QUALITY MANAGEMENT MODEL FOR CURBING FAILURE OF REINFORCED CONCRETE BUILDINGS IN DAR ES SALAAM, TANZANIA

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Quality Management Model for Curbing Failure of Reinforced Concrete Buildings in Dar es Salaam, Tanzania

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This work is dedicated to my father William Elisamia Meena and to the memory of my lovely mother Awuaichi Uforosia Meena, for bringing me up. Also the work is dedicated to my wife, Upendo Meena to whom I will forever be thankful. Her love, patience and believe in me were the driving force behind every step I took. Last but not least, I dedicate the work to my children Brian and Beatrice; I appreciate their patience for life hardship they experienced during the time of preparing this work.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACET	Association of Consulting Engineers Tanzania
AQRB	Architects and Quantity Surveyors Registration Board
BICO	Bureau for Industrial Cooperation
BS	British Standards
CBD	Central Business District
CI	Construction Industry
CIP	Construction Industry Policy
CM	Construction Management
CPA	Critical Path Analysis
CRB	Contractors Registration Board
DBB	Design-Bid-Build
DSM	Dar es Salaam
ERB	Engineers Registration Board
EU	European Union
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GOT	Government of Tanzania
IAP	Implementation Action Plan
ICT	Information and Computer Technology
IET	Institution of Engineers Tanzania
ILO	International Labour Organization
ISO	International Standards Organization
KIM	Kenya Institute of Management
JKUAT	Jomo Kenyatta University of Agriculture and Technology
LGAs	Local Government Authorities
MECCO	Mwananchi Engineering and Contracting Corporation
MEM	Master of Engineering Management
MoF	Ministry of Finance

MoID	Ministry of Infrastructure Development
MoW	Ministry of Works
MoWTC	Ministry of Works, Transport and Communication
NAO	National Audit Office
NBS	National Bureau of Statistics
NCC	National Construction Council
NEDCO	National Estates Designing Corporation
NDC	National Development Corporation
NHBRA	National Housing and Building Research Agency
NHC	National Housing Corporation
OSHA	Occupational Safety and Health Authority
PERT	Project Evaluation and Review Techniques
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PPA	Public Procurement Act
PPRA	Public Procurement Regulatory Authority
QFD	Quality Function Deployment
RC	Reinforced Concrete
SABS	School of Architecture and Building Sciences
SADC	Southern African Development Community
SPSS	Statistical Package for Social Sciences
TABCA	Tanzania Building Contractors Association
TACO	Tanzania Association of Consultants
TBS	Tanzania Bureau of Standards
TQM	Total Quality Management
UDSM	University of Dar es Salaam
URT	United Republic of Tanzania

ABSTRACT

Failure of reinforced concrete buildings raised concerns about quality of buildings in Dar es Salaam. Manufacturing companies realized that key area to ensure commercial success is quality of product and several methods to help in this regard have emerged under Total Quality Management (TQM). Literature indicated that associated research in the construction industry has received little attention by comparison. The purpose of this research was to develop a model to facilitate quality management to curb failure of reinforced concrete buildings in Dar es Salaam. The study adopted triangulation research strategy with cross-sectional and case study research designs. The cross-sectional design employed face to face interview using research schedule, while the case study design employed collective case studies. A survey of 46 reinforced concrete buildings under construction in Dar es Salaam was undertaken. In addition, 36 cases of structural soundness investigations including two cases of multi-storeyed reinforced concrete buildings collapse and one multi-storeyed reinforced concrete building demolished for claims of poor quality in Dar es Salaam were analyzed. The results revealed that over half (64.2%) of reinforced concrete buildings do not meet minimum structural strength requirements. Null hypothesis was rejected ($p < 0.001$ and $F = 23.336$) implying that there is relationship between structural integrity and quality management practices of reinforced concrete buildings' construction in Dar es Salaam. To ameliorate the weaknesses found in the study results, a facilitative quality management model has been developed. The model is based on TQM with five components, two of the components are management tools and three are TQM principles. Results of the model's evaluation in five building construction companies were in general, positive and encouraging. Practitioners concurred that the proposed model offers a simple, easy to understand and well structured. They also recognized that the model is systematic, applicable and practical for the intended purpose. Overall, the objectives set at the outset of this research have been achieved.

CHAPTER ONE

INTRODUCTION

1.1 Background

Global marketplace belongs to organizations that meet or exceed quality requirements (Delgado & Aspinwall, 2008; Dale *et al.*, 1998). Over the last two decades approaches such as Just in Time (JIT), Quality Function Deployment (QFD) and Concurrent Engineering (CE) gained prominence as methods to attain the required quality. Literature reports that the implementation of these approaches is mainly centred on the experiences of large manufacturing companies. Examples of successful companies include Ford, General Motors, IBM, Mitsubish, Motorola, and Toyota (Delgado, 2006; Lema, 1996). Very little by comparison has been published with reference to the construction industry.

Different to the the success stories reported in manufacturing industry, attainment of acceptable levels of quality in the construction industry has always been a problem (Haseeb & Huang, 2013; Wanberg *et al*., 2013; Shofoluwe *et al.*, 2012; Rad & Khosrowshahi, 1998; Arditi & Gunaydin, 1997). Poor quality in construction projects is a common phenomenon (Shittu *et al*., 2013). Apart from quality problems, the industry also has performance difficulties, the main reasons for which according to Pheng and Teo (2004) and Abdul-Rahman *et al*. (2010) are the construction process and its management. Subsequently, in the absence of effective quality management procedures, huge resources have been wasted due to construction failures (Haseeb & Huang, 2013; Rad & Khosrowshahi, 1998; Arditi & Gunaydin, 1997).

Resources wasted in construction industry due to absence of effective quality management procedures in developed and developing countries include accidents, failure and building collapse. According to Health and Safety Commission (UK) (2001 cited in Bennett, 2003) the non-fatal injury rate in the United Kingdom, construction industry was the highest for all industries in 2000 constituting 2.53%, with a rate of 2530 such injuries per 100 000 workers. Wanberg, *et al.* (2013) reported that in 2010 construction industry accounted for more fatalities than any other industry in the United States. Same or even worse quality related problems have been reported in Asia (Abdul-Rahman *et al*. 2010; Sandaraj, 2007) and Africa (Ofori, 2015; Figueroa, 2014; Windapo & Rotimi, 2012).

While most of developed countries have moved forward and focus on customer satisfaction and include voices of customer in their building construction (Delgado, 2006), most of developing countries still focus on avoiding building failures in their construction processes. Buildings failure among the existing and those under construction in many of developing counties is common, the worst scenario being buildings collapse (Figueroa, 2014, Windapo & Rotimi, 2012; Ahzahar*et al*., 2011). Tanzania is not exempted from incidents of buildings failure and collapse. At least five reinforced concrete buildings were reported to have suddenly collapsed in Dar es Salaam suspected of poor quality (NCC, 2017; Rubaratuka, 2013; CRB, 2010). Also, four reinforced concrete buildings were demolished by order of government in Dar es Salaam due to poor quality (NCC, 2017; NHBRA, 2016; Financial Junction, 2013; The African, 2013)

Literatures like (Abdul-Rahman *et al*. 2010; Wang & Yap, 2010; Hiyassat, 2000) show that, quality problems facing the construction industry can be dealt with by application of total quality management (TQM) concepts and methods. The reasons advanced by some other authors (Haseeb & Huang, 2013; Hoonakker *et al*., 2010; Rad & Khosrowshahi, 1998; Arditi & Gunaydin, 1997) is based on the experience and lesson learnt from manufacturing where TQM was successfully implemented.

1.2 Statement of the Problem

Construction of reinforced concrete buildings in Dar es Salaam is frequently criticized by clients and the public in general (NCC, 2017; Rubaratuka, 2008; Mrema and Mhando, 2005; Muhegi & Malongo, 2005; Baradyana, 2000; Lema, 1996). The criticisms among others are on abandonment of unfinished reinforced concrete buildings, failure and collapse of multi storey reinforced concrete buildings. For example between 1987 (when first collapse was reported) and 2017 (when data collection of this study was conducted) at least five multi-storey reinforced concrete buildings were reported to have collapsed in Dar es Salaam (NCC, 2017; CRB, 2010; Rubaratuka, 2008). Also, between 2007 and 2017 four multi-storey reinforced concrete buildings were demolished by order of government in Dar es Salaam, because they were unsafe for habitation (NCC, 2017; NHBRA, 2016; Financial Junction, 2013; The African, 2013).

Problems facing reinforced concrete buildings construction in Dar es Salaam have made the building sector not able to provide good environment for socio-economic development of Tanzania (NBS, 2013). Although contribution of construction industry to Gross Domestic Product (GDP) in Tanzania as of 2014 was 12.5% (NCC, 2017), the housing sector contributes less than 1.0% to the National GDP per annum. Contribution of the housing sector to GDP in some developed as well as developing countries' is between 15% and 60% per annum (Inuwa, 2014).

Symptoms and the consequences presented above is an indication of existence of problem. Those indicators led to further inquiry into literature to find out what could be the problem. Literature indicated that, manufacturing industry applied TQM to improve quality problems of its products (Delgado, 2006; Abdul-Rahman *et al*. 2010; Arditi & Gunaydin, 1999), but very little by comparison has been published with reference to construction industry (Hoonakker *et al*., 2010). Further literature review (NCC, 2017; Rubaratuka, 2008; Mrema and Mhando, 2005; Muhegi & Malongo, 2005) indicated that little is published on relationship between construction quality management practices and quality of reinforced concrete buildings. Thus, relationship between construction quality management practices and quality of reinforced concrete buildings in Dar es Salaam represents a significant knowledge gap.

Therefore, knowledge gaps that required further research include: structural integrity of reinforced concrete buildings; factors affecting quality of reinforced concrete buildings; the level of application of quality tools and techniques in reinforced concrete buildings construction; supervision level of reinforced concrete buildings construction; and practices of quality assurance & quality control of reinforced concrete buildings construction in Dar es Salaam. Moreover, no enough information was available in the literature of a suitable construction management model that could facilitate proper quality management of reinforced concrete buildings construction in Dar es Salaam. Therefore, this study aimed to adds to the body of knowledge by collecting and analyzing data from representative sample of reinforced concrete buildings in Dar es Salaam.

1.3 Research Objectives

To achieve the aim of this research, the following objectives are set up:

1. To examine the structural integrity of reinforced concrete buildings in Dar es Salaam.
2. To establish factors affecting quality of reinforced concrete buildings in Dar es Salaam;
3. To determine relationship between quality management practices and structural integrity of reinforced concrete buildings in Dar es Salaam;
4. To develop a model to facilitate quality management of reinforced concrete building construction in Dar es Salaam.

1.4 Research Hypothesis

Null and alternative hypothesis was formulated as shown below:

Null hypothesis (H_o):

There is no relationship between construction quality management practice and structural integrity of reinforced concrete buildings in Dar es Salaam.

$$Y \neq a + b_1X_{1j} + b_2X_{2j} + \cdots + b_kX_{kj} + \varepsilon_j \neq \sum_{j=1}^{k} b_j X_j + \varepsilon_j$$

or $\quad Y \neq f(X)$

Alternative hypothesis (H_a):

There is relationship between construction quality management practice and structural strength of reinforced concrete buildings in Dar es Salaam.

$$Y = a + b_1X_{1j} + b_2X_{2j} + \cdots + b_kX_{kj} + \varepsilon_j = \sum_{j=1}^{k} b_j X_j + \varepsilon_j$$

or $\quad Y = f(X)$

Where: Y = Dependent variable

a = Y intercept

b = Regression coefficients

X = Predictor variables

ε = Error term

1.5 Justification of the Study

For the last four decades quality in construction industry has been a problem in developed countries as well as in developing countries (Abdul-Rahman *et al.,* 2010; Hoonakker *et al.,* 2010). The construction sector deals mainly with the provision of capital infrastructure, which has an impact on economic growth (Baradyana, 2000). The delivery of these infrastructures creates significant employment opportunities for the population, which generates further investment in other sectors of the economy through the multiplier effect (Ofori, 2012). This study was carried out by considering the fundamental significance of the construction sector in employment creation, capital formation, an important sector of the economy, and its aggregate spillover effects.

Motivation to study building construction is due to its significance both in terms of its construction volume share and its employment provision in Tanzania. Statistics indicate that building construction consumes about 70 percent of the construction investment in developing countries (Lema, 1996). Analysis of Gross Fixed Capital Formation (GFCF) for 2010 in Tanzania, revealed that buildings contributed 56% and civil works contributed 44% of the total GFCF (NCC, 2017). On the other hand, in 2010 construction industry employed 9.1% of the formal workforce, making it Tanzania's fourth largest industry (NBS, 2013). A total of 109,879 persons were engaged in construction industry in this period compared to 97,081 persons engaged in the manufacturing industry (NBS, 2012; NBS, 2013).

Analyzing the results by construction activity NBS (2013) showed that construction of buildings had the largest share (48.7%) of the total persons engaged followed by construction of civil engineering projects (40.9%) whereas other specialized construction activities had 9.7 percent of the total persons engaged. Large civil engineering projects are normally executed by foreign contractors who also undertake large building projects. In 2006 for example, the majority of enterprises in the construction sector in Tanzania were in the category of small contractors with a few in the medium category (NCC, 2017). Despite that local firms constituted 95% of the total construction enterprises (about 4,300 registered contractors and 250 consultants), they only managed to undertake construction projects worth 10 percent in terms of monetary value. The remaining 90 percent share was taken by foreign firms which constituted only 5 percent of the total registered firms (NBS, 2013).

Local designers and contractors mainly execute small and medium size projects. The building construction industry provides excellent improvement opportunities for local contractors and therefore forms the initial basis for research aimed at enhancing local firms. This study focused on multi-storey reinforced concrete buildings because the available literature (NCC, 2017; CRB, 2010; Rubaratuka, 2008) gives evidence that all the reported cases of buildings collapse in Dar es Salaam, involved multi-storey reinforced concrete buildings. Further, 98% of stoyed buildings in Dar es Salaam are constructed using reinforced concrete (Rubaratuka, 2013) In light of this information; it justifies the focus of multi-storey reinforced concrete buildings constructed or under construction in Dar es Salaam to be a unit of analysis for this study.

1.6 Significance of the Study

The main beneficiary of this work is various building construction industry stakeholders. Building construction process involves various parties including clients, designers, construction companies and regulatory authorities at different construction phases. In this study it is believed that important construction phases that require attention for quality are design phase and construction phase. Here designers particularly reinforced concrete buildings structural strength designer and building construction main contractors will benefit from the findings of this research. There are various problems associated with the approaches that are available to the designers and contractors for their building construction process. The concept of prioritization which has its root from Pareto Principles has widely been applied to improve process in manufacturing industry (Koch, 1998). Pareto Principles is fairly new in construction research; therefore research into its applicability in construction industry is very timely.

In terms of significance of this research, a very similar argument to that presented by Delgado (2006) is put forward. In the construction management field, there are proponents of different strategies for improving the quality of the industry's products. This is a sign of the importance and relevant of the research topic. Similarly, it is important to recognize that different approaches or viewpoints give solutions to a wider variety of problems. Inspections and quality control are the traditional systems used in construction. So far they have been applied without regard to the Pareto Principles that a relatively small number of causes typically produce a large majority of problems (Suarez, 1992). Inclusion of the latter in building construction process in design and construction phases can bring about benefits such as better buildings designs, better construction specifications, improved working drawings with the necessary details required and improved construction process. The main contribution of this work is the development of a model for quality improvement throughout the building construction process. The main benefits therefore, is not only the possibility of solving quality problems but also of suggesting methods for improving quality of building construction process at the two important building construction phases.

1.7 Scope of the Study

Total Quality Management (TQM) philosophy was seen as the main framework on which to initiate quality improvement efforts. Within the TQM, this study confined to the concept of prioritization which has its roots from Pareto Principles. The study focused on quality in reinforced concrete buildings construction. Focus on quality on one hand is based on the argument that quality is one of the metrics to measure construction project performance or successes (Chan & Chan, 2004). On the other hand quality in construction industry has been a global problem for sometime (Abdul-Rahman *et al.,* 2010; Hoonakker *et al.,* 2010) therefore efforts concentrated on enhancing quality in construction are likely to result in a significant improvement of the industry. The contribution of construction industry to socio-economic development (Ofori, 2012) motivated the conduct of this study.

The research was carried out in Dar es Salaam, the former capital and current business center of Tanzania. This does not in any way underestimate the importance of reinforced concrete buildings in other regions and its contribution to economic development of Tanzania. The research focused on reinforced concrete building and concentrated in Dar es Salaam for two reasons. Firstly, 98% of storeyed buildings in Dar es Salaam are constructed using reinforced concrete (Rubaratuka, 2013) and reported cases of buildings failure and collapse in Tanzania involved reinforced concrete buildings (NCC, 2017; The African, 2013; CRB, 2010; Rubaratuka, 2008). Secondly, reported cases of reinforced concrete buildings' failure and collapse in Tanzania, occurred in Dar es Salaam. Therefore this study was carried out in Dar es Salaam, because it is where symptoms of research problem are evidenced and there is little information in the literature on the root cause and how to mitigate the problem.

1.8 Limitations of the Study

Structural integrity of reinforced concrete buildings depends on two factors. First factor is the strength of concrete used in construction and the second is strength of reinforcement steel bars used in construction. Although quality of reinforced concrete building depend on both quality of concrete and reinforcement steel bars, this study managed to get data for quality of concrete used in construction of reinforced concrete buildings only. Reports on the quality of reinforcement steel bars embedded in reinforced concrete building structural members in terms of strength, size and amount (number) were unavailable and could not be determined in the study.

Most of report obtained from construction site did not include report for reinforcement steel bars. Also report of various investigation conducted on structural integrity of reinforced concrete buildings in Dar es Salaam did not contain information for this variable. The proposed model's evaluation was limited in five construction companies. The use of the model in practice in a wider scope is the best way to validate it and identify its limitations and improvement opportunities.

1.9 Study Assumption

i) Since it would take considerable time and effort to validate answers of each participant, it was assumed that participants gave honestly and factually answers to the interview questions. The interview participants were assured that their responses are confidential and kept secure, therefore, they knew in advance that their identities would be concealed and their confidentiality preserved.

ii) Reinforcement steel bars embedded in reinforced concrete buildings are normally not seen and equipment for testing to detect if they met required quality could not be obtained. Therefore, it was assumed that quality, size, and spacing of the reinforcement steel bars used in the reinforced concrete buildings investigated were according to the design specifications.

1.10 Operational Definitions of Terms

The following are the definitions of the basic technical terms used in this study:

1) **Framework:** Is defined as a structure composed of parts framed together, especially one designed for enclosing or supporting anything; a frame or skeleton (Delgado, 2006).
2) **Model:** Is defined as a simplified or idealized description or conception of a particular system, situation or process that is put forward as a basis for theoretical or empirical understanding; a conceptual or mental representation of something (Delgado, 2006).
3) **Quality:** Means the concept of compliance with defined requirements. In this context, defined requirements include working drawings, technical specifications, bills of quantities, meeting legal and construction regulations requirement, and construction contract (Oke *et al*., 2017; Arditi & Gunaydin, 1997).

4) **Quality Assurance (QA):** Is defined as a program covering activities necessary to provide quality in the work to meet the project requirements (ISO, 2000).Is a planned and systematic action necessary to provide adequate confidence that a structure, system or component will perform satisfactorily and conform with project requirements, it is proactive action (Arditi & Gunaydin, 1999)

5) **Quality Control (QC):** Quality control is part of quality assurance (PMI, 2004). It is the part of quality management focused on fulfilling quality requirement (ISO, 2000). Is a set of specific procedures involved in the quality assurance that lead to monitor the process and to pursue the elimination of sources that lead to unsatisfactory quality performance, this is reactive action (Arditi & Gunaydin, 1999)

6) **Performance:** Cost, time and scope have traditionally been recognized as the main perameters for construction performance (Love *et al*., 2005; Lema, 1996) but after the introduction of total quality managemet (TQM), a project performance is a measure of cost, time, quality, productivity, safety and health, and customer satisfaction performance (Khosravi & Afshari, 2011; Rad & Khosrowshahi, 1998).

7) **Reinforced concrete building collapse:** Is a phenomenon of building falling down when the building cannot withstand the load applied upon it (Reynolds & Steedman, 1997).

8) **Reinforced concrete building failure:** it is inability of the building components to perform as expected or required. In broad terms it comes in various forms and degree of severity, the worst can be a collapse (Ede, 2010; Oloyede *et al*., 2010).

9) **Total Quality Management (TQM):** Is defined as the mutual cooperation in an organization and associated business processes to produce value-for-money products which meet and hopefully exceed the needs and expectations of customers (Lema, 1996).

1.11 Thesis Structure

This thesis is organized into seven chapters as presented in Figure 1.1

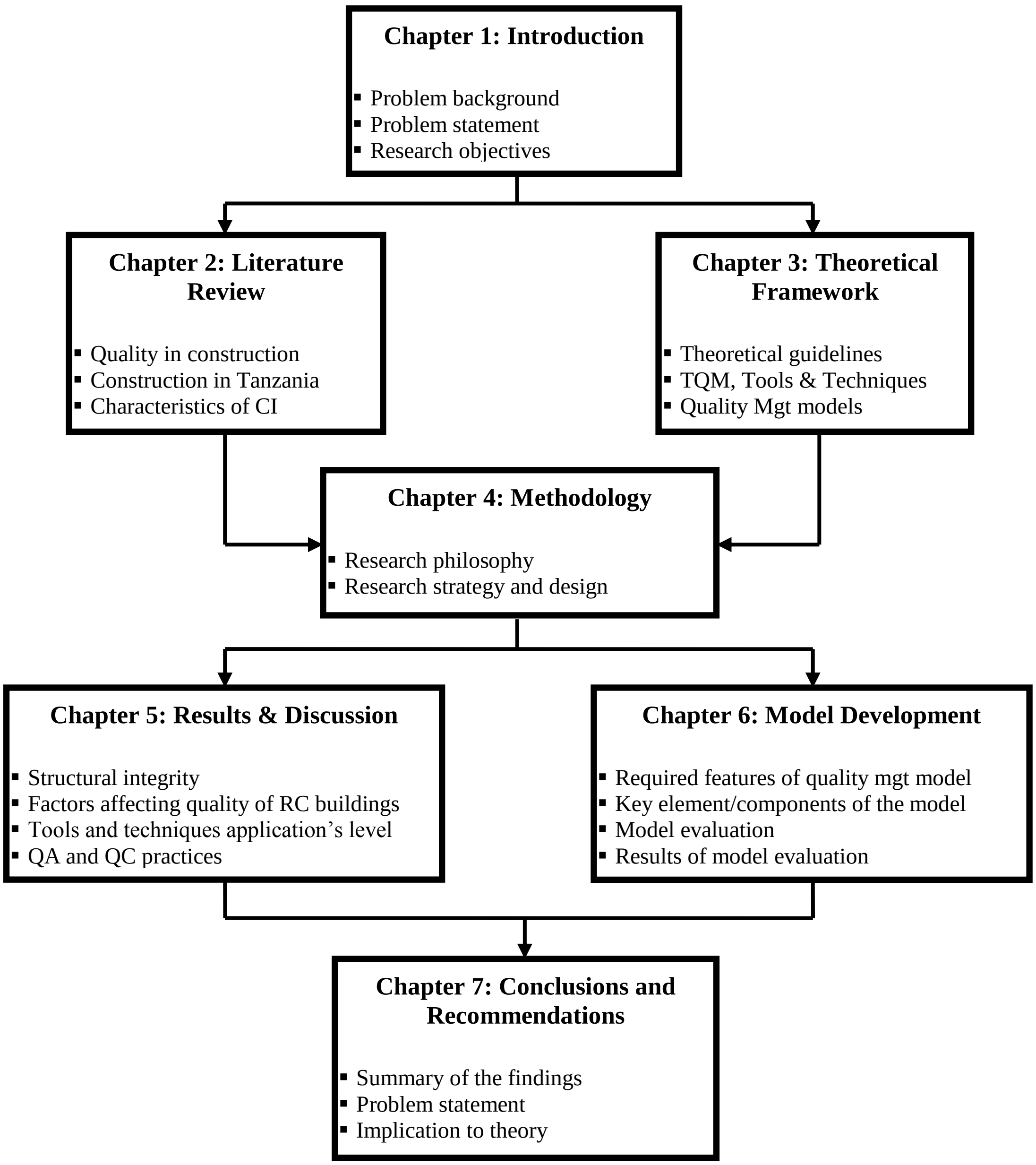

Figure 1.1: Thesis structure

Source: Author (2018)

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter includes global perspective of quality in construction, highlight of Tanzanian construction industry as well as quality improvement techniques. The chapter also presents various quality initiatives from manufacturing and characteristics of construction industry. Quality improvement models and various initiatives in construction industry are discussed in the chapter. Reinforced concrete building design and construction requirements are presented together with factors affecting their quality requirements. Total quality management tools and techniques, quality management concepts, quality assurance and quality control are presented. The theory underlying this research together with conceptual framework of the study is discussed in the chapter.

2.2 Quality in construction - Global perspective

Studies from developed nations (Arditi, Koksal and Kale, 2000) and depeloping countries (Enshassi, Hallaq and Mohamed, 2006) show that project failure are common in construction. Several reasons are cited for these failures. Bjeirmi, Begg and Scott (2207) noted that the UK construction industry has been the subject of ongoing criticsm for its fragmentation and poor record on quality, waste and safety. They noted that a major cause is inadequate communication troughout the construction process because inappropriate procurement approaches were adopted. Toor and Ogunlana (2008) observed that the major problems that construction projects in Thailand faced include discrepancies between design and construction, inadequate project management practices and inadequate resources.

Abdul-Rahman et al., (2007) found that quality of management was unsatisfactory for contractors that undertake public design-and-build project in Malaysia. There is consensus from various authors (Haseeb & Huang, 2013; Wanberg *et al*., 2013;

Shofoluwe *et al.*, 2012; Rad & Khosrowshahi, 1998; Arditi & Gunaydin, 1997) that attainment of acceptable quality has always been a problem in construction industry. Poor quality of construction projects as emphasized by Shittu *et al*., (2013) are a common phenomenon, and therefore it is an issue of concern in many countries. Construction industry is also, one of the dangerous sectors of economy due to quality related problems (Wanberg *et al.,* 2013). According to ILO (2005) at least 60,000 fatal accidents happens in a year on construction sites around the world. Construction industry produces 30% of fatal accidents across the European Union, the industry accounts for 20% of fatal accidents in the United States and in Japan, construction fatalities accounts for 30 - 40% of the industrial accidents (ILO, 2005).

Health and Safety Commission of United Kingdom (2001 cited in Bennett, 2003) reported that in the United Kingdom the injury rate in construction industry was the highest for all industries in the year 2000 with a rate of 2530 injuries per 100 000 workers. Wanberg, *et al.* (2013) noted that in 2010 construction industry in United States accounted for more fatalities than any other industry. Stanhope (1993) made a study on quality performance if construction industry in UK and made comparison with data from USA, Japan and Europe. The following findings emerged: prior to 1993, there was little interest of TQM in the construction industry in the UK; quality was found to be poor with many defects; 20% of the defects were caused by operative while 80% were caused by management; cost of rework was 12 - 15 % of the construction cost; and cost of waste was 10 – 20 % of the construction cost.

The situation is not better in developing countries. Literature (Figueroa, 2014, Windapo & Rotimi, 2012; Ahzahar*et al*., 2011) shows that building failures among the existing and those under construction in many of developing counties have occurred, the worst condition being collapse of the building. Failures of reinforced concrete buildings and associated tragedies are reported in Asia (Abdul-Rahman *et al*. 2010; Sandaraj, 2007) and Africa (Ofori, 2015; Figueroa, 2014; Windapo & Rotimi, 2012) where thousands of people lost their life and huge loss of properties were reported. Figueroa (2014) reported that between 2006 and 2014, at least 17 reinforced concrete buildings collapsed in Kenya; causing 84 deaths of people and 291 others were injured. Between 1974 and 2010 at least 91 buildings collapsed in Nigeria where 382 people died and 176 others were injured (Windapo & Rotimi, 2012.

A factory collapse in Bangladesh in 2013 killed over 1100 people and injured more than 2500 people (Figueroa, 2004). In India, Waje and Patil (2007) found that 6 - 15% of construction cost is wasted due to rework of defective components detected late during construction. According to Waje and Patil (2007), 20 - 40% of all site defects in India, have their root in errors arising during construction phase, where, 54% of the construction defects is attributed to human factors like involvement of unskilled workers or insufficient supervision of construction and 12% of construction defects are based on materials and system failures.

2.3 Construction Industry in Tanzania

According to Lema (1996) the then Tanganyikan construction industry statistics, for the period before independence in 1961, is scarce. Wells (1986) show that, Tanzanian construction industry suffered major setbacks soon after independence in 1961. It was recorded that there was no Tanzanian in the construction industry above the level of a general foreman at the time of independence. Following slump in the construction activities in the country foreign companies along with its experts moved away. According to Bienefeld (1968) with the exception of simple warehouses and simple repetitive construction, all other areas of the construction market were characterized by a serious lack of competition, high contract prices and excessive profits. Lema (1996) observed that contractors of Asian origin dominated the construction industry during this time.

After independence in 1961 and especially in 1962, objectives of construction activities by the government remained almost the same as in the colonial period (Baradyana, 2000). According to Baradyana (2000) although after independence the government took some corrective steps, these steps were geared towards preparing the nation for the birth of the Arusha declaration in 1967 where it declared Tanzania a socialist state. Following the Arusha declaration, building Act, 1971 was passed, where all rented property was nationalized, and this caused a substantial number of contractors of Asian origin to leave the country (Baradyana, 2000).

From the independence, construction industry deteriorated till 1970 when initiatives were made to improve the local construction industry capacity (Lema, 1996). According to Lema (1996) Tanzanian public owned construction organizations were established as stimulants for performance improvement. National institutions such as the National Development Corporation (NDC), public institutions for the construction industry notably the National Estates Designing Corporation (NEDCO) and the Mwananchi Engineering and Contracting Corporation (MECCO) were established (MoW, 1992). Lema (1996) noted that, public owned construction organizations failed to perform for a variety of reasons. One of the reasons includes concentration on the symptoms without considering the root causes, which resulted in the implementation of broad based improvement policies (Lema, 1996).

In 1977, a major study was carried out aimed at identifying factors contributed the problems inherent in Tanzanian construction (MoW, 1977). The study established that the industry was characterized as: low productivity; unavailability of required resources, skilled manpower, materials, equipment; unsatisfactory capacity utilization; imbalances of capacities of the different sub-sectors; low competition, high contract prices and high profit rates and unsatisfactory work quality. As a result of this study, the National Construction Council (NCC) was established by an Act of Parliament No. 20 of 1979, to bring order to the construction industry (Mlinga, 2001; Baradyana, 2000). Unfortunately, the establishment of NCC did not go hand in hand with the establishment of a construction Policy. Therefore NCC was left to play its advisory role without guidance (Meena, 2008; Baradyana (2000). Establishment of NCC could not bring about required improvement in the construction industry. Therefore another study was carried out by Ministry of Works in 1985 which was then reviewed in 1992 (Mlinga, 2001; Baradyana, 2000). As a measure to implement recommendations of the MoW (1992), three laws were enacted in 1997:

(a) The Engineers Registration Act No. 15 of 1997;

(b) The Architects and Quantity Surveyors Registration Act No. 16 of 1997; and

(c) The Contractors Registration Act No. 17 of 1997.

The Engineers Registration Board (ERB) was established through Engineers Registration Act (URT, 1997a) charged with the responsibility and mandate for regulating engineering activities and conduct of engineers and engineering consulting firms in Tanzania. On the other hand, Architects and Quantity Surveyors Registration Board (AQRB) was established by the Architects and Quantity Surveyors Registration Act (URT, 1997b) with the responsibility of protecting the public, promoting professionalism and excellence in the construction industry, and creating and maintaining standards of the built environment. While The Contractors Registration Board (CRB), was established under the Contractors Registration Act (URT, 1997c) as regulatory body charged with responsibility for registration, regulation and development of contractors in Tanzania. After five years of carrying out their mandated functions (ERB, AQRB and CRB) a considerable overlap of functions between the regulatory boards and NCC were observed (NCC, 2002).

Concern on quality performance in the Tanzanian construction industry also resulted to various reforms in the procurement systems. The result of the reforms made, is the enactment of Public Procurement Act (URT, 2004) and the associated regulations (URT, 2005) which were repealed by new Procurement Act of 2011 (URT, 2011) and the associated regulations of 2013 (URT, 2013). The Public Procurement Act put in consideration quality issues in respect of design matters in construction. According to Public procurement Act (2011) four types of consultant selection procedures shall be applied according to the characteristics of the consultancy services required: (i) selection based solely on technical quality (ii) selection based on technical quality with price consideration (iii) selection based on compatibility of technical quality and least cost, and (iv) selection based on technical quality and fixed budget.

A study to review construction industry policy of 2003 was conducted in 2015 where the following (NCC, 2017) were identified: lack of strong leadership in the promotion of the local construction industry; under sourced and undercapitalized local construction industry in combination with lack of supportive institutional mechanism for financial credit facilities and equipment hire; uncoordinated approach and insufficient incentive towards promoting continuous professional skills development in the local CI, particularly in targeting the youth; excessive competition in the market for small contracts; unfavourable bid eligibility criteria making it very difficult for local contractors to qualify for larger (foreign funded) tenders; unbalanced packaging of works and unpredictable work opportunities discourages contractors from making investments in their business; rapidly increasing cost of construction including local labour cost; climate change effects and environmental pollution caused during construction and unsustainable use of construction material; and overlap of NCC functions with the PPRA on matters related to procurement of goods, works and services.

Further challenges among public sector clients were identified (CIP, 2015 cited in NCC, 2017; Mwombeki, 2017) as: awarding contracts with inadequate funds in the budget, leading to delayed payment to contractors and consultants; poor performance in managing contracts for construction and for design; poor quality designs and failure to ensure that design is complete before tender for construction contracts, which necessitates expensive changes during construction; inability of LGA clients to produce accurate estimates of actual construction costs and to distinguish actual costs from sums in the budget; the contract is generally awarded to the bid closest to the budget, which makes a nonsense of competitive tendering; and weak supervision of construction and failure to ensure that the contract is carried out according to the specifications and required quality.

2.4 Importance of the Construction Industry in Tanzania

Despite of the foregoing challenges, construction industry of Tanzania remains to be one of the most important sectors of economy. The industry plays very big role in providing the country with its infrastructural and housing needs and alleviating poverty through creation of employment (NCC, 2017). In 2010 the construction industry in Tanzania grew at a rate of 10.2% compared to 7.5% in 2009 and contributed 8.0% to the national GDP. In the financial year 2010/11, the industry employed 9.0% of the workforce in Tanzania (MoF, 2011). In fiscal year 2016/17 the Government expected to spend 5.47 trillion in its budget which is equivalents to 25.4% of the total budget excluding servicing of public debt, for infrastructure development (MoF, 2016).

Tanzanian Construction Industry has been performing well since year 2000 (NCC, 2017). Construction output has grown at an average rate of 10% a year since 2000. The share of construction in Gross Domestic Product (GDP) has increased from 7.0% in 2005 to 12.5% in 2014 (NCC, 2017). According to NCC (2017) the growth was attributed to ongoing construction of roads, residential and non-residential buildings.

Despite that contribution of construction industry as a whole to national GDP is making good progress, the housing sector contributes less than 1.0% to the GDP (CRB, 2010). Analysis by NCC (2017) Gross Fixed Capital Formation (GFCF) for year 2010 revealed that buildings comprised 56% of the total and civil works 44%. The output of buildings was further divided into residential (20%), non-residential (50%) and own account rural (30%). Analysis of GFCF as a whole (which includes capital formation in equipment) revealed that the private sector was responsible for 74% of the total. The private sector is certainly the biggest investor in buildings. According to NCC (2017) GFCF in buildings in 2010 was above TShs. 900 billion (excluding own account rural), whereas public sector investment in buildings in 2012/13 was only

TShs. 151 billion, (NAO, 2014), which is only 16.7% of the total, with public sector predominating in civil works (NCC, 2017). The trend of contribution of construction industry to GDP from year 2005 to year 2014 is shown in Figure 2.1.

