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Six Sigma to Enhance Time Efficiency and Quality in Nepal's Construction Sector

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Abstract: ***The world has taken the word "construction" as nation developing phenomena. The country's economic and social development depends upon its rate of productive construction. The productivity is acquired if time and quality of construction has taken into consideration. There were various methods of increasing the construction productivity such as Project Management Technique-Critical Path Method, Program Evaluation and Review Technique etc. These techniques some-how increased the construction efficiency but it didn't obtain the required expectation. Thus, Six-Sigma- as a philosophy, which was considered in this paper. The five phases of Six-Sigma will provide the systematic way to increase the efficiency. Define(D), Measure(M), Analyze(A), Improve(I) and Control(C) are the five phases of Six Sigma. The paper is based on two work portions, one with questionnaire and other is practical use of Six Sigma in construction industry. The questionnaire was sent to 100 individuals out of which only 60 questionnaires were retrieved. The obtained questionnaire was evaluated with the RII (Relative Importance Index) method. The case study in which six-sigma was used is of internal tiling work for a residential building. The flat was of 2BHK and 2 numbers of flat were observed. The initial tiling work was evaluated without any direction and the sigma level was 2.08. After applying the Six Sigma Concept, the obtained level was 3.7. Hence, this research paper demonstrate that Six-Sigma is able to optimize and improve time and quality of construction projects.***

Keywords: Six-Sigma, Delay, Quality, Factors, Sigma level, Construction.

1. Introduction

Nepal is a sandwich country with rugged topography between China and India. This country was isolated till 1950 from the world and no means of transportation and communication were available. The economic development of Nepal commences after the 1956. Almost 90 percent of the population lives in the rural areas and most of them depend upon agricultural sector. 40% of contribution to GDP is through this sector. The Nepalese contractors have been able to develop their management skill, improve working capacity, financial and technical capabilities, and acquire suitable construction equipment. As a result, local contractors have been able to compete and participate in construction project. Though contractors are able to participate in the project, they are not giving their best to complete the project within time and quality. The construction project's is not static, which makes it harder to evaluate the accomplishment achieved. An ideal project management needs a team of skilled and talented personnel who has ability to manage the project. A new concept which can be used as alternative management method. Thus, a Six-Sigma concept can be approached for construction industry of Nepal.

2. Six-Sigma Concept

Six-Sigma is a philosophical process improvement method developed in 1986 at Motorola by K. B. Gola to reduce the defect from activities. It can be represented mathematically as

DPMO (Defect per Million Opportunities) = Defect / (total number of opportunity x no. of units) * 10,00,000

Six-Sigma principle can be explained by normal distribution curve where mean is situated at centre of curve and the upper, lower limits are six times the standard deviation from the centre line [7].

Different level of Six-Sigma can be represented in tabular form:

Table1: Sigma Conversion Table

Non-Defects percentage (%)	Defects per million opportunities (DPMO)	Sigma Level
30.9	6,90,000	1
69.2	3,80,000	2
93.4	66,800	3
99.4	6,210	4
99.98	320	5
99.9997	3.4	6

3. Six-Sigma Procedure - DMAIC

An efficiency enhancing procedure in construction process with five key elements known as DMAIC is Six-Sigma Procedure. DMAIC stands for Define, Measure, Analyse, Improve and Control.

Define (D): In this phase, the requirement for performing the work is listed down, the project goals, scope, and process are noted. SIPOC and Checklist tool is used for defining the project.

Measure (M): In this phase, the whole process is analysed and the relevant data related to the defects are collected. Pareto-Chart tool is used for measuring the data.

Analyse (A): The measured data is analysed through Cause and Effect Diagram. It finds the root cause of the unsatisfactory performance.

Improve (I): This phase identifies the solution for the root defects found in the analyse phase. Brainstorming tool is used for providing suggestion.

Control (C): In this phase, the monitoring is done based on the check list.

