USE OF LEAN TECHNOLOGY FOR INCREASE OF PRODUCTIVITY IN CONSTRUCTION INDUSTRY

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Abstract: Waste in construction projects indicate that waste can arise at any stage of the construction process from beginning, right through the design, construction and operation of the built facility. Waste in the construction industry has been the subject of numerous research projects around the world in recent years. It is commonly recognized that a very high level of waste subsists in construction. The following factors are considered to reduce the waste in the construction industry such as site time and cost. The objective of this study is to minimize the construction waste through lean construction principles and improve the site productivity using work sampling. Author work on **Sai Construction site** which is located at Karvenagar Pune as a case study. Lean Construction considers construction wastes as potential wastes that hinder flow of value to the client and should be eliminated. Mapping out the activities in the manufacturing process with cycle time, downtime, in process inventory, material moves, information flow paths, helps to envision the current state of the process activities and guide towards the future desired state. The process usually includes the physically mapping of the current state while also flowing on where you get to or the future state map, which can serve as the foundation for the other lean strategies. Minimizing material wastage would not only improve project performance and enhance value for individual customers, but also have a positive impact on the national economy.

Keywords: Lean Technology, Waste Minimization, Construction Industry, SPSS

1. INTRODUCTION

Lean construction is a way to design production systems to minimize waste of materials, time and effort in order to generate the maximum possible amount of value. It is also aholistic design and delivery philosophy with an overarching aim of maximizing value to all stakeholders through systematic, synergistic and continuous improvements in the contractual arrangements, product design and method of selection, the supply chain and the workflow reliability of site operations. The construction industry lags far more years behind the manufacturing industry because of theseveral reasons. The prime reason it is being split approachrather than a mixed approach. The other reason is that the construction industry is more complex than the manufacturing industry and therefore development of technical modernization is to be implemented significantly.

Lean construction is a new production methodology which will bring a radical change in the construction industry. Construction companies have improved their work effectiveness and quality of work, and reduced waste and costs and increased their profits to ensure their survival in today's competitive market.

Lean construction much like current practice has the goal of better meeting customer needs while using less of everything. But unlike current practice, lean construction rests on production management principles, the "Physics" of construction. The result is a new project delivery system that can be applied to any kind of construction but is particularly suited for complex, uncertain, and quick projects. Waste elimination is one of the effective ways to increase the profit of any industry. Construction waste consists of unwanted and undesired materials produced directly or indirectly by various construction processes.

Lean construction (LC) is technique which aims to eliminate all defects and minimize wastage of materials, time and effort in order to generate the maximum possible amount of value by using less input. Less inputs includes: less labor, less machinery, less space, less time etc...The methodology of Lean Construction is to minimize the bad and maximize the good. It include a clear setoff objectives for maximizing the benefits through concurrent design of construction facilities and processes. In Lean Construction, materials are available on site only at the time when it is required.

- Roads
- Railways
- Urban infrastructure
- Ports
- Airports

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 ofproject management into the lean management approach.

1.1 Objective of the Study

1. Access lean construction from the view point of various project participants.
2. Identify the benefits and barriers associated with lean implementation.
3. To identify and analyze the defects in construction using Lean six sigma approach and SPSS software.
4. To evaluate Lean six sigma as a process improvement method to improve the various works during construction.

1.2 Scope of the Study

- Lean Six Sigma provides structured methods of improvement to reduce waste, reduce cost, reduce lead times, and promote concurrent work and to improve planning and control.
- Improve the quality, reduces rework and implementation time.
- Identification of waste in construction process
- Deliver a custom product instantly, without waste.

1.3 Construction Waste

Construction and demolition waste has been defined as wastage which are arising from construction, renovation , explosion activities ,surplus and damaged products and material arising in the course of construction work and on site work. Waste in construction is important not only from the perspective of productivity but also from the environmental considerations. Many times actual percentage of waste generation is much higher than envisaged initially causing needless utilization of resources.

It means there is a plenty of scope for enhancing project productivity simply by taking waste out of construction. Construction waste once generated is difficult to recycle and reuse due to high level of contamination and heterogeneity. Researchers see waste as a non-value adding activity that always negatively affects project performance in the form of cost overruns and delays. C&D debris means the waste that gets generated in construction, renovation, or demolition processes.

