USE OF LEAN TECHNOLOGY FOR INCREASE OF PRODUCTIVITY IN CONSTRUCTION INDUSTRY

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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. Therefore practical ideas and techniques need to be used in construction that will help projects teams to deal with wastages in construction with the use of optimum resources and this can be achieved by using lean construction principles and techniques. So this paper 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. In India, the implementation of lean management in construction industry is a major task. Due to lack of attention and illiterate towards the lean management principle the owner, contractor, engineers etc. are still developing stage to implement this principle in their project. This project mainly focuses on to identify the possibilities of implementation of lean management in construction industry. It will be achieved by preparing the questionnaire and also conducting the interview with the project personals like top management, engineers and site supervisors etc. The questionnaires were evaluated to adopt the techniques through statistical methods. This paper presents the possibilities of effective utilization of lean management principle in construction industry, which can surely increase the quality of work and profit rate by eliminating the wastage of materials.

KEYWORDS: lean, construction, management, and implementation, Lean Management, Lean Manufacturing, Lean Leadership
I. INTRODUCTION

Lean construction has been introduced as a new management approach to improve the productivity in construction industry. Lot of researches is going on towards the lean concepts and principles to get results of the successful adaption of lean ideas from car manufacturing industry to the construction industry. The construction companies struggling to transform their current forms of project management into the lean management approach. 

In India, the construction industry is second largest industry after agriculture. It is diversified and involved in all spheres of construction like as following: Roads, Railways, Urban infrastructure, Ports, Airport.

Projects have been considered as temporary based production systems which need to be designed, planned, produced and delivered within a specified time. Fast track projects with long, complicated supply chains involving many players and subject to multiple, extensive process design changes have complex flow management that has failed miserably. As a result, the industry is characterized by delays and often has suffered cost and time overruns. In general, a very high level of wastes/non-value added activities is confirmed to exist in the construction industry. Several studies from various countries have confirmed that, wastes in construction industry represent a relatively large percentage of production cost. The existences of significant number of wastes in the construction have depleted overall performance and productivity of the industry, and certain serious measures have to be taken to rectify the current situation. It has been contended by the Lean Construction Institute that about 57% of productive time waste can be found in the construction industry.

The conventional project management approaches have inadequacies in resolving the problems in the industry. In the United States, meticulous studies have been carried out by CII (Construction Industry Institute), which estimate that between 25% and 50% of the cost of construction corresponds to waste due to the inefficiency of the traditional management system. According to (LCI) Lean Construction Institute, The construction industry is characterized by a ratio production/waste higher than that of the manufacturing industry. Nevertheless, lean manufacturing principles and techniques provide the foundations for minimization or total elimination of the waste faced by the industry. Lean construction has change the traditional view of labor flow and work flow reliability and gives the value added construction.

Present scenario of construction:

Infrastructure is the second largest sector after agriculture in India and is the integral part of country’s development. It includes hospitals, townships, schools, offices, houses and other buildings and urban infrastructure. Construction is the basic input for socio economic development. In the past years many researchers stated there are number of waste can occur at any stage of the construction project. Since construction has directly or indirectly impact on many other industries so reducing the waste in the construction industry and saves the great cost of employer. Waste can be classified as natural waste which is unavoidable and avoidable waste. And the main root cause of waste comes from construction processes such as Planning, Design, Material procurement, Material handling, Material supply and Material manufacturing as well as construction stages, lack of work knowledge in labours, casual approach towards work, improper concrete mix design, faulty shuttering. Accidents due to negligence, choice of wrong construction process, cement/ mortar, timber, blocks, steel as the major material wasted on construction projects.
It has become crucial to seek innovative and creative solutions/alternatives that ensure better and more optimized management techniques that could minimize the sources of wastes and increase the performance of the construction process. The construction industry facing various problems as a result of the uncertainties of the global economic climate, environmental hazards, including labor delayed projects and zero margin contract bids, greenhouse gas emissions etc. So there is need for waste minimization and enhancement of productivity in construction activity. Productivity is critical determinant of cost efficiency. The conventional system of construction is not sustainable. In one of the research it is estimated that current system of construction had around 50% of non-value added efforts or waste. Most of The present construction practices run with traditional work flow methods and uses conceptual models of construction management because there are some barriers to adopt lean management in present construction practices those are mentioned further.

WHAT IS LEAN

In all industries have used Lean principles to streamline their workflows, reduce costs, and improve quality—most notably in software development, where Lean concepts (presented as Agile or Scrum) have significantly accelerated the pace of innovation. Software development teams have used Lean to improve workflow reliability — which is also a critical part of Lean construction, as we’ll demonstrate in this article later.

While The Cost Of Steel And Cement Are Making Headlines, The Less Publicized Failures In The Management Of Construction Projects Can Be Disastrous. We Are Not Talking About Just Materials, Methods, Equipment, Or Contract Documents. We Are Talking About How We Work To Deliver Successful Capital Projects And How We Manage The Costs Of Inefficiency.” Everyone involved in the construction process has incentive to get projects done faster and at a lower cost. And yet, 70% of construction projects today are completed late and over budget. Construction labor efficiency has decreased in past decades, while all other non-farming labor efficiency has doubled or more since the 1960s. Safety standards are also lagging behind, with the industry averaging 800 or more work-related deaths per year.

The lack of improvement in the industry can be contributed to a number of factors, including industry fragmentation, lack of trust between key participants, the traditional contracting environment, craft-oriented culture, increased regulations, safety issues, and lack of process innovation. Forward-thinking organizations are turning to Lean principles to improve efficiency, reduce costs, and boost morale. Applying Lean principles to construction is enabling:

- Improved safety
- Greater customer satisfaction
- Higher quality construction
- Reduced project schedule
- Greater productivity
- Greater profitability/reduced costs
- Better risk management

Research by the Lean Construction Institute (LCI) has found empirical evidence to support the idea that projects with high Lean intensity are three times more likely to be completed ahead of
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schedule, and two times more likely to be completed under budget. In this article, we’ll discuss the basics of Lean construction, and how it can help alleviate the major pain points of the industry.

What Is Lean Construction?
The Lean Construction Institute defines Lean Construction as, “A collaboration-based system that is founded on commitments and accountability. It requires a significant shift in the trust that each stakeholder places on another. The adversarial relationship that has existed in the industry between contractors and design teams over many centuries is challenged, with all stakeholders having to align with goals and objectives. In projects where Lean construction management principles are applied, teams integrate through collaborative tools and search for ways to eliminate waste. Teams seek to continuously improve through reflection. Lean processes are designed to remove variation and create a continuous workflow to drive significant improvement in predictability and strongly encourages respect for all people involved.”

