Lean Concept and Productivity Performance in Indian Construction Industry – Review Paper

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Abstract

The purpose of this paper is to explore the lean concept in order to increase productivity in Indian construction industry.There is need for enhancement of productivity in construction especially in developing countries, where most of the building construction work is still on manual basis.The lean approach is recognized as one of the ways that can bring improvement in time, cost, and quality of construction projects through minimization of waste and maximization ofperformance. However, there is lack of knowledge about lean concept in India. This paper highlights factors affecting productivity and how to use lean tools to improve productivity.

Keywords: Lean Construction, Productivity, Lean tools.

Introduction: Lean

Today, principles and practices of Lean manufacturing are widely used by industries to eliminate waste and make the process more efficient. Leanprinciple has been recognized as one of the key approaches in enhancing the productivity and hence the competitiveness of an organization.[1]

Applying Lean thinking has transformed many industries and its implementation in construction has now started to show the potential benefits. The lean principleapproach is the only way that improvements in time, cost and quality can be made simultaneously without trade off. [2]

"Lean Construction is a combination of operational research and practical development in design and construction with an adaption of lean manufacturing principles and practices to the end-to-end design and construction process. Unlike manufacturing, construction is a project based-production process."[3]

Lean construction is the application of lean (Production principle) thinking to the design and construction process creating improved project delivery to meet client/customer needs and improve profitability for construction. [3]

History of Lean

When we talk about lean, the first name that strikes our mind is Toyota. However, it is worth noting that the history of lean started way back in 1450s in Venice, and thereafter the first person who integrated the concept of lean in the manufacturing system was Henry Ford. Further, in 1799, Eli Whitney came with the concept of interchangeable parts. Further, in 1913, Henry Ford propounded the flow of production by experimenting with interchanging and movement of different parts so as to achieve standardization of work. However, there was a limitation to the Ford's system that it lacked variety and was applied to only one specification.

Although there are instances of rigorous process thinking in manufacturing all the way back to the Arsenal in Venice in the 1450s, the first person to truly integrate an entire production process was Henry Ford. At Highland Park, MI, in 1913 he married consistently interchangeable parts with standard work and moving conveyance to create what he called flow production. The public grasped this in the dramatic form of the moving assembly line, but from the standpoint of the manufacturing engineer the breakthroughs actually went much further.

Ford lined up fabrication steps in process sequence wherever possible using special-purpose machines and go/no-go gauges to fabricate and assemble the components going into the vehicle within a few minutes, and deliver perfectly fitting components directly to line-side. This was a truly revolutionary break from the shop practices of the American System that consisted of general-purpose machines grouped by process, which made parts that eventually found their way into finished products after a good bit of tinkering (fitting) in subassembly and final assembly.

The problem with Ford's system was not the flow: He was able to turn the inventories of the entire company every few days. Rather it was his inability to provide variety. The Model T was not just limited to one colour. It was also limited to one specification so that all Model T chassis were essentially identical up through the end of production in 1926. (The customer did have a choice of four or five body styles, a drop-on feature from outside suppliers added at the very end of the production line.) Indeed, it appears that practically every machine in the Ford Motor Company worked on a single part number, and there were essentially no changeovers.

When the world wanted variety, including model cycles shorter than the 19 years for the Model T, Ford seemed to lose his way. Other automakers responded to the need for many models, each with many options, but with production systems whose design and fabrication steps regressed toward process areas with much longer throughput times. Over time they populated their fabrication shops with larger and larger machines that ran faster and faster, apparently lowering costs per process step, but continually increasing throughput times and inventories except in the rare case-like engine machining lines-where all of the process steps could be linked and automated. Even worse, the time lags between process steps and the complex part routings required ever more sophisticated information management systems culminating in computerized Materials Requirements Planning (MRP) systems.

As Kiichiro Toyoda, TaiichiOhno, and others at Toyota looked at this situation in the 1930s, and more intensely just after World War II, it occurred to them that a series of simple innovations might make it more possible to provide both continuity in process flow and a wide variety in product offerings. They therefore revisited Ford's original thinking, and invented the Toyota Production System.

