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Application of Lean Construction in Commercial Building

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Abstract:- Lean construction is a new form of construction which we are going to study in this paper. Firstly we are going through the history of lean construction and then we will see the actual case study which is carried out in Hinjawadi Area of Pune district, Maharashtra, India.

Keywords:- *Last Planner System, Master Schedule, Reverse Phase Scheduling, Six Week Lookahead, Weekly Work Plan, Percent Plan Complete, Increased Visualization, Daily Huddle Meeting, First Run Studies, The 5S Process.*

I. INTRODUCTION

We are the citizens of India which is a developing country. After the 70 years of freedom we still lacking behind the world and need much improvement in every sector of a nation. Development starts everywhere in India now so as in construction industry. In India and the rest of the world traditional methods are used for the construction. But after knowing about the lean production, we are using this technique for the construction industry to minimize the time, cost, and efforts and to maximize the profit.

II. DEFINITION

A. Lean construction:

The term 'Lean' means 'slope in one direction' according to dictionary. Now the first question arises 'how this is related to construction?' Answer is very simple, when this technique is applied to the construction site, and graphical representation of the results shows the slope which reduces the waste i.e. it shows slope in one direction. So the term is given to the construction and then it is known as lean construction. So in term of construction lean construction means, 'this minimizes the waste and maximizes the profit, and deliver the product on time to the customer'.

B. Commercial building:

The type of a construction which is specially designed for commercial use only is known as commercial building. For example, corporate offices, shops, shopping mall etc.

III. LEAN CONSTRUCTION HISTORY

Engineer Ohno worked on the Toyota Production Unit of Toyota car manufacturing company. He observed wastage at every stage of the manufacturing start to end process. He was a great and hardworking person who loves his job. He decided to minimize the waste. He also observed that product is not delivered on time and it is not satisfy the customer demand. So he thought to change the manufacturing process in which nothing can left behind in the inventories. So he try something new which cannot be used by anyone before. According to him design n manufacturing can be made simultaneously and while doing this we have to keep customer need in our mind. For that he also suggest that production can be done when we have order as a result we can focus on that particular order and nothing left behind in inventories. It also minimizes the wastage of money, time and efforts. This thinking is known as 'Lean Thinking'.

Scientist Koskela and Howell then apply this Lean thinking to construction and give the name Lean Construction. They are the working professors of Lean Construction Institute. They also modify something into the lean manufacturing while applying it to construction industry.

IV. LITERATURE REVIEW

Lean construction institute has their website, where they publish their journals on Lean Construction. Major data source is that journals which can be published at the lean construction website by many others. Prof. Ballard is the co-founder of Lean construction institute and Prof. Howell is the former president of lean construction institute. They both work on lean construction so they publish their journals many times on various topics related to lean construction. They also notice that only 50% of the task is completed in a end of the planed week.

V. APPLICATION OF LEAN CONSTRUCTION TO ACTUAL SITE

With the help of following tools lean construction can be applied to actual construction site. The tools are mentioned below.

A. Last planner system

According to scientist Ballard, Last Planner System (LPS) is helpful for construction to manage the workflow or to address the variation in project or construction. Last Planner is group of person or a single person who is all responsible for operational planning. Operational planning consists of structure of design of product by facilitating work flow and production unit control up to the completion of the entire project which can be assigned in the operational level. Schedule framework for various activities can be set into the Last Planner System according to their sequence of implementation and which is very efficient by nature with

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the help of pull technique. Pull techniques shapes work flow, sequence and rate. It also matches the work flow with the capacity and develops the methods to improve the work and execute it properly. it also helps to improve the communication between trades.

Ballard in year 2000 also develops Weekly Work Plan that is WWP. Should Can Will these are the key words of WWP. It is seen by observation that Last Planner is succeeded in achieving these things that is Should Can Will. In LPS various key constrains from various techniques are included to improve the work flow such as two-way communication, variance analysis after assignments are completed.

LPS helps to replace optimistic planning with realistic planning by observing the performance of workers and their ability to do work to achieve the target.

