



Arab American University

Faculty of Graduate Studies

**Applying Six Sigma Approach to Improve Performance in
Concrete Mixtures in the Northern Governorates of the West
Bank**

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**This thesis was submitted in partial fulfillment of the
requirements for the Master's degree in quality management
02/2022**

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Thesis Approval

Applying Six Sigma Approach to Improve Performance in Concrete Mixtures in the Northern Governorates of the West Bank

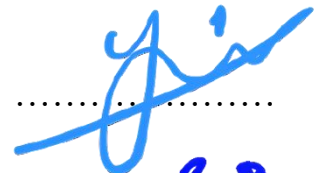
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Declaration

I understand the nature of plagiarism, and I am aware of the University's policy on this. The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted by others elsewhere for any other degree or qualification.

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Dedication

To my father who has always loved and supported me, not only during this research, but also throughout all my life,

To my beloved mother whose love, care, and support inspired me to reach this far,

To my beloved husband for his support,

I dedicate this study to those who have always encouraged me to Accomplish this mission.

Acknowledgements

This thesis is the final requirement for the completion of the master's Program in Quality Management at the Arab American University, West Bank

I am first grateful to ALLAH the Almighty for all His blessings in this life and for giving me good health, strength and ability to complete this study. All thanks and praise are due to ALLAH.

I would like to express my deepest gratitude to my supervisor, Prof. Fathallah Ahmad Ghanem, for his valuable criticism and guidance during the completion of this research, and for his patience throughout the process.

My thanks are also due to my professors who have made it possible for me to complete this MBA program. They have greatly enhanced my knowledge and ability to come up with this work.

Abstract

Concrete is considered the second most used material worldwide after water. Regarding the industrialized countries, the production of concrete annually amounts to 1.5-3 tons per capita and is still increasing. Yet it is considered one of the main components of building materials which are used for housing and infrastructure.

The Six-Sigma DMAIC can be considered a guide for problem solving and product or process improvement. Most factories start to implement Six Sigma using the DMAIC methodology.

This research deals with application of Six Sigma using the DMAIC methodology in the construction sector to figure out the defects in the concrete mixtures, which directly affect the manufacturer with all the implications of costs, time and unsatisfied customer.

The researcher has used a mixed-method approach. Data was collected using quantitative and qualitative methods. For data obtained through the quantitative method, the hypotheses of this study were tested and analyzed, using the Pearson Correlation Coefficient test; Statistical Package for Social Science (SPSS) version 21.0.

Results showed that there was a significant correlation between performance of concrete mixture factories in the Northern Governorates and applying six sigma using DMAIC methodology, in contrast, the qualitative data of the study was obtained through unstructured interviews.

Findings from this study showed that the concrete mixture factories in the Northern Governorates had a high level of DMAIC methodology especially the factories that hold an ISO certificate.

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The consistency of most findings with past studies and related theories or quality models showed that DMAIC methodology plays an effective role in influencing the company's performance.

Finally, the researcher recommends any factories or organization to develop their operations through six sigma approach. This aims at adopting six sigma approach and its effect on optimizing the performance of factories and organizations.

keywords: DMAIC methodology; Six Sigma; Concrete mixtures factories, company's performance

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List of Abbreviations

Abbreviation	Full Form
COPQ	Cost of Poor Quality
CTQ	Critical to Quality
DFSS	Design for Six Sigma
DMAIC	Define, Measure, Analyse, Improve, Control
DMADV	Define, Measure, Analyse, Design, Verify
DOE	Design of Experiments
ISO	International Organization for Standardization
PAU	Palestine Accreditation Unit
QC	Quality Control
QFD	Quality Function Deployment
SPC	Statistical Process Control
SPSS	Statistical Package for the Social Sciences
TRIZ	Theory of Inventive Problem Solving
VOC	Voice of the Customer

Chapter One Introduction

- 1.1. Overview
- 1.2. General Introduction
- 1.3. Research Problem
- 1.4. Research Significance and Justifications
- 1.5. Research Objectives
- 1.6. Research Questions
- 1.7. Research Hypotheses

Chapter One: Introduction

1.1. Overview

This chapter begins with an introductory overview of the research study. It provides a background of the study. Then it moves to the research problem, its significance, and justification. Furthermore, the chapter spells out the objectives of this study, the research questions and research hypotheses.

1.2. General Introduction

In a study introduced by Koskela (1992) a production management prototype was presented where production was actualized in three integral manners, specifically, as transformation, as flow, and as value. This three-sided perspective on production has led to the introduction of Lean construction as a control that divides the transformation ruled modern management of construction (Koskela and Howell 2002, Bertelsen and Koskela 2002).

A significant ramification of the TFV idea of creating the understanding of the TFV (Transformation-Flow-Value generation) theory of production. This theory identifies three interdependent angles to production: transformation (achieved by resources workers, machines, etc.) oriented (T), materials oriented (F) and customer oriented (V). It changes the definition of Construction Management from "The wise assignment of assets to finish a project at financial plan, on schedule, and at wanted quality" (Clough and Sears 1994) to "The sensible allotment of assets to change inputs to outputs while augmenting flow and value to the client".

Reviewing production as flow of materials and data has prompted the standard of waste removal, which was Ohno's main adversary (Howell 1999). Indeed, Ohno named seven origins of waste in a production interaction and energetically chipped away at removing them. The essential thing was that elimination of waste would bring about better work process (Womack and Jones 1996). This same saying is underscored in the lean construction literature (Everett 1992, Koskela 1993, Howell and Ballard 1994, and Howell 1999).

A related rule with waste expulsion is variability decrease (Bertelsen and Koskela 2002). This implies that inconsistent work process is by implication brought about by variability coming from single or various causes that need to be focused on independently or collectively. In the construction business, causes of variability incorporate late delivery of material and hardware, plan mistakes, change orders, tools breakdowns, device breakdowns, inappropriate crew use, work strikes, natural impacts, ineffectively planned production frameworks, mishaps, and actual demands of work (Abdelhamid and Everett 2002). While variability has a horde of causes it shows itself basically as poor work process depending on the production measures. The harming and corrupting impacts of variability on subordinate cycles has been discussed in Tomalin et al. (1999), Tomalin 2000, and Howell et al. 2001.

Under a lean model, the impacts of fluctuation on work process unwavering quality are alleviated using cascade of piles, plan cushions, and additionally adaptable limit (Ballard and Howell 1998). Piles could be as crude as well as produced material. Plan support alludes primarily to having an excess of work for groups. Adaptable limit alludes to purposeful underutilization of a team or the capacity of utilizing a resource in various manners by having broadly educated specialists. Different instances of adaptable limit

can be found in Hopp and Spearman (2000). These three methodologies are endeavors to battle the impacts of variability and not to take out variability entirely. In current practice, cascade of heaps or maybe abundance of inventory beats the other two methodologies. Professionals likewise use effectiveness factors or the 45-minute productive hour to represent the impact of fluctuation on group profitability.

Schonberger (1986) distinctly expresses that "variability is the universal enemy" and that lessening variability builds consistency and diminishes process durations. Koskela (1992) adds that lessening procedure variability will likewise build consumer loyalty and diminish the volume of non-value adding exercises.

The disposal or, undoubtedly, the decrease of variability requires the identification and expulsion of the underlying drivers of variability. Koskela (1992) specifies that actualizing standard methods is one procedure to diminish variability in reformation and flow measures. He additionally refers to error-proof gadgets and methods as another technique to diminish variability. Koskela (1992) additionally expresses that analysts have been combating variability through statistical quality control hypothesis and strategies. This last system has been revived in the modern and business areas through the Motorola-created Six Sigma approach.

Six Sigma is a statistical based technique that gives an organized structure to sort out and actualize key item and interaction improvement activities to accomplish decreases in product and interaction variability. In 1985, Bill Smith of Motorola created and actualized a way to accomplish perfect item manufacturing called Six Sigma (Breyfogle et al. 2001). Six Sigma alludes to a collection of statistical and interaction-based strategies and procedures utilized as a feature of an organized methodology for taking care of production

and business measure issues tormented with variability in implementation (Harry and Schroeder 2000, Pande et al. 2000). A few scientists accept that Motorola created Six Sigma with an end goal to restore Philip Crosby's (one of the heads of the quality development) zero imperfections approach (Behara et al. 1995). Today, Six Sigma has become a way of life in numerous other manufacturing associations (e.g., General Electric, Ford, and Eastman Kodak) just as in the service business (Breyfogle 2003).

Six Sigma has gotten away from sanctioned definition in both the scholarly and the expert literature (Abdelhamid and Everett 2002). This is fundamentally brought about by an absence of a deliberation of the fundamental theory of the Six Sigma approach. Utilizing Goal theory, Linderman et al. (2003) created helpful speculations for the Six Sigma theory. The accompanying definition, proposed by Linderman et al. (2003), typifies the ideas and standards which are basics of Six Sigma: Six Sigma is a coordinated and methodical technique for vital interaction improvement and new products and service advancement that depends on statistical strategies and the scientific strategy to make sensational decreases in client characterized imperfection rates.

While this definition may appear to be conventional for any cycle improvement activity, the emphasis on defect rates is the thing that makes it exceptional. The defect rates, as characterized by an inside or outside client, are brought about by procedure fluctuation. Diminishing variability has been supported by numerous individuals of the quality development pioneers like Deming, Conway, Juran, Crosby, Taguchi, and Shingo (Breyfogle 2003). In this manner, Six Sigma stresses distinguishing and maintaining a strategic distance from variety. Yet, what makes Six Sigma extraordinary is the unequivocal acknowledgment of the connection among the quantity of product defects, wasted working expenses, and the degree of consumer loyalty.

All 'stigmatists' realize the system used to accomplish Six Sigma objectives as DMAIC (Define, Measure, Analyze, Improve, Control). In its early stages, the DMAIC was polished and culminated on performance improvement activities coordinated at existing cycles that came about in manufacturing defects. Today, the system is utilized for some business measures that neglect to meet client needs. The DMAIC system includes (Harry and Schroeder 2000):

1. Characterizing and understanding the issue being tended to by recognizing the basic client prerequisites and key variables influencing the procedure output.
2. Estimating important information to the issue fundamentally through Six Sigma measurements.
3. Breaking down, utilizing statistical quality control devices, the production or business measures related to the issue to recognize the main causes.
4. Improving the cycle utilizing options inferred in the analysis stage (number 3).
5. Controlling and observing the interaction utilizing statistical cycle control to support the increases and upgrades.

Another arising set of steps called Design for Six Sigma (DFSS) is utilized when a product or then again, a procedure does not exist (complete product or procedure design) or when gradual changes should be joined into existing products or cycles (Breyfogle et al. 2001). DFSS utilizes existing strategies, like Quality Function Deployment (QFD), the Axiomatic Design (AD) strategy, and the theory of inventive problem-solving (TRIZ), to show up at designs that takes into consideration a bunch of issues; performance, assembling, manufacturability, ergonomics, recyclability, dependability, and practicality (Breyfogle 2003).

Organizations experiencing Six Sigma give its employees high and separate degrees of training in Six Sigma strategies and methodologies (Pande et al 2000, Breyfogle et al. 2001, Linderman et al. 2003). Full-time employees' 'black belts' get broad training, typically 4-6 weeks, on the DMAIC or DFSS approaches and are set up to lead Six Sigma improvement projects. Black belts are trained and taught by experienced and exceptionally trained people called Master Black Belts. Green belts are people who give a supporting (low maintenance) job on progress tasks and accordingly get less training compared with black belts. Six sigma projects are recognized and chosen by 'Six Sigma Champions' who get large scale level training instead of detailed training.

Concrete is viewed as the second most utilized material worldwide after water. With respect to industrialized nations, the manufacturing of cement every year adds up to 1.5-3 tons per capita and yet expanding (fib Bulletins, 2013). Yet it is considered one of the principal parts of building materials which are utilized for lodging and foundation (Teixeira et al., 2015).

Contemplating that concrete mixture is presented as a fundamental part for both people and the economy, the researcher saw from various construction engineering labs, and some concrete mixture manufacturing plants an issue (some sort of cheating in the mixture) as confirmed by individuals, and some construction engineering labs records. This may cause hazardous and disastrous results that straightforwardly undermine individuals' lives specifically and may compromise the economy in general.

This turned out to be obvious to the researcher as records showed that there are a few roofs bombed with the pressure and firmness test after concrete was poured, forcing the concrete mixture's owner to annihilate the rooftop and bear its results because of its non-conformance with the standards affirmed in such manner. These reasons are because of

the dependence of concrete mixture industrial facilities on crude materials from an assortment of sources, including, yet not restricted to, the coarseness stones utilized in the concrete mixture as there are hard coarseness stones and delicate coarseness stones utilized in the concrete mixture without inspecting it before its manufacturing interaction, which influences the solidness of the rooftop. Also, the control of concrete amounts, colors, sand, gravel which may cause disappointment in the design.

Along these lines, this study plans to sort out the imperfections in the concrete mixtures, particularly in the construction division, which straightforwardly influence the customer and accordingly the manufacturer with every one of the ramifications of expenses, time and unsatisfied clients. Notwithstanding the way that numerous Palestinian concrete mixture factories are certified with ISO 9000 series and obliged to submit to the Palestinian Accreditation Unit (PAU) rules details, still there is an unmistakable decrease in the quality of concrete mixtures as confirmed by the records of construction engineering labs.

1.3. Research Problem

Concrete is important for all walks of life, it is everywhere around us, in houses, schools, hospitals, bridges, roads, markets, offices, factories, and all aspects of life. It is also considered the main construction material distinguished by its durability, efficiency, and its contribution the economic growth in general. As there is an increase in the population and an expansion of urban areas, cities are demarcated, roads are constructed, and the need for construction, urbanization, and new buildings are increased. The increase and the expansion led to a significant increase in the use of concrete, as estimated at 30 billion metric tons per year in the world (Rumana, 2011).

The research problem focuses on the existence of defects in concrete mixtures and their non-conformity with the Palestinian specifications and ISO standards. This was observed by the researcher during her interview with an engineer in his construction engineering lab for concrete mixture examination in the city of Jenin. A problem was found in concrete mixtures and the presence of defects in them can be estimated at a rate ranging from 5-10% annually, according to the records of the construction engineering lab.

The main component of concrete mixture is sand, gravel and cement, and the factories use it to obtain it from Gaza city, bearing in mind the raw material of Gaza is solid, pure and clean, as it had a very positive effect on concrete mixture. However, due to the inability to obtain the raw materials from Gaza for several reasons, the concrete mixture factories obtain the raw materials from a variety of sources or hand-made from quarries such as Qabatiya quarries, as it is not solid and strong enough as compared to the sand obtained from Gaza, as this sand is soft and brittle.

This affects the quality of concrete mixture negatively, and thus directly affects the customer where there are many unsatisfied customers and this makes the factories responsible for all the costs and time. Therefore, the researcher will apply the Six Sigma methodology to raise the production efficiency of concrete mixture by reducing the percentage of defects and maximizing profits through the application of the DMAIC tool.

1.4. Research Significance and Justifications

This research is to apply Six Sigma approach on the manufacturing concrete mixtures by using DMAIC tool, which consists of five phases: “Definition of the constraint, Measuring the performance, Analysis using statistical methods and procedures, Improvement of the defects that may cause the problem, and Control the processes to

make sure that the problem will not happen again.” (Morales, et al., 2016), (Zahid et al., 2013) concluded that “it is possible to implement Six-Sigma in a cement industry and increase its productivity”.

By implementing the DMAIC system, continuous improvement in the manufacturing process will be achieved. In addition, the causes of the defects in the concrete mixtures in the manufacturing factories will be detected, with the assistance of the fact that all concrete mixture companies go by, respect and comply with Palestine Accreditation Unit (PAU) and the standards of ISO 9000 concurrently.

In addition, applying Six Sigma DMAIC system, will give more control on the produced cement to squander its manufacturing defects. Accordingly, the manufactured concrete will satisfy the necessary design guidelines and concrete tests (concrete collapse test and pressure strength test) as per the standards and market demands. Morales et al., (2016) have shown the effect and the significance of Six Sigma, particularly the DMAIC tool in improving production tasks, as the study showed the effect of Six-Sigma in tackling the low effectiveness issue in an agreeable way. The issues and causes were resolved, and corrective actions were applied, and the size of the gravel utilized in the mixture was controlled, just as the client assistance level expanded.

1.5. Research Objectives

Specific Objectives:

- To identify the factors that cause the decrease in the performance of concrete mixtures factories, despite its conformance to the ISO 9000 and Palestine Accreditation Unit (PAU) standards.

- To determine the process of continuous improvement in concrete mixtures preparations.
- To investigate the impact of using DMAIC tools to cement mixture factories.
- To investigate the impact of product quality, service quality factory image and price to cement mixture performance.

1.6. Research Questions:

Q1: Is there any significant relation between using Define defects stage by using DMAIC tool and factory performance?

Q2: Is there any significant relation between using Measure stage by using DMAIC tool and factory performance?

Q3: Is there any significant relation between using Analysis stage by using DMAIC tool and factory performance?

Q4: Is there any significant relation between improvement stages by using DMAIC tool and factory performance?

Q5: Is there any significant relation between using Control stage by using DMAIC tool and factory performance?

Q6: Is there any significant relation between quality of product and factory performance?

Q7: Is there any significant relation between service quality and factory performance?

Q8: Is there any significant relation between factory image and factory performance?

Q9: Is there any significant relation between price and factory performance?

1.7. Research Hypotheses:

H1: There is a significant relationship between using six sigma methodology by DMAIC tool and product quality

H2: There is a significant relationship between using six sigma methodology by DMAIC tool and service quality

H3: There is a significant relationship between using six sigma methodology by DMAIC tool and the factory image

H4: There is a significant relationship between using six sigma methodology by DMAIC tool and price

H5: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample according to the demographic profile (Gender, Age, Educational level, Experience, Districts and having ISO certificate).

H6: The DMAIC tool will positively explain the variation in factory of cement mixture performance.

Chapter Two

Review of Literature

2.1. Overview

2.2. Introduction

2.3. Six sigma methodologies

2.4. The six sigma DMAIC methodology

2.5. Usually used Quality Control (QC) Tools in Six Sigma

2.6. A Review of Green, Lean, and Six Sigma Approaches towards Environmental Sustainability

2.7. Constraints of Lean, Green, and Six Sigma Approaches

2.8. Lean Six Sigma arrangements in the association

2.9. Building the coordinated supply chain network dependent on Lean Six Sigma philosophy

Chapter Two: Review of Literature

2.1. Overview

This chapter is devoted to a review of the literature relevant to the research problem of the study.

2.2. Introduction

Six-Sigma is a focused, information driven philosophy for disposing of deformities in any procedure. Within Six Sigma, tools and philosophy manage in general expenses of quality, both unmistakable and elusive parts, attempting to limit it, and in a similar time, expanding quality level adding to organization business achievement, productivity, and profitability. Achievement of Six Sigma is estimated in monetary terms, defects per million opportunities, customer gratification, and performance of work procedures and in chain supply performance. Six Sigma is fundamentally an organized method of tackling issues in current interaction dependent on examination of genuine cycle information and facts.

Six-Sigma is a thorough and efficient technique that uses statistical investigations and data (management by facts) to gauge and improve an organization's operational exhibition, practices and frameworks by distinguishing and forestalling deficiencies in manufacturing and service-related cycles to surpass and expect assumptions for all partners to achieve adequacy (Tonner, 2003).

Six Sigma is a tool measure and program for enhancing quality in manufacturing procedures. A system which plans to lessen variability in any procedure (Prewitt, 2003).

Six-Sigma, a bunch of strategies and apparatuses to measure improvement, was created

by Motorola in 1986. Six-Sigma tends to be the significant root causes and ensures the ideal outcomes, both regarding improvement and interval of time. This upgrade approach conveys outcomes of efficiency, profitability and quality enhancements dependent on its profoundly important methodology (Chandra, P., and Chandra A., 2009). Six-Sigma is embraced by numerous ventures due to its demonstrated advantages in expanded productivity, profitability and decrease in cost particularly for medium scale enterprises. Manufacturing division is at the top in executing Six Sigma with 69% commitment followed by IT (Information Technology) businesses (Desai, D.A.,2008). Sigma (σ) is a Greek letter that addresses the standard deviation of an example populace in any statistical analysis. When estimating procedure capacity, the standard deviations between the cycle mean and the closest detail limit is assigned in sigma units. The more noteworthy the sigma factor, the greater number of standard deviations fits between the mean and the closest detail limit.

"One Sigma" is a serious level of variance (for example 7 "errors" out of 10 chances) "Six Sigma" is a low level of variance (for example 3.4 "errors" out of 1,000,000 chances). This converts into 99.99966% flawlessness.

2.3. Six-Sigma methodologies

Principle focal point of Six Sigma is to improve all critical cycles of manufacturing arrangement and take quality as a component of cycles and decrease the dismissal rate. Six Sigma principally utilizes two fundamental procedures one is called Define, Measure, Analyze, Improve and Control, typically known as DMAIC and the other is Define, Measure, Analyze, Design and Verify, known as DMADV. DMADV is utilized for making new cycles of production with least deformity rate. Both methods depend on

Edwards Deming's Plan-Do-Check-Act cycle. Some Other techniques that are being utilized during six sigma execution are given as.

