Implementation of Lean Tools and Principles In Precast Construction Process - Cost Case Study

Lekha Shankar G R¹, Janakaraj M²

PG Scholar, Department of Civil Engineering, NMAM Institute of Technology, Nitte Udupi, India
Assistant Professor, Department of Civil Engineering, NMAM Institute of Technology, Nitte Udupi, India

ABSTRACT: The implementation of lean construction principles in precast casting is achievable when it is applied in a strategic way. Lean construction focuses on improving productivity and providing value to the customer. Construction industry is often questioned about low productivity, with respect to schedule, cost overrun, quality. To overcome productivity problems, to achieve higher productivity, new management tools were introduced. One among such methodology was Lean construction. Article presents an idea of introducing lean construction tools and principles in precast casting process in casting yard, to avoid cost overrun and loss.

Article is based on study and observations made in precast casting yard in Bangalore. The casting process was divided into different phases and two process were prioritized to reduce and save cost overrun. Proposed possible solutions could be used for other construction sites.

KEYWORDS: Lean construction, Precast technology, Kanban, kaizen.

I. INTRODUCTION

A. GENERAL

Projects are considered as a key factor in success of an organization. An organisation grows with increase in successful projects. There is an increase in demand for improved project management practices to overcome or to avoid factors, which threaten to damage the successful execution of projects. While looking at the failed projects, studies highlighted on schedule delay and cost overrun as major factors. Execution in construction projects involves many hurdles, one such hurdle is avoiding cost overrun. Many projects experience cost overrun or loss incurred due to many unforeseen reasons. One such reason could be seen in over procurement of materials to avoid risking in last minute delay and shortage of materials. Notable loss occurs in materials procurement and loss due to mistakes during execution.

B. PRECAST TECHNOLOGY

Precast concrete is produced by casting concrete in a reusable moulds, these moulds are cured in a controlled environment and temperature. The product is later carried to the construction site, where the precast product is placed as per requirement and design. Precast technology helps in reducing waste and helps in faster construction. It is standardized with machines and it is more economical when compared to conventional type. Productivity in construction industry can be increased by precast technology. Precast construction is such technique where structural components are casted at casting yard and then assembled in the construction site. Precast construction
has demonstrated faster construction with improved quality control, which has led to better method when compared to conventional construction.

II. LITERATURE REVIEW

Implementation of lean principles is dependent on management learning and knowledge creation, acceptance of new technology and management methods can increase in productive construction. Furthermore, lean also reduces the cost and time delay and in turn improves the quality. (Lianying Zhang, 2016). Lean principles can determine and reduce waste and delay in construction projects (U. Vimal Kumar, 2018), we can enhance both projects deliver time and cost of project by adopting lean construction (Sreema Moha, 2017), by adopting lean principles, we can identify and reduce Non-value added activities and delivering high quality at lower cost in short time (Phaniraj K, 2015). Questionnaire surveys have shown many factors which are responsible for the schedule delay of the construction project (Mulenga Mukuka, 2015). From the survey conducted it was observed that 8 projects out of 13, lean applied projects was completed ahead of schedule (Helena O’Connor, 2015), there is a need or implementation of lean to reduce waste in construction projects (Harsh N, 2013). Precast construction has effective role in time, labour, quality, material requirement etc. but the productivity in precast construction is not taken up by the construction firms (Shreyanka Murari, 2017).

III. OBJECTIVE

Fundamentally, this paper prioritizes in identifying the problems in casting yard, which has potential in contributing loss of expenditure. The objective focused is on

1. To Examine the cost incurred in the project phase and suggestion of lean tool for avoiding over expenditure.

IV. CASE STUDY

The study area for precast casting yard is located in Bangalore. The yard covers an area of 40 acres, where it produces precast products, like Box girders, I Girders/ Beams, Pier arms, Concourse beam and Parapet walls. This is an open factory, it means it is exposed to sun, wind and rain. It is a notable factor cause, change in weather can effect in labour productivity, inventory maintenance and daily productivity.

Fig 1: Casting of box girder

A. COST ESTIMATION

Many projects experience cost overrun or loss incurred due to wastage of inventory. Improper estimation of materials, over procurement of materials, to avoid unforeseen risk can lead to wastage of inventory.
In this study area it was observed that, the total cost required for casting of 10 box girder for 28m span was calculated and it was found that, the total quantity of concrete used for S1-S10 box girder is 155.82 cu.m and reinforcement used was 31.164 MT.

**Data collection**

In this study, effort has been made to propose solution to the problem identified in the casting yard. Data required was collected by focusing on two process in precast yard, where changes can be done without investing much money. Identified stage of casting were,

1- Steel bar stocking yard.
2- Bent and cut rebar scrap yard.

