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Application of Six Sigma Quality Control Tool at Construction site

Ajinkya .D. Upawar[1], R.D. Shinde[2]

[1]P.G. Student, RMD Sinhgad Technical Institute Campus, Warje, Pune. Maharashtra, India
[2]Professor, Dept. of Civil Engineering, RMD Sinhgad Technical Institute Campus, Warje, Pune. Maharashtra, India

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Abstract - *Due to increasing competition, the law of survival of the fittest plays an important role in today's market. The increasing customer demand for quality assurance, which demands improvements in internal quality and pays attention to quality control, has increased the pressure on construction companies against the market and its competitors. Economic benefits depend heavily on quality control in the business. Construction companies should pay more attention to quality principles and insist on quality standards.*

***Key Words*: Quality, Quality Control, Quality Assurance, Quality Management, Six Sigma,**

1. INTRODUCTION

The Indian housing industry is an integral part of the economy, paving the way for a significant portion of its development investment, showing increasing expectations for industrialization, urbanization, economic development and improving the quality of life of people. I am. , Prepare for growth. Construction accounts for 40-50% of the cost of projects in various sectors such as highways, roads, railways, energy, airports and irrigation, making it the second largest industry in India after agriculture. It accounts for about 11% of India's GDP. Improving construction performance and quality has become an important focus in the construction industry in all countries. However, many researchers have observed a significant reduction in construction quality over the past 20 years. Construction projects face a variety of issues and complications such as cost, time frame, quality, safety and human resources. The construction industry plays an important role in the development of all countries. The development of the housing industry depends on the standards of construction projects. Quality is one of the key factors in the success of a construction project. Improving the quality of construction projects is related to managing the quality of the project life cycle. While quality control at all stages of the project life cycle is essential, standard control at the execution (construction) stage contributes significantly to the final quality result of a construction project. This project focuses primarily on the importance and factors that influence standards management within the execution (build) phase. The project includes visits to several construction companies, conducts a questionnaire survey, analyzes the difficulties (main factors) of poor quality control due to poor quality control, and changes in costs, and implements the construction project to do.

Sukumar & Radhika (2017) In India, the construction industry is one of the largest after agriculture. It produces a large amount of waste and consumes a lot of resources, which makes construction an awkward task. The application of new technology, which is the concept of Lean Six Sigma, seems to be effective in improving the efficiency of the construction industry. It aims to eliminate all defects, minimize material waste, minimize time and effort and create maximum value. The purpose of this study is to evaluate Lean Six Sigma as a process improvement method that improves the construction process by understanding and analyzing the factors that influence the formation of construction waste. This paper attempts to improve the overall construction process using the Six Sigma DMAIC technique. Data is collected from respondents and analyzed using SPSS software. The expected outcome of the research is the implementation of Lean Six Sigma in the construction industry to reduce defects and minimize waste. When all the work is done, you will get the following benefits: use of exchanges, reduction or recycling, elimination of unnecessary things, simultaneous execution of different tasks, easy workflows, collaboration development, introduction of cross-training, level of Focused on improvement inspections, preventive maintenance of tools and equipment, institutionalization, accident planning, reducing component count, presenting site displays to expose project information, deleting negotiators.

Swethaa and Chris Anto (2016) Six Sigma is one of the promising tools that can be efficiently used to monitor the quality requirements of any process. While very popular in manufacturing, this study also attempts to implement this simple and efficient approach in construction. Considering strength as the most important of the numerous deliverables in construction, the Six Sigma strategy applies to the above characteristics. Deviations or defects that occur in the concrete process due to various controllable and uncontrollable factors are identified and remedial measures are proposed. In this study, we introduced the concept of DMAIC-Define Measure Analyze Improve and Control to eliminate defects and achieve results near zero defects. Quality is the most desirable artifact of any project, and its rapid storage and deployment pave the way for project success. Therefore, it is imperative to adjust the parameters that affect quality and place the deliverables in the best possible condition. Six Sigma technology helps ensure product compatibility. Construction and concrete are no exception. This method works best when the sequence of steps is evaluated in cycles until near-zero defects are

achieved, rather than when the mechanism is finished in one go.