- CDOC (Conceptualize, Design, Optimize and Control)
- DCCDI (Define, Customer, Concept, Design and Implement)
- DMADOV (Define, Measure, Analyze, Design, Optimize and Verify)
- DMEDI (Define, Measure, Explore, Develop and Implement)
- DCDOV (Define, Concept, Design, Optimize and Verify)
- IIDOV (Invent, Innovate, Develop, Optimize and Validate)
- IDOV (Identify, Design, Optimize and Validate)

2.4. The six sigma DMAIC methodology

The most notable and most broadly utilized approach in Six Sigma is The DMAIC procedure. Most organizations start actualizing Six Sigma utilizing the DMAIC strategy and later add the DFSS (Design for Six Sigma, otherwise called DMADV or Define, Measure, Analyze, Design, Verify) approaches when the association's culture and experience level allows that. The Six Sigma is certifiably not a totally new beginning. The underlying foundations of Six Sigma as an estimation and measurement standard can be traced back to Carl Frederick Gauss (1777-1855) who presented the idea of the ordinary curve. It tends to be considered as a guide for critical thinking and item/measure improvement. The reason for this stage is to explain the objectives and estimation of a project. The Define stage and the start of the Measure stage are generally subjective and qualitative. Now and then quantitative information from measure assessments are utilized. An issue to be settled should be detailed from individuals' encounters.

The DMAIC system is viewed as a more current way to deal with Six Sigma and is, most of the time, alluded to as the "Breakthrough Approach" created by Mikel Harry and Richard Schroeder (2000) (Pande et al., 2000) and (Jain and Gupta, 2004).

2.4.1. Define Stage of the Six-Sigma

The Define phase of the Six Sigma technique and reasoning is the start of the range for a Six Sigma project. The reason for this progression is to distinguish possible activities, to characterize and select a task and to set up the venture group. Gryna (2001) determined five general steps of the Define stage, they are summed up as:

1. To Identify the Potential Projects: This stage incorporates the sorting and choosing of projects. The chances that they will expand consumer loyalty and decrease Cost of Poor Quality (COPQ) are the focal point of this stage.
2. Evaluate Projects: The assessment of ventures incorporates an audit which goes from an investigation of the extension and advantage to an appraisal of elements to help set needs.
3. Select Project: This is about choice of the project. The underlying venture ought to be fruitful and a successful one. This is on the grounds that a fruitful venture is a type of proof to the task group that the cycle works and assists with gathering driving power to future projects.
4. Statement of purpose for Project and Prepare Problems: A statement of purpose depends on the issue articulation, yet it gives guidance to the venture group. Building up of a difficult assertion brings to the cutting edge what it is while permitting seeing an arranged result.
5. Choice and Launch of Project Team: Generally, a venture group has support, a recorder, a pioneer, colleagues and a facilitator. Building up a sanction that

characterizes what the group will do and how the group will work is a choice that may help in this progression.

This Define stage basically establishes the pace for the whole plan project where the plan issue is characterized by the management, projects which are steady are assigned with in general business methodology and chosen dependent on benefits (De Feo et al. 2002). Pareto rule is an approach to survey the expected projects. The Pareto Principle expresses that a couple of contributors of the expense are accountable for the greater part of the expense. These imperative few contributors should be distinguished with the goal that quality improvement assets can be moved in those regions.

2.4.2. Measure

One of the Six Sigma techniques is The Measure stage which distinguishes key cycle portrayed and product descriptions and measures the current interaction capacity. This stage additionally focuses on key clients and their basic requirements. The means in this stage as laid out by Gryna (2001) include:

1. Confirm the project need and measure the standard performance: It helps in legitimizing the time spent on the undertaking just as assisting with beating the resistance to tolerating and actualizing a cure. It is a smart thought to affirm the size of the error in numbers since it considers a reasonable perspective on the errors that you need to manage.
2. Documentation of the Process: Using apparatuses, for example, measure flow graphs or cycle maps are helpful in this stage. Documentation of the cycle considers others to see the issues you are managing.

3. Information Collection Plan: This stage includes evaluation effects and the detailing of theories and layout of manifestations.
4. Estimation System Validation: Variation comes from various perspectives, from the interaction itself or even from the estimation framework. Approving the estimation can include such things as precision, repeatability, reproducibility, linearity and soundness.
5. Cycle Capability Measurement: Knowing the underlying interaction capacity assists with characterizing the work to be done in the investigation and improving stages to accomplish an ability at the six-sigma level. Interaction capacity alludes to the natural capacity of a cycle to meet the limits of an item.

In arranging parts of tasks, it is vital that the cycles will want to meet the specifications. A valid justification for having the option to evaluate measure capacity is to have the option to register the capacity of the cycle to hold item specifications. To utilize the cycle ability estimations is one method of guaranteeing that the cycle can meet particulars. Organizers attempt to select cycles with the six-sigma measure ability well within the width; a proportion of this relationship is the capability proportion (C_p). It is helpful to have an ability record that reflects both variety and the area of the interaction average; such an indicator is C_{pk} , on the grounds that the average is frequently not at the midpoint. The higher the C_p , the lower the measure of item outside cutoff points, if the average is equal to the midpoint of the detail range, C_{pk} is equaled to C_p , most capacity records expect that the quality trademark is normally distributed (Gryna, 2001).

2.4.3. Analyze

To distinguish the reasons for variety and cycle execution, this phase of the Six Sigma pattern basically analyzes the past and current performance information. Choice a

significant level plan from a few distinct alternatives and creating point by point necessities against which a plan will be upgraded is the primary reason for this stage according to (De Feo, 2002). The means of this as expressed by Gryna (2001) include:

1. Assortment and Analysis of Data
2. Create and Test Theories on Sources of Cause-and-Effect Relationships and Variation. An enormous part of the Analyze stage is to have the option to test the speculations of the management controllable errors. Doing this would require the utilization of current realities, instead of feelings to arrive at decisions about the reasons for a quality issue. The real methodology decides the genuine reason as well as assists with acquiring concurrence on genuine reason by the entirety of the people involved in this question (Gryna, 2001). Approaches to test theories that have been developed are to gather new information. It expects information to be gathered in the new cycles that have been created to perceive how well it is getting along when contrasted with the cycles previously. A few estimates that should be incorporated are (Gryna, 2001):

- Measurement following non-controlled tasks.
- Measurement at moderate phases of a solitary activity.
- Measurement of extra or related properties of the item or interaction.
- Study of specialist methods.

In examining the mistakes of cycles and methods there will be no doubt that a few mistakes are inferable from the way they are done. There are likewise human mistakes that management should deal with. In any case, not every mistake can be made with the procedures or even the machines being utilized. There are overall four kinds of mistakes

that can be inferable from laborers; they incorporate unintentional mistakes, deliberate mistakes, technical mistakes, and correspondence mistakes (Gryna, 2001).

2.4.4. Improve

In this stage, the group should be prepared to go back and forth between out of sight ideas alongside the features of executing an arrangement (Pande et al., 2002). This period of Six Sigma basically plans a cure, demonstrates its adequacy and has an execution plan ready. The means as illustrated by Gryna (2001) include:

1. **Remedy Design:** This progression recognizes clients, characterizes their requirements and demonstrates the adequacy of the cure. The cure planned should satisfy the first project mission, especially regarding addressing client needs.
2. **Demonstrate Effectiveness of the Remedy:** There are two principal steps that can be taken to demonstrate the cure. Either by having a last assessment under true conditions and a primer assessment of the cure under conditions that reenact this present reality. Before any cure is acknowledged, it should be proved.
3. **Assessment Alternative Remedies:** The cure chosen should make an enhancement for the unique error and it ought to improve both organization expenses and client costs. Surveying the cures given, surveying which ones would have the biggest effect and which of these are suitable.
4. **If it is important, Design Formal Experiments to Optimize Process Performance:** The planning of the tests can incorporate production tests, assessing suspected prevailing factors, exploring investigations to decide predominant factors, reaction surface examinations and reproduction.

5. **Manage Resistance to Change:** Resistance to change is normal in this sort of execution, yet an approach to managing this obstruction is to train individuals engaged with the change.
6. **Move the Remedy to Operations:** This stage involves changes in staffing and obligations. Extra hardware, materials and supplies alongside considerable training might be included. Moving the remedy to tasks may involve updates for working norms and standard operating procedures.

A helpful device in the Improve stage is the utilization of Evolutionary Operations or EVOP. The utilization of EVOP brings little changes into factors as indicated by an arranged example of changes, these changes are adequately limited to maintain a strategic distance from a diversion from the norm, but enormous enough to continuously build up which factors are significant. EVOP depends on the idea that each manufactured lot has data which can be utilized to contribute to the impacts of interaction factors on a quality trademark (Gryna, 2001). Offering point of interest to the planning of investigations would permit simpler conformance to quality later. The Six Sigma approach utilizes the Design of Experiments (DOE) as a significant piece of its procedures. Tests can have various destinations, and the best technique relies upon the goal. Utilizing DOE resembles setting a solid intended to direct the test. DOE takes into consideration building up the significant factors that influence quality.

2.4.5. Control

The Control stage is the last period of the Six Sigma strategy where the planning and usage of specific exercises to hold the benefits of progress happen. Statistical Process Control (SPC) is a procedure for applying statistical analysis to screen, measure, and control procedures where the significant segment is the utilization of the control plotting

methods (Wortman et al, 2001). SPC is something that can be utilized in this stage. The utilization of control diagrams has numerous advantages. At the point when a control diagram shows that a cycle is within cutoff points and in control, it is frequently conceivable to take out the expenses identified with investigation. The Control stage alludes to the interaction used to fulfill guidelines reliably. The means as indicated by Gryna (2001) are:

1. Report the Improved Process and Design Controls: Control during activities is finished through utilization of a feedback circle which is an estimation of genuine performance, correlation with the activity on the distinction and standard of performance.
2. Validate the Measurement System: This progression could incorporate new estimation gadgets, the assortment of new information and extra training for process staff. In the wake of setting up the estimation framework for the improved cycle, it should be assessed and made fit and capable.
3. Determine the Final Process Capability: The cycle changes executed ought to be irreversible. Basically, this progression guarantees that the cycle capability acquired can be held during typical working conditions.
4. Implement and Monitor the Process Controls: The means referenced above are utilized to screen the procedures and product performance. In this progression, the entirety of the remedies is actualized into the activities. Actualizing and observing the improved cycle is the last advance in a quality improvement project.

As reported by Gryna (2001), the control cycle is in the idea of a feedback circle, control includes several steps: pick the control subject, measure real performance, build up standards, set up estimation of performance, contrast genuine estimated performance with

standards and make a move on the distinction. Pande et al. (2002) states that the fundamental motivation behind the Control stage is very straightforward: "when the improvement's been made and results recorded, keep on estimating the performance of the interaction regularly, changing its activity when the information unmistakably shows you ought to do as such or when the client's demands change."

2.5. Usually used Quality Control (QC) Tools in Six Sigma

Huge number of value confirmation and quality management devices are accessible and choosing a fitting device is not generally a simple errand. Seven fundamental quality instruments utilized in Six-Sigma philosophies are:

1. Flow chart.
2. Pareto graph.
3. Check sheet.
4. Control diagram.
5. Histogram.
6. Dissipate plot.
7. cause and effect graph.

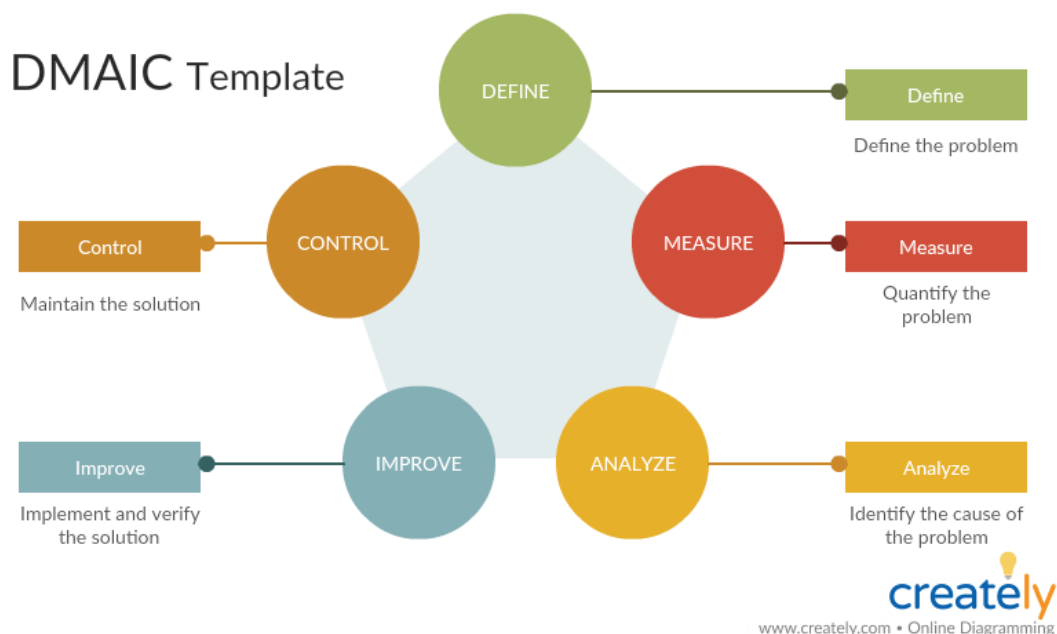


Figure 2.1: The DMAIC approach.

2.6. A Review of Green, Lean, and Six Sigma Approaches towards Environmental Sustainability

2.6.1 Green Approach

Green manufacturing as a way of thinking decides, quantifies, assesses, and controls natural waste by taking care of mistakes related to the products and procedures (Garza-Reyes, 2015). The green idea has acquired significance as it encourages an ever-increasing number of associations to limit their ecological effects. A plenty of literature has underlined the effect of green strategies like Life Cycle Assessment (LCA), Environmental Management Systems (EMS), Design For Environment (DFE), energy management system (EnMS), and 3R (reducing, reusing, and recycle) on ecological performance (Al Sheyadi et al., 2019, Guo et al., 2019, Canellada et al., 2018, Nguyen and Hens, 2015, De Sousa et al., 2016).

These practices have positive results through adjusting regulatory necessities, fulfilling clients' needs of natural cordial products, and accomplishing ecological proofs (Prasad, et al., 2016). The center goal of green methodology is to limit natural effects like perilous waste, air discharges, wellbeing of people and the environment, and energy and asset protection. Green waste comprises of contamination, superfluous water utilization, air emanation, extreme energy and material use, eutrophication (increasing the number of plants and algae in the environment), and trash (Hines, 2009). Green manufacturing involves different natural activities such as green showcasing, green packaging, green buying, green advancement, and green plan (Kazancoglu et al., 2018). Ecological activities such as EMS, eco-naming, and natural enactment have spurred an interest for green manufacturing in associations (Prasad, et al., 2016).

2.6.2. Lean Approach

Lean Manufacturing began with the Toyota Production System and acquired acknowledgment after the book entitled *The Machine That Changed the World* was distributed (Womack, et al., 2007). The lean way of thinking deals with "to accomplish more with less" and limits waste in pretty much every territory of an association (Prasad, et al., 2016). Lean as an idea depends on the end of non-value-added exercises and can be depicted as a gathering of apparatuses planned to accomplish the destinations of waste minimization and value expansion (Panwar, et al., 2017). Associations actualize lean procedure to make an incentive for clients by limiting lead time, diminishing wastes, and improving progression of the procedures (Sony and Naik, 2019). Besides, value expansion in lean manufacturing, likewise, incorporates offering some incentive in items and services that mirror the ecological necessities from clients, and activities taken by the association (Sony and Naik, 2019).

Lean model offers an assortment of apparatuses which can be used to decrease ecological effects of producing associations (Alhuraish et al., 2017). These strategies do not just assist associations in accomplishing operational performance and acquiring upper hand in aggressive edge yet in addition in achieving natural targets (Garza Reyes, 2018). A few studies have perceived the natural benefits of lean practices by saving assets and energy (Garza Reyes, 2018, Chugani et al., 2017, Dieste, 2019). In such manner, various instances of the lean tools are: Total Productive Maintenance (TPM), Kaizen, 5S (Sort, Set, Shine, Standardize, Sustain), Value Stream Mapping (VSM), Cellular Manufacturing (CM), Just-In-Time (JIT), single minute exchange of die (SMED), visual administration, and work normalization which have been used to upgrade the natural performance (Farias et al., 2019, Garza Reyes, 2018, Ramos et al., 2018).

2.6.3. Six-Sigma Approach

Six Sigma Approach was first presented by Motorola, in 1987, in the manufacturing area. The idea depends on the statistical process control (SPC) method, which is utilized to lessen defects up to 3.4 parts per million chances and the term sigma is utilized to depict variation. It gives an orderly and organized methodology of mistake solving critical thinking through the DMAIC cycle that incorporates Define (D), Measure (M), Analyze (A), Improve (I), and Control (C) stages (Hilton et al., 2012). Six sigma not just makes a difference in eliminating manufacturing errors in the production procedures yet additionally achieves improvements all throughout the association (Singh and Rathi, 2018). There are two main objectives of six sigma which are to control procedure variation and imperfection decrease (Pacheco et al., 2015, Anderson et al., 2006).

Although lessening ecological waste is not the essential target of a six-sigma approach, it is fit for accomplishing natural performance, for example, decreasing air outflows, energy utilization, and wastewater (Chugani et al., 2017, Sagnak and Kazancoglu, 2016, Powell et al., 2017). Procedure variation contrarily affects natural performance of an association as going amiss from the particulars brings about blemished products as well as resource and energy utilization (Ben Ruben et al., 2017). Along these lines, the natural effects of six sigma are seen as a side-effect or by product (Chugani et al., 2017). By using its devices in lessening defects, six sigma acquires the destinations of asset protection and conservation, air contamination, and waste minimization (Chugani et al., 2017). Literature, likewise, demonstrates the ecological advantages of six sigma procedure, for example, through utilization of Pareto analysis, gage repeatability and reproducibility (gage R&R), control outlines, Design of Experiment (DOE), histogram, failure mode effect analysis (FMEA), DMAIC strategy, and supplier-input-process-output-control

(SIPOC) chart (Shih and Wang, 2016, Sagnak and Kazancoglu, 2016, Sony, 2019, Kaushik et al., 2012, Rimantho and Hanantya, 2017).

2.6.4. Lean-Green Approach

The contrast between lean and green waste is that the first is about non-value-added exercises, and the second is about superfluous use of water, energy, and environmental resources (Duarte and Cruz-Machado, 2013). Notwithstanding, US Environmental Protection Agency (EPA) (EPA, 2007) introduced a connection between lean mudas (identified 7 Mudass or Wastes: Transportation, Inventory, Motion, Waiting, Overproduction, Over processing, and Defects). and green wastes after an examination of American firms which showed the concurrent event of the ecological wastes alongside the lean wastes. Moreover, the non-value-added exercises could be viewed as a part of wastage of power and environmental assets. For example, unneeded movement of crude materials, work-in-procedure, and completed products are viewed as wastes from both lean and green points of view as far as power utilization, vaporous discharges, and extreme use of assets (Carvalho et al., 2011). Considering the common goal of waste minimization, lean and green have been coordinated into a joint procedure (Sony and Naik, 2019). This synergistic connection among lean and green not just accomplishes the ecological advantages yet in addition lessens costs through waste minimization (Shokri and Li, 2020).

2.6.5. Lean-Six Sigma Approach

The integration of lean and six sigma is a set up and well-established idea (LSS) and all around recognized in literature (Parmar and Desai, 2019). The significant regular parts of lean six sigma are waste minimization, constant improvement, and consumer gratification (Maleyeff et al., 2012). Since waste additionally incorporates rework and scrap which are

frequently created because of interaction variability, subsequently, lean and six sigma are likewise associated (Klochkov et al., 2019). A few associations are building up a simultaneous lean six sigma (LSS) approach, which coordinates lean with six sigma as they add to a typical target of waste minimization (Salah et al., 2010).

2.7. Constraints of Lean, Green, and Six Sigma Approaches

Even though, lean application has a positive and solid effect on ecological issues (Chugani et al., 2017), studies have stressed that lean cannot eliminate the main causes of operational and ecological wastes, as it comes up short on logical and scientific methodology in controlling manufacturing procedures (Assarlind et al., 2013). Furthermore, lean separately cannot beat issues of imperfection discovery and decrease in the process to address ecological concerns (Kaswan and Rathi, 2019). Then again, green is unequipped for tending to the variance issues in the process which prompts natural waste (Kaswan and Rathi, 2019).

While green manufacturing incorporates use of a decision supportive network and well experienced people framework (Garza Reyes, 2015), these procedures need effective critical thinking and mistake solving approach (Chan et al., 2010). Further, green manufacturing has restrictions about the essential worries of an association and dynamic towards speculation openings for investments, for instance, how to execute green practices in a way that accomplishes the organizational objective towards natural supportability, productivity, and profitability (Nunes and Bennett, 2010). Also, six sigma alone cannot accomplish the ideal natural performance since it comes up short on the capacity of tending to lean wastes in an association, and life cycle sway appraisal identified with products (Zhang and Green, 1999).

