

TOTAL QUALITY MANAGEMENT IN CONSTRUCTION INDUSTRY

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Abstract— Total Quality management (TQM) is a management philosophy which has been widely implemented in manufacturing and other services industries, and it shows how significant it can improve the quality in these fields. The objective of this paper is to point out the latest studies which focused on increase the business quality through implementation of TQM in construction industry and its suitable application in different phases of project construction and it also describes the basic theory of Six sigma, principles, methodology, and various tools used for reducing defects. A case study of residential building is taken in which 7 QC tools used by applying DMAIC principle. The six sigma methodologies have been adopted to improve the quality. 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.

Keywords— TQM In construction industry, PDCA Cycle, DMAIC, 7 QC tools.

I. INTRODUCTION

The construction industry in many parts of the world suffers from problems such as workmanship defects, time, and cost overrun. Construction industry for its poor performance and history of waste and rework, coupled with chronically low levels of customer satisfaction.

A need for change becomes inevitable in order to improve the condition of the construction industry. The industry problems will remain until each organization in the procurement of construction industry begins to take the responsibility for initiating changes within their own organization. Such change can be initiated through the effective implementations of a total quality management (TQM) system.

The management approach of an organization centered on quality, based on the participation of all of its members and aiming at long-term success through customer satisfaction and benefits to all members of the organization and to society. The construction industry arrived late to TQM probably due to tendency to easily

brush aside anything in management that is new, but the implementation of TQM in other industries shows clearly that the TQM is not fad and confirm the benefits of implementing

this philosophy and how much it can improve the customer satisfaction as the measure of business quality.(1)

A. Quality Control:

Quality Assurance: it is a program covering activities necessary to provide quality in work to meet requirements. It is about improving and stabilizing production and associated processes to avoid or at least minimize issues that led to defects in the first place.

Quality Control: It emphasizes testing and blocking the release of defective products.

QA does not necessarily eliminate the need for QC. Some product parameters are so critical that testing is still necessary just in case QA fails.

B. Elements of TQM:

- i. Leadership: The first step towards the excellence is the major decision to provide leadership for quality as a basic strategic goal.
- ii. Leadership Commitment: total commitment of top management is considered as a key factor in implementing TQM. Members of top management must lead to TQM efforts.
- iii. Recognition and Rewards: recognition is a process whereby management shows acknowledgement of employee's outstanding effort or performance. It is essential as people need to be accepted by others and recognition helps them to find themselves in a winning role.
- iv. Education and Training: The Education and Training of all employee from top to bottom are fundamental building blocks for successful implementation of TQM.
- v. Customer Orientation: The customer is a king. The customer is the purpose for existence of our business. The customer want value at reasonable price.
- vi. Team work and employee Empowerment: The purpose of team work is to have all people involved in a process, working to achieve a

common goal gained at less expense, if the traditional inter-departmental conflicts are eliminated.

- vii. Feedback and mechanism: For success of the TQM program, feedback mechanisms for the both external and internal customers need to be developed.
- viii. Statistical process control: Variation is the law of nature. Understanding the nature variations, and estimating the capability of the process, help the organization to reduce the inspection and improve the quality.

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C. Need of TQM in construction industry:

The construction industry and process is often characterized as being burdened with problems, cost and time overruns, disputes and lawsuit. The construction process is very complex, requiring the use of many labour skills, different materials, and complex technical and management systems.

In addition, uncertain and changing weather conditions and external factors such as regulations make it very difficult to control project results. Frequently one reads in news paper or journals about project that take too long to construct, go over budget or include disputes that may be need to resolved by legal means of arbitration.

The industry can also be viewed as one where the project owner has seen cost go up while productivity, or the work the project owner receives per unit expenditure, has remain relatively flat.

D. ELEMENTS OF QUALITY IN CONSTRUCTION:

- Leadership and Top Management Commitment
- Customer Management
- Training and Education
- Teamwork
- People Management and Empowerment
- Supplier Partnership
- Quality Policy and Strategy
- Process Management
- Rewards and Recognition
- Effective Communication

E. Six Sigma In TQM

Six Sigma methodology was first espoused by Motorola in the mid 1980s. (Antony & Banuelas, 2002; Wiklund & Wiklund, 2002). At that time, Motorola was facing Japanese competition in the electronics industry and needed to make drastic improvements in its levels of quality (Harry and Schroeder, 2000; Linderman et al., 2003). A Six Sigma

initiative which is originally focused on manufacturing process and product quality (Harry & Schroeder, 2000), is also designed to change the culture in an organization through breakthrough improvement in all aspects of the business.

