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**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY****APPLICATION OF LEAN TOOLS IN CONSTRUCTION OF REAL ESTATE
PROJECT****Dhruv Shaileshbhai Patel ^{*1}, Dr. J. R. Pitroda ²**

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DOI: <https://doi.org/10.29121/ijesrt.v10.i4.2021.6>**ABSTRACT**

In the Indian economy, the real estate industry is of significant importance as it contributes between 6-8% to the Indian gross domestic product (GDP). Indian real estate building has fantastic growth prospects. Some Challenges such as Waste generation, Lack of skilled labour, Time overrun, Cost Overrun, Low Productivity etc. Average cost of waste as Proportion of cost of the project, excluding the cost of Performance varied from 5.38% to 14.70%.for Waste reduction and improve the productivity construction companies have started improvement through Lean Construction. It is essential to recognize waste and its related root causes at Indian construction sites in order to adopt lean principles, in which a major focus is on waste minimization. To evaluate the goals and functionalities of each LC instrument, a systematic literature review will be carried out. The functionality of lean software must be consistent with the accompanying procedures in order to effectively implement LC. The work presented would assist construction project management in making informed decisions on construction sites to schedule, handle, and monitor work activities related to equipment.

KEYWORDS: Lean Construction, Value stream mapping, Last Planner Systems, Kaizen, Construction**1. INTRODUCTION**

In the Indian economy, the real estate sector holds significant importance as it contributes about 6-8% to the Indian gross domestic product (GDP) and is projected to contribute about 13% by 2025. The Indian real estate market is anticipated to cross USD 1 trillion by 2030, being the third largest worldwide. It is also the nation's third largest employer (after agriculture and production) and reportedly hires more than 50 million workers.

With its mission of driving progress and growth for the real estate industry, the National Real Estate Development Council (NAREDCO) is pleased to host a workshop on "Real Estate - Sales and Marketing in Current Times" along with EY (knowledge provider), for a powerful live session on a shared forum to share ideas and experiences. The need for residential units has always existed only to provide a history, but the confusion due to COVID-19 has generated a huge disturbance for investors, clients, financial institutions, and the related eco-system. It has also created a fresh opportunity and a way of working with the ecosystem as a whole.

Lean theory is a focused on lean manufacturing principles. In the beginning, Henry Ford implemented the assembly line concept, which revolutionized the automobile manufacture. Toyota, led by engineer. Ohno introduced early lean production management concepts. Taiichi Ohno, father of Toyota Production Company has been focused on seeking means of transforming 'muda,' as well as moving emphasis and thoughts on worker's efficiency and mass production of machinery from the limited focus of craft production to the entire production sector.

Lean Construction (LC) is a different approach to project management, since it has specific priorities for the implementation process. It is designed to optimize customer performance at the project level, designs products and systems simultaneously, and exerts control of output over the whole product life from creation to production.

2. NEED OF STUDY

Building and demolition waste is not only defined as physical waste, but also includes waste created from construction activities such as transport, waiting times, excess materials, rework, delays, and defects.

Waste is often defined as any construction operations or procedures that generate costs that do not add value to the construction project directly or indirectly. These construction activities can include value-adding & non-value-adding activities (wastes, wasteful operations). Building waste may be due to structural flaws, modifications, redoing work, failures and the use of excess materials. Therefore, ensuring that waste generation is minimized in construction is important Activities and procedures.

3. OBJECTIVES OF STUDY

Following are the destinations of directing this examination.

- 1) To identify the problems faced by “real estate project” & which can be solved by Lean procedure.
- 2) To identify the lean construction Practices which can be apply during the different phase of project.

4. LITERATURE REVIEW

Lean Construction Institute (2014), Lean Enterprise Institute (2008) has identified lean practices that are particularly applicable to the construction process. A summary list of common lean practices implemented during construction is provided in Table 1.

