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QUALITY ANALYSIS IN CONSTRUCTION PROJECTS USING SIX SIGMA CONCEPT

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ABSTRACT

Six sigma is new to construction sector and this philosophy is to reduce the defects in the construction process. The critical objective of construction industries nowadays is to complete a project within a stipulated time and cost as per the required standards and specifications, minimization of waste and efficient use of resources. Six Sigma principles with an effective methodology in construction helps in reducing variation and eliminating the root causes of defects. Six Sigma can provide a broader quality concept, detailed performance measurement, coordinated and repeatable process/performance improvement. 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. This paper aims to improve the quality of concrete structures, paint work, brick work , welding and joints 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 is done. Thus the questionnaire fulfils the criteria for control plans of the construction activities in the final stage. The answered questionnaires were collected then by using SPSS software, the collected data's is analyzed. The results of the study indicate that the implementation of Six Sigma in construction context will be achieved its aim by reducing the defects. This process suggest that proper training and management support and minor changes in current work procedure can help improve the quality in construction process and ultimately customer satisfaction which is of prime importance.

Keywords: define measure analyze control (dmaic) , six sigma, statistical package for social studies (spss)

I. INTRODUCTION

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. 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. 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 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. 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.

1.1 OBJECTIVES

- To study the various defects in construction site which influence the quality of project.
- To apply six sigma concepts in construction projects for quality improvement using DMAIC (DESIGN, MEASURE, ANALYSE, IMPROVE, CONTROL) methodology.

II. METHODOLOGY

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 . In this study, a survey-based approach is used to identify the Continuous Improvement initiatives commonly practiced in construction companies as well as understanding the approach of these companies to Six Sigma. 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. 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 most common reasons for industries to implement Six Sigma to resolve issues facing the construction industries :

• 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.

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 Chennai, Tamil Nadu. 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 Chennai.

III. QUESTIONNARIE SURVEY

The primary goal of Six Sigma is to improve customer satisfaction, and thereby profitability, by reducing and eliminating defects. 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 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. 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.

IV. 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

$RII=\Sigma W/AN$

Where,

W=weight of scale

A=highest weight (5‘in this case)

N=total number of respondent.

4.1 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.

4.2 RELATIVE IMPORTANT INDEX (RII)

The questionnaires are collected and analyzed using statistical software package SPSS v 23. The ranking of factors was calculated based on Relative Importance Index. 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.

4.3 MULTIPLE REGRESSION ANALYSIS

A statistical tool that allows to examine how multiple independent variables are related to a dependent variable and also allows to take information about all of the independent variables and use it to make much more powerful and accurate predictions about why things are the way they are. This latter process is called “Multiple Regression”. Multiple regression is an extension of simple linear regression. It is used to predict the value of a variable based on the value of two or more other variables. The variable which is to be predicted is called the dependent variable. The variables using to predict the value of the dependent variable are called the independent variables. For example, use of multiple regression to understand whether exam performance can be predicted based on revision time, test anxiety, lecture attendance and gender. Alternately, multiple regression can be used to understand whether daily cigarette consumption can be predicted based on smoking duration, age when started smoking, smoker type, income and gender. Multiple regression also allows to determine the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained. The "quick start" guide shows how to carry out multiple regression using SPSS Statistics, as well as interpret and report the results from this test.

V. RESULT AND DISCUSSION

The collected data were analyzed by using the SPSS software. The questionnaire has been collected on following two modes direct interview and through mail.

5.1 RELIABILTIY TEST

TABLE 5.1 RELIABILITY STATISTICS USING SPSS

CRONBACH’S ALPHA	NO. OF QUESTIONS
0.968	**62**

The above table shows the calculated cronbach value using spss. The value is found to me 0.968 which is a very reliable source.

