

Lean Construction

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Abstract: Lean construction is a new way philosophy to manage construction processes. However, Lean Construction is a concept that can develop advanced and original changes in the construction area and a way to design production systems to minimize waste of materials, time, and effort to generate the maximum possible amount of value for customers. To become a Productive Engineer Lean Techniques and Lean Tools must be learned. Today India is a rapidly growing economy in which Construction plays a vital role. Every construction industry whether it is on a small scale or big challenges the issues of delays in possession, budget overruns, and providing sustainable construction with good quality. One approach for improving the situation is using Lean Construction Techniques. This case study aims to apply Lean Construction concepts desirably, proper implementation, and to demonstrate its influence on the Cost, Time, and Quality of the project.

Keywords: Just in Time, Lean construction, Lean tools.

1. Introduction

In today's world, it has become most important to the construction company to improve the quality of their work, increase work effectiveness, and reduce cost and waste with increased profit. At the same time, the combination of specified project duration, high quality as well as the low cost has become a key engineering and managerial effort in facing the growing competition in the construction business. Such a kind of approach cannot be managed by conventional methods just like Traditional Construction Method for example Critical Path Method, PERT, Earned Value method, etc. In a Construction firm, most construction managers agree that the industry is susceptible to cost and time overruns, multiple wastes, errors, and inefficiency. As a result, 70% of projects are over budget and delivered late. The purpose of this paper is to understand the concepts, implantation of lean tools, and techniques in the construction industry. The concepts of Lean construction were drawn from Toyota Production Management (originally developed at Toyota Production System in the 1950s) to create a new way to manage construction projects (Womack and Jones, 2003). This method is all about to build the project while maximizing value, minimizing waste, and engaging people in innovations. In the context of both construction and production, Waste is primarily defined in seven categories: Over-production, waiting, excess inventory, unnecessary

transport and conveyance of materials and equipment and, unnecessary motions and movement of people, defects (rework of errors), over-processing. It is the collection of data to improve the delivery and design processes in a construction firm. It also improves the growth of productivity level in this sector. Although this concept is still new to many construction industries, previous research showed that minimizing cost using lean methodology is the best supportive sustainability through "reducing waste and increasing cost" and also this industry transformed from the traditional project management approach to the Lean management approach. According to Ballard and Howell (2003), countries such as the UK, Australia, the USA, and Brazil have gained significant benefits from the adoption of Lean Construction concepts. It increases the quality of the work by eliminating waste, minimizing cost and time, and optimizing efforts in the industry.

2. Objectives

- The main objective of this study is to quality, cost, delivery, and safety and identify the benefits of implementation of lean management.
- Quality and Cost: Increasing the quality level of a project by means removing non-value-added activities and minimizing the cost of a project.
- The benefits and challenges of the lean implementation should be identified.
- To find out loopholes in the construction industry regarding lean construction and to suggest remedial majors.
- To eliminate non-value-added activity on sites.
- A production approach that preserves value and minimizes waste.

3. Purpose

- The construction industry coming out with new infrastructure development. As companies are increasing nowadays, competition between them also increased and to get high profit. To avoid that kind of problem companies adopted the new and innovative technology, this technique called lean management. This will improve construction work.
- The purpose of this project is to improve the performance level of work on the construction site.
- Proper scheduling for standardized work completion is

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adopted.

- Execution of work properly and implement lean tools like just in time and pull approach method.

4. Lean Construction

Lean construction principles in the construction industry have been investigated by the researchers for past two decades. Lean construction is the project management theory based on a set of approaches in production management. Lean Construction is a philosophy based on lean principles that were developed by Toyota Production System (TPS) over the last 50 years. It is named lean manufacturing principles and further developed as lean Construction and Lean Philosophy. It was assigned to eliminate waste (Howell, 1999). Lean principles state that conversion activities add values and non-add values are flowing activity should be eliminated or reduced (Koskale, 1992). Ballard and Howell (2003) say that lean construction is targeted to minimize waste (i.e.) materials, money, and time and to maximize the value. According to Senaratne and Wijesiri (2008). However, Lean thinking or lean construction has been used significantly in countries like the UK, Singapore, Brazil, Chile, The Netherlands South Africa, Turkey, and many others countries. Lean construction is a new innovative concept in the construction industry. The elimination of waste from such processes can become "less" (Womack and Jones, 2003). Lean construction is the process of reducing waste regularly and meeting all the needs of customers stated by Salem and Zimmer (2008). Lean Construction is the application of lean principles, which gives an idea about the elimination of waste and non-value-adding activities in the process, of engineering and design. Lean manufacturing techniques are not only applied to the manufacturing but also applied in all services acclimatized and other environments. This is because each system has some levels of waste. This process is mainly based on a quality control method that reduces waste in the process to near preserve value and quality.