This system in essence shifted the focus of the manufacturing engineer from individual machines and their utilization, to the flow of the product through the total process. Toyota concluded that by right-sizing machines for the actual volume needed, introducing self-monitoring machines to ensure quality, lining the machines up in process sequence, pioneering quick setups so each machine could make small volumes of many part numbers, and having each process step notify the previous step of its current needs for materials, it would be possible to obtain low cost, high variety, high quality, and very rapid throughput times to respond to changing customer desires. Also, information management could be made much simpler and more accurate.[4]

Principles of lean construction

In various subfields of the new production philosophy, a number of heuristic principles for now process design, control and improvement have evolved. There is ample evidence that through these principles, the efficiency of flow processes in production activities can be considerably and rapidly improved. The principles may be summarised as follows [5]

- Reduce the share of non-value-adding activities (also called waste)
- Increase output value through systematic consideration of customer requirements
- Reduce variability
- Reduce cycle times
- Simplify by minimizing the number of step parts and linkages
- Increase output flexibility
- Increase process transparency
- Focus control on the complete process
- Build continuous improvement into the process
- Balance now improvement with conversion improvement
- Benchmark

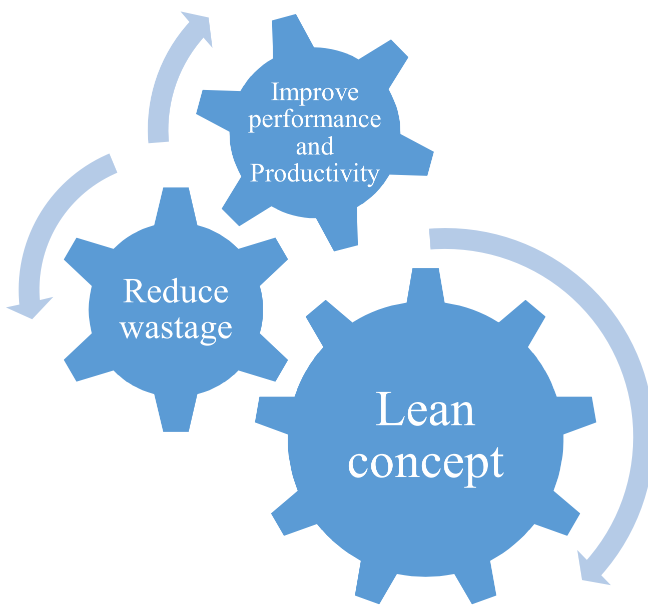

Figure: 1 - Overall Criteria of Lean and Productivity

Introduction: Productivity

Productivity plays an important role in the construction industry. Productivity is one of the most important issues in both developed and developing countries. Productivity plays an important role in the construction industry. Productivity is one of the most important issues in both developed and developing countries. The term “Productivity” expresses the relationship between outputs and inputs. Every project has productivity; cost, quality, and time have been the main concern. The productivity of labour is particularly important especially in developing countries, where most of the building construction work is still on manual basis. Better productivity can be achieved if projects management includes the skills of education and training, the type of tools, machines, required equipment and materials, personal skills, the workload to be executed, expected work quality, work quality, work location, the type of work to be done, and supervisory personnel. Proper management of resources in construction projects can yield substantial saving in time and cost. Inefficient management of construction resources can result in low productivity.[6]

$$\text{Productivity} = \frac{\text{Output}}{\text{Labour} + \text{Equipment} + \text{materials}}$$

Factors affecting on productivity

Factors identify by literature survey, which affected in productivity are classified under the 4th groups.[7]

Human / labour group

- Labor Fatigue
- Labor Skill
- Availability of Experienced Labor
- Labor Motivation

External group

- High/Low Temperature
- Sandstorms
- Rain
- High Humidity
- High Winds

Management group

- Unrealistic Scheduling and Expectation of Labor Performance
- Incentive Scheme
- Labor Interference and Congestion
- Storage Locations
- Communications between Site Management and Labor
- Sequence of Work
- Late Arrival, Early Quit and Frequent Unscheduled Breaks.
- Lack of Construction Manager Leadership
- Delay in Payment
- Method of Construction
- labor Supervision
- Lack of Recognition Program
- Unavailability of Suitable Tools
- Delay in Inspection by Site Management
- Material Shortage
- Lack of Training Offered to Operatives
- Lack of Periodical Meeting with Crew Leader
- Lack of Suitable Rest Area Offered to labor on Site
- Crew Size and Composition
- Working Overtime
- Lack of Providing Laborwith Transportations
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Technological group

- Clarification in Technical Specifications
- Team Spirits
- Delay in Responding to Requests for Information's
- Rework
- Delay in Inspection by the Engineer
- Site Restricted Access
- Extents of Variations/Change Order During Executions
- Layout of Site

Lean construction tools

There is no doubt that lean construction is the way forward for construction industries around the world. About 57% of productive time waste are said to exist in the construction industry.[8]

In general, lean construction tools are intended to improve the delivery systems and processes by minimizing wastes, increasing productivity and health and safety and overall, achieving client's requirements. In essence, it will lead to better delivery processes and value-added systems through the removal of wastes; transportation, overproduction, inappropriate processing, lead time, inventories, rework and unnecessary movements in construction processes, hence, improve project and financial performance of the industry.[8]