Maryam Dabbaghi Tehrani, (2010) The importance of quality improvement and good performance in the highly competitive global marketplace has led many organizations, their top managers, project managers, and engineers, to introduce new philosophies, such as pull scheduling and lean principals, to their organizations. This paper describes the Six Sigma principles and framework as the highest quality improvement strategy for business success. First, I will explain the background of Six Sigma in industry and the statistical theory behind it. While the Six Sigma concept is presented in terms of principles, methodologies, and frameworks, the focus of this report is to adopt the Six Sigma approach to new projects in the housing industry, construction projects. Therefore, the adoption of the DMAIC procedure in construction projects outlines what is referred to in this report as a so-called performance improvement of construction projects based on the Six Sigma principle. This paper theoretically explored the idea of applying the Six Sigma principle to the construction industry and explored the advantages of the DMAIC procedure and its potential to improve the quality level and efficiency of construction projects. In addition, the flexibility of the DMAIC framework in construction projects is demonstrated, and a way to implement each phase taking into account the construction index is recommended. This study introduced Six Sigma as a continuous improvement method that provides a systematic strategy for effectively controlling and coordinating all processes involved in construction projects. Clearly, the text concludes that the only key success factors for implementing Six Sigma in the construction industry are those in the manufacturing industry, which are more complex and sensitive. Focusing on proper definition of all critical items in construction projects, CTQ, proper metrics, proper coordination schemes between all prerequisites and key processes and activities, and commitment of all involved, the construction industry helps you through the entire Six Sigma program. .. Practical work in future research can evaluate this claim and add effective comments to this essay.

1.1 Need for Quality Management

The need for quality management in construction is now widely accepted. Implementing the quality standard elements in the field, practically there will be lots of hurdles and most of the employers are very much interested and indulging themselves in this process but they don't get a proper way or benchmark to fix the standards. This study aims at analyzing the significance and importance of construction firms regarding implementation of Total Quality Management at all the levels of the Projects. The problems and conclusions are weighed and assessed respectively. Today, India is that the second fastest growing economy within the world. The Indian housing industry is an integral a part of the economy and a conduit for a considerable part of its development investment, is poised for growth on account of industrialization, urbanization, economic development and people's rising expectations for improved quality of living. To be competitive in today's market, it's essential for construction companies to supply more consistent quality and value to their owners/customers.

Now it's the time to put behind the old adversarial approach to managing construction work. It is time to develop better and more direct relationships with our owners/customers, to initiate more teamwork at the jobsite, and to supply better quality work. Such goals demand that a continuous improvement process to be established within the company. Recently construction companies have increasingly adopted TQM as an initiative to unravel quality problems and to satisfy the requirements of the ultimate customer. Many construction companies within the US, Singapore, UK, and other European countries are using TQM successfully for variety of years and reaping rich rewards in improved client, consultant, and supplier relations, reduced "cost of quality", on time and within budget project completions, and a well informed and highly motivated team of staff. In order to grasp the necessity for improvement within the housing industry and to raised manage our projects and construction companies, we'd like to seem for a way to try to to so. Construction managers need to improve their performance. Construction costs are becoming far too high. Construction project management is harder than it should be. When turnaround at the end of a project becomes a gut-wrenching experience with unnecessary disputes (which must be settled) that arise due to insufficient quality or indifference to quality, settlement by negotiation, arbitration, or maybe litigation imposes a significant drain on the financial resources of a corporation and limits profit potential. To be competitive in today's market, it's essential for construction companies to supply more consistent quality and value to their owners/customers. Now is the time to put behind us the old adversarial approach to managing construction work. It is time to develop better and more direct relationships with our owners/customers, to initiate more teamwork at the jobsite, and to supply better quality work.

