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Value Stream Mapping as a Lean Construction Tool – a Case Study

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***Abstract*— Low productivity is the chronic problem in construction industry. One way to increase the productivity is to reduce non-value adding activities. Productivity improvements achieve higher cost savings with minimal investment. This paper describes the concepts of value stream mapping, a lean construction tool to help reduce the non-value adding activities in construction projects and increase the productivity.**

Keywords*— Non-value adding activity; Productivity; Value stream mapping; Lean construction

I. INTRODUCTION

Since many years, the construction industry in India has suffered from not delivering the projects in time, within budget and with the quality demanded by the customer. Due to these problems, the loss of big projects to international companies is obvious. This study is concerned with the need to spread and apply The Lean Construction concepts and principles in the real world in order to contribute to the consolidation of a theory. Also to learn to discover and Reduce/Eliminate wastes in the organization.

Past research into the causes of waste in construction projects indicate that waste can arise at any stage of the construction process from inception, right through the design, construction and operation of the built facility. Waste in the construction industry has been the subject of several research projects around the world in recent years. It is commonly acknowledged that a very high level of waste exists in construction. The creation of this waste can be prevented by applying lean construction principles.

Due to the unique nature of most on-site projects, it can often be difficult to define generic production steps that are adding value. This is perhaps more evident in civil engineering construction projects as value is often viewed differently by different participants. Also, the time between award of contract and start of the construction work is normally short. Even though the construction process is not standardized and needs to be re-developed each time, the contractors focus is not to plan and optimize the on-site building process. Several productivity also indicate that there is much waste generated on construction sites. (Peter Simonsson et al., 2012)

The key to improving on-site construction is in the management of flow of materials, resources and information. For this, site management must be trained to differentiate between value adding and wasteful activities and hence, eliminate waste from the construction process.

Value Stream Mapping (VSM) is described as an iterative method for mapping and analyzing value streams. Its purpose is to quantify and communicate production process characteristics such as material and information flows as well as non-value adding activities. VSM consists of the elements of 'The Current State Mapping' and 'The Future State Mapping'.

The Current State Mapping - The goal of current state mapping is to create the clear picture of the existing process and to identify waste. Mapping the current state reveals both value and non-value adding activities.

The Future State Mapping - The focus of future state mapping is to eliminate the root cause of wastes and to link the value stream in a smooth flow. The objective of the future state (to-be scenario) is to create a value stream where every individual process is connected to a customer by either continuous flow or a pull system

CASE STUDY

Value stream mapping (VSM) is used to identify value-adding activities and those considered wasteful of materials and the flow of information and people. The purpose of studying this tool is to understand how Value stream mapping (VSM) is helpful in lean implementation and to develop the road map to tackle improvement areas to bridge the gap between the existing state and the proposed state of different construction activities.

For mapping the current state map, the information for different RCC activities for slab preparation was collected from the contractor, site engineer, site supervisors and workers. The data like, types of activities, its quantity for a typical slab, no. of days and resources required for RCC activities are gathered. It is shown in the table 1.

TABLE I. RESOURCES REQUIRED FOR EACH ACTIVITY

Activity	Qty	Resources Required					Day
		Carpenter	Fitter	Helper	Mason + MC	Total	
Starters fixing & Shuttering	17 nos.	3	2	1	-	6	2
Columns fixing & Shuttering	17 nos.	4	3	2	-	9	4
Beam bottom & Slab Shuttering	265 SQMT.	11	-	9	2	22	4
Slab Reinforcement Fixing	5.5 T	-	19	4	-	23	4
Concreting	265 SQMT.	4	1	8	19	32	1

According to current practice, a single slab takes 15 days to complete. This process is put in the graphical form to understand the value stream and identify waste. Consider activities in blue colour as pre-activities, Green as main activities and red as post-activities.

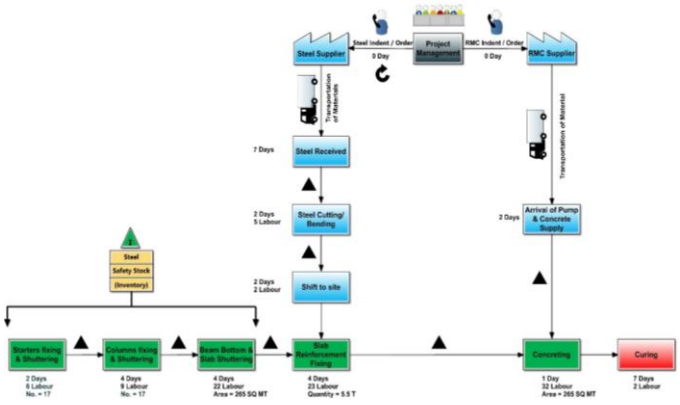

Fig.1 Current State Map

The graphical chart is prepared based on the information and data gathered from the contractors, engineers, supervisors and workers. According to the current state map, the steel for slab reinforcement is ordered 11 days before the execution of work. The raw steel provider provides the steel within 7 days. It arrives at steel yard on the 7th day of indent. Here, for Service floor slab (Part-1) of 265 SQMT, the quantity of steel required is 5.5 T. It require 2 days for 5 labours to cut and bend the steel according to the bar bending schedule (BBS). After cutting the steel, it is required to shift to the site where it is to be fixed. Shifting takes 2 days for 2 labours to shift 5.5 T of steel to site.

