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Quality Management Practices of Construction Project Teams in Concrete Works

by

Samuel Abdulai Yelibora (BSc Civil Engineering)

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MASTER OF PHILOSOPHY

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DECLARATION

I hereby declare that this submission is my own work towards the MPhil Construction Management and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of any University, except where due acknowledgement has been made in the text.

Samuel Abdulai Yelibora (PG 1748414)

…………………………..
Signature

………………………….
Date

Certified by:

Professor Bernard K. Baiden
Supervisor

…………………………
Signature

……………………………
Date

Certified by:

Dr. Theophilus Adjei-Kumi
Head of Department

………………………….
Signature

…………………………..
Date

ABSTRACT

The use of concrete in the Construction industry is widespread. However, several cases of deterioration of concrete structures associated with the lack of durability is a major cause of concern worldwide. The cost involved in restoring or replacement of these structures runs into millions of dollars. Poor quality concrete has been blamed on workmanship and ultimately poor Quality Management Practices. This research delved into the quality management practices of construction teams in concrete works. The aim of the research was to explore the nature and scope of quality management practices adopted by construction teams in concrete works. The objectives included the identification of current quality management practices used by construction teams in concrete works and an assessment of their knowledge on factors considered as basic but very important in the production of durable concrete. Other objectives were to assess the perception by Construction Project teams of the critical success factors in the implementation of total quality management in concrete works, and finally to propose a framework for quality management practice in concrete. A structured questionnaire survey was used to collect data from Construction Project teams namely; Project Managers, Project Engineers, Site Engineers, Clerk of works and Quality Control/Assurance Managers of D1K1 Contractors. The data collected was analyzed using descriptive statistics, One sample t-test and factor analysis. Analysis of the data revealed that most of the D1K1 contractors did not have a formal quality management system nor were they ISO certified. They however practiced several elements of these systems. The use of quality control/assurance tools were limited and not effective. The respondents had a narrow definition of what quality concrete was.

The perception of the importance of some identified critical success factors for implementing Total Quality Management was however, found to be high. Implementing a formal quality management system will improve the durability and quality of concrete works. The study was limited to D1K1 contractors who are members of the Association of Building and Civil Engineering Contractors of Ghana and focused on in-situ concrete works at the Construction site. It brought to the fore the need for top management to be involved in concrete works in order to achieve quality concrete and also organize regular training for professionals involved in concrete works.

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DEDICATION

This work is dedicated to my lovely family and to the memory of my late father Yelibora Antunmini

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The use of concrete in the building and construction industry is widespread as a result of its versatility, high strength and durability. Concrete remains the most widely used artificial material on earth (Lomborg, 2001). According to the Cement Association of Canada, twice of it as much as the total of all other building materials, amounting to about 3.8 billion cubic metres globally every year (Ecosmart Concrete, n.d.).

In the advent of democratization and favorable prospects of oil and gas, Ghana has witnessed a significant foreign direct investment. The construction and services sector account for more than 50% of Nation’s output (Granado, 2015). For this reason, massive infrastructural developments in Ghana, the country is witnessing a lot of high rise buildings, mostly reinforced concrete structures. However in spite of the popularity of concrete structures, if it is not properly constructed and maintained, it can deteriorate prematurely which is often referred to as our “crumbling infrastructure” (Meyer, 2002). Many concrete structures have suffered a lack of durability which has a consequence on the resource productivity of the industry (Mehta, 2004). Gambhir (2013) has asserted that over the past decade a good number of concrete structures have exhibited signs of distress even though they are within their design life which he attributed to lack of durability considerations. He adds that, the cost incurred in restoring these structures could have been avoided if quality control measures had been applied.

In Ghana there are several reports of concrete structures failing whilst still under construction (Bediako, 2015; Joy online, 2002; Graphic Online, 2014; Smith-Asante, 2015), and across the sub region notably in Nigeria, several cases of concrete structural failures have been reported (Anosike, 2011).

Amongst the causes of these failures are the quality of the concrete and poor supervision (Anosike, 2011; Boampong, 2015).

Neville & Brooks (2010) asserts that the large incidence of failure of concrete structures such as buildings, bridges, pavements and runways in recent years is an indication that the professionals in the industry do not always know enough about concrete. This is in spite of the fact that research in the past 30 years in concrete is said to be far more than the previous 150 years, as a result of which there is an unprecedented knowledge in the production of concrete of desired properties and strength (Meyer, 2002). Poor quality control of input materials, improper batching and mixing, inadequate training and management of construction team members can all lead to poor quality concrete (Naiknavare *et al*., 2012).

The right materials needed to constitute good concrete is well known, however, merely selecting the right aggregates do not guarantee quality even though it is essential (Nawy, 2008). Thus, several factors affect the quality of concrete which must be well understood and practiced in order to achieve quality concrete. If not properly mixed and placed, the life span gets affected, thus deteriorating prematurely (Meyer, 2002). Also the climate, temperature and exposure conditions have effect on the durability of the concrete (Neville & Brooks, 2010).

Construction team members play different roles to achieve a successful project. In concrete production, it is important for the construction team members, who may not be specialist in concrete, to fully understand concrete technology. The Site Engineer may for instance use knowledge of concrete technology in the construction of foundations, retaining walls etc. (Neville & Brooks, 2010).

Quality management practices have proved successful in the manufacturing industry and most of the literature is written in a factory vernacular. However, any organization that depends on success for survival can adopt same. The construction industry, however, has some significant differences compared to the manufacturing sector. This presents some further challenges. Construction companies can also reap some success if these quality management practices are adopted (Ashford, 1989). Quality management in construction implies maintaining and ensuring that the required standards are achieved so as to meet customer satisfaction that will eventually bring about sustained competitiveness and financial survival (Tan & Abdul Rahman, 2005).

Several definitions of quality exist in literature. Juran & Gryna (1980) defined quality as "fitness for use". According to Ashford (1989) from the engineering perspective "quality conveys the concept of compliance with a defined requirement of value for money, of fitness for purpose or customer satisfaction". It follows that to achieve quality for a product, certain basic dimensions of quality will need to be fulfilled.

There exist a lot of literature on the parameters for quality concrete, its production and placement (Chudley & Greeno, 2008; McCormac & Nelson, 2006; Shetty, 2005; Neville & Brooks, 2010). The literature also abounds in management practices necessary for the success of projects (Ashford, 1989; Garvin, 1984; Pyzdek & Keller, 2013; Juran & Godfrey, 1999). Additionally, there are guides on quality management for concrete works such as ACI 122R and ISO 9001. However, not much can be found in the literature with specific reference as to the application and adoption of these management practices in concrete construction by project teams in Ghana.

1.2 STATEMENT OF PROBLEM

The incidence of lack of durability and defects occurring in concrete structures subsequently resulting in huge cost incurred in their repair or replacement is a matter of public concern.

The lack of durability is perceived as a threat to the glorious future of concrete by the public (Mehta, 1997). To the Engineer and designer, durability poses severe constraints (Davidovits, 1988). Durability or deterioration of concrete has been widely researched Litvan & Bickley (1987): Gerwick (1989): Khanna *et al* (1988): Shayan & Quick (1992) as cited by Mehta (1997) and several factors have been attributed to the lack of durability. However, Allen, (2005) notes that the immediate mechanism may be due to chemical reactions or corrosion of the reinforcement but in a majority of the cases the fundamental cause can be traced back to poor workmanship or unrealistic detailing. Tasker (1985) has also asserted that most defects in concrete are caused by ignorance of the correct use of the constituents, lack of adequate concrete cover and curing requirements. This brings to the fore the quality management practices adopted by construction teams in concrete construction or works.

In the manufacturing sector, the concept of quality management is widely used and relatively old as compared to the concrete construction industry. Because concrete performs fairly well for a reasonable period of time without much application of rigid quality management, most in the industry have a misconception of its importance. Thus, in spite of the great benefits of this culture, developing countries are yet to enjoy it (Gambhir, 2013).

The concept of quality has transitioned from quality inspection, quality control, quality assurance and finally, total quality management (Dahlgaard *et al*., 2007). It emphasizes on teamwork to improve on quality output and satisfaction of the customer (Oberlender, 2000). The queries arising is whether construction team members are aware of these quality management techniques that can be applied in concrete works in order to achieve quality and durable products

1.3 RESEARCH QUESTIONS

1. What parameters influence the production of durable quality concrete?
2. How is quality management being practiced by construction team members in concrete construction?
3. What are the perceptions of construction team members in quality management practice of concrete works?
4. What are the quality management tools and techniques applied?
5. What are the causes of poor quality concrete with respect to durability?

1.4 AIM

To explore the nature and scope of quality management practices in concrete works in Ghana among construction team members on construction sites.

1.5 OBJECTIVES

1. To identify the parameters for quality durable concrete construction.
2. To assess the knowledge of construction team members with regards to the basic requirements for durable concrete works
3. To identify current quality management practice in concrete works
4. To assess how Project teams, perceive the factors necessary for successful quality management practice in concrete works
5. To propose a framework for quality management practice in concrete works

1.6 SIGNIFICANCE OF STUDY

The annual cost for repairs of concrete in the USA is estimated at between 18 and 21 billion US dollars (International Concrete Repair Institute, 2006). In India over 7 billion US dollars is lost due to distress of concrete (Bhanumathidas & Kalidas, 2002). This indicates that the life cycle cost can be very high if quality issues are overlooked.

The advent of new technology and the utilization of certain materials has improved the service life of concrete to over thirty years, but advantage is not being taken of these technologies, additionally these new technologies have little tolerance of workmanship and design errors (International Concrete Repair Institute, 2006).

Quality management has become an important pillar for the existence or success of Construction Companies having transitioned from a reactive nature to a strategic business function (Harris *et al*., 2013). With the collapse of a structure or rejection by the customer, there is loss of human lives for which the company is liable, loss of profit and future opportunities to the company and the Client also suffers. The life cycle cost as a result of poor quality concrete is also prohibitive. Good quality management practices will subsequently lead to profitability. According to Juran and Deming's 1964 work (cited in Ashford, 1989), the cost incurred in education and training for quality is rewarded many times by an increase in output, efficiency and profitability. The current trend of international competition will eventually drive out poor quality firms and only the best will survive. This research is therefore important as it will bring to the fore; emerging trends in quality management practices applicable to concrete works. Quality management practice will lead to safe, cost effective structures with a low maintenance cost (Ozyildirim, 2011).

1.7 RESEARCH METHODOLOGY

This research was based on a quantitative survey approach. A closed ended structured questionnaire based on a thorough research of literature was employed to collect the required data. It was designed so as to elucidate answers to the aim of the research. To achieve the research aim, the following objectives were set as follows:

Objective one; identifying the factors necessary for achieving durable quality concrete. This was resolved from the literature review. Knowledge of factors necessary for producing quality durable concrete.

Objective two; to assess the knowledge of construction team members with regard to the basic factors in producing durable concrete. This was achieved from the section B of the questionnaire, where respondents were required to rank certain factors and also asked questions on quality management practices. Mean score ranking was used to analyze this section.

Objective three; this was to identify the current quality management practices adopted by respondents' firms. Section C of the questionnaire was used to answer this objective.

Objective four; this section assessed the perception of respondents on the critical success factors for total quality management. Respondents were questioned on these factors. One sample t-test was used to analyze their responses.

Objective five; this was resolved by a proposed framework drawn largely from the critical success factors (CSF) adopted from literature and the short comings observed from responses to the questionnaire.

As a result of the huge amount of data collected from respondents, SPSS version 23 was used for the analysis in the following areas

- One sample t-test
- Descriptive statistics
- Cross tabulation
- Factor analysis

Factor analysis was used to verify the construct validity of the questionnaire instrument as to whether it was measuring what it was intended to and Cronbach's alpha for the reliability of the responses

The sample frame consisted of (D1K1) Contractors who were registered members of the Association of Building and Civil Engineering Contractors of Ghana based in the Greater Accra Region. A simple random sampling was used to select the Contractors and Subsequently, a purposive sampling was used to select the targeted team members namely Site Engineers, Project Engineers, Project Managers Site Supervisors and quality Managers. In-situ concrete works at site was the focus of this research.

The questionnaires were distributed to 85 respondents based on the use of the Kish formula in selecting the sample size.

1.8 SCOPE/DELIMITATION

This study considered only in-situ concrete works at the construction site. This is because ready mixed concrete is more likely to undergo more rigorous quality control checks at the point of production compared to that at the site. The study was limited to D1K1 contractors in the Greater Accra Region of Ghana. This is because the Region has the highest concentration of D1K1 Contractors in the Country. The Greater Accra region is also a microcosm of the entire Country. The choice of D1K1 Contractors was chosen because they often employ highly trained professionals on a long-term basis compared to the other classes. They are better organized and have the capacity to adopt quality management practices.

1.9 STRUCTURE OF REPORT

The research work consisted of five chapters, namely: Chapter one consisted of an introduction, a background to the study, statement of problem, aims and objectives, research questions and scope of research and significance of the study. Chapter two consisted of the literature review on an overview of concrete works and quality management. Chapter three addressed the philosophical stance of the researcher and the methods used; research design, sampling technique and the data collection methods adopted. Chapter four involved data presentation and analysis of the work whilst Chapter five was on recommendations and conclusion

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is divided into three sections: the first section looked at the concept of quality, the various definitions and theories, its evolvement and the current trends. The second section was a brief review of concrete whilst the final section delved into quality management of concrete works.

2.2 QUALITY

Several definitions exist for quality and non is universally accepted as the ultimate. (Pyzdek, 2003). The definition of quality in the construction sector is different from that of the manufacturing sector. This is as a result of construction not being repetitive in nature compared to manufacturing or the service sector (Rumane, 2011).

ISO (1994a) cited by Chung (1999) defines quality as “the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs”.

Other well-known gurus have defined quality as shown in Table 2.1 below (cited in Rumane, 2011. p7):

Table 2.1: Definitions by Quality Gurus

1. Philip B Crosby	"conformance to requirements"
2. W. Edward Deming	"quality should be designed into both process and product".
3. Armand V. Feigenbaum	"best for customer use and selling price".
4. Kaoru Ishikawa	"Quality of the product as well as after-sales service, quality of management, the company itself and the human being".
5. Joseph M Juran	quality is fitness for use".
6. John S Oakland	"quality is meeting customer's requirements".

Source;(Rumane, 2011. P.7)

Chung (1999 p.8) has summarized the above definitions as follows;

- "Meeting the customer's needs".
- "Fitness for use".
- "Conforming to requirements".

Juran & Gryna (1980) asserts that, there are wide variety of multiple elements to satisfy the "fitness of use", which are known as quality characteristics. The authors add that these can be categorized into parameters of fitness for use and two of the major parameters are quality of design and quality of conformance.

In the construction industry, the client is not the only customer to satisfy in terms of contractual obligations and conformance to requirements but also other users of the facility, with varying needs; this makes the definition of quality difficult (Chung, 1999).

Chung (1999) defines quality in construction as achieving all contractual and regulatory requirements within the budget and schedule.

Garvin (1984) has outlined five approaches to define quality shown in table 2.2 as follows:

Table 2.2: Approaches to quality Definition

1. The transcendent approach"
2. "The product-based approach"
3. "The user-based approach".
4. "The manufacturing-based approach".
5. The value-based approach".

According to Garvin (1984), the different definitions of quality all fall under one of the above approaches and account for the differing views/perceptions of quality by different departments of an organization or different people.

2.2.1 DIMENSIONS OF QUALITY

Garvin (1984) also identified eight dimensions of quality which are shown in Table 2.3 as follows:

Table 2.3: Dimensions of Quality

1. “Performance
2. Features
3. Reliability
4. Conformance
5. Durability
6. Serviceability
7. Aesthetics
8. Perceived quality”

Source: Garvin (1984)

These dimensions of quality have either complementary or competing attributes with each other and Garvin (1984) argues that these dimensions can be used strategically by organizations to make Companies competitive.

2.2.2 QUALITY MANAGEMENT

It is described by the American Society of Quality (ASQ) as cited in Rumane (2011p.24) as “the application of quality management system in managing a process to achieve maximum customer satisfaction at the lowest overall cost to the organization whilst continuing to improve the process”.

The concept of quality management which emerged after the Second World War strives to develop initiatives which engages the entire workforce in a systematic way so as to achieve quality. Extension of these concepts led to the development of total quality management (TQM). Thus quality has transformed through different stages from inspection, quality control, quality assurance and TQM (Rumane, 2011).

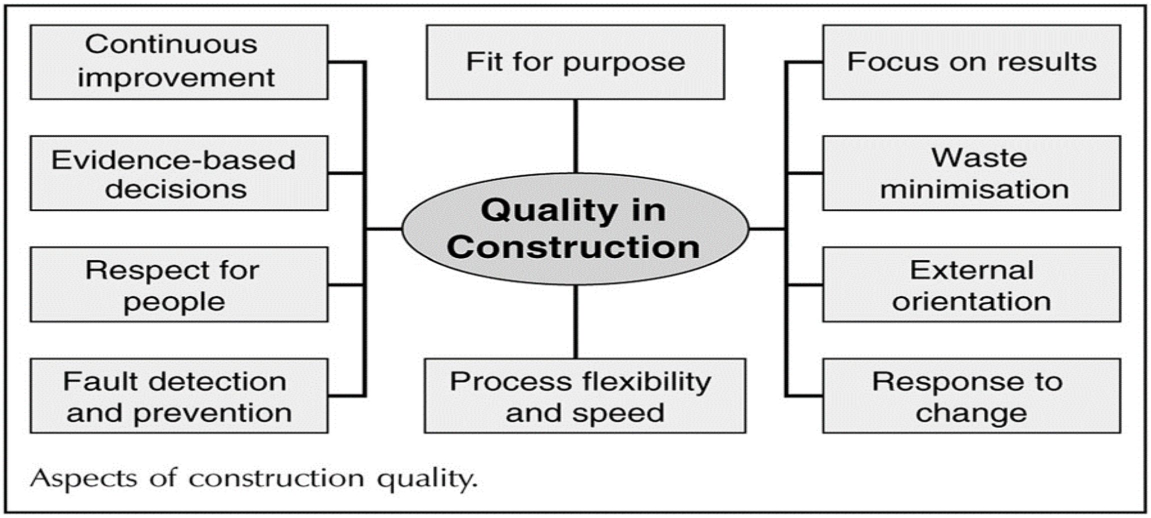
In the Construction industry, quality management is defined as maintaining a quality standard that meets customer satisfaction (Chin-keng & Hanuzah, 2011) and which subsequently make the Company financially viable to survive competition in the market; thus it leads to long term competitiveness and survival of organizations (Harris *et al*., 2013; Chin-keng & Hanuzah, 2011; Juran & Godfrey, 1999).

The use of quality management concepts has an influence on the cost effectiveness of projects and yields positive results in terms of project performance and this view is supported by research (Rumane, 2011).

Project Management Institute (2013) have three sub-divisions for quality management:

- Quality Planning
- Quality Assurance
- Quality Control

The main feature of these processes is the concept of continuous improvement which is referred to as PDCA- Plan – Do – Check – Act. Harris *et al*. (2013) illustrate this in the construction industry as shown in Figure 2.1



|Figure 2.1; Aspects of Construction Quality

Source: Harris *et al*.(2013 p.67)

2.2.2.1 QUALITY PLAN

It is a document specifying quality activities and the resources a project requires; drawn from the quality system, the contract documents and includes training requirements of employees, inspection and quality procedures. Quality plan is usually undertaken before construction activities commences. It is undertaken in conjunction with other project planning activities such as selection of sub-contractors and suppliers, determination of construction methods etc. It is updated periodically to reflect contractual requirements and other changing circumstances (Chung, 1999).

2.2.2.2 QUALITY CONTROL AND QUALITY ASSURANCE

Quality control/quality assurance is sometimes wrongly used synonymously with each other (Fick *et al*., 2012). As a result of the confusion between quality assurance and control, one cannot be certain of what quality assurance in a company is unless the activities represented by the term are determined (Juran & Gryna, 1980). Certain industries have viewed quality control as a Contractor responsibility and quality assurance as the Consultant's responsibility (Fick *et al*., 2012), however a more comprehensive approach is to consider quality control as an element of quality assurance (Fick *et al*., 2012; Oberlender, 2000). This is illustrated in Figure 2.2

Figure 2.2; Relationship between Quality management, Assurance and Control.

Source: (Bennett, n.d.)

In the early days of the international standards organization (ISO), work was done to harmonize internationally, the meanings and terms such as quality assurance and quality control. ISO 9000 (2005 p.9) defines quality assurance as:

"part of quality management focused on providing confidence that quality requirements will be fulfilled" and quality control as "part of quality management focused on fulfilling quality requirements".

ACI 121R-08 (2008) defines quality assurance as;

"*actions taken by an organization to provide and document assurance that what is being done and what is being provided are in accordance with the contract documents and standards of good practice for the work' whilst quality control is defined as 'actions taken by an organization to provide control and documentation over what is being done and what is being provided so that the applicable standard of good practice and the contract documents of the work are followed"*

Quality control and quality assurance has a lot in common, each of them compares and evaluate performance to the objectives. The difference however lies in the fact that quality control maintains control and the comparisons are made during the operation phase; any results received is used in operations. Quality assurance on the other hand verifies that control is being maintained and performance is measured after the operations have ended. The results achieved is used both by the operations team and others who may need to know such as management (those not directly involved in the operations but who need to be assured that all is well) (Juran & Godfrey, 1999).

Quality assurance can be compared to an insurance policy where each involves expenditure of a small sum to secure protection against a bigger loss. In the case of quality assurance the protection against loss is the early warning that helps to avert a bigger loss (Juran & Godfrey, 1999)

According to the Project Management Institute (2013) control of quality process makes use of tasks and operations to ensure that the products meet requirements; it is used during the execution and closing phases to demonstrate with relevant data that the customer's acceptance criteria have been met. Quality assurance on the other hand is used during planning and execution stages to provide confidence that customer's requirements will be met. Kerzner (2009) asserts that quality assurance includes external efforts to the processes that provide information for improving the internal process; this function attempts to integrate scope, time and cost functions of projects.

Quality control activities eliminates or prevent causes of unsatisfactory performance during production; it controls incoming material; monitors production process and tests finished products (Chung, 1999).

According to Chung (1999), the guiding principle of quality assurance is “doing it right the first time, every time”. He asserts that quality assurance has been Client led in the construction industry, but there are obvious benefits for the Contractor. He adds that there is a general move towards making the implementation of a quality system a contractual requirement, therefore the basis for competition will shift from price only to a combination of quality and price. Quality assurance starts with the Client defining the requirements which are specified in the drawings and specifications and for a quality based contract, the supervision and verification shifts to the Contractor, but the client reserves the right to monitor verification, he notes.

2.2.2.3 QUALITY SYSTEM

“A quality system is a framework for quality management and it embraces the organizational structure, processes, procedures and resources needed to implement a quality management system” (see ISO, 1994a as cited in Chung, 1999).

Its purpose is to satisfy the requirements of quality management and assuring customers of the quality of the products. The features of the framework are as follows (Harris *et al.*, 2013); Policies, plans, functions, processes, resources, responsibilities, authorities and relationships.

