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AN IMPLEMENTATION FRAMEWORK FOR INTEGRATED LEAN CONSTRUCTION SYSTEM FOR INDIAN SCENARIO

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ABSTRACT

Indian Construction projects suffer from cost and time overruns which leads to wastage and productivity problems that directly affect overall industry's profitability and economy. Today's economically developed nations also face these problems. As a result, researches and methodologies have been developed to reduce the risk of overruns and improve project outcomes. A number of these methods are based upon Lean production principles that focus on identifying value, eliminating wastage and creating a smooth flow of materials, information and work. Slow adaption of these Lean concepts by contractors has also been noticed from the past decade. This principle has been found to improve the reliability of project delivery in complex construction environments. However, implementation of this technique is being a great challenge as it requires technical expertise as well as lots of paper works behind. This paper focus mainly on incorporating traditional management system followed with Lean construction thereby developing a simplified lean implementation framework and recording format to measure daily performance occurred and required in construction projects. By effectively utilizing these data, various analyses generating value adding reports and information for continual improvement of the project shall be achieved. Proper investigation of these reports and finding out the root cause would facilitate construction projects to be free from time and cost overrun.

Keyword: lean construction, framework, time, cost overrun.

INTRODUCTION

Lean Construction is not an algorithmic technique or a tool but a raw concept of reducing waste by highly focusing on developing flexible system which create value to the time and money invested. It is a blend of operational research and practical development in construction with an adoption of Toyota manufacturing principles and practices to the construction process. Unlike manufacturing, construction is a project based-production process. Lean construction is concerned with the alignment and holistic pursuit of concurrent and continuous improvements in all dimensions of a construction environment in design, production, activation, maintenance, salvaging, and recycling (Abdelhamid *et al,* 2008). Lean approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs (Koskela *et al*, 2002). Pioneers of Lean construction havelisted that, losses in construction projects occur due to the wastages caused in these main areas, such as:

- Transport (moving products that are not actually required to perform the activity over that period)
- Inventory (all components, equipment in process, and finished product not being processed or arranged in order for future use)
- Motion (people or equipment moving or walking more than is required to perform the processing due to improper logistic plan)
- Waiting (waiting for the next production step, interruptions of production during shift change or activity change)
- Overproduction (production ahead of demand)
- Over Processing (resulting from poor tool or product design creating activity)
- Defects (the time and cost involved in reworking or fixing defects)
- Knowledge (waste of human talent)

The lean implementation framework is based on avoiding and reducing these eight areas of wastages.

DEVELOPMENT OF FRAMEWORK

Framework here is a systematic process for implementation of lean construction works. There is a huge gap between research development and practical implementation by construction contractors. In India, in many construction projects still the conventional methods are only adopted. For example, advance EOQ models are developed by researchers for practical implementation, but still the construction contractors hesitate to adopt a change and use replenishment procurement model only, which leads to shortage of materials in the necessary time. Hence, the base of this framework is the traditional management model, which is been reinforced with the advanced lean methodologies in order to make the project managers to get easily adopted with lean concepts without destructing their old practices. A few techniques used in this project are as follows,

Traditional Management

- Critical Path Method
- Gantt chart
- Earned Value Management
- Procurement Models

Modernistic Management

- Lean Management
- Life Cycle Costing
- Integrated Project Delivery System

A macro model of the detailed lean implementation framework is being illustrated below in the Figure-1. It describes how the traditional management can be incorporated in Lean construction for the ease of implementation in a traditional work environment like India. The procurement model and earned value management are the traditional practices followed in construction industry. Hence to introduce lean thinking traditional management is required. Integrated project delivery is adopted which gives path for iterative study, thereby continuous improvement is achieved.