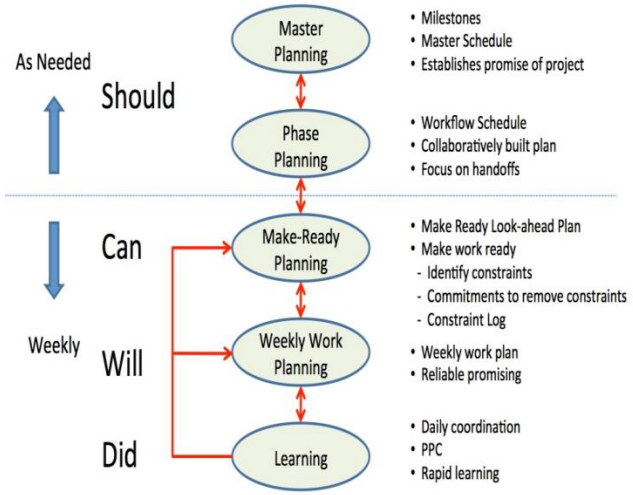

Fig 1:- diagrammatical representation of Last Planner System (source-Google)

B. Master schedule

Master schedule is nothing but the overall schedule of project in which various targets can be mentioned which are used in the bid package. In other words Master schedule is the soul of the project in which all the information regarding the project is mentioned.

C. Reverse phase scheduling

Reverse phase scheduling is based on master schedule. In year 2003, Ballard and Howell developed this technique. In which they concluded that the backward schedule from the completion date is possible with the help of pull technique by team planning. This is then well known as Reverse Phase Scheduling. The main purpose of RPS is to produce a plan for integration and coordination of various stages of the project. In current practices we use critical path method to schedule the total duration of project but if any activity can be delayed, the entire project can be delayed in this. But when we are doing reverse phase scheduling if any activity is lacking behind, we can easily reschedule the project by ignoring that activity and focusing on other non dependent activities and complete our project on time.

However, without considering the actual state of the project, the results of RPS are less accurate and there is lot of scope for improvement in this.

D. Six-week lookahead

The widow represents six week lookahead in which all the data is mentioned. Six-Week Lookahead indicates the upcoming work that is it shows the work which supposed to be done in the near future. The window of SWLA, week 1 is next week after WWP meeting.

E. Weekly work plan

Weekly Work Plan is generated on the basis of SWLA, the actual state of the project, constraints available at the site before the weekly meeting. WWP includes the complete schedule of the week, all the issues regarding safety, quality, manpower, material need, construction methods, backlog of ready work, and if there is any problem arise at the field area. It will also improve the work as well as the relationship between the team members. In WWP, the causes of variance should be documented in that sheet.

PROJECT: 1 WEEK PLAN DATE: FOREMAN:											
ACTIVITY	EST	ACT	MON	TUE	WED	THU	FRI	SAT	SUN	PPC	REASONS FOR VARIANCE
WORKABLE BACKLOG											

Table 1. Weekly Work Plan

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F. Percent plan complete

It can be calculated as the number of activities completed as planned divided by the total number of planned activities. If the slope between the two PPC values is positive then the production planning was reliable and vice versa.

G. Increased visualization

This is the communication tool in which we have to post signs and boards and labels all around the construction site. Signs such as safety related information boards, schedule and quality related information.

H. Daily huddle meeting

In this tool, two-way communication is the important factor between the employee and the higher authorities related to the construction. It helps to improve the involvement of the employee in to the process.

I. First run studies

Ballard and Howell in 1977 states that first run studies are used to redesign critical assignments. Productivity study and to review the work flow is also done in this tool.

J. The 5S process

This is also known as Visual Work Place. This process has five steps involved such as Seiri means sort, Seiton means Straighten or set in order, Seiso means shine, Seiketsu means standardize, Shitsuke means sustain.

This process helps to reduce the wasteful resources. This process improves the safety, productivity, quality. Minimizes time and cost.

VI. CASE STUDY

Yash Technologies Pvt. Ltd. Is the leading information company for corporate or business IT solutions. They are the developers of the site located at Hinjawadi area of phase 3 of Pune. The details of project are as below.

Project Name	Yash Technologies Pvt. Ltd
Developer	Yash Technologies Pvt. Ltd
Contractor	Ratnarup Pvt. Ltd
Project Type	Commercial building
Total Construction	5 Lac Sq. Ft.

At Yash site Hollow Concrete Blocks are using instead of conventional bricks. The requirement of hollow concrete blocks at Yash site is 25000 per month. Egg laying machine is used for preparing the blocks and 5/7 concrete mixer is used to prepare concrete.