Implementation of Six Sigma

- ❖ improvement steps;
 - * staff roles; and
 - * investment in training

Improvement steps

There have been many improvement models for process improvement or re-engineering. Most of these have been based on the steps introduced by W. Edwards Deming, which can be characterized as 'Plan', 'Do', 'Study', and 'Act' (PDSA)(Deming, 1993). Six sigma has a five-phase improvement cycle that has become increasingly popular in Six Sigma organizations: 'Define', 'Measure', 'Analyze', 'Improve', and 'Control' (DMAIC). There is another cycle characterized as 'Define', 'Measure', 'Analyze', 'Design', and 'Verify' (DMADV) (Pande et al., 2000). Like other improvement models, the DMAIC (or DMADV) model is grounded in the original Deming PDCA cycle. Usually, Six Sigma organizations use DMAIC for process improvement and DMADV for process design (and redesign).

1) Statistical Theory Behind Six Sigma

Six Sigma is a statistics based methodology and relies on the scientific method to make significant reductions in customer defined defect rates in an effort to eliminate defects from every product, process and transaction. The Six Sigma principle can be represented on a normally distributed product quality distribution curve. When the mean is located at the center of the normal distribution curve, the lower and upper limits are six times the standard deviation (sigma) from the center line. In other words the range of lower and upper limit defect is +/- 6 sigma from the mean. Table.1 illustrates the rate of defects per million opportunities in different sigma levels.

TABLE 1: overview of sigma levels and DPMO.

Yield	DPMO	Sigma Level
30.9	6,90,000	1
69.2	3,08,000	2
93.3	66,800	3
99.4	6,210	4
99.98	320	5
99.9997	3.4	6

F. Basic Framework of Six Sigma Principle – Based Management

“Six Sigma Based Approach to Improve Performance in Construction Operations” the six sigma principle concept can be applied to the construction process control within the basic framework of CTQ inputs, DMAIC procedures and output measures as shown in figure below:

Performance Indicators (Input CTQ)
Six Sigma Application Procedure DMAIC
Indices of Performance improvements (outputs)

G. DMAIC Procedure:

Six Sigma is a 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 a 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. This methodology offers structured framework in following steps to establish systematic continuous improvement.

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.

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.

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

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.

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.

H. Implementing six sigma in construction:

In this paper we shall see how six sigma is applied in construction, for this we shall consider a residential building and try to improve the quality of internal finishing work. For this a checklist is prepared for various components as

shown in TABLE 2. The assessment is done for each item, the one which meets the standard requirement is marked as „√“ else it is marked as „X“ and a „-“ indicates that the item is not applicable. The score is computed based on the number of „√“ over the total number of items assessed. The yield is then calculated as follows:

$$DPMO = \frac{\text{(No. of „X“ in data collection sheet/ No. of Opportunities of defects X No. Of Units)} \times 1,000,000$$

Based on DPMO, using sigma conversion table (TABLE 1) the sigma level is calculated. Then using the DMAIC procedure of six sigma the quality is improved and then the above procedure is followed to calculate the sigma level, the sigma level of quality is expected to be improve by the above procedure. Various tools are present at each step of DMAIC procedure depending upon the difficulty level. In this paper we shall use the following tools at each step of DMAIC methodology.

- 1) Define – SIPOC – Suppliers Input Process Output Customer
- Measure – Pareto Diagrams
- Analysis – Cause and Effect Diagram
- Improvement – Corrective Action
- Control – Control Plan

2) Case Study

Data Analysis For Preliminary Survey By using various tools ie. Check sheets, Pareto Chart, Fishbone Diagram, different analysis and graph data is obtained and analysis is done. Check sheets for site work (Defective item checklist)

Table 2. Check sheets for site work (Defective item checklist)

Type	Check	Subtotal
Surface cracks	✓ IIII ✓ III ✓ III IIII	19
Segregation	✓ IIII	5
Efflorescence	✓ IIII III	8
Spalling	✓ IIII	5
Blisters	✓ IIII I	6
Pop outs	IIII	4
Disintegration	--	00

