JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

REAL TIME MONITORING OF VALUE ADDED TIME OF CONSTRUCTION ACTIVITIES THROUGH VALUE STREAM MAPPING TECHNIQUE

[1]Akhil Ramesh Nair, [2]Ankitkumar S. Patel, [3]Jayraj V. Solanki

[1]PG Student, [2]PG Coordinator & Assistant Professor,[3]Head PG & Assistant Professor

[1,2,3]Civil Engineering Department,

[1,2,3]U. V. Patel College of Engineering, Ganpat University, Kherva, Gujarat, India

Abstract: Construction sector is evolving on regular basis with the technologies improving their productivity. Lean construction was first introduced by Toyota company in 1993 for production companies and later on it was implemented in construction sector. Lean model focuses on efficient use of manpower and machineries to eliminate waste. Value stream mapping (VSM) is a lean tool that helps us to visualize, analyze and improve all the steps involving in any activity of a construction project. Activities which are important, add value to the project. Whereas, some activities are considered as waste for not contributing in the productivity of the project. These activities constitute of almost 80-85% of all the activities in the construction projects. It shows the flow of both materials and information as they progress through the whole process. Literatures addressing VSM and the method of analysis were studied which lead to site investigations and sometimes survey conducting its use. Two projects were approached and five activities were monitored in total. Stopwatch was used to monitor all the activities and then the information was entered in the prepared observation sheet for further analysis. The motive of this paper is to map the current practice and then formulate the future map with the help of lean tools. So, the method of research was explanatory case study. The future state map objectified subsequent increase in percentage of value addition in activities Blockwork, Plasterwork, Slab-Reinforcement work, Slab-Shuttering work and Slab-Casting work up to **29.56%, 11.32%, 40.7%, 11.79% and 14.41%** respectively. A considerable reduction in the cycle time of the above-mentioned activities states the implementation idea of this technique in all the construction project.

Index Terms – Productivity, Value-adding activities, Non-value-adding activities, Cycle time, Value Stream Mapping (VSM), Lean Construction (LC), Construction Management.

I. INTRODUCTION

The term 'lean construction' is a variation of lean creation procedures applied to the construction industry. Extensively it tends to be described as methods pointed toward amplifying value and limiting waste. Lean construction was first introduced by Toyota company in 1993. Lean model focuses on efficient use of manpower and machineries to eliminate waste.

In a construction project, activities which are important, add value to the project. Whereas, some activities are considered as waste for not contributing in the productivity of the project. Value stream mapping (VSM) is a lean tool that helps us to visualize, analyze and improve all the steps involving in any activity of a construction project. Value Stream Mapping is best utilized for planning the progression of value when certain activities are performed more than one time i.e. value mapping.

VSM involves various steps starting from identifying or defining the product family i.e. justifying the field in which the value is to be increased. The second step is to study and layout the current activities schedule or map. The third step is to generate the future map that has improvements in terms of corrections and modifying the non-value-added activities to increase the yield of the project. The final step is to generate a proper plan to implement the future state map into the current map with all the aspects included.

II. NEED FOR STUDY

This research was carried out for the purpose of understanding the implementation of VSM technique in construction projects. Also, to obtain future analyzed state maps of the current project with reduced lead time and to search for a method to reduce the time involving non-value-added activities and to reduce the overall cost of the project.

III. OBJECTIVE

The primary objective of this research is to improve the cycle time of all the activities for construction projects. The secondary objective of this research is to improve the activities that don't contribute in addition of value to the project i.e. wastes time thus by

increasing the overall productivity of the task and to increase the value of the project. Cost optimization is an important aspect for carrying out this research.

