Lean Management in Construction Project

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Abstract- **Waste is one of the main problems plaguing the construction industry. The need for identifying the sources of waste and eliminating them has resulted in the extension of the concept of lean and the development of lean principles and tools, especially for the construction industry. In order to improve the efficiency and reduction of waste, the lean construction has been introduced as a new management principle for better implementation. Currently many construction companies like USA, UK, Australia, Brazil, and Singapore are started to implement the lean construction to obtain better result from their current projects. There are many challenges to implement the lean concept in construction industry. 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 in developing stage to implement this principle in their project. The paper presents the possibilities of using lean management principle in construction industry, which can surely increase the quality of work and profit rate by eliminating the wastage of materials. Most of the lean construction tools selected for the project are either ready to use, or are recommended with some modifications. The data collected from questionnaire survey are going to analyze by using Statistical packages for social science (SPSS) version22.**

Index terms- **Lean management tools, Eliminate waste, Questionnaire survey, Statistical packages for social science**

I.INTRODUCTION

Lean construction is a philosophy based on the concepts of lean manufacturing. It is about managing and improving the construction process to profitably deliver what the customer needs. Lean construction is a translation and adaptation of lean manufacturing principles and practices to design and construction process. Unlike manufacturing, construction is a project based-production process. Lean construction is concerned with the holistic pursuit of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, and activation, maintenance, salvaging and recycling. This approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs. 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.

The core idea is to maximize customer value while minimizing waste. Lean means creating more value for customers with fewer resources. A lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

Some of the lean management tools are:

Huddle Meetings (Daeyoung Kim et al 2009)

Last Planner (Daeyoung Kim et al 2009)

5S System (Salem et al 2010)

Cellular Layout (Salem et al 2010)

First-Run Studies (Plan, Do, Check, Act)(Eric Joansen et al 2012)

Kanban System (Albert Agbulos et al 2012)

Visual Control (Albert Agbulos et al 2012)

Fail-Safe for Quality (Esquenazi et al 2013)

Just in Time (JIT) (Sepani Senaratne et al 2014)

Poka Yoke or Mistake Proofing (Matilda Hook et al 2015)

TPM (Total Productive Maintenance) (Haitao Yu et al 2015)

Value Stream Mapping (Haitao Yu et al 2015)

Standard Operating Procedures (SOPs) (Lee Davis et al 2016)

Kaizen Blitz or Rapid Improvement Process (Isabelina Nahmens et al 2018)

Customer needs to be a shift in everyone‘s way of thinking; owners must be the agents of change and must demand change; lean must become the new culture of the industry. There is so much waste in

Construction Industry that there is a great profit opportunity to those who go Lean.
The benefits of lean construction techniques have been demonstrated by the improved performance of many projects at each and every project phase. Lean construction may require more time in the design and planning phases, but this attention eliminates or minimizes conflicts that can dramatically change budgets and schedules. Reducing major source of waste. Increase the value of their products and services in order to maximize the quality and profit.