A. Information of Old Block

SIZE OF BLOCK: 400X200X200
CONCRETE GRADE: 1:12:6

- 9% replacement for cement with fly ash.
- Crushed sand is used instead of river sand
- Volume of concrete per block is 0.010CM

COMPRESIVE STRENGTH: 5.2 MPa

- Compressive strength of block is calculated by putting hollow face on upper side and closed face to the bottom.

TARGET PRODUCTION: 1000 Blocks per day
HANDLING METHOD: Manual
PERCENTAGE FAILURE: 20%
NET PRODUCTION: 800 blocks per day
WEIGHT OF BLOCK: 22.5 Kg
DEPTH OF HOLLOW PORTION: 170MM

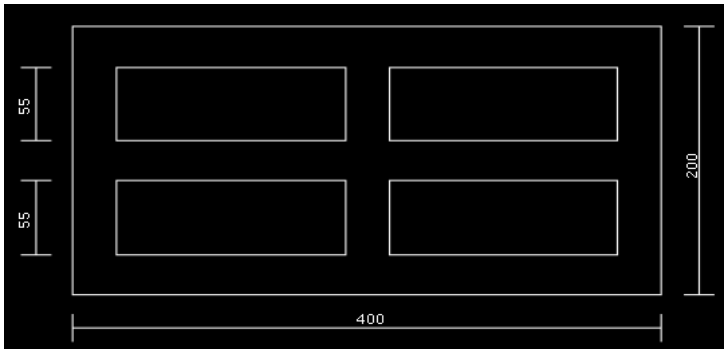

Fig 2:- Design of old block

SR. NO.	ITEM	QTY	UNIT	RATE	AMOUNT
1	CEMENT	37	BAG	145	5337.80
2	FLY ASH	13	BAG	60	780.00
3	CRUSH SAND	9.43	CM	750	7070.68
4	METAL 10MM	4.71	CM	450	2121.20
MATERIAL COST FOR 1000 BLOCKS					15309.68

Table 2. Cost of material of old block

Effective material cost of block=15309/800
=19.14Rs.

B. Procedure to Apply Lean Thinking to the Construction Site

- Make Lookahead Planning to produce 6000 block in a week.
- Enter the Estimated work in the Est column.

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DATE	WEEK	ACTIVITY	EST	ACT	MON	TUE	WED	THU	FRI	SAT	SUN	PPC	REASON FOR VARIENCE
29/6/15-4/7/15	1	BLOCK MAKING	6000	4790	812	808	793	789	791	797		79.83	BREAKAGE/SPACE
6/715-11/7/15	2	BLOCK MAKING	6000	4725	772	785	788	801	778	801		78.75	BREAKAGE/SPACE
13/7/15-18/7/15	3	BLOCK MAKING	6000	4748	803	778	786	802	778	801		79.13	BREAKAGE/SPACE
20/7/15-25/7/15	4	BLOCK MAKING	6000	4758	801	798	785	803	786	785		79.3	BREAKAGE/SPACE
27/7/15-1/8/15	5	BLOCK MAKING	6000	4766	778	806	803	778	804	797		79.43	BREAKAGE/SPACE
3/8/15-8/8/15	6	BLOCK MAKING	6000	4748	803	775	816	793	774	784		79.13	BREAKAGE/SPACE
10/8/15-15/8/15	7	BLOCK MAKING	6000	4714	796	784	775	785	776	798		78.57	BREAKAGE/SPACE
17/8/15-22/8/15	8	BLOCK MAKING	6000	4764	809	796	784	773	806	796		79.4	BREAKAGE/SPACE
24/8/15-29/8/15	9	BLOCK MAKING	6000	4702	805	763	785	792	776	781		78.37	BREAKAGE/SPACE

Table 3. Lookahead Planning for old block

- Calculate the net production of the day and make entry in Lookahead planning.
- Enter the total of net weekly production in Act column.
- Calculate the Plan Percentage Completion (PPC)
  PPC = Actual Work / Estimated Work
- Mention the reason why estimated work is not completed in Reason for Variance column.
- Plot the graph Reason of Variance vs. No. of notations.
- From graph it's noted that the variance in work due to the wastage
- To reduce the wastage improvement in design is needed.