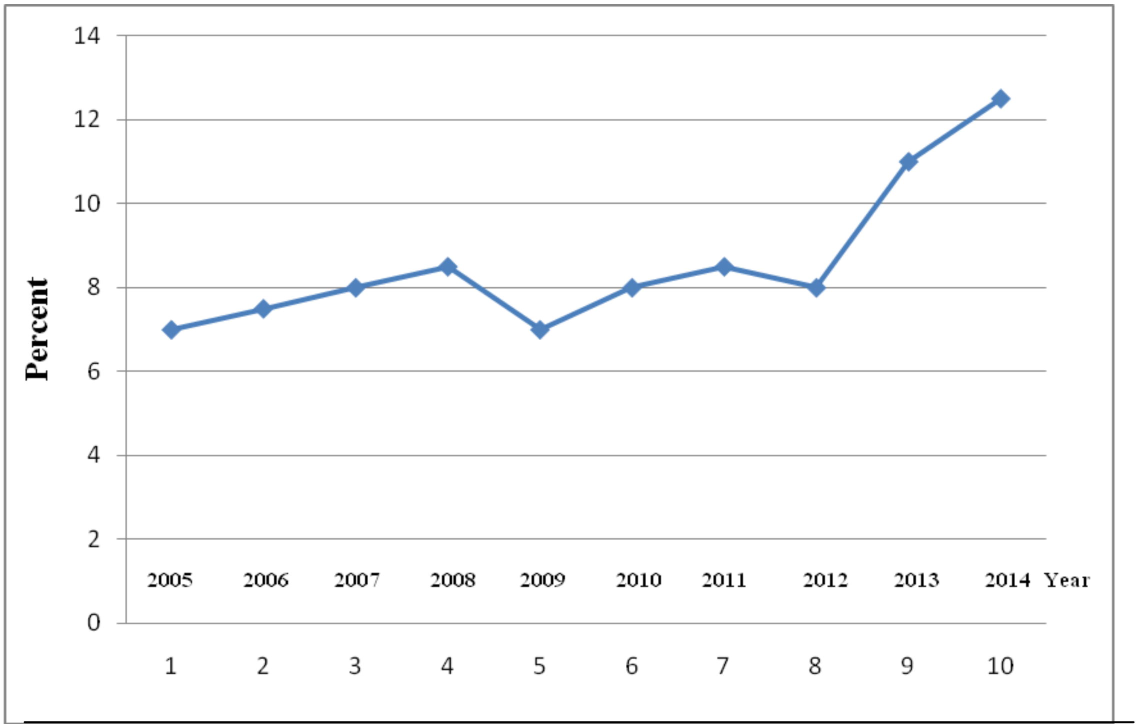

Figure 2.1: Contribution of the construction industry to the national GDP

Source: NBS (2014) cited in NCC (2017)

Although the Government has invested in the infrastructure development, but Tanzania's firms (consultants and contractors) have not benefitted as much. In 2003 Tanzanian contractors were estimated to be responsible for only 20% of the total value of construction contracts put out to tender in any one year. Data compiled by the CRB (2017) shows that the market share of Tanzanian contractors by 2014 had grown to 40%, but large contracts are still awarded to foreign firms. Therefore, Tanzania still has a long way to go before most of the services in the industry can be offered by the local players.

2.5 Structure of Construction Industry in Tanzania

Construction industry in Tanzania is divided into three service groups: groups that offer professional services; groups that offer support services and that offer construction services. The organizational structure for Tanzanian construction industry was analysed by Lema and Mbuya (2002) as presented in Figure 2.2. The Ministry of Works (MoW) is responsible for policy and planning in the construction sector. The Ministry has the overall responsibility for creating an economic, safe and reliable construction industry through development and implementation of appropriate policies, strategies and standards (NCC, 2017). Relevant public sector institutions have been created in this respect including: The National Construction Council (NCC) for promotion and providing strategic leadership for growth, development and expansion of the Construction Industry in Tanzania with emphasis on the development of the local capacity; The Contractors Registration Board (CRB), as regulatory body charged with responsibility for registration, regulation and development of contractors; The Engineers Registration Board (ERB) charged with the responsibility and mandate for regulating engineering activities and conduct of engineers and engineering consulting firms in Tanzania; The Architects and Quantity Surveyors Registration Board (AQRB) charged with the responsibility of protecting the public, promoting professionalism and excellence in the construction industry, and creating and maintaining standards of the built environment.

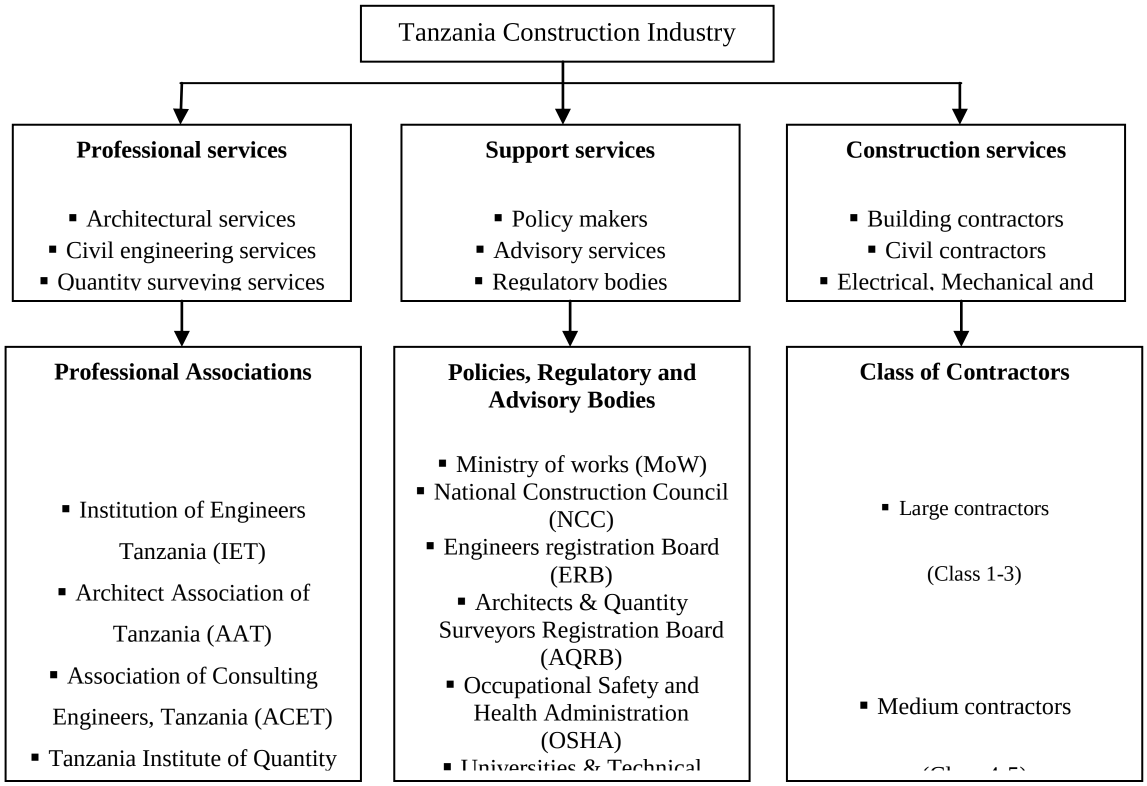

Figure 2.2: Construction industry structure in Tanzania

Source: Lema and Mbuya (2002)

The construction process in Tanzania was inherited from British system of construction (Baradyana, 2000). Construction involves a number of stages depending on the nature of the construction and procurement methods. Various procurement systems are used in Tanzania including: traditional procurement methods; design and build methods; project management and Build Operate Transfer (BOT) methods. For a typical building construction traditional procurement method is mostly used in Tanzania. Based on traditional procurement system, building construction process is divided in four phases, namely briefing, design, construction and operation and maintenance. Briefing phase is regarded as the early stage in the construction process during which the client's requirements are formally documented. The briefing provides a reference point for building design by the designers (i.e architect, engineers and quantity surveyor). At the design phase, architect produce the architectural design, engineer produce engineering design while quantity surveyor produce a bill of quantities and cost estimates for the construction project. Key players in a building project under traditional procurement system are the client, contractor, designers/consultants and regulatory authorities. These parties come together to form a temporary organization to undertake the project for a specific period (Ntiyakunze, 2011).

2.5.1 Clients/Owners

Client is the owner or developer of a building project who leads the process of stating construction requirements. Under the traditional procurement method, the client enters into contract with the design team (consultants) for the design and supervision of the construction works. Also a client enters into a separate contract with a contractor for construction works. Clients of the construction industry include private and public sector. According to NCC (2017) clients in the public sector include various Ministries, Government Agencies and Parastatal organisations with major ones being: Ministry of Education, Science and Technology; Ministry of Health, Community Development, Gender, the Elderly and Children; Ministry of Home Affairs; Ministry of Water and Irrigation; Ministry of Trade, Industry and Investment; Ministry of Energy and Minerals; Ministry of Lands, Housing and Human Settlement Development; Ministry of Agriculture, Livestock and Fisheries; Tanzania Bureau of Standards; Tanzania Electric Supply Company Limited; Tanzania Petroleum Development Corporation; Rural Electrification; Agency Local Government Authorities and Pension Funds (NCC, 2017). In the private sector, particularly in the buildings and industries sub-sector there has been an increase in the size and complexity of the structures being built which are intended for use by the general public. Unlike the public sector, many of these structures built by the private sector clients are not subject to the same scrutiny to ensure that they are built in accordance with the required standards and quality (NCC, 2017).

2.5.2 Contractors

Contractors working in Tanzania must be registered by Contractors Registration Board (CRB) of Tanzania (URT, 1997c). Under the CRB Act, 1997 as amended in 2008, all construction work for structures which have an input of structural design must be carried out by a registered contractor (URT, 1997c). CRB categorizes contractors into four types (i.e. Building works contractors; Civil works, contractors; Mechanical services contractors and Electrical services contractors). The contractors are also categorized into local and foreign contractors, with the latter comprising of firms with local shareholding of less than 50% (CRB, 2015). Foreign contractors are registered in class one only (CRB, 2015). The four main types of contractors (building, civil, mechanical and electrical) are registered in seven classes (i.e. class one to class seven; class one being the largest and class seven the smallest). Structure of contractors in Tanzania is in a form of pyramid with few contractors (class 1 - 3) at the top of the pyramid and the highest number (class 5 – 7) at the bottom.

Table 2.1 shows the number of registered contractors in each class as of January 2015. The Table shows that Foreing contractors are only registered in class one and therefore out of 167 registered contractors in class one (in Civil, and Building) in this period of time, 77 were foreign and 90 were local contractors. For building contractors which is a focus of this study, foreign contractors in class one were 39 while local contractors in class one were 68 making a total of 107 contractors. The class limit provided in Table 2.1 is applicable for building contractor.

Table 2.1: Class and type of registered contractors by December 2015

	Class	Civil	Building	Total	Class limit in
	Local	38	39	77	Unlimited
	Foreign	22	68	90	Unlimited
One	**Total**	60	107	167	
Two		16	37	53	3,000
Three		44	58	102	2,200
Four		168	191	359	1,200
Five		2,740	580	3,320	600
Six		900	560	1,460	200
Seven		1,060	1,360	2,420	120
	TOTAL	**4,988**	**2,893**	**7,881**	

Source: CRB (2015)

Contracting industry in Tanzania is characterized by two distinct market segments (Muhegi & Malongo, 2005). One segment is the high end, high value, complex projects segment, which is dominated by foreign contractors (owing to their superior technical and management expertise and access to financial resources), and about 5% of the local construction firms which are in Classes 1-3. The other segment is the low end, low value projects segment, serviced by 95% of purely local contractors. The local contractors segment is overcrowded by small family based contractors (Muhegi & Malongo, 2004).

A typical Class 1 (class one) Tanzanian contractor is allowed by law to undertake works of unlimited value (URT, 2009) while other classes have limits as shown in Table 2.2. The largest contract executed by a local contractor is in the tune of USD 8.0 million (Muhegi & Malongo, 2005). As analysed by Muhegi and Malongo (2005) a class one Tanzanian Contractor is characterized as a small to medium sized enterprise when compared by International Standards. This situation may have hindered growth of contractors as well as construction industry in Tanzania.

Table 2.2: Class limit and increase of building contractors for two decades

Class	1994		2014		Increase in
	Number	Class limit in 1,000,000 Tsh	Number	Class limit in 1,000,000 Tsh	Percent (%)
One	48	Unlimited	107	Unlimited	128
Two	20	600	37	3,000	85
Three	53	400	58	2,200	9
Four	85	200	191	1,200	125
Five	105	100	580	600	452
Six	78	50	560	200	618
Seven	632	25	1,360	120	115
Total	**1021**		**2,893**		**183**

Source: NCC **(**2017); CRB (2009) and Lema (1996)

For the last two decades, from 1994 - 2014 there has been a big shift from high bidding as noted by Lema (1996) to vevy low bidding as noted by NCC (2017). In this period of time, there had been no significant change in terms of number, class limits of contractors and number of high class contractors.

2.5.3 Consultants or Designers

Consultants in construction industry of Tanzania are professional in the fields of Civil engineering, Architecture, Quantity surveying, Electrical engineering and Mechanical engineering registered as consultant by Engineers Registration Board (ERB) or Architects and Quantity Surveyors Registration Board (AQRB) (URT, 1997a & b). These professionals are responsible for designing projects, estimating the cost, supervision and quality control of the construction (NCC, 2017). Therefore, consultants have to ensure that the project is constructed according to drawings and specifications.

Consultants in Tanzania are paid according to standard fees set by law. Statutory consultancy fees for building construction services provided by consultants in Tanzania are as summarised in Table 2.3. Consultants are paid 30% for preliminary and sketch design, 40% for detailed design and, 25% for supervision at the construction phase. In total, consultants are paid 70% for design and 25% for construction supervision. The consultancy services shown in Table 2.3 are not stages of payment but are fees to be paid for consultancy service for a particular phase.

Table 2.3: Consultancy fees for building construction in Tanzania

S/N	Consultancy service	Fee Payable
1	Design phase (stage I - Preliminary and sketch)	30%
2	Design phase (stage II - Detailed design)	40%
3	Tendering phase	5%
4	Building construction phase (supervision)	25%

Source: URT (2010)

Consultant and the client normally agree on stages of payment for each phase. In practice it shows that the stages of payment are two i.e 50% at the beginning of the contract and 50% on submission of the required documents (for preliminary and detailed design). So this 50% will be out the fees for preliminary and detailed design that is 70%. This arrangement of fees is considered unfourable and may be a source of poor quality, because consultants may provide minimum supervision during the construction phase (Rubaratuka, 2013).

2.5.4 Regulatory Bodies and Authorities

Construction industry is one which is highly regulated (Baradyana, 2000). Professionals and construction activities carried out by contractors and consultants are regulated by the Engineers Registration Board (ERB); the Architects and Quantity Surveyors Registration Board (AQRB) and Contractors Registration Board (URT, 1997a; 1997b; 1997c). Also any reinforced concrete building to be constructed in local authority (town, municipal or city council) must have building permit from the relevant local authority in which the building is to be constructed. Prior to issuance of building permit, a client must submit the building's working drawings to the local authority for scrutiny. When satisfied by the working drawings submitted, the relevant local authority issues a building permit. During the building construction, the local authority in which construction is carried out is supposed to inspect the construction to ensure that construction is carried out according to the issued building permit (Rubaratuka, 2013). Normally there is a contractual relationship between client (owner) of the construction property and consultants and contractors. Various parties involved in construction of reinforced concrete buildings in Tanzania and their relationship is as summarised in Figure 2.3.

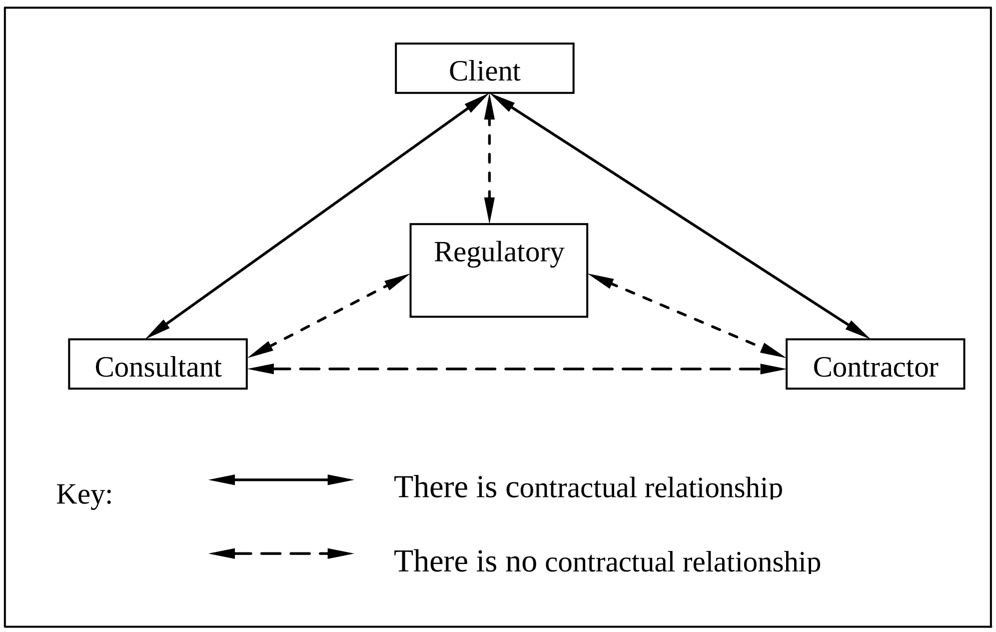

Figure 2.3: Relationship of parties in the construction industry

Source: Author (2018)

Although consultants supervise construction works and gives instruction to contractor on behalf of client, there is no contact between consultant and the contractor. Also various regulatory bodies can enter site for inspection any time, but also there is no contact between them and either consultant and contract or the client.

Various efforts have been made to improve quality performance of construction industry in Tanzania particularly in terms of policy (MoW, 1992, 1977) and Mlinga (2001) productivity (Lema, 1996) cost overruns, poor quality, and time overruns (Baradyana, 2000), quality performance (Muhegi & Malongo, 2004) and other performance of general nature like safety, environment, adherence to construction laws and regulations (Mwombeki, 2017; Rubaratuka, 2013; Mlinga, 2001; URT, 1997 a, b, & c). The efforts applied notwithstanding, construction industry in Tanzania is still blamed for unsatisfactory performance in terms of quality of the final product particularly reinforced concrete buildings (NCC, 2017; Rubaratuka, 2013; CRB, 2010).

2.6 Characteristics of the Construction Industry

Improvement in the construction industry lies in understanding construction processes, process variables and process performance measurement. Construction characteristics have been reported by various researchers (Kam *et al*., 2012; Hai *et al*., 2012; Hoonakker *et al*., 2010; Bubshait & Al-Atiq, 1999; Lema, 1996; Koskela, 1992). Construction industry has some characteristics that differentiate the industry from other industries. One of the construction characteristic is that, it is one of the few industries whose products tend to increase in value over time, unlike the majority of other industries whose products begin to depreciate immediately from the time of purchase (Harvey & Ashworth, 1993). Other characteristics that separate the construction industry from other industries (Kam *et al*., 2012; Delgado, 2006; Baradyana, 2000; Bubshait & Al-Atiq, 1999; Arditi & Gunaydin, 1999; Lema, 1996) are listed below. These construction characteristics are common to both developing and developed countries, and include the following:

a) The wide variation in terms of materials used in the production and the standards in terms of space, quality, durability and aesthetic considerations;
b) The product is normally manufactured and left fixed on the client's premises, i.e. the construction site;
c) Many of its projects are one-off designs and lack any prototype model being available;
d) Every site is different and construction is a one-time-only industry;
e) The location of production area changes constantly and is subject to interference from weather;
f) The organization of the construction process comprises of a large number of diverse specialized trades often casually employed;
g) The organizations structure of a construction company varies depending on the nature of the project and this affects communication and coordination between each party;
h) Not practicable to disapprove the whole constructed project after completion while attached to purchaser's land;
i) Rejection of a defective part need to be taken before the succeeding parts is constructed.

The above characteristics affect construction industries of both developed and developing, construction industries. But in addition, developing countries have other special characteristics affecting the industry. These characteristics that separate the construction industry of developing countries from that of developed countries have been extracted (Figueroa, 2014; Baradyana, 2000; Lema, 1996) and include:

i. Major projects are undertaken by foreign companies as local companies lacks capacity and capability in terms of technical competence and financial resources to handle big projects;
ii. Construction activity tends to be more labour intensive in developing countries mostly.

The above characteristics revels that nature of construction industry is unique and so it require special attention. A common mistaken notion is that quality improvement does not apply to construction because of its unique characteristics. It is however argued that construction processes are the same and so are the methods and techniques. Also it is argued that the same perculiarities is shared by many product development projects in manufacturing, and it has been possible to improve the output quality by implementing total quality management (TQM) principles and philosophy (Hoonakker *et al*., 2010; Lema, 1996; Koskela, 1993). Therefore, quality improvement can successfully be applied in construction as in manufacturing industry.

2.7 Research on Quality Management in Construction

A number of researches on quality management in construction have been conducted by various scholars. Lema (1996) investigated strategies for construction performance improvement in Tanzania. His research established that Total Quality Management (TQM) philosophy provided a feasible long term performance improvement strategy. According to Lema (1996) benchmarking was identified as a tool for initiating and sustaining the TQM program. The study developed a conceptual model for TQM implementation in order to appreciate the role of benchmarking in kick-starting and sustaining the TQM implementation process.

Research done by Arditi and Gunaydin (1997) based on literature and industry survey of building construction in USA observed that there was a great potential for quality improvement in the building construction process. The study also revealed that: management commitment to quality and to continuous quality improvement was very important; construction industry professional were aware of the importance of quality training; partnering agreements among the parties in the construction process constituted an important step in securing a high quality product; a feedback loop could upgrade the original quality standards used in the industry; clarity of project scope and requirements as well as drawings and specifications were a prerequisite for high process quality.

Research by Bubshait and Al-Atiq (1999) made evaluation of quality systems of construction contractors in Saudi Arabia. The evaluation was performed against the ISO 9000 standard. The results revealed that contractor's quality systems varied in complexity from an informal inspection and test system to a comprehensive system. Further, they found that the clauses of ISO 9000 most often complied with are those dealing with: Inspection and test status; inspection and testing; control and nonconformance product and handling storage and preservation. Furthermore, they found that clauses least complied with concern: design control; internal auditing; training and statistical techniques. Also, they found that documentation of a quality system was scarce for the majority of the contractors.

Baradyana (2000) focused on measures to improve construction industry in developing countries and focused Tanzania as a case study. The study advanced the following variable as responsible for poor quality in construction: lacks of qualified and experienced technical staff; poor salaries and incentive; corruption; poor construction technology and poor quality of materials. Other variables identified were poor quality control techniques; lack of quality awareness; poor supervision and lack of government policies and regulations.

Chan and Chan (2004) determined key performance indicators (KPIs) for measuring construction success. Two type of performance indicators were identified i.e. objective indicators and subjective indicators. Indicators under objective measures include construction time, time variation, accident rate, and speed of construction while those under subjective measures include quality, functionality, end user's satisfaction, client's satisfaction, design team's satisfaction and contractor's satisfaction. To verify the practicality and usefulness of the KPIs case study was performed and found that the identified KPIs were good indicators of the performance of construction projects.

Based on literature review and case study, Pheng and Teo (2004) addressed the issue of applying TQM in the construction industry and examined possible steps for restructuring construction organizations for TQM. The results showed that TQM can be successfully implemented in the construction industry. Further, the study indicated that there were benefits of applying TQM in construction that included: reduction of quality costs; work was carried out correctly right from the start; and recognition by clients. They concluded that, TQM has been recognized as a successful management philosophy in the manufacturing industries, so can likewise be embraced in the construction industry to help raise quality.

Mrema and Mhando (2005) conducted a study on causes of failure of housing project on unfinished buildings in Dar es Salaam, Tanzania. Based on over hundred unfinished buildings projects they found that growing number of unfinished buildings in Dar es Salaam is due to poor relationship between clients and consultants. The major causes of frustration to bulding project according to Mrema and Mhando (2005) lie on the abuse of the roles of consultants, manager and clients in addressing design and management of construction process. On one hand, induced professional corruption and compromise give too much power and room to poorly informed clients. On the other hand, clients' avoidance of their statutory obligation towards their consultants and managers breed discomfort to consultants who in turn produce designs that are poorly thought and less refined.

Delgado and Aspinwall (2008) carried out a comprehensive survey in construction industry in UK and Mexico aimed at determining whether the use of quality tools and techniques are important aspects of continued improvement. The results showed that quality, performance measure and technology tools were common practice in the industry, but how to apply the for better quality results was a problem.

Hoonakker *et al.* (2010) discussed the problems of defining quality in the construction industry, examined possible benefits of implementing quality and looked at barriers to quality implementation in construction. The results showed that contractors do understand the potential benefits of quality implementation, but there are also many barriers to implementation. So, they recommended that different actors in construction need to understand to understand that change is slow and often painful and that much effort is required to implement quality in construction industry.

Abdul-Rahman, Wang, and Yap (2010) determined how professional ethics impact construction quality. They indicated that majority of quality related issues in construction are caused by human factors and conducted questionnaire survey of construction industry in Malaysia. The results indicated that various form of unethical conducts had significant impact on construction quality. The study concluded that professional ethics is a pre-requisite to attaining sustained and acceptable quality in construction and suggested that several approaches to enhance professionalism among construction professional to improve quality in construction.

Mustafa & Talib Bon (2012) performed an empirical study to examine and to compare the total quality management (TQM) practices and organizational performances of small and medium enterprises (SMEs) with and without ISO 9000 certification in Malaysia. Based on the outcomes of the analysis of the study, it was concluded that top management leadership is one of the TQM factors that had a significant positive relationship with the organization performance in ISO 9000 certified organization.

Keng and Abdul-Rahman (2011) reviewed practices of quality management in Malaysia. Based on the literature review they summarized (10) constructs practices that affect quality management in construction namely: Approaches, methods, tools and techniques; Management commitment; quality attitude and culture; customer focus; human resource management; supplier relationship; cost of quality; measurement; information and analysis, and continuous improvement and sustainability.

Khosravi and Afshari (2011) described the definitions of project success, and showed that the definition of project success has changed over the years. They advanced that in the 1960s, project success was measured entirely in technical terms: either the product worked or it did not, in the 1980s, project success was stated in terms of meeting three objectives: (1) completed on time, (2) completed within budget, and (3) the project scope realized But after the introduction of Total Quality Management (TQM) around 1990s, a project is considered to be a success by not only meeting the internal performance measures of time, cost and technical specifications but also making sure that the project is accepted by the internal and external customers.

Fakere *et al.* (2012) made an assessment of a Naval building collapsed in Abuja, Nigeria. They found that poor quality control arising from the adoption poor mix ratios, presence of impurities in the aggregates used for construction. Also inadequate placing and concrete compaction resulted in voids and poor bonding between concrete and reinforcement. So it was established that, poor workmanship as a result of poor supervision was the root cause of the building collapse. They recommended that proper supervision to be done by all responsible construction players.

Rubaratuka (2013) studied quality challenges of reinforced concrete buildings in Dar es Salaam, Tanzania. He found that quality of designs and construction of reinforced concrete buildings in is still a challenge. He advanced that design deficiencies, inadequate monitoring of construction work by regulatory authorities, lack of quality control for concrete works, lack of appropriate technology and inadequate supervision of construction works among challenges for quality of reinforced concrete buildings in Dar es Salaam. The study recommended that regulatory authorities should be staffed with qualified technical staff, adoption of appropriate construction technology and enhancing supervision of construction works.

Wanberg *et al.* (2013) empirically examined the relationship between construction quality and safety performance. They found that there are two stastistically significant relationships. That the recordable injury rate is positively correlated to rework and the first aid rate is positively related to number of defects. The outhors concluded that a project with a poor quality performance has a higher likelihood of ijuries.

Figueroa (2014) carried out a research on the structural integrity of reinforced concrete buildings in Kenya for the purpose of finding strategies to reduce the risk of building collapse in developing countries. The study found that concrete quality; theft of construction materials at site particularly cement; insufficient curing of concrete; concrete compaction; prompt placement of concrete and quality of concrete ingredients being among factors affecting quality of reinforced concrete buildings. He recommended that proper quality control tools to be applied in construction process.

2.7.1 Analysis of the Previous Research in Construction Management

Before a problem is solved, the problem that actually exists need to be established as well as exact definition of what the problem is (Pilcher, 1992). This is the diagnosis stage of the problem solving and, in the context of reinforced concrete building construction in Dar es Salaam, there are indicators of the existence of a problem. Some of the indicators include: customers/clients complains (Baradyana, 2000; Lema 1996); presence of abandoned and unfinished buildings (Mrema & Mhando, 2005); failure and incidences of collapse of reinforced concrete buildings in Dar es Salaam (NCC, 2017; Rubaratuka, 2013).

Basically, most researchers concluded that TQM has been recognized as a successful management philosophy in the manufacturing and service industries, so can likewise be embraced to help raise quality in the construction industry (Khosravi & Afshari, 2011; Hoonakker *et al*., 2010; Pheng & Teo, 2004; Arditi & Gunaydin, 1997; Lema, 1996). While definition of quality in construction industry seems to be a source of quality problem (Hoonakker *et al*., 2010), others (Delgado & Aspinwall, 2008; Lema, 1996) considered that application of TQM tools and techniques could help improve quality in construction.

On the other hand, quality was related to construction safety performance (Wanberg *et al.*, 2013) Also, human factors considered to cause majority of quality related problems in construction (Wang *et al.*, 2010). Some of human factors and other factors considered to be responsible for poor quality in construction including: lacks of qualified and experienced technical staff; poor incentive; corruption; poor construction technology and poor quality of materials, poor quality control techniques; lack of quality awareness; and poor supervision (Figueroa, 2014; Rubaratuka, 2013; Fakere *et al.*, 2012; Keng & Abdul-Rahman, 2011; Baradyana, 2000).

Together these studies provide a broad base on which to understand status of construction industry and importance of TQM in improving what Koskela (1993) called critical problems in construction industry. Despite this wealth of literature, relationship between construction quality management practice and quality of reinforced concrete buildings represents a significant knowledge gap. Therefore, this study aimed to adds to the body of knowledge by collecting and analyzing data from representative sample of reinforced concrete buildings in Dar es Salaam. The knowledge gap starts from structural integrity of reinforced concrete buildings and extend to factors affecting quality of reinforced concrete buildings, the level of application of quality tools and techniques in reinforced concrete buildings construction, extent of reinforced concrete buildings construction supervision and practices of quality assurance & quality control of reinforced concrete buildings construction in Dar es Salaam.

When the problem has been diagnosed it needs to be defined and then a solution is developed (Wanberg *et al*., 2013; Pilcher, 1992). So it was important to establish definition of quality in building construction industry. This is not an easy task because, quality in building construction, means different things to different people. Building owners, designers or consultants, contractors, individuals as well as regulatory authorities have their own definition of quality. According to Juran (1988) and Crosby (1992) quality can be defined in terms of conformance to requirement and a product free of deficiencies. In the building construction industry, quality can be defined as meeting the requirements of the designer, contractor and regulatory agencies as well as the owner (Arditi & Gunaydin, 1997). In the construction industry, quality can be defined as meeting the legal and functional requirements of a project, which conforms to laws, regulations, technical specifications, drawings and construction contract (Zhang *et al*., 2010).

In terms of function, a quality building can be described as ease in understanding drawings, level of agreement in drawings and specifications, and ease of operation and maintenance (Arditi & Gunaydin, 1999). Zhang *et al*. (2010) added that functional requirements can be shown from the view of how closely the project conforms to its physical, chemical, and structural property requirements. Physical property requirements include: size, specification, warm-keeping, heat, and sound insulation. Chemical property i.e. acid-resistant, corrosion-resistant and fire resistant, while structural property i.e. the firm intensity of foundation, rigidity and stability of structure. Definition given by Zhang *et al*. (2010) is comprehensive and it is appropriate for this study and was adopted.

Thus, quality is defined as meeting the legal and functional requirements of a project, which conforms to laws, regulations, technical specifications, drawings and construction contract. The functional requirements can be shown from the view of how closely the project conforms to its physical, chemical, and structural requirements. The physical requirements include: size, specification, warm-keeping, heat, and sound insulation. Chemical property requirements include: acid-resistant, corrosion-resistant and fire resistant, while structural property requirements include: firm intensity of foundation, rigidity and stability of the building structure. Quality of reinforced concrete buildings in this research was determined in terms of building structural strength or structural integrity.

2.8 Structural integrity of Reinforced Concrete Buildings

Reinforced concrete is widely used in the construction of buildings in Dar es Salaam. Reinforced concrete being a fabricated material, its properties is much dependent on the procedures adopted during design and construction (Rubaratuka, 2013). Most of reinforced concrete buildings constructed in Dar es Salaam are of in-situ concrete which is labour intensive (Makenya & Nguluma, 2007). According to Rubaratuka (2013) about 98% of storeyed buildings in Dar es Salaam are constructed using reinforced concrete. According to Makenya and Nguluma (2007) major materials used for building construction in Tanzania are classical type including, cement, cement block, concrete reinforced concrete, galvanized iron sheets and recently roofing tiles dominate the building construction industry.

Reinforced concrete is designed based on the function of the proposed building, following code of practice and standards (Allen, 1988). Normally reinforced concrete building is in a form of framed structure. Framed structure is a structure designed to transfer design loads by a system of structural members (columns, beams and slabs) (Reynolds & Steedman, 1992). The structural members through columns should transmit the design loads safely to the firm ground underneath (Allen, 1988). The designed reinforced concrete members have to provide durability for the environmental conditions as well as adequate strength for loading requirements (Neville, 1997).

Reinforced concrete (RC) buildings are designed using code of standards and practice. According to Rubaratuka (2013) reinforced concrete buildings in Tanzania are mostly designed to BS8110 (1997) code of practice and standards. Code of design and standards for RC building design, provide guidance for minimum quality in terms of strength requirements for reinforcement steel bars and concrete materials (Rubaratuka, 2013). BS 8110 code of design for reinforced concrete buildings puts into consideration factors or conditions which cause unfitness of a building (Reynolds and Steedman, 1992). In the design, the code takes into account variations that may occur in the loadings and material strengths and inadequacies in the analytical methods and qualities of construction (Reynolds and Steedman, 1992) the aim being to produce a structure that will not became unfit for its intended purpose during its planned lifetime. A building structure will become unfit for use, if part or all of it collapses, deflects too much or if large cracks form (Ayodeji, 2011; Allen, 1988).

Each and every member of a structural system of a building should be able to resist, without failure or collapse, the applied loads under the service conditions (Fakere *et al*., 2012). Quality of reinforced concrete building depends on compressive strength of concrete (Reynolds & Steedman, 1992). According to Allen (1988) minimum required strength of concrete for reinforced concrete building construction is 25 N/mm^2 or 25 MPa based on BS8100 code of design, standard and practice. This quality of concrete is normally refered to as concrete grade C 25.

2.8.1 Quality of Concrete for RC Building Construction

Quality of reinforced concrete depends on various factors including quality of concrete ingredients; concrete mixing; water/cement ratio; concrete placing; concrete compacton and concrete curing. Figure 2.4 gives a summary these requirements of quality for concrete used for construction of reinforced concrete buildings as extracted from various authors (Figueroa, 2014; Rubaratuka, 2008; Neville, 1997; Reynolds & Steedman, 1992; Allen, 1988) as follows:

Quality of concrete ingredients: Good concrete is made of cement, water and aggregate (Rubaratika, 2008). Aggregates, sand and water must satisfy the design specifications. Aggregates must be clean, free from dust and of required strength (Neville, 1997)

Concrete compaction: Concrete should be compacted or vibrated to achieve a dense product with minimum permeability that is free of air pockets. (Rubaratuka, 2013; Neville, 1997);

Concrete curing: After concrete placement and compaction, curing should be done to achieve designed compressive strength. Concrete that has moist-cured for 7 days reaches 75% of its rated strength and achieves 100% strength by the end of 180 days (Figueroa, 2014). According to Rubaratuka (2008) concrete cured for 3 days attains only 80% strength and uncured concrete attains only 55% of the rated strength.

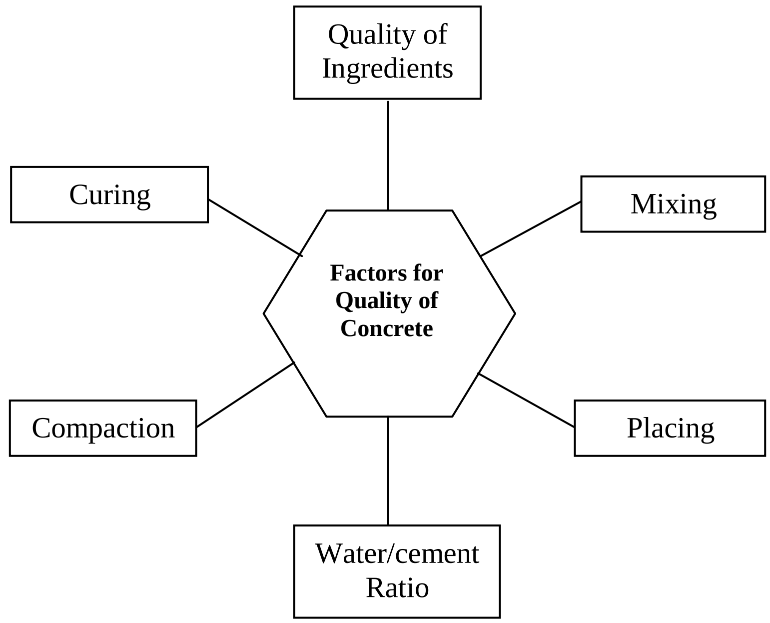

Figure 2.4: Factors affecting quality of concrete

Source: Author (2018)

i. **Concrete mixing:** Mixing time is important to produce a homogenous concrete of uniform strength (Figueroa, 2014). However, if mixing takes place over a long period evaporation of water from concrete mix can take place hence reducing the concrete workability (Rubaratuka, 2013);

ii. **Water/cement ratio:** The water/cement ratio (w/c) is the ratio by weight of water to cement in a concrete mixture (Rubaratuka, 2013). Water/cement ratio is an important factor in determining the strength and permeability properties of concrete. Compressive strength of concrete improves with lower w/c ratio. Water permeability for concrete increases exponentially when concrete has w/c greater than 0.5, therefore concrete with lower permeability is desired (Rubaratuka, 2008). If excess water is used in making concrete, the resulting mixture will have more space between the particles of the concrete mixture than can be filled by the cement gel (Neville, 1997). The result is a weaker, more porous and less durable concrete (Rubaratuka, 2008).

2.8.2 Cases of RC Building Failure in Dar es Salaam

Failure of reinforced concrete buildings has been described differently by different authors. According to Windapo and Rotimi (2012) building failure can be described as an unacceptable difference between expected and observed performance of a building structure. Ahzahar *et al*. (2011) described building failures as the condition or fact of not achieving the desired end; it is the termination of the ability of an item to perform an intended or required function. To Ede (2010) building failure is inability of the building components to perform as expected or required. Structural failure in buildings, in broad terms comes in various forms and degree of severity, the worst of which is a collapse (Oloyede *et al*., 2010). Reinforced concrete building collapse is the ultimate and most serious structural failure (Ahzahar *et al*., 2011).

