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Application of Lean Principles in the Production Management of Construction Sites

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Abstract:
The basic concepts of lean thinking in construction projects are to reduce waste, improve communication, and promote teamwork integration through a common set of tools and techniques. With increased demand for construction projects, there is a need to focus attention on the efficient delivery of construction project. The objectives of this paper are to analyze how lean construction techniques and principles improve performance in construction project delivery and provide a new knowledge of how lean techniques can reduce non-physical waste related to project delivery process. A case study of workshop carried on the site showed that the NVA (Non Value Added) and ENVA (Essential Non Value Added) activities have the highest impact on the project duration. Therefore with implementation of the proposed lean techniques, the NVA and ENVA activities have found to be improved and their durations can be reduced considerably. The scope of the paper is limited to use of lean construction techniques to overcome problems, facilitate project progress, and offer recommendations for better construction project processes. This paper determines a goal, identifies and categorizes the waste, and takes the action by applying the appropriate lean techniques. Conclusion are drawn regarding various aspects like material utilization and control, Standard operating Procedure Manual (SOPM), morale of people, documentation etc.

Keywords: Construction Management, Construction waste, VA, NVA, ENVA, Lean Principles, Lean techniques, Kaizen.

I. INTRODUCTION

Lean construction is considered as a concept or approach that needs to be introduced within the construction industry, specifically to increase the sector's productivity level through the elimination of activities and actions deemed as being wastage in the construction process. Through the concept of waste elimination and value enhancement in a construction project, this approach is seen as being able to create a process of implementing activities in the project in a systematic and effective manner. Since the early 1990's, the construction research community has been analyzing the possibility of applying the principles of lean production to construction. In India, the use of the lean construction concept in the industry is still considered to be a new and novel approach. In fact, its application within the construction firms of the country is very much limited. However, this situation is seen as being in tandem with the achievements of a number of developed nations. Lean construction is similar to the current practices in the construction industry; both practices pursue better meeting customer needs while reducing waste of every resource. However, the difference between the current practices and lean construction is that lean construction is based on production management principles, and it has better results in complex, uncertain, and quick projects.

II. AIM

I. To provide a new knowledge to the existing literature on the topic of how lean techniques can reduce waste in construction project delivery process.

II. To analyze how lean construction techniques improve performance in construction project delivery

III. METHODOLOGY

Lean construction is a systematic approach to identifying and eliminating waste through continuous improvement by flowing the product at the demand of the customer. Lean construction considers construction wastes as potential wastes that hinder flow of value to the client and should be eliminated. The main objective is to waste minimization through the application of lean principles on construction site. Thesis methodology is conducted through the following steps

1) Identifying the waste associated with the construction projects process
2) Specifying waste in certain categories
3) Structuring the decision factors
4) Conducting survey of industry professionals
5) Analyzing the data and discussing the results

A construction site of a residential project was selected for implementing lean principles and observations were recorded. Salient features of the project are given below

Name of Project -Megapolis
Company -Pegasus Properties (JV of Kumar Properties & ABIL)
Owner -Hitesh Kumar Jain
Area of project -150 Acres
Location -Hinjewadi

IV. WASTE IDENTIFIED IN CONSTRUCTION PROJECT

To make your own template, open a new document and begin Waste in a project is unavoidable. It is the thing which absorbs resources but adds no value to the project. Following are the

probable types of wastes involved in project management process,

I. Faults in design process
II. Wrong ordering of the material
III. Product defects
IV. Excess inventory of consumables at site
V. Un-necessary material handling
VI. Excess/ un necessary processing
VII. Waiting

TABLE.1. WASTE IDENTIFIED

Sr. No	Wastes	Reasons
1	Over production	• Excess ordering of the material • Producing reports no one needs • Making extra copies
e.g Sometimes material is ordered in excess due to lack of clarity in scope		
2	Faults in design process	• Standards not defined • Design specifications not known • Lack of knowledge of the product to be designed • Wrong inputs from the project stakeholders
e.g Wrong inputs from project stakeholders like project consultants,		
3	Wrong ordering of material	i. Wrong indenting from execution department i. Lack of clarity in scope i. Lack of communication
e.g Wrong inputs given by the projects department to the purchase department		
4	Defects	v. Rework robs resources, "chokes" flow and must be minimized or eliminated. v. Poor quality of material i. Wrong entries in ERP package / scheduling software i. Incorrect information on documents
e.g Poor quality of raw material received from the supplier. Lack of training for working on ERP package., scheduling software etc.		
5	Excess inventory of material in office and at site	i. Lots of inventory on shelves, racks, and at site. x. Documents/files awaiting signatures or approvals x. Work awaiting task completion by others i. Unnecessary document/data storage
e.g Obsolete drawings/documents are still maintained in the office. Excess supply of consumables at site.		
6	Un-necessary material handling	i. Long distance between storage areas to work area at site. i. Hand-carrying paper to another process v. Mailing documents
e.g Location of storage area at site far from work area/ Poor site layout		
7	Excess/unnecessary processing	v. Process includes unnecessary operations i. Standardization of operations not thorough enough i. Not enough training
e.g Lack of standardization of operations Not enough training imparted to the employees		
8	Waiting	i. Delays in receiving information x. Operations not balanced, waiting for previous operation. x. On decisions (disposition, inspection, approval etc.) i. On systems i. Waiting for shared equipment
e.g In case of interdependent work, one contractor has to wait till the other contractor finishes his job. In case of centralized authority delay in decisions from the project HO. Due to constraint on using number of major equipments, the same equipment cannot be used parallel for the other operation hence one of the activities needs to be stopped.		
9	Unrealized creativity	i. Failure to use good ideas from anywhere
e.g Suppressing others good ideas and not considering ideas from new joinees /sub ordinates.		

