

Evaluation of Six Sigma Concepts in Construction Industry

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Abstract—Six sigma is new to construction sector and this philosophy is to reduce the defects in the construction. The aim of this study is to evaluate Six Sigma as a process improvement method within construction sector. In order to improve the process in construction it is important to understand the factors affecting the construction process and analyze the factors for the construction improvement. In this paper we have tried to improve the Painting work, Tile work and Brick work of a building by using DMAIC methodology. From the point of view of achieving Six Sigma concept on site the recommended corrective action plans on the defect were done. Thus the questionnaire fulfils the criteria for control plans of the construction activities in the final stage. The answered questionnaires were collected from the Site Engineers, Contractors, Consultants and Project managers. Then by using SPSS software, the collected data's were analyzed. The overall results of the study indicate that the implementation of Six Sigma in construction context will be achieved its aim by reducing the defects. In future, work on this concept is to be taken for the implementation to the real construction process.

Keywords— Six sigma, DMAIC, SPSS.

1 INTRODUCTION

Total Quality Management which is management philosophy focuses on continually work processes. Particularly, Six Sigma became a useful method as a performance indicator and process improver for the companies from different industry. Six Sigma is a rigorous, focused, and highly effective implementation of proven quality principles and techniques. Six Sigma aims for virtually error-free business process. Sigma, σ , is a letter in the Greek alphabet used by statisticians to measure the variability in any process [1]. Increasing numbers of companies start to integrate the full implications of Six Sigma. 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.

- Construction work has fragmented and project-oriented work processes compared to the manufacturing industry. So, the evaluation of Six Sigma within construction context becomes an interesting research question considering quality, performance

and management aspects. 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 quality initiative, performance indicator / improver and management strategy. 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.

2 METHODOLOGIES AND FRAMEWORKS

In this study, a survey-based approach is used to identify the Continuous Improvement (CI) initiatives commonly practised in construction companies as well as understanding the approach of these companies to Six Sigma [3]. Six Sigma continuous improvement methodology which known as DMAIC (define, measure, analyze,

improve, control) aims to enhance the efficiency of the existing processes and increase customer

satisfaction through designed products and services. DMAIC framework is an integration of several techniques such as QFD (quality function deployment), SPC (statistical quality control), DOE (design of experiments), and FMEA (failure mode and effects analysis) in a logical direction. This approach is more suitable when the current design of the products, services and processes are correct and satisfactory regarding to the requirements, customers and business. It emphasizes the identification and avoidance of variations. Moreover, six sigma principles underline the explicit recognition of the root causes of defects and statistical process control to sustain continuous improvement [5]. This methodology offers structured framework in following steps to establish systematic continuous improvement.

(i) Define- In this step 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.

(ii) 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.

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

(iv) Improve-Identify alternative solutions and methods based on the knowledge derived from analyze step, study and assess the potential solutions to distinguish the most successful improvement solution. Implement that successful method.

(v) 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.

The Six Sigma drive for defect reduction, process improvement and customer satisfaction is based on the "Statistical Thinking" paradigm [6]:

- i) Everything is a process
- ii) All processes have inherent variability
- iii) Data is used to understand the variability and drive process improvement decisions. Once an effort

or project is defined, the team methodically proceeds through Measurement, Analysis, Improvement.

The other methodology IDOV (identify, design, optimize, validate) design products, services and processes before their initiation, or redesign to achieve very high level quality. This also known as DFSS (Design for Six Sigma) which intends to enhances not only efficiency but effectiveness of the future products and services. This approach aims to provide the capability of very high level performance, being robust against variation, efficient usage of resources and focus on customer demands [2].

The most common reasons for industries to implement Six Sigma to resolve issues facing the construction industries [4]:

- Cost reduction
- Cycle time reduction
- Error and waste reduction
- Increase competitive advantage
- Improve customer satisfaction
- Change company culture
- Improve quality.

In the construction industry, the use of the six sigma principle for performance assessments, particularly aimed at high quality and variability control. Introduced the six sigma principle as one of the approaches to augmenting productivity, which concentrated on reducing cycle time and eliminating any defects or errors engaged in the processes [5].

2.1 Questionnaire Design

The survey questionnaire is designed to probe the cross sectional behavioural pattern of the six sigma in construction industry. The questionnaire was prepared for the survey was formulated by seeing the relevant literature in the area of construction six sigma. The interviewer was free to ask additional question that focused on issues during the course of interview. This survey is conducted on some zones in Tamilnadu. The freedom to follow the interview to ask for clarification and the focus on specific projects, knowledge made the interviews insightful.

