International Journal On Engineering Technology and Sciences – IJETS
ISSN (P):2349-3968, ISSN (O): 2349-3976 Volume XI - Issue II, February – 2024

IMPACT OF LEAN CONSTRUCTION AND SAFETY MANAGEMENT

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ABSTRACT: One of the first success stories to lean construction is that of the Empire State Building, was completed more than fifty years before the concepts of lean were even published. By basing the design of the project on the owners' requirement that the building be completed by a specific date, the Empire State Building was designed, engineered, permitted, had existing buildings demolished, and was constructed in just 20 months (Ghosh & Robson, 2014). The construction industry has been slow in the adoption of lean construction practices however. Some industry professionals estimate that "only a very small minority of firms truly understand what it means to be lean" (Warcup, 2015 p.39). If construction companies operating in the current market climate want to realize the same benefits of lean that successful implementers have reported, then there needs to be a greater emphasis on lean construction and the adoption of lean theory. Lean construction has proven to be a successful business model for construction companies who have been able to implement it successfully. McGraw Hill's Construction Research and Analytics (2013) surveyed contractors on the benefits of implementing lean construction and found that more than 60% of respondents reported: higher quality (84%), greater customer satisfaction (80%), improved productivity (77%), reduced costs or improved profitability (64) Lean Construction, as envisaged by the International Group

INTRODUCTION

Lean Construction in 1993, began by specializing Lean concepts from manufacturing to construction projects. In the Institute's research of the term, we have not found a single universally accepted definition of "Lean Construction" nor a single standard-setting institution – there are several institutions that research and teach the subject of Lean Construction, and so a number of slight variations of Lean Construction have evolved. However, we note that the principals behind the International Group for Lean Construction, founded in 1993, coined the term, and that the IGLC explicitly call their vision "Lean Construction." Examples of other institutions include the numerous subgroups spawned fro construction m the International Group for Lean Construction, such as the European Group for Lean Construction, the Institution for Lean Construction Excellence and numerous universities such as the P2SL Lab at UC Berkeley, Construction Industry Research at Michigan State University and the Center for Lean Projects at Nottingham Trent University. Regardless of whichever specific definition of "Lean Construction" one chooses to follow, a general trend has been to broaden the subject from simply the operations science roots of Lean. For example, one such variation has broadened the topic of Lean Construction into a framework [2] defined by the Lean Construction Institute, one of the institutions researching and teaching Lean Construction, to address other wider-ranging topics encountered in construction project execution, such as integrated project delivery and project governance.

LEAN CONSTRUCTION

Lean construction is a combination of operational research and practical development in design and construction with an adoption of lean manufacturing principles and practices to the end-to-end design and construction process. Unlike manufacturing, is a project-based production process. Lean Construction is concerned with the alignment and holistic pursuit of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, activation, maintenance, salvaging, and recycling (Abdelhamid 2007, Abdelhamid et al. 2008). This approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs. (Kossel et al. 2002[1])

Six Principle of Lean construction

Identify Value from the Customer's Point of View

The traditional approach to construction focuses on what the customer wants you to build – what's included in the plans and specifications. Lean construction, on the other hand, recognizes that the customer's values are deeper than that. It isn't just about what to build, but why. Truly understanding value from the customer's point of view requires a different level of trust established very early in the planning phases of a project.

Lean construction brings together all stakeholders, including the owner, architect, engineers, general contractor, subcontractors, and suppliers. The project

team not only delivers what the client wants, but they provide advice and help shape expectations throughout the project.

Define the Value Stream

Once you have a clear understanding of value from the customer's point of view, you can lay out all of the processes necessary to deliver that value. This is called the value stream. for each activity, the necessary labor, information, equipment, and materials are defined. This encourages businesses to focus on what truly matters to customers, enabling them to prioritize and allocate resources effectively. When any steps or resources are identified as non-value adding, they are either eliminated, minimized, or improved to reduce the time and effort required, thus enhancing overall value delivery.

Eliminate Waste

A primary goal of Lean construction is eliminating or minimizing waste at every opportunity. Lean construction targets eight major types of waste:Defects: Defects are anything that is not done correctly the first time, resulting in rework that wastes time and materials. Overproduction: In construction, overproduction happens when a task is completed earlier than scheduled or before the next task in the process can be started.