Non Value Adding Items Were Measured for the Site Defined as Follows:

TABLE.2. GEMBA OBSERVATION

Activity	Description	Classification	Time		Duration
			Start	End	
Walk	Walk to position	NVA	10:04:40	10:05:28	**00:00:48**
Material Handling	Tools & Material	NVA	10:05:28	10:08:48	**00:03:20**
Construct	Screwing	VA	10:08:48	10:09:51	**00:01:03**
Discussion	Problem Solving	NW	10:09:51	10:10:58	**00:00:37**
Material	Handling Material	NVA	10:10:28	10:11:53	**00:01:25**
Preparation	Work with plywood	VA	10:11:53	10:18:24	**00:06:31**
Material	Measuring material	NW	10:18:24	10:20:23	**00:01:59**
Construct	Working on wall	VA	10:20:23	10:21:20	**00:00:57**
Discussion	Problem solving	NW	10:21:20	10:22:14	**00:00:54**
Construct	Working on wall	VA	10:22:14	10:25:49	**00:03:35**
Discussion	Problem solving	NW	10:25:49	10:27:42	**00:01:53**
Construct	Working on wall	VA	10:27:42	10:42:04	**00:14:22**
Material	Picking up material	NVA	10:42:04	10:43:42	**00:01:38**
Construct	Screwing up plywood	VA	10:43:42	10:51:27	**00:07:45**
Material	Handling plywood	NVA	10:51:27	10:59:42	**00:08:15**
Discussion	Discussing how to proceed	NW	10:59:42	11:07:37	**00:07:55**
Material	Handling plywood	NVA	11:07:37	11:08:17	**00:00:40**
Preparation	Cutting plywood	VA	11:08:17	11:09:16	**00:00:59**
Material	Handling drywall & tools	NVA	11:09:16	11:12:15	**00:02:59**
Preparation	Cutting drywall	VA	11:12:15	11:31:43	**00:19:28**
Material	Measuring	NW	11:31:43	11:37:15	**00:05:32**
Preparation	Cutting drywall	VA	11:37:15	11:45:10	**00:07:55**
Material	Move material	NVA	12:25:56	12:31:35	**00:05:39**
Construct	Put up beams	VA	12:31:35	12:34:37	**00:03:02**
Material	Fetch beams	NVA	12:34:37	12:35:54	**00:01:17**
Preparation	Cut beams	VA	12:35:54	12:36:32	**00:00:38**
Material	Get & fix tools	NVA	12:36:32	12:41:22	**00:04:50**
Construct	Put up beams	VA	12:41:22	12:42:15	**00:00:53**
Material	Move material	NVA	12:42:15	12:44:23	**00:02:08**

Total duration: 02:39:43
Value Added (VA): 55%
Non-Value Added (NVA): 27%
Necessary Work (NW): 18%

V. RED TAG EVALUATION

Training was given to employees on the site regarding red tag evaluation. This is simply a method for identifying potentially unneeded items in the factory or warehouse, evaluating whether they are needed, and dealing with them appropriately. As implied, red tags are used to identify items removed from the work area for evaluation. In order to implement red-tagging effectively, a red-tag holding area must be created. People tend to be more ready to let go of questionable items if they are not needed after a given time of review. A red-tag holding area is an area set aside for use in storing red-tagged items that need further evaluation. Each department or production area that participates in red-tagging should create a local red-tag holding area to manage the flow of red-tagged items within the department or local production area. If items are not needed in the area, they can be reviewed in a central red-tag holding area, created to manage the flow of items that cannot be disposed of by individual departments.