As expected, as Lean management becomes more widely adopted in the construction industry, some of the benefits that the manufacturing industry experienced are now making their way into how construction teams operate and projects are executed.

HOW DOES LEAN APPLY TO CONSTRUCTION?
Researchers and Lean construction pioneers Ballard and Howell found in an analysis of project plan failures that, “normally only about 50% of the tasks on weekly work plans are completed by the end of the plan week,” and that the industry could mitigate most of its problems through “active management of variability, starting with the structuring of the project (temporary production system) and continuing through its operation and improvement.”

Much like automotive manufacturing in the early-mid twentieth century and software development in the 1990s, the construction industry is ripe for a radical, sustainable change. However, the construction industry faces unique challenges that make the implementation of Lean different from manufacturing and other industries: Construction projects are generally unique and complex, completed in highly uncertain environments, under significant time and schedule pressure. Forward-thinking organizations are looking to adopt Lean principles to improve the ways people, processes, and practices work together to complete construction projects.

The goals and priorities for all construction projects are generally the same: To improve workflow reliability (to keep progress moving); reduce inventory of material and tools; and reduce costs by staying on schedule. Variability will always be a part of construction; inclement weather, inventory issues, unreliable suppliers, inaccurate plans, and changing requirements can all impact the progress of a project.

So the goal of Lean construction isn’t to completely eliminate variability, because this is not a realistic or attainable goal. But in every project, there is an abundance of opportunity for mitigating the disruption caused by variables both internal and external to the project. Lean construction helps crews recognize opportunities for improvement and act upon them in a way that is measurable, valuable, and constructive.

Lean construction should be viewed as a supplement to traditional management methods, adding the following additional perspectives:

Two critical and necessary dimensions for successful capital project delivery by requiring the deliberate consideration of material and information flow and value generation in a production system; and

Different project and production management like planning-execution-control paradigms
In other words – Lean construction helps everyone involved understand how materials, information, and people can be used more efficiently to deliver higher quality results, on time and on budget.

1.1 BACKGROUND

Lean manufacturing was originally pioneered and developed at the Toyota Motors Corporation manufacturing plants in Japan, based on the ideas of the employed Engineer. The lean concept JIT, should contribute to the increase of production volume and the productivity in a mixed small-series-production (lots of many product varieties). Lean and JIT was therefore a response to the production demands arising in Japan after the Second World War, where the production machinery should convert to the production of cars and trucks among others, instead of weapons.

Application of Lean thinking, principles and tools to the lifecycle of capital construction projects is known as ‘Lean Construction’. The term ‘Lean Construction’ is intended to cover the application of Lean thinking, principles and tools to the entire process of a project from the concept through decommissioning. However, the initial reaction to the term within the industry caused opposition and exclusion. Lean Construction was misinterpreted as applying only to the ‘construction’ phase of a project. Therefore, constituencies like owners and architects did not think that the methodology also applied to them – this is changing.

Lean construction is a management philosophy spun off from the principles of lean manufacturing. Lean is a philosophy that focuses on value instead of cost, and seeks to optimize productivity by removing all non-value adding processes. Specified the following concepts, which became the five governing principles of lean:

- Precisely specify value from the ultimate costumer’s perspective
- Identify the value delivery process (Value stream) – Eliminate non-value adding steps
- Make the value adding steps flow without interruption
- Establish a pull from the costumer. Do not produce until it is needed.
- Pursue perfection

These principles all concerns the problem of waste. Activities or processes that take up resources without creating value, which should be eliminated in order to deliver things right at the right time - For the good of the producer and the costumer; the different types of waste that can occur in a production.

- Defects in products
- Overproduction of items no one wants;
- Inventory waiting to be processed;
- Unneeded processing;
- Unnecessary transport of goods;
- People waiting for input to work on;
- Design of goods and services that do not satisfy customer needs.

In order to achieve an optimal production without waste, the following concepts and ideas have been developed as management tools.
Lean Construction was introduced in 1993 in USA by the International Group of Lean Construction (IGLC). The IGLC objective is to meet the customer demands better, dramatically improve the Architectural, Engineering and Construction (AEC) process as well as the product (IGLC, 2010). Lean Construction is a relatively new Construction Management philosophy in developing countries like India.

Lean Construction has evolved from Lean manufacturing principles. Lean Construction along with its various tools like the Last Planner System, Just in Time, Total Quality Management and Continuous Improvement has received a lot of attention in developing nations. Large-scale construction projects suffer from cost and time overruns that are typically a symptom of productivity problems and directly affect overall industry profitability. As a result, methodologies have been developed to reduce the risk of overruns and improve project outcomes.

A number of these methods are based on Lean production principles that focus on identifying value, eliminating ‘Waste’ and creating a smooth flow of materials, information and work. The manufacturing industry is indeed different than the Construction Industry as the construction projects are unique and do not include mass production as in the case of the manufacturing industry. Hence, it is difficult to analyze any construction project from only historical data collected. The laborers working in construction projects are not trained as the professionals and projects are carried out in outdoors where climatic conditions need to be considered. Though that is the case, Lean principles can be modified and implemented in the Construction Industry.

The practical value of Lean Construction has been demonstrated in many case studies. For instance, evaluated the effectiveness of Lean Construction techniques, including the last planner, increased visualization, daily huddle meetings, and first-run studies and their case study showed that these techniques achieved successful outcomes; when projects are managed with Lean Construction,

- The facility and its delivery process are designed together to better reveal and support customer requirements. Positive iterations within the process are supported and negative iterations are reduced.
- Work is structured throughout the process to maximize value and to reduce ‘Waste’ at the project delivery level.
- Efforts are made to improve total project performance.
- Control’ is redefined from ‘monitoring results’ to ‘making things happen’. Performance of planning and control systems is measured and improved.
- Coordination is improved since the release of work from one specialist in design, supply and assembly to the next is more reliable

1.2 Related Work

- **Using A Lean Health Check To Assess Performance**

- **Lean Training.** Contractors that have not yet put their lean knowledge into action can benefit from a multiday training program. In addition to helping participants understand theoretical principles, an effective program will include simulations that allow attendees to actively experience how using a lean approach can improve the performance of projects.

- **Lean Project.** Contractors can apply the six lean levers discussed earlier to a specific project in order to achieve gains in productivity and profitability. Contractors can launch
this effort when planning a project or to support the turnaround of a project that has encountered issues during construction.