IV. RESEARCH METHODOLOGY

4.1. Methodology flow chart

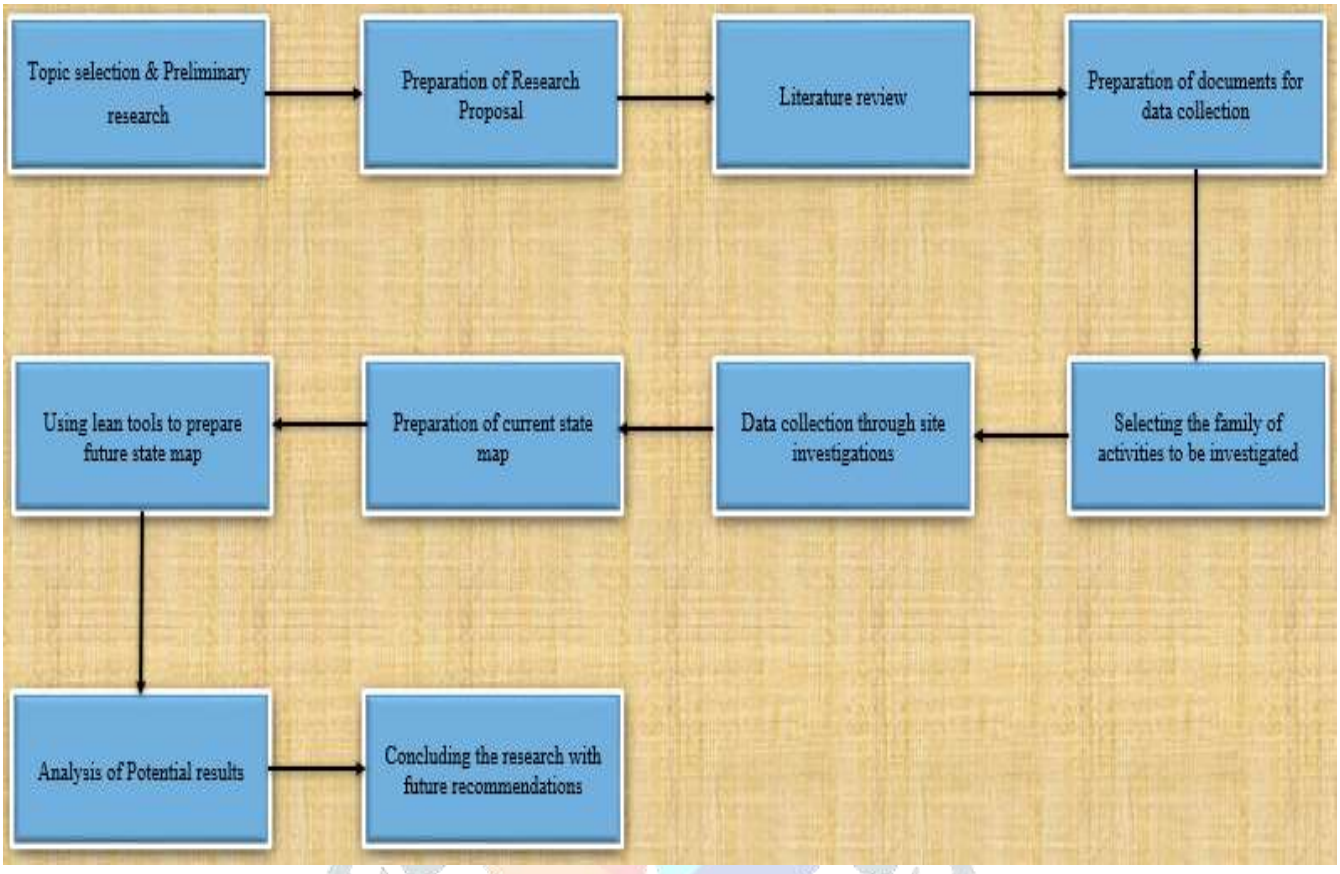


Figure 1. Research Methodology

V. LITERATURE SUMMARY

Research papers, journals, conference readings have been read and sorted to find the suitable literatures. The literatures studied from lean production were narrowed down to value stream mapping. These literatures are shown in the below table:

Table 1. Literature Summary

Sr. No.	Country	Author/s	Research Applicable			Method of Analysis	Remark
			Yes	No	Maybe		
1	Italy	(Fontanini & Picchi, 2004)			x	Case study of aluminium components of a particular residential building.	Value stream macro mapping utilization for identification of waste.
2	Australia	(Pasqualini & Zawislak, 2005)	x			Case study	Waste identification & elimination from the project.
3	Canada	(Yu, Tweed, Al-Hussein, & Nasseri, 2009)	x			Case study	Use of lean tools such as FIFO to eliminate inventory waste.
4	Chile	(Rosenbaum, Toledo, & González, 2013)	x			Case study of a medical center.	Reduction in activity time as well as reduction in

							the project cost. Productivity improvement.
5	India	(Desai & Shelat, 2014)	x			Case Study	The VSM philosophy will permit construction managers to distinguish and quantify waste sources proficiently.
6	Greece	(Melo, de Lima, & de Melo, 2017)	x			Case Study	Wastes connected with abundance inventory, material transportation, were distinguished.
7	India	(Sudhakar, Vishnuvardhan, & Ganesh Babu, 2017)	x			Case study	Reduction in non-value-added time to good extent.
8	Qatar	(Gunduz & Naser, 2018)	x			Case study of construction of underground pipelines.	Future State map developed results in expense reduction of the project.
9	India	(Vilventhan, Ram, & Sugumaran, 2019)			x	Case study of skyscraper.	Lean tools such as 5S application for waste reduction.
10	India	(Ramani & KSD, 2019)	x			Case study of Pre-Engineered Building.	Increase in productivity by eliminating the identified wastes.

Here is the figure shown below depicting the countries included in the sample literatures:

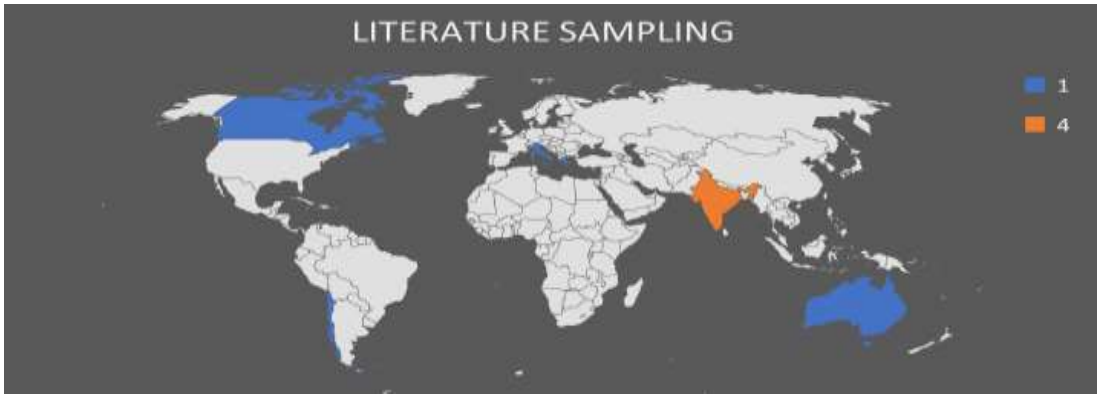


Figure 2. Literature Sampling

VI. Literature Findings

Literature selection was narrowed down into studies conduction lean construction and value stream mapping (VSM) in construction projects. Also, activity-based literatures were studied so to map the future state. VSM is a lean tool which is not that popular in India and so this thesis recommends its use in our construction projects. Lean construction was basically developed to identify wastes in the manufacturing industries, but later on it became an opportunistic tool for construction industries.

