

# International Journal of Innovative Research in Science, Engineering and Technology

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## Application of Six Sigma in Construction

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**ABSTRACT:** The importance of quality improvement and excellent performance in the highly competitive world market, lead many organizations, their top managers, project managers, and engineers to implement the new philosophies such as pull scheduling and lean principle at their organizations. This paper describes the Six Sigma principle and framework as a quality improvement strategy through the successful business. In this paper we proposed the Six Sigma is a statistical methodology that provides a structured framework to organize and implement strategic process improvement initiatives to attain reductions in process variability or defects. The basic theory of six sigma, DMAIC (Define, Measure, Analyze, Improve & Control) methodology is been discussed in this paper. A case study on a commercial building was conducted to which six sigma principles were applied for few internal finishing works: Brickwork, Plastering, flooring and Painting. A defect assessment sheet has been prepared to compute the process sigma level of the existing practice of work and after applying DMAIC (Brickwork, Flooring and Painting). The improvement is presented in terms of process sigma and standard deviation. The purpose of this study is to analyze Six Sigma within construction context and evaluate its features through Literature Review and Interviews with case study. This thesis aims at understanding the needs of construction industry from process improvement perspective and matches these needs with the expected outcomes of Six Sigma.

### I. INTRODUCTION

Construction management and technology are the two key factors influencing the development of the construction industry. The productivity of the construction industry worldwide has been declining over the past 40 years. One approach for improving the process is using Six Sigma concepts in construction. Six Sigma is a quality improvement technique based on statistics was used firstly by Motorola in 1980s by Bill Smith of Motorola to decrease cost, increase quality by improving process and reduce the production time. It received little publicity until late 1990s. Six Sigma results the application of a new form of management technique to construction. Essential features of Six Sigma 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, Six Sigma-based tools have emerged and have been successfully applied to simple and complex construction projects. In general, six sigma projects are easier to manage, safer, completed sooner, and cost less and are of better quality. Sigma within construction context becomes an interesting research question considering quality, performance and management aspects.

Six Sigma is a quantitative approach for improvement with the goal of limiting defects from any process, specially a numerical goal of 3.4 defects per million opportunities (DPMO). Six Sigma is reportedly easier to apply than many other quality management programs because it provides information about the change needed and the programs to execute the change. The strategy it uses is a five step improvement process: Define Measure, Analyze, Improve and Control (DMAIC). This process is deeply integrated with the overall goals of the organization and as such, requires top down implementation. The project work is carried out to study the analysis of Six Sigma within construction context and evaluate its features through Literature Review and Interviews with case study. After the evaluation of interviews with contractor, site-supervisor, occupants and visual observations, defects and their reasons were determined. Reasons of poor quality in commercial units were listed as firstly poor workmanship, then improper or of poor quality material

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usage and lastly problems in design of detailing. Despite different construction dates of units studied, the results show that nothing was learned from the previous mistakes and same defects were repeated. This shows the importance of a system providing feedback and evaluation of quality level of a construction project and quality improvement efforts of the contractor, and measuring the progress over time like Six Sigma.

## II. LITERATURE SURVEY

According to Sneha P. Sawant and Smita V. Pataskar [1] suggested that, Six Sigma is a Quality improvement technique that has been implemented in manufacturing and other industries. Six sigma is new to construction industry. This paper describes the basic theory of Six Sigma, principles, methodology and various tools used. A case study of a residential building is taken in which the Six Sigma principles are applied for internal finishing work, the Six Sigma methodology has been adopted to improve the quality and is checked against the sigma level. The findings suggest that proper training and management support and minor changes in current work procedure can help improve the quality and ultimately customer satisfaction which is of prime importance.

Sunil v. Desale and Dr. S. V. Deodhar [2] The authors suggested that, This paper comprises of literature review and discussing process improvement methods used in the construction industry and analysis of features and principles of six sigma and there in to review of a project manager, a field and a cost engineers on the same. The interview on Six Sigma is based on quality, performance and management aspects. This study defends and removes any doubt about the positive effects of Six Sigma on construction projects. Particularly, Six Sigma can provide a broader quality concept, detailed performance measurement, and coordination in repetitive process is and performance improvement. It has produced quality improvements directly/indirectly with positive increase in production efficiency.