**Lean Team** Contractors with lean experience that are highly motivated to capture the full lean advantage are ready to establish a lean team to move the effort forward, ideally in combination with launching a lean project. Establishing a permanent lean team is essential for all contractors that seek to anchor lean thinking in their operations sustainably over the long term.

**STEPS OF LEAN MANUFACTURING IMPLEMENTATION**

1. **Identification of wastes in the system:** Many organizations need to know that they have many hidden and unhidden wastes in their systems.

2. **Wastes present in the organization can be of different types:**
   There is a need to recognize the types of waste and their causes. Lean manufacturing believes in treating the causes and curing the problems permanently. There are various tools and techniques that are quite helpful in reducing or eliminating these types of waste.

3. **The next step is to find the solution for the root causes:**
   One must stick to basic lean concepts and identify the root causes. Looking at causes might not help properly, so there is a need to identify the effects of the solution on the entire system.

4. **The final step in the lean implementation process is to find the solutions and test the solutions first:**
   Once solutions are tested then they should be implemented. Training and following up are important in each and every step explained above. One needs to be patient because the implementation process might take a long time.

**1.3 PROBLEM DEFINITION**

This study attempted to determine how profit and efficiency of construction projects could be increased using Lean Construction Management principles. This study also explored and evaluated differences between construction in India, by analyzing the methods of minimum wastage and by Lean thinking implemented in the construction projects.

**1.4 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.

**1.5 AIMS AND OBJECTIVES**

- The research seeks to confirm following objectives, which are:
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- To examine the general perceptions of the construction industry with the lean construction principles and practices.
- To identify the source of wastes (classified under lean construction) for specifically chosen activities at a construction site and relate them to the waste identified in construction industry.
- To increase project productivity improvements by reducing and eliminating the wastes as classified under lean construction.
- To give Recommendations for the control of the waste by reducing the non-value adding activities in the construction projects.
- To verify and re-evaluated the status of existing productivity and performances on construction activities and processes for local construction industries.
- To identify the problems in processing of heavy equipment on site and find out the best solution for the efficient work by reducing the cycle time for more output.
- Proper relationship study of equipment can be made as per activity like excavation, Concerting etc. and utility should be determined, for e.g. Bucket utility can be increased if every bucket is allotted with 2 tippers.
- Study of Materials and components to meet the best needs of supply chain discipline to increase the efficiency of work.
- To find out the critical situations on site and how to overcome them immediately to increase the productivity in construction.
- Identify Labour productivity in the construction industry. Analyze and calculate the SPSS of those factors affecting lean manufacturing using Lean Technology.
- To statistically analyze the factors affecting labour productivity. To make recommendations to improve labour productivity in construction.
- To find out the Disputes in construction industry.

II. LITERATURE REVIEW

Applying lean thinking in construction and performance improvement
Author: Remon Fayek Aziz, Sherif Mohamed Hafez in (2013)

Abstract: The productivity of the construction industry worldwide has been declining over the past 40 years. One approach for improving the situation is using lean construction. Lean construction results from the application of a new form of production management to construction. Essential features of lean construction include a clear set of objectives for the delivery process, aimed at maximizing performance for the customer at the project level, concurrent design, construction, and the application of project control throughout the life cycle of the project from design to delivery. An increasing number of construction academics and professionals have been storming the ramparts of conventional construction management in an effort to deliver better value to owners while making real profits. As a result, lean-based tools have emerged and have been successfully applied to simple and complex construction projects. In general, lean construction projects are easier to manage, safer, completed sooner, and cost less and are of better quality. Significant research remains to complete the translation to construction of lean thinking in Egypt. This research will discuss principles, methods, and implementation phases of lean construction showing the waste in construction and how it could be minimized. The Last Planner System technique, which is an important application of the lean construction concepts and methodologies and is more...
Implementing Lean Construction: Stabilizing Work Flow
Author: G. Ballard, Greg Howell
Abstract: Lean construction has at least two foci that distinguish it from traditional construction management. One focus is on waste and the reduction of waste. Breaking from the conversion process model, and reconceiving production processes in terms of Koskela’s flow process model reveals the time and money wasted when materials and information are defective or idle. Instead of simply improving the efficiency of conversion processes, the task is extended to the management of flows between conversions. Consequently, in addition to its focus on waste, lean construction also focuses on managing flows, and to do so, puts management systems and processes into the spotlight along with production processes. Flow management is a much more difficult task on complex, fast track projects such as refineries, chemical plants, food processing plants, paper mills, etc. These projects have long, complicated supply chains, many players, typically are under pressure to hit market windows for product, and are subject to multiple, extensive process design changes motivated by the opportunity to make much more money than is lost through disruption of construction. In this environment, traditional approaches to construction management fail miserably. The conversion process model conceals everything that needs to be revealed; particularly the design of systems and processes to manage work and work flow.

Requirements for building information modelling based lean production management systems for construction
Author: Rafael Sacks, Milan Radosavljević, Ronen Barak
Abstract: Smooth flow of production in construction is hampered by disparity between individual trade teams’ goals and the goals of stable production flow for the project as a whole. This is exacerbated by the difficulty of visualizing the flow of work in a construction project. While the addresses some of the issues in Building information modeling provides a powerful platform for visualizing work flow in control systems that also enable pull flow and deeper collaboration between teams on and off site. The requirements for implementation of a BIM-enabled pull flow construction management software system based on the Last Planner System™, called ‘KanBIM’, have been specified, and a set of functional mock-ups of the proposed system has been implemented and evaluated in a series of three focus group workshops. The requirements cover the areas of maintenance of work flow stability, enabling negotiation and commitment between teams, lean production planning with sophisticated pull flow control, and effective communication and visualization of flow. The evaluation results show that the system holds the potential to improve work flow and reduce waste by providing both process and product visualization at the work face.

Lean Construction: An effective approach for project management
Author: Richard Hannis Ansah, ShahryarSorooshian, Mustafa Shariman (2015)
Abstract: Projects have been considered as temporary based production systems which need to be designed, produced and delivered within a specified time. It has been asserted by a number of researchers that fast, complex and uncertain projects cannot be managed through the conventional
ways and that fast track projects with long, complicated supply chains involving many players and subject to multiple, extensive process design changes have complex flow management that have failed miserably. The conceptual models of construction management and the tools it utilizes (work breakdown structure, critical path method, and earned value management) have been criticized to be deficient in handling the present unique challenges of projects. As a result, the industry is characterized by a number of wastes including: overproduction, lead time, transportation, inappropriate processing, inventories, unnecessary movements, rework and making do wastes. There is therefore the need for practical and robust models and techniques that will help projects teams deal with the issues of wastes in projects. This can only be achieved through the adoption of lean production systems in the construction industry, thus, Lean Construction (LC). In this paper, LC approach and the importance for its implementation has been discussed as the robust approach for project management.