2.7.1. Limits of Lean-Green, Lean-Six Sigma, and Green-Six Sigma Approaches

Because of the inalienable impediments of the lean, green, and six sigma systems, mixes of these systems like lean-green, lean-six sigma, and green-six sigma likewise experience impediments. For instance, on account of lean-green, even though lean and green can distinguish wastes for ecological effects, they ordinarily do not present organized critical errors-correcting ways to deal with waste decrease (Han et al., 2008) nor are they ready to control procedure variation (Sagnak and Kazancoglu, 2016). Regardless of lean and green being intently related, they do not address main causes of errors which are basic from a waste minimization perspective (Garza Reyes and Green, 2015). Thus, contemplates have zeroed in on joining six sigma with lean and green to determine the above constraints of these systems and improve ecological manageability and sustainability (Banawi and Bilec, 2014, Sagnak and Kazancoglu, 2016).

Although, lean six sigma can improve the ecological performance concomitantly, natural waste decrease is not the essential target of LSS. This union additionally comes up short on the capacity of tending to life cycle impacts and employing ecological improvement programs while green techniques can survive this impediment by using apparatuses, for example, LCA, EMS, and DOE (Banawi and Bilec, 2014, Zhang and Green, 1999). Likewise, if six sigma and green are joined then this mix will be unable to feature lean wastes that have a roundabout effect on natural performance (as lean procedure/production wastes have a commitment on ecological wastes (Arroyo and Gonzales, 2016). Lean can beat this restriction through its waste examination and the management approaches.

Garza-Reyes and Green, 2015 have clarified the connection between green, lean, and six sigma by featuring lean's job as a middle system for associating green and six sigma.

These three methodologies are interrelated, versatile, share normal highlights, and conquer constraints of one another (Banawi and Bilec, 2014). Due to these attributes, green, lean, and six sigma systems as a bound together methodology can address the points of waste minimization, asset reserve funds, and ecological effects.

2.7.2. Green Lean Six Sigma (GLSS) Approach

The relationship among these three systems can be better perceived by their intrinsic attributes of consumer loyalty accomplished through waste decrease and value inclusion (Garza-Reyes and Green, 2015, Gaikwad and Sunnapwar, 2020). Every procedure in GLSS approach beats constraints of the other system to offer some incentive by recognizing and eliminating wastes bringing about natural manageability and sustainability (Gaikwad and Sunnapwar, 2020). Squander has a different explanation within the green, lean, and six sigma procedures. In green manufacturing, waste is characterized as natural waste, and the green practices intend to eliminate these to satisfy clients' necessities of a naturally protected product. Green procedure additionally incorporates the idea of green value addition (GVA) which adds an incentive for the association, partners, and in the end for the environment (Ndubisi and Nair, 2009). Lean alludes to the end of non-value-added exercises to fulfill clients, furthermore, it tries to limit different lean wastes (Garza-Reyes and Green, 2015). Then again, six sigma improves client fulfillment by decreasing deformities (waste) which can bring about a high-quality item. It produces value in the items and services through steady and dependable cycles by decreasing variation (Kazancoglu, y. et al., 2018).

Even though waste has various implications in these techniques, the impact of waste is comparative from "resource utilization" perspective, which is a definitive effect of all these three systems. Regarding natural effects of these systems, green manufacturing

unmistakably centers around the ecological performance and resource preservation as one of its primary measurements (Thanki and Thakkar, 2018). Lean likewise saves resources by lessening waste, accordingly, it is perceived as an "environmentally friendly technique" (Chugani et al., 2017). Additionally, six sigma implies deformity as material waste, space involved, wellbeing issue, and energy consumption (Goyal et al., 2019). The connection between these three methodologies is clear from Figure 2.1.

From the above discussion, the ecological performance can be improved if the green, lean, and six sigma systems are consolidated to help each other as every one of these has limits. Even though the practices related with the green, lean, and six sigma techniques have positive ecological impacts, their consolidated impact is more noteworthy when contrasted with practices of each single system (Green et al., 2019).

Perhaps the main strides of the LSS project expect to distinguish between the Critical-to-Quality (CTQs) interaction factors, taking the Customers assessment into consideration. Indeed, the emphasis on the clients is a prime concern of the LSS theory (Tenera and Pinto, 2014, Brook, 2010). Along these lines, their feelings and requirements should be reflected in the result or service to be delivered. In Project management rehearses, it is common to actualize consumer loyalty reviews in the end period of each venture overseen. This normal act of Project Management would then be able to be utilized to distinguish the fundamental prerequisites of the Customer, to recognize the Voice of the Customer (VOC) on the DMAIC approach (PMI, 2008). Another normal review device choice is the incorporation of free-reaction inquiries on customers' overviews which can be methodically and equitably broke down with information/text mining draw approaches (Tenera and Pinto, 2014) to find what, from the customer viewpoint, will be the primary improvement factors to be continued.

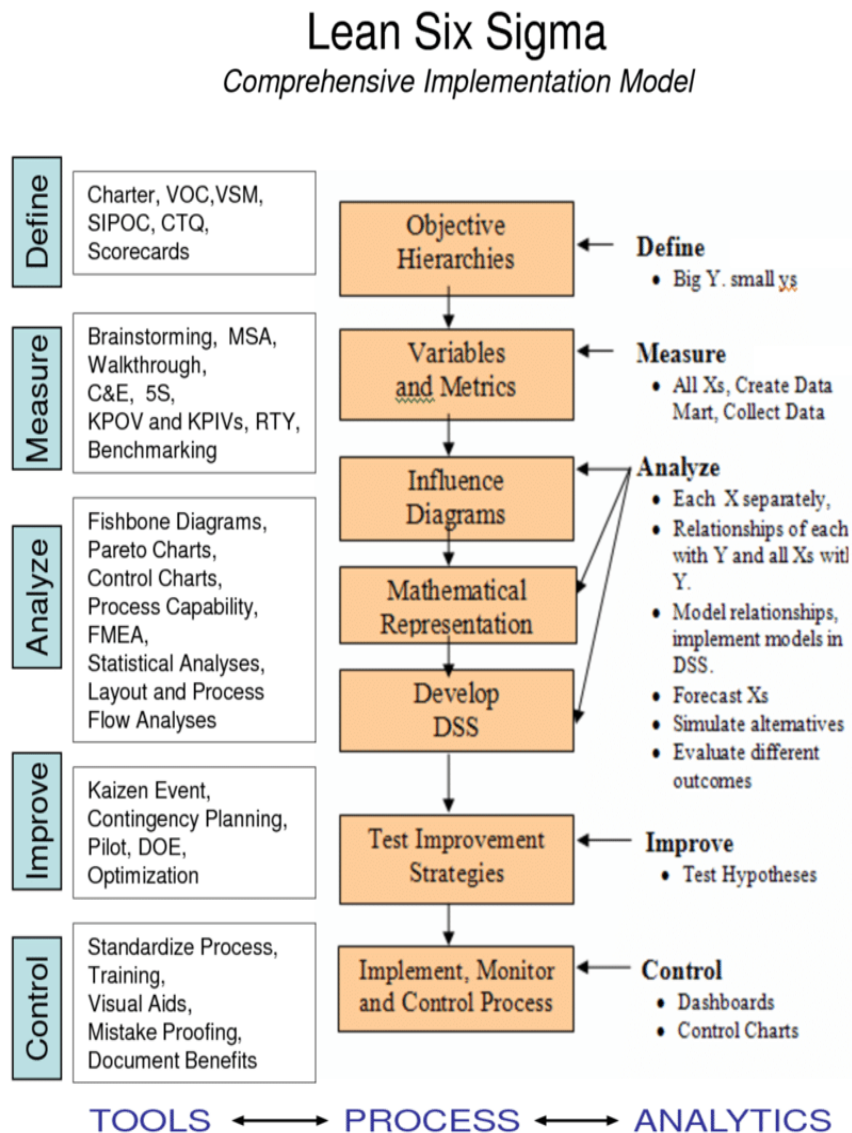


Figure 2.2: Connection between Green and Lean and Six Sigma Approaches.

In the Process Mapping stage, it is important to zero in on the procedures and their principal partners that will be later applicable to the improvement focus that ought to be straightforwardly identified with the recognized CTQs. To understand a significant level interaction, the SIPOC (Supplier, Input, Process, Output and Customer) graph can be very helpful, for specifying the elaborate partners just as the primary venture exercises to be tended to. In the subsequent stage, the Measure stage, all means are centered around estimating the interaction performance (sigma level), just as refreshing the objectives

which were characterized in the stage previously. The third stage is especially significant and plans to examine in details the procedure, upheld by a huge gathering of tools and techniques: Lean tools like i) Value Stream Mapping to acquire a better look at the improvement measure chances and ii) Root causes distinguishing proof and investigation, utilizing affinity outlines which are significant LSS accessible instruments to help Ishikawa diagram development (demonstrate where quality control issues might arise and determine which resources are required at specific times) (Tenera and Pinto, 2014).

The main causes characterized in the past stage need currently to be dealt with. In this way, the Improve stage means to recognize likely explanations just as doing their prioritization, by the utilization of six sigma instruments, for example, Prioritization Root causes matrix (Pereira and Requeijo 2008) and Pugh grid (technique to determine which of several potential solutions or alternatives should be selected) for main causes categories. In the last period of the LSS proposed, procedures and control devices ought to be actualized all together to acquire systematical improvement on a persistent base.

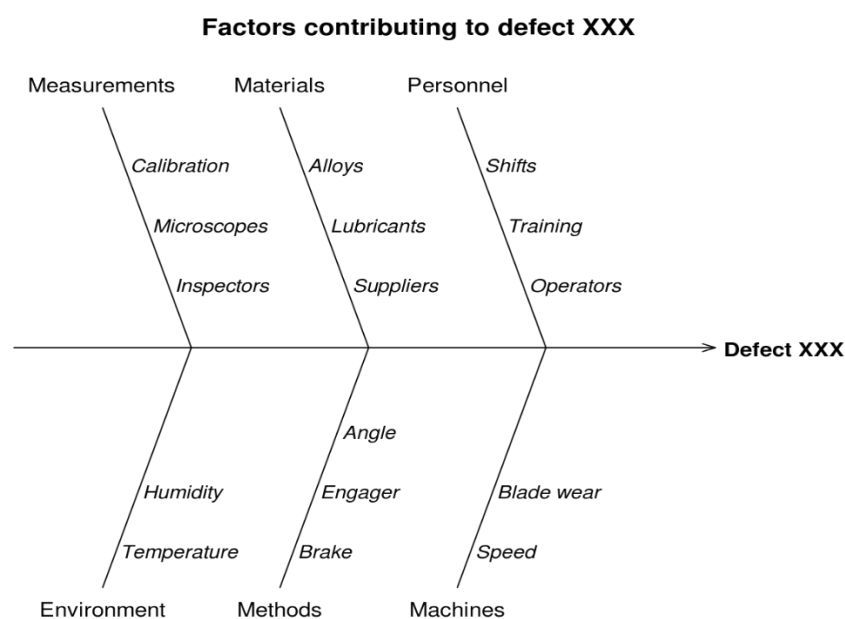


Figure 2.3: Factors that help in detection of any defect.

2.8. Lean Six Sigma arrangements in the association

Arrangement of the Lean Six Sigma procedure starts in the chief worker's association, and afterward falls to different associations in stages, contingent upon the criticality and significance level of the conveyed items/services for accomplishing the fundamental objective. The Lean Six Sigma technique arrangement is basically a project, for example an action that has a certain period, requires certain assets and points toward acquiring certain outcomes. As well as acquiring certain outcomes (which may incorporate, improved procedures, funds for other things, abbreviated cutoff times, satisfaction of specific prerequisites, increased share of the market, and so forth).

The upper-level association goes through a change interaction that is more profound than unmistakable and obvious task results, that is, smooth progress from the present status of authoritative culture to the elite culture level. The change cycle, just as the technique of the arrangement project itself, requires nonstop and close consideration of the management. However dissimilar to the deployment project, the improvement projects usage is executed on an orderly premise and by the well-trained work force of the association (Linde and Philippov, 2020). At the upper level, the Lean Six Sigma strategy deployment is completed in a few phases, which reasonably duplicates the DMAIC project execution cycle conforming to the Lean Six Sigma approach:

1) Conceptualization

The conceptualization (definition) stage is the underlying period of the project, at which the assets for its usage are resolved, connections are set up between the task members and partners, a methodological process is executed to gather data about the association's present status, permitting to comprehend the connections in the association and pre-decide the aggregation territories of misfortune, expenses, imperfections and overhead

expenses, the principle cycles, necessities and assumptions for buyers, basic and significant sorts of items, prerequisites forced on providers association (Linde and Philippov, 2020).

2) Research

The exploration (measurement and analysis) stage is an intermediate task stage, where the association's state is evaluated as per the scores of diagnostic and analytic review and distinguishing proof of association's development level to convey the Lean Six Sigma philosophy, just as an investigation of circumstances and logical results connections between aggregation territories of misfortunes, expenses, imperfections and overhead expenses and the present status of the association. The consequence of the examination stage is an affirmed rundown of progress projects (for instance, the quality capacity arrangement) to be executed by project groups (Linde and Philippov, 2020).

3) Implementation

The execution (improvement) stage is the principal phase of the Lean Six Sigma approach deployment. When improvement measures and tasks are cultivated (for instance, measure improvement), fundamental training materials are produced, workers are trained, guaranteed, certified and occupied with projects, Projects are guided by internal successful confirmed representatives and guided by external advisors (Linde and Philippov, 2020).

4) Evaluation

The assessment (control) stage is the last stage before replication of the Lean Six Sigma technique, where the improvement projects results and the association's state from "as it was" to "how it became" are assessed, a point by point plan for the Lean Six Sigma

philosophy advancement is set up at upper-level management in the association, including the fundamental work for continuous improvement (CI).

5) Replication

Ventures of moving existing work strategies as indicated by the Lean Six Sigma system and imparting the chief contractor's prerequisites for items/works/services to the providers of construction materials/items/services, which are, for instance, some portion of the coordinated supply chain networks (Linde and Philippov, 2020).

2.9. Building the coordinated supply chain network dependent on Lean Six Sigma philosophy

For a long time, such abnormalities of construction industry as conflicting and divided cycles and absence of coordination among providers and contractors, inferior quality construction items, have been savagely scrutinized. As indicated by specialists in different nations, these issues are unavoidable and involve genuine results such as methodical inability to fulfill set up time for delivery, surpassing construction and ensuing activity costs, wasteful utilization of workers, misuse of construction materials, and last, however not least, dubious possibilities for benefit for members associated with the construction. One way to deal with taking care of these issues is building incorporated supply chains dependent on the Lean Six Sigma procedures (Stewart and Spencer, 2006).

The production of incorporated supply chains is the most recent and progressive innovation in the stock administration and coordination (Womack and Jones, 2003). The principal benefit of an incorporated supply chain network is the chance of making profit for every party included - from the end client to the provider of construction materials. The core point of the incorporated supply chain network is in centralization of full duty

at the top management level of the key project worker, just as close coordination and arrangement in the supply chain network (Mikhalchenko and Rubanik, 2019). When in doubt, the focal connection in the authoritative design of a coordinated supply chain network is the chief's project worker's acquisition division, which places the orders and requirements of all customers. Each progression - from crude materials sources to conclusive conveyance to the client - is viewed as a feature of the supply chain network (Yelubayeva M. et al., 2018).

Making a coordinated supply chain network is a critical chance to accomplish the objective of making an incentive for the customer at the most minimal expense by increasing the extent of control and impact (Oakland J.S., 1995).

The fundamental standards of building the incorporated supply chain network are:

1. Rivalry through making an incentive for the consumer and guaranteeing the best incentive for cash.
2. Recognizable proof of significant value for the consumer.
3. Setting up connections with the providers.
4. Facilitated and adjusted venture exercises.
5. Cost management.
6. Nonstop improvement.
7. Work force improvement.

The utilization of the seven standards of coordinated supply chain network creation requires a reliable and organized way to deal with the administration of construction projects, which offers ceaseless help for all supply chain network members joining by including all individuals invested in the procedure - from the provider to the end client.

Because of this methodology, the shopper (client) gets advantages such as saving, clearness of consumption, improving the income consistency both during the construction interaction and all through the construction site life (Rumane A.R., 2019). The functional use of this methodology in foreign construction organizations permitted acquiring the accompanying outcomes (Plenert G., Plenert J., 2018):

- Construction time decreased by 20%.
- Number of therapeutic exercises in the project by 98%.
- The probability of profit increment for contractors and providers by 8-14%.

Presently, an expanding number of associations elect at nonstop improvement of cycles versus a one-time project for the procedures reengineering. Improvement is fundamental for any association, on the grounds that the degree of most cycles' markers will in general diminish after some time if not upheld, and current customers are getting increasingly tough and even wasted about quality. The fast development of purchaser assumptions inspires the association to meet them. Assuming that this is not done, the organization will lose the customer for sure.

As implementation shows, the idea of "Six Sigma" at foreign ventures permit in a genuinely brief timeframe (about a year) and with own assets to accomplish the accompanying outcomes (Desale and Deodhar, 2013):

- Production and services costs decrease by 30-60%.
- Service conveyance time decreased by up to 50%.
- Increase in the volume of work performed by 20% without extra expense.
- Decrease of the plan cost by 30-40%.
- Finished projects time decreased by up to 70%.

In a study carried out by Heon Han et al., 2008 showed that investigations on the current strategies for performance improvement and recognized the benefits of the six-sigma system over the customary strategies. As a result, measure reproduction models have shown that construction performance improved as the sigma level progressed by upgrading the state of CTQ. Also, the six-sigma system gave more advantages by getting the advanced solution sets from performance indicators, particularly when the objective measures are confounded and broadened. So, the six-sigma system is not just an administrative device for profitability and quality improvement yet additionally a systemized device for quality and interaction control. With the guide of the six sigma system strategies, quality changes or imperfections associated with construction cycles can be controlled in more functional manners to fit in an attractive range.

Energized by the advantages of six sigma system application, future exploration will focus on creating itemized instructions on the CTQ control of target factors dependent on the assorted attributes of various organizations on the grounds that the customization of the six-sigma standard procedure encourages construction firms to accomplish their own cycle assessment model. For these goals, progressed monetary plausibility examination ought to be created before the execution of the six-sigma system to a genuine construction activity. Besides, as a reason for getting more powerful outcomes from the six-sigma standard, different parts of construction activities and cycles should be examined in various projects. Finally, base data should be given from which the improvement targets can be specifically picked dependent on the functional advantages. In the long run, a coordinated management framework ought to be set up to control the variations of all the cycle exercises overall, instead of the isolated cycle, through the general performance quality evaluation (Heon Han et al., 2008).

The significant goal of the current investigation (Abdulhasan, et al., 2015) was to assess essential procedures of quality for the military construction association in Iraq, as indicated by ISO 9000. Thus, the presence of a break alludes to an awkwardness in both of a structure to direct senior management of associations towards improved performance and assessing quality cycles addressing the arrangements of occasions to plan, control, and improve quality. Since EQP has three components: assessing Quality affirmation measure, assessing Quality control measure (EQP), and assessing Quality improvement measure, in this way, a successful Quality Management Processes (QMPs) can help the Military Construction Organization (IDMW) to improve standard prerequisite's reaction and EQPs. Engaging Statistical examination of this exploration show of QMPs are high in the military construction association in Iraq.

This reflected positively on the reaction to the standard prerequisites. While the assessing quality improvement measures are less than assessing quality confirmation and quality control, yet it ought to be higher to guarantee ceaseless improvement. The Current degree of assessing quality improvement measures did not accomplish the objective of continuous improvement. The framework transformed arrangement should zero in on raising, assessing quality improvement measures through upgrading the utilization of a structure to advise senior management of associations towards improved performance rate (Abdulhasan, et al., 2015).

The goal of this exploration (Sarhan, et al., 2014) is to examine the actuality of the quality control in bridges projects in Iraq, to distinguish factors influencing the quality control of intact concrete piles for these ventures utilizing the fishbone strategy, to discover the relative significance of these factors, to assess the field application by thinking about the logical reason for the quality control in the construction business, to arrive at set a of

conclusions and suggestions expected to improve the quality control measure in bridges activities to a more elevated level, lastly to build up the actuality of quality management in the construction division in Iraq. To accomplish the above targets, the necessary information was gathered through open surveys, closed polls, conceptualizing, field sharing of certain projects, visits to some prepared blended concrete plants, and visits to some construction research facilities. In this survey, 66 of architects who work in bridges projects in Iraq were partaken.

