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# Application of lean Technology in Small Residential Construction

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## ABSTRACT

*Lean Construction (LC) is aimed at reducing waste, increasing productivity and health and safety in fulfilling the client's requirements of the construction industry. This paper provided the fundamental knowledge of LC and highlighted its implementation in the construction industry. It was discovered that the knowledge of stakeholders are reasonably significant as the principles of LC is widely implemented in the work field. However, the stakeholders are indifferent in their understanding on the basic terminologies of LC hence unable to reap its full potential. It was proven that by implementing LC, the construction industry benefits by maximizing value and improved sustainability.*

***Keywords-Lean construction, Sustainable construction, Reducing Waste***

## I.INTRODUCTION

Construction is a very old industry. The problems of construction are well-known. Construction productivity lags than that of manufacturing. Occupational safety is notoriously worse than in other industries. Due to inferior working conditions, there are work force shortages in many countries construction sector. The quality of construction is considered to be insufficient. A number of solutions or visions have been offered to relieve the chronic problems in construction. Solutions are in the form of development of various specialized tools like CPM ,Gantt charts, EVA etc to plan and control projects which have proved to be ineffective for fast paced and change prone construction projects. We hear the term "lean" used very often today, usually associated with lean manufacturing, lean thinking, lean production, and lean construction. There are many arguments and debates on what each of these have in common, or what their differentiators are. The single undeniable similarity is that they all use the word "lean". So, what does "lean" really mean? The word "lean" has many meanings and uses. One meaning is to minimize and eliminate waste, which is a common definition of the word. However, it is not what is eliminated, but added, that is the most defining denominator: value. Another use of the word "lean" is to sway towards an opinion. This definition may be the most applicable for the industry use of "lean", as a common factor in all lean thinking, ideas or principles, is that it requires adopters to "lean" or sway a new direction, and change their mind-set and philosophy. This white paper will explore lean construction and how advances in technology are making implementation of lean construction practices achievable for the industry, with core functionality built into the products as standard out-of-the-box features. By embedding these lean

principles in the software; technology is creating lean tools that will become a major differentiator in shifting the construction paradigm, and delivering maximum value to the industry.

## II. PRESENT STATUS OF LEAN CONSTRUCTION IN INDIA:

Earlier there have been only a few sporadic attempts to implement Lean concepts, and there is a general lack of awareness of Lean concepts in the Indian construction industry. To create awareness and get the Indian construction industry to start implementing Lean concepts, a group of industry leaders initiated the setting up of an organization, Institute for Lean Construction Excellence (ILCE), in 2009 (Raghavan and Satyanarayana 2011). IIT Madras (IITM), a leading educational and research institution in the country, was chosen as the academic partner by ILCE. During the last five years, ILCE has conducted a number of seminars and workshops across the country to familiarize the Indian construction Industry with Lean concepts. International experts such as Dr. Lauri Koskela, Mr. Greg Howell and Dr. Carlos Formoso were invited to conduct seminars.

## III.WHAT IS LEAN?

Lean is producing what customer needs, when he needs and in what quantities he needs while optimizing resources. Lean construction is a translation and adaption of lean manufacturing principles and practices to the end-to-end design and construction process. Lean construction

emphasizes on process improvement rather than concentrating on the final product by increasing Value Adding activities (VA) and reducing Non-Value Adding activities.

Value Adding Activities are activities that convert material and/or towards that which is required by the customer.

Non-Value Adding Activities are the activities that take time, resources or space but do not add value.

In Lean Construction conversion activities are made more efficient where conversion activities are usually value adding but not all and flow activities are non value adding but not always. Lean construction mainly focuses on three aspects which in Japanese are termed as,

Muda (Waste)

Mura (Variations)

Muri (Over burden)