1.2 Need for Six Sigma

Six Sigma may be a set of techniques and tools for process improvement. It was introduced by engineer Bill Smith while performing at Motorola in 1986.Jack Welch made it central to his business strategy at General Electric in 1995. Today, it is used in many industrial sectors. Six Sigma seeks to enhance the standard of the output of a process by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. It uses a group of quality management methods, mainly empirical, statistical methods, and creates a special infrastructure of individuals within the organization, who are experts in these methods.

Each Six Sigma project carried out within an organization follows a defined sequence of steps and has specific value targets, for example: reduce process cycle time, reduce pollution, reduce costs, increase customer satisfaction, and increase profits. The term Six Sigma originated from terminology associated with statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield or the percentage of defect-free products it creates. A six sigma process is one in which 99.99966% of all opportunities to produce some feature of a part are statistically expected to be free of defects (3.4 defective features per million opportunities), although this defect level corresponds to only a 4.5 sigma level. Motorola set a goal of "six sigma" for all of its manufacturing operations, and this goal became a by-word for the management and engineering practices used to achieve it.

1.3 Objectives of investigation

Objectives of this study are as follows:

1) To inculcate the concepts of quality and total quality management.

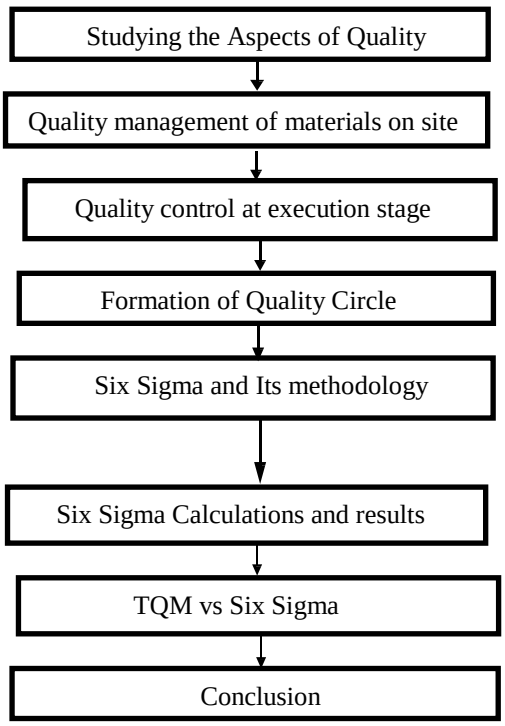
2) To study the traditional methods adopted for maintaining the quality on site.

3) To study the concept of six sigma and its methodology.

4) Comparison between conventional methods and six sigma methodology.

2. METHODOLOGY

This research follows a step by step methodology:



a) Quality Circle Formation: Quality Circle (QC) is a very simple TQM method that can be easily adopted in this case. No cases of QC use in the housing industry have been reported, but experimental studies of QC use in the US housing industry have been conducted. A quality circle is a small group of employees who add to the same environment and meet regularly to discuss and analyze work-related issues, deficiencies, deficiencies, and suggest management solutions. .. These implementations can also overcome these problems. Using quality circles can be an efficient problem-solving method and potentially improve the standards of construction.

The purpose of the quality circle:

1. Change the attitude of employees.
2. Promote continuous improvement of employees and organizations.
3. Bring out the potential of workers and bring self-development to workers.
4. Develop solidarity among workers and eliminate conflicts between management and employees.
5. Improve organizational culture. Change employee attitudes.

Circles usually consist of 10 members working together. This includes individuals who add offices, mid-level units, oversight, and oversight. They meet about an hour each week to identify, isolate, discuss, and resolve problems they face, such as quality and productivity issues.

Quality circle process: The quality circle is a process oriented method as it is one way of TQM. Once the circle is formed, the facilitator provides training to members. Once their training is complete, the highest quality circles are ready to be implemented.

The first step in this method is to identify the problem and have members of the circle meet daily to discuss the problem/probable cause of the problem. Then proceed to rank issues or isolate the largest issues. They further analyze the problem, discuss possible solutions and rank or prioritize the most effective or efficient solutions. These proposals suggest management to approve any approvals that may be implemented. The first step in this method is to identify the problem and have members of the circle meet daily to discuss the problem/probable cause of the problem. Then proceed to rank issues or isolate the largest issues. They further analyze the problem, discuss possible solutions, and rank or prioritize the most effective or efficient solutions. These proposals suggest management to approve any approvals that may be implemented.