It is assumed that the steel for starters, columns and beam bottom are used from the safety stock (Inventory). Fixing and shuttering of 17 starters take 2 days for 6 labours, fixing and shuttering of 17 columns take 4 days for 9 labours, Fixing and shuttering of beam bottom and fixing of slab shuttering of area 265 SQMT take 4 days for 22 labours, Fixing of Slab reinforcement of 5.5 Ton take 4 days for 23 labours, concreting of a slab is completed in a single day using ready mix concrete. It takes 32 labours for the slab area of 265 SQMT.

Concrete is ordered 2 days before the day of concreting by the management. And after concreting, curing is done for at least 7 days by 2 labours.

• *Identifying wastes from current process:*
According to the present state map, the 5.5 T steel is ordered 11 days before the execution of work. Steel is received on the 7th day of order.

Fig. 2 Steel Received at the steel yard

Once the raw steel is received at the steel yard, which is at 100 meter distance from the construction site, it is sent for cutting/bending. To cut and bend the quantity of 5.5 T steel, 2 days and 5 labours are required. Shifting of cut/bent steel of 5.5 T steel to the construction site takes 2 days for 2 labours.

Daily wages paid to the semi-skilled labour for cutting and bending of steel is Rs. 300. So, for 2 days, wages paid to each labour is Rs.600. Therefore, total money spent for cutting and bending of 5.5 T steel is Rs. 3000.

Daily wages paid to the unskilled labour for shifting of steel is Rs. 270. So, for 2 days, wages paid to each labour is Rs. 540. Therefore, total money spent for shifting the steel of 5.5 T is Rs. 1080. So, total money spent after cutting,

bending and shifting of steel is, Rs.3000 + Rs. 1080 = Rs.4080 and the whole process took 11 days.

Fig. 3 Steel Inventory

Fig. 4 Security at Inventory

The large space is occupied because of the steel inventory. Heavy Inventory holding cost is paid to the security agency. Three watchmen work at the steel yard in Day, Evening and Night shifts. Daily wages paid to each is Rs. 240. So, money spent for the security of steel yard is Rs. 720 each day. Therefore, for 11 days the expense for security of steel yard is Rs. 7920.

Fig. 5 Waste of cut pieces of steel

Waste is generated due to the cut pieces of steel. Error in cutting or bending steel or mistake in reading of bar bending schedule (BBS) causes the waste in steel.

So, the money spent in cutting, bending and shifting of steel is Rs.4080 and the money spent in security is Rs. 9820 for 11 days.

Total money spent is Rs.4080 + Rs. 9820 = Rs.12000.

Total time spent for the whole procedure = 11 days.

• *Recommendations for improvement in current process*

To avoid such expenses in cutting and bending of steel and its holding cost, it was suggested by the author to order readymade steel on site. Readymade steel is a company made steel prepared as per client's requirements and bar bending schedule given. There are many benefits for using readymade steel in construction works.

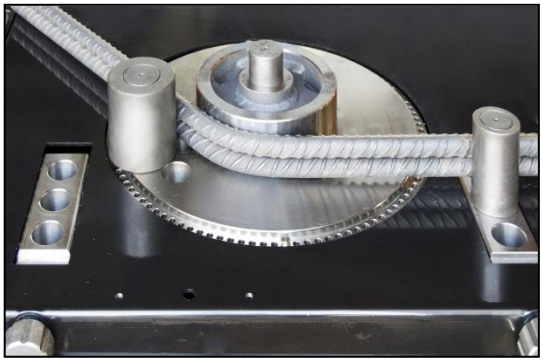

Fig. 6 Steel bending machine

Fig. 7 Readymade steel

Readymade steel providers give a faster delivery of final product. It can be received at site on the 8th day of indent.

Following are the benefits of using readymade steel for this case study:

- Rs.4080 paid to the Labors for cutting, bending and shifting of steel can be saved.
- Space for the steel inventory is saved. It can be used for other purposes.
- Security is no longer required at steel yard. Rs. 7920 is saved.
- No waste generation by cut pieces of steel.
- Procurement planning can be improved.
- 11 days were reduced to 8 days. 3 days are saved.

But, these are the improvements in the parallel activities. It would not affect the main activities of slab. Our focus is to propose a future state which reduce the slab cycle time by identifying waste in the current process for main activities or by applying innovative ideas.

Fig. 8 Current process of construction

In the current process, there is no wasteful process was found. But, there is a room for improvement by using innovative technique.

- It is possible to fix the column off-site and erected using crane.
- Off-site column fixing can be started two days earlier using safety stock of steel.
- Risk of working on heights can be avoided.
- Slab can be completed within 13 days, instead of 15.