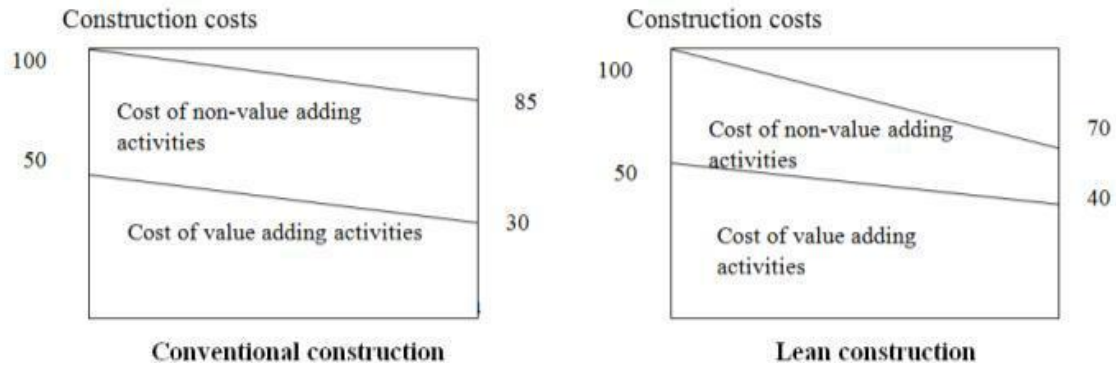


Fig I. Comparison between Conventional construction and Lean construction.

### A. NEED FOR LEAN IN CONSTRUCTION

The construction process is a set of activities, each of which is controlled and improved. Conventional managerial methods, like the sequential method of the project realization or the CPM network method, deteriorate flows by violating the principles of flow design and improvement. They concentrate on conversion activities. The resultant problems in construction to compound and self- perpetuate. In project control, fire-fighting current or looming crises consumes management resources and attention so totally that there is a little room for planning, let alone improvement activities. As a consequence it leads to non-optimal flows and an expansion of Non-Value Adding activities.

## IV. LITRETURE SURVEY

### A. IMPLEMENTING LEAN CONSTRUCTION CONCEPTS IN A RESIDENTIAL PROJECT

Bruno Pontes Mota1, Ricardo Rôla Mota2 and Thaís da C. L. Alves3-A case study

The main goals of this paper are to present a case in which Lean Construction concepts were implemented and to discuss the benefits achieved during the process. The case study was developed during the construction phase of a residential project in the urban area of Fortaleza, Brazil. The project comprised the construction of 18 houses financed by a private investor and it was constructed and managed by a small sized construction company. After lean concepts were implemented the project achieved a more stable flow of work and the number of emergency requests for resources decreased dramatically. Also, the project was completed a month in advance when compared to its original schedule thus allowing the investor to sell the units sooner than expected. Finally, after analyzing the benefits achieved in this pilot project the company's upper management has decided to use Lean concepts in other projects, and the private investor wants to make sure Lean is used in other projects financed by his company. The paper aims at contributing to the literature on Lean Construction on the industry papers section by Presenting a success story experienced by a small-sized construction company.

### B. Implementing LEAN Construction

Concepts in A Residential Project Article · January 2008

The study presented in this paper was carried out in a project that comprised the construction of 18 houses financed by a private investor. The project was constructed north-eastern Brazil. During the study, the project managers implement lean construction concepts, tools, and techniques aiming at organizing the construction company's production planning and control system worked on the design of the suggested by Schramm et al.'s (2004) model for production system design.

The company decided to embark in a lean journey after the crews had almost finished the first of the 18 houses in the complex. The project had started at house number 09, in the front part of to be presented to potential customers 2001) for the management to evaluate actual productivity rates at the site. duration had been estimated in 10 months according to the experience of director. After the first house was finished analyzed, the project managers realized that the entire complex could be months. The original estimates were far off the mark as the duration indicated in the contract had too much slack in it.

*C.* **APPLICATION OF LEAN CONCEPT IN CONSTRUCTION: A CASE STUDY** Ruby Dolas1, *Jay Deotarse2*

Construction is a very old industry. The problems of construction are well-known. Construction productivity lags than that of manufacturing. Occupational safety is notoriously worse than in other industries. Due to inferior working conditions, there are work force shortages in many countries construction sector. The quality of construction is considered to be insufficient. Good existing processes, systems and behaviors should not automatically be discarded when implementing lean. Current strengths and capabilities must be used as foundation stones, rather than discarded. The concepts of lean are consistent with many other widely known improvement approach chased introducing lean should be seen as knitting together, and the next ending, recognized strengths. A lean programmed should be seen as all encompassing, effectively becoming the mortar between the bricks' of other initiatives.It should be seen as enabling the business to deliver customer needs and strategic business objectives, rather than run by a specialist team of people. Alternatively if a strongly defined performance management programmed already exists then achieving successful lean deployment may involve only the addition of a 'brick' or two (e.g. incorporating an appropriate lean tool, such as Value Stream Mapping).Lessons learned from past programmers must be used to avoid similar pitfalls and develop robust plans. The ideas behind lean are now neither new nor unique, but they can often require a major mind-set shift from top to bottom in the business.