Table 1. Lean Practices for the different phase of Projects

| Category | Common Practices |
|-----------------------------|--|
| Lean Design Practices | Cross-functional teams |
| | Deferring Decisions to the last responsible moment |
| | Early involvement of specialty contractors |
| | Frequent team communications |
| | Last Planner System (LPS) |
| | Pull Scheduling |
| | Set-Based Design |
| | Simultaneous product and process design |
| | Target Value Design |
| | Waste Reduction |
| Lean Construction Practices | 5 S's |
| | 5 Whys |
| | Andon |
| | First-run Study |
| | Integrated Project delivery (IPD) |
| | Just-in-time (JIT) |
| | Kaizen |
| | Kanban |
| | Kitting |
| | Last Planner System (LPS) |
| | Lean Project delivery System |
| | Value Stream Mapping |
| | Work Structuring |

S.K.Garg et al.(2011)[37] summarizes available literature published in refereed journals, conferences and books on Value Stream Making and its applications in different areas all over the world from 1990 to 2010 and classified it according to classification scheme given by in to four categories (1) conceptual work, (2) empirical/modelling work, (3) case studies, (4) survey articles. Based on that attributes in accordance to their decreasing order of importance in the literature in Table 2.

Table 2. Importance based on various attributes during Value Stream Mapping

| | | | | | | |
|---------------------|------------------------|--------------------------|------------------------|------------------------|------------------------|----------------------|
| Attributes | Value Addition | Takt Time | Waste of Transporation | Continuous Improvement | Lead Time Reduction | Current State Map |
| % importance | 64 | 50 | 46 | 42 | 40 | 40 |
| Attributes | Future State Map | Finished-Goods Inventory | Cycle Time Reduction | Zero Defects | WIP | Setup Time Reduction |
| % importance | 40 | 34 | 32 | 30 | 30 | 28 |
| Attributes | Raw Material Inventory | Electronic informatoion | Bottle Necking | Pace Maker Process | Proximity of Suppliers | Kanban |
| % importance | 28 | 28 | 28 | 24 | 22 | 22 |
| Attributes | Kaizen burst | Small shipment size | Suppliers involvement | Flexible Supplier | Reduction in Manpower | |
| % importance | 22 | 20 | 18 | 14 | 12 | |

Min Liu, A.M.Asce et al. (2011)[24] in this paper different flow variation and how they affect workflow in project had been studied using previous research papers. Relationship between workflow and labour factor were evaluated by data collected from 134 weeks of production. The labour productivity was correlated with Percent Plan Complete. This finding will help the project manager achieve more effectiveness in productivity and contractors to find the productivity loss.

Samaila Adamu et al. (2012)[1] was performed research in Nigeria by to determine the efficacy of lean building. A field research was carried out to compare the last planning scheme and the conventional approach of constructing 300 homes in the Yobe State of Damaturu. The research was finished before the planned date by using LPS and it did not take longer than expected time to achieve it in the conventional process. The outcome of this paper is to provide contractors with productive instruction on lean construction to create a seamless workflow process and reduce construction waste.

Raid Al-Aomar et al. (2012)[2] the paper tries to identify lean construction practise in Abu Dhabi construction. A survey was conducted in local construction companies to identify waste. In the result 27 construction waste and 18 key causes for waste was identified. This study helped to understand current construction waste and usefulness in adopting lean techniques.

Usama Hamed Issa et al. (2013)[17] this study is based on minimizing the risk factor on time using lean construction techniques. The evaluation was made with two tools Percent Expected Time (PET) overrun and Percent Plan Completed (PPC). First risk was identified and then PET was applied, schedule was revised regularly using PPC. By doing this total project time was minimized 15.57% due to decreasing PET value and increasing PPC value.

M.Abdul Mannan Hussain et al. (2014) [3] this paper says that lean has gained its position in construction industry in developed nation, now the real challenge lies in implementing it in developing nation like India. The effectiveness of last planner system was tested by implementing it in local construction on reducing complexity in construction. It was appropriate in solving construction complexity and it gave idea in better planning and perfectly predicting the project cost.

Chien-Ho Ko et al. (2014) [22] this author strongly believed that waste can be minimized by proper design. First waste is identified in design and planning, then design is revised by eliminating waste and reducing design errors. New design had increased the reliability on design and attained smooth work flow.

Soren Lindhard et al. (2014) [24] this author says variation is root causes for generating waste because it interprets the workflow and reduce productivity. Hence variation should be handled with more care. Some and Pudukkottai area. literature reviews were made and few terms for measurement of variation was selected like Network Gap, Variation Gap, waiting days, Delay total, Delay negative, delay positive with this term's variation was found. Variation was found to be more in on-site construction. Variation is not creating waste itself the waste is only emerging between handoffs.

