

MANAGEMENT OF PRECONSTRUCTION USING LEAN MECHANISM

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ABSTRACT

In rapid, construction projects, it is not possible to manage the project through the conventional ways. It has been observed many times that the productivity of the construction depleting and leads to rework and produces many wastages such as over production, inventory, unnecessary transportation, workers displacements, over-processing, defect, waiting of materials, unused employee creativity, work accident, etc. In this Project focus on Lean Preconstruction Management i.e. Lean' is just way far greater than just a philosophy. In construction industry, eliminating waste and satisfying client's requirements is of utmost importance. Quality Assurance can be only attained if everything goes with standards and advanced thinking and furthermore implementation of newest trends in technology. Lean Construction Technology is one of them tied up for betterment of Construction Industry. Objectives of this research are to identify and record perception of different construction project participants on lean based wastes on construction sites and quantify them via. Questionnaire Survey, to study and demonstrate Value Stream Mapping on residential projects as a Lean Tool and identify possible benefits emerging from application of this tool and to increase output value through a systematic consideration of customer requirements; So this report aims to overview and discuss the applicability of lean principles and its techniques used in construction project which helps to reduce wastages in construction and brings the quality of work in product developing process with raising the profit level and also which factors affects to adopt lean management in construction has discussed with the current construction practices and past studies. This report review on the principles and techniques of lean management currently used in civil industry to reduce various types of waste and discuss the obstacle of lean management in construction in construction. This research study is limited to residential construction projects only.

Keywords- Lean Mechanism, Residential Building, Waste Reduction, Value Stream Mapping (VSM)

1. INTRODUCTION

1.1. Construction Overview: India

The construction industry is the second largest industry in India after agriculture. It is highly diversified and involved in all spheres of construction like: Infrastructure, Highways, Airports, Seaports, Commercial, Offices, Malls, Residential, Apartments, Houses, Industrial, Refineries and Mills. Most of the Indian contractors are not well equipped to handle the growing demand and hence the projects quite frequently run in to time and cost overruns, disputes and lower quality. Another major factor causing delays is the lack of proper "faith" between the contractor and the owner due to which the disputes often end up as litigations and the work stalled (World Bank Report, 2008). The Indian construction industry is also facing a severe resource setback in terms of skilled and semi-skilled man power. Though the above mentioned problems need noteworthy thought and time, it is crucial that increased emphasis is given to new project management strategies so that the Indian growth story doesn't meet a hasty end. After some research the medium and big firms need to look to the developed nations and also China for new strategies and implement them here.

1.2. Lean Construction

Lean construction is an amalgamation of original research and development in design and construction with a mutation 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 is concerned with the holistic approach of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, maintenance, salvaging, and recycling (Abdelhamid 2007). This approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs. (Koskela et al.

2002). The term "Lean Construction" was coined by the International Group for Lean Construction in its first meeting in 1993.

1.3. Study of the Waste in Construction

The analysis is structured and divided into six sections, of which the first five correspond to the wastes in construction, identifying waste, measuring waste, waste prioritization and potential effects of a lean approach. The sixth and last section analyses how the environmental impact of a construction project might be affected if a lean approach is implemented at a construction site.

1.4. Need Of the Study:

As construction industry gets competitive, thinking and applying Lean to Construction activity in India is critical to winning customers and ensuring profitability. The aim of Lean Systems is to design, produce and deliver products/services, which exceed customer expectations in terms of Cost/ Quality/Time/Performance. Lean construction is a new way to manage construction. The objective, principles and techniques of lean construction taken together form the basis for a new project delivery process. Value Stream Mapping is a logical chart methodology for process tracking which helps the tracker to identify value adding activities and non-value adding activities.

1.5. Problem Statement of the Study:

Despite being in picture since 1993 and providing effective results in eliminating wastes and improvising project efficiency and value, Lean is in dark side of implementation in large scale. Main factors contributing to less importance given to Lean production in construction sector are generally guru-hype of Lean Philosophy, critical theory and empowerment, customer responsiveness and recorded wastages.

