Application of Six Sigma for Quality Control in Residential Construction

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Abstract

Construction industry is the second largest industry in India after agriculture. It is an industry where maximum waste is generated due to lack of Quality. Due to this large amount of waste is produced and huge amount of resources are consumed. A new technology, Six Sigma is introduced for Quality Control to improve the efficiency of construction industry. It aims to benefit the projects and improve them in terms of quality and time management by eliminating defects and minimizing the wastage of material. This study aims to evaluate six sigma as a continuous process improvement method by analysing the factors affecting the generation of construction wastes. In this paper, a Six Sigma tool **DMAIC** is used for analysing and improving the construction process. The data for different processes such as Slump test and Cube test are collected by the observations made from ongoing construction site and analysed. The expected output is the study is elimination of defects and minimising waste by implementing Six Sigma in construction industry.

Keywords: **Six Sigma, quality control, DMAIC, slump test**

1. Background

With Construction is one of the largest industries around the globe. It acquires a huge amount of money and manpower. There are many defects occurred during its execution which results in over cost and the desired output is not achieved, hence Quality Control is introduced. Among the various techniques for Quality Control, Six Sigma became a useful method as a performance indicator and process improver for the construction companies. Six Sigma is a rigorous, focused, and highly effective implementation of proven quality principles and techniques. The term “sigma” of Six Sigma comes from the Greek letter σ which is the symbol for standard deviation of a population in statistical mathematics. It was developed by Motorola in 1986 that emphasizes cycle-time improvement and the reduction of manufacturing defects to a level of no more than 3.4 per million

2. Introduction

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process. Six Sigma is a measure of quality that strives for near perfection. It is a methodology for continuous improvement. It is a methodology for creating products/ processes that perform at high standards. It is a set of statistical and other quality tools arranged in unique way. It is a way of knowing where you are and where you could be. It is a Quality Philosophy and a management technique.

The term “Six Sigma” is derived from the normal distribution used in statistics and graphically represented as a bell-shaped curve or a normal distribution.

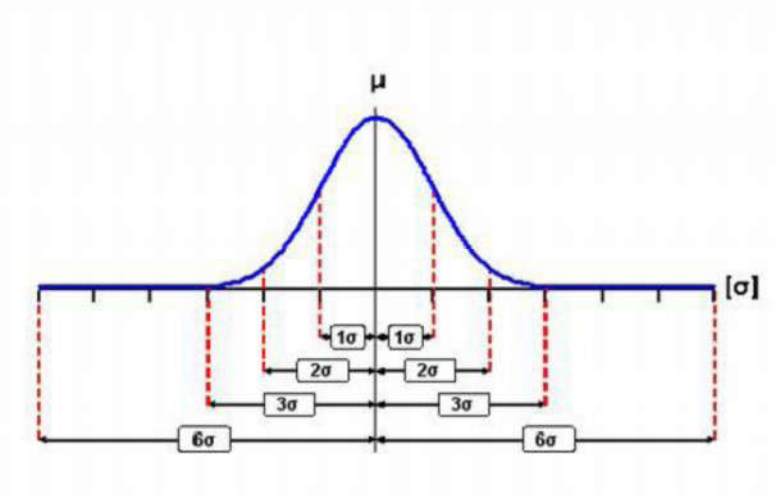

Figure 1 Normal Distribution Curve / Bell shaped curve

The portion at peak representing μ is the mean that describes most desirable value. The symbol σ represents the standard deviation which deviates on both the sides and are termed as lower and upper specification limits. If the data extends beyond or below the specification limits, it is considered as a defect as per Six Sigma philosophy and DMAIC tool is used for continuous improvement.

3. Methodology

For acknowledging the defects and analyzing the data and forming a Bell shaped curve, one needs mean, Standard Deviation, Upper and Lower Specification limits.

where,

Mean = the desired value or the average of all values that coincide within

Upper Specification Limit = Mean + σ (Standard Deviation)

Lower Specification Limit = Mean - σ (Standard Deviation)

Standard Deviation = sqrt $[\sum\Delta^2/(n-1)]$

Δ = difference

n = number of observations

After gaining the amount of defects, analysis of the data can be done by different analytic tools such as Ford Global 8D tool, DMAIC tool, DMADV tool, DMADDD tool.

DMAIC (define measure, analyze, improve, control) is a methodology for continuous improvement. It aims to improve the efficiency of the existing processes and increase customer satisfaction through designed products and services. This methodology offers structured framework in following steps to establish systematic continuous improvement.

Define- In this phase it is necessary to define customer requirements and any things do not meet those requirements known as defect, determine key processes, key roles and team charter, define project goals and scope, and estimate the risks and financial impact.