Six Sigma and Its Methodology: Six Sigma is an emerging approach to quality assurance and quality control with an emphasis on continuous quality improvement. The main objective of this approach is to meet and exceed the levels of quality and reliability to meet the demands and expectations

of today's demanding customers. The term Sigma quality level is used as an indicator of process goodness. The lower the sigma quality level, the greater the chance of defective products, and the higher the sigma quality level, the less likely defects in the process. The concept of Six Sigma derives from what is known as the "standard normal distribution," which is represented by a symmetrical bell-shaped curve. "Theoretically, this normal curve has been extensively studied and proved to be very useful. It seems that many natural continuous phenomena follow or are often close to it." Each segment is named "Sigma", symbolized by "σ" (Greek letters), and statistically the deviation from "Mean" (μ: Bell curve mean or peak). Most of the curves cover the range of -3σ and +3σ by covering 99.73% of the population, and Six Sigma considers the range of -6σ and +6σ covering 99.9997% of the data. .. The curve shrinkage indicates that the main population is cumulatively close to the mean. This is the specification limit for good performance.

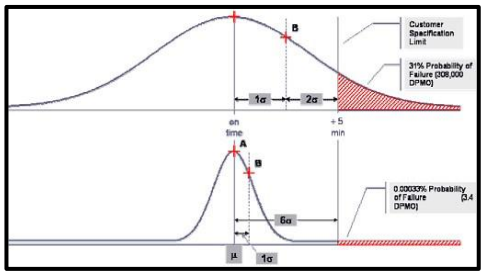


Fig. -1: Evolvement from 3 Sigma to Six Sigma

The purpose of Six Sigma is to strengthen near-perfect standards that suggest 3.4 flaws per million opportunities (DPMO) to maximize customer satisfaction and business benefits. This goal occurs when the Sigma level is 6. For example, at the 3 sigma level, 93.3% of the items meet the requirements, are flawless (yield) and have 66,800 defects per million opportunities (DPMO), but improve performance to 5 sigma. The level is defective. The quantity is reduced to 320 items per million opportunities. Therefore, companies working on Six Sigma must strive for Six Sigma performance goals. Table. 1 shows the failure rate per million opportunities at various sigma levels.

Table -1: Overview of sigma levels and DPMO

Yield	DPMO	Sigma Level
30.9	690,000	1
69.2	308,000	2
93.3	66,800	3
99.4	6,210	4
99.98	320	5
99.997	3.4	6

To achieve high quality at the 6 Sigma level at a low cost, Six Sigma uses statistical metrics and techniques to measure process performance, assess defects, analyze performance for stakeholders and understand how business is done. Teach you the right tools to improve. In addition, Six Sigma's systematic strategy guides employees and processes to maintain and control the high performance achieved.

3. RESULTS AND DISCUSSIONS

We considered a B+G+7 storey building in Kadadi, Pune. This study considers column defects and reveals the root cause of the defects. The basic causes of defects are poor quality raw materials, poor workmanship, damaged formwork materials, improper mix design of concrete, last modification of design, poor concrete mix. The effects and causes will be investigated after construction.