4. Case Study

In this study, a residential building consisting 2 numbers of 2BHK flat is evaluated. A procedure for internal tile finishing is prepared with the checklist. This checklist will occupy the quality variables that needs to be checked. The table 4 and Table 5 as checklist and procedure (SIPOC) is presented. The studied data is filled in the checklist as per the SIPOC-Suppliers Input Process Output Customer. The defects are marked as **"X"** and the standard works are marked as **"√".**

The summary of the data for the building is shown below:

Table 2: Summary of observation for first floor

Sr. No.	Flat	Defects	Opportunities
1	A	11	40
	Total	11	40

Table 3: Summary of observation for second floor

Sr. No.	Flat	Defects	Opportunities
1	B	1	40
	Total	1	40

The observed DPMO = (11/40) * 10,00,000
DPMO = 2,75,000

As per the Sigma Conversion Table,
σ = 2.08

Final DPMO = (1/40) * 10,00,000
DPMO = 25000

As per the Sigma Conversion Table,
σ = 3.7

4.1. Define: SIPOC-Suppliers Input Process Output Customers, Check list

Before starting any project, it is very essential to understand the activity and process that are involved in the project. This tool (SIPOC) will allow to define the work area with certain limits that should not be crossed. If any work done out of the box then it is regarded as defects. The table 4 will clear the work to be checked. The table 5 will provide the SIPOC process for tiling work.

Table 5: SIPOC for tiling

Inspection First/Second Floor Check List							
Location/ Observation	Bed Room		Hall	Kitchen	Toilet	Ladder	Remark
	1	2					
Uneven Surface	√	√	√	√	√	√	
Right angle at corner	NA	NA	√	x	√	√	
Hollow Sound	NA	NA	√	√	√	√	
Cracks observed	NA	NA	√	√	√	√	
Stain Mark	NA	NA	x	x	x	√	
Skirting are at line, level and Rt. Angle	√	√	x	√	√	x	
Bad Pointing or grouting of joints	NA	NA	√	√	√	x	
Damage due to Plumbing &Sanitary fitting	NA	NA	NA	x	x	NA	
Proper Slope maintained for floors to prevent water logging	√	√	√	√	x	x	Total
No. of Defects							
No. of Checks							

Table 5: SIPOC for tiling

Suppliers	Inputs	Process	Output	Customers
Builder	Tiles Level Ruler OPC Cement Tape Water Carpenter Square Contour Gauge Tile nipper Tile cutter Diamond Paper Firm Sponge Tile grout	1. Clean the surface before the starting the work. 2. Mortar must be laid down at the ratio 1:8 (cement and crushed sand) with the water to make consistency paste with 20-30 mm thickness. 3. Level the mortar after level the 4 corners. 4. Use cement slurry mixture on the back of tile after cleaning. 5. Place the tile at Rt. Angle taking one side of room as base side with 2 – 5mm space between the tiles. 6. With the help of rubber hammer or wooden mallet press the tile gently. 7. Remove the extra slurry from the tile joint with clean cloth and leave it for curing for 7 days. 8. After 7 days clean the tile with cloth and grouting should be done.	Floor surface work finished	Owners.

4.2 Measure (M): Pareto-Chart

The second phase of six sigma is measure phase. This phase will identify the causes of defects. After finding the defects the sigma level will be calculated by sigma conversion table and DPMO. The pareto chart is used for measuring the defects.

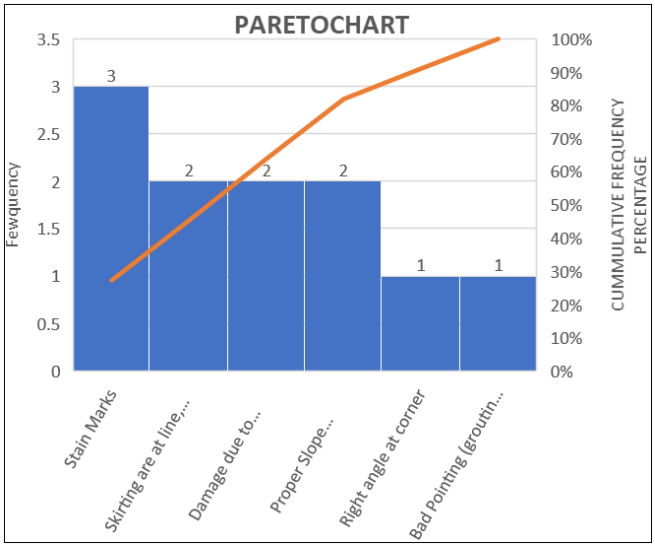

Figure 1: Pareto-Chart Analysis

4.3 Analyse (A): Cause and Effect Diagram

Analyze phase will identify the root cause of the problems. The root cause can be analyzed by the Cause and Effect Diagram (C&E Diagram). This cause and effect diagram are also known fish and bone diagram. The pictorial representation of the cause and effect diagram is provided as below:

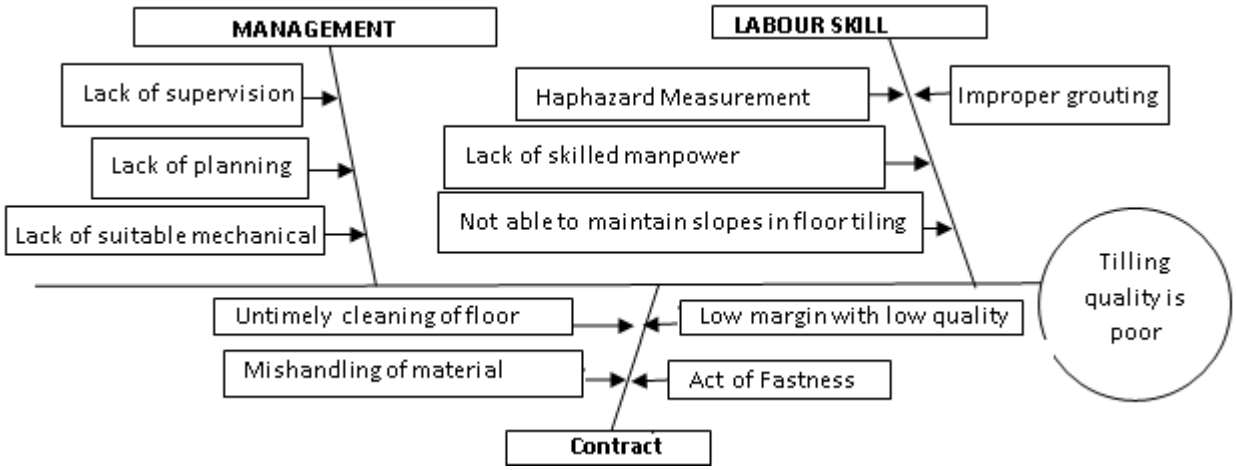

Figure 2: Cause and Effect Diagram

4.4. Improve (I): Brainstorming

Improve phase tends to increase the efficiency of the work by establishing the new ideas and alternatives. This phase plans about removing the defects found while working in the field. This phase is carried out by Brainstorming method. This method mainly concerned with do's and don'ts. It is used for identifying the solution for the problem.

Table 6: Recommendation

S.No	Defects	Recommendations
1.	Stain marks	1. Carefully handle the materials. 2. Protect the tile surface from external agent. 3. Use of Skilled manpower. 4. Proper supervision.
2.	Skirting are at line, level and Rt. Angle	1. Measurement should be done properly. 2. Use of modern equipment. 3. Working should be done in own pace.
3.	Damage due to Plumbing &Sanitary fitting	1. Before starting the work, mark the working area. 2. Use proper machine for specific works. 3. Proper guidance should be provided.
4.	Proper Slope maintained for floors to prevent water logging	1. Use of levelling machine. 2. Proper planning should be done. 3. Make sure to maintain the slope as per required. 4. Uniformity of tile should be considered.
5.	Right angle at corner	1. Measurement should be carried out carefully. 2. Alternative ideas should be generated to place the tiles with minimum damage.
6.	Bad Pointing or grouting of joints	1. Joints between the tiles should be filled with grouting material i.e. tiles would not be damage and fair beauty will be generated. 2. Surface area of tile must be cleaned properly after installation.

4.5. Control Plan

Controlling is important part in every project to ensure the quality of the work. It evaluates from define phase to

improve phase, in order to increase the efficiency. Checklist from table 4 can be used for control plan.

5. Conclusion

It is very important to identify the root causes of the problems that has happened or will happen in the construction work. The defects will reduce the quality work if action is not taken in right time. In this paper tiling work of residential building has been studied and sigma level has been calculated for the first floor which was 2.08. DMAIC methodology has been implemented to identify the defects, their root cause and the plans to minimize them. DMAIC can be used to increase the quality as well as reduce the performing time in a simultaneous manner. After the implementation of DMAIC at second floor, the observed sigma level was 3.7. Thus, the increase in quality can be measured through the difference in final outcome and previous result that can be noted as 3.7-2.08=1.62. Briefly, Six-Sigma as a most innovative philosophical methodology that evaluates the process occurring defect and enhances the project quality and time at a simultaneous manner. Six-Sigma can be used in construction industry to enhance the quality work.

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