II.LITERATURE REVIEW

Rafael Sacks et al (2015) had two basic approaches; first was a conceptual approach to project and lean construction and second was a transformative information technology. Building Information Model (BIM). While the two were conceptually independent and separate, it appeared to be synergies between them that extend beyond the essentially circumstantial nature of their approaching maturity contemporaneously. At the outset, the different ways of conceptualizing lean construction including the whole project life cycle and BIM as presented in prior literature were examined. Based on this, a framework or taxonomy of analyses was created for assessing the interconnections of lean and BIM. Any company or project implementing BIM should ensure that their adoption/change process was contributing to the fullest extent possible to making their processes leaner. Second, in the current stage of both BIM and lean, it was probable that most companies and professionals were still on a learning curve. BIM tools themselves and of course lean construction principles should be rooted in conceptual understanding of the theory of production in construction.
Lee Davis et al (2016) presented a Soft Systems Methodology (SSM) approach which is developed for addressing complex, multi- disciplinary project problems. Research was proposed to examine the use of SSM in construction projects undertaken by a large UK contractor. Such a use enabled project managers and SCM practitioners to view the process of developing lean supply in a holistic manner and also to take into account the soft‘ cultural and project-based features of construction, leading to more effective solutions for delivering their project. They also proposed that the success of lean supply in construction is highly influenced by the unique culture and fragmented nature of the industry. They had described the case for using SSM in order to develop lean supply in construction due to it having the scope to identify and analyze these influences at a practical level.
Haitao Yu et al (2017) developed a production system for the effective application of lean tools in building components prefabrication to overcome the prevalent skepticism among middle management. The lean journey started with a pilot project involving one production line. Over a six- month period, lean tools such as 5S, standardized work, take time planning, variation management, and value stream mapping were implemented to a communication shelter production line. The implementation successfully won the support of the middle managers established the foundation for expanding lean practices to other parts of the factory and applying relevant lean tools and techniques.
Isabelina Nahmens et al (2018) proposed the use of lean construction as a viable and effective strategy, in particular the lean tool Kaizen. This paper used several case studies to showcase the effect of lean on the triple bottom line of sustainability in modular homebuilding. Sustainable construction could be operationalized by using a kaizen approach and focusing on environment, social, and economic performance of the homebuilding processes. A kaizen event helped to eliminate waste be empowering employees with the responsibility, time, and tools to uncover areas for improvement and to support change. The case studies presented in this journal used kaizen combined with safety and environmental analysis to increase sustainability in modular homebuilding processes. Lean construction resulted in a significant environmental effect by reducing material waste by 64%, a significant social effect by reducing or eliminating key safety hazards of excessive force and a significant economic effect by reducing production hours by 31%.

III.METHODOLOGY

The methodology is the general research strategy that outlines the way in which research is to be undertaken and among other things to identify the method to be used in it. The methodology defines the analysis of the principles of methods, rules and postulates that has been employed in the project. The methodology was proposed one to analyze and implement the lean management principles in construction project.

PREPARATION OF QUESTIONNAIRES

From the literature collection and from the case studies, the questionnaires were examined and the questions were framed in accordance with the situation of the project. The preliminary structure of this questionnaire is consists of 35 questions and its categorized under six criteria according to its type of waste. The design for this questionnaire such as, NO, MODERATE and YES

In this step the questions which are prepared are to be evaluated by means of conducting interview with the persons who are all involved in a project like top management peoples, contractors, engineers etc .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 six categories as follows,

- Design and Documentation
- Procurement
- Material handling, Storage & Transportation
- Operation
- Residual

1. QUESTIONNAIRE SURVEY

Sources & Causes of waste	YES	MODERATE	NO
DESIGN AND DOCUMETATION			
Any changes made to the design while construction is in progress			
Inadequate project definition and planning			
Lack of knowledge about construction among new workers			
Choice of low quality products			
Designer have inexperience			
Delay in receiving design documents and drawings			
Any error in contract documents			
PROCUREMENT			
Imperfect planning of material like Over-ordering or Under-ordering			
Supplier’s error like poorly executed price increases			
Lack of possibilities to order small quantities			
Use of incorrect material requiring replacement(substitution by expensive one)			
MATERIAL HANDLING,STORAGE AND TRANSPORTATION			
Material damage during transportation			
Inappropriate storage facilities leads to damage			
Unpacked material supply(Example-Bricks ,Stones etc.)			
Material damage due to labor mishandling			
Use of material which is low rated			
Use of defected material			
Lack of onsite control			
Use of inappropriate tools/equipment			
OPERATION			
Human error			
Equipment malfunction/frequent breakdown during operation			
Accident due to negligence			
Required quantity of products unknown due to imperfect planning			
Lack of coordination between main contractor and subcontractor			
Lack of coordination among different crews			
Use of untrained/semi-trained manpower			
RESIDUAL			
Rework due to error by management			
Work not done as specified due to absentees of labor			
Motion of employees with no purpose			
Over-mixing of material due to lack of knowledge			
OTHERS			
Criminal waste due to damage or theft			

Lack of waste management plan			
Stoppage due to natural hazards			
Lack of supervision and delay in inspection			
Poor communication & coordination between the parties involved in the project			

2. COLLECTION OF DATA

The study will be conducted using structured survey questionnaire. The questionnaire distribution will be done randomly using two approaches, namely via postal mail as well as direct visitations to the respective firms. The Questionnaire is of Objective type. Respondents were requested in the questionnaire to identify the major waste attributes in waste generation on sites by responding on a 3-point rating scale as: 3 - Yes, 2 - Moderate, 1- No.