Pull Planning and Scheduling

Creating reliable workflows depends on work being released based on downstream demand. Lean construction recognizes that this is best done by those performing the work, often subcontractors. Participants communicate and collaborate closely with each other to determine the schedule of tasks. This collaboration is essential at it helps align everyone's understanding of the project's goals and objectives, ensuring that the work is coordinated and synchronized efficiently.

Flow of Work Processes

The ideal state of a Lean construction project is a continuous, uninterrupted workflow that is reliable and predictable. The sequence is key in construction; you can't start building the frame until the footings are set, for example. Clear communication between all parties is essential to achieving flow. When one part of the project gets behind or ahead of schedule, it is essential to let everyone know so that adjustments can be made to avoid the wastes of waiting, motion, and excess inventory.

Continuous Improvement

The belief that it is possible and necessary to continuously improve processes and eliminate waste is the heart of the Lean philosophy. Opportunities for improvement are identified and acted upon during the project and applied to future projects.

The construction industry is not immune to the tendency to stick to old ways and resist change, but the many benefits of the Lean approach are compelling more and more firms to take on the challenge. When projects come in on time, on budget, and with exactly the value the customer expected, everyone involved is better for it.

Five Lean construction benefits

- Better planning and scheduling. Inefficient scheduling is one of the largest reasons why construction professionals see productivity loss on the job site.
- Improved safety, fewer risks.
- More control over costs.
- Satisfied employees, satisfied clients
- Enhanced quality of output.

Objective of this study

- Look ahead planning
- Commitment planning
- Learning
- Lean construction, is primary goal is to turn waste of reduction in to customer benefits
- The lean method continuously improves processes which stream lines project efficiencies
- Safety first is a very common scenery that we can see at most construction sites in our country

Scope lean construction

Lean construction focuses on maximizing efficiency and minimizing waste in construction process. Its scopes include improving collaboration among project stakeholders, optimizing work flows, and enhancing overall project delivery. By emphasizing continuous improvement and lean principles, such as reducing delays and excess inventory its aim to enhance project outcomes and reduce costs. This approach is applicable across

various construction projects, promoting a more streamlined and value driven construction industry

Relationship between Lean Constructions

Lean advocates minimizing the waste and continuous improvement Safety and health intends to control hazards for attaining unacceptable level of risk Construction in the process of accidents in the sequences of event that produces un intended injury death (or) properly damage Waste in efficiency that that result use of equipments materials labor or capital quantities' necessary in a products

