

IMPLEMENTATION OF LEAN SIX SIGMA IN CONSTRUCTION: A REVIEW

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Abstract- The Indian Construction industry is highly diversified in nature. Most of the Indian Contractors are not much aware about the potential demands and hence the projects are always effected by low quality and cost-overruns. Occurrences of wastes in construction sites is one of the problems that we are facing. Introduction of Lean concepts have provided an opportunity to address the existing problems in the construction sector. They are many non-value-adding activities in construction sector that cause loss of quality and profits in quantitative or qualitative terms. In this paper, Lean Six Sigma concept is 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. The integration of lean principles with Six Sigma methodology is a coherent approach for continuous improvement, and it provides a conceptual method for their successful integration. The overall results of this study indicate that the implementation of lean Six Sigma in construction context will be achieved its aim by reducing the defects.

Keywords: Lean construction; Lean principle; Non-Value-Adding-Activities; Lean Six sigma; waste minimization, etc.,

I.INTRODUCTION

India is one of the most developing country in this world. The construction industry in India is gaining various achievements. Construction management and technology are the two key factors prompting the development of the construction industry. The construction industry has been suffering from low productivity and poor performance as compared to other industries. During the construction project, certain causes leads to delay in construction activities. There are a lot of wastes in construction processes, which were left unnoticed. In order to improve its performance, industrial experts and researchers have looked at the manufacturing industry as a point of reference and a source of innovation. And they have introduced the concept of Lean Technologies. Lean construction is about designing and operating the right process. Lean construction results from the application of new form of production management to construction. Lean manufacturing is about controlling the resources in accordance with the customer needs and to reduce unnecessary waste with non-value added activities (including the waste of time). It is about the elimination of waste activities and processes that absorb resources and does not create no any value. The primary focus is to identifying the waste within it, and eliminating it step by step. The two of the most popular continuous improvement tools are six sigma and lean management. Both have evolved into comprehensive management system which clarify in lean six sigma methodology such as a prominence on customer satisfaction, high quality, and comprehensive employee

training and empowerment. Lean construction is a systematic approach to reducing the costs by cutting waste, by the engaging people and organizing the work place to be more efficient. And the main target of lean thinking seven forms of waste has been identified. They are over production, Unnecessary inventory, Inappropriate processing, Waiting and Unnecessary motion. In this paper, I have tried to improve the whole construction work of a building by using DMAIC methodology. Datas are collected and analyzed by using a MATLAB software. Finally, the problems are evaluated and solutions have been recommended to construction companies.

II. LEAN CONCEPT

Lean is a systematic method for the elimination of waste. Lean also take into account waste created through unevenness in workload. Lean is the set of tools that is used for the 3 identification and steady elimination of waste. As waste is eliminate quality improves and it turns to reduce the production times and cost. This is fundamentally a different approach for most of the improvement methodologies and requires considerably more persistence than basic application tools, which may account for its lack of property. Lean can be introduced in the fields of manufacturing, management, production, construction, etc., Lean techniques include a variety of tools, strategies and technologies. Benefits of lean concepts are improved quality, eliminate waste, reduce time, reduce total cost, improve employee morale, ensures a safer. **Richard Hannis Ansah [1]** In this paper, the conceptual models of construction management and the tools have been criticized. The need for practical and robust models techniques that will help project teams to deal with the issues of wastes in projects are needed. In this paper, LC approach and the importance has been discussed. A very high level of wastes/non-value added activities exist in the construction industry which represent production cost. Lean construction aims at reducing the wastes in workflow. And also, the application of lean tools and techniques will minimize or

eliminate waste, improve performance and lead to a great cost savings. It is expected that this paper will contribute to the knowledge and practice from delay control or waste elimination and also serve as a benchmark for continuous improvements. **Mohammed Abu Zaiter [2]** This paper Investigates the implementation of lean tools in construction project and its impact on safety conditions in the Gaza Strip. A questionnaire survey was undertaken with contractors and clients in order to express their attitudes on the implementation of lean tools in construction projects. It was found that there is a significant weakness in the knowledge about the construction projects and there is very limited amount of information about lean construction tools. Training will be a key aspect of implementation and success of the lean construction techniques. This training result in an increased burden in early stages of implementation but over all, it will serve to increase the efficiency and safety level of construction companies. The analysis and discussion presented in this paper provides theoretical and empirical reasoning.