IV. RESULTS AND DISCUSSION

The gathered data was analyzed by using SPSS software version 22 and statistical methods. Following are the test conducted,

1 One sample Test (ANOVA test)

2 Friedman Test

ONE SAMPLE TEST

The variables with higher mean values indicate, that they are causes of wastage in higher degree and lower mean value indicate degree of their insignificancy of being causes of waste. The variables with mean values lesser than 2 do not have major influence on conclusions and suggestions. The mean score were calculated to waste causes. The common major waste attributes in both were determined based on waste variables using one sample t-test and 95% confidence interval. Test value 2 was used to compare means. Those with mean value of 2 and above were considered as major waste attributes and those waste attributes found to have mean scores less than 2 were considered insignificant and were left out.

The following table shows the output of one sample t test conducted for the collected data.

Sources & Causes of Waste	Mean	Identified Waste
Any changes made to the design while construction is in progress	2.3	Time, Material & Man hour consuming Waste
Any error in contract documents	2.03	Time, Material & Man hour
Delay in receiving design	2.23	Time, Material & Man hour
Choice of low quality products	2.37	Material Waste
Lack of knowledge about construction among new	2.2	Time, Material & Man hour consuming Waste
Sources & Causes of Waste	Mean	Identified Waste
Imperfect planning of Materials	2.63	Time, Material & Man hour
Use of incorrect material requiring replacement (substitution of a material by an expensive one)	2.4	Time, Material & Man hour consuming Waste
Supplier‘s error	2.57	Time Waste
Lack of possibilities to order small quantities	2.43	Time, Material Waste
Sources & Causes of Waste	Mean	Identified Waste
Material damage during transportation to site/ on site	2.1	Material Waste
Material damaging due to labour Mishandling	2.4	Material, Man hour consuming Waste
In appropriate storage facilities at site leading to damage or deterioration	2.33	Material, Man hour consuming Waste
Unpacked material supply (handling, storage and atmospheric influences on construction site for example sand-lime bricks & elements, stone tablets, etc.)	2.23	Material Waste
Lack of onsite materials control	2.27	Time, Material & Man hour consuming Waste
Sources & Causes of Waste	Mean	Identified Waste
Human error (by craftsmen or other laborers)	2.47	Time, Material & Man hour consuming Waste
Equipment malfunction/frequent breakdown during operation	2.33	Time, Material & Man hour consuming Waste
Lack of coordination among different crews	2.06	Time, Material & Man hour consuming Waste
Lack of coordination between the main contractor and Sub-contractor	2.27	Time Waste
Accidents due to negligence	2.33	Time Waste
Residual	Mean	Identified Waste
Rework due to error by management	2.1	Time, Material & Man hour consuming Waste
Work not done as specified due to absentees of labour	2.17	Time, Man hour consuming Waste

Motion of employees with no Purpose	2.4	Time Waste
Other	Mean	Identified Waste
Lack of waste management plans	2.27	Time, Man hour consuming Waste
Stoppages due to natural hazards	2.37	Time Waste
Criminal waste due to damage or theft & vandalism	2.13	Material Waste
Lack of supervisions and delay in Inspections	2.17	Time Waste
Poor communication coordination between parties involved in the Project	2.2	Time, Material & Man hour consuming Waste

FRIEDMAN TEST

The Friedman test is a non-parametric statistical test developed by the U.S.economist Milton Friedman. Similar to the parametric repeated measures ANOVA, it is used to detect differences in treatments across multiple test attempts. The procedure involves ranking each row (or block) together, then considering the values of ranks by columns. Applicable to complete block designs, it is thus a special case of the Durbin test.

