

Implementation of six sigma DMAIC methodology in precast industry for quality improvement

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Abstract

Six sigma's DMAIC (Define Measure Analyse Improve Control) method is an approach for quality improvement. This paper presents statistical case study for quality improvement of precast elements using DMAIC in a precast construction industry. Six sigma implementation explores major defects in precast elements (Panels and Columns) and determine its causes as well as current sigma level of organisation. Study suggest improvement actions for current performance and control plan to inspect the actions. Study motives to achieve higher quality level for mutual benefits of organisation and customer.

Key words- Defects, Precast, Measure, Analysis, Quality Improvement

1. Introduction

Sigma is a Greek letter, σ , standing for standard deviation. Standard deviation is a statistical way to describe how much variation exists in a set of data, a group of items, or a process. Standard deviation is the most useful measure of dispersion. Six Sigma means that, for a process to be capable at the Six Sigma level, the specification limits should be at least 6σ from the average point.

Six sigma is a powerful quality improvement tool widely used in manufacturing industry. Applicability of six sigma is also investigated in other industries. Six sigma level of quality is a highest level where only 3.4 defects per million opportunity found i.e. 99.9997 % accuracy this level is always desirable. As construction industry has quite large probability of variations in its process use of six sigma for improvements is undoubtedly beneficial. In this study six sigma theories and practices are implemented in stages with systematic approach in precast construction industry.

2. Problem Formulation and Objective

2.1 Product and Problem

There are two items for which company is doing mass production. One is Plank or Panel and another is Column. Applying Six Sigma at precast industry to improve the quality of products. Company is producing more than 500 items per day and cannot inspect each item before dispatch. It is required to inspect samples at some frequency. Industry were facing critical quality related problems and rejection of lots at consumer end. Repeated defects are noted uncontrollable to company since last 3 years. Defects are random and organization fails to predict and eliminate continuous defects. Company is having large project orders including Government solar and thermal plant since last three years, but due to rejections and lot returns company is willing to work and research critically for quality related problems to identify the root cause of defects in precast elements.

PLANK	
Length	7ft
Height	1ft
Width	2inches
Use 3 pre stressed bar of 3mm HT steel and M20	



COLUMN	
Length	10ft
Cross section	6x6 Inch
Use 7 pre stressed bars of 3mm HT steel and M30	



Figure 2-1 Specification of Plank and Column

Company is having large project orders including Government solar and thermal plant since last three years, but due to rejections and lot returns company is willing to work and research critically for quality related problems to identify the root cause of the defects.

2.2 Research Objective

1. To execute case study at organization and identify major defects.
2. To quantify statistical data for present rejections and defects found.
3. To find out the sigma level of the company.
4. To find out whether the process is in control or not?
5. To analyse the exact root cause for most frequent defects and problems.
6. To eliminate quality issues by suggesting and implementing standard procedures and improved techniques of operation.

3. Methodology

DMAIC Approach

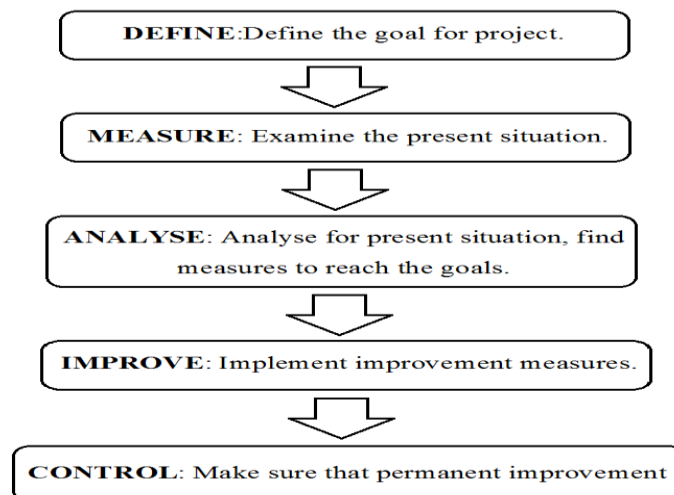



Figure 2-2 DMAIC Approach

4. Data Collection and Analysis

4.1 DEFINE

SIPOC – Suppliers Inputs Process Outputs Customers. It is important for high level understanding of process.