Hyun-Soo Lee et al. (2014) [38] this paper is about relationship between workflow and labour factor like stability and loyalty. A model was developed based on assumption about labour loyalty and worker change ratio to evaluate the above relationship, path analysis was adopted to check causal model. Based on some measurement factors like Waiting time ratio, worker attendance ratio, worker change ratio this relationship was evaluated. It was concluded that these factors must be maintained properly in order to attain good construction work process.

Mohammad Azwanie Naim Mohammad Asri et al. (2015) [26] this author strongly believed that lean construction can be effective when overcoming the barriers in implementation. A literature review was made to find the barriers in implementation of lean construction. Major barriers found from review was Management aspect, Financial aspect, Educational aspect, Governmental aspect, Technical aspect and Attitudinal aspect. By overcoming this barriers lean can be more effective.

Richard Hannis Ansah et al. (2016) [3] this research is to use lean construction with robust approach because by using traditional method (work breakdown structure, CPM, PERT) more complex project which have long, complicated supply chain, a greater number of players, multiple design change has failed miserably. Literature survey was made and effectiveness of lean was understood and concluded that by using lean waste will be minimised, performance will be increased and cost saving both for industry and society.

Franco and Picchi et al., Khodier and Othman et al. (2016) [14] have identified the key lean principles include (i) eliminate non-value add-in (ii) improved consumer demand consideration (iii) minimize uncertainty (iv) reduce cycle time (v) simplify by reducing stage and phase number (vi) enhance the performance consistency (vii) improving the transparency of the process (viii) focus on full system management (ix) building quality improvement in the process.

It can indeed be concluded from the above-mentioned submissions that the underlying purpose of lean thought and approach to production is ultimately the use of less effort and energy to achieve optimum consumer satisfaction and to minimize all types of waste; and can therefore be described as a sustainable approach to production.

Problem faced in Real Estate Industry

From the different Literature and identifying the problems faced by "real estate industry" in various phases of the project & Some are listed below Table 3.

Table 3. Problem faced in Real Estate industry by various Researches

| Sources | Problems |
|---|---|
| Small et al. (2017) [39],Khaba and Bhar (2017)[20] | Lack of awareness and lack of consumer interest |
| Cano et al. (2015) [10] | Resistance to change management |
| Bashir et al. (2015)[9] | lack of a long-term plan and philosophy |
| Cano et al. (2015) [10],Viana et al. (2012)[42] | Lack of waste detection and controls |
| Fernandez-Solis et al. (2012)[31], Khanh and Kim (2013)[21] | Insufficient administration of the knowledge required for the generation of a training cycle and corrective steps |
| Li and Ma (2017)[23], Awada et al. (2016)[4], Olamilokun (2015)[30] | The project members are unable to share risks |

| | | |
|--|----------|---|
| Olamilokun (2015)[30], (2015)[19] | Kanafani | Hierarchies in the systems of organizations/ inappropriate organisation. |
| Olamilokun (2015)[30], (2015)[19] | Kanafani | Lack of delivery and delays in delivery of goods |
| Herrala et al. (2012), Kanafani (2015)[19] | | Long-term supply partnerships |
| Aapaoja and Haapasalo (2014)[5] | | Less use and lack of prefacing of off-site building techniques |
| AlSehaimi et al. (2014)[6], Kanafani (2015)[19] | | The decentralized essence of the buildings industry has joined so many businesses, in particular subcontractors and suppliers |
| Kanafani (2015)[19], Khaba and Bhar (2017)[20] | | Failure to incorporate contracts |
| Tezel et al. (2017)[40], Khaba and Bhar (2017)[20] | | Employees oppose changing and dread uncertain procedures |
| Bashir et al. (2015)[9] | | centralize decision-making to stop decision-making to assume responsibility among those not at top level |
| Hamzeh et al. (2016)[15], Awada et al. (2016)[4] | | Mismatch between stakeholder representation and accountability |
| Gao and Low et al. (2014)[35] | | high labor turnover |
| Khaba and Bhar (2017)[20] | | Lack of inspiration and benefits and low skilled salaries |
| Small et al. (2017)[39], Khaba and Bhar (2017)[20], Kanafani (2015)[19], Gao and Low et al. (2014)[35] | | Any government funding & finance origins & contract approvals |

Mughees Aslam(2020) [7] finding that Theoretically, the results of this analysis will be applied to the current body of information by providing a thorough assessment of the aims and functionalities of various methods and a guide for choosing the best lean tools. And functionally, the result of this research will make it easy for designers to use resources that are entirely compatible with lean standards and project specifications and will still be viable in the future.