A quality system must cover all the activities leading to the finished product such as planning, design, development, purchasing, production, inspection, storage, delivery and after sales services (Chung, 1999)

Establishing a quality system puts the house in order by clarifying every one's responsibility, putting the current practices into writing and ensuring that they are adhered to at all instances. For instance a common task of inspecting material before usage is recorded any time it is undertaken (Chung, 1999). This concept is illustrated in Figure 2.3.

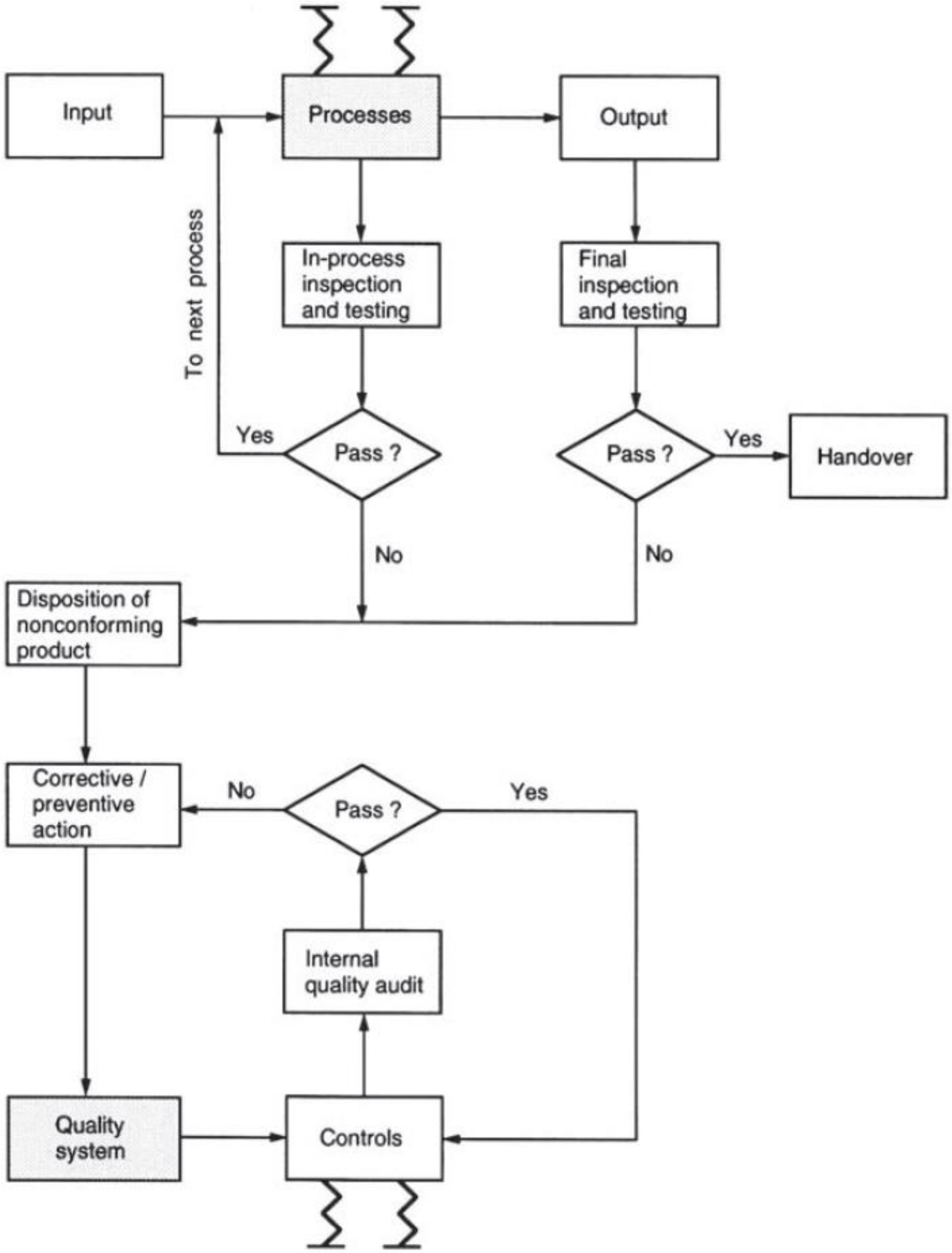


Figure 2.3;Integration of quality system with operational processes

(Pyzdek, 2003 p.12)

2.2.2.4 QUALITY STANDARDS

Pyzdek, (2003p.203) defines a standard as;

"Documents used to define acceptable conditions or behaviors and provide a baseline for assuming that conditions or behaviors meet the acceptable criteria".

He asserts that standards define the minimum criteria which is different from world-class quality. The quality system standard is used to judge the adequacy of a quality system (Chung, 1999).

Different entities and nations had their own quality standards by which they measured the quality systems of others. The disadvantages of this system was overcome by the adoption of the ISO standard internationally (Pyzdek, 2003).

Sullivan's 1983 work (cited in Pyzdek, 2003) list some of the benefits of the international standards organization (ISO) as follows;

- Educate: it sets ideals for the guidance of manufacturers and customers. Helpful to the new entrant manufacturer and the naïve user purchasing the product
- Simplify: minimizes overhead costs by reducing number of sizes, the variety of processes, paperwork and stocks.
- Conserve: by enabling the large-scale production of standard designs, better tooling as a result, and more careful design minimizing the production of defective products and surplus pieces which leads to cheaper cost of production.

- Certification: it allows for certification by third party. The trade mark serves as an inestimable value for advertising.

The ISO 9000 family of standards was produced in 1987. It is made up of the following standards ISO 9000; ISO 9001; ISO 9002; ISO 9003 and ISO 9004. Each of these cater for a peculiar area of quality; thus, ISO 9001, ISO 9002 and ISO 9003 are for contractual, assessment or certification use. ISO 9000 and ISO 9004 are used as guidance to the use of the other standards in the family. In the construction industry ISO 9001 and ISO 9002 are the ones used. The former is suitable for companies that are involved in design and construct projects whilst the latter is suitable for only construction phase (Chung, 1999). The flexible nature of the ISO 9000 family of standards allows organizations to develop their own policies and procedures based on this framework (Harris *et al*., 2013).

Adopting an international standard at the beginning of a Project is beneficial to the organization(Chung, 1999);

- It ensures that quality assurance activities are not missed
- It reveals the deficiencies in the current practices
- It allows third party certification which is essential for organizational survival

Figure 2.3 illustrates how the ISO quality management system is structured.

The quality activities consist of the determination of the quality policy, objectives and responsibilities which are implemented with the quality system through quality management tools such as quality assurance, quality control and quality improvement (ASQC, 1997).

2.2.2.5 QUALITY POLICY

Management has the responsibility of defining and documenting the policy objectives for quality and their commitment to it; which should be understood and implemented (ANSI/ASQC Q9001, 1994).

2.2.2.6 QUALITY PLANNING AND QUALITY MANUAL

The quality planning defines, documents and identify which quality standards, processes, resources and procedures are required to achieve the quality objective. The quality manual makes references to the procedures to be applied in the quality system. Figure 2.4 illustrates this point.

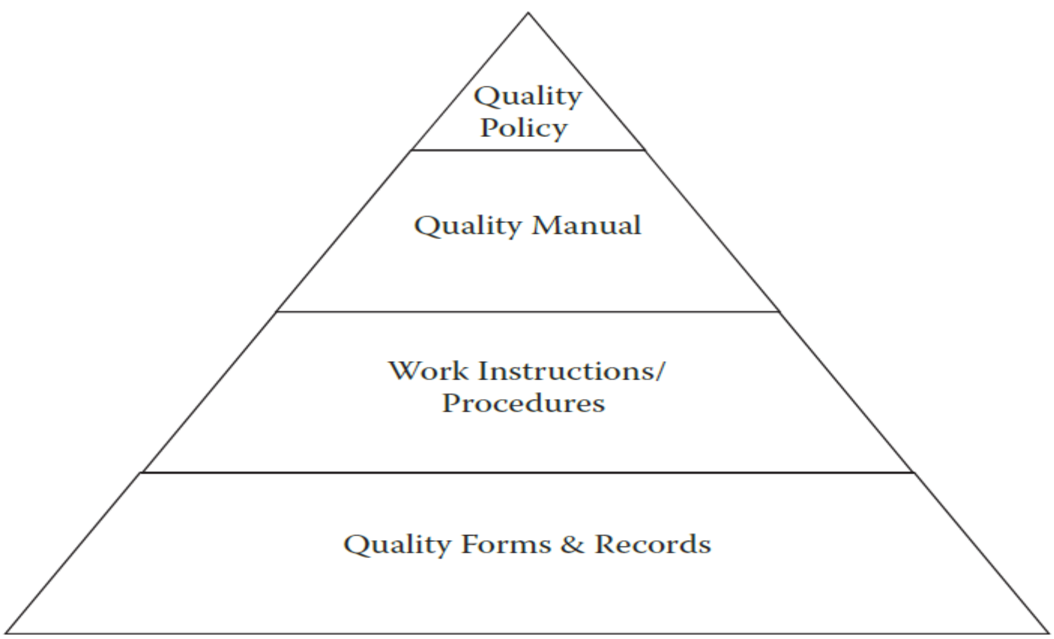


Figure 2.4; ISO Quality management system pyramid.

(Rumane, 2011 p.107)

2.2.3 TOTAL QUALITY MANAGEMENT (TQM)

Total quality management(TQM) is defined as a top-management-led process aimed at involving all employees in order to continuously improve the performance of all (Harris *et al*., 2013).

According to ASQ as cited in Rumane (2011 p.52) TQM is defined as;

"A management approach centered on quality, based on organization-wide participation, and aimed at long-term success through customer satisfaction*"*.

TQM brings about an organizational culture and climate and it is not about inspecting the quality of products after they are complete. It permeates the whole organization and its philosophy is "doing it right the first time" (Singh *et al*., 2011). It acts as an umbrella for continuous improvement, employing principles, tools, techniques and, incorporating quality assurance to achieve the goal of satisfying the customer (Harris *et al*., 2013).TQM is considered a process-oriented philosophy which contrast with quality management practices of the past which was more of product oriented; however some authors regard the two as the same (Mehra & Agrawal, 2006).

Proponents of TQM argue that, its implementation will result in several benefits such as: improved services to customers, competitive and financial survival, increased returns of the shareholder investments, better quality and safety, shorter project duration and lower costs, better utilization of talents of the people and improved products, (Dahlgaard *et al*., 2007; Mehra & Agrawal, 2006; Harris *et al*., 2013; Arditi & Gunaydin, 1997; Walton, 1986).

However, critics disagree that TQM leads to improved financial performance. Others raise the obstacles to implementation such as retraining cost, time consumed by management, prioritizing process over results, unrealistic demand to address the needs of small firms Naj (1993); Fuchsberg (1992a, 1993b); Shaffer & Thomson (1992) as cited in Powell (1995). A considerable number of firms have failed trying to implement TQM (Douglas & Judge, 2001) and it takes time to yield positive results; it may take up to five years according to Luft (2007) as cited in (Singh *et al*., 2011).

Powell (1995), asserts that empirical evidence shows considerable variability in TQM performance impact, he relies on resource-based theory to argue that different firms have resource heterogeneity which implies that, what may work for one firm may not for the other or may not be replicated.

Powell (1995) concludes that for operational excellence to be consistent, firms must focus their attention on quality principles, executive commitment, open organization and employee empowerment rather than imitating TQM methodologies such as benchmarking, training, flexible manufacturing, process improvement and improved measurement. He adds that an environment that allows TQM to thrive is better.

Young (1992) also argues that one cannot adopt quality practices successfully if current employees lack discipline, team orientation, cultural and demographic homogeneity, but rather prefer work rules, reject training and are not accustomed to linkages between performance and compensation.

2.2.3.1 PRINCIPLES OF TQM

Deming, Juran and Crosby used different paths for the achievement of TQM as shown in Table 2.4. they all however gravitate towards the following areas (cited in Aghazadeh, 2006):

- Leadership
- Human resource
- Strategic Planning

Table 2.4 Popular Perspectives on TQM

DEMING'S 14 POINTS[1]	THE JURAN TRILOGY[2]	CROSBY'S 14 QUALITY STEPS[3]
1. Constancy of Purpose	I. *Quality Planning*	1. Management commitment
2. Adopt the Philosophy	Set goals	2. Quality improvement teams
3. Don't rely on mass inspection	Identify customers and their needs	3. Quality measurement
4. Don't award business on price	Develop products and processes	4. Cost of quality evaluation
5. Constant improvement	II. *Quality control*	5. Quality awareness
6. Training	Evaluate performance	6. Corrective action
7. Leadership	Compare to goals and adapt	7. Zero-defects committee
8. Drive out fear	III. *Quality improvement*	8. Supervisor training
9. Break down barriers	Establish infrastructure	9. Zero-defects day
10. Eliminate slogans and exhortations	Identify projects and teams	10. Goal-setting
11. Eliminate quotas	Provide resources and training	11. Error cause removal
12. Pride of workmanship	Establish controls	12. Recognition
13. Education and retraining		13. Quality councils
14. Plan of action		14. Do it over again

Sources: 'Walton (1986); 2 Juran (1992); 3 Crosby (1979), cited in (Powell, 1995 p.18)

(Dahlgaard *et al*., 2007) list five principles of TQM as;

- “Management’s commitment (leadership)”
- “Focus on the customer and employee”
- “Focus on facts”
- “Continuous improvement”
- “Every body’s participation”

These principles are illustrated in Figure 2.5 below;

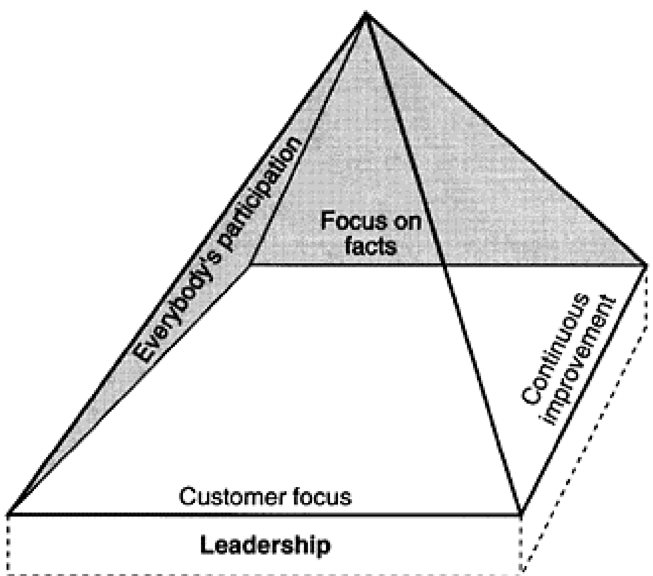


Figure 2.5; The TQM Pyramid

Source: (Dahlgaard *et al*., 2007p.18)

Similarly, the Construction Industry Institute’s 1990 report (cited in Oberlender 2000) identifies customer satisfaction and continuous improvement as ingredients for TQM. The report goes further to list the elements that support these basic requirements as shown in table 2.2 below;

Table 2.5: List of Critical Success factors

1	Management commitment and leadership
2	Training
3	Teamwork
4	Statistical methods
5	Cost of quality
6	Supplier involvement
7	Customer service
8	Management commitment and leadership

Source:(CII Report, 1990 cited in Oberlender, 2000)

Figure 2.6 illustrates how continuous improvement can be undertaken through the Plan-Do-Check-Act.

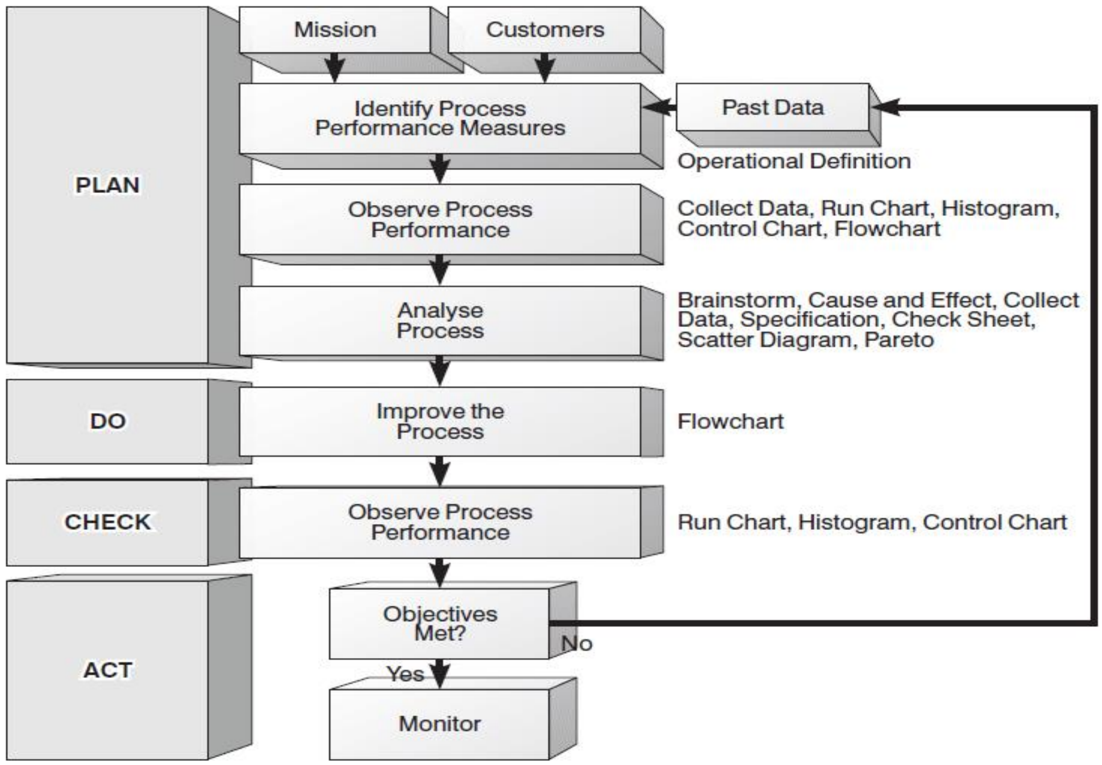


Figure 2.6; Plan-Do-Check-Act applied to process review

Source:(Oakland, 2003p.440)

Oakland developed a pictorial view of how to implement total quality management which is illustrated in Figure 2.7 (Harris *et al*., 2013).

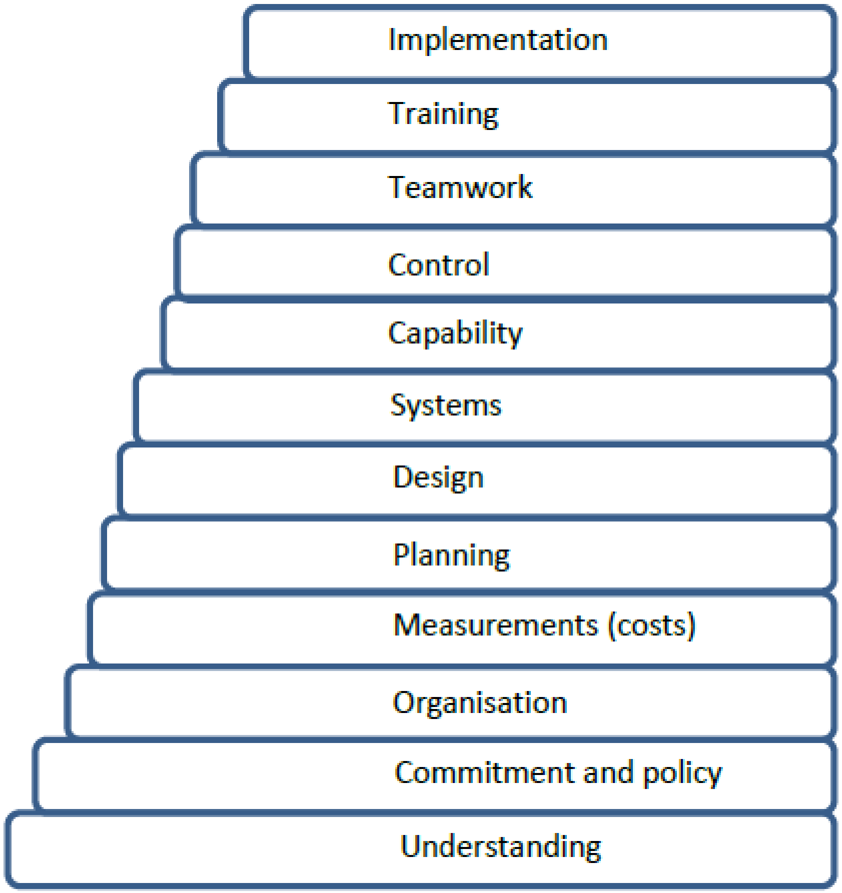


Figure 2.7; Oakland's Steps to TQM

Source: (Harris *et al*., 2013 p.70)

2.2.3.2 QUALITY CHAINS

Company-wide quality improvement in an organization hinges on a series of internal suppliers and customers. And this relation is known as the "quality chains". Each internal supplier must ensure that the next inline of an internal customer receives a product that meets the specified requirements. Failure to meet any of these requirements in the chain leads to more problems which has a multiple effect. Unfortunately the transfer of information between these internal customers and suppliers in an organization is often poor (Oberlender, 2000).

2.2.3.3 TOOLS AND TECHNIQUES OF TQM

Continuous improvement in processes to improve the quality of products is one of the principles of TQM and this is achieved by the ability to identify problems within the process, analyzing them, resolving the problem and also determining the root causes in order to prevent further occurrence (Harris *et al*., 2013; Project Management Institute, 2013). There are several tools and techniques available for undertaking these continuous quality improvement systems in order to implement TQM. Some are simple to use whilst others are more complex and suitable with Companies that have much experience in TQM; thus the more matured or experience a firm is in quality management, the more complex the tools and techniques they tend to use (Dale, 2007; Revuelto-taboada *et al*., 2011).