There are several cases where reinforced concrete buildings showed signs of distress and deterioration before their expected service life in Dar es Salaam (Rubaratuka, 2013). Further, between 1987 and 2017 five incidences of storeyed reinforced concrete buildings collapsed in Dar es Salaam (NCC, 2017; Financial Junction, 2013). Also, between 2007 and 2017 four multi-storey reinforced concrete buildings were demolished in Dar es Salaam by order of government due to what was claimed to be poor quality (NCC, 2017; NHBRA, 2016; Financial Junction, 2013; The African, 2013). One of the reinforced concrete building collapsed is a 16 storey reinforced concrete building shown in Figure 2.5.

Figure 2.5: A 16 Storeyed building collapsed in Dar es Salaam in 2013

Source: NCC (2017, pp.15)

Reinforced concrete building failure occurs when there is a defect in one or more elements of a building caused by inability of the material making up the components of such building element to perform its original function which may finally lead to building collapse (Rubaratuka, 2013; Ayodeji, 2011; Oloyede *et al*., 2010; Oluwunmi & Fagbenie, 2010). List of reported cases of mult-storey reinforced concrete buildings in Dar es Salaam is shown in Table 2.4.

Table 2.4: Reported cases of RC buildings collapse in Tanzania

Type of Building	Location	Year	No of Deaths
4 - storey building under construction	Msimbazi Street **Dar es Salaam**	1987	Not known
4 - storey building under construction	Chang'ombe **Dar es Salaam**	2006	4 people
10 - storey building under construction	Mtendeni Street **Dar es Salaam**	2008	3 people
4 - storey completed building and occupied for residential	Sinza Mori **Dar es Salaam**	2013	Not known
16 - storey building under construction	Indira Gandi Street **Dar es Salaam**	2013	36 people

Source: NCC (2017); Financial Junction (2013) and Rubaratuka (2013)

A number of factors can be cause of reinforced concrete buildings failure some of which are natural disaster while other factors are human action or inaction (Ayegba, *et al*., 2014; Agwu, 2014; Achi *et al*., 2013). Causes of reinforced concrete buildings failure include: deficiency in building design; poor quality of concrete; poor construction supervision; incompetence of construction teams; poor method of construction; poor quality assurance and control; and poor quality management (Rubaratuka, 2013; Philip *et al*., 2012). Other factors causing failure of reinforced concrete buildings include: overloading; poor construction workmanship; poor quality of reinforcement steel bars; poor feasibility study; and foundation problems (Fakere, 2012; Adenuga, 2012; Ede, 2011). Also deficiency in building design; poor quality of concrete; poor construction supervision; incompetence of construction teams; poor method of construction; poor quality assurance and control; and poor quality management were determined to be responsible for buildins failureand collapse (Figueroa, 2014; Ayodeji, 2011; Ede, 2010; Rubaratuka, 2008). Causes of reinforced concrete buildings failure are summarized as shown in Figure 2.6.

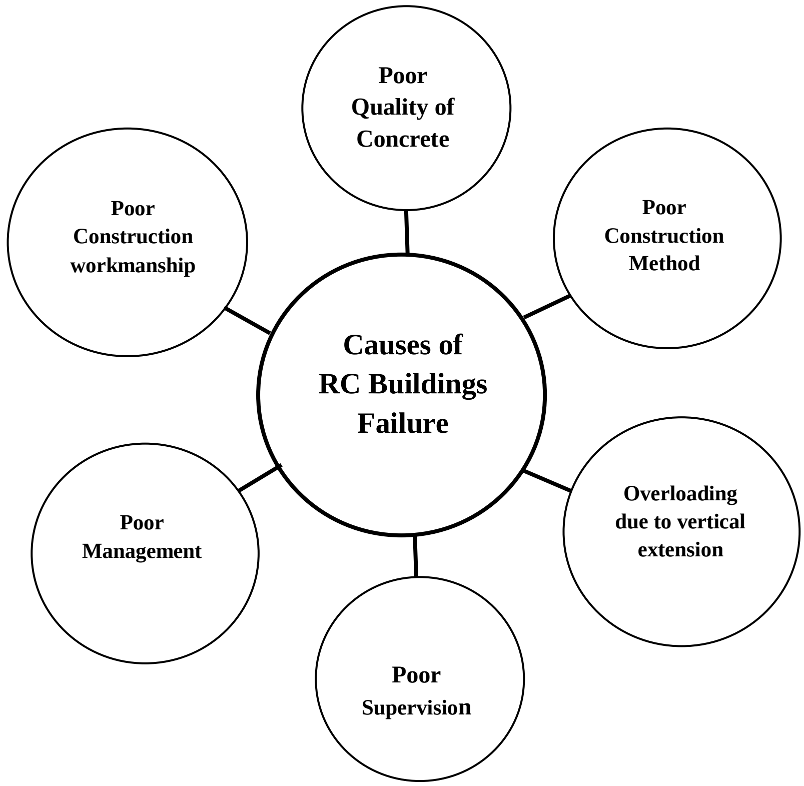

Figure 2.6: Causes of RC building failure as were captured from literature

Source: Author (2018)

2.9 Factors Affecting Quality of RC Building Construction

Reinforced concrete is a concrete in which reinforcement in the form of steel bars is incorporated to strengthen the naturally brittle concrete (Figueroa, 2014). Concrete has relatively high compressive strength, but significantly lower tensile strength of about one-tenth of the compressive strength (Rubaratuka, 2008). Concrete may fail from tensile stresses even when loaded in compression (Reynolds & Steedman, 1992). As a result of these facts, concrete elements that are subjected to tensile stresses must be reinforced (Allen, 1988). Therefore, reinforced concrete (RC) building is constructed using concrete and reinforcement steel bars.

Quality of RC building construction can be affected by a number of factors. Based on literature review numerous and diverse factors affecting quality of reinforced concrete buildings were identified (Ayeni, 2014; Shittu *et al*., 2013; Windapo & Rotimi, 2012). A study of literature and survey conducted in USA by Arditi and Gunaydin (1997) established that factors affecting quality in the construction process includes: management commitment and leadership; training; teamwork; statistical methods; cost of quality; supplier involvement; and customer service. Love and Edwards (2004) identified a number of factors affecting the quality of building construction as: lack of understanding of end-user requirements; poor contract documentation; low consultant fees; incompetent standard of workmanship; lack of focus on quality and inadequate supervision.

Pheng and Peh (1996) mentioned poor workmanship; unclear drawings and specifications; lack of coordination lack of build ability; unrealistic completion time; lack of involvement of contractors in design; and lack of code of design and standards as leading factors affecting quality in building construction in developed as well as developing countries. Ahzahar *et al.* (2011) identified the followings factors to be among the factors affecting quality of building quality: climatic conditions; location of building; construction materials; building type and change in use; maintenance of the building; faulty design; corruption; and lack of supervision.

A survey conducted by Abdul-Rahman *et al.* (2013) exposed 15 factors affecting quality of building construction in Malaysia. The factors are summarized as follows: poor quality improvement programs; poor document control; lack of training; poor selection of suppliers, vendors and sub-contractors; insufficient skill levels; delayed purchased material; unclear or incomplete construction drawings and specification; lack of site layout studies; constructability problems; poor safety problems; inadequate operability review and value engineering studies; improper soil analysis; inadequate review of the design and engineering drawings; poor checking, inspecting and testing internally; and poor checking, inspecting and testing externally.

Afolarin (2013) studied factors affecting quality in the delivering of housing project. The factors are summarized as lack of contractor supervision; lack of process improvement; low effective project management system; poor application of quality tools and techniques; lack of quality policy; low quality drawing and specification; lack of motivation; and low tendency to teamwork. Baradyana (2000) and Rubaratuka (2008, 2013) noted that shortage of quality construction materials; reluctance to use registered contractors and consultants; inadequate skilled and experienced staff; poor quality control and quality assurance; delay or late payment from clients to consultants or contractor; deficiency in working drawings; and low level of application of quality tools and techniques among factors affecting quality of buildings in Tanzania.

The study conducted in Kenya by Figueroa (2014) found that six of the list of ten factors affecting quality of reinforced concrete buildings in Kenya is linked to concrete quality. Others factors according to Figueroa (2014) includes: theft of construction materials at site particularly cement; insufficient curing of concrete; concrete compaction; prompt placement of concrete and quality of concrete ingredients. Through literature review (Khattak *et al.* 2015; Hai *et al*., 2012; Bowen *et al*., 1998) identified factors affecting quality of construction projects summarized as: poor financial capability of contractor; poor management system; difficult availability of technical people; poor coordination; shortage of materials and equipment; low bid; bad weather condition; low participation of regulatory authorities; lack of continuous improvement techniques. Summary of factors affecting quality of reinforced concrete buildings is as shown in Table 2.5.

Table 2.5: Factors affecting quality of RC building construction

S/N	Factor
1	Theft of construction materials at site
2	Shortage of quality materials in the market
3	Reluctance of private clients to use registered consultants
4	Lack of law to regulate building construction
5	Poor construction supervision
6	Reluctance of private clients to use registered contractors
7	Inadequate of construction technology
8	Lack of own code of design, standard and practice
9	Poor coordination of key players of construction project
10	Inadequate skilled & experienced human resource
11	Deficiency in design and errors in working drawings
12	Poor quality of construction management
13	Lack of quality policy
14	Delaying/late payments to contractors from clients

Source: Author (2018)

NCC (2017) reported that lack of coordination among professional regulatory bodies; lack of capacity in the local government authorities (LGAs); lack of proper systems for selecting firms with required qualifications; experience in private sector; and absence of legislation to regulate construction of buildings among factors affecting quality of building construction in Tanzania.

2.10 Quality Assurance and Quality Control in RC Buildings Construction

The way building construction is managed affects the outcome of the building quality. Several factors determine construction project quality among which according to Abdul-Rahman *et al.* (2010) and Baradyana (2000) is project management. Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements (PMI, 2004). Quality performance is one of project requirements parameters (Wanberg *et al.*, 2013; Love *et al.*, 2005) other than cost and time performance. According to Chan-Keng and Abdul-Rahman (2011b) the implementation of quality management in project management the concepts of quality assurance and quality control in the quality management process are important.

Quality assurance and quality control are frequently used interchangeably but quality control is part of quality assurance (Arditi & Gunaydin, 1999). Quality Assurance is the planned and systematic activities implemented within quality system to provide confidence that the project will satisfy the relevant quality standards while quality control is the part of quality management focused on fulfilling quality requirement (Dale *et al*., 1998). Quality assurance focuses on prevention rather than detection which is normally quality control activity and therefore quality assurance is proactive (Delgado, 2006). Quality assurance refers to administrative and procedural activities implemented in a quality system so that requirements and goals for a product, service or activity will be fulfilled (Nyomek, 2010). Table 2.6 summarizes quality assurance and quality control operations for reinforced concrete building construction.

Table 2.6: Quality assurance and control operations in construction

S/N	Quality assurance and quality control practice
1	Review and approval of working drawings
2	Frequent testing materials for building construction
3	Proper mixing, compaction and curing of concrete
4	Carryout frequent building inspection
5	Construction supervision
6	Carryout frequent site meetings
7	Availability of qualified staff
8	Formwork and steel fixing are inspected before concrete is placed
9	Inspection of materials brought to site from suppliers
10	Availability of appropriate construction equipments

Source: Author (2018)

Quality assurance is what must be done during the actual tasks to ensure that the standards identified during quality planning are met. According to Delgado (2006) the intent of quality control is to identify anything that is not according to requirements and either fix it or eliminate it, to make sure it conforms to the specifications, and functions as required. The activities focus on identifying defects in the actual products produced and therefore quality control is a reactive (Delgado, 2006). Quality control involves monitoring specific project results to determine if they comply with relevant quality standards and identifying ways of eliminate causes of unsatisfactory results and this should be performed throughout the project (PMI, 2004). El-Mikawi (2007) differentiated the two concepts arguing that, Quality assurance is a management tool while Quality control is a production tool.

2.11 Quality Management Tools and Techniques

Quality management is a complex effort (Baradyana, 2000). As a result of this complex nature of quality management, modern concept of quality management emerged and that is total quality management (TQM). Psychogios and Priporas (2007) argued that TQM is comprised of two aspects: management tools and techniques as well as management concepts and principles. According to Psychogios and Priporas (2007) tools and techniques applied in quality management can be referred as "hard" aspects of TQM whereas TQM principles are referred as the "soft" aspects of TQM. In support of Psychogios and Priporas (2007) idea, Haseeb and Huang (2013) argued that TQM elements may be grouped into two directions: the management system and technical system.

Total Quality Management tools are technical means used to work in the quality programs, and also used to improve processes in any organization by identifying, analyzing and evaluating data that is relevant to the organization. Therefore, by using tools and techniques one, can investigate problems identify solutions and implement them in work practices. Literature on TQM tools and techniques (Singh *et al.*, 2013; PMI, 2004) found that there are different classification of total quality management tools and techniques. There are tools classified as quantitative tools and others classified as qualitative tools (Chin-Keng & Abdul-Rahman, 2011a). Some of qualitative tools include brainstorming; cause-and-effect diagram; and flowcharts, whereas quantitative tools include PDCA cycle, Pareto chart and control charts.

According to Bamford and Greatbanks (2005) TQM tools are practical methods, skills or mechanism that can be applied to a particular task. Tools are described as a device that have a clear role, often narrow in focus and used on its own, such as Ishikawa diagram or Pareto analysis and charts. On the other hand, TQM technique has a wider application, often resulting in the need for more thought, skill and training to be used effectively, such as benchmarking; quality function deployment (QFD) or project evaluation and review technique (PERT). All tools and techniques have similar importance, but they are different and applicable in different situations (Dale, 2003).

A wide range of tools and techniques have been developed within total quality management as part of implementation process of quality management (Haseeb and Huang, 2013). According to Chin-Keng and Abdul-Rahman, (2011a) quality management has to provide the environment within which related tools and techniques can be deployed effectively. Tools and Techniques commonly applied in TQM for quality management as collected from various authors (Inuwa, 2014; Haseeb & Huang, 2013; Al-Sulaihi *et al*., 2013; Chin-Keng & Abdul-Rahman, 2011a; PMI, 2004; Baradyana, 2000; Lema, 1996; Suarez, 1992) were summarized. Summary of tools and techniques commonly used for quality management are as presented in Table 2.7.

Table 2.7: Application of quality tools and techiques

S/N	Tools and Techniques
1	Benefit Cost Analysis
2	Benchmarking
3	Design of Experiment
4	Project Evaluation and Review Techniques (PERT)
5	Quality audit
6	Inspection
7	Bar Chart
8	Pareto Chart
9	Statistics Sampling
10	Critical Path Method
11	Ishikawa diagram

Source: Author (2018)

2.12 Management of Buildings Construction in Tanzania

Reinforced concrete building construction is a creative activity involved in transforming physical resources into a useful structure (Baradyana, 2000; Lema, 1996). The practice of managing most building projects is to divide the management responsibility between the parties to a construction contract. In the building construction industry, the Client, the Architect, the Quantity Surveyor and the Contractor/Builder, all assume responsibilities in the conventional role (Baradyana, 2000). In the conventional approach, the ultimate responsibility for project management rest with the client whose primary function is to define project parameters and to provide decisions, as well as approvals and general guidance (Delgado, 2006). For building construction work, an architect and structural engineer are responsible for design and supervision of construction (URT, 1997a; 1997b). The architect shares the responsibility for construction contract administration with a quantity surveyor (Baradyana, 2000).

Municipal councils are responsible for approving designs, issuing building permits and inspecting and approving building construction works at their areas of authority (Rubaratuka, 2013). Contractors Registration Board (CRB) is responsible for regulating all construction works (URT, 1997c). Also it is the responsibility of CRB to inspect reinforced concrete building construction to ensure that they are constructed according to established laws (Rubaratuka, 2013). The National Construction Council (NCC) was established by the Act of Parliament in 1981 as amended in 2008 charged with promoting construction industry development in Tanzania. In view of the risks associated with project failures, NCC recognized that project promoters and financiers require an independent review on the performance of their projects. Therefore, NCC established project audit service in 1991 to fulfill such needs. Project audit is applied at any of the phases of a construction, that is: design, construction, and commissioning. Despite many authorities being established for overseeing reinforced concrete building construction in Tanzania and Dar es Salaam in particular, yet a number of problems related to poor management, still are reported.

A study by Hollway (2000) revealed that consultants frequently produce deficient working drawings and construction works are carried by contractors are normally poorly supervised. An audit carried by National Audit Office (NAO) (2014) in buildings constructed by Local Government Authorities (LGAs), based on data covering the period from 2011 to 2013 showed deficiency of working documents prepared by consultants (NCC, 2017). According to (NCC, 2017) most of the contracts sampled exhibited unsatisfactory quality of the work. Further, 19 out of 51 (37.3%) buildings projects audited revealed poor supervision by consultants (NAO, 2014). Also, value for money audits of 137 construction contracts in the financial year 2011/12 carried by Public Procurement Regulatory Authority (PPRA) (2012) showed poor quality performance. This situation suggests that something different is to be done in terms of how to deal with problems constantly reported in the literature (NCC, 2017; NAO, 2014; Baradyana, 2000; Lema, 1996). Summary of various authorities responsible for construction monitoring, inspection, and supervision is presented in Table 2.8.

Table 2.8: Authorities for overseeing construction activities in Tanzania

S/N	Authority
1	Responsible consultant (Architect/Structural Engineer)
2	Contractors Registration Board (CRB)
3	Engineers Registration Board (ERB)
4	Architects and Quantity Surveyors Registration Board (AQRB)
5	Municipal council/Local Government Authorities (LGAs)
6	National Construction Council (NCC)

Source: Author (2017)

2.13 Summary

This chapter has examined global perspective of quality in construction. The need for quality improvement in the construction industry worldwide is well accepted. The need to adopt powerful quality management philosophy such as TQM in construction has been emphasized. This research was motivated by the need to improve quality of reinforced concrete buildings construction in Dar es Salaam. The structure and characteristics of the Tanzania construction industry have been examined to appreciate the scope for improvement. The economic significance of the construction industry in Tanzania was observed but building sector is not performing to the expectation.

Various researches were reviewed with a view to get big picture of the problem. The literature indicated that relationship between construction quality management practices and quality of reinforced concrete buildings in Dar es Salaam represented a significant knowledge gap. Quality management tools and techniques (Table 2.7); quality assurance and quality control (Table 2.6) together with construction supervision (Table 2.8) were identified from literature as variables responsible for quality in the process of reinforced concrete buildings' construction. Also, other factors that were considered to affect quality of reinforced concrete building construction were pre-determined as shown in

Table 2.5. The identified factors were put to determine their level of application at reinforced concrete building construction site in Dar es Salaam. Before embark to methodology and data collection process, theoretical framework to guide the study follows in the next chapter.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

In this chapter, theoretical framework for the research work is developed. This research aimed to develop quality management model to facilitate quality management of reinforced concrete buildings construction in Dar es salaa. From this background, therefore, the chapter gives a brief description of theoretical ande conceptual frameworks as applied in research; highlights concepts and evolution of total quality management. Further, the chapter describes quality management tools (i.e. Pareto chart and Ishikawa diagram). These tools were considered to be appropriate total quality management tools for this study. Quality management models proposed by previous researchers are presented and discussed. Finally, systems theory as it was used to guide this study is explained and conceptual framework of for the study is presented.

3.2 Theoretical Guidelines

Theoretical and conceptual frameworks are often confused and used interchangeably by researchers to explain each other, and as steps in the research process (Rocco & Plakhotrick, 2009). Theoretical framework is sometime referred to as a conceptual framework but the two terms are neither interchangeable nor synonymous (Adom, Hussen & Agyem, 2018). Because both theoretical and conceptual frameworks are important in research work, it is important to give a brief description of the two terms.

Grant and Osanloo (2014) linked theoretical framework to elevations of a house blueprint for the entire research inquiry. It is a structure that guides research by relying on a formal theory, established by using an established, coherent explanation of certain phenomena and relationships (Kivunja & Kuyini, 2017). Theoretical framework of this study is as presented in Figure 3.1.

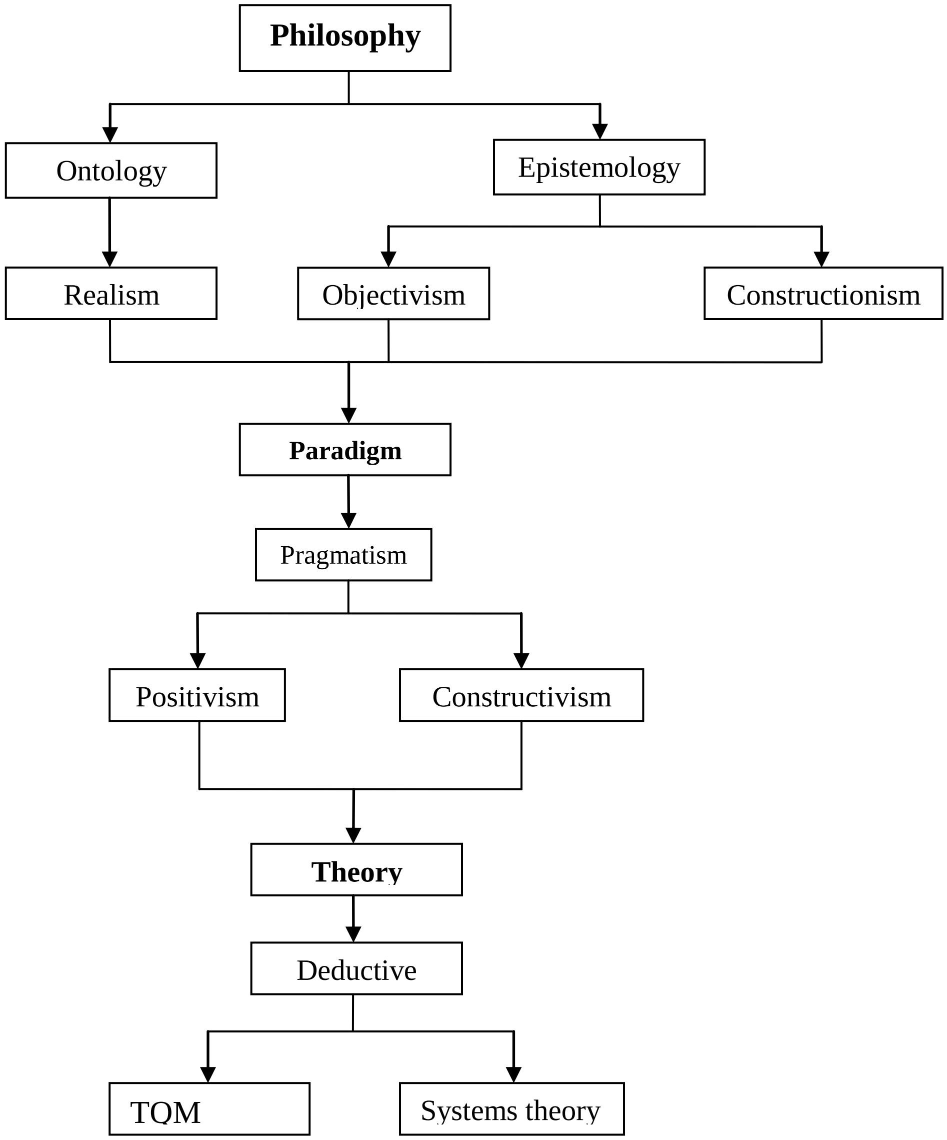

Figure 3.1: Theoretical framework of the research

Source: Author (2018)

A theoretical framework is based upon theories that have already been tested, it is a group of related ideas that provides guidance to the research project (Rocco & Plakhotnik, 2009).Therefore, theoretical framework consists of theoretical principles, constructs, concepts and tenants of a theory (Adom, *et al*., 2018).

There are similarities and differences in approach and style between theoretical and conceptual framework (Imenda, 2014). The theoretical framework provides a general representation of relationship between things in a given phenomenon, while conceptual framework embodies the specific direction by which the research will have to be undertaken in relation to the direction given by the theoretical framework. Conceptual framework describes the relationship between specific variables identified in the study as guided by the theoretical framework. Theoretical framework developed is a blueprint or guide for this research and served as the foundation upon which this reaseach was constructed. The framework provided the structure in showing how the research work is defined philosophically, ontologically, epistemologically, theoretically and paradigmically.

3.2.1 Research Philosophy

This research is guided by realism ontology philosophy. Realism ontology holds that one reality exists and it's the researcher's work to discover the reality (Guba & Lincoln, 1994). Therefore this research is guided by this belief that truth and knowledge is out there to be discovered by research and there exists a world of material objects. Some statements about these objects can be known to be true through sense – experience. This kind of thinking differs with the relativism ontology which asserts that reality is socially constructed, therefore multiple mental constructions can be apprehended, and some of which conflicts with each other, and perception of reality changes throughout the process of the study.

Ontology is a philosophical study of the nature of existence or reality of being or becoming as well as the basic categories of things that exist and their relations (Scotland, 2012). Paradigm defines a research philosophical orientation and has significant implication for every decision made in the research process (Kivunja & Kuyuni, 2017). Ontology is essential to a paradigm because it help to provide an understanding of things that constitute the world as they are known (Scott & Usher, 2004).

Ontology has a complex relationship to epistemology i.e., epistemology is about empirical evidence gleaned that will be described or characterized by ontology (Poli *et al.*, 2010). While ontology is primarily about the entities, relations, properties of the world, and the categories of things, epistemology is about the perceived and belief-attributed entities, relations and properties of the world, i.e. ways of knowing or ascertaining things. Epistemology is concerned with all aspects of the validity, scope and methods of acquiring knowledge (Scotland, 2012).

This research adopted objectivism and constructionism epistemology because from the otology point of view, the study supported the idea that objective object exist and it waits to be discovered. Objectivism on the one hand, is epistemology which assumes that reality exist independent of the researcher's mind. On the other hand, constructionism epistemology assumes that truth or meaning arises in and out of humans' engagement with the realities in their world (Moon & Blackman, 2014). That is a real world does not pre-exist independent of human activity. Therefore, value of constructionism epistemology research is in generating contextual understanding of a defined problem. Constructionism assumes that it is not possible to access truth about the real world solely by virtue of a single scientific method and also human understanding is gained through the application of reason. Therefore, this research adopted both objectivism and constructionism epistemology because, they complement each other.

3.2.2 Research Paradigm

This research views the world from a pragmatic paradigm. As it was pointed out by Grant and Osanloo (2014) when selecting a theoretical framework, it is important to examine ontological and epistemological beliefs of the study. Pragmatic paradigm argues that it is not possible to access the truth about the real world solely by virtue of a single method as advocated by Positivist paradigm, nor is it possible to determine social reality as constructed under the constructivist paradigm (Biesta, 2010; Patton, 1990).

Social inquiry involves ‘methodology - as - technique’ and ‘methodology - as - philosophy’ (Dieronitou, 2014). According to Hammersley (2006) the former depicts research as the involvement of particular methods or procedures, those that fall within the category of natural sciences and are distinguished from humanistic disciplines, while the latter concerns fundamental questions about the goal of knowledge of research, the ideal of truth and the possibility of objectivity. Although Hammersley (2006) views the role of philosophy as essential to research, he argues that there are limits to its contribution for it does not enlighten researchers how best to go about investigating particular topics. According to Bryman (2012) objectivism entails that the social entity in question adheres to an external objective reality independent of the researcher’s awareness.

A philosophical perspective, based on realist ontology, asserts that reality is driven by immutable natural laws. Research then becomes objective, measurable, predictable and controllable. As far as epistemology is concerned, it is rooted in an objectivist position. It is commonly asserted that the positivist approach to research is deductive in nature in that is tests a priori hypothesis or theory. This emphasis on arguing from the general to the particular has been noted by many authors (Patton, 1990). Guba and Lincoln (1994) acknowledge this as they impose a top-down approach to research. In contrast to this view, Bryman (2012) argues that positivism entails elements of both a deductive and an inductive approach.

Constructivism is a paradigm for conducting qualitative research (Guba & Lincoln, 1994). Guba and Lincoln (1994) the well-known qualitative researchers, mapped out a series of black and white contrasts between positivism and constructivism. They asserted that ontologically speaking, there are multiple realities constructed by actors of research. Thus they argued that research is grounded on a relativist ontology which rejects the existence of any possible correct reality. On an epistemological level, they reflect Smith’s (1983) contention that the researcher takes a subject-subject posture whereas facts and values are inextricably linked. Hence, since the subject and the object are inseparable, research is value-bound. Another tenet of constructivism concerns the relationship between theory and research. Research based on constructivism aligns to an emphasis of inductive logic by means of arguing from the particular to the general (Bryman (2012). From a methodological point of view, it proceeds by depicting individual construction in order to compare and contrast it with the aim of reaching and generating a substantial consensus (Dieronitou, 2014).

3.3 Quality Management Theories

Total Quality Management (TQM) is a management philosophy that effectively determines the needs of the customer and provides the framework, environment, and culture for meeting those needs (Dale *et al*., 1998). This management thinking brought a paradigm shift from the traditional approach to a more integrated approach (Hanseeb & Huang, 2013). This approach; gave priority to customer satisfaction, shifted the management style from control to leadership, increased employee empowerment through teamwork and decision making, and an emphasis on process and statistical process control. Total quality management philosophy recognizes that attainment of required quality objectives can only be achieved through management involvement at all levels; continuous improvement of products, services and processes; education and training of employees; and participation of all employees in problem solving.

3.3.1 Evolution of Total Quality Management

The quality revolution brought about by Japanese management philosophy in 1970's and 1980's together with challenges of new global competitive environment, led companies to consider quality as an integral part of their strategic plan through new management philosophy that is Total Quality Management (TQM) (Hanseeb & Huang, 2013; Lema, 1996; Koskela, 1992). According to Powell (1995), TQM's origin can be traced back to 1950 when the union of Japanese scientists and engineers formed a committee of scholars and enhancing their post-war quality of life. On the other hand, Dale *et al.* (1998) considered that Crosby, Deming, Feigenbaum, Juran, Ishikawa, and Shewhart could be the founders of the total quality management (TQM) because, TQM drinks from their works. However, Dale *et al.* (1998) believed that the term TQM arose in UK from the activities of the Department of Trade and Industry National campaign launched in 1983 and the pioneering work of IBM Company. American firms began to take serious notice of TQM around 1980's after penetration of Japanese quality products in its market together with the impact of the writings of Crosby (1979), Deming (1986), Feigenbaum (1991) and Juran (1986).

There is agreement of researches (El-Mikawi, 2007; Delgado, 2006; Lema, 1996; Koskela, 1992) that TQM have evolved through four stages from inspection, quality control, and quality assurance to total quality management. Dale (2003) described the evolution of quality as the four levels in the evolution of TQM and emphasized that they should be considered as levels in a hierarchical progression. According to Lema (1996) TQM has two main streams, scientific and quality. The merging of the two streams created a new philosophy that brought quality concepts from product to process (Koskela, 1992).

Analysis of the origin of the TQM indicates the following: Research activities related with workforce and the need for top management leadership have their origin in the USA arising from the work of Maslow (1970), McGregor (1960) and Ouchi (1981). With respect to flow management and statistical process control (SPC) has its root in the USA by Shewhart (1931). Mistake proofing system is a Japanese idea by (Shingo, 1986) with emphasis on the importance of cleanliness, and organization of tools and housekeeping using the 5s principles. The concern about customers needs has been the development work conducted in Japan and USA (Dale *et al.,* 1998). Recommendation about design processes have arisen from Japanese procedures and best practices. Quality function deployment (QFD) methods were developed in Japan (Ishikawa, 1990), but with many other Japanese management tools and techniques, were popularized word-wide by USA writers (Hanseeb & Huang, 2013). Supplier relationship dimension can be grounded mostly in just in time (JIT) theories which were first developed in Japan by Toyota (Monden, 1983).

Hellard (1993) described TQM as the third industrial revolution emerged from a rapid development in the third quarter of the 20^{th} century. According to Nyomek (2010) during this time three groups of experts in quality management emerged: In the early 1950s Americans (Deming, Juran and Feigenbaum) took the massage of quality to Japan; In the late 1950s Japanese (Ishikawa and Shingo) in response to the Americans concepts of quality used the concepts and also developed new concepts; and around 1970s to 1980s Western experts followed the Japanese industrial success (Crosby) (Suarez, 1992). Analysis of literature (Kerzner, 2003; Dale *et al.*, 1998; Lema, 1996; Suarez, 1992) shows that the works of Crosby (1988, 1979), Deming (1989, 1986, 1982), and Juran (1988, 1986) have played a great role in shaping the quality management evolution.

Analysis of works by these experts (Crosby, Deming and Juran) shows points of agreement and disagreement. Points of agreement in their quality improvement approaches can be summarized as follows:

i. It is management's responsibility to establish an organizational culture in which commitment to quality is the main focus;
ii. Continuous education and training at all levels is necessary to foster a common language of quality and to develop employee skills and knowledge;
iii. Effective communication, cooperation and teamwork throughout the organization are essential;
iv. The pursuit of customer-focused quality is a long-term process that will not produce results overnight and must be a continuous effort;
v. Improvement should not be viewed in terms of final product and post-production inspection needs to be minimized.

Differences in approach of the three quality experts mentioned above (Crosby, Deming and Juran) together with their points of agreement are summarized shown in Table 3.1.

Table 3.1: Comparison of experts' approaches on quality

	Crosby	Deming	Juran
Definition of quality	Conformance to requirement	Current and future need of the customer	Fitness for use and customer requirement
Quality measurement	Focus of measurement is the monetary cost of quality	Statistical thinking and statistical methods	Both measurement is the monetary cost of quality and statistical thinking
Goals setting	Defect free product is the ultimate goal	Opposes the use of goals to manage work	Emphasis on company-wide goal and the deployment of goals
Training	Target training to help managers to develop a new organizational culture	Target training toward quality management practices and problem-solving techniques	Addresses the need for education and training for enhancing knowledge and developing skills
Quality improvement	Emphasizes prevention to meet specifications	Uses three quality-oriented processes (Planning, control and improvement) to achieve improvement	Views the organization as a system and applies the scientific method to optimize the system. Uses statistical method to monitor variation

Source: Kerzner (2003) and Suarez (1992)

The literature above has shown that TQM has two main streams; the scientific development and quality development (Lema, 1996). The progression from inspection around 1910s to TQM in 1990s took about 100 years. The merging of the two streams in the 1980s and the emergence of TQM in the 1990s created the new philosophy and brought back the quality concept from production into process (Hanseeb & Huang, 2013). The new TQM philosophy shifted management style from control to leadership; teamwork and emphasis on production process (Maemura *et al*., 2018). Satisfied customers, reduction of variation and rework in the work process; greater alignment of individuals and corporate objectives, and greater business including, long-term business relationship are some of TQM application (Lin & Gibson, 2011; Hoonakker *et al*., 2010). Comparatively low level of quality in the construction industry compared to the manufacturing industry has resulted in calls for quality in the construction industry.

Implementation of TQM requires application of quality management tools and techniques (Psychogios & Priporas, 2007). Quality management tools to identify problems and establish priority areas where minimum efforts can be applied for maximum benefit are required. To achieve this, tools such as Pareto chart and Cause and effect diagram can be applied.

3.3.2 Pareto Chart

Pareto chart is developed by Pareto Principle. Pareto Principle was discovered in 1897, by Pareto (1848–1923) (Fellows & Liu, 2008). The discovery has since been called many names, including the Pareto Principle, the Pareto Law, the 80/20 Rule, the Principle of Least Effort and the Principle of Imbalance (Koch, 1998). According to Koch, (1998) by a profound process of influence on many important achievers, especially business people, computer enthusiasts and quality engineers, the Pareto Principle has helped to shape the modern world. The Pareto Principle asserts that a minority of causes, inputs or effort usually lead to a majority of the results, outputs or rewards (PMI, 2004; Koch, 1998).

Pareto Principle states that there is an inbuilt imbalance between causes and results, inputs and outputs. Essentially, Pareto Principle means that, 80 per cent of the problems come from 20 per cent of the causes (Suarez, 1992). The value of the Pareto Principle for a quality management is that it requires focusing on the 20 per cent of quality problems that matter. It is required to identify, and focus on the 20 per cent first, but the remaining 80 per cent of the causes should not entirely be ignored (PMI, 2004). The Pareto principle suggests that most effect or problem come from relatively few causes. Therefore efforts aimed at the right 20% can solve 80% of the problems. The general use of Pareto chart is to decide where to apply initial effort for maximum effect (Singh *et al*, 2013).

The phenomenon of the vital few and trivial many (Pareto Principle) as a universal, applicable to many fields was first identified by Juran. IBM is one of the earliest and most successful corporations to spot and use the Pareto Principle, where in 1963, the company discovered that about 80 per cent of a computer's time is spent executing about 20 per cent of the operating code (Koch, 1998). According to Koch (1998) the IBM Company immediately rewrote its operating software to make the most used 20 per cent very accessible and user friendly, thus making their computers more efficient and faster than their competitors'. Personal computer and its software developed in the next generation, such as Apple, Lotus and Microsoft, applied the Pareto Principle (Fellows & Liu, 2008). Pareto Principle and the associated chart can as well be applied in construction industry. Pareto chart has been applied to priorities factors affecting failure of reinforced concrete buildings in Dar es Salaam. Figure 3.2 presents Pareto chart.