The literatures involve case studies of different projects like bungalows, pre-engineered buildings (PEBs), multi-storey buildings of RCC and construction activities of small scale. These case studies develop a methodology of recording the time taken by an activity to complete i.e. cycle time of an activity. An observation table including necessary details is prepared and the data collection is done for a particular duration.

The papers included limited activities which cannot determine the addition of value to the project. Improvement to sampling process of the activities is required so that the analysis method will be justified. Overall cost of the project is found to be less if had been worked as per the future state map. There are total 14 tools of LC out of which tools like FIFO, KANBAN and KAIZEN are used in developing future state map.

VII. Data Collection by construction site visit

Case study approach was considered suitable method for data collection. In this approach, two construction projects were approached to carry out VSM technique. The first project was a 2 block G+13 frame structure each & 1 Basement, at Ghuma, Ahmedabad. The second project was a G+1 apartment load bearing structure at Juhapura, Ahmedabad. Stop watch method was used to monitor each activity to carry out detailed time analysis of its execution work. An observation sheet is prepared to collect the data for the further analysis.

Data collected in the observation sheet is through real time observation of the activities being commenced at the construction site. Activities are recorded with the help of stopwatch and value-added time as well as non-value-added time are bifurcated. Stopwatch time study is the most famous strategy for work estimation. It was first evolved by Frederick W. Taylor in the early twentieth century. It is currently utilized overall to decide the time expected to complete a task.

The activities observed in project 1 includes AAC blockwork, plasterwork and slab reinforcement work. Slab shuttering work and slab casting were the two activities considered and observed in the 2nd project. The cycle time (C/T) is obtained for the required activity and then the process of developing the current state map begins. Cycle time is basically an accumulation of all the types of time for an activity to complete i.e. Value-added time (VAT) & Non-value-added time (NVAT). VAT is obtained by bifurcating the working and non-working time during data collection.