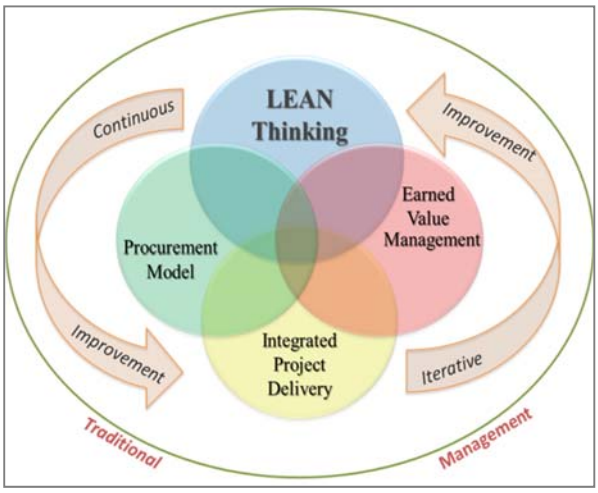

Figure-1. Traditional Lean model.

The lean implementation framework is developed with integrating a number of lean construction tools and traditional management techniques, considering the methodological approaches and the research outcome of the pioneer lean construction scientists. The lean implementation framework has been framed and illustrated in Figure-2.

LEAN TOOLS AND ITS UTILIZING SYSTEM

All parameters in the framework are tools and techniques where several tools are core lean practices and rest are traditional management practices which act as copper mixed with pure gold in order to give it a form and make it usable.

The micro level implementation strategies of each tool in the framework are discussed below,

Project master schedule& phase schedule

The project master schedule is a holistic planning of a project (i.e. not only construction but also all other related pre and post works) and it creates milestones to be achieved with respect to time and cost.

Phase schedules are derived from the project master schedule. They are proportioned based on time period and work package. Phase schedule includes specific schedules for various activities which is categorized based on the works delegated to the specialized sub-contractor. For example, separate contracts shall been assigned for excavation work. Though excavation as well as footing works are simultaneous activities, but separate work packages is to be assigned, which gives clarity in work. This is a part of traditional management; however it has been noticed that following these schedules alone is not sufficient for completion of project within the scheduled time. These schedules are usually presented in Gantt chart. Software like MS project, primavera and other open source software support abundantly in developing master schedule and phase schedule for construction projects.

Last planner system

It is a short term planning system that integrates pull planning, make-ready, look-ahead planning with constrain analysis, weekly work planning based upon current labour productivity and learning byanalyzing PPC (plan percent complete) thereby listing the reasons for variance.

Pull planning technique integrates the last planner (i.e.) Draughtsman or Mason, into the process of planning where managers are involved bringing out reliable plans from weekly meetings. This team scheduling process works backward from labour capacity so that the network of activities required to be completed by conforming to the crew productivity. This allows the management to 'Pull' workforce from the staffs rather than pushing the work to them as done in traditional management model.

The inference of last planner system leads to development of look ahead planning, in which initially "4 week look ahead planning is done where the schedule for following four weeks is derived from the phase schedule. From this the requirement of resource is extracted. With this acquired data for EOQ models for procurement can be planned. Following the "4 week look ahead" is "Weekly look ahead" which acts as an indicator to assure that the resource will be available for the week in right time, at the right place, at the right quantity. "Daily planning" is the can do work quantum that is possessed by the labour which is derived by analyzing the labour productivity mean of past week. This leads to mobilization planning through task made ready checklist that is discussed below.

Task made ready checklist

Before work starts, the team leader (i.e., planning manager or project manager) through supervisor make tasks ready so that when work should be done, it can be done. This avoids starting to work before the pre-requisite are not ready.

