CAUSES OF POOR QUALITY OF ROAD CONSTRUCTION WORKS: A CASE STUDY OF ROAD CONSTRUCTION PROJECTS IN BLANTYRE

MASTER OF SCIENCE IN INFRASTRURE DEVELOPMENT AND MANAGEMENT (IDM) THESIS

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BY

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Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Master of Science Degree in Infrastructure Development and Management to the Department of Mechanical Engineering, Faculty of Engineering, University of Malawi.

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September 2019

DECLARATION

I, Flora Khanje Hauya, hereby declare that this thesis is my own work and that it has not been previously submitted for assessment at another University for another qualification.

SIGNATURE : _____

DATE : _____

CERTIFICATE OF APPROVAL

We, the undersigned, certify that we have read and hereby recommend for acceptance by the University of Malawi a thesis titled '*Causes of Poor Quality of Road Construction Works: A Case Study of Road Construction Projects in Blantyre.*'

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Main supervisor : _____

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Date : _____

Co-Supervisor : _____

Signature : _____

Date : _____

Head of Department : _____

Signature : _____

Date : _____

DEDICATION

I dedicate this thesis to my late mum, Maria Paulo, who always encouraged me to work very hard in school. Her advice has made me to be what I am today. May her soul rest in eternal peace.

ACKNOWLEDGEMENTS

I would like to thank my husband and my children, Grace, Gift and Glory for their understanding during the time I was writing this thesis. I would also like to thank all the people who assisted me while I was writing the thesis.

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Above all I thank God Almighty for giving me the grace to complete my studies.

ABSTRACT

The increasing complexity of infrastructure projects and the environment within which they are delivered place greater pressure on construction managers to deliver projects on time, within budget and free from defects. A road construction project is generally considered to be successful if it is implemented within the intended budget, time and also constructed to the desired quality. However, most road construction projects in Malawi have experienced challenges in terms of quality, completion time and project cost. This study aimed at identifying causes of poor quality of road construction works in Malawi. Specifically, the study identified major defects in road works construction and their causes, analysed the identified causes and ranked them based on their influence on quality of road construction works. The methods adopted in this study included: review of literature, administration of questionnaires and Dynamic Cone Penetrometer test (DCP). The study demonstrated that poor quality of road construction in Malawi are caused by; use of lowest price tender method of procurement, lack of qualified and experienced technical personnel, quality of construction materials used during construction, corruption by site personnel and collusion in carrying out laboratory tests. In order to improve on quality of constructed roads in Malawi, it is recommended that (i) the current procurement system should be reviewed in order to ensure that contracts are awarded to deserving bidders who have the capacity to do the works. (ii) verification of test results be randomly conducted through independent accredited laboratories. (iii) thorough scrutinising of contractors applying for upgrading be enhanced by NCIC. Training institutions in Malawi need to conduct more capacity building trainings (foremanship and inspector of works) in order to avert the problem of shortage of site technical personnel.

Key words: Defects, Quality, Construction, Roads, Projects

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ABBREVIATIONS AND ACRONYMS

ASTM:	American Society for Testing and Materials
CBR:	California Bearing Ratio
GoM:	Government of Malawi
ISO:	International Organisation for Standards
FIDIC:	International Federation of Consulting Engineers
MGDS:	Malawi Growth and Development Strategy
MoTPI:	Ministry of Transport and Public Infrastructure
NCIC:	National Construction Industry Council
NRA:	National Roads Authority
PPDA	Public Procurement and Disposal of Public Assets Authority
QMS:	Quality Management Systems
RA	Roads Authority
RFA:	Roads Fund Administration
RII:	Relative Importance Index
RMI:	Road Maintenance Initiative
RUC:	Road User Charges
SPSS:	IBM Statistical Package for the Social Sciences (IBM SPSS Statistics)
TQM:	Total Quality Management
TRL:	Transport Research Laboratory