5 Components of Lean Thinking:

1) *Specify Value*

Customer needs at a specific time and specific price. It is about "measurements, Design, & Management".

2) *Value Stream*

Identify the chain of processes that add value to each service without no value-added step.

3) *Flows*

Effective and efficient flow of materials and information. Seek that services flow through the steps that create value, eliminating waste.

4) *Pull*

Allow the customer to use the service when they need it (create a pull system).

5) *Perfection*

Apply continuous improvement that is, the number of steps and the amount of time and information necessary to reach the customer continuously decreases.

5. Wastes in Construction

Lean construction is a method used to minimize waste and maximize profit. It is operated in the flow process continuously. Wastes are consuming resources without providing value. According to the new production theory, Waste is produced by any activities and it creates direct and indirect costs. Wastes are from the equipment, material, labor, or initial investment in large quantities. The waste in the companies increases the loss and execution of unnecessary work, which gives additional costs to the project. And from the clients' point of view, it does not add any value to the project. There are seven types of waste:

Overproduction: Overproduction is the process of fabricating material too soon or ordering extra material because of poor quality, rather than producing and delivering the right amount of material at the time it is needed. This means that there is an overlap between overproduction and inventory waste. If such waste happens, you will need to store it on an often-overcrowded site, in case your plan changes, you will need to change the materials you are using too.

Inventory: On the Construction site, inventory waste forms when excessive work is in progress. This includes all materials being stored on-site or at storing yard, work in progress, and unused tools or parts. Optimize your inventory to reduce this type of waste.

Waiting: This is any form of waiting that must be done by either staff or machinery to complete work. This will rarely happen when one process along the production line takes more time than required and results in wasted worker time. Employees can be paid when not being productive, and materials can be spoilt when waiting for production.

Transportation: Transportation is the process of moving materials from one place to another. Transportation itself does not add value to customers or products, so minimizing this cost is essential. Transport can also cause the waste of waiting, as one part of the production chain must wait for the material to arrive on site. Excessive movement of materials can be costly to your work and leads to damage quality of the project. Often, transportation may force you to pay additionally for time, space, and machinery.

Motion: This kind of waste is a result of movements of employees (or machinery), which are complicated and unnecessary. They can cause injuries, extended production time, and more. This includes time spent looking for a tool or file, as well as moving or walking extra yards due to improperly designed working areas. With 70% of a worker's day wasted on-field coordination. So, it's important to adopt construction management technology to reduce this number.

Over-processing: This type of waste usually refers to unnecessary steps taken in the project value chain such as double handling material or transforming. Work that does not bring any additional value, or it brings more value than required and increased your business cost. Instead of paper works can replace with blueprint software and having one place to communicate from will ensure the job site team and staff are always on the same page and information is not lost in various paper files.

Defects/ Rework: Defects are incorrect work that needs to be

repaired, replaced, or redone. Defects can cause rework, or even worse, they can lead to scrap. Most of the time, defective work should go back to production again, which costs valuable time. Sometimes, an extra reworking area is required, which comes with additional exploitation of labor and tools. For example, tiles not installed as per specifications or a finished wall damaged by the electrical contractor would fall under the category of Defects.

As above seven wastes are toxic to your project. However, you can see them more as an opportunity to improve quality and create value for projects by eliminating the above waste but there is an 8th waste that is mentioned in the literature, both in lean manufacturing and construction.

Skills and Underutilized Talent: The 8th waste of lean involves failing to make use of people's skills, creativity, or knowledge on a project. Your employees are your greatest asset, so they should be empowered with the tools they need to thrive. The help of Construction management software allows everyone from the office to the field to communicate and collaborate in real-time, ensuring that no idea goes unheard. Construction apps help to ensure that everyone's skills are being utilized.