## V.PROBLEM STATEMENT

The productivity of the construction industry worldwide has been declining over the past few years. One approach for improving the situation is using lean construction. Lean construction results from the application of a new form of construction management. Current global and Indian construction industry faces the problem of delay in construction works and wastage of recourses and investments during construction works. Wastage of recourses ultimately affecting on overall cost of project. Improper planning and scheduling of construction works and it may indirectly results in project delay and cost overrun.

The construction process is a set of activities, each of which is controlled and improved. Conventional managerial methods, like the sequential method of the project realization or the CPM network method, deteriorate flows by violating the principles of flow design and improvement. They concentrate on conversion activities. The resultant problems in construction to compound and self- perpetuate. In project control, fire-fighting current or looming crises consumes management resources and attention so totally that there is a little room for planning, let alone improvement activities. As a consequence it leads to non-optimal flows and an expansion of Non-Value Adding activities. There is need of adopting this technique to overcome the constructional cost and wastage in construction related various activities.

To develop a tool in how to identify and measure waste, guide in how to prioritize eventual waste reduction activities. It is maintained that processes such as lean construction can arguably reduce costs within the construction process.

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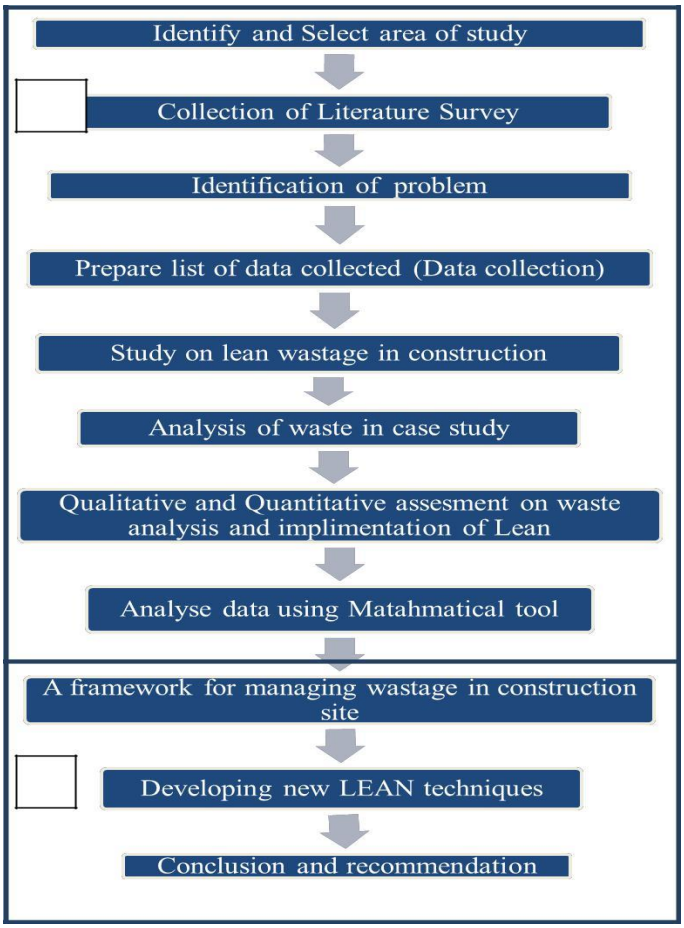
### A. Eliminating Waste

In order to help us see waste within our process, we split it down further into the 7 wastes (remembered with the acronym WORMPIT):

- **Waiting** – for materials or specifications for a job before it can start, waiting for others to finish their part of a job, waiting for sign off before moving on.
- **Over Production** – producing more than is required by the customer; in a construction environment this may be working on items which are not on the critical path instead of items which are
- **Rework** – any job which is not to the right specification or quality and has to be rectified is waste
- **Motion** – the movement around the site of the people themselves is not actually adding any value to the site
- **Processing (over)** – doing too much to a job, producing too high a specification when it is not necessary, for example painting 3 times what only needs to be painted once
- I**nventory** – too much or too little inventory is waste, we need the right amount to enable us to do the job well
- **Transportation** – moving equipment, tools or materials around the site is waste as it does not add value to the construction work.

