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Lean Construction: A Case Study at Precast Plant

Phaniraj K
Associate Professor, Construction Engineering and Management Branch, Dept. of Civil Engineering, MIT, Manipal

Venkatesh A L
Student (M.Tech), Construction Engineering & Management, Dept. of Civil Engineering, MIT, Manipal

Ganapati M G
Vice-President, BCV Developers, Precast Brigade Group, Bangalore

***Abstract* -This paper acts as a resource to precast constructions who are attempting to implement lean production technique to improve their production operations by eliminating waste. In general lean is an approach for production management that identifies and eliminates non value added activities to satisfy the clients/customers by delivering the highest quality at the lowest cost in the shortest time. Kaizen method a lean production technique is used in this research, this paper focuses on two fundamental lean concepts, eliminating the non-value added activities and improving value added activities which enhances the productivity. To develop these concepts, this paper uses a case-study approach at Brigade orchards Precast Plant near Devanahalli. Kaizen method is successfully implemented in plant and this results increase inproductivity. This study also found employee involvement, labour cooperation and management support is a key factors for successful lean implementation. Challenges that limited implementation success and the related lessons learned are also presented in this study.**

***Keywords*-Lean Construction, Kaizen Method, Productivity, Labour, Value added, Non-value added, Paired T-test.**

INTRODUCTION

The concept of precast construction was first introduced by Roam person, England city engineer called John Alexander Brodie in the year 1905, Liverpool. He was the first person to develop and perfect the idea of using precast concrete forms in modern Architectural Design. Precast concrete popularity increased rapidly and many new precast companies started. Color, surface texture, light and shade profiling and large panel construction gave architects a design freedom that was not possible in cast-in situ concretes.

Precast construction is a construction product produced by casting of concrete in a reusable mould or form which is then cured in a controlled environment, transported to the construction site and lifted into place.

In the precast buildings where the majority of structural components are standardized and produced in plants in a location away from the building in the proper environment by fulfilling the quality requirements, and then transported to the site for assembly in a suitable arrangement i.e., on trailors, A-frames, long trucks. Those elements which are sent to site for erection are placed in a proper location as shown in the drawing with the help of mobile cranes or tower cranes. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost.

Precast is a new emerging technology this is mainly preferred because man power required in the precast plant/site is less as when compared to conventional construction method, hence man power productivity plays a very important role in the precast industry. Therefore precast is called as fast track construction this is because of its productivity. Now a days as there is a shortage ofman power especially due to lack of skilled man power there is a difficulty in achieving the target in time with quality requirements, to overcome this problem improving the productivity as to be done. This paper discusses regarding the implementation of Lean construction technique in the precast plant to enhance the man power (labour) productivity.

Productivity is defined as a ratio of output and input while performing a process or creating a product.

Lean production was first originated from the Toyota Production System, it was developed as a new way of thinking which advocates reducing or eliminating non value adding activities as well as improving the efficiency of value adding activities.

There are many techniques in lean production system among those Kaizen is a method used in this research. Kaizen means improvement, continuous improvement involving everyone in the organization from top management, to managers then to supervisors, and to workers.The Kaizen Institute defines Kaizen as the Japanese term for continuous improvement that is traced to the meaning of the Japanese words ‘Kai’ and ‘Zen’, which means ‘to break apart and investigate’ and ‘to improve upon the existing situation’**.**The Kaizen methodis a valuable technique that is used to increase productivity and to raise the overall precast performance on a tough competitive market. Non-value added activities means which is not adding any value for the final output of the product which satisfies the customer.

OBJECTIVE

The aim of the paper is Implementation of Lean Production Technique (Kaizen Method) in the Precast Plant to improve the performance of Labor Productivity.