Lean Construction Techniques in Indian Construction Industry: Some Analysis
Author: Vinaya D. More, Dr. Shrikant Charhate and Madhulika Sinha,
Abstract: Lean construction is an effective management tool to enhance the productivity in construction field. Large research is being done in recent past and is an ongoing process to adopt lean principles from manufacturing industry to the construction industry. In order to improve the efficiency, reduction of waste, the lean construction has been introduced as new management tool. There are many challenges in implementing the lean concept in construction industry in India. Due to lack of attention and illiteracy towards the lean management principle, stakeholders associated to this like builder, contractor, and engineering and project management firms etc. are still in process of adopting this principle for construction project. In this paper efforts are made to find out main barriers towards the implementation of lean techniques in Indian construction industry with the help of questionnaire survey and actual site implementations are made to develop a process map for ongoing projects. Results of the survey showed that some of the lean techniques should be given more focus to enhance the process. The framework results show that the NVA (Non Value Added) and ENVA (Essential Non Value Added) activities have the highest impact on the project duration. Therefore with implementation of the proposed lean techniques, the NVA and ENVA activities have found to be improved and their durations can be reduced considerably.

Lean Manufacturing: 3 Critical principles for improving productivity
Author: Christine Wheeler, May 2014
Abstract: The "go green" movement may have seemed like a passing fad many years ago when it first entered mainstream consciousness. To some, it resembled something that brought to mind the free-spirited and anti-establishment countercultures of the late 1960s more than it did a modern step toward environmentally responsible living. Despite scepticism, sustainable living has become an integral part of our daily lives. Principles and standards that guide eco-friendly ways of living and doing business are often referred to as "lean" principles, and the term is used most frequently in the manufacturing industry. Essentially, operating under lean concepts means you're trimming the fat, so to speak, and reducing the amount of by-products and waste generated by your company during the production process. Originally introduced by Japanese automaker Toyota Production Systems, lean manufacturing focuses on eliminating everything that goes into creating your product, from employee labor to raw materials that does not add value in some way for your customers. Lean manufacturing can include a variety of principles that focus on the reduction or elimination of all parts of the production process that do not create a more valuable product, and here are some of
those principles that, when applied, can help your company develop less wasteful ways of doing business.

Name: Productivity Improvement by Implementing Lean Production Approach.
Author: Mahmood, K., ShevtShenko, E.
Abstract: This paper aims to provide a better understanding of lean production approach in order to enhance productivity, reduce cost and maximize customer value while minimizing waste during the production processes. Lean tools enabling a company to differentiate value from waste and facilitate to maximize customer value while minimize waste. Although there are many key factors for this methodology but here authors would be focusing on the Value Stream Mapping (VSM), Pull system and Dedicated Flow that are contribute to change the process by eliminating different kind of wastes (such as inventory) which slows down the process. A case from metal manufacturing company will be taken into account that focus on lowering down the inventory (waste) levels with the help of lean tools.

General overview of Lean Management in Construction Industry
Author: Tejas Vidhate, Asst. prof Ashwini salunkhe
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. Therefore practical ideas and techniques need to be used in construction that will help projects teams to deal with wastages in construction with the use of optimum resources and this can be achieved by using lean construction principles and techniques So this paper 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.

Can Lean Manufacturing Principles improve Construction?
Author: Andy Haltmann
Abstract: If construction jobsites have one thing in common, it’s that they’re all different. This variation in project size, scope, type, materials, timelines, etc.; makes a philosophy like lean manufacturing seem unsuited to the construction industry. Lean, an approach to manufacturing first developed by Toyota, focuses on streamlining and standardizing processes by reducing waste, improving flow and designing what you do based on what’s valuable to end customers. It aims to continually improve all facets of operations, including productivity, an area that has become a key performance indicator for contractors.

That sounds great, right? But what about that inevitable variation; Manufacturing is a controlled environment where companies can easily minimize variation. How can you standardize your processes when jobsites are all different and conditions constantly change?
It is possible to use lean in construction. Doing so just requires focus, good communication and some adjustments. The significant benefits are worth the extra attention. According to the Lean
Construction Institute, using lean in construction can result in improved productivity, increased safety on jobsites and significant cost savings. When your business uses lean principles, you can have better operations and a better end product.

Site Implementation and Assessment of Lean Construction Techniques
Authors: O. Salem, J. Solomon, A. Genaidy, and M. Luegring
Abstract: The goal of this paper is to test the effectiveness of some lean construction tools, in particular, those tools that can be applied in medium size construction firms. Due to the success of the lean production system in manufacturing, the construction industry has adapted lean techniques to eliminate waste and increase profit. A field study was conducted to evaluate the effectiveness of some lean construction techniques including last planner, increased visualization, daily huddle meetings, first run studies, the 5s process, and fail safe for quality. The data collection methods included direct observations, interviews, questionnaires, and documentary analysis. The effectiveness of the lean construction tools was evaluated through the lean implementation measurement standard and performance criteria. It was found that last planner, increased visualization, daily huddle meetings, and first run studies achieved more effective outcomes than expected. However, the results of implementation of 5s process and fail safe for quality did not meet the expectations of the tool champions and the research team. It was found that there is need for behavioral changes and training for effective use of lean tools. Most of the lean construction tools selected for the project are either ready to use, or are recommended with some modifications. A summary of the results is provided, and future research needs are outlined.

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Abstract: The lean methodology is a modern approach to managing construction in a way that delivers successful projects in the most time-efficient and cost-effective manner. The lean approach emphasises on maximising customer value while minimising waste through the implementation of predefined holistic practices and so, it makes perfect sense in the construction industry where timeframe, cost and safety are crucial.

The lean principles were originally developed by the Japanese auto manufacturer Toyota to achieve a sustainable competitive advantage and this changed the industry’s best practices forever. Later the lean principles were adopted by various manufacturing organizations to improve productivity, increase safety and enhance quality. The lean management approach has evolved considerably over the last few decades and today it is being widely practiced in different forms that include Six Sigma, Total Quality Management, Kaizen and Just-in-time

III. METHODOLOGY
In this investigation with reference to various papers, it is conclude that for any medium to large scale construction site applying lean technology or the principles of the lean techniques we will increase the productivity of the construction in following manner.

- To find out the variables non value added activity for different types of work/component and wastes in terms of material, time and efforts generated in construction activities are mainly due to its large fieldwork component by observation from project site visits.