A measured data is prepared from the observation table with using the equation given below in the table.

Table 2. Formulae

Non-value-added time (NVAT)	C/T-VAT
Value added percentage (VAP)	(VAT/(C/T)) x 100
Setup time percentage (STP)	(Setup Time/(C/T)) x 100

VIII. Data Analysis

7.1. Data Analysis Method

There are data of total of 5 activities collected from Project 1 & Project 2. Excel tool is used for recording and analyzing the data. The productivity obtained is determined of current state project as well as of the future ideal state project.

After the measured sheet is prepared, the current state map of the required activity is drawn that consists of necessary VSM symbols. The current state map helps in differentiating the value-added time and the non-value-added time. The aim of this exercise is to reduce the non-value-added time so that the productivity gets improved and the cost of the project is minimized. The next process of the data analysis includes the formation of future state map of the required activity.

This map is built with adding some of the VSM tools which help in increasing the productivity and reduce the cycle time as well as the non-value-added time. The future state map is the resulting part of the study that gives all the required information of the altered activity.

7.2. Data Analysis

7.2.1.AAC Blockwork

The current state map and future state map along with improvements in value is shown in the below figures:

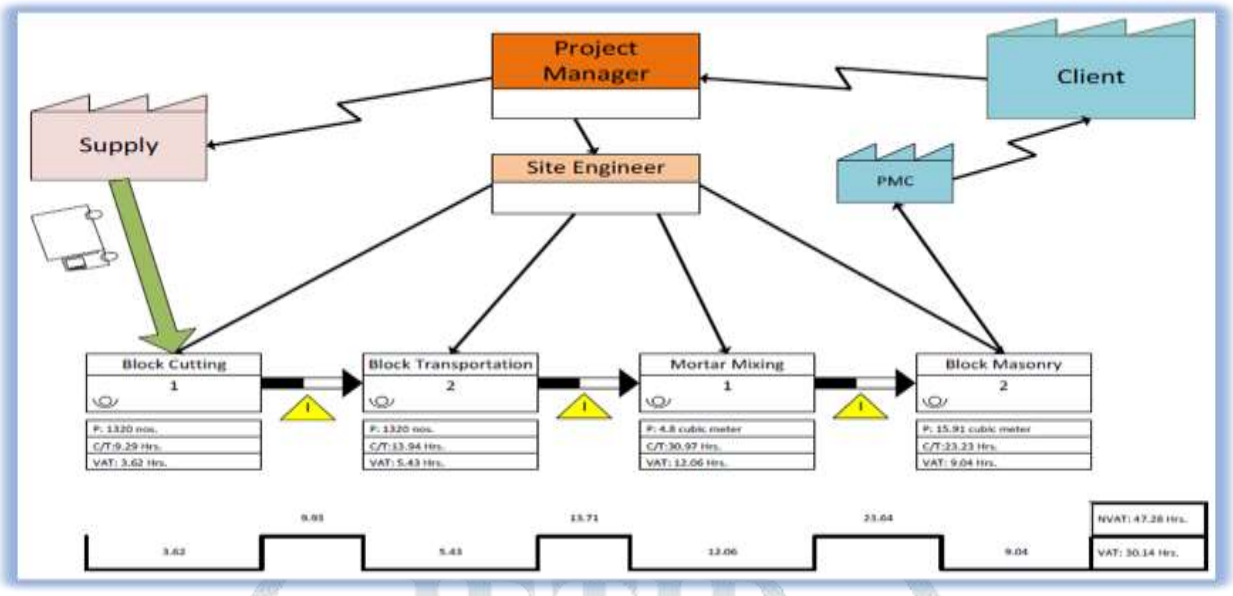


Figure 3. Current State Map of AAC Blockwork

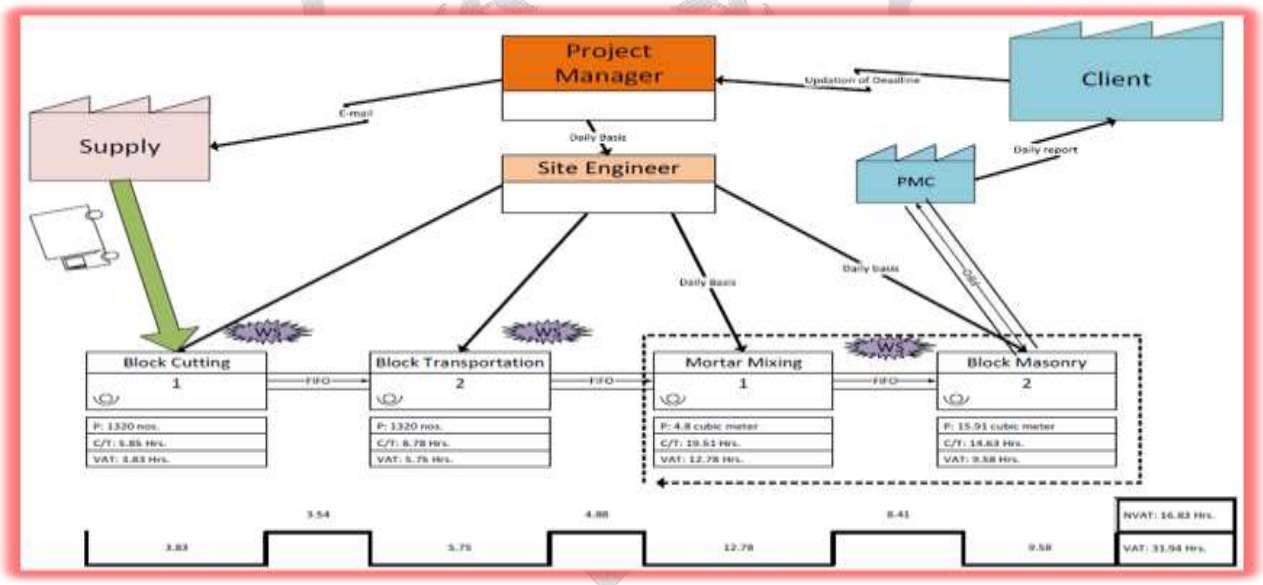
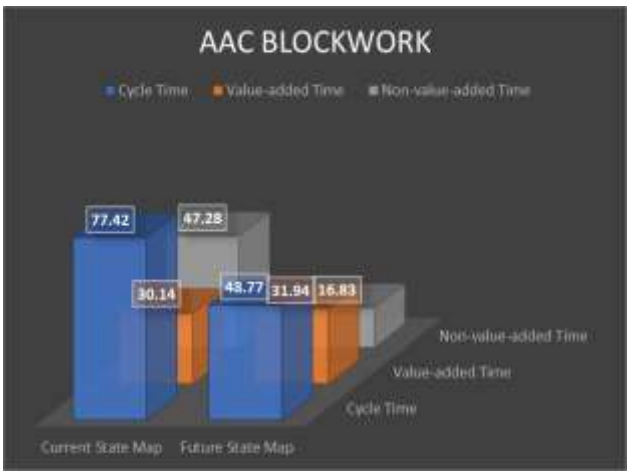
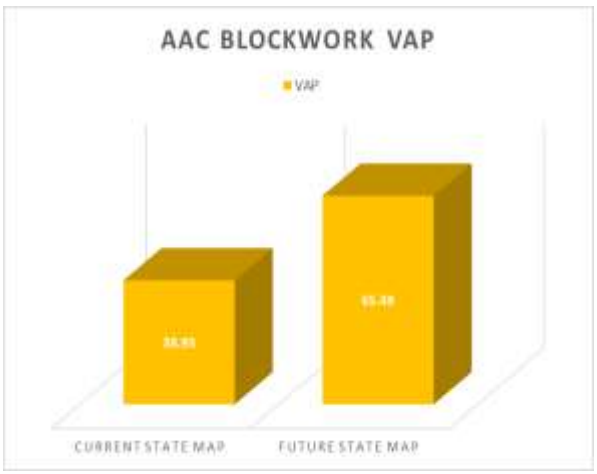