The simpler tools known as the seven basic tools are (Project Management Institute, 2013):

- Flow chart
- Check sheet
- Histogram
- Scatter diagrams
- Control charts
- Cause and effect
- Pareto analysis

A conceptual example of each of the B7 tools is illustrated in Figure 2.8 below

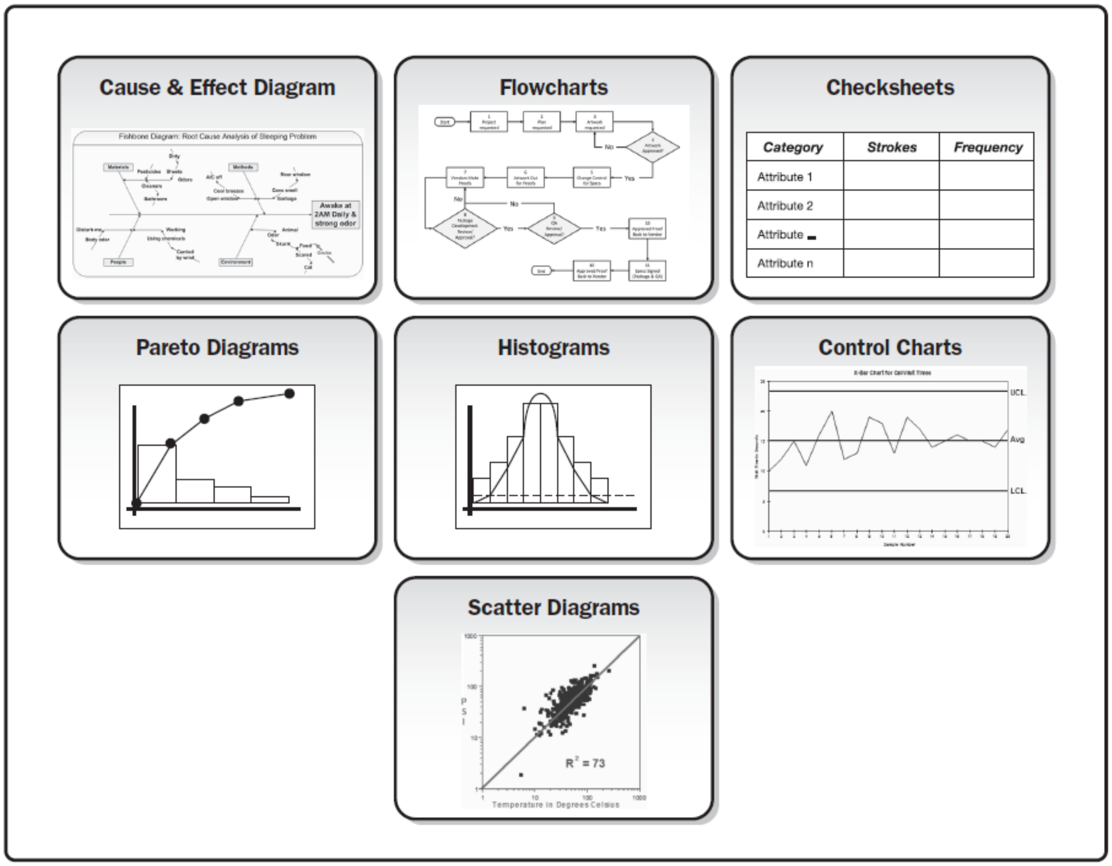


Figure 2.8; Conceptual Example of Each of the Seven Basic Quality Tools

Source:(Project Management Institute, 2013 p.239)

These seven basic tools are best used for data analysis, process control, quality improvements and numerical data. The sequence of usage is shown in Figure 2.9 below

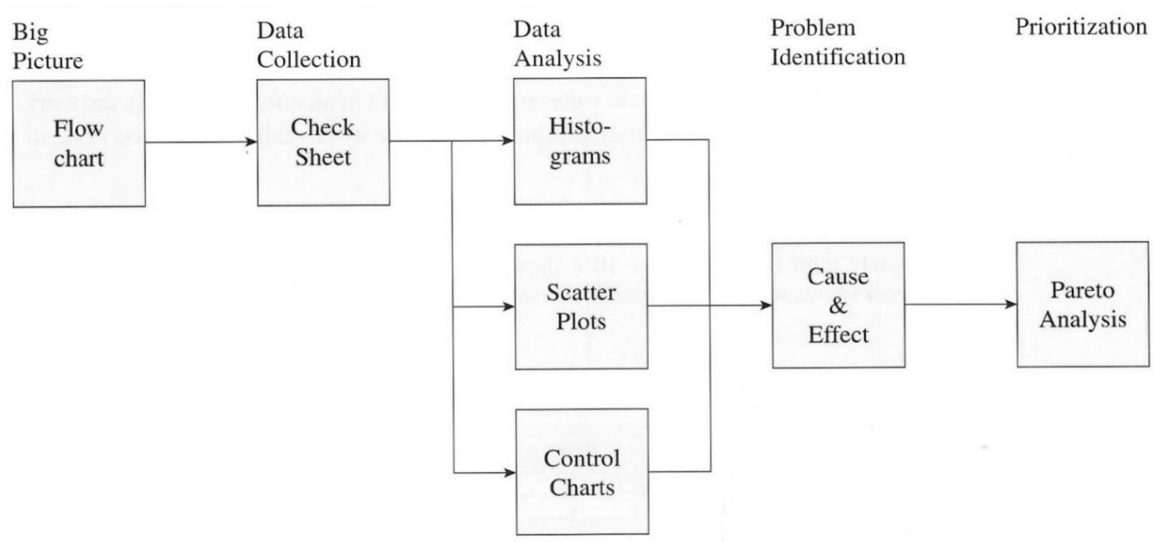


Figure 2.9; Logical order of the B7 tools

Source: Pearson Education Inc.

The new seven tools normally denoted as N7 tools are used for organizing verbal data. They are listed below in Figure 2.10 (Project Management Institute, 2013):

- Affinity diagrams
- interrelationship diagraph
- Tree diagrams
- Activity Network diagram
- Prioritization matrices
- Matrix diagram
- Process decision Program charts

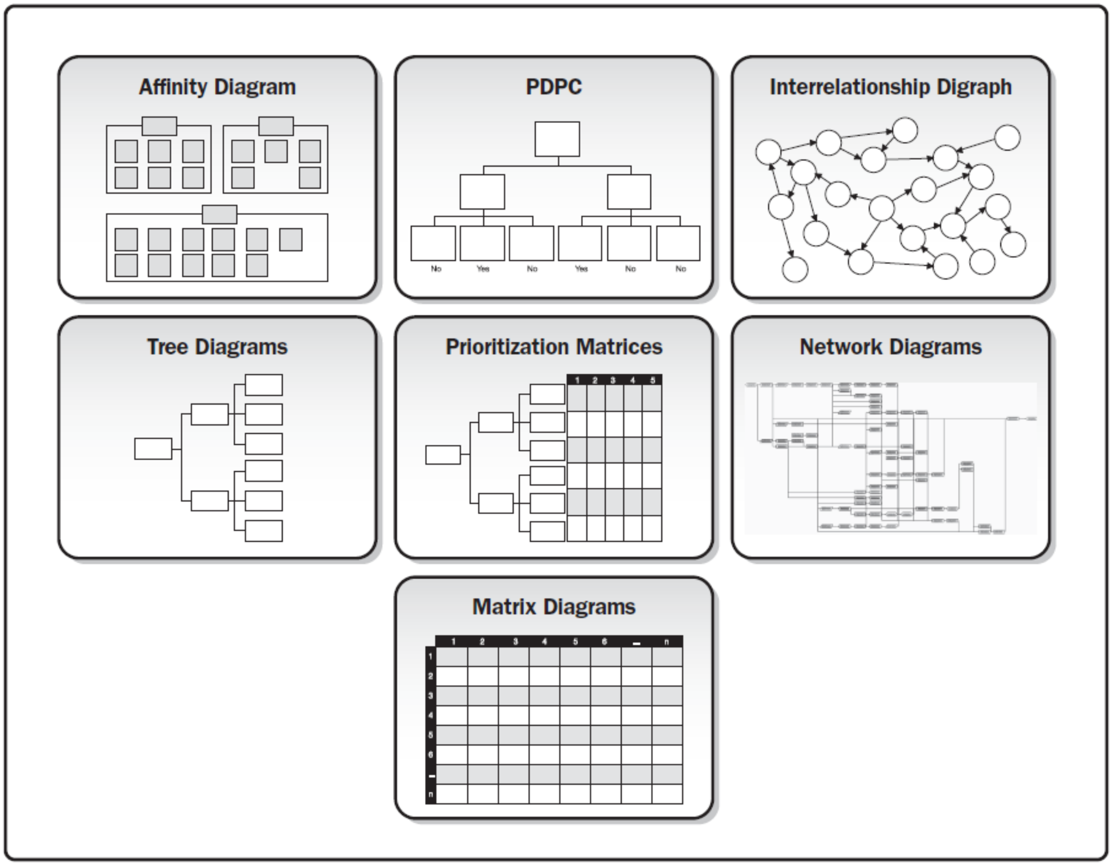


Figure 2.10; Conceptual Example of the N7 Tools

Source: (Project Management Institute, 2013 p.246)

N7 and B7 tools combine effectively to organize and generate ideas. These tools can be used at various stages of the construction process to identify problems, find solutions and institute preventive measures (Rumane, 2011).

Some of the more complex tools are ISO 9001, benchmarking, cost benefit analysis, cost of quality, design of experiments, productive maintenance etc. but it is preferable for firms implementing TQM to begin with the simpler ones mentioned earlier (Dale, 2007).

2.3 AN OVERVIEW OF CONCRETE

2.3.1 CONCRETE

Concrete is a mixture of fine and coarse aggregate bound together by a paste of cement and water, forming a rocklike mass (McCormac & Nelson, 2006; Chudley & Greeno, 2008).

The cement acts as the binder and bonds the other aggregates together after undergoing a chemical reaction with water.

Concrete is weak in tension but strong in compression. Introducing steel into the concrete provides the tensile strength lacking in concrete as steel has a high tensile strength. This composite material is reinforced concrete. (McCormac & Nelson, 2006)

2.3.2 CONCRETE MATERIALS

Concrete basically consist of a binder usually Portland cement, water, and aggregate (fine aggregates and coarse aggregate). Admixtures are sometimes added for particular purposes.

2.3.2.1 WATER

Water triggers a chemical reaction in the cement known as hydration which results in the binding of the aggregates. Water used for mixing concrete must not contain any deleterious material which can interfere with the process of hydration or affect the durability of the concrete. Some of the deleterious substances found in water are carbonate and bicarbonates of sodium and potassium, calcium chloride, inorganic salts, algae, oils, suspended particles, alkalis, acids, salts in seawater etc. Generally, water fit for drinking is suitable for concrete. However, this does not hold true for all cases, that is water that contains a little sugar may be suitable for drinking but not for mixing concrete, the converse is also true (Shetty, 2005). There are standards set as to the limits of acceptable quantities impurities present (Handoo & Puri, 1997).

There is an optimum amount of water required in the making of concrete as too much weakens it and too little inhibits the full hydration process. It is estimated that 38% water of the cement weight will result in a full hydration, whereas above that point will cause capillaries to be formed thus weakening the resulting product(Shetty, 2005). Researchers are unanimous in the use of sea water for un-reinforced concrete but there are divergent views on the use of seawater for reinforced concrete. Whilst one school of thought holds the view that corrosion of the reinforcement bars will occur, a contrary view is that if the concrete is dense and not porous with enough concrete cover corrosion will not occur (Shetty, 2005). Thus, corrosion will occur regardless of the type of water used if the concrete is porous and has inadequate concrete cover.

Water is also used for curing and washing of aggregates. Water used for washing aggregates must be free of impurities that can prevent bonding of aggregates with the cement paste. Similarly, water with considerable amounts of salts, silt etc. should not be used for curing of concrete. The necessary test should be carried out before using water for this purposes (Handoo & Puri, 1997).

For a given strength of concrete, the water content is directly proportional to the cement content. A low water cement ratio gives a better or higher concrete strength in most cases and more water is more deleterious than less cement (Day, 2006)

2.3.2.2 CEMENT

Portland cement remains the most widely used cement and was invented in 1824 by Joseph Aspdin. It is manufactured by mixing and grinding lime and clay and burning in a furnace. Cement has been in use for thousands of years as evidenced in Roman ruins. Some researchers such as Langton and Roy as cited in Davidovits (1988) has asserted that the major difference between ancient cement and modern Portland cement is in the extensive carbonation of the ancient cement. Davidovits (1988), also cites other research works in which cement used more than a thousand years in structures were still intact whereas 40-year-old modern cement showed signs of deterioration.

During the chemical reaction with water about 24% of water by weight of cement chemically reacts with the cement and an additional 15% water is required to fill the gel-pores that forms (Shetty, 2005).

Cement will start setting upon getting in contact with water and so must be stored in such a way so as not to come into contact with moisture.

2.3.2.3 AGGREGATE

Aggregates are chemically inactive granular material which give mass to concrete when bound together by the cement paste (Handoo & Puri, 1997). However according to Shetty(2005); Neville & Brooks (2010) earlier aggregates were once thought as chemically inactive but it is now recognized that certain aggregates undergo a chemical bond at the interface of aggregate and paste. They assert that aggregates reduce shrinkage and due to the larger proportion, they provide in the concrete their impact on the properties of the concrete is significant.

Aggregates occupy 75% of the total volume of concrete. They are comparatively cheaper than the other constituents of concrete and so, as much as possible is desirable in the production of the concrete (McCormac & Nelson, 2006; ACI Committee E-701, 1999).

2.3.2.4 ADMIXTURE

"It is defined as a material, other than cement, water, and aggregate, that is used as an ingredient of concrete and added to the batch immediately before or during mixing" (Shetty, 2005).

2.3.2.5 TYPES OF ADMIXTURES

- Water-reducing admixtures or plasticizers; used to improve workability of the mix
- Retarding admixtures; slows down rate of hardening
- Accelerating admixtures; increases the rate of hardening.
- Water repelling admixtures
- Air entraining admixtures- increases workability whilst lowering water content (Chudley & Greeno, 2008).

2.3.3 FRESH CONCRETE

Fresh concrete is a freshly mixed material which can be molded into any shape, and its properties are determined by the relative quantities of the constituents (Shetty, 2005).

The long term properties of hardened concrete is dependent on the degree of compaction and so it is important that the workability of fresh concrete is such that it can be well compacted, transported and placed without causing segregation (Neville & Brooks, 2010).

2.3.3.1 WORKABILITY

Workability is the amount of useful internal work required to produce full compaction. In practice, it is difficult to measure workability based on this definition. The workability measured is that which is applicable to a particular method adopted (Neville & Brooks, 2010).

Workability of concrete is influenced by; water content, mix proportion, size of aggregate, shape of aggregate, surface texture, grading and the use of admixture (Neville & Brooks, 2010).

100% compaction of concrete mix is required for maximum strength, however the theoretical water-cement ratio determined is not enough to give the mix sufficient workability. That is water has an additional responsibility to lubricate the concrete and provide sufficient workability without causing segregation. The degree of workability required varies according to the type of work and also the method of placement and compaction type used i.e. by hand or vibrator. A comprehensive knowledge of workability is required for the design of a mix and consideration must be given to the mode of transport distance, extent of reinforcement. Understanding of all this will make the operation economical and durable (Shetty, 2005).

Strength of concrete is significantly and negatively affected by the presence of voids; thus, concrete mix must achieve maximum density. Therefore adequate workability is required for complete compaction using a reasonable amount of work under the given condition (Neville & Brooks, 2010).

2.3.3.2 TEST FOR WORKABILITY

The slump test is often used to measure the relative workability of a concrete mix, however according to Day (2006), this is not a good measure of workability albeit an excellent measure of water content for successive concrete deliveries. Neville & Brooks (2010) recommend visual inspection and the use of a trowel to measure workability which is reliable, easy and gets better with experience.

Despite the limitations associated with the slump test it is useful in detecting variability in the ingredients used for the concrete which will then require correction (Shetty, 2005).

2.3.3.3 SEGREGATION

The tendency for concrete to lose its homogeneity and have its constituent materials separated is known as segregation. Good concrete must have all its constituents evenly distributed to form a homogeneous mix (Shetty, 2005; Neville & Brooks, 2010)

2.3.3.4 BLEEDING

Bleeding is a form of segregation described as water gain. It occurs when water which has the least specific gravity moves to the surface. Bleeding occurs in highly wet mix, improper proportioning of constituents and insufficiently mixed concrete. Bleeding causes cavities to be left in the concrete as the water moves up the surface. This makes the concrete porous. Bleeding reduces the resistance to wearing of the surface of the aggregate since the coarse aggregate are absent from that part (Neville & Brooks, 2010; Shetty, 2005).

2.3.4 MANUFACTURE OF CONCRETE

Concrete making is a manufacturing process (Handoo & Puri, 1997) which requires strict adherence to good rules and practices at every stage of its production in order to produce quality concrete and so it is important to be abreast with the good practices or rules to follow (Shetty, 2005).

The stages of concrete manufacture are as follows; batching, mixing, transporting, placing and compacting, curing and finishing.

2.3.4.1 BATCHING

It is the process of measuring the ingredients for mixing the materials to make concrete. Volume and weighing are the two options for batching, however weigh batching is the better of the two (Shetty, 2005).

2.3.4.2 MIXING

The objective of mixing is to coat the surface of all the aggregate particle with the cement paste and to thoroughly mix all the ingredients to achieve a uniform mix (Neville & Brooks, 2010). It must become homogeneous , uniform in colour and have consistency (Shetty, 2005). Two methods are available; hand mixing and machine mixing.

2.3.4.3 TRANSPORTING

In transporting concrete it must be ensured that the mix maintains its homogeneity (Shetty, 2005; Chudley & Greeno, 2008).

2.3.4.4 PLACING AND COMPACTING

Placing and compacting goes hand in hand and it is very important in ensuring strength, impermeability, and durability of concrete. Placing must be done in such a way that segregation does not occur (Neville & Brooks, 2010). The formwork should be firm and strong to withstand placing and compaction and joints well sealed to prevent loss of slurry. Various forms of compacting is used such as tamping, rodding, ramming or by use of vibration (Shetty, 2005).

2.3.4.5 CURING

Curing is used to promote hydration of cement which leads to the development of strength and durability (Neville & Brooks, 2010). Curing helps maintain a satisfactory moisture and favorable temperature just after placing, which improves tremendously the quality of hardened concrete (Shetty, 2005).

2.3.4.6 FINISHING

This is the last stage of the concrete making. It gives the concrete a pleasant appearance. Since concrete takes the shape and surface texture of the formwork it is imperative to have a good formwork finishing. Other types of finishing are surface treatment and applied finishes (Shetty, 2005).

2.3.5 CURRENT TRENDS IN CONCRETE

2.3.5.1 INTRODUCTION

Several new developments are emerging in the concrete industry and a few worthy of mention is reactive powder concrete and self-consolidating concrete.

2.3.5.2 REACTIVE POWDER CONCRETE

It is also known as ultra-high performance concrete (UHPC). This yields very high strength concrete (200Mpa). It has a high workability and the resulting product is durable as well (Perry & Zakariasen, 2004).

2.3.5.3 SELF-CONSOLIDATING CONCRETE

This type of concrete produces very high strength concrete which needs no vibration. It's able to flow into narrow areas and thus very useful for modern architecture (Portland Cement Association, 2015)

2.4 QUALITY MANAGEMENT IN CONCRETE WORKS

2.4.1 DEFINITION OF QUALITY CONCRETE

Quality concrete must be durable, perform satisfactorily in service, be cost effective and safe (Ozyildirim, 2011). Quality as alluded to earlier on has several definitions. Arditi & Gunaydin (1997) defines quality in construction as "meeting the legal, aesthetic and functional requirements of a project". The authors further note that because some of the definitions such as aesthetics are subjective, it generates lots of disagreement to what quality is; coupled with the fact that there are different players involved in the Construction Industry who interprets quality differently.

However, adopting the definition of quality as "conformance or meeting requirements" is capable of been managed, unlike the other definitions. This is because requirements can be specified, communicated and measured. Additionally the other definitions such as "fitness for purpose' or 'level of excellence" can still be achieved on the basis of conformance to requirements Cornick (1991) cited by Rwelamila (1996).

Following from the above, quality concrete can be defined as "the extent to which it conforms to established requirements". The "established requirements" are those specific to a project and derived from design criteria, application of current standards and codes of practice and the preparation of drawings, specification, procedures and instructions (Loh, 1981) cited by Rwelamila (1996).

Quality is therefore defined for the purpose of this research as "the extent to which the concrete product conforms to the established requirements" (Rwelamila, 1996; Chung, 1999; Titman, 2003; Arditi & Gunaydin, 1997). In this regard measuring quality of concrete will involve determining the extent to which the product conforms to the established requirements Pomeroy (1985); Ballim (1991) Mather (1986) as cited by Rwelamila (1996).

2.4.2 QUALITY ASSURANCE AND CONTROL IN CONCRETE CONSTRUCTION

Concrete is a variable material and sources of variability arise from many sources such as; mix ingredients, changes in concrete making and placement, test results, sampling procedure etc.(Neville & Brooks, 2010; Day, 2006). These sources of variability can be grouped into three; materials, production and testing (Myers & Carrasquillo, 1998).

As a result, to maintain quality concrete, every step of its production must be carried out according to the right procedure in order to minimize variation (Constructor, 2014).

To assess the quality of concrete, it is required that certain characteristics of concrete are selected depending on the specified requirements or function of the product; such as durability, strength or permeability. The right procedures for testing are then used. Due to the variability of concrete as mentioned earlier, statistical tools are employed in the test, so that the allowable range around the target is used. Additionally the specification must be clearly stated indicating the characteristics of the fresh and hardened concrete (Ozyildirim, 2011).

Quality control and quality assurance are therefore important to manage this variability in order to meet the specified requirements (Myers & Carrasquillo, 1998).

The variable nature of the strength of concrete makes it imperative that, the mix design strength be higher than the minimum required structural strength in order to provide adequate strength in the entire structure (Neville & Brooks, 2010; Myers & Carrasquillo, 1998).

It is generally agreed that the strength of concrete follows a normal distribution and can be expressed as follows (Day, 2006; Neville & Brooks, 2010; Myers & Carrasquillo, 1998):

Required strength = specified strength + $K\delta$

Where δ is the standard deviation and k varies for different countries but is around 1.64 in the United Kingdom. This equation caters for the deviation that occur between the strength results obtained during production and the minimum required. This will ensure that less than 5% defective product is possible in the structure (Day, 2006; Neville & Brooks, 2010).

ACI 121R-08(2008) advocates the process approach in quality management to achieve quality in concrete construction in line with ISO 9001:2000; thus placing more emphasis on “continual improvement rather than avoidance of non-conformity”. Chung (1999) asserts that ISO evolvement has shifted toward TQM.

The process approach enables the task to be broken into “series of inputs, processes and sub-processes which can be measured and monitored before been used as output for the next stage; planning, monitoring and improving”(ACI 121R-08, 2008).

The processes for concrete construction can be broken down as; structural design; mixture proportioning; procurement and control of the materials; selection of suppliers and sub-contractors; formwork design and procurement; scheduling supply of logistics and access; inspection, testing and curing (ACI 121R-08, 2008). This is illustrated in the model shown in Figure 2.11 below. It consists of management responsibility, resource management, product realization and measurement.

The process approach is based on the principle that; the products are realized through a process which is made up of a series of activities that converts inputs into outputs (products). The inputs consist of requirements/specifications from the customer and the output is the products and satisfaction to the customer. The model is also based on continual improvement of the system through monitoring and planning (ACI 121R-08, 2008).