FIGURE 5.1 SHOWS THE SPSS REPORT OF RELIABITY ANALYSIS

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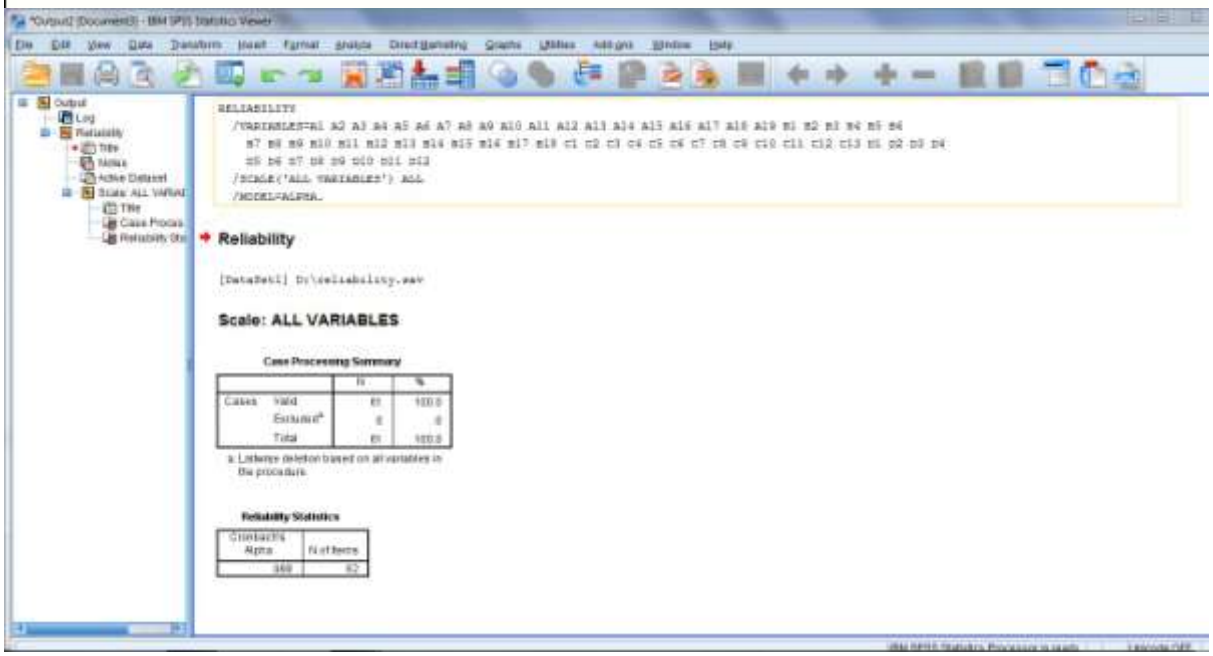
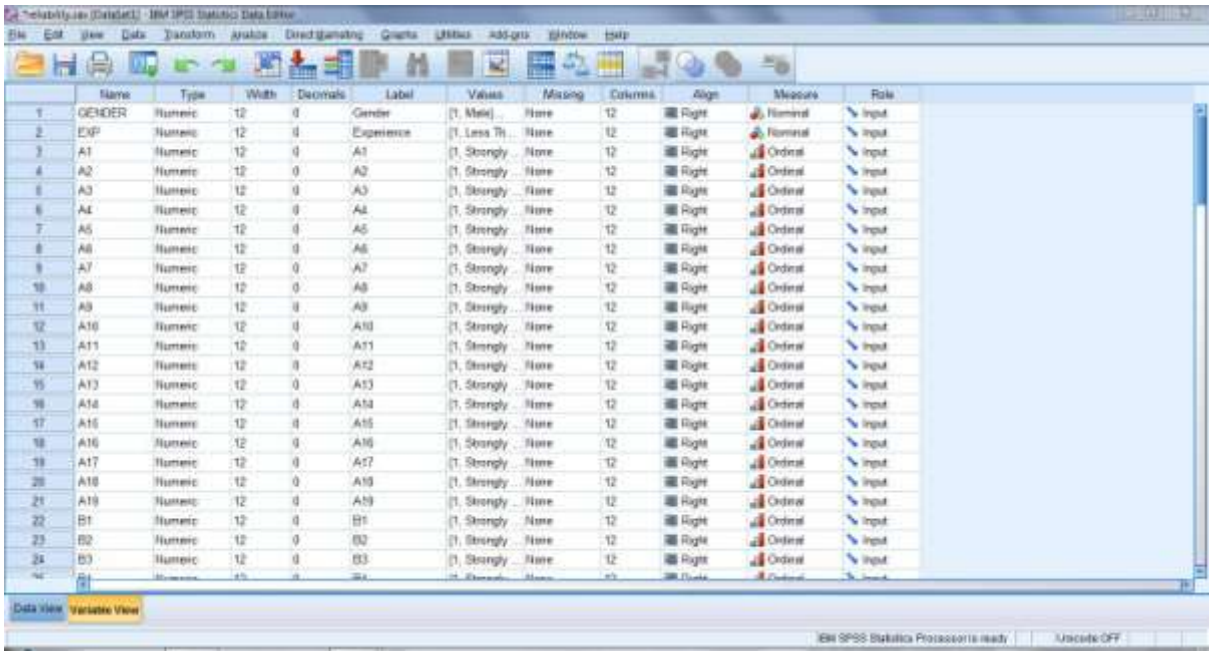


5.2 SPSS REPORT AND RESULTS

Based on the various factor of questionnaires, analysis for defects in concrete structures, paint work, brick work, welding and joints with the corresponding mean value and arrange in rank wise. From the ranking order the top five ranks are selected and separates it for the further evaluation.

Figure 5.2 SPSS TEST REPORT-1



The following table 5.1 shows the top ranks of defects in concrete structures

Table 5.1 TOP RANKING OF DEFECTS IN CONCRETE STRUCTURES

SL.NO	DESCRIPTION	RANK
1	DUE TO EXTERNAL FACTORS	1
2	CRAZING	2
3	EFFLORESCENCE	3
4	ROCK POCKETS	4
5	HONEY COMBING	5

The following table 5.2 shows the top ranks of defects in paint work

Table 5.2 TOP RANKING FOR DEFECTS IN PAINT WORK

SL.NO	DESCRIPTION	RANK
1	ENVIRONMENTAL FACTORS	1
2	GRINNING	2
3	BLOOMING	3
4	SAGGING	4
5	FLAKING	5

The following table 5.3 shows top ranks of defects in brick work

Table 5.3 TOP RANKING OF DEFECTS IN BRICK WORK

SL.NO	DESCRIPTION	RANK
1	EXTERNAL FACTORS	1
2	THERMAL EXPANSION	2
3	SHRINKAGE EFFECT	3
4	SULPHATE ATTACK	4
5	LEVELING	5

The following table shows the top ranks of defects in welding and joints

Table 5.4 TOP RANKING OF DEFECTS IN WELDING AND JOINTS

SL.NO	DESCRIPTION	RANK
1	INADEQUATE JOINT PENETRATION	1
2	CORROSION	2
3	CRACK	3
4	UNDERCUT	4
5	TUNGSTEN INCLUSIONS	5

VI. CONCLUSION

The aim of this thesis is to develop a project questionnaire model based on the theory of Six Sigma. Questionnaire were prepared based on each of the DMAIC phases in the Six Sigma model. The SPSS V.23 software used to analyses the questionnaire factors. The top ranking factor in concrete structures, paint work , brick work, welding and joints were found. Results will give a guide on how to implement the project six sigma model in construction projects thereby increasing the quality. Using the result, Recommendations and mitigation measures can be given to the construction sites.

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