CHAPTER 1: BACKGROUND OF THE RESEARCH PROJECT

1.1 Introduction

Malawi is a land locked country which mainly depends on roads, rail, water and air for transportation of goods and passengers. Road transport handles over 90% of all international freight and passenger traffic and locally 70% of internal freight and 99% of passenger traffic are handled by road transport (Ministry of Transport and Public Infrastructure [MOTPI], 2011:25). The Malawi Growth and Development Strategy cites transport infrastructure as a priority. It is for this reason that the Malawi Government with the assistance of development partners sets aside funds for the construction, rehabilitation and maintenance of roads to enhance the transport system. A road is expected to provide the backbone to sustainable economic prosperity of a nation or region through efficient mobility of goods and services (Gautrans, 2009).

Every road construction project is unique even if there appears to be some deviations from practices and procedures that have been documented over the years. Project specifications often change with regard to scope, risks, cost, client expectations, amount of capital invested and the expected quality. According to Ali and Kamaruzzaman (2010), scope, cost, time and quality of works are the four fundamental constraints needed to be considered when managing construction projects. Delivery of a final product that meets the expected quality levels requires elimination of obstacles at every construction stage. There are different ways of constructing a road pavement each of which may be appropriate for a combination of factors like temperature, pavement thickness, material properties as well as experience of contractors (White, 2006). These factors if not controlled may result in quality of construction being compromised.

After the road has been constructed, it may deteriorate due to traffic, weather, natural ageing and physical damage. Road deteriorations affects the society as it becomes grounded and paralysed due to inability to move and transport goods and services in an economically sound road network.
A model showing general road deterioration is shown in figure 1.1 below. Accumulation of stresses on the pavement causes gradual deterioration of the pavement until the level of service becomes unacceptable.

Soon after construction, the road is in a very good condition and it deteriorates to good condition and then fair condition, then poor and very poor condition. When the road is in fair condition, it can be brought back to a good condition through resealing. However, if nothing is done it further deteriorates to a poor condition.

