



ISSN: 0976-3031

Available Online at <http://www.recentscientific.com>

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 10, Issue, 03(F), pp. 31581-31585, March, 2019

**International Journal of
Recent Scientific
Research**

DOI: 10.24327/IJRSR

Research Article

IMPACT ASSESSMENT OF LEAN CONSTRUCTION TOOLS AND TECHNIQUES IN RESIDENTIAL PROJECT

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DOI: <http://dx.doi.org/10.24327/ijrsr.2019.1003.3291>

ARTICLE INFO

Article History:

Received 13th December, 2018

Received in revised form 11th

January, 2019

Accepted 8th February, 2019

Published online 28th March, 2019

Key Words:

LEAN tools, Construction industry, production, Pareto analysis, six sigma

ABSTRACT

Lean production not only successfully challenged the accepted mass production practices in the automotive industry, significantly shifting the trade-off between productivity and quality, but it also led to a rethinking of a wide range of manufacturing and service operations beyond the high-volume repetitive manufacturing environment. (Holweg, 2007). Toyota production system was initially introduced by Japan after World War II when Japan required producing small batches of cars in many varieties in contrary to the Ford principle of mass production (same cars with large production runs) (Conte 2002). Toyota concluded that the principle of mass Production is not efficient anymore, especially, after the collapse in sales that Toyota encountered and led to releasing large part of their workforce. Hence, they came up with new ideas and introduced the Toyota Production system, known as LEAN production (Ahrens 2006). This research work is regarding the problems facing by the construction industry in Gujarat, where India is the second fastest growing economy in the world. The purpose of this research is to increase the productivity in construction projects by using LEAN tools also improve time, cost, quality and safety in construction by the using of LEAN tools and after that determine performance at construction site after and before the use of LEAN tools. As a research says that 55% of respondents are not aware about LEAN construction but have potential to use new management techniques. Research also presents some of LEAN principles that are used in construction projects in Gujarat. This research shows Implementation in construction activity by using Appropriate LEAN tools also increase productivity and quality of construction.

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INTRODUCTION

Lean is a production management-based method of project delivery. Though it has taken off from Toyota's Lean manufacturing techniques, Lean Construction has already been well adapted for construction. Toyota's main purpose behind introducing this new concept, known as lean production, was to enhance production efficiency by producing high quality products with maximum value and at less cost (Jacobs 2010). Lean production system aims to meet customer requirements by delivering the product instantly and with no intermediate inventories (G.A.Howell, What is Lean Construction 1999). Lean's main idea is to eliminate waste from manufacturing process. LEAN enables you to deliver higher quality products at significantly lower cost. LEAN method are suitable for any manufacturing and service industry to identify value add activities. Bertelsen *et al.* (2001) indicated that Danish contractors had increased productivity by 20%, minimized project duration by 10%, expanded efficiency by

20%, and enhanced profitability 20% - 40% on projects where lean principles are adopted.

Experimental Section

This study was conducted in Junagadh, Gujarat, India. The preliminary study was taken to check the output of Production at construction and problems occurring in construction which decrease its productivity for first week. After that for any activity suitable LEAN tool was adopted and applied on the activity, which productivity is less and there are more errors during working period. Production management is at the Center of lean construction (LC) and keeps running from the project initiation through project handover to maintenance. Several powerful lean production techniques and tools have been developed over the past decade to manage construction projects. Some of these are procedural, some are conceptual, and some are embedded in programming. Here there are tools which are used for the LEAN construction. Different tools have its different specialty.