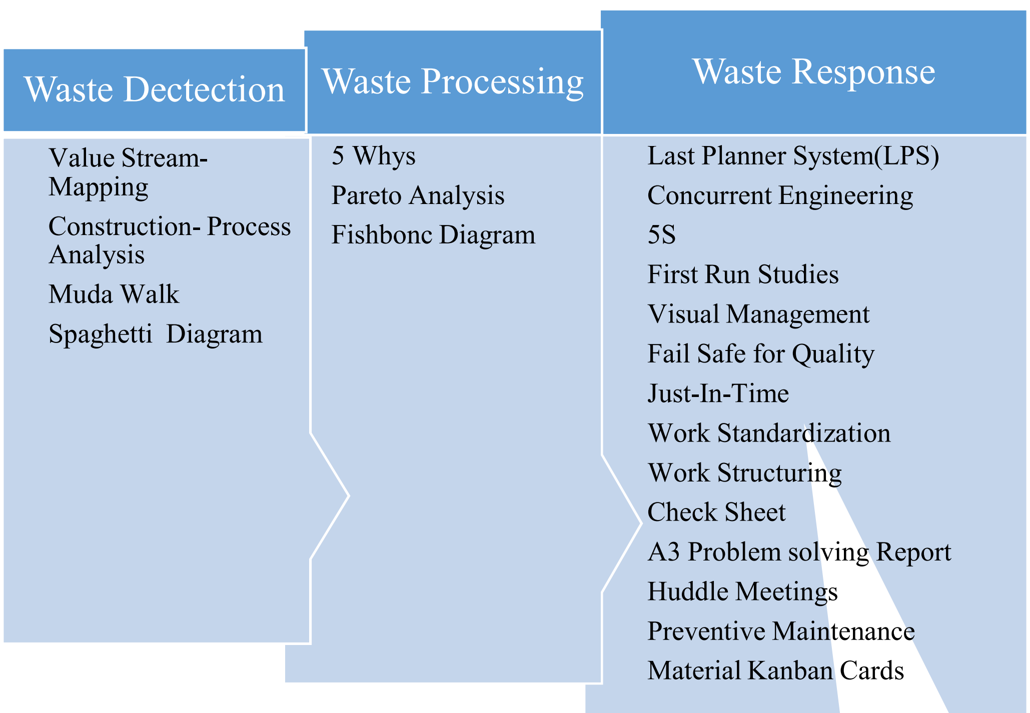

Figure: 2- Waste Management Framework *[8]*

Description of figure-2of important tools of lean construction following as Table-1

Table:1- Lean Construction Tools [8]

No.	Tools	Description
1	Value Stream Mapping	A technique for visually analysing, documenting and improving the flow of a process in a way that highlights improvement opportunities.
2	Construction Process Analysis	This actualizes process charts and top-view flow charts common among process analysis methods. These diagrams and charts depend on standardized symbols and effectively describe process flow and enable a quick determination of areas where problems exist in the process. The charts comprise of six symbols; Operation, Storage, Transportation, Volume Inspection, Delay, and Quality Inspection. The process diagram records every progression or step of a construction operation. Furthermore, it records flow within units, sections, and departments.
3	Muda Walk	Muda is a Japanese word meaning waste. Muda walk is a technique used to identify waste through observation of operations, how work processes are conducted, and noting areas where improvements are needed.
4	5 Whys	This is a quality management tool for problem-solving and it tries to find the root cause of an issue. It stipulates that workers should be asking why five times repeatedly until they identify the underlying root or the nature of the issue and its solution becomes clear. The procedure tries to fix a system by eliminating the root cause to avoid its recurrence.
5	Pareto Analysis	This is a bar graph that is used for analysing data about the frequency of the causes or problems in processes. It visually depicts which situation are more important.
6	Check Sheet	Also known as Defect Concentration Diagram. This is a structured form prepared for collecting and analysing data. It is a generic tool adapted for a variety of purposes including observation and a collection of data on the frequency of patterns of problems, events, defects, causes, etc.
7	5S	Stands for Seiri, Seiso, seiton, Seiketsu and Shitsuke, (meaning Sort, Straighten, Shine, Standardize, and Sustain). This is a process for waste removal from the workplace through the use of visual controls.
8	Work Standardization	Manufacturing documented procedures that capture best practices. This "living" documentation that is easy to change.
9	Just-in-Time (JIT)	This is a technique aimed primarily at minimizing flow times within a production as well as response times from suppliers and to end users. In any case, JIT is a way of thinking, working and managing to eliminate wastes in processes.
10	The Last Planner	The last planner is a person or group of people with the task to control production unit. They are responsible necessitating control of workflow; verify supply stream, design, and installation in all the production units.