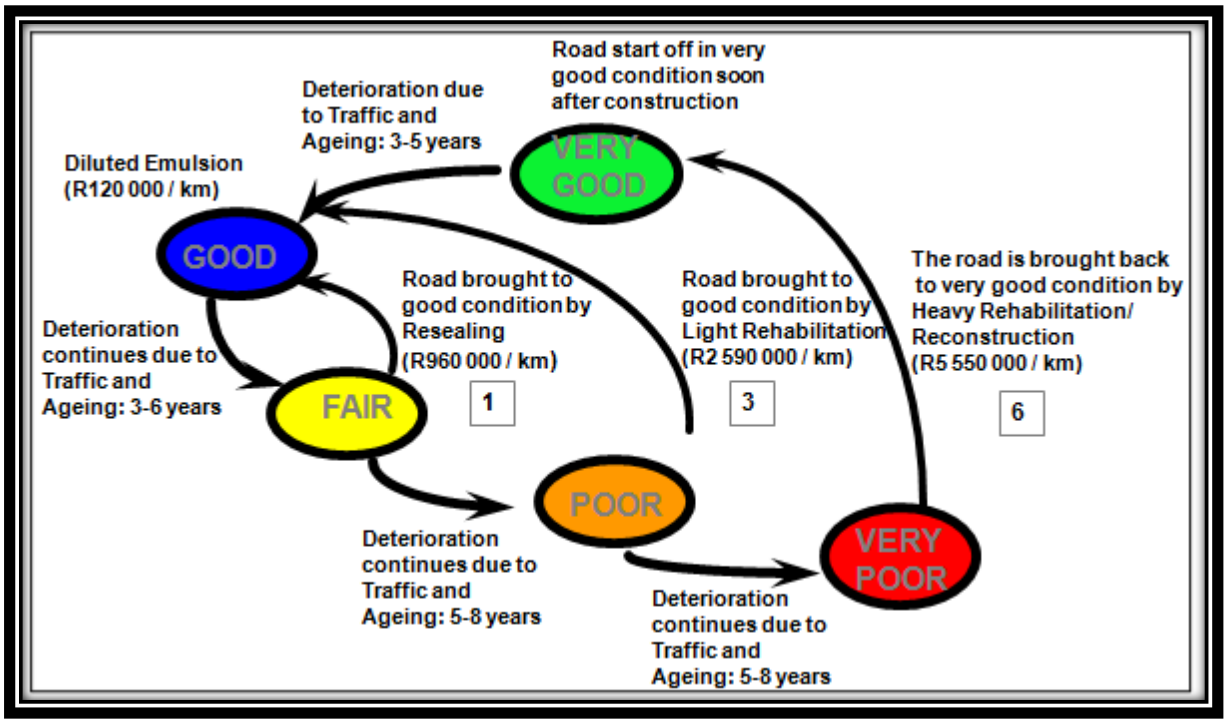

Figure 1.1: General Road Deterioration and Maintenance Model (Source: Gautrans, 2009)

The cost taking the road to good condition from poor condition becomes three times the cost of bringing it back to a good condition from a fair condition (Gautrans, 2009). When the road deteriorates to a very poor condition, the cost of maintaining it to a very good condition is six times the cost of attending to the road when it is in fair condition. At this stage the road cannot be maintained anymore but needs heavy rehabilitation or reconstruction.

In Malawi, The Roads Authority (RA) was established with the responsibility of construction, rehabilitation and maintenance of the public road network. RA carries out its mandate by outsourcing all works and services in line with Section 25(3) of Roads Authority Act. Procurement of works, goods and services is in line with the Public Procurement and Disposal of Public Assets

Act No.27 of 2017 as well as regulations and guidelines and rules published by the Public Procurement and Disposal of Public Assets Authority (PPDA).

Road construction projects if not properly managed may experience problems in quality, cost and time overruns. For a project to be successful it has to conform to these parameters as a minimum for clients' and stakeholders' satisfaction. According to Oakland and Marosszeky (2005) quality is a key competitive weapon in the construction industry as organisations compete on reputation, reliability price and delivery. When a construction company is known for poor quality product, it takes a long time to recover from that reputation. Battikha (2002) indicates that lack of quality is recognised through non-conformance of work to the requirements when construction works do not meet client's needs and specifications.

According to ISO 8402, quality is defined as the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs. In the context of construction this means the ability to meet specifications, satisfy customers' needs and achieve project objectives. ISO 8402 further defines quality control as the operation means to fulfil quality requirements while quality assurance aims at providing confidence in this fulfilment to both the organisation and customers.

Road pavements can be classified as flexible, rigid and unpaved. In this study more emphasis is on flexible pavement. A flexible pavement will bend under the load of a tyre. Failure of a pavement to withstand loading results in pavement failure. Pavement performance can be influenced by traffic loading, moisture, subgrade strength, construction quality and maintenance. Types of pavement deterioration include cracking, surface deformation, potholes and surface defects e.g. bleeding.
The study aims at analysing causes of poor quality work in road construction works undertaken by Roads Authority. It specifically (a) identifies causes of low quality (b) analyses the identified causes in order to come up with those that have high occurrence and (c) to find out whether quality management systems are used in Malawi. The study will focus on programs like road rehabilitation and bridge construction works.

Roads Authority has three regional offices and its headquarters in Lilongwe. The study will concentrate on works in Blantyre carried out by Roads Authority over the past 10 years. Interviews and questionnaires will be used in collecting information for the study.

1.2 Research Background

The construction industry in Malawi has made a significant contribution to economic growth through infrastructure development and job creation (Kamanga & Steyn, 2013). The Malawi Growth and Development Strategy cite Transport Infrastructure as a key priority in accelerating economic growth in Malawi. Roads play a very important role in transportation of goods and passengers. That is why the Government of Malawi and its development partners invest a lot of resources in construction, rehabilitation and maintenance of roads in order to facilitate socio economic development.