METHODOLOGY

Literature review was done of around 12 journals regarding lean construction, there were three techniques of lean production among those kaizen is one of the method chosen in this case because it is the only method which can be implemented in precast plant to enhance productivity.Kaizen Method involves 4 steps they are:

1. Documenting the current process
2. Identifying the waste
3. Develop Lean options
4. Document the changes

CASE STUDY:Brigade Orchards Precast Plant at Devanahalli, Bangalore

This project is of 130 Acres land named as first smart city in Bangalore. It consists of Villas, Stadium, Hospital, School, Commercial Complex and Precast Buildings (4 No's).This is an in-house project which means precast factory and site will be in same place, the main advantage in this project is tax exemption because of in-house. Production of precast elements like wall panels, slabs, beams, staircase and landings will be casted in factory and after 7 days from the date of casting those elements can be delivered to site for erection. This is an open factory which means it is exposed to sun, wind and rain. Open factory is one of the important factor because it varies the labour productivity from season to season. If it is closed factory constant productivity will be achieved.

Step 1: Documenting the current process

In this case study a group of 4 labours is taken, as per the kaizen method according to steps initially documenting the current process is done. Documenting includes number of panels they worked in that day with time taken for each panel and also includes value added and non-value added activities. There are 4 phases which includes in casting of panels they are:

- Layout: In this step time taken for fixing of outer mould/forms and fixing of window/door mould is recorded.
- Prep: it means preparation of mould for concreting, includes buffing means removal of concrete particles on the table, application of oil, placing of reinforcement and lifting accessories/carpentry work.
- Pour: In this step concrete is poured into the mould/forms by fulfilling the quality norms.
- Lift: According to de-moulding schedule panels are lifted and stacked in place.

These are the phases which includes in casting of each panel. For all the above mentioned phases time taken for each phase is recorded with value added and non-value added activities as shown in the Table 1.

Date	Panel Number	Activities												Total time taken for each Activity(Min)	Dimension (m2)	Openings (m2)	Productivity (m2/man/day)
		Mould Fixing (Min)	NVA (Min	Buffing & Oil (Min)	NVA (Min	Reinforcement (Min)	NVA (Min	Deha & Carpentry	NVA (Min	Concreting (Min)	NVA (Min	Lifting (Min)	NVA (Min				
Percentage (%)																	
VAA	0.00																
NVA	0.00																

Table 1: Format for Data collection.

Step 2: Identifying wastes

In this step after documenting current process identifying the waste is done by value added and non-value added activities. Value added activities means which adds value to the output of the final product and non-value added activities means which will not add any value to the output of the final product like fixing time for doors/window moulds, repairing moulds, lack of reinforcement supply, waiting time for instructions, waiting time for tools, waiting time for materials, waiting for another work to complete, rework, talking. All these waste will consume time for regular flow of work, this will reduce the number of panels to cast and hence productivity will be reduced rapidly.

Step 3: Developing lean options

After identifying all forms of waste a lean option has to be developed means to remove these waste an option/way has to implement. For each and every waste/non-value added activities solution is founded and implemented to reduce consumption of time this will increase the casting numbers and hence productivity will also be increased. In this case fixing of doors/window mould is done outside the table so that it will not hamper the work for other activity, repairing work for doors/window mould is avoided by lifting and placing the mould in exact place, marking the position of doors/window on the table, providing daily production plan for all the departments so that it will eliminate the waiting time for inspection/instruction/lack of reinforcement, preventing the reworks, enhancing the communication between the labours, providing the required materials in time without delay. Assigning the roles and responsibilities for workers.Training is provided for those 4 labours to carry out all the above mentioned corrective actions.

Step 4: Document the changes

After the implementation of lean options the changes has to be documented and it should be checked to know whether the productivity is increased. This process is continued from the first step after the implementation of lean options and if any further changes/ non-value added activities is identified then it has to be eliminated if not it has to be avoided.