- To prepare waste identification matrix is meant for identification of waste in various operations involved in execution of an activity.

- To collect all the data regarding the particular activity and component and analyze

- Apply the lean technology and the principles of lean technology to minimize the non-value added activity or wastage and increase the productivity of the construction industry.

- To verify and re-evaluated the status of existing productivity and performances on construction activities and processes for construction industries.
The cost of design is made up of costs of value-adding activities and waste. The waste in the design process is formed by.
Rework (due to design errors detected during design)

- Non value-adding activities in information and work flows
- Proper relation flow is made for heavy equipment and for critical situation.
- Minimize physical and process waste.

IV. LEAN PRINCIPLE

- 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. 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 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.

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 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.

❖ 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 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 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.

❖ 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 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 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

❖ Just-in-Time Resource Pull

In a lean operation, resources and materials are pulled into the process just in time to satisfy project requirements. The just-in-time approach allows contractors to eliminate waiting times, avoid storing materials, and reduce costs for stock. This approach also promotes flexibility by allowing contractors to accommodate their clients’ last-minute decisions. To avoid delays and higher costs, however, this approach must be carefully managed on the basis of lead times for each resource and
the various materials. In supporting project management for the construction of a cruise ship, BCG worked with the shipbuilding company to demarcate “frozen zones” periods during which the ship owner could not change the type or specifications of materials to be ordered. The ship owner was required to communicate the specifications for the various materials to the shipbuilding company before the frozen zones, so that it could place orders with sufficient lead time to adhere to the agreed-upon schedule and budget.

Zero Defects

Through continuous improvements fostered by control and feedback mechanisms, contractors can strive to come as close as possible to achieving the goal of zero defects and thereby standardize and stabilize processes. Short-cycle processes can be deployed throughout the project value chain to significantly reduce the number of defects. Such processes allow project managers to detect mistakes quickly, so that they can remediate the errors and prevent them from recurrings in subsequent work at the site. Catching defects early is especially important with regard to repeated elements and processes, which may recur dozens or even hundreds of times in any given project.

V. DATA ANALYSIS

<table>
<thead>
<tr>
<th>Lean Technique</th>
<th>Lean Technique description</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last planner System</td>
<td>Supports the timely realization of plans by reducing delays, getting the work done in the</td>
<td>Manpower flow</td>
</tr>
<tr>
<td></td>
<td>best constructability sequence, matching manpower to available work, coordinating multiple interdependent activities,</td>
<td>Equipment and tools flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workflow</td>
</tr>
<tr>
<td>Providing operational Flexibility and Responsiveness</td>
<td>Allows reactions to problems that induce variable conditions by providing sufficient resources when necessary</td>
<td>Manpower flow, material flow</td>
</tr>
<tr>
<td>Providing visual control and inspections</td>
<td>Refers to equipment and structure inspection by workers using raw human senses and any non-specialized inspection equipment to immediately recognize deviations from standards</td>
<td>Workflow</td>
</tr>
<tr>
<td>Installing fail-safe (Poka-yoke) devices</td>
<td>Refers to automatic warning, identification and prevention of defects going to the next process</td>
<td>Workflow</td>
</tr>
<tr>
<td>Preventative maintenance</td>
<td>Intended to keep all equipment in excellent working condition through proactive and preventative maintenance</td>
<td>Equipment &amp; Tool flow</td>
</tr>
<tr>
<td>Batching</td>
<td>Refers to creating package sets needed to accomplish tasks and reduce work-in-process inventories</td>
<td>Manpower flow, material flow, Equipment &amp; Tool flow, Information flow</td>
</tr>
<tr>
<td>Concept</td>
<td>Description</td>
<td>Flow Areas</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Involving “takt time” planning</td>
<td>Aimed at making task duration consistent for every trade</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Restructuring work</td>
<td>Refers to any work that should be performed ahead of its scheduled time</td>
<td>Workflow</td>
</tr>
<tr>
<td>Changing activities from sequential order to parallel order</td>
<td>The number of work teams that can work in parallel rather than in series</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Multiskilling</td>
<td>Performing large packages of continuous work</td>
<td>Manpower, work flow, equipment &amp; tool flow</td>
</tr>
<tr>
<td>Optimizing components/structures and integrating more functionality into them</td>
<td>Reducing the part count of products through design changes or prefabricated parts</td>
<td>Workflow</td>
</tr>
<tr>
<td>Standardizing activities</td>
<td>Related to efficiently organizing the sequence of job tasks that are repeatedly followed by a team member</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Value Stream Mapping (VSM)</td>
<td>Decreasing activities that takes time, resources or space but does not add value</td>
<td>Workflow</td>
</tr>
<tr>
<td>Pull System</td>
<td>Refers to the signals that make a process transparent and allow timely production in the required quantity</td>
<td>Work flow, Manpower flow</td>
</tr>
<tr>
<td>Reducing interdependence of production unit</td>
<td>Allows correct timing and spacing between crews</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Increasing visualization</td>
<td>Refers to signs and labels around the construction site reminding workers about various issues</td>
<td>Manpower</td>
</tr>
<tr>
<td>Making the process directly observable</td>
<td>Related to providing an observable machine layout and materials that allow an understanding of possible problems</td>
<td>Material flow, Equipment &amp; Tool flow</td>
</tr>
<tr>
<td>Using visual devices</td>
<td>Related to a management tool that emphasizes the visual status of operations (e.g., amount of machine operating), a quality or process problem via a signal alerting about abnormalities</td>
<td>Equipment &amp; Tool flow</td>
</tr>
<tr>
<td>Incorporating information into the process</td>
<td>Related to inserting helpful workplace worker information</td>
<td>Manpower Flow &amp; Information flow</td>
</tr>
<tr>
<td>Involving Five S’s</td>
<td>Refers to organizing an efficient, effective work space by identifying and storing items used, maintaining the area and sustaining the new order</td>
<td>Material flow, Equipment &amp; Tool flow</td>
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<tr>
<td>-------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Rendering invisible attributes visible through measurements</td>
<td>Reveals critical situations before they become problems</td>
<td>Workflow</td>
</tr>
<tr>
<td>Concurrent Engineering</td>
<td>Aimed at integrating all construction teams (e.g., general and specialty contractors, architects and design engineers) and integrating the construction and design stages</td>
<td>Information flow</td>
</tr>
<tr>
<td>Synchronizing and aligning</td>
<td>Aimed at synchronizing delivery rate and sequence with installation rate and sequence</td>
<td>Material flow</td>
</tr>
<tr>
<td>Supplier-managed inventories</td>
<td>Applies when suppliers have access to inventory data and are responsible for maintaining inventory levels</td>
<td>Material flow</td>
</tr>
<tr>
<td>Establishing interpersonal communication</td>
<td>Aimed at using verbal and nonverbal exchange of information</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Showing respect</td>
<td>Intended as a means of showing appreciation for good worker ideas or qualities</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Deploying policy</td>
<td>Aimed at encouraging employees and giving them a common go</td>
<td>Manpower flow</td>
</tr>
<tr>
<td>Involving creative thinking</td>
<td>Refers to reviewing problems or unorthodox solutions from a fresh perspective</td>
<td>Workflow</td>
</tr>
<tr>
<td>Developing problem-solving skills</td>
<td>Refers to a way of considering a problem in detail in order to prevent its recurrence</td>
<td>Workflow</td>
</tr>
</tbody>
</table>
First Run Studies/ “Plan-Do-Check-Adjust”
Aimed at reviewing work methods by redesigning and streamlining the different functions involved
Manpower flow, Workflow