LITERATURE REVIEW

The History of Lean Construction Henry Ford IS often thought of as the grandfather of the Lean methodology with his creation of the assembly line for the Model T in the early 1900s. But the use of Lean in design and construction actually begins with the erecting of the Empire State Building, even if they didn't know it at the time **The 1930 – 1990** Design on the Empire State Building began in late 1929. Construction started in early 1930, and the construction process was completed just a year later. Today, it seems remarkable that the tallest structure of the early 20th century was built not only ahead of schedule, but under-budget too. At their most productive, Empire State Building workers were building a floor a day.The term "Lean Construction" wasn't officially coined until 1993, just four years before the Lean Construction Institute was founded. Since then, construction projects around the world have benefited from Lean construction practices. Lean Theory and Construction Industry 1. In 1950's after World War II, the ideas of new production philosophy were semiautonomous Machines, co-operation with suppliers, and other techniques (Menden 1983, Ohio 1988, Shingo 1984, and Shingo 1988). At the same time, quality concerns were introduced to Japanese industry by American Specialists like Deming, Jordan and Feigenbaum. 2 .Lean Construction Organization pointed out that the reliable release of work between specialists in Design, supply and assembly assure value is delivered to the customer and waste is reduced (2006). Lean Construction is believed to be particularly useful on complex, uncertain and quick projects. There are Substantial researches that have been focused on lean construction. Glenn Ballard and Greg Howell IN 1997started the Lean Construction Institute in an effort to develop and share information about how to improve the management of construction projects . Lean Construction Institute (LCI), a non-profit organization dedicated to applying Lean theory, principles and techniques to create a new form of project management to design and build capital facilities. But Lean principles and practices initially developed independently within the construction industry. The early contributors to Lean Construction include Greg Howell, who worked in the above-mentioned construction battalion and often told the story of his commanding officer's actions. There was Glenn Ballard, a former pipefitter's apprentice who as an area construction engineer and later productivity manager worked relentlessly to improve productivity. Dr. Ballard brings 25 years of construction industry expertise to his role and is a recognized expert in the area of project performance improvement. An accomplished educator, author and public speaker, Dr. Ballard is currently a member of the construction engineering and management program faculty at UC Berkeley and Stanford. His teaching focuses on improving, as opposed to controlling, project performance. His principle research interest is adapting lean production theory from manufacturing to construction management practice. Toward that end, he has developed a model for lean delivery of capital facility projects, the Lean Project Delivery System. Dr. Ballard is also a founding member of the International Group of Lean Construction, which is dedicated to the development and application of production control concepts and techniques in the construction industry. Greg, Glenn, and Laurie was Discovered "The Machine that Changed the World," which explored how Toyota's production methods helped it supplant General Motors as the world's largest automaker. The trio realized that what they had been implementing in construction was much like what the book's authors saw happening in Japan with Toyota. It was at about this time that they adapted the word Lean for their work in construction productivity even though the work informing lean construction had been underway for more than a decade before the term lean construction existed. Glenn, Laurie, and Luis Alarcon founded the International Group for Lean Construction (IGLC), so named during the group's first conference in 1993. The IGLC was a group of primarily academic researchers that gathered and shared their field-based research. They sought an understanding of how they could apply Lean Construction ideas more widely. At this conference Glenn presented a paper where he introduced the term "last planner

Luis had been a student of Glenn's in 1989. In 1994 Luis organized a construction industry conference in Santiago, Chile, in his role as chair of the construction engineering department at the Catholic University of Santiago. During this conference Glenn made his first public presentation on the "Last Planner." It was a term for a practice everyone would soon come to know .some would love it some would loathe it. But nobody was neutral about it John Krafcik The term Lean was coined in 1988 by American businessman in his article "Triumph of the Lean Production System", and defined in 1996 by American researchers James Womack and Daniel Jones to consist of five key principles: "Precisely specify value by specific product, identifyf the value stream for each other product, make value flow without interruptions, let customer pull value from the producer, and pursue perfection. Companies employ the strategy to increase efficiency. By receiving goods only as they need them for the production process, it reduces inventory costs and wastage, and increases productivity and profit. The downside is that it requires producers to forecast demand accurately as the benefits can be nullified by minor delays in the supply chain. It may also impact negatively on workers due to added stress and inflexible conditions. A successful operation depends on a company having regular outputs, high-quality processes, and reliable suppliers. **Ballard and Howell** ART [39] indicated of giving priority to PPC alone, WWP also need to be analyzed to find the reasons behind inability to complete a week's promised task. It is necessary to identify preventive measures for these reasons in-order to avoid them in future and for a continuous improvement. A team should be assigned to identify the areas of reoccurring failures that require analysis of cause using a suitable problem solving technique such as five why or root-cause analysis. At the end of each week, the reasons for failure in activities committed was analyzed using daily progress reports and by taking feedback from the site engineers**.**

HISTORICAL BACKGROUND

Lean concept was originated with thinking of waste reduction. Pre- 20th century highlights the contribution given by Benjamin Franklin for waste reduction thinking. Sparks (1836) noted the guidelines related to this concept provided by Benjamin Franklin through the essay titled as "The Way to Wealth". The scientific management then came into play in waste reduction in 20th century. Frederick Winslow Taylor who was the father of scientific management emphasized the importance of work standardization. He suggested replacing existing procedures with new or improved procedures so that all non-value added activities and time wastes could be eliminated. Further studying the work with efficiency calculations,

Frank Gilbert recognized wastes built into the jobs. Then he introduced predetermined motion time systems (PMTS) which enabled any organization to improve the performance of its workers. These studies encouraged further development of many theories then he introduced predetermined motion time systems (PMTS) which enabled any organization to improve the performance of its workers.

