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# Performance Improvement in Construction Project based on Six Sigma Principles

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## **Performance Improvement in Construction Project based on Six Sigma Principles**

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## 1. Introduction

The importance of quality improvement and excellent performance in the highly competitive world market, lead many organizations, their top managers, project managers, and engineers to implement the new philosophies such as pull scheduling and lean principle at their organizations. This paper describes the Six Sigma principle and framework as a quality improvement strategy through the successful business.

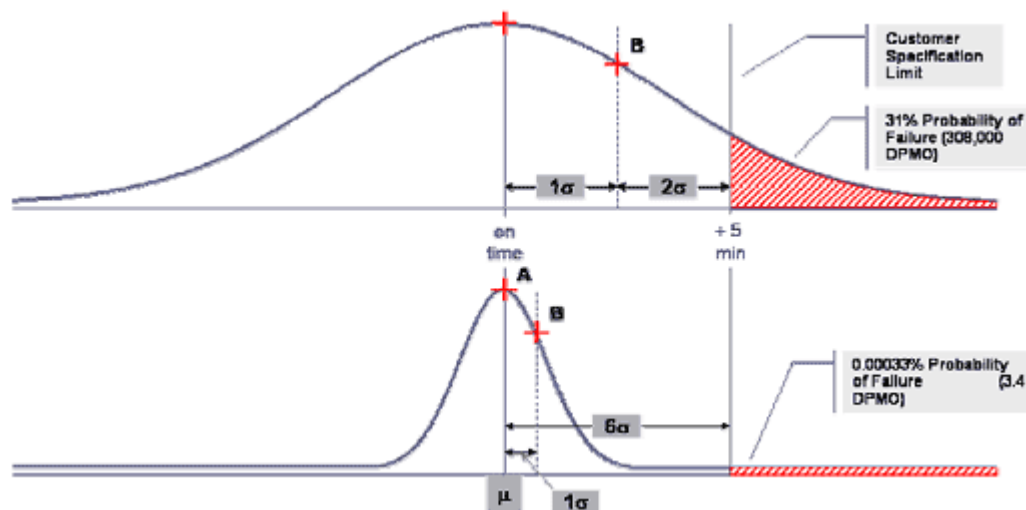
Firstly, the background of the Six Sigma in industry will be described and statistical theory behind it will be illustrated. Although the Six Sigma concept will be presented in terms of principles, methodologies and framework, the main focus in this report is on adopting the Six Sigma approach in construction projects which is still new concept in construction industry. Hence, adopting DMAIC procedure in the construction projects will be examined in this report to give an overview of what is called **Performance Improvement in Construction Project based on Six Sigma Principles**.

### 1.1. Background

At early 1980s, Motorola Corp was the initiator of the Six Sigma concept and led the organization successfully through the implementation of the Six Sigma principles. However, till mid 1990s when the organizations such as General Electric and Black & Decker adopted the Six Sigma principles for quality improvement and economic development, the concept was unpopular. Since then, many organizations have been impressed by Six Sigma framework toward the excellence performance, and the concept of Six Sigma has spread widely in a decade so that many books and articles have been written under the subject of the Six Sigma and the large number of researches has been done in its application in different industries and services. Many different quality magazines are published monthly and address the potential area for performance improvement in terms of Six Sigma strategy and numbers of case studies are reviewed to evaluate the flexibility of the principles in complex industries such as construction industry. However, in this paper Six Sigma principles and framework have been studied firstly to present an overview of its methodology, and then its application in construction projects has been explained theoretically.

### 1.2. Statistical theory behind Six Sigma

The Six Sigma concept has derived from statistical distribution known as “*standard normal distribution*” illustrated by symmetrical bell-shaped curve. “*Theoretically this bell-shaped curve has been extensively studied and has been proven very useful as numerous natural continuous phenomena seem to follow it or can be approximated by it.*”<sup>1</sup> The curve represents the total “*population*” (whatever is measuring) by the infinite series of segments in its both directions. Each segment has been named “*Sigma*” which symbolize by “ $\sigma$ ” (Greece letter) and is deviation from “*mean*” ( $\mu$ : average or peak of the bell-shaped curve) in Statistical terms. The considerable part of the curve is the range between  $-3\sigma$  and  $+3\sigma$  due to covering 99.73% of the population where as Six Sigma considers the range between  $-6\sigma$  and  $+6\sigma$  which covers 99.9997% of the data. The contraction of the curve illustrates that the main population is cumulatively around average and in specification limits which presents the excellence performance. Graph.1 illustrate that only 0.0003% of data are out of range.