2.2 Data Collection

- ❖ Questionnaires were mailed to respondents (Site engineers, Consultants, Contractors and Project managers).
- ❖ Completed forms were requested to be mailed or faxed back to the study, and the response for this request was poor..
- ❖ Forms were given to respondents to complete, and completed forms were

collected later.

- ❖ In many instances, forms were completed at the meeting; this method had the added benefit of making clarifications to respondents about questions in forms;
- ❖ The data's collected from some companies in Tamilnadu.

2.3 Evaluation

Relative importance index (Rii) analysis was employed to measure the likert (ordinal) scale. in this study, five scale rating was used and the weight was give as below:

- 1 – Strongly Disagree/ least Important;
- 2 – Disagree/ Of Little Importance;
- 3 – Neutral/ Neither Important;
- 4 – Agree/ Important;
- 5 – Strongly Agree/ Most Important

The RII was calculated by using the formula as below

$$RII = \sum W / AN$$

Where

W=weight of scale

A=highest weight (5'in this case)

N=total number of respondent

2.4 Reliability Analysis

Reliability test is conducted to check the stability and consistency of a data by using cronbach alpha method that is widely adopted. Reliability of the data is considered at low level when cronbach alpha is less than 0.3 which means the data is not reliable and cannot be adopted. Reliability is at high level when cronbach alpha is more than 0.7.

2.5 Relative Important Index (RII)

The questionnaires are collected and analyzed using statistical software package SPSS v 22. The ranking of factors was calculated based on Relative Importance Index.

2.6 Ranking of causes of Delay Factors

Hierarchal assessment of factors was carried out to determine ranking of the factors based on level of significance. It was assessed based on Relative important index (RII) value and calculated for each group of respondent's i.e. contractor, consultant and owners and also the overall respondents as presented. It shows that top 5 most significant factors of delay factor ranked by overall respondents are material market rate, contract modification, high level of quality requirement, project location, depends on the fresher's to bear the whole responsibility. Material market rate was ranked first (RII) as agreed by the entire respondent.

3 QUESTIONNAIRE SURVEY

3.1 Research Strategy

Qualitative research is designed to reveal a target audience's range of behavior and the perceptions that drive it with reference to specific topics or issues. The primary goal of Six Sigma is to improve customer satisfaction, and thereby profitability, by reducing and eliminating defects [6]. It uses in-depth studies of small groups of people to guide and support the construction of hypotheses. The results of qualitative research are descriptive rather than predictive. A qualitative strategy was adopted in this study due to the fact that it can be used at both the data collection and data analysis stages of a research project. The qualitative research type are typically more flexible i.e., they allow greater spontaneity and adaptation of the interaction between the researcher and the study participant. In qualitative research, only a sample (that is, a subset) of a population is selected for any given study. The most common sampling methods used in qualitative research are purposive sampling, quota sampling, and snowball sampling.

The interview is divided into two main stages which are preliminary interview and main interview. Initially preliminary interview was conducted through communicating with the key personnel of contractor and engineers. This interview was done through asking open ended questions. The results from this stage then used mainly to get some ideas and establish the objectives through finding the problems.

The interview was used specially for identifying other factors six sigma methods. After preliminary data gathering, questionnaire survey has carried out to reach the objective of this study among brick work, tile work and painting work based on six sigma concepts involved in construction projects. Questionnaire survey specifically has been used for evaluation of various modes of six sigma concepts.

3.2 Method of Surveying

The general methodology of this study relies largely on the survey questionnaire which will be collected from the site engineers, contractor, consultant and project manager by mail or by personnel meeting. A thorough literature survey was initially conducted to identify the factor of six sigma performance of construction industry as a whole six sigma.

This study has adopted the more general and broad definition of six sigma. More factors from other literature. Also some interviews with industrial practitioners were conducted to produce to check effectiveness of questionnaire.

3.3 Questionnaire Structure

The questionnaire was tested with a survey for clarity, ease of use and value of information that could be gathered. The questionnaire survey is divided into two parts. The first part consist of general information like type of company, experience value of their project etc and the second part consist of the construction six sigma factors for evaluation.

4 RESULTS AND DISCUSSION

4.1 Mode of Data Collection

This chapter presents the data analysis and discussions based on the questionnaire survey. The collected data were analyzed by using the SPSS software. The questionnaire has been collected on following two modes

- Direct Interviews
- Through Email

4.2 Response Rate

In this survey there are 45 questionnaires were distributed to various construction companies to the targeted respondent in order to identify the most important factors that six sigma. The questionnaire was completed by experienced consultants, contractors, project managers and site engineers. In those 26 responses has been received. The response rate of this survey was 57.77%. The response rate will be explained in following table and chart.