## VI. PROJECT METHODOLOGY

**1**



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## VII. VARIOUS LEAN TECHNIQUES USED FOR DATA COLLECTION AND PROJECT WORK ARE AS FOLLOWS-

### A. Last Planner System (LPS)

One of the most effective ways to increase efficiency of construction industry is to improve planning and control process. In Lean Construction, planning and control are considered to be complementary and dynamic processes maintained during the course of the project. Planning defines the criteria and creates strategies required to reach project objectives, control makes sure that each event will occur following the planned sequence. Re-planning must be done when the previously established sequences are no longer applicable or convenient. Feedback facilitates learning when the events do not occur as planned [15, 45]. One of the best known Lean techniques is the Last Planner System which has been demonstrated to be a very useful tool for the management of construction process, and continuous monitoring of the planning efficiency, to assist in developing Foresight, smoothing workflow variations, and reducing/removing uncertainties plaguing construction processes. It consists of work flow control and production unit control. Work flow control is accomplished primarily through the look-ahead process, while production unit control is accomplished primarily through weekly work planning. Mossman [46] defined the last planner as a system for collaboratively managing the network of relationship and conversations required for program coordination, production planning and project delivery, by promoting conversations between trade foreman and site management at appropriate levels of detail before issue become critical [46]. Last Planner System aims to shift the focus of control from the workers to the flow of work that links them together. The two main objectives of LPS are to make better assignments to direct workers through continuous learning and corrective action and to cause the work to flow across production units in the best achievable sequence and rate. The last planner integrated components are: master plan, phase planning, look-ahead planning, weekly work planning, Percentage of Promises Completed on time or Percent of Planned Completed ‘‘PPC’’ (A measure key of the Last Planner System success) and reasons for incompleteness, when systematically implemented can bring many advantages and add major benefits to construction management practice in general and planning practice in particular. PPC does not measure productivity or production, only planning

Figure. II. Last Planner System

### B. Pull Planning

A Phase Pull Plan is prepared by a project team in a collaborative fashion to display the activities necessary to complete a phase of work and identify the best sequence to complete those activities. The phase typically is defined by an “end” target or event – pouring slab on grade, ready to erect steel, or (in the case of a design

phase) target cost agreed upon, permit package issued, etc. The team works backwards (pulls) from the end date to the start of the phase to identify the activities necessary to reach the "end" target. The team pays special attention to the "handoffs" – what is necessary to be completed in one activity before the next one can begin. The actual time or duration of a phase is based on the master schedule or the team's best estimate – phases can be measured in hours for shut-down, weeks for a typical construction Activity, or months if the team is developing an overall project plan. In using the Last Planner System or traditional project management, it is important that the team understands and accepts the schedule to which they are committing their efforts. Pull Planning, with its requirement for discussion and collaborative development, allows the participants to have ownership of the schedule as well as providing the most realistic information as to the actual sequence and duration of the activities on the schedule.

**C. Value Stream Mapping**

Value Stream Mapping is a more in-depth technique designed to set out each of the steps from the beginning to the end of a specific process (including how much inventory, rework and waiting there is within a process) and includes:

- teaching the crew(s) working in the area/on the task about the 7 wastes
- asking the Team Leader/Superintendent to Go & See the work site and spend some time (~1-3 days) mapping out each step of the process, engaging with the crew
- using post-it notes to display these steps up on a wall, including data for each step:
    a) number of people doing the work
    b) how long it takes
    c) any rework seen
    d) any inventory seen between steps
    e) any waiting between steps
- inviting the crew in, refreshing them on the 7 wastes, asking them to review and agree with the process, then identifying waste in the process with a different coloured post-it note
- brainstorming countermeasures for each of the wastes (once again some further investigation may be necessary) and adding these to the wall
- ranking the countermeasures by ease of implementation and benefit to the process
- Implementing the easy, high benefit countermeasures first and then working through the others.

Figure 3 shows a Value Stream Map for a process. The yellow post–it notes describe the process and data and the different colored notes are the countermeasure ideas identified by the crew.

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## VIII. STUDY AND DATA COLLECTION FROM VARIOUS CONSTRUCTION SITES

Data collected from various sites like Sanket Construction Pvt.Ltd, Kawshik Reality, Karda Constructions, Digvijay Constructions and Adke Construction. And analyze the whole work of dividing the whole construction work in various activities to control cost overrun and delay in construction work. Data collection should be done during various activates on a construction site aim of study and data collection is to reduce time required for overall activities and reduction of delays from work and to complete work within financial limits way-out wastage of inventory.