Table 4-1 SIPOC for precast elements

Supplier	Inputs	Process	Output	Customer
Raw Material Vendors	Wire Cement Sand Stone Water Vibrator Measuring tape Tri-square Cleaning cloths Moulding stations Mixing Machine Trollies Mould coat oil		Finished Pre-cast	Consumer

4.2 MEASURE : Samples inspected 42 per day for 10 days

Table 4-2 Defects measurement in precast element

Defects	Frequency	Cumulative%
Cracks	8	25
Dim.Dev.	7	46
Chip-off	6	64
Damage	5	79
Warp	2	85
Honey comb	1	88
Pin hole	1	91
Alignment	1	94
Scaling	1	97
Spall	1	100

Defects in plank and column observed at plant



Figure 4-1 Dimensional Defect



Figure 4-2 Warp



Figure 4-3 Honey Combing



Figure 4-4 Crack



Figure 4-5 Chip-Off



Figure 4-6 Damage

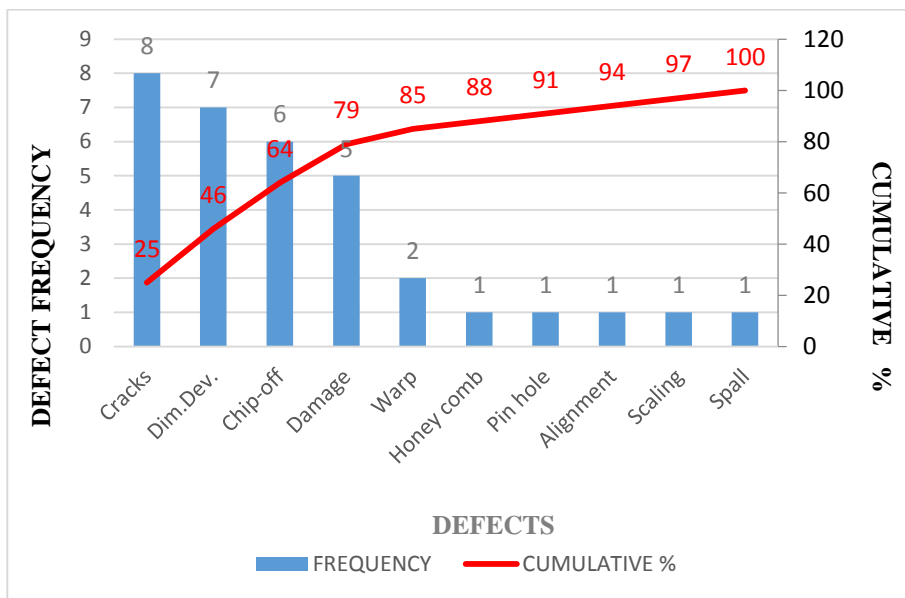


Figure 4-7 PARETO Chart for Effects in Precast Elements

Statistical Quality Control

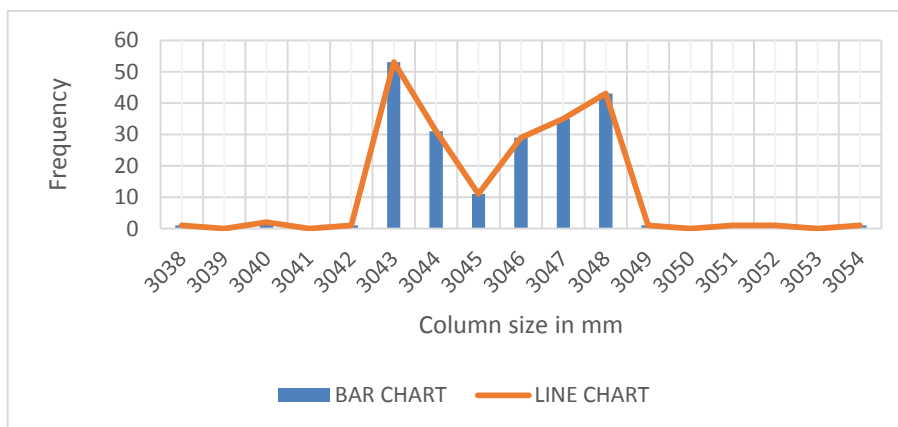


Figure 4-8 Normal Distribution for Column Size

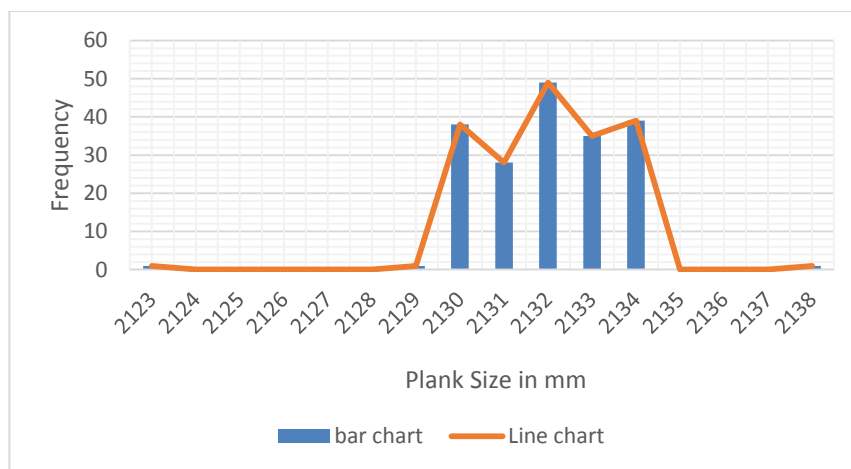


Figure 4-9 Normal Distribution for Plank Size

For Sigma Level

$$DPMO = \frac{\text{No.of "defects" in data collection sheet}}{\text{No.of Opportunities of defects no.Of Units}} \times 1000000$$

$$DPMO = (33 / 420) \times 1000000$$

$$DPMO = 78571.428$$

It is clear from DPMO that the company is working at 3 σ level.

