APPLICATION OF SIX-SIGMA TOOL IN COMMERCIAL PROJECT AT SURAT

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Abstract— Quality of the work is of prime importance to any person who has undertaken the project so that the client could be satisfied with the deliverable. Six-Sigma tool is the one that deals with the quality. The Six-Sigma takes attention to the quality that customers are concerned with and also contribute to achieve efficiency and reduce costs. This study explores whether Six-Sigma principles that were originally and widely applied to the manufacturing industry can be applied to the construction industry or not. Here, this tool is applied to the commercial construction project namely Millennium Textile Market at Surat which costs about 10.25 cr. In this paper, details of application of DMADV methodology of Six-Sigma is shown for the case study and there was positive outcome. The result shows that the Six-Sigma tool is quiet helpful in achieving the quality not only in the manufacturing industry but also in the construction industry.

Index Terms— Quality, Six-Sigma, Defects, Construction Industry

I. INTRODUCTION

For any construction project, Time, Cost and Quality are very vital. Quality can be achieved by applying the Six-Sigma tool that was first found out and implemented by Motorola Corp in early 1980s. Six-Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. The word *Sigma* is a statistical term that measures how far a given process deviates from perfection. Six-Sigma is a data driven methodology, and requires accurate data collection for the processes being analysed. Six-Sigma is a business-driven, multi-dimensional structured approach for: improving the processes, lowering the defects, reducing the process variability and the costs, Increasing the customer satisfaction and profits.

II. LITERATURE REVIEW

According to Frank T. Anbari and Young Hoon Kwak [2] have discussed the challenges and obstacles in the application of the Six-Sigma method. They have also identified the success factors for Six-Sigma. According to their findings, the main factors influencing the success of Six-Sigma projects include organizational involvement, management commitment, project selection, project governance, implementation methodology, planning, project management and control, cultural change and continuous training.

Ganesh U. Borse and Prof. P. M. Attarde [3] have carried out the literature survey and have presented the review of eight literatures in which Six-Sigma is applied in the construction industry.

Low Sui Pheng and Mok Sze Hui [4] carried out the case study at the Housing and Development Board (HDB), Singapore. Six-Sigma was applied to improve the quality of internal finishes where improvement measures taken by Contractor A helped to raise the Sigma from 2.66σ to 3.95σ.

Ruchika S. Patel, Dr. Neeraj D. Shah and Hiren A. Rathod [5], in their paper, gave the review of various papers related to Six-Sigma in Construction Industry.

Sarathkumar K and Loganathan R [6] aimed on developing a project questionnaire model based on the theory of Six-Sigma. They tried to improve the painting work, tile work and brick work of a building by using DMAIC methodology.

Seung Heon Han, Ho Dong Ryu, Myung Jin Chae, Han Him Kim, Do Yon Kim, Sun Hee Kim [7] carried out a case study of the standard unit activity groups. It was concluded by them that the Six-Sigma principle had brought more benefits in generating the optimized solution sets from initial performance indices as the target processes became complicated and extended.

Sneha P. Sawant and Smita V. Pataskar[8] described the basic theory of Six Sigma, principles, methodology and various tools used. A case study of a residential building is taken in which the Six Sigma principles are applied for internal finishing work, the Six Sigma methodology has been adopted to improve the quality and is checked against the sigma level. The findings suggest that proper training and management support and minor changes in current work procedure can help improve the quality and ultimately customer satisfaction which is of prime importance.

III. PROBLEM STATEMENT

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 many past years. In order to achieve high quality level in construction industry and improve the performance, feasibility and suitability of different new philosophies in construction projects have been studied in recent years, but due to the various processes associated with construction projects, their complexity, and lack of specific metrics, this issue is still questionable and demands further studies. One approach for improving the process is using Six Sigma concepts in construction.

IV. OBJECTIVES

- To develop strategy for applying Six-Sigma in construction industry.
- To investigate the probable changes after applying Six-Sigma tool.

V. RESEARCH METHODOLOGY

Six-Sigma tool has two methodologies viz. DMAIC (Define, Measure, Analyze, Improve and Control) and DMADV (Define, Measure, Analyze, Design and Verify). DMAIC is used for projects aimed at improving the existing process whereas DMADV is used for projects aimed at creating new product or process designs. In this case-study, DMADV methodology was used. Firstly, two activities viz. masonry and flooring were identified by carrying out the interviews with the main consultant, technical advisor and site engineers. Then, the existing processes were identified by interview. Also, the defects were found out by carrying out checks for 100 shops on the ground floor & first floor and time-study for the concreting work in the pile foundation, columns and base floor was carried out. Then, in the analysis phase, the current sigma level was calculated. Also, the reasons for the defects were found out by studying the literatures and interview with the personnels at the site. Next, the recommendations were prepared so that the number of defects can be reduced. The implementation was then done as per the recommendations on the sixth and seventh floors; only some, that were not feasible, were not implemented. In the next step, again the defects were found out for total 110 shops on the sixth and seventh floor and the new sigma level was calculated.