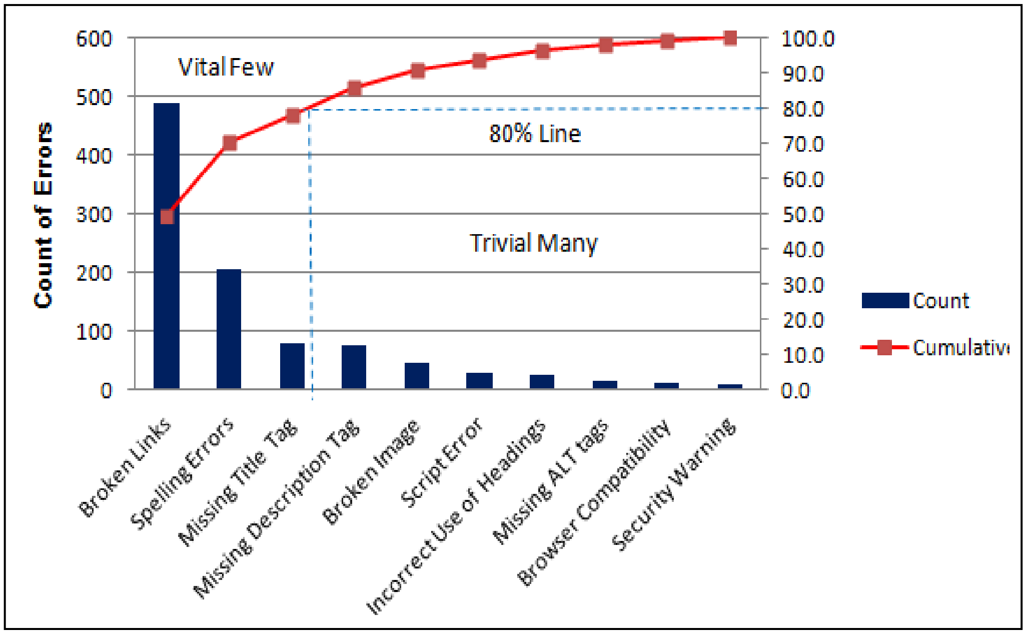

Figure 3.2: Pareto chart

Source: Singh *et al*. (2013, pp.112)

Pareto chart is a special type of bar chart where the plotted values are arranged from largest to smallest (Singh *et al.*, 2013) A Pareto chart is used to highlight the most frequently occurring defects, the most common causes of defects, or the most frequent causes of customer complaints (Maemura *et al*., 2018). Pareto chart is generally used to decide where to apply initial effort for maximum effect using Pareto Principle, by selecting the 20 percent of frequently occurring defects or most common causes of customer complaints. Once the most important sources of quality problem have been identified, effort is focused on dealing with these, rather than trying to tackle all the problems at once (Fellows & Liu, 2008).

The left vertical axis of the Pareto chart has "counts" or frequency. Each vertical bar represents the contribution to the total from a given "problem". The bars are placed on the graph in rank order - that is, the bar at the left has the highest contribution of errors. A cumulative line is used to add the percentages from each bar, starting at the left (highest count) bar. Purpose of the Pareto diagram is to distinguish the "vital few from the trivial many." Therefore, bars on the left side of the Pareto chart (broken links, spelling errors, and missing title tag) account for most (80%), of the errors problem. From the analysis presented by the Pareto chart, Figure 3.2 the broken links represents the major cause for errors. In order to eliminate errors problem, one can focus and put maximum efforts on the controlling the broken links without neglecting the other causes. If enough resources are available, effort to eliminate broken links, spelling errors, and missing title tag would help to solve 80% of errors problem at once.

3.3.3 Ishikawa Diagram

Ishikawa diagram also called cause-and-effect diagram or Fishbone diagram helps to lead to the root cause of the problem (Maemura *et al*., 2018). According to PMI (2004) the Ishikawa diagram shows how various elements might be linked to potential problem or effects. It illustrates how various causes and sub-causes relate to create potential problem of effect (Sigh *et al*., 2013). Having analyzed Cause-and-effect diagrams from literature (Maemura *et al*., 2018; Sigh *et al*., 2013; PMI, 2004) the study conceptualized causes and sub-causes in different levels as shown in Figure 3.3. Ishikawa diagram can be applied to help in identifying root causes of a particular problem in construction industry.

When Pareto chart helps to identify and prioritize where to apply initial effort for maximum effect, Ishikawa diagram helps to lead to the root cause of the problem. Particularly, Pareto chart was utilized to identify the vital few that caused trivial many of the building failures, while Ishikawa diagram was applied to determine root cause of buildings failures in Dar es Salaam. Figure 3.3 shows Ishikawa diagram.

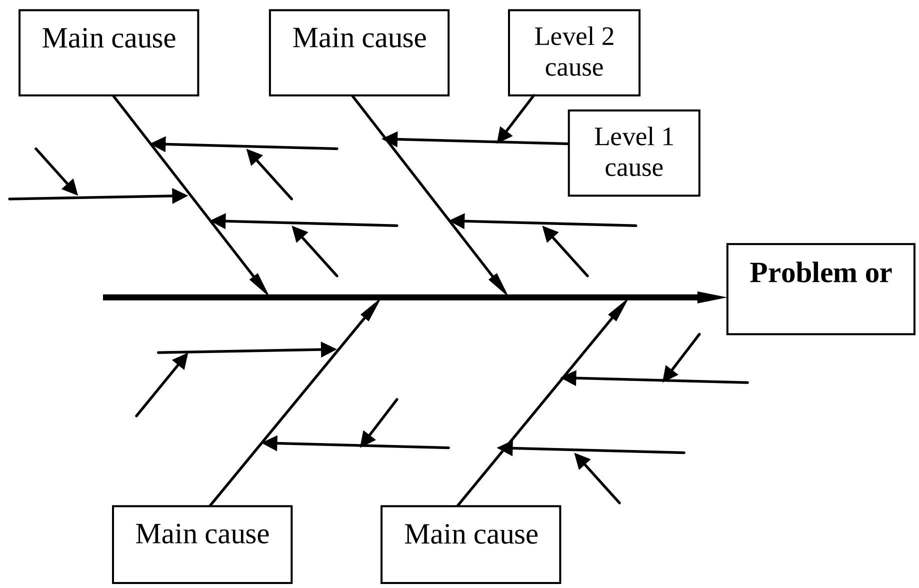

Figure 3.3: Ishikawa diagram

Source: Author (2018)

3.4 Quality Management Models

This research aimed to develop a model to help in facilitating quality management of reinforced concrete buildings construction in Tanzania. Various models and framework have been developed for the purpose of improving quality. Delgado (2006) observed that there has been confusion between the two terms “model” and “framework”. Wong (2005) analyzed the two concepts and concluded that a model provided an answer to “how to” while a framework answers “what is”. Delgado (2006) explained that model and framework are descriptive and conceptual in nature. With this light in mind, some of the initiatives reported in the quality management literature are presented.

According to Al-Sulaihi *et al*. (2013) the most utilized management frameworks and models are: the Malcolm Baldrige National Quality Award (MBNQA) in the United States; the European Foundation for Quality Management (EFQM) Excellence Model in Europe; and the Deming Prize in Japan. According to Oakland and Marosszeky (2006) the Baldrige (MBNQA) and EFQM Excellence Model were recognized as descriptive holistic business models, rather than just quality model. The Malcolm Baldrige National Quality Award (MBNQA) Model aims to promote performance excellence and improvement in competitiveness through a framework of seven categories (i.e. leadership, strategic planning, customer focus, measurement, analysis and knowledge management (Al-Sulaihi *et al*., 2013).

Pryor *et al.* (2009) developed 5P's model to help small and medium business for long-term survival and success. The 5P's model is as summarized in Figure 3.4. The 5P's model uses purpose, principles, process, people and performance as its core principles. According to Pryor *et al*. (2009) the establishment of strategic direction and the strategic management model is included in one of five elements necessary for an organization to be successful. The arrows depict the connection between strategy (Purpose) and structure (Principles as internal structures and Processes as external structures) and the influence of structures on employee behavior (People) and corresponding results (Performance). Strategy drives structure; structure drives behavior; and behavior drives results. The arrow from Performance to Purpose represents the feedback mechanism for guiding an organization toward its objectives.

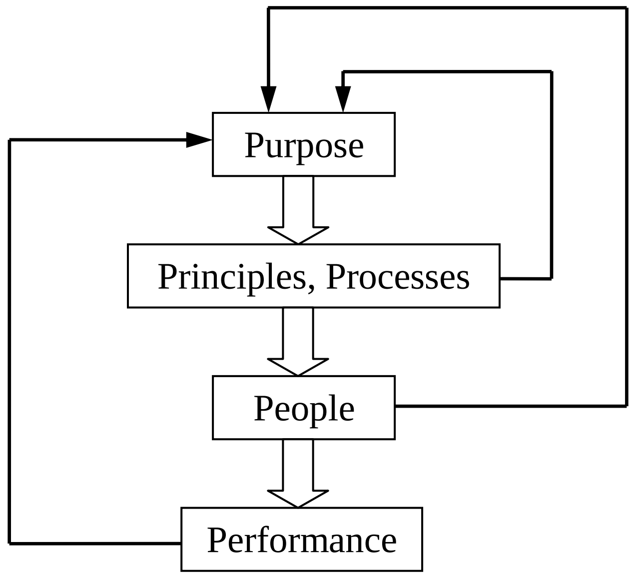

Figure 3.4: The 5P's model

Source: (Pryor *et al.*, 1998)

A strong emphasis in process improvement centers on measurement of variation, the control of variation, and the knowledge of variation to seek improvement (Juran, 1986). A process is a way of getting things done and it consists of the tasks, procedures and policies necessary to carry out an internal or external customer need (Adrian 1995). If the process is correct, so will be the end result (product), thus the organization should work to improve processes so as to improve the end product. A process can possibly be improved by changing process of the generic five M's namely man, machine, material, method and measurement as summarized by Suarez (1992) in Figure 3.5.

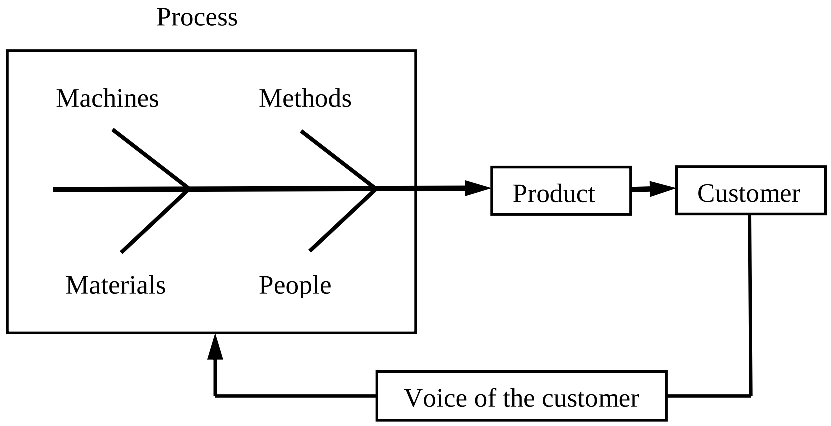

Figure 3.5: Production process improvement

Source: Suarez (1992, pp.9)

Quality improvement begins with what Crosby (1979) called four absolutes of quality management namely: quality is conformance to the requirements; the system of quality is prevention; the performance standard is Zero Defect; and the measurement of quality is the price of nonconformance. Anderson *et al*. (1994) agreed with Crosby's absolutes of quality, that inspection at the end of the production process is too late and too costly; therefore, prevention is considered a good approach for quality improvement.

Crosby's prevention process resembles Deming cycle for continuous quality improvement. Deming cycle is a multipurpose quality improvement model and its prevention process begins by establishing the product requirement, developing the product, gathering data, comparing the data to the requirement, and taking action on the result (Lema, 1996). The process of ongoing quality improvement designed by Shewhart and poularized by Deming (Plan-Do-Check-Act (PDCA)) cycle is summarized by Lema (1996) as shown in Figure 3.6.

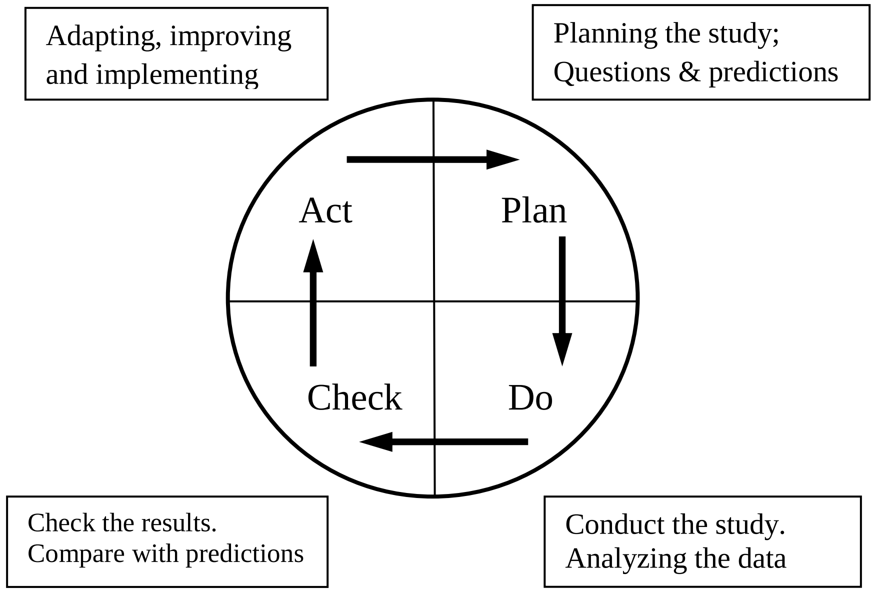

Figure 3.6: Deming cycle for continuous quality improvement

Source: Lema, (1996, pp.78) modified

Underson *et al.* (1994) articulated a theory of quality management to describe and explain the effects of adopting the Deming management method. According to Underson *et al.* (1994) Deming is one of the strongest proponents of quality management, a member of the select few credited with contributing to the rapid revitalization of Japanese economy after World War II. Underson *et al*. (1994) summarized the theory underlying Deming management method leading to the following theoretical statement: "*The effectiveness of the Deming management method arises from leadership efforts toward the simultaneous creation of cooperative and learning organization to facilitate the implementation of process management practices, which, when implemented, support customer satisfaction and organization survival through sustained employee fulfillment and continuous improvement of processes, product and services*". This theoretical statement is summarized by Underson *et al*. (1994) as shown in Figure 3.7.

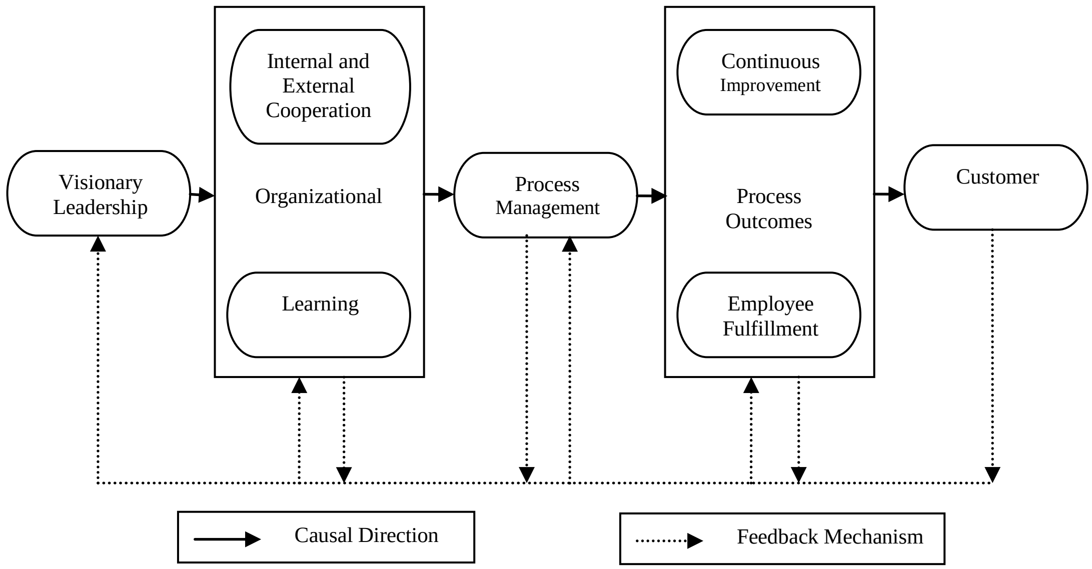

Figure 3.7: Quality management underlying Deming method

Source: Anderson *et al*. (1994, pp.481)

Along with various concepts, principles and methodologies for quality management (Haseeb and Huang, 2013; Singh *et al*., 2013; Paul, 2012; Koskela, 1993) a number of tools and techniques have been developed and proposed for use in the quality management process (PMI, 2004). Among the powerful tools recognized in the literature for adoption and used by this research to improve quality in construction include Pareto chart and Cause-and-effect diagram.

Lema (1996) developed a conceptual model to identify a clear role of total quality management (TQM) using benchmarking tool. According to Lema (1996) the model was developed to give a clear vision of how benchmarking could be applied in kick-starting and sustaining the TQM implementation process in construction industry. Lema (1996) argued that while priorities for quality improvement had been identified there was no clear vision of how the priorities could be achieved. The model developed by Lema (1996) focused on five principles of leadership, teamwork, training, process improvement and customer involvement to achieve improvement as shown in Figure 3.8.

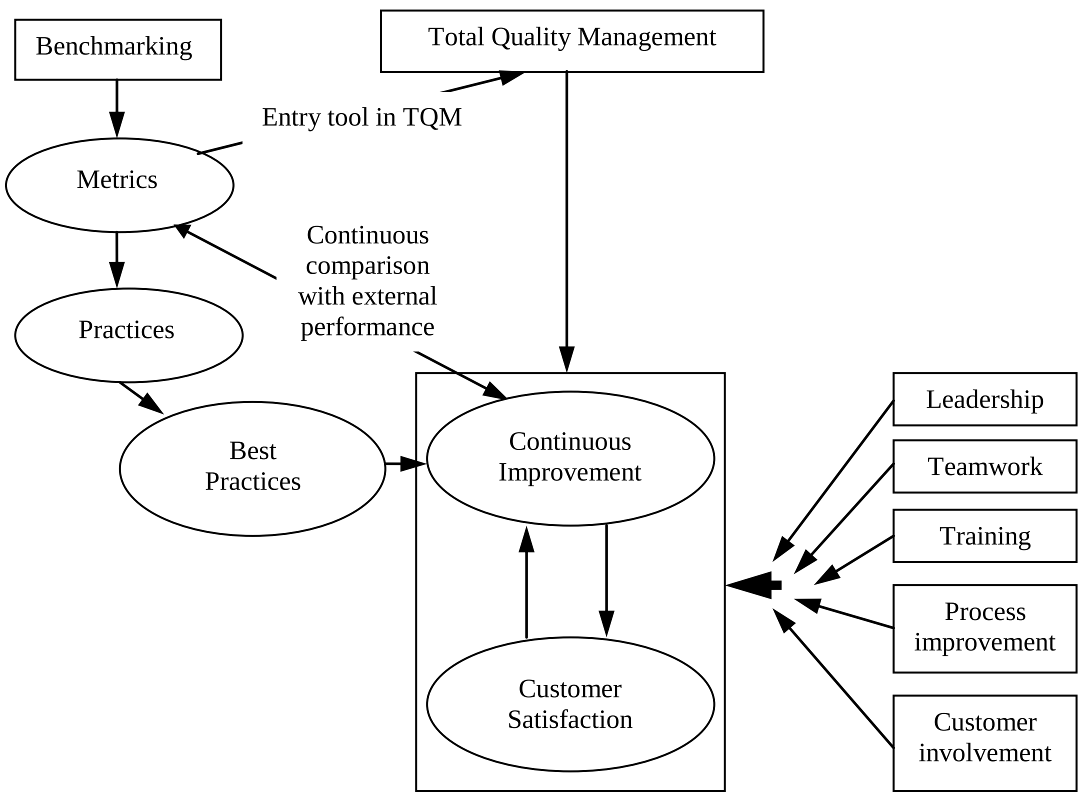

Figure 3.8: Benchmarking for TQM implementation

Source: Lema (1996, pp.89)

Arditi and Gunaydin (1997) illustrates that construction is a process, and that TQM principles that have been applied to other processes are potentially adaptable to the construction industry. Figure 3.9 shows the Juran's triple role concept applied to construction as summarized by Arditi and Gunaydin (1997). According to Juran (1988) and Burati *et al.* (1992) every party in a construction process has three roles (i.e. supplier, processor, and customer), referred to as the triple role concept. According to Arditi and Gunaydin (1997) the contractor is the designer's customer, who uses the designer's plan and specifications to carry out the construction process and supplies the completed facility to the owner. The owner supplies the requirements to the designer and receives the facility from the contractor, and is responsible for the facilities operation.

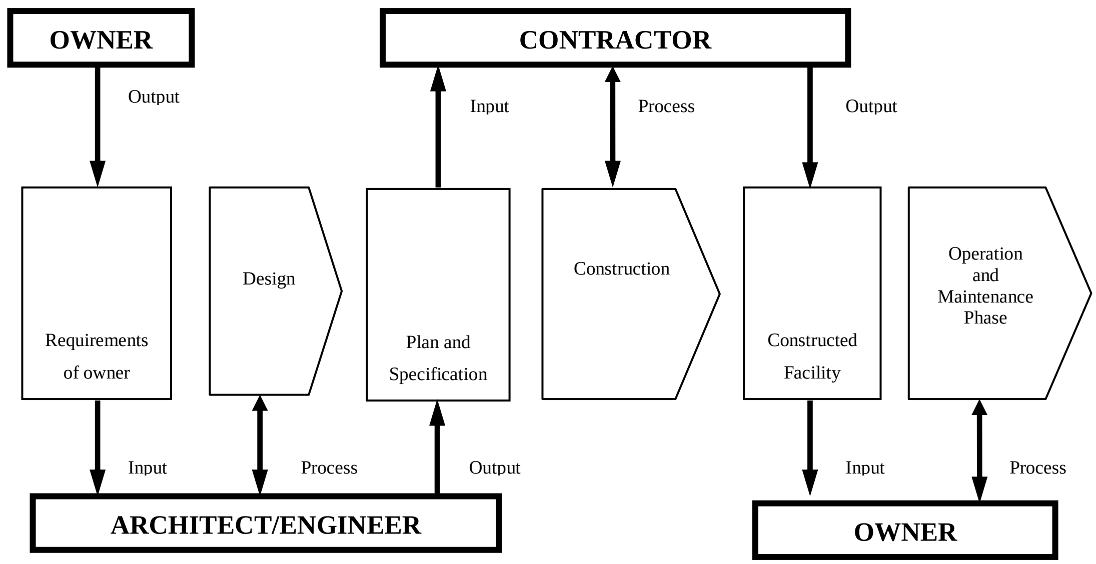

Figure 3.9: Juran's triple role concept applied to construction

Source: Arditi and Gunaydin (1997, pp.240)

Koskela and Howell (2002a) suggested that construction industry could be viewed in three ways at the same time: Transformation, Flow and Value generation (TFV). The value generation concept of production arose as a criticism of mass production (Koskela, 1993).

Transformation: New production philosophy views all production systems as conversion and flow (Koskela, 1992). According to Koskela (1992) conversion activities add value to the material or piece of information being transformed into product. Principles of transformation are based on a set of assumptions about how work is accomplished and how the outcomes of the work should be evaluated and the notion that variation is inherent to all phenomena (Anderson *et al.*, 1994). The TFV concept is summarized by Biton & Howell (2013) as presented in Table 3.2.

Table 3.2: Theoretical foundation of project management

Subject of theory		**Relevant theories**
Project		Transformation
		Flow
		Value generation
Management	Planning	Management -as-planning Management -as-organizing
	Execution	Classical communication theory Language/action perspective
	Control	Thermostat model Scientific experimentation model

Source: Biton and Howell (2013, pp.126)

Flow- Koskela and Howell (2002b), viewed production path of a project as a flow composed of value adding activities (transformation) and non-value adding activities (inspection, waiting and moving). As it is argued by Koskela (1992) in the new production philosophy, materials and information flows are the basic unit of analysis. The main objective of the flow concept is to eliminate or minimize the non value adding activities through improvement of project lead time, variability reduction, flexibility, and transparency (Delgado, 2006).

Value- The value concepts focuses on how best, the produced project products match or meet customer requirement. While all activities of a project expend cost and consume time only conversion activities add value to materials and information transformed into a product (Koskela, 1992). It is expected that the design and specifications and construction of a project capture, integrate and produce a product to meet customer requirements by exhibiting value for money.

The model proposed by Oakland and Marosszeky (2006) provides the basis of excellence in the construction industry and covers various angles and aspects of construction organization and its operations as shown in Figure 3.10. The model addresses hard and soft issues of quality. Quality performance is improved through better planning and the management of people and processes in which they work. These three Ps are important in delivering quality products and service to customers. The three Cs, i.e., culture, communication and commitment are soft foundation of TQM. According to Oakland and Marosszeky (2006) the soft foundations must encase the hard necessities of planning people and processes.

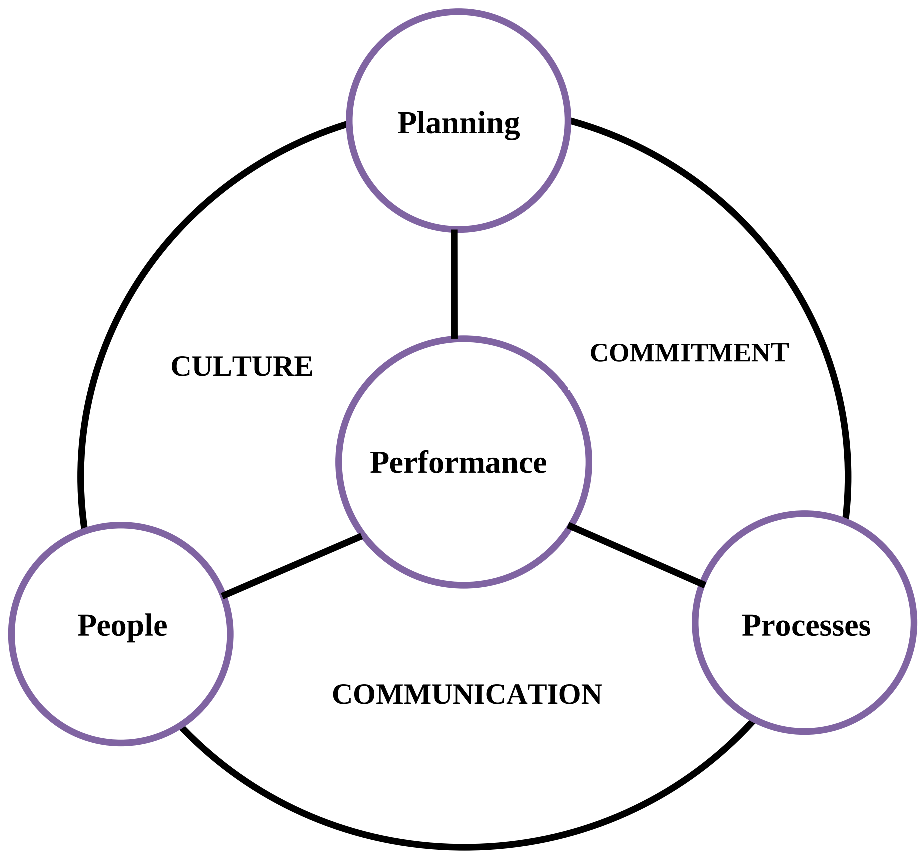

Figure 3.10: A Model for Total Quality Management

Source: Oakland and Marosszeky (2006)

3.4.1 Analysis of Quality Improvement Initiatives

As shown from the foregoing discussion quality improvement has been a focus of wide range of research. While manufacturing has been in the forefront with significant improvement, construction industry on the other hand is blamed for over three decades of poor performance (Hoonakker *et al.*, 2010). As a point of reference and source of innovation, construction industry has turned to the manufacturing industry, the successful concepts derived from manufacturing such as total quality management (TQM) and lean production or Just-in-Time (JIT) are being adopted and integrated into construction industry.

The important determinant of the success in implementing TQM in construction is the ability to translate, integrate and ultimately institutionalize TQM concepts and principles into everyday practice on the job. TQM is a way of thinking about goals, organization, processes and people to ensure that the right things are done right the first time. Various initiatives have been taken with different approaches to improve quality performance in both the manufacturing and construction industry as shown above.

The Malcolm Baldrige National Quality Award (MBNQA) and European Foundation for Quality Management (EFQM) Excellence Model were recognized as descriptive holistic business models, rather than just quality model (Oakland & Marosszeky (2006) therefore, no much analysis effort was put on them because this study focused on quality improvement in construction industry particularly reinforced concrete building construction.

Underson *et al.* (1994) developed a model for quality improvement underlying Deming method. The concepts in their model include seven principles of visionary leadership, internal and external cooperation, learning, process management, continuous improvement, employee fulfillment and customer satisfaction. Lema (1996) developed a conceptual model to identify a clear role of total quality management in benchmarking.

His model aimed to compare performance of best performers to identify areas for improvement. Looking at this model indicates that it is a results oriented model.

Arditi and Gunaydin (1997) developed a model to illustrate construction as a process highlighting customer satisfaction by adopting the Juran triple role concept. The concept requires that each party (owner, contractor and architect/engineer (consultant)) plays the role of customer, processor and supplier. There are internal customers who receive process and supply semi-finished product in the process chain to the external customer who receive the final product. This model is intended to define participants' role in construction.

The flow concept by Koskela and Howell (2004) is more oriented towards managing flow and reducing waste than defining participants' role. Pryor *et al.* (2009) developed a 5P model with five principles of purpose, principle, processes, people, and performance. Although 5P model follows TQM concepts, it is essentially intended to improve quality performance of small and medium business rather than for production or construction.

This analysis has highlighted some approach and concepts used by the researchers to solve problems in the construction industry. The analysis has shown that main emphasis given by the researchers include: elimination of waste by improving works flow (Koskela & Howell, 2004); improving internal and external customer coordination (Ardit & Gunaydin, 1997); improving works process to achieve good product (Lema, 1996); customer needs (Suarez, 1992; Underson *et al.*, 1994) and quality performance (Oakland & Marosszeky, 2006; Pryor *et al.*, 2009) . Little emphasis has been given to the role played by quality tools to improve quality in the construction process. Summary of the various initiatives taken to improve quality is presented in Table 3.3.

Table 3.3: Comparison of quality improvement initiatives

S/N	Model	Criteria	Focus
1	Suarez (1992)	Prosess , machines, methods material and people	Customer
2	Underson *et al.* (1994)	Leadership learning process team work	Customer
3	Lema (1996)	Benchimarking, leadership, teamwork, training customer	Process
4	Arditi and Gunaydin (1997)	Supplier, processor, input, output, and customer	Coordination
5	Koskela (2002)	Transformation, flow, value, planning, and control	Flow
6	Oakland & Marosszeky (2006)	(3C) culture, communication, commitment + (4P) Planning, performance, processes, people	Performance
7	Pryor *et al.* (2009)	(5P) Purpose, principles, process, and people	Performance

Source: Author (2018)

Several model for TQM implementation has been proposed. The study by Maloney (2002) showed that when clients are about to select a contractor, they consider not only service quality but also satisfaction factors. According to Delgado (2006) the use of Maloney's ideas was tested to examine relationship between customer satisfaction and contractor selection and the result revealed that there were differences between the two cases. The differences observed are associated to Maslow's (1970) hierarchy of needs but needs vary. So customer needs not only vary from one project to another but also over time during the execution of a project even for the same customer. This variation of customer needs makes it difficult to generate list of customer needs that will satisfy all customers in all projects (Delgado, 2006). Therefore this study supported the idea of improving building process proposed by Lema (1996). However, the model proposed by Lema (1996) adopted benchmarking as a performance comparison tool, leaned much on productivity performance than quality performance. Hence, practical model to identify and prioritize areas where minimum efforts can be applied for maximum reduction of reinforced concrete buildings failure in Dar es Salaam is required.

This study aimed to determine relationship between quality management practices (in terms of the application of TQM tools and techniques, level of construction supervision and quality assurance and control practices) and structural integrity of reinforced concrete buildings in Dar es Salaam. Deductive or top-down approach was adopted because most of its data are essentially quantitative. This type of research approach starts with a theory and tries to prove or discredit it with the available information (Bryman, 2012). According to Pilcher (1992) construction industry belongs to open system. Therefore, application of systems theory to study problems in the industry is appropriate.

3.5 Systems Theory

Most scholars employ a common reference point when defining a 'system'. Flood and Jackson (1991) defined a system as a complex and highly interlinked network of parts exhibiting synergistic properties - the whole is greater than the sum of its parts. Systems theory is an interdisciplinary organizational theory about every system in nature in a society and in many scientific domain as well as a framework with which phenomena from a holistic approach can be investigated (Copra, 1997). It is a collection of interrelated parts acting together to achieve some goal which exists in the environment (Cornell & Jude, 2015). Also, system is defined as a set of objects together with relationships between the objects and between their attributes related to each other and to the environment so as to create or form a whole (Schoderbek *et al.,* 1985).

Systems thinking come from a shift in attention from the part to the whole. The systemic perspective argues that phenomenon can not fully be comprehended by beaking it up into elementary parts and then reforming it; but instead a global vision to underline its functioning need to be applied. Systems theory focuses on the relations between the parts, it focuses on the arrangement of and relations between the parts and how they work together as a whole. The way the parts are organized and how they interact with each other, determines the properties of that system (Bertalanffy, 1968). The behaviour of the system is independent of the properties of the elements (Barile & Polese, 2010).

This often referred to as a holistic approach to understanding phenomena (Jackson, 2003).

Systems theory was proposed to better understand the systems of the world around humans. Bertalanffy (1968) outlined systems inquiry into four domains: System philosophy, theory, methodology, and application. According to Mele and Colurcio (2006) system philosophy, methodology and application are complementary. Philosophy and theory were integrated to be knowledge while methodology and application were integrated as action; hence systems inquiry is an action of developing knowledge. Through systems theory scholars can better understand the world around them and explore problems and their causes (Flood & Jackson, 1991). Through studying this theory, researchers learn what makes up a system and how they are supposed to function.

A system can be closed or open. Construction industry is an opens system because has both inputs, process, and outputs. Closed system is one in which the system is self-sustaining and needs no input from outside and hence there is nothing to put out (Mele *et al.,* 2010). A true closed system is considered to be purely theoretical or hypothetical because every system needs some sort of input and output functions (Copra, 1997). However, on the opposite side, there is no perfectly open system, because open systems do have to have some point of closing or restriction in place to maintain balance through self-regulating process (Jackson, 2003).

This research is concerned with failures of reinforced concrete buildings in construction industry and therefore it is open systems because has free interaction with the environment within which it exists (Pilcher, 1992). A system can be natural or built; physical or conceptual; closed or open; static or dynamic; in regard to its elements, a system can be detaled in terms of its components, composed of people, processes and products; its attributes, composed of the inputs, process and output characteristics of each components; and its relationships, composed of interactions between components and characteristics (Tien & Berg, 2003). Key concepts of systems theory have been set forth by many researchers (Cornell & Jude, 2015; Mele *et al.*, 2010; Jackson, 2003; Bertalanffy, 1968), and the characteristics of systems which seem to have wide acceptance is as summarized:

Subsystems or Components: A system by definition is composed of interrelated parts or elements. This is true for all systems-mechanical, biological, social, and management. Every system has at least two elements, and these elements are interconnected;

Holism and Synergism: The whole is not just the sum of the parts; the system itself can be explained only as a totality. Synergy is a combined effect of a system working together where a combined result is greater or more powerful than of the individual components);

Input-Transformation-Output Model: The open system can be viewed as a transformation model. In a dynamic relationship with its environment, it receives various inputs, transforms these inputs in some way, and produces outputs;

Steady State, Dynamic Equilibrium, and Homeostasis: There is a proper balance that must be maintained in a system to achieve homeostasis. An open system may attain a state where the system remains in dynamic equilibrium through the continuous inflow of materials, energy, and information. Is based on information exchanges between the system and the external environment, and it allows the system to maintain a state of equilibrium over time.

Feedback: The concept of feedback is important in understanding how a system maintains a steady state. Information concerning the outputs or the process of the system is fed back as an input into the system, perhaps leading to changes in the transformation process and/or future outputs. Feedback can be both positive and negative, although the field of cybernetics is based on negative feedback. Negative feedback is informational input which indicates that the system is deviating from a prescribed course and should readjust to a new steady state. In order for that to be achieved, there must be a proper feedback channel and adaptation in place.

Hierarchy: A basic concept in systems thinking is that of hierarchical relationships between systems. A system is composed of subsystems of a lower order and is also part of a supra-system. Thus, there is a hierarchy of the components of the system.

All systems have components in them that have interdependent relationships in them. Systems are comprised of subsystems which are smaller entities that make up the larger system. Systems theory suggests that when there is a problem with one component in the system, that component should not be isolated but takes a holistic approach and view the whole system to understand what the problem could be Problems and failures of the system are a sign of a malfunctioning process.

Building construction belongs to construction industry which highly interacts with the environment. The environment within which building construction takes place is generally very wide-ranging and consists of all influences that can act on organization including: legal requirements, technological constraints, educational limitations and other factors of this nature (Pilcher, 1992). Construction as an open system is as shown in Figure 3.11.