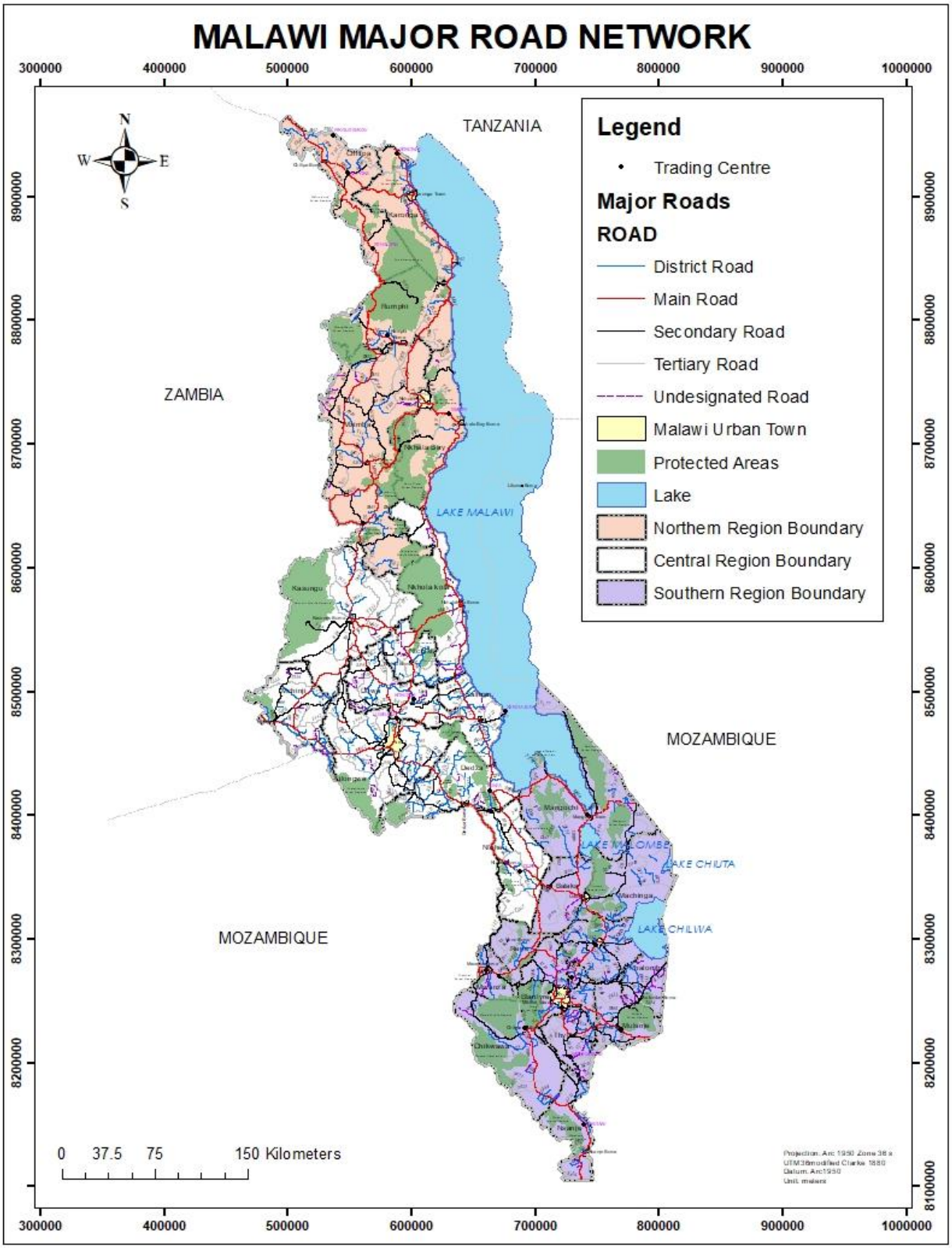

Figure 1.2: Map of Malawi Major Road Network (Source: Roads Authority)