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List of LEAN Tools

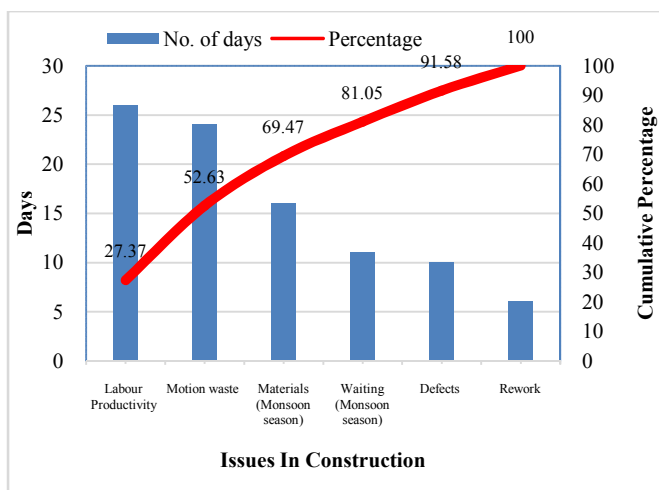
- ✓ Last Planner System (LPS)
- ✓ 5S
- ✓ Kanban (Pull System)
- ✓ Just-In-Time
- ✓ Work Standardization
- ✓ Value Stream Mapping
- ✓ Poka-Yoke (Error Proofing)
- ✓ Continuous Flow
- ✓ Six Sigma
- ✓ Pareto Chart
- ✓ PDCA (Plan, Do, Check, Act)
- ✓ 5 Whys
- ✓ Root Cause Analysis
- ✓ Jidoka/Autonomation
- ✓ FIFO line (First In, First Out)
- ✓ Takttime

Pareto Analysis

The PARETO procedure creates Pareto charts, which display the relative frequency of quality-related problems in a process or operation. The frequencies are represented by bars that are ordered in decreasing magnitude. Thus, a Pareto chart can be used to decide which subset of problems should be solved first or which problem areas deserve the most attention. By using Pareto analysis, different issues were observed at site like, With the help of observation of one month (30 days) issues occurred are shown in table.

Table 1 List of Issue in construction site by using Pareto Analysis

Issues	No of days issues occurred in 1 month
Labor productivity	26
Motion waste	24
Materials (Monsoon season)	16
Waiting	11
Defects	10
Rework	08



Graph 1 Pareto Analysis Graph

Continuous Flow

A continuous flow process is a method of manufacturing that aims to move a single unit in each step of a process, rather than

treating units as batches for each step. The process is called “continuous flow” because you are continuously producing new products. It’s advantageous in many industries, such as vehicle manufacturing, where you need to keep up with high demand from consumers. Batch production is useful in other scenarios as well, such as completing one-time work for a client. There are so many problems related to continuity in project activity so with the help of this tool we can make tiles activity smooth and fast and also with the help of this tool we can make productivity more accurate and fast as per requirements. By this tool we can manage time for the activity and completion of time becomes very fast.

In Glaze tiles work with grout fitting For 1 labor set up time for one piece is 3 to 5 minutes so for the first tile work done in 3:23 minutes and second tile done in 2:31 minutes and third tile done in 2:04 minutes. so, now to ready the tile for apply on the wall is 1:03 minutes. so, total time is Total time: 2:66+1:00= 3 minutes 12 seconds for 1 tile work. Now after using continuous flow, work will be taken by two labors. First labor prepare tile for apply on wall and second labor apply tile on the wall and level it. After that, time requirement is as below:

1 tile work with measurements: 2:12 minutes, at that time helper makes tile with cement mixture layer and takes same time 1 minute. So after this Total time for 60 sq feet work: 2 hour 10 minutes by applying continuous flow.

Total time for same work: 3 hour 14 minutes without applying continuous flow. Total time for 24 blocks without applying continuous flow: 77 hour. Total time for 24 block by applying continuous flow: 52 hour. Total savings of time for 24 blocks: 25 hour



Figure 1 working without continuous flow



Figure 2 Working with continuous flow

Six Sigma

Lean Six Sigma is a methodology that relies on a collaborative team effort to improve performance by systematically removing waste and reducing variation. It combines lean manufacturing/lean enterprise and Six Sigma to eliminate the eight kinds of waste.

In construction continues improvement is very helpful for organization and also construction. With the help of six sigma tool we can improve customer satisfaction and make it more valuable as per customer requirements. In this tool we can do a residential survey to identify the problems occurring in construction and also try to eliminate in next construction projects.