Brainstorming
Aimed at generating creative ideas and solutions through intensive group discussion
Workflow

Reengineering
Refers to the radical reconfiguration of processes and tasks to achieve dramatic improvements in performance measures such as cost, quality, service, and speed
Workflow

Designing key performance indicators
Designed to eliminate inefficiency and maximize cost effectiveness and productivity
Workflow

DEFINITION OF WASTE

According to Koskela, waste can be defined as “any inefficiency that results in the use of equipment, materials, labour or capital in larger quantities than those considered as necessary in the construction of a building”. Waste can be classified as unavoidable waste (or natural waste), in which the investment necessary for its reduction is higher than the economy produced, and avoidable waste, in which the cost of waste is higher than the cost to prevent it. The percentage of unavoidable waste depends on the technological development level of the company. Waste can also be categorized according to its source; namely the stage in which the root causes of waste occurs. Waste may result from the processes preceding construction, such as materials manufacturing, design, materials supply, and planning, as well as the construction stage.

- Design
- Procurement
- Materials Handling
- Operation
- Residual

DIRECT WASTE

According to waste that can be prevented and which involves the actual loss or removal and replacement of material is called direct waste. Most of the times, the cost of direct waste do not end up in the cost of material, but followed with the cost of removing and disposing. Thus, by preventing direct waste straightforward financial benefits can be obtained. Direct waste can occur at any stage of the construction process before the delivery of material to the site and after incorporating the materials at the building.
## Categories

<table>
<thead>
<tr>
<th>Categories</th>
<th>Reason</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery Waste</td>
<td>During the transportation of material to the site, unloading and placing in addition to the initial storage</td>
<td>Bricks, Blocks, Glass, Bulk Material</td>
</tr>
<tr>
<td>Cutting and Conventional waste</td>
<td>Cutting material into various size and uneconomical shapes</td>
<td>Formwork, tiles and reinforcement</td>
</tr>
<tr>
<td>Application and residue waste</td>
<td>Hardening of the excess material</td>
<td>Paint, mortar and plaster</td>
</tr>
<tr>
<td>Waste caused by</td>
<td>Damage occurred by</td>
<td>Painted surfaces</td>
</tr>
<tr>
<td>other trades</td>
<td>succeeding trade</td>
<td></td>
</tr>
<tr>
<td>Criminal waste</td>
<td>Theft and vandalism</td>
<td>Tiles, cement bags, wires, metal parts</td>
</tr>
<tr>
<td>Management waste</td>
<td>Lack of supervision or incorrect decision of the management</td>
<td>Throwing away excess material</td>
</tr>
<tr>
<td>Waste due to wrong usage</td>
<td>Wrong selection of material</td>
<td>Rejection of inferior quality, marble, tiles bulk material</td>
</tr>
</tbody>
</table>

### Indirect Waste

Indirect waste occurs when materials are not physically lost; causing only a monetary loss. Waste due to concrete slab thickness larger than that specified by the structural design. Indirect waste arises principally from substitution of materials, waste caused by over allocation, where materials are applied in superior quantity of those indicated or not clearly defined in contract documents, from errors. Waste caused by negligence, where materials are used in addition to the amount required by the contract due to the construction contractor’s own negligence.
Sr. No. | CATEGORY | REASON | EXAMPLE
---|---|---|---
1 | Substitution waste | Substitution of material in work, which will incur losses to either contractor or client | Use of facing for common bricks, fixed blocks for brick mortar, ready mix concrete
2 | Execution waste | Contractor does not receive any payment for the work done | Excess thickness of slab- concrete waste
3 | Negligence waste | Site error because of the condemned work or use of additional material | Over excavation of foundation resulting in use of additional concrete, wrong drawing, handing over status of concrete
4 | Operational Waste | Unavailability of proper quantity of material on site | Formwork, Reinforcement, Low Equipment utility, concrete order.

**ELIMINATING WASTE**
In order to help us see waste within our process, we split it down further into the 7 waste.

- **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** – 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
- **Inventory** – 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.

**There are some factors affecting on lean Technology**

1. Cost
2. Resources
3. Labour Productivity
4. Disputes

**COST**- Construction cost estimating is the process of forecasting the cost of building a physical structure. Of course, builders and clients both worry about the financial impact of cost overruns and failing to complete a project. That’s why they devote time and effort to estimating how much a
project will cost before deciding to move forward with it. Clients considering large projects often seek multiple cost estimates. Construction cost estimating is the process of forecasting the cost of building a physical structure. Builders and clients both worry about the financial impact of cost overruns and failing to complete a project. That’s why they devote time and effort to estimating how much a project will cost before deciding to move forward with it. Clients considering large projects often seek multiple cost estimates, including those prepared by contractors and those calculated by independent estimators. Project owners use cost estimates to determine a project’s scope and feasibility and to allocate budgets. Contractors use them when deciding whether to bid on a project. We usually prepare estimates with the input of architects and engineers to ensure that a project meets financial feasibility and scope requirements. A good cost estimate prevents the builder from losing money and helps the customer avoid overpaying. It’s a core component of earned value management, a project management technique that tracks a project’s performance against the total time and cost estimate. There are many aspects which can impart poor value to the project.

- Proper information is not considered as there is time shortage.
- Whenever there is a problem some adjustments are done and the problems are tried to be solved which lacks the quality.
- Sometimes the requirements and needs of the customer are not taken into consideration and after the completion of the projects it lacks its functions for which it was meant to be.
- No proper communication is being done and few aspects are misunderstood.

