A Study of Implementing Lean Six Sigma in Construction Industry

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Abstract: In India, the construction industry is one of the largest industries after agriculture industry. It produces a large quantity of waste and consumes more resources, that makes construction a troubling task. The application of a new technology, Lean Six Sigma concept is likely to be effective for improving the efficiency of construction industry. It aims to eliminate all defects and also to minimize the wastage of materials, time and effort inorder to generate the maximum possible amount of value. The aim of this study is to evaluate Lean six sigma as a process improvement method to improve the construction processes by understanding and analyzing the factors affecting the formation of construction wastes. In this paper, it is tried to improve the whole construction process by using Six Sigma DMAIC methodology. Datas are collected from the Respondents and by using SPSS software the collected datas are analyzed. The expected results of the study is the reduction of defects and minimization of wastes by the implementation of Lean six sigma in construction industry.

1. Introduction

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 a technique which aims to eliminate all defects and minimize wastage of materials, time and effort inorder to generate the maximum possible amount of value by using less input. Less inputs includes: less labour, 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 set of 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.

1.1 Objective of the Study

The Objective of this study is;

- To reduce the wastes in construction and to harmonize the non-value added activities through lean principles.
- To identify and analyze the defects in construction using Lean six sigma approach and SPSS software.
- 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, promote concurrent work and to improve planning and control.
- DMAIC, the Six Sigma Concept can be used as an improvement process to address the individual problems that have occurred or can be used for preventive actions.

2. Non-Value Added Activities

Activities that consumes time, resource or space, but do not add value to the process are generally known as non-value added activities. The Value loss occur due to: Poor Quality of works, Improper Constructability, Poor Material management, Non-productive time, Safety issues. They are pure wastes which should be eliminated completely and involve unnecessary actions. The seven lean wastes considered in this research are; Excessive Transportation, Unnecessary Inventory, Unnecessary Motion, Waiting, Over production, Over processing, Defects.

3. Literature Review

A literature review is a detailed report of information obtained from the literature that are related to our topic of study. The review describe, summarize, evaluate and clarify this literature. It gives a base for the research and helps in
Determining the nature of the study. This section represents the review of literature collected from various journals and articles that are most relevant to the study.

**Ahmed Mousa [1]:** This paper explains the elements to eliminate wastes and to improve flow in the value stream. Six Sigma uses a powerful framework (DMAIC) and tools to uncover the root causes to understand and reduce variation. It is about doing things defect free. A combination of both lean and six sigma, solves problems and creates rapid transformational improvement at lower cost.

**Thomas Gachie [2]:** This paper is a case study of application of Six Sigma methodology within operation Department in National Bank. The main goal of this project was to establish the Implementation of stage of Lean Six Sigma and its impact on operation efficiency. Datas were gathered through a questionnaire via email. These data’s 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.

**Sunil V. Desale [3]:** The objective of this paper is to complete a project within a designated time and cost through standardization of the process, waste minimization, and efficient use of resources by using techniques like six sigma. Most of the clients are unsatisfied due to non-completion of the work. Six sigma assign to the minimization of variation by maintaining proper work flow and thereby to performance improvement. Leaner and cost competitive construction processes has been ensured.

**Sanjay Kumar [4]:** This paper says that ‘Reduction of waste’ is the main theme of implementing ‘lean’ concept in manufacturing, process and service sectors of industries. The concept of ‘six-sigma’ focusses on improvement in production and delivery of products. By combining Lean and six-sigma improved benefits had been achieved. The concept of Lean six sigma helps in identifying, analyzing and ranking that helps in formulating policies and also making decisions related to planning. Analytical hierarchy process (AHP) has been used to rank identified LSS from the experts’ opinions. Decision making authorities are benefitted in dealing with planning and implementation of the concept of ‘lean six-sigma’.

**Xiaoning Zhu Dongling [5]:** This paper reviews the published literature related to lean six sigma from beginning to date. It involves the study of 116 papers related to Lean six sigma. The paper includes the details from different aspects such as implementation of Lean six sigma, Focus Area, country focussed, Year Wise Publications etc. The review of various literature helped in finding that Lean Six Sigma has been implemented effectively in various industries including the Health industry. Research on LSS is conducted on elementary stage.

**M.P.J. Pepper [6]:** Although many research has been carried out on the implementation of lean within various industries, its integration with Six Sigma leads to the integration of the two management approaches. This paper aims at evaluating the integration of lean principles with Six Sigma methodology as a comprehensive approach for continuous improvement, and provides a theoretical model for their successful integration. Research and a literature review of each separate approach is provided, and follows a view on the literature of the unified approach. It was finally found that no standard framework for lean Six Sigma or its implementation exists till that. There was a need of adopting a systematic approach, which optimises systems as a whole, focusing the right actions at the correct places. This paper provides an insight into the evolution of the lean Six Sigma archetype. It is suggested that a clear combination of the two approaches must be achieved, with sufficient scientific support.