Factors understood that are generating problem statement for this research are;

1. Indian Construction Industry lack knowledge of implementing Lean Philosophy thereby considerable wastes are generated.
2. There is no better option available to eliminate process wastes.
3. A level of expertise is necessary to evolve more in Profits from the projects.
4. Reduction of waste is prominent in any profit maximization theory.
5. If there is a break in the chain, lean cannot work there.
6. There are certain people in an organization who take interest in transformations and those who don't, oppose the transformation.
7. Management has various goals and agendas and therefore they avoid using alternatives for improvement.
8. For any Lean thinking to be implemented, there are two major aspects; a) engaging teams in the transformation effort, and b) having leaders as mentors, both requires efforts and time to get in picture therefore general avoidance for change is created within the organization.

1.6 Scope of Study:

1. Implementation of Value Stream Mapping as a Lean Management tool to the study.
2. This research study is limited to residential construction projects only.
3. Use of software platforms like MS Project, Microsoft Visio, Lean Pilot, Quality Companion 3 and Spreadsheets for tracking and plotting Value Stream Map.

1.7. Objectives of the Research:

Objectives of this research are:

- i. To identify and record perception of different construction project participants on lean based wastes on construction sites and quantify them via. Questionnaire Survey.
- ii. To study and demonstrate Value Stream Mapping on residential projects as a Lean Tool and identify possible benefits emerging from application of this tool.
- iii. To increase output value through a systematic consideration of customer requirements.

- iv. To access lean construction technique from the view point of various experts and top management.
- v. To enhance the quality of the project and profit by minimizing the wastages.
- vi. To examine non-value adding activities from the current state map and then give provision for process improvement in future state map.

2. LITERATURE REVIEW

P. Vijay Ram Reddy et al. This report reviews current productivity measurement literature, particularly that pertaining to the construction sites, and offers recommendations/suggestions, for improvement of productivity at the site.

Kassu Jilcha et al. Some research finding concluded that pressures from communities have led to the enactment of various safety legislations and safety standards in different countries and regions for different industries.

Hariharan Pethaperumal et al. Safety management systems require highly qualified management and professionals who have sound Knowledge in safety procedures.

Maxwell S. Akple et al. The study showed that the use of faulty tools and equipment, workers physical condition and noncompliance to standard safety rules and regulations were the main causes of accidents in automobile repair workshops.

Wing Hang Lee et al. One of related major safety concerns is cranes falling, that has become a worldwide major safety cross-cutting and challenging issue in construction industry. Experts in various fields are therefore proactively working on such critical aspect in order to avoid major causes of fatal accidents and enhance safety on construction sites.

Faheem Ahmed Malik et al. Their primary on scene responsibilities includes securing the crash site, caring for injured persons, and re-establishing traffic flow. Therefore, on scene data collection systems must consider the officer's needs when implementing new technologies.

Evan A. Nadhim et al. Construction projects are described as dynamic and complex because of their sites and manpower. They are also characterized as temporary and transitory. For example, the workforce for construction firms is usually temporary employees.

3. METHODOLOGY

The following methodology has been adopted to collect and analyze the necessary data. The data on which this work is concluded is collected in the form of three phases described below.