STEPS INVOLVED IN THE KAIZEN METHOD

STEPS	PROCESS	EXAMPLES
STEP 1	Document current process	Mould fixing
		Laying of Reinforcement
		Pouring of concrete
		De-moulding
STEP 2	Identify all forms of waste	Fixing time for window and door moulds
		Repairing of window and door moulds
		Lack of reinforcement cage supply
		Waiting time for Instruction
STEP 3	Develop Lean options	Providing and circulating DPP
		Fixing window moulds outside the table
		Marking on table
		Preventing rework
		Training the labour to carry out the above mentioned corrective actions
STEP 4	Document the changes	Documenting the changes
		Comparing the before and after training Productivity

COMPARING THE PRODUCTIVITY BEFORE TRAINING AND AFTER TRAINING

Time motion study has been conducted to document the process and work sampling is collected to measure the value added and non-value added activities, this is done to estimate cycle times for each wall panel. A time study was conducted to determine the labour hours required for wall panel by value added activities. An observation was made from moulding stage to lifting stage this gives the duration for each panel which includes both value added and non-value added activites, likewise time motion study has been done for each and every panel and duration is recorded in the format shown above. Time motion study is conducted before and after training which shows the effectiveness of implementing kaizen method. A summary of process performance before and after training in percentage is shown in figure 4 and figure 5.

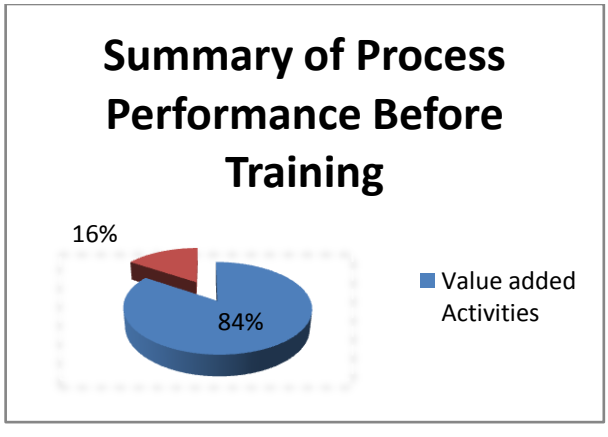


Fig. 4 Process Performance for Before Training

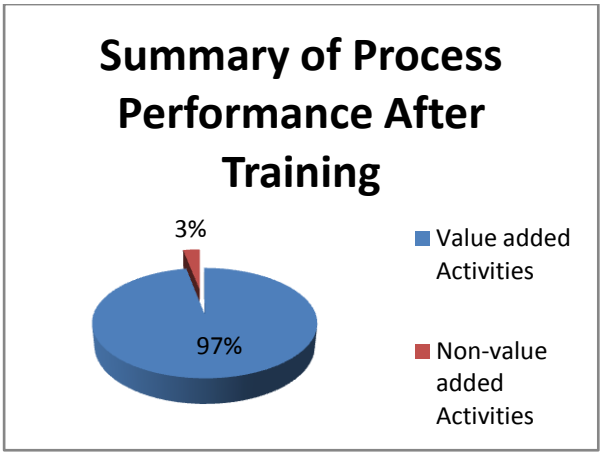
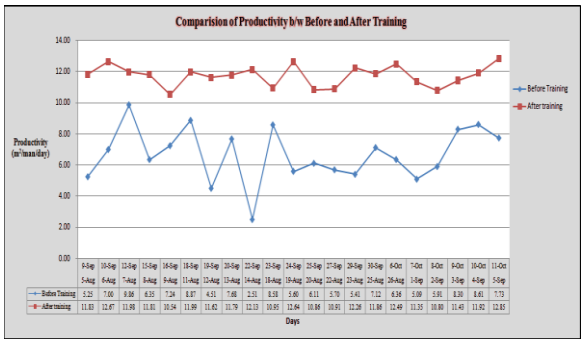


Fig. 5 Process Performance for After Training

By this above two charts the difference is shown between two charts that is the value added activities is increased from 84% to 97% which is 13% and non- value added activities is reduced from 16% to 3% which is 13%. The percentage of non-value added activities is reduced by eliminating some of the waste activities which was involved in the production of panels, this will reduces the time consumption for production of panel, hence the value added activityPercentage(%) has been increased. As the percentage of value added activities is increased the number of panels produced per day is also increased this will increase the productivity of labour.

According to kaizen method documentation process is done for both before and after training, we can see there is an increase in productivity this increase is because of elimination of non-value added activities. Graph 1 represents comparison of labor productivity for about two months, each day productivity is calculated by knowing the number of panels they have casted.