Measure- Identify and collect the appropriate data which are relevant to the defects and the processes need improvement. Measure the processes performance and establish the measurement system based on Six Sigma techniques and tools.

Analyze- Study and analyze the data collected in previous step to find out the root causes of the defects and unsatisfactory performance.

Improve- Identify alternative solutions and methods based on the knowledge derived from analyze step, study and give the solutions to find out the most successful improvement solution and implement that successful method.

Control- Establish a control plan to ensure that expected improvement has been achieved, and the knowledge and experiences have been documented and shared to remain at attained high level performance.

4. Study Area Profile

The study area taken for the thesis is Ahmedabad city as Ahmedabad is the administrative capital of Gujarat. There are many multipurpose constructions going on and among them project selected for this study is "The Bungalows" which resides at the prime location of Ahmedabad city. It is located at prime junction of city i.e. Iskcon Cross road on SG Highway. "The Bungalows" is a 17 floored residential building consisting 70 flats which include most of Duplexes. An estimated overall cost of project is 80 crores which is financed by E-City Projects Private Limited as client which includes 28 crores as labour contract which is carried out by Creative Projects & Contracts Private limited (CPC).

5. Data Analysis

The analysis of data is done for two parameters i.e. Slump test and Compressive strength of cube for 7 days and 28 days respectively.

Slump test

As a sample data, analysis of 30 cycles for slump test is done for this research. After collection of data the mean slump value we desire is 143.27 and by applying the standard deviation for formula given above we get the value of σ as 6.21. The Upper and Lower Specification limits we gained are 137.06 and 149.48 respectively. So by analyzing the values we get percentage of desirable values and defects in the form of pie chart.

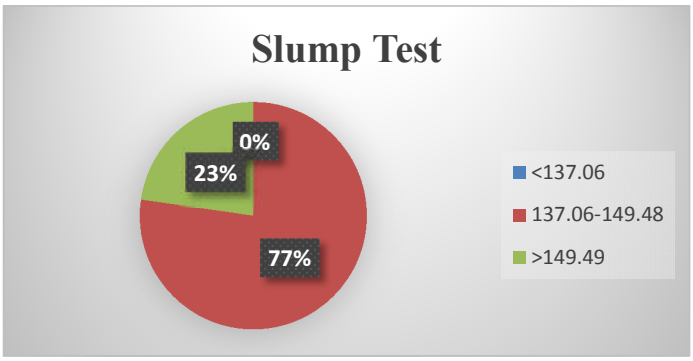

Figure 2: Slump test

From the chart, we can see that about 77% of data resides within the specification limits which everyone desires. We can also see there are 0 defects which were gone below lower specification limit and there are 23% defects which are gone above upper specification limit. It means the slump value obtained is higher than desired one. And for construction work we know that higher slump value means higher percentage of water which diminishes the strength of concrete and reduces the durability of structur

Compressive strength of cube at 7 days and 28 days

For cube test, a data of about 130 cycles are taken for each i.e. 7 days and 28 days. The grade of concrete used in construction is M30. The mean for 7 days and 28 days testing, we get as 23.69 MPa and 39.33 MPa respectively. The standard deviation for 7 days and 28 days we get as 2.12 and 4.75 MPa respectively. The Upper and Lower Specification limits for 7 days we gained are 25.82 and 21.57 MPa respectively and for 28 days we get 44.08 and 34.58 MPa respectively. By inserting our collected cycle data in the form of histogram we get the following graphs:

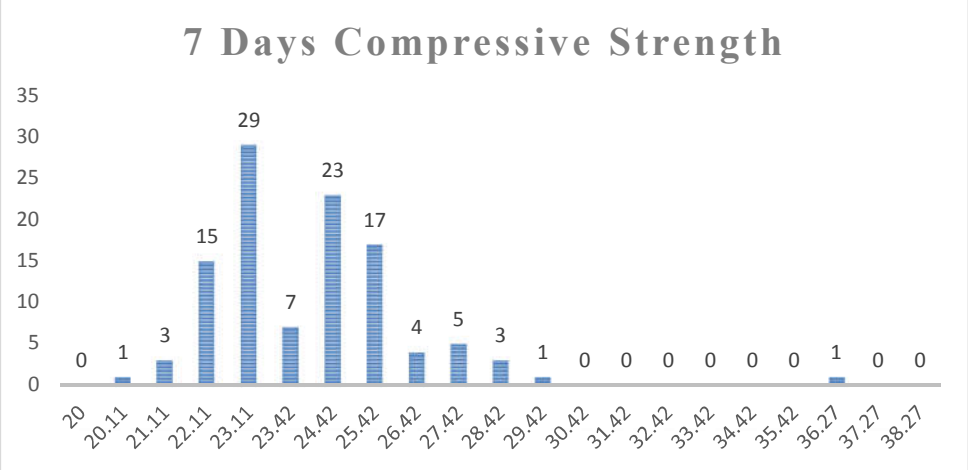

Figure 3: 7 days Histogram

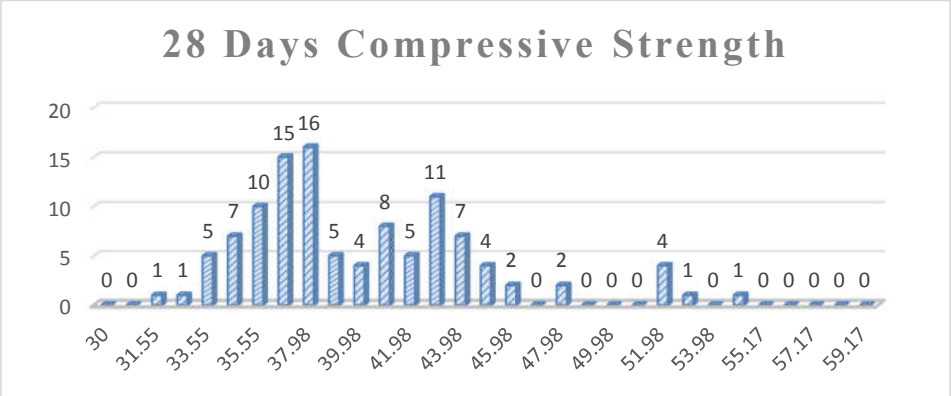

Figure 4: 28 days Histogram

In the above graphs we can observe that most of values resides around the mean. We can also have a glimpse of Bell shaped curve from the above histograms. There are many defects too in the above data, hence to get the percentage errors and outputs; pie chart is plotted in Figure 5.

From the below chart, we can observe that for 7 days' strength about 77% of data resides within the specification limits which one desires. We can also observe that there are 10% defects which were gone below lower specification limit and there are 13% defects which are gone above upper specification limit. Hence considering overall data, there are 23% data which are considered defects as per Six Sigma concept. For 28 days' strength about 75% of data resides within the specification limits which is desirable. We can also observe that there are 12%defects which were gone below lower specification

limit and there are 13% defects which are gone above upper specification limit. Hence overall there are 25% data which are considered as defects as per Six Sigma.

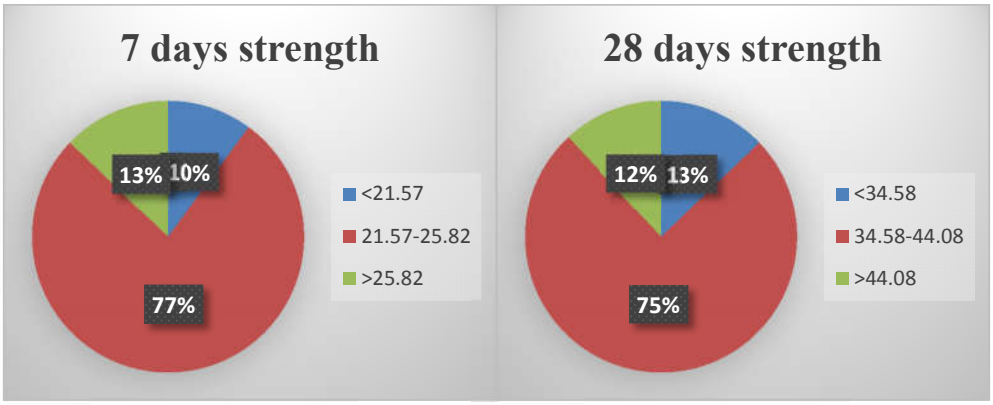

Figure 5: 7 days strength and 28 days strength respectively

6. Conclusion:

The main purpose of this study is, how to apply Six Sigma in the construction industry as the philosophy was originally developed for automobile industry. In automobile industry an accuracy of 3.4 defects per million can be obtained which is not possible for construction industry. For performing Six Sigma, a huge amount of data is needed but for this thesis sample data are taken to convey this technique. By analyzing the data, it was concluded that by continuing the procedure as per present scenario the defective data defined are about 25%, that is the define and measure phase of DMAIC tool. By performing Analyze, Improve and Control phase of the tool, the process can be improved and the defects can be reduced. Six Sigma is a continuous improvement process hence this process is to be repeated, for eliminating the data and getting desired output.

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