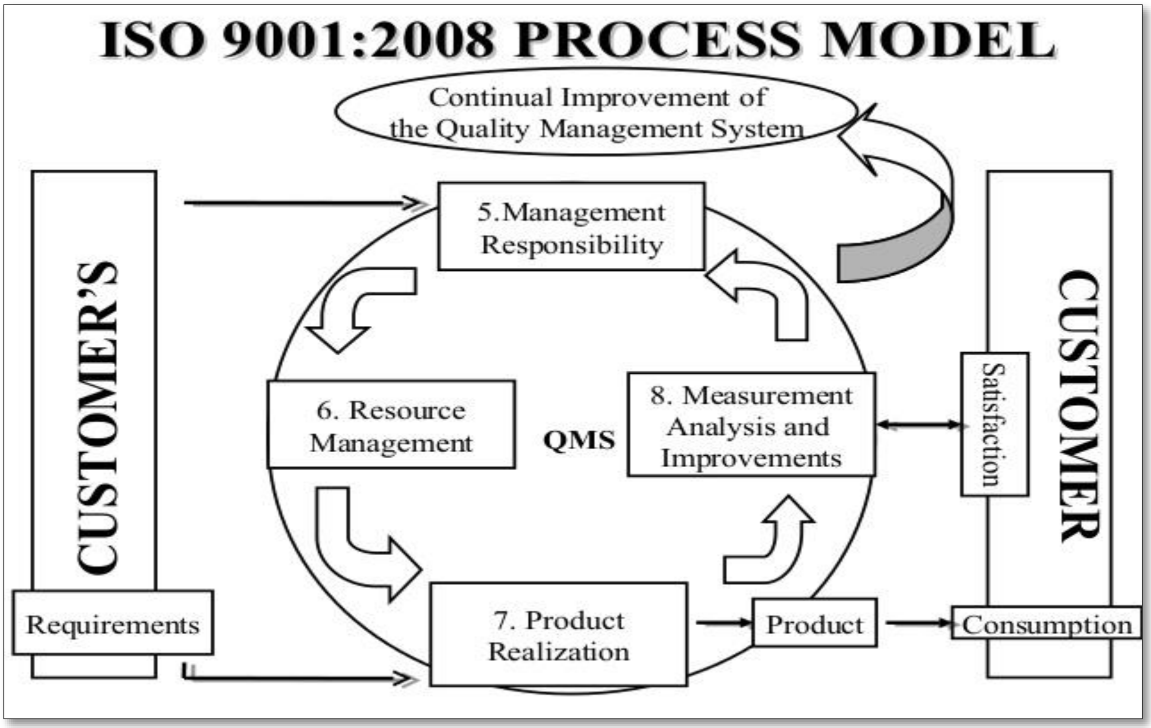


Figure 2.11; model of a process-based quality management system

Source: ISO 9001

There are two aspects of quality control in quality concrete construction; maintaining a low variability and avoiding failure. The two are complimentary as the maintenance of a low variability will avoid failure and vice versa. A control system will detect an early variability and change points, if however, it fails to detect and correct changes immediately then, it will contribute to the overall variability. Implementing a quality assurance system will however eliminate the sources of variability rather than their early detection (Day, 2006).

Day (2006) asserts that an adequate control system should be able to detect issues such as moisture content and materials that will affect mean strength of concrete and quickly make adjustments early enough rather than wait for results of the 28-day strength, which may be too late. He adds that the compensatory adjustments could be in cement content.

Quality assurance is “documented quality control” and these are written down; it requires that all incoming materials, production process and results be monitored. Quality control on the other hand will undertake the actual activity by controlling the incoming materials, production process and testing of the finished product (Day, 2006). It follows that an adequate quality system should include; inspection and testing of materials, fresh and hardened concrete; then documenting all procedures; with close participation and cooperation of all parties (Bamforth, 2003).

The needs of the customer should be specified or clarified and understood from the beginning of the project. It is essential that more time is spent at the beginning to define requirements. The drawings and specification must be unambiguous. The design team must be familiar with the construction materials and techniques that the contractors will use (Arditi & Gunaydin, 1997).

2.4.3 DOCUMENTS AND RECORDS

Battikha (2003) lists some of the documents and records essential for a quality assurance and quality control program as follows; specifications; work instructions; acceptance plans; inspection and test report; non-conformance report; corrective action report; construction deficiency report; defective notice; quality manual, quality management procedures.

2.4.3.1 SPECIFICATIONS

Specifications are provided to ensure that the desired products are realized. They define the requirements sought and provide means to determine that, the desired product quality is achieved (Ozyildirim, 2011).

There are two types of specification (Ozyildirim, 2011);

- Method specification
- End results specifications

The method specification defines the method of work, equipment to use, type and quantities of materials to use.

In end results specification, the responsibility for providing the specified product is entirely the responsibility of the contractor. Statistical sampling is used to estimate the quality. Current end results specification incorporates some aspects of method specification, such as limit to air content and temperature during placement (Ozyildirim, 2011).

2.4.4 PARAMETERS FOR QUALITY CONCRETE

The desirable properties of concrete are; durability, strength, impermeability, workability, dimensional stability, aesthetics, and economy (Neville & Brooks, 2010; Day, 2006). Many of these desirable properties are related to the compressive strength of concrete, excluding dimensional stability and to some extent durability (Neville & Brooks, 2010).

In the past, the compressive strength of concrete was the most important factor with the thinking that it was an all-encompassing factor for the other desirable properties of concrete, however it holds that even though compressive strength is a measure of durability to some extent, it is not entirely true that strong concrete means durable concrete. Exposure conditions place an important role to concrete durability (Shetty, 2005; Mehta, 1997).

In this work, special attention is dedicated to concrete durability. ACI 201.2R-01 (2008) defines durability as "its ability to resist weathering action, chemical attack, abrasion or any other process of deterioration". It asserts that durable concrete will retain its original form, quality and serviceability when exposed to its environment.

Most national codes of practice on concrete construction contain clauses for ensuring durability of concrete structures(CPWD, 2002). Other codes such as ACI 311.1R, ACI 201.2R-01 etc. describe good concrete practices and guides to durable concrete.

To achieve durable concrete, it is recommended that, the structure be designed to minimize exposure to moisture; use low water/cement ratio; suitable materials; adequate curing and good construction practices. Even though air entrainment is an important factor to improve durability, it applies to regions that experience thawing and freezing. In hot climates deleterious processes such as corrosion and alkaline-oxygen reactions are worsened (ACI 201.2R-01, 2008).

Aside the water/cement ratio, concrete cover is the next most important parameter in durability as alluded to earlier on concrete review section.

It is clearly evident that quality concrete can be achieved when the right ingredients are used in the right quantities and proportions, the processing and placement methods and finally the quality management practices adopted.

2.5 APPLICATION OF TQM ELEMENTS IN QUALITY CONCRETE CONSTRUCTION

Arditi & Gunaydin (1997) list the elements of TQM in construction which is shown in Figure 2.12 below as follows:

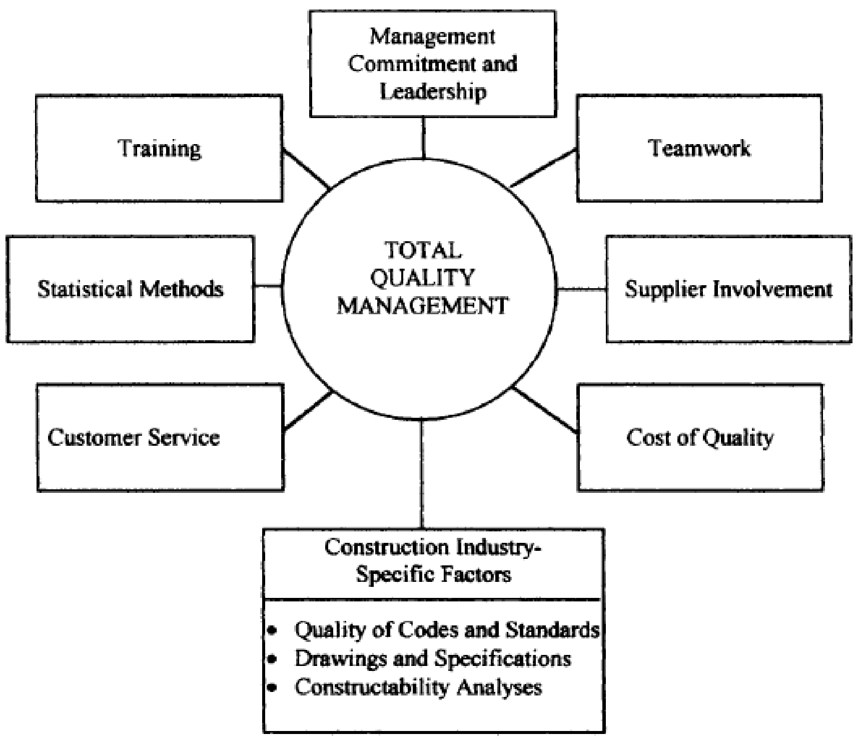


Figure 2.12: Elements of TQM in Construction

Source: (Arditi & Gunaydin, 1997 p. 237)

The above constructs have been modified and used as critical success factors necessary to implement a good quality management practice for concrete construction in this research.

2.5.1 MANAGEMENT COMMITMENT AND LEADERSHIP

Top management has the responsibility of providing a quality policy, setting out its commitment and quality objectives. They have the responsibility of creating an organizational chart indicating the responsibility and inter-relationship. Management must provide all the necessary resources at the right time; organize training and lead in the communication of quality objectives throughout the organization (Chung, 1999). Management must also ensure that customer requirements are understood and resources provided to meet the needs (ACI 121R-08, 2008).

2.5.2 TRAINING

The required quality will only be achieved when every employee from the least to the top is involved and has a mindset of doing it right the first time and always. This can only be achieved if employees are trained and are aware of the quality standard required. This is reinforced if they witness that non-conforming work is removed voluntarily no matter the cost (ACI 121R-08, 2008).

ANSI/ASQC Q9001 (1994) advocates the establishment and maintenance of a documented procedure to identify training needs of all personnel and provide training.

Ozyildirim(2011) states that, to achieve quality, personnel must undergo training and certification; the trained personnel must be present during the production, placement and testing of concrete; which will thus allow the proper procedures to be followed. He adds that there should be continuous training and certification of equipment.

2.5.3 TEAMWORK

Construction projects are usually a onetime project with several professionals brought together for the first time with varying business culture, different formats and methods of performing tasks (ACI 121R-08, 2008). Therefore, in order to implement a successful TQM, it is essential that a positive culture that encourages teamwork and cooperation at all levels of the organization is practiced (Rumane, 2011). The ultimate aim of the team process is to get everybody involved, that is; the Client, Contractor, Suppliers, Subcontractors etc.(Arditi & Gunaydin, 1997). Oberlender (2000) notes that project teams consist of all parties playing a role in the project, both internal and external. He adds that every team must have a leader who guides and motivates members with diverse background and goals to focus on the project goals; he must be able to communicate effectively to members, specifying their responsibilities and importance of information sharing.

2.5.4 STATISTICAL METHODS

Statistical methods are used as tools for solving problems. They aid in identifying and separating problems leading to quality issues and described in clear terms. It enables decisions to be based on facts and not opinions. Examples are histograms, cause and effect diagrams, control charts etc. (Oberlender, 2000).

In a study by Gunaydin (1995), as cited by Arditi & Gunaydin (1997), he concluded that statistical methods was the least important in rankings by construction personnel in design and construction phase. This is contrary to the importance of statistical methods highlighted by ISO 9001(1994), as cited in Arditi & Gunaydin (1997) and advocated by ANSI/ASQC Q9001 (1994); its importance in TQM is also highlighted in Oberlender (2000).

2.5.5 SUPPLIER INVOLVEMENT

According to Oberlender (2000), the quality of the final product depends on the preceding processes Thus, because there are several individuals involved in the process to arrive at the final product (i.e. both internal and external customers), good relationship with all suppliers is essential. These include plans and specifications from the designer, materials and equipment from vendors and so on. Arditi & Gunaydin (1997) conclude, that both internal and external customers must be satisfied in the construction process.

2.5.6 CUSTOMER SATISFACTION

TQM is based on customer satisfaction and continuous improvement. The goal is to supply the customer with products that satisfy their needs. By ensuring quality at each stage of the construction process, the quality of the final product will satisfy the customer. The customer is either internal or external. The internal customer is within the organization. The plans, drawings and specifications are examples of the products of one stage of the construction process and the customers of this process are the owner and construction organization. All parties have three complimentary roles, that is as a supplier processor and customer (Oberlender, 2000). Thus, in concrete production each stage of the production process, from selection of material, processing to the finished product must be done to satisfy the needs of the successive customer. This concept is better illustrated in Figure 2.13 below.

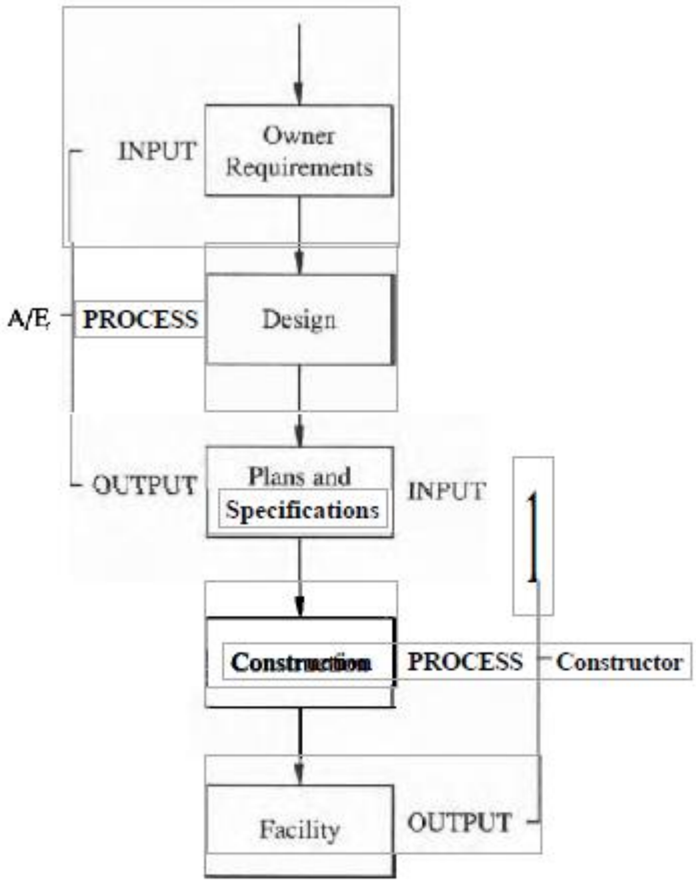


Figure 2.13 Triple Roles in construction

Source; (CII source document no. 51 as cited in Oberlernder, 2000 p.315)

In Figure 2.13 the "Architect/Engineer (A/E) is a customer of the owner, a processor of the design and supplier of plans and specifications to the contractor". Likewise the relationship between the Contractor, A/E and the owner (Oberlender, 2000).

2.5.7 THE COST OF QUALITY

The cost of quality is used as a measure of the effectiveness of the TQM process (Juran, 1988: Crosby 1967) as cited by Oberlender (2000)

Quality cost consists of the control cost and failure cost; control cost consists of cost of prevention and appraisal cost; failure cost consists of internal failure cost such as rework, whilst external failure cost is cost of rejection by the customer (Oberlender, 2000).

According to Oakland (2003), the cost of quality, in order to meet customer satisfaction must be carefully managed so that, there are long term benefits to the organization.

The production of quality concrete will reflect in cost of quality reduction as rework and rejection of products will be minimized. There will also be rewards in repeat business opportunities.

2.5.8 QUALITY OF CODES AND STANDARDS

The ASCE's 1988 manual (cited in Arditi & Gunaydin, 1997), asserts that, the main purpose of codes and standards is to ensure public health and safety. They give the minimum standards of the product and must be well understood by the professionals.

Enforcement of the codes and standards must be resolved early enough in the design stage to avoid reworking of plans and specifications (Arditi & Gunaydin, 1997).

Inspection plans of an organization will extract detailed requirements from the codes, standards and specifications. Standard inspection checklists are developed to account for any special requirements. These checklist are signed off by all parties concerned (ACI 121R-08, 2008). Several codes exist in the construction industry and sometimes constitute part of the contract documentation (General specifications). An example is the Ghana standard specification for Roads and Bridges, Ghana Building Code etc.

Other documents such as ISO 9000 series, quality manual, work instructions, inspection and test plans, non-conformance reports and other records of quality activities are essential (Battikha, 2003)

2.5.9 QUALITY OF DRAWINGS AND SPECIFICATIONS

The quality of concrete is evaluated based on its conformance to the specified requirements. These specified requirements are made up of drawings and specification and other contract documents. It must therefore be ensured that the right documents are available at the right place for use by the team members (Bruce, 1981) cited by Rwelamila (1996).

Gunaydin's 1995 study (cited in Arditi & Gunaydin, 1997) the quality of drawings and specifications has an influence on the quality of the final product.

The supervision team must be conversant with the requirements of the specifications and drawings; have ready access to these documents and have initial planning period (Rwelamila, 1996).

2.6 SUMMARY OF LITERATURE REVIEW

This section reviewed the relevant literature with regards to Quality, Quality Management, application of quality Management in the Construction industry and concrete construction.

It was divided into three parts; the first part looked at the concept of quality, the various definitions of quality and transitions in quality management. The second section was a brief review of concrete. It examined the various constituents of concrete and causes of lack of quality and durability of concrete structures.

The final section examined the application of total quality management in concrete construction or works.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discussed the research methodology and design used in the study. It gave a brief description of the various research philosophies through the concept of research paradigm and the research approach. This chapter guided the way data was collected, analyzed and interpreted in order to answer the research questions.

3.2 RESEARCH PHILOSOPHY AND APPROACH

3.2.1 RESEARCH PHILOSOPHY

According to Saunders *et al*. (2009), research philosophy " relates to the development of knowledge and the nature of that knowledge". Pathirage *et al*. (2008) asserts that research philosophy refers to epistemological, ontological and axiological assumptions and undertakings. where epistemology refers to how researchers know about the reality and assumptions about how knowledge should be acquired and accepted; ontology explains what knowledge is and assumptions about the nature of reality; axiology reveals the assumptions about the value system.

The research philosophy adopted contains an important assumption about the researcher's view of the world, although the choice is also influenced by practical considerations (Saunders *et al*., 2009) and this ontological stance a researcher takes influences the core assumptions concerning epistemology (Pathirage *et al*., 2008). Thus, a researcher's epistemology is a result of their ontological position (Easterby-Smith *et al*., 2002).

Easterby-Smith *et al*. (2002) emphasizes the importance of understanding the philosophical issues and approaches, as it enables the researcher to take more informed decisions with respect to the research design; knowledge of which design will work and which will not, and finally adopt a research approach according to the constraints of different knowledge structure

Two aspects of ontology are identified as objectivism and subjectivism.

"*Objectivism portrays the position that social entities exist in reality, external to social actors concerned with their existence whilst subjectivism holds the view that social phenomena are created from the perceptions and consequent actions of those social actors concerned with their existence"*(Saunders et al., 2009).

The ontological position adopted by this researcher in this study is that of the objectivist perspective leaning more towards the positivist. This is because the subject being researched has a reality independent of the researcher.

The epistemological stance of the researcher is that of empiricist, thus according to Saunders *et al*.(2009) only observable phenomena can provide credible data and facts.

3.2.2 RESEARCH APPROACH

The research approach adopted in this research is that of the deductive approach which falls in line with the positivist view selected. Gill and Johnson (2002) as cited by Pathirage *et al*. (2008) argue that deductive approach to research has become synonymous with positivism whilst inductive approach with social constructionism.

Deductive approach moves from theory to data and employs scientific principles. It involves the collection of quantitative data; explains causal relationships between variables and uses a highly structured approach (Saunders *et al*., 2009).

3.3 RESEARCH DESIGN

3.3.1 RESEARCH DESIGN

Saunders *et al*.(2009) notes that research design is the general plan of how the researcher will go about answering the research questions. The research design specifies the sources from which data will be collected and also consider the constraints that may arise.

This research work is descriptive and explanatory. Primary data was collected from professionals in the construction industry. Other secondary sources of data were from literature and ABCECG

Explanatory studies establishes causal relationship between variables; it focuses on studying a problem or situation in order to explain the relationship between variables.(Saunders *et al*., 2009). In this respect this research attempts to examine the quality management practices of construction team members and quality of concrete works as a result of the quality management practices adopted.

Descriptive research on the other hand is usually used to portray "an accurate profile of persons, events or situations" (Robson, 2002) as cited by Saunders et al. (2009).

Fisher (2010) also notes that descriptive research tells what is, however it does not classify and organize, whilst Pinsonneault & Kraemer (1993) notes that descriptive research finds out what situations, events, attitudes or opinions are occurring.

This study is partly descriptive because it describes the current situation in terms of quality management practices adopted by construction teams.

3.3.2 RESEARCH STRATEGY

The research strategy is dictated by the aims, objectives and questions of the research and several types exist; such as experimental, survey, ethnography, case study, action, grounded theory and archival (Saunders *et al*., 2009). De Leeuw *et al*.(2008) describes survey as a type of research strategy in which quantitative data is collected from large samples of a populations.

This study adopted the survey strategy as it is usually associated with the deductive approach. The survey strategy allows the researcher to collect large amounts of data which can be generalized (Saunders *et al*., 2009). According to Cohen *et al*. (2007) positivist researchers often adopt approaches such as survey and experiment strategies.

This is suitable for this type of research as it allows for generalization of the quality management practices of construction team members in concrete works. The survey strategy is suitable for answering questions such as how, who, where, how much and how many type of questions. Survey data is financially economical. Data collected using this method can be analyzed using descriptive and inferential statistics. It is also suitable for establishing relationships between variables and to produce models of these relationships

(Cohen *et al*. 2007). The survey questionnaire was then used as the data collection instrument.

3.3.3 RESEARCH METHOD

Fellows & Liu (2008); Neuman (2014) list three types of research approaches as qualitative, quantitative and triangulation.

According to (Naoum, 1998), quantitative approach is suitable for collecting "facts about a concept, a question or an attribute". He adds that, it is also used in collection of factual evidence and to study the relationship between facts in order to test a hypothesis or theory.

The research approach chosen for this research was therefore the quantitative approach which is also in line with the survey strategy and the philosophical stance of the researcher.

3.3.4 RESEARCH SCOPE AND POPULATION

The research covered the Greater Accra Region of Ghana which also serves as the capital of Ghana. According to the 2010 population census of Ghana, Greater Accra has the second highest population of Ghana, second to the Ashanti Region (Ghana Statistical Service, 2012). However, the highest concentration of D1K1 contactors is in the Greater Accra Region. Data collected from the ABCECG indicates that out of 58 members of D1K1 contractors in good standing, 38 are based in the Greater Accra Region. The Capital of Ghana-Accra is also a microcosm of the entire Country. Most Construction firms have their headquarters in the capital and often have branches in the other Regions. similar studies have concentrated mainly in the Greater Accra and Ashanti Region for similar reasons (Ahadzie, 2007; Ofori-kuragu *et al*., 2016)

The population consists of all Project Managers/Construction Managers, Project Engineers, Site Engineers, Clerk of Works, Site Supervisors and Quality Managers/Quality Assurance/Control Officers who belong to D1K1 contractors according to the ministry of works and housing classification for class one contractors. The contractors must also belong to the ABCECG and be in good standing. This is to enable for easy identification of active Contractors and their contacts and location. The classification is undertaken by the Ministry of Water Resources Works and Housing and indicates the capacity of work that can be undertaken. Out of the four categories, the D1K1 contractors represent the highest class and have no limit to the size of project they can undertake. The decision to use this class was taken because, these Contractors are relatively well organized. They have professional teams and also have the administrative structures to implement quality Management Practices. They normally have permanently employed professionals.

