

Minimization of Wastage in Residential Construction Using Lean Concept-Case Study

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Abstract - The main aim of this paper is to minimization of wastage in construction industry. India is still on manual basis construction. Here wastage are of material, time, cost, labour etc. 10 to 15% project cost are of wastage in construction activities. The lean concept construction ideology are seen as an opportunity to address the existing problems in local construction industry. Low productivity in the construction industry due to shortage of materials and equipment, labour shortage, high reduction in skill level of construction workers, weathers, low level of monitoring and control of projects etc. This research is existing productivity and performance on construction activities and processes for local construction industries.

Keywords: Lean, productivity, construction, factors

I. INTRODUCTION

Construction is the second largest activity in India after agriculture. Construction constitutes 40% to 50% of India's capital expenditure on projects in various sectors such as highways, roads, railways, energy, airports, irrigation, etc. The construction industry in India has a share of about 8% of its GDP and provides employment to around 35 million people.[1]

II. WHAT IS LEAN?

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. Lean construction projects are easier to manage, safer, completed sooner, and cost less and are of better quality. Lean construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value".

Applying Lean thinking has transformed many industries and its implementation in construction has now started to show the potential benefits. The lean approach is the only way that improvements in time, cost and quality can be made simultaneously without trade off. Lean construction focuses on delivering precisely what the client and end-user want. Its application requires a fresh approach in thinking about the complete process from design through to construction in order to remove waste, to create 'continuous flow' and to radically enhance value to the customer. Rethinking Construction identified Lean as one of the key approaches that could lead to great improvements in quality and efficiency. [2]

III.PRODUCTIVITY

Productivity doesn't have proper definition. The term "productivity" expresses the relationship between outputs and inputs.[3]

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

Productivity is the ratio of output to all or some of the resources used to produce that output. Output can be homogenous or heterogeneous. Resources comprise: labour, capital, energy, raw materials, etc. Productivity may then be defined as the ratio of earned to actual hours. The problem with this concept is in establishing reliable, for setting standards. It also depends on the method used to measure productivity, and on the extent to which account is taken of all the factors which affect it. At a project site, contractors are often interested in labour productivity. It can be defined in one of the following ways.

IV. IMPORTANT FACTORS AFFECTING ON PRODUCTIVITY

This factors are identify by literature survey, which affected productivity in construction [4]

- Wages
- Other Financial Bonuses
- Leadership/Management
- Experience
- Level of Supervision
- Teamwork
- Level of Skill
- Physical Strength
- Training
- Material Availability
- Weather/Climate
- Safety
- Quality of Tools
- Resources- Equipment

V. DATA COLLECTION METHOD

DATA COLLECTION TECHNIQUES

I. The direct observation technique:

Direct observation is one of the continuous observation methods. A researcher observes workers activities throughout the work day. Tool time and Noon-tool time activities are easily and accurately identified because the times are recorded to the nearest minute. The direct observation method is generally considered tedious and time wasting. One technique to increase this methods efficiency is to highlight only the non-tool time activities provided that the workers spend more time on tool time activities than non-tool time activities. Another criticism of this method is that the observer's presence may disturb workers. It is recommended that the observer could locate himself in a suitable vantage point where there is a full view of all workers but at the same time does not interfere with the operations progress. The direct observation method has the following advantages:

- a. The data collected is accurate and precise.
- b. The length and pattern of time of each work task can be collected.

The disadvantages of the direct observation method are the following:

- a. A crew of five workers is the maximum crew size one observer can manage.
- b. If poorly managed the observation can interfere with the workers carrying out their tasks.

II. Time study technique:

Time study was the fundamental approach to productivity improvement introduced by Frederick W. Taylor and Frank Gilbreth in the late 19th and early 20th centuries, and it is the principal technique of work measurement even today. In the current usage, it is not simply the timing of an operation but a process designed to develop standard time or standard output for any construction operation irrespective of the rate of work being observed. Time study therefore involves:

- a. Timing, to discover how long various operations are taking;
- b. Rating, to assess the worker being observed against a norm;
- c. Building up of time standards, by allowing for appropriate relaxation and Contingency allowances.

III. Activity sampling technique:

It is a technique that measures the percent of time craftsmen spend in various categories of tasks, such as direct work, transporting materials, or waiting. In addition, it is physically impossible to observe and record all the minute details of every repetition of any construction operation. Activity sampling refers to any measurement technique for which observations are non-continuous. Thus, the observations represent a sampling of the total activity.