According to [3] the objective of this research paper is to investigate how Lean and Six Sigma methodologies are implemented together on construction projects through a case study and to measure the process capability index (Cp) to measure the performance of Six Sigma efforts.

Some of the conclusions drawn from the literature review and case studies, and can be summarized as follows;

1. Both Six Sigma and Lean are strong production management tools and the combination complements each other. Lean in principle eliminates anything that doesn't add value to the customer and achieves reliable workflow. On the other hand Six Sigma aims to control and reduce the variations by understanding the root cause.
2. The complexity of the construction project has its own unique and uncertain environments, which made the use of Lean Six Sigma methodology somehow different from the other industries, especially manufacturing.
3. The methodology of Lean Six Sigma was effective in reducing variability of daily panel production rate. However, taking into account inherited uncertainty in construction processes, the value of Cp can be applied flexibly to construction processes.

In system [4] D. Lade, A. S. Nair, P. G. Chaudhary, N. R. Gupta aims that, there has been a steep rise in the production of Ready Mix Concrete (RMC) in India due to ever increasing demand of concrete from the infrastructure as well as the real estate sector. It has become a great challenge for the RMC manufacturers to supply consistent level of quality of concrete to the customers. In this study, the quality performance of an RMC plant at Mumbai, India, using the Six Sigma philosophy has been evaluated by using various quality tools. The existing sigma level of the process has been found to be 1.23, which is very less than the manufacturing industry and RMC production process has been found neither stable nor capable. Some recommendations for process improvement and conclusions based on the observations of the present study are also presented at the end.

Thanveer M. Beary, Tariq S. Abdelhamid [5] proposes a Lean Construction and Six-Sigma based assessment framework for the production planning process in the homebuilding industry which will assist in finding improvement opportunities in the production planning process. The framework can also be modified and used to assess and improve other construction industry sectors. Six Sigma and Lean Construction are both powerful tools. Lean Construction aims at creating a standard process by eliminating waste or unnecessary work and Six Sigma aims at reducing variability in a process using scientific methods to identify areas that are root causes for the variability. This study developed this idea further by applying the power of both tools to production planning process in residential construction. Both Lean Construction and Six Sigma were used in conjunction to develop a Production Planning Model. The aim was to develop a system that helps in identifying defects in a construction production process, eliminating it and thus creating a zero-defect process. Continuous improvement of the process is also important to keep the process in control and make it efficient.

According to Muharrem Firat Yilmaz [6] This thesis includes Literature Review and three interviews. Literature Review had discussed process improvement methods used in construction industry and analyzed the basic features and principles of Six Sigma. Three interviews were conducted about the basic principles of Six Sigma and Quality Concept. Interviewees are a Project Manager, Field and Cost Engineer. The approach of the interview to Six Sigma is based on quality, performance and management aspects. This study defends that there is no doubt about the positive effects of Six Sigma on construction projects. Particularly, Six Sigma can provide a broader quality concept, detailed performance measurement, coordinated and repeatable process/performance

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improvement. It has increased quality directly/indirectly and has positive effects on production efficiency. Since construction industry includes lots of unrepeatable tasks and different process design techniques, Six Sigma does not seem applicable as a whole management approach in construction industry. Furthermore, it can be integrated to the existing management procedures of companies. Taking everything into consideration, it is obvious that Six Sigma has a lot in order to accelerate fundamental and cultural challenges construction industry needs.