Fig. 9 Risk of working on heights

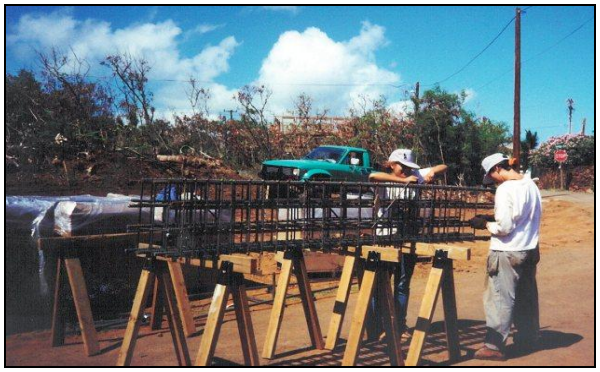

Fig 10. Off-site column fixing

Fig 11. Off-site fixed column cages

- Future state Map

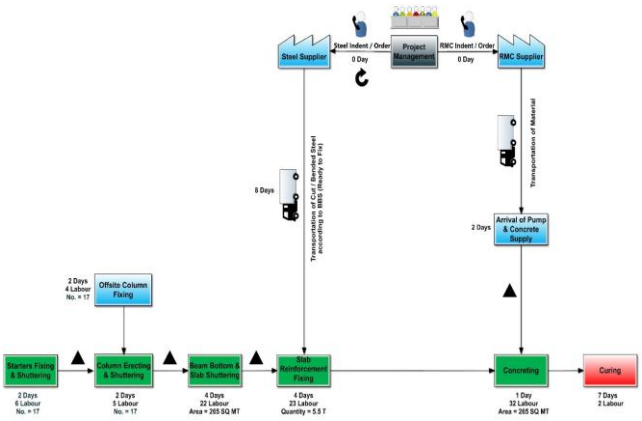

Fig. 12 Future state map

Using this technique, column fixing can be started earlier and 2 days can be saved. Earlier, in the current state map, a slab cycle time was 15 days which was reduced to 13 days in future state. Procurement planning can be improved due to indent of readymade steel. It makes a great impact in cost savings as well as time savings if it can be carried out throughout the project. In this case study, it is G+28 story residential building. So, if 2 days is saved in each slab cycle. There can be saved more than 56 days. A project can be complete before 56 days of its project delivery time. The wages of all the labours of these 56 days, which would be a huge amount, can be saved.

Few considerations to be taken care of:

A. Readymade steel are 8% to 10% more expensive than normal steel.

B. Normal steel = □ 40,000/Ton; therefore, for 5.5 Ton = Rs. 2,20,000

C. Readymade steel = Approximately Rs. 2,42,000/- for 5.5 T

D. Rental of crane for erecting the columns should be considered.

II. RESULTS AND DISCUSSION

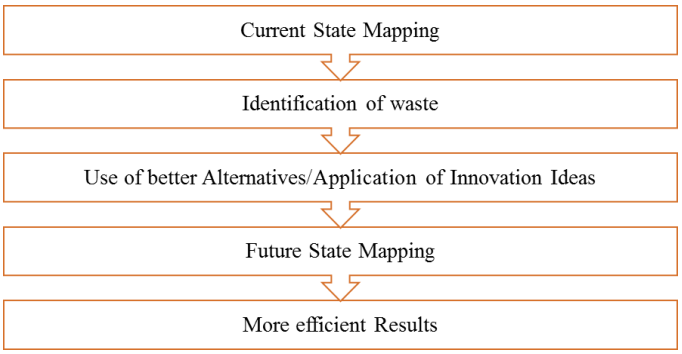

Fig.13 Methodology for Value Stream Mapping

Using this methodology, the considerable results were achieved. The slab cycle time for a typical slab, Service floor slab (Part-1) was reduced to 13 days from 15 days. The additional cost required for applying innovations should be considered. For this case study, the off-site column fixing saves 2 days in the cycle time but, for erecting the cage of column a tower crane is required. The rental of tower crane should be considered. It should not exceed the amount saved for two days. Applied Innovation has to get savings in comparison with the current practice on construction site. It should be considered that the readymade steel is 8 to 10% costlier than the normal steel. And the scrap value of waste cut pieces of steel should also be considered before taking decisions.

IV. CONCLUSIONS

The VSM methodology will allow construction managers to efficiently identify and measure waste sources. It will enable managers to more effectively see improvement opportunities and propose tangible plans to implement them. Thus, they will be able to reduce costs as well as materials and energy usage, improve the human resource management, comply with the schedules and quality standards, and decrease the process variability.

This study has explicated the major limitations of traditional VSM and proposed a practical approach to utilizing VSM in a construction industry. Compared to the current state, the future-state demonstrates a remarkable improvement in overall performance.

Hope that this research paper will help the construction industry to achieve better profit margins and better productivity by successfully implementing value stream mapping.

REFERENCES

[1] Peter Simonsson[1], Anders Björnfot[2], Jarkko Erikshammar[3] & Thomas Olofsson[4], "'Learning to see the Effects of Improved Workflow in Civil Engineering Projects", Lean Construction Journal, 2012