IV. Forman delay survey

The objective of this technique is to identify the reasons for delays and the extent of it. In a delay survey, foremen are asked to report any delays greater than a specified time that were experienced during the day. By correlating there ported lost time with the causes of delays, project management can take action to resolve the problems and to eliminate the delays (Alfold, 1988).

V. Craftsman questionnaire sampling

Craftsman questionnaire sampling (CQS) was recently developed for performance measurements and productivity improvement at construction sites. The main idea of CQS is to use questionnaires as a means of data collection. CQS provides information regarding the sources of delay, the amount of rework performed, as well as creating a participating atmosphere on site. In performing the CQS, the administrator of CQS walks around the field as the work sampling sampler does. The administrator randomly selects craftsmen to answer the questionnaires. Because of the manner of random selection and the determination of the activities, the craftsmen are involved in the immediate post. After the questionnaires are filled out by craftsmen and foreman, the administrator repeats the cycle until he gets an adequate sample size.

VI. Recording methods

A detailed record of the current method must show exactly how the work is being done. This recording can be done in several ways. The most common uses the stopwatch or interval timer. The study consists of recording the times for different tasks or fractions of a task that a man or machine performs. When observing activities of short duration with a stopwatch, on appreciable error is accumulated if the watch is stopped, read, and started each time. These errors can be eliminated if the timer runs continuously. A second method of recording the activities of a crew is time-lapse photography. This method consists of taking single pictures at interval of one, two, three or four second for long periods. Exposures are made at precise intervals so that elapsed times can be computed accurately as a product of the number of pictures and the photographic time interval. The time-lapse camera has proved an excellent means of collecting information and data for work- improvement studies. The camcorder technique offers a means to identify productivity problems and provides a systematic procedure to resolve them. A video camera, being a more accurate and superior data collection method, can take the place of several observers because it captures all concurrent activities. The camcorder technique involves several steps: Collection of video equipment, Preplanning for the taping process, conducting brainstorming sessions, analysis of recorded data, and development of recommendations. [5]

VI. METHOD TO STUDY

- To improve construction main activities by eliminating wastage in residential building using lean concept. Before starting data collection have to study background area by research paper and literature paper.
- For data collection selected study local area of construction.
- Select the main activity to study and observation by data collection method.
 - Record the time scaled report with photographs.
 - Questioner form filled by analysis and asking question to different site main labour.
 - Note down the wastage or obstruction factor in the activity.
- Analyse data after complete data collection.
- Identify the factors and source of wastage (obstruction the activity) in the construction.
- By completing analysis of data collection and giving conclusion to achieves higher productivity.

VII. DATA COLLECTION AND ANALYSIS

Data required to carry out the research was collected by Questionnaire method and observation of 14th important factors to the main labour of that activities. In this study measurement skill of 1 to 5 was used to determine the effect level. Collected 6 sites data were required to rate using their experience how all factors affects labour productivity. And found some important issues during activities Relative Importance Index (RII) was used for analysis of data. RII method helps to determine the relative importance of the various factors affecting on labour productivity. RII was used by following equations.

$$RII = \frac{\sum w}{A * N} * 100$$

Where,

- W is the weight given to each factor by the respondents and ranges from 1 to 5.
- W ranges 1 = Not applicable
 - 2 = Does not affect
 - 3 = some-what affects
 - 4 = highly affect
 - 5 = very highly affect
- A is the highest weight = 5.
- N is the total number of responses collected for the ordinal scale. (6)