4.3 Analysis of Results

The objective of conducting the analysis for this section is to establish the factors under the groups of causes identified from the literature review and the ranking according to their significant influence towards construction project in six sigma. To identify six sigma factors, literature reviews, books, conference proceedings and discussion with practitioners of all parties involved in construction industry were carried out. Questionnaire for the survey was developed based on 52 factors. Prior to formulating questionnaire, a field study was carried out to get feedback from experts in construction industry on the factors identified from literature reviews.

4.4 Respondent's Profile

The questionnaires were distributed to site engineers, consultants, contractors and project managers of Indian construction industry. The respondents involved in the survey had several years of experience in handling various types of projects. The characteristics of the respondents participated in survey are summarized in Table. All the respondents had experienced in handling large projects with 64% of respondents executed

building projects. A significant number of respondent's i.e. 57.77% of respondents have executed more than 40 projects.

Table 1
Response rate

Description	Count
No of questionnaire distributed	45
No of response received	26
Response rate (%)	57.77%

In the following table describes that the various respondent's percentage with their frequency level.

Table 2
Respondent's Percentage

Parameter	Frequency	Percentage (%)
Site engineer	2	7.69
Contractor	13	50
Consultant	9	34.62
Project manager	2	7.69

The following bar chart shows that the ratio between the number of questionnaire distributed and the number of response received in the figure.

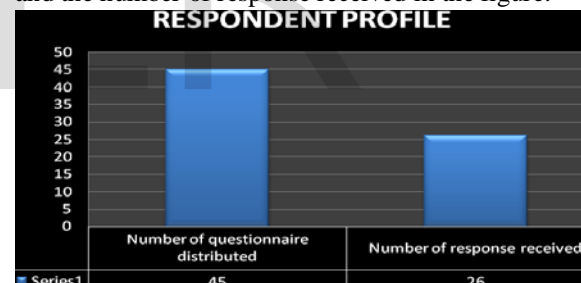


Figure 1 Respondent Profile

The following bar chart shows that the various respondent details (Site engineers, Contractor, Consultant, Project Managers) with series 1 and 2 in the figure.

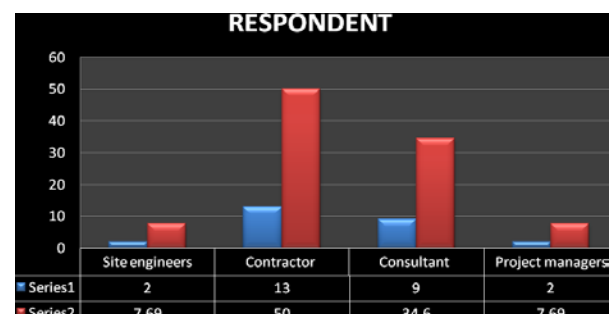


Figure 2 Respondent details in bar chart

(i) SPSS Report and Results

The following figures shows that the report of

Statistical Package Social Science (SPSS)