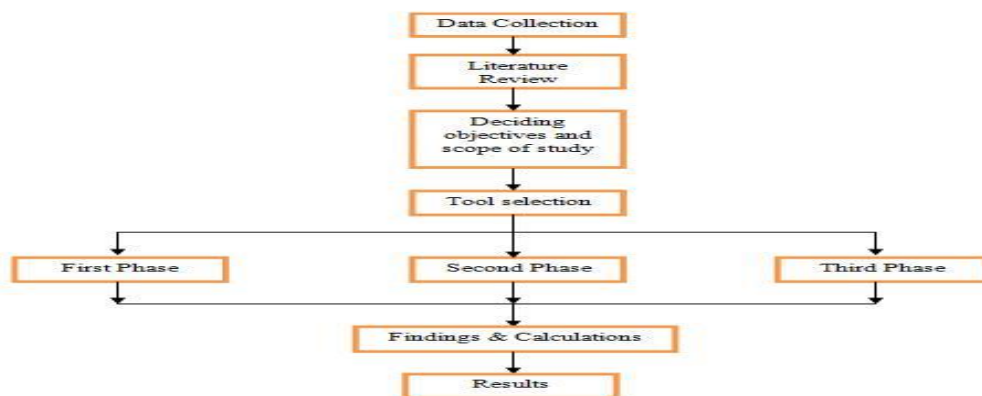


Fig.1. Flowchart showing Methodology adopted for work

- a) **Data Collection:** Collection of various data, literature and methodologies available in various sources like Journals, Articles and with the help of Internet.

- b) **Literature Review:** Thorough study of relevant articles, atleast 15, from various nationally and internationally recognized journals showing prior implementation and results that are availed by using Lean Philosophy in Construction industry.
- c) **Deciding objectives and scope of study:** Based on the literature reviewed, objectives that are important to be implemented for completion of project are necessary to be decided and these objectives will act towards actual completion of project. Furthermore, scope or limitations of this study are also decided well in hand. Scope of Study will help in only prioritizing on important factors that are supposed to fulfill the requirements of objectives decided.
- d) **Tool selection:** After all above works are completed, Lean tools that can be effective to be selected, in this case Value Stream Mapping and implemented in three phases on a construction site.
- e) **Phases:** The three phases will include domains like;
- 1st Phase- Training on Lean, interviews with Project Managers and Planning Engineer, Questionnaire Surveys.
- 2nd Phase- Collection of survey responses, analysis of responses, identification of cycle times, resources required, inventory time, lead time and customer demands for each activity.
- 3rd Phase- Plot current state map and identify value adding activities, analysis of current state map and preparation of future state map.
- f) **Findings and Calculations:** By implementing above methodology included are the results that are concluded in this domain. Difference in actual and planned cost and time schedule of studies are observed in this domain.
- g) **Results:** After all the above domains are completed, results are concluded whether the implementation of Lean will be successful on the concerned construction site or not. Various barriers and implementation problems that were seen during project are also to be studied thoroughly.

4. DATA COLLECTION

4.1. Interview and Survey Response Analysis

4.1.1. Survey I (Based on 7 Mudras):

A questionnaire survey specially designed for easy understanding to Lean or Non-lean practitioner was designed and the data collected was analysed using a simple tool, Relative Importance Index (RII).

Relative Importance Index (RII) is a method which is used to identify relative importance of each factors and parameters included in the survey. This tool is widely used for delay analysis and identification of occupational health risks. Since this statistical tool is very much helpful in ranking the factors, it has been widely used by field experts and organizations to identify their priority factors for which the survey is adopted. The data is collected and is processed in tabular form and the sum of weights of each factor is divided by product of highest point (in our case 5) and number of respondents participating.

In this research, the five point scale is as follows;

- Never-1
- Very Rare-2
- Seldom-3
- Frequent-4
- Very Frequent-5

$$RII = \frac{\sum W}{A*N} (0 \leq RII \leq 1)$$

Where,

W = weights given to each factor by the respondents and will range from 1 to 5

A = highest weight (i.e. 5 in this case), and N = total number of respondents i.e. 45 nos.

Responses of different project participants involved in the survey are given in table below.

