International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Use of Six Sigma on internal finishes in construction

Deepanjali P. Patil[1], Rajnikant Devalkar[2], Pushpanjali P. Patil[3]

[1]*M.E Civil, N.D.M.V.P.S's K.B.T. College of Engineering Nasik, Maharashtra, India,*
patildeepanjali14@gmail.com
[2]*M.E Civil, N.D.M.V.P.S's K.B.T. College of Engineering Nasik, Maharashtra, India,*
rajanikant99@gmail.com
[3]*B.E Civil, S.S.V.P.S's. College of Engineering Dhule, Maharashtra, India,*
pushpanjalipatil08@gmail.com

Abstract: Six Sigma was developed in 1980's in manufacturing industry & became popular as process improvement method. Although Six Sigma has been implemented in the manufacturing & other services industries, it is still relatively a new concept in the building industry. This paper includes the detailed methodology of Six Sigma. The market survey about need of process improvement is done particularly to know concepts of quality, cost, productivity, productivity time, customer satisfaction and use of Six Sigma within construction industries in Maharashtra zone And a case study on how Six Sigma can be implemented on internal finishing work of a public building to minimize defects and thereby to improve quality of work.

Particularly Six Sigma can provide a broader quality concept, detailed performance measurement, coordinated & repeatable performance improvement. Six Sigma is discussable within construction context due to differences of manufacturing & construction industry. Taking everything in consideration, it is obvious that Six Sigma has a lot in order to accelerate fundamental & cultural challenges construction industry needs.

Keywords: Six Sigma[1], Construction[2], Quality Control[3], Process improvement[4], DMAIC[5], DPMO[6].

I. INTRODUCTION

Construction management and technology are the two key factors influencing the development of the construction industry. The productivity of the construction industry worldwide has been declining over the past 40 years. One approach for improving the process is using Six Sigma concepts in construction. Six Sigma is a quality improvement technique based on statistics was used firstly by Motorola in 1980s by Bill Smith of Motorola to decrease cost, increase quality by improving process and reduce the production time. It received little publicity until late 1990s. Six Sigma results the application of a new form of management technique to construction. In general, six sigma projects are easier to manage, safer, completed sooner, and cost less and are of better quality. Sigma within construction context becomes an interesting research question considering quality, performance and management aspects. Six Sigma is a quantitative approach for improvement with the goal of limiting defects from any process, specially a numerical goal of 3.4 defects per million opportunities (DPMO). Six Sigma is reportedly easier to apply than many other quality management programs because it provides information about the change needed and the programs to execute the change. The strategy it uses is a five step improvement process:

Define Measure, Analyze, Improve and Control (DMAIC). This process is deeply integrated with the overall goals of the organization and as such, requires top down implementation. Six Sigma is more intense, focused and detail than any other quality improvement techniques.

1.1 Purpose & Objective of the Research

1. To study the Six Sigma concept
2. To check the awareness of process improvement (Six Sigma) in market at Dhule and nearby zones.
3. Applying DMAIC technique of Six Sigma methodology on internal finishing work.
4. Compare Six Sigma value results of regular method of working and Six Sigma methodology.

1.2 Scope of the study

1.3 Six Sigma can be implemented in different types of construction projects and site environment such as: Industrial and residential projects, transportation, water, power plant, structure, etc. That's why; this study will attempt to cover site and office based operations of construction project. Considering the mentality differences between various contractors, builders, consultants, project managers, site and office engineers, it is important to reflect their ideas and perspectives about process improvement.

II. LITERATURE REVIEW

- Harry and Schroeder (2000), who are the key developers and proponents of the Six Sigma program at Motorola, defined Six Sigma as ''a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them.''[1]
- Snee (2000) indicated that ''Six Sigma should be a strategic approach that works across all processes, products, company functions and industries.''[2]
- Chowdhury (2001) explained that Six Sigma represents a statistical measure and a management philosophy that teaches employees how to improve the way they do business, scientifically and fundamentally, and how to maintain their new performance level. It gives discipline, structure, and a foundation for solid decision-making based on simple statistics.[3]
- Pande et al. (2000) defined Six Sigma as (1) a way of measuring processes, a goal of near perfection represented by 3.4 defects per million opportunities (DPMO) ; and more accurately, (2) a comprehensive and flexible system for achieving, sustaining, and maximizing business success. It is uniquely driven by a close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes.[4]
- Pande and Holpp (2002) defined Six Sigma as (1) a statistical measure of the performance of a process or a product; (2) a goal that reaches near perfection for performance improvement; and (3) a system of management to achieve lasting business leadership and world-class performance.[5]

2.1 SIX SIGMA METHODOLOGY: DMAIC

The standard Six Sigma methodology consists of five phases: Define Measure, Analyze, Improve and Control (DMAIC). It sequences the steps that are essential to achieving results and briefs as follows: (1)Define: this phase is to define the requirements of customers, the scope of processes to be investigated. Project targets then set based on the customer's requirements.