### III. METHODOLOGY

The basic idea of the concerned study focuses or deals with the thorough study and understanding of the literature survey and understanding the current status or practices in construction and as to how the application of Six sigma can result into a development of a process in projects which will be efficient, safer to manage, completed sooner and of better quality. Sigma within construction context becomes an interesting research question considering quality, performance and management aspects. Recently, many organizations have attempted to achieve customer satisfaction. One of the most important aspects of customer satisfaction is achieved through a high quality product, which also means a low defect product. Traditionally, defects include products containing a flaw in the manufacturing process, customer dissatisfaction in the service department, or documentation errors in an office. It has proven its best results in various fields specifically in manufacturing and recognizes that business quality is highest when the costs of delivering products and services to meet the customer's requirements at the absolute lowest for both the producer and purchaser. The following flow chart gives the details of work carried out with the sequence of activities from start to end of the work.

### IV. PROJECT FLOW

In order to reach a result of this evaluation several sub research questions will be answered theoretically and empirically. The following flowchart gives the detail work carried out with the sequence of the activities from starting to the end of the work.

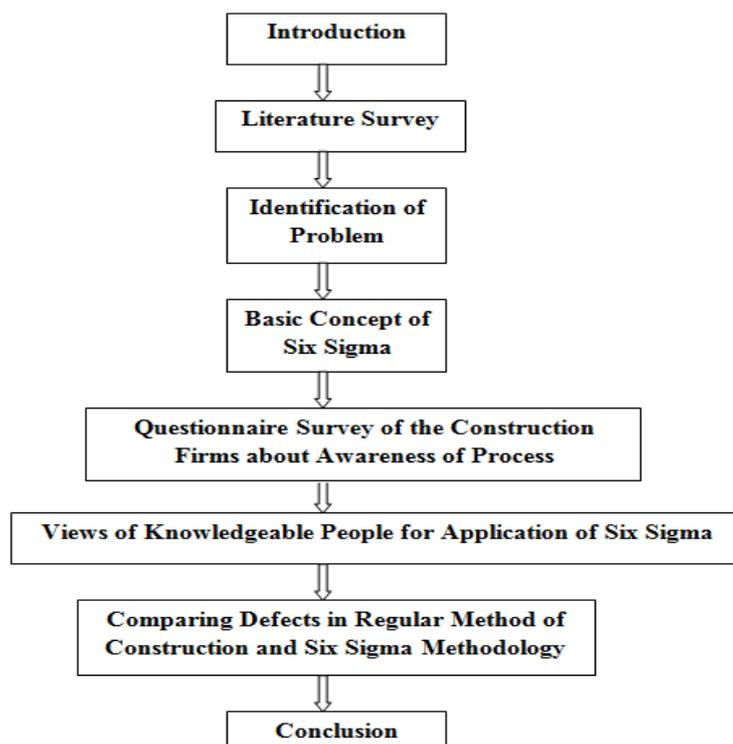


Figure 1: Project Methodology flow chart

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## Work Procedure

- i. Finding out the exact problems of construction industries in market.
- ii. Define the problems.
- iii. Interviews of people within construction context to know the need of process improvement (i.e. Six Sigma).
- iv. Case study on applying DMAIC technique of Six Sigma methodology to internal finishing work of a Building (Two buildings, Building A with regular method of Internal finishing and Building B applying DMAIC technique for Internal finishing)-The evaluation of process sigma level and sigma level in terms of standard deviation based on results obtained from the case study was carried out.
- v. Correlating/ analyzing the existing practices with refined/ modified practices.
- vi. Conclusion.

## Research Statement

Six Sigma principle is a statistics-based methodology that relies on the scientific methods to make significant reductions in customer-defined defect rates in an effort to eliminate defects from every product, process, and transaction. Increasing number of companies start to integrate the full implications of Six-Sigma. It has proven its best results in various fields specifically in manufacturing and recognizes that business quality is highest when the costs of delivering products and services to meet the customer's requirements at the absolute lowest for both the producer and purchaser. Six-Sigma is therefore developed as a business strategy and philosophy built around the concept that companies can gain a competitive edge and stay ahead of the competition around by reducing defects in their industrial and commercial processes. So various construction industries are applying Six-Sigma for their process improvement and minimizing defects by improving quality of work. As Six Sigma is a process improvement methodology and has proven its best results in manufacturing industries because of the repetitive production, since 1980s. But still it's a relatively new concept for construction industry because of its unrepeated work process. Previous researches about Six Sigma in construction say that Six Sigma as in whole cannot be implemented in construction industry but some of the techniques and ideas will definitely prove its best results on construction work process. The aim of this present work is to find out the need of using Six-Sigma in construction context particularly for areas and zones in state Maharashtra (India). Produce something with equal or better quality with lower cost is the purpose of process improvement in construction industry.