Table.1. Responses of survey participants (Survey I)

| Sr. No | Description | Scores | | | | | Weighted Total | R.I.I | Rank |
|--------|--|--------|-----------|--------|----------|---------------|----------------|-------|------|
| | | Never | Very Rare | Seldom | Frequent | Very Frequent | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | Waiting for Raw Materials | 1 | 5 | 7 | 12 | 20 | 180 | 0.8 | 4 |
| 2 | Labor/Resources idle for long time | 0 | 2 | 8 | 5 | 30 | 198 | 0.88 | 1 |
| 3 | Equipments idle for long time without Processing | 0 | 0 | 9 | 12 | 23 | 190 | 0.84 | 2 |
| 4 | Lack of available space for labor gang to work on site | 1 | 3 | 15 | 18 | 8 | 164 | 0.73 | 5 |
| 5 | Overproduction of concrete | 0 | 2 | 8 | 16 | 19 | 187 | 0.83 | 3 |
| 6 | Too early fabrication of steel reinforcements | 1 | 13 | 21 | 6 | 4 | 134 | 0.6 | 12 |
| 7 | Frequent changes in drawings and Specifications | 0 | 15 | 18 | 8 | 4 | 136 | 0.6 | 10 |
| 8 | Poor design and specifications | 1 | 22 | 17 | 2 | 3 | 119 | 0.53 | 20 |
| 9 | Lack of planning and control | 3 | 17 | 12 | 9 | 4 | 129 | 0.57 | 15 |
| 10 | Excessive thickness of plastering, door or window frames, etc. | 10 | 12 | 8 | 7 | 8 | 126 | 0.56 | 16 |
| 11 | Unnecessary movements done by workers on job site | 5 | 6 | 10 | 12 | 12 | 155 | 0.69 | 6 |
| 12 | Poor work site-layout | 11 | 12 | 16 | 3 | 3 | 110 | 0.49 | 22 |
| 13 | Travelling too far on a work site to accomplish the work assigned to workers | 10 | 13 | 9 | 7 | 6 | 121 | 0.54 | 18 |
| 14 | Over processing on surface finishes | 0 | 23 | 8 | 8 | 6 | 132 | 0.59 | 14 |

| | | | | | | | | | |
|----|---|----|----|----|----|---|-----|------|----|
| 15 | Concreting and cleaning of mixer/pump | 2 | 12 | 11 | 12 | 8 | 147 | 0.65 | 7 |
| 16 | Concrete pump line choke up | 1 | 18 | 22 | 3 | 1 | 120 | 0.53 | 19 |
| 17 | Cement mortar waste during brick shifting | 21 | 11 | 4 | 6 | 4 | 99 | 0.44 | 24 |
| 18 | Due to inadequate stock conditions on site | 11 | 12 | 9 | 8 | 5 | 119 | 0.53 | 20 |
| 19 | Due to robbery, theft or vandalism | 8 | 22 | 11 | 3 | 1 | 102 | 0.45 | 23 |
| 20 | Deterioration of stocked materials like cement, sand, steel, etc. | 2 | 15 | 13 | 11 | 4 | 135 | 0.6 | 11 |
| 21 | Ordering materials and resources more than Requirement | 2 | 10 | 16 | 8 | 9 | 147 | 0.65 | 7 |
| 22 | Breaking of fragile materials like glass | 3 | 11 | 15 | 9 | 7 | 141 | 0.63 | 9 |
| 23 | Bad conditions of pathway for movement of materials from one place to another | 5 | 13 | 17 | 9 | 1 | 123 | 0.55 | 17 |
| 24 | Stockyard at far distance from installation Point | 3 | 17 | 11 | 7 | 7 | 133 | 0.59 | 13 |

Table-I Interpretation:

The above table of responses shows that the largest rank is of Labour/Resources idle for long time (88%). This is because most project managers and site supervisors fail to identify importance of on-time procurement of materials/resources required for executing the work. Labours mostly remain idle for long time because of delay in arrival of raw materials on-site. This also keeps machines idle for considerable time. Also, most of the time, labours are not informed thoroughly what they are supposed to do. This ultimately causes waiting of resources which is one of the prime wastes in lean. To control such wastes, management must plan each and every arrival of raw material to the site and should also keep some raw materials in inventory, if possible.

