Review Paper on Application of Lean Production Principles in Construction Project

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Abstract

In current scenario of construction industry, most of projects faces a serious issue of getting cost and time over run due to various reasons. In line with that lean construction concept has been introduced in construction industry to reduce waste and increase productivity for efficient execution of project. Lean construction is nothing but management system that applying lean production principles in different phases of construction project.In this paper, author wants to introduced lean construction, history and how it comes to the construction industry. Main purpose of this paper is to study various applications of lean production principlesin construction project; how to apply lean production principles in construction project and which are the possibilities, importance, advantages and disadvantages in application of lean production principles in construction project.This paper is helpful to researcher to get clear idea about evolution and concept of lean production principles and its applications in construction industry.

Keywords: **Lean Construction, Lean concept, History, Introduction, Background.**

Introduction of Lean

Lean production aims to design and make things differentiated from mass and craft forms of production by the objectives and technique, and to optimize performance of the production system against a standard of perfection to meet unique customer requirements[11].

Lean offers significant benefits in terms of waste reduction and increased organizational and supply chain communication and integration [10].

Lean practices reduce wastes in all hidden forms like defect, motion, inventory, transportation, overproduction, processing and waiting[14].

Lean construction should be considered as a management method to sustain improvement PDCA cycle. It is to stimulate the motivation of field engineers and young technicians through evaluation or visualization [15].

The important thing of lean construction is to have the desire to get better and creates an environment to continue to use project management tools, evaluate the results, discover the problems and improve again. It is the lean construction that creates their motivation to continue improvements [15].

Lean construction practices is applied to solve significant process issues in particular of collaboration between stakeholders. It approaches value rather than cost and efficiency rather than schedule. Ultimate goals in lean construction are to minimize physical & process waste, & improve value generation to client [14].

History of Lean

The foundations of lean production were developed in post–World War II Japan, when the Japanese manufacturing industry underwent a complete rebuilding. Lean pioneers Kiichiro Toyoda, Eiji Toyoda and Taiichi Ohno of the Toyota Motor Company developed many of the underlying principles of lean production in response to pragmatic considerations and existing geographic circumstances. The impetus for lean production occurred when Kiichiro, president of Toyota at the time, demanded that Toyota "…catch up with America in three years. Otherwise the automobile industry of Japan will not survive". At the time, limited supply of raw materials and inadequate space for inventory in Japan fostered an atmosphere in which concepts such as just-in-time (JIT) and zero inventories became necessary. During the spring of 1950, Eiji Toyoda visited American manufacturers, namely Ford's Rouge Plant in Detroit, to study mass production and perhaps look for ways to improve the country's own rebuilding industry. This was the second visit to study US manufacturing practices made by the Toyoda family; the first was made by Kiichiro in 1929. What Eiji Toyoda found was a system rampant with muda, a Japanese term that encompasses waste. He noted that only the worker on the assembly line was adding value to the process. Another striking feature was the emphasis placed by their American counterparts on continually running the production line. This common practice was thought to be justified by the expense of purchasing such equipment. To the Japanese, this practice appeared to compound and multiply errors, a mistake the Japanese could not afford to make [6].

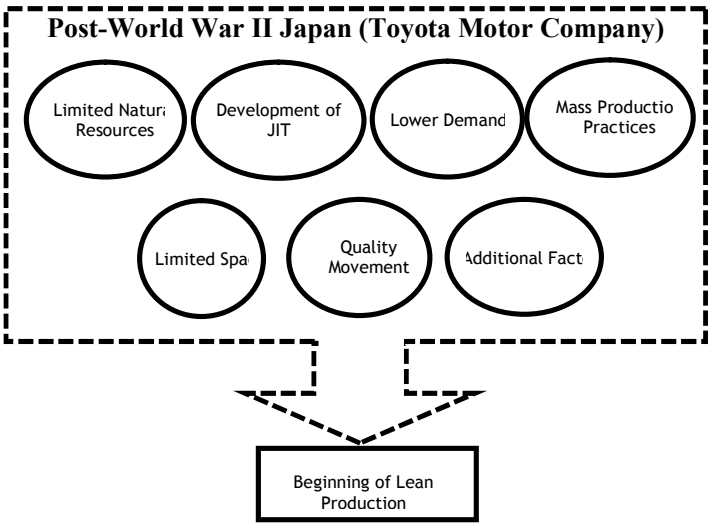

Figure 1:-Beginning of Lean Production [6]

Japan's labour productivity at the time was one ninth that of the United States, and it became obvious to Toyota that it could not compete with the United States by depending on economies of scale to produce massive volumes for a small market that did not have the same type of demand. Toyota then made the strategic decision to focus its manufacturing efforts not on massive volumes of a product but, rather, on many different products in smaller volumes. In his numerous experiments focused on reducing machine setup times, Ohno, Toyota's chief production engineer, noted that the cost of producing smaller batches of parts was less than that of producing larger quantities as practiced in the United States [6].