11	Visual Management	This is information communication technique employ to increase efficiency and clarity in processes through the use of visual signals.
12	Daily Huddle Meetings	This a technique used for communicating and for everyday meeting process of the project team in order to accomplish workers involvement. With project awareness and problem-solving contribution alongside some training that is given by different tools, the satisfaction of job (sense of growth, self-esteem,) will increase.
13	First Run Studies	Trial execution of a process with a specific end goal to decide the best means, strategies, sequencing, among others to perform it. First run studies are done a couple of weeks ahead of the scheduled execution of the process, in order to secure some time to acquire diverse or extra essentials and resources. In construction, this is used for redesigning critical assignments. This is part of continuous improvement effort, and incorporate efficiency studies and review work techniques by redesigning and streamlining the distinctive functions involved. The techniques involve the use of photographs, video files or graphics to demonstrate the process.
14	Preventive Maintenance	This is regular maintenance performed on equipment to reduce the probability of its failure. It is usually performed while the equipment is working to avoid unexpected breakdown.
15	Fail Safe for Quality	This relies on the generation of ideas which alert for potential defects. This is almost the same as Poka-Yoke techniques but it can be extended to safety. However, the concentration in safety is on potential hazards rather than potential defects, and it is identified with the risk assessment technique. It requires action plan that avoids bad outcomes.
16	Work Structuring	This is used for the development of process design and operation in alignment with the supply chain structure, allocation of resources, product design, and assembly design efforts with the objective of making work process more reliable and quick while delivering quality to the client.
17	Concurrent Engineering	This methodology involves the various tasks Parallels executed multi-disciplinary teams with the aim of optimizing. Engineering cycles of products for efficiency, quality, and functionality.
18	Six Sigma	Sets of tools and techniques for improving quality through identification and removal of defects and reduction of variability in processes. Six Sigma is able to achieve process quality of 99.99966% that is free from defects.
19	SMART Goals	Goals that are Specific, Measurable, Attainable, Relevant, and Time-Specific.
20	PDCA (Plan, Do, Check, Act)	This is an iterative approach for improvements implementation. It involves; Plan (set up a plan and expect results); Do (execute the plan); Check (verify anticipated result achieved); and Act (evaluate; do it again).

How to improve productivity in Construction Industry?

- **Increase predictability of delivery**
  Clients/customerwants certainty and predictability of delivery. Major causes of lost productivity include interruptions/poor coordination, poor site management/supervision, poor up-front planning, lack of integration in project teams, lack of commitment to productivity improvement, poor skills/competencies, poor design and design management, and a lack of productivity data and analytics.
- **Drive greater integration and collaboration**
  Production systems are disappearing in other sectors but are still pervasive in construction. Organisations which can control and integrate the entire supply chain from design through to construction to manufacturing and facilities management are better able to manage risk and to deliver a whole-of-life solution which better responds to client's needs.
- **Move to a service-based rather than a product-based delivery model**
  Lump-sum contracting is being replaced with a game-changing paradigm of a fully integrated service-based delivery model. Clients have a business need and many are happy for the industry to provide a 'service' solution to satisfy that need. Many clients want an organisation that will take entire one-stop responsibility for delivering a high performance asset.
- **Technology**
  It is a key to increase industry engagement with new technologies which have driven productivity improvements in other sectors. Technologies that offer particular promise to increase productivity includes ICTs, off-site fabrication, robotics, materials management systems, automated tracking and GPS, cameras and bar coding technologies, mobile technologies, BIM, and augmented reality.
- **Improve project management and supervisory skills**
  Under-investments in training and an aging workforce means we are losing project management skills – particularly in communication, coordination, logistics and execution. There is also a need to address years of under-investment in construction blue-collar worker skills development. The subcontracting model has impacted significantly on investments in people.
- **Deeper supply chain collaboration**
  Subcontractors are typically poorly integrated into projects. The term subcontracting is derogatory and reflects embedded mistrust, risk transfer cultures and power imbalances within the industry. A better term would be specialist subcontractors, co-contractors or contract partners. These organisations are key to improving productivity and there are many productivity and cost benefits of treating subcontractors as partners and involving them earlier on.
- **Workplace culture is critical**
  Workplaces need to be set up to perform highly. High performance workplaces combine strong diagnostic use of performance data; high level of external connectedness to customers, communities and supply chains; strong internal connectedness between functions and levels; effective communication; good employee relations; strong connections between effort and reward; employee participation and empowerment; and fairness and dignity at work. [9]

Conclusion

Lack of knowledge of how waste is minimized and maximize the productivity in Indian construction, so there is a need the lean approach is recognized as one of the ways that can bring improvement in time, cost, and quality of construction projects through minimization of waste and maximization of performance. This paper has reviewed the published literature on lean concept and productivity performance in construction. Based on that one can conclude that minimization of waste in construction is possible using lean principle. More over Productivity of a project is associated with wide range of factors which are classified into groups.

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