Graph.1. Evolvement from 3σ to 6σ reduces the number of defects to 3.4 per million opportunities.<sup>2</sup>

## 2. Six Sigma Principles

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. For instance, at 3 sigma level 93.3% of items meet requirements and are without any defects (yield) where 66,800 defects occur per million opportunities (DPMO), but improving the performance to 5 sigma level reduces the number of defects to 320 items per million opportunities. Therefore, any companies work on Six Sigma

<sup>1</sup> Low Sui Pheng & Mok Sze Hui, 2004. Implementing and Applying Six Sigma in Construction, page 483

<sup>2</sup> [http://www.fibre2fashion.com/resources/industry-articles/1/72/images/72\\_2\\_1.gif](http://www.fibre2fashion.com/resources/industry-articles/1/72/images/72_2_1.gif)

should strive for the goal 6 sigma level performance. Table.1 illustrates the rate of defects per million opportunities in different sigma levels.

Table.1. overview of sigma levels and DPMO<sup>3</sup>

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

In order to obtain high quality of 6 sigma level at the low price, Six Sigma uses the statistical metrics and techniques to measure the processes performance and rate the defects, and teaches involved people appropriate tools to analyze their performance and improve the way of business. Moreover Six Sigma systematic strategy leads the employees and processes to maintain and control the achieved high performance. Bonuelas and Antony (2002),define Six Sigma as below:

*“Six Sigma has been considered as a philosophy that employs a well-structured continuous improvement methodology to reduce process variability and drive out waste within the business processes using statistical tools and techniques.”<sup>4</sup>*

Although the theory behind Six Sigma principles is Total Quality Management (TQM), there are different factors which add value to the Six Sigma strategy such as structured workflow (DMAIC), and apparent metrics. However, Six Sigma principles can be summarized as below:

1. The real focus on customer and emphasize on CTQ (critical to quality).
2. Strive for resource efficiency which means good timing, no idle workforce, and no waste of material and equipments.
3. Decision making and management according to the fact and data. As Six Sigma uses the metric tools to measure the organization performance and success, all the decision and management are based on those numeric data.
4. Focus on processes is the key factor to run the organization, measure the success and improve the efficiency, effectiveness and customer satisfaction.
5. Focus on eliminating the root causes of defects before their occurrence rather than reacting when the problems occur.
6. Improve collaboration and teamwork.
7. Business oriented, so that the achievement of a Six Sigma project is intended to express in financial words.
8. “*project-by-project*” implementation which leads the organization to more learning, keep planning, and continue reviewing the progress.

<sup>3</sup> Implementing and Applying Six Sigma in Construction, page 483

<sup>4</sup> Six Sigma or Design for Six Sigma? Page 250

9. Despite striving for perfection, it is essential to tolerate failure and setback to manage them properly.

In terms of implementation, it can be said that this is a “*top-down*” approach from top manager to entire involved people. Six Sigma stresses the importance of people involvement; therefore it is essential to define the involved people and their roles and responsibilities in any Six Sigma project from top to down. Those roles and responsibilities are defined as below:

1. Executive leadership. This encourages and drives force behind the scene to adopt Six Sigma in organization since the first day.
2. Executive champion. The CEO appoints this to support and supervise the whole mission. Executive champion has to aware everyone who is involved in implementing Six Sigma.
3. Deployment champions. They provide Six Sigma project with resources, work and commitment, set the goals and ensure their alignment with the organization priorities. They may administrate the project and take the logistics roles.
4. Project champions. They are the process owners who support and supervise project and find the necessary personnel to do the job.
5. Master Black Belts. They are the Six Sigma project managers and the most responsible people for fundamental changes. They are usually outside consultants but work full-time as inside experts during the implementation. They are the coaches who help champions to choose the appropriate people and projects and teach Black Belts Six Sigma main points.
6. Black Belts.  
*“The Black Belts are the people who really work. They are the ones, apart from Master Black Belts, who work full-time on the job. They are the key to the whole projects, the true leaders of Six Sigma.”*<sup>5</sup>
7. Green Belts. Their job is similar to Black Belts but they work mainly on their real job in the organization and part-time on Six Sigma, support the Black Belts and provide their needs.