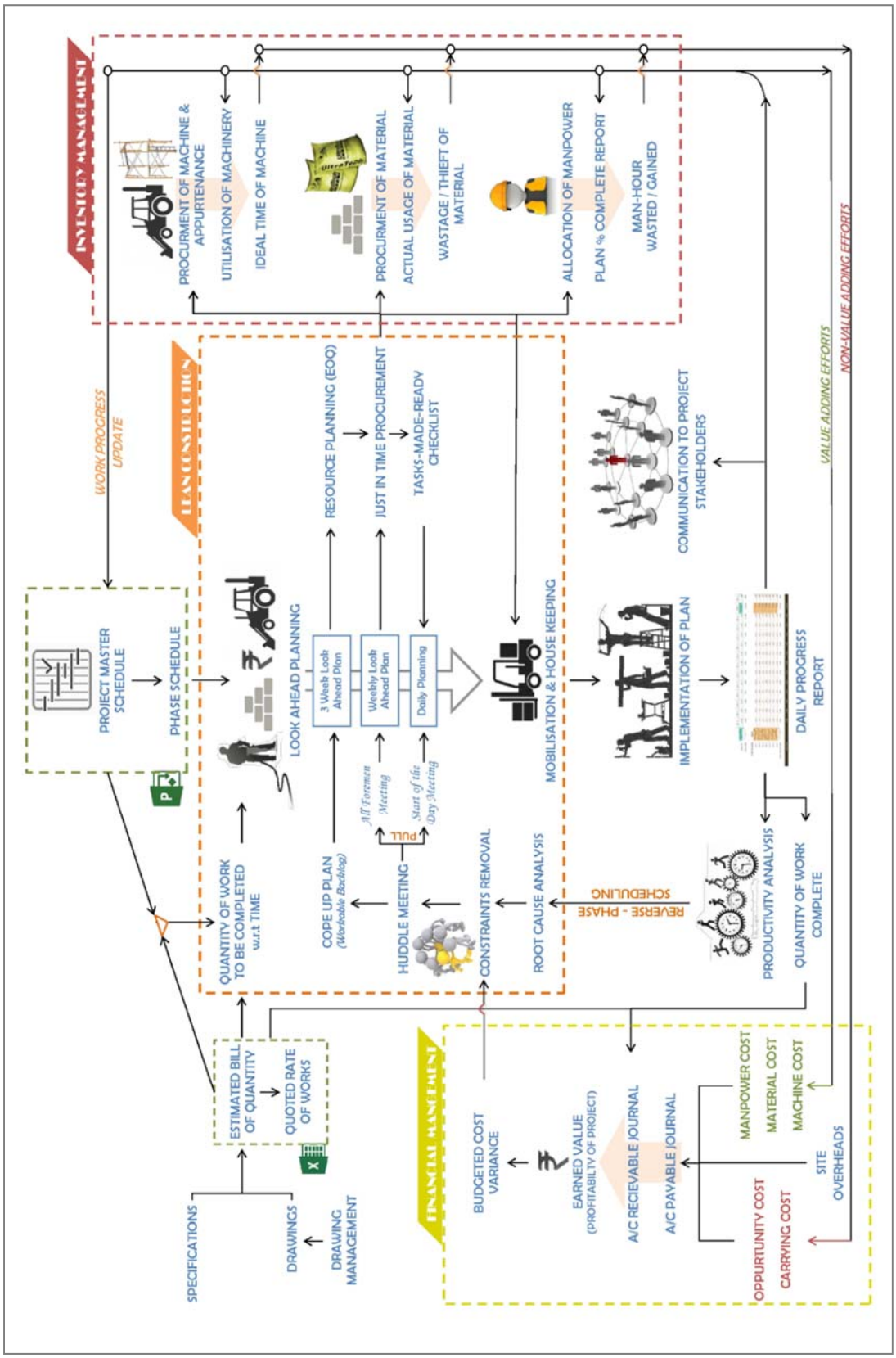

Figure-2. Developed Lean implementation framework.

Table-1. Task made ready checklist.

Project name	**Name of the project**			**Date**	**Present date**	
Phase	**Periodic stage or work package range of works**			**Weather**	**Prevailing current weather condition**	
WBS Code	Item of work	Crew Details	Can do	Resources required	Pre requisite	Notes
item code of work to be done as per BOQ or Master Schedule	activity or task name, its description and scope of work to be completed	labour mix and quantity required to achieve can do as per their commitment or crew productivity	quantity of work to be completed in a man-day	quantity of several materials required to complete the can do	conditions or facilities required to prevail in site before start of work	additional descriptions and imperatives
duly signed as an acceptance and conformance of good to start setup at site		* Explanatory note			duly signed as a command to supervisor to make ready the above 12 hour before start	
Site Supervisor					Planning / Project Manager	

Commencement of work without pre-requisite reduces the crew productivity or could even cause sudden stop of an activity leading to waste of manpower and time which would in turn cause project cost overrun if it prolongs without identifying root cause.