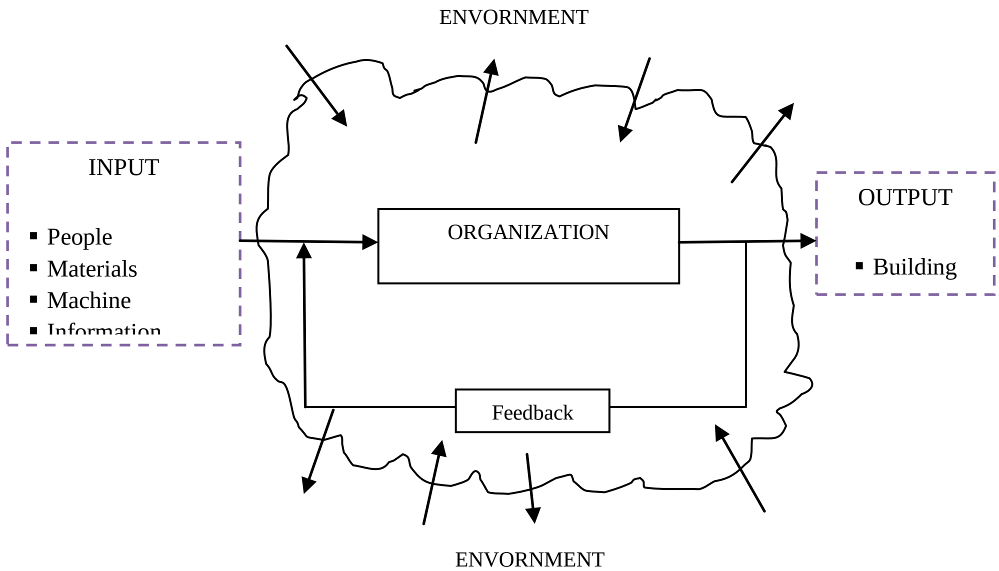

Figure 3.11: Theoretical model: Construction as an open system

Source: Pilcher, (1992, pp.10)

3.5.1 Relationship between TQM and Systems Theory

When discussing quality issues, it is necessary to focus on the link between total quality management (TQM) and systems thinking (Mele *et al*., 2010). In TQM, the systemic conception of the construction firm is strengthened by its emphasis on the importance of the relationships of the parts to the quality goals to be reached. TQM can be thought of a system for learning new skills for developing individual, teams and company skill (Kim, 1990). Systems theory and systems thinking can be applied in management and construction as well. According to Mele and Colurcio (2006) organization like construction firms are seen as a learning systems and having a set of skills and competences that enable it to produce its own knowledge. System thinking, personal mastery, mental models building shared vision and team learning are the basis for the development of three cores learning capabilities: fostering aspiration, developing reflective conversation, and understanding complexity to address value generation (Tien & Berg, 2003).

TQM views an organization as an internal system with a common aim rather than individual departments acting to maximize their own performances. Construction organization is a social-technical system: social component (people) and technical component (technology) (Emery & Trist, 1960). TQM tools are technical means used to work in the quality programs to improve processes in building construction (Singh *et al*., 2013). Constructions firm's competitive behavior is linked to the ability to identify and manage functions and relationships, thereby establishing communication channels, organizing information flow, and rationalizing and harmonizing a firm's development aligned with all external relationships. In regard to its elements, a system can be detailed in terms of its components composed of people, processes and products; its attributes, composed of the inputs, process and output; and its relationships composed of interactions between components and characteristics (Fisher, 2007).

Groups (people) in construction can often achieve more than the sum of each individual group member's capability (Taylor, 1967). This phenomenon is known as synergy explained in systems theory that the whole is greater than the sum of the parts (Pilcher, 1992). Also groups are frequently more successful than individuals when a problem responds to a collection of individuals' skills and the sharing of information because according to Maslow (1970) groups tend to be more creative and innovative than individuals. This relates to the TQM philosophy that it assures maximum effectiveness and efficiency within an organization by putting in place processes and systems which ensure that every aspect of its activities are aligned to obtain required objectives by using the full potential of every person in the organization (Delgado, 2006). Process on the other hand is any activity that accepts inputs, adds value to these inputs for customers both internal and external (Lema, 1996).

Construction organization exist because no one individual can successfully cope, either mentally or physically, with all various demands for skills, experience, knowledge, and ability that are required when a large reinforced concrete building construction is to be undertaken (Pilcher, 1992). Construction organization therefore results from a combination of people who work within the boundaries of their particular strengths and skills. The total work is broken down into smaller tasks, to be carried out by groups of people or by individuals who have specialist skill and knowledge. This creates systems and subsystems and that each element has an effect on the functioning of the whole and each element is affected by at least one other element in the system (Lester, 2005).

3.6 Conceptual Framework

Conceptual framework provides the direction that is missing in theoretical framework (Kivunja & Kuyini, 2017). Conceptual framework make things easier by delineating the input as well as output of the research project (Rocco & Plakhotnik, 2009). It is a structure which researchers believe can best explain the natural progression of the phenomenon to be studied. It is arranged in a logical structure to aid provide a picture or visual display of how idea in a study relate to one another (Grant & Osanloo, 2014). Cnceptual framework can be graphical or a narrative showing the key variables or construct to be studied and the presumed relationship between them (Camp, 2001). In a statistical perspective, conceptual framework describes the relationship between the main concepts of the study (Adom, *et al.*, 2018).

Reinforced concrete buildings construction is an open system which accepts its input of human resources, construction materials, financial resources, information, tools and techniques from the environment and transform or convert them into output in the form of building structure as a construction product. Building construction project involves multiple participants such as clients, design teams, and contractors, who have different roles from conceiving to a typical project commissioning. Also building construction project is guided and regulated by various regulations, regulatory authorities in both the designing and construction phase processes.

Building construction project is in hierarchical nature of the system where there are levels and sublevels that influence each other. A building construction project is a system that is part of the larger system such as the construction industry in which the process of quality management is undertaken. Again the building construction industry is part of the wider construction industry system that operates and is influenced by the nature of the specific country such as political, economical and its regulations framework. Also nature of the construction organizations or firms and their management influence construction process while at the same time influence quality of the constructed building product.

In the same line of thinking, construction industry is an open system that has free interaction with the environment within which it exists. The environment within which reinforced concrete buildings construction is carried out in Dar es Salaam can affect quality of the final building product. To determine relationship between quality management practices and quality of reinforced concrete buildings, three variables (application level of quality tools and techniques; quality assurance and quality control practices; and level of construction supervision) were identified as independent or predictor variables, whereas structural integrity of reinforced concrete buildings was identified as dependent variable.

Syetems theory helped to create an awareness of the system and how it could be affected by changing one component of that system. As asserted by (Camp, 2001) systems theory allows researcher an in depth look to better analyze and attepts to explain relationship between components of the system and the holistic viewpoint to understand their relationships. According to Mele *et al.* (2010) systems theory not only allows a researcher to take a better llok at a problem, but also helps to identify why there is a problem.

The systems theory allows considering that there might be more to the problem than what meets the eye. So instead of addressing just the problem, it needed to see what the whole system looks like to gain a better understanding of what are seen and why. Therefore, three sub levels of building construction system were also identified (Project system, organizational system, and institutional system). Quality assurance and quality control practices, and application level of quality management tools and techniques fall under project and organizational systems while level of construction supervision is under project and institutional systems. Project system, organizational system, and institutional system relate to level of a system at which particular problem(s) can originate and may affect the whole system. Conceptual framework of this study is as shown in Figure 3.12.

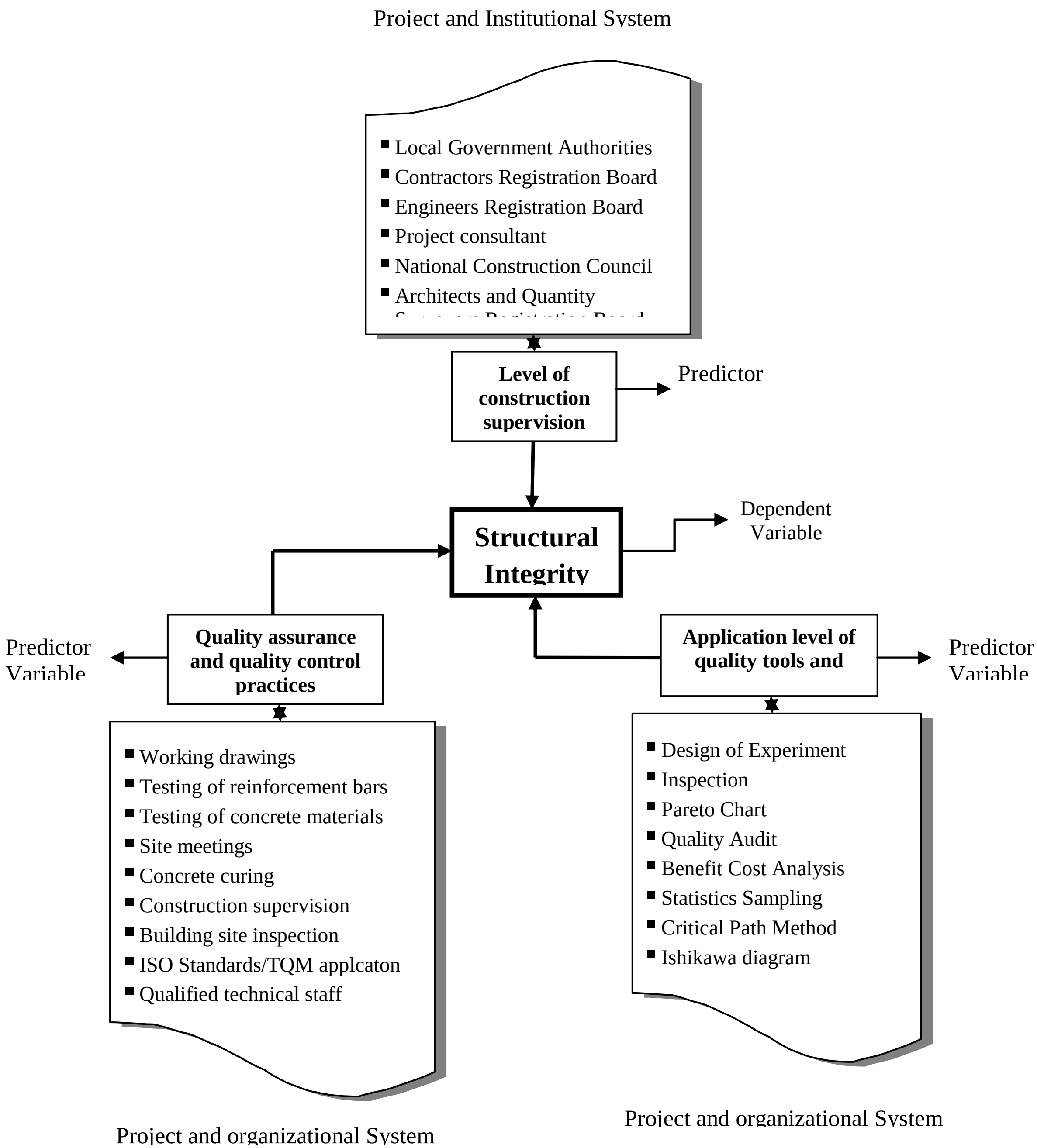

Figure 3.12: Conceptual framework

Source: Author (2018)

3.7 Summary

This chapter has reviewed construction process and quality issues in construction. In general there is agreement amongst researchers in the construction industry that its characteristics can lead to fragmentation because many participants with different interests are involved in the same project. Moreover, construction has peculiarities associated with natural, organizational and contractual uncertainty that can hinder improvement efforts. Construction process and the related uncertainties are considered to be the origin of most of the problems in the industry. In order to overcome these problems, different authors recommended the adoption of manufacturing concepts and principles within the construction industry. Total Quality Management (TQM) was identified and suggested as a viable performance improvement philosophy. The TQM concepts a management philosophy widely applied in the manufacturing industry offers a promising future for the construction industry. Pareto chart/principle as well as Ishikawa diagram has been identified as powerful tools to initiate and sustaining quality improvement efforts. While, Pareto chart helps to identify and prioritize where to apply initial effort for maximum effect, Ishikawa diagram helped identify root cause of the problem. This study was deductive in nature because it views the nature of the relationship between theory and social research (Bryman, 2012; Fellows & Liu, 2008). Literature and theory helped to deduce hypothesis and drive the process of data collection. Research design and methodology follows in the next chapter.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter describes the research design and methodology followed to carry out the study. The research design gives plan or outline followed to generate answers to the research problems, while methodology presents the general principle which guided this research. The chapter includes a description of the study area, study population, sampling techniques, data collection instrument, data collection process and analysis of the data. In line with objectives of the study together with the data and analytic techniques, this research used triangulation approach as suggested by Fellows and Liu (2008). Qualitative and quantitative research strategies were employed to eliminate disadvantages of each individual approach whilst gaining the advantages of each research approach (Bryman, 2012; McNabb, 2009).

4.2 Philosophical Aspects of the Research

Dawson (2002) defines research methodology as the philosophy or the general principles which guides the research. To Fellows and Liu (2008) research methodology is the principles and procedures of logical thought processes which are applied to a scientific investigation. The logical thought is considered to be ontology and epistemology, the philosophical assumptions which make a basic component of a research (Crotty, 2003). According to Crotty (2003) ontology and epistemology concepts need to be clearly set out at the beginning of the methodology chapter. The ontology and epistemology orientation of this research refer section 3.1.1 and section 3.1.2.

4.3 Research Strategy

Research strategy simply means a general orientation to the conduct of research. Researchers (Bryman, 2012; McNabb, 2009; Fellows & Liu, 2008) have different perceptions on research strategy. According to Bryman (2012) quantitative and qualitative research form two distinctive clusters of research strategy. Quantitative and qualitative research differs with respect to their ontological and epistemological foundations as well as the connection between theory and research (Bryman, 2012). McNabb (2009) termed quantitative and qualitative research as research approaches, while Fellows and Liu (2008) viewed quantitative and qualitative research as research methods. According to Bryman (2012) quantitative research can be construed as a research strategy that emphasizes quantification in the collection and analysis of data and that; entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories. According to Fellows and Liu (2008) quantitative research is used to address research questions such as what, how much, and how many. The strategy is appropriate to answer the research objectives one and three of this study (i.e. compressive strength of concrete for RC buildings in DSM and relationship between quality management practice and structural strength of reinforced concrete buildings in Dar es Salaam).

By contrast, qualitative research can be construed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data and that; predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories (Kivunja & Kuyini, 2017). According to Fellows and Liu (2008) qualitative strategy seek to find out why things happen as they do; to determine the meanings which people attribute to events, process or structures. This research strategy is appropriate to answer question like why reinforced concrete buildings fail and what construction practitioners think is a problem and also establish factors affecting quality of reinforced concrete buildings in Dar es Salaam. Therefore, qualitative strategy was appropriate to find answers for objective two of this research.

Triangulation research strategy was employed in this study to complement the advantages while minimizing the disadvantages of the individual (quantitative and qualitative) strategies (Cresswell, 2003; Mlinga, 2001). The study adopted both quantitative and qualitative research approach as proposed by Fellows and Liu (2008) and research strategy suggested by Bryman (2012). The use of two approaches or strategies to investigate the same thing is called mixed method research (Bryman, 2012) or triangulation (Fellows & Liu, 2008).

The essential feature of research for doctoral degree is leading to provision of new fact and information that makes an original contribution to knowledge (Mlinga, 2001). In order to contribute to knowledge, a research may aim to generate new theory, in which case it is inductive research or may aim to test an existing theory in which case it is deductive research (Bryman, 2012; Fellows & Liu, 2008). From this light, this research is essentially deductive in the sence that it did not aim to generate new theory but sought to test the existing systems theory. Systems theory was used to formulate hypothesis put forward in chapter one. The hypothesis was formulated based on the existing body of knowledge relating to systems theory, quality management, and construction industry particulaly the buildings sub sector. This research aimed to test the existing knowledge with regard to the following issues:

i. Structural integrity of reinforced concrete buildings;
ii. Factors affecting quality of reinforced concrete buildings;
iii. Relationship between structural integrity and quality management practice of reinforced concrete buildings' construction.

The study approached its methodology in the following stages: extensive literature review was conducted to gain insight about the research problems; through the literature review dependent and independent variables associated with the problem under study were identified; reconnaissance / preliminary survey was conducted between June and July 2015 for the purpose of getting more insight to the problem understudy; data collection instrument was then developed. Pilot survey was conducted to test the data collection instrument; the data collection instrument was finalized. Data was collected and then analyzed.

4.4 Research Design

According to Kenya Institute of Management (KIM) (2009) research design is the plan or structure of investigation conceived so as to obtain answers to research objectives. Objectives of a research determine the research design to be adopted (Kombo & Tromp, 2006). This research adopted cross-sectional (survey) and case study as suggested by Bryman (2012). Research methodoloty framework for this study is shown in Figure 4.1.

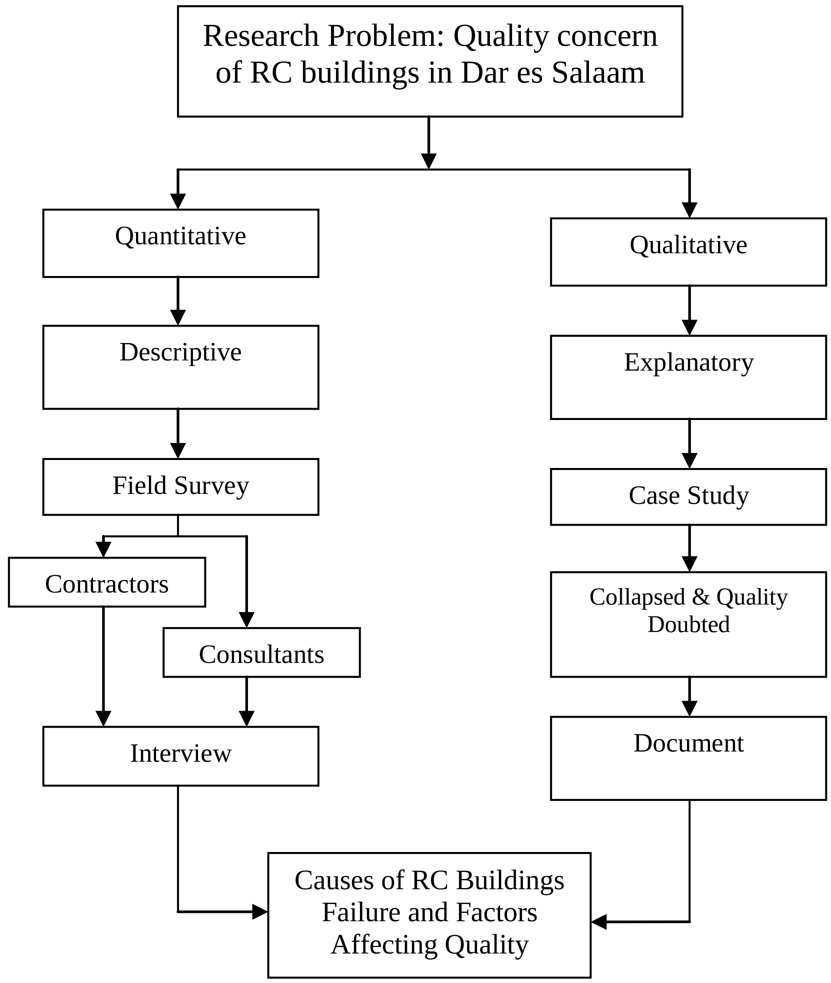

Figure 4.1: Research methodology framework

Source: Author (2018)

Cross-sectional research design is employed when a researcher is interested in establishing relationship between variables (Kivunja & Kuyini, 2017). This reseach aimed to establish relationship between quality structural integrity and management practice of reinforced concrete buildings' construction in Dar es Salaam, therefore cross-sectional research design is appropriate. As it is further emphasized by Bryman (2012), inorder to establish relationship between cases, it is necessary to have systematic standardized method for gauging the relationship. The systematic standardized method for gauging the relationship is by use of quantitative or quantifiable data which is the research strategy adopted in this study.

4.5 The Study Area

Preliminary survey was conducted in the following areas of Tanzania: Arusha City Council (Arusha); Ilala Municipal Council (Dar es Salaam); Kinondoni Municipal Council (Dar es Salaam); Temeke Municipal Council (Dar es Salaam); National Construction Council (NCC) (Dar es Salaam); Contractors Registration Board (CRB) (Dar es Salaam); Engineers Registration Board (ERB) (Dar es Salaam); Tanzania Bureau of Standards (TBS) (Dar es Salaam), University of Dar es Salaam (UDSM) (Dar es Salaam) and Dodoma Municipal Council (Dodoma). The survey helped to reveal that many cases of reinforced concrete buildings failure and even collapse occurred in Dar es Salaam as evidenced in the literature (NCC, 2017; Rubaratuka, 2013, 2008; CRB, 2010, 2007). In addition, communication with governmental officials from the organizations mentioned above revealed that they had little information of building failure tragedies in other parts of the country compare to Dar es Salaam cases. The preliminary survey was again followed by thorough literature review. Information from the literature review and outcome of the preliminary survey were used as a basis for developing the interview schedule as a data collection tool used for this research.

This research was conducted in Dar es Salaam. Selection of Dar es Salaam as a study area was done because of two reasons, firstly, Dar es Salaam is the center of business where building construction activities are more than any other area in Tanzania (Mlinga, 2001) and since then has never changed (MoLH, 2015; MoF, 2013). Secondly, cases of failure and collapse of reinforced concrete buildings as a symptom of quality problems occurred in Dar es Salaam (NCC, 2017; Rubaratuka, 2013; CRB, 2010). Also concern for poor quality of reinforced concrete buildings in Dar es Salaam was raised by the Tanzanian government which ordered a thorough investigation of high rise buildings in

Dar es Salaam to be conducted (The African, 2013). The situation presented above attracted and justified the need for research to be conducted in Dar es Salaam.

4.5.1 Study Population

Research population is the group to which the results of the study are intended to apply; it is the entire set of relevant units of analysis or data (Kothari, 2004). In this research, unit of analysis was reinforced concrete building. In order to establish population from which a sample could be drawn, a list of buildings that were under construction in Dar es Salaam was obtained from Contractors Registration Board (CRB). The Board (CRB) was contacted because it is mandated by law to register all construction projects worth ten millions Tanzanian shillings and above (URT, 1997c). However, the obtained list could not help to identify buildings that would provide required data. Buildings that would provide data for this study had to satisfy the following requirements:

i. Reinforced concrete buildings under construction by the time of data collection;
ii. Buildings that had reached at least, third floor of construction progress;
iii. The buildings construction site to be operational or active.

First requirement was put forward because according to Reynolds and Steedman (1997) reinforced concrete buildings above three floors are more susceptible to failure and collapse than below buildings, if not properly constructed. Further, buildings that had been reported to have collapsed mostly were above three floors (Table 2.4). Observation showed that some of construction sites with buildings under construction were closed and no construction activities were on progress, hence a need for condition two and three. For that reason, physical counting of the required reinforced concrete buildings under construction in Dar es Salaam was necessary. Before counting was conducted, sampling of the required area and of the units of analysis considered to be important since according to Scott and Usher (2004) researcher rarely have access to all the members of the population. For this reason, cluster sampling was conducted whereby

Dar es Salaam was divided into a number of smaller non-overlapping areas (KIM, 2009).

Administrative districts smaller non overlapping areas considered to be convenient for the study. Dar is Salaam has five administrative districts namely, Ilala, Kinondoni, Kigamboni, Temeke and Ubungo (Appendix III & IV). Two out of the five districts considered to be appropriate for data collection. Names of the districts were written on a paper and folded in a form of a ball and two districts were randomly picked (Bryman, 2012). Ilala and Kindononi districts were picked and became a focus area for data collection of the study. Then counting of the reinforced concrete buildings was conducted, where, 50 reinforced concrete buildings were found in Ilala district and 20 reinforced concrete buildings were found in Kinondoni district, making a total of 70 reinforced concrete buildings, constituting population for the study.

4.5.2 Sampling of Under-construction Buildings

A sample size of 59 was determined in accordance with the approach proposed by Kothari (2004) for calculating the sample size (n) that should be drawn from a population to ensure that the results can be generalized. The sample is calculated by the following formula:

$$n = \frac{N \text{ x } z^2 \text{x } p \text{ x } q}{E^2\ (N-1) + \ z^2 \text{ x } p \text{ x } q}$$

Where: a value of z = 1.96 was chosen as the standard normal value for a conventional 95% confidence level with an acceptable error, E, of 5% as proposed by Delgado (2006); N is the population size; and p is the population proportion assumed to be 0.5 while q is equal to 1 – p.

Substituting the pre-defined variables a sample size of n = 59 is obtained. The sample size was considered sufficient for analytical purposes because according to Kothari

(2004) the number of sample items is more than 30 therefore it is a big sample. From the total sample size of 59, a proportion of 42 and 17 from Ilala and Kinononi districts respectively were calculated using the following relationship:

$$n_1 \text{ and } n_2 = \frac{N}{P} \text{ x n}$$

Where: n_1 and n_2 is sample 1 and sample 2 for Ilala and Kinondoni respectively.

P is the study population, and N is total sample of the study.

Therefore; $n_1 = \frac{50}{70} \text{ x } 59 = 42$; and $n_2 = \frac{20}{70} \text{ x } 59 = 17$

Sampling of 42 units out of 50 reinforced concrete buildings from Ilala district and 17 units out of 20 reinforced concrete buildings from Kinondoni district was done by simple random method. The buildings were given numbers from one to fifty and from one to twenty for Ilala and Kinondoni respectively. Seven buildings and three buildings were randomly picked from the two clusters (i.e. Ilala and Kinondoni respectively). The remaining buildings from both cluster constituted sample size for the study.

4.5.3 Sampling of Previous Investigated RC Buildings

This study adopted both survey and case study to investigate quality of concrete used in reinforced concrete buildings in Dar es Salaam. Structural strength of concrete used for reinforced concrete building construction was determined through survey of buildings under construction and also through cases of reported failed buildings. It could be possible to get structural strength of reinforced concrete building by collecting data from the report of concrete test of reinforced concrete buildings under construction. But research done by Figueroa (2014) found that in most cases (60%) the concrete used in reinforced concrete buildings is on average 9 N/mm^2 (MPa) weaker than the official reports claims. Hence, he concluded that, the reports concerning structural strength of concrete for the buildings normally correspond to samples that are not representative of the concrete used in the building structures.

Based on Figueroa (2014) observation, this study considered to conduct test of the existing buildings. It was considered to adopt core cutting (destructive method) test method commonly used in Tanzania. By this method, samples of concrete are taken from built structural elements of the building under consideration. This method is destructive and relatively expensive (Neville, 1997). For these reasons therefore, test by rebound hammer (non destructive) method was opted. Although 46 building construction sites were active and were involved for data collection, eleven building construction sites accepted their buildings to be tested by rebound hammer. The structural elements or members of building required for testing are the framed structures (i.e. columns, beams and slabs). Three tests were taken from each element i.e. columns, beams, and slabs and the mean of the three tests were taken as the strength of the particular element. Structural strength of the building was taken as the mean of all elements tested for a particular building.

Since a number of building construction sites that accepted their buildings to be tested by rebound hammer test was small, alternative way was considered. Structural strength of existing and collapsed reinforced concrete buildings from reports of various structural integrity investigations that have previously been conducted was considered. About 500 reinforced concrete buildings have been investigated as a result of check up following failure of some reinforced concrete buildings in Dar es Salaam (Financial Junction, 2013). These numbers of investigated buildings were considered as the population for the investigated reinforced concrete buildings in Dar es Salaam. A sample size of 216 was determined in accordance with the approach proposed by Kothari (2004) for calculating the sample. The sample was calculated using the following formula:

$$n = \frac{N \times z^2 \times p \times q}{E^2 (N - 1) + z^2 \times p \times q}$$

Where: a value of z = 1.96 was chosen as the standard normal value for a conventional 95% confidence level with an acceptable error, E, of 5% as proposed by Delgado (2006); N is the population size; and p is the population proportion assumed to be 0.5 while q is equal to 1 – p.

4.6 Data Collection Method

This study adopted cross-sectional (survey) with case study research design. According to Bryman (2012) data collection method commonly used in cross-sectional research design is questionnaire and research schedule (structured interview). Research schedule was used to collect data in this study because it was considered to be better than questionnaire. This is because as it was observed by Lema (1996) mailed questionnaires has limited success in developing countries and cautioned against using sophisticated techniques which may be unsuccessful due to logistical problems. Disadvantages associated with quastionnaires include: no control over the speed with which participants return the completed questionnaires; lack of opportunity to clarify respondent doubts and low response rate.

In practice, questionnaire survey has always reported low rate of response. For example Oney-Yazic *et al*. (2006); Karim *et al.* (2005); Chin *et al.* (2002); and Lahndit (1999) reported response rate for questionnaire as 8%, 27%, 11%, and, 16% respectively. Further, Kothari (2004) and (Lema, 1996) observed the following advantages of using interviews in research: (i) the interviewer can explain in detail the objective, (ii) the interviewer can elaborate any queries that the interviewee might have, (iii) the interviewer can query the interviewee where an unclear response has been given, (iv) sometimes interviews can provide lines of further inquiry which might have not been considered by the researcher, (v) interviews are more detailed than questionnaires, and

(vi) sometimes confidential data can be obtained through interviews. The main disadvantage is that interview is time consuming on the part of the researcher who has to be physically available for the interview (KIM, 2009). It was felt that if interview schedule is carefully designed, would overcome the disadvantage and so the advantages would outweigh the disadvantage.

4.6.1 Interview Schedule Development

The advantages of using interview schedule considered outweighing the disadvantage as shown above, therefore interview schedule was adopted. The schedule was divided into four sections. Section one intended to collect information that would enable to determine quality of reinforced concrete buildings constructed in Dar es Salaam. Section two intended to gather information on reinforced concrete buildings construction practices in Dar es Salaam. This section contains two parts, that is Part A and Part B. Part A intended to gather information to enable establishing the application level of quality tools and techniques in reinforced concrete building construction in Dar es Salaam.

Part B intended to gather information that could establish level of quality control and quality assurance application in reinforced concrete buildings' construction in Dar es Salaam. Section three intended to gather information that could identify factors affecting quality of reinforced concrete buildings construction in Dar es Salaam. Section four provided a room for the respondents to put any other information that they considered important to improve quality of reinforced concrete buildings construction in Dar es Salaam. Also this section provided a room for the researcher to put any observation from a construction site that may affect quality of RC building product and did not be considered in the interview.

The interview schedule was prepared using a 5 point Likert ordinal scale from 1-indicating very low to 5-indicating very high. The research schedule for contractors and consultant have same questions except in Section three where contractors were asked to indicate level of influence of a factor in a Likert scale while consultants were asked to indicate only one factor among the eight factors listed that was considered to cause failure and even collapse of reinforced concrete buildings in Dar es Salaam the format, content and wording of the survey form was repeatedly checked and appropriate alterations made. Two sets of research schedule were prepared to each building construction project, one for contractor and another for consultant in structural engineering.

4.6.2 Pre-testing of the Research Schedule

The research schedule was pre-tested by conducting a pilot survey in reinforced concrete building construction sites. Once a research schedule is finalized, it should be tried out in the field for pre-testing (Mugenda & Mugenda, 2003). Pre-testing is the surest means for a research schedule to be comprehensible and error free (Cooper & Schindler, 2003). In this light, this research used a sample of 15 reinforced concrete buildings as a pilot study. The pilot sample of 15 units of analysis was considered sufficient because was greater than 10 units recommended in literature (Mugenda & Mugenda, 2003).

The pilot study was conducted in Arusha, Tanzania (Appendix VI), from June 2015 to August 2015. Arusha was selected based on two reasons, firstly, the researcher was based in Arusha, hence travel and accommodation costs were not incurred and secondly, Arusha is the main tourist centre and the third largest city with a large proportion of construction activities in Tanzania. It was considered that, reinforced concrete building construction practices in Arusha is the same and of similar characteristics to that of Dar es Salaam (Mlinga, 2001). Therefore, as recommended by Mugenda and Mugenda (2003) and Nyakundi and Memba (2014) carrying out pilot study in Arusha was acceptable. The interview schedule was then finalized ready for actual data collection (Appendix I & II).

4.7 Data Collection Process

Primary data was collected from reinforced concrete buildings which were under-construction through interview and rebound hammer test. After identifying the reinforced concrete building construction sites from where data was to be collected the exercise which was done in April 2017, the actual survey around the building construction sites was done. This was carried out from May 2017 to September, 2017. During the primary data collection process at construction sites, some challenges arised, which required assistance from Contractors Registration Board (CRB). The Board considered appropriate because CRB is mandated by law to register all contractors and also monitor and regulate all activities of construction nature in Tanzania as indicated in URT (1997, 2009). The author then wrote a letter to CRB for assistance (Appendix-VII). The Board, i.e. CRB provided the assistance requested (Appendix-VIII). With the assistance from CRB, the exercise continued without much resistant of site operatives at construction sites.

Secondary data were collected from various sources including: investigation reports for collapsed buildings and previous investigation on structural integrity of existing reinforced concrete buildings. Investigation reports were obtained through request made by letters to appropriate authorities (Appendix VII, IX and X). Organizations or offices that were considered to have the investigation reports were requested to help by providing any information they had. Some of them accepted while many others did not provide the requested information instead they gave apology by giving reasons that they forwarded the reports to the higher authorities and they did not retain copies of the same.

The study involved various cases of previous investigations; therefore it could be regarded as multiple case studies (Ying, 2009). Within quality management and construction fields, various researchers have used case study to investigate current practices in building construction (Chan & Chan, 2004; Pheng & Teo 2004; Formoso *et al*., 2002; Love *et. al*., 2002; Lema, 1996). Non probability sampling by convenience was applied on previous investigation as proposed by (McNabb, 2009). This is because the investigation reports were not for public consumption and therefore getting them was a bit difficult. The investigations were conducted by different investigation teams, therefore, getting the reports depended on convenience of the teams involved in the investigations.

A sample size of 216 reinforced concrete buildings investigated as a result of check up following failure of some buildings in Dar es Salaam was determined. Out of this number of investigated buildings, thirty three investigation reports were conveniently accessed. Also five reinforced concrete buildings collapsed in Dar es Salaam (NCC, 2017, Rubaratuka, 2013; CRB, 2010) were investigated where two investigation reports out of the fives were accessed for analysis. Further, four reinforced concrete buildings were ordered by the government to be demolished due to poor quality (NHBRA, 2016). Prior to demolition, the buildings were investigated and out of the four investigation reports, one report was obtained in this study. In total, 36 investigation repots were analyzed. The numbers of cases were considered appropriate because carrying out various case studies may be compared with executing various experiments (Delgado, 2006).

4.8 Data Processing and Analysis

The collected data were coded and analyzed using IBM Statistical Package for Social Sciences (SPSS) Version 22. Calculation of statistical means and percentages from the collected data, where appropriate were analyzed by the help of SPSS. Also significance tests on difference of means were computed where Mann Whitney U Test and T-test for ordinal and ratio measurement scale of data were used respectively. Relationship between quality management practice and structural strength of reinforced concrete buildings was determined by regression analysis, where a regression model of the relationship was computed.

4.8.1 Reliability Test

This research adopted Cronbach's alpha (α) to test the reliability of the interview schedule, because, according to Black (1999) Cronbach's alpha is a common indicator used for determining reliability of research instruments like research schedule used in this study. Further, Cronbach's alpha was used in this study because it is widely used in social science research to estimate the internal consistency of reliability of a measurement scale (Sun *et al*., 2007; Delgado, 2006). The reliability test was computed using the following Cronbach's alpha (α) formular (Tavakol *et al.*, 2011):

$$\alpha = \frac{k\,(S^2 - \sum s^2)}{S^2(k-1)}$$

Where: α = Cronbach's alpha; k = number of item in the instrument;

S^2 = variance of all scores and s^2 = variance of individual items.

Cronbach's alpha level of at least 0.7 is recommended (Inuwa, 2014; Tavakol *et al.,* 2011). The IBM Statistical Package for Social Sciences (SPSS) for Windows Version 22.0 was employed to calculate the Cronbach's alpha.

4.8.2 Significance test of the Ratings

The consistences of the groups' ratings were evaluated by testing the null hypothesis "that there was no significant agreement between contractors and structural engineering consultants on the ratings of quality assurance and control practices and on factors affecting quality of reinforced concrete building construction they were involved". The analysis was aimed at establishing that the ratings had not been agreed upon by chance. Two groups (contractors and consultants) were the respondents to the interview conducted in this study. Measurement is in ordinal scale; therefore to test the hypotheses, non-parametric statistical test particularly Mann Whitney U test is appropriate (McNabb, 2009). Mann Whitney U test was computed using the following formula (Nachar, 2008; Kothari, 2004):

$$U = n_1 x\, n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

Where; U = test statistic, n_1 and n_2 are the sample sizes and R_1 is the sum of ranks assigned to the values of the first sample.

4.8.3 Significant Test of the Failed and Existing Buildings

Statistical analysis was conducted to examine if there was difference of concrete strength between the failed and existing reinforced concrete buildings in Dar es Salaam. The difference between failed and existing reinforced concrete buildings was ditermined by testing the null hypothesis “that there was no difference of structural strength between the failed and existing buildings”. Data for this test was in ratio measurement scale, hence to test the hypothesis, parametric statistical test particularly unpaired T-test is appropriate (Fellows & Liu, 2008). Therefore, the study used the following T-test formular suggested by Kothari (2004):

$$T = \frac{X - \mu_{H_0}}{\sigma_s / \sqrt{n} \, x \sqrt{(N - n / N - 1)}}, \quad \text{with degree of freedom} = (n - 1)$$

Where: T = test statistic; X = mean of the sample; μ_{H_0} = hypothesized mean for population; σ_s = standard deviation of sample; n = number of item in a sample; and N = population size.

4.8.4 Correlation and Regression Analysis

Regression analysis measures the way in which two or more variables are related to one another, whereas correlation analysis provides a measure of the strength of the relationship (Kothari, 2004). Regression analysis was performed to determine relationship between quality management practice and structural strength of reinforced concrete buildings in Dar es Salaam. Multiple regression is appropriate method for analysis when relationship between a number of independent variables and dependent variable is required (KIM, 2009). Multiple regression was conducted to analyse influence of variability of the structural integrity from the variability of preditor variables (quality tools & techniques, quality assurance & control, and construction supervision) as proposed by Lema (1996).