So we can improved the project for next customer and also make construction more qualitative. In this survey we take 6 house holders to talk about construction issues after they took place at the duplex. And requirements of things they need in construction also. Also we take customer's satisfactions level out of 10 points.

Table 3 Customer's requirements survey

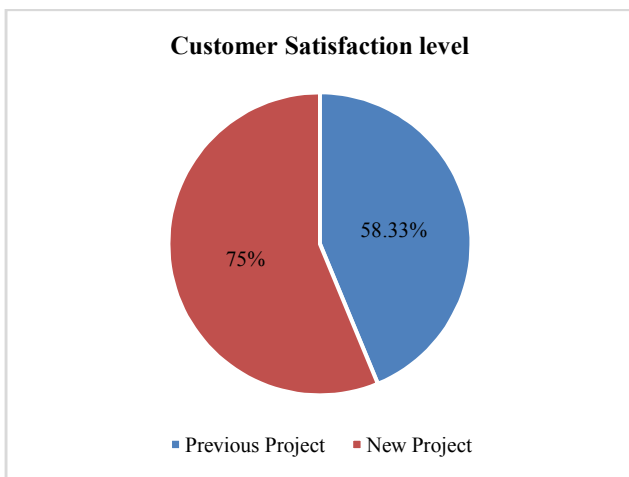
Customer requirements	location
Long platform	Kitchen
Door Quality	Rooms
Wash basin	Bathroom
Window frame	Kitchen and rooms

Table 4 Customer's satisfaction level on previous project

Total Score	Scores given by customers	Customer Satisfaction Level
10	7	
10	5	
10	8	
10	3	58.33%
10	6	
10	6	
Total=60	Total= 35	

Table 5 Customer's satisfaction level on current or new project

Total Score	Scores given by customers	Customer Satisfaction Level
10	6	
10	8	
10	8	75%
10	8	
Total=40	Total= 30	



Graph 2 Customer's satisfaction level comparison

Just in Time

The Just-in-Time or JIT is an inventory management system wherein the material, or the products are produced and acquired just a few hours before they are put to use. The Just-in time system is adopted by the firms, to reduce the unnecessary burden of inventory management, in case the demand is less than the inventory raised. The objective of Just-in-time is to increase the inventory turnover and reduce the holding cost and any other costs associated with it. This concept is again popularized by the Japanese firms, who place an order for the material, the same day the product is to be produced.

On Construction site excess of material is a common issue nowadays. Due to highly requirements, we order material continuous with high number of orders. By these number of orders excess of materials on site, there is more cost of storage also. With the help of just in time tool we can order material and goods as per requirement and as per time and also as per quality and quantity. After the observation current situation of material management is very poor. So we apply tool on the purchase department also on number of orders and quantity of orders. In the current situation order load is 340 cement bags and usage of one month is 750 cement bags. So, we have to orders 3 time of 340 cement bags in one month.

Before Using Just in time

- No of orders: 3
- Total bag: $340 \times 3 = 1020$ bags in one month
- Requirement of bags (1 month): 750 bags
- 1020 bags - 750 bags = 270 cement bags excess in 1st month
- 2nd Month: 270 bags + $(340 \times 2) = 950 - 750 = 200$ bags excess of cement bags in 2nd month

After using Just in time

- No of orders: 2
- Total bag: $440 \times 2 = 880$ bags in one month
- Requirement of bags (1st month): 750 bags
- 880 bags - 750 bags = 130 cement bags excess in 1st month
- 2nd Month: 130 bags + $(340 \times 2) = 810 - 750 = 60$ 2nd month excess of cement bags

5. 5s

5S is a workplace organization method that uses a list of five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. These have been translated as "Sort", "Set In order", "Shine", "Standardize" and "Sustain". It helps to reduce cost and increases productivity and also gives safer work environment.

These visuals use text, colors, and symbols to convey information. They can indicate the contents of drawers, call out hazards, or tell people where to store parts. 5s tags can help manage material procurement system and also we can identified time for order and number of orders.