(2)Measure: identify the key metrics, possible factors that affect the key metrics, the data collection plan, and execute the plan of data collection. And also preliminarily analyze the causes that result of variation.

(3)Analyze: Analyze the data collected and the process to determine the root causes of the problem that need to be improved.

(4) Improve: verify the relationship of key root causes that affected the variation of the key metrics. Then, aim the key factors and develop solutions to improve the process or production tools. Plot them on a small scale to determine if they positively improve the process performance, Successful improvement methods are then implemented on a wider scale. Results of process changes are quantified.

(5)Control: develop and implement a control plan to ensure that performance improvement remains at the desired level. The process have to be monitored to prevent abnormal changes occurred.

2.2 DPMO

The sigma concept of measuring defects was started by Motorola in the early 1980s as a way to develop a universal quality metric that applied regardless of product complexity or dissimilarities between different. products or processes. Higher sigma values indicate better products or processes with fewer numbers of defects per unit of product or service. Products produced at a Six Sigma level of quality operate virtually defect-free by definition, with only 3.4 defects per million opportunities (DPMO) as shown in Table-1. Through Six Sigma, every measurable can be compared on the same platform through converting yields or DPMO to sigma level, no matter how different they may be. All the organization needs to do is to set out guidelines in determining measurable during implementation.

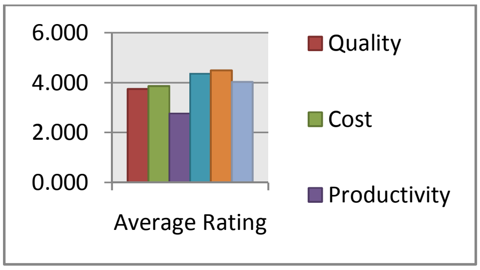
Table-1: Basic Six Sigma Conversion Table [6]

Basic Sigma Conversion Table		
Yield=Percentage of items without defects	Defects per million opportunities (DPMO)	Sigma Level
30.9	690 000	1
69.2	380 000	2
93.3	66 800	3
99.4	6 210	4
99.98	320	5
99,9997	3.4	6

III. Case Study

A) Market survey about need of process improvement:

To know need of process improvement in market the survey is taken of 60 people within construction context at Dhule and nearby zones (Maharashtra). The questions regarding quality, cost, productivity, productivity time, customer satisfaction and need of Six Sigma are asked and average ratings are calculated and shown in the form of graphical representation shown below;



Graph 1- Market survey about need of process improvement in construction

B) Applying Six Sigma for internal finishes:

An example of how Six Sigma may be applied for improving the quality of internal finishes on "Dr. Babasaheb Ambedkar Bhavan Construction" of Public Work Department, Dhule is now described. It comprising of 3 buildings called building A, B and C. Amongst that building A and B are nearly identical so they are selected for study. A checklist is prepared for internal finishing work, which covers various points whose quality needs to be checked. The checklist as shown in table is prepared. The data is filled in the checklist for building A. the one which confirms to standards are marked as ''√'' else ''×''. The number of ''×'' leads o defects and the total number of checks leads to opportunities. To reiterate, the architectural elements associated with internal finishes are most visible to the naked eye. It is necessary to reduce the incidence of defects associated with internal finishes in order to eliminate the number of complaints relating to poor quality for internal finishes. For this purpose following components are selected as prominent zones. • Floors and walls: finishing, alignment & evenness, cracks & damages, hollowness, and jointing;
• Ceilings: finishing, alignment & evenness, cracks & damages, roughness, and jointing;

i. Regular method of internal finishing work of Dr. Babasaheb Ambedkar Bhavan:

LOCATIONS		FLOORS					WALLS					CEILINGS				
		FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	HOLLOWNESS	JOINTING	FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	HOLLOWNESS	JOINTING	FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	ROUGHNESS'	JOINTING
ROOM NO. 1	WALL 1	×	√	√	√	√	×	√	√	×	√	√	×	√	√	√
	WALL 2	√	×	√	√	×	√	√	√	√	√	×	√	√	√	×
	WALL 3						×	×	√	√	√					
	WALL 4						√	√	√	×	√					
ROOM NO. 2	WALL 1	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√
	WALL 2	√	×	√	×	×	√	√	×	√	√	√	×	√	×	√
	WALL 3						×	×	√	×	√					
	WALL 4						√	√	×	×	×					
ROOM NO. 3	WALL 1	√	√	×	√	√	√	√	√	√	√	×	√	√	√	√
	WALL 2	√	×	√	×	√	√	×	×	√	√	√	×	√	√	√