C. Concept of New Design

After studding the results of lookahead planning we conclude that the wastage is because of the breakages. Hence we need to change the design so as to minimize the waste. The reasons we calculated responsible for breakages are as follows.

- The width of the outer face is 30 mm, depth 170 mm and 400 mm long. 30 mm width for the outer face is very small to give stability to the outer face of the block and due to this maximum breakages occur on outer face of the blocks.
- Inner portion is also weak because of 30 mm width.

Following things are important to consider while design a new block,

- Volume of hollow portion should be same as old block
- 30 mm width increase up to 50 mm
- If width is 50 mm it allows using 20 mm aggregate.

That's why it is necessary to improve the design of block. To give stability for outer face of the block it is necessary to increase the width of outer age which also allows, using the 20 MM aggregate in the concrete mix. Using 20 MM aggregate in concrete also make cost effective and it also improve the strength of the block.

D. Information of New Block

Size of Block	400 X 200 X 200
Concrete Content	1:12:6 9% replacement for cement with Fly ash Used crush sand 65% of 10 MM aggregate is replaced by 20 MM aggregate Volume of concrete per block is 0.010 CM
Strength	5.8 MPa
Target Production	1000 blocks per day
Handling Method	Manual
Percentage failure	10%
Net Production	900 blocks per day
Weight of Block	23.6 kg
Depth of Hollow Portion	170 MM

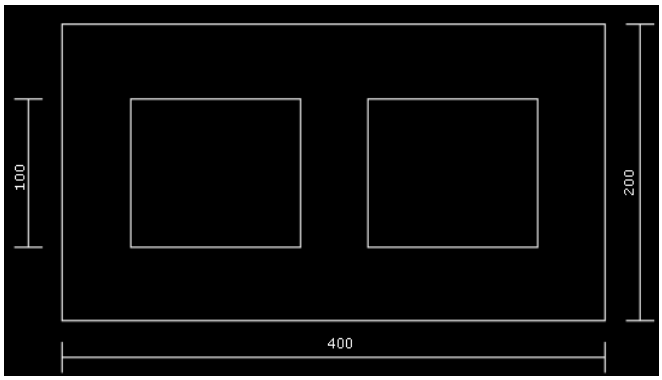

Fig 3:- Design of New Block

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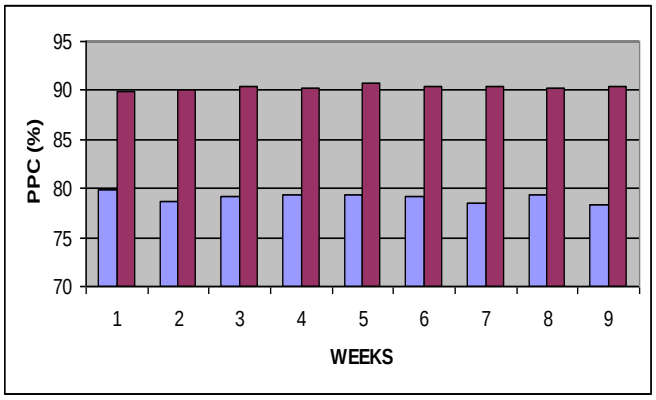
SR. NO.	ITEM	QTY	UNIT	RATE	AMOUNT
1	CEMENT	35	BAG	145	5075.00
2	FLY ASH	13	BAG	60	780.00
3	CRUSH SAND	9.43	CM	750	7070.68
4	METAL 10MM	1.71	CM	450	769.50
5	METAL 20MM	3.00	CM	250	750.00
PRICE FOR 1000 BLOCKS					14445.18

Table 4. Cost of material of new block

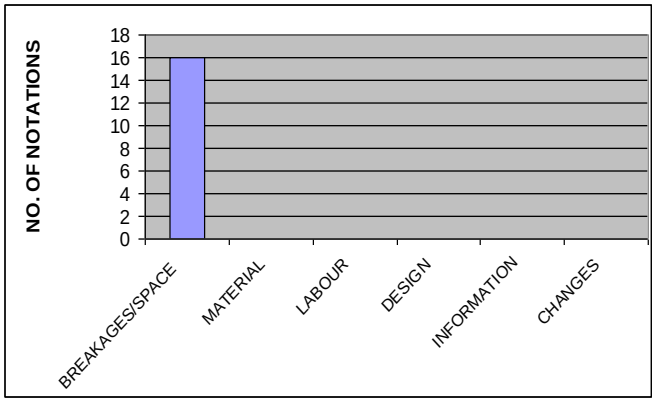
Effective material cost of new block=14445.18/900
=16.05Rs.