As it explained above, Six Sigma offers the certification program and certifies the participants as Green Belts, Black Belts, Champions and so on. This is the elaborate training which is arranged and organized in details to teach Six Sigma tools and skills and their suitability, priorities, scopes and applications. The training scheme can be divided into three different categories, which considers specific roles and responsibilities. First is the Champions program which lasts one day to give the comprehensive perspective of Six Sigma principles, determine the champions’ roles and responsibilities to drive the Six Sigma project, and to identify the expected outcomes of the project. Second is the Black Belts program which takes 4 weeks of training and can be spread over couple of months so after each week the trainees can practice the learning items at their workplace. Third is the Green Belts program which can be half of the Black Belts. Green Belts

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<sup>5</sup> Low Sui Pheng & Mok Sze Hui, 2004. Implementing and Applying Six Sigma in Construction, page 484

also can be trained by the Black Belts. The certified Black Belts are supposed to be able to utilize Six Sigma tools and skills such as statistics and design of experiments in order to measure, analyze, improve and control the processes in a way that meet customer satisfaction and financial benefits. However, it is of paramount importance to link the appropriate people to the appropriate roles and involve them in right projects and teach them the right tools.

### 3. Six Sigma Methodologies and Frameworks

Six Sigma 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.

The other methodology IDOV (identify, design, optimize, validate) design products, services and processes before their initiation, or redesign to achieve very high level quality. This also known as DFSS (Design for Six Sigma) which intends to enhances not only efficiency but effectiveness of the future products and services. This approach aims to provide the capability of very high



level performance, being “*robust*” against variation, efficient usage of resources and focus on customer demands.

Although the coexistence of both methodologies, “*continuous improvement*” (DMAIC) and “*continuous innovation*” (IDOV) has remained questionable, the main questions consider the suitability of each methodology under different circumstances over the other one. Numerous researches have been done to set criteria that are able to prioritize the appropriate methodology regarding specific occasions and different perspectives appeared as results. One of the main hypotheses believes that for the organizations which have adopted DMAIC methodology and have attained five sigma level, the only way to improve to higher sigma level and surpass “*five sigma wall*” is adopting IDOV methodology (or DFSS) and redesign products, services and processes. The other perspective states that wide variety of criteria and variables such as risk, strategy and availability need to be considered to implement the most suitable methodology. This hypothesis conclude that regard to all those criteria and variables, provides the proper guideline in this issue towards factual decision making.

In this essay the main focus is on DMAIC methodology, and regarding time limitation and diversion from the purpose of project, reasons and details about this issue will not be discussed.

## 4. Adopting Six Sigma in Construction Projects

Construction industry has essential role in many other industries and is the infrastructure of the numerous organizations, therefore any improvement and development in construction industry results in progress of the associated business and industry. Despite the importance of high quality level in construction industry regarding to its close interaction with the other firms, achievement of appropriate quality level in construction industry has long remained questionable. However, inefficient handlings of the resources, lack of systematic quality improvement, and pragmatic approach in management, have caused significant losses and wastes in construction industry during the years. Hence, numbers of quality improvement principles such as just-in-time (JIT), lean production, and pull scheduling have been adopted in construction industry to attain high quality level in construction operations. However, Six Sigma principles as an effective methodology in construction industry, stress on reducing variation and eliminating the root causes of defects. In contrast to the other improvement methodologies Six Sigma metrics and tools are able to measure the defects rate, analyze the performance and improve the quality level in construction projects. This study is a proposal to any construction company which aims to enhance the quality level into very high sigma level. This proposal offers the systematic strategy to reduce the number of defects and variation from specification to have fully satisfied customers and maximize the financial benefits. As an example adopting Six Sigma principles in house building processes has been explained in this report.

### 4.1. Define

The first step in this phase is to identify customers and their requirements, obviously different kinds of clients can be defined, but in this project focus is on the company itself as an internal customer and the customers of the built houses such as individual people or any housing association as an external customer. In terms of business and finance, company aims to reduce the costs and maximize financial benefits as well as customer satisfaction to be back for further business, on the other hand customers wish to pay as less as possible for on time delivery and high quality (with no defects). According to these requirements the goal of implementing Six Sigma principles is to handle resources such as material, time, money, and work force, efficiently and effectively in order to reduce the defects and costs.

As it mentioned earlier defect is anything that does not meet the requirements, On the other hand defect can be defined as any fault, failing, and weakness in the construction, and different quality dimensions such as safety, appearance and environmental impact are considerable to identify the defects. Moreover, any construct project includes different phases and subprojects so in each phase different defects and failures are identifiable.