TABLE I - DIFFERENT LABOUR RANKING FACTORS

Factors	Activity	Score (Between 1 to 5)						R.I.I (%)
		Site-1	Site-2	Site-3	Site-4	Site-5	Site-6	
Wages	Brickwork	4	3	2	2	3	4	60
	Flooring	4	3	2	2	3	3	57
	Reinforcement	4	3	2	2	3	3	57
	Concreting	4	3	2	2	3	4	60
Other Financial Bonuses	Brickwork	2	1	1	2	2	2	33
	Flooring	2	2	2	1	1	2	33
	Reinforcement	2	1	1	2	2	2	33
	Concreting	2	1	1	2	2	1	33
Leadership/ Management	Brickwork	3	4	3	4	3	4	70
	Flooring	4	3	4	3	4	3	70
	Reinforcement	3	4	3	4	3	4	70
	Concreting	3	4	3	4	3	4	70
Experience	Brickwork	4	5	4	5	4	5	90
	Flooring	5	4	5	4	5	4	90
	Reinforcement	4	5	4	5	4	5	90
	Concreting	4	3	4	4	4	5	80
Level of Supervision	Brickwork	5	4	4	4	3	4	80
	Flooring	4	3	4	4	4	5	80
	Reinforcement	5	4	4	4	3	4	80
	Concreting	5	4	4	4	5	4	87
Teamwork	Brickwork	4	4	4	4	4	3	77
	Flooring	3	4	4	4	4	4	77
	Reinforcement	4	4	4	4	4	3	77
	Concreting	4	4	4	4	4	3	77
Level of Skill	Brickwork	2	3	3	3	3	4	60
	Flooring	5	5	4	5	5	4	93
	Reinforcement	5	5	4	5	5	4	93
	Concreting	2	3	3	3	3	4	60
Physical Strength	Brickwork	4	2	3	4	4	5	73
	Flooring	4	5	4	4	4	5	87
	Reinforcement	4	4	3	4	4	4	77
	Concreting	4	3	5	4	4	5	83
Training	Brickwork	1	3	2	2	2	3	43
	Flooring	4	3	4	5	4	5	83
	Reinforcement	4	5	4	5	4	5	90
	Concreting	1	3	2	2	2	3	43
Material Availability	Brickwork	5	4	4	4	4	5	87
	Flooring	5	4	3	4	4	4	80
	Reinforcement	5	4	3	4	4	4	80
	Concreting	5	4	4	4	4	5	87
Weather/ Climate	Brickwork	4	2	2	3	3	4	60
	Flooring	1	2	2	3	2	2	40
	Reinforcement	3	4	4	3	4	4	73
	Concreting	4	2	2	3	3	4	60
Safety	Brickwork	3	2	3	2	3	3	53
	Flooring	3	2	3	2	3	2	50
	Reinforcement	3	2	3	2	3	2	50
	Concreting	3	2	3	2	3	3	53
Quality of Tools	Brickwork	4	2	3	3	2	3	57
	Flooring	4	3	4	3	4	4	73
	Reinforcement	4	3	4	3	4	4	73
	Concreting	4	2	3	3	2	3	57
Resources- Equipment	Brickwork	5	3	3	4	3	3	70
	Flooring	5	3	3	4	3	3	70
	Reinforcement	5	3	3	4	3	3	70
	Concreting	5	3	3	4	3	3	70

COLOUR HIGHLIGHT	INDICATES
	Brick work top 3 factors
	Flooring work top 3 factors
	Reinforcement work top 3 factors
	Concreting work top 3 factors

VIII. DESCRIPTION OF ABOVE TABLES AND SOME IMPORTANT ISSUES BY ACTIVITY-WISE

A. BRICKWORK

- I. The clarification in experience factor ranked 1st among the 14 main factors having RII value is 90%. Its important factor for productivity.
- II. Material availability factor ranked 2nd among the 14 main factors having RII value is 87%.
- III. Level of supervision factor ranked 3rd among 14 main factors having RII value is 80%.

OTHER IMPORTANT ISSUES DURING BRICK WORK

- Labour not followed standard rules and regulation of different type of bricks. (Sand base brick.....etc.)
- Broken bricks are not placed in horizontal and vertical line according to required.
- Mortar between two bricks should be 10mm.
- Material property like sand not sieve property, sand contain more moisture, and bricks become hard due to not water curing.
- Labour are not verified wall by plum-bob, right angle, horizontal scale etc.
- Wall plaster material increase if wall having mistaken.
- Daily wages contract labour work less than lump-sum contract.
- Bricks are dried. (Not wetted).
- Mortar preparation placed are not clean.
- Finishing and packing by mortar are not proper.

B. FLOORING WORK

- I. The clarification in level of skill factor ranked 1st among the 14 main factors having RII value is 93%. Its important factor for productivity.
- II. Experience factor ranked 2nd among the 14 main factors having RII value is 90%.
- III. Physical strength factor ranked 3rd among 14 main factors having RII value is 87%.