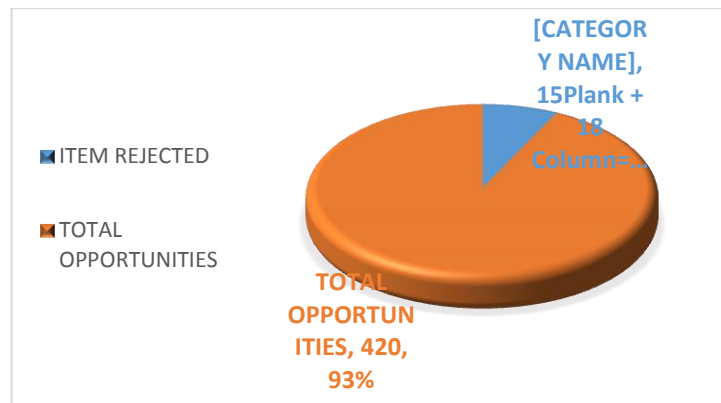


Figure 4-4 Summary of rejection for defected precast elements

4.3 ANALYSIS

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.

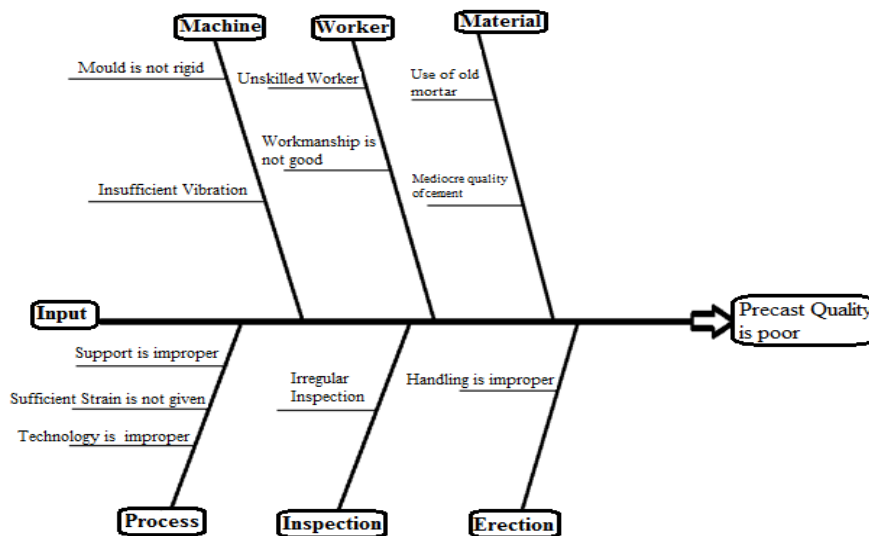


Figure 4-4 CAUSE & EFFECT DIAGRAM FOR POOR QUALITY OF PRECAST ELEMENTS

5. Result and Discussion

5.1 IMPROVE: Corrective Action

- a) Lack of skilled labours are found during analysis phase as a major quality influencing factor, it is so suggested that skilled labour and employees must be employed and proper training with training schedule should be given to them.
- b) The labour found unsatisfied and demotivated of the wage and incentive system of company, due to which they are not aware of the quality issues and not willing to participate to solve quality issues. It is suggested to implement a fresh attractive incentive plan with ongoing wage plan to motivate quality skilled workers which are good quality product producer and efficient and consistent performer with respect to quantity with quality.
- c) As per analysis mould before moulding is found dirty and presence of scaling from previous process, so, inspection of mould before start moulding is suggested and is insist to follow strictly. If the moulds are not up to the mark replace it to avoid dimensional defects.
- d) Use of stale mortar for casting of plank and column is prohibit after improvement. It was participating for honeycomb and pinhole defects. Practically it is found that fresh mortar did not produces such defects.
- e) Quality of Cement is to be always checked before purchasing and use for production. Prefer only good quality cement for manufacturing panels.
- f) Automatic line, automatic transfer machines, and modern testing equipment's are suggested to develop and purchase. Latest Technology should be used for manufacturing pre-stress precast Panel.
- g) Equipment which are used for preparing mortar, moulding, setting and finishing process must be checked regularly, preventive maintenance schedule should be planned and equipment should be replace when they are not perform up to the mark.
- h) Care should be taken in transportation and erection, it is playing major role to damage defects.

