construction Project U Sing Collaborative Pull Planning." 825–36.
12. Hamzeh, Farook, et al., (2016) The first extensive implementation of lean and LPS in Lebanon: results and reflections. Proceedings of the 24th annual conference of the international group for lean construction, Boston, EE. UU.
13. Hermes, Michael. (2015) Prefabrication & modularization as a part of lean construction-Status quo in Germany. Proceedings for the 23th Annual Conference of the International Group for Lean Construction.
14. Issa, Usama Hamed. 2013. "Implementation of Lean Construction Techniques for Minimizing the Risks Effect on Project Construction Time." *Alexandria Engineering Journal* 52(4):697–704. doi: 10.1016/j.aej.2013.07.003.
15. Jadhav, Sonali A., and D. I. Mittapuli. 2018. "Application of Lean Construction in Commercial Building." *International Journal of Innovative Science and Research Technology* 3(7).
16. Jati Utomo Dwi Hatmoko, Human Adi Darmawan, Zuldi Sabrian, and Mochamad Agung Wibowo MATEC Web of Conferences 195, 06012 (2018) https://doi.org/10.1051/matecconf/201819506012
17. Johansen, Eric, and Lorenz Walter. (2007) Lean construction: Prospects for the German construction industry. Lean construction journal 3.1: 19-32.

18. Kanafani, Jamil A. (2015) Barriers to the implementation of lean thinking in the construction industry–the case of UAE. Master of Business Administration, Master thesis, University of Leicester, Leicester.
19. Khaba, Sorokhaibam, and Chandan Bhar. (2017) Modeling the key barriers to lean construction using interpretive structural modeling. Journal of Modelling in Management.
20. Khanh, Ha Duy, and Soo Yong Kim. (2014) Identifying causes for waste factors in high-rise building projects: A survey in Vietnam. KSCE Journal of Civil Engineering 18.4: 865-874.
21. Ko, Chien-Ho, and Neng-Fu Chung. (2014) Lean design process. Journal of Construction Engineering and Management 140.6: 04014011.
22. Li, Shuquan, et al., (2017) A study on the evaluation of implementation level of lean construction in two Chinese firms. Renewable and Sustainable Energy Reviews 71: 846-851.
23. Lindhard, Søren, and Søren Wandahl. (2014) Exploration of the reasons for delays in construction. International journal of construction management 14.1: 36-44.
24. Liu, Min, Glenn Ballard, and William Ibbs. (2011) Work flow variation and labor productivity: Case study. Journal of management in engineering 27.4 (2011): 236-242.
25. Mohammad Asri, Mohammad Azwanie Naim, and Mohd Nasrun Mohd Nawi. (2015) Actualizing lean construction: Barriers toward the implementation. Advances in Environmental Biology 9.5: 172-174.
26. Murguía, Danny, Xavier Brioso, and Angela Pimentel. (2016) Applying lean techniques to improve performance in the finishing phase of a residential building. 24th Annual Conference of the International Group for Lean Construction. IGLC Boston, Ma, USA.
27. Nikakhtar, Amin, et al., (2015) Application of lean construction principles to reduce construction process waste using computer simulation: a case study. International Journal of Services and Operations Management 20.4: 461-480.
28. Ogunbiyi, Oyedolapo, Jack Steven Goulding, and Adebayo Oladapo. (2014) An empirical study of the impact of lean construction techniques on sustainable construction in the UK. Construction innovation.
29. Olamilokun, O. (2015) Investigating facilitators and barriers for adopting lean construction principles in the Nigerian building consulting firms. International Journal of Innovative Research & Development 4.12: 234-239.
30. Porwal, Vishal, Bhargav Dave, Jose Fernandez-Solis, Lauri J. Koskela, and H. S. Mehta. (2012) State of production plan reliability–a case study from India.
31. PATEL, DHRUV, and J. R. Pitroda. 2021. "APPLICATION OF LEAN TOOLS IN CONSTRUCTION OF REAL ESTATE PROJECT." (April). doi: 10.29121/ijesrt.v10.i4.2021.6.