➤ OTHER IMPORTANT ISSUES DURING FLOORING WORK

- Bad habit like smoking, tea, Tabaco.....etc.
- Other activities problems (floor bad level are not uniform due to that more material waste).
- No inspection by any specific guideline person.
- Due to safety equipment (helmet, jacket, shoes) labours are feeling uncomfortable.
- Proper set or cutting of tiles.
- Activity must be in proper sequence.
- Skilled person can set tile properly.
- Slopes are not as per requirement.
- Hollow sound problem.
- Quality of material.

C. REINFORCEMENT WORK

- I. The clarification in level of skill factor ranked 1st among the 14 main factors having RII value is 93%. Its important factor for productivity.
- II. Experience factor ranked 2nd among the 14 main factors having RII value is 90%.
- III. Training factor ranked 3rd among 14 main factors having RII value is 90%.

➤ **OTHER IMPORTANT ISSUES DURING REINFORCEMENT WORK**

- Height of building/climate.
- Proper guidance.
- Safety equipment (gloves) decrease the efficiency of work.
- Experience and skill effect the productivity.
- Other mistake (deflected column effect entire span).
- Centring must be perfect.
- Bar must be proper cut.
- Connecting of bars are not proper.
- Diameter of bars, spacing between bars not proper.
- Cover for reinforcement must be proper fixed.

D. CONCRETING WORK

- I. The clarification in level of supervision factor ranked 1st among the 14 main factors having RII value is 87%. Its important factor for productivity.
- II. Material availability factor also ranked 1st among the 14 main factors having RII value is 87%.
- III. Physical strength factor ranked 2nd among 14 main factors having RII value is 83%.

➤ **OTHER IMPORTANT ISSUES DURING CONCRETING WORK**

- Lack of materials.
- Technical problem. (cable, lift, rail, electrical)
- Foam work leakage problem.
- Supervision required to guide the about concrete variation in different types of building.
- Concrete should be placed in time due to setting.
- Proper equipment required to level and vibrator.
- Safety equipment.
- Reinforcement bind properly.
- Plumb error.
- Initial check reinforcement as per drawing.
- Reinforcement cover and electric pipe are not placed properly.
- During concreting to care about covers and pipes.

IX. CONCLUSION

After response from various sites labour, analysis data of questionnaires by Relative important index method and get important three factors which affect the individual activities. This factors improve labour productivity. And some important issues are found during observation of one each time activity. From that concluded we derived checklist table to minimization wastages in four main activities of construction. This checklist can be analysis by supervision or main labour of that activities at time of construction phases. Last planner, increased visualization, first run studies (Plan, Do, Check, Act), 5s etc. methods also used to minimization of wastage in construction activity.

A. CHECKLIST OF BRICK WORK

Checklist For Masonry (Brickwork)					
Project		Site			
Location		Date			
No.	Description	Yes	No	Remark	
Before Brickwork					
1	Cleaning entire work area off loose material/concrete.				
2	Availability of material as per daily requirement (sand, cement, bricks)				
3	Stack the bricks/blocks, cement bags, sand properly instead of throwing them on slab.				
4	Check the quality and properties of sand, cement, bricks.				
5	In case of clay bricks, bricks should be soaked in water before start of work.				
6	Check the plan if any changes in brickwork by customer.				
7	Line out rechecked? (Room dimension, diagonals, alignment with one layer of brick work, door opening position....etc.)				
8	Labour awareness about standard rules and regulation of different types of bricks.				
During Brickwork					
1	Check mortar preparation & provision of platform.				
2	Check mix proportion of mortar.				
3	Check mortar thickness between bricks.				
4	Check the plumb from the beam edge depending on which side the wall is flushing the beam.				
5	Check the level and right angle at the corner for the first layer.				
6	Check all joints should be uniform and not exceeding 10 to 12mm.				
7	Over burnt/under burnt clay bricks should not be used.				
8	Gap between top layer of brickwork and beam bottom shall be filled with metal and mortar properly.				
9	Check the surface of wall by horizontal scale.				
10	Brickwork should not be done more than 4ft in a day.				
11	Check the broken bricks should not place in one layer.				
After Brickwork					
1	Brickwork surface should be cleaned with jute bag at the end of day work.				
2	Check the proper pointing, packing, and finishing.				
3	Check cleaning of dead mortar.				
4	Check curing				
5	Pin bricks should be left every alternate layers as to have bonding/interlocking between the walls.				
6	Thin mortar should be applied to the column where the brickwork would be touching the column.				
Signature		Remarks			
Checked By:					