It was inferred that the bridges projects in Iraq experience the ill effects of the absence of productive staff and specialized workers in quality control field with an overall significance of 90 %, absence of statistical techniques for operations modeling with an overall significance of 83%, absence of data framework for quality control and issuing of contracting for lower offers, absence of devices owned by construction laboratories to the prerequisites of ISO, absence of clearness and reasons of plan prerequisites, absence of clearness in the technical details, poor consciousness of engineering significance of quality control , absence of courses and dissemination of information and occasional training on quality, absence of coordination gatherings between the people involved in the venture. These elements could be considered as the primary components that led to a low quality of the concrete utilized in bridges projects in Iraq. Finally, a few arrangements and recommendations that could add to dodge a portion of the issues of value the board was introduced in this exploration (Sarhan, et al., 2014).

There were a few vulnerabilities in the legitimacy and dependability of the inspected information that were utilized in past to break down and improve the concrete manufacturing measure. The primary reason for this study (Hasan, et al., 2013) is to implement Six-Sigma for the case association with less imperfect item. Even though this

contextual investigation has been directed in a concrete manufacturing association, the methods and the results can be utilized for any manufacturing association. The Sigma Level determined for the case association at the last phase of completed item is 3.6. From the Six-Sigma value chart, it very well may be presumed that the case association is an average company in the industry.

Six-Sigma is probably going to stay one of the key activities to improve the management cycle. Furthermore, the essential spotlight ought to be on improving general management performance, not simply pinpointing and tallying errors. As it has been seen that the level of its sigma is not agreeable, it is impossible to improve this by DMAIC. Finally, it tends to be presumed that it is conceivable to execute Six-Sigma in a concrete industry and increase its productivity, which is the fundamental reason of this investigation. Later, almost certainly, more changes will arise; making Six-Sigma much more useful application for associations of different types and sizes (Hasan, et al., 2013).

In this exploration (Ramadan, 2013), the issue was the customary way for blending Base Course materials does not create a quality product; hence, to mix again, cost more cash and burn-through additional time. While applying Six Sigma Methodology, the issue had appropriately been characterized, and the clients had been distinguished. In the wake of gathering significant information and utilizing control graphs it had been tracked down that the nature of the product was extremely poor and the interaction couldn't accomplish the cutoff points expressed in the American Standard and that prompted client disappointment just as burned additional time and cash. After underlying causes had been resolved, it was discovered that utilizing the volumetric procedure for mixing Base Course Materials was viewed as the principal factor that influenced the nature of the product, in this way the exertion centered of discovering options for volumetric technique

like utilizing Concrete Batch Plant. It has been seen after carrying out the Six Sigma Methodology-which is an information driven, problem solving philosophy for improving business and authoritative performance-which the way toward blending Base Course materials has been improved and delivered High Quality item which prompted consumer loyalty. Cycle improvement is the demonstration of making the system work better to fulfill client requirements and needs. It is an indispensable component all together for nonstop improvement to turn into a reality.

Ramadan et al., (2013) recommended that Six Sigma programs in the construction business need further turn of events. The essential issue in the huge construction ventures could be ascribed to the absence of correspondence and organizing among the multi-activity people engaged with the task, and furthermore there is no sufficient attention to the problem-solving procedures. So, it's prescribed to give some attention to the problem-solving strategies for every one of the project's architects. After execution of progress activity, Risk Priority Number (RPN = is a numeric assessment of risk assigned to a process, or steps in a process, as part of Failure Modes and Effects Analysis (FMEA.), reexamined and found that there is another potential danger that could influence the achievement of the task that is "Labor force which are not competent". It is prescribed to give more focus on the preparation of the labor force including yet not restricted to engineering laboratory experts, construction directors, quality control groups, and concrete plant manufacturers. It is recommended also that the significant essentials to effective Six Sigma execution incorporate extremely strong and cooperative management, obligation to quality, achieving consumer loyalty, and educated staff.

In present-day manufacturing, production organizations are more concerned about consumer loyalty, while guaranteeing extraordinary profits, which is a decent plan of action. In a study carried out by Ikumapayi, et al., (2020), two fundamental methods that have been examined which target accomplishing a triumphant attitude on the provider as well as the client, which are 'the six sigma' and the 'Lean production' strategies. The essential thought is to have the most ideal way for the association of devices in a rational manner to have organization achievement and generally safe with minimal material waste henceforth guaranteeing low production costs conceivable. Lean and six sigma production joined together, delivers best outcomes an organization can, at any point, consider.

The two consolidated take out the less significant strides in manufacturing and predominantly focus on steps that would enhance the item or service delivered. While the six sigma plans to bring down the interaction variation without influencing the quality of the result, the production turns out to be carefully what the customer/client requires and is ready to pay for, barring all interaction exercises that do not really enhance a product (Quality Assurance and mishaps during tasks are reduced from the price). If the clients are unquestionably happy and satisfied with the item, at that point the organization runs a superior capability of fortifying its prestige on the market and experiencing less dangers to be boycotted. There are unquestionably no questions about expanded organization profits while guarding against operational speed and quality of the items (Ikumapayi, et al., 2020).

Chapter Three

Research Methodology

3.1. Overview

3.2. Research Strategy

3.3. Research Timeframe

3.4. Design of the Study

3.5. Research Location

3.6. Research Population, Sample and Sampling Procedure

3.7. Instruments of the Study

3.8 Pilot Study

Chapter Three: Research Methodology

3.1. Overview

This chapter covers research design, population of the study, sample size, data collection, questionnaire design and content, instrument validity, pilot study, methods of data processing and analysis.

3.2. Research Strategy

The research strategy presented a general plan for what and how data must be collected and how the results will be analyzed. The selected research plan affects the type and the quality of collected data (Ghauri and Grønhaug, 2010). The researcher has used the quantitative survey approach to answer the research questions and test the hypotheses of Applying Six Sigma Approach to Improve Performance in Concrete Mixing Plants in the northern West Bank governorates.

3.3. Research Timeframe

The study commenced in January 2021. The literature review was completed at the end of May 2021. Testing of validity, pilot study questionnaire administration and data collection were completed at the beginning of October 2021. Data analysis, discussion, conclusions and recommendations were completed at the end of December 2021.

3.4. Design of the Study

In this study, the researcher has used the mixed-method approach (qualitative and quantitative). She has also used data collection techniques and analysis procedures in research design. According to Creed, Freeman, Robinson, and Woodley (2004), in the mixed-method approach, quantitative and qualitative data collection techniques and

analysis procedures are used either at the same time or one after another, but it does not combine them. This implies that by using this approach, quantitative data of the study are analyzed quantitatively while qualitative data are analyzed qualitatively (Saunders, Lewis & Thornhill, 2009, p.153).

The researcher has chosen the mixed-method research approach for this study because it allows better opportunities to answer the research questions and have a better evaluation of the scope. The research findings can be trusted, and inferences can be made from them (Johnson, Onwuegbuzie & Turner, 2007; Saunders, Lewis & Thornhill, 2009, p.154). This means that the findings from a primary quantitative study can be better understood when complemented by a qualitative narrative account (Rusli & Hasbee, 2011, p. 134).

Using the mixed-method approach, both qualitative and quantitative methods are explained in this chapter. For the quantitative method, the researcher administered the questionnaire to randomly selected participants in different concrete mixing plants. The quantitative method is where inferential statistics are used to analyze and determine the relationship between the independent variables and dependent variables. The qualitative methodology can help the researcher to have a deeper and better understanding of how things happen and an understanding of the study variables (Rusli & Hasbee, 2011, p.127).

3.5. Research Location

This study was conducted in the northern West-Bank governorates: Jenin, Tubas, Nablus, Qalqiliya and Tulkarm.

A group of employees working in the concrete mixing plants was randomly chosen to participate in this study.

3.6. Research Population, Sample and Sampling Procedure

Population and sample were very important in this study as they provided critical information and inputs which the researcher has used to make inferences. A population can be described as a complete set of groups of people whom the researchers use in conducting their research (Yount, 2006).

In this study, the population consisted of employees working in concrete mixing plants in the northern West Bank governorates

For the quantitative method, the samples were drawn from the population, using a simple random sampling technique. The simple random sampling is a probability sampling that enables the researcher to select the sample randomly from the sampling frame.

According to Rusli and Hasbee (2011, p.161), simple random sampling is best used when the researcher has an accurate and easily accessible sampling frame that lists the entire population. By using simple random sampling, each respondent from a group of employees will have the same probability of being chosen at any stage during the sampling process in this study. The main advantage of using simple random sampling is that it enables the researcher to select the sample without bias. The sample selected can be representative of the whole population. Furthermore, this type of sampling procedure is also easy to understand and apply in research activities.

In getting an accurate number of samples, under the simple random technique, Herbert Arkin (1974) proposed a suitable formula. It is used to calculate and obtain the minimum sample size. In this case, the population of this study was represented by the total number of employees who were working in the concrete mixing plants in the northern West Bank Governorates Therefore, the sample size was limited to 200 employees. However, to

obtain the desired and correct sample size, the researcher administered the questionnaire to 230 employees to obtain good and reliable results.

Thus, the formula to find the sample size is,

$$n = P(1-P) / (E/Z)^2 + [P(1-P)/N]$$

n = required sample size.

Z = Confidence coefficient, used to determine the precision interval, represents the number of standard errors along the horizontal axis about the mean under the normal distribution (1.96)

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

E = the degree of accuracy expressed as a proportion (.05).

Furthermore, the researcher also used the qualitative approach. She conducted several unplanned (unstructured) interviews. The researcher had to explain some issues to familiarize the employees with the Six Sigma approach and DMAIC tool. This sampling technique later helped the researcher in answering all the research questions and in achieving the objectives of the study.

3.7. Instruments of the Study

The instruments used in this study were based on the quantitative and qualitative research approaches.

1. A questionnaire based on the objectives of the study
2. Unstructured Interviews: a less formal set of questions

3.7.1. Questionnaire Design

The initial questionnaire draft was designed to be revised depending on the pilot results. The questionnaire framework was modified and refined by the supervisor. It included a cover letter explaining the aim of the research, the confidentiality of the information to encourage a high response rate and the way of responding.

The questionnaire had a variety of items, and it aimed at achieving the research objectives. It covered the main domains of the study and allowed the researcher to collect all the necessary data to support the study findings, hold discussion and arrive at conclusions and recommendations.

The questionnaire was divided into three sections: A, B and C.

Section A: Demographic Information

Section A mainly aimed at collecting background information about the participants: gender, age, educational level, work experience, governorate and possession of ISO certificate in the concrete mixing plants.

Section B: Applying DMAIC Tool to Improve Performance in Concrete Mixing Plants in the northern West Bank governorates

This section consisted of two subsections. The researcher used the five- point Likert Scale to obtain the participant's preferences or degree of agreement with a set of statements constructed in the questionnaire. This allowed the participants to have wider choices of answers. The neutral point can be seen as an easy option to take when a participant is unsure of the statement that is constructed in the questionnaire set.

- The first subsection consisted of 56 statements that measured the application of DMAIC tool in concrete mixing.

- The second subsection consisted of 22 statements which measured the productivity of concrete mixing plants.

Table 3.1: Sample of Likert Scale used in the questionnaire

Score	Responses
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

This type of questionnaire has the following advantages:

1. It is easy to compare the results or outcomes of the research between employees in different departments as the questions have been structured.
2. Respondents will not be influenced by the researcher.
3. It is easy to analyze the data collected by using the Statistical Package for Social Sciences (SPSS).
4. The respondents are given more time to answer the questionnaire.

3.8 Pilot Study

A pilot study can be defined as a small experiment designed to gather information prior to a larger study and to test logistics to develop the latter's quality and efficiency (Altman et al., 2006; Woken, 2002).

For the quantitative data, the purpose of conducting a pilot study is to ensure that the expectations of the researcher, in terms of the information that will be obtained from the questionnaire, are met (Aaker & Day, 1995, as cited in Rusli & Hasbee, 2011, p.141). In addition, piloting on the questionnaire also helps the researcher to identify the reliability of the measurement scale used in the study before doing the actual study and to measure

the validity of the data or scores. According to Foster and Cone (2006), the validity of scores is the extent to which scores on a measure are related to scores on other measures.

In this research, a pilot study was conducted after the survey questionnaire had been approved by the supervisor and the referees. The questionnaire in this study was verified in terms of the language or statements used, and in terms of their appropriateness and suitability. To these ends, the statements were formulated in polite and soft language (Ghauri et al., 1995, as cited in Rusli & Hasbee, 2011, p 137). In addition, the questionnaire had two versions: Arabic and English. It is believed that translation can iron out errors and distortions (Rusli & Hasbee, 2011, p.141).

To conduct the pilot study, the researcher administered questionnaire to 30 participants from Jenin, Tubas, Tulkarem, Nablus and Qalqilya. This means that 30 employees have been involved in determining the reliability of the study questionnaire.

The reliability and validity of the questionnaire were tested and analyzed, using the Cronbach Alpha technique and SPSS Version 21. According to Yu (1979) and Santos (1999), Cronbach Alpha is a measure of the squared correlation between observed scores and true scores. Cronbach's Alpha is also a measure of internal consistency, and it is well known that a reliability alpha coefficient of 0.70 or higher is considered acceptable in most social science research situations (Santos, 1999). The purpose was to ensure the items in the questionnaires were consistent and were measuring the variables of the study (Sekaran, 2000).

Based on the Cronbach's Alpha values, as Table 3.2 below shows, it can be said that all subsections in the questionnaire exceeded the value of 0.70. This means that these

subsections met the standard of reliability and all the statements constructed within these subsections were reliable.

Thereby, it can be said that the researcher has proved that the questionnaire was reliable, valid, and ready for administration to the population sample.

Table 3.2: Cronbach's Alpha Value

Sections	Cronbach's Alpha Coefficient Values
Define	0.701
Measure	0.821
Analyze	0.900
Improve	0.701
Control	0.852
DMAIC	0.892
Quality of Product	0.799
Quality of Service	0.802
Plant Image	0.738
Price	0.832
All Items	0.921

3.8.1. Data Collection Method and Procedures

Two types of data collection methods were used in this study: primary data and secondary data. The primary data was used by the researcher to collect data, using a questionnaire and interviews and observation. The secondary data depended basically on books and journal articles.

For the quantitative part, the researcher administered a questionnaire directly to the concrete mixing plants' participants after getting the approval from the general manager of each plant.

After its administration, questionnaire was collected over a four- week period. Then, the researcher had to recheck the number of the completed questionnaire forms.

3.8.2. Data Analysis Technique

The data analysis technique for the mixed-method approach involved several processes and techniques.

For the quantitative method, the research data were screened and analyzed through descriptive and inferential statistics, using the Statistical Package for Social Science (SPSS) version 21.

Before the quantitative data were analyzed to test their significance to the research hypotheses, the data were screened to ensure that they were entered correctly. The data screening technique is known as part of the data cleaning process in the quantitative method.

The probability of errors in data entry is common, and therefore, the data files are carefully screened. To check if data had been entered correctly, the data were screened, using the frequencies or descriptive commands within the descriptive statistics method. The data screening results indicated that there were no missing values in each variable. Thus, this implies that there were no data losses or biases

On the other hand, the demographic profile (as shown in Section A of the questionnaire) was analyzed, using descriptive statistics. Descriptive statistics were used in this study to summarize and make some general observations about the collected data (Coakes & Steed, 2007, p.51). The overall demographic profile of the participants was explained in the form of percentages and frequencies.

To test the research hypotheses, the researcher used inferential statistics. The researcher also used the Pearson Correlation test to find out whether there was a significant relationship between two variables (Coakes & Steed, 2007, p.58). In identifying whether the research hypotheses tested, using this technique, were significant or not, the researcher

was primarily concerned with the significance level represented in the “correlation” column output. If the significant “Sig.” value was equal to $p = 0.00$, or less than 0.05 ($p < 0.05$), then the researcher could conclude that the alternative research hypotheses were accepted or failed to be rejected.

Therefore, to identify the strength of the relationship between the variables, the Pearson Correlation coefficient was used. When using Pearson Correlation in analyzing the data, the strength of the relationship was identified by looking at the value of “r” as shown in the Pearson Correlation table. Normally, the sign of the correlation coefficient indicates the strength of the relationship or the degree of association between two variables. However, if there is no relationship, the correlation coefficient will show a value of zero. Table 3.3, adapted from Muchinsky (1993), shows the strength of the relationship between independent and dependent variables.

Table 3.3: Pearson Correlation Value

Value of “r”	Strength of relationship between variables
0.00-0.20	Very low or no relationship
0.21-0.40	Low relationship
0.41-0.60	Moderate relationship
0.61-0.80	High relationship
0.81-1.00	Very high relationship

* (Source: Muchinsky, 1993)

On the other hand, Table 3.4 presents a summary of data technique analysis used to analyze each of the research objectives of the study.

Table 3.4: Summary of Data Analysis Technique

Research Hypothesis	Data Technique Analysis
1. Demographic Variable	Descriptive Statistics (Frequency and Percentage)
2. There is a significant relationship between using the Six Sigma methodology by DMAIC tool and product quality.	Pearson Correlation
3. There is a significant relationship between using the Six Sigma methodology by DMAIC tool and service quality.	Pearson Correlation
4. There is a significant relationship between using the Six Sigma methodology by DMAIC tool and concrete mixing plant image.	Pearson Correlation
5. There is a significant relationship between using the Six Sigma methodology by DMAIC tool and price.	Pearson Correlation

Chapter Four

Data Analysis and Discussion

4.1 Overview

4.2. Demographic Characteristics of Participants

4.3. Non-parametric Test

4.4. Validity of the Study Questionnaire

4.5. Reliability Analysis

4.6. Analysis of Research Questions

4.6. Testing of Research Hypotheses

Chapter Four: Data Analysis and Discussion

4.1 Overview

This chapter is devoted to data analysis, hypotheses testing and discussion of the study findings. Data has been analyzed, using SPSS V.21 as well as descriptive and inferential statistical tools.

This chapter concludes with a quantitative analysis of questionnaires and testing of the research questions and research hypotheses.

4.2. Demographic Characteristics of Participants

The questionnaire of the study was administered to 200 employees working in concrete mixing plants in the northern West Bank governorates

The researcher was able to collect 230 copies of questionnaires, However, of these 30 were not fully answered/ completed,

Table 4.1: Valid and missing Demographic data

Items	Valid	Missing
Gender	200	0
Age	200	0
Educational Level	200	0
Work Experience	200	0
Governorates	200	0
Have ISO	200	0

*All the demographic variables were valid with no missing values.

Table 4.2 is a summary of the demographic characteristics of the participants. It contains six variables. The first variable is gender. Around 89% of participants were males while 11% were females. The second variable is age. Around 90% of the participants were less than 40 years old. This table also shows that 43% of the participants had a diploma

while 25% had a bachelor's degree. Pertaining to experience, most of the participants (90%) had less than 10 years of experience. When we examined the variable of governorates, we found 34% of participants worked in Nablus concrete mixing plants as opposed to 31% who worked in Jenin concrete mixing plants. However, 75% of the concrete mixing plants didn't have ISO as opposed to 25% which had it.

Table 4.2: Demographic Characteristics of Participants

Demographic Data	Frequency	Percent
Gender		
Male	178	89%
Female	22	11%
Total	200	100%
Age		
20- 30 yrs old	82	41.0%
31 –40 yrs old	98	49.0%
More than 40 yrs old	20	10.0%
Total	200	100.0%
Educational Level		
Less than high school	63	31.5%
Diploma	86	43.0%
Bachelor's degree	49	24.5%
Master's degree or higher	2	1.00%
Total	200	100.0%
Work Experience		
Less than 5 yrs	97	48.5%
6-10 yrs	83	41.5%
11-15 yrs	20	10.0%
More than 15 yrs	0	0.0%
Total	200	100.0%
Governorates		
Jenin	61	30.5%
Nablus	68	34.0%
Tulkarem	46	23.0%
Qalqilya	25	12.5%
Tubas	0	0.0%
Total	200	100.0%
Have ISO?		
Have ISO	50	25.0%
Don't have ISO	150	75.0%
Total	200	100.0%

*Demographic Characteristics of Participants

4.3. Non-parametric Test

Non-parametric methods are commonly used for studying populations that take on a ranked order. The use of non-parametric methods may be essential when data on ordinal scale or data has a ranking but without a clear numeric clarification. Non-parametric methods make fewer assumptions; their applicability is much wider than the corresponding parametric methods. They may be practical in situations where little is known about the application in question. Also, due to the dependence on fewer assumptions, non-parametric methods are more successful. Another reason for the use of non-parametric methods is simplicity.

4.3.1. Sign Test

This test was used to determine if the meaning of a statement was significantly different from a hypothesized value 3 (Middle value of Likert scale). If the P-value (Sig.) were smaller than or equal to the level of significance, $\alpha = 0.05$, then the meaning of the statement would be significantly different from a hypothesized value 3. The sign of the Test value indicates whether the meaning is significantly greater or smaller than a hypothesized value 3. However, if the P-value (Sig.) were greater than the level of significance, $\alpha = 0.05$, then the meaning of the statement would be significantly different from a hypothesized value 3. However, in this study, the level of significance was less than 0.05. This means all statements were significantly different from a hypothesized value 3.