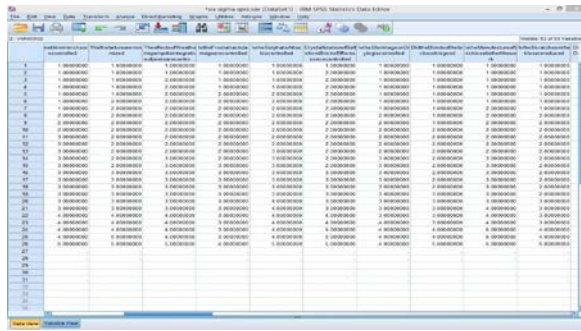


Figure 3 SPSS Report_1

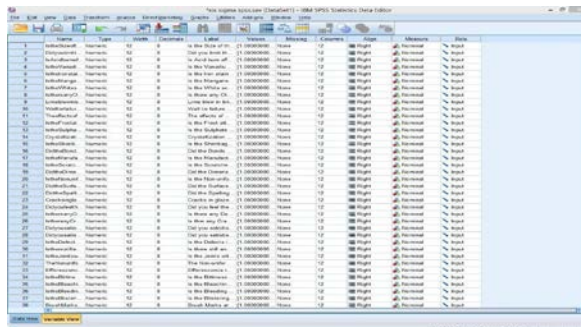


Figure 4 SPSS Report_2

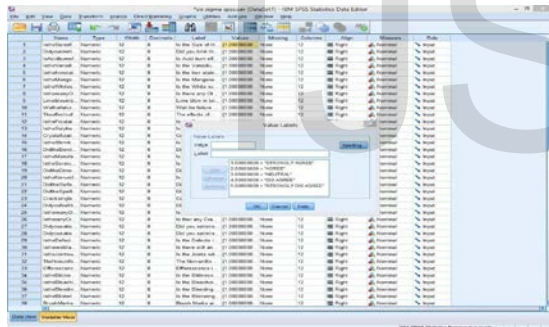


Figure 5 SPSS Report_3

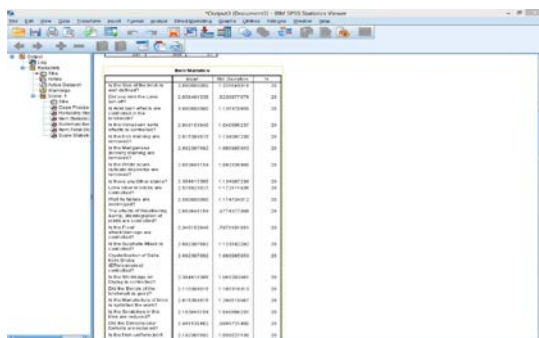


Figure 6 SPSS Report_4

(ii) Most Significant Factors

Based on the various factor of questionnaires, evaluate the work of brick, tile, and paint with the corresponding mean value and arrange in rank wise. From the ranking order of brick, tile, paint work to select the top five ranks and separates it

for the further evaluation.

The following table 3 which includes top ranking for the evaluation of brick work.

Table 3
Top ranking of brick work

S.no	Description	Rank
1.	Size of the brick	1
2.	Acid burn effects	1
3.	Vanadium salts effects	3
4.	Manganese (brown) staining	4
5.	Sulphate Attack	4
6.	Crystallization of Salts from Bricks	4

The following table 4 which includes top ranking for the evaluation of tile work.

Table 4
Top ranking of tile work

S.no	Description	Rank
1	Cracking in floor tiling	1
2	Cracking in wall tiling	1
3	Efflorescence	3
4	Detachment in wall tiling	4
5	Unsafeness in walking on the tile	4

The following table 5 which includes top ranking for the evaluation of paint work.

TABLE 5
Top ranking of paint work

S.no	Description	Rank
1	Efflorescence	1
2	Slow drying	2
3	Blistering	3
4	Rain-spotting	3
5	Peeling	3

5 CONCLUSION

The main purpose of the master thesis has been to develop a project questionnaire model based on the theory of Six Sigma. In order for the model to actually be used, a guide on how to implement the project questionnaire model has also been developed. Questionnaire for each of the DMAIC phases in the Six Sigma model and also gave brief introduction for Six Sigma model. The instructions on followed by some literature reviews and senior engineers. The six sigma is SPSS V.22 software used to analyses the questionnaire factors. The top ranking factor in brick work, tile work and painting work finding. Results which give a guide on how to implement

the project six sigma model in construction projects. The Six Sigma maturity level is a measure developed by the authors to be able to compare the wished position and the current situation to best practice according to Six Sigma.

REFERENCES

- [1] Adure, gautam s and shusma s. kulkarni, (2012), —Process improvement in construction industry through six sigma approachl, Global J. of Engg. & Appl. Sciences, 2012: 2(1). Review Paper: Adure and Kulkarni, Pp.49-55.
- [2] Maryam Dabbaghi Tehrani, “Performance Improvement in Construction Project based on Six Sigma Principles” University of Boras, February 2010.
- [3] Mehmet Tolga Taner, (2013),Critical Success Factors For Six Sigma Implementation In Large-Scale Turkish Construction Companiesl by Uskudar University, Istanbul 34662, Turkey. Vol. 3, No. 4, pp.212-225.
- [4] Okonkwo,v.o and mbachu, v. m (2015), —A Comparative Analysis of Application of Six Sigma Project Management Technique in Small and Medium Scale Construction Companies in Nigerial, Nigeria European Journal of Engineering and Technology Vol. 3 No. 3, ISSN 2056-5860
- [5] Seung Heon Han, Myung Jin Chae, Keon Soon Im, and Ho Dong Ryu (2008),—Six Sigma-Based Approach to Improve Performance in Construction Operationsl Yonsei Univ., Seoul 120-749, Korea. Vol. 24, No.1, ISSN 0742-597X/2008/1-21–31
- [6] Sunil V. Desale, Sharad V. Deodhar, (2014), —Identification And Eliminating Waste In Construction By Using Lean And Six Sigma Principlesl, Department Of Civil Engineering, S. V. Institute Of Technology, Indore, Madhya Pradesh, Pin India. Volume 3, Special Issue 4, ISSN (Print): 2347 – 6710.

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