A. SANKET BUILD TECH.PVT.LTD (1ST SITE)

B. SANKET BUILD TECH.PVT.LTD(2ND SITE)

C. KAUSHIK REALITY.PVT.LTD(3RD SITE)

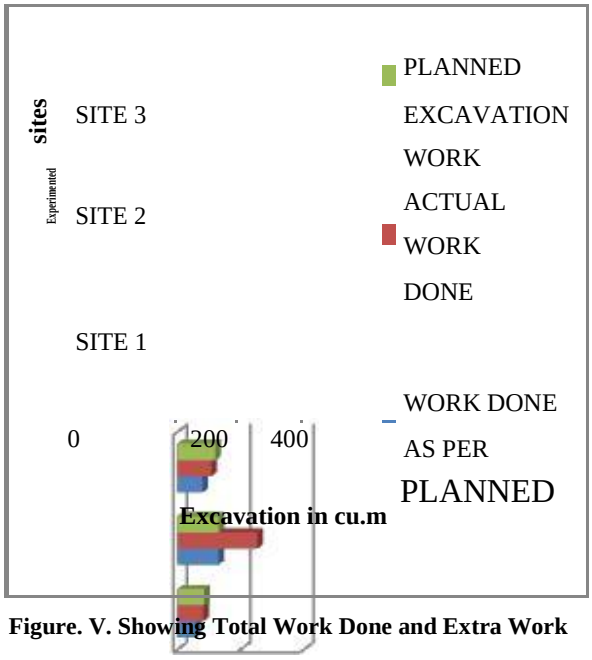
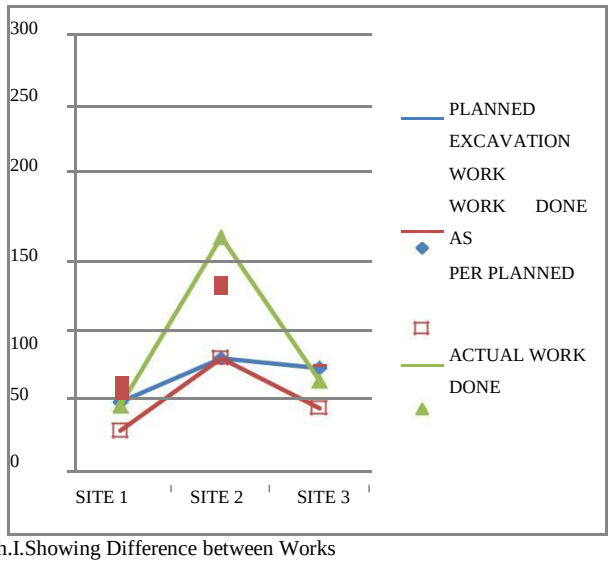



**Figure. V. Showing Total Work Done and Extra Work**




Graph.I.Showing Difference between Works Planned, Done As Per Plan and Accrual Work Done

## IX. INFORMATION CENTRE MEETINGS

Information Centre Meetings are 10 – 15 minute stand up meetings around a whiteboard to review key performance metrics (KPIs) for the team on a daily basis.

Information Centre Meetings are 10 – 15 minute stand up meetings around a whiteboard to review key performance metrics (KPIs) for the team on a daily basis. Information Centre Meetings form the nerve centres of the project, ensuring each person on site is aware of their role, delivering the site KPIs and enabling problem solving around concerns as they arise

### A. What is TAKT time?

Takt time can be defined as the maximum time per unit allowed producing a product in order to meet demand. It is derived from the German word Taktzeit which translates to cycle time. Takt time sets the pace for industrial manufacturing lines. In automobile manufacturing, for example, cars are assembled on a line, and are moved on to the next station after a certain time - the Takt time. Therefore, the time needed to complete work on each station has to be less than the Takt time in order for the product to be completed within the allotted time.

Takt time can be first determined with the formula:

T=Ta/Td

Where,

T = Takt time, e.g. [minutes of work / unit produced]

Ta = Net time available to work, e.g. [minutes of Work / day]

Td = Time demand (customer demand), e.g. [units required / day]

Net available time is the amount of time available for work to be done. This excludes break times and any expected stoppage time (for example scheduled maintenance, team briefings, etc.).