Cost Engineering is always applied on a service or product for its analysis and design. In value engineering the people who are experts take into consideration of all the parameters based on their experience and knowledge with construction. During the review, the external factors are also taken into consideration so that to identify its impact on the projects and also the extent of the impact. Also it is necessary to keep in mind to check is these parameters are able to tackle all the challenges. Then the experts check for all the alternate possibilities and which can suit with the existing conditions. The alternatives should be able to resist all the influences.

Because “costs” are measurable, “cost reduction” is often thought of as the sole criterion for a value improvement application and indeed it is primarily addressed in this document. However, the real objective of is “value improvement” and that may not result in an immediate cost reduction. Cost and Time Engineering is a systematic, low-cost approach to assessing the “value” of a project. Typically, VE on projects can be used to gain the following benefits:

- cost reductions;
- time savings (schedule & Planning)
- quality improvements
- isolation of design deficiencies

The costs of a constructed facility to the owner include both the initial capital cost and the subsequent operation and maintenance costs. Each of these major cost categories consists of a number of cost components. The capital cost for a construction project includes the expenses related to the initial establishment of the facility:

- Land acquisition, including assembly, holding and improvement
- Planning and feasibility studies
Avoiding and engineering design
- Construction, including materials, equipment and labor
- Field supervision of construction
- Construction financing
- Insurance and taxes during construction
- Owner's general office overhead
- Equipment and furnishings not included in construction
- Inspection and testing
- The operation and maintenance cost in subsequent years over the project life cycle includes the following expenses:
- Land rent, if applicable
- Operating staff
- Labor and material for maintenance and repairs
- Periodic renovations

GST –

It is often wondered that how does it concern for a Civil Engineer to study the GST impact, for the same following points can be stated for which a Civil Engineer needs to study GST & it’s consequences in construction sector:

- High Initial Investing Sector.
- Contractor’s relied on Labor’s.
- Service Charges.
- Machinery Cost.
- Material Cost.
- Man Power Cost.
- Rate of Interest on Borrowings.
- Labour Contracts Turn Dicey.
- Transparency of Tax Reforms.
- No Scope of Cheat.
- Organizing the Unorganized Sector.
- Project Planning, Scheduling & Budgeting.
A single tax structure is definitely a welcome move and the introduction of Goods and Services Tax (GST) seeks to do just that by way of amalgamating a large number of Central and State taxes into a single tax. GST will not only address the concerns of double taxation but will also help in reducing the overall tax burden on goods and services. Furthermore, it will also help in making Indian goods competitive internationally thus providing a much-needed boost to the economy. The Construction industry is one of the most pivotal sectors in India and has seen a phenomenal growth, not just in cities, but even small towns. GST is another development that will have a significant impact on this sector. Let’s take a look at the impact of GST on the construction industry and the construction sector.

RESOURCE- Resource management is therefore mainly concerned with non-consumable resources. Also, resources may be classified according to their importance to key resources, secondary resources and general resources. Key resources are the most important, expensive and not available resources in the project such as skilled labors, or equipment. These types of resources will have a great attention in the resource scheduling process. Secondary resources are those resources which have no constraints on their availability, such as normal labour. General resources are defined as those resources that are used by all or most of the activities on the project such as site overheads. General resources will not be included in the resource management.

Resource management plans
A resource management plan can be used to:

- Ensure resource availability and resolve resource conflicts.
- Optimize time, effort and cost
- Ensure workers with the right skills are available.
- Identify limitations, such as site access, weather condition and so on.
- Resign resources in response to circumstances
- Track resources utilization to avoid excessive resourcing or under-utilization

Making a resource management plan work in construction
Successful resource management requires a good resource management plan

1. Access to the up-to-date project plan with clear definition of the different phases of work and activity scheduling
2. Understanding the types of resources that are needed.
3. Understanding the availability and optimum utilization of resources.
4. Understanding the potential for developing resources for new uses.
5. Understanding of the lead time require to ensure that resources for new uses.
6. The ability to redeploy resources if works need to be accelerated. Resource management system can improve overall efficiency; replacing less efficient data collection method such as paper forms, spreadsheets, and so on.
LABOUR:

**Accurately Measuring Actual Productivity**
This research uses three Canon XF professional camcorders to collect video data from three different locations, which capture the movements of workers. The camcorders provide the benefit of reviewing the video whenever required as well as to break down tasks and actions. One thing to note here is: whether the analysis is done at activity level or task level the events must be repetitive in nature.

**Estimating System Inefficiencies**
The identification of system inefficiencies necessitates a qualitative analysis. Different methods and models for assessing qualitative factors and their implementation can be found in papers such as Thomas and Inspired by these papers, this research developed a Qualitative Factor Model (QFM) to evaluate the productivity lost due to system inefficiencies—those factors that affect productivity but are outside the control influence of project managers. The QFM uses a severity score technique following a probabilistic approach. In this context, \( \Delta s_i \) is the estimated productivity loss due to system inefficiencies rather than the actual productivity loss \( \Delta s_i \). Based on this QFM, system inefficiencies for the research is calculated as follows:

\[
\Delta' s_i = \Delta'_{(PF-OP_{LU})} + \sum_{z=1}^{n} \left[ \sum_{l=1}^{m} \frac{S_l}{T_s} \right] W_z
\]

**Estimating Operational Inefficiencies**
The process of estimating operational inefficiencies involved developing a DES to model the construction process. The purpose of this simulation was to emulate the processes observed in the video recordings as close as possible so as to later be able to differentiate contributory from non-contributory actions. Contributory actions include those actions that are necessary to accomplish the task. For example, if one considers the bulb replacement task, then basic actions and movements required to replace bulb are contributory actions.

**Estimating Optimal Productivity**
The estimate of upper boundary and lower boundary determines the range over which optimal productivity can fluctuate. Once the upper and lower limits are estimated the average of these limits provides the best estimate for optimal productivity. The project managers can then use the result to determine the efficiency of their labour-intensive construction operations by comparing actual vs. optimal rather than actual vs. historical productivity.

Ankush D. Mali And Prof. G. N. Kanade 25
Guidelines for Improving the Labour Productivity

- Properly training to the labourers
- Motivation to workers towards project completion
- Properly and in advance material procurement and management
- On time payment to the workers
- Systematic flow of work
- Properly, clearly & in time supervision
- Advance site layout
- Maintain work discipline
- Facilities to the labourers
- Clearance of legal documents before starting of work
- Systematic planning of funds in advance
- Pre-monsoon plan to avoid work stop
- Maximum use of machinery and automation system
- Advance equipment planning.