This was true because making small lot sizes greatly reduced the carrying costs required for huge inventories, and the cost of rework was reduced because defects showed up instantly in smaller batches. Ohno also managed to reduce the amount of time required for machine setup from an entire

day to three minutes, a task that enabled Toyota to increase the flexibility of its production lines as well as reduce production times [6].

The concept of JIT was developed to complement this new production philosophy undertaken at Toyota. The model for JIT was the American supermarket, a relatively new idea to the Japanese in the 1950s. The American supermarket provided customers with what they needed, when they needed it and in the right amount needed. These concepts are referred to as the seven zeros: zero defects, zero lot size, zero setups, zero breakdowns, zero handling, zero lead time and zero surging. The actual process, however, took many years of trial and error. The Toyota Production System presents an outline of the foundations of lean production. Figure illustrates the forces that influenced the development of lean production. Studies have shown the incredible benefits lean production methods have brought specifically to the automobile manufacturing industry where the ideas originated [6].

In the beginning of the 1990s, the new production philosophy, which is known by several different names, is as follows: (1) world class manufacturing; (2) lean production; and (3) new production system.Since 1992, Koskela has reported the adaptation of lean production concepts in the construction industry and presented a production management paradigm where production was conceptualized in three complementary ways, namely as (1) Transformation; (2) Flow; and (3) Value generation (TFV) theory of production. Toyota production system and to contrast it with craft and mass forms of production. Starting from efforts to reduce machine setup time and influenced by TQM, a simple set of objectives was developed for the design of the production system including to (1) Identify and deliver value to the customer value: eliminate anything that does not add value; (2) Organize production as a continuous flow; (3) Perfect the product and create reliable flow through distributing information and decision making; and (4) Pursue perfection [11].

Womack and Jones in 1996 suggested that lean production is able to reduce the overall cost especially the indirect cost while still maintaining the quality standards & reducing manufacturing cycle time [9].

It's aimed for the delivery process, concurrent product design and process, and production control throughout the life of the project. Black in 2008 stated that LC extends from the objectives of a lean production system, which are maximizing value and minimizing waste; to specific techniques and applies them in a new project delivery process [9].

Lean Production Principle

In 1996, Womack and Jones presented a set of five fundamental principles that combined actions involving different concepts (value, value stream, flow, pull, perfection) present in a Lean system and suggested an order for their implementation [4].

There are five fundamental principles for lean thinking, which have to be followed step by step to gain the maximum benefit of the lean success:

1. **Specify Value:** Specify value from customer's own definition and needs and identify the value of activities, which generate value to the end product.
2. **Identify the Value Stream:** Identify the value stream by elimination of everything, which does not generate value to the end product. This means, stop the production when something is going wrong and change it immediately. Processes which have to be avoided are miss production, overproduction, storage of materials and unnecessary processes, transport of materials, movement of labor workforces and products, and finally production of products which does not live up to the wished standard of the customer as well as all kind of unnecessary waiting time.
3. **Flow:** Ensure that there is a continuous flow in the process and value chain by focusing on the entire supply chain. Focus has to be on the process and not at the end product. However, the flow will never get optimal until customer value is specified, and the value stream is identified.

4. **Pull:** Use pull in the production and construction process instead of push. This means produces exactly what the customer wants at the time the customer needs it and always prepared for changes made by customer. The idea is to reduce unnecessary production and to use the management tool ‘‘Just in Time’’.
5. **Perfection:** Aims at the perfect solution and continuous improvements. Deliver a product which lives up to customer’s needs and expectations within the agreed time schedule and in a perfect condition without mistakes and defects. The only way to do so is by having a close communication with the customer/client as well as managers, and employees are between [11].

Lean Construction

The application of lean thinking in construction was pioneered by Koskela who suggested that construction production should be seen as a combination of conversion and flow processes for waste removal. The concept of lean is attributed to the manufacturing industry and was introduced to construction [10].

The application of lean principle to construction has been presented to result in benefits such as improved quality, improved safety, waste reduction, increased productivity, more client satisfaction, increased reliability, and improvements in design [10].

Table 1:-Difference between Traditional and Lean Construction [7]

Traditional Construction	Lean Construction
Uses the same activity cantered approach used in mass production and project management	Defines a clear set of objectives for delivery process
Aims to optimize the project activity by activity and identifies customer value in design	Aims at maximizing performance to the customer at the project level
Breaks the project into pieces and puts them in a logical sequence focusing on each activity	Designs concurrently product and process
Considers control as monitoring each activity against its schedule and budget projections	Applies production control throughout the entire project life

Definition of Lean and Its parameters

Koskela (in1992) Advantages of the new production philosophy in terms of productivity, quality, and indicators were solid enough in practice in order to enhance the rapid diffusion of the new principles [9].

