Quality Evaluation in Precast HCS using Six Sigma Approach

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Abstract

Use of Precast concrete elements is one of the latest methods of construction. The speed of the construction is highly increased using precast elements. Six sigma is a project driven business systems method. Successful implementation and growing organizational interest in the six sigma method have been exploding in the recent year. This report provides detailed overview of six sigma management method and its use of project management. Six sigma as a tool has been very successful in increasing the quality of product. The report deals with an application of six sigma DMAIC (Define-Measure-Analyze-Improve-Control) methodology in an industry which provides a framework to identify, quantify and eliminate sources of variation in an operational process, to optimize the operation variables, improve and sustain performance viz., the process yield with well executed control plan.

Keywords: DMAIC, HCS, Precast, Six Sigma, Variation

I. INTRODUCTION

India is witnessing rapid economic growth, due to this demand for infrastructure has increased. This has led to introduction of various new construction techniques. One of the popular method is precast construction or using precast elements for rapid construction of buildings. As the market for precast elements increase it becomes necessary to control the quality at precast plant itself.

The Greek alphabet Sigma (σ) is the statistical symbol and metric of process variation. The sigma scale of measurement is perfectly correlated to such characteristics as defects-per-unit, parts-per-million defectives, and the probability of a failure. Six is the number of sigma measured in a process, which has a target variation of only 3.4 per million as defects under the assumption that the process average could diverge over the long term by as much as 1.5 standard deviations. Six Sigma can be defined in several ways. Six Sigma is “a program aimed at the near-elimination of defects from every product, process and transaction”. Six Sigma is “a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality.”

Six Sigma was launched by Motorola in 1987. As a result of a series of changes in the quality area starting in the late 1970s, with ambitious ten-fold improvement drives. After some internal pilot implementations, Galvin, in 1987, formulated the goal of “achieving Six-Sigma capability by 1992” in a memo to all Motorola employees. The reduction in process variations were on-track and cost savings totaled US$13 billion with labor productivity achieved 204% increase for over period 1987–1997, to companies such as IBM, DEC and Texas Instruments launching Six Sigma initiatives in early 1990s. However, it was only part 1995 when GE and Allied Signal launched Six Sigma that a rapid dissemination took place in non-electronic industries all over the world. In early 1997, the Samsung and LG Groups in Korea began to introduce Six Sigma, Samsung SDI, reported a cost savings through Six Sigma projects totaling US$150 million (Samsung SDI, 2000a). It is statistical measurement of quality level. It is a new management strategy to create quality innovation and total customer satisfaction. As a means of doing things right the first time and work smarter by using data information.

Six Sigma is a quality improvement technique based on statistics, was used firstly by Motorola in the 1980s. It helps to decrease costs, increase quality by improving process and reduce the production time. Six Sigma has statistical and business perspectives and its applications are improved by Six Sigma Academy [5].
DMAIC model is a strategy used to improve processes. It is a systematic method for analyzing and improving business processes. DMAIC is a data-driven quality strategy used to improve processes. It is an integral part of Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives.

However, construction work has fragmented and project-oriented work processes compared to the manufacturing industry (Han et al., 2008). So, the evaluation of Six Sigma within construction context becomes an interesting research question considering quality, performance and management aspects [3].

That’s why, this study discusses Six Sigma as a process improvement method through some research questions and tries to understand its features and implications as a quality initiative, performance indicator/improver and management strategy.

II. RESEARCH OBJECTIVES

1) Conducting the survey of voice of customer (both, external and internal VOC).
2) Evaluation of sigma level of HCS based on histogram.
3) Studying the HSC production process.
4) Collecting quality parameter data of previous production.
5) Analyzing co-relation of deflection due to formation of camber using the scattered plot.
6) Also verifying the stability and capability of the HCS production process using control charts ($\bar{X}$ and R Chart).

III. LITERATURE REVIEW

- Dale H. Besterfield, in his book Quality control stated that, “standard deviation is the best measure of process variability because the smaller the standard deviation the less variability in the process. If we can reduce sigma, $\sigma$, to the point that the specification are at $+or–six, then 99.9999998% of the product or service will be between specification, and no conformance rate will be 0.002 parts/million with Cp value of 2.0.”[2].
- Harry and Schroeder(2000), defined six sigma as a disciplined method using extremely rigorous data gathering and statistical analysis to point sources defects and ways to eliminate them [7].
- Anbari F. T., Kwak Y.H. (2004) gave the governance and organizational structure as given below-Governance of Six Sigma projects is accomplished by using the “Belt” system in a strong matrix organizational structure[1].
- D. Lade et al. (2015) after extensive study on Six Sigma Approach for Quality Evaluation of a RMC Plant concluded that the Six Sigma DMAIC methodology can be applied to the RMC production in order to find the root causes of variations, eliminating the causes of variations and achieving the process improvements by applying the quality tools [4].