Table 2. Data Considered For the Study

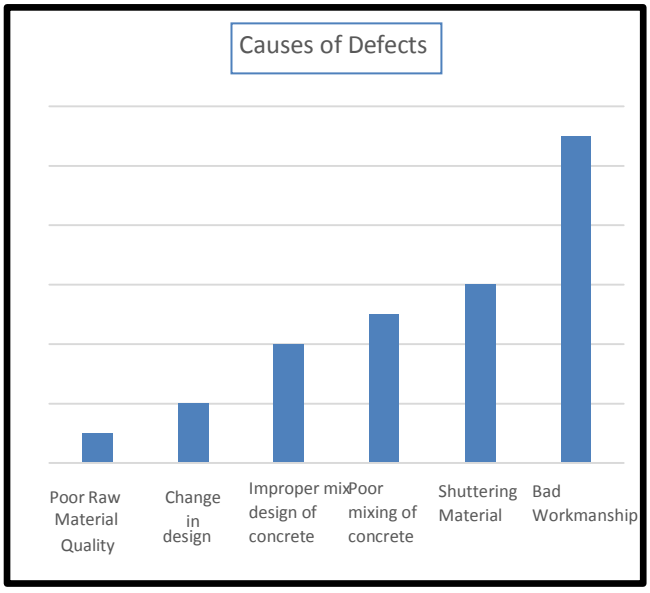
SN.	Floor	No. of Defects	Opportunities
1	Basement	2	14
2	Ground	1	14
3	First	3	14
4	Second	7	14
5	Third	4	14
6	Fourth	6	14
7	Fifth	3	14
8	Sixth	5	14
9	Seventh	2	14
	Total	29	112

Therefore DPMO = 29/ (112*4) x 1000000
DPMO = 64,732 Based on Sigma conversion table,
Sigma = 3.02 Yield = 93.53

Fig.-2 Commonly Found Defect - Honeycombing

Fig.- 3 Improper Covering

In this step causes of the defects were found out. Following were the main causes. The causes are depicted by a chart:



TQM VS SIX SIGMA:

Integration: In the overall quality control framework, quality is not well associated with strategy or performance. The team responsible for quality improvement is autonomous and separated from the top manager as well as the process executive. Six Sigma process management, process improvement and measurement is considered the day-to-day responsibility of all employees and goes beyond the responsibility of all operations managers and direct executives of business processes. This concept allows quality and cost, and their relationships, to become an integral part of each employee's work.

Leadership: When it comes to quality, a quality leader is a manager who is committed to quality improvement, advocates quality improvement, and takes steps to take the quality of the business to the next higher level. But if they lack the support of top management and they are skeptical of the ideas of the leader, then these ideas remain and are not viable. In such companies, Six Sigma suggests that top managers need to understand the need for change and the need for quality improvement. Therefore, quality improvement is a temporary job if the top manager lacks support. Business continuity has not been very successful. Without the support of a top manager, the ideas of leaders and other employees will not come true.

Quality: The purpose of comprehensive quality control is mainly to stabilize the quality level, not to improve it. The messages driven by Six Sigma include continuous customer-focused enterprise improvement, process management and process improvement.

Goal: The goals promoted by Total Quality Management are commonly described as "attaining or exceeding customer requirements". However, meeting customer needs today does not guarantee future customer satisfaction, as customer requirements may change. Six Sigma defines challenging and ambitious goals and is described as "providing zero defects." This goal is very clear as it is defined as the defect rate or accuracy rate. This is about 99.99966%.

Attitude: Care is taken by the team responsible for overall quality management to create a “quality policy” and to carry out business processes in accordance with this policy. Quality policies are defined without consulting the direct executives of the process, but they must be adhered to. As a result, executives reporting to them often leave a defined quality policy. Six Sigma includes the expertise of employees who perform certain activities, especially in adapting to changing conditions and mechanically applying technical guidelines, programs, or policies. Employees can work the way they want, but the fact that work results reflect the results of the entire enterprise should always be borne in mind.

4. CONCLUSIONS

The Six Sigma concept differs from TQM in terms of attitudes towards flaws and variability. Six Sigma is more comprehensive and appropriate than TQM in the modern construction era. To successfully implement this concept, managers need to have a clear vision and present it to all employees how it becomes a vision. In addition, companies must strive to attract and recruit the best talent in their particular field. There should be clear relationships between employees at all levels of the organization. Employees of an organization need to respect each other, even if they are good or bad. Developing leadership is important because leaders are usually good at dealing with complex and stable

phenomena, and their role is outstanding in the field of innovation. Therefore, a commitment to change among employees needs to be developed. Six Sigma has proven to be more efficient, with all its differences from TQM, due to its increased presence in global markets and economies. Implementation of this concept is necessary in terms of market competition.

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