Howell (in 1999) Lean construction is much like the current practice as the goal of better meeting customer needs while using less of everything [9].

Lukowski (in 2010) Lean construction is the practical application of lean manufacturing principles, or lean thinking, to the building environment [9].

Yahya and Mohamad (in 2011) Lean construction is about managing and improving the construction process to profitability deliver what the customer needs by eliminating waste in the construction flow by using the right principle, resources and measure to deliver things right first time [9].

Lean Construction is the project management method in which after discovering problems of the site, the project improvement tools basically related to eradicating waste are continually used, evaluated and improved to increase the added-value of the project with less labor. (Here “the project improvement tools” are specific improvement activity routines or patterns) [15].

Waste should be defined as any losses produced by activities that generate direct or indirect costs, but do not add any value to the product from the point of view of the client [13].

Waste of the project site can be classified as follows [3].

- Waste of over-production,
- Waste of waiting,
- Waste of transporting,
- Waste of over-processing,
- Waste of inventories,
- Waste of moving,
- Waste of defectives.

Customer value: - This implies identifying the client and understanding what the client is expecting from the product or service and what customer is willing to pay for. Only then one is able to provide the right product the right way, while reducing or eliminating the waste within the processes [4].

Value stream: - The value stream is all the specified actions that are required to bring a specific product (a good, a service, or a combination of the two) from the conceptual stage until it is delivered to the final customer. The identification of the value stream requires looking at the process to deliver a product or service as a whole, including the work performed by all intervening companies and all handoffs exchanged the process. It is worth noting that the value stream comprises all activities, i.e., value-adding and non-value adding, necessary to deliver a product or service. Once the value stream is identified it can be mapped into a value stream map (VSM). The VSM is a management tool that graphically represents the value stream, with all of its participants for a defined scope of work, and allows the visualization of the flow of materials and information exchanged [4].

Implement flow: - Which requires focusing on the product instead of the organization. Womack and Jones suggest that companies should focus on the processes necessary to continually deliver the product from start to finish making it flow continuously, or as defined by the Lean Lexicon, “producing and moving one item at the time (or a small and consistent batch of items) through a series of processing steps making just what is requested by the next step” [4].

Implement pull: - Traditionally, each department or company optimizes their own processes or services to produce as much as they can, as fast as they can, and pushes their products or services downstream without considering what the customer really wants at the time of production or what the actual demand is. Implementing pull means that upstream processes (the one at the beginning of the value stream) only design and produce exactly what customers downstream (at later stages) need when needed, drastically reducing lead times and inventories, and all the waste that overproduction represents. Implementing pull results from the fundamental concept of JIT, which states that production should be triggered based on actual demand from customers [4].

Seek perfection: - Continuous improvement, through a Plan-Do-Check-Act (PDCA) cycle. Seeking perfection in Lean systems requires transparency, a characteristic of the Lean systems, where “everyone (...) can see everything” and systems are able to communicate with people, e.g., use of indicators and standards that allow immediate recognition of deviations [4].

Application of Lean Production Principle in Construction Industry.

Managing construction under lean is different from typical contemporary practice because it

1. Has a clear set of objectives for the delivery process.
2. Is aimed at maximizing performance for the customer at the project level.
3. Designs concurrently product and process.
4. Applies production control throughout the life of the project [11].

One of the most interesting methodologies proposed to deal with these issues is the Lean Construction (LC). Lean Construction aims to identify and minimize wastes through four main elements:

- Built in quality: reduction of rework doing the right thing the first time.
- Customer focus: elimination of no value-added activities for the customer.
- Minimization of waiting: involvement of supplier in planning task.
- Creation of a continuous flow: availability of needed resources and components, when and where [7].

Advantages and Disadvantages of Lean Production Principle

Application of lean production principles is very vast field for all industries as well as construction industry, that's why having advantages and as well as disadvantages.