**Problem identified:** During the casting of box girders, it was observed that, there is an over procurement of steel for the casting yard and too many mistakes is costing in the proper production of the girders. It was drawn out by using Ishikawa diagram. It is presented in Fig 2.

![Ishikawa diagram showing root cause of problems.](image)

**Fig 2: Ishikawa diagram showing root cause of problems.**

1- **Steel bar stocking yard:**

The rebar stocking yard comprises of an area of 3200sqft, rebar for the casting yard is procured from JSW. The monthly procured quantity of rebar is 300MT, this 300MT will be used for various casting activities in yard. The safety stock maintained in the yard is 30% of the stock. i.e. when the rebar quantity reaches 30%, new order is placed. There is 13% of oxidised steel in the yard.

**Problem Identified:** The yard comprises of raw materials resulting in excess inventory. Due to poor site management. When a new order is placed, the previous stock is not completely used or relocated for the new stock to be placed. From this, the worker uses only new load and the previous stock lies beneath the new load of steel bar. This has resulted in the oxidation of the older stock, which will affect the quality of steel. The figure 10.3(a) shows the wasted safety stock. The fig 3 shows the wasted safety stock.
2- **Cut and bent rebar scrap generated**

Steel scrap in the yard stacked in the yard is nearly 40MT. This is due to improper cutting and bending work done by the labours ad lack of supervision by the engineers.

**Problem Identified:** In the filled, it was observed that, due to improper cuts from one box girder, there is a wastage of 4-7 rebar’s and 1 helical reinforcement.

This has led to following things:

1- Waste of raw materials.
2- Waste of time spent for bending and cutting.
3- Loss in re-selling of the scrap.

The scrap generated in the casting yard can be seen in **Fig 4**.

The quantity of rebar wasted from one box girder was calculated and approximate estimation of loss from the waste generated was calculated.
Table 1: The quantity of bars wasted from one box girder

<table>
<thead>
<tr>
<th>Segment</th>
<th>Number</th>
<th>Dia (mm)</th>
<th>Single bar length (m)</th>
<th>Total bar length (m)</th>
<th>Single bar weight (kg) (d2/162)</th>
<th>Total bar weight (kg)</th>
<th>Amount (50kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>4</td>
<td>10</td>
<td>1.95</td>
<td>7.8</td>
<td>0.62</td>
<td>4.81</td>
<td>241</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>3.212</td>
<td>6.424</td>
<td>0.89</td>
<td>5.71</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>2.781</td>
<td>5.562</td>
<td>0.89</td>
<td>4.94</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16</td>
<td>2.666</td>
<td>5.132</td>
<td>1.58</td>
<td>6.11</td>
<td>405</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10</td>
<td>3.196</td>
<td>9.586</td>
<td>0.62</td>
<td>5.92</td>
<td>296</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total weight 20.5 1474.87</td>
</tr>
</tbody>
</table>

Table 2: Total quantity of rebar waste and cost of the rebar wasted.

<table>
<thead>
<tr>
<th>Cut bars</th>
<th>Waste (kg/m)</th>
<th>Rate (Rs)</th>
<th>Total (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>29</td>
<td>50</td>
<td>1475</td>
</tr>
<tr>
<td>S2</td>
<td>11</td>
<td>50</td>
<td>541</td>
</tr>
<tr>
<td>S3</td>
<td>21</td>
<td>50</td>
<td>1031</td>
</tr>
<tr>
<td>S4</td>
<td>21</td>
<td>50</td>
<td>1031</td>
</tr>
<tr>
<td>S5</td>
<td>19</td>
<td>50</td>
<td>960</td>
</tr>
<tr>
<td>S5A</td>
<td>11</td>
<td>50</td>
<td>542</td>
</tr>
<tr>
<td>S4</td>
<td>13</td>
<td>50</td>
<td>625</td>
</tr>
<tr>
<td>S3</td>
<td>16</td>
<td>50</td>
<td>769</td>
</tr>
<tr>
<td>S2</td>
<td>11</td>
<td>50</td>
<td>543</td>
</tr>
<tr>
<td>S1</td>
<td>16</td>
<td>50</td>
<td>749</td>
</tr>
<tr>
<td>Helical Reinforcement</td>
<td>25</td>
<td>50</td>
<td>1244</td>
</tr>
</tbody>
</table>

The bar bending schedule was used for all 10 box girders, which showed, following quantity of rebar wasted during casting of 28m span segment. It is given the Table 2.
From 28m span, it can be seen that, total of 190 kg of rebar wasted. Which results to loss of Rs 9,510. The resell value of rebar/kg is Rs 28. Which gives total amount of Rs 5,320. This leads to loss of Rs 4,190.

The overall loss in steel inventory and Scrap storage is given in Table 3.