VI. DATA COLLECTION AND ANALYSIS

The checks for the defects were carried out for the ground floor and the first floor which are given in the table 1 below. There were 100 total shops where the checks were carried out but here, in the table below sample of only four shops is shown. And the total number of checks and defects are as per the 100 shops.

Table 1 Checks to find out defects in Flooring and masonry

Location		Floor				Masonry		
		Alignment	***Cracks and Damages***	***Hollowness***	***Jointing***	***Hollowness***	***Cracks and Damages***	***Alignment***
Shop 1	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					X	√	√
	Wall 4					√	√	√
Shop 2	Floor	X	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Shop 3	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	X
	Wall 3					√	√	√
	Wall 4					√	√	√
Shop 4	Floor	√	X	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Total number of checks							1600	
Total number of defects							136	

The aim of Six Sigma is to improve the quality near perfection which means 3.4 Defects Per Million Opportunities (DPMO), to maximize the customer satisfaction and business benefits. This goal will occur when the sigma level is 6. Table 2 illustrates the rate of defects per million opportunities in different sigma levels.

Table 2 Rate of defects per million opportunities in different sigma levels

Yield	DPMO	Sigma level
30.9	690,000	1
69.2	308,000	2
93.3	66,800	3
99.4	6,210	4
99.98	320	5
99.9997	3.4	6

The yield is calculated as follows:

$$\text{Yield} = \frac{\text{Total no. of perfects}}{\text{Total no. of checks}} \text{ x } 100\ \%$$

$$\text{Yield} = \frac{(1600 - 136)}{1600} \text{ x } 100\ \%$$

Yield = 91.5%

To calculate sigma for the processes, the DPMO (or defects per mil- lion opportunities) formula is used:

$$\text{DPMO} = \frac{\text{No. of defects}}{\text{No. of opportunities} \times \text{No. of units}} \text{ x } 1000000$$

$$\text{DPMO} = \frac{136}{1600} \text{ x } 1000000$$

DPMO = 85000

Based on the sigma conversion table in Table 2, the equivalent sigma for 85000 DPMO was 2.92 σ. It was found out by interpolating the values. Thus, initially, the Sigma level of the Millennium Textile Market was 2.92 σ.

The checks carried out for finding the new sigma level were carried out after the implementation of the recommendations for the sixth and seventh floors. In total, checks were carried out for 110 shops out of which the sample of only first four shops are shown in the Table 3. The total number of checks and defects are as per 110 shops.

Table 3 Checks to find out defects in Flooring and Masonry

Location		**Floor**				**walls**		
		Alignment	***Cracks and Damages***	***Hollowness***	***Jointing***	***Hollowness***	***Cracks and Damages***	***Alignment***
Shop 1	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Shop 2	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Shop 3	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Shop 4	Floor	√	√	√	√			
	Wall 1					√	√	√
	Wall 2					√	√	√
	Wall 3					√	√	√
	Wall 4					√	√	√
Total number of checks							1760	
Total number of defects							26	

Now, again the sigma level is calculated as shown below:

The yield is calculated as follows:

$$\text{Yield} = \frac{\text{Total no. of perfects}}{\text{Total no. of checks}} \text{ x } 100\ \%$$

$$\text{Yield} = \frac{(1760 - 26)}{1760} \text{ x } 100\ \%$$

Yield = 98.52%

To calculate sigma for the processes, the DPMO (or defects per mil- lion opportunities) formula is used:

$$\text{DPMO} = \frac{\text{No. of defects}}{\text{No. of opportunities} \times \text{No. of units}} \text{ x } 1000000$$

$$\text{DPMO} = \frac{26}{1760} \text{ x } 1000000$$

DPMO = 14772.73

Based on the sigma conversion table in Table 2, the equivalent sigma for 14772.73 DPMO was calculated approximately as 3.859 σ. It was found out by interpolating the values from Table 2. Thus, the new Sigma level of the Millennium Textile Market is 3.859 σ which showed a great improvement.

VII. CONCLUSION

The strategy for applying the Six-Sigma tool in construction project was studied by undertaking a case study on Millennium Textile Market, which suggests that DMADV methodology works more suitably. For the successful application of Six-Sigma it is required to have a very supportive management, allegiance to quality, attaining satisfaction of the customer and knowledgeable staff which was fortunately the case with the undertaken case study that helped us out with effective practice of Six-Sigma tool in construction project.

The processes and procedures are likely to be more complex at Millennium Textile Market as it is a large scale project. The concept of Six-Sigma is new when talked about the quality in the construction industry but the results obtained from the case study revealed that if standard procedure of detecting the defects is adopted in the terms of quality, the sigma level can be calculated which gives a prediction about the level of quality and the room for improvement.

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