1.4 Lean

Lean means to derive more value by using less of everything. Production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination.

2. LITERATURE SURVEY

Giorgio Locatelli et al. The paper provides three original set of results: (1) a fuzzy cognitive map of LC showing how the different elements are linked to each other; (2) a pathway for the implementation of LC; (3) a synthesis of the strengths and the weaknesses of LC merging literature review with case studies analysis. This papers aims to present an overview of Lean Construction (LC) and how this construction philosophy tackles the aforementioned problems. The research is empirical and based on data from the literature, 7 new Case Studies built with primary data, 12 Case Studies on CLIP (Construction Lean Improvement Programmed) projects, 4 semi-structured Interviews with Firms adopting LC and several interviews (face to face and email) with LC experts.

Richard HannisAnsah et al. In this paper, the result from this study would serve as an implementation guideline for lean construction projects; thus, offer an understanding of the specific lean tools to adopt in projects. It is expected that this provides construction managements with suitable lean construction tools to build a realistic and rational lean application guide. In this paper, a new set of lean construction tools for addressing construction projects has been presented. In order to ensure that every aspect of LC tools is captured in relation to the lean tools suitability, the study extended the existing LC tools. The identified lean tools were evaluated through the interview and the findings confirmed 30 lean tools including Last Planner System (LPS), Concurrent Engineering and Daily Huddle Meetings as being the most effective lean-delay control tools for the delay sources mitigation.

S. A. AbbasianHosseini et al. This paper seeks to test the applicability of lean principles to one of construction operations using discrete-event simulation. One of the general simulation tools with a powerful 3D animation in this regard is ARENA, which is used in this paper. Data required to simulation model development were gathered from the construction site. It concluded that the concepts of lean construction can be applied properly using simulation as means of testing lean concepts prior to actual field implementation. The lean techniques applying to a construction processcan have different results depending in the process features.Simplification, just-in-time delivery of materials andoptimized utilization of labors and crews, are the appropriatetechniques to make a process lean, while applying together.Results of the simulation models showed that lean principlesenhanced the performance of the selected processes bydecrease the total time of the project and also improveprocess efficiency, i.e., increase the time, labors spent onvalue adding activities.

S. Dinesh et al. This paper is to draw a special attention to review on literature. Researchers have used pertaining methods for examining reimbursement of lean construction by analyzing and describing the obtainable literature. This study assumes the existence for understanding the lean concept in desirable manner, proper implementation and sustainability concepts that contribute to lean construction. Lean Construction, Project Management Method & Sustainability. We summarized that planning and control of production, improving the safety measure performance, risk level forecasting for time and new approach developing to construction safety and removal of waste in every stage. Impact in the construction activities on our environment have to be minimized by green growth and sustainable and also by proper implementation. The application lean in construction is not only possible at operational; it should planned at strategic level. This paper establishes the application of lean tools and techniques by projects, and then it will minimize the waste, enhances the performance and lead to profit. It is expected that fundamental knowledge about lean construction provided by this paper and practice from elimination of waste and also assist as a criterion for

continuous improvements of performance in construction industry.

Vinaya D.More et al. This paper effort 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 results of site implementation showed the effect of the various types of activities on the overall project duration. The factors affecting the use of lean tools have great impact on the percentage of improvement in the process durations.

Aakanksha Ingle et al. The construction industry and other industries also are 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, green house gas emissions etc. The construction industry is seen as one of the worst performing industry as regards to the innovation. This calls for concern about the poor state of construction innovation. The emergence of lean construction is to bring significant reform to the construction industry to achieve the objectives of value addition and waste minimization within the built environment in the critical social, economic and environmental aspects.