The National Roads Authority (NRA) was created in 1996 through an act of parliament to construct, rehabilitate and maintain the public road network. In 2006 NRA was split into Roads Authority (RA) and Road Fund Administration (RFA) with RA responsible for project implementation while RFA is responsible for raising funds for the construction, rehabilitation and maintenance of public roads and administering the funds. Major constraints being faced by RA include increased construction costs, inadequate capacity of contractors and consultants, inadequate construction equipment, climate change and environmental degradation, scarcity of local construction materials such as natural gravel within the locality of some road projects and encroachment of the road reserve as some of its challenges. (RA, 2018, p. 6). These can be classified as those that impact on operations and those that influence management of projects.

1.3 Statement of the Problem

Often there has been a general complaint that most road construction projects being delivered in Malawi are of low quality. It has become a norm for politicians, the media and the general public to lament that quality of road construction works is of low standard. According to Phiri (2014), it has almost become a norm for construction projects to be completed late and with cost overruns. This is true to some extent because most works have defects that have appeared soon after completion. For example, part of the Blantyre–Zomba Road which was constructed recently has started developing potholes soon after the project was handed over to the client.

The Institution of Structural Engineers (1991) recognises that the construction industry is generally associated with a patchy reputation, with the public believing that many projects have time and cost overruns. It is important therefore that the industry should commit to good quality management if its reputation is to be improved.

Figure 1.3 and Figure 1.4 below show the potholed section of newly constructed road and the inconvenience being caused to road users on Market Street in Limbe which was rehabilitated less than 5 years ago.

Figure 1:3: Part of Newly Constructed Blantyre-Zomba Road (Limbe Section)

Figure 1:4: Market Street in Limbe

Several studies have been conducted on the three parameters of project management i.e. time, cost and quality. Of the three parameters, very little has been researched on quality of road construction

works in Malawi. In addition, very little is known on quality management approaches that are in use in the Malawi Construction industry and it is doubtful if any research has been conducted to establish whether there are any efforts being made towards promoting any of the modern quality management concepts. Hugo and Martin (2004) ague that Highway practitioners face problems for which information already exists, either in documented form or undocumented experience and practice.

This research therefore investigated causes of poor quality in road construction works in Malawi so as to come up with ways of mitigating them.

1.3.1 Sub Problems

Sub Problem 1

Most road construction projects being delivered in Malawi lack quality

Sub problem 2

Projects end up being expensive because maintenance starts earlier than expected

Sub Problem 3

Lack of technical expertise often times leads to poor quality work

Sub Problem 4

There is no proper construction quality monitoring and management system to assess quality of construction works.

1.4 Aims and Objectives

The aim of the study is to identify and analyse causes of poor quality of road construction works undertaken by Roads Authority.

1.4.1 Objective of the Study

The study seeks to achieve the above main aim by focussing on the following objectives:

i. To identify major and common defects on road works projects
ii. To identify possible causes of these defects
iii. To analyze the identified causes in order to come up with those that have a high occurrence

iv. To find out whether quality management systems are used in the road construction industry in Malawi

1.5 Significance of the Study

Malawi is a land locked country and depends largely on road infrastructure for transportation of its goods. Since the closure of Beira Railway line due to Chiromo washaway, roads have become the most important means of goods and passenger transport in Malawi (MoTPI, 2011, p. 25).

Considering that Malawi largely depends on roads as its main mode of transport, it is important that road construction, rehabilitation or periodic maintenance works are carried out within budget, time and the required quality. Any deviation from these parameters may lead to negative socio – economic consequences. It is therefore important that all barriers that affect implementation of road construction projects should be identified and analysed so that the goals set by the government concerning the Malawi Growth and Development Strategy (MGDS III) can be achieved.