6. Lean Tools

Lean construction uses many lean tools to improve production and value by getting the most out of each resource. The main aim of Lean construction is to find better ways to do things- requires less time, less effort, and fewer resources. Some lean tools may be more useful for one project than another. The manufacturing industry was developed the several lean tools as follows:

- Kaizen
- 5S
- Kanban
- Value Stream Mapping
- Focus PDCA
- Last Planner
- Just In Time
- Poka-Yoke
- Visual Management
- Stopping the Line
- Reverse Phase Scheduling
- Huddle Meeting
- Fail-Safe Quality
- Off-Site Manufacturing
- Target Value Design
- SMED- Single Minute Exchange of Diary
- Kamishibai
- TPM
- 5 Why
- Jidoka
- Andon System
- Overall Equipment Effectiveness

Kaizen:

The word Kaizen comes from Japan after World War II, Japanese words for "Good" and "Change." This tool mainly refers to activities that continually improve all processes and involve every employee from the executive team to front-line workers. "Kaizen means to find a better way and create rapid change in the workplace. Most of the time, individual improvements don't lead to major changes by themselves; rather, a continuous stream of small changes leads to major improvements in eliminating waste, productivity, and safety.

5S:

The 5S system is considered a "foundational" lean concept, as it designed the operational stability required for making and sustaining continuous improvements and the main approach to organization and cleanliness in the workplace. The five S fundamentals guidelines help to give better work efficiency. The 5S are Sort, Set in Order, Shine, Standardize and Sustain. It is an effective tool that helps the organization to improve the workplace more efficient and effective by Productivity, Quality, On-time delivery, Reducing cycle time, and minimizing inventory also some important points are as follows:

1. Sort:

Removing unneeded items from the work area.

2. Set:

A place for everything and everything in its place.

Shine:

Clean and inspect. Cleaning each work area after every shift to help find and eliminate issues before they become major problems.

3. Standardize:

Make up the rules, follow and enforce them. Documenting improvements so they can be more easily applied in other work areas.

4. Sustain:

To ensure continuous improvement make sure every step is repeated.

The method that helps you to reduce or keep out waste is called 5S. It can be one of the easiest lean tools to use in a firm and also it can be used with Kaizen and Kanban to create the most efficient workplace possible.

Kanban:

Kanban system can resolve the major issue in Construction firm is that delivery of material from the supplier, a concept of pull system which says that right amount of goods should be produced at the right time. This lean tool mainly works on that worker have what they need, when they need it, and where they need it. Historically, employees used Kanban cards to signal when they needed more parts, and new parts were not delivered until there was a card signaling a demand for new parts. Nowadays Kanban cards get replaced with electronic signals demand, with the help of some specialized software and are commonly known as E-Kanban, where the system can automatically request new parts using a series of barcodes that are scanned to signal when new parts are needed. With the help of Kanban, workers can more easily manage inventory and reduce the unneeded stock by focusing, on the items that need

to be stockpiled. Kanban and Kaizen are both encouraged to participate in constant improvement of work. Kaizen and 5S can be implemented in conjunction with Kanban.

PDCA:

PDCA is a Plan-Do-Check-Act process. It is an organized approach to improving processes and it includes steps that its predecessor omits. The main motto of this tool is that strength comes from its clear, no-nonsense steps.

PDCA is a tool that provides a structure that guides the process of improvement and problem-solving. This approach establishes a comprehensive analysis, response, action plan, and feedback loop to ensure success.

Value stream mapping:

Value Stream Maps are typically used to analyze the current situation, highlight problems, and develop solutions. VSM as the name suggests provides a visual aid or map that helps participants understand the current problems by:

Displaying the interaction between all items within the process.

Bringing secondary items to the primary just like department workflow, scheduling, material management, etc.

Visually representing information and material flow throughout the process.

Last planner:

Last Planner is the method of lean that is mainly divided into four process areas: Weekly plan, Phase Schedule, master schedule and look ahead schedule. This method was developed to increase worker productivity and accountability through tight scheduling and detailed group planning. The main purpose of that principle in the system is to ensure that each project manager, contractor, and subcontractor on a construction site can manage their workload while holding them responsible for the work they promised to complete. The main phase of the project must be complete before the next phase begins.

Data collected from sites where lean management does not follow:

The various companies visited to learn and spread knowledge regarding Lean techniques over our conventional methods of construction in some construction firms are as follow:

- A J Associates
- Pooja Construction
- DM Design

The process in construction companies mainly depends on the management and how they manage their site and complete the project within the project period but on the actual site, it is too difficult to manage all things. So, when I visited construction companies I asked some questions regarding project completion duration, waste, management, and some basic problems faced by them highlighted and analyzed. The most important part of the project is labor and from the supply chain of the materials, we can be analyzed workflow. On-site, eliminating non-value-adding activities is the most important task to add customer satisfaction and also give value to the project.

AJ Associates: A J associate is one of the growing companies in Vidarbha. In their construction, observed some less experienced supervisors and labor working on-site work i.e.,

lack of experience person doing works such as centering and others then there is a problem should face them by improper centering like all. And also identified some wastes, that's waste of rework which is a staggering number of movements and the average unnecessary material handling on a job site and also material waste observed on their site. They waiting for machinery and material on site. It's called secondary waiting which generally includes contractor issues, equipment breakdown, delay in getting materials, or less availability of construction materials. For example, when I visited the site on slab casting day the concrete mixer should arrive at morning 10'O Clock but because of poor supervision and management, this mixer reached on-site at afternoon 3'O Clock. Such waiting is a major problem in the project completion process and just because of this contractor should pay the extra amount. Also, not only labor works for extra hours but also engineers and contractors. In their projects lack of supervision, waiting, and delaying of work have occurred. From the site some photos have been taken as below:



Fig. 1. Laborers waiting for machinery



Fig. 2. Delays in project work and a lack of management

Pooja Construction: On this construction site, the project working on the construction of the canal. So, the main problem with this site is site location is too away from the city area (Locality). Because of this outside site almost time delayed in getting construction materials and storing materials on site. Also from site information, it was observed to be unclear and late in processing. In this process inventory waste is mainly the result of storing extra material due to over-ordering the unnecessary materials and it leads to a waste of material, time, and efforts. So simply by applying the Just in Time Lean method they can tackle this problem and gets a solution. As a result, when all materials are required, they are present and based on actual demand where production input is calculated.

Suppliers and contractors collaborate at a higher level than conventional construction methods, as per JIT Method.

DM Design: In this construction site, where less quality is the main factor was observed because of less space available for material storage, poor quality of material handling, and damaged materials due to improper purchasing. And also, the dispute between the owner and contractor was get observed. Customers need a good quality product at a minimum price, so on job sites customer satisfaction is most important. A production approach should be less waste and preserve value. Non-added value activities also slightly occurred there such as excessive paperwork, design, field rework and mainly waiting for decisions and information.

7. Lean Construction in India

The application of Lean Techniques is not a new method. In many countries, industries have used lean principles for improvement and change over conventional methods. In India, very few construction industries are aware of Lean Concepts. So many companies have very low awareness regarding this philosophy. Some projects that followed Lean tools areas:

Bostaci Metro Line Project at Dudullu.

Last Planner System in Kamarajar Port Limited by AFCONS Infrastructure in South India.

Last Planner System at Godrej Construction.

Lean tool applied to reduce the cycle time of piling by AFCONS Marine Infrastructure.

The main reasons for the non-implementation of lean methods in India areas:

Generally, the lean method is based on proper strategy but generally, in the construction field, it is always a push-based system. If something happens or not being productive, they will always push their ineffectiveness on others.

Lean means collective decision from the initial stage to the final stage and should consider everyone's advice.

Less skilled and trained labor.

Followed their conventional method, resist to change.

Avoided formal planning.

8. Lean Methodology

Lean is more of a philosophy than a methodology. It's a set of principles and tools to implement on Jobsite from the initial stage of a project to the final stage. By eliminating waste Lean seeks to improve the efficiency of the process. Where waste is defined as anything that does not produce value for the customer. A methodology is a system of principles and tools used in a particular area of study for creating value for a project.

Philosophy is a theory or attitude held by a person or organization that acts as a guiding principle. In Lean construction, there are so many methods, principles, and tools to implement Lean but Lean is an organizational strategy, cultural mindset, and philosophy.

Lean construction is like applying some methods to optimize resources and eliminate waste on-site only a few basic tools and methods should apply to the project as per the necessity of projects 3 to 5 Lean tools are successfully applied in construction work. Some basic principles and tools are discussed above by following a Lean Method implemented on the project. Waste means simply being a process that does not value and more importantly our client is not paying for it, so Customer satisfaction is more needed.

9. Conclusion

This paper presented an overview on the lean construction.

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