There are seven steps in the red tag process:

i. Launch the red tagging project
ii. Identify red tagging targets (specify the types of items and the physical work areas to be evaluated)
i. Set red-tagging criteria. Ask three questions:
ii. Is it needed?
iii. In what quantity
iv. Where does it need to be located?
v. Make red-tags

vi. Attach the tags
vii. Evaluate the tags
viii. Document results of red-tagging

RESULTS OF THE RED TAG EVALUATION ON SITE:

TABLE.3. RESULTS OF RED TAG EVALUATION

#	Description	2015	2016										
		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	Number of Red Tags in Current Month	10	2	1	2	0	0	3	4	2	2	1	2
2	Red Tag Action Completed in Current Month	7	0	0	0	0	4	0	4	2	1	2	
3	Cumulative Red Tags Closed	18	20	21	23	23	23	26	30	32	34	35	37
4	Red Tags Open Till Date	5	3	2	0	0	4	1	1	1	0	1	2

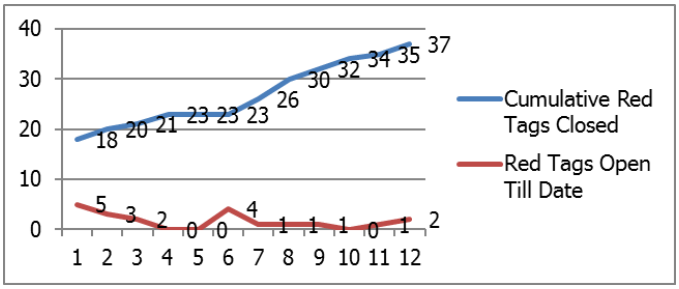

Figure.1. Graphical Representation of Red Tag Evaluation Report

There was a five day intensive workshop focused on making improvement by implementation of Lean Principles The workshop was conducted for application of **5s** principles by mobilizing 4 teams on the four areas of the project namely:

Area	Place	Team Name
I	Main Store – Store	Pride
II	Ground Floor - Building 'A'	Sunflower
III	First Five Floors – Building 'B'	Eagles
IV	Aluform Shuttering–Building 'D'	Sankalp

VI. RESULTS AND CONCLUSION

RESULTS:

Area.I. Main Store – Team Pride

Parameter	Result
Space Released	7 racks freed up
Search Time	Reduced by 50% to an average of 10 min.
Stock Taking Time	Reduced by 50% from 300 to 180 min.

Figure .2. Before & After (Main stores)

Area II: Ground Floor – Building 'A'

Problem	Action	Result
Not Systematic	Sorting	Size Wise Countable

Figure.3. Before & After (Ground Floor)

Figure.4. Before & After (Systematic arrangement of reinforcements)

Area III: Top Five Floors – Building 'B'

Figure.5. Before & After (Proper Placing of Materials)

Area IV: Aluform Shuttering – Team

Parameter	Target	Achieved	% Achieved
Red Tags Fixing	41	40	98%
Systematic arrangement of Aluform material 'A' yard	230 m^2	230 m^2	100%
Stacking of Aluform material 'B' yard	350 m^2	270 m^2	77%
Available free space in material yard	10,000 ft^2	6,000 ft^2	40%

Problem	Action	Result
Missing Aluforms Panels	Applied 5s principles	Found missing panels

Figure.6. Before & After (Missing Aluform Shuttering found)

Lean Planner System was also applied and the results were-

Problem	Action	Result
Magnitude of Delays were not known	Applied Lean Planner	Delay and the Causes are captured

Figure. 7. Before & After Applying Lean Planner

VII. CONCLUSION:

Lean Construction is formed by integrating the project deliverables and the diverse service agencies through the principles of Collaboration and Adaptability. The non-value adding activities are identified and reduced from the Value Stream of a project, thereby maximizing value at the point of delivery within shortest possible throughput time. The following benefits were obtained by applying lean principles on the site.

1. Shuttering for Alluform is sustained, not disturbed due to the movement. It is also being appreciated by the contractor as they are able to retrieve whatever piece they want.
2. Documentation that was done during the workshop was tremendous and it helped the team members get the improvements in place.
3. The competition that was held in view of the Projects in GKW 1 was worth the time spent by people. Everyone was involved.
4. Labour Training – Worker groups were trained on 5S and the Process. It has a far reaching outcome, as it brought down errors in the Work they were doing.
5. SOPM – this is different from SOP, as it also connects the finer aspects of implementation. Safety, Quality, Handover and integration of activities had happened during the making of the SOPM. SOPM has brought crystal clarity in how the things must be done at the Gemba.
6. Material utilisation and Control – it has come out as a practice, because of the Zone Map where the contractor or the Worker is advised to store the material in certain designated places. Control over the Material that was leftover earlier, has enabled them to think of innovative ways of using the material. Like Safety Barricade made out of Waste Material.

The current RERA Bill is going to impact the overall Industry. Speed of Execution and PPC Compliance are going to play the pivotal role in all areas of Project Management. Adherence to timeline has to be 95%, if we wish to stay away from the fangs of penalty mentioned in RERA. A fundamental aspect that is necessary to emphasize is the necessity of creating awareness about the lean concepts. People generally do not know the principles involved in lean concept, and tend to work according to their habits, fundamentally based in the traditional conversion model. In fact, lean concept is the basis for analysis and later improvement. This means that tools and methods that support lean design concepts and principles must be introduced and applied. However the tools and techniques contribute to only one third part of the application of lean concept to construction projects. Management's approach and employees' involvement contribute to the remaining two third part of application of lean concept.

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