## Site Survey and Data Collection

We have selected some activities like brick work, plastering, flooring using vitrified tiles, internal coloring to improve the quality of internal finishing work of building using DMAIC methodology.

### Site Details

**Name of Project:** Saubhagya Arcade

**Builder and Developers:** Nirjay Constructions

**Address:** Pipeline Road, Gangapur Road, Nasik

The Capital is a commercial Project of Nirjay Construction Group located in the heart of city of Nasik with state-of-the-art office space built to international standards. The Capital offers a bounty of comprehensive features and facilities for software development companies, BPOs, Bank's, showrooms and corporate offices.

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**Figure 2: Site View “Saubhagya Arcade” Project of Nirjay Constructions, Nashik**

**A. Regular method of internal finishing work of “Saubhagya Arcade” :** —Saubhagya Arcadel is comprising of 4 buildings called building A, B, C and D. Amongst that building A and B are nearly identical so they are selected for study. A checklist is prepared for internal finishing work, which covers various points whose quality needs to be checked.

To find out the problems faced by construction companies and using Six sigma effectively in construction context for the benefits and minimizing defects thereby improving quality of work. The questionnaire will be based on problems of construction industry and how six sigma can be used beneficially for process and quality improvement. The questionnaire survey will be taken to know the need of process improvement in construction. The questions will be regarding need of improvement in quality, cost, productivity, productivity time, Customer satisfaction and Six sigma application.

### **Questions to be asked in interview for market survey:**

- i. What's the definition of quality according to construction industry requirements?
- ii. What types or categories of problems are common?
- iii. What's different about most common types of problems?
- iv. Are there locations where the problem is greater?
- v. How those places where the problems occurs more unusual?
- vi. What are the times, days, weeks or conditions when the problem is most prevalent? What's going on that's unique during those times?
- vii. How does quality, cost, productivity, productivity time, customer satisfaction, Six Sigma collectively or individually affect construction work? Rate them accordingly?

