IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X,
PP 01-05
www.iosrjournals.org

Quality Improvement in Building Construction Using Six Sigma

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Abstract: *There are number of factors which affect the quality of product, time of work, cost , waste of material, etc. the objective of construction industry is to complete a project within a stipulated time, cost as per required standard and specifications , minimum waste efficient use of resource. This paper describes the study on Six Sigma and quality improvement in building construction using Six Sigma principle. By using the DMAIC methodology of Six Sigma which help to identify the quality of existing structure by analyzing the defects that will suggest in DFSS for changes that required in current work.*

Keywords: *Six Sigma, Defects, Construction, Quality Improvement, DMAIC, DFSS*

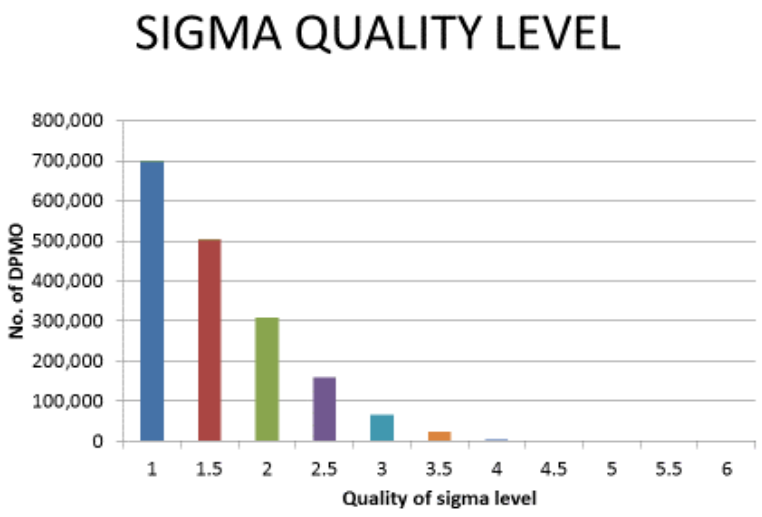
I. Introduction

Quality management is used to achieve and sustain the quality with considering the requirements to meet the customer satisfaction. For any company, construction industry quality improvement, high performance is necessary in the competitive world market. For achieving quality with high performance by identifying and analyzing necessary changes required for quality improvement Six Sigma is used. Six sigma problem solving process.

II. Six Sigma Theory

The Greek word, "σ" used to denote the standard deviation of set of data. The standard variation is associated with calculation of average value for a particular set of data. Sigma is nothing but a deviation from mean. Six Sigma derived from statistical distribution called "standard normal distribution". Six Sigma consider the range of lower and upper limit defect is +/- 6 sigma from the mean. Six Sigma is a statistics based methodology based on scientific method to the reduction in defect rates defined by customer for eliminate defects from every product process. Following graph illustrates the rate of defects per million opportunities in different sigma levels.

Graph 1: Overview of Sigma Level and DMPO



DMAIC Procedure:-

As per paper publish by Miroslav RUSKO named "Application of Six Sigma method of EMS design". Six sigma is based mainly on understanding the customer needs and expectations, improving and establishing new process, manufacturing and service process. Six sigma is a continuous improvement methodology by using DMAIC. For implementation of six sigma method to improve the quality of products and processes base tool is DMAIC (Define, Measure, Analyze, Improve, Control). DMAIC framework gives some techniques such as DOE (Design of Experiments), FMEA (failure mode and effect analysis), control chart, QFD (Quality Function Deployment) in a logical direction. This methodology offers structured framework in following steps to establish systematic continuous improvement.

Define: To define customer requirements and any things that do not meet those requirements are defects. Identify problems which affect quality. To define project aim and need.
Measure: Construction activity is a set of various dependent activities. Identify the performance requirements of the process with respect to its defects characteristics.
Analyze: To study and analyze the data collected in previous step and find out the root causes of defects.
Improve: Improve for eliminate the defects. Identify the ways to destroy the existing defects. Develop the solution.
Control: Measure the performance of the new process under a controlled plan to control the quality level of the process. For increase the sigma level.

