

# Lean Production Theory and its Application in the Construction Industry

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## ABSTRACT-

*Lean manufacturing is a performance-based process used in manufacturing organizations to increase competitive advantage. Initially pioneered and developed by Japanese car manufacturers, lean production was seen as the step in an historical progression of production, which took industry from the age of the craftsman through the methods of mass production and into an era that combined the best of both. A key driver of the lean project delivery approach is understanding that rewards and compensation are tied to the value of the completed project as a whole. Lean manufacturers have moved away from traditional relationships with their suppliers to partnering arrangements with a smaller number, based on good communications and open-book accounting. Lean is focused on evaluating value, more than on cost, and seeks to remove all non-value adding components and processes whilst improving those that add value. Construction is basically the design and assembly of immovable objects rooted to a place, and accordingly has, more or less, the characteristics of site production delivering an unique product by using temporary teams. The construction industry has always been under pressure to provide value for money, sustainable design and construction. Lean production presents a new approach to the construction management which has enabled production enterprises to attain very high levels of efficiency, competitiveness and flexibility in production systems. The proposed paper will highlight the lean principles that can be applied fully and effectively in construction by focusing on improving the whole process.*

**Index Terms**— Construction, efficient, lean manufacturing, production, value.

## I INTRODUCTION

The construction industry in India is the second largest industry after agriculture. The Indian construction industry is highly fragmented in which only 0.4% firms can be classified as medium to large firms based upon the number of people employed per firm. Most of the Indian contractors are not well- equipped to handle the growing demand and hence the project run-in on time and cost overruns disputes and lower quality.

On the other hand, the manufacturing industry has made significant progress in increasing productivity and product quality while lowering product lead times. The improvements in manufacturing processes have included reducing the amount of human effort, space and inventory required in the factory

and increasing the quality and variety of products and the flexibility of manufacturing operations. The application of “lean production” principles to manufacturing processes has been instrumental in achieving these results.

If manufacturing can make such vast improvements in quality and productivity, while reducing costs and lead times; the application of Lean principles to construction could work wonders.

## II PRODUCTION SYSTEMS

Traditionally, US manufacturing systems of the 20th have been viewed as a mass production system focussing primarily on the process of conversions.

Batch and queue refers to the theory that for machines to achieve a high utilisation rate, they must run continually. Batch and queue theory leads to many manufacturing problems such as bottlenecking and large inventories from high work-in- progress (WIP) levels.

The concept of manufacturing a product based on forecasted sales data and then selling it is referred to as “push” production [1]. This traditional approach of manufacturing manufactures a product just to keep the production line moving which greatly differs from the idea of producing an item only when it has been ordered or purchased, which is “pull” production.

While all activities expend cost and consume time, only conversion activities add value to the material or piece of information transferred to a product.

## III LEAN PHILOSOPHY

The prelude to lean philosophy is based on doing the simple things well, on gradually doing them better and, above all, on squeezing out waste in every step. Though several issues have been attributed to the Lean Philosophy, the following three issues have been considered as the key in defining the lean philosophy:

- (a) **Cognizance of Customer’s Requirements:-** Attention is paid to quality as defined by the requirements of the customer. The success of production hinges on the satisfaction of the customer. A practical approach to this is to define the customers for each stage and analyze their requirements [2].

(b) **Elimination of Waste:** - Seven forms of wastes have been identified by Toyota, applicable in many different types of operations. They are listed as follows [3]:

- (i) Over-production - Producing more than that is immediately needed by the next process.
- (ii) Waiting Time - Equipment efficiency and labour efficiency are two popular measures which are used to the respective efficiencies and improvement in the two helps in reducing the WIP.
- (iii) Transport - Moving items around the operation, together with the double and triple handling of WIP, does not add value. Layout changes which bring processes closer together, improvements in transport methods and workplace organization can all reduce waste.
- (iv) Process - The process itself may be a source of waste.
- (v) Inventory - All inventory should be a target for elimination.
- (vi) Motion - Simplification of work is a rich source of reduction in the waste due to motion.
- (vii) Defects - Quality waste is often significant in operations.

(c) **Involvement of Staff in the Operation:** - Lean philosophy is often put forward as a total system. Its aim is to provide guidelines which embrace everyone and every process in the organization [4]. The intention is to encourage a high degree of personal responsibility, engagement and 'owning' the job.

The lean philosophies can apply to design, procurement and production. The ideas developed by Lean can be conceptualised on the following three levels [5]:

- (i) Process Level - A set of tools, such as Kanban cards, poke yoke etc.
- (ii) Project Level - A production planning method, such as JIT.
- (iii) Organisation Level - General Management Theory, such as TQM.