<table>
<thead>
<tr>
<th></th>
<th>Lack of labor surveillance</th>
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<tbody>
<tr>
<td>2</td>
<td>Misunderstanding between labours and superintendent</td>
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<tr>
<td>3</td>
<td>Opposition by local due to inadequate conceptual design</td>
</tr>
<tr>
<td>4</td>
<td>Addition in scope of work</td>
</tr>
<tr>
<td>5</td>
<td>Deletion in scope of work</td>
</tr>
<tr>
<td>6</td>
<td>Drawing and specification alteration during execution</td>
</tr>
<tr>
<td>7</td>
<td>Skill and experience</td>
</tr>
<tr>
<td>8</td>
<td>Planning and Management</td>
</tr>
<tr>
<td>9</td>
<td>Material availability</td>
</tr>
<tr>
<td>10</td>
<td>Lag of material</td>
</tr>
<tr>
<td>11</td>
<td>Delay in arrival of materials</td>
</tr>
<tr>
<td>12</td>
<td>Unclear instruction of labour</td>
</tr>
<tr>
<td>13</td>
<td>Labour strikes</td>
</tr>
<tr>
<td>14</td>
<td>Financial difficulties of the owner</td>
</tr>
<tr>
<td>15</td>
<td>Construction technology and method</td>
</tr>
<tr>
<td>16</td>
<td>Supervision</td>
</tr>
<tr>
<td>17</td>
<td>Improper Project planning</td>
</tr>
<tr>
<td>18</td>
<td>Delay In approval of design and drawing</td>
</tr>
<tr>
<td>19</td>
<td>Scarcity of manpower/skilled labour</td>
</tr>
<tr>
<td>20</td>
<td>Shortage of experienced labour</td>
</tr>
<tr>
<td>21</td>
<td>Communication between site manager and labour force</td>
</tr>
<tr>
<td>22</td>
<td>Incentive programs</td>
</tr>
<tr>
<td>23</td>
<td>Availability of the material and ease of handling</td>
</tr>
</tbody>
</table>
Leadership and competency of construction management

Competency of labour supervision

Absence of worker

Labour skill and experience

Financial Shortage

Inspection and instruction delay

Incomplete drawings

Accident due to construction equipment / machinery

Accident due to moving traffic adjacent to project site

Disputes due to discrepancy in contract document

Poor Performance of sub-Contractors

Adverse Weather Conditions

Disease and Epidemic

Shortage of Personal protective equipment

Availability of health and safety training

Delay in salary, poor wages, Lack of Financial motivations

Lack of training sessions, lack of labour recognitions programs, lack of place for eating & relaxation, Lack of team spirit

DISPUTES-

DISPUTE PREVENTION TECHNIQUES

The best dispute management skill is the ability to stay out of dispute not as an avoidance technique but rather, as specific prevention strategy. Three key areas to manage are:

**Clear specifications**

Writing a specification that will be interpreted the same way by different people is a skill that takes years to acquire. In a dispute, it does not matter what was meant, only what is in the contract. An independent specification review should find and correct material ambiguities. Unfortunately, most organizations do not conduct such reviews and find out later, after the contract has been put into operation, that the specification should have been much, much clearer.

**Clear communication protocols**

Internal policies and procedures regarding communication, approvals, signoffs and the like, have no bearing in a dispute unless incorporated into the contract and made an obligation of the parties. Consider the number of people who might have a discussion, some form of correspondence, or even just contact with anyone in the other party – there will be quite a few people acting with presumed authority and inadvertently committing your organization. Have clear internal processes, authorities, forms and the like, incorporate them into the contract and make them binding on both parties.
Proactive issue management

It is not unusual, in a contract of reasonable size and complexity, to have up to 300 unresolved issues at any given time; they can quickly grow into disputes if the environment is right. Before declaring something a dispute, consider managing it as an issue, at least to begin with. Defining a problem an ‘issue’ rather than a ‘dispute’ has a big impact. You can apply normal project management techniques to issue management. Have a mechanism for anyone to raise an issue track and assign all issues, and have regular issue resolution meetings.

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<tbody>
<tr>
<td>1</td>
<td>Lack of surveillance</td>
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<tr>
<td>2</td>
<td>Failure of contributors to instantly handle changes</td>
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<tr>
<td>3</td>
<td>variations in legislation and guidelines</td>
</tr>
<tr>
<td>4</td>
<td>Lack of understanding</td>
</tr>
<tr>
<td>5</td>
<td>Incompetent designer</td>
</tr>
<tr>
<td>6</td>
<td>Poor communications among project contributors</td>
</tr>
<tr>
<td>7</td>
<td>Lack of cooperation among contributors</td>
</tr>
<tr>
<td>8</td>
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**LOGISTICS –**

The engineering construction project physical distribution management is the plan, the organization, coordinated and the control carries on to the physical distribution activity. It is for the purpose of making the project process to be easier and quickly, simultaneously obviously and controllable. In view of the fact that the engineering construction project physical distribution constructs scene the physical distribution cost to account for the entire project physical distribution cost the very major part, says from the function angle, may divide into the engineering construction project physical distribution the supply physical distribution and the scene physical distribution.
The supply physical distribution and in the production process circulates the work activity related, the basic activity includes: Definite resources (material, equipment and man-power) specification, supply plan, resources purchase, storage control, ex works. Scene physical distribution and in scene production process material plan, organization, direction with control related, including: The scene transportation and the delivery, the field processing, the scene operating system management, the safety equipment, the site layout, the work order's arrangement, as well as between various engineer brigades conflicts solution measure

**The Construction Logistics Plan:**


A brief outline of the content of a typical CLP, as specified by current policy documents:

**Overview of the Project**- A brief description of the development and general site location, as well as proposed site layouts and basic maps of surrounding roads and transport routes

**Introduction to the Supply Chain**-A brief description of primary products required for the development and their source, as well as the method by which they will be transported. A brief investigation of expected material waste, its removal and recovery

**Planning the Supply Chain**-This section contains the policies and procedures to be utilized by trade contractors and suppliers for reducing road traffic before and during the construction process. Some examples include:

- Materials–A record of all the materials expected to be delivered to and removed from the site and their predicted mode of transport;
- Consolidation Centre and Pre-fabrication (aka. Off-site Manufacture);
- Integration with neighboring sites–Details of any potential delivery consolidation available through
- Combining loads for separate sites situated close to each other. Outlines the processes to be shared and which sites will be collaborating with each other;
## ACKNOWLEDGMENT

We express our sincere thanks to PG coordinator Patil A.B., for his continuous support. We also thankful to our Head of Department of Civil Prof. L.B. Patkure For support

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