In this paper delay or late delivery of the products is defined as a significant defect in all phases from cradle to grave, since affects the other phases subsequently. Delay can cause following disadvantages and COPQ (cost of poor quality):

- Customers are dissatisfied
- Company has to cost for extra labour and equipment to accelerate constructing.
- Company has to cost for maintaining labour and equipments on site for extra days.
- Company probably has to pay the penalty for delay.
- Delay means less productivity and business for the company.

The other types of defects occur on the complete building or during each phase. These types of defects are mainly associated with aesthetic aspects, safety measures, appropriate function, and flawlessness. These defects can be identified through collecting appropriate data from the previous projects and/or by monitoring all processes during the project.

As an example, in order to identify the defects, a complete building can be studied and tested regarding different perspectives as below:

- Material tests
- Functional tests: water-tightness of the walls, windows, doors and any moisture area, appropriate performance of the water piping, heating center and equipments, electrical equipments, air conditions, isolation, kitchen equipments, and etc.
- Safety tests: perseverance and tolerance to storm, earthquake, flood, lightening, and etc.
- Internal finishes: flawlessness of the walls, roofs, ceilings, doors, windows, and components in different internal locations such as bedrooms, kitchen, toilets, bathrooms and etc.
- External finishes: flawlessness of the walls, roofs, ceilings, doors, windows, and etc of the main building as well as any other external area and facility such as parking, balcony, fences, and etc.

**Note.1:**

In terms of flawlessness it is necessary to consider the items such as joint and gaps, smoothness and roughness, cracks, damages, straightness, functionality, and etc.

**Note.2:**

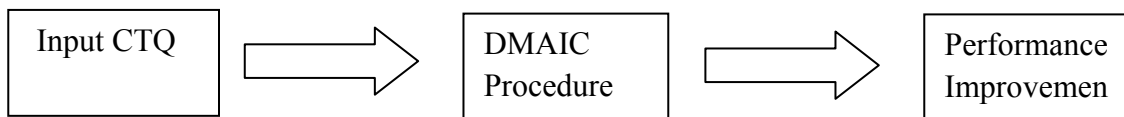
In order to recognize the defects properly it is essential to define technical characteristics of each item according to the customer requirements, which is possible through technical tests such as simulation and laboratory work and comprehensive survey of customer requirements.

The next step in this phase is to identify the key processes such as logistics, purchase, design, construct and assembly as well as process owners and any involved people such as different engineers, managers, coordinators, labor, and etc. This leads Six Sigma project to prioritize the processes for implementation of Six Sigma and allocate an appropriate role to specific person. According to the explanation of different roles and responsibilities and Six Sigma certification, and importance of those roles such as Black Belts and Champions, it is requisite to arrange the task force and assign those responsibilities to appropriate people at the beginning of the program.

The paramount question that must be answered in advance is the feasibility and possibility of the plan considering different aspects and prerequisites such as availability of data. Besides, since Six Sigma is a business oriented strategy and all achievements state in financial terms, it is required to estimate the investment and expends of implementing Six Sigma principles, determine the expected outcomes, and approximate its profitability earlier.

## 4.2. Measure

In this phase current performance of the processes and products are evaluated and measured, therefore a systematic performance measurement based on Six Sigma principle is required to manage it appropriately. The essential main factors to establish the systematic performance measurement are performance indicators and CTQ (critical total quality). CTQs are the key input variables for the DMAIC procedure which affect the performance rate, On the other hand it can be said that CTQ (critical total quality) is the customer requirements but in quantitative terms. Since DMAIC is the continuous procedure, input CTQs and output values are evaluated and calculated continuously, this assessment and modification procedure can be determined as a simple framework: Identify performance indicators and CTQs, operate DMAIC procedure, and evaluate the outputs. As construction projects include numerous uncertainties, this framework is able to provide the entire Six Sigma project with quantitative inputs and outputs by the mean of CTQs and performance improvement, respectively. That framework can be illustrated as below:



Different activities are demanded to define CTQs, such as interview with the engineers, managers and any other involved people in the project and collecting their opinions, analyze diagrams, process analysis, and etc. Following steps leads Six Sigma project to determine the appropriate CTQs and quantitative targets for performance improvement.



To clarify the topic as an example, some of the typical principle indices, CTQs, and target CTQs in construction projects are collected in the table.2.

Table.2. comprehensive view of CTQs in construction operation

Principle Indices	CTQ	Target CTQ
On time delivery Productivity High quality of the construction Valuable business ...	Variation of time Idle equipment Idle labor Material quality Safety measure Functionality flawlessness financial benefits ....	Within 100 days No idle equipment No idle labor Within specification Within specification Very high yield more than 99.98% Not less than ... ...