#### IV LEAN MANUFACTURING

The principles of lean theory are conceptualised at the process, project and enterprise or organisation levels. Lean manufacturing is a production practice that considers the expenditure of resources for any goal other than creation of value for the end customers to be wasteful, and thus a target of elimination [6].

One of the best researched industries is car manufacturing [1]. Lean car production is characterised as using less of everything as compared to mass production: half of human effort in the factory, half the manufacturing space, half the investments in tools, half

the engineering hours to develop a new product in half the time.

#### V LEAN PRODUCTION TOOLS

Several Tools have been developed for implementing Lean Production, six of which have been described as follows [6]:

(a) **Cellular Manufacturing:** - The shop floor is subdivided into cells which consist of equipment and workstations that are arranged in such an order that maintains a smooth flow of materials and components through the process. Some benefits associated with cellular manufacturing include:

- Inventory reduction.
- Reduced transport and material handling.
- Better space utilisation.
- Lead time reduction.
- Identification of causes of defects and machine problems.
- Improved productivity.
- Enhanced teamwork and communication.
- Enhanced flexibility and visibility.

(b) **Continuous Improvement:**-Continuous improvement or Kaizen includes a thorough and a systematic approach to gradual and continuous improvement, which promotes reduction of inventory as well as reduction of defective parts. one of the most effective tools of Kaizen is 5S, which consist of the Japanese words Seiri (Sort), Seiton (Straighten), Seiso (Sweep and Clean), Seiketsu (Systematise) and Shitsuke (Standardise). The underlying concept behind 5S is to look for waste and then try to eliminate it.

(c) **Just-in-Time (JIT):**-JIT attempts to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. JIT effectiveness depends heavily on having a strategic alliance between buyers and suppliers.

(d) **Production Smoothing:**-Heijunka, the Japanese word for production smoothing, is where the manufacturers try to keep the production level as constant as possible from day-to-day. In order to decrease production cost, is necessary to balance the demand with supply and thereby not overproducing. Inability to do so lead to waste (such as work-in-progress inventory) at the workplace.

(e) **Standardisation of Work:**-Standardized work ensures that each job is organised and is carried out in the most effective manner. A tool used to standardise work is the "takt" time, which refers to how often a part should be produced in a product family based on the actual customer demand.

(f) **Total Productive Maintenance (TPM):**-Machine breakdown is one of the most important issues concerning the people on the shop floor. Hence it becomes necessary to effective maintenance strategies. There are three main components of TPM program, namely, preventive maintenance, corrective maintenance and maintenance prevention.

## VI CONSTRUCTION AS A TYPE OF PRODUCTION

Construction and manufacturing differ significantly in the physical features of the end product. In manufacturing, the finished goods can generally be moved as a whole to retailers or end consumers. Construction on the other hand, deals with larger units that cannot be transported. Furthermore, the construction industry has three other features that distinguish it from manufacturing [7]:

- (a) On-site Production.
- (b) One-of-a-kind Projects.
- (c) Complexity.

The combined effect of the above three leads to uncertainty. The manufacturing process makes it possible to reduce uncertainty by increasing control over the process itself.

## VII LEAN CONSTRUCTION

The traditional method of construction management has been followed for a long time. The main characteristics of traditional construction management are as follows [8]:

- (a) All activities are considered as value adding activities
- (b) No distinction is made between processing and flow activities.
- (c) The total cost is estimated on the basis of the Work Breakdown Structure.
- (d) Little emphasis is given to the importance of resource flows.
- (e) From the cost point of view, all activities are assumed to be independent of each other and it is assumed that reducing the cost of each activity will reduce the cost of the project.
- (f) Generally, it doesn't take into consideration the effects of poor quality output and effects of variability and uncertainty.
- (g) The work progresses linearly from one process to the other.

Another significant feature or so-called flaw of project management is the fact that all the cost and time overruns are attributed to the failure of the labourers in following the schedules and budget during the construction. No questions, however, are raised regarding the planning preceding the construction [4].

The adoption of Lean manufacturing principles to construction is an innovative approach for managing and improving construction processes by reducing cost and maximizing value considering customer needs [9]. Same as manufacturing principles, minimizing waste at early stages lead to a better quality and thus successful project in terms of time and cost. The manufacturing process has seen noticeable improvements and

development after applying lean principles to the industry. By eliminating cost-consuming flow activities, Lean approach provides potential advantages for cost reduction when successfully implemented in a construction company and can be considered as a cost leadership [10].