Amitha P et al. This research paperLean Six Sigma concepts are as waste elimination and process improvement technique. The Six Sigma concept can be considered as a continuous improvement process for reducing variation in process which means the defected products or defected service, which focus on continuous and breakthrough improvements. Lean Six Sigma is also used for improving performance; develop effective leadership, waste and variation reduction, customer satisfaction and bottom line results by applying DMAIC and DMADV. This study aims to provide abetter understanding of the Last Planner System (LPS) whichis a Lean Construction concept used for analyzing the variousschedule systems involved. This paper focuses onimplementing Last Planner System in residential construction.The data is collected from few respondents throughquestionnaire survey.

Harsha N. et al. This paper reports a study that identified the presence of value and waste in a construction engineering project. Finally, the paper describes the objectives and anticipated contributions of current research conducted at the construction site. Specifically, delay andother types of wastes due to poor coordination among various project participants have beenwell documented in many previous studies. The highly fragmented nature of the constructionindustry has caused considerable low productivity, cost and time overruns, and conflicts anddisputes, all potentially resulting in claims and time-consuming litigations.

Remya R et al. The main aim of this study is at examining the ability of lean construction principles to reduce construction process waste through a case study (reinforcement process). Computer simulation is utilized to reveal the results of lean principles application prior to real implementation. Results show that different kinds of waste in a construction process can be reduced via adopting lean construction principles using computer simulation. The result obtained as part of diagnosis, and the further analysis realized on them has permitted to determine agents of change that boost improvements inside the organization, but also to validate perception and inferences established in the preliminary experiences of implementation of Lean improvement methodologies in the Chilean Construction companies.

Richard HannisAnsah et al. This paper was able to establish the fact that the employed or existing project management models and strategies have not been able to deliver projects on time and as a result have created wastes in the construction industry through a comprehensive literature survey. The paper also discussed LC, its principles and wastes in the industry. This was illustrated with some highlights of the importance of LC application (Why LC). Finally, the paper established that, the application of lean tools and techniques by project teams and industry's practitioners will minimize or eliminate waste, enhance performance and lead to a great cost savings for the industry as well as the society.

O. Salemet al. This paper reviewed and tested the effectiveness of lean construction tools that are suitable to apply in construction firms. The authors found that the lean manufacturing tools can be modified for use in construction projects and successfully implemented. The commitment of the top management for implementation of these tools may prove to be the most important factor in successful implementation of these tools. The authors observed a complete attitudinal shift in the project participants in this project. At the beginning of the project, the project manager questioned the applicability of these tools at the site. However, by the end of the project, everyone on the site participated in the implementation of these tools.

3. LEAN TECHNOLOGY

3.1 Lean Principles

1. **Perfect first- time quality:** Achieve zero defects, revealing and solving problems at the source.
2. **Waste minimization:** Eliminating all non-value adding activities and maximizing the use of resources.
3. **Continuous improvement:** Reduction of costs, increase quality and productivity.
4. **Pull processing:** Products pulled from the consumer end, i.e. not pushed from the production end.
5. **Flexibility:** The production of different mixes and/ or greater diversity of products, without compromising efficiency.
6. **Relationships:** Building and maintaining long-term relationships with suppliers.

3.1.1 Value Stream Analysis

A value stream is all the actions, both value added and non - value added, currently required to complete a product or service from beginning to end. Value adding Activities (VA)

- It generates a positive return on the investment of resources and cannot be eliminated without impairing a process. Non Value adding Activities (NVA) - It generates a zero or negative return on investment of resources and usually can be eliminated without impairing a process.

3.2 Classification of Activities

3.2.1 Construct

When a construction worker performs an activity that is value adding, e.g. pouring concrete or processing the material, the activity should be registered as construct

3.2.2 Material Handling

Whenever material needed to be transported or moved in some way at the construction site it was registered as material handling. Tools were more or less also moved along with material thus tool handling came to be registered as material handling as well.

3.2.3 Discussion

Every time a conversation was started it was registered asdiscussion. However, the sort of discussion varied mainly between two types; (1) problem solving and (2) small talk. One can see the first one as necessary waste since the discussion is needed to be able to precede the construction in a correct way whereas the small talk is pure waste given that it has nothing to do with the construction work. If discussion and walk happened simultaneously the discussion is registered and appropriate time is noted in order to avoid missing out on problem solving conversations.