Equipments idle for long time before processing takes second position in table with 84% because of the very same reason given above. Delay in arrival of raw materials on site will keep machine idle also. This will not only stop timely production but also will increase time of completion causing further delay to activities planned.

Overproduction of concrete with third place in table with almost equal weight of 83% is because even after knowing possible advantages of ready mixed concrete, contractors keep swaying towards manual batching and mixing. In manual batching and mixing, chances of production of concrete in ample amount are very rare nowadays. Ready-mixed concrete provides with exact amount of quantity required for a day's work and management can also keep record of amount of concrete used per batch. Therefore, contractors or project heads can collectively prompt towards 'Continual Improvement' and capitalize new technologies that can serve them with profits of time and cost.

5. RESEARCH DETAILS AND STUDY

5.1. Case Study I:

5.1.1. Observations on site:

The main goal of VSM is to provide the tracker with possible process improvement strategies which can convert non-value adding activities to value adding. VSM serves as a road map for process improvement of proposed process by tracking it in present state.

The beginning of this case study started from collecting data like cycle time, resources required and number of days required for individual tasks in a RCC slab construction activity. Data was collected from site engineers, site supervisors, workers and manual look-up. The data collected from the concerned site is shown in Table 2 below.

Table.2. Resource requirement for a RCC Slab activity

| Activity | Quantity | Resources Required | | | | | Days |
|------------------------------|-----------|--------------------|--------|-------|--------|-------|------|
| | | Carpenter | Helper | Mason | Fitter | Total | |
| Column fixing and shuttering | 20 nos. | 6 | 2 | – | 2 | 8 | 3 |
| Shuttering of slab | 310 sq.mt | 13 | 10 | – | – | 23 | 4 |
| Steel Reception | – | – | 2 | – | – | 2 | 2 |
| Steel Cutting & Bending | – | – | 3 | – | 3 | 6 | 2 |
| Steel shifting to site | – | – | 3 | – | – | 3 | 1 |
| Reinforcement of Slab | 6 T | – | 6 | – | 21 | 27 | 4 |
| Checking and Rectification | – | 1 | 1 | – | 1 | 3 | 1 |
| Concreting | 310 sq.mt | 2 | 6 | 20 | 1 | 29 | 1 |
| Curing | – | – | 1 | 1 | – | 2 | 7 |

According to the current practice, for a slab of 295sq.mt concreting and 6T of reinforcement work, a total duration of 25 days are required. Steel used for site work is Fe500TMT. The diameter of bars used is 6 mm to 10 mm. The Current State Map of this slab work is shown in Fig 19 below.

According to the current practice, steel is ordered 13 days from the day of actual reinforcement work. Raw steel supplier provides steel on 5th day of indent. Here, for the slab of 295sq.mt, it takes 2 days of 6 labours to cut and bend the raw steel according to BBS. After cutting and bending of steel, it takes 1 day and 3 labours to shift the steel to the site which is 75 meters away from the cutting and bending location.

5.1.2. Identification of waste from Current State Practice:

According to the current state, steel is ordered 13 days prior to the execution of work. Steel is received 5th day from indent.

Daily wages of Rs. 350 is provided to semi-skilled labours to cut and bend the steel. So for the period of 2 days for 6 labours a total of Rs. 4200 is paid for 6T of steel cutting and bending.

To shift the steel to the site, Rs. 300 is paid to each un-skilled labour. So, for the period of 1 day, a total of Rs. 900 is spent for 3 un-skilled labours. So, total amount spent for these 8 days = Rs. 4200+Rs. 900= Rs. 5100.

For keeping security of inventory yard, two watchmen work on site for two shifts. Each watchman is paid Rs. 250/shift/day. So for these 8 days, a total of Rs. 4000 is spent as expense of security of inventory yard.