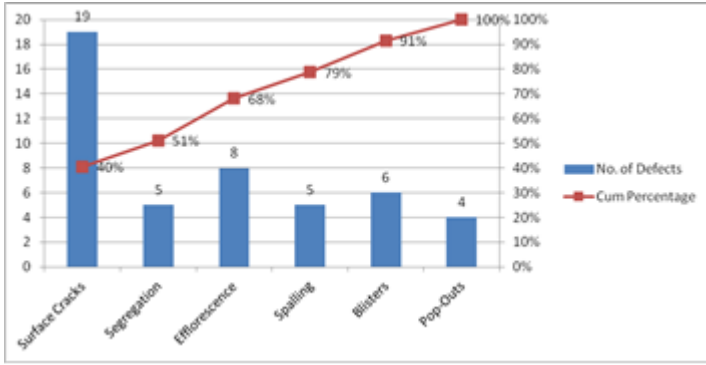


Fig. 1 No of Defect in building

II. MEASURE: PARETO CHARTS

Each construction activity is a set of various dependent activities; Pareto chart helps to identify the most significant factors, shows where to focus efforts and allows better use of limited resources. Chart (FIG 2) below shows us the Pareto Analysis for flooring using vitrified tiles.

A Pareto Chart can answer the following questions:
What are the largest issues facing our team or business?
• What 20% of sources are causing 80% of the problems?
• Where should we focus our efforts to achieve the greatest improvements?

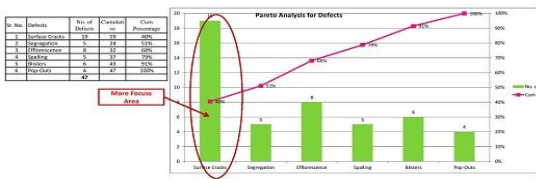


Fig.2 Pareto Chart

III. ANALYZE: CAUSE AND EFFECT DIAGRAM

Cause and Effect diagram helps us to visualize in a graphical manner the outcome and various factors that influence that outcome. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called a "fishbone diagram" because of the way it looks.

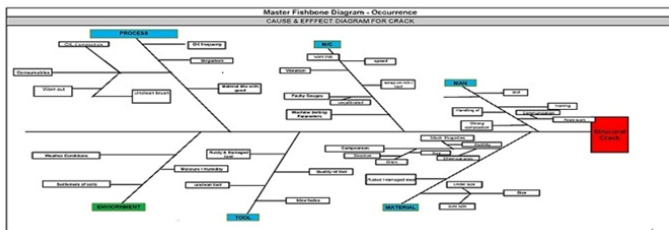


Fig 3 Fishbone diagram

IV. IMPROVE: CORRECTIVE ACTION

As per the „Preventive and Corrective Actions Guidelines’ given by R.M. Baldwin the Corrective Action is defined as, a term that encompasses the process of reacting to product problems, customer complaints or other nonconformities and fixing them.

The process includes:

- Reviewing and defining the problem or nonconformity
- Finding the cause of the problem
- Developing an action plan to correct the problem and prevent a recurrence
- Implementing the plan
- Evaluating the effectiveness of the correction.

Thus, from the above analysis following corrective actions were taken:

- Skilled labors were employed and proper training was given to them.
- The Mix design for substrate was revised from 1:8 to 1:4:4 were there was 1 part of Cement, 4 parts of Fine aggregate and 4 parts of Coarse aggregate.
- Tiles of better quality were used.

Table 3 Multi voting

SR.NO	4-M CAUSES					TOTAL	%	REMARK
	HT	CR	AG	AV				
Valid Cause if Multivoting % is >= 40% Non Valid Cause if Multivoting % is < 40%								
Multivoting criteria : 2-Not agreed 4-Partially Agreed 8-Agreed 10-Strongly Agreed								
A	ISSUE :					TOTAL	%	Remark
1	2	2	2	2	8	20		
2	4	4	4	3	20	50		
3	2	2	2	2	8	20		
4	2	2	2	2	8	20		
B	REASON :							
1	2	2	2	2	8	20		
2	2	2	2	2	8	20		
3	2	2	2	2	8	20		
4	2	2	2	2	8	20		
C	SOLUTION :							
1	2	2	2	2	8	20		
2	2	2	2	2	8	20		
3	2	2	2	2	8	20		
4	2	2	2	2	8	20		
5	2	2	2	2	8	20		
6	2	2	2	2	8	20		
7	2	2	2	2	8	20		

V. CONTROL : CONTROL PLAN

Control plan will help us to keep a check on the various preventive measures which are taken to achieve the desired result. As per the „Guide to Control Plans’ a control plan is the

documented description of those procedures, checks or assigned activities necessary to verify that production units continue to conform to the type approval requirements with regard to specification, marking and performance. The aim of the control plan information is to show that the appropriate level of control exists in relation to those aspects of the product, which are critical to its continued compliance. Thus we shall use the checklist which is prepared earlier as a control plan. Here two plans are used WHY WHY Analysis and Cause analysis.