**S. Sriman [7]:** This paper depicts the implementation of Six Sigma concepts in Construction project to achieve the customer satisfaction. The objective of construction industries nowadays is to complete a project within a designated time and cost according to the required standards and specifications. Reducing the waste and efficient use of resources. The principles of Six Sigma with an effective methodology in construction industry accentuates on reducing variation and eliminating the causes of defects. The paper explains the basic theory of Six Sigma, Six Sigma principles, DMAIC methodology and tools used in each stage of DMAIC methodology. A case study was conducted in a residential building in which Six Sigma principles were applied for preventing the problems in internal finishing work. A defect valuation sheet has been prepared and the level of the process has been found. DMAIC methodology has been applied to improve the quality of the existing process by analyzing the defects, their percentage of existence, the causes and effect of defects and recommendations to overthrow them. The findings suggests that proper training, management support and minor changes are required to improve the quality and also for enhancing the customer satisfaction.

**Mehmet Tolga Taner [8]:** This paper aims to identify the Factors for the successful application of Six Sigma in large-scale construction companies in
Turkey. In this, in order to identify and understand the current quality practices, a survey based approach is used. The factors are identified and analyzed. Involvement and commitment of top management, teamwork and commitment of middle managers were found to be the most important Critical Factors for the construction companies to introduce Six Sigma, whereas lack of knowledge of the system to initiate and sense of security inhibits its implementation. High costs and large amount of waste are found to lower the performance of the companies.

Mohamed K. Hassan [9]: This study was conducted in a welding wire manufacturing plant to improve the quality, reducing the manufacturing waste and increasing the yield of the manufacturing process, by applying the Lean Six Sigma (LSS) methodology. The objective of this study was to use a systematic method in judging the impact of the causes of waste on the amount of waste to upgrade the effectiveness and facilitate some comfort of use in the practical field. LSS is treated as one of the successful accesss in improving the quality and reduction of cost. The plant working environment was analyzed to detach the causes for the waste propogation. Remedies and converse measures were suggested and some were applied. The performance of the plant before and after implementation of the desired actions for waste minimization was compared in this study. Improvements in the level of yield, decrease in waste, decreased defects Per Million Opportunities (DPMO), and sigma levels were found to be obtained. The LSS concept was associated to the Analytic Hierarchy Process (AHP) to compute the causes of waste.

Shahrul Kamaruddin [10]: This paper is about the application of new Lean Six Sigma (LSS) concept during the analysis phase of the action and here Six Sigma is used to reduce and then eliminate the alteration. The LSS structure in this paper is concentrated towards SME, specifically in the label printing industry. The LSS methodology is used in identifying problem, providing appropriate actions to solve problem(s) and controlling the enhancement made. It is concluded that, the adoption of the LSS structure has provided a systematic and managed approach and also helps in identifying the problem and to provide a achievable solution and preserve the improvement made.

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.

Karin Schon[12]: The aim of this paper is to present a study of how Six Sigma influences job satisfaction. The study was performed by a survey distributed to those companies affected by the implementation of Six Sigma. The changes are related to particular and new skill advancement, influence on works and enjoying the work. The results constitute a platform and job satisfaction.

4. Methodology

Research methodology is a standardized way to find out the result on the research problem. It is a science of studying how a research is to be conducted and depicts the work plan of the research.

4.1 Research Methodology

4.1.1 Problem Identification

A problem arise 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 behaviour. 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
4.1.2. Preparing Questionnaire

A questionnaire is an analyzing instrument consisting of a set of questions for the purpose of collecting information from the respondents. They are designed for statistical analysis of the responses. Questionnaires must be prepared such that the respondents must be capable of reading the questions and answer to them.

The design of questionnaire is one of the essential parts in this study to know about the awareness of people in the construction field in lean concepts. In this thesis, the questionnaire survey consists of two parts. The first part consist of general details like the type of company, experience, value of the project etc and the second part consist of factors affecting the implementation of lean six sigma in construction industry.

The questionnaire for this project survey is formulated by referring the relevant literature in the area of Lean six sigma. The survey is done by direct interview with the key personnel of contractor and engineers. It is done through asking open ended questions. The results from this stage is used mainly to get some ideas related to the identified problems. After preliminary data gathering, questionnaire survey is to be conducted to achieve the objective of this study on construction works based on six sigma concepts involved in construction projects. Questionnaire survey definitely has been used for evaluation of various results obtained. The data which is collected is analyzed with an objective of checking data and reducing the defects and delays by implementing Lean Six Sigma.

Analysis was employed using four point Likert scale and the weight is given as below:

1 – Strongly Agree
2 – Agree
3 – Disagree
4 – Strongly Disagree

4.1.3 Analysis Using Software

Statistical Package for Social sciences is a software used for executing analysis in social sciences. It is also used by market, education and health researchers and also various organizations. The ‘Data View’ shows a spreadsheet using rows and columns. The following table shows the mean, Standard deviation and rank of the major seven lean wastes. These values are obtained as a result of the responses obtained from the Respondents of 30 Construction companies and the obtained datas are analysed and ranked using the software.