A list of Contractors belonging to the Association of Building and Civil Engineering Contractors of Ghana and also registered with the Ministry of Works Water Resources and Housing available to the researcher indicate that 58 D1K1 contractors were in good standing operating nationwide as at August, 2015. Out of this, 38 of them operate in the Greater Accra region of Ghana representing 65%.

Multiplying the number of Contractors actively operating in the Greater Accra Region by the construction team members of five professionals from each firm gives a total number of 190 which constitutes the sample frame for the research. Thus the individual members forming the construction team is the sampling unit or element (Israel, 2009).

3.3.5 SAMPLE SIZE

According to Israel (2009), the sample size determination is influenced by factors such as; purpose of the study, population size, risk of selecting 'bad' sample and the allowable sampling error.

A 95% confidence level is widely used by researchers and indicates that 95 out of a 100 sample will be a true representation. Additionally a level of precision of 5% indicates the range within which the true value lies (Israel, 2009). These values were thus adopted for the study.

A number of methods are available for selecting the sample size as enumerated by Israel (2009) such as census for small populations; the use of published tables; use of size from similar studies and applying formula. In this research a formula was adopted to determine the sample size.

Thus from the above, the sample size was determined using Kish (1965) formula;

$$n = \frac{n^1}{1 + n^1/N}$$

Where;

n = sample size

N = total population size

$$n^1 = \frac{s^2}{v^2}$$

s = standard deviation in the population element at a confidence interval of 95%

$$s^2 = p(1 - p)$$

p = the proportion of population elements

v = maximum standard error of the distribution at 0.05

$$s^2 = 0.5(1 - 0.5)$$

$$s^2 = 0.25$$

$$n^1 = \frac{0.25}{0.05^2}$$

$$n^1 = 100$$

Now, N = 190

Therefore, sample size, $n = \frac{100}{1+100/190}$

n = 66.5, which is approximately 67

However, since every Contractor must be represented by a team made up of five professionals, it implies 13 contractors will be selected (66/5 =13.2). Adjusting this number by 30% increase to cater for non-responsive rate (Israel, 2009), it implies 17 contractors will be selected to satisfy this condition. Therefore, a total of 85 questionnaires were sent out (17X5=85)

3.3.6 SAMPLING TECHNIQUE

A sample is a subset of the population, and since the population is often large and cannot all be used, a sampling technique is adopted (Macdonald & Headlam, 2006). According to Fellows & Liu (2008) only rarely are full population surveys possible and for practical reasons, statistical sampling is used to obtain a representative sample of the population. In order to get an unbiased sample of the population for this research which is truly representative of the population, the researcher first employed simple random sampling on the sample frame of contractors to select 17 Contractors.

In the second stage, purposive sampling was used. Purposive sampling is a non-probability type of sampling technique also known as judgemental sampling. According to Neuman (2014), purposive sampling enables the selection of an expert with a purpose in mind.

In this research the researcher targeted construction team members who undertake the practices being researched into.

Five questionnaires were issued to each of the 17 firms and using purposive sampling technique the following professionals employed with the Contractors, were targeted; Project Manager, Project Engineer, Site Engineer/Clerk of Works, Site Supervisor, And Quality Manager/Quality Assurance/Control Officer. This is repeated till all 85 questionnaires were distributed.

The Project Manager or Construction Manager is the head of the project team and mostly undertake the planning, resource allocation and general monitoring of the progress of work. The Project Engineer, Site Engineer and Site Supervisor were in charge of the day to day technical activities of the site. Whilst the Quality Manager/Quality Assurance/ Control Officer was in charge of managing the quality activities of the Contractor.

3.4 DATA COLLECTION AND INSTRUMENTATION

3.4.1 DATA SOURCES

There were two main sources of data consisting of a desk and field survey. The desk survey was mainly literature review of an extensive store of relevant materials to the study whilst the field survey involved the collection of primary data from respondents.

In order for this study to be replicated with fairly similar results a thorough and systematic method was employed in obtaining the primary data.

(Neuman (2014); Fellows & Liu (2008) asserts that a research must be capable of being verified and replicated under similar conditions. The researcher first visited the Association of Building and Civil Engineering Contractors of Ghana to source for data on registered members in good standing. A list of members in good standing with addresses and phone numbers were received.

3.4.2 DATA COLLECTION INSTRUMENT

A structured closed ended questionnaire was used in collecting primary data from the respondents. This questionnaire was self-administered. It was designed in such a way as to allow electronic answering. Where it was practically impossible to meet a respondent face to face the questionnaire was emailed to respondent. To improve the response rate, several reminders in the form of text messages and phone calls were placed to respondents.

3.4.3 QUESTIONNAIRE DESIGN

The questionnaire was designed to look presentable, professional and attractive in order to encourage a high response rate. As suggested by Fisher (2010), it was made as short as possible; it was divided into parts which corresponds to the various objectives of the research.

Cohen *et al*. (2007) suggest that the "appearance of a questionnaire is very important and it must look easy, attractive and interesting".

The questionnaire was designed in such a way that it could also be electronically answered. This was to enable respondents who could not be physically served to be rather emailed so as to have a higher response rate.

According to Oppenheim (1992); Morrison (1993);Willson & Mclean (1994) as cited by Cohen *et al*. (2007 p.341), piloting a questionnaire has several advantages, mainly to increase the "reliability, validity and practicality" of the questionnaire. Among others, they add that it checks clarity of the questionnaire items; gains feedback to eliminate ambiguities and checks readability level of the audience.

Prior to the distribution of the questionnaire, it was piloted using two Project Managers, two Project Engineers, two Site Engineers and three Site Supervisors making a total of ten questionnaires. Out of this number, nine were returned. Some of the issues raised were as follows:

- A respondent required clarification with regards to a question that required some five factors to be ranked in terms of importance. Following this the question was rephrased to make it easily understood.
- Another respondent complained she did not understand the question. Subsequently some questions were rephrased to make it clearer.
- Other respondents in the pilot were satisfied with the questionnaire and had finished answering it within 10-15 minutes,

3.4.4 CONTENT OF QUESTIONNAIRE

In order to answer the researcher's questions and achieve the aim of this research, several materials on relevant literature were gleaned in order to come out with the success factors of quality management practices. Questions from similar studies were also adopted and adapted to suit this particular research. Factors critical for producing durable concrete with varying degrees of importance were presented and respondents asked to rank them in terms of importance from 1-5 with 5 been most important and 1 been the least important (Rwelamila, 1996; ACI 201.2R-01, 2008).

The Likert scale was mainly used as it is able to measure the importance or weight of the respondent's perception of the issue and by far the easiest to construct (Kumar, 2011).

A five point Likert scale was thus used for part of Section B and C as follows;

Section B; the questions were formulated using the Likert scale ranging from 1-5 with 1=strongly disagree; 2=disagree; 3= neither agree nor disagree, 4=agree and 5= strongly agree. Whilst section C which also were similarly formulated with Likert scale ranging from 1-5 required respondents to answer questions of their perception on critical success factors for implementing TQM. With 1= extremely unimportant; 2= unimportant; 3=neutral; 4 =important; 5=extremely important.

The questionnaire was divided into three sections;

Section A required information on the respondents' data. This section was meant to get data on the experience of the professional and how much time the respondent spent during the planning stage of the project which is essential in good quality management practices in terms of planning before start of the project. This also gave credence and reliability to the responses from the respondents. According to the literature quality planning is very essential in quality management and begins before construction activities start (Chung, 1999). Descriptive statistics was used in the analysis of this section.

Section B concerned basic knowledge of the respondent on the parameters necessary to achieving durable quality concrete; the quality management practices adopted by the respondents' company and the quality management tools applied; thus, the quality control and assurance measures adopted in concrete works. This section was used to answer objective two and three of the research which is as follows;

- Objective 2; to assess the knowledge of construction team members with regards to the basic requirements for producing durable quality concrete.

- Objective 3; to identify current quality management practices among construction teams in concrete works.

Section C enquired about the perception of respondents with regard to the critical success factors required for a successful implementation of TQM adopted from (Arditi & Gunaydin, 1997; Oberlender, 2000). This section was used to answer the fourth objective which is as follows;

- Objective 4; to assess how project team members perceive the factors necessary for the successful implementation of quality management practices.

Insights drawn from the above objectives were then used to propose a framework for quality management in concrete works.

Section B and C were categorical ordinal data which required the use of non-parametric and descriptive data analysis. However this was converted into interval data in order to use parametric statistical analysis (Velleman & Wilkinson, 1993; Norman, 2010)

3.5 DATA ANALYSIS

This section discusses the methods used to analyse the data collected in order to answer the research questions and achieve the aim and objectives of the research.

This research adopted exploratory data analysis which focuses on what the data itself suggest. According to Cohen *et al*. (2007), this format is usually descriptive and relies on frequencies, percentages and graphical representations which is corroborated by Saunders *et al*. (2009) who adds that aside from answering the research questions , exploratory data analysis allows the flexibility to introduce previously unplanned analysis to respond to new findings.

This research used SPSS 20 for data analysis and presentation due to the large quantity of data dealt with. Saunders *et al*.(2009) advocates the use of computer software when respondent rate is greater than 30.

The returned questionnaires were first cleaned and checked for completeness. It was then coded and fed into SPSS version 23 for analysis. The analytical tools used in this research were;

- Descriptive statistics were used to analyse the demographic data of respondents
- Mean score ranking was used to analyse parts of section A where respondents were asked to rank factors in order of importance.
- One sample t -test was used to analyse section C where the perception of respondents on critical success factors for TQM were being measured
- Cronbach's alpha was used to analyse the reliability of the instrument used in collecting the data.
- Confirmatory factor analysis was used to analyse the construct validity of the questionnaire.

3.5.1 RELIABILITY

In order to determine the reliability of the instrument used in collecting the data , two main forms are advocated by Cohen *et al*. (2007); split half coefficient and Cronbach's alpha coefficient. This study adopted the latter which gives a measure of the internal consistency among the items (Cohen *et al*. 2007). Bryman and Crammer (1990) cited by Saunders *et al*. (2009) advocates that a reliability level is acceptable if alpha value is 0.8.

3.5.2 CONSTRUCT VALIDITY

Construct validity gives an indication of how well the questionnaire measures the constructs that were intended to be measured (Fisher, 2010; Saunders *et al*., 2009). According to Kumar (2011) construct validity is determined by estimating how much each construct contributes to the total variance observed. In this research, Confirmatory factor analysis was used to determine the construct validity.

3.6 SUMMARY OF RESEARCH METHODOLOGY

This chapter discussed the philosophical stance of the researcher. It laid out the path taken to achieve the research objectives. The Positivist point of view was used to undertake a quantitative research using a structured questionnaire. The results were analysed using SPSS version 23.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This section discusses the findings from the analysis of the data collected. It used methods of data analysis discussed under the previous chapter- methodology. A total of 85 questionnaires were sent out to respondents. This number includes the increase by 30% of the sampling size to cater for the non-responsive rate. 51 questionnaires were returned representing a response rate of 77%.

4.2 PROFILE OF RESPONDENTS' BACKGROUND

Figures; 4.1, 4.2, 4.3, 4.4 and 4.5 present descriptive analysis using pie charts and bar charts for the respondents' background. It summarizes the educational background, experience of the respondents and number of years their companies have been in existence. It also presents the stage at which the respondents joined their current position. This aided in inspiring confidence in the credibility of data collected and the fact that respondents understood the questions being asked.

In Figure 4.1, 55% of respondents possess a degree in their respective field, 20% have a diploma or HND and 20% have a postgraduate degree with the least been technician qualification which stood at 6%. The results indicate that majority of the respondents are highly educated and well qualified. The respondents work for well-established firms that have a lot of experience. They also fall within the targeted group the researcher intended to study.

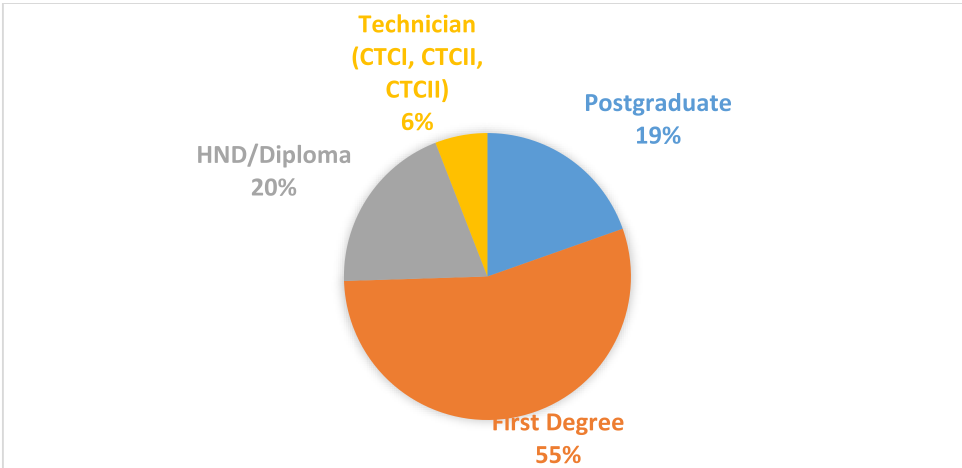


Figure 4.1; Respondents' Level of Education

Figure 4.2. present the various job positions of the respondents with the highest being Site Engineers representing 29%. Quality control/assurance officers was among the least represented. This indicates that most of the firms do not have personnel for this position and probably their role is taken up by other team members. This may not auger well for good quality management practice. The results indicate that all the respondents belong to the construction team members targeted by the researcher.

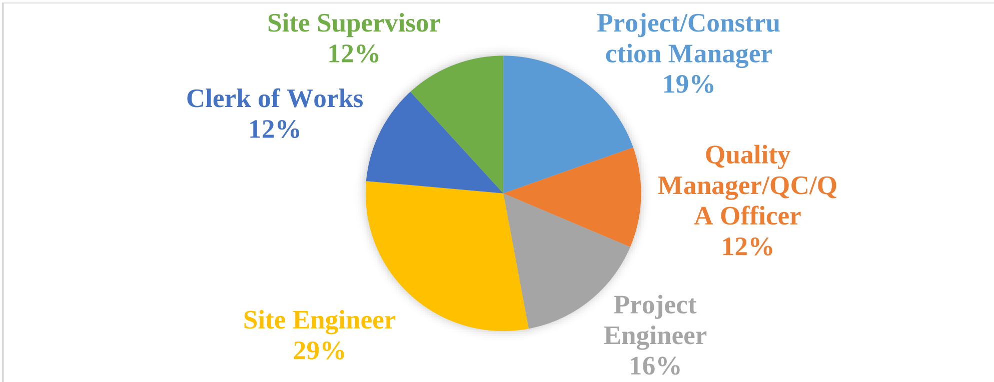


Figure 4.2; Job title or position of respondents in the company

As shown in Figure 4.3, 57% of respondents have over eleven years of work experience, less than 14% have 0-5 years of work experience, 28% have between 6-10 years and just 2% have more than 16 years of work experience. Thus, majority of the respondents are well experienced in their area of speciality which gives confidence in the data collected

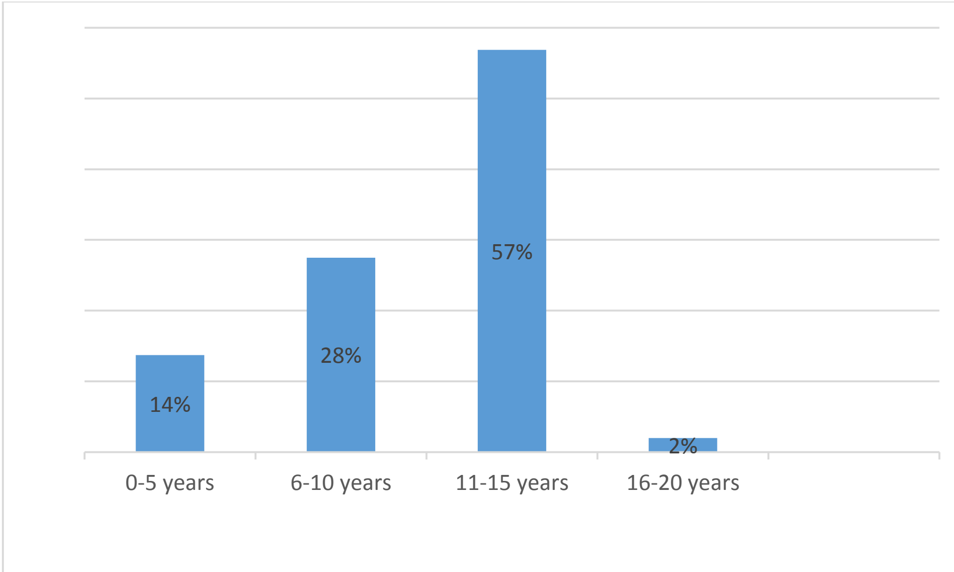


Figure 4.3; Respondents' Years of Experience

In Figure 4.4 28% of respondents joined their current project at the pre-tender stage, 22% joined the project at the post tender stage. This indicates that the majority of respondents were not present during the planning stages of the project which may not auger well for quality management planning. Since planning at the initial stages of projects are very essential as shown in the literature, the majority of respondents might not have been part of the initial planning (Chung, 1999).

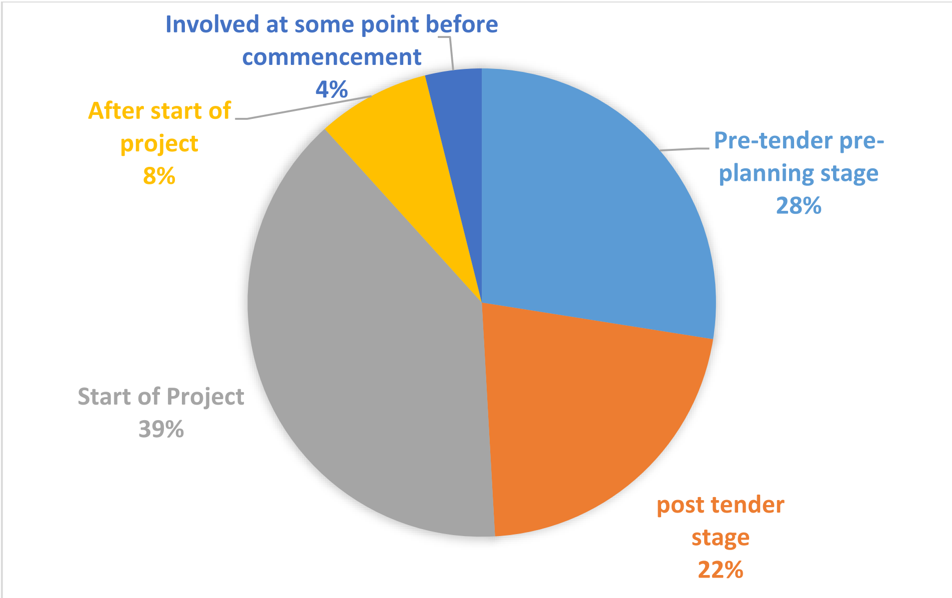


Figure 4.4; The Stage Respondent Joined their Current Project

The results in Figure 4.5 indicate that over 82% of respondents' firms have over 11 years of work experience, indicating they are well established and likely to have the necessary structures in place to practice quality management.

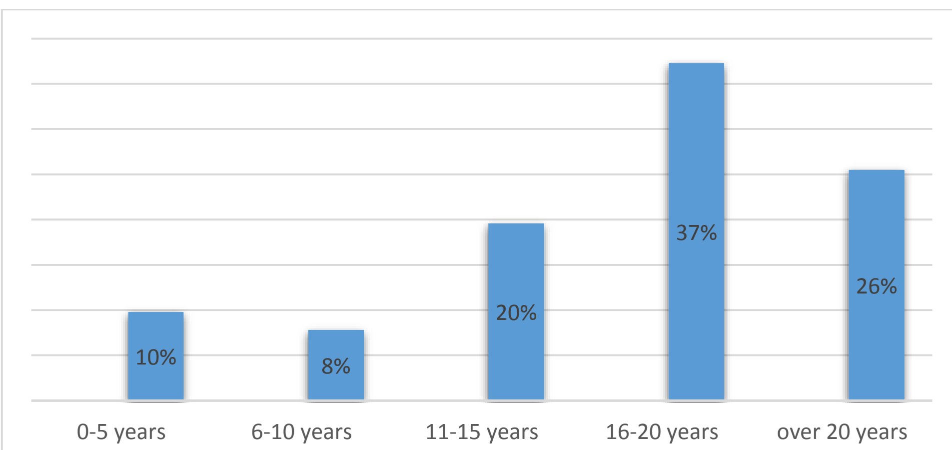


Figure 4.5; Age of Respondents' Firm

4.3 Knowledge of Factors Necessary for Durable and Quality Concrete Works

It was essential to determine the understanding and perception of construction team members on the critical factors necessary to produce durable and quality concrete. Since the main force driving this research is the production of durable and quality concrete. Five critical factors necessary to achieve durable and quality concrete but with varying degrees of importance were listed. Respondents were asked to rank them in terms of importance with five being the most important and one the least. Respondents were instructed not to repeat a rank for any of the factors. The factors listed were as follows;

- Cement/water ratio
- Curing
- Cover to reinforcement
- Cement content
- Compaction

The analysis as presented in Figure 4.6 indicate the percentages of respondents who considered particular factors as most important. The results indicate that majority of respondents, representing 47% considered cement content as the most important factor in producing durable concrete. 28% of respondents considered water/cement ratio as the second most important factor and 26% selected cover to reinforcement as the third most important, whilst none of the respondents considered compaction and curing as the most important.

These findings are contrary to the literature which places water/cement ratio as the most important factor and cover to reinforcement as the second most important. It however confirms a similar study in South Africa by Rwelamila (1996) in which respondents selected cement content as the most important.