B. CHECKLIST OF TILING WORK (FLOORING WORK)

Checklist For Tiling (Flooring)					
Project		Site			
Location		Date			
No.	Description	Yes	No	Remark	
Before Tiling					
1	Availability of material - Sand, Tiles, Cement				
2	Check quality of materials				
3	Check tools & equipment working properly or not (tile cutter, trowel, tile spacers, rubber mallet, spreader, grout sponge)				
4	Remove all the loose/hardened mortar from the slab & clear the slab.				
5	Proper stacking of tiles				
6	Make sure that service lines like electrical, water conducts are laid before mortar bedding.				
7	Check for any additions & alterations				
8	Check for levels, button marking, mortar thickness				
9	Check for any platform, B/W for wardrobe area				
10	Check other construction activities problem.				
11	Labour should be guided properly by specific person.				
During Tiling					
1	Drag. No./Date as per which pattern given/starting point				
2	Line/level fixed, checked & slopes are as per requirement				
3	The mortar bedding should be compacted properly to avoid voids				
4	Check difference in colour shade of tiles and replace with same batch/lot				
5	Check the proportion of bedding mortar mixing				
6	Clearing waste tiles/mortar				
7	Clearing for joints/workmanship				
8	Slopes are provided according to requirement.				
9	Make sure that the cement slurry is laid uniformly to avoid voids.				
10	Check the right angle by placing tiles at the corner of the room and skirting the projection etc.				
After Tiling					
1	Clean the tiling surface properly.				
2	No material stacked after fixing? (crack or any damage)				
3	Do the curing for 4 to 7 days after grouting.				
4	Fill the joints with grout & clean them properly.				
5	Check for any hollow sound				
6	Are there any damage or cracked tiles? Should be replaced.				
7	Check the pointing and grouting materials.				
Signature		Remarks			
Checked By:					

C. CHECKLIST OF REINFORCEMENT WORK

Checklist For Reinforcement					
Project		Site			
Location		Date			
No.	Description	Yes	No	Remark	
Before Reinforcement					
1	Check structural drag. No. and date as per which reinforcement.				
2	Check bar bending schedule prepared?				
3	Check availability of steels as requirement				
3	Check for test reports for steel and approved brand or not				
4	Cleanliness of shuttering and Bars OK?				
5	Check cover for reinforcement.				
6	Provision of cover blocks/ preparation of cover blocks				
7	Check the construction joint for proper concrete bonding before placing reinforcement				
8	Laying of bars of required dia. As per requirement				
9	Checked centre line diagram				
10	Check safety for height of column.				
11	Labour should be guided properly by specific person.				
12	Check other construction activities problem.				
During Reinforcement					
1	Connecting of bars to existing dowels to be checked for alignment. OK?				
2	Placing of Bar diameter, number, spacing match with the Construction Schedule?				
3	Lap Length, Position of lap, OK?				
4	Maintaining records and getting approval for additional reinforcement not shown				
5	Check colour coding for identification				
6	Check for proper binding (double strand/quality of binding wire of 18 SWG)				
7	Check connection of two joints.				
After Reinforcement					
1	Check for any rework or alteration				
2	Check binding wire properly tightened				
3	Check structural drawing as per which reinforcement are done.				
Signature		Remarks			
Checked By:					

D. CHECKLIST OF CONCRETING WORK

Checklist For Concreting					
Project		Site			
Location		Date			
No.	Description	Yes	No	Remark	
Before Concreting					
1	Check surface preparation.				
2	Check shuttering, form work and centre line as per drawing.				
3	Conduits, ducts opening, insert plates provided				
4	Check for tools are working properly. (vibrators, mixer, rail)				
5	Check the platform and walkways provided.				
6	Check reinforcement as per drawings.				
7	Check embedded parts.				
8	Check cover to reinforcement.				
9	Check construction joint location.				
10	Check availability of required materials.				
11	Check quality and properties of material. (cement, sand, fine and coarse aggregate)				
12	Check technical equipment (cable, lift, electrical supply)				
During Concreting					
1	Check mix proportion of mortar.				
2	Surface preparation by fresh mortar bedding.				
3	Check plumb and reduced levels.				
4	Slump testing as requirement.				
5	Vibration by different type of needle				
6	Continuity of operation (No break)				
7	Check form work leakage.				
8	Supervision required				
After Concreting					
1	Remove form work.				
2	Check surface. (honeycombing not allowed)				
3	Check curing is being done properly.				
Signature		Remarks			
Checked By:					

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