III. Applying Six Sigma in Building Construction

The checklist is prepare for various components. The one which meets standard requirement is marked as '0' else it is marked as '1' and NA shows that item not applicable. The total number of defects and total number of opportunities for defects in each checklist is calculated as follows.

$$DPMO = \frac{\text{No. of '1' in checklist} * 1000000}{\text{No. of Opportunities of defects} * \text{No of units.}}$$

In this paper the following tools are used in each stage of DMAIC methodology:

Define: SIPOC (Suppliers inputs process outputs customer)
Measure: Pie chart
Analyze: Cause and effect diagram
Improve: Remedies for corrective action
Control: Control plan.

Case Study:

A residential building in which one is before handover to customer consist 14 flats and another after handover to customer consist 10 flats are considered for this study by using DMAIC process. A checklist done for plastering work, which covers various points whose quality was checked as shown in table.

Table 1: The summary of data for the two buildings is as shown below:

Sr. No.	Building	Defects	Opportunities
1.	Building before handover to customer	2013	5777
2.	Building after handover to customer	2190	3237
	Total	**4203**	**9014**

Formula :

$$DPMO = \frac{\text{No. of defects} * 1000000}{\text{No. of opportunities}}$$

=4203*1000000/9014
=466274.68

Based on Sigma Level Table

$\sigma = 1.8$

Table 2: Checklist for Plastering

Sr. No.	Points Description	L.R.	Kit	Bath	W.C.	Bal.
1	Swelling of small patches in plastering	0	0	0	0	0
2	Cracks on plastered surface	0	0	0	0	0
3	Falling of plaster	1	1	0	0	1
4	Whitish crystalline substance on plastered surface	0	0	0	0	0
5	Peeling off ceiling plaster	0	0	0	0	0
6	Rust stains	0	0	0	1	0
7	Softness	0	0	0	0	0
8	Uneven surface of plaster	0	0	0	0	0
9	Peeling off top finish layer of internal plaster	0	0	0	0	0
10	Vertical and horizontal edges of beams, columns and slabs	0	0	0	0	0

Note: 0=Defects, 1= Non-defect

DMAIC Methodology:

By studying the checklist we have selected some activities like walls and ceiling, tiling, doors and windows, plumbing and sanitation, electrification, painting, plastering. Out of the above mentioned activities, in this paper we have tried to improve the quality of plastering by using DMAIC methodology. After evaluation of Sigma level, DMAIC methodology was applied to improve the quality of Plastering work as follows.

1. Define : (SIPOC)- Suppliers Inputs Process Outputs Customers)

SIPOC helps to finding the boundaries of what we will be working. As shown in below in the table.