Harish Babu S [3] This study aims to provide a better understanding of the Last Planner System (LPS) which is a Lean Construction concept used for analyzing the various schedule systems involved. This paper focuses on implementing Last Planner System in residential construction. The data is collected from few respondents through questionnaire survey. The results were analyzed using the software Statistical Package for Social Sciences (SPSS). The survey is conducted from each company that differs from the technique they implement regarding the results were obtained using SPSS software, initially for the survey work carried out in many companies were asked mainly regarding the method of construction they follow. From the result or answers obtained from the companies a data sheet is made using SPSS software. The main challenge associated with implementing the LPS is to ensure that the work identity of employees alters. **Okpala Kenneth Enoch [4]** This paper reveals the influence of LSS on the profitability of MSMEs in Nigeria. The population of the study comprises of 450 manufacturing SMEs

with 2250 employees. Questionnaires are prepared and the result obtained shows that LSS implementation among MSMEs in Nigeria. The study concluded that the LSS manufacturing should undertake training on quality improvement and to provide a strong leadership. LSS consultants should be employed to help them improve the quality improvement; MSMEs should focus on the factors to reduce the effect on the LSS implementation. There was a difficulty experienced in measuring and quantifying the benefits flowing from LSS implementation in Europe. **Sherif Mohamed Hafez [5]** The purpose of this paper is to improve the productivity of the construction industry by using lean construction. Lean construction Emerges from the application of production management to construction. The features of lean construction include the delivery process for maximizing performance at the project level, concurrent design. Lean construction projects are very much easier to manage, safer, completed sooner, and cost less and are of better quality. This paper discussed the principles, methods, and implementation of lean construction phases showing the construction wastes and their elimination. The paper discusses the implications and argues the different perspectives that lead to different improvement approaches. A dynamic model of performance improvement process is proposed. **P. Ghoddousi [6]** The aim of this paper is to test the applicability of lean principles using discrete-event simulation. Here, the tool used is ARENA. It is concluded that the simulation can be applied for testing the lean concepts. In this paper, for simulating the construction process, it follows six steps. First, the process flow, detailed tasks, sequences and linkages were identified. In the second step, data were collected. Third, the model was constructed using computer simulation. Fourth, developed model was subjected to comparison between model and actual outputs. Fifth, selected lean principles applied to the model. And in the final step, the contrast between the outputs of the base-line and lean process was done. The lean techniques applying to a construction process can have different results. Some of the steps are Simplification, just-in-time delivery of materials and

optimized utilization of labors and crews. Finally, it should be concluded, that the construction operations have highly optimizing through application of lean principles. **Chen Wang [7]** The purpose of this paper is to improve the performance, at the manufacturing industry as a reference point and a source of innovation. The basic principle is identifying and eliminating the wastes in construction process rather than reduction of construction material waste. This paper aims to expose and recommend the application of lean principles to improve the Malaysian construction performance. The successfulness of lean principles in improving performance was due to its concept of optimizing and eliminating wastes. Wastes mentioned in this paper are identified by Taiichi Ohno as the seven deadly wastes in production.

III.SIX SIGMA CONCEPT

Six sigma is a set of techniques and tools for improvement. It was introduced by engineer Bill Smith while working at Motorola in 1986. It seeks to improve the quality of the output of a process by identifying and minimizing variability in manufacturing and business process. It uses a set of quality management methods, such as empirical, statistical methods and creates a special improvement methods within the organization, who are the experts in these methods. Each six Sigma project carries out within an organization follow a defined sequence of steps and has specific value targets. Six sigma enables the organization to improve their process by making them more capable for delivering what the customer wants at right time. The resulting benefits are greater productivity, improved quality, reduced cycle times, less firefighting, smoother operation, reduced operating cost. **B S Deore[8]** The critical objective of this paper is to complete a project within a stipulated time and cost through minimization of waste. Most of the construction companies face poor client satisfaction due to noncompletion of the work as per the required standards and specifications. Six sigma refers to the minimization of variations through proper work flow maintenance and it leads to improve the performance of the

contractors in terms of cost and quality by increasing the value of the products. It ensures that construction processes become leaner and cost reduceable by increasing value. **Karin Schon [9]** The aim of this paper is to present a study of how Six Sigma influences job satisfaction. Design/methodology/approach – The study was performed by a survey distributed to those companies affected by the implementation of Six Sigma. The largest changes are related to personal and new skill development, influence on work duties and enjoying the work. Research limitations/implications – The results constitute a platform and job satisfaction–The paper fills a knowledge gap for future, concerning the effect of Six Sigma on employees’ wellbeing and job satisfaction.