Graph. 1 Comparison of Productivity between Before and After Training.

PAIRED T-TEST

According to research methodology to know the effectiveness of training provided paired t-test has to be conducted. Nessecary datas required are collected and by using formulas of Paired t-test check has been done.

1. To find the mean of differences $\overline{D}$, X_i and Y_i are assumed as before and after training,

$$\overline{D} = \frac{\sum D_i}{n}$$

where, n is sample size and $D_i = X_i - Y_i$

2. To find the standard deviation of differences σ_{diff}, following formula is used

$$\left(\sigma_{diff.}\right)^2 = \frac{\sum D_i^2 - \left(\overline{D}\right)^2 \cdot n}{n-1}$$

3. Formula of paired T-test for judging the significance of training provided

$$t = \frac{\overline{D} - 0}{\sigma_{diff}/\sqrt{n}}$$

Sample size is taken as n=21, mean of difference obtained is D = -5.09. Calculating the square of each differences that is D_i^2 and summation of D_i^2 , leads for obtaining standard deviation of differences σ_{diff} that is 3.416. After getting all these values final is to find out whether the training is significant or not that is t value it is obtained as -6.83. By considering 1% significance level from the T distribution table for 20 degrees of freedom we get t = - 2.528 but the observed value of t is -6.83, hence we can conclude that training provided is been success.

Some of the major problems encountered during case study and necessarycorrective actions taken:

Lack of Production Plan : Daily production plan was not provided for rebar supervisor, mould supervisor and carpenter so this was the major problem which leads to increase the non-value added activities. Since rebar, mould and carpenters are interlinked to each other to produce panels they must know the plan and all these departments should have common plan but this was not happening, hence Daily production plan is started issuing for all departments.

Repairing of moulds : This work was done in all most all the panels because of damage in window/door moulds, this is because during setting of panel hammering of mould is done to keep in exact position of window according to drawing so every time they use to repair and fix the mould. Solution is provided for this problem that is instead of fixing the window mould on the table, it should be fixed outside the table and marking of window/door position is done on the table by marker, as the window/door mould is fixed outside the table those fixed mould is lifted with gantry crane and placed on the table in the exact position on the marking done.

Preventing rework : As the plan was not provided the rebar workers were binding the steel randomly due to this there was many steel binded but not casted as the binded steel becomes older they need to repair those steel during casting period. Similarly mould settors use to set the mould but at the end of the day they will come to know steel is not ready for that perticular panel so they should change the mould. All these reworks are eliminated after implementing the kaizen method.

Waiting time : Workers were waiting for instructions of supervisors so to eliminate this waiting time target was provided for perticular workers so that after completing the target they can move towards their room, this will act as a incentive for workers.

Lack of communication : Communication plays a very important role in any working environment, even miscommunication endsup with huge problems. There was a communication gap between carpenters and mould fixers due to this carpenters will come to know which are the panels ready for casting only at the end of the day, hence this will reduce the production so to over come this problem mould fixers should intimate carpenters at some certain intervals throughout the day which panels they are fixing mould so that carpenter can work on that panel.

CONCLUSION

Results are showing that there is a increase in productivity after the implementation of kaizen method one of the lean construction technique.This method not only improves the productivity it also provides standardization of quality, reduces wastage, reduction in rework. Results from the casestudy clearly demonstrated that by implementing kaizen method the non- value added activities are reduced and the productivity is increased as shown in graph 1. According to research methodology paired T-test is conducted and it clearly shows training given to the labours is effective.

Due to lack of skilled labours and lacking in a system that people are not continuosly engaging in the improvement of process the project will face problems with kaizen method. If the people are involved in continous improvement, management support and monitoring the work is done then the kaizen method can be carried over throughout the project successfully.Identification of wastes should be done at certain intervals and lean options to be given to eliminate those wastes then it reduces the non-value added activities and improves the productivity hence this kaizen method is known as continous improvement method. It can be concluded that any type of precast plant/factory can implement this kaizen method and enhance their performance of productivity.

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