	WALL 3						√	√	√	√	√					
	WALL 4						√	√	×	√	√					
ROOM NO. 4	WALL 1	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√
	WALL 2	√	×	×	√	√	×	√	√	×	√	×	√	√	×	√
	WALL 3						√	√	√	√	√					
	WALL 4						√	√	×	√	√					
ROOM NO. 5	WALL 1	√	×	√	√	√	×	√	√	√	√	√	√	√	√	√
	WALL 2	×	√	√	√	×	√	√	×	√	√	×	√	×	√	√
	WALL 3						√	√	√	×	√					
	WALL 4						×	√	√	√	√					
NO . OF DEFECTS		14					23					12				
NO . OF DEFECTS		50					100					50				
TOTAL NUMBER OF DEFECTS												49				
TOTAL NUMBER OF CHECKS/OPPORTUNITIES FOR DEFECTS												200				

ii. Applying Six Sigma methodology on internal finishing work of Dr. Babasaheb Ambedkar Bhavan:

LOCATIONS		FLOORS					WALLS					CEILINGS				
		FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	HOLLOWNESS	JOINTING	FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	HOLLOWNESS	JOINTING	FINISHING	ALIGNMENT & EVENESS	CRACKS & DAMAGES	ROUGHNESS'	JOINTING
ROOM NO. 1	WALL 1	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√
	WALL 2	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	WALL 3						×	√	√	√	√					
	WALL 4						√	√	√	√	√					
ROOM NO. 2	WALL 1			√	√	√	√	√	√	√	√	√	√	√	√	√
	WALL 2		×	√	√	√	√	√	√	√	√	√	×	√	√	√
	WALL 3						√	×	√	√	√					
	WALL 4						√	√	√	√	√					
ROOM NO. 3	WALL 1	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√
	WALL 2	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√
	WALL 3						√	√	√	√	√					
	WALL 4						√	√	√	√	√					
ROOM NO. 4	WALL 1	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	WALL 2	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√
	WALL 3						√	√	√	√	√					
	WALL 4						√	√	√	√	√					
ROOM NO. 5	WALL 1	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	WALL 2	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√

	WALL 3		√	√	√	×	√	
	WALL 4		×	√	√	√	√	
NO . OF DEFECTS		2	5					4
NO . OF DEFECTS		50	100					50
TOTAL NUMBER OF DEFECTS								11
TOTAL NUMBER OF CHECKS/OPPORTUNITIES FOR DEFECTS								200

Calculations for Sigma value:

i. Regular method of internal finishing work of Dr. Babasaheb Ambedkar Bhavan: For Building A:

The DPMO (defects per million opportunities) formula is used:
DPMO= (No. of defects) / (No. of opportunities*No. of units)*1,000,000
The DPMO relating to the internal finishes of building A unit recently completed by Contractor was then calculated based on the data collected and presented in Table1.
DPMO= (No. of ''X'' in the data collection sheet)/ (No. of opportunities of defects*No. of units) *1,000,000
DPMO= (49)/ (200*1)*1,000,000=245000
Based on the sigma conversion table in Table-1, the equivalent sigma for 245000 DPMO was approximately 2.2σ and according to belt holders it was decided that 2.2σ was not acceptable where quality of internal finishes is concerned. So a decision was made to apply Six Sigma on Building B which is identical to building A to improve the quality of work.

ii. Applying Six Sigma methodology on internal finishing work of Dr. Babasaheb Ambedkar Bhavan For Building B:

DPMO= (11)/ (200*1)*1,000,000=55000
Based on the sigma conversion table in Table-1, the equivalent sigma for 55000 DPMO was approximately 3.4σ
Remark: By comparing both the above processes, increase of 1.2σ is found in building B by application of DMAIC technique of Six Sigma methodology.

CONCLUSION

1. The market survey shows that, there is a desperate need of process improvement where the quality concept is concerned.
2. Although Six Sigma is a relatively new quality initiative in the building industry, the results of this case study show that it can be implemented and can minimize the defects.
3. By comparing the regular method of working for internal finishing work of building A with DMAIC technique of Six Sigma methodology on building B, increase of 1.2σ is found in building B.
4.

REFERENCES

[1].Harry, M., and Schroeder, R. (2000). Six Sigma: The breakthrough management strategy revolutionizing the world's top corporations, Doubleday, New York.

[2].Snee, R. D. (2000). ''Impact of Six Sigma on quality engineering.'' Qual. Eng., 12(3), ix–xiv.

[3].Chowdhury, S. (2001). The power of Six Sigma: An inspiring tale of how Six Sigma is transforming the way we work, Financial Times/Prentice-Hall, London.

[4]Pande, P. S., Neuman, R. P., and Cavanagh, R. R. (2000). The Six Sigma way: How GE, Motorola and other top companies are honing their performance, McGraw-Hill, New York.

[5]Pande, P. S., and Holpp, L. (2002). What is Six Sigma? McGraw-Hill, New York.

[6].Pheng, L. S. & HUI, M. S.2004. Implementing and applying Six Sigma in construction. Journal of construction engineering and management,130,482.