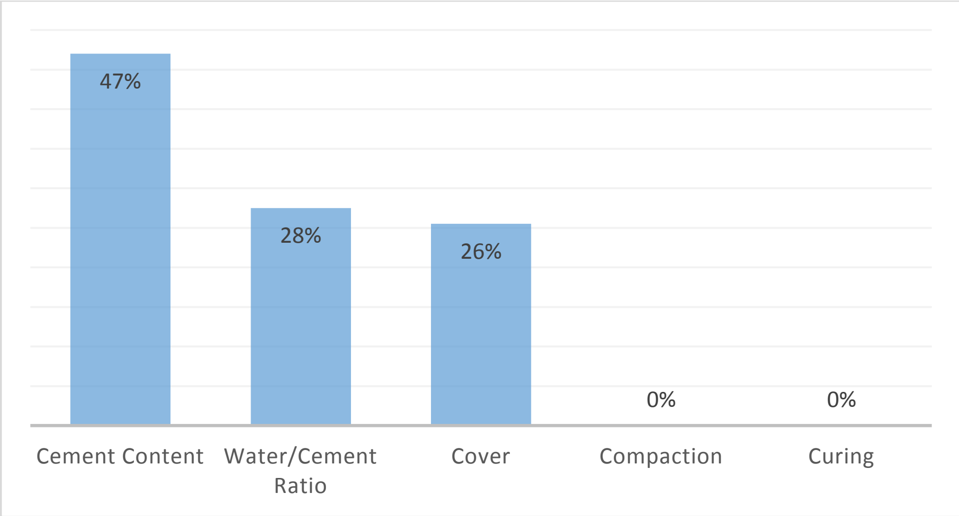


Figure 4.6; Summary of rankings of factors for Durable Concrete

Using the mean score to rank the data and where there is a tie the one with the least standard deviation is given priority the results indicates that Cement content was considered the most important with a mean value of 4.09 and standard deviation of 1.195 as shown in Table 4.1, water/cement ratio was ranked second with a standard deviation of 1.385 and a mean of 3.32. Cover to reinforcement followed closely with a mean of 3.19 and a standard deviation of 1.409 indicating. All the factors had a standard deviation higher than one, indicating a high variability in agreement of respondents. Compaction and curing placed fourth and fifth respectively with standard deviations lower than one which indicates a lower variability in answers to this question.

Table 4.1; Mean Score Ranking of Factors for Durable Concrete

	Mean	Std. Deviation	Rank
Cement Content is the most important factor	3.84	1.419	1st
Water/Cement ratio is the most important	3.45	1.404	2nd
Cover to reinforcement is the most important	3.25	1.369	3rd
Compaction is the most important	2.63	.894	4th
Curing is the most important	1.84	.987	5th

4.4 QUALITY MANAGEMENT PRACTICES CURRENTLY ADOPTED BY RESPONDENTS' FIRM

4.4.1 MODE OF COMMUNICATION

The mode of communication in the construction industry is very important as highlighted in the literature (Rwelamila, 1996). Verbal communication is not the best and most of the specifications, drawings etc. are in written form. Instructions issued to personnel must be written and records kept for effective quality management. Respondents were asked to select the most frequent mode of communication in concrete works construction. Table 4.2 gives a breakdown of the mode of communication. The results indicate that 84% of the respondents use verbal rather than written as the mode of communication.

Table 4.2; Response on common form of communication

		Percent
Valid	Written	15.7
	Verbal	84.3
	Total	100.0

4.4.2 DEFINITION OF QUALITY CONCRETE

From the literature quality concrete was defined as conformance to specified requirements. As alluded to earlier in the literature this enabled the quality of concrete to be measured and encompassed all other desirable features (Rwelamila, 1996).

Table 4.3 presents the results as follows; structural functionality was ranked as number one having the highest mean and lowest standard deviation indicating there was much agreement between respondents compared to the other definitions. This was followed by conformance to specified requirements and least been aesthetic.

Cornick (1991) and Loh, (1981) as cited by Rwelamila (1996) suggest that "conformance to specified requirements" will encompasses the other two elements i.e. aesthetic and structural functionality. This is an indication that respondents have a good idea of what quality concrete should be but are not aware of the all-purpose definition which enables the quality of concrete to be measured.

Table 4.3; Response on Definition of Quality concrete

	N	Mean	Std. Deviation
Quality concrete is defined as conformance to specified requirements	51	4.59	0.726
Structural functionality	51	4.47	0.703
Aesthetic features	51	3.12	1.351

4.4.3 QUALITY CONTROL AT SITE

The respondents were given a list of quality control measures during concrete works and asked to select the appropriate option with respect to their current practice at the site. These stated factors which are all essential in concrete works were to be ranked on a Likert scale in order to verify their extent of practice at the site.

The responses are analyzed in Table 4.4. below. The results indicate that inspection during concrete operation was ranked highest with a mean of 4.55 and a standard deviation of 0.802. This indicates that inspection during concrete works is widely practiced by the construction teams. over 80% of respondents agree or strongly agree. This is positive because the literature advocates inspection during concrete operation (Ozyildirim, 2011; ACI 201.2R-01, 2008). This will ensure that concrete produced meets the consistency required.

Table 4.4; Response on Quality Control of Concrete at Site

	N	Mean	Std. Deviation
Inspection during the concreting operation	51	4.51	.784
Test cubes are produced	51	4.18	.896
Strength test are performed	51	4.16	.903
Results of strength test on cubes are recorded	51	4.12	1.032
Slump test is undertaken	51	4.10	.944
Use of check list	51	3.98	.927
Results of slump test are recorded	51	3.94	1.139

The use of checklist and recording of slump test was among the least used by respondents with mean values of 3.98 and 3.94 respectively as shown in Table 4.4, even though they recorded higher than average.

On slump test, the data indicate that, majority of respondents undertake this activity with a mean value of 4.10 and a standard deviation lower than one. However, it is different when it comes to recording of results of slump test. Even though the mean value 3.94 is high as shown in Table 4.4 the standard deviation is higher than one. This shows a very high variability in the agreement between respondents.

4.4.4 QUALITY OF SUPERVISION

Respondents were asked the question whether "quality of supervision is dependent on specifications and drawings" or "on the experience of the supervisor". There was a general agreement that both are important but experience of supervisors was ranked higher than drawings and specifications as shown in Table 4.5 The results also show that whilst there was a low variability for those who ranked experience of supervisor higher, there was a very high variability for the ranking for that of specifications and drawings. The results do not auger well for the production of quality concrete as team members will rather depend on experience rather than the drawings and specifications.

Table 4.5; Quality of supervision

Quality of supervision is dependent on	N	Mean	Std. Deviation
Experience of the supervisor	51	4.57	.806
Specifications and drawings	51	4.45	1.026

4.4.5 FORMAL QUALITY MANAGEMENT

Respondents were asked two questions under this heading; firstly "Your company does not have a formal quality system" and "Your Company is not ISO certified. The results as shown in Figure 4.7 indicate that 35% of respondents agree to have a formal quality management system. The rest were neutral or disagreed. This indicates that majority of the firms did not have a formal quality management system. The large number of respondents (43%) who answered neutral could also mean that they did not understand what a formal quality management entailed and most likely did not have it. This is shown in Figure 4.7.

It can therefore be suggested that there is a low level of adoption of formal quality management system.

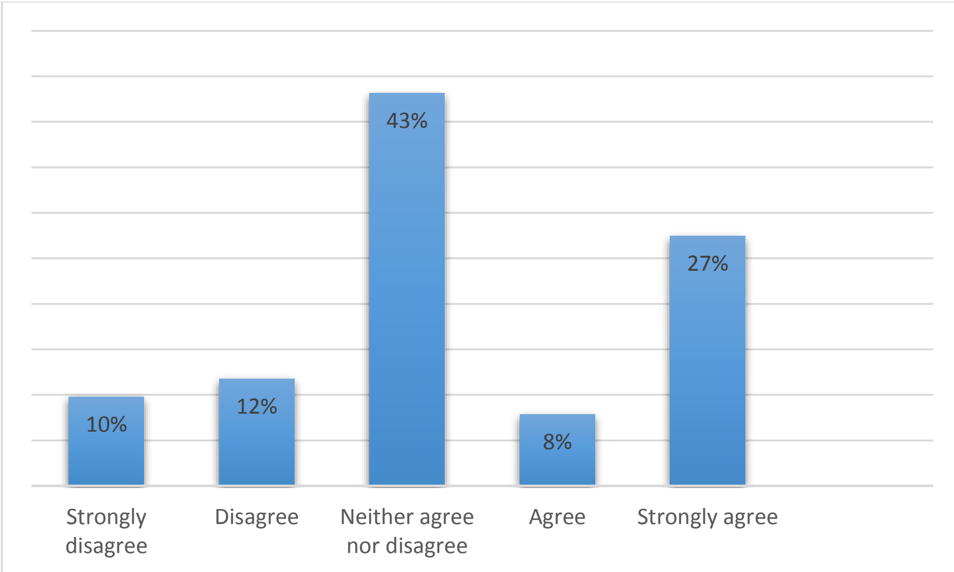


Figure 4.7; Response on Formal quality management system

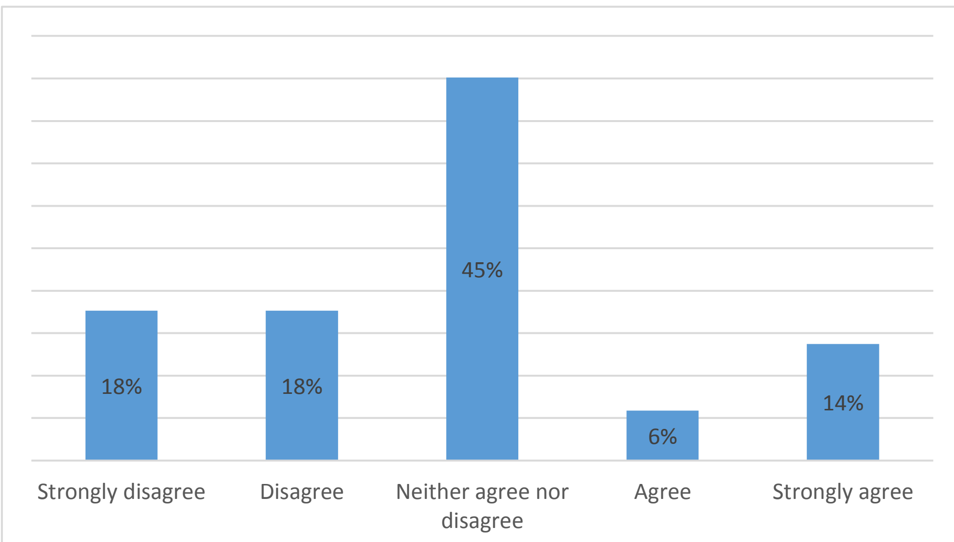


Figure 4.8; Response on ISO Certification

On ISO certification 20% of respondents claim to be ISO certified as shown in Figure 4.8, however this is sharply contradicted upon a cross tabulation of job title against ISO certification as shown in Table 4.7. Quality Managers were unanimous that their

Companies were not ISO certified. This view is more acceptable as Quality managers are more knowledgeable on Quality issues and their answers have a greater weight.

Table 4.6; Cross tabulation of Job positions with formal quality

		Your company has a formal quality management system				
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
What is your Job title or position in the company	Project/Construction Manager	20.0%	20.0%	30.0%	20.0%	10.0%
	Quality Manager/QC/QA Officer					100.0%
	Project Engineer	25.0%	12.5%	12.5%		50.0%
	Site Engineer		13.3%	60.0%	6.7%	20.0%
	Clerk of Works	16.7%		66.7%	16.7%	
	Site Supervisor		16.7%	83.3%		

Similarly, as shown in Table 4.6, whilst respondents who are quality managers unanimously agreed that they had a formal quality management system the other job title respondents contradicted this view. Most of the Site Supervisors, Site Engineers and Clerk of Works selected the neutral position. The Project Engineers largely agreed with the Quality Managers. This could be an indication that firms that employed quality managers also used formal quality management systems.

Table 4.7; cross tabulation of Job title on ISO certification

		Your company is ISO cerified				
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
What is your Job title or position in the company	Project/Construction Manager	30.0%	20.0%	20.0%	30.0%	
	Quality Manager/QC/QA Officer	16.7%	66.7%	16.7%		
	Project Engineer	25.0%	12.5%	12.5%		50.0%
	Site Engineer		6.7%	73.3%		20.0%
	Clerk of Works	16.7%		83.3%		
	Site Supervisor	33.3%	16.7%	50.0%		

4.4.6 QUALITY MANAGEMENT TOOLS

The respondents were given a list of quality management tools and asked to rank them using a 5 point Likert scale, if they were used by their respective companies. The list was as follows;

- Quality planning
- Quality control
- Quality assurance
- Total Quality Management
- Quality improvement
- Quality Management systems

The results indicate that quality improvement was ranked in terms of importance as the highest with a mean of 3.96 and a standard deviation less than one. This was followed by quality planning, quality control, quality assurance, total quality management and quality management system respectively. These are summarised in Table 4.8

Table 4.8; Response on Quality management tools

	N	Mean	Std. Deviation
Your company uses quality improvement as a tool	51	3.96	.958
Your company uses Quality planning as a tool	51	3.94	.835
Your company uses quality control as a tool	51	3.90	.806
Your company uses quality assurance as a tool	51	3.82	.767
Your company uses total quality management as a tool	51	3.75	.913
Your company uses a Quality management system	51	3.71	.965

Further analysis of the results indicates that, 76% of respondents claim that their companies use quality planning as a quality management tool. 20% were neutral whilst 4% disagreed. This is illustrated in Figure 4.9.

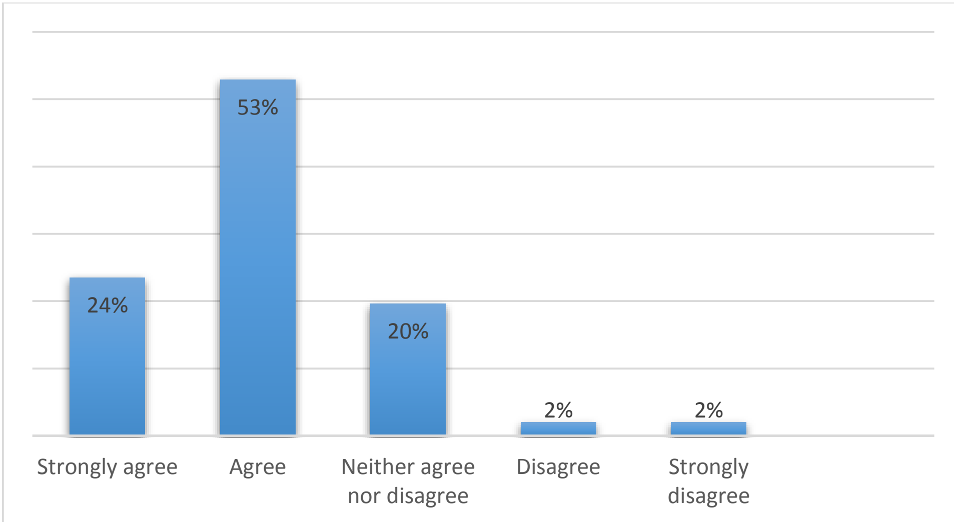


Figure 4.9; Response on Quality planning as a tool

4.5 QUALITY CONTROL/ASSURANCE

4.5.1 AVAILABILITY OF CODES AND STANDARDS

Respondents were asked if codes and standards were available and readily accessible to them. The results as summarized in Figure 4.6 below indicate that 20 respondents representing 39% were indifferent about it. Whilst about 4% disagreed to their availability. 57% representing 29 respondents agreed or strongly agreed to their availability. This suggest that works are undertaken by a large number of respondents with reference to these documentation, however the rest who do not have access to these documents is significant. The literature emphasizes on the use of codes and standards to achieve quality and public safety (Oberlender, 2000).

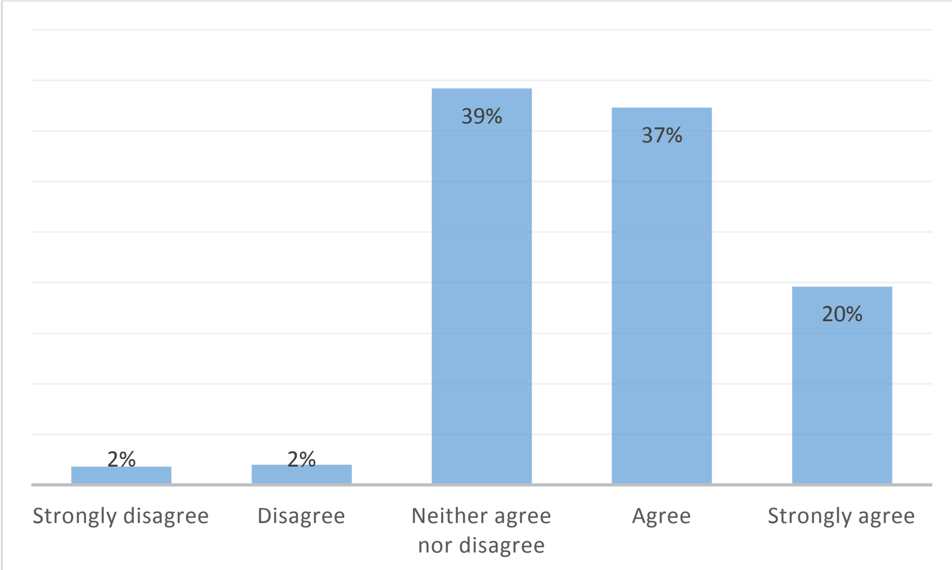


Figure 4.10; Availability and accessibility of codes, standards and drawings

4.5.2 CONTROL MEASURES IN PLACE TO MAINTAIN ACCURACY OF TEST EQUIPMENT

Respondents were asked if their firms have control measures to ensure that inspection and test equipment were capable of functioning accurately. The results presented in Figure 4.11 below suggest that sufficient attention was given to this factor. 78% or 40 respondents strongly agreed or agree that this is being done by their firms. This is welcome information as the literature emphasizes on the accuracy of test equipment.

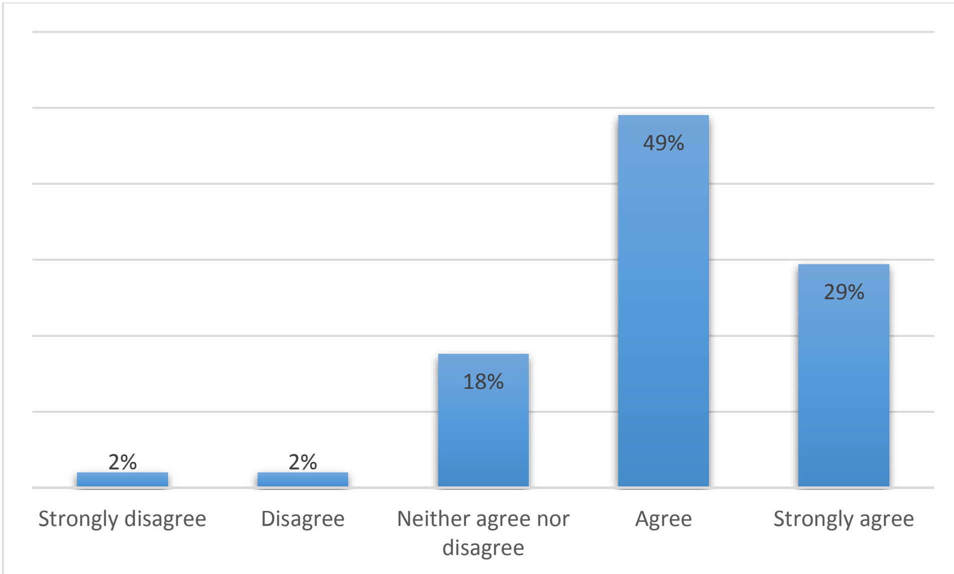


Figure 4.11; Response on Maintenance of test equipment

4.5.3 DOCUMENTED PROCEDURE FOR REMOVAL OF NON-CONFORMING PRODUCTS

Documented procedures are very important in quality assurance; respondents were asked if their firms have documented procedures in the removal of non-conforming products. Majority of the respondents, that is 74% representing 38 of the respondents agreed or strongly agreed that this was done by their firms. This is illustrated in Figure 4.12

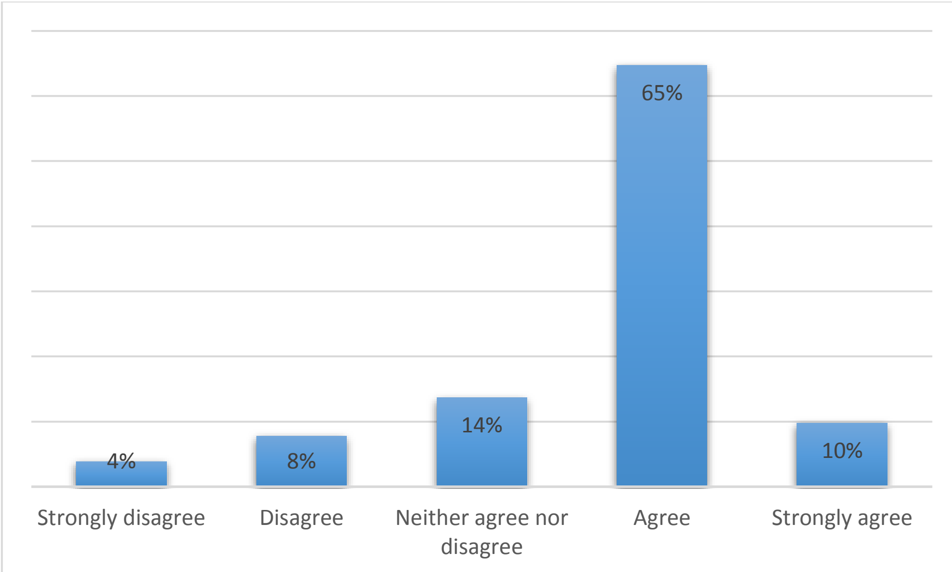


Figure 4.12; Response on Documented Procedure for removal of non-conforming products

4.5.4 DOCUMENTED PROCEDURE FOR IMPLEMENTING CORRECTIVE AND PREVENTIVE ACTION

Documentation of procedures is an important aspect in quality assurance as detailed in the literature (ISO 9000, 2005). The respondents were asked whether their firms had documented procedure for implementing corrective and preventive actions. In the results shown in Figure 4.13 67% of respondents agreed or strongly agreed that procedure for implementing corrective and preventive actions were done.