So, the cutting and bending and shifting of steel to the site takes total of = Rs. 5100+ Rs.4000= Rs. 9100 has to be spent for a total of 8 days.

Total cost of steel for one slab:

Steel per ton cost: RS 45000

For 6 T cost: RS 2, 70,000

Total cost of wages for one slab = 81900

Total steel cost for one slab = 2430000

For G + 8 structure required total cost of usable steel for 9 slab = RS 2511900

Wastage of steel is 5% to 8%

Total used steel is 5.5T for one slab. (from observation)

5.1.3. Recommendations for Process Improvement

A suggestion can be made to the concerned contractor to implement use of readymade steel. There are many benefits of using Readymade steel in construction works. Readymade steel provides these following advantages to this case study:

- Space of steel inventory can be saved using readymade steel on construction site. This space can be used for other purposes.
- Rs. 5100 can be saved by using readymade steel which can be achieved by reducing resources wages paid to labours for steel cutting and bending and shifting.
- Rs. 4000 spent on watchmen for security purposes can be saved using readymade steel on construction site.
- Procurement planning can be improved.
- Reduction in waste of steel cut pieces.
- Readymade steel suppliers can provide steel within 7 days once ordered by project management. This can save up to 6 days of project schedule.

Using the above strategy, 5 days can be saved. The project schedule by using readymade steel on site can lead to reduction of single slab time from 25 days to 20 days. The case study which was used in this research was a G+8 RCC structure. So if 5 days are saved in each slab cycle then up to 45 days can be saved by project heads by using strategies like this. Considerably wages expended for these 45 days can be a huge profit for the overall cost savings of the concerned project.

By using this process improvement strategy, slab cycle time of the site studied as a case reduced from 25 days to 20 days. But there are some considerations that have to be kept in mind before using readymade steel on site:

- Readymade steel is 8-10% costlier than normal steel.
- Cost after applying process improvement strategy:

Readymade steel cost per ton = RS 48600

Total used steel is 5.5 T for one slab.

Therefore, total cost for readymade steel for G+8 building slab is approximate = Rs 2405700

Difference in cost is Rs 106200

Therefore, Profit applying lean mechanism for reinforcement of slab is 106200 /-.

Moreover, according to current state and future state map calculations, there are approximately 5 days that can be controlled using Lean tools and Managerial strategies suitable for particular set of activities.