4.3.2. Mann-Whitney Test

This test was used to examine if there was a statistically significant difference between two means, among the participants, pertaining to the **performance** of concrete mixing

plants by measure (product quality, service quality, plant quality and price) which could be attributed to gender and possession of ISO certificate variables

4.3.3. Kruskal-Wallis Test

This test was used to find out if there was a statistically significant difference between several means, among the participants, pertaining to the **performance** of concrete mixing plants by measure (product quality, service quality, plant image and price) which could be attributed to age, educational level, work experience, and governorate variables.

Table 4.3: Phase according to Demographic data

Define	<i>M</i>	<i>S. D</i>
Gender		
Male	3.83	0.37
Female	3.93	0.39
Age		
20- 30 yrs old	3.81	0.34
31 –40 yrs old	3.84	0.39
More than 40 yrs old	3.94	0.36
Educational Level		
Less than high school	3.82	0.41
Diploma	3.80	0.32
Bachelor's degree	3.92	0.38
Master's degree or higher	4.36	0.13
Work Experience		
Less than 5 yrs	3.82	0.32
6-10 yrs	3.81	0.40
11-15 yrs	4.05	0.37
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.80	0.32
Nablus	3.92	0.41
Tulkarem	3.83	0.38
Qalqilya	3.74	0.30
Tubas	0.00	0.00
Total		
Have ISO?		
Have ISO	4.22	0.26
Don't have ISO	3.71	0.31
Total		

Table 4.3 shows the use of defined phase in DMAIC tool to determine the constraints and defects based on the variables of gender, age, educational level, work experience, governorate and possession of ISO certificate. The ‘mean value’ column was used to determine which category really had a high level of use of defined constraints.

The researcher noticed that the old employees had a high mean ($M=3.94$) which indicates they had a higher use of defined constraints and defects in their plants.

Pertaining to the educational level, the researcher found that the employees, holding a master’s degree, had a high level of defining constraints and defects in their plants. She also found that the employees who had 11-15 years of experience had a high level of defining the constraint in the plant. Nablus governorate concrete mixing plants used to define constraints the most, while the plants which had an ISO certificate used the define constraints the most.

Table 4.4: Measure according to Demographic data

Measure	M	S. D
Gender		
Male	3.32	0.64
Female	3.63	0.66
Age		
20- 30 yrs old	3.34	0.63
31 –40 yrs old	3.37	0.67
More than 40 yrs old	3.36	0.59
Educational Level		
Less than high school	3.24	0.64
Diploma	3.30	0.63
Bachelor’s degree	3.59	0.64
Master’s degree or higher	4.00	0.00
Work Experience		
Less than 5 yrs	3.36	0.63
6-10 yrs	3.28	0.67
11-15 yrs	3.66	0.51
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.42	0.66

Nablus	3.41	0.63
Tulkarem	3.26	0.63
Qalqilya	3.23	0.67
Tubas	0.00	0.00
Have an ISO?		
Have ISO	3.88	0.26
Don't have ISO	3.18	0.64

Table 4.4 shows the use of measuring phase in DMAIC tool to determine the problems based on the variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The ‘mean value’ column was used to determine the category which had a high level of measure phase use.

The researcher noticed all employees, regardless of their ages, had the same level of measure phase which included identification of the side effects of failure and the mechanisms of dealing with the causes of failure, listing and categorization of the problems, recording of all possible causes of concrete mixing problems as well as their classification. This is in addition to discussion of each element to integrate and clarify its causes. Concerning the educational level, the researcher found that the employees, holding a master’s degree, had a high level of using the measure phase in their plant. She also found that the employees who had 11-15 years of experience had a high level of measuring the problems in their plants. Nablus and Jenin governorates used the measuring of the problems the most in their concrete plants. In contrast, the concrete mixing plants which had ISO certificates used the measure of problems the most in their work.

Table 4.5: Analyze according to Demographic data

Analyze	M	S. D
Gender		
Male	3.30	0.50
Female	3.46	0.45
Age		
20- 30 yrs old	3.27	0.51
31–40 yrs old	3.35	0.51
More than 40 yrs old	3.36	0.37
Educational Level		
Less than high school	3.31	0.57
Diploma	3.22	0.41
Bachelor's degree	3.48	0.50
Master's degree or higher	3.97	0.29
Work Experience		
Less than 5 yrs	3.30	0.51
6-10 yrs	3.28	0.49
11-15 yrs	3.56	0.42
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.31	0.50
Nablus	3.43	0.52
Tulkarem	3.26	0.50
Qalqilya	3.16	0.36
Tubas	0.00	0.00
Total	0.00	0.00
Have ISO?		
Have ISO	3.94	0.27
Don't have ISO	3.11	0.37

Table 4.5 shows the use of analysis by statistical methods and procedures in DMAIC tool based on variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The 'mean value' column was used to determine the category which had a high level of use of analysis by statistical methods and procedures.

The researcher found that the employees, over 31 years old, had a high level of using analysis phase which included analysis of possible failures in the production process and process problems, using statistical tools, determination of the quality or poor performance of the process, analysis of the capability and stability during period. Pertaining to the

educational level, the researcher found that the employees, holding a master's degree, had a high level of using the analysis phase in their plants by using statistical methods and procedures in their work. She also found that the employees, who had 11-15 years of experience, had a high level of analysis by statistical methods and procedures in their plants. Nablus-based concrete mixing plants used analysis the most in their operations. It was also found that the concrete mixing plants which had an ISO certificate used the most analysis in their work. To that end, they regularly used statistical methods and procedures.

Table 4.6: Improve according to Demographic data

Improve	M	S. D
Gender		
Male	3.65	0.38
Female	3.77	0.35
Age		
20- 30 yrs old	3.63	0.39
31 –40 yrs old	3.67	0.39
More than 40 yrs old	3.70	0.29
Educational Level		
Less than high school	3.64	0.43
Diploma	3.59	0.32
Bachelor's degree	3.80	0.38
Master's degree or higher	4.10	0.51
Work Experience		
Less than 5 yrs	3.64	0.38
6-10 yrs	3.65	0.39
11-15 yrs	3.84	0.32
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.67	0.38
Nablus	3.74	0.40
Tulkarem	3.62	0.39
Qalqilya	3.52	0.26
Tubas	0.00	0.00
Total	0.00	0.00
Have ISO?		
Have ISO	4.15	0.20
Don't have ISO	3.50	0.27

Table 4.6 shows the use of improvement of defects that may cause problems in DMAIC tool based on the variables of gender, age, educational level, work experience, governorate and possession of ISO certificate. The ‘mean value’ column was used to determine the category which had a high level of use improvement of defects that may cause problems.

The researcher found that the employees, over 40 years old, had a high level of improvement in the defects that may cause problems in the concrete mixing plants. Regarding the educational level, the researcher found that the employees, holding a master’s degree, had a high level of using improvement phase in their plants. She also found that the employees, who have 11-15 years of experience, had a high level of improvement that may cause problems in their plants. Nablus-based plants used improvement of the defects the most when it came to the cause of problems. It was also found that the plants which had ISO certificates used improvement of the defects the most when it came to the likely cause of the problems.

Table 4.7: Control according to Demographic data

Control	M	S. D
Gender		
Male	3.60	0.40
Female	3.78	0.41
Age		
20- 30 yrs old	3.56	0.39
31 –40 yrs old	3.66	0.42
More than 40 yrs old	3.63	0.37
Educational Level		
Less than high school	3.61	0.43
Diploma	3.51	0.31
Bachelor’s degree	3.80	0.44
Master’s degree or higher	4.12	0.18
Work Experience		
Less than 5 yrs	3.58	0.40
6-10 yrs	3.60	0.39
11-15yrs	3.85	0.41

More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.61	0.41
Nablus	3.72	0.43
Tulkarem	3.57	0.40
Qalqilya	3.43	0.18
Tubas	0.00	0.00
Total		
Have ISO?		
Have ISO	4.25	0.18
Don't have ISO	3.41	0.17

Table 4.7 shows the use of control of the process to guarantee the problems would not occur again in DMAIC tool based on the variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The ‘mean value’s column was used to determine the category which had a high level of control of the process.

The researcher found that the employees, more than 31 years old, had a high level of using the control phase. This phase included using statistical control methods to monitor concrete mixing and determine the capacity of the production process, and whether the operations were running as expected and whether the processes were changed to take corrective action and monitor the continuous improvement procedures for concrete mixing. The researcher also examined whether the collected data were used to take advantage of weaknesses, draw control charts to determine specific causes if they existed. Pertaining to the educational level, the researcher found that the employees, holding a master’s degree, had a high level of using the control phase in their plants. She also found that the employees, who had 11-15 years of experience, had a high level of control of the process to guarantee the problems would not occur again. Nablus governorate concrete mixing plants used the most control of the process in their work. The researcher also found that the concrete mixing plants, which had an ISO certificate, used control of the process the most to make sure the problems would not occur again.

Table 4.8: DMAIC according to Demographic data

DMAIC	M	S. D
Gender		
Male	3.54	0.41
Female	3.71	0.39
Age		
20 - 30 yrs old	3.52	0.41
31 –40 yrs old	3.58	0.43
More than 40 yrs old	3.60	0.36
Educational Level		
Less than high school	3.52	0.46
Diploma	3.48	0.35
Bachelor's degree	3.72	0.41
Master's degree or higher	4.12	0.15
Work Experience		
Less than 5 yrs	3.54	0.41
6-10 yrs	3.52	0.43
11-15 yrs	3.80	0.35
More than 15 yrs	0.00	0.00
Districts		
Jenin	3.56	0.41
Nablus	3.64	0.44
Tulkarem	3.51	0.42
Qalqilya	3.41	0.33
Tubas	0.00	0.00
Total		
Have ISO?		
Have ISO	4.10	0.07
Don't have ISO	3.38	0.32

Table 4.8 shows the use of DMAIC tool based on the variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The 'mean value' column was used to determine the category which had a high level of using the DMAIC tool.

The researcher found that the employees, more than 31 yrs. old, had a high level of using phases, like DMAIC tool phases, in their work. These included definition of constraint, measurement of performance, analysis of statistical methods and procedures, improvement of the defects that may cause the problem and control of the processes to

make sure that the problem would not occur again. Concerning the educational level, the researcher found that the employees, holding a master's degree, had a high level of using phases, as phases in DMAIC tools, in their plants. She also found that the employees, who had 11-15 years of experience, had a high level of using phases as phases in DMAIC tool. Nablus governorate concrete mixing plants used the phases, as phases in the DMAIC tool, the most in their work. In addition, she found that the concrete mixing plants which had an ISO certificate used the phases, as phases in DMAIC tool, the most in their work.

Table 4.9: Product quality according to Demographic data

Product Quality	M	S. D
Gender		
Male	3.62	0.39
Female	3.80	0.44
Age		
20- 30 yrs old	3.58	0.36
31 –40 yrs old	3.68	0.43
More than 40 yrs	3.70	0.44
Educational Level		
Less than high school	3.62	0.40
Diploma	3.54	0.33
Bachelor's degree	3.81	0.45
Master's degree or higher	4.33	0.00
Work Experience		
Less than 5 yrs	3.59	0.40
6-10 yrs	3.64	0.33
11-15 yrs	3.88	0.45
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.59	0.35
Nablus	3.76	0.46
Tulkarem	3.63	0.42
Qalqilya	3.45	0.17
Tubas	0.00	0.00
Total	0.00	0.00
Have ISO?		
Have ISO	4.27	0.18
Don't have ISO	3.43	0.17

Table 4.9 shows the quality of product based on the variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The ‘mean value’ column was used to determine the category which really had a high level of quality of product.

The researcher found that the employees, more than 40 years old, had a high level of taking care of the quality of product in their plants. Concerning the educational level, the researcher found that the employees, holding a master’s degree, had a high level of concern about the quality of products in their plants. She also found that the employees, who had 11-15 years of work experience, had a high level of concern about the quality of product. Nablus governorate concrete mixing plants showed concern the most about the quality of product. Moreover, the researcher found that concrete plants, which had an ISO certificate, cared the most about the quality of product by providing the products to its customers, according to the standards of the engineering offices, to make sure the products enjoy high reliability by customers. To that end, teams were tasked with follow up of the production process to ensure product quality and handle customers' complaints to meet their expectations and achieve their satisfaction.

Table 4.10: Service of quality according to Demographic data

Service of Quality	M	S. D
Gender		
Male	3.56	0.46
Female	3.81	0.47
Age		
20- 30 yrs old	3.53	0.43
31 –40 yrs old	3.62	0.48
More than 40 yrs old	3.65	0.55
Educational Level		
Less than high school	3.57	0.47
Diploma	3.49	0.43
Bachelor’s degree	3.75	0.47
Master’s degree or higher	4.33	0.24

Work Experience		
Less than 5 yrs	3.54	0.42
6-10 yrs	3.55	0.47
11-15 yrs	4.00	0.49
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.55	0.40
Nablus	3.71	0.52
Tulkarem	3.53	0.47
Qalqilya	3.43	0.37
Tubas	0.00	0.00
Total		
Have ISO	4.16	0.29
Don't have ISO	3.40	0.34

Table 4.10 shows the quality of services based on the variables of gender, age, educational level, work experience, governorate and possession of an ISO certificate. The ‘mean value’ column was used to determine the category which had a high level of quality services.

The researcher noticed that the employees, more than 31 years old, had a high level of taking care of the quality of services provided by their plants. Pertaining to the educational level, the researcher found that the employees, holding a master’s degree, had a high level of concern about the quality of services provided by their plants. She also found that the employees who had 11-15 years of experience had a high level of concern about the quality of services. Furthermore, the researcher found that Nablus governorate concrete mixing plants showed the utmost concern about the quality of services. She also found that concrete plants which had an ISO certificate, cared the most about the quality of services. They always prepared the customers’ requests in a manner that facilitated their receipt on time, trained the employees in the skills of dealing with the customer and providing services that comply with the standards of engineering offices.

Table 4.11: Concrete Plant image according to Demographic data

Plant Image	M	S. D
Gender		
Male	3.69	0.34
Female	3.80	0.33
Age		
20- 30 yrs old	3.67	0.34
31 –40 yrs old	3.72	0.35
More than 40 yrs old	3.70	0.33
Educational Level		
Less than high school	3.72	0.37
Diploma	3.61	0.30
Bachelor's degree	3.78	0.33
Master's degree or higher	4.50	0.00
Work Experience		
Less than 5 yrs	3.68	0.34
6-10 yrs	3.69	0.33
11yrs-15 yrs	3.85	0.38
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.65	0.27
Nablus	3.80	0.42
Tulkarem	3.68	0.34
Qalqilya	3.57	0.22
Tubas	0.00	0.00
Total	0.00	0.00
Have ISO?		
Have ISO	4.14	0.25
Don't have ISO	3.55	0.22

Table 4.11 shows the concrete plant image based on the variables of governorate and possession of an ISO certificate. The 'mean value' column was used to determine the category which had a high level of concern about the plant image. The researcher found that Nablus governorate concrete mixing plants had highest concern about their image. She also found that the plants, which had an ISO certificate, cared the most about their image. Advertising messages were formulated by a specialized committee that considered the psychological dimension of the customer and chose the appropriate advertising media to encourage the customer to buy their products

Table 4.12: Price according to Demographic data

Price	<i>M</i>	<i>S. D</i>
Gender		
Male	3.70	0.37
Female	3.91	0.38
Age		
20- 30 yrs old	3.70	0.36
31 –40 yrs old	3.74	0.38
More than 40 yrs old	3.80	0.41
Educational Level		
Less than high school	3.67	0.36
Diploma	3.69	0.36
Bachelor's degree	3.88	0.38
Master's degree or higher	3.90	0.14
Work Experience		
Less than 5 yrs	3.71	0.35
6-10 yrs	3.70	0.38
11-15 yrs	3.95	0.35
More than 15 yrs	0.00	0.00
Governorates		
Jenin	3.74	0.38
Nablus	3.77	0.37
Tulkarem	3.68	0.38
Qalqilya	3.66	0.37
Tubas	0.00	0.00
Total		
Have ISO?		
Have ISO	4.10	0.23
Don't have ISO	3.62	0.35

Table 4.12 shows the price based on variables of governorate and possession of an ISO certificate. The 'mean value' column was used to determine the category which had a suitable/reasonable price.

The researcher found that Nablus governorate concrete mixing plants had the highest concern about the prices. She also found that the plants which had an ISO certificate cared the most about the price by offering good discounts to loyal customers, keeping a stable price policy, and offering good products to the customer compared to what they pay for.

4.4. Validity of the Study Questionnaire

Statistical validity of the questionnaire indicates the degree to which an instrument measures what it is assumed to be measuring (Poilt, 1985). Validity has several different aspects and assessment approaches.

To check the validity of the questionnaire, two statistical tests were used.

The first test was the Criterion-related Validity Test. This test measured the correlation coefficient between each statement in one field and the whole field. The second test was the Structure Validity Test (**Pearson** test). This was used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. It measured the correlation coefficient between one field and all the fields of the questionnaire that had the same level.

4.4.1. Criterion- Related Validity

Internal consistency of the questionnaire was measured by a scouting sample, which consisted of 30 copies of the questionnaires. It measured the correlation coefficients between each statement in one domain and the whole domain. The tables in **Appendix C** illustrate the correlation coefficient for each statement in each domain and the total domains. The p-values (Sig.) were found to be less than 0.05, so the correlation coefficients of this domain were significant at $\alpha = 0.05$. Therefore, the statement or item of each domain was consistent and valid to measure what it was set for.

4.4.2. Structure Validity of the Study Questionnaire

Structure validity was the second statistical test used to test the validity of the questionnaire's improved structure. The validity of each domain and the validity of the whole questionnaire were tested. It measured the correlation coefficient between one domain and all the domains of the questionnaire that had the same level of Likert scale.

Table 4.3 shows the correlation coefficient for each domain and the whole questionnaire. The p-values (Sig.) were found to be less than 0.05. Therefore, the correlation coefficients of all the domains were significant at $\alpha = 0.05$. Accordingly, the domains were valid to measure what they were set to measure.

Table 4.13: Correlation coefficient of each domain and the whole questionnaire

Item	Correlation Coefficient (Pearson)	P-Value
DMAIC	0.906**	.000
Quality of Product	0.855**	.000
Quality of Service	0.765**	.000
Plant Image	0.619**	.000
Price	0.858**	.000

4.5. Reliability Analysis

Reliability aims at examining the quality of measurement. It is the "consistency" or "repeatability" of the analysis. The primary goal is the accuracy of the measures of the dependent variable. In a correlation study, both the dependent and independent variables should be examined. Reducing sources of measurement error is the key to enhancing the reliability of data.

The reliability of an instrument is the degree of consistency that measures the attribute it was supposed to measure (Poilt, 1985). The less variation an instrument generates in repeated measurements of an attribute, the higher its reliability.

Reliability can be equated with the consistency, stability, or dependability of a measuring tool. The test is administered twice to the same sample of people on two occasions and then the scores obtained are compared by computing a reliability coefficient (Poilt, 1985).

This method was used to measure the reliability of the questionnaire between each domain and the meaning of the whole domains of the questionnaire. The normal range of Cronbach's coefficient alpha value is between 0.0 and + 1.0 (Richard and Anita, 2008).

The higher values reflect a higher degree of internal consistency. The Cronbach's coefficient alpha was calculated for each domain of the questionnaire.

Table 4.14 shows the values of Cronbach's Alpha for each domain of the questionnaire and the entire questionnaire. For the domains, values of Cronbach's Alpha were in the range of 0.738 and 0.954. This range is considered high; the result ensured the reliability of each domain of the questionnaire. Cronbach's Alpha equaled 0.954 for the entire questionnaire. This indicates excellent reliability in the entire questionnaire.

Table 4.14: Cronbach's Alpha Value

Sections	Cronbach's Alpha Coefficient Values
Define	0.796
Measure	0.912
Analyze	0.929
Improve	0.763
Control	0.872
DMAIC	0.928
Quality of Product	0.802
Quality of Service	0.855
Mental image	0.738
Price	0.816
All items	0.954

4.6. Analysis of Research Questions

The research questions have been set to study the relationship between the use of each of **DMAIC** tool stages (Define, Measure, Analysis, Improve and Control) separately against factory performance, applying the Six Sigma approach on the manufacturing of concrete mixtures, to improve the efficiency of the **performance** of concrete mixing industry in the northern West Bank governorates

The descriptive statistics, i.e. Means(M), Standard Deviations (SD) and finally Degree of Agreement (DOA) were established and presented in the research questions.

As the table below shows, the researcher has used the range of Likert scale to describe the agreement on each item in the questionnaire.

Table 4.15: Scoring Range of Likert Scale

Range	Description of Range
1.00-1.80	Strongly Disagree
1.81-2.60	Disagree
2.61-3.40	Neither/Nor Agree
3.41-4.20	Agree
4.21-5.00	Strongly Agree

Q1: Is there any statistically significant relationship between using Define defects stage, using DMAIC tool, and concrete mixing plant performance?

To answer this question, the researcher developed 11 statements to determine and define the defects and problems in the plants to improve their **performance** in the northern West Bank governorates.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.16**.

The researcher found that the overall meaning of the defined defects stage was ($M=3.84$, $S.D=0.62$).