The daily mobilization plan can also be intended based on the task made ready checklist, followed by a short huddle meeting on start of the day conforming the duties allotted and the safety to be concerned by the mason and supervisor. Another huddle meeting at the end of the day in which the issues regarding incompletion of the planned work is discussed with the in-charge responsible and reasons for default isanalyzed. The cope up plan is given on the huddle meeting held next day before the start of the work. This process upshots great flow and reliability in work reducing uncertainty.

The Table-1 is a specimen of the task made ready checklist, which is to be used at construction site in daily routine.

Lean procurement management

The lean procurement management is not the process of reducing the inventory required but decreasingthe exposure of inventory thereby reducing its wastage. The main input required (i.e., the demand for resources) are extracted from monthly, weekly and daily look ahead plan generated from the process of last planner system.

Just in time procurement system is considered to be the genre of lean management (Koskela *et al*, 2002), but it is not applicable in all activity involved in a construction site due to its heterogeneityin nature, therefore unique system has to be developed with lean thinking synchronized with the selling model of local vendors. For example, vast procurement of material leads to constrains like large space occupancy, disturbance in mobilization of workforce as well as equipments and huge capital investment in made due to vast procurement. The transportation cost may get reduced but the holding cost, including the interest of the huge capital investment makes the procurement expensive. Hence the solution for this can be following "Just in Time" in which the materials will arrive at site directly on the commencement of work of the day at right time, right place and right quantity. This eliminates the holding cost, cost of huge capital and opportunity cost of poor mobilization.

In general, economic order quantity (EOQ) of several inventories can be premeditated from the demanded resource for the four week look ahead calculated.

The just in time procurement model can be used for certain valued inventories intended from the demanded resource for the weekly look ahead plan.

The daily plan shall be used as a core for procurement within construction site (i.e., Mobilization of resources) which increases the labour efficiency circuitously.

Mobilization and housekeeping (5S Concept)

5S is the core concept of lean; it describes the process of organizing the work space thereby making the process more tranquil in identifying, using and storing inventory (Osada, Takashi, 1995). The 5S methodology describes,

- Sort
- Set in order
- Shine
- Standardize
- Sustain / Systematize

Here under the first 'S' Sort classification of procurement is done initially based on the conventional inventory management practices like ABC, VED, XYZ

analysis etc. Based on sorting of resources and the task made ready checklist the required resources are 'Set in order' to provide the resources at right time. Following the third 'S'shine leads to site cleanliness, which gives transparency and safety in construction site. The fourth 'S' Standardize is to promote awareness among the work force to follow the first 3S. The fifth 'S' Sustain is a protocol that insist all the above 4S is to be followed for a long time even though there will not be fixed labours working throughout the project. The 5S Technique is the easy to follow and the best Techniques out of all other Lean tools.

The major input for the practical implementation of this process is the data on the available and required inventory, as well as the task made ready checklist to sort and priorities the inventory for handiness and accessibility. This decreases the conventional lag time wasted in searching and transferring inventories.

Table-2. Specimen of the daily progress.

Daily Progress Report

Project Name :						Date :							
Area / Location :						Weather :							
WBS code	Item of Work	UOM	Outstanding scope	Quantity for the day		Labour		Material		Type of Machine	Machine		Remarks
				Planned	Actual	Type	No's	Type	Qty		In	Out	
unique code as in TMR	*Task name and description*	*unit of measurement*	*work yet to be completed in respective item*	*planned quantity as per TMR*	*quantity of work actualy completed*								

Lean accounting

In India accounting is mostly done only for taxation purpose, because of this tradition proper decisions are not made based upon the monetary success of the project. Instead of following these traditional practices lean accounting integrates the traditional accounting practices twisted with concept of lean. Simplifying the accounting methods and comprising project management principle thereby effectively measuring and motivating the organization by evaluating the value chain, operational and financial performance.