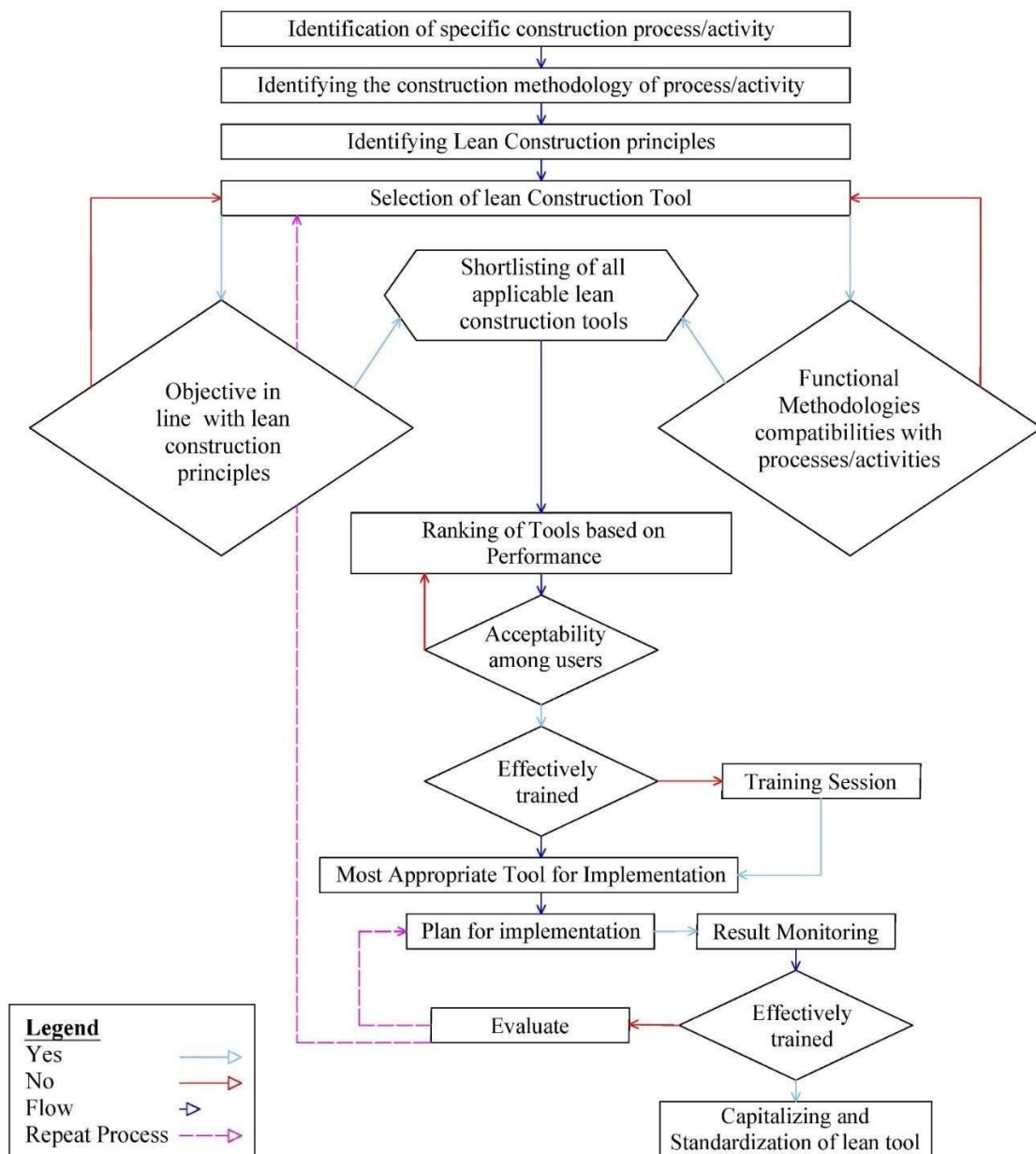


Figure 1. Process for Implementation of activity in real estate projects

Lean Construction Practices (LCPs)

From the Literature Survey from 2000 to 2020 & identifying the Lean Construction Practices (LCPs) and then those have been categorized into four main groups based non areas of their possible implementation in the design, planning and construction of building and real estate projects.