Table 3: Total quantity of rebar wasted from 28m span segment and amount of wasted rebar

| Total Weight | 190 |
| Total Amount (Rs) | 9510 |

Table 3: Overall loss incurred in steel inventory and scrap storage

<table>
<thead>
<tr>
<th>Steel inventory</th>
<th>Quantity (MT)</th>
<th>Rate (Rs)</th>
<th>Total amount (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly procurement</td>
<td>300 MT</td>
<td>50000</td>
<td>1,50,00,000.00</td>
</tr>
<tr>
<td>Safety Stock</td>
<td>90 MT</td>
<td>50000</td>
<td>45,00,000.00</td>
</tr>
<tr>
<td>Wastage</td>
<td>40 MT</td>
<td>50000</td>
<td>20,00,000.00</td>
</tr>
<tr>
<td>Scrap</td>
<td>40 MT</td>
<td>50000</td>
<td>20,00,000.00</td>
</tr>
<tr>
<td>Resell value</td>
<td>40 MT</td>
<td>28000</td>
<td>11,20,000.00</td>
</tr>
</tbody>
</table>

Total scrap found in the yard is around 40MT (40000kg)
Total cost of rebar of 40MT is = 40 x 50000
= Rs 20,00,000/-

Resell value of scrap rebar is
= 40 x 28000
= Rs 11,20,000/-
Loss incurred in steel scrap = 20,00,000 – 11,20,000
= Rs 8,80,000/-
Loss incurred in wastage = 20,00,000 - 11,20,000
= 8,80,000/-
Total loss incurred in the steel = 8,80,000 + 8,80,000
= Rs 17,60,000/-
V. RESULTS AND DISCUSSION IN COST SAVINGS.

Analysis of cost estimation of implementation for suggested tools is difficult, it is very hard to compare and measure different management ideas in the same process.

<table>
<thead>
<tr>
<th>Problem in Process</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel bar stocking yard</td>
<td>1. Wastage of safety stock due to oxidisation</td>
<td>Two Basket System</td>
</tr>
<tr>
<td></td>
<td>2. Over procurement of materials</td>
<td></td>
</tr>
</tbody>
</table>
| Cut and Bent rebar scarp    | 1. Improper cutting and bending leading to excess of scrap. | 1. GembaWalk
|                             |                                              | 2. Training             |
|                             |                                              | 3. Kanban rack           |

1. Steel bar stocking yard
It was observed that problem is due to lack of utilization of old stock, which is resulting in oxidisation of steel and generating waste. This can be avoided by providing 2 basket system. It is given in figure 6

Two Basket System: The basket size of 20*80ft could be built, in horizontal side of 20ft, 4 divisions should be made to sort and store different dia of rebar in each.
1. Once the rebar in 1st basket is over, 2nd basket stock should be used.
2. when the stock in 2nd bin is almost 50%, new order should be placed to fill the bin.

2. Cut and Bent rebar scrap
It was observed that, the problem is due to lack of skilled labours, negligence during work, lack of supervision. This can be avoided by providing Muda walk, kanban system and training workers.
1. **Muda walk**: Muda walk requires a supervisor to walk through the workplace every hour and check the accuracy of work.

2. **Training Workers**: Instead of making labours by look and learn, training should be provided. New labours or unskilled labours should be taught for 1 hour every day for a week by an experienced labour or a skilled labour.

3. **Kanban system**: A rack system should be provided near rebar bending and cutting area to store properly bent and cut bars in one place. This can avoid in mixing up of improper cut bar with properly cut bar.

![Fig 6: Cut and bent rebar storage rack.](image)

**VI. CONCLUSION**

The cost estimation was concentrated on points in the casting process, which are Steel inventory and scrap yard. Implementation of lean tool can help in avoiding wastage of safety stock, mistakes in cutting and bending of rebar’s, increase of wastage during binding of reinforcement cage.

1. Two basket system from Kanban lean tool can reduce wastage of safety stock from 13% to 3%, oxidation of safety stock, loss in inventory.

2. Gemba walk helps in identifying delays of the casting work process and monitoring the labours. The monitoring of labours will facilitate the skills of labours in completion of work.

3. Continued training process will help in maintaining constant productivity.

4. Gemba walk helps in monitoring casting process.

5. Training labours monthly once can help in saving cost and reducing waste by turning a
   a. Semi-skilled labour to skilled labour.
   b. Unskilled labour to skilled labour.

6. This can result in decrease of improper cut and bent rebar’s, which in turn results in reduction of scrap in casting yard.
The paper gives an outline for a framework for the company to adopt Lean tools to improve the process in the casting yard. Due to lack of knowledge about lean construction, there is a high resistance in the management to adopt new techniques but implementation of the innovative methodologies, tools will result in improvement of casting process.

REFERENCES