32. Patel, Mayurkumar, J. R. Pitroda, and J. J. Bhavsar. 2016. "SUCCESS FACTOR FOR SMART INFRASTRUCTURE DEVELOPMENT THROUGH Success Factor for Smart Infrastructure Development through Lean Management : A Review." (February 2017).
33. Ramaswamy, K. P., and Satyanarayana N. Kalidindi. "Waste in Indian building construction projects." Proceedings of the 17th Annual Conference of the IGLC. Taipei, Taiwan. 2009.
34. Raghavan, N., Satyanarayana Kalidindi, Ashwin Mahalingam, Koshy Varghese, and A. Ayesha. 2014. "IMPLEMENTING LEAN CONCEPTS ON INDIAN CONSTRUCTION SITES : ORGANISATIONAL ASPECTS AND LESSONS." *IGLC- IITM* 1181–90.
35. Raol, Parthrajsinh H., Sagar Deshmukh, and J. R. Pitroda. 2021. "Integration of BIM with Lean Principles in Indian Construction Industry." (August).
36. Rached, Farid, et al., (2014) Implementation of IPD in the Middle East and its Challenges. Proceedings International Group for Lean Construction : 293-304.
37. Ramaswamy, K. P., and Satyanarayana N. Kalidindi. "Waste in Indian building construction projects." Proceedings of the 17th Annual Conference of the IGLC. Taipei, Taiwan. 2009.
38. Sacks, R., A. Esquenazi, and M. Goldin. 2007. "LEAPCON : Simulation of Lean Construction of High-Rise Apartment Buildings." 133(7):529–39.
39. Sacks, R., and M. Goldin. 2007. "Lean Management Model for Construction of High-Rise." *ASCE* (May):374–84.
40. Song, Lingguang, Daan Liang, and Aditi Javdekar. 2007. "A Case Study on Applying Lean Construction to Concrete Construction Projects." (1996).
41. Soomro, Mohsin, and Aftab Memon. n.d. "Current Status of Lean Construction Techiques in Local Construction Industry."
42. Srinivas, K. 2020. "Lean Construction in a Real Estate Project - A Case Study." 01(02):25–29.
43. Sarhan, Jamil Ghazi, et al., (2017) Lean construction implementation in the Saudi Arabian construction industry. Construction Economics and Building 17.1: 46-69.
44. Shang, Gao, and Low Sui Pheng. (2014) Barriers to lean implementation in the construction industry in China. Journal of technology Management in China.
45. Shin, Mingyu, et al., (2014) A system dynamics approach for modeling construction workers' safety attitudes and behaviors. Accident Analysis & Prevention 68: 95-105.
46. Singh, Bhim, Suresh K. Garg, and Surrender K. Sharma. (2011) Value stream mapping: literature review and implications for Indian industry. The International Journal of Advanced Manufacturing Technology 53.5-8: 799-809.

47. Singhal, Rohan, et al., (2018) MDM-based buffer estimation in construction projects. 26th Annual Conference of the International Group for Lean Construction (IGLC), 18-22 July, Chennai, India.
48. Small, Edgar P., Khaled Al Hamouri, and Husameddin Al Hamouri. (2017) Examination of opportunities for integration of lean principles in construction in Dubai. Procedia engineering 196: 616-621.
49. Tezel, B. A., and Z. U. H. Aziz. (2017) From conventional to IT based visual management: a conceptual discussion for lean construction. Journal of information technology in construction 22: 220-246.
50. Tiwari, Saurabh, and Partha Sarathy. n.d. "PULL PLANNING AS A MECHANISM TO DELIVER CONSTRUCTION DESIGN." (Icc).
51. Verutti, Josselyn. 2019. "Best Practices for Lean Scheduling and Coordination in Commercial Construction." *California Polytechnic State University San Luis Obispo, CA Efficiency*.
52. Vaidyanathan, Kalyan, et al., (2016) Application of lean principles to managing construction of an IT commercial facility-an indian experience. 24th Annual Conference of the International Group for Lean Construction. International Group for Lean Construction Buston, MA, USA.
53. Viana, Daniela Dietz, Carlos Torres Formoso, and Bo Terje Kalsaas. (2012) Waste in Construction: a systematic literature review on empirical studies. ID Tommelein & CL Pasquire, 20th Annual Conference of the International Group for Lean Construction. San Diego, USA.