Firstly, regression analysis was used to identify the strength of the effect that quality tools & techniques, quality assurance & control, and construction supervision have on structural strength of reinforced concrete buildings in Dar es Salaam. Secondly, regression analysis used to forecast effects or impact of changes. Regression analysis is appropriate to analyze how much structural strength will change when one or more of quality tools & techniques, quality assurance & control, and construction supervision variables changes. The regression analysis was performed on IBM SPSS statistics version 22 using stepwise method. By default, SPSS regression applies standard (Enter) method which forces all predictor variables to be in the model and cause over fitting.

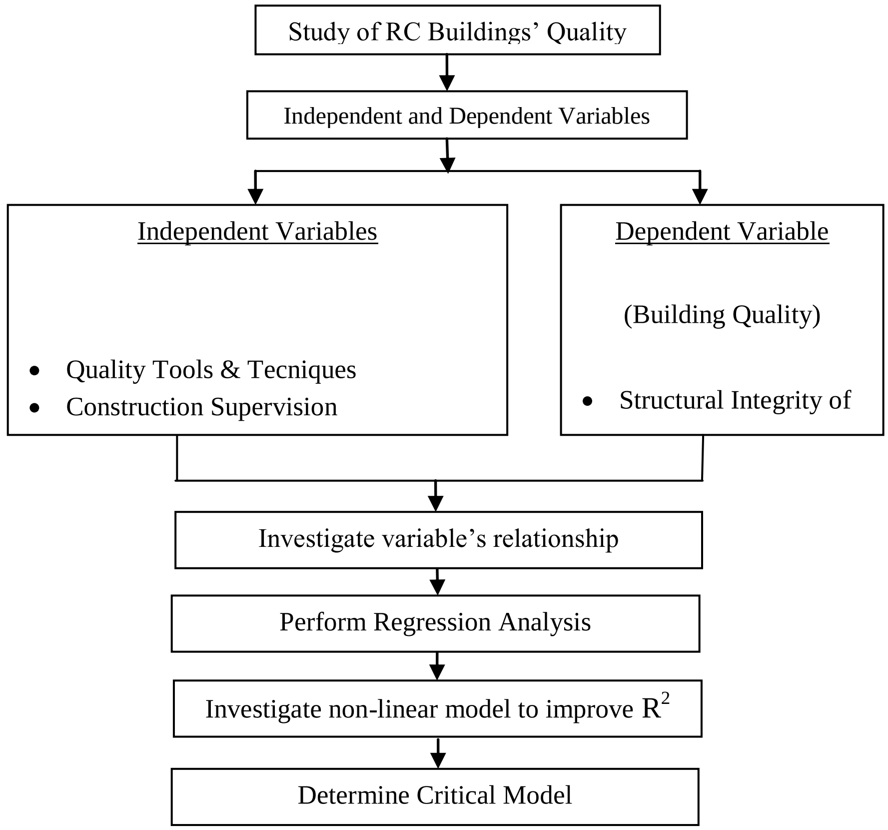

Figure 4.2: Regression modeling framework

Source: Author (2018)

Over fitting makes it difficult to identify the critical predictor variables in the regression model (Landau & Everitt, 2004). As a result of this complication, the most commonly methods applied is stepwise method (Lema, 1996). Stepwise method includes only the predictor variables in the model that explain a significant amount of additional variance. A framework for modeling analysis is presented in Figure 4.2.

4.9 Ethical Consideration

This study was guided by research ethics in the planning, conducting, and reporting the results of the research. In recognition of ethical requirements in research, this study followed four ethical principles in research: truthfulness, thoroughness, objectivity, and relevance as proposed by McNabb (2009). High standard of professionalism, guided this research to ensure that the research ethics are properly adhered to. All the respondents engaged in the study were assured of confidentiality, and none were coerced, or unduly engaged in the study. Also permission for data collection from various authorities was sought (Appendix 5, 6, 7 & 9).

4.10 Summary

This chapter has set out the methodology upon which this research was based. The chapter has examined quality of reinforced concrete building construction process and quality of the final buildings product. The research problem has been revisited in the light of literature review performed in Chapter 2. The need to evaluate quality of construction process and that of the final product in terms of structural integrity has been identified. Determination of relationship between structural intergrity and quality management practices of reinforced concrete building construction was considered. Data were obtained through actual field survey, and from previous investigation reports. Research schedule for face to face interviews was adopted after consideration of the advantages and disadvantages described by Lema (1996). Despite the advantages, the method is not without challenges.

Sometimes, availability of required person as interviewee on site at a particular time was difficult. This required patient and rescheduling of interview to get the required interviewee. Some contractors restricted access of guest to construction site, this necessitated obtaining introduction letter from contractors regulatory authority i.e. contractors registration board (CRB). However, 78% of the reinforced concrete buildings were accessed for data collection. This rate is higher than any previous questionnaire survey conducted in the construction industry as observed by Hoonakker *et al.* (2010) and Chan and Chan (2004). Analysis of the data including Cronbach’s alpha test, Mann Whitney U test, T-test, correlation, and regression analysis was conducted. Presentation of the results and their discussion are presented in the next chapter.

CHAPTER FIVE

RESEARCH RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents results of the study in line with the research objectives presented in section 1.3 of this thesis. The chapter is concerned with discussion of the results and interpretation of the findings in light of previous studies as well as describing the implication of the findings. Qualitative and quantitative strategies with cross-sectional and case study research design were adopted in this study. Qualitative approach was used to investigate root causes of failure of reinforced concrete buildings and establish factors affecting quality of reinforced concrete building's construction. On the other hand, quantitative research approach was used to investigate quality (in terms of structural strength/integrity) of reinforced concrete buildings in Dar es Salaam.

Reinforced concrete buildings that were under construction, had reached at third floor and the site was active in the sence that construction activities were carried out by the time of data collection were considered appropriate unit of analysis for this study. On the other hand, previous investigations of buildings of similar characteristics or investigation of collapsed reinforced concrete buildigs were also appropriate unit of analysis for the study. This chapter presents results of reliability test, response rates, structural integrity of investigated building, factors affecting quality of concrete, and causes of reinforced concrete failure. The chapter will also present results of factors affecting quality of RC building construction, level of application of quality tools and techniques, quality assurance and quality control practices, and level of supervision in reinforced concrete building's construction. Finally, results of regression analysis to determine relationship between quality and management practices of reinforced concrete building's construction will be presented followed by discussion of the results.

5.2 Reliability Test Results

Values of the calculated Cronbach's alpha are presented in Table 5.1. The Cronbach's alpha measure shows that reliability of the interview schedule's construct is above the cut off score of 0.7. Since all the alpha values exceeded minimum level 0.7, according to Sun *et al*. (2007) and Tavakol *et al.* (2011) the instrument had internal consistency and therefore the data collection instrument is reliable.

Table 5.1: Reliability analysis results of the research schedule

S/N	Factor of measurement	No of Item	Cronbach's Alpha (α)	Reliability status
1	RC Building project particulars	15	0.75	Good
2	Application of quality Tools and Techniques	11	0.72	Good
3	Quality assurance and control practice	18	0.71	Good
4	Root cause of reinforced concrete buildings failure	8	0.71	Good
5	Factors affecting quality of RC building construction	12	0.74	Good

Source: Author (2018)

5.3 Response Rate and Profile of the Investigated Buildings

a) Response Rate

Sample size of 59 reinforced concrete buildings under construction were to be investigated. Out this number, 46 reinforced concrete buildings were investigated making a response rate of 78%. This rate condidered to be sufficient because it is higher than 8%, 27%, 11%, and, 16% obtained in construction industry by Karim *et al.* (2005); Chin *et al.* (2002); and Lahndit (1999) respectively.

b) Owner of the Investigated buildings

The analysis shows that 90% of the buildings surveyed are private owned, while 10% of the buildings are owned by Government (central government, public corporation, parastatal organization or public institution)

c) Structure of the Investigated Buildings

Results of the analysis show that 8.3% of the buildings surveyed comprised of 1 to 5 floors and 55.0% consisted of 6 to 10 floors. Either 21.7% of the buildings comprised of 11 to 15 floors while 10.0% comprised of 16 to 20 floors. Only 1.7% of the buildings consisted of 21 floors and above. The results indicate that majority (55.0%) of the buildings comprised of 6 to 10 floors. The results are as summarized in Figure 5.1.

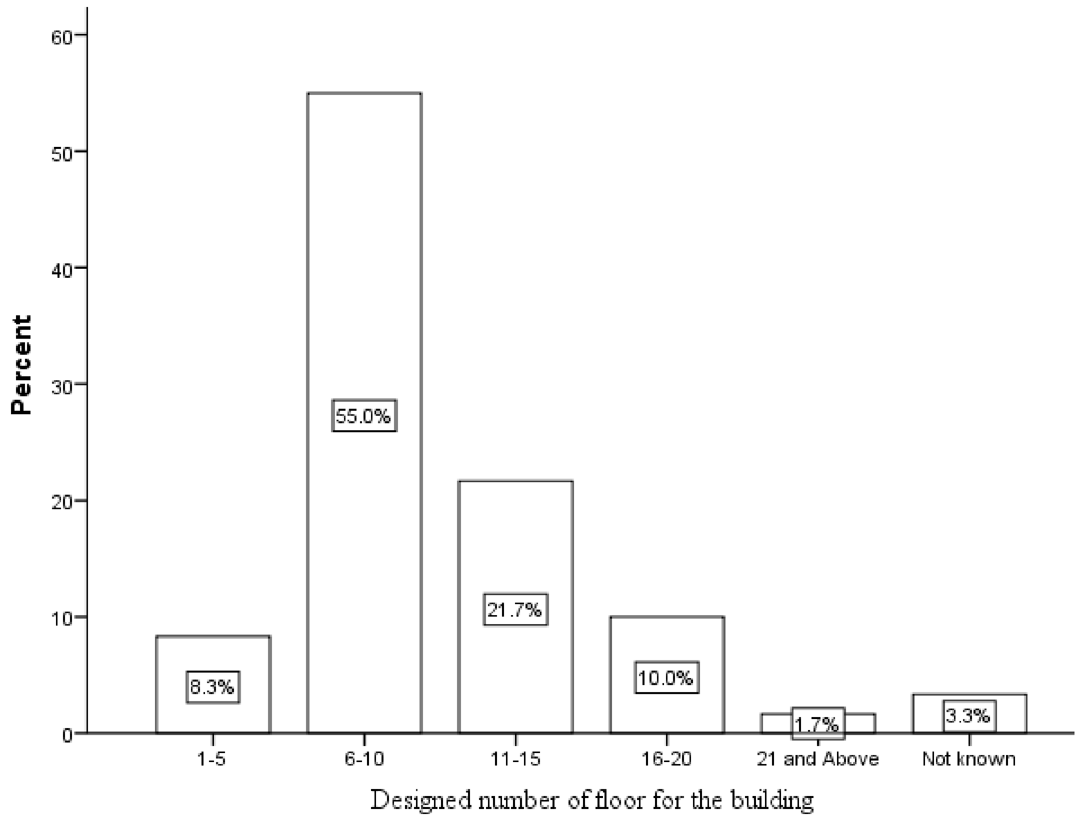

Figure 5.1: Number of Floors

Source: Author (2018)

d) Constractors Involved in Construction of the Investigated Buildings

The results indicate that majority (48.3%) of buildings were constructed by contractors categorized as medium (Class III and IV) contractors registered while 45.0% of buildings were constructed by large (Class I and II) contractors. From the former, the results further showed that 43.3% of buildings were constructed by contractors registered in class III, while 5.0% were constructed by class IV contractors. From the later, results showed that 23.3% of buildings were constructed by contractors registered in class I and 21.7% were constructed by class II contractors as shown in Figure 5.2.

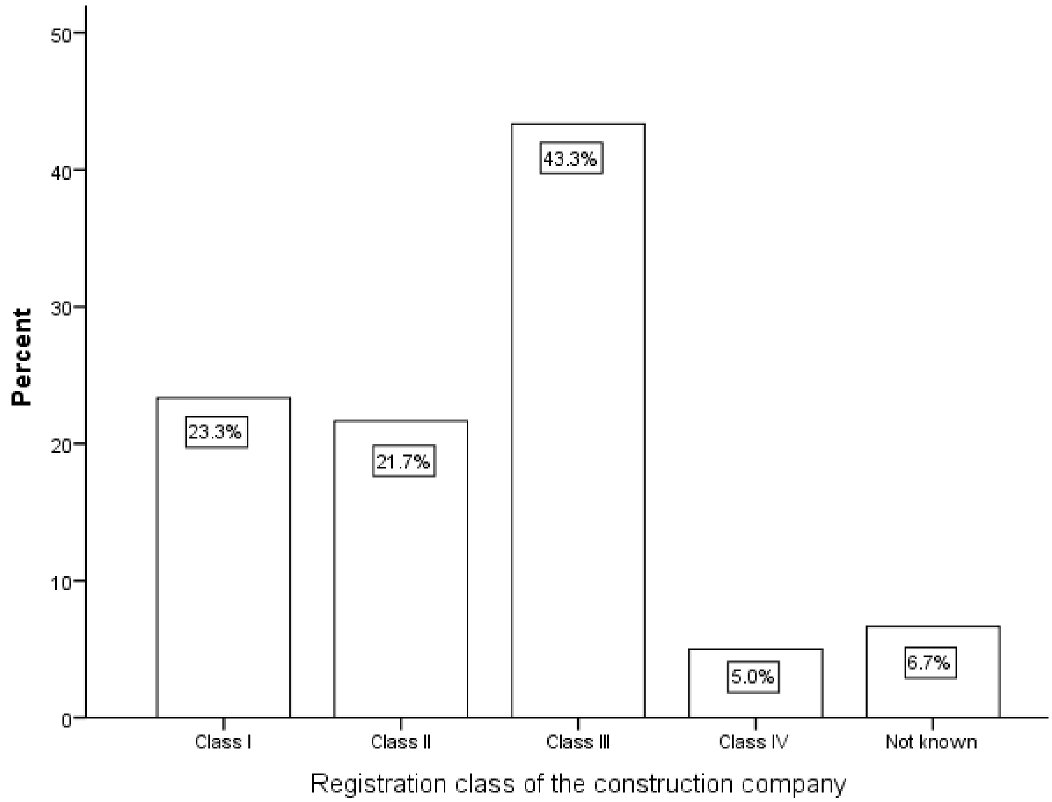

Figure 5.2: Contractors' registration class

Source: Author (2018)

5.4 Structural Integrity of Reinforced Concrete Buildings

Investigation of structural integrity of reinforced concrete buildings was done by survey and case studies. 36 investigation cases of buildings failure were analysed and eleven non destructive test on the under construction reinforced concrete buildings were conducted. Thematic analysis of the investigated cases and the results of the rebound hammer test are shown in Table 2 appendix XI. The data shows that common defects observed in the investigated buildings include: cracks on buildings' structural members, particularly, columns and beams; poor workmanship in a form of concrete honeycombs.

Detail of concrete strength used in investigated buildings is presented in Figure 5.3. Although minimum strength of concrete required for reinforced concrete is 25 N/mm^2 (MPa), the results shows that grades of concrete normally used for mass conctere structures were used for reinforced concrete building construction. In total, 33.6% of all reinforced concrete buildings surveyed were constructed using concrete of lowest grade (10 MPa and 15 MPa). For example, 5.8% of reinforced concrete buildings found to have used concrete of 10 MPa while 27.8% of the buildings were constructed of concrete grade C15 or 15 MPa. Either 30.6% of buildings were constructed of concrete grade C20. In general, 64.2% of buildings were constructed of concrete below minimum required strength of concrete.

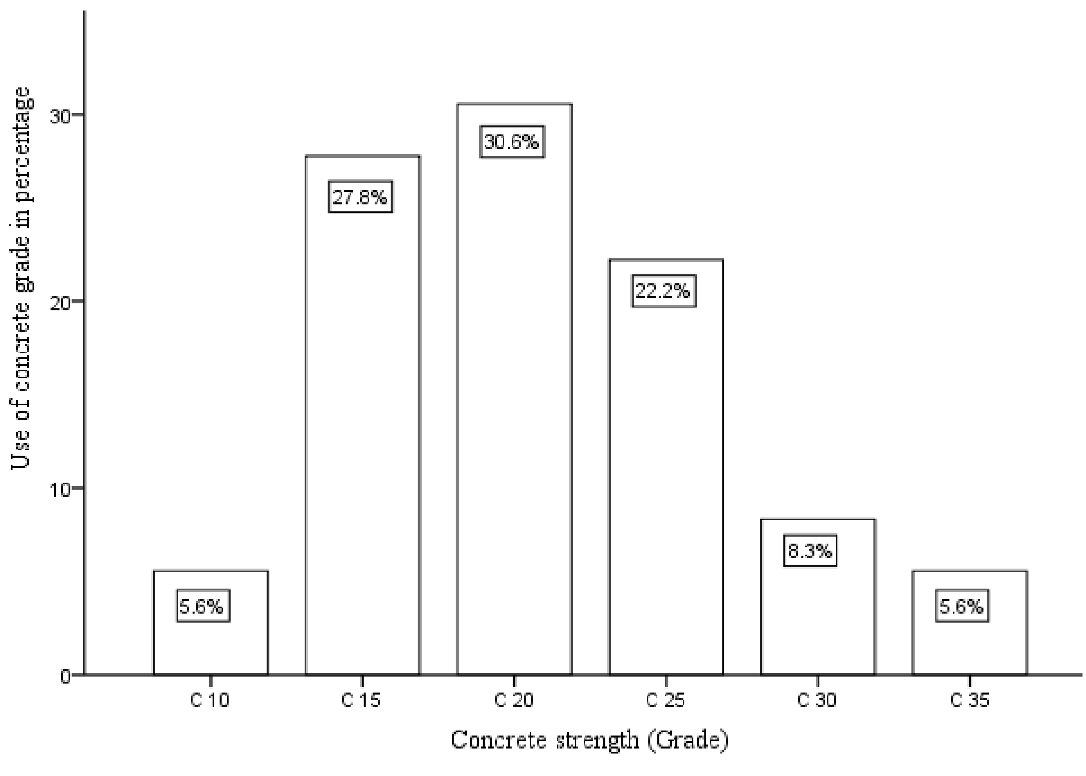

Figure 5.3: Grades of concrete used in the investigated buildings

Source: Author (2018)

The results reveals that, over a half (64.2%) of reinforced concrete buildings surveyed did not meet required structural strength. Further, the results show that less than quarters (22.2%) of the buildings were constructed by using concrete within the required quality while 13.9% of buildings were constructed of concrete above the minimum required quality.

The result is in agreement with the study by Figueroa (2014) which found that, 65% of reinforced concrete buildings in Nairobi were below the required quality. The results also corroborate Rubaratuka's (2013) findings that, quality of concrete produced in Dar es Salaam is poor. Moreover, the result agrees with NCC (2017), CRB (2010), and Baradyana (2000) that, poor quality is a reason for reinforced concrete buildings failure in Dar es Salaam. The results imply that there is a great opportunity for improving quality of concrete used for reinforced concrete buildings construction in Dar es Salaam. The results necessitated to look at factors affecting quality of concrete for reinforced concrete buildings construction in Dar es Salaam.

5.4.1 Factors Affecting Quality of Concrete

Factors affecting quality (strength) of concrete in Dar es Salaam were also established. The results of the analysis are as presented in Table 5.2. On one hand, water to cement ratio, concrete mixing, and compaction were ranked top among factors affecting strength (quality) of concrete in Dar es Salaam. On the other hand, quality of concrete ingridients, cement content and concrete curing were rated among the least among factors affecting strength of concrete in Dar es Salaam.

Table 5.2: Factors affecting quality of concrete (Combined rating)

Factors affecting quality of concrete	Mean	%	Rank
Water/cement ratio	3.875	77.5	1
Concrete mixing	3.620	72.4	2
Concrete compaction	3.570	71.4	3
Concrete curing	3.480	69.6	4
Cement content	3.450	69.0	5
Quality of concrete ingredients	3.400	68.0	6
Average	**3.566**	**71.3**	

Source: Author (2018)

The results reveal that there is consistency of the results and the findings of the strength of concrete actually found in reinforced concrete buildings in Dar es Salaam. Strength of concrete depends on sufficient mixing and prompt placement, but depending on mixing method, concrete may be prolonged. Prolonged concrete mixing poses problem where concrete begins setting and looses workability (Neville, 1997). When concrete reduces workability the quick solution which is a common practice to retain concrete plasticity by many of operators at site is re-tempering by adding water, the act of which can significantly reduce concrete strength (Salter, 1993). Increase of water to facilitate workability affects water to cement ratio (Rubaratuka, 2013).

Either low strength of concrete found in reinforced concrete buildings in Dar es Salaam is a result of poor compaction. Compaction is the process of removing bubbles and voids in the placed concrete. Insufficient and excessive vibration of concrete both causes problem. Insufficient compaction leave voids in the concrete while excessive compaction cause concrete segregation. Care should be taken so that concrete compaction is done just to the optimum for good results of concrete strength. Further to concrete compaction problems, it is established that concrete requires moisture to attain its maximum strength (Neville, 1997). Therefore, curing involves ensuring that constantly pouring of water is done. Curing is importantly required during the first 28 days after casting, failure of which can reduce concrete strength to as low as 50% of the rated concrete strength (Rubaratuka, 2008).

The results imply that low thrength of reinforced concrete found in many of reinforced concrete buildings (64.2%) can be a results one or combination of the factors in Table 5.2. All the factors indicated in Table 5.2 are associated with quality management problems; therefore proper quality management is required from the beginning of building construction process.

It was surprising to find that low cement content was not considered to be among the top of factors affecting quality of concrete in Dar es Salaam. Cement accounts for about 70% of the cost of materials used to produce concrete (Rubaratuka, 2013). Since errors and fraud related to cement is not prompt to detect, practice has shown that there have been a tendency of some operators stealing cement at construction site and selling to people around the construction site at a lower than the market price (Figueroa, 2014).

5.5 Factors Affecting Quality of RC Buildings in Dar es Salaam

Objective three of this research was to determine factors affecting quality of reinforced concrete buildings construction in Dar es Salaam. Contractors and consultants were interviewed to give their opinion regarding what they consider are the factors affecting quality of reinforced concrete buildings in Dar es Salaam. The results are as summarized in Table 5.3. The results shows calculated mean values of the factors as were perceived by the contractors and consultants. The contractors’ mean ranged from 2.66 to 4.42 while that of consultants’ ranged from 2.50 to 3.53, showing that contractors’ mean range is slightly bigger than that of consultants. This means that contractors’ views had higher deviation compare to consultants. The results show that there was agreement and disagreement of opinion in some of attributes between the contractors and consultants. On one hand, both contractors and consultants were in agreement with regard to building construction supervision, quality of materials in the market, quality policy, design code of practice, and use of consultants as among the factors affecting quality of reinforced concrete buildings in Dar es Salaam.

On the other hand, both contractors and consultants gave different opinion on: building construction technology, coordination among key stakeholders, theft of construction materials at site, payment to contractors and consultants and skilled & experienced technical staff among the factors affecting quality of reinforced concrete buildings in Dar es Salaam.

Table 5.3: Factors affecting quality of RC buildings (Group's rating)

Factor	Contractors		Consultants	
	Mean	**Rank**	**Mean**	**Rank**
Poor construction supervision	4.42	1	3.53	1
Inadequate of construction technology	3.34	2	3.08	8
Lack of coordination of key stakeholders	3.00	6	3.37	2
Deficiency in design	2.92	8	2.50	12
Lack of quality construction materials	2.95	7	3.16	6
Theft of construction materials at site	2.87	10	3.32	4
Delaying/late payment	2.66	12	3.13	7
Inadequate skilled & experienced staff	3.24	3	2.74	10
Lack of quality policy	2.86	11	2.66	11
Lack of design code of practice	3.11	4	3.39	3
Use of unregistered consultant	3.03	5	3.23	5
Use of unregistered contractor	2.90	9	2.98	9

Source: Author (2018)

It is interesting that contractors and consultant gave different opinion either where their interest differed or due to different role each play in building construction at site. This argument can be justified by having a look to late payment, of which contractors suffers more than consultants do. The delay is in two forms, first one is where consultant delays payment to contractor by failing to promptly prepare payment certificate after receiving request for payment from the contractor. Second form of delay is when the client delay to pay the contractor after has received approved certificate for payment from the consultant. There is a notion that, late honoring of payment to contractors goes as far as two to three years after completion of the building construction and this practice came from the public as well as private clients. Implication of this may give rise to use of inferior construction materials and also poor workmanship of the construction works by use of little available funds to avoid site demobilization and mobilization which also affect smooth running of construction works.

Contractors and consultants differed on building construction technology probably due to the role played by each. While contractors are required to do the actual construction to produce physical building product, consultants are required to supervise and give instructions to the contractors. Contractors find it difficult when working drawings do not contain important details while consultant is not frequently at site to give required clarification on how to go about. On the other hand, contractors may consider building construction technology by looking at the methods and equipment available to carry out the construction while consultants may consider building construction technology to be the available technology to produce the working drawings and construction management skills acquired from training and experience. Another area where the contractors and consultants differed in their perception is on theft of construction materials at site.

It is interesting to see that contractors considered the factor not severe while consultants considered the factor severe. There is a notion that it is a common practice that contractors' operators particularly the reinforcements fixing gangs and concrete mixing gangs do steals reinforcement steel bars and cement from construction site. Combined mean score of the consultants and contractors are presented in Table 5.4.

Table 5.4: Factors affecting quality of RC buildings (Combined rating)

Factor	Mean	%	Rank
Poor construction supervision	3.98	79.6	1
Lack of own code of practice	3.25	65.0	2
Inadequate of construction technology	3.21	64.2	3
Lack of coordination of key stakeholders	3.19	63.8	4
Theft of construction materials at site	3.10	62.0	5
Shortage of quality materials in the market	3.06	61.2	6
Reluctance to use registered consultants	3.04	60.8	7
Inadequate skilled & experienced staff	2.96	59.2	8
Reluctance to use registered contractor	2.94	58.8	9
Delaying/late payments to contractors	2.90	58.0	10
Deficiency in working drawing	2.79	55.8	11
Lack of quality policy	2.75	55.0	12
Average	**3.098**	**62.0**	

Source: Author (2018)

Results show that combined mean score ranged from 2.75 (55.0%) to 3.98 (79.6%). When they were ordered, construction supervision; lack of own code of design and practice; and inadequate of construction technology, were ranked top of the list as serious factors affecting quality of reinforced concrete buildings in Dar es Salaam. On the other hand, delaying or late payment to contractors and consultants, deficiency in working drawings and lack of quality policy were ranked less serious among factors affecting quality of reinforced concrete buildings in Dar es Salaam. The analysis has shown that the order of factors affecting quality of reinforced concrete buildings in Dar es Salaam does not differ between contractors and consultants as supported by Mann Whitney U test at 5% level of significance (Table 5.12).

The finding is in agreement with the result of the study by Baradyana (2000) on measures to improve the performance of the construction industry in the developing countries particularly Tanzania. The results reveal that factors affecting quality of reinforced concrete building construction in Dar es Salaam have almost been the same over the last two decades. Despite the long list of factors as shown in Table 5.4, the serious factors were grouped and summarized as presented in Figure 5.4.

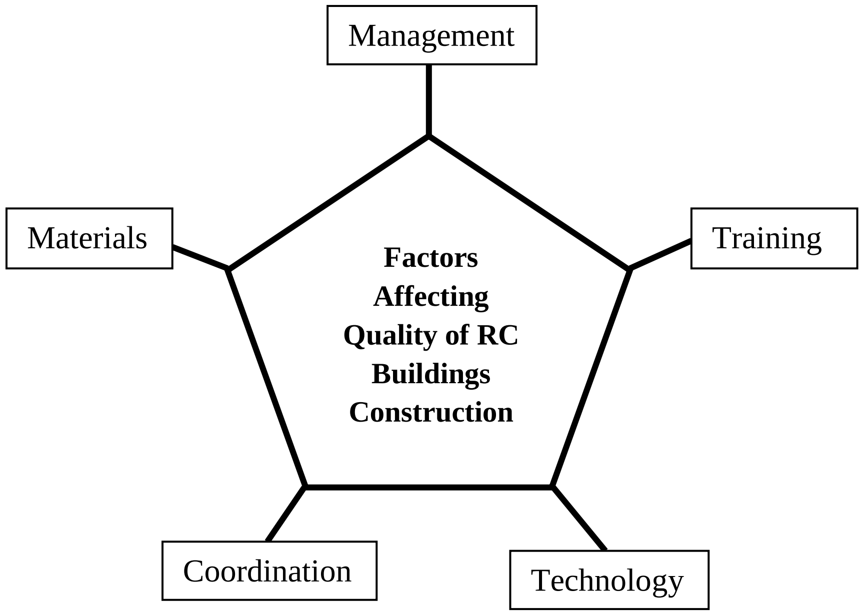

Figure 5.4: Factors affecting quality of RC buildings in Dar es Salaam

Source: Author (2018)

5.6 Root Cause of RC Buildings Failure in Dar es Salaam

This research aimed to develop a model to facilitate quality management for curbing failure of reinforced concrete buildings in Dar es Salaam. Before embark on the model development it was considred appropriate to find out root causes of failure of the reinforced concrete buildings in Dar es Salaam. Table 5.5 and Table 5.6 summarize results of the findings. Table 5.5 shows Contractor’s opinion in a Likert scale of 1 - 5 while Table 5.6 shows frequency of consultants on factors causing failure of reinforced concrete buildings in Dar es Salaam. The results show that poor construction supervision, poor quality of concrete and overloading are top among the serious factors behind failure of reinforced concrete buildings in Dar es Salaam. However, there was agreement and disagreement between contractors and consultants with regard to the root cause of failure of reinforced concrete buildings in Dar es Salaam.

Table 5.5: Causes of RC buildings failure (Contractor's rating)

Factors affecting RC buildings failure	Mean	%	Rank
Poor construction supervision	4.39	87.8	1
Poor quality of concrete	4.00	80.0	2
Overloading	3.97	79.4	3
Deficiency in building design	3.53	70.6	4
Poor construction workmanship	3.13	62.6	5
Incompetence of construction teams	2.89	57.8	6
Poor method of construction	2.82	56.4	7
Poor quality of reinforcement bars	2.55	51.0	8
Average	**3.410**	**68.2**	

Source: Author (2018)

Both contractors and consultants ranked poor construction supervision first among the top serious factors causing failure of reinforced concrete buildings in Dar es Salaam. While contractors ranked poor quality of concrete second, consultants ranked overloading second among the serious factor causing failure of reinforced concrete buildings in Dar es Salaam. Contractors ranked overloading third of the factors list, while consultants ranked poor quality of concrete in the third of the list. Both contractors and consultants agreed that poor quality of reinforcement bars, poor method of construction and poor construction workmanship are less serious factors causing failure of reinforced concrete buildings in Dar es Salaam.

Table 5.6: Causes of RC buildings failure (Consultants' ranking)

S/N	Factors influence building failure	Frequency
1	Poor construction supervision	9
2	Overloading due to vertical extension	8
3	Poor quality of concrete	7
4	Deficiency in building design	6
5	Poor construction workmanship	5
6	Incompetence of construction teams	4
7	Poor method of construction	3
8	Poor quality of reinforcement bars	2

Source: Author (2018)

It was not surprising to find that, root cause of failure of reinforced concrete buildings in Dar es Salaam is human action or inaction. The results indicated that construction supervision is one of the factors affecting reinforced concrete buildings failure in Dar es Salaam. Although construction supervision is not seen as a direct cause of reinforced concrete building's failure, but it is a serious factor that causes failure of reinforced concrete buildings in Dar es Salaam. This is shown from further analysis of the results using quality management tools (Pareto chart/principle and Ishikawa diagram). Pareto chart shown in Figure 5.5 used the Pareto Principle to identify the few (20%) causes of failure that results majority (80%) of failure of reinforced concrete buildings in Dar es Salaam.

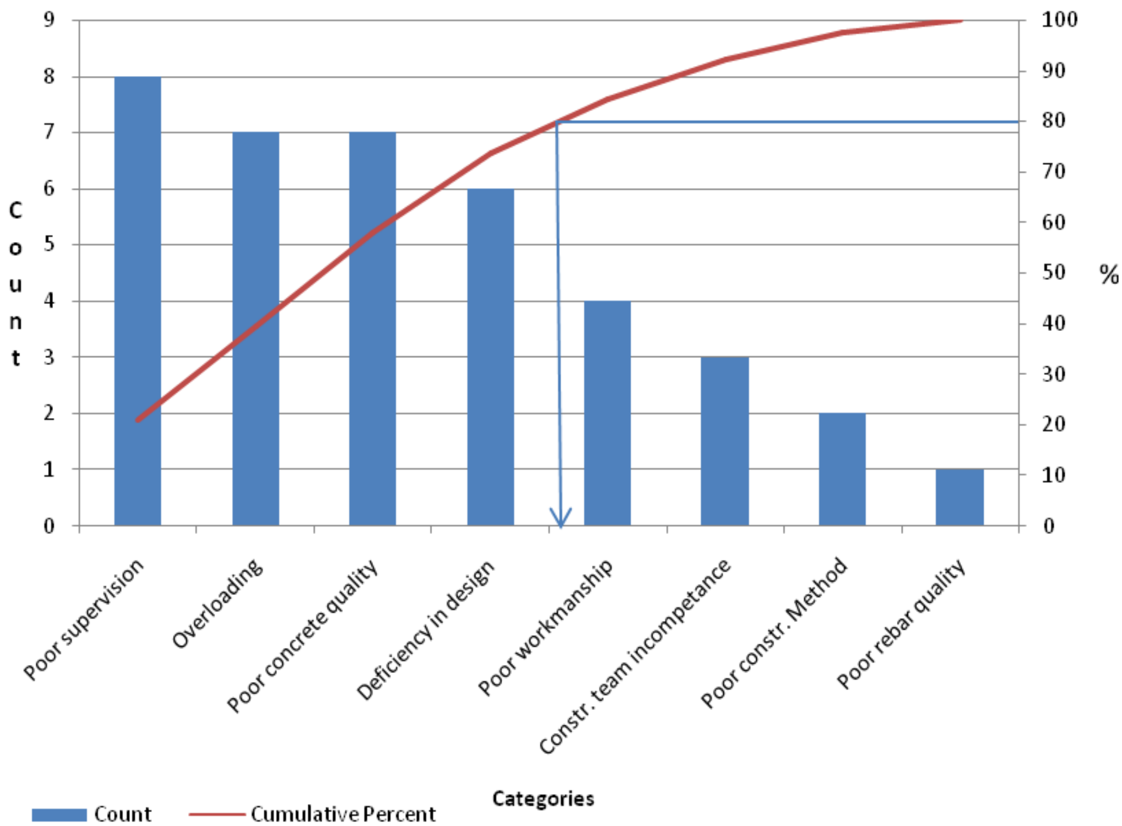

Figure 5.5: Pareto chart showing causes of RC buildings failure in Dar es Salaam

Source: Author (2018)

This research used Pareto chart as well as Ishikawa diagram as quality management tools to identify few factors that causing majority of quality problems of reinforced concrete buildings in Dar es Salaam and roots cause of these factors. Pareto chart helped to identify the 20% factors that cause 80% of the RC buildings failure, while Ishikawa diagram helped to identify root cause of the buildings failure. From the Pareto chart, 20% of the causes of reinforced concrete buildings failure in Dar es Salaam that if fixed will solve 80% of the problems were identified. The identified root causes include: poor supervision; excessive loading; poor quality of concrete material; deficient in design and errors in working drawings. According to Pareto principle, most priority should be given to construction supervision followed by loading, concrete quality and design deficiency.

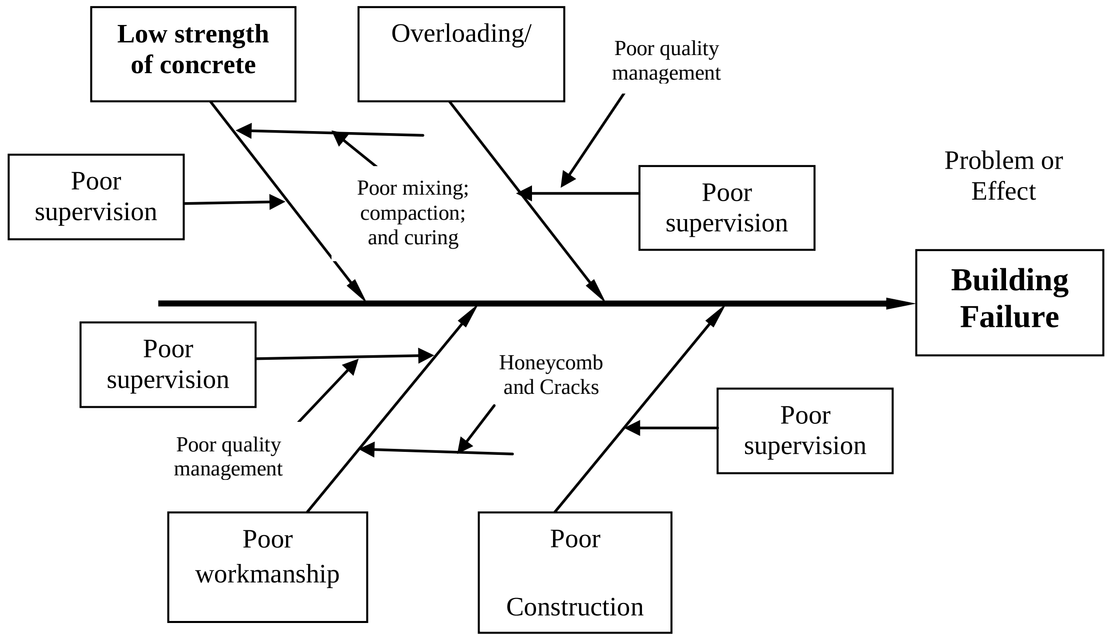

Figure 5.6: Ishikawa diagram showing root cause of RC buildings failure

Source: Author (2018)

Ishikawa diagram shown in Figure 5.6 was used to determine cause and effect to identify root causes of reinforced concrete buildings failure in Dar es Salaam. Figure 5.6 indicates that poor construction management; poor supervision; poor concrete mixing, compaction and curing; and low strength of concrete were identified as the root causes of reinforced concrete buildings failure in Dar es Salaam. Further analysis from Figure 5.6, it shows that root causes of reinforced concrete buildings failure in Dar es Salaam is as summarized and presented in Figure 5.7. The diagram indicates that, the root cause of reinforced concrete buildings failure in Dar es Salaam is poor quality of concrete used in construction. From a systems theory, no one single component can make a system, but it is a relationship of related components in a system or subsystem. Quality management and poor quality of concrete are two extremes of cause and effect relationship of concrete production subsystem in a building construction system (Figure 5.7). Low strength of concrete on the one end can be eliminated or tackled by following proper quality management from the other end.