These four categories are

1. Design and Engineering practices (DEPs)
2. Planning and Control Practices (PCPs)
3. Construction and Site Management Practices (CMPs)
4. Health and Safety Management Practices (HSMPs).

Table 4. Design & Engineering Practices (DEPs)

| DEPs | Description | Sources |
|------------------------------------|--|---|
| Virtual Design construction (VDC) | Computer-aided modeling (CAD) design platform and simulations. It can also be used to evaluate specification and design defects and direct error-free design transition for manufacturing or prefabrication. It is also possible. | Franco & Picchi, 2016[14] |
| Design structure matrix (DSM) | Using to organize the design process into series segments | Johansen & Walter, 2007[18] |
| Prefabrication and Modularization | In producing components in an offsite warehouse which are transported to the prefabrication plant for installation. The modularization consists of splitting spaces into replicated segments or equal-sized modules to enable mass prefabrication processes of project components. | Hermes et al. (2015)[16] |
| Detailed briefing | Customer briefs review and brief transition to design | Seim et al., 2012[36] |
| Design workshops/big room workshop | This is a conference space for project planners, which explores and analyzes the whole concept and operation, to solve challenges and propose new suggestions for design solutions. | Vaidyanathan et al. 2016[41] |
| Integrated project delivery (IPD) | The project delivery strategy includes the conclusion of a deal between the customer and main planners, vendors and other project stakeholders. | Riached, Hraoul, Karam & Hamzeh, 2014[32] |
| Target Value Design (TVD) | A project-oriented planning tool based on customers set expense and time goals. | Franco & Picchi, 2016[14] |
| Standardization | The use of agreed measurements, specifications and requirements for the design and execution of the Project Part. | Fernandes, Valente, Saggin, Brito, Mourao and Elias, 2016[13] |
| Concurrent Engineering (CE) | In order to achieve practical architecture, a result of high quality and an efficient operation, this includes exchanging the knowledge collaboratively in the execution of various activities in a project. | Sarhan et al. (2017)[34] |

Table 5. Planning & Control Practices (PCPs)

| PCPs | Description | Sources |
|---|---|------------------------------|
| Last planner system (LPS) | LPS is an improving planning and management mechanism used for building phase tracking. Which covers the introduction of master planning, phase planning, forward planning and weekly planning. | Li et al., 2017[11] |
| Work structuring and scheduling | This is used to segment design into sequentially and independently small elements such that job uncertainty is minimized. | Murguia et al. 2016[27] |
| Location-based management system (LBMS) | This models the development process to tasks and, according to their relationships, each module is related. | Vaidyanathan et al. 2016[41] |
| Benchmarking | Benchmarking consists of separating building jobs into parts with a reward plan added to each segment of a team of staff as the strategic and inspiring source for tasks teams. | Andersen et al. 2012[8] |
| 6 Sigma | It helps to evaluate the building process from a mathematical viewpoint (i.e. the detection of challenge, evaluation of results, | Sarhan et al., 2017[34] |

| | | |
|--|---|--|
| | analysis of variations) to ensure continuous process development. | |
| Value based management (VBM) or value stream mapping (VSM) | This Technique is used to chart non-value added operation to optimize value and bring it to the consumer in the course of development. | Murguia et al. 2016[27] |
| Daily cluster or huddle meeting | Regular cluster or huddle meetings entail all project managers gathering to address project problems and thereby further enhance contact between project managers and site personnel. | Sarhan et al., 2017[34] |
| Pull Scheduling/ planning | The whole supply chain process consists of the collection of resources to get it available for manufacturing in compliance with the project schedule or strategy. | Franco & Picchi, 2016[14] |
| Error proofing (Poka- yoke) | This is used in the pre-compliance check of errors in the construction process to prevent the free flow of errors. | Nikakhtar, Hosseini, Wong, and Zavichi, 2015[28] |