IV.SIX SIGMA PROCESS

Six Sigma project follows two project methodologies, composed of 5 phases in each. They are DMAIC and DMADV. DMAIC is used for the projects which is aimed at improving the existing business process. DMADV is used for the projects which aimed at creating new product or process designs. The 5 phases of DMAIC project methodology are define the system, measure, key concepts, analyze the data to investigate, improve or optimization of current process and finally control the future state process. The 5 phases of DMADV project methodology includes Define design goals, Measure and identify CTQS, analyze to develop and design alternatives, design an improved alternative and finally verify the design. **Thomas Gachie [10]** Purpose-This paper reveals a case study of application of Six Sigma methodology within operation Department in National Bank. The main goal of this paper was to establish the Lean Six Sigma and its impact on operation efficiency. Datas were gathered through a questionnaire via email. These datas were analyzed and finally concluded that, positive factors that emerged due to Lean Six Sigma Implementation include positive change in operation culture, process, leadership, commitment, error reduction, etc. **Adebayo Akanbi [11]** This paper presents a detailed study on

the results of questionnaire survey among construction participants on implementing lean construction techniques in construction industry. The data collected were analyzed with SPSS 19.0 version software. This study also identified waste reduction, environmental management, value maximization, and health and safety improvement among others. **Ahmed Mousa [12]** This paper includes the elements to eliminate wastes and to improve flow in the value stream. It’s about doing things quickly and defect free. Six Sigma uses a powerful framework (DMAIC) and tools to uncover the root causes to understand and reduce variation. A combination of both solve problems and create rapid transformational improvement at lower cost

V.LEAN SIX SIGMA CONCEPTS

Using more problems solving techniques can help solve a larger number and variety of business problems. Starting in 1980’s, consultants trained in both techniques such as lean and Six Sigma. The different tools of Six Sigma focus on improving quality and Lean focused on removing waste, together, it’s a combined management approach, the benefits of Lean Six Sigma include cost reduction, value addition, reduction in process variation, customer satisfaction, financial performance learning, etc. **Shahrul Kamaruddin [13]** This paper is about implementation of new Lean Six Sigma (LSS) concept . Lean tools added during the analysis phase of the initiatives and Six Sigma is used to reduce and then eliminate the variation found. The LSS framework in this paper is focused towards SME, particularly in the label printing industry. The development of the framework depends on the environment of the particular company in which it belongs. The LSS framework is used in problem identification, providing suitable solutions to solve problem(s) and controlling the improvement made. This method emphasizes on problems derived and the solutions. This paper concludes that, the adoption of the LSS framework has provided a systematic and guided approach help to identify the problem and to provide a feasible solution and sustain the improvement

made. **Sanjay Kumar [14]** 'Reduction of waste' is the key theme of 'lean' concept implementation in manufacturing process and some extent in service sectors also; however, 'six-sigma' concept implementation focusses on 'quality improvement techniques' in production and delivery of products and services. 'Lean six-sigma' concept combines tools and techniques of 'lean' and 'six-sigma' to achieve improved benefits. Implementation of LSS concept helps to identify, analyze and ranking the decision making authorities. Analytical hierarchy process (AHP) has been used to rank identified LSS enablers from the experts' opinions. Decision making authorities are benefitted in dealing with planning and implementation of 'lean six-sigma' concept in manufacturing and service sectors. **M.P.J. Pepper [15]** The purpose of this paper is to examine the Lean principles with Six Sigma Methodology and provide a model for successful integration. Identification of value added and non-value added activities was the first step. It is done by using Value stream mapping and it acted as a qualitative analysis tool. Finding the opportunities for improvement was the aim of integrating lean and six Sigma. Finally, they have concluded that, if the two methods such as Lean and Six Sigma are fused together, it acts as a powerful tool for improvement.

VI.DMAIC PROCESS

It is the science of studying how research is to be carried out. It describes the work plan of the research. In order to determine the lean Six Sigma factors, an overview of literature collected from various journals. The most relevant journals related to the topic are reviewed. After literature review, the next step is to identify the problems to be solved and the causes due to which the problems are occurred. To get, the details about the factors affecting the implementation of lean Sigma concepts, a detailed questionnaire has to be structured and data should be collected from site supervisors, contractors, and workers through direct meeting, telephone and through emails. The data are collected are analyzed using a software and the data are ranked according to their priority obtained

from software. After analyzing, the data are evaluated by using Six Sigma approach, the methodology used for evaluating is DMAIC in which the problem identified is Defined, Measured, Analyzed, Improved, and controlled. In this paper, clear idea about the problem is analyzed and a solution is obtained. This method is a complex and maintaining and maximizing the success of process. The next step is to evaluate and conclude whether the problem has been solved in an improved, quality, by using Six Sigma, successfully implemented solution are further recommended. Prevention and recommendation measures should be provided for each and every problem that is being analyzed. This methodology is expected to achieve the benefits of cost reduction, reduction in process variation, customer satisfaction, financial performance, waste elimination and so on.

VII.CONCLUSION

The overall results of this study indicate that the application of lean Six Sigma concepts in construction reduce the defects and increase the value. Lean Six Sigma framework is used for problem identification, providing suitable solutions to solve problem and controlling the improvement made. And it is hoped that, Implementation of Six Sigma methodology leads to process improvement and enhance the reduction in wastes. If the two methods such as Lean and Six Sigma are fused together, it acts as a powerful tool for improvement of construction process.

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