This means that the employees, working in concrete mixing plants, agreed **that the management always defined and determined the defects and problems** to search for possible solutions to the problems and fix the defects.

It was also found that most of participants strongly agreed that the plant management determined the time required to complete the concrete mixing operation. Furthermore, they agreed that the management always determined the necessary material for concrete

mixing, identified the reasons behind profit decline, and increase of cost and customer dissatisfaction.

Table 4.16: Descriptive statistics of applying six sigma approach by using Define stage

NO	Statements	M	SD	DOA
1	Plant management determines the materials that are necessary for concrete mixing	4.09	0.28	Agree
2	Plant management determines the reasons for customer dissatisfaction	3.29	0.85	Neutral
3	Plant management determines the reasons for the decline in profit	3.80	0.51	Agree
4	Plant management determines the reasons for the increase in costs	4.14	0.35	Agree
5	Plant management determines the reasons for increase of the cycle time for concrete mixing	3.88	0.50	Agree
6	Plant management determines the time required to complete the concrete mixing	4.23	0.62	Strongly Agree
7	Plant management determines the money necessary to complete the concrete t mixing	4.15	0.65	Agree
8	Plant management determines the appropriate human resources to complete the concrete mixing	4.11	0.85	Agree
9	Plant management identifies ways of reducing costs	3.55	0.78	Agree
10	Plant management identifies the mechanisms to increase profits	3.48	0.67	Agree
11	Plant management identifies the mechanisms to increase customer satisfaction	3.55	0.72	Agree
Overall Average		3.84	0.62	Agree

Q2: Is there any statistically significant relationship between using Measure stage, using DMAIC tool, and plant performance?

To answer this question, the researcher developed 9 statements to identify and measure plant defects and problems to improve its **performance** in –the northern West Bank governorates

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.17**.

The researcher found that the overall meaning of the measure phase was ($M=3.36$, $S.D=0.81$).

This means that the employees working in concrete mixing plants neither **agreed nor disagreed with whether the management measured the defects and problems** and searched for possible solutions to the problems and fixed the defects.

The researcher also found that most of participants agreed that the plant management always identified the causes of failure in concrete mixing, the side effects of the causes of failure, the mechanisms for dealing with the causes of failure. They also agreed that the management would make a list of problems that did not meet customer requirements and identify the main categories of problem causes. However, the participant **neither agreed nor disagreed** with whether the management conducted interviews with technicians and engineers to hear their opinion.

Table 4.17: Descriptive statistics of applying six sigma approach by using Measure stage

NO	Statement	M	SD	DOA
1	Plant management conducts interviews with technicians and listens to their opinions.	3.06	0.81	Neutral
2	Plant management conducts interviews with engineers and listens to their opinions.	3.13	0.88	Neutral
3	Plant management identifies the causes of failure in concrete mixing.	3.67	0.55	Agree
4	Plant management identifies the side effects of the causes of failure in concrete mixing.	3.42	0.49	Agree
5	Plant management identifies the mechanisms for dealing with the causes of failure in concrete mixing. g	3.76	0.93	Agree
6	Plant management makes a list of problems that do not meet customer requirements as specified in the contract and specifications.	3.65	0.78	Agree
7	Plant management identifies the main categories of problem causes: manpower, machinery, materials, methods, measurements, health, safety and environment.	3.78	0.91	Agree
8	Plant management conducts systematic fact-finding through group discussion and brainstorming sessions to identify the reasons that may lead to non-fulfillment of customer requirements as a possible reason.	2.99	1.00	Neutral
9	Plant management records all possible causes of concrete mixing problems, classifies them and	2.76	0.93	Neutral

discusses each element to integrate and clarify the causes.			
Overall average	3.36	0.81	Neutral

Q3: Is there any significant relationship between using analysis stage, using DMAIC tool, and plant performance?

To answer this question, the researcher developed 17 statements to analyze plant defects and problems, using statistical methods and procedures to improve their performance.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.18**.

The researcher found that the overall meaning of the analysis stage was ($M=3.32$, $S.D=0.71$).

This means that the employees working in concrete mixing plants neither **agreed nor disagreed with whether the management analyzed defects and problems using statistical methods and procedures** and searched for possible solutions to the problems and fixed the defects.

Furthermore, the researcher also found that most of participants disagreed that the plant management analyzed process problems, using statistical tools; they also disagreed that the management failed to collect data to determine the relationships between the variable factors in the process and the direction of improvements. However, the participants **agreed** that the plant management always identified the causes of failures in concrete mixing and took the necessary measures to avoid failure within the production conditions. They also agreed that it always predicted the chances of failure and its effects on the design of concrete mixing, evaluated the severity of failures and identified the degree of risk for each possible scenario to deal with it.

Table 4.18: Descriptive statistics of applying six sigma approach by using analysis stage

NO	Statement	M	SD	DOA
1	Plant management analyzes possible failures in the production process.	3.31	1.00	Neutral
2	Plant management analyzes the potential effects on the production process.	3.37	0.83	Neutral
3	Plant management identifies the causes of failures in concrete mixing.	3.66	0.81	Agree
4	Plant management takes necessary measures to avoid failure within the production conditions.	3.60	0.81	Agree
5	Plant management identifies the chances of failure and its effects on the design of concrete mixing.	3.36	0.67	Agree
6	Plant management sets priorities for potential risks by developing measures aimed at reducing them.	3.28	0.53	Neutral
7	Plant management periodically reviews and identifies failure modes	3.04	0.77	Neutral
8	Plant management continuously evaluates severity of failures.	3.50	0.59	Agree
9	Plant management determines the degree of risk for each possible scenario to deal with it.	3.74	0.44	Agree
10	Plant management conducts brainstorming circles to calculate the degree of danger in concrete mixing in terms of number and arrangement according to priorities.	2.82	0.66	Neutral
11	Plant management implements and evaluates corrective actions.	3.23	0.62	Neutral
12	Plant management analyzes process problems, using statistical tools.	2.57	0.73	Disagree
13	Plant management collects data to determine the relationships between the variable factors in the process and to determine the direction of improvements.	2.59	0.75	Disagree
14	Plant management determines the quality or poor performance of the current process.	3.22	0.99	Neutral
15	Plant management identifies potential root causes of variation in the quality of concrete mixing.	3.65	0.67	Agree
16	Analyzed data helps plant management to reveal the course and behavior of the process.	3.90	0.48	Agree
17	Analyzed data shows how capable and stable the process is over a long period of time.	3.59	0.68	Agree
	Overall average	3.32	0.71	Neutral

Q4: Is there any statistically significant relationship between using Improve stage, using DMAIC tool, and plant performance?

To answer this question, the researcher developed 7 statements to identify and improve the procedure that may cause the problems to improve the **performance** of concrete mixing plants in –the northern West Bank governorates

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.19**.

The researcher found that the overall meaning of the Improve stage was ($M=3.66$, $S.D=0.59$).

This means that the employees working in concrete mixing plants **agreed that the management always improved the procedures that may cause problems**, so they could solve the problems and fix the defects. The researcher also found that most of participants said that plant management always worked to improve the procedure that may cause the problems by determining the steps to solve the problem in partial cement mixing, deciding on the alternative solution to concrete mixing, based on cost and profitability, implementing the alternative solution for continuous improvement in concrete mixing. They also said that the management resorted to calculating the return on investment to assess the efficiency of the investment and reviewed the failure modes to improve the process periodically.

Table 4.19: Descriptive statistics of applying six sigma approach by using improve stage

NO	Statement	M	SD	DOA
1	Plant management determines the steps to solve problems in concrete partial mixing.	3.77	0.51	Agree
2	Plant management determines the steps to solve problems in concrete complete mixing.	3.27	0.64	Neutral
3	Plant management decides on an alternative solution to concrete mixing based on cost and profitability.	3.73	0.55	Agree

4	Plant management implements alternative solutions for continuous improvement in concrete mixing.	3.61	0.61	Agree
5	Plant management resorts to calculation of the return on investment to assess the efficiency of the investment.	3.79	0.65	Agree
6	Plant management resorts to calculation of the return on investment to compare the efficiency of several different investments.	3.72	0.56	Agree
7	Plant management periodically reviews the failure modes to improve the process.	3.76	0.63	Agree
Overall average		3.66	0.59	Agree

Q5: Is there any statistically significant relationship between using Control stage, using DMAIC tool, and plant performance?

To answer this question, the researcher developed 12 statements on control stage of the plant operations that guarantee non-occurrence of the problems again to improve the **performance** of concrete mixing plants in the northern West Bank governorates.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.20**.

The researcher found that the overall meaning of the control process phase was ($M=3.62$, $S. D=0.59$). This means that the employees working in concrete mixing plants agreed **that the management had control of the operations that** allowed fixing the defects and preventing them from happening again. She also found that most of participants believed that plant management determined the capacity of the production process, and whether operations were running as expected. They also reported that management determined whether processes had to be changed to take corrective action, determined the date of the action to be taken regarding the removal process, monitored the continuous improvement procedures for concrete mixing, and collected samples for laboratory tests on an ongoing basis.

Table 4.20: Descriptive statistics of applying six sigma approach by using control stage

NO	Statement	M	SD	DOA
1	Plant management resorts to using statistical control methods to monitor concrete mixing.	3.00	0.87	Neutral
2	Plant management determines the capacity of the production process.	3.59	0.89	Agree
3	Plant management determines whether operations are running as expected.	4.11	0.31	Agree
4	Plant management determines whether processes must be changed to take corrective action.	4.12	0.33	Agree
5	Plant management determines the date of the action to be taken regarding the removal process.	4.10	0.43	Agree
6	Plant management determines the date of the action to be taken regarding the improvement process.	4.00	0.55	Agree
7	Plant management monitors the continuous improvement procedures for concrete mixing.	3.41	0.49	Agree
8	Plant management resorts to extracting arithmetic averages and standard deviations to show and compare the variation experienced by concrete mixing during specific time periods.	2.87	0.64	Neutral
9	Plant management takes advantage by using the collected data	3.28	0.91	Neutral
10	Plant management resorts to visual inspection of the delivered raw materials.	4.19	0.39	Agree
11	Plant management collects samples for laboratory tests on an ongoing basis.	3.73	0.55	Agree
12	Plant management resorts to drawing control charts to determine specific causes (if they existed)	3.04	0.74	Neutral
	Overall average	3.62	0.59	Agree

Q6: Is there any statistically significant relationship between quality of product and plant performance?

To answer this question, the researcher developed 6 statements on determination of the effect of product quality on plant performance in the northern West Bank governorates.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.21**.

The researcher found that the overall mean of the product quality was ($M=3.64$, $S.D=0.54$).

This means that the employees working in concrete mixing plants agreed **that the product quality had an important effect on plant performance.**

The researcher found that most of participants agreed that the plant management always paid attention to the product quality to improve performance by providing and delivering the products to customers on time, in the right quantity and according to the standards of the engineering offices. They also reported that customers' complaints were taken seriously by management to meet their expectations and achieve their satisfaction. However, most participants reported that that there were no special teams to follow up the production process to ensure product quality.

Table 4.21: Descriptive statistics of product quality

NO	Statement	M	SD	DOA
1	Plant management provides products to customers on time.	4.11	0.31	Agree
2	Plant management provides products to customers in the right quantity.	4.09	0.29	Agree
3	Plant management provides products to customers according to the standards of the engineering offices.	3.78	0.65	Agree
4	Planting products enjoy high reliability by customers.	3.75	0.61	Agree
5	Plant management takes care of customers' complaints to meet their expectations.	3.68	0.58	Agree
6	There is a team tasked with the follow-up of the production process to ensure product quality.	2.45	0.80	Disagree
	Overall average	3.64	0.54	Agree

Q7: Is there any statistically significant relationship between service quality and plant performance?

To answer this question, the researcher developed 6 statements on the effect of service quality on **performance** of concrete mixing plants –in the northern West Bank governorates

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.22**. The researcher found that the overall meaning of the service quality was ($M=3.59$, $S. D=0.58$).

This means that the employees working in concrete mixing plants agreed **that the service quality had an important effect on plant performance.**

The researcher found that most of participants agreed that the management paid attention to the quality of service to improve performance by implementing procedures quickly and easily, for concluding financial transactions for customers, preparing their requests in a manner that facilitates their receipt on time. This was in addition to providing distinguished services that complied with the standards of engineering offices and using calibrated equipment in production. However, most participants said that plant management did not train its employees in how to deal with the customers and failed to take employees' suggestions to provide high quality services to them.

Table 4.22: Descriptive statistics of service quality

NO	Statement	M	SD	DOA
1	Plant management implements procedures quickly and easily to conclude financial transactions for customers.	3.88	0.57	Agree
2	Plant management prepares the customers' requests in a manner that facilitates their receipt on time.	4.05	0.22	Agree
3	Plant management trains its employees in how to deal with the customer properly. .	2.88	0.90	Neutral
4	Plant management seeks to provide distinguished services that comply with the standards of engineering offices.	3.51	0.65	Agree
5	Plant management makes the suggestions of the employees to provide high quality services to its customers.	3.35	0.48	Neutral
6	Equipment used is calibrated in production.	3.85	0.65	Agree
	Overall average	3.59	0.58	Agree

Q8: Is there any significant relationship between plant image and its performance?

To answer this question, the researcher developed 5 statements on the effect of concrete mixing plant image on its performance.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.23**. The researcher found that the overall meaning of the factory image was ($M=3.49$, $S. D=0.54$).

This means that the employees working in concrete mixing plants agreed **that the plant image had an important effect on its performance.**

The researcher also found that most of participants believed that the management always paid attention to the plant image to improve **performance** by treating customers in a friendly manner

Table 4.23: Descriptive statistics of plant image

NO	Statement	M	SD	DOA
1	Plant has an acceptable image which makes customers deal with it.	4.14	0.35	Agree
2	Plant management chooses appropriate advertising media which motivates customers to deal with it.	2.66	0.65	Neutral
3	Advertising messages are formulated by a specialized committee which considers the psychological dimensions of the customers.	2.66	0.65	Neutral
4	Same customers repeat their business with the plant.	3.74	0.59	Agree
5	Plant management treats customers in a friendly way.	4.26	0.44	Strongly Agree
	Overall average	3.49	0.54	Agree

Q9: Is there any statistically significant relationship between price and plant performance?

To answer this question, the researcher developed 5 statements around the effect of price on concrete mixing plant's performance.

These statements were subjected to the views of the participants. Results of the analysis are shown in **Table 4.24**. The researcher found that the overall meaning of the price was ($M=3.73$, $S. D=0.48$).

This means that the employees working in concrete mixing plants agreed **that the price had an important effect on plant performance**.

The researcher also found that most of participants **believed** that the plant management always paid attention to the price to improve performance by offering a stable price policy and good discounts to loyal customers.

Table 4.24: Descriptive statistics of price

NO	Statement	M	SD	DOA
1	Products offered to customers are good compared to what they pay for.	4.14	0.57	Agree
2	Price policy followed by plant management is relatively stable.	4.08	0.27	Agree
3	Customers prefer our plant products regardless of price.	3.29	0.45	Agree
4	Plant management often offers good discounts to loyal customers.	3.69	0.53	Agree
5	Plant management always compares/examines the quality of its products.	3.45	0.56	Agree
	Overall average	3.73	0.48	Agree

4.6. Testing of Research Hypotheses

To test the research hypotheses, the researcher used inferential statistics. The researcher also used the Pearson Correlation test to find out whether there was a significant relationship between two variables (Coakes & Steed, 2007, p.58). In identifying whether the research hypotheses tested, using this technique, were significant or not, the researcher was primarily concerned with the significance level represented in the “correlation” column output. If the significant “Sig.” value was equal to $p = 0.00$ or less than 0.05 ($p < 0.05$), then the researcher could conclude that the alternative research hypotheses were accepted or failed to be rejected.

Therefore, to identify the strength of the relationship between the variables, the Pearson Correlation coefficient was used. When using Pearson Correlation in analyzing the data, the strength of the relationship was identified by looking at the value of “r” as shown in the Pearson Correlation table. Normally, the sign of the correlation coefficient indicates the strength of the relationship or the degree of association between two variables. However, if there is no relationship, the correlation coefficient will show a value of zero.

Table 4.25, adapted from Muchinsky (1993), shows the strength of the relationship between the independent and dependent variables.

Table 4.25: Pearson Correlation Value

Value of “r”	Strength of relationship between variables
0.00-0.20	Very low or no relationship
0.21-0.40	Low relationship
0.41-0.60	Moderate relationship
0.61-0.80	High relationship
0.81-1.00	Very high relationship

*(Source: Muchinsky, 1993)

Hypotheses have been formulated to study relationships between variables; four hypotheses have been tested, using the Pearson correlation coefficient. The Pearson's Correlation coefficient was used to measure the strength and direction of the relationship (linear correlation) between two quantitative variables, where the value ($r = 1$) means a perfect positive correlation, whereas the value ($r = -1$) means a perfect negative correlation. Each hypothesis was tested separately.

Ha1: There is a significant relationship between using Six Sigma methodology by DMAIC tool and product quality.

Table 4.26: Relationship between dmaic tool and product quality

Variables	
Six Sigma Methodology by DMAIC tool Product Quality	$r = .855^{**}$ $p = .000$

The result of Pearson Correlation, between using the Six Sigma methodology by DMAIC tool and product quality, showed that the test was **significant**, where the correlation value was $r = 0.855$ and significant value was $p = 0.000$ or $p < 0.05$. Thus, the first hypothesis (Ha1) was accepted assuming that there was a significant relationship between using the Six Sigma methodology by DMAIC tool and product quality.

The closer (r) is to $+1$, the stronger the positive correlation is, while the closer (r) is to -1 , the stronger the negative correlation is. Based on that, the researcher found that the relationship between using the Six Sigma methodology by DMAIC tool and product quality was strongly (very highly) positive because $r = 0.855$. This result means when one variable increases in value, the second variable increases in value, too. In other words, using DMAIC tools, with all stages in the right manner, means an improvement in the quality of product.

Table 4.26 shows that the first hypothesis (Ha1) in this study was accepted. This means that the findings were consistent with previous studies. (Jirasukprasert et al., 2014) found that applying the Six Sigma and DMAIC could help manufacturing plants in achieving quality improvements in their operations and products, thus contributing to their search for process excellence.

Ha2: There is a significant relationship between using the Six Sigma methodology by DMAIC tool and service quality.

Table 4.27: Relationship between dmaic tool and Service quality

Variables	
Six Sigma Methodology by DMAIC tool Service Quality	$r = .765^{**}$ $p = .000$

The result of Pearson Correlation, between using the Six Sigma methodology by DMAIC tool and service quality, showed that the test was **significant**, where the correlation value was $r = 0.765$ and the significant value was $p = 0.000$ or $p < 0.05$. Thus, the second hypothesis (Ha2) was accepted assuming that there was a significant relationship between using the Six Sigma methodology by DMAIC tool and service quality.

The closer (r) is to +1, the stronger the positive correlation is, while the closer (r) is to -1, the stronger the negative correlation is. Based on that, the researcher found that the relationship between using the Six Sigma methodology by DMAIC tool, and the quality of services was strongly (highly) positive because $r = 0.765$. This result means when one variable increases in value, the second variable increases in value, too. In other words, using DMAIC tool, with all stages in a right manner, means improvement of quality of service.

Table 4.27 shows that the second hypothesis (Ha2) in this study was true. This means that the findings were consistent with previous studies. Kumar, Strandlund, and Thomas (2008) found that “DMAIC methods” at Six Sigma could be implemented upon designing service system before, during, and after interaction with customers by giving good services to them which at the end will increase customers’ satisfaction and loyalty and increase company’s earnings. Chang and Wang (2008) explained the Six Sigma methodologies as a method that could lead to a continuous decrease in process variation and improvement of service quality.

Ha3: There is a significant relationship between using six sigma methodology, by DMAIC tool, and plant image.

Table 4.28: Relationship between dmaic tool and plant image

Variables	
Six Sigma Methodology by DMAIC Tool Plant Image	r = .619** p = .000

The result of Pearson Correlation, between using the Six Sigma methodology by DMAIC tool and plant image, showed that the test was **significant**, where the correlation value was $r = 0.619$ and significant value was $p = 0.000$ or $p < 0.05$. Thus, the third hypothesis (Ha3) was accepted assuming that there was a significant relationship between using the Six Sigma methodology by DMAIC tool and the plant image.

The closer (r) is to +1, the stronger the positive correlation is, while the closer (r) is to -1, the stronger the negative correlation is. Based on that, the researcher found that the relationship between using the Six Sigma methodology by DMAIC tool, and the plant image was strongly (highly) positive because $r = 0.619$. This result means when one variable increases in value, the second variable increases in value, too. In other words,

using DMAIC tool with all stages in a proper way would mean an improvement of the plant image, thus increasing number of customers and plant profits.

Table 4.28 shows that the third hypothesis (Ha3) in this study was true. This means that the findings were consistent with previous studies, Morales et al., (2016) have shown the effect and the significance of Six Sigma, and the DMAIC tool in particular, on improving production tasks, company image and increasing customers' loyalty in an agreeable way.