3.3 Lean Construction

Lean construction is defined as the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire stream and pursuing perfection in the execution of the project work. Figure 2 shows the lean principals

Figure 2 Lean principals

TABLE 1

COMPARISON OF LEAN AND TRADITIONAL PRODUCTION

	Traditional production	Lean production
Scheduling	Forecast product is pushed through facility	Customer order product is pulled through facility
Production	Replenish finished goods inventory	Fill customer orders only
Product Cycle time	Long Weeks/ months	Short hours /days
Batch size	Large batches moving between operation product is send	Small and based on one price flow between operations

3.3.1 Benefits of Lean Construction

- More satisfied clients,
- Productivity gains,
- Greater predictability,
- Shorter construction periods
- Improved design
- Reduced cost and less waste.

3.4 Waste Elimination

Waste elimination is very important process in the construction industries to improve the quality and profit of the project. Waste may be produced directly or indirectly during the construction in the construction industry.

3.5 Types of Waste

3.5.1 Sources of Construction Waste

3.5.1.1 Overproduction

Related to the production of a quantity greater than required or earlier than necessary. This may cause waste of materials, man-hours or equipment usage. It usually produces inventories of unfinished products or even their total loss, in the case of materials that can deteriorate. An example of this kind of waste is the overproduction of mortar that cannot be used on time.

3.5.1.2 Substitution

Related to the substitution of a material by a more expensive one (with an unnecessary better performance); the execution of simple tasks by an over-qualified worker; or the use of highly sophisticated equipment where a much simpler one would be enough.

3.5.1.3 Waiting time

Related to the idle time caused by lack of synchronization and leveling of material flows, and pace of work by different groups or equipment. One example is the idle time caused by the lack of material or by lack of work place available for a gang.

3.5.1.4 Transportation

Concerned with the internal movement of materials on site. Excessive handling, the use of inadequate equipment or bad conditions of pathways can cause this kind of waste. It is usually related to poor layout, and the lack of planning of material flows. Its main consequences are: waste of man hours, waste of energy, waste of space on site, and the possibility of material waste during transportation.

3.5.1.5 Production of defective products

It occurs when the final or intermediate product does not fit the quality of specifications. This may lead to rework or to the incorporation of unnecessary materials to the building (indirect waste), such as the excessive thickness of plastering. It can be caused by a wide range of reasons: poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc.

3.5.1.6 Inventories

Related to excessive or unnecessary inventories which lead to material waste (by deterioration, losses due to inadequate stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up. It might be a result of lack of resource planning or uncertainty on the estimation of quantities.

3.5.1.7 Inappropriate processing

This waste is about taking unnecessary steps to process the parts. Inappropriate processing can for instance be depicted as using expensive highly advanced equipment where simple tools would be sufficient to do the work. The over complexity generally discourages ownership and encourages the employees to overproduce so that the large investment in the complex machines can be recovered.

3.6 Waste Minimization in Construction

The building industry is using a considerable amount of resources, but if the life cycle of the material on site is closely examined, it is generally known that there is a relatively large portion of the materials being wastedbecause of poor material control on building sites. Re-use isa form of waste reduction that: (1) extends resource supplies; (2) keeps high-quality-matter resources from being reduced to low-matter-quality waste; and (3) reduces energy and pollution even more than recycling. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. The successful research and development of new building materials or components using waste as raw material, is a complex and multidisciplinary task, including technical, environmental, financial, marketing, legal and social aspects.

3.6.1 Recycling

Recycling is commonly defined as a process of separating recyclable materials from non-recyclable materials and supplying them to a hauler or business so they can be processed to make new products. Buying building materials with recycled content helps develop a market for the waste material one recycles from the job site.

3.7 The Benefits of Minimizing Waste

1. Reducing demand for landfill space;
2. Saving resources and energy;
3. Reducing pollution; and
4. Increasing the efficiency of production.

3.7.1 Financial Benefits

Waste minimization can provide financial benefits, and in some cases can even save cost and time. The financial benefits can be appreciated over a short term or long-term period. But overall, cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. Financial benefits include: Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.

- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials whenconsidering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

3.7.2 Environmental Benefits

Waste minimization can provide environmental benefits, which are important to be considered due to the alarming situation of materials waste on construction sites.

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.

3.8 Waste Minimization Measures

- Purchasing raw materials that are just sufficient
- Using materials before expiry dates
- Use of more efficient construction equipment
- Good coordination between store and construction personnel to avoid over ordering
- Adoption of proper site management techniques
- Accurate and good specifications of materials to avoid wrong ordering
- Checking materials supplied for right quantities and volumes
- Change of attitude of workers towards the handling of materials
- Mixing, transporting and placing concrete at the appropriate time
- Waste management officer or personnel employed to handle waste issues

3.9 Identification of Waste

In this step, the wastages which produced during the project are to be identified and examined, causes are analyzed. Based on the questionnaire survey collected from the companies they are cluster together and formulated related to their usage and divided in to seven categories as follows,

- Resource Wastes
- Management Related Waste
- Design Related Waste
- Operational Related Waste
- Waste due to Labour
- Waste while Procurement
- Miscellaneous Waste

The bar and pie chart prepared by using quantitative method. The following bar and pie chart showing thepercentage of waste occurred in construction industry. Thequestionnaire survey was carried out among 70 companies in various parts of Tamil Nadu in India. The following result are obtained based on the questionnaire survey is shown in figure for each wastes.

3.9.1 Resource Waste

The resource waste (cement, brick, steel etc.) is the major problems in the construction sites. It's calculable that on the average construction resource waste constitutes 15-30% of the entire construction sites. It happens frequently in all sites because of carelessness of unskilled labors.

3.9.2 Operational Waste

Operational waste mainly happens due to error by trade person or laborer, equipment malfunction, Equipment frequently break down, Unreliable equipment, inclement climate, accidents, damages caused by subsequent trades, use of incorrect material requiring replacement etc.

3.9.3 Design Waste

Mostly it happens due to error in contract documents, incomplete at the commencement of project, change in design after commencement of project. Designers have to be compelled to embody rationalization of specification in every material and element that's required within the

contract. Sometimes, ordered material cannot attain the location on time, forcing them to use substitute material terribly very short time. With a restricted time, designers are susceptible to opt for material that's low in quality rather than the initial demand.

3.10 Problem Identification

A problem arises when there is a distinction between what "should be" and what "is"; between the optimal and the definite situation. A problem expresses the difference between the hoped for and the actual situation. It is directly or indirectly related to an expected outcome or standard of behavior. Identifying a very clearly characterized and exact problem is the first step to implement the problem solving process successfully. The problems identified in this research are:

1. Lack of materials due to waste,
2. Transport difficulties
3. Improve handling on site,
4. Lack of work plan
5. Delays due to climate changes
6. Equipment break downs
7. Poor work planning
8. Repeated work
9. High labour turn over
10. Poor communication

It was seen how the complexity of the building greatly affected the amount of work. In addition, it was observed quiet often that the workers disregard for the little things like screw, nuts and bolts. The workers need to be made aware of waste in construction and how their actions affect their work environment, cost, time and ultimately, customer satisfaction. Waiting and unnecessary movements were also identified .Waiting could be for material but for tools and colleagues as well. Unnecessary movement was a type of waste that was very visible during the observations. A great deal of time was spent searching for tools, material, colleagues or walking back and forth for different reasons.

CONCLUSION

Based on the work will be carried out it will be found that 70% of companies accepted the criteria that wastes are generated in the construction industry which is accepted by the companies according to the responds of the various project participants in construction industry. The leanprinciples/concepts have been studied in depth, it was understood that Lean construction system is beneficial to industry as it minimizes the waste and increase the productivity. The concept of lean construction is studied in view of India. The most affected factors are identified by ranking using Statistical Package for Social Sciences analysis. The establishment of the incidence of non – value added activities during the process enables the construction managers to identify the best actions and paths to apply new techniques for reducing waste, leading to process improvement. Since for sustainable and green growth we have to minimize the impact of construction activities on our environment, this is possible with the proper implementation of lean construction, in case of India training and consultancy is needed for acceptance of this lean system in construction.

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