The next step in this phase is to collect appropriate data for CTQs in order to measure performance of the processes and/or products. Those data can be collected via studying the documentation of the previous projects, inspection and monitoring of the current project, survey and/or interview with the customers, engineers and any other involved people, etc.

Subsequently, appropriate measurement tools are required to measure current processes and products performance based on defined CTQs. Several Six Sigma metrics are available to measure the sigma level of the performance; one of them is process capability index on the supposition that numerical data for CTQs are available, mean and standard deviation are calculable by using those data, and acceptable boundaries are given. Process capability index expresses by following formula.

$$(Process\ copability\ index)\ C_p = \frac{(USL - \mu)}{(3 \times \sigma)}$$

*USL = Upper Specification Limit*

$$Sigma\ level = 3 \times C_p$$

As an example, where the on time delivery set as principle indices of performance then variation of time cycle is reasonable to assume as the CTQ due to its close association with on time delivery. In this regard process capability index is suitable to measure performance level if target CTQ is defined as maximum limit for cycle time variation, and mean and deviation are calculated according to the collected data from previous projects.

In the matter of flawlessness, Six Sigma offers following formula to calculate percentage of the flawless products (yield) and number of defects per million opportunities (DPMO) according to the collected data from the first inspection of the complete house. Those data can be categorized

in a data sheet collection, it is necessary to consider all opportunities of the defects and all parts of the complete house in this data sheet.

$$Yield = (total\ No.\ of\ correct\ item / No.\ of\ opportunities)$$

$$DPMO = (No.\ of\ defects / No.\ of\ opportunities \times No.\ of\ units) \times 1,000,000$$

As it mentioned earlier number of defects per million opportunities (DPMO), leads to the sigma level of performance. In other words, those formulas quantify the quality of the houses and provide the Six Sigma project with accurate data.

### 4.3. Analyze

In this phase the main task is to identify when, where and why the defects occur in the construction project, which includes actual and potential problems and these purpose will be satisfied through finding the root causes of problems. A cause-and-effect analysis in association with process owners, field engineers, and/or any other team members is an appropriate tool to find out the general causes of defects. In order to run an appropriate investigation and analysis of root causes of problems, it is advantageous to study an overall project in three different sections as below:

- Pre-construction activities and processes
- Construction work flow and involved processes and activities
- Quality of material, level of equipment, and competency of team members

Since a construction project includes numerous subprojects, processes, and preceding activities, comprehensive review of them with regard to resource efficiency and effectiveness during the overall project is required to lead this phase properly. Clearly a well done cause-and-effect analyses will identify the problematic preceding activities which affect the success of the project.

On the other hand as it explained above any construction project demands heavy reliance on different processes and activities and their interconnection, therefore it is necessary to consider the coordination of these processes and activities and their interface to meet the success. Moreover it can be said that each process is a customer of some other processes and poor coordination between these processes reveals that each process team works individually and the process members do not consider their customers. For example the assembly team is a customer

of logistics team, so in case that the logistics team is not fully aware of the needs of the assembly team and do not consider their needs, assembly process might face with considerable problems such as receiving damaged material or with delay. However, departmentalization and lack of effective coordination of the different activities and processes and their interface causes main problems for overall project.

From the CTQs perspective, the first priority in this phase is to identify the factors which influence the CTQs, classify those factors and determine the critical influence factors. Those critical factors that affect CTQs can be explored through an Ishikawa diagram; further more it should be considered that a cause-and-effect analysis in cooperation with engineers, project supervisors, team members, and using their knowledge, information and experience is able to investigate the critical influence factors. Subsequently, an evaluation of the effects of those critical factors and verification of their serious impacts on CTQs are vital to consider those factors as the root causes of the problems. To simplify the earliest tasks, Six Sigma offers different tools such as simulation test, “what if” analysis, and etc. However, identification of critical factors and the consequent determination of the root causes of problems are achieved through the comprehensive analysis of the project regarding the CTQs and all independent variables, either.

**Note:** as *“the construction process is an outdoor activity that is affected by external conditions and repetitive than manufacturing process”*<sup>6</sup> Besides all typical influence factors such as site access, equipment, logistics, resources, team members skill and competence, it should be noted that natural phenomena have considerable effects on the progress of the construction projects and influence the quality of the complete houses. For example a bad weather condition might cause delay in cycle time and subsequently reduce the rate of productivity, and also humidity might cause mould and cracks after while if they were not considered during the different phases such as design and assembly, and these mean poor quality and customer dissatisfaction.