5.2 CONTROL: Control Plan

Table5-1 Control Checklist to Control Corrective Actions

S. No	Points Description
1.	Check inward material quality
a.	Check for Cement Quality. (On field and Lab test)
b.	Check for sand and stone quality for cleanliness and size.
c.	Check for cleanliness of water used.
d.	Check for diameter and quality of wire for rust and bands
2.	Check for mixture of mortar for material ratio and water.
3.	Moulding station checks
a.	Visual check for mould dirt.
b.	Dimensional check for length, and cross section of mould.
c.	Check for supports and setting of mould stations.
d.	Check proper pre stressing and position of wires in mould.
4.	Pouring process check for error free pouring
a.	Check uniform pouring of material and vibrator status.
b.	Check surface in process for levelling and finishing of upper surface.
c.	Check for mortar filling at mould corners.

5.	Mould removal care and inspection
a.	Setting time as per season should be completed before removing mould.
b.	Mould should be removed with care to protect weak surface damage and chip off.
c.	Wire should be cut with proper distance and care.
6.	Transport care and inspections
a.	Lift column or panel with proper equipment's.
b.	Handle with proper trollies and care to curing area.
c.	Unload parts at curing area at cleaned flat surface with care.
7.	Curing should be proper and noticed at proper frequency.
8.	Dispatch, transportation and erection cares.
a.	Load dispatch vehicle with expert equipment's.
b.	Expert supervisor is available at loading and unloading point.
c.	Labour at erection should join and assemble planks and columns with care.

6. Conclusion

Using DMAIC methodology detailed analysis of major defects in precast panel and column shows frequency of occurrence. Currently organisation is working at 3σ level. Organisation is willing to increase sigma quality level. Major defects noticed after arranging defects in ascending order are **Cracks, Dimensional Deviation and chip off**, which covers **80%** of the overall defects. One more defect which is major at fourth number is **Damage** which is also noticed critical. Process is not in control for both items and improvement suggestions are given to improve the process. One more checklist is created and implemented to control the process

7. References

1. M. Sokovic "Application of Six Sigma methodology for process design" Journal of Materials Processing Technology 162-163 (2005) 777-783
2. S.J. Harjac "Six Sigma review of root causes of corrosion incidents in hot potassium carbonate acid gas removal plant" Engineering Failure Analysis 15 (2008) 480-496
3. S.H. Han "Six Sigma-Based Approach to Improve Performance in Construction Operations" Journal of Management in Engineering / January 2008
4. M. Sokovic "Quality Improvement Methodologies -Pdca Cycle, Radar Matrix, Dmaic and Dfss" Journal of achievement in material and manufacturing engineering Vol 43 Issue 1 November 2010.
5. G. Büyüközkan, D. Öztürkcan "An integrated analytic approach for Six Sigma project selection" Expert Systems with Applications 37 (2010) 5835-5847
6. M. Dudek Burlikowska "Using control charts X-R in monitoring a chosen production process" Vol 49 Issue 2 December 2011
7. J.de. Mast, J. Lokkerbol "An analysis of the Six Sigma DMAIC method from the perspective of problem solving" International journal of Production Economics 139 (2012) 604-614
8. R. Evins "A case study exploring regulated energy use in domestic buildings using design-of-experiments and multi-objective optimisation" Building and Environment 54 (2012) 126e136
9. M. F. Yilmaz "As a Quality Initiative, Performance Indicator/Improver, Management Strategy" Stockholm 2012
10. S. Sharma "Six Sigma Approach: Application, Benefits and Scope" International Journal of Mech. Eng. & Rob. Res. 2013

11. Kent Cronholm "Design of Experiment based on VMEA" *Procedia Engineering* 66 (2013) 369 – 382
12. Tanvir Ahmed et al "An Application of Pareto Analysis and Cause-Effect Diagram for Minimizing Defect Percentage in Sewing Section of a Garment Factory in Bangladesh" (*IJMER*) www.ijmer.com Vol. 3, Issue. 6, Nov - Dec. 2013
13. S. P. Sawant "Applying Six Sigma Principles in Construction Industry for Quality Improvement" *Advances In Engineering And Technology - ICAET-2014*
14. V.O. Okonkwo "A Comparative Analysis Of Application Of Six Sigma Project Management Technique In Small And Medium Scale Construction Companies In Nigeria" *EJAT* Vol 3 ISSU 2056 2015.
15. S.A. Javed "A Review on Six Sigma (DMAIC) Methodology" *IJMER* ISSN: 2249-6645 Vol. 5 Issue 2 Feb 2015.