In conducting its business Roads Authority ensures all work is carried out according to acceptable design standards and specifications. In order for this to be achieved there is need for research studies to analyse and understand factors that lead to poor quality works and possible solutions. From this research RA will be able to develop a quality management system in order to overcome the problems of poor quality in road construction works.

1.6 Structure of the Report

The report contains six Chapters:

i. **Chapter 1** describes the background of the study and the problems that the study seeks to address are highlighted. It further directs the reader towards the objectives that the paper seeks to achieve and the significance of achieving the objectives.
ii. **Chapter** 2 contains review of the existing literature in order to draw lessons from professional journals, books and internet search. The chapter sets the context of the research and also contains definitions for common terms related to quality.

iii. **Chapter 3** provides the methodology used for the study to achieve its objectives. It highlights the philosophy of the research, the approach, tools and techniques used to obtain data to support the findings.

iv. **Chapter 4** provides analysis and interpretation of data collected from questionnaires, tests and case study.

v. **Chapter 5** discusses the insights and findings obtained in the previous chapter leading to conclusions and recommendations on factors affecting quality of road construction works. These conclusions are the views of the researcher in relation to the objectives of the study.

vi. **Chapter 6** contains references cited in the report in alphabetical order to enable the reader locate the source of information.

The appendices contain relevant information that supports and validates the content and findings of the report which could not be placed in the main report. This information includes questionnaires and test results.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The previous chapter introduces the study by presenting the background, justification, aims and objectives of the study. This chapter reviews available literature on road construction projects in Malawi and the problems the industry is facing with regards to quality of works, defects and reworks. It also reviews literature on causes of poor quality work from previous research studies and how the studies have contributed to the body of knowledge.

2.2 Road Construction

Roads play a very crucial role in transportation of freight and passengers worldwide. It is the most dominant mode of transport and is the single largest government asset for most of the developing countries. Every year governments and developing partners invest a lot of money in construction and maintenance of roads in order to facilitate socio – economic as well as infrastructural development. An efficient and well established road network is inevitable for promoting trade and commerce in addition to providing sound transportation system in a country. As such road construction should be given the highest priority in development planning.

In Asia, Quality Assurance in construction received a lot of attention in recent years. For instance, the Singapore construction industry boomed in the early 1980s. During that time, construction was relatively labour intensive and the shortage of skilled construction workers resulted in poor workmanship in many construction projects. As a result, in 1988, the Construction Industry Board (CIDB) of Singapore began to implement a quality development strategy towards ISO 9000 standards for the construction industry.

In most SADC countries, more than 75% of the road network consists of gravel and earth roads. These roads often fulfil a potentially socio – economic function by providing access to rural areas and connecting productive agricultural areas to the primary road network. However, these rural roads suffer from a number of inherent problems. They often become impassable during the rainy season and this requires frequent grading in order to restore the riding quality. Quality is a key function in all infrastructure development projects. It is one of the important factors in any

construction project (Love and Heng, 2000). It is worth noting that poor quality affects performance and productivity aspects of construction projects.

Many researches have been carried out in both developed and developing countries to investigate factors that have a substantial effect on construction projects. A study carried out by Shobana and Ambika (2016) identified that factors that affect quality of construction projects in India include poor coordination among workers, labour shortage, late supply of materials, lack of proper inspection, lack of skilled labour, financial problems arising during construction and changes in designs. Said et al. (2009) stated that main factors affecting quality in the construction Industry in Malaysia include lack of quality awareness in project participants, lack of support from top management, improper planning and unskilled workers.

In Swaziland, a study carried out by Oke et al. (2017) showed that unexperienced subcontractors, poor supervision on site, unskilled labour, poor planning, lack of communication, poor plant and material management and design changes were some of the factors affecting quality in construction projects. A study by Oyedele et al. (2015) found that factors affecting quality in Nigeria are poor quality of construction materials, low skill workers, lack of quality assurance, poor technical knowledge of contractors, unrealistic project cost and inadequate site supervision.