Ha4: There is a significant relationship between using the Six Sigma methodology by DMAIC tool and price.

Table 4.29: Relationship between dmaic tool and price

Variables	
Six Sigma Methodology by DMAIC Tool	r = .858** p = .000
Price	

The result of Pearson Correlation, between using the Six Sigma methodology by DMAIC tool and the price, showed that the test was **significant**, where the correlation value was $r = 0.858$ and significant value was $p = 0.000$ or $p < 0.05$. Thus, the fourth hypothesis (Ha4) was accepted assuming that there was a significant relationship between using the Six Sigma methodology by DMAIC tool and the price.

The closer (r) is to +1, the stronger the positive correlation is, while the closer (r) is to -1, the stronger the negative correlation is. Based on that, the researcher found that the relationship between using the Six Sigma methodology by DMAIC tool, and the price was strongly (Very highly) positive because $r = 0.858$. This result means when one variable increases in value, the second variable increases in value, too. In other words, using DMAIC tool with all stages in the right way would mean a suitable price, thus increasing demand for concrete mixing products and accordingly increasing plant profits

Table 4.29 shows that the fourth hypothesis (Ha4) in this study was accepted. This means that the findings were consistent with previous studies. Does and Koning (2006) explained the uses of lean six sigma concepts in a hospital to provide healthcare services to patients at the lowest possible cost and time which is perhaps one of the most important quality indicators from the perspective of patients in healthcare facility.

Table 4.30: Summary of Hypotheses Testing

Research Hypothesis	Measures	Significance
There is a significant relationship between using the Six Sigma methodology by DMAIC tool and product quality.	Pearson Correlation (r = 0.855)	p<0.05 (Accepted, where p = 0.000)
There is a significant relationship between using the Six Sigma methodology by DMAIC tool and service quality.	Pearson Correlation (r = 0.765)	p<0.05 (Accepted, where p = 0.000)
There is a significant relationship between using the Six Sigma methodology by DMAIC tool and plant image	Pearson Correlation (r = 0.619)	p<0.05 (Accepted, where p = 0.000)
There is a significant relationship between using the Six Sigma methodology by DMAIC tool and price.	Pearson Correlation (r = 0.858)	p<0.05 (Accepted, where p = 0.000)

Hypothesis Related to Participants' Profiles (Analysis of Responses)

Ha5: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample according to the demographic profile variables: gender, age, educational level, work experience, governorate and possession of ISO certificate).

This hypothesis predicted differences in the opinions of the participants toward using the Six Sigma methodology, using DMAIC tool, according to the demographic variables. The Mann-Whitney test and the Kruskal-Wallis's test are nonparametric methods used to detect whether two or more samples come from the same distribution or to test whether

medians between comparison groups are different under the assumption that the shapes of the underlying distributions would be the same.

Ha5.1: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to gender.

Table 4.31: Mann-whitney Test Grouping by Gender

Constructs	Sig
DMAIC tool	.056
Product Quality	.042
Service Quality	.022
Plant Image	.143
Price	.019

Table 4.31 shows that in all the domains (using DMAIC tool, product quality, service quality, plant image and price) the p-value (Sig.) was greater than the level of significance $\alpha = 0.05$. However, no significant difference was found among the participants for all domains due to gender. The researcher concluded that the gender had no effect on all domains in this study: DMAIC tool, product quality, service quality, plant image and price.

Ha5.2: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to age.

Table 4.32: Kruskal Wallis Test Grouping by age

Constructs	Sig
DMAIC tool	.584
Product Quality	.318
Service Quality	.588
Plant Image	.535
Price	.456

Table 4.32 shows that in all the domains (using DMAIC tool, product quality, service quality, factory image and price) the p-value (Sig.) was greater than the level of significance $\alpha = 0.05$. However, no significant difference was found among the participants for all domains due to age. The researcher concluded that age had no effect

on all domains in this study: DMAIC tool, product quality, service quality, plant image and price.

Ha5.3: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to the educational level.

Table 4.33: Kruskal Wallis Test Grouping by educational level

Constructs	Sig
DMAIC tool	.002
Product Quality	.002
Service Quality	.002
Plant Image	.002
Price	.015

Table 4.33 shows that all domains (using DMAIC tool, product quality, service quality, plant image and price) of the p-value (Sig.) were smaller than the level of significance $\alpha = 0.05$. Therefore, the researcher found a significant difference among the participants for all domains which could be attributed to the educational level. The researcher concluded that the educational level influenced all domains: using DMAIC tools, product quality, service quality, plant image and price.

Ha5.4: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to experience.

Table 4.34: Kruskal Wallis Test Grouping bywork experience

Constructs	Sig
DMAIC tool	.026
Product Quality	.020
Service Quality	.002
Plant Image	.083
Price	.016

Table 4.34 shows that in all domains (except plant image) the p-value (Sig.) was smaller than the level of significance $\alpha = 0.05$. Therefore, the researcher found a significant difference among the participants for all domains (except plant image) in this study which

could be attributed to work experience. The researcher concluded that, to save the plant image, work experience influenced all domains in this study.

. Ha5.5: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to governorate.

Table 4.35: Kruskal Wallis Test Grouping by governorate

Constructs	Sig
DMAIC tool	.054
Product Quality	.080
Service Quality	.047
Mental Image	.051
Price	.435

Table 4.35 shows that the p-value (Sig.) was smaller than the level of significance $\alpha = 0.05$ for service **quality domain**. This means there was a significant difference, among the participants, in the service quality domain due to governorate. The researcher concluded that the governorate influenced the service quality. Pertaining to the other domains, the p-value (Sig.) was greater than the level of significance $\alpha = 0.05$. However, no significant difference was found among the participants in this domain due to governorate. The researcher concluded that the governorate had no effect on the other domains.

Ha5.6: There are statistically significant differences at $\alpha \leq 0.05$ in the responses of the research sample due to possession of ISO certificate.

Table 4.36: Kruskal Wallis Test Grouping by having ISO certificate

Constructs	Sig
DMAIC Tool	.000
Product Quality	.000
Service Quality	.000
Mental Image	.000
Price	.000

Table 4.36 shows that in all domains (using DMAIC tool, product quality, service quality, plant image and price) the p-value (Sig.) was smaller than the level of significance α

=0.005. Therefore, the researcher found that there was a significant difference among the participants for all domains due to possession of an ISO certificate. The researcher concluded that the plant, which had an ISO certificate, influenced all domains: using DMAIC tool, product quality, service quality, plant image and price.

H6: The DMAIC tool will positively explain the variation in concrete mixing plant's performance.

Table 4.37: Multiple Regressions Analysis

Constructs	Beta	T	Sig	R ²
Define	.576	14.65	.005	
Measure	.140	7.66	.000	
Analysis	-.101	-1.90	.050	
Improve	-.555	-10.34	.000	0.922
Control	.825	20.78	.000	

*Predictors :(Constant), Define, Measure, Analysis, Improve, Control

**Dependent variable: Plant Performance

Multiple Regressions have been conducted to test the variance in the dependent variable on whether plant productivity (represented by the quality of product, service quality, plant image and price) could be explained by the five independent variables. The result shows that 92.2 % of the variation (R-Square) in plant productivity could be significantly explained by the five independent variables. Looking at Beta value, the highest number in the beta was 0.825 for control stage, which is significant at the 0.000 level. This means that the control stage influenced most the variation in plant productivity. This result implies that all the five independent variables (Define, Measure, Analysis, Improve, Control) positively explained the variance in the dependent variable:(plant performance). This supports hypothesis 6.

Chapter Five

Conclusion and Recommendations

5.1. Overview

5.2. Summary of the Study

5.3. Conclusions of the Study

5.4. Recommendations and Suggestions

5.5 Further Research

Chapter Five: Conclusion and Recommendations

5.1. Overview

This chapter is devoted to the conclusions and recommendations based on the study findings. The researcher recommends gradual adoption of the Six Sigma approach starting with the DMAIC tool to optimize the performance and productivity of concrete mixing plants. Then the chapter presents an overview, discussion and assessment of the extent to which the research objectives have been met. The chapter concludes with suggestions for future research in this field.

5.2. Summary of the Study

This study has researched the effectiveness of applying the Six Sigma approach starting with DMAIC tool. To that end, it has assessed the use of DMAIC tool by the concrete mixing plants and its effect on their productivity by measuring the quality of product, quality of services, plant image and price.

In addition, the study has conducted an extensive review of related literature to achieve its aims and objectives. The purpose was also to develop a clear understanding of the application of the Six Sigma approach, using DMAIC tool, which plays a major/key role in concrete mixing plants.

The results of the administered questionnaire were analyzed quantitatively and then were presented, using an interpretive and descriptive method for qualitative data analysis.

5.3. Conclusions of the Study

To achieve the purposes of the research, several objectives have been spelled out through the analysis of data. These objectives have been linked to the study questions raised to increase one's knowledge and familiarity with this field.

Researcher's Findings

The old employees had a higher use of defined constraints and defects in their plants.

The employees holding a master's degree had a high level of using DMAIC tool in their plants.

Nablus governorate used the steps in DMAIC tool the most. This could be attributed to the presence of plants which had ISO certificates in comparison with other governorates. The Nablus-based plants also showed the highest concern about quality issues.

All employees, regardless of their age, had the same level of using the measure phase which included identifying the side effects of failure, the mechanisms of dealing with the causes of failure, listing and categorization of problems, recording all possible causes of concrete mixing problems, classifying them, and discussing each element to integrate and clarify them.

Nablus governorate concrete mixing plants also showed the highest concern about their image and cared the most about advertising messages. They set up specialized committees which considered the psychological dimension of the customers and chose the appropriate advertising medium to motivate the customer to deal with them.

Furthermore, Nablus concrete mixing plants cared the most about the price by offering good discounts to loyal customers. They also maintained a stable price policy and consistency and balance between products offered to the customers and their prices.

Nablus governorate concrete mixing plants also cared the most about their product quality by providing their customers with products according to the standards of the engineering offices, they also used products that enjoyed high reliability by customers. Furthermore,

they had building team that followed up the production process to ensure product quality, and proper handling of customers' complaints to meet their desired expectations and achieve their satisfaction.

Nablus-based concrete mixing plants also cared the most about their service quality by preparing the customers' requests in a manner that facilitated their receipt on time. They also trained their employees in the skills of dealing with the customers and providing services that complied with the standards of engineering offices.

The employees, working in concrete mixing plants, defined and determined the problems that were likely to arise during the mixing process, thus making it easy to solve them. To that end, they always determined the material needed for concrete mixing, identified the reasons for profit decline, increase of cost, and customer dissatisfaction.

Most concrete mixing plants identified the causes of failure, the side effects of the causes of failure in concrete mixing and the mechanisms for dealing with the causes of failure. They also always made a list of things that failed to meet customers' requirements and identified the main categories of problem causes.

The plants also always identified the causes of failures in concrete mixing and took the necessary measures to avoid failure within the production conditions. This was in addition to prediction of the chances of failure and its effects on the design of concrete mixing, evaluation of the severity of failures and the degree of risk for each possible scenario to deal with it properly.

The concrete mixing plants also worked to improve the procedures that may cause the problems and made efforts to solve the problems and fix the defects by taking the steps to solve them in partial concrete mixing. Moreover, the plants decided on alternative

solutions to the concrete mixing problems based on cost and profitability and implemented alternative solutions for continuous improvement in concrete mixing. They always also examined the failure modes to improve the process periodically.

The plants also used the control process to fix the defects and make sure they would not occur again. To that end, they always determined the capacity of the production process, whether the operations were running as expected, and whether the processes were changed to take corrective action. In addition, they always fixed the date of the action to be taken, regarding the removal process, monitored the continuous improvement procedures for concrete mixing and collected samples for laboratory tests

Furthermore, the plants always pay attention to the product quality to increase productivity. To that end, they always provided products to customers on time, in the right quantity and according to the standards of the engineering office. They also processed customers' complaints to meet their expectations and achieve their satisfaction.

The plants also paid attention to the service quality to increase productivity by concluding financial transactions with customers, preparing their customers' requests in a manner that facilitated their receipt on time, providing distinguished services that complied with the standards of engineering offices and using calibrated equipment in production.

They also paid attention to the product prices to increase productivity by maintaining a stable price policy and offering good discounts to loyal customers.

The quality of product and service and image and price are the basic factors that affect the concrete mixing plants' performance and productivity.

The price and the product quality were the most significant components which affected the plants' performance and productivity.

The control stage was found to be the most significant phase that affected the plants' productivity.

The plants, which had an ISO certificate, used DMAIC tool more than their counterparts which had no possession of ISO certificates.

Finally, the researcher concluded that the plants which had ISO certificates paid more attention to product and service quality, plant image and price than their counterparts which had no ISO certificates.

5.4. Recommendations and Suggestions

Concrete mixing plants should measure problems and defects to solve the problems and fix the defects.

Plant management should conduct interviews with technicians and engineers and listen to their opinion to increase efficiency and improve performance.

Plant management should assign teams and task them with analysis of plant defects and problems, using statistical methods and procedures. This would help to solve plant problem, and this may guarantee the problems would not arise again.

Plant management should set up teams to collect data, thus determining the relationships between the variable factors in the process and the direction of improvements.

Plant management should set up teams to follow up the production process to ensure product quality.

There is also a need to form special teams to oversee introducing and implementing SIX Sigma approach by applying DMAIC tool.

Periodic meetings between employees should be held to increase rapprochement between them and break psychological barriers. This is in addition to holding periodic workshops to explain the work procedures and share any updates. In this context, employees should be involved in the decision-making process to encourage them to take responsibility and promote their sense of belonging and loyalty to the plant.

Training

Plants can deliver the best in-service training to the employees. This training can be given in the workplace, thus allowing the employees to have a clear view of how to practice DMAIC tools in the field. The employees can understand the importance and benefits they would gain from the implementation of the DMAIC tool. The plants should also organize regular training courses for the employees, or groups involved as well as for new employees, thus making all the employees familiar with the role they must play in the implementation of DMAIC tool.

Productivity of Employees

It can be concluded that the productivity of the employees can be improved if/when the Six Sigma approach is implemented. To ensure high productivity of the employees the plants should exchange ideas and receive comments from employees and people directly or indirectly involved. This is important as the employees are the main key to increasing plant productivity. Establishing a recognition system that offers rewards to every successful employee should also be introduced.

Role of Senior Management

The senior managements in the plants also should provide, support and encourage commitment to applying the Six Sigma approach. They should also always assist the employees. All the employees involved in using the Six Sigma methodology should be given clear instruction on how to practice and use the DMAIC tool so that they can work comfortably, improve their productivity and maintain a high quality of performance, thus reducing costs. They also should always make the right decision for the plants and for the employees as this always influences performance. A wrong decision might have a negative impact on the plant.

5.5 Further Research

5.5.1. Conducting comparative studies on the West Bank—based concrete mixing plants which have ISO certificates and their counterparts which don't have them

5.5.2. Conducting comparative studies on West Bank-based concrete mixing plants and their counterparts in the Gaza Strip

One future research area could be conducting comparative studies after and before adopting and using the Six Sigma approach, using DMAIC tool in the concrete mixing plants in the West Bank and the Gaza Strip.

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Appendices

Appendix A: Questionnaire-Arabic

Appendix B: Questionnaire-English

Appendix C: Correlation Coefficient

Appendix A: Questionnaire-Arabic



الجامعة العربية الأمريكية

ARAB AMERICAN UNIVERSITY

FACULTY OF GRADUATE STUDIES

السيدة/ة المجيب/ة المحترم/ة

تقوم الباحثة بإجراء دراسة حول " تطبيق منهجية ستة سيجما لتحسين كفاءة انتاجية الخلطات الخرسانية في المحافظات الشمالية الضفة الغربية"، وذلك استكمالاً لمتطلبات الحصول على درجة الماجستير من الجامعة العربية الأمريكية. ولغرض تحقيق أهداف الدراسة فقد تم تصميم نموذج استبانة أدناه، وعليه أرجو من حضراتكم التكرم بالإجابة عن جميع الفقرات الموجودة بالاستبيان، حتى يتم السماح للباحثة بإكمال الدراسة. مع العلم أن الإجابات والمعلومات التي سترد في الاستبانة سيتم معاملتها بسرية تامة ولأغراض البحث العلمي فقط.

للتواصل معي لأي استفسار عبر البريد

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مع جزيل الشكر والتقدير،

الباحثة

سيمون الشافعي

القسم الأول: معلومات ديمغرافية

- الجنس: ☐ ذكر ☐ انثى
- العمر: ☐ 30-20 ☐ 40-31 ☐ أكثر من 40 سنة
- التحصيل العلمي: ☐ توجيهي وأقل ☐ دبلوم ☐ بكالوريوس ☐ ماجستير
- فأعلى
- سنوات الخبرة: ☐ 5 سنوات فأقل ☐ 10-6 ☐ 15-11 ☐ أكثر من 15 سنة
- المحافظة: ☐ جنين ☐ نابلس ☐ طولكرم ☐ قلقيلية ☐ طوباس
- حيازة شهادة الأيزو: ☐ نعم ☐ لا

القسم الثاني: متغيرات الدراسة

أولاً: سيجما ستة: هي عبارة عن استراتيجية ومنهجية للتحسين المستمر تقوم على الحد من الأخطاء إلى أقصى درجة ممكنة من أجل الوصول إلى هدف الجودة العالية. من خلال تطبيق نموذج DMAIC الذي سيتم التقصي حول استخدامه كما يلي:

الرقم	الفقرة	أوافق بشدة	أوافق	محايد	أعارض بشدة	أعارض
1- التعريف						
1.	تحدد إدارة المصنع المواد اللازمة للخلطات الاسمنتية					
2.	تحدد ادارة المصنع اسباب عدم رضا الزبائن					
3.	تحدد ادارة المصنع أسباب تراجع الارباح					
4.	تحدد ادارة المصنع اسباب زيادة التكاليف					
5.	تحدد ادارة المصنع اسباب زيادة وقت الدورة للخلطات الاسمنتية					
6.	تحدد ادارة المصنع الوقت اللازم لاتمام الخلطات الاسمنتية					
7.	تحدد ادارة المصنع المال اللازم لاتمام الخلطات الاسمنتية					
8.	تحدد ادارة المصنع العدد المناسب من الموارد البشرية لاتمام الخلطات الاسمنتية					
9.	تحدد ادارة المصنع طرق تقليل التكاليف					
10.	تحدد ادارة المصنع آليات زيادة الارباح					
11.	تحدد ادارة المصنع آليات زيادة رضا العملاء					

2- القياس				
1.	تقوم ادارة المصنع بعمل مقابلات مع الفنيين واخذ آرائهم			
2.	تقوم ادارة المصنع بعمل مقابلات مع المهندسين واخذ آرائهم			
3.	تقوم ادارة المصنع بالتعرف على اسباب الفشل في الخلطات الاسمنتية			
4.	تقوم ادارة المصنع بالتعرف على الآثار الجانبية لمسببات الفشل في الخلطات الاسمنتية			
5.	تقوم ادارة المصنع بالتعرف على آليات التعامل مع مسببات الفشل في الخلطات الاسمنتية			
6.	تقوم ادارة المصنع بوضع قائمة بالمشاكل التي لا تلبي متطلبات العملاء على النحو المحدد في العقد والمواصفات.			
7.	تقوم ادارة المصنع بتحديد الفئات الرئيسية لأسباب المشكلة: (القوى العاملة، الآلات، المواد، الطرق، القياسات، الصحة والسلامة والبيئة)			
8.	تقوم ادارة المصنع بتقصي الحقائق المنهجية من خلال المناقشة الجماعية: أثناء جلسات العصف الذهني، للتعرف على الاسباب التي قد تؤدي إلى عدم تلبية متطلبات العملاء كسبب محتمل			
9.	تقوم ادارة المصنع بتسجيل جميع الأسباب المحتملة لمشاكل الخلطات الاسمنتية وتصنيفها ومناقشة كل عنصر لدمج الأسباب وتوضيحها.			
3- التحليل				
1.	تقوم ادارة المصنع بتحليل حالات الفشل المحتملة في العملية الانتاجية			
2.	تقوم ادارة المصنع بتحليل التأثيرات المحتملة في العملية الانتاجية			
3.	تقوم ادارة المصنع بتحديد مسببات عمليات الفشل في الخلطات الاسمنتية			
4.	تقوم ادارة المصنع بالاجراءات اللازمة لتجنب الفشل ضمن الظروف الانتاجية			
5.	تقوم ادارة المصنع بتحديد فرص الفشل وتأثيراتها في تصميم الخلطات الاسمنتية			

					تحدد ادارة المصنع الاولويات للمخاطر المحتملة بوضع اجراءات هدفها التقليل من هذه المخاطر	6.
					تقوم ادارة المصنع بمراجعة وتحديد اوضاع الفشل بشكل دوري	7.
					تقوم إدارة المصنع بتقييم درجة الخطورة لعمليات الفشل بشكل مستمر	8.
					تحدد ادارة المصنع درجة الخطورة لكل سيناريو محتمل للتعامل معه	9.
					تقوم ادارة المصنع بعمل حلقات عصف ذهني لحساب درجة الخطورة في الخلطات الاسمنتية من حيث عدد وترتيبها وفق اولويات	10.
					تقوم ادارة المصنع بتنفيذ الاجراءات التصحيحية وتقييمها	11.
					تقوم ادارة المصنع بتحليل مشاكل العملية باستخدام الأدوات الإحصائية	12.
					تقوم ادارة المصنع بجمع البيانات لتحديد العلاقات بين العوامل المتغيرة في العملية لتحديد اتجاه التحسينات	13.
					تقوم ادارة المصنع بتحديد مدى جودة أو ضعف أداء العملية الحالية	14.
					تقوم ادارة المصنع بتحديد الأسباب الجذرية المحتملة للتباين في جودة الخلطات الاسمنتية	15.
					تساعد البيانات التي تم تحليلها ادارة المصنع في الكشف عن مجريات العملية وسلوكها	16.
					توضح البيانات التي تم تحليلها مدى قدرة العملية واستقرارها على مدى فترة زمنية طويلة.	17.
4- التحسين المستمر						
					تقوم ادارة المصنع بتحديد خطوات حل المشكلة في الخلطات الاسمنتية بشكل جزئي	1.
					تقوم ادارة المصنع بتحديد خطوات حل المشكلة في الخلطات الاسمنتية بشكل كلي	2.
					تقوم ادارة المصنع بتحديد البديل الامثل للخلطات الاسمنتية ضمن قاعدة التكلفة والربحية	3.