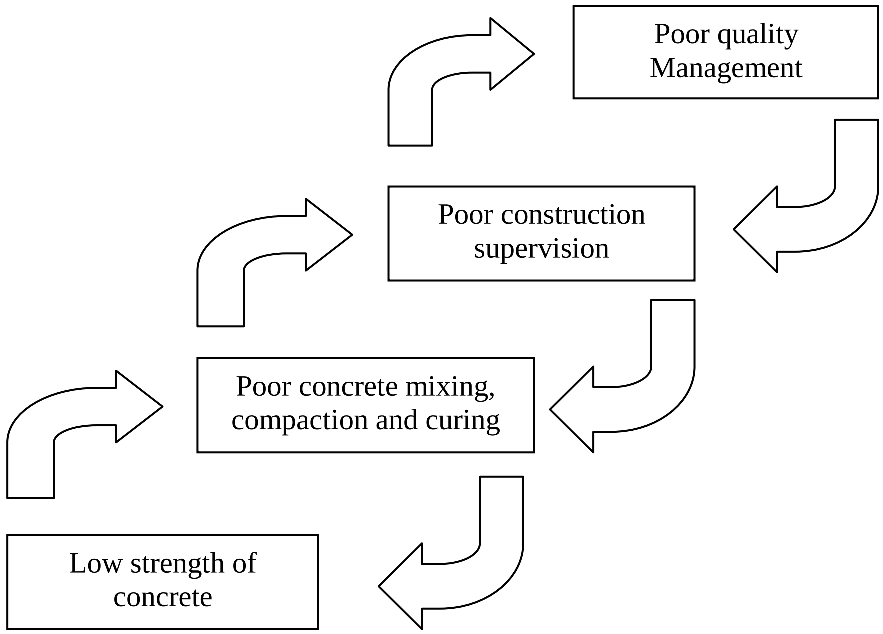

Figure 5.7: Root cause of RC buildings failure in Dar es Salaam

Source: Author (2018)

5.7 Construction Quality Management Practice

Objective three of this study aimed to determine relationship between construction management practices and structural integrity of reinforced concrete buildings in Dar es Salaam. On the part of construction quality management practices, three issues were focused which are: application of quality management tools and techniques, construction supervision level and practices of quality assurance and quality control in reinforced concrete building construction.

5.7.1 Application of Quality Tools and Techniques

Data on application of quality management tools and techniques is shown in Table 5.7 and 5.8. Table 5.7 presents the results of individual group of consultants and contractors while table 5.8 presents the ranking according to results of the combined groups. The results reveal that, although a number of quality management tools and techniques are available in the literature (PMI, 2004), only few of them, are applied for building construction in Dar es Salaam. Bar chart, inspection and critical path method are mostly applied tools and techniques. The results show that contractors and consultants generally are fairly in agreement concerning application of quality tools and techniques for their building construction practice in Dar es Salaam. Mann Whitney U test indicated that there is no statistically significant difference between the two groups at $\alpha = 0.05$ (Table 5.12).

Table 5.7: Use of quality Tools and Techniques (Group's rating)

Application of quality Tools and Techniques	Contractor		Consultant	
	Mean	**Rank**	**Mean**	**Rank**
Benefit Cost Analysis	2.03	6	2.26	5
Benchmarking	1.46	10	1.66	10
Design of experiment	1.54	9	1.69	9
PERT	2.40	4	2.42	4
Quality Audit	2.14	5	2.23	6
Inspection	4.09	2	3.94	2
Bar Chart	4.57	1	4.51	1
Pareto Chart	1.31	11	1.51	11
Statistics Sampling	1.63	8	1.86	7
Critical Path Method	3.06	3	3.20	3
Ishikawa diagram	1.86	7	1.83	8

Source: Author (2018)

When the two groups score were combined and ranked as shown in Table 5.8, the results reveal that on average, the mean application of quality management tools and techniques in Dar es Salaam is 2.408 (48.2%). Based on 5 points Likert scale of measurement used in this study, the result suggests that the application of quality management tools and techniques for reinforced concrete building construction in Dar es Salaam is low. The results agree with the findings of Baradyana (2000) that network planning techniques such as CPM and PERT have been in use 1% of the time and bar charts have been in use

71% of the time in Tanzania. Bar charts have been often used in Tanzania irrespective of project size and therefore is one of the areas that have often affected quality performance especially on large projects where bar chart fail to be an efficient planning tools (Baradyana, 2000).

Table 5.8: Use of quality Tools and Techniques (Combined rating)

Application of quality Tools and Techniques	Mean	%	Rank
Bar Chart	4.540	90.8	1
Inspection	4.015	80.3	2
Critical Path Method	3.130	62.6	3
PERT	2.400	48.0	4
Quality Audit	2.185	43.7	5
Benefit Cost Analysis	2.145	42.9	6
Ishikawa diagram	1.845	36.9	7
Statistics Sampling	1.745	34.9	8
Design of Experiment	1.615	32.3	9
Benchmarking	1.460	29.2	10
Pareto Chart	1.410	28.2	11
Average	**2.408**	**48.2**	

Source: Author (2018)

5.7.2 Quality Assurance and Quality Control Practice

As part of construction management, this study sought to get picture of quality assurance and control practices in reinforced concrete building construction in Dar es Salaam. Contractors and consultants from a selected sample of reinforced concrete buildings under construction were faced to give their experience of how they conducted various quality assurance and control in their projects under construction. The respondents were interviewed using a structured interview schedule structured so that measurement was in terms of 5 points Likert scale. There has been agreement and disagreement between the two groups (contractors and consultants). On one hand, both contractors and consultants agreed that working drawings are approved by the local authorities before building permit is issued. Also both the contractors and consultants agreed on issues pertaining to testing of reinforcement steel bars; and rectification of detected building defects. On the other hand, contractors and consultants disagreed on the part of building blocks/bricks testing; curing of reinforced concrete products; building inspection; site meetings; and on the qualification of construction staff. The results of individual groups are presented in Table 5.9 and the results of combined groups are presented in Table 5.10.

Table 5.9: Quality Assurance and Control practice (Group's rating)

Quality assurance and Quality control practice	Contractor		Consultants	
	Mean	**Rank**	**Mean**	**Rank**
Approval of working drawings	3.63	1	3.84	1
Testing of building blocks/bricks	2.79	6	3.16	4
Testing of reinforcement bars	2.92	5	3.18	3
Curing of RC concrete products	2.95	3	3.24	2
Implementation of ISO/TQM	1.75	10	2.15	10
Conduct of building inspection	2.29	8	2.58	8
Site construction supervision	1.95	9	2.21	9
Conduct of site meetings	2.74	7	2.89	6
Qualified construction staff	3.16	2	2.88	7
Rectification of defects detected	2.95	4	2.95	5

Source: Author (2018)

The disagreement between the two groups in some of the points is considered to be, the different roles played by the groups in building construction. Contractors are required to translate and do the actual construction from working drawings to required physical building product. On the other hand, consultants are responsible for the construction supervision to make sure that, the construction follows the specified construction method, use the specified construction materials, tools and equipment. Also consultants are responsible to provide clarification where working drawings do not provide enough details. Consultant and contractors are required to closely co-operate and assist each other to achieve or exceed the client's expectation. Contrary to this, experience shows that most of the time building construction is carried out at construction site without presence of consultant and even presence of contractor's qualified staff. This can lead to different understanding of what is happening at construction site by responsible persons from both the consultant and contractor.

Although approval of working drawings for RC building before construction was ranked highest with a mean score of 3.735 (74.7%) implying that is highly practiced, studies (NCC, 2017; Rubaratuka, 2008) have shown that although working drawings are approved by municipal and city councils authorities, but in most cases the drawings lacks necessary details. These anomalies are attributed to inadequate number of qualified and experienced personnel in the Local Government Authorities as it was also reported by NCC (2017).

Combined results of the two groups as summarized in Table 5.10, it shows that in practice approval of working drawings, curing of concrete and testing of reinforcement steel bars is among the most quality assurance and control performed in their building construction projects in Dar es Salaam. Although the result indicates that working drawings are approved before construction is executed, but level of application is however moderate. Apart from approval of working drawing with mean of 3.735 (74.7%) indicating high application practice, other quality assurance and control practices ranged between a mean of 3.095 (61.9%) and 2.815 (56.3%) of which according to 5 points Likert scale of measurement used in this study are moderate.

The results shows construction supervision; inspection of construction works; conduct of site meetings and implementation of TQM/ISO Standards are the least in the rank of performed quality assurance and control in reinforced concrete building construction in Dar es Salaam. In its totality, based on 5 points Likert scale of measurement as applied in this study, the results show that application of quality assurance and control as far as these aspects are concern is moderate.

Table 5.10: Quality Assurance and Control practice (Combined rating)

Quality assurance and quality control practice	Mean	%	Rank
Approval of working drawings	3.735	74.7	1
Curing of concrete products/elements	3.095	61.9	2
Testing of reinforcement bars	3.040	60.8	3
Getting qualified technical staff	3.025	60.5	4
Testing of building blocks/bricks	2.975	59.5	5
Rectification of defects detected	2.950	59.0	6
Conduct of site meetings	2.815	56.3	7
Conduct of building inspection	2.435	48.7	8
Carry out construction supervision	2.080	41.6	9
Implementation of ISO/TQM	1.950	39.0	10
Average	**2.810**	**56.2**	

Source: Author (2018)

The results revealed that in general, the mean application of quality assurance and control in reinforced concrete buildings in Dar es Salaam is moderate with mean of 2.810 (56.2%). The results of this study corroborate Kalinga's (2005) findings that about 50% of medium and small contractors (Class IV-VII) in Tanzania do not undertakes quality control test for construction materials. The results also agree with the findings from the study by Rubaratuka (2008) that implementation of quality control measures at most of construction sites in Dar es Salaam generally is not carried out. This is attributed to construction culture which is characterized as very rigid to change (Hoonakker *et al*., 2010). As it was argued by Arditi and Gunaydin (1997) Total Quality Management is a culture that must permeate an organization as the method of management. The result indicates lack of quality management culture and commitment on the part of construction organizations in Tanzania and Dar es Salaam in particular. The implication of this result is that unless serious measures are taken to improve construction management in construction of reinforced concrete building in Dar es Salaam, failure and spontaneous collapse of reinforced concrete buildings will likely continue to occur.

5.7.3 Construction Supervision

Proper construction supervision was related to frequency of construction site visit made by various authorities required by law to oversee construction activities in Tanzania. Table 5.11 present results of the extent each of the identified authority played during construction of the buildings investigated. The results show that consultant responsible for construction supervision, for the buildings construction investigated recorded mean of 2.852 (57.2%). Contractors Registration Board and Engineers Registration Board in that order visited the construction site more frequently than did National Construction Council and Local Government Authorities in the same order. Contractors Registration Board, Engineers Registration Board and Architects and Quantity Surveyors Registration Board seem to have moderately visited construction site, while Local Government Authorities who issues building permit, poorly (mean 1.923 or 38.5%) visited the construction site to verify whether construction was carried out according to the building permit issued. In general, site visit by all the authorities was low (Mean 2.370 or 47.4%).

Table 5.11: Construction supervison (Contractors)

S/N	Building construction supervision	Mean	%	Rank
1	Responsible consultant	2.852	57.0	1
2	Contractors Registration Board (CRB)	2.724	54.5	2
3	Engineers Registration Board (ERB)	2.661	53.2	3
4	Architects and Quantity Surveyors Registration Board (AQRB)	2.583	51.7	4
5	Local Government Authorities (LGAs)	1.923	38.5	5
6	National Construction Council (NCC)	1.471	29.4	6
	Average	**2.369**	**47.4**	

Source: Author (2018)

5.7.4 Significance Test on Difference of Means

As stated earlier, the groups of respondent (structural consultants and contractors) differed in some of the areas concerning: factors affecting quality of reinforced concrete buildings (Table 5.4); application of tools and techniques in building construction in Dar es Salaam Table 5.8); and on quality assurance and control practices in building construction in Dar es Salaam (Table 5.10). Statistical tests were performed, to ascertain whether the differences were significant or not. One further test was conducted to determine if there was a significant difference of structural strength between the existing and collapsed reinforced concrete buildings in Dar es Salaam. The following hypotheses were formulated and a 5% level of significance used throughout the analysis:

1. To test if there was a significant difference between consultants and contractors rating on: factors affecting quality of reinforced concrete buildings in Dar es Salaam.

   H_o: $\mu_o - \mu_1 = 0$, i.e. there is no difference between the two means;

   H_1: $\mu_o - \mu_1 \neq 0$, i.e. there is a significant difference between the two means.

2. To test if there was a significant difference between consultants and contractors rating on application of quality management tools and techniques; and on quality assurance and control practices; similar hypotheses were used.

   H_o: $\mu_o - \mu_1 = 0$, i.e. there is no difference between the two means;

   H_1: $\mu_o - \mu_1 \neq 0$, i.e. there is a significant difference between the two means.

3. To test if there was a significant difference between structural strength of failed and existing reinforced concrete buildings.

H_0: $\mu_o - \mu_1 = 0$, i.e. there is no difference of structural strength between the failed and existing reinforced concrete buildings;

H_1: $\mu_o - \mu_1 \neq 0$, i.e. there is a significant difference of structural strength between the failed and existing reinforced concrete buildings.

The Mann Whitney U test results are presented in Table 5.12. The items number one to three indicates that there is no statistically significant difference between the contractors and consultants on factors affecting quality of reinforced concrete building in Dar es Salaam; application of management tools and techniques; and also on quality assurance and control practice at 5% level of significance. The result imply that although there was slight difference between contractors and consultant on some of areas concerning factors affecting quality of reinforced concrete building construction; application of quality management tools and techniques; and quality assurance and control practice in Dar es Salaam, the differences was by chance. Essentially, both the contractors and consultants agreed that application of management tools and techniques is low (Mean 2.408 or 48.2%) see Table 5.8. Further, both contractors and consultant agreed that quality assurance and control practice for reinforced concrete building construction in Dar es Salaam is moderate (Mean 2.810 or 56.2%) see Table 5.10.

Furthermore, item number four of the results in Table 5.12 show that statistically there was no significance difference between the collapsed and existing reinforced concrete buildings in Dar es Salaam at 5% level of significance.

Table 5.12: Comparison statistics results (5% level of significance)

S/N	Variable	Mean Contractors	Mean Consultants	P-Value	Result
1	Application of mgt tools and techniques	2.372	2.465	0.342	Not Sig
2	Quality assurance and quality control practices	2.713	2.908	0.599	Not Sig
3	Factors affecting quality of RC buildings	3.108	3.091	0.426	Not Sig
	Variable	**Collapsed bldgs**	**Existing bldgs**		
4	Integrity of reinforced concrete buildings	18.24	20.06	0.188	Not Sig

Source: Author (2018)

The results imply that despite that the reported number of reinforced concrete buildings collapse in Dar es Salaam is relatively small compare to number of existing buildings, but the study is 95% confident that 64.2% of reinforced concrete buildings in Dar es Salaam is at risk of collapse. It is not surprising to see that the buildings still exists despite their low structural strength which theoretically would have been collapsed. These results agree with the findings by Figueroa (2014). Same argument to that presented by Figueroa (2014) is also presented here that "some structurally poor strength reinforced concrete buildings in Dar es Salaam have failed and collapsed. Many others structurally poor quality buildings in spite of their weakness might remain in use for many years unless substantial earth vibrations like earthquake happen to reveal their inherent weaknesses".

5.8 Relationship between Structural Integrity and Construction Management

Third objective of this research was to determine relationship between quality management practice and structural integrity of reinforced concrete buildings in Dar es Salaam. The analysis was done with a help of IBM SPSS version 22. The first step was to check whether there is a linear relationship in the data. Results of correlation analysis are as shown in Table 5.13. Correlation analysis in Table 5.13 shows that Pearson's correlation coefficient is 0.650 and 0.602 which signifies a medium positive linear correlation between concrete strength on one side and quality tools and techniques and construction supervision on the other side respectively. The results show a very high statistical significance of $p < 0.001$ thus null hypothesis that there is no positive or negative correlation between the variables ($r = 0$) is rejected and it was assumed that concrete strength was linearly associated with the level of application of quality tools & techniques and supervision of reinforced concrete building construction in Dar es salaam.

Table 5.13: Correlation test

Correlations

		Concrete strength	Tools & Techniques	Quality Assurance & Control	Construction supervision
Pearson Correlation	Concrete strength	1.000	.650	-.017	.602
	Tools & Techniques	.650	1.000	-.050	.324
	Quality Assurance & Control	-.017	-.050	1.000	.010
	Construction supervision	.602	.324	.010	1.000
Sig. (1-tailed)	Concrete strength	.	.000	.461	.000
	Tools & Techniques	.000	.	.388	.029
	Quality Assurance & Control	.461	.388	.	.478
	Construction supervision	.000	.029	.478	.

Source: Author (2018)

Multiple linear regression analysis was then conducted. Results of the regression analysis are presented in Table 5.14. The first table in Table 5.14, the column labelled R in the model summary are the values of the multiple correlation coefficient between the predictors and the outcome. When anly tools & techniques is used as a predictor (model 1), it shows that there is a correlation between structural integrity and tools & techniques ($R = 0.65$) the value which is equal to the value obtained in the correlation analysis. The next column gives a value of coefficient of determination (R^2), which is a measure of the variability in dependent variable that is accounted for (explained) by the predictors. The final model (model 2) gives the value of R^2 equal to 0.593 or 59.3%. This means that the linear regression model with the predictors, i.e. tools & techniques and supervision explaines 59.3% of the variance of the buildings' structural integrity. Adjusted R^2 gives idea of how well the model generalizes and its value is suggested to be the same or very close to the value of R^2. In this study, the difference is a fair bit (0.593 – 0.568 = 0.025 or 2.5%).

Table 5.14: Model summary and F-test

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.650[a]	.422	.405	5.268
2	.770[b]	.593	.568	4.488

a. Predictors: (Constant), Tools & Techniques

b. Predictors: (Constant), Tools & Techniques, Construction supervision

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	668.924	1	668.924	24.108	.000[b]
	Residual	915.648	33	27.747		
	Total	1584.571	34			
2	Regression	940.043	2	470.022	23.336	.000[c]
	Residual	644.528	32	20.142		
	Total	1584.571	34			

a. Dependent Variable: Concrete strength. b. Predictors: (Constant), Tools & Techniques.

c. Predictors: (Constant), Tools & Techniques, Construction supervision

Source: Author (2018)

The ANOVA table in Table 5.14 provides an F-test for the null hypothesis that there is no linear relationship between dependent and the predictors (none of the independent variables (predictors) are related to dependent variable, in other words $R^2 = 0$) (Landau & Everitt, 2003). With F = 23.336 and 34 degrees of freedom the test in Table 5.14 is highly significant, hence it can be concluded that, there is a linear relationship between the variables in the developed model. It can further, be elaborated that, there is a linear relationship between structural integrity of buildings in Dar es Salaam and level of construction supervision as well as application of quality tools and techniques in construction.

The output shown in Table 5.15 provides estimates of the regression coefficients, the intercept, t-tests and the significance of all coefficients in the model. In multiple regression the model takes the form of equation, that contain a coefficient (b) for each predictor. The b values tell about the relationship between dependent variable and each predictors. The results shows a non significant intercepts of 0.233 but commonly it happens and it has no problem (Landau & Everitt, 2003).

Table 5.15: Regression coefficients

(a) Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.567	3.943		.397	.694
	Tools & Techniques	5.117	1.042	.650	4.910	.000
2	(Constant)	-4.566	3.753		-1.217	.233
	Tools & Techniques	4.001	.939	.508	4.262	.000
	Construction supervision	3.119	.850	.437	3.669	.001

a. Dependent Variable: Concrete strength

Source: Author (2018)

Also results show highly significant coefficients for quality tools & techniques as well as construction supervision. The results imply that there is relationship between building structural strength and quality tools & techniques as well as construction supervision. On the other hand, results indicate that there exists no enough evidence to show relationship between structural strength and quality assurance and control although in principle there should be. The estimated regression coefficients are given under the heading "unstandardized Coefficients B".of Table 5.15. One regression coefficient goes with each predictor and give, for each of the predictor variables, the predicted change in the outcome (dependent variable). Based on this table, the equation for the regression model is:

Stractural Integrity = - 4.57 + 3.12 (Supervision) + 4.00 (Tools & Techniques)

Therefore: $Q = -4.57 + 3.12\,S + 4.00\,T$

Where: Q = Building quality or structural integrity;

S = Construction supervision;

T = Application of quality tools and techniques

Since we have multiple predictors in the analysis the Beta weights compare the relative importance of each predictor in standardized terms. It is found that application of quality management tools & techniques (Beta = 0.508) has a higher impact than the level of construction supervision (Beta = 0.437).

Relationship between structural integrity (quality of building) and management practice (i.e. level of supervision; quality assurance and control practices; and application level of quality tools and techniques) was investigated. The stepwise multiple linear regression analysis found that level of supervision and application of quality tools and techniques had relevant explanatory power. Together the estimated regression model ($Q = -4.57 + 3.12S + 4.00T$) explain 59.3% of the variance of the achieved quality with adjusted R^2 of 56.8%. The regression model is highly significant with $p < 0.001$ and $F = 23.336$. Null hypothesis was rejected and thus the regression not only show a linear relationship between supervision and application of quality tools and techniques, but can also be concluded that quality in terms of structural strength of buildings could increase by 3.12 units for every additional level of construction supervision. Also, for every additional application of quality management tools & techniques, the structural strength of a building increases by 4.00 units.

5.9 Analysis of the Relationship between Quality and Management Practices

Literature (NCC, 2017; Rubaratuka, 2013; Baradyana, 2000; Lema, 1996) connoted symptoms of problem in reinforced concrete buildings' construction in Dar es Salaam. In order to properly explain and gain a better understanding of the problem, systems theory was adopted to analyze and find root cause of the problem. Systems theory was applied because not only it allows a researcher to take a better look at a problem, but also help to identify why there is a problem (Lester, 2005). Construction industry is an open system that accepts inputs from the environment and processes them to produce useful output (Pilcher, 1992). Reinforced concrete buildings' construction system must be capable of maintaining its stability regardless of any change that may take place in the environment, contrary to this; there must be a problem (Mele *et al*., 2010; Pilcher, 1992).

Quality of reinforced concrete buildings for this study is building's fitness for use and conformance to structural strength requirements. Minimum structural strength requirements of concrete for reinforced concrete buildings' construction is 25 MPa (Reynolds & Steedman, 1997; Allen, 1988). The results of this study revealed that structural strength of concrete in the investigated reinforced concrete buildings was 20.06 MPa. This result indicates that the buildings' structural strength was 4.94 MPa (19.8%) lower than the required quality. The results showed that 64.2% of the reinforced concrete buildings are not fit for use because they were below the minimum requirements of quality (20.06 MPa instead of 25 MPa). These results confirmed the existence of a problem.

Relationship between quality and management of reinforced concrete buildings' construction was determined by a help of systems theory. The regression modeling results rejected the null hypothesis at 5% level of significance and indicated that relationship exists between buildings' quality and construction management practices. The regression analysis showed that construction supervision and application of tools and techniques in construction process were significant predictor variables of buildings' quality. Practice of construction supervision was found to 2.369 (47.4%) while application of quality management tools and techniques was 2.408 (48.2%). Both of the variables' practices in the industry were below moderate. These results were not surprising and are in accordance with those reported in the literature (Figueroa, 2014; Rubaratuka. 2013).

In order to overcome quality problems in construction, different authors (Hanseeb & Huang, 2013; Hoonakker *et al*., 2010; Pheng & Teo, 2004) have recommended the adoption of manufacturing industry's concepts and methods particularly the use of TQM within the construction industry. Various approaches and initiatives reported in the literature were reviewed to determine the status of construction management. While some initiatives focused on customer's satisfaction (Underson *et al*., 1994) others tried to improve construction process (Lema, 1996). Also there are others who tried to improve flow's management (Koskela, 2002) and performance (Oakland & Marosszeky, 2006). Overall, the initiatives reviewed looked at the different sides of quality management.

A few of the initiatives combined both the soft and hard sides of TQM. For istance, Lema (1996) combined TQM principles and benchmarking as a techniques but the model could not be used to identify root cause of the problem. Therefore, there is a need to generate a more comprehensive model that combines TQM tools & techniques as well as TQM principles in the design and construction processes. Particularly a model that could help management to identify areas to put minimum effort for maximum results as well as identify root causes of quality problems in reinforced concrete building construction.

5.10 Summary

This chapter has presented the results of the study aimed at determining relationship between quality of reinforced concrete buildings in terms of structural integrity and quality management practices. The quality management practices on the one hand, were examined by focusing on level of construction supervision, application of quality tools and techniques, and practices of quality assurance and quality control in building construction. On the other hand, structural integrity was determined on the basis of structural strength of concrete in the building's structural component members. Multiple regression modeling incorporating the quality management practices were used to establish their relationship to buildings' structural integrity. Level of supervision as well as tools and techniques application was found to be critical. The results presented in this chapter formed the foundation on which to base the development of the model presented in the next chapter.

CHAPTER SIX

MODEL DEVELOPMENT

6.1 Introduction

The rationale for developing a quality management model is based on literature review and findings of the study. The results have shown that there is about 60% potential for quality improvement in reinforced concrete building construction in Dar es Salaam. Total quality management (TQM) provides principles, tools, and techniques for continuous quality improvement. Delgado (2006) observed that there has been confusion between model and framework and explained that model and framework are descriptive and conceptual in nature. Wong (2005) discussed the two terms and concluded that a model provided an answer to "how to" while a framework answers "what is".

This research aimed to answer how to facilitate quality management of reinforced concrete building construction for better quality of reinforced concrete buildings in Dar es Salaam. Therefore, relevant answer to the question on how to facilitate proper quality management of reinforced concrete buildings is a quality management model.

6.2 Required Features for Quality Management Model

According to Delgado (2006) a model for quality in construction requires to show the elements that should be considered to achieve quality. In order for the model to be effective and widely adopted, Aspinwall and Delgado (2008) recommended the following as the key requirements of a quality management model:

i. Able to answer what is quality reinforced concrete buildings construction (present the elements that constitute quality);
ii. Should determine the role of various quality improvement methods within the construction process (show how to achieve quality);

iii. Should be simple [user friendly to everyone involved in a construction project e.g. designers (architects and engineers) and contractors];
iv. Easy to understand by all the construction participants;
v. Comprehensive (applies to a great variet of building construction projects);
vi. Practical (the relevant participants in a building construction project can use it in real situation without need of experts); and
vii. Applicable (it is accepted and perceived as credible and useful by its users in a wide variety of building projects).

In developing the quality management model, soft and hard side of TQM as viewed by Psychogios and Priporas (2007) was considered. On the one hand, soft side of TQM is principles or critical success factors (CSFs). Some researchers (Rad & Khosrowshahi, 1998; Suarez, 1992; Crosby, 1979) refer them as get it right, the first time, every time; quality is journey, not destination and continuous improvement while others (Love *et al*., 2005; Lema, 1996) refer them as management leadership, education and training, systems and processes, teamwork, and resources. On the other hand, hard side of TQM is tools and techniques such as Pareto chart/principle, Ishikawa diagram and benchmarking. TQM is a strategic choice made by top management, and must be consistently translated into guidelines provided to the whole organization. When TQM is not implemented cost organizations money, therefore, it is management's choice to obtain these improvements (El-Mikawi, 2007). This quality improvement begins with Crosby's (1979) absolutes of quality management. The absolutes of quality management consider that system of quality is prevention (eliminate errors before they occur); performance standard is zero defects (do it right the first time); and the measurement of quality is the price of nonconformance. Cost of nonconformance includes accidents, errors and poor quality product while costs of prevention are costs associated with error prevention in a product, process and service. The lower the nonconformance and prevention cost, the less the cost of quality.

6.3 Elements of the Proposed Model

The proposed model is based on seven key elements i.e. Quality requirement; feedback; Pareto chart; Ishikawa diagram; education and training; leadership; and teamwork. Pareto chart and Ishikawa diagram represents TQM tools (hard side of TQM) while education and training, leadership, and, teamwork represents TQM principles (soft side of TQM).

The total quality management (TQM) in this study is considered as a total corporate focus on attainment and exceeding quality requirements and significantly reducing cost resulting from poor quality by adopting new management system (Lema, 1996). The new system is a philosophy aimed at achieving business excellence through the use and application of tools as well as management of soft aspects, such as coordination and team work (Mustafa & Bon, 2012). The proposed model is shown in Figure 6.1.

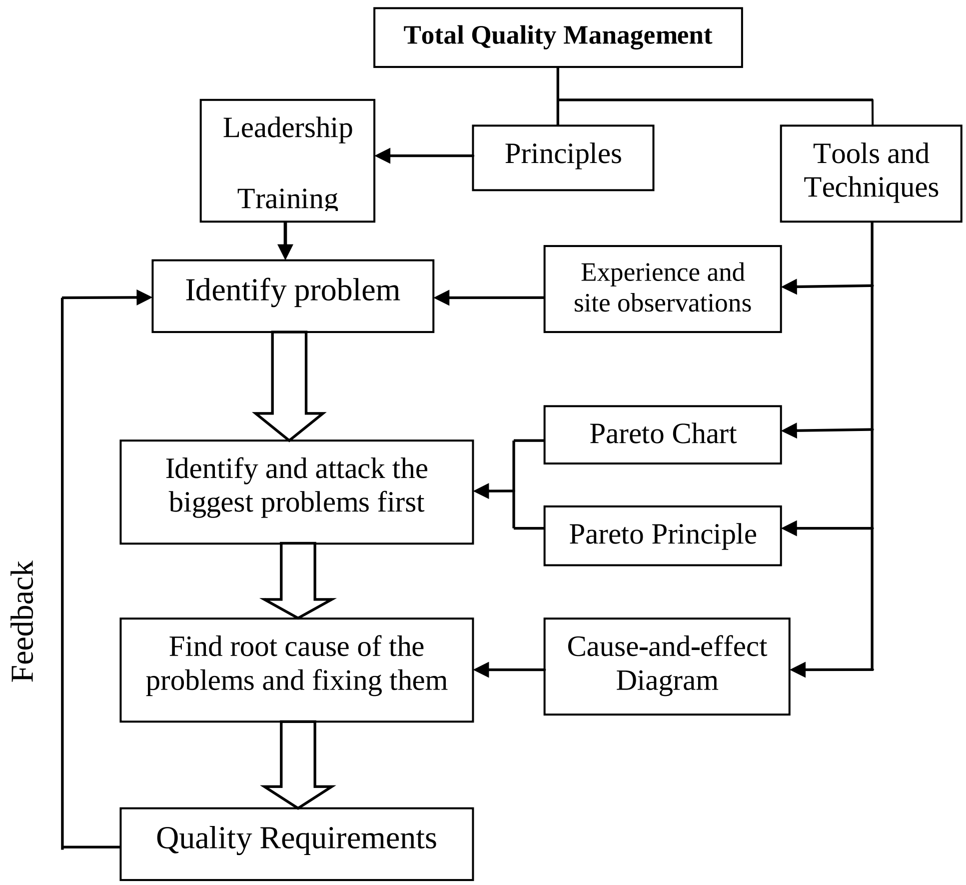

Figure 6.1: Proposed quality management model

Source: Author (2018)

The major component of the proposed model is quality requirements which are derived from the definition of quality. Quality requirements can also be derived from current database created through feedback from previous projects. For this case, quality is meeting legal and functional requirements of a project, which conforms to laws, regulations, technical specifications, drawings and construction contract. On the other hand, the functional requirements can be shown from the view of how closely the project conforms to its physical and structural requirements. The physical requirements may include: size, specification, warm-keeping, heat, and sound insulation, while structural property requirements include: firm intensity of foundation, rigidity and stability of the building structure.

Over 80 per cent of quality problems are attributed to top management (Suarez, 1992). It is the role of top management to provide good leadership and to provide sufficient resources required for quality management (Anderson *et al.*, 1994). Commitment of top management leadership is generally a preliminary point for implementing a practicing TQM to enhance quality performance of an organization. It is impracticable to adopt quality management and improve quality performance without strong top management support (Mustafa & Bon, 2012). Top management leadership carries the primary responsibility for commitment to quality and support efforts necessary for successful implementation of TQM (Crosby, 1979). Hence the most critical factor to successful TQM program is top management leadership.

Construction top management perceive TQM as extra cost, but in fact, it is not the quality that costs but rather the non conformance to quality that is expensive. They should consider costs associated with non conformance of quality such as the costs of rework, correcting errors, and reacting to customer complaints. Costs incurred from not achieving quality can cost up to 12% of the total project cost (Pheng & Teo, 2004) let alone catastrophes like failure and collapse of a multi storeyed building.

Good quality performance depends on ability to identify and fixing quality problem in the construction process. This is very much depends on application of knowledge and skills. There is no substitute for knowledge, because even hardwork and best efforts can not be the aswer (Deming, 1986). Therefore, education and training is very important to aquire the required knowledge and skills to perform the required task. Education and training gives knowledge and skills required for a particulat work that needs to be done.

Ability to produce a quality building product, lagely depends on the relationship among patities involved in the construction process; the supplier, the processor and the customer (Teamwork). Quality of any stage in a process depends upon quality of the previous stage. Therefore every party in a construction process has three roles (triple role concept): supplier, processor, and customer (Arditi & Gunaydin, 1997). The triple role concept can give good results if all people involved whether internal or external have principles of teamwork in mind and apply them in practice.

Defects and any other failures can be identified and corrected early through commitment of well educated and trained people working in a team work using proper quality management tools (Pareto chart/principle and Ishikawa diagram). The Pareto principle holds that most effect or problems come from relatively few causes. Therefore efforts aimed at the right 20% can solve 80% of the problems. Therefore, Pareto chart/principle in the model is required to identify the relatively few causes that results most effect. After identification of the right 20%, Ishikawa diagram is to be engaged to identify root cause of this right 20%. Since the process is continuous, it will reach a point where the resulting 20% cause is the part of 80% that was not considered in the previous round. The process should continue even after production of required quality is achieved. The feedback expands the quality database to eliminate repetition of the identified defects and any other failures.

6.4 Model Evaluation

Following the development of the proposed model shown in Figure 6.1, this section presents results of evaluation by five companies performed as part of this research to assess the proposed model. The assessment was made to check suitability of the proposed model within the industry and also to evaluate it in terms of attractive requirements, being simple, easy to understand, well structured, practical and applicable. The purpose of this phase of the study was not to carry out a complete validation of the proposed model, which would entail its use within building construction projects and the evaluation of its outcome, but to determine whether the proposed model is practical and applicable approach that could be used in the building construction industry. The methodology employed to perform the evaluation is firstly described, then evaluation of the proposed model will follow. Finally, the general findings will be discussed.

6.4.1 Methodology

The construction companies previously surveyed were requested to participate in the evaluation process. In order to collect consistent data, a protocol was developed (Appendix 12). Two of the advantages of using such a tool are that it helps to reduce biases and increases the reliability (Yin, 2009). In terms of its content, the protocol had one section which is the evaluation of the proposed model. Twenty-five construction companies and twenty consultancy firms agreed to participate in the second phase (Evaluation phase). However, in the event, three construction companies and two consultancy firms participated. The number was considered adequate for the purpose because such evaluation responce is a common practice in construction industry. For instance Pheng and Teo (2004) developed a framework for implementing TQM in construction industry, based on two construction companies. Also Chan and Chan (2004) verified practicality and usefulness of key performance indicators they established in their study using three case studies of building projects.

Companies were asked to rate the attractive requirements of the model by means of a 5 points scale in which 1 meant strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. In addition, companies were asked to provide comments and suggestions to improve the model.

6.4.2 Results of the Model's Evaluation

Table 6.1 presents a summary of the ratings given by participants in the five companies. Looking at the extreme values, it can be seen that company A disagreed that the model was comprehensive. At the other extreme, only company C strongly agreed with the applicability of the model. Apart from the two extremes shown above, participants agreed, in general that the model provided a simple, practical and it is applicable, the three requirements obtained 4 each. They also tended to agree it was easy to understand, well structured and systematic, since the mean scores for these aspects were 3.6, 3.6 and 3.8 respectively. Comprehensiveness of the model had the lowest score (3.4). This result was not surprising because as mentioned earlier, the score given by Company A to this requirement was low. This company wanted to include safety issues but it was felt that since this area was not considered in the study could not be added prior study. Inclusion of new component without systematic investigation was felt to be inappropriate. Further study can be undertaken in future and see ways of improving the model by adding the component if it will found suitable.