Advantages:

- Increased efficiency – By creating defined work processes, expanding project planning, devising a coherent strategic vision, employing visual management devices, and instituting practices will be able to enhance productivity by cutting wasted resources, time and materials [12].
- Higher quality –If this principle is transferred to construction and embraced throughout an organization, it will result in significant, and continuous, quality improvements [12].
- Elevated customer satisfaction – With higher quality and increased efficiency come greater client satisfaction [12].
- Boosted profits and reduced costs – Streamlined work processes will inevitably raise profitability, but the lean approach to project management takes it a step further by focusing on all of the ways costs can be trimmed from the minimization of defects to making sure that no unnecessary materials are purchased. Excessive movement of supplies, avoidable delays, wasted resources, and superfluous or unessential equipment are all "sins" that will be uncovered and rectified by adhering to lean principles [12].
- More employee accountability – When a company "goes lean," one of the major changes is the establishment of very specific performance measurements. Tracking the success or failure of initiatives is critical to monitoring operational health and gauging the impact the lean approach has had on the business. This close observation also provides insight into the contributions of individual team members and can help determine if further training or other intervention is needed [12].
- Improved safety – By employing organization and standardization strategies like uniform tool storage and common worksite configurations, lean construction companies have achieved noticeable reductions in accidents and lost-time injuries [12].
- Closer partnerships, better communication – Lean construction compels team members and stakeholders to work closely with one another, making coordination and communication key to success [12].
- Lean reduces the wastes or sometimes even eradicate the wastes completely. Less wastes means more profit [8].
- Lean helps company's management to focus on smart work rather than hard work by making strategic plans for the future [8].
- Lean promotes focus on workers by supervisory staff. Showing Worker importance increases the productivity by the worker [8].
- Lean ensures a smooth flow of important or critical activities [8].
- With Lean, a company commits to continuous improvement to seek perfection [8].
- Productivity also increases all around for high rate of planning [8].
- By reducing the communication gap between worker & employer, overall results are improved. [8].

Disadvantages:

- Team unity, commitment, and focus required – For the lean approach to be successful, all parties must be dedicated to a common goal and prepared to stick with this methodology for the long haul. Becoming a lean construction company is an ongoing effort, not a project with a start and end date. A weak link can threaten any possible gains, and this stretches beyond just immediate team members and employees. Subcontractors and suppliers must also be committed to making the lean management style work and understand the part they have to play in the project as a whole [12].
- Immediate results are uncommon – Any partners who are searching for instant gratification from the adoption of lean principles will be severely disappointed. It takes time to see the full effects of this production management technique and although noticeable quality improvements should be quick to manifest themselves, increases to profitability will be more gradual [12].
- Training requires significant investment of time/resources – As with implementing any major change in direction, adopting lean principles will entail much time spent instructing your workforce on new policies, procedures, and strategies. This will take an exceptional amount of time and energy and should not be overlooked [12].
- Some team members and partners may be resistant to change – It bears repeating that for a lean construction operation to work, everyone involved needs to be on board and focused on the same goal. If employees have not bought into the change in direction, performance will be affected and the business may suffer [12].
- Pressure on management – Responsibility for the success or failure of implementation will rest with management and their ability to communicate goals and guide the workforce [12].
- Current projects could suffer – If your company is in the middle of a project while trying to adopt a lean approach, careful coordination will be needed to ensure that the transition to a new production philosophy – and the training that will require – does not affect quality or customer relations [12].
- Impact on employee morale – As mentioned above, its human nature to be wary of significant disruptions to the status quo. For this reason, as your company begins to transition to a lean environment, you may have to deal with a dip in morale from employees who struggle to handle the new approach. These declines in staff satisfaction are usually temporary, however, as personnel adjust to the new status quo and settle into their roles [12].
- For the Lean process to work, everyone involved in construction should follow its methodology ranging from owner, engineer to the workers. There should be unity amongst themselves. If anyone of them doesn't follow, then there will emerge a weak link and hence decreases the productivity [8].
- It isn't easy to convince everyone in the company to get on board with the process as some people might not be alright with the change [8].
- Lean delivery method takes some time to bear fruit as immediate results are very rare [8].
- Frustrations of managers are very common when applying this method as it takes some time and dedication [8].
- Each worker should get along with one another or else there will be no teamwork and hence, less productivity [8].
- Management should stay strong with this procedure and eliminate all the issues as a breakdown can occur easily [8].
- All the distributors and suppliers should be informed about the change which could cause havoc [8].
- Because of the change in policy, there will be a decrease in morale amongst the employees. [8].

Conclusions

This paper concludes that how lean production principlesareevaluated and became management system that having good span of control on production, waste reduces and time saving. Also described thepros and cons of applying lean production principles in various field. Lean production principlescomes from automobile production industry after world war-2 in Japan, which is more easily acceptable in industry like pharmaceutical, hospital, automobile, logistic, food, etc. Effective application of lean production principles in construction industry is still question due to many reasons which need to be work out with their probable solutions for attaining full flagged benefits of lean production principles.

Future scope

Construction industry having lack of knowledgeabout lean production principlesas compare to other industries, that create large scope of application of lean production principles in construction industry in India.

In India, many industries using JIT, ABC analysis, 5s, 5why but still somewhere unknown from lean production principles. Also needed awareness and application of lean construction management system for betterment of construction industry in India.

Not enough case studies have been done in Indian construction industry, causes gape between implementation of lean production principlesin projects and promotion.

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