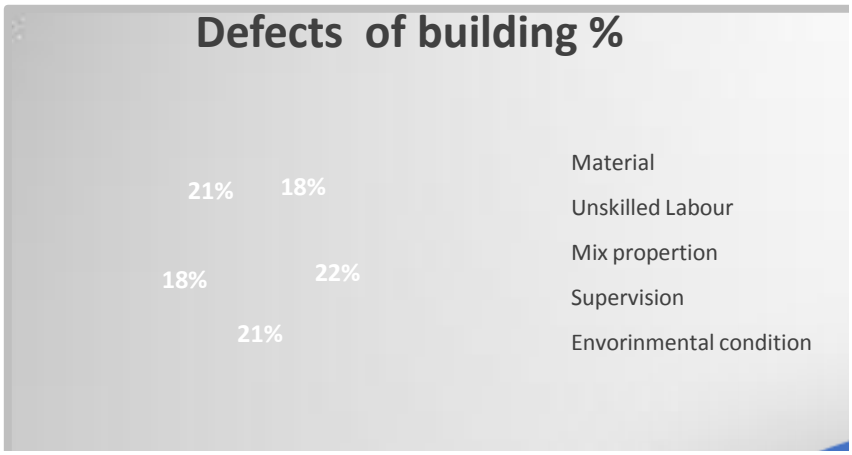
Table 3: SIPOC Analysis for Plastering

Supplier	Inputs	Processes	Outputs	Customer
Builder	1. Cement 2. Sand 3. Water 4. Admixtures 5. Neeru 6. Mortar pans 7. Spade 8. Chisel 9. Hammer 10. Trowel 11. PVC water level tube 12. Wooden float 13. Metal float 14. Batten for making groves 15. Aluminum box section of 1.8m length 16. Right angle, small and big 17. Measuring tape 18. M. S. Corner 19. Nylon string 20. Plumb bob 21. Scaffolding material 22. Chicken mesh, plumbing nails, cutter, wire nails, GI washers etc 23. Drilling machine 24. Measuring boxes for measuring sand 25. Screens for sieving sand 26. Wire brush 27. Sponge for sand face plaster	1. Arrange M.S. chairs wooden planks, kathya for scaffolding and check it for stability and proper height. 2. Dump the required sand , measuring boxes as per the proportions of mixes 3. Mixed the ingredients in proportions and use the required quantity of water 4. Mix only2-3 bags depots at a time and use mixed depots within half an hour 5. Start plastering of ceiling first and then walls 6. Apply neeru to all the walls after two hours except where tiles in dado are to be fixed . 7. Leave and cut the plaster correctly 23cm from floor level for skirting fixing 8. Neatly finish all the corners of windows , doors and column etc with pure cement 9. Clean all window , fan , door frame 10. Finish of neeru should be very smooth 11. See that no chicken mesh wires are seen outside the plaster. If observed , cut them and finish immediately. 12. Ensure that maximum plaster thickness should dose not exceed 20mm 13. On the second day, smooth finishing should be done with the mason's trowel, before starting day's work . 14. Do not carry out the plastering of bottom 30cm portion in WC and bath from slab level. 15. As no skirting is to be provided below and to the sides kitchen otta and balcony , plaster all the four walls up to 25mm from bottom slab level	Finishing plastering surface	Flat owners

2. Measure :

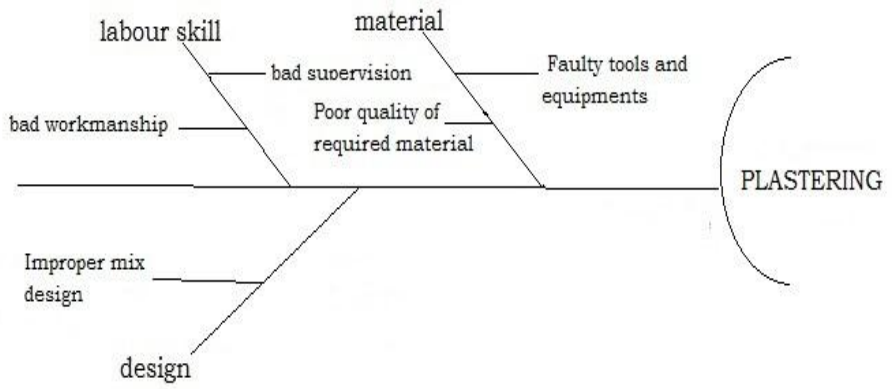
Helps to identify the most significant factors, shows where to focus efforts and better use of limited resources.

Graph 2: Defects in Building Construction



3. Analyze : (Cause and effect diagram)

Figure 1: Cause & Effect Diagram



4. Improve : Remedies for plastering

Table 4: Defects & Remedies

Sr. No.	Defects	Remedies
1.	Swelling of small patches in plastering.	The lime should be properly slacked before use. Slacked lime should be left for some week to cool before use.
2.	Cracks on plastered surface	a. Proper mixing of mortar b. Control on mix proportion of mortar c. Avoid excess trowelling. d. Suitable control over variations in temperature subsequent to plastering.
3.	Falling of plaster	a. To ensure proper key by racking out joints and roughening of background material on the base coat. b. Watering of base coat at least one day before plastering. c. Fresh surface should be kept wet and cool for at least 15 days. d. Surface should be kept semi wet as per exact requirement.

5. Control:

Control plan will help us to check on the various preventive measures which will help to achieve the desired result. Control plan is a description of the procedures, checks or assigned activities with respect to specifications, marking and performance. For check the preventive measures use the checklist as a control plan.

IV. Conclusion

We study the various factors affected to quality of the construction. These factors must be identified as early as possible so that the quality of construction can be improved. The methodology of six sigma principles gives systematic approach to identify and improve the current construction process. It also measure whether the quality has been improved or not. It is used to reduce and eliminate variation which cause defect, to meet the quality standards also improve the quality and ultimately customer satisfaction.

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