Table 6.1: Ratings for the evaluation of the proposed model

Requirements	Company A	Company B	Company C	Company D	Company E	Mean Score
Simple	4	4	4	4	4	4
Easy to understand	4	3	3	4	4	3.6
Well structured	3	4	3	4	4	3.6
Systematic	4	4	4	4	3	3.8
Comprehensive	2	4	4	3	4	3.4
Practical	4	4	4	4	4	4
Applicable	4	4	5	3	4	4

Note: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree

Source: Author (2018)

In an effort to improve the model, the suggestions gathered in this phase were analyzed. Company B noted on the use of codes and standards in building design and recommended that codes and standards should be an issue addressed early in the design phase. This observation was taken and included in the model because design professional must be knowledgeable about the provisions of codes and standard before starting the design process. Building codes directly control the minimum standard of many components of a building project, and are responsible for much of the finished product quality. The new version is as shown in Figure 6.2.

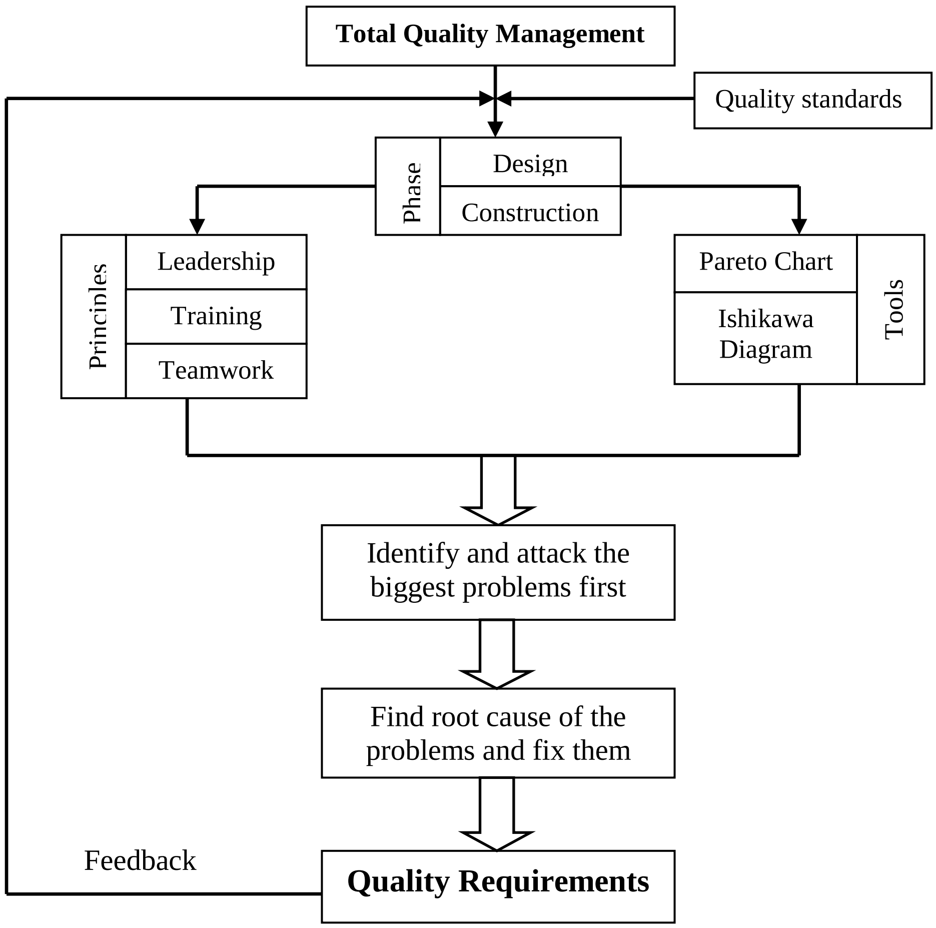

Figure 6.2: Modified version of the proposed model

Source: Author (2019)

Another comment from Company D referred to the fact that people play a key role in building construction projects. This aspect had already been included in the model, because teamwork and training involves people. Company E made observation on the structure by recommending that the box containing principles should have been combined with the principles likewise that for tools and techniques should have combined with tools and techniques. As a result of the suggestions made, the model was modified.

6.5 Summary

The development of the model has been presented (Figure 6.1) and the rationale for its development was explained. It was argued that a model provide answer of how to facilitate quality management in reinforced concrete buildings' construction. a set of requirements to develop the model was proposed and the components of the proposed model were presented in detail. The model was compared with approaches found in the literature to highlight its features together with its innovative aspects. Following the development of the model, its evaluation in five construction companies was done and the results have been presented. The results of it evaluation in the five companies were in general, positive and encouraging. Practitioners concurred that the proposed model offers a simple, easy to understand and well structured. In addition, they recognized that the model is systematic, applicable and offered practical approach. However, two minor modifications were made to the original model. A component for quality standard was added together with a component showing construction phases where quality problems normally originate. Modified version of the proposed model is as shown in Figure 6.2.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter presents summary, conclusions and recommendations of the study findings in relation to the study objectives presented in Section 1.3 of this thesis. The study aimed at investigating quality of reinforced concrete buildings in Dar es Salaam with a view to find root cause of their failure. The purpose is to develop a model to facilitate quality management of reinforced concrete building construction. This is in relation to reported cases of reinforced concrete buildings failure in Dar es Salaam, Tanzania (NCC, 2017; Rubaratuka, 2013, 2008; CRB, 2010; CRB, 2007; Muhegi and Malongo, 2005; Mlinga, 2001; Baradyana, 2000; Lema, 1996) which were attributed to poor quality. The chapter presents these findings in some detail together with identified areas that required further research.

7.2 Summary

This research was motivated by the need to curb failure of reinforced concrete buildings in Dar es Salaam. It was argued that early initiatives to improve quality performance of reinforced concrete building construction in Tanzania failed because probably they did not address root causes of the problem. The study used four objectives to achieve its purpose.

7.2.1 Summary of the Study Findings

In light of the study objectives the following summary is presented:

i. Objective one of this study set to examine structural integrity (strength) of reinforced concrete buildings in Dar es Salaam. Structural integrity of existing and collapsed multistorey reinforced concrete buildings was examined. Analysis of the results revealed that, over a half (64.2%) of reinforced concrete buildings examined in Dar es Salaam, did not meet required minimum structural strength of 25 MPa. Their average structural strength was found to be 20.2 MPa. Independent t-test showed that there was no significant defference of structural strength between collapsed and existing reinforced concete buildings in Dar es Salaam with P-value of 0.188 (Table 5.12).

ii. Objective two aimed to determine factors affecting quality of reinforced concrete buildings in Dar es Salaam. A rating opinion survey of two independent groups (Consultants and Contractors) on the influence of pre-determined factors affecting quality of reinforced concrete building construction was conducted. An analysis of the rating using Mann Whitney U test indicated that there was agreement of both groups with P-value of 0.426 (Table 5.12). The rating was used as a basis for the ranking of the factors in order of their influence. The results revealed that five factors are most critical. The factors include: poor quality management; inadequate number of trained pasonnel, non availability and use of contemporary technologies, poor coordination of key players in the construction industry both internal and external; and poor quality of construction materials particularly concrete.

iii. Objective three was to determine relationship between structural strength and quality management practice of reinforced concrete buildings' construction in Dar es Salaam. Several quality management factors that may have some influence on structural strength of reinforced concrete building were pre-determined from literature review. A rating opinion survey of two independent groups (Consultants and Contractors) on the application and practices of the pre-determined factors on reinforced concrete building construction was conducted. The pre-determined factors formed three independent variables (i.e. application level of tools and techniques, quality assurance and quality control, and level of construction supervision). On the other hand, quality of reinforced concrete buildings measured in terms of structural strength of concrete use in construction formed the dependent variable. The independent and dependent variables were used to determine the relationship between dependent and independent (predictor) variables. Through multiple regression analysis, the following relationship model was established:

$$Q = - 4.57 + 3.12\ S + 4.00\ T$$

Where: Q = Quality or buildings' structural integrity;

S = level of construction supervision;

T = application level of quality tools & techniques

iv. Objective four of the study aimed to develop a model to facilitate quality management of reinforced concrete construction in Dar es Salaam. Analysis of results has indicated that there is a need for quality improvement of reinforced concrete building construction in Dar es Salaam with potential of above 60%. A model to facilitate improvement of quality management of reinforced concrete building construction in Dar es Salaam was developed (Figure 6.2). Important aspects of the model include: leadership, education and training, and teamwork on one hand, and Pareto chart/principle and Ishikawa diagram on the other hand. Total quality management (TQM) provides principles, tools, techniques and methodology for continuous quality improvement. Pareto chart/principle and Ishikawa diagram were identified as tools for initiating quality improvement efforts. Leadership, training and teamwork were identified as TQM principles to guide the improvement efforts.

7.3 Implication to Theory

This research was built on a systems theory, for systems theory served as a foundation upon which this research was constructed. Reinforced concrete building industry considered as a system that has many different members, components, and parties and relationships between those members, components, and parties. All of the relationships within the subsystems of building construction project are interdependent on each other and can directly affect the operation of the system.

Systems theory was used to formulate the null hypothesis that, there is no relationship exist between structural integrity of reinforced concrete buildings and quality management practices. Analysis of structural integrity of reinforced concrete buildings in Dar es Salaam indicated that 64.2% of the buildings did not meet quality of structural requirements. This result is an indication of a problem, and they show that there is no proper balance in a system to achieve homeostasis. Regression analysis showed that this structural integrity results (64.2%). of the buildings has relationship to construction supervision and the level of quality tools and techniques application.

According to Lester (2005) after the entire study has been conducted, the research findings accrued from the study must corroborate, extend, or modify the existing theory that was borrowed for the study. Results of the findings corroborate the existing systems theory, because null hypothesis was rejected and it therefore, implies that relationship exists between structural integrity and quality management practices of reinforced concrete building's construction. The results is also in agreement with the study by Arditi and Gunaydin (1999) that the higher the quality management efforts the better the quality of the final product and vice versa.

7.4 Originality of the Study and Contribution to Knowledge

This section presents the originality of this research work and shows how this thesis will contribute to knowledge, which is an essential feature of a doctoral degree (Fellow &

Liu, 2008). According to Phillips and Pugh (1994 cited in Mlinga, 2001, p.157) a doctoral degree research could be regarded as making an original contribution to knowledge if the research will qualify in one or combination of the following that the research:

(i) Carries out empirical work that has not been done before;

(ii) Makes a new synthesis that has not been tried before;

(iii) Makes a new interpretation of existing material;

(iv) Tries out something in a geographical area, such as a country that has previously not been carried out in that area before;

(v) Applies a particular technique in a novel way;

(vi) Introduces substantive new evidence to an old issue;

(vii) Is cross-disciplinary and uses different methodologies; and

(viii) Adds knowledge in a way that has not previously been tried before.

This research determined relationship between structural integrity and quality management practices of reinforced concrete buildings construction in Dar es salaam, Tanzania. There is no evidence in the literature that similar research has been conducted in Tanzania, therefore, the research fits well with criterion (iv) of Phillips and Pugh (1994 cited in Mlinga, 2001, p.157) Also, this research applied TQM tools (Pareto chart and Ishikawa diagram) commonly used in manufacturing industry, to construction industry, thus, the theme fits well with criterion (v). The research fits with criterion (vi) because it established the nature of relationship that exists between structural integrity of reinforced concrete buildings and quality management practices in Dar es Salaam, hence substantiate the assumed relationship.

Coverage of the above three themes, on the one hand, justifies the study as an original PhD research. On the other hand, the study collected and analyzed data from representative sample of reinforced concrete buildings in Dar es Salaam. Results of the study together with the proposed quality model developed are expected to fill the knowledge gap identified in the literature (section 1.2) and therefore, contribute to the existing body of knowledge.

7.5 Conclusion

This study dealt with failure of reinforced concrete buildings in Dar es Salaam, Tanzania. Literature gave better anderstanding of construction problems and various methods traditionally used in manufacturing for quality improvement. The traditional method used to improve quality in manufacturing used as a base for developing a model aimed at improving quality of reinforced concrete building construction. The main argument behind this study is that early initiatives to improve quality performance of reinforced concrete building construction in Tanzania failed because probably they aimed at broad based policy issues which did not address root causes of the problem. Literature showed that research on quality in the construction industry has received little attention in comparison with other industries such as manufacturing. As a result, problems in construction grew and become chronic as noted by Koskela (1992, 1993). Researchers and governments have tried to solve some of them but there is little evidence in the literature of their practical application (Delgado, 2006). Improvement in the construction industry can help to increase quality of life in general because everybody is a customer of the industry (Ofori, 2012).

Manufacturing industry is at the frontline in developing and implements quality improvement methods (Egan, 1998), but when construction is trying to adopt some of concepts and methods that have produced quality improvement in manufacturing is challenged in the sense that construction is peculiar (Hoonakker *et al*., 2010). Most of the peculiarities of construction exist in other domains of engineering as argued by Koskela (1992). Therefore, solution of reinforced concrete buildings failure in Dar es Salaam was sought by adopting and implementing initiative for continuous quality improvement. A review of quality improvement was carried out where various methods and practices were identified and chosen for further analysis. The resultants were surveyed to determine their level of use in construction. The results revealed that the industry had paid little attention to quality management. To overcome the drawbacks found in the approaches reported in the literature and the results from the study, a model to improve quality of reinforced concrete building construction in Dar es Salaam was developed. Essentially the model provides the structure for launching quality initiaves in a planned manner and offer guidance to achieve quality goals in RC building construction. Finally the objectives set in Section 1.3 of this thesis have been achieved.

7.6 Recommendations

To improve the weaknesses identified in the study results (Fig. 5.3, Table 5.8, Table 5.10, and Table 5.11), a model based on total quality management (TQM) has been developed. The model is considered by this study to be simple and easy to use by building construction practitioners. The advantage of this model over other models that have been developed is that, it incorporates both the soft and hard side of TQM. On the soft side of TQM the model includes the principles i.e. leadership, training and teamwork which are considered important driving force for quality management initiatives, while on the hard side of TQM are the tools and techniques i.e. Pareto chart and Ishikawa diagram which are considered to be very powerful tools for quality management (Figure 3.2 and 3.3).

The TQM principles, tools and techniques in different arrangements have been applied and improved quality performance in manufacturing but very little has been applied in construction. Therefore, general recommendation is made for consultants and contractors to apply the model for use in reinforced concrete (RC) building construction to improve quality of RC buildings construction in Dar es Salaam. Quality improvement of RC building construction will eventually alleviate failure of the buildings in Dar es Salaam, hence achievement of the study objectives.

7.7 Recommendations for Further Studies

This research has concluded that construction quality is still very much a subject for further research, especially with the construction performance improvement concepts like TQM. From its findings, this study recognized areas of concern and importance to Tanzanian construction industry that could not be studied appropriately in the course of this work, hence are worthy of further study as indicated below:

1. **Perception of Total Quality Management in construction industry in Tanzania:** There is a notion that, implementing TQM principles in construction is particularly difficult and is not an easy matter. Further study can be conducted to study perception of Total Quality Management application in Tanzanian construction industry.
2. **Strategies to overcome coordination among key construction participants:** There is a concern that there is overlap of functions among established Regulatory and advisory Bodies responsible for overseeing and regulating construction activities in Tanzania. Further study can be conducted to determine factors affecting coordination among the Regulatory Bodies in construction industry in Tanzania.
3. **Safety in construction is an issue of concern in Tanzania:** Although this research focused on quality, during the survey it became evident that the industry was also concerned about safety issues. Further research is required to address this important aspect that, undoubtedly, would make the proposed model more comprehensive. Safety improvement tools would then need to be investigated in detail along with their potential roles within the construction process.
4. **Validation of the Proposed Model:** The proposed model was limited in five construction companies. Its use in practice is the best way to identify its limitations and improvement opportunities. Further study can be conducted to validate the proposed model for use in a wider area.

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APPENDICES

Appendix I: Research Schedule Cover Letter

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

Setting Trends in Higher Education, Research and Innovation

SCHOOL OF ARCHITECTURE AND BUILDING SCIENCES

DEPARTMENT OF CONSTRUCTION MANAGEMENT

Research Schedule/Structured Interview

CONSTRUCTION PRACTICE AND QUALITY ANALYSIS

FOR CURBING FAILURE OF BUILDINGS IN TANZANIA

The aim of this Research Schedule/Structured Interview is to investigate and analyze construction practice and quality of buildings constructed in Tanzania. The purpose is to develop a model to curb failure of buildings. All information provided in this Research Schedule/ Structured Interview will be used solely as empirical data to enhance the reliability of the study and achieving the research objectives. Information provided will be strictly confidential.

Researcher:	Supervisors:
Victor William Meena	1. Prof. Bernard M. Otoki.
2015	JKUAT
	2. Dr. Gerryshom Munala.
	JKUAT

Appendix II: Research Schedule/Structured Interview

SECTION 1: DEMOGRAPHIC DATA

This section requires demographic information about the individuals working for the building construction project.

1. Name of the Project …………………………………………………………………
2. Name of Contractor ………………………………………………………………...
3. Contractor is involved Yes ☐ No ☐ Not Known ☐
4. Contractor class

☐ Class I ☐ Class IV

☐ Class II ☐ Other (Please specify)

☐ Class III

7. Construction Proposal: ☐ New construction ☐ Vertical extension

8. Building function: Commercial ☐ Office ☐ Residential ☐

Others specify ☐

9. Building owner: Government ☐ Private ☐

10. Number of floors: ☐

11. Construction level: Foundation ☐ Framed structure ☐ Finishing ☐

8. Average project construction duration (Years) ☐

9. Was the project stopped from construction for any reason? Yes ☐ No ☐

10. What caused the construction to stop? ………………………………….

10. Status of construction works at the moments: In progress ☐ Stopped ☐

SECTION 2: FACTORS AFFECTING QUALITY OF RC BUILDINGS CONSTRUCTION

a) Indicate impact of the following factors as they can affect quality of reinforced concrete building construction

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate: 4 - High: 5 - Very high:

S/N	Challenges to achieve required quality of buildings	Rank Scale				
		1	2	3	4	5
1	Lack of construction supervision					
2	Lack of proper building technology					
3	Lack of coordination among key players of construction industry					
4	Deficiency in working drawings					
5	Shortage of quality construction material in the market					
6	Theft of construction materials at site					
7	Delay/ late payment to contractors/consultants					
8	Inadequate skilled and experienced technical staff					
9	Lack of Quality and Audit Policy					
10	Lack of own code of design and construction practice					
11	Reluctance to use registered contractors/consultants for building construction					

SECTION 3: QUALITY PRACTICES IN BUILDING CONSTRUCTION PROCESS

A: QUALITY TOOLS AND TECHNIQUES PRACTICE IN RC BUILDING CONSTRUCTION

Indicate the level of application of Quality Management Tools and Techniques in the project.

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate: 4 - High: 5 - Very high:

SN	Tools and Techniques	Rank Scale				
		1	2	3	4	5
1	Benefit/Cost analysis					
2	Benchmarking					
3	Design of experiment					
4	Program Evaluation and Review Technique (PERT)					
5	Quality audits					
6	Inspection					
7	Gantt/Bar Chart					
8	Pareto diagram					
9	Statistical sampling					
10	Critical path Method (CPM)					
11	Ishikawa/Fishbone					

B: QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) PRACTICE IN RC BUILDING CONSTRUCTION

Indicate the level of quality assurance and quality control practice in the project.

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate: 4 - High: 5 - Very high:

S/N	Quality assurance and control practice	Rank Scale				
		1	2	3	4	5
1	Working drawings were approved by appropriate authority before construction					
2	Construction blocks were tested before applied for construction					
3	Reinforcement bars were tested before used for construction					
4	Concrete materials were/are well cured after construction/pouring					
5	Inspection of materials and components are done before use or next stage of construction					
6	Construction works were carried out by qualified team					
7	Construction works were constantly supervised					
8	Site meetings are conducted monthly or other specified time					
9	Defects in constructed building components are constantly rectified					
10	Low quality construction materials were strictly removed from site					
11	Poor quality structural components were demolished					

C: CONSTRUCTIO SUPERVISION PRACTICE

1. Has this project been visited by staff of any Regulatory Board/ Municipal/City council?

   Yes ☐ No ☐

2. What is the frequency of visitation by the indicated authorities shown below?

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate: 4 - High: 5 - Very high:

S/No	Authority/Board	Rank Scale				
		1	2	3	4	5
1	Local Government Authorities (LGAs)					
2	Engineers Registration Board (ERB)					
3	Responsible consultant					
4	Architects and Quantity Surveyors Registration Board (AQRB)					
5	Contractors Registration Board (CRB)					
6	National Construction Council (NCC)					

SECTION 4: FACTORS INFLUENCING BUILDINGS FAILURE AND COLLAPSE (Contractors Only)

1) Indicate the level of influence of a factor to building failure and collapse.

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate:

4 - High: 5 - Very high:

S/N	Factors influencing buildings failure and collapse	Rank Scale				
		1	2	3	4	5
1	Deficiencies in building design					
2	Poor method of construction					
3	Poor or lack of construction supervision					
4	Poor workmanship					
5	Poor quality of concrete					
	Poor quality of reinforcement/rebar					
6	Disregard to building regulations, standards and specifications					
7	Overloading as a result of excessive vertical extension					
8	Incompetence of the construction team					
9	Other (Please specify)					

SECTION 4: A) FACTORS INFLUENCING BUILDINGS FAILURE AND COLLAPSE (Consultants Only)

1) Indicate only one factor that you think mostly influence collapse of buildings in Tanzania

S/N	Factors influencing buildings failure and collapse	Tick one only
1	Deficiencies in building design	
2	Poor method of construction	
3	Poor or lack of construction supervision	
4	Poor workmanship	
5	Poor quality of concrete	
	Poor quality of reinforcement/rebar	
6	Disregard to building regulations, standards and specifications	
7	Overloading as a result of excessive vertical extension	
8	Incompetence of the construction team	
9	Other (Please specify)	

SECTION 4: B) FACTORS AFFECTING QUALITY OF CONCRETE

2) Indicate impact of the following factors as they can affect quality of reinforced concrete

The Rank scale: 1 - Very low: 2 - Low: 3 - Moderate: 4 - High: 5 - Very high:

Factors affecting quality of concrete materials used for reinforced concrete buildings construction	Rank Scale				
	1	2	3	4	5
Water/cement ratio					
Concrete mixing					
Concrete compaction					
Concrete curing					
Cement content					
Quality of concrete ingredients					

SECTION 5: ANY OTHER IMPORTANT INFORMATION

Any other comments

1) Please state your opinion measures you think can enhance adequate quality in reinforced concrete construction in Tanzania.

……

2) What is your opinion on the proportion of consultants design vs. supervision fee currently applied in reinforced concrete building construction in Tanzania?

………………………………………………………………………………………………………..

Any observation

3) Observations made by a researcher at building construction site that may affect quality of final product.

…….

…….

…….

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Appendix III: Map of Tanzania

Appendix IV: Map of Dar es Salaam

Appendix V: Acceptance for data collection from Kinondoni Municipal Council

KINONDONI MUNICIPAL COUNCIL

ALL CORRESPONDENCES TO BE ADDRESSED TO THE MUNICIPAL DIRECTOR

Tel: 2170173
Fax: 2172606

In reply please quote:

Ref. KMC/R.18/1

MUNICIPAL DIRECTOR
KINONDONI MUNICIPAL COUNCIL
P. O. BOX 31902
DAR ES SALAAM

Date 30/06/2014

Mr. Victor W. Meena,
Jomo Kenyatta University of Agriculture and Technology,
P.O. Box 62000-00200,
NAIROBI, KENYA.

RE: **RESEARCH PERMIT**

Refer to the above heading.

I am pleased to inform you that your above request has been considered by the Municipal Director, and has offered you a place to research.

Upon receipt of this letter, please report to **Municipal Engineer** for commencement of your research.

Hoping to see you soon.

....
A.B.Tutuba
For: **THE MUNICIPAL DIRECTOR**
KINONDONI

Copy: Director, Board of Postgraduate Studies,
Jomo Kenyatta University of Agriculture and Technology,
P.O. Box 62000-00200,
NAIROBI, KENYA.

Appendix VI: Acceptance for data collection from Arusha City Council

ARUSHA CITY COUNCIL

(All correspondence to be addressed to the City Director)

TEL: 2508073/2503494
DIRECT LINE: 2544330
FAX: 2505013
Web site: www.arushamunicipal.go.tz
E-mail: info@arushamunicipal.go.t

HALMASHAURI YA JIJI LA ARUSHA

CITY HALL
P.O. BOX 3013
ARUSHA – TANZANIA

REF. NO. CD/R.30/32/I/VOL.II/35

10th July, 2014

JOMO KENYATA UNIVERSITY OF
AGRICULTURE AND TECHNOLOGY,
P.O. Box 62000-00200,
NAIROBI,
KENYA.

RE: RESEARCH INFORMATION FOR MR.VICTOR W.MEENA

Reference is made to your letter dated on 13th Jun 2014 with the above caption

I would like to inform you that permission is granted to the above mentioned student to conduct his research information at Arusha City Council as requested from **10th July,2014 to 10th August, 2014.**

However the research cost remains his responsibility due to financial constraints in our Council.

He should report to the City Engineer with the copy of this letter.

Regards

Hamba Y.S.
For: CITY DIRECTOR
ARUSHA

For: CITY DIRECTOR
ARUSHA CITY COUNCIL

Copy: Mr Victor W. Meena. - For information and follow up

" CENG - For supervision when the time due.

Appendix VII: Letter to Contractors Registration Board

VICTOR W. MEENA,
P.O.BOX 296,
ARUSHA.
16-06-2017

REGISTRAR,
CONTRACTORS REGISTRATION BOARD,
TETEX BUILDING,
DAR ES SALAAM.

Dear Sir,

RE: REQUEST OF ASSISTANCE FOR RESEARCH DATA COLLECTION

Reference is made on the above subject.

I am employee of Arusha Technical College. Currently I am pursuing PHD studies at Jomo Kenyata University of Agriculture and Technology in Kenya, whereby I am in a process of data collection. My research is concerning "construction practice analysis for curbing building failure in Tanzania".

With this letter, your office is requested to provide any help to assist me for smooth data collection from building construction sites in DSM. The experience I have observed from few construction sites visited is that, construction operatives at site have no or very small cooperation.

Your office is also requested to provide any other assistance or support that may render this research study successfully,

I thank you in advance.

Yours faithfully

……………………

VICTOR MEENA

CONTRACTORS REGISTRATION BOARD
16 JUN 2017

Appendix VIII: Letter from Contractors Registration Board

CONTRACTORS REGISTRATION BOARD

CRB TANZANIA

HEAD OFFICE
P.O. Box 13374
DAR ES SALAAM
Tel: 255 22 2131169, 2137963
Fax: 255 22 2137964
E-mail: crbhq@crbtz.org
Web: www.crbtz.go.tz

Ref. No. **CRB/R.10/5/VOL.VII/29** Date: 19/06/2017

TO WHOM IT MAY CONCERN

Dear Contractor,

RE: RESEARCH DATA COLLECTION

Reference is made to the above heading.

The Board is introducing to you Mr, Victor Meena an employee of Arusha Technical College and PHD student at Jomo Kenyata University of Agriculture and Technology in Kenya.

Mr. Victor Meena is undertaking his research on **"Construction practice analysis for curbing building failure in Tanzania"**

This serves to request you to assist him with some information he is collecting to enable him accomplish the research. Please note that any information requested will be used for academic purposes only.

Yours Faithfully,
CONTRACTORS REGISTRATION BOARD

D.Jere
For Registrar

HEAD OFFICE: 3RD FLOOR, TETEX HOUSE, PAMBA ROAD - DAR ES SALAAM
ZONAL OFFICE: STATION ROAD MWANZA, TANROADS BUILDING - MBEYA, SOKOINE ROAD - ARUSHA, EAST ZONE - DSM, JOSAM HOUSE MWENGE
LAPF BUILDING - DODOMA

Appendix IX: Letter to Engineers Registration Board

VICTOR W. MEENA,
P.O. BoX 296,
Mob: 0784 499269,
E-Mail: vmeena68@yahoo.com,
ARUSHA.

28-06-2017

REGISTRAR,
ENGINEERS REGISTRATION BOARD,
TETEX-BUILDING,
DAR ES SALAAM.

Dear Sir,

RE: REQUEST FOR RESEARCH DATA

Please, reference is made to the above heading and my letter dated 16-06-2017.

First, I am grateful to you and your good office for the support it has provided to me so far. As I introduced to you earlier, I am employee of Arusha Technical College, mean time I am pursuing PhD studies at Jomo Kenyatta University of Agriculture and Technology in Nairobi Kenya. For now, I am in a process of data collection and my research is about "***Construction Practice and Quality Analysis for Curbing Buildings Failure in Tanzania***".

At this critical moment of data collection, any data or information relevant for the study is very important. I know that your office has research unit of which collects and analyze various data from construction activities carried out across the country. With this letter your good office is requested once again to give help in providing any information that may render this research successful. It is known that, some information in your disposal are not for public consumption, but you are assured that any data or information that will be provided to me will be solely as empirical data for this research for academic purpose and will be strictly confidential.

I thank you in advance

Yours faithfully

....

Victor Meena

Received ERB
by Rose Shayo
28/06/2017

Appendix X: Letter to National Construction Council

VICTOR W. MEENA,
P.O. BoX 296,
Mob: 0784 499269,
E-Mail: vmeena68@yahoo.com,
ARUSHA.

23-06-2017

EXECUTIVE SECRETARY,
NATIONAL CONSTRUCTION COUNCIL
P.O. BoX 70039,
DAR ES SALAAM.

Dear Sir/Madam,

RE: REQUEST OF ASSISTANCE FOR RESEARCH DATA

Please, reference is made to the above heading.

I am employee of Arusha Technical College, mean time I am pursuing PhD studies at Jomo Kenyatta University of Agriculture and Technology in Nairobi Kenya. My research is concerning "***Construction Practice and Quality Analysis for Curbing Buildings Failure in Tanzania***" For now, I am in a process of data collection.

According to The Guardian and Citizen news papers (2013) the history of building collapse in Tanzania started in August, 1987 when a four-storey building that was under construction along Msimbazi Street in Dar es salaam collapsed. The same source revealed that, five storey buildings have collapsed between 1987 and 2013. Last incidences of building collapse occurred in 2013 when two buildings collapsed. In February, 2013 a four-storey residential building at Sinza Mori, in Kinondoni Municipality collapsed, and in March, 2013 a 16 storey building collapsed in Dar es salaam city centre killing 36 people and several others were injured. Several official committees were formed to investigate sources of these buildings failure. Any information regarding these failure and collapse, will be of good help for this study.

With this letter your good office is requested to give help in providing any information that may render this research successful. I know that some information in your disposal are not for public consumption, but you are assured that any information provided will be solely as empirical data for this research and will be strictly confidential.

I thank you in advance

Yours faithfully

....

Victor Meena

NATIONAL CONSTRUCTION COUNCIL
RECEIVED
28 JUN 2017
P. O. Box 70039
DAR-ES-SALAAM

Appendix XI: Structural strength from investigated buildings

Table 1: Structural strength from various previous investigation reports

Building S/No	Client's type	Concrete strength (N/mm^2)			Failure, building defects or cause of building investigation	Number of storey	Building status
		Low	High	Avg.			
B01	Public	18	22	20	Cracks on some of walls and columns	6	Existing
B02	Private	17	22	20	Poor workmanship (Concrete honeycombs); Cracks along walls.	9	Existing
B03	Private	13	19	16	Vertical extension failed (Low concrete strength)	6	Existing
B04	Private	10	20	15	Vertical extension failed (Weak concrete strength)	8	Existing
B05	Private	12	18	15	Doubt of structural integrity (Poor workmanship)	10	Existing
B06	Public	18	22	20	Horizontal and vertical cracks along columns and walls; concrete honeycombs	8	Existing
B07	Private	32	36	34	Vertical extension from 16 to 20 storeys failed	18	Existing
B08	Public	34	42	38	Horizontal crack along basement walls	8	Existing
B09	Public	20	30	25	Crack and budging in some of columns	6	Existing
B10	Public	36	40	38	Vertical extension passed (No defects was identified)	5	Existing
B11	Private	8	12	10	Collapsed (Weak concrete strength)	4	Collapsed
B12	Private	16	24	20	Doubt of structural integrity of the building	7	Existing
B13	Public	18	22	20	Vertical extension failed (Weak foundation)	6	Existing
B14	Public	23	27	25	Crack on some of beams and columns	8	Existing
B15	Public	20	24	22	Cracks and budging in some of building columns	8	Existing
B16	Private	22	28	25	Vertical extension passed (No defects was identified)	7	Existing
B17	Private	21	29	25	Crack on some of columns	12	Existing
B18	Private	10	18	14	Doubt of structural integrity of the building	8	Existing
B19	Private	14	16	15	Crack on some of columns and walls	6	Existing

Building S/No	Client's type	Concrete strength (N/mm^2)			Failure, building defects or cause of building investigation	Number of storey	Building status
		Low	High	Avg.			
B20	Private	15	19	17	Vertical extension failed (Weak concrete strength)	5	Existing
B21	Public	18	22	20	Vertical and horizontal cracks along some of walls	7	Existing
B22	Private	10	12	11	Collapsed (Weak concrete strength)	16	Collapsed
B23	Private	12	18	15	Vertical extension failed (Weak concrete strength)	8	Existing
B24	Private	8	12	10	Structural integrity doubt of the building	16	Demolished
B25	Public	26	34	30	Column and beam cracks	6	Existing
B26	Private	15	21	18	Cracks and budging in some of building columns	6	Existing
B27	Public	16	24	20	Doubt of structural integrity of the building	10	Existing
B28	Private	34	38	36	Vertical extension failed (Low concrete strength)	8	Existing
B29	Private	13	19	16	Poor workmanship, concrete honeycombs and cracks	8	Existing
B30	Public	23	27	25	Doubt of structural integrity of the building	7	Existing
B31	Public	20	24	22	Cracks and budging in some of building columns	12	Existing
B32	Private	13	19	16	Doubt of structural integrity of the building	8	Existing
B33	Public	18	22	20	Vertical extension failed (Weak foundation)	9	Existing
B34	Private	16	20	18	Doubt of structural integrity of the building	11	Existing
B35	Public	22	26	24	Vertical extension failed (Low concrete strength)	8	Existing
B36	Private	14	20	16	Doubt of structural integrity of the building	10	Existing

Table 2: Rebound Hammer Test results

S/N	Structural strength (MPa)
A1	20
A2	24
A3	18
A4	22
A5	24
A6	20
A7	27
A8	25
A9	17
A10	25
A11	20

Appendix XII: Evaluation of the proposed model

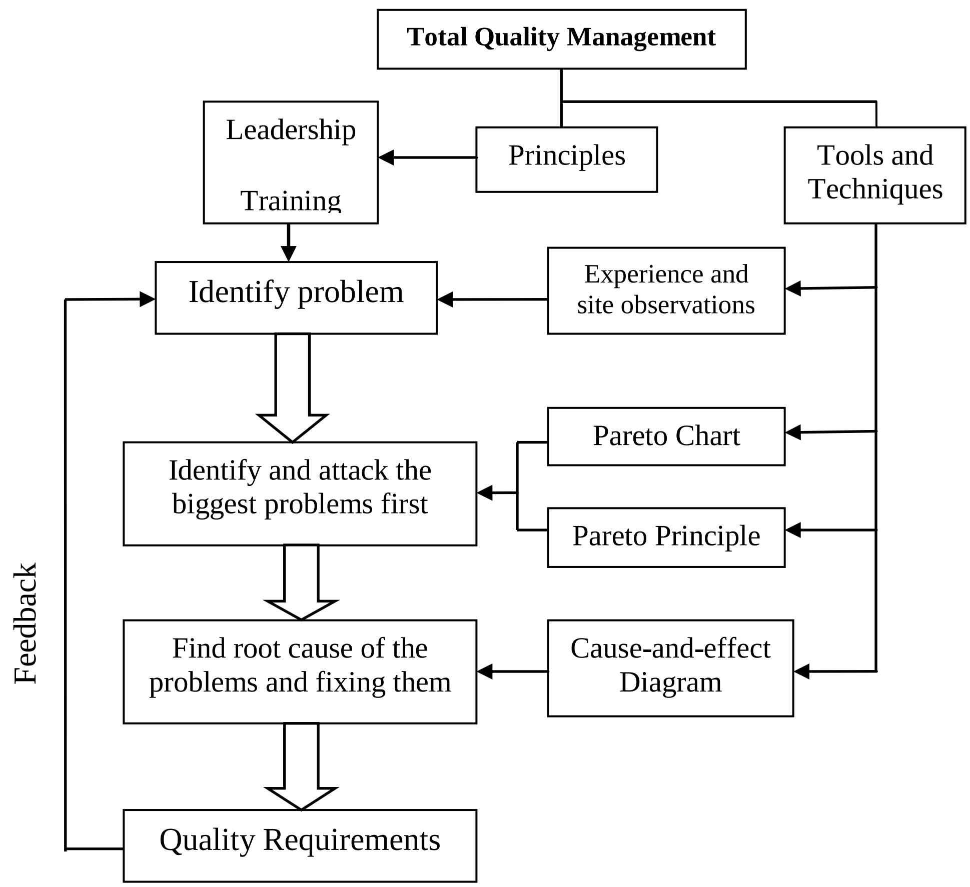

Figure 1: Quality Management Model for Building Construction

Table 1: Please evaluate the model with regard to the following requirements

Requirements	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
Simple					
Easy to understand					
Well structured					
Systematic					
Comprehensive					
Practical					
Applicable					

Any comment to improve the proposed model

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………………………………………………………………………………………………..

Thank you for participating in this study