IV. METHODOLOGY

A. DMAIC:

The standard six sigma methodology DMAIC is applied on existing manufacturing process of HCS. It consists of five phases as follows:

1) Define:
Quality expectations of clients are surveyed through voice of customers and other methods of collecting customer information are identified. Survey of number of customers of HCS, consultants, designers was conducted to know their quality requirement. Following observations are reveled from VOC:
   - Conformance to dimensions, camber within permissible limit, smooth finishes, Product must be free from structural cracks, Edges must be sharp, Slippage of strands within permissible limit, Strands should not be exposed to surface.
   - Based on observations of VOC, Camber should be within permissible limit because this is critical to quality parameter.

2) Measure:
It is the identification of important parameters, factors affecting these parameters, collection of data and measuring the current performance of process. The production process of HCS was carefully studied. The deflection due to camber of HCS from previous data were collected from quality department. Factors which affect the camber such as tension in tendons, setting time of concrete, temperature, design specification of HCS, stacking, seasonal variation were also studied.

3) Analyze:
Analyze the data collected and the process to determine the root causes of the problem that need to be improved. Inspect the collected data and transform it into meaningful quality tools such as control charts, histogram, cause and effect diagram, etc.
The sigma level of the current process is determined by histogram. The sigma level of the process is 2.68 which indicate that there is a substantial variation in performance of process. Sigma level is minimum of either \( \frac{(USL-Mean)}{6\sigma} \) or \( \frac{(Mean-LSL)}{\sigma} \) [2]. Standard deviation is the best measure of process variability because smaller the standard deviation, less the variability in the process [4].

The performance of the process can be measured by using process capability which is equal to \( 6\sigma \). The process capability for the process is found to be \( C_{pk} = 0.288 \). The process capability and tolerance are combine to form capability index expressed as \( C_p = \frac{(USL-LSL)}{6\sigma} \).

The control charts (\( \bar{X} \) and R charts) are the graphical record of quality of particular characteristics. It shows whether or not the process is in stable state. \( \bar{X} \) chart is used to record the variation in the average value of samples. The \( \bar{X} \) chart and R chart for HCS is given in fig. 2 & fig. 3 resp. The subgroup size for the control chart is 3 as three slabs were casted on one bed belongs to one subgroup. Careful examination of \( \bar{X} \) chart shows that many points are beyond Upper Control Limit (UCL) and Lower Control Limit (LCL), hence the production process is out of control. The points above UCL and below LCL represent the event of special cause of variation in process which can be attributed to factors affecting camber.
The simplest way to determine if a cause-and-effect relationship exists between two variables is to plot a Scatter Diagram. The scatter diagram of camber of precast HCS is shown in fig. 4 with date of production on X axis and camber on Y axis. The scatter diagram shows that the correlation between production and camber is very weak as coefficient of correlation is \( R^2 = 0.0958 \) which is less than 1.

**V. CONCLUSION**

In this paper the quality requirement of precast HCS by the clients in construction industry are surveyed and use of DMAIC methodology of six sigma philosophy has been used for quality evaluation of production process of precast HCS. Plant Pune, India. The conclusions drawn from observation and results of this paper are as follows:

1) The production process capability \( (C_{pk}) \) is 0.288 which is less than 1. Hence the process is out of statistical control. The existing process is undesirable and unstable.

2) The sigma level of precast HCS production under study was found to be 2.68, which is very low compared to manufacturing industry. The percentage of defects is 11.9%.

3) The DMAIC methodology can be applied to precast production in order to find the root causes of variation, eliminating the causes of variation and achieving process improvement by applying quality tools.

4) The control chart should be used to monitor the performance of process as they reflects occurrence of variation, to determine the process capability, to access the results of new process models.

5) There is a lot of scope in improvement in quality management techniques used by precast manufacturers. The statistical quality approach such as six sigma philosophy is well suited for precast industry.
REFERENCES