## **V. RESULTS AND DISCUSSIONS**

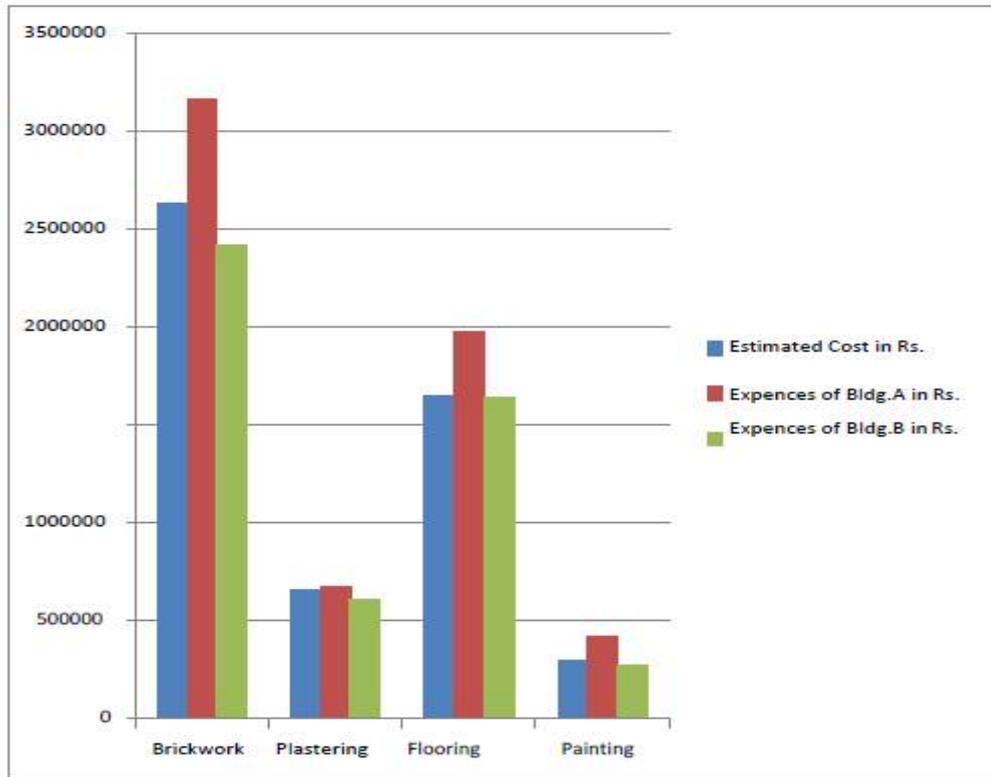
This section provide the detail calculations of comparative study of regular method of working on internal finishing work versus Six Sigma methodology is given. By making this comparative study of both the working methods we get the need and importance of process improvement methodology in construction context for quality, cost, productivity, productivity time, customer satisfaction and Six Sigma. In this work we have considered two different buildings for cost comparison. Here X-Axis Represents Cost in Rs and Y- Axis represents items of work. Here building A has used traditional technology for and construction and Building B which is done by applying Six Sigma methodology

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**Figure 3 : Cost comparison of traditional building and six sigma methodology**

Base on above figure 3 we can conclude, a construction firm which wishes to increase the quality of its projects, must reduce the amount of defects during the construction work. For this, it is important to determine basic architectural, structural and constructional concepts, standards and parameters of quality assessment related with construction and the sources of problems which lead to low quality in the construction projects.

## VI. CONCLUSION

The proposed implementation identifies that vast literature was obtained on Six Sigma concept, which gave a wide idea of existing practices of implementing DMAIC methodology which is a concept of Six Sigma to the existing ongoing processes or activities in construction which objects at developing and providing a highly effective process improvement and quality improvement technique in construction. The studies conducted deploy that Six Sigma applications are widely accepted by manufacturing/ production industries and it is also possible to implement it in construction. Past case studies disclose that it requires team efforts involving top management and every worker in the organization to fully employ the concept. However awareness among consultants, engineers, employees and regarding Six Sigma in construction should be produced for the actual execution of the process/ activity.

## REFERENCES

- [1] Sneha P. Sawant and Smita V. Pataskar; "Applying Six Sigma Principles in Construction Industry for Quality Improvement", The International Conference on Advances In Engineering And Technology – ICAET (2014).
- [2] Sunil v. Desale , Dr. S. V. Deodhar; "Lean six sigma principal in construction: A literature review related to conclusion", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 certified journal, Vol. 3, Issue 5, May (2013).



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**Vol. 6, Issue 11, November 2017**

- [3] Celep Oguz, Yong-Woo Kim, John Hutchison, Seungheon Han; "Implementing lean six sigma: A case study in concrete panel production".
- [4] A. D. Lade, A. S. Nair, P. G. Chaudhary, N. R. Gupta,(2015) "Implementing Six Sigma Approach for Quality Evaluation of a RMC Plant at Mumbai, India, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p- ISSN: 2320- 334X, Volume 12, Issue 2 Ver. I (Mar - Apr. 2015), PP 01-04
- [5] Thanveer M. Beary, Tariq S. Abdel hamid, (2005),"Production planning process in residential Construction using lean construction and six sigma Principles". DOI: 10.1061/40754(183)16.
- [6] Muharrem Firat Yilmaz "Six Sigma within Construction Context : As a Quality Initiative, Performance Indicator/Improver, Management Strategy Six Sigma Project Management"(2012).