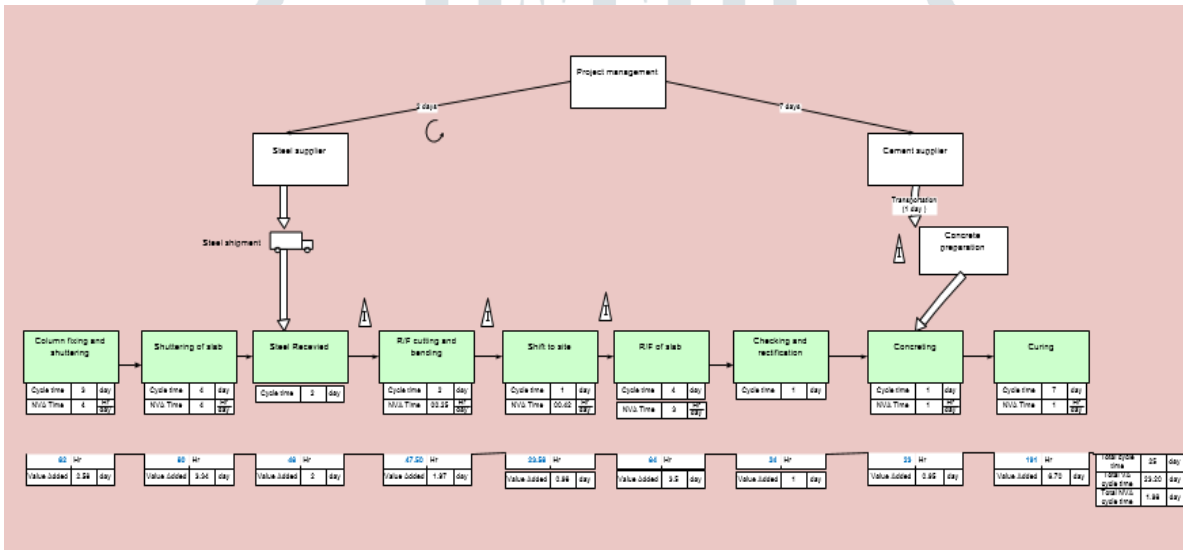


Fig.19. Current State Map (Case I)

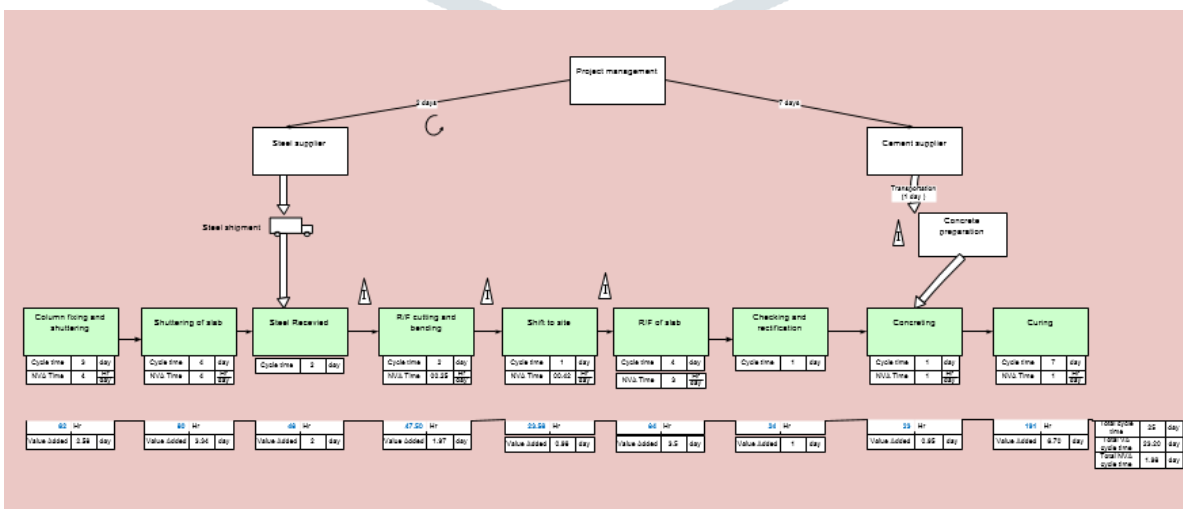


Fig.20. Future State Map (Case Study I)

CONCLUSION

- Based on the research work done, it can be easily interpreted that according to different project participants waste in construction is obvious to happen. Since, one cannot control thoroughly on waste from construction but one can strive to control it through different measures and latest innovative techniques.
- According to questionnaire responses, it can be actually seen that project participants are very much eager to reduce wastes in construction. These wastes do not only hamper the finance of projects but also many a time viewed as a minus point under the perception of customers.
- Based on the survey I, 84-80 % of wastes according to the project stakeholders are directly related by waiting for materials and idle state of labours and resources. This delay in procurement in quantity of resources is mainly due to poor supplier-client relationship or communications. Moreover, management is also responsible for such delays.
- Tools like Last Planner System and Just-In-Time can be very much helpful in tackling such delays. Ordering materials and procuring them well before the initial execution of the activity will ultimately serve in proper and timely completion of processes.
- According to case study I, by using Value Stream Mapping, if one can save 45 days from complete construction schedule and save Rs. 106200 for slab manufacturing. Also, readymade steel brings down construction costs by up to 11%.

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