<table>
<thead>
<tr>
<th>Sources of waste</th>
<th>Mean</th>
<th>Std deviation</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Production</td>
<td>2.50</td>
<td>1.008</td>
<td>3</td>
</tr>
<tr>
<td>Waiting</td>
<td>2.27</td>
<td>1.048</td>
<td>7</td>
</tr>
<tr>
<td>Transportation</td>
<td>2.37</td>
<td>1.098</td>
<td>5</td>
</tr>
<tr>
<td>Processing</td>
<td>2.63</td>
<td>1.159</td>
<td>1</td>
</tr>
<tr>
<td>Inventory</td>
<td>2.40</td>
<td>1.133</td>
<td>4</td>
</tr>
<tr>
<td>Movement</td>
<td>2.30</td>
<td>1.119</td>
<td>6</td>
</tr>
<tr>
<td>Making defective Product</td>
<td>2.50</td>
<td>1.167</td>
<td>2</td>
</tr>
</tbody>
</table>

5. Results And Discussion

This section represents the data analysis and discussions based on the questionnaire survey. The collected data are analyzed by using the SPSS software. The objective of conducting the analysis for this section is to establish the factors for the causes identified from the literature review and the
ranking them according to their influence in construction project. The main aim of this thesis is to eliminate all defects by using less input. Less input includes; less labour, machinery, space and time by reducing the number of activities and flows in making a process. The end result shows:

- A reduced proportion of non-value added activities
- Less variability in quality
- Fewer steps, stages and linkages in the flow patterns
- Quicker construction cycles
- Balance in flows

5.1. Pie Chart Obtained Based on SPSS Report

Figure 2: Analysis of Inventory

Figure 3: Analysis of Processing

Figure 4: Analysis of Waiting Time

Figure 5: Analysis of Transportation Time

Figure 6: Analysis of Over production
Lean Six sigma is the combination of two management concepts lean and six sigma into one methodology, that is being integrated for improving overall performance and to maximize the positive facets. The most important characteristic of this new methodology is that it consolidates the speed increasing and waste reducing philosophy and statistical approach to process improvement of Lean and the quality standard from Six Sigma.

Six Sigma is a combination of various systems and means for process enhancement. It seeks to improve the quality by identifying and removing the causes of defects and minimizing the deviation in manufacturing and construction processes. Each Six Sigma project follows a specified sequence of steps and has specific value points, such as reduction in process cycle time, pollution, costs, increased customer satisfaction and profits. Six Sigma projects follow two major project methodologies similar to Plan-Do-Check-Act Cycle. Each methodologies, composed of five phases each. They are; DMAIC and DMADV.

6. Lean Six Sigma Approach

There is another methodology called DFSS - Design For Lean six sigma, which is a quality scenario for designing or redesigning a process from the ground up. In some cases, a DMAIC project may change into a DFSS project for further enhancement of process. In this research, DMAIC Methodology is used as a solution for minimizing the wastes.

6.1. Benefits Of Lean Six Sigma

The major benefits of Lean Six Sigma includes:Sustained success

- Sets a performance goal for everyone
- Enhances value to customers
- Increases the rate of improvement
- Executes strategic change

6.2 DMAIC Methodology

DMAIC in the Six Sigma methodology is being used as the definitive for planning and application of the project and for improving the process. This methodology abide of five steps.

Define --> Measure --> Analyze --> Improve --> Control

- Define : The problem that needs to be advised is determined
- Measure : Measure the problem and process from which it was developed.
- Analyze : Analyzing the data and process to determine root causes of defects.
- Improve : Improve the process by analyze actions to decide, decline and Prevent forthcoming problems
- Control : Implement, control, and preserve the actions to improve the processes.
7. Conclusion

The basic idea of lean six sigma is that if performance is enhanced, quality, capacity, cycle time, inventory levels, and other key factors such as reduction waste, energy sources and environment will also enhanced. 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. The suggested actions will be acknowledged and the improvement activities are carried out by using Lean Six Sigma approach.

In this thesis, after the completion of the entire works, the following benefits will be obtained: Use replacement, Reduce or recycle, Eliminate the unnecessary things, Doing different tasks at the same time, Easy work flow, Develop collaboration, Introduce cross training, enhance the level of inspection, concentrate on preventive maintenance of tools and equipment, Institutionalize, Develop accident plans, Reduce the number of components, present job site displays to publicize project information, Remove negotiator.

8. Acknowledgement

On the very beginning of this paper, I would like to prolong my sincere & heartfelt responsibility towards all the personalities who have helped me in the completion of this undertaking. Without their active guidance, help, cooperation & encouragement, I would not have completed this paper.

9. References