					تقوم ادارة المصنع بتنفيذ البديل الامثل لإجراء التحسين المستمر في الخلطات الاسمنتية	4.
					تلجأ إدارة المصنع بحساب العائد على الاستثمار لتقييم كفاءة الاستثمار	5.
					تلجأ إدارة المصنع بحساب العائد على الاستثمار لمقارنة كفاءة عدد من الاستثمارات المختلفة	6.
					تلجأ إدارة المصنع بمراجعة اوضاع الفشل بشكل دوري للتحسين العملية	7.
5- التحكم والسيطرة						
					تلجأ ادارة المصنع لاستخدام طرق التحكم الاحصائي في مراقبة الخلطات الاحصائية	1.
					تقوم ادارة المصنع بتحديد قدرة العملية الانتاجية	2.
					تقوم ادارة المصنع بتحديد ما إذا كانت العمليات تعمل على النحو المتوقع	3.
					تقوم ادارة المصنع بتحديد ما إذا كانت العمليات قد تغيرت لاتخاذ اجراءات تصحيحية	4.
					تقوم ادارة المصنع بتحديد موعد الاجراء الذي سيتم اتخاذه الخاصة بعملية الازالة	5.
					تقوم ادارة المصنع بتحديد موعد الاجراء الذي سيتم اتخاذه الخاصة بعملية التحسين	6.
					تقوم ادارة المصنع بمتابعة مراقبة اجراءات التحسين المستمر للخلطات الاسمنتية	7.
					تلجأ ادارة المصنع لاستخراج المتوسطات الحسابية والانحرافات المعيارية لإظهار ما تمر به الخلطات الاسمنتية من تباين خلال فترات زمنية محددة ومقارنتها	8.
					تستخدم ادارة المصنع ما تم جمعه من بيانات للاستفادة من مواطن الضعف	9.
					تلجأ ادارة المصنع للفحص البصري للمواد الخام المسلمة	10.
					تقوم ادارة المصنع بجمع العينات وإجراء الاختبارات المعملية بشكل مستمر	11.
					تلجأ ادارة المصنع برسم مخططات التحكم لتحديد الأسباب الخاصة (إن وجدت)	12.

ثانياً: تحسين أداء المصنع

الرقم	الفقرة	أوافق بشدة	أوافق	محايد	أعارض	أعارض بشدة
1- جودة المنتج						
1	توفر إدارة المعمل منتجاتها لزبائنها في الوقت المناسب					
2	توفر إدارة المعمل منتجاتها لزبائنها بالكمية المناسبة					
3	توفر إدارة المعمل منتجاتها لزبائنها وفق مقاييس المكاتب الهندسية.					
4	تتمتع منتوجات المعمل باعتمادية عالية من قبل الزبائن.					
5	تهتم إدارة المعمل بشكاوى الزبائن لتلبية احتياجاتهم التي يرغبونها.					
6	هناك فريق مخصص لمتابعة عملية الإنتاج للتأكد من جودة المنتج					
2- جودة الخدمة						
7	تمارس إدارة المعمل إجراءات سريعة وسهلة لإنجاز المعاملات المالية للزبائن.					
8	تهيئ إدارة المعمل طلبات الزبون بأسلوب يسهل استلامها في الموعد المحدد.					
9	تسعى إدارة المعمل باستمرار لتدريب العاملين على مهارات التعامل مع الزبون.					
10	تسعى إدارة المعمل إلى تقديم خدمات متميزة تتوافق مع مقاييس المكاتب الهندسية.					
11	تأخذ إدارة المعمل بعين الاعتبار اقتراحات العاملين لتقديم خدمات عالية لزبائنها.					
12	تتم عملية معايرة المعدات المستخدمة بالإنتاج.					
3- الصورة الذهنية						
13	يتمتع المعمل بصورة مقبولة تدفع الزبائن للتعامل معه.					

14	تختار إدارة المعمل الوسائل الإعلانية المناسبة التي تحفز الزبون للتعامل معها.				
15	تصاغ الرسائل الإعلانية من قبل لجنة متخصصة تراعي الجانب النفسي للزبون.				
16	غالباً ما يكرر الزبائن أنفسهم تعاملهم مع المعمل.				
17	تحت إدارة المعمل العاملين على التعامل الودود مع الزبائن.				
4- السعر					
18	تعد المنتجات المقدمة للزبون جيدة مقارنة مع ما يدفعه من قيمة للحصول عليها.				
19	السياسة السعرية التي تتبعها إدارة المعمل مستقرة نسبياً.				
20	يفضل الزبائن منتجات معملنا بغض النظر عن السعر.				
21	غالباً ما تقدم إدارة المعمل خصومات مناسبة للزبائن الدائمين.				
22	دائماً ما تقوم إدارة المعمل بمقارنة جودة منتجاتها.				

القسم الثالث: أسئلة مفتوحة

* أي تعليقات ترى في إضافتها من فضلك اكتبها هنا:

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انتهى، مع خالص الشكر والتقدير

Appendix B: Questionnaire-English

1. Applying DMAIC tool

No	Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Define						
1	The factory management determines the materials needed for cement mixtures					
2	Factory management determines the reasons for customer dissatisfaction					
3	Factory management determines the reasons for the decline in profits					
4	Factory management determines the reasons for the increase in costs					
5	The factory management determines the reasons for increasing the cycle time for cement mixtures					
6	The factory management determines the time required to complete the cement mixtures					
7	The factory management determines the money needed to complete the cement mixtures					
8	The factory management determines the appropriate number of human resources to complete the cement mixtures					
9	Factory management identifies ways to reduce costs					
10	Factory management identifies mechanisms to increase profits					
11	Factory management identifies mechanisms to increase customer satisfaction					
Measure						
12	The factory management conducts interviews with technicians and takes their opinions					
13	The factory management conducts interviews with engineers and takes their opinions					

14	The factory management identifies the causes of failure in cement mixtures					
15	The factory management is identifying the side effects of the causes of failure in cement mixtures					
16	The factory management identifies the mechanisms for dealing with the causes of failure in cement mixtures					
17	The factory management makes a list of problems that do not meet customer requirements as specified in the contract and specifications.					
18	Factory management identifies the main categories of problem causes: (manpower, machinery, materials, methods, measurements, health, safety and environment)					
19	The factory management conducts systematic fact-finding through group discussion: during brainstorming sessions, to identify the reasons that may lead to non-fulfilment of customer requirements as a possible reason					
20	The factory management records all possible causes of cement mixture problems, classifies them, and discusses each element to integrate and clarify the causes.					
Analyze						
21	The factory management analyzes possible failures in the production process					
22	The factory management analyzes the potential effects on the production process					
23	The factory management determines the causes of failures in cement mixtures					
24	The factory management takes the necessary measures to avoid failure within the production conditions					
25	The factory management determines the chances of failure					

	and its effects in the design of cement mixtures					
26	Factory management sets priorities for potential risks by developing measures aimed at reducing these risks					
27	The factory management periodically reviews and determines the failure modes					
28	The factory management continuously evaluates the severity of failures					
29	Factory management determines the degree of risk for each possible scenario to deal with					
30	The factory management conducts brainstorming circles to calculate the degree of danger in cement mixtures in terms of number and arrangement according to priorities.					
31	The factory management implements and evaluates corrective actions					
32	Factory management analyzes process problems using statistical tools					
33	The factory management collects data to determine the relationships between the variable factors in the process and to determine the direction of improvements					
34	The factory management determines the quality or poor performance of the current process					
35	The factory management Identify potential root causes of variance in the quality of cement mixtures					
36	The analyzed data helps the factory management to reveal the course and behavior of the process					
37	The data analyzed shows how capable and stable the process is over a long period of time.					
Improve						
38	The factory management determines the steps to solve the problem in partial cement mixtures					

39	The factory management determines the steps to solve the problem in cement mixtures completely					
40	The factory management determines the optimal alternative to cement mixtures within the base of cost and profitability					
41	The factory management is implementing the optimal alternative for continuous improvement in cement mixtures					
42	The factory management resorts to calculating the return on investment to assess the efficiency of the investment					
43	The factory management resorts to calculating the return on investment to compare the efficiency of several different investments					
44	The factory management periodically reviews the failure modes to improve the process					
Control						
45	The factory management resorts to using statistical control methods to monitor cement mixtures					
46	The factory management determines the capacity of the production process					
47	Factory management determines whether operations are operating as expected					
48	Factory management determines whether processes have changed to take corrective action					
49	The factory management determines the date of the action to be taken regarding the removal process					
50	The factory management determines the date of the action to be taken regarding the improvement process					
51	The factory management monitors the continuous improvement procedures for cement mixtures					

52	The factory management resorts to extracting arithmetic averages and standard deviations to show and compare the variance experienced by cement mixtures during specific time periods.					
53	The factory management uses the collected data to take advantage of weaknesses					
54	Factory management resorts to visual inspection of the delivered raw materials					
55	The factory administration collects samples for laboratory tests on an ongoing basis					
56	The factory management resorts to drawing control charts to determine the special causes (if any.)					

2. Improve Factory Productivity:

No	Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Quality of Product						
1	The factory management provides its products to its customers in a timely manner					
2	The factory management provides its products to its customers in the right quantity					
3	The management of the plant provides its products to its customers according to the standards of the engineering offices.					
4	The factory's products enjoy high reliability by customers.					
5	The factory management takes care of customers' complaints to meet their desired needs.					
6	There is a dedicated team to follow up the production process to ensure product quality					
Quality of Service						
8	The factory management practices quick and easy procedures for completing financial transactions for customers.					

9	The factory management prepares the customers' requests in a manner that facilitates their receipt on time.					
10	Continuously managing the factory to train the employees in the skills of dealing with the customer.					
11	The factory management seeks to provide distinguished services that comply with the standards of engineering offices.					
12	The factory management makes the suggestions of the employees to provide high services to its customers.					
13	The equipment used is calibrated in production					
Factory Image						
14	The factory has an acceptable image that pays customers to deal with it.					
15	The factory management chooses the appropriate advertising media that motivates the customer to deal with them.					
16	Advertising messages are formulated by a specialized committee that considers the psychological aspect of the customer.					
17	Often the same customers repeat their interactions with the factory.					
18	Factory management working on friendly dealing with customers					
Price						
19	The products offered to the customer are good compared to what they pay for.					
20	The price policy followed by the factory management is relatively stable					
21	Customers prefer our factory products regardless of price					
22	Factory management often offers convenient discounts to regular customers					
23	The factory management always compares the quality of its products					

Please write any observations or concerns.

Thank You for Your Participation!

Appendix C: Correlation Coefficient

Table C.1: Correlation coefficient of each item of “Define” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management determines the materials that are needed for cement mixtures	.371**	.000
Factory management determines the reasons for customer dissatisfaction	.694**	.000
Factory management determines the reasons for the decline in profit	.489**	.000
Factory management determines the reasons for the increase in costs	.535**	.000
The factory management determines the reasons for increasing the cycle time for cement mixtures	.467**	.000
The factory management determines the time required to complete the cement mixtures	.330**	.000
The factory management determines the money needed to complete the cement mixtures	.222**	.002
The factory management determines the appropriate number of human resources to complete the cement mixtures	.403**	.000
Factory management identifies ways to reduce costs	.589**	.000
Factory management identifies mechanisms to increase profits	.863**	.000
Factory management identifies mechanisms to increase customer satisfaction	.429**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.2: Correlation coefficient of each item of “Measure” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management conducts interviews with technicians and takes their opinions	.655**	.000
The factory management conducts interviews with engineers and takes their opinions	.235**	.001
The factory management identifies the causes of failure in cement mixtures	.531**	.000
The factory management is identifying the side effects of the causes of failure in cement mixtures	.131**	.000
The factory management identifies the mechanisms for dealing with the causes of failure in cement mixtures	.599**	.000
The factory management makes a list of problems that do not meet customer requirements as specified in the contract and specifications.	.614**	.000

Factory management identifies the main categories of problem causes: (manpower, machinery, materials, methods, (measurements, health, safety and environment	.665**	.002
The factory management conducts systematic fact-finding through group discussion: during brainstorming sessions, to identify the reasons that may lead to non-fulfilment of customer requirements as a possible reason	.941**	.000
The factory management records all possible causes of cement mixture problems, classifies them, and discusses each element to integrate and clarify the causes.	.860**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.3: Correlation coefficient of each item of “Analysis” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management analyzes possible failures in the production process	.763**	.000
The factory management analyzes the potential effects on the production process	.599**	.000
The factory management determines the causes of failures in cement mixtures	.717**	.000
The factory management takes the necessary measures to avoid failure within the production conditions	.372**	.000
The factory management determines the chances of failure and its effects in the design of cement mixtures	.768**	.000
Factory management sets priorities for potential risks by developing measures aimed at reducing these risks	.619**	.000
The factory management periodically reviews and determines the failure modes	.670**	.000
The factory management continuously evaluates the severity of failures	.274**	.000
Factory management determines the degree of risk for each possible scenario to deal with	.860**	.000
The factory management conducts brainstorming circles to calculate the degree of danger in cement mixtures in terms of number and arrangement according to priorities.	.348**	.000
The factory management implements and evaluates corrective actions	.714**	.000
Factory management analyzes process problems using statistical tools	.891**	.000
The factory management collects data to determine the relationships between the variable factors in the process and to determine the direction of improvements	.900**	.000
The factory management determines the quality or poor performance of the current process	.862**	.000
The factory management Identify potential root causes of variance in the quality of cement mixtures	.245**	.000
The analyzed data helps the factory management to reveal the course and behavior of the process	.522**	.000

The data analyzed shows how capable and stable the process is over a long period of time. .452** .000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.4: Correlation coefficient of each item of “IMPROVE” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management determines the steps to solve the problem in partial cement mixtures	.763**	.000
The factory management determines the steps to solve the problem in cement mixtures completely	.369**	.000
The factory management decides the alternative solution to cement mixtures based on cost and profitability	.232**	.001
The factory management is implementing the alternative solution for continuous improvement in cement mixtures	.691**	.000
The factory management resorts to calculating the return on investment to assess the efficiency of the investment	.692**	.000
The factory management resorts to calculating the return on investment to compare the efficiency of several different investments	.670**	.000
The factory management periodically reviews the failure modes to improve the process	.700**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.5: Correlation coefficient of each item of “CONTROL” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management resorts to using statistical control methods to monitor cement mixtures	.519**	.000
The factory management determines the capacity of the production process	.506**	.000
Factory management determines whether operations are operating as expected	.425**	.001
Factory management determines whether processes have changed to take corrective action	.544**	.000
The factory management determines the date of the action to be taken regarding the removal process	.500**	.000
The factory management determines the date of the action to be taken regarding the improvement process	.704**	.000
The factory management monitors the continuous improvement procedures for cement mixtures	.862**	.000
The factory management resorts to extracting arithmetic averages and standard deviations to show and compare the	.620**	.000

variance experienced by cement mixtures during specific time periods.

The factory management uses the collected data to take advantage	.794**	.000
Factory management resorts to visual inspection of the delivered raw materials	.712**	.000
The factory administration collects samples for laboratory tests on an ongoing basis	.189**	.007
The factory management resorts to drawing control charts to determine the special causes (if exists)	.704**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.6: Correlation coefficient of each item of “QUALITY OF PRODUCT” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management provides their products to customers on time.	.561**	.000
The factory management provides their products to customers in the right quantity	.522**	.000
The factory management provides their products to customers according to the standards of the engineering offices.	.703**	.001
The factory's products enjoy high reliability by customers.	.743**	.000
The factory management takes care of customers' complaints to meet their desired needs.	.751**	.000
There is a dedicated team to follow up the production process to ensure product quality	.788**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.7: Correlation coefficient of each item of “QUALITY OF SERVICE” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory management do their procedures quickly and easily to complete financial transactions for customers.	.604**	.000
The factory management prepares the customers' requests in a manner that facilitates their receipt on time.	.377**	.000
The factory management train their employees to deal with the customer probably.	.801**	.001
The factory management seeks to provide distinguished services that comply with the standards of engineering offices.	.944**	.000

The factory management makes the suggestions of the employees to provide high services to its customers.	.804**	.000
The equipment used is calibrated in production	.738**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.8: Correlation coefficient of each item of “factory IMAGE” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The factory has an acceptable image that makes customers deal with it.	.636**	.000
The factory management chooses the appropriate advertising media that motivates the customer to deal with them.	.374**	.000
Advertising messages are formulated by a specialized committee that considers the psychological aspect of the customer.	.374**	.001
The same customers repeat their interactions with the factory.	.735**	.000
Factory management dealing friendly with customers	.519**	.000

** . Correlation is significant at 0.01 level (2-tailed).

Table C.9: Correlation coefficient of each item of “PRICE” and the total domain.

Item	Correlation Coefficient (Pearson)	P-Value
The products offered to the customer are good compared to what they pay for.	.599**	.000
The price policy followed by the factory management is relatively stable	.484**	.000
Customers prefer our factory products regardless of price	.644**	.001
Factory management often offers convenient discounts to regular customers	.639**	.000
The factory management always compares the quality of its products	.922**	.000

** . Correlation is significant at 0.01 level (2-tailed).

الملخص

تعتبر الخرسانة ثاني أكثر المواد استخدامًا في جميع أنحاء العالم بعد الماء. حيث يبلغ إنتاج الخرسانة سنويًا من 1.5-3 طن للفرد بالنسبة للدول الصناعية ولا يزال في ازدياد. ومع ذلك فهو يعتبر أحد المكونات الرئيسية لمواد البناء التي تستخدم للإسكان والبنية التحتية.

يمكن اعتبار منهجية ستة سيجما باستخدام أداة DMAIC دليلاً لحل المشكلات وتحسين المنتج أو العملية حيث بدأت غالبية المصانع في تنفيذ ستة سيجما باستخدام أداة DMAIC.

يتناول هذا البحث تطبيق منهجية ستة سيجما باستخدام أداة DMAIC في قطاع البناء لمعرفة العيوب في الخلطات الخرسانية التي تؤثر بشكل مباشر على الشركة المصنعة مع جميع الآثار المترتبة على التكاليف والوقت والعملاء غير الراضين.

تم اعتماد المنهج الكمي والنوعي. بالنسبة للبيانات التي تم الحصول عليها من خلال الطريقة الكمية، تم تحليل فرضيات البحث لهذه الدراسة باستخدام اختبار ارتباط بيرسون من خلال الحزمة الإحصائية للعلوم الاجتماعية.

أظهرت النتائج أن هناك علاقة ارتباط ذات دلالة إحصائية بين أداء مصانع الخلطات الخرسانية في المحافظات الشمالية وتطبيق منهجية ستة سيجما باستخدام أداة DMAIC ، من ناحية أخرى، تم الحصول على البيانات النوعية لهذه الدراسة من خلال مقابلات غير منظمة.

أشارت النتائج المستخلصة من هذه الدراسة إلى أن مصانع الخلطات الخرسانية في المحافظات الشمالية تتمتع بمستوى عالٍ من تطبيق أداة DMAIC خاصة المصانع الحاصلة على شهادة الأيزو.

أظهرت معظم النتائج مع الدراسات السابقة والنظريات ذات الصلة ونماذج الجودة أن تطبيق منهجية ستة سيجما باستخدام أداة DMAIC لعبت دورًا فعالًا في التأثير على أداء المؤسسات.

وأخيرًا توصي الباحثة أي مصانع أو منظمات بتطوير عملياتها من خلال منهجية ستة سيجما وذلك لأثرها في تحسين أداء المصانع والمؤسسات.

الكلمات المفتاحية: منهجية DMAIC، ستة سيجما، مصانع الخلطات الخرسانية، أداء المؤسسة.