Figure 4. Future State Map of AAC Blockwork



Graph 1. Time analysis of AAC Blockwork



Graph 2. Value added percentage of AAC Blockwork

Final Cycle Time = 48.77 Hrs. Initial Cycle Time = 77.42 Hrs. Mason cost per day = ₹600; Unskilled Labours cost per day = ₹350. Total labours employed constitute 2 Mason & 4 Unskilled Labours. Cost of labours for 11 days of work as per current state map = ₹28,600. Cost of labours for 7 days of work as per future state map = ₹18,200

So, cost reduction in the project due to the reduced cycle time based on the manpower is ₹10,400.

7.2.2.Plasterwork

The current state map and future state map along with improvements in value is shown in the below figures:

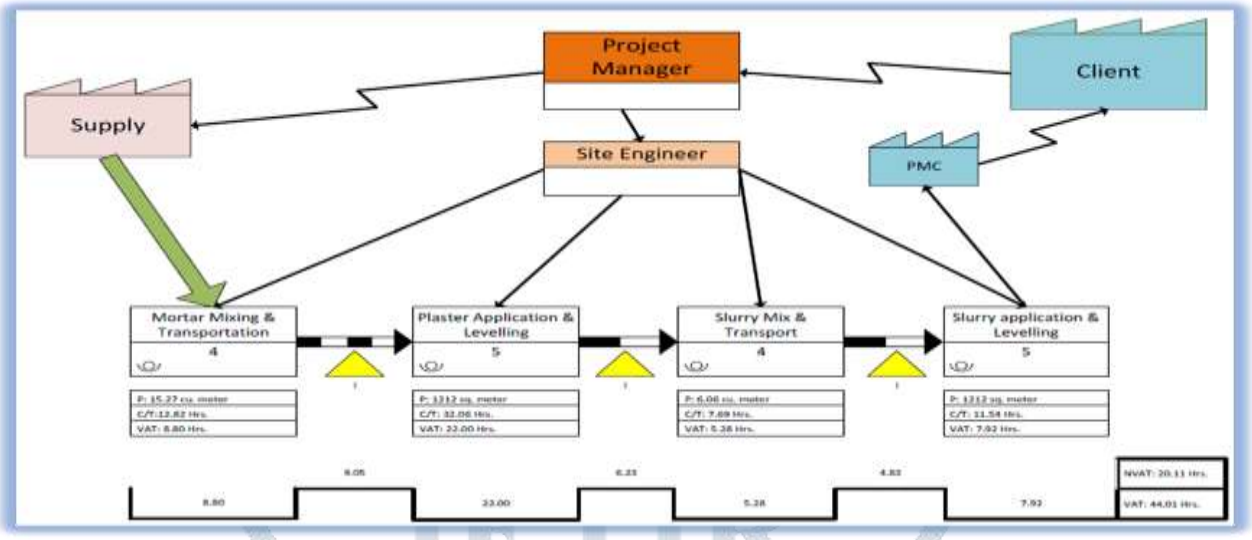


Figure 5. Current State Map of Plasterwork

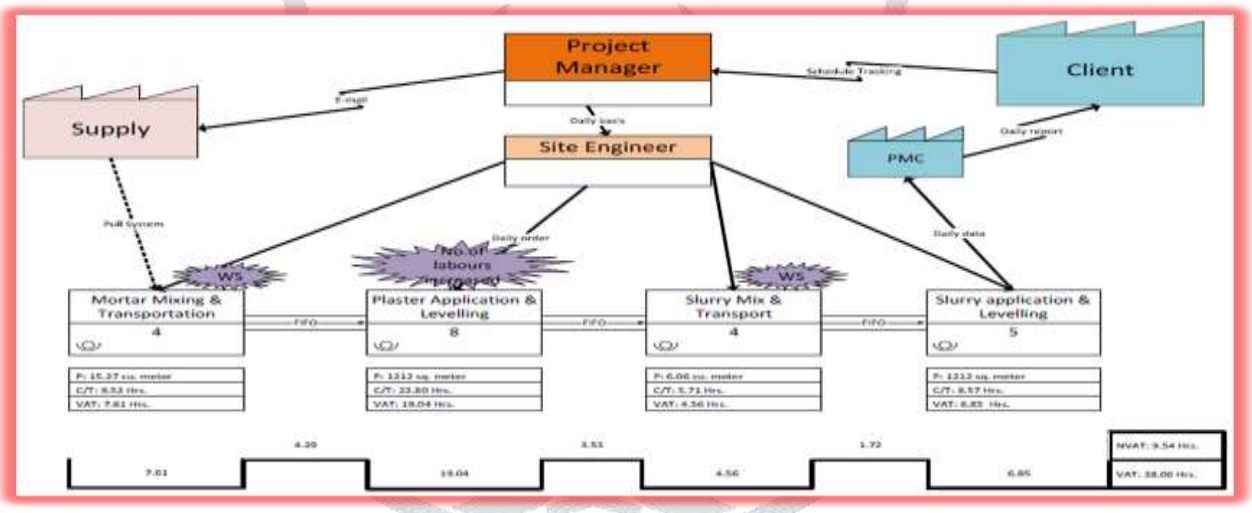
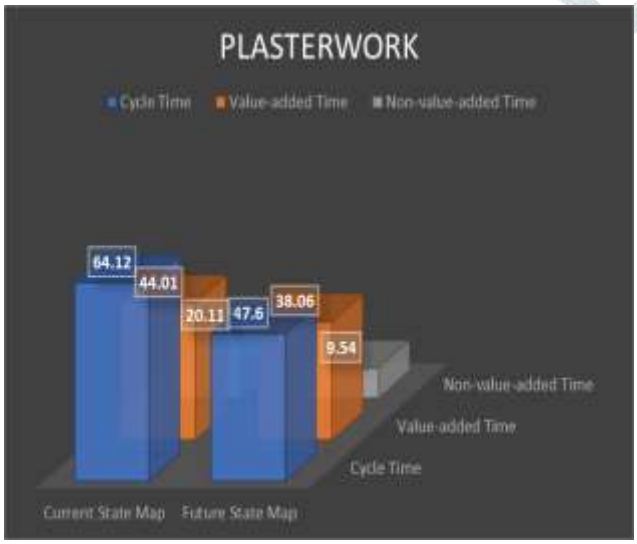
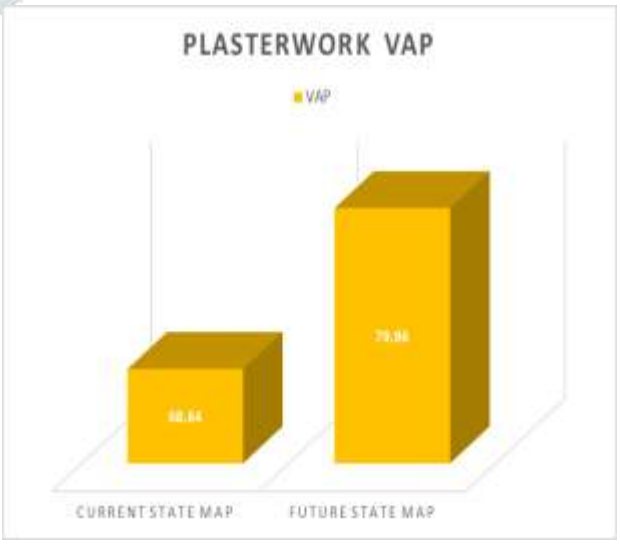


Figure 6. Future State Map of Plasterwork



Graph 3. Time analysis of Plasterwork



Graph 4. Value added percentage of Plasterwork

Final Cycle Time = 47.60 Hrs. Initial Cycle Time = 64.12 Hrs. Mason cost per day = ₹600; Unskilled Labours cost per day = ₹350. Total labours employed constitute 5 Mason & 4 Unskilled Labours. Cost of labours for 8 days of work as per current state map = ₹35,200. Cost of labours for 6 days of work but 3 masons extra for 2 days as per future state map = ₹31,200.

So, cost reduction in the project due to the reduced cycle time based on the manpower is ₹4,000.

7.2.3.Slab Reinforcement work

The current state map and future state map along with improvements in value is shown in the below figures:

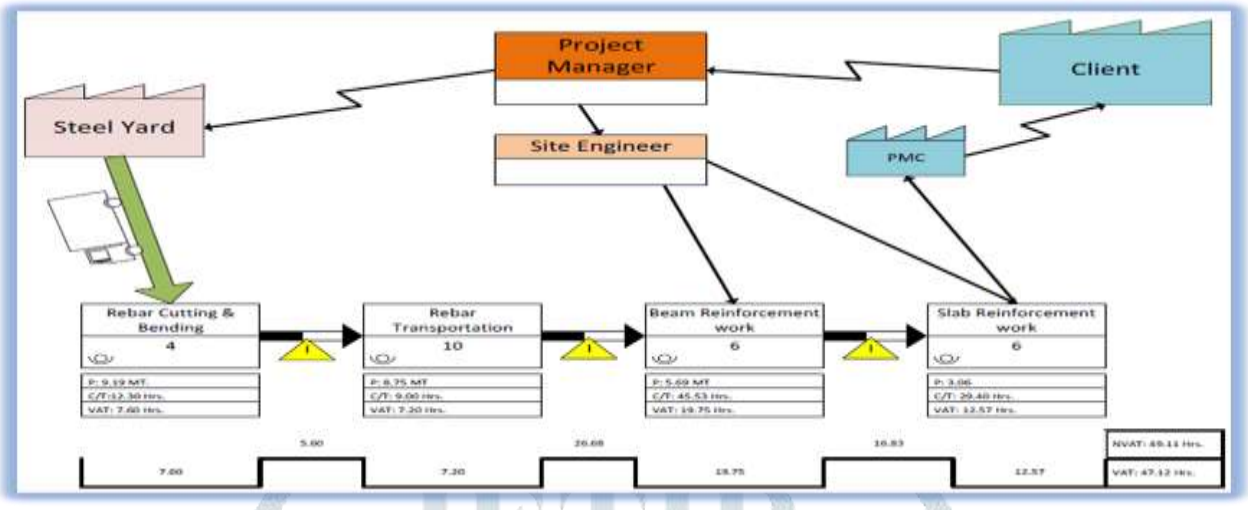


Figure 7. Current State Map of Slab Reinforcement work

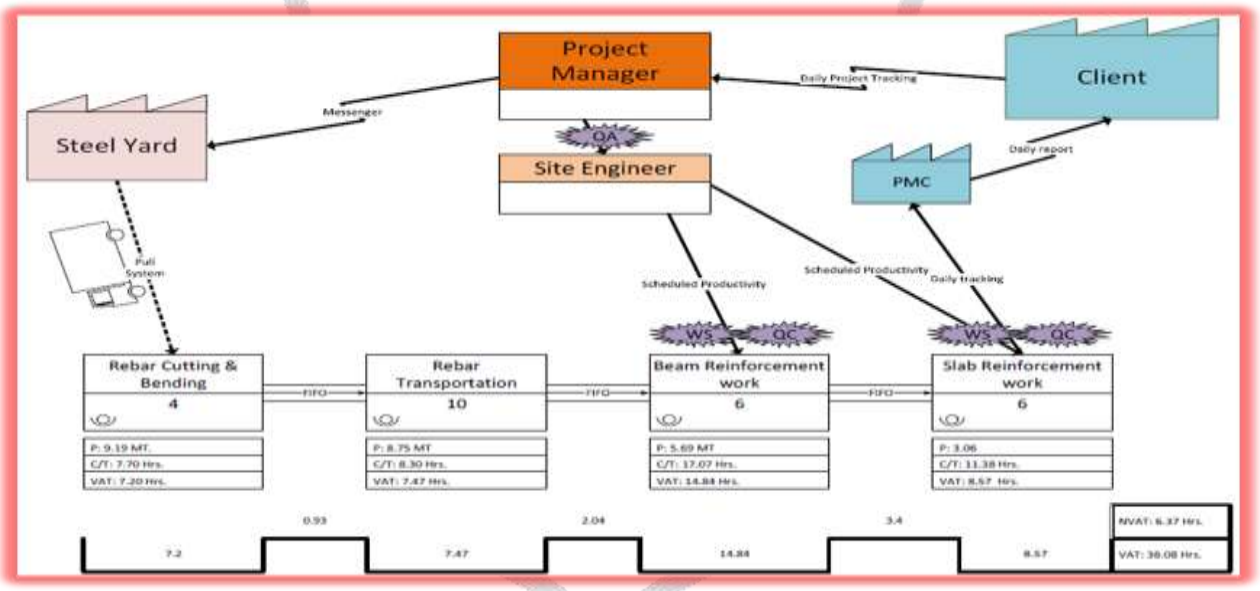
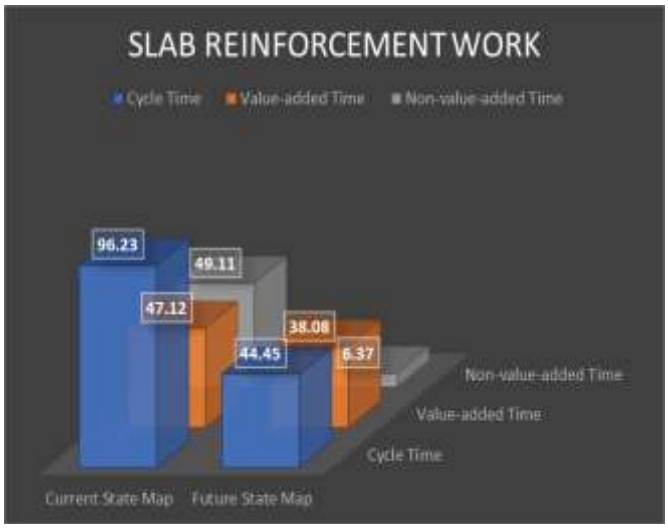


Figure 8. Future State Map of Slab Reinforcement work



Graph 5. Time analysis of Slab Reinforcement work

Graph 6. Value added percentage of Slab Reinforcement work

Final Cycle Time = 96.23 Hrs. Initial Cycle Time = 44.45 Hrs. Fitter cost per day = ₹700; Unskilled Labours cost per day = ₹350. Total labours employed constitute 3 Fitter & 8 Unskilled Labours. Cost of labours for 12 days of work as per current state map = ₹58,800. Cost of labours for 6 days of work as per future state map = ₹29,400.

So, cost reduction in the project due to the reduced cycle time based on the manpower is ₹29,400.

7.2.4.Slab Shuttering work

The current state map and future state map along with improvements in value is shown in the below figures:

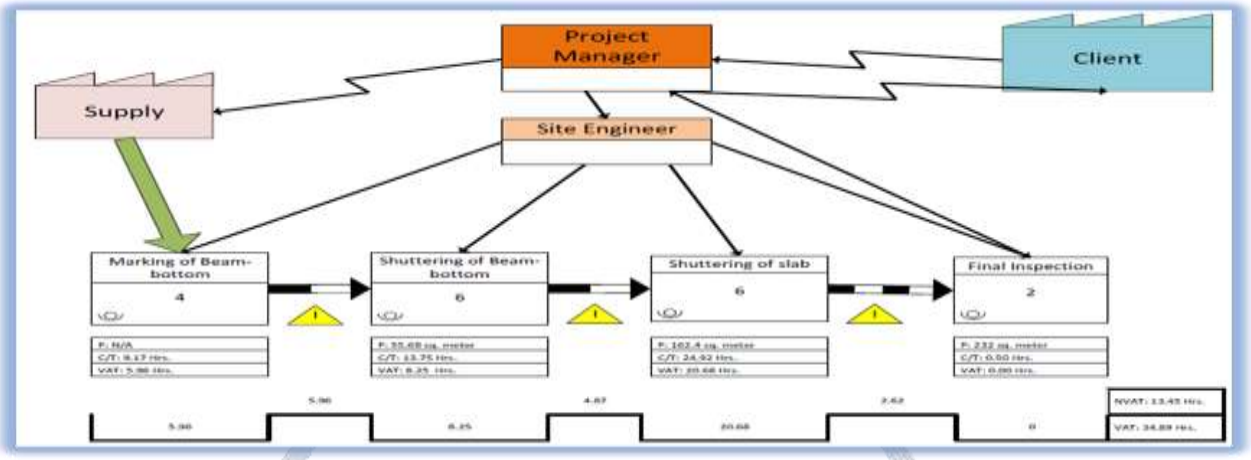


Figure 9. Current State Map of Slab Shuttering work

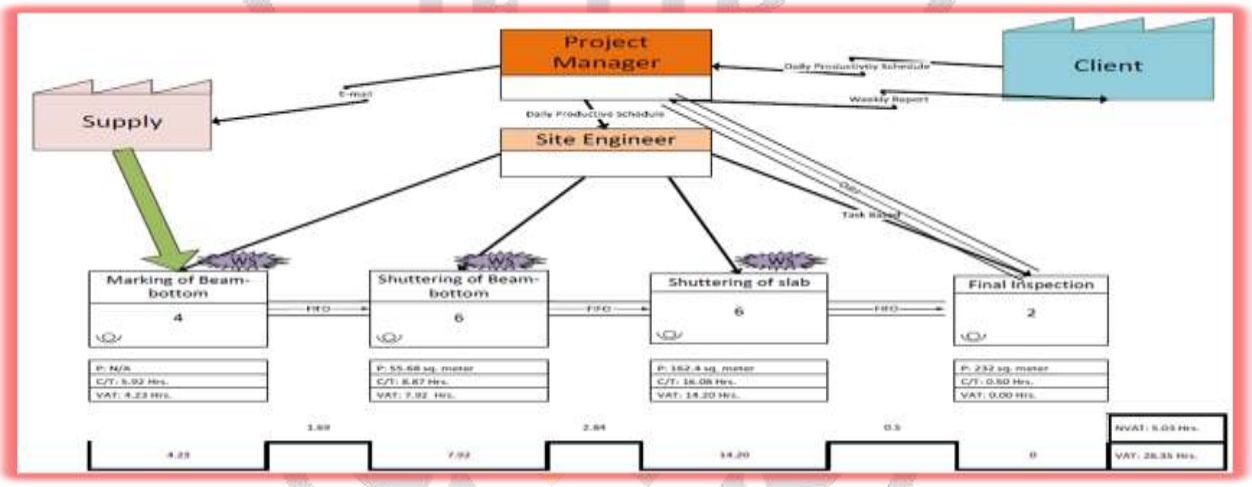
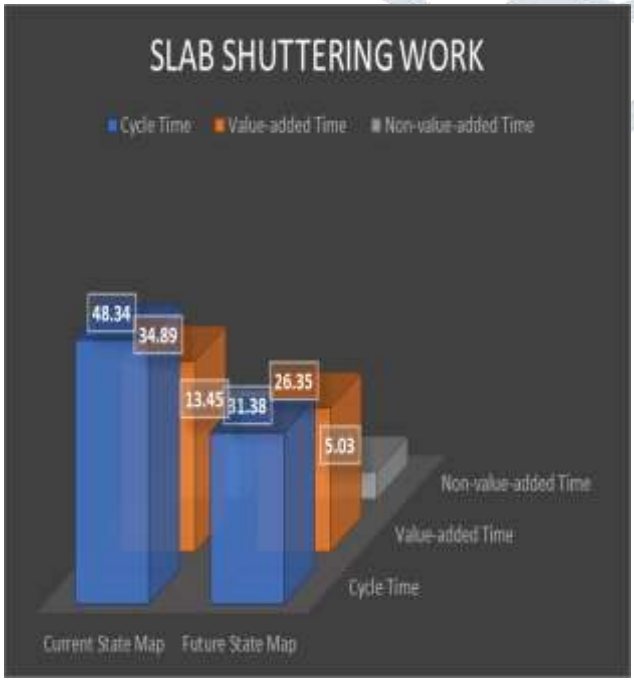
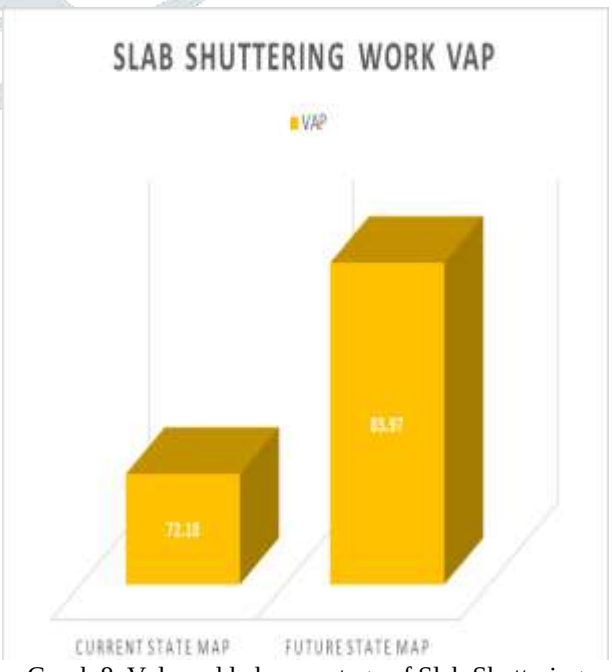


Figure 10. Future State Map of Slab Shuttering work



Graph 7. Time analysis of Slab Shuttering work



Graph 8. Value added percentage of Slab Shuttering work

Final Cycle Time = 31.38 Hrs. Initial Cycle Time = 48.34 Hrs. Carpenter cost per day = ₹550; Unskilled Labours cost per day = ₹400. Total labours employed constitute 3 Carpenter & 3 Unskilled Labours. Cost of labours for 6 days of work as per current state map = ₹17,100. Cost of labours for 4 days of work as per future state map = ₹11,400.

So, cost reduction in the project due to the reduced cycle time based on the manpower is ₹5,700.

7.2.5.Slab Casting

The current state map and future state map along with improvements in value is shown in the below figures:

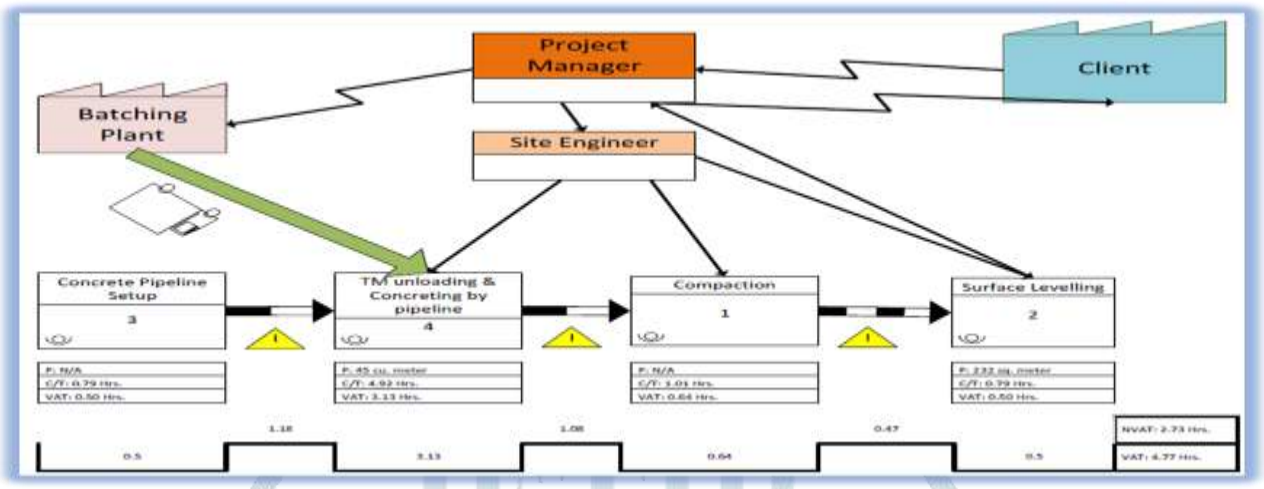


Figure 11. Current State Map of Slab Casting

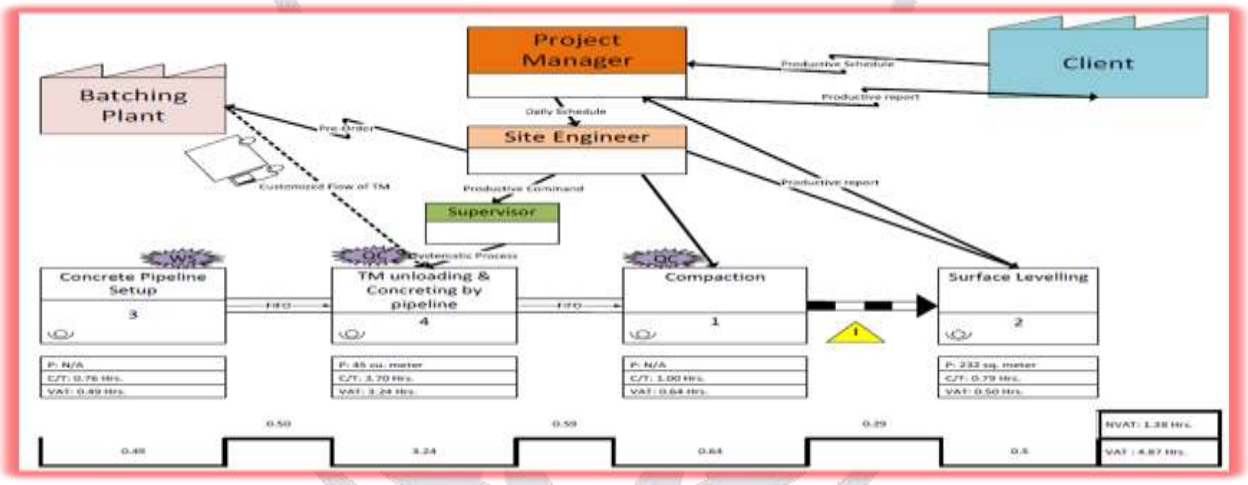
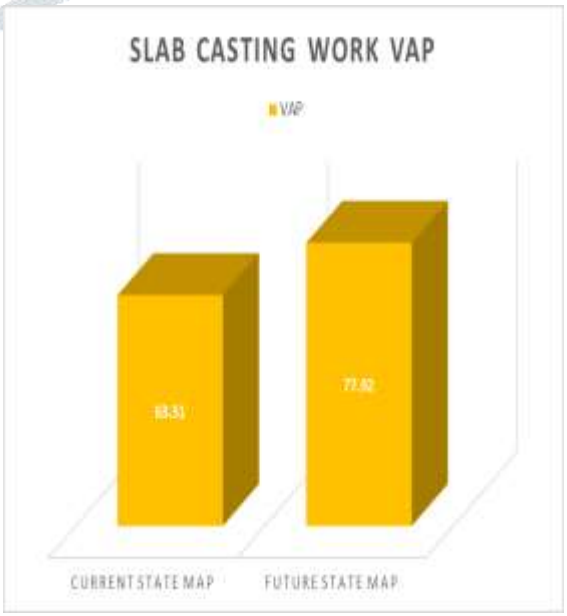


Figure 12. Future State Map of Slab Casting

Graph 9. Time analysis of Slab Casting



Graph 10. Value added percentage of Slab Casting

IX. CONCLUSION

Construction sector consists of different types of projects out of which mainly are time consuming. In this sector, events which are not judged or predicted can occur out of nowhere. Time, quality, cost and safety is of very importance in the construction sector and thus a lean tool called value stream mapping came into existence. With the help of this tool, the time that do not contribute in adding value to the activity or process is eliminated. There are seven waste factors, that are responsible for the increase in non-value-adding time and are: 1) production excess; 2) waiting time; 3) shifting of materials; 4) rework; 5) inventory; 6) movement & 7) faulty equipments or materials.

In this paper, two projects were visited and total of 5 construction activities were monitored. There was subsequent addition in value in each activity after the analysis based on the state maps of VSM. AAC Blockwork had an efficient increase in value of about **29.56%** and cycle time reduction of about **37%**. Plasterwork had increase in value of about **11.32%** and cycle time reduction of about **25.76%**. Slab Reinforcement work did add value of **40.7%** with reduction in cycle time of about **53.8%**.

Slab shuttering work did fairly add value and same is with the Slab casting work which is about **11.79%** and **14.41%** respectively. The reduction in cycle time of slab shuttering work and slab casting work is of about **35.05%** and **16.78%** respectively. Hence, a new perspective is developed for the construction companies to implement VSM in their projects.

8.1. Future Scope

The data analysis of 5 construction activities lead to idea of implementing this lean tool in the construction projects. The factors that would attract the construction companies to use VSM in their projects are elimination of waste adding activities and time to great extent, improving the cost overrun of the project and increase in value of the time-consuming construction activities.

X. REFERENCES

1. Desai, A. E., & Shelat, M. J. (2014). Value Stream Mapping as a Lean Construction Tool - a Case Study. *International Journal of Engineering Research & Technology*, 354-358.
2. Fontanini, P. S., & Picchi, F. (2004). Value Stream Macro Mapping - A Case Study of Aluminium Windows for Construction Supply Chain.
3. Gunduz, M., & Naser, A. F. (2018). Value Stream Mapping as a Lean Tool for Construction Projects., (pp. 69-74).
4. Melo, L. A., de Lima, V. F., & de Melo, R. S. (2017). Value Stream Mapping: A Case Study in Structural Masonry. *International Group of Lean Construction*, (pp. 755-762). Heraklion.
5. Pasqualini, F., & Zawislak, P. (2005). Value Stream Mapping in Construction: A Case Study in A Brazilian Construction Company. *International Group for Lean Construction*, (pp. 117-125). Sydney.
6. Ramani, P. V., & KSD, L. K. (2019). Application of Lean in Construction using Value Stream Mapping.
7. Rosenbaum, S., Toledo, M., & González, V. (2013). Imroving Environmental and Production Performance in Construction Projects Using Value-Stream Mapping: Case Study. *Journal of Construction Engineering and Management*.
8. Sudhakar, N., Vishnuvardhan, K., & Ganesh Babu, K. T. (2017). Value Stream Mapping in Construction for Improving Productivity. *International Journal of Scientific Research in Civil Engineering*, 05-08.
9. Vilventhan, A., Ram, V., & Sugumaran, S. (2019). Value Stream mapping for identification and assessment of material waste in construction: A case study. *Waste Management & Research*, 1-11.
10. Yu, H., Tweed, T., Al-Hussein, M., & Nasseri, R. (2009). Development of Lean Model for House Construction Using Value Stream Mapping. *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, 782-790.