The Friedman test is used for one-way repeated measures analysis of variance by ranks. In its use of ranks it is similar to the Kruskal-Wallis one-way analysis of variance by ranks. Friedman test is widely supported by many statistical software packages.	Mean Rank	Ranking	Identified Waste
Imperfect planning of Materials like Over ordering or Under ordering.	23.67	1	Time, Materials & Man hour consuming Waste
Supplier's error like poorly executed price increases or Poor negotiation skills.	23.15	2	Time waste
Use of any material which is very low rated	22.27	3	Time waste
Human error (by craftsmen or other laborers)	21.57	4	Material, Man hour consuming waste
Lack of possibilities to order small quantities	21.1	5	Time, Materials & man hour consuming Waste
Use of incorrect material requiring replacement	20.78	6	Time Waste
Material damaging due to labor Mishandling	20.68	7	Time waste
Motion of employees with no Purpose	20.47	8	Time, Material waste
Stoppages due to natural hazards	20.47	8	Time, Materials & Man hour consuming waste
Choice of low quality products	20.23	9	Time waste
Accidents due to negligence	20.2	10	Time, Materials & Man hour consuming waste
Lack of coordination between the main contractor and subcontractor	19.22	11	Material waste
Lack of onsite material control	19.42	12	Time, Materials & Man hour consuming waste
Any changes made to the design while construction is in progress	19.28	13	Material waste
In appropriate storage facilities at site leading to damage or Deterioration	19.25	14	Material waste
Lack of coordination between the main contractor and	19.22	15	Time waste
Lack of waste management plans	19.07	16	Time, Materials & man hour consuming waste
Inadequate project definition and planning & poor project Communication	18.77	17	Time waste
Delay in receiving design documents and drawings	18.52	18	Man hour consuming waste
Unpacked material supply (handling, storage and atmospheric influences on construction site)	18.43	19	Time, materials & man hour consuming waste
Poor communication coordination between parties involved in the project	18.12	20	Time waste
Lack of supervisors and delay in inspections	18.12	21	Time, materials & man hour consuming

			waste
Lack of knowledge about construction among new workers	17.92	22	Time, materials & man hour consuming waste
Criminal waste due to damage or theft & vandalism	17.78	23	Time, materials & man hour consuming waste
Work not done as specified due to absentees of labor	17.6	24	Material waste
Material damage during transportation to site/ on site	17.5	25	Time waste
Rework due to error by management like frequent design changes or poor quality of Resources	17.1	26	Time, materials & man hour consuming waste
Lack of coordination among different crews	16.07	27	Time waste
Any error in contract document	15.68	28	Negligible
Designer have inexperience in method and sequence of construction	12.78	29	Negligible
Use of untrained/semiskilled manpower	12.8	30	Negligible
Required quantity of products unknown due to imperfect planning(for example concrete)	11.83	31	Negligible
Over mixing of material for wet trades due to a lack of knowledge of requirements	11.12	32	Negligible
Use of inappropriate tools/equipment	10.45	33	Negligible
Use of defected material	9.02	34	Negligible

V. CONCLUSION

In the first phase of the project, the literature review collection has been made. The scope and objective of the project work has been identified from the review of literature. The proposed methodology has also been derived. In the second phase (main project), the adopted methodology has been found. The questionnaire has been prepared by using the 3 point scale based on the literature review. Then the questionnaire survey has been conducted by using direct interview method and postal mail method. By using the qualitative method the percentage of waste has been identified based on the respondents of the companies. Then the collected data have been analyzed by using the SPSS software, Microsoft office Excel, and statistical method.

In this data analysis one sample test (ANOVA) and Friedman test have been conducted. The according to the result, the lean tools and Techniques (5stechniques, last planner, increased visualization, huddle meetings, first-run studies, just-in-time and fail-safe for quality) has been applied and suggestions were provided to implement the lean tool for reducing the wastes that generated during the progress of the project as well as increasing the profit of the project in the construction project.

FUTURE SCOPE OF THE PROJECT

Here I have done the part of work only. I have conducted the questionnaire survey in parts such as Vellore and also i have applied 5S methodology only. This may proceed further in National level by using another lean tool such as pull approach method, Pull Approach, Multifunctional Task Groups, Kaizen (Total Quality Improvement), Benchmarking, A3 Reports, Cellular Layout, Value Stream Mapping and Standard Operating Procedures (SOPs). Really it will be useful for construction industries for our country.

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