According to Smallwood, (2000), lack of quality management systems in South African construction companies is among the causes of poor contractor performance. The construction Industry in South Africa is regulated by the Construction Industry Development Board (CIDB). Within CIDB structures, there is the Construction Industry Indicators (CII) that measure performance in terms of client satisfaction, health and safety, quality of work, quality of tender documents and specifications used, among others (CIDB, 2010).

2.3 Road Construction in Malawi

Road transport is the dominant mode of transport in Malawi for both freight and passenger transport. Currently roads carry 99% of all passenger transport, 70% of domestic freight and 90% of international freight (MoTPI, 2011). As a landlocked country, a reliable road access is very crucial in economic development and prosperity. The country is heavily dependent on links to regional and overseas markets for the transfer of goods which is predominantly by road.

Malawi has a total road network of 15,451km which comprises of 4,312km of paved roads representing 28% of the total road network. The rest of the road network (i.e. 72%) is of earth/gravel surface. Studies carried out in 2005 by Ministry of Transport and Public Infrastructure identified an additional 9,500km of undesignated road network that serve the rural communities. Hence the total road network will approximately be 25,000 km once the new classification has been gazetted (RA, 2018: 14).

Prior to 1998, road maintenance and construction were largely under the Ministry of Works and Supplies with funding based on appropriations from government. However, allocations of financial resources to the road sector failed to match the maintenance requirements due to economic challenges (MOTPI, 2010: 7). This led to deterioration of service delivery on road infrastructure development and management from 1990 onwards. This development led to road sector reforms which were implemented through the Road Maintenance Initiative (RMI) in 1995. The Malawi Government mandated the RMI to effectively address the development, management and funding of road infrastructure. The RMI recommendations led to the establishment of the National Roads Authority (NRA) in 1998 as an implementing agency under the Ministry of Works and Supplies.

The NRA Act was repealed in 2006 resulting in creation of two separate entities; Road Fund Administration, RFA under Act No. 4 of 2006 and Roads Authority, RA, under Act no. 5 of 2006. The Roads Authority is mandated by an Act of Parliament (Act No. 5 of 2006) to construct, rehabilitate and maintain the designated road network in Malawi. On the other hand, RFA has the responsibility of raising funds for construction, maintenance and rehabilitation of public roads and administering the funds. The primary source of road maintenance is from road user charges (RUC)

and support from the Malawi Government. RUC comprise of transit fee charges on all foreign based trucks entering Malawi and fuel levy on petrol, diesel and paraffin.

The Malawi construction industry is regulated by the National Construction Industry Council (NCIC). NCIC was created under an Act of Parliament of 1996. Its mandate is to build capacity of the construction industry. NCIC gets its funding from registration fees of contractors, consultants and charges from training courses. The Council also receives income from 1% levy which is charged on all Building and Civil Engineering projects awarded in Malawi. All contractors and Consultants practicing in Malawi are required to register with NCIC and pay subscription fees annually. The NCIC has classified the contractors into categories that will relate to the size or amount of work they can tender for and be able to perform. The categories are small scale, medium scale and large scale enterprises

2.3.1 Internal Controls within Roads Authority

RA has an Internal Audit Department which carries out technical audits on selected road construction projects. The main aim of the audits is to assess the progress of works on site and check the quality of the works to ensure that the works comply with the technical specifications as specified by the client, within the allocated budget and time frame so as to ensure that the client gets value for money on those works projects. The RA also engages external auditors whose aim is to provide assurance to the contracting authority in terms of:

i. Compliance with the contractual conditions of the works contracts and the terms of reference of the supervision contracts.
ii. The technical quality of the works executed in relation to the contracts' technical specification and expenditure made.
iii. The sound contractual management of the contracts by the supervising engineers to minimize the risk of avoidable claims, complaints, disputes and / or litigation.
iv. The existence and the compliance with the relevant procedures of contractual documents such as: Addenda and Variation Orders.