Lean construction thinking applied to production systems on site has increased awareness of the benefits of stable work, of pull flow of teams and materials to reduce inventories of work in progress (WIP), and of process transparency to all involved [11].

## VIII APPLICATIONS

Lean has recently started penetrating the construction industry to reform the tradition construction management approach [12]. The following summarises a few of the various applications of in different trades of construction:

- (a) **Construction Supply Chain:**- Being complex, a study was conducted to show the potential improvements in applying lean concepts to construction supply chains by presenting the case of pipe supports used in power plants. It was concluded that value stream analysis, one of the lean concepts, is a reliable tool to improve supply chain performance as it helped in identifying wastes in the process. Also, several lean principles were used to improve the performance such as reducing batch size, early involvement of suppliers in design stage, standardization of process, and improve supplier selection [12].
- (b) **On-site Subcontractor Evaluation:** - A study was conducted in Chile to develop on-site evaluation method for subcontractors based on lean principles and partnering practices. This method helped in resolving many disputes, and helped the subcontractors' supervisors to monitor their workers on-site performance. It also helped the main contractor to select the suitable subcontractor based on their previous performance in future works. This supports the idea of collaborative relationship with the subcontractors that consistently perform well [14].
- (c) **Precast Concrete Fabrication:** - A study was conducted to describe the application of lean production concepts and techniques to structural precast concrete fabrication. Last Planner and Five S techniques were used to improve the performance. The results achieved included shop cycle time and lead time reduction, increased throughput rate, and improved productivity [15].

## IX CONCLUSION

Construction as it is today can be said to be a project centred form of production as opposed to a process centred form of production in manufacturing. The goal of Lean construction is a further industrialization of construction. Implementation of lean production concepts and techniques in the construction industry is the way to the future, but

following that path requires letting go of traditional thinking.

### REFERENCES

- [1] J. P. Womack and D. T. Jones, "Lean Thinking", New York, NY, Simon & Schuster, 1990.
- [2] J. E. Diekmann, M. Krewedl, J. Balonick, T. Stewart & S. Won, "Application of Lean Manufacturing Principles to Construction", The Construction Institute, University of Texas, 2004.
- [3] Womack, P. James, and D. T. Jones, "The Machine that Changed the World." Rawson Associates, New York. 323 p., 1990.
- [4] A. Bhatla, "Implementation of Lean Construction in IIT Guwahati", BTP Report, IIT Guwahati, 2010.
- [5] L. Koskela, "An Exploration into a Production Theory and Its Application to Construction", Helsinki University of Technology, Espoo, Finland, VTT Publications, 2000.
- [6] F. Abdullah, "Lean manufacturing tools and techniques in the process industry with a focus on steel", Dissertation, University Of Pittsburgh. School Of Engineering, U.S.A., 2013.
- [7] O. Salem, J. Solomon, A. Genaidy, and I. Minkarah, "Lean Construction: From theory to Implementation", Journal of Management in Engineering, october 2006.
- [8] S. Kartam, G. Ballard, and G. Howell, "Construction Models: A new integrated approach", Lean Construction, A.A.Balkema, 1997.
- [9] L. Koskela, "Application of the New Production Philosophy to Construction", CIFE Technical Report # 72, Stanford University, 1992.
- [10] Senaratne, Sepani, and D. Wijesiri, "Lean Construction as a Strategic Option: Testing its Suitability and Acceptability in Sri Lanka.", Lean Construction Journal, 2008
- [11] R. Sacks, M. Treckmann, and O. Rozenfeld. "Visualization of Work Flow to Support Lean Construction." Journal of Construction Engineering and Management, December, 2009.
- [12] M. G. Swefie, "Improving Project Performance Using Lean Construction in Egypt: A Proposed Framework." Thesis, The American University in Cairo, 2013.
- [13] Tommelein, R. J. Arbulu and D. Iris, "Value Stream Analysis of Construction Supply Chains: Case Study on Pipe Supports Used in Power Plants." Proceedings IGLC-10, Gramado, Brazil, 2002.
- [14] Maturana, Sergio, L. F. Alarcon, P. Gazmuri, and M. Vrsalovic, "On-Site Subcontractor Evaluation Method Based on Lean Principles and Partnering Practices." Journal of Management in Engineering, April, 2007.
- [15] G. Ballard, N. Harper and T. Zabelle, "Learning to see work flow: an application of lean concepts to precast concrete fabrication." Engineering, Construction and Architectural Management Volume 10, Number 1, 2003.