Table 6. Construction & Site Management Practices (CMPs)

| CSMPs | Description | Sources |
|--|---|---------------------------|
| Gemba walk | In order to discover the root of a problem and fix it, it requires investigating the origins of an issue. | Franco & Picchi, 2016[14] |
| Total productive/ Preventive maintenance (TPM) | It is a hands-on protective technique to protect the facilities of the site director. This means that, when they use it, operators take care of their facilities. | Sarhan et al., 2017[34] |
| Kanban system | This is an ancient lean instrument that requires the use of an inventory management card or a stock taking sign on the site of the project. This tends to facilitate productive holding of inventory and recording on building project sites. | Sarhan et al., 2017[19] |
| 5s Onsite management | In order to ensure effective building site management, 5S means sorting, straightening, shining, standardizing, and sustaining of all site processes and practices. | Li et al., 2017[11] |
| First run study | This is the modeling of construction site activities that is necessary, especially when those involved have little to no idea about the operation. It needs the analysis of mistakes and the avoidance or reduction of alternate methods. | Ogunbiyi, 2014[29] |
| Kaizen | In any construction site phase, this promotes continual progress. | Sakka et al., 2016[12] |
| Teamwork and Partnering | As the name suggests, this entails cooperation with all parties in the building process, such as buyers, builders, architects, contractors, vendors and others. | Franco & Picchi, 2016[14] |
| Total quality management (TQM) | TQM is a construction management method used to define and analyze potential challenges, to create and apply new solutions and to evaluate outcomes. | Sarhan et al., 2017[34] |
| Just-in-time (JIT) | JIT allows the supplies, details and sketches or something needed for a project to be shipped to the point of use promptly. | Sarhan et al., 2017[34] |
| Visualization tools/management | VM is a method used for sending precise instructions to on-site staff. It could require the use on building sites of sign boards or posts in specified areas. | Sarhan et al., 2017[34] |
| Conference Management (CM) | CM is a lean tool for coordinating conferences, workshops and trainings on a project. | Li et al., 2017[11] |

Table 7. Health & Safety Management Practices (HSMPs)

| HSMPs | Description | Sources |
|--|---|---------------------------------|
| Fail safe for quality and safety, | It helps to mitigate disruption on site, in some cases ensuring that no employee is injured at all on site by anticipating the likely likelihood of my incident and taking preventive measures to prevent it. | Ogunbiyi, 2014[29] |
| Plan of conditions and work environment or ESM | In preparing for safety and health by evaluation, detection, and management of probable risk, this lean approach is useful. It normally requires planning and setting the arrangements necessary to ensure the maximum protection of the employees. | Sarhan <i>et al.</i> , 2017[34] |
| Health and Safety improvement management | This is an innovative lean tool that includes preparing for site workers health and safety conditions. | Sarhan <i>et al.</i> , 2017[34] |

Aslam, Mughees *et al.* (2020) [7] has identify the data set, LC tools are further classified into groups of objectives. Reducing process variabilities is the objective targeted by the most tools. Nineteen (19) out of twenty-two (22) (or 86%) tools have the objective of reducing process variabilities. This suggests that researchers and companies implementing teams are keeners in reducing the process variability within the construction to control the waste. Similarly, the objective of improving the workflow, one of the major principles of LC, is targeted by thirteen (13) (or 59%) of the LC tools. 41% or Nine (9) tools have the objectives of reducing design and planning variabilities.

Table 8. Lean Tools & Objectives

| Lean Tools Objectives | L | V | D | F | S | F | S | K | J | K | C | P | L | P | T | S | B | I | S | T | V | F |
|-------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | M | H | R | S | S | S | A | I | A | E | F | O | Y | O | P | I | P | B | V | S | M |
| | S | | M | S | | Q | | N | T | Z | | | B | | C | | M | D | D | D | M | A |
| 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 | * | * | | | * | * | | * | | * | | | * | | * | | | | | * |

5. CONCLUSION

This work presented from Literature the Last Planner System is full fill the most of the Objectives so this technique is used for Lean Construction Implementation. All lean tools are majorly used for reduce the process differences, continues improvements & improving workflow & its work on that effectively for improving productivity. From the Literature the Key Lean principles, Implementation by P-D-C-A cycle approach & terminology which are taken care during the implementation are listed likes. Lead time, Current State map, Future State map etc. The Major barriers in implementation of lean construction found from reviewers was Management aspect, Financial aspect, Educational aspect, Technical aspect and Attitudinal aspect.

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