The Table-2 shows the Daily progress report specimen which activates the financial management and its integration with the project as shown in the framework. The process of inventory management includes procurement of resource in which stocking of resources more than required for the particular time leadsto at least 10% loss due to holding cost. Procurement of resources and allocation of manpower are the main investment of a construction project. On the process of converting these raw materials to finished products involve lot of wastages in terms of materials and idleness of manpower and machinery. These non-value adding efforts is always been a complex issue to measure in terms of monetary values which stands as an opportunity cost to the contractor. On understanding the above framework it is apparent that the daily progress report plays a major role in extracting data required to practice lean accounting. The Daily progress report used extracts actual daily resources used through daily iterations from the start of the project and concludes the action plan to achieve the future target. From the obtained iterative data with respect to the market cost, both value adding as well as the non-value adding efforts can be measured in monetary values through earned value management. The Table-2 shows a specimen of daily progress report designed to mine essential input to perform lean accounting.

Visualization techniques

The concept of visualization used in lean doesn't have a definite methodology alike other tools conferred above. The main thinking behind the visualization technique is to create awareness of status and performance of the project, like Commitments to be accomplished by different crews, milestones to be achieved and safety measure across all range of employees in construction site, This is achieved by daily huddle meeting and even by displaying plan percent complete chart, commitment chart, safety sign boards, etc. Therefore the choice of mode of awareness is based on the site environment and the employee's performance and dedication towards the project.

Visualization techniques will also boost healthy relation between the crews and sub-contractors which will thereby increase the productivity of the employees.

The Table-3 discusses the simple implementation relation between the tools, where the output of one tool follows as an input for another tool. The tools and methodologies shall be easily followed, but successful implementation is only accomplished by focusing on the attitude and culture of lean.

Table-3. Lean implementation setup.

Tools	Pre - requirement	Process	Output / Inference
Phase Schedule	Master Schedule	Period wise division	Periodic phase schedule
		Work package segregation	Work package Schedule
Last Planner System & Look Ahead Planning	Phase Schedule	4 week activity detail	4 week look ahead plan
	Mason & Supervisor meeting	Weekly target scheming	Weekly look ahead plan
	Start of the day meeting, Task made ready checklist	Today work designation	Daily work plan
Task Made Ready Checklist	Daily work plan	Listing the preparatory works to be fulfilled to start the activities of next day	Achievement of flow in work by reducing uncertainty thereby avoiding lag
	Mobilization data		
Resource Planning	4 week look ahead plan	Economic order quantity	Procurement model for men, material & machinery required
	Weekly look ahead plan	Just in time procurement	
	Daily Planning	Prompt mobilization	Effective usage of resource
Mobilization &House Keeping (5S Concept)	TMR Checklist	Sort inventory available	Reduced delay due to work action, Reduction in wastage of resources, Increased safety by high transparency in construction site
	Inventory data	Set in order	
		Shine (clean after work)	
		Standardize	
		Sustain / Systematize	
Lean Accounting	Resource schedule	Earned value analysis	Total cost variance
	Daily progress report	Segregation of value adding and non-value adding cost	Total material variance
	Bill payables		
	Bill receivables		
Visualization Techniques	Phase schedule	Graphical and pictorial presentation of available data in chart and sign boards	Plan percent complete chart
	Daily progress report		Commitment chart
	Minutes of meetings		Project milestones
	Safety audit		Mobile safety signs

CONCLUSIONS

The lean implementation framework and formats was developed based on the limitedresearch works done by Pioneers of Lean Construction and exploratory study on management trends followed in Indian construction sites, which has given an insight that lean is not just a tool or technique but it is an socio-economical awareness that has to be brought to construction sector of every nation thereby reducing waste and making efficient construction possible, thereby reducing cost and time overrun of projects giving way to economic growth and reliability of the infrastructural and real estate projects of the country.

As a way forward, this project can be advanced bydeveloping software incorporating all tools and techniques of lean management with a traditional blend as discussed, added with a user friendly graphical interface which makes implementation of lean construction possible without much paper works or technical expertise.

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