EXAMPLE:

If your customer requires 100 units a day and working time is 7.30 hrs, the Takt Time

= Available time/ customer demand

= 7.30/100

= 7.30 x 60/100

= 4.5.min

Table I showing comparison between actual time taken by JCB and TAKT time for JCB

| Sr. No | Activities | Actual Time Taken by JCB | TAKT Time for JCB |
|---|---|---|---|
| 01. | Excavation (Site 1) | 5.17min/$m^3$(11.00hrs) | 2.83.min/$m^3$(6. hrs) |
| 02. | Excavation (Site 2) | 8.130.min/$m^3$(17.30hrs) | 2.77.min/$m^3$(6. hrs) |

| | | | |
|---|---|---|---|
| 03. | Excavation (Site 3) | ----- | ----- |
| 04. | Excavation (Site 4) | 7.050.min/$m^3$(8.30.hrs) | 4.52.min/$m^3$(5. hrs) |

## B. REDUCING THE WAITING TIME

Waiting time is an important type of construction waste. The causes that are found accountable of waiting time are presented in the following figure. The graphic displays the total frequency of occasions where each factor is identified as responsible for waiting time. Overmaning clearly is the most critical factor which is consistent with other observations. Many construction projects normally have more people than needed, especially unqualified people. In this project study the waiting time in planning is considered. In the conventional planning the various Gangs of labors and equipment have to wait for a long time. This waste in form of waiting time can be completely eliminated by effective planning which is one of the options in this project study. more people than needed, especially unqualified people.In this project study the waiting time in planning is considered. In the conventional planning the various Gangs of labors and equipment have to wait for a long time. This waste in form of waiting time can be completely eliminated by effective planning which is one of the options in this project study.

## C. NEW TECHNOLOGY

There are various new technologies which are increasingly being used on construction projects so as to increase the speed of construction to complete the project in tight schedule leading to high profits. Traditionally we say that even if we reduce the total waiting time still for launching of spans of nearly 40m it takes ten days but as we know today there is a fierce competition in the construction industry, so the contractor has become more conscious about the completion of the project by speedy construction within time bound period. For example HCC is doing a similar project as of the case study project in Badarpur where it has reduced the duration of span launching to four days with the application of LPS i.e. Last Planner System of Lean Construction. Considering the above example of HCC, in this option the span launching duration is considered four days and the planning has been tried out. The Developing and Developed companies have been practicing “SWLA” and “SMLA” and QC Meetings are been carried out in inner circle of companies to carry out the progress of the constructions companies or firms.

## X.RESULTS AND DISCUSSION

Different pie chart and bar charts shows the simple results of the excavation work. All the analytical and mathematical calculations show the extra work done during excavation work and it may leads to wastage of money through cost overrun of project. Data and calculations show that the poor planning and execution techniques in construction leads to delay in construction and wastage of recourses and money. By using lean techniques wastage controlled and also the cost and time controlled / minimized. Lean tools and techniques used in projects help to control and run construction project in a efficient manner by minimizing wastage .Overall

study shows that how lean techniques helps to controlled delays and wastage on construction site and develop lean construction by implementation of lean tools

## XI. CONCLUSION & RECOMMENDATION

The industry struggles with inefficient processes leaving much to be desired in order to meet this challenge the construction industry must become more efficient by using fewer resources. Small changes in the operational costs by reducing waste, which improves the efficiency, can make substantially changes in profit.

Previous researchers have identified the problems of how the construction industry works today and pointed to possible solutions by using the lean philosophy and tools along with solutions that are part of what is known as 'lean construction Data collected and analyzed shows the extra excavation done during excavation because of improper planning .about more than 40% of planned cost is waste on a extra excavation that occurs because of poor planning .by using lean techniques and tools on a construction project that 40% extra cost is being controlled.

As per the methodology which we had adopted in the project work we were able to calculate the loss of The Lean Construction Tool explains how to identify and measure waste through the use of a value stream mapping tool, interviews and observations. To fully understand the reason behind the waste, the tool recommends that is used to study the waste.

Furthermore, the Lean Construction Tool aims to guide in what order waste should be reduced by suggesting the use of a Pareto Analysis which is useful in measuring the waste as well. By performing these just mentioned activities, estimations of economical and environmental consequences can be made. This will give the construction companies the possibility to work out countermeasures for the wastes in the form of an action proposal plan that will later be implemented.

## XII. ACKNOWLEDGMENT

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| ANNEXURE | |
|---|---|
| Abbreviation | Full forms |
| LC | Lean Construction |
| CPM | Critical Path Method |
| VA | Value Adding |
| NVA | Non- Value Adding |
| SWLA | Six Weeks Look Ahead |
| SMLA | Six Months Look Ahead |
| QC | Quality Circle |
| LPS | Last Planner System |
| PP | Pull Planning |
| VSM | Value Stream Mapping |
| EVA | Earned Value Analysis |
| LOB | Line Of Balance |