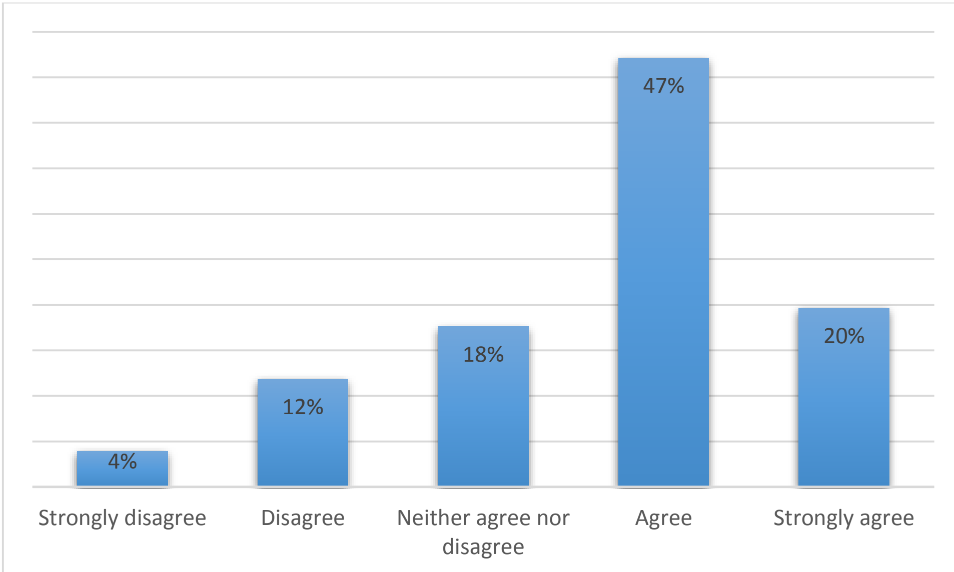


Figure 4.13; Documented Procedure for implementing corrective and preventive action

4.5.5 DOCUMENTED PROCEDURE FOR HANDLING, STORING PRESERVING CONCRETE MATERIALS AND FINISHED PRODUCTS

The results indicate that, about 67% representing 39 respondents strongly agree or agree that there are documented procedures for storing, handling and preserving concrete materials and finished products. This is important as demonstrated in the literature for maintaining high quality (ISO 9000, 2005). Figure 4.14 indicates 77% of respondents have documented procedure for handling, storing, preserving concrete materials and finished works

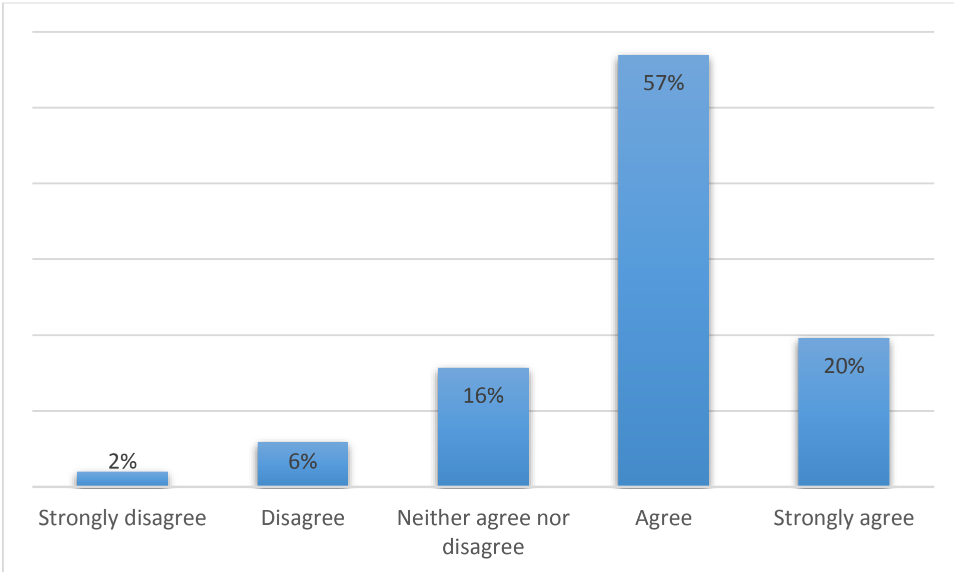


Figure 4.14; Handling, Storing, Preserving Materials & Finished Works

4.5.6 SYSTEMATIC FILING AND ACCESSING PROCEDURES

The respondents were asked if their firms had a systematic filing and accessing procedures that will enable an efficient quality record retrieving. The results are summarised in Figure 4.15 below. It suggests that about 70% of respondents either agree or strongly agree that such a system exist.

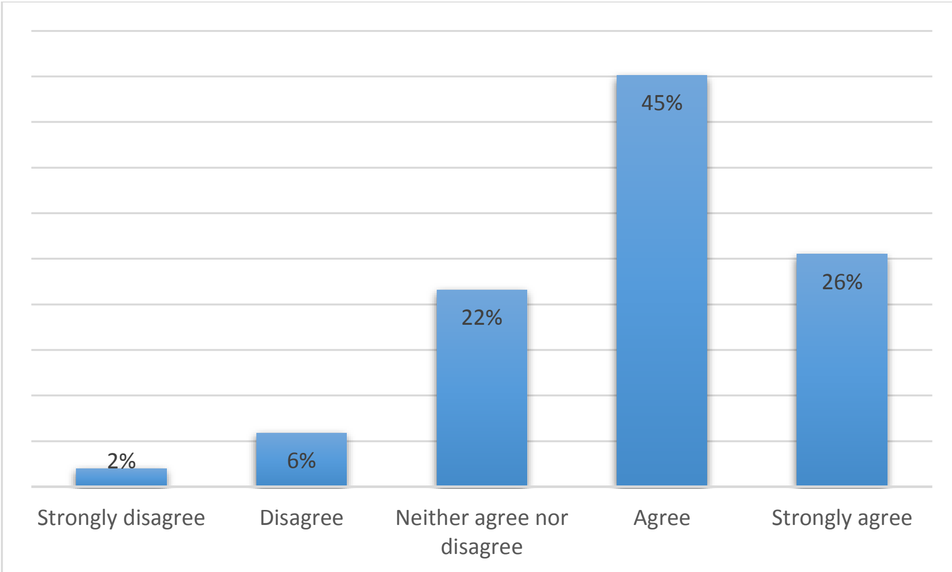


Figure 4.15; Response on record keeping

4.5.7 PERIODIC INTERNAL AUDITING OF THE SYSTEM

Respondents were asked if there were regular auditing of their system by internal, but independent personnel to guarantee efficiency of the quality system. About 53% representing 27 respondents indicated in the affirmative, that is either strongly agree or agree.

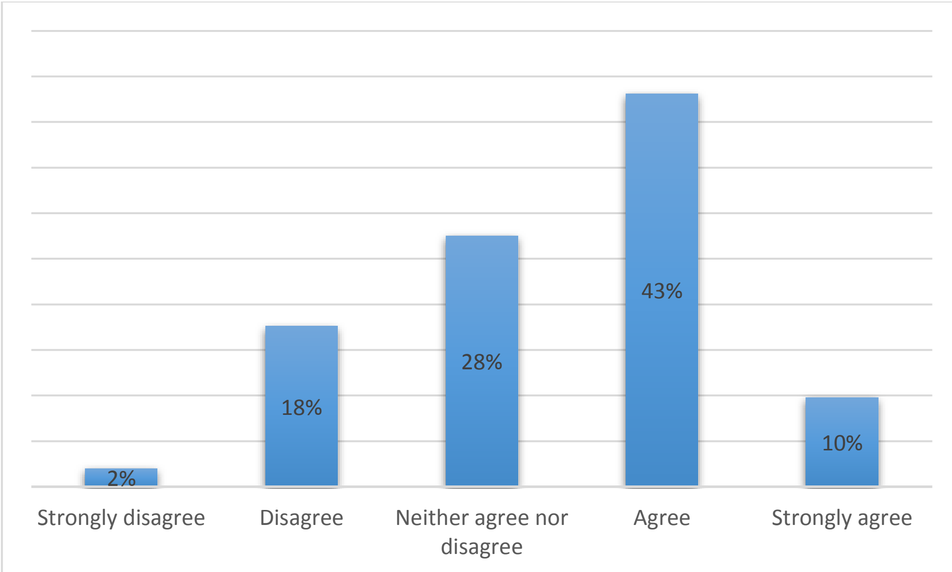


Figure 4.16; Response on Periodic internal auditing

4.5.8 SUMMARY OF QUALITY ASSURANCE MEASURES ADOPTED BY FIRMS

The results of quality assurance measures adopted by the respondents' firms indicate that systematic filing and accessing procedures to enable efficient quality record retrieval and documented procedure for handling, storing and preserving concrete materials had the same mean score of 3.86, however the latter had a lower standard deviation indicating a higher consistency among respondents and was therefore ranked higher. These are summarised in Table 4.9 below.

Table 4.9; Quality Assurance Measures adopted by firms

	Mean		Std. Deviation
	Statistic	Std. Error	Statistic
Your company has a systematic filing and accessing procedures to enable efficient quality record retrieving	3.86	.131	.939
There is a documented procedure for handling, storing and Preserving concrete materials and finished works	3.86	.122	.872
Codes, standards and other relevant documents are available at the site and accessible to you	3.71	.123	.879
Documented Procedure for reviewing the disposition of non-conforming products exist in your company	3.69	.127	.905
There are documented procedures for implementing corrective and preventive actions in your company	3.67	.147	1.052
Regular auditing by independent personnel	3.41	.135	.963

The results indicate that even though majority of respondents noted that they did not have a formal quality system or were ISO certified, there were several elements of formal quality management in their firms. This implies on the average they practice a lot of the quality management practices advocated by ISO and total Quality Management even though they are not formally subscribed to them.

4.6 SUCCESS FACTORS OF TOTAL QUALITY MANAGEMENT

One sample t-test was used to test data from this section of the questionnaire, which assessed the perception of respondents to the critical success factors for total quality management. These factors were adopted from Arditi & Gunaydin (1997); Oberlender (2000). Thus, there is either a low level, medium level or high level perception of the critical success factors for TQM. The one sample t-test was therefore used to rank these success factors in terms of their relative importance to the respondents. It enabled the researcher to determine if the population considered some factors more important than others. It also gave a general picture about the understanding of TQM by the population. In order to use the one sample t-test the sample must be normally distributed. Since the sample size is higher than 30, the central limit theorem can be invoked, thus the sampling distribution will approach the normal distribution (Field, 2009).

Also, as alluded to earlier, even though the scaling used was ordinal, it was treated as interval. This is acceptable if the spacing between the scales are equal (Norman, 2010). In order to do this comparison, the means of the various variables were compared to a hypothesized mean.

The null hypothesis for each factor was that, the factor is not important. This implies that most respondents will select 1, 2 or 3 which represents extremely unimportant, unimportant and neutral respectively.

Thus, the null hypothesis Ho: Uo = 3.5

The alternate hypothesis Ha: Uo > 3.5

Uo is the hypothesized mean which was selected as 3.5 which means that any value greater than 3.5 indicates the factor is considered important. Similar studies have adopted a mean of 3.5 (see Ling, 2002 cited in Ahadzie, 2007) The significance level used in this work was 95% which is generally accepted and widely used (Field, 2009). The factors with higher mean were ranked higher and vice versa. Wherever two or more factors had the same mean the one with the lower standard deviation was ranked higher.

The standard error calculates the standard deviation between the sample means. It indicates how much deviation exist between sample means from the same population. It is therefore an indication of how representative the sample mean is of the population mean. A small standard error indicates that the sample is an accurate representation of the population (Field, 2009).

The standard deviation on the other hand indicates how representative the mean is of the sample. A higher standard deviation indicates a high variability among respondents whilst a low standard deviation indicates consistency of the responses (Field, 2009).

Results of the one sample t-test are summarized in Table 4.10. The results indicate that the factor "drawings and specifications are reviewed prior to authorization for construction" was ranked as number one with a mean of 4.53, a standard deviation of 0.731 and standard error of 0.102. Since the standard deviation and standard error are all less than one it indicates the low variability and the accuracy of the sample mean with respect to the population respectively. The factor "cost of quality is used to track the effectiveness of TQM" was ranked lowest. This suggest that that respondents attached less importance to this factor compared to the rest.

With the exception of one factor, "Project team members must have thorough knowledge of the codes and standards during the design stage'', all the other factors had a standard deviation and standard error less than one which confirms low variability and high accuracy respectively compared to the population mean. The exception of the factor in question is an indication that respondents were not consistent with their answers to it.

Table 4.10; T-test with one sample statistic and ranking for success factors of TQM

Factors	Mean	Std. Deviation	Rank
Drawings and specifications reviewed prior to authorization for construction	4.53	.731	1
Testing and inspection of incoming materials for specification Compliance	4.53	.612	2
providing clear and concise specifications to suppliers	4.39	.777	3
There must be early identification of codes and standards	4.39	.603	4
Drawings and specifications are concise, clear and uniform	4.37	.774	5
Implementing quality management will lead to cost reduction	4.37	.958	6
Codes and standards have an effect on the quality of the final product	4.37	.692	7
Establishing courteous attitude and efficient communication with the client	4.35	.770	8
Employees introduced to the principles and tools for total quality Management at project commencement	4.33	.712	9
Identification and provision of required training for all staff including the basics of total quality management	4.31	.678	10
Establishing closer and long term relationship with suppliers	4.29	.672	11
Employees feel top management provides full support to process and project quality improvement	4.24	.790	12
Effective coordination between various departments of the firm and	4.22	.503	13
Conducting value engineering workshops with the client at project commencement in order to highlight potential cost or time saving	4.22	.856	14
Policies to encourage all employees to take part in quality improvement discussion	4.20	.664	15
Satisfying both internal and external customers	4.18	.740	16

Table 4.10 continued from previous page

Factors	Mean	Std. Deviation	Rank
Management actively leading and directing quality management programs assuming responsibility for evaluating and improving Quality management system at pre-defined intervals	4.16	.731	17
Establishing courteous attitude and efficient communication with the Sub contractor and suppliers	4.16	.644	18
Regular training organized for staff	4.14	.601	19
Policies for regularly reviewing the clients Project priorities	4.14	.775	20
offering reasonable explanation and solutions to legitimate complaints	4.14	.749	21
Codes and standards primarily protect the public health and safety	4.14	.849	22
Project team members must have thorough knowledge of the codes and standards during the design stage	4.14	1.040	23
Make decisions that are facts, based on data rather than opinions	4.12	.816	24
effective access to obtain the latest construction drawings and specifications	4.10	.922	25
Responding quickly to client's enquiries and complaints	4.10	.806	26
Satisfying internal and external customers/suppliers	4.10	.728	27
Practices to encourage Project quality improvement discussions at internal and external meetings	4.06	.544	28
Dealing with suppliers who have quality assurance programs	4.04	.894	29
Relying on few dependable suppliers who are committed to quality.	4.00	.938	30
Undertakes survey for assessment of client's satisfaction	3.98	.678	31
Employees feel positive about the company's quality policy	3.98	.648	32
Cost of quality is effective in raising awareness of quality and identifying improvement opportunities	3.98	.812	33
Activities to encourage frequent contact between parties involved in in the Project	3.96	.720	34
Explaining the Proposed construction processes to the client Prior to construction commencement	3.94	.881	35
Use of statistical tools such as histograms, check sheets, control charts, Pareto etc.	3.88	.739	36
Use of process flow charts, inspection and test plan for activities that directly affect quality	3.78	.730	37
cost of quality is used to track the effectiveness of TQM	3.75	.868	38

Results of the one sample t-test are summarized in Table 4.11 with the significant or p values which are for a 2-tailed test converted to 1-tail. This is because as can be seen in the values in the t-test sample statistic in Table 4.10 all the values of the mean are greater than the hypothesized mean of 3.5. This indicates that it is one directional test and therefore appropriate to convert to one tail test. The null hypothesis is rejected whenever the p value is less than the significance level of 0.05. The results in Table 4.11 below indicate that all the converted p-values are less than 0.05. Therefore, the null hypothesis is rejected and the alternate hypothesis accepted. This indicates that, there is a very high level of importance attributed by respondents to the critical success factors of total quality management.

Table 4.11: One sample t-test and 2-tailed converted to 1-tail for success factors of TQM

	Test Value = 3.5					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Management actively leading and directing quality management programs assuming responsibility for evaluating and improving Quality management system at pre-defined intervals	6.414	50	.000	.657	.45	.86
Employees feel top management provides full support to process and project quality improvement	6.650	50	.000	.735	.51	.96
Drawings and specifications reviewed prior to authorization for construction	10.059	50	.000	1.029	.82	1.23
effective access to obtain the latest construction drawings and specifications	4.632	50	.000	.598	.34	.86
Drawings and specifications are concise, clear and uniform	8.055	50	.000	.873	.65	1.09
Testing and inspection of incoming materials for specification Compliance	12.019	50	.000	1.029	.86	1.20
Identification and provision of required training for all staff including the basics of total quality management	8.572	50	.000	.814	.62	1.00
Regular training organized for staff	7.577	50	.000	.637	.47	.81
Employees introduced to the principles and tools for total quality Management at project commencement	8.361	50	.000	.833	.63	1.03
Undertakes survey for assessment of client's satisfaction	5.060	50	.000	.480	.29	.67
Make decisions that are facts, based on data rather than opinions	5.405	50	.000	.618	.39	.85
Use of process flow charts, inspection and test plan for activities that directly affect quality	2.782	50	.004	.284	.08	.49

Table 4.11 continued from previous page

	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
Use of statistical tools such as histograms, check sheets, control charts, Pareto etc.	3.696	50	.001	.382	.17	.59
Policies to encourage all employees to take part in quality improvement discussion	7.487	50	.000	.696	.51	.88
Practices to encourage Project quality improvement discussions at internal and external meetings	7.329	50	.000	.559	.41	.71
Effective coordination between various departments of the firm and	10.170	50	.000	.716	.57	.86
Activities to encourage frequent contact between parties involved in in the Project	4.570	50	.000	.461	.26	.66
Employees feel positive about the company's quality policy	5.296	50	.000	.480	.30	.66
Policies for regularly reviewing the clients Project priorities	5.871	50	.000	.637	.42	.86
Explaining the Proposed construction processes to the client Prior to construction commencement	3.575	50	.000	.441	.19	.69
Responding quickly to client's enquiries and complaints	5.297	50	.000	.598	.37	.82
offering reasonable explanation and solutions to legitimate complaints	6.077	50	.000	.637	.43	.85
Establishing courteous attitude and efficient communication with the client	7.910	50	.000	.853	.64	1.07
Satisfying both internal and external customers	6.525	50	.000	.676	.47	.88
Conducting value engineering workshops with the client at project commencement in order to highlight potential cost or time saving	5.972	50	.000	.716	.47	.96
Establishing courteous attitude and efficient communication with the Sub contractor and suppliers	7.283	50	.000	.657	.48	.84
Relying on few dependable suppliers who are committed to quality.	3.806	50	.000	.500	.24	.76
Establishing closer and long term relationship with suppliers	8.438	50	.000	.794	.61	.98

Table 4.11 continued from previous page

		T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference
providing clear and concise specifications to suppliers	8.204	50	.000	.892	.67	1.11
Dealing with suppliers who have quality assurance programs	4.310	50	.000	.539	.29	.79
Satisfying internal and external customers/suppliers	5.865	50	.000	.598	.39	.80
Implementing quality management will lead to cost reduction	6.502	50	.000	.873	.60	1.14
cost of quality is used to track the effectiveness of TQM	2.016	50	.025	.245	.00	.49
Cost of quality is effective in raising awareness of quality and identifying improvement opportunities	4.224	50	.000	.480	.25	.71
There must be early identification of codes and standards	10.573	50	.000	.892	.72	1.06
Codes and standards primarily protect the public health and safety	5.360	50	.000	.637	.40	.88
Project team members must have thorough knowledge of the codes and standards during the design stage	4.378	50	.000	.637	.34	.93
Codes and standards have an effect on the quality of the final product	9.009	50	.000	.873	.68	1.07

4.7 RELIABILITY AND VALIDITY TEST

4.7.1 RELIABILITY

Cronbach's alpha was used to verify the reliability of the instrument used to collect the data. As alluded to earlier, split half coefficient and Cronbach's alpha can be used to verify it. A Cronbach's alpha of 0.8 and above was deemed adequate. The results as shown in

Table 4.12 below indicates a Cronbach's Alpha greater than 0.8. This therefore confirms the reliability of the instrument used to collect the data.

Table 4.12; Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.944	.952	76

4.7.2 CONSTRUCT VALIDITY

Factor analysis according to Williams & Brown (2012), can be used among others to;

- Reduce the number of variables
- Examine the structure or relationship between variables
- Evaluate the construct validity of a scale, test or instrument
- Develop theoretical constructs
- Used to prove or disprove theories.

In this study, confirmatory factor analysis was used to evaluate the construct validity of the test instrument. Confirmatory factor analysis was used because the variables are already grouped as adopted from literature. The groupings each measure a factor (see Williams & Brown, 2012). In this research a Kaiser-Meyer-olkin (KMO) and Bartlett's test of sphericity were used to assess the suitability or as a measure of the sampling adequacy. The KMO measures the strength of the relationship between variables (Chetty & Datt, 2015).

KMO values range between 0-1, and a value of 0.5 and higher is considered adequate. Aside the KMO value, Bartlett's test of sphericity should be significant ($p < 0.05$) (Williams & Brown, 2012).

In this research the extraction method used was "maximum likelihood", an Eigen value greater than 1 and a direct oblinim rotation.

Whilst authors such as Fiedel (2005) as cited in Chetty & Datt (2015) maintain that a sample size of 300 is adequate. It is universally accepted that a sample size below 50 is inadequate for factor analysis (Chetty & Datt, 2015). The sample for this research satisfied this condition.

4.8 FACTOR ANALYSIS RESULTS

4.8.1 CRITICAL SUCCESS FACTORS FOR TQM

Table 4.13 summarises the output from the factor analysis that was conducted indicating the KMO and Bartlett's test of sphericity. The results indicate that apart from one factor "Quality of codes and standards" where the KMO value was less than 0.5, all the other factors had a KMO value greater than 0.5. This confirms that the sampling responses are adequate. Also, Bartlett's test which measures the strength of the relationship between variables are all significant as their p-values are all less than 0.05. This also confirms that the probability of the results occurring by chance is less than 5%.

It can therefore be concluded that the survey instrument is measuring what it was intended to measure.

Table 4.13; Summary of KMO and Bartlett's test for Critical Success Factors

Management Commitment and Leadership	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.7636
	Bartlett's Test of Sphericity	Approx. Chi-Square	125.383
		df	15
		Sig.	.000
Drawings and specification	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.794
	Bartlett's Test of Sphericity	Approx. Chi-Square	94
		df	6.000
		Sig.	0
Training	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.6655
	Bartlett's Test of Sphericity	Approx. Chi-Square	45.668
		df	3
		Sig.	.000
Statistical Methods	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.7391
	Bartlett's Test of Sphericity	Approx. Chi-Square	105.265
		df	6
		Sig.	0.0000
Teamwork	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.7391
	Bartlett's Test of Sphericity	Approx. Chi-Square	105.265
		df	6
		Sig.	0.0000

Table 4.13 continued from previous page

Customer Service	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.8060
	Bartlett's Test of Sphericity	Approx. Chi-Square	221.690
		df	21
		Sig.	.000
Supplier Involvement	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.7297
	Bartlett's Test of Sphericity	Approx. Chi-Square	128.293
		df	15
		Sig.	.000
Cost of Quality	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.691947857
	Bartlett's Test of Sphericity	Approx. Chi-Square	38.629
		df	3
		Sig.	.000
Quality of Codes and Standards	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.107516249
	Bartlett's Test of Sphericity	Approx. Chi-Square	185.589
		df	10
		Sig.	.000

4.9 A PROPOSED FRAMEWORK FOR QUALITY MANAGEMENT OF CONCRETE WORKS

4.9.1 INTRODUCTION

A proposed framework is presented in this section to guide Construction Project team members in quality management of concrete works in order to produce durable and quality concrete. The elements of this framework are mainly derived from the critical success factors essential for total quality management extracted from literature and the short comings of the quality management practices currently practiced by respondents.