According to the technical audit reports which were sampled, the issue of poor quality works features highly. For instance, the Audit report for March 2019 recommended to RA management

to ensure that the supervision consultants are adequately providing their supervision services in order to ensure that quality is not compromised on construction projects. The report emphasized on strict supervision on works projects in order to achieve the desired quality on the works so that the client gets value for money thereby resulting in successful implementation of the works projects.

2.4 Understanding Quality in Construction

Defining quality in the construction industry is somehow difficult. However, in construction, customer satisfaction is an obvious outcome measure but most of the time this measure is not adequately quantified (Hoonaker, Caryon, & Loushine, 2010). Quality is defined as a comparison between a standard achieved and the standard required and specified, Hassan et al., (2000). However, Love, Mandal, & Li, (1999) defines quality performance as reduced rework or defects while Crosby (1979) defines quality as conformance to requirements. According to ISO 8402, quality is defined as all characteristics of an entity that bear on its ability to satisfy stated and implied needs. In terms of construction, quality means the ability to meet specifications, satisfy customer's needs and achieve project objectives.

Ardit and Gunaydin (1998), defines quality in the construction industry as meeting the requirements of the designer, constructor and regulatory agencies as well as the owner. Quality can be characterized as follows:

i. Meeting the requirements of the owner in terms of functional adequacy; completion on time and within budget; life cycle costs and operation and maintenance.
ii. Meeting requirements of the design professional through provision of a well-defined scope of work; budget to use qualified, trained and experienced staff; provision of adequate field information and timely decisions by the owner and designer and contract to perform the work at a reasonable fee and time.
iii. Meeting requirements of the constructor according to contract plans, specifications, timely provision of decisions and changing orders, timely interpretation of contract requirements from designs and contract for performance of work at a reasonable time.
iv. Meeting the requirements of the regulatory agencies in terms of public health and safety, environmental considerations, protection of public property and conformance with

applicable laws, regulations, codes and policies.

Construction projects contribute significantly to the wellbeing of the economy hence ineffectiveness of the sector has negative ripple effects on the other sectors (Milford, Hodgson, Chege & Courtney, 2000). The construction industry is very important because it provides employment for individual professionals, consultants and construction companies. It is also a key delivery mechanism for improvement for economic and social infrastructure (Latham, 1994). According to Van Wyk (2004), infrastructure development plays a significant role in poverty alleviation which was one of the key Millennium Development Goals. The construction sector also provides training to unskilled personnel who contribute to provision of innovative engineering solutions and high quality work. Thus the role of the construction industry cannot be ignored just like quality management in delivering construction projects that are efficient and fit for the purpose.

The construction industry is viewed as one that has poor emphasis on quality (Mahmood, Mohammed, Misnon, Yusuf, & Bakri, 2006). However, it is possible to ensure that in the course of project execution, quality levels are maintained. According to Frimpong (2003), infrastructure projects undergo the following stages:

i. Project brief and feasibility study phase
ii. Design and development phase
iii. Construction (Implementation) phase which involves setting up, establishing and executing works, controlling scope, time, cost and quality and resolving problems
iv. Handover or commissioning phase

Each stage has its quality requirements that influence the overall expected quality levels of the finished product (Conradie & Roux, 2008). The construction phase is critical because more parties are involved than during all the other stages. Hence this report focusses more on quality of works at the construction phase.

The construction process requires three parties namely the Owner, the Designer (consultant) and the Constructor as shown in figure 2.1 below. Each party performs three roles for the other in a cyclic manner. These roles are supplier, processor and customer. The owner supplies the

requirements to the designer; he receives the facility from the contractor and is also responsible for the operation of the facility. Ahmed, Azhar, & Castillo, (2002) shows the sequential flow of activities which indicate that construction is a process and that total quality management principles that have been applied to other processes are adopted in the construction process.