DATE	WEEK	ACTIVITY	EST	ACT	MON	TUE	WED	THU	FRI	SAT	SUN	PPC	REASON FOR VARIENCE
31/8/15-5/9/15	1	BLOCK MAKING	6000	5398	896	912	903	876	895	916		89.97	BREAKAGE/SPACE
7/9/15-12/9/15	2	BLOCK MAKING	6000	5399	897	913	895	885	919	890		89.98	BREAKAGE/SPACE
14/9/15-19/9/15	3	BLOCK MAKING	6000	5428	927	896	915	883	911	896		90.47	BREAKAGE/SPACE
21/9/15-26/9/15	4	BLOCK MAKING	6000	5412	903	896	882	916	921	894		90.2	BREAKAGE/SPACE
28/9/15-3/10/15	5	BLOCK MAKING	6000	5445	923	932	894	886	914	896		90.75	BREAKAGE/SPACE
5/10/15-10/10/15	6	BLOCK MAKING	6000	5421	915	886	924	876	927	893		90.35	BREAKAGE/SPACE
12/10/15 - 17/10/15	7	BLOCK MAKING	6000	5429	922	896	877	887	921	926		90.48	BREAKAGE/SPACE
19/10/15 - 24/10/15	8	BLOCK MAKING	6000	5417	911	896	883	903	910	914		90.28	BREAKAGE/SPACE
26/10/15 - 31/10/15	9	BLOCK MAKING	6000	5420	913	896	899	903	913	896		90.33	BREAKAGE/SPACE

Table 5. Lookahead Planning for new block



Graph 1. Ppc Comparision Of Both The Block



Graph 2. Reasons For Varience

E. Analysis of Process

By applying lean construction you able to give right solution to right problem. Managing construction under

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Lean is different from typical contemporary practice because it;

- Has a clear set of objectives for the delivery process,
- Is aimed at maximizing performance for the customer at the project level,
- Designs concurrently product and process, and
- Applies production control throughout the life of the project.

By contrast, the current form of production management in construction is derived from the same activity centered approach found in mass production and project management. It aims to optimize the project activity by activity assuming customer value has been identified in design. Production is managed throughout a project by first breaking the project into pieces, i.e. design and construction, then putting those pieces in a logical sequence, estimating the time and resources required to complete each activity and therefore the project. Each piece or activity is further decomposed until it is contracted out or assigned to a task leader, foreman or squad boss.

Following are the advantages of applying lean construction which we observe in block making case:

- *Strength:* After applying the new design for block and by using 20 MM aggregate in the new design of block it help to improve the strength of block from 5.2 MPa to 5.8 MPa
- *Cost:* After applying the new design for block cost of per block is come down by one rupee. It is because of using 20 MM aggregate and due to this cement content is also reduced. Material cost of old block is Rs. 19.5 and Material cost of new block is Rs. 16.05
- *Wastage:* The main reason to change the old design is stability to outer age of block. In old design the dimension of outer age is 30 MM X 170 MM which is not giving stability to the outer age. In new design the width of 30 MM is increase up to 50 MM which allows using the 20 MM aggregate and also gives the stability to the block.

VII. CONCLUSION

After applying lean thinking to the actual construction site we can conclude that, lean construction is very helpful for construction industry. It reduces the wastage at every stage of the project. We apply lookahead planning for the research work. In which we can easily manage the work and note down everything related to the project. This gives the idea about where we lacking behind and gives us sufficient time to rearrange the work or rethink on any decision. Also it gives us enough time to handle any situation arise at the site as we have enough prepared for the situation all thanks to lookahead planning.

Lean construction gives transparency to everyone. In daily huddle meetings each person related to construction is involved so it increases the work efficiencies as team sprite is generated through it.

After personal interviews with the people present in the construction industry, we observed that they are really happy with the results of lean construction.

It is a cost effective and delivers product on time.

VIII. ACKNOWLEDGEMENT

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