4.9.2 COMPONENTS OF THE FRAMEWORK

The proposed framework consists of an input and output of resources. The output been the desired results after the implementation of the essential activities. The whole framework is underpinned by the principle of continuous improvements. Thus, errors identified such as cubes not meeting required test strength or inappropriate slump results are corrected by adjusting the factors causing them. This helps in continuously improving the system and achieving the desired results.

Nine critical success factors identified in the literature for a successful total quality management were adopted and are as stated; Management commitment and leadership, Drawings and specifications, Training, Statistical methods, Teamwork, Customer service, supplier involvement, cost of quality and quality of codes and standards. The objective of the firm is to satisfy the customer and make profit. The customer first presents his needs and requirements as the initial inputs. Based on this, the specifications and drawings are drafted with regards to the codes and standards. A supplier is involved in the provision of quality materials based on the codes, standards, drawings and specification.

The firm uses statistical methods for the various sampling and laboratory testing to ensure that material input and output meets the desired specification.

In the particular instance of concrete works the definition adopted is "meeting specified requirements". The mixed design is undertaken to ensure that with the given materials and environment the specified requirements defined are achieved.

As shown in the framework in Figure 4.17 the quality assurance/control measures are undertaken during the concrete operation, which involves the use of checklist to ensure that nothing is left out. Inspection of concrete operation is another important aspect of ensuring that the concrete produced is of the right consistency. The use of the slump test confirms the water content and consistency. These must be recorded and compared to subsequent operations. Test cubes are also produced tested and results recorded. This will confirm the strength of concrete being produced.

Top Management commitment and leadership permeates the entire activities and symbolically seen as a roof of the entire frame. Without top management input, resources and motivation for implementation of the system cannot survive.

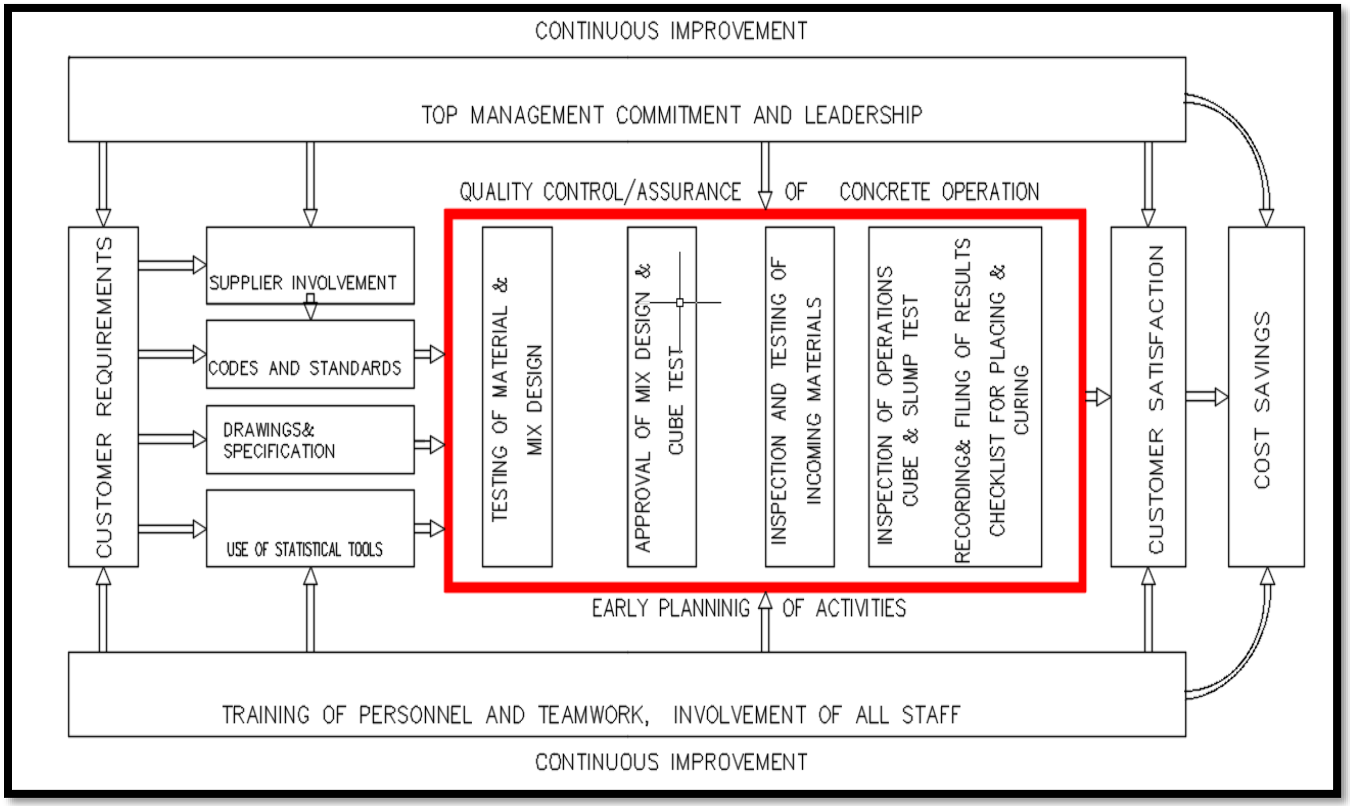


Figure 4.17; Framework for Quality Management Practice in Concrete Works

Training of personnel, teamwork and involvement of all staff is symbolically represented as the foundation upon which the system is built on. Training will introduce the needed culture of quality management practices and the concept that quality is the responsibility of all. The concept is that each person in the quality chain is either a supplier or customer of the next stage or previous stage and must satisfy all customers.

Customer requirements and customer satisfaction symbolically represent the support columns of the entire system. Without the customer being satisfied, then it is not deemed to be successful.

Implementation of a total quality management system is expected to yield savings in cost. Regular monitoring and evaluation is therefore required to discover if savings are being made.

CHAPTER FIVE

CONCLUSIONS AND RECOMENDATIONS

5.1 INTRODUCTION

The aim of this research was to explore the nature and scope of quality management practices among construction team members in concrete works.

The research questions were:

- What parameters influences the production of durable quality concrete?
- How is quality management being practiced by construction team members in concrete works?
- Is the philosophy of quality management practices adopted by construction teams?
- What are the perceptions of construction team members with regard to the critical success factors of Total Quality Management?
- What are the possible causes of poor durability in concrete works?
- What quality management tools and techniques are applied?

The problem of durability of concrete products attributed to poor quality management practices is a worldwide phenomenon. In the recent past it was assumed that the most important parameter in concrete products was the strength and once the required strength was achieved the concrete will be durable as well. However, research in the literature has indicated that high strength concrete does not automatically guarantee durable concrete. Durability of concrete is mostly dependent on the water cement ratio and the cover to reinforcement.

Billions of dollars are lost in the construction industry to repair failing concrete which could have been avoided had time tested quality management practices being applied.

Certain basic quality control and assurance measures are often disregarded leading to costly outcome when the concrete fails or do not meet the durability requirement.

To answer the research questions, the following objectives were thus set;

1. To identify the parameters for quality durable concrete.
2. To assess the knowledge of construction team members with regard to some basic requirements for producing durable quality concrete.
3. To identify current quality management practices adopted by construction team members in concrete works.
4. To propose a framework for quality management practices in concrete works.

5.2 FINDINGS

The research determined from literature certain critical factors which are necessary in producing durable concrete. These were water cement ratio and cover to reinforcement among others. Also identified were the quality assurance and quality control measures imperative for producing quality products and finally critical success factors necessary for the practice of total quality management in the construction industry. Thus, **objective one** was achieved by this.

Objective two; respondents were tested on the factors necessary for producing durable concrete. The results indicated that majority of the respondents were not aware that in terms of achieving strength and durability, water cement ratio was the most important followed by cover to reinforcement for the case of durable concrete.

Objective three assessed the current quality management practices adopted; there was generally an appreciable level of quality management elements in the firms of respondents.

Majority of respondents relied on verbal instructions as a means of communication for undertaking concrete works. This does not auger well in the production of concrete since instructions must be written down and properly filed. It also came to light that; respondents tend to depend more on the experience of supervisors rather than on the drawings and specification. This means that things will always be done the same way it was in previous works without sticking to the specifications and requirements. Even though majority of respondents defined concrete as meeting specified requirements their dependence on experience to achieve quality contradicted the definition.

The results also indicate that majority of the respondents did not have a formal quality management systems or ISO certification.

On quality control measures, it was observed that inspection of the concrete operation, test cubes production and testing, recording of the results and slump test were highly practiced. This is positive for producing quality concrete. However, recording of slump test results and the use of checklist even though encouraging, was relatively low which does not auger well for a good quality management system. A system which does not use a checklist will imply that personnel may not be able to conform to all specified requirements in order to meet the required quality.

The research also determined that less than half of the respondents joined the project prior to start of the project. This means that there was not enough time for planning in terms of quality management. In the ideal situation staff, should be recruited prior to the start of the project to study the requirements and also plan the project in terms of quality management.

Objective 4 was on the perception of respondents on the critical success factors for the implementation of total quality management. Under this section forty-two questions grouped under nine headings were asked the respondents. These nine critical factors for the implementation of total quality management in the construction industry were adopted from literature, notably (Oberlender, 2000; Arditi & Gunaydin, 1997). The factors are; Management Commitment and Leadership, Drawings and Specifications, Training, Statistical Methods, Teamwork, Customer Service, Supplier Involvement and Cost of Quality.

The results indicated that respondents placed very high importance on these factors. The one sample t-test was used to analyze the data and the results indicated an above average importance for the factors. The results indicated a high degree of unanimity among respondents with the exception of one factor i.e. "Project team members must have thorough knowledge of the codes and standards", which had a standard deviation of a little more than one indicating the lack of unanimity in this factor response.

Objective Five; objective five proposed a framework for practicing quality management in concrete works. The framework was developed based on the literature and the short comings identified from responses of the respondents. This framework can serve as a road map in producing quality and durable concrete that meets the specified requirements of the Client.

5.3 CONCLUSION

Based on the findings the following conclusions are drawn:

- The research revealed that majority of Construction team members belonging to D1K1 Contractors did not fully appreciate the basic requirements for producing durable concrete. A majority considered Cement content as the most important in achieving durability of concrete.
- Majority of the Construction team members understood quality concrete in a narrow sense; as satisfying structural functionality, rather than the all-encompassing definition of satisfying "specified requirements"
- Quality control and assurance techniques currently used were not fully implemented, as most of them failed to appreciate the importance of keeping records of test carried out particularly slump test. The usage of check list was among the least. This is rather unfortunate considering the importance of checklist in quality control.
- Even though most of the firms did not have formal quality management system and were not ISO certified, it was discovered most of the firms had several elements of quality management techniques in their operation.
- The respondents' perception of the importance of critical success factors for implementing TQM was very high.

5.4 RECOMMENDATIONS

The following recommendations will help in in-situ concrete works at construction site. They are based on short comings observed from the respondents;

- Implementation of Formal quality management systems must be encouraged.
- Team members of Construction teams must strictly stick to satisfying the specified requirements.
- There appears to be inadequate application of basic concrete principles during concreting operations and personnel need to be trained routinely to remind them of these basics.
- Rather than depend on experience of supervisors, personnel should focus on satisfying specifications and requirements. This can be done by applying quality management principles in concrete works.
- The use of checklist is highly recommended. This will guide personnel on all the essential activities to undertake and only proceed to the next stage only when a previous stage is accepted.
- Variability of concrete materials and concrete should be controlled by encouraging the maintenance of good record keeping. The use of the slump test for instance is recommended for maintaining consistency with previous batches.
- Top management must show commitment and leadership in concrete works quality. All team members must be encouraged to get involved to achieve quality and not leave it to low level personnel.

5.5 FUTURE RESEARCH

There is the need for further research into quality management of concrete works. This is because of the serious consequences poor quality has in terms of financial and public safety. This is further boosted by this research which showed that poor quality management affects the quality and durability of concrete. Some of the areas that need further research are

- Quality assurance in concrete works
- Quality management practices in placement of concrete.

5.6 LIMITATIONS OF THE STUDY

The research studied the highest class of Contractors (D1K1) who are well structured and employs qualified professionals for their projects. The results can therefore not be generalized for all categories of Construction firms. In-situ concrete produced on site was the focus of the research. It was also limited to Contractors who are registered and in good standing with the Association of Building and Civil Engineering Contractors of Ghana.

5.7 PRACTICAL IMPLICATIONS

This study will highlight the need for Construction Firms to pay more attention to the quality management of concrete works. It will encourage firms to routinely train their personnel in quality management of concrete works and the need to achieve not only the target concrete strength but its durability. It would also inform academia that some students although taught the fundamentals of concrete do not apply this on the field.

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APPENDIX A

QUESTIONNAIRE

This questionnaire is designed for a Master of Philosophy research titled "Quality Management Practices of Construction Teams in Concrete Works". It is meant to solicit information from construction project team members with the aim of examining the current quality management practice and perception of the factors necessary for successful quality management in concrete works. The respondent's information provided will be treated as confidentially as possible.

SECTION A

To complete this questionnaire electronically, click on the appropriate box. If you want to reverse your decision click again on the same box. Where text or number is required type in with your keyboard. After completing save the work before returning it to the researcher.

Respondents' data

1. What is your level of education?

a) Postgraduate ☐

b) First Degree ☐

c) HND/ Diploma ☐

d) Technician (CTC I, CTC II, CTC III) ☐

e) Other (specify) ☐

2. What is your job title/position in the company?

   a. Project/Construction Manager ☐
   b. Quality Manager/QC/QA officer ☐
   c. Project Engineer ☐
   d. Site Engineer ☐
   e. Clerk of works ☐
   f. Site Supervisor ☐
   g. Others (specify) ☐

3. How many years of experience do you have in the industry?

   0-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ over 20 years ☐

4. How long has your company been in existence?

   0-5 years ☐ 6 -10 years ☐ 11-15 years☐ 16-20 years ☐ over 20years ☐

5. At what stage, did you join the current project?

a) Pretender-pre-planning stage ☐

b) Post tender stage ☐

c) Start of project ☐

d) After start of project ☐

e) Involved at some point before commencement ☐

f) If other (please specify) ☐

Section B

Quality management Practice in Concrete works

1. Rank the factors listed below in relation to its effect on the durability of concrete as 1,2,3,4, 5 in order of importance with 5 being the most important factor followed by 4, 3, 2 and 1 being the least important. Type or write the number in the box. Do not tie any factor.

a) Cement content Choose an item.

b) Cover to reinforcement Choose an item.

c) Water/cement ratio Choose an item.

d) Compaction Choose an item.

e) Curing Choose an item.

f) If other (please specify)

2. Which of the following is the most frequent mode of communication at your site with respect to concrete works?
   a) Verbal ☐
   b) Written ☐

On a scale of 1= Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly Agree, how would you rate the following statements (Please Tick/cross only one option)	**1**	**2**	**3**	**4**	**5**
Quality Concrete is defined as					
1. Conformance to specified requirements	☐	☐	☐	☐	☐
2. Aesthetic features	☐	☐	☐	☐	☐
3. Structural functionality	☐	☐	☐	☐	☐
How is the quality of concrete works controlled at the site					
1. Use of check list	☐	☐	☐	☐	☐
2. Inspection during the concrete operation	☐	☐	☐	☐	☐
3. Test cubes are produced	☐	☐	☐	☐	☐
4. Strength test are performed on cubes	☐	☐	☐	☐	☐
5. Results of strength test on cubes are recorded	☐	☐	☐	☐	☐
6. Slump test is undertaken	☐	☐	☐	☐	☐
7. Results of slump test are recorded	☐	☐	☐	☐	☐
Quality of supervision is dependent on					
1. Experience of the supervisor	☐	☐	☐	☐	☐
2. Specifications and drawings	☐	☐	☐	☐	☐
Formal Quality					
1. Your company does not have a formal Quality management system	☐	☐	☐	☐	☐
2. your company is not ISO 9000 certified	☐	☐	☐	☐	☐
Your company uses the following quality management tools listed below					
1. Quality planning	☐	☐	☐	☐	☐
2. Quality control	☐	☐	☐	☐	☐
3. Quality assurance	☐	☐	☐	☐	☐
4. Total Quality Management	☐	☐	☐	☐	☐
5. Quality improvement	☐	☐	☐	☐	☐

6. Quality management systems	☐	☐	☐	☐	☐
Assurance/Control					
1. Quality management techniques include the determination of quality policy, objectives, responsibilities and implementing them within the quality system	☐	☐	☐	☐	☐
2. Codes, standards and other relevant documents are available at the site and accessible to you	☐	☐	☐	☐	☐
3. Control measures are in place for ensuring that the inspection and test equipment is capable of the necessary function and accuracy	☐	☐	☐	☐	☐
4. Documented Procedure for reviewing the disposition of non-conforming products exist in your company	☐	☐	☐	☐	☐
5. There is documented procedure for implementing corrective and preventive actions in your company	☐	☐	☐	☐	☐
6. There is a documented procedure for handling, storing and Preserving concrete materials and finished works	☐	☐	☐	☐	☐
7. Your company has a systematic filing and accessing procedures to enable efficient quality record retrieving	☐	☐	☐	☐	☐
8. Periodic internal auditing of the System by independent Personnel to ensure effectiveness of the quality system is performed by your company	☐	☐	☐	☐	☐
If other (please specify)					
9. Click here to enter text.	☐	☐	☐	☐	☐

SECTION C

Success factors of Total Quality Management (TQM)

Below are a number of quality characteristics which can have an impact on quality management in your firm.

On a scale of 1= extremely unimportant 2= unimportant 3= neutral 4= important 5= extremely important, how would you rate the significance of the following statements (Please Tick/cross just one appropriate box)

Management commitment and leadership	1	2	3	4	5
1. Top Management sets objectives for quality and is committed to quality	☐	☐	☐	☐	☐
2. Top management defines the responsibility of personnel who manage, perform and verify work that affect quality	☐	☐	☐	☐	☐
3. Existence of a communication system notifying all staff about the quality responsibilities of every individual	☐	☐	☐	☐	☐
4. Adequate provision of appropriate resources for performance of work	☐	☐	☐	☐	☐
5. Management actively leading and directing quality management programs assuming responsibility for evaluating and improving Quality management system at pre-defined intervals	☐	☐	☐	☐	☐
6. Employees feel top management provides full support to process and project quality improvement	☐	☐	☐	☐	☐
If other (please specify)					
7. Click here to enter text.					
Drawings and specifications	1	2	3	4	5
1. Drawings and specifications reviewed prior to authorization for construction	☐	☐	☐	☐	☐
2. effective access to obtain the latest construction drawings and specifications	☐	☐	☐	☐	☐
3. Drawings and specifications are concise, clear and uniform	☐	☐	☐	☐	☐
4. Testing and inspection of incoming materials for specification Compliance	☐	☐	☐	☐	☐
If other (please specify)					
5. Click here to enter text.					

Training	1	2	3	4	5
1. Identification and provision of required training for all staff including the basics of total quality management	☐	☐	☐	☐	☐
2. Regular training organized for staff	☐	☐	☐	☐	☐
3. Employees introduced to the principles and tools for total quality Management at project commencement	☐	☐	☐	☐	☐
If other (please specify)					
4. Click here to enter text.					
Statistical methods	1	2	3	4	5
1. Undertakes survey for assessment of client's satisfaction	☐	☐	☐	☐	☐
2. Make decisions that are facts, based on data rather than opinions	☐	☐	☐	☐	☐
3. Use of process flow charts, inspection and test plan for activities that directly affect quality	☐	☐	☐	☐	☐
4. Use of statistical tools such as histograms, check sheets, control charts, Pareto etc.	☐	☐	☐	☐	☐
If other (please specify)					
5. Click here to enter text.	☐	☐	☐	☐	☐
Teamwork	1	2	3	4	5
1. Policies to encourage all employees to take part in quality improvement discussion	☐	☐	☐	☐	☐
2. Practices to encourage Project quality improvement discussions at internal and external meetings	☐	☐	☐	☐	☐
3. Effective coordination between various departments of the firm and project team members	☐	☐	☐	☐	☐
4. Activities to encourage frequent contact between parties involved in in the Project	☐	☐	☐	☐	☐
5. Employees feel positive about the company's quality policy	☐	☐	☐	☐	☐
If other (please specify)					
6. Click here to enter text.	☐	☐	☐	☐	☐
Customer service	1	2	3	4	5

	1	2	3	4	5
1. Policies for regularly reviewing the clients Project priorities	☐	☐	☐	☐	☐
2. Explaining the Proposed construction processes to the client Prior to construction commencement	☐	☐	☐	☐	☐
3. Responding quickly to client's enquiries and complaints	☐	☐	☐	☐	☐
4. offering reasonable explanation and solutions to legitimate Complaints	☐	☐	☐	☐	☐
5. Establishing courteous attitude and efficient communication with the client	☐	☐	☐	☐	☐
6. Satisfying both internal and external customers	☐	☐	☐	☐	☐
7. Conducting value engineering workshops with the client at project commencement in order to highlight potential	☐	☐	☐	☐	☐
If other (please specify)					
8. Click here to enter text.	☐	☐	☐	☐	☐
Supplier involvement	1	2	3	4	5
1. Establishing courteous attitude and efficient communication with the Sub contractor and suppliers	☐	☐	☐	☐	☐
2. Relying on few dependable suppliers who are committed to quality.	☐	☐	☐	☐	☐
3. Establishing closer and long term relationship with suppliers	☐	☐	☐	☐	☐
4. providing clear and concise specifications to suppliers	☐	☐	☐	☐	☐
5. Dealing with suppliers who have quality assurance programs	☐	☐	☐	☐	☐
6. Satisfying internal and external customers/suppliers	☐	☐	☐	☐	☐
If other (please specify)	☐	☐	☐	☐	☐
7. Click here to enter text.	☐	☐	☐	☐	☐
On a scale of 1= Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly Agree, how would you rate the following statements (Please Tick/cross only one option)	1	2	3	4	5
Cost of quality					
1. Implementing quality management will lead to cost reduction	☐	☐	☐	☐	☐

2. cost of quality is used to track the effectiveness of TQM	☐	☐	☐	☐	☐
3. Cost of quality is effective in raising awareness of quality and identifying improvement opportunities	☐	☐	☐	☐	☐
If other (please specify)					
4. Click here to enter text.	☐	☐	☐	☐	☐
Quality of codes and standards	1	2	3	4	5
1. There must be early identification of codes and standards	☐	☐	☐	☐	☐
2. Codes and standards primarily protect the public health and safety	☐	☐	☐	☐	☐
3. Project team members must have thorough knowledge of the codes and standards during the design stage	☐	☐	☐	☐	☐
4. Codes and standards have an effect on the quality of the final product	☐	☐	☐	☐	☐
If other (please specify)					
5. Click here to enter text.	☐	☐	☐	☐	☐

End

Thank You