## 4.4. Improve

In this phase Six Sigma project aims to eliminate the identified defects through the knowledge derived from analyze phase. As it mentioned earlier elimination of the root causes of problems and modification of critical factors which cause deviation from target CTQs and goal, result in elimination of defects, enhancement of sigma level and performance improvement.

In accordance to the analyze phase and demands for great coordination between different processes and activities and their interface, it is necessary to organize a formulated program to

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<sup>6</sup> Six Sigma-Based Approach to Improve Performance in Construction Operations, page 29

link the main teams and activities. The importance of the coordination program is considerable because of the wide range of activities during an overall construction project. Such program provides the project with meetings and workshops in which project teams are able to discuss the whole project improvement, their requirements for efficient work, future problems, and etc. an appropriate coordination program offers following advantages:

- Eliminates the gaps between different processes and/or activities.
- Leads preceding activities and subprojects to fulfill the requirements of the other processes which known as their customer.
- Minimize the impacts of failure in one process or activity on the other ones.
- Leads to identify the potential problem areas and act before occurrence.
- Enhances cooperation to eliminate the failures immediately to prevent forming the chain of problems.
- Etc.

However, effective coordination of the different processes and activities and their interface are required to improve the entire construction project. On the other hand although Six Sigma principles emphasize on collaboration and team work, it is significant to motivate the team members to be the owners of their work and strive for their own specific goal regarding their tasks beside the cooperation and effort toward the common goal and overall success of the project.

As it mentioned above the main task in this phase is the elimination of the root causes of problems based on the knowledge and information obtained in previous phase, such as upgrading equipments, purchasing the material of higher quality, and improving the competency, but it is absolutely imperative to consider its financial benefits. There is no doubt that improvement and progress demands investment and capital expenditure, but it is non value added work and is not advocated unless it is able to improve the business and increase the profitability in midterm or long term in some cases. Therefore it is strongly recommended to estimate the profitability in advance to avoid of risks and inefficient costs. In short, it is necessary to implement an alternative action that provides financial benefits and business development apart from improving the performance and sigma level as high as possible. Optimization methods lead the project to maximize profits in an appropriate performance level. For instance, in case improvement from level 5 to 6 demands numerous activities and vast investments whereas business stands at its former level, the improvement is not reasonable and sensible and operates ineffectively. Hence, this matter is of paramount importance to maintain stable at the optimal point of improvement.

Subsequently, elaborate improvement schemes, such as competence development program are required to eradicate identified gaps and weaknesses of the whole project in its all different aspects. Finally, it should be noted that improvement and high quality level attain gradually during the years in an upstream flow.



## 4.5. Control

The control phase is responsible to ensure the sustainability and development of the improvements that have been obtained through the implementation of Six Sigma principles. In this matter, it is requisite to collect data continuously during the project and measure the performance, continuous review of the project and monitoring the improvements provide the following advantages and opportunities for the Six Sigma project.

- Leads to proper evaluation of improvement to ensure that estimated improvements have been attained.
- Leads to prevention of reversion to the former failures
- Explore the potential area for further improvements and continual perfection.

The next task in this phase is recording and documentation of the knowledge and experiences which gained during the different revision of the project and sharing that knowledge with team members and team supervisors and receiving their feedback. The importance of continual actions through the control of performance improvement, necessitate the establishment of the comprehensive control plan. It is even recommended to allocate the specific people to this process, who are responsible to monitor the overall project.

## 5. Conclusion

As stated, 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.

This paper studied the idea of applying Six Sigma principle on construction industry theoretically and explored the advantages of DMAIC procedure and its potential to enhance the quality level and efficiency of the construction projects. Moreover, the flexibility of DMAIC framework in construction projects has been demonstrated and recommended how to implement each phase considering the constructional indices. This study introduced Six Sigma as a continual improvement method which offers a systematic strategy to control and coordinate all involved processes in any construction project, effectively.

Obviously, according to the text it could be concluded that the key success factors to implement Six Sigma in construction industry are nothing more than the success factors in manufacturing industry, but with more complexity and sensitivity; Appropriate definition of all critical items in any construction project, more emphasize on CTQs, proper metrics, suitable coordination scheme between all prerequisite and major processes and activities, and commitment of all involved people are able to leads the overall Six Sigma program successfully in construction industry. Practical works in future researches can evaluate this claim and add effective comments on this essay.

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