Table 4 Why Why Analysis

Why/Why Analysis Causes		WHY	WHY	WHY	WHY	ACTION PLAN
Sr. No.	Description					
1	INSUFFICIENT CURING	SHORTAGE OF WATER.	IMPROPER EQUIPMENT FOR WATER LIFTING. WEATHER CONDITIONS ARE UNCONTROLLABLE	NEGLIGENCE IN PLANNING OF EQUIPMENTS PROPERLY. CONCRETING NOT DONE IN PROPER WEATHER CONDITION	FAULT OF EXECUTION DEPARTMENT	1. CRACK CAN BE HEALED BY CEMENT GROUTING 2. CRACKS CAN BE PREVENTED BY REGULAR PROPER INSPECTION 3. CONTINUOUS AVAILABILITY OF WATER ON SITE 4. AVOIDING CONCRETING IN EXTREME HEAT CONDITIONS 5. USING STANDARD METHODS FOR HOT WEATHER CONCRETING

Table 5 Why Why Analysis

Causes	Is there any Standard/ specification ? (YES/NO)	If YES what is the specification ?	What is the basis of Spec?	Is it checked?	What is Actual?	Is there any Difference?	
No	Description						
1	UNSKILL MANPOWER	YES	NOT ALLOWED	LABOUR SHOULD BE PROPERLY TRAINED	YES	TRAINED	NO
2	INSUFFICIENT CURING	YES	NOT ALLOWED	ACCORDING TO WEATHER CONDITIONS	NO	NOT CHECKED	YES
3	ADVERSE WEATHER CONDITIONS	YES	ACCORDING TO WEATHER CONDITION	VISUAL CHECKING	YES	CHECKED	NO

It is seen that no proper quality control was practiced on site. lack of QA and QC resulting into various defects on structure which mainly due to improper inspection and control.

If we apply 7 QC tools properly on site we can go through details of each and every defect and Root cause of the defect can be studied deeply and action plan can be taken correctly.

From the results and conclusions from case study in this paper, it's clearly now that TQM is not a fad and how much benefits that TQM can bring to your construction business (Improve business quality, increase customer satisfaction, reduce cost, save time and much more).

The reason that the construction industry has arrived late to TQM is that the construction professionals unaware of the TQM principles and techniques.

To bring these benefits to the construction industry, more efforts must be made to spread the culture of TQM among the

construction professionals and TQM courses must be in the engineering under graduated programs.

VI. CONCLUSION

It is seen that no proper quality control was practiced on site. lack of QA and QC resulting into various defects on structure which mainly due to improper inspection and control.

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REFERENCES

1. Ahmed S. Agha Development Of Quality Culture In The Construction Industry, Management Decisions, 29(8), 46-51. Nicholas Chileshe1, MSc, ACIOB, AB Eng Dr Paul Watson Journal for Quality and Participation, 3, 82-90
- 2] Ms. Aiswarya.K.Lalaji Ms. Sivagami.M, Total Quality Management Practices In Construction Companies (Kerala) ISSN 0976 – 6308 (Print) ISSN 0976 – 6316(Online), Volume 5, Issue 12, December (2014), pp. 230-234.
- 3] Anantha Subramaniam Study On Challenges In Implementing Total Quality Management In Construction Firms At Coimbatore, Global Journal Of Engineering Science And Researches, Issn 2348 – 8034
- 4] Gul Polat, Atilla Damci, Yalcin, Barriers And Benefits Of Total Quality Management In The Construction Industry: Evidence From Turkish Contractors
- 5] Hale Kaynak, The Relationship Between Total Quality Management Practices And Their Effects On Firm Performance Journal of Operations Management 21 (2003) 405–435, Received 6 June 2000; accepted 10 November 2002
- 6] H. James Harrington, Frank Voehl, Hal Wiggin, (2012), THE TQM JOURNAL "Applying TQM to the construction industry", The TQM Journal, Vol. 24 Iss: 4 pp. 352 – 362
- 7] Construction Management By S. Seetharaman
- 8] Construction Management and Engineering By S.C. Sharma.