Many styles and sizes exist, and some businesses even choose to make these in-house with a label and sign printer. With the help of 7 days audit we can conclude that how much material is required and also status of consumed material and wastage also. After that 5s can help to define material type and its function segment like electric segment and drainage segment and pipe fitting segment.



Figure 3 Material management without 5s tool



Figure 4 Material management by 5s tool

FIFO (first in first out)

A FIFO warehouse system is an inventory management system in which the first or oldest stock is used first and the stock or inventory that has most recently been produced or received is only used or shipped out until all inventory in the warehouse or store before it has been used or shipped out.

First in first out system is very helpful to manage usage of material, through FIFO we conclude that which material is to be used first and which one is to be used after that or last. In FIFO, first empty the old material or last procured material then use the latest procured material to reduce variation and improve quality in purchase.

With the help of FIFO method we can use fresh and nice material at the construction for better result and also to improve quality of construction and manage the material. Also we can manage warehouse, which material is procured first and which one is latest procured material. In case of any issues in material or construction we can identified the problem in material (if it is responsible).

Poka yoke (Error Proofing)

There are number of errors occurred during the construction time and it causes delay in activity and extra time many times and also waste in construction. So to eliminate error we can take a proper sheet of identification which is called poka yoke identification. In this tool we can identify the problem or error and we eliminate this error in future project and also in current

project for better flow of work and time and activity management. On every problems or error we take a poka yoke sheet and we note down that error on that sheet for better results and eliminate error next time.

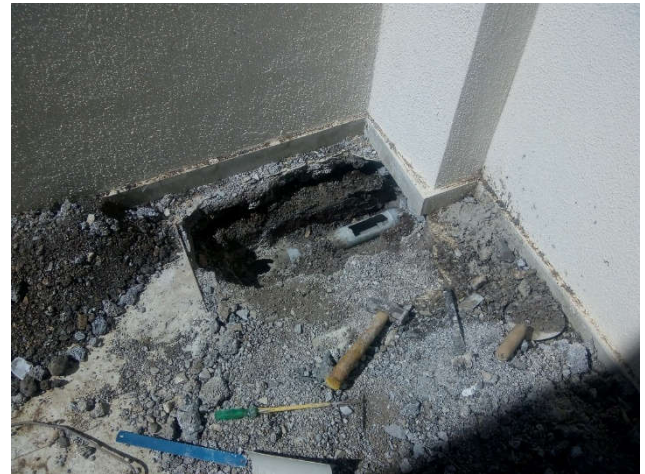


Figure 5 Error after construction (Identified by poka yoke)

RESULTS AND DISCUSSION

After using Pareto analysis we can make sure that in which segment the rate of productivity and problems are more. So after that we can focus on it and eliminate it and make activity precise and more productive. As per analysis, it states that **27.37 %** problem is in labor productivity. So it helps to focus on labor productivity and make it more valuable.

By using continuous flow tool we can maximize the productivity of labor and make it quicker and we can manage time by saving time up to **67%** time for whole project. Also it helps to manage activities of labor as per schedule and make it more accurate and qualitative. It helps to reduce productivity waste of labor. It helps to take right work at right time with right numbers of labors.

With the help of six sigma we can make construction more qualitative and as per customer requirement, also we can improve customer satisfaction up to **40 %** more than previous project by considering customer's requirement survey. It helps to prevent issues regarding customer requirement and make it more improved also having latest facility in construction.

Just in time eliminates the excessiveness of materials on site and handling cost of material. This tool also reduce excessiveness up to **30%**, which is very helpful for construction. It helps to save holding cost of material at site and make working location clean and safer for labor.

5s tool maintain the material management and also procurement. This tool also useful to identify which material's consumption is more and number of order requires more. This tool is helpful in to reduce crises of materials. It create a proper theme for procurement and arrangement of materials at warehouse.

FIFO manage the quality for material which is used in construction and also to reduce mixing of new and old procured material. By using this tool, fresh and newly arrived materials are used in construction. Also helpful to identified that which procured material is defective.

Poka yoke helps to remove the errors in construction activity and also for future activity which is taken in new project. It also help to eliminate the time wastage and delay in current process of construction.

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