Toyota Production System (TPS) During the Second World War, the economy of Japan collapsed and Japanese manufacturers had to device new methods to reduce costs and remain in the market. They developed some concepts focusing on waste minimization (Levinson 2002) so that unnecessary costs were to be reduced. The philosophy of the Toyota Production System consists of continuous improvement of products, processes or activities in the manufacturing system according to set standards for minimizing the waste together with the participation of all employees. Therefore this philosophy gives the responsibility to all in the work place for each and every aspect inside organizational boundary.In the Toyota Production System house, Just in Time is one pillar which is a famous concept. It emphasizes the delivery of right product, at the right time in the right quantity to the customers using minimum necessary resources. This approach therefore creates a minimum level of inventory leading to a minimum level of inventory handling cost. But in most cases, the organizations are facing problems and creating disruptions in the work floor by keeping additional amounts of inventory as **Ballard & Zabelle** compare designing to a good conversation, from which everyone leaves with a different and better understanding than anyone brought with them. How to promote this conversation (iteration) and differentiate between positive (value

generating) and negative (wasteful) iteration are some of the central principles of Lean Design. Hansen and Olsson5 states that Lean thinking in design has at least two main objectives: to find the best design to meet the client's needs in order to support effectiveness, efficiency and user satisfaction; and to define systems, structures and materials to ensure effective, streamlined construction. Lean Design considers three perspectives to describe the design process (1) Transformation (transformation of inputs into outputs); (2) Flow (flow of material and information through time and space); and (3) Value (the generation of value for customers), rather than the more traditional view of the design process as only a transformation process4. The 'transformation view' has been the dominant view of production and is best described as 'getting the task done'. Several practices such as work breakdown structure support this view. The 'flow view' emphasizes on the interconnectivities of tasks with the aim of shortening lead times and elimination of waste, including reduction of rework, use of team-based approaches to avoid time-consuming iterations, and release of information in small batches to allow for rapid feedback from team members. The 'value view' stresses the use of analysis of requirements and constraints to deliver what matters to the customer6. The Lean Design process involves all three perspectives, even though each perception is orthogonal to one another (e.g., having just the transformation view does not guarantee that the flow and value view are taken into account and vice versa).

Laurel Koskela Began to implement this philosophy in the construction sector; the result of this is his work "Application of the new production philosophy to construction", produced in the CIFE research group at Stanford University, in which he argued that production should be improved by eliminating material flows and that conversion activity would improve efficiency (Koskela et al., 2019; Lean Construction Institute, The theoretical bases of LC proposed by Koskela intend to see production in construction as a process of transformation, flow and value generator, consequently, the objective of Lean Construction is to create good production systems that allow optimizing, reducing, or eliminating the flows to improve delivery times. In this sense, LC is new thinking in construction project management that challenges the current management guide of the Project Management Institute PMBOK, with a high boom in the United States, hence LC should not be conceived as a model or system in which only a few steps are followed, but as a thought directed to the creation of tools that generate value to the activities, phases and stages of construction projects. Understanding the value

LEANCONSTRUCTION AND SAFTEY

The first was the effect of the safety planning layer elements. To lay the groundwork for the safety look-ahead plan, the safety master plan conducts a risk analysis for the project, identifying potential risk points and the resources required to address them. The safety look-ahead plan is the front stage of the safety weekly plan, focusing on the project's resources, team evaluation, and on-time supply chain design to eliminate hidden trouble and remove the obstacles to the safety weekly plan's implementation. To prepare for further statistical analysis of the results, visual management and 6S management are required to eliminate unsafe factors at the construction site and gradually record the construction information of the site according to the safety weekly plan

The second consideration was the effect of safety planning on safety control. Workflow control examines whether front-line employees' capabilities match the workload of the next stage, whether the work environment is safe, and whether product quality is guaranteed. The safety look-ahead plan identifies and analyzes project risks as well as establishes acceptable risk levels for all activities.

Therefore, workflow control is carried out under the guidance of the safety look-ahead plan ART [12]. Safety investment and safety supervision are important measures for controlling the work unit. The safety weekly plan establishes routine maintenance and emergency measures, such as scaffolding maintenance, and serves as the foundation for staff training and work unit control. The goal of the results statistics is to find acceptable levels of risk for the project and to warn of potential safety issues that could lead to an accident, thereby laying the groundwork for controlling the work unit . Work unit

control not only oversees worksite and material-driven delivery, but it also focuses on the macro-ergonomic perspective, focusing on employees' daily physical and mental well-being, such as measuring daily oxygen demand, heart rate, and energy consumption, which helps to reduce workflow instability and has a positive impact on further work flow control

Koskela in 1992, researchers working closely with practitioners have been investigating the theory, principles, and techniques of Lean Construction and Lean Construction as it relates to construction safety. These efforts cover a wide range of topics and the International Group for Lean Construction (IGLC) has become a platform to showcase all these research efforts. • Four themes emerge for approaches to safety and lean construction: 1) a new approach to construction safety, 2) performance measurement of safety, 3) forecasting risk levels, and 4) safety through production planning.

NEW APPROACH TO CONSTRUCTION SAFTEY Increasing safety is critical in the context of improving productivity and efficiency in construction industry. Thus, the development of valid safety performance metrics is an important first step towards improving safety. • Unfortunately, most conventional metrics of safety performance deals with rates of accident or incident occurrence. This type of metric has inherent limitations: it is reactive in nature, causal relationships cannot be established, and it does not include positive aspects of safety performance. Development and implementation of safety-related performance measures within the lean construction paradigm can be classified into two broad categories. The first is related to safety process improvement and other at the detailed operational level. • The study by Marosszeky et al. employed an iterative process analysis: identifying potential performance measures, prioritizing and selecting measures, and finally the development of key performance.

PERFORMANCE MEASUREMENTOF SAFTEY Increasing safety is critical in the context of improving productivity and efficiency in construction industry. Thus, the development of valid safety performance metrics is an important first step towards improving safety. •Unfortunately, most conventional metrics of safety performance deals with rates of accident or incident occurrence. This type of metric has inherent limitations: it is reactive in nature, causal relationships cannot be established, and it does not include positive aspects of safety performance. Development and implementation of safety-related performance measures within the lean construction paradigm can be classified into two broad categories. The first is related to safety process improvement and other at the detailed operational level.

FORECASTING RISK LEVEL It has been stated that a proactive safety policy is a more efficient way of managing safety in order to prevent accidents than a reactive policy. Sacks et al. presents a conceptually advanced model to support proactive safety management. The authors argue that most common factors that have a substantial influence on most construction projects are time dependent such as human factors, physical hazards, environmental factors, etc. • Thus, knowing the level of risk as it changes with time would help in identifying high risk construction activities and allocate precautions accordingly. The model put forth by Sacks et al. enables forecasting risk levels for teams as well as individual workers as a function of time. This time dependent model can be used to implement management strategies that focus efforts where needed and reduce efforts where it is wasted, in contrast to safety activities that are planned with constant effort.

SAFTEY THROUGH PRODUCTION PLANNING **A** Safety planning and control model (SPC) has been integrated into the production planning and control process .the model integrates safety into three hierarchical levels of production control safety long term planning starts with the preliminary hazards analysis (PHA) of construction processes and employee

Implementing safety protocols, regular training and continuous monitoring are key elements in a comprehensive production safety plan.

PHASE I REPORT

The detailed literature survey is carried out in phase I. Review of literature is help to develop the knowledge and understand the specific topic of interest .moreover, reading of various papers of this specified topic give the skill to frame the methodology of the work for the particular study. The methodology has been framed from the above literature study for future purpose of the project. Various kinds of knowledge about the safety lean construction among the engineer's and the labors are found in the literature. The results will be produced on the phase II report.

CONCLUSION

The above review of literature explains the lean construction and safety management in the construction sector the safety in lean construction In Construction. in phase I literatures are collected for the future purpose of the project and for the detailed study of the project. By the detailed study of the literature, methodology has prepared and need to follow the successful l for completion project The view of quality in the engineers and contractors will determined by the survey taken. by the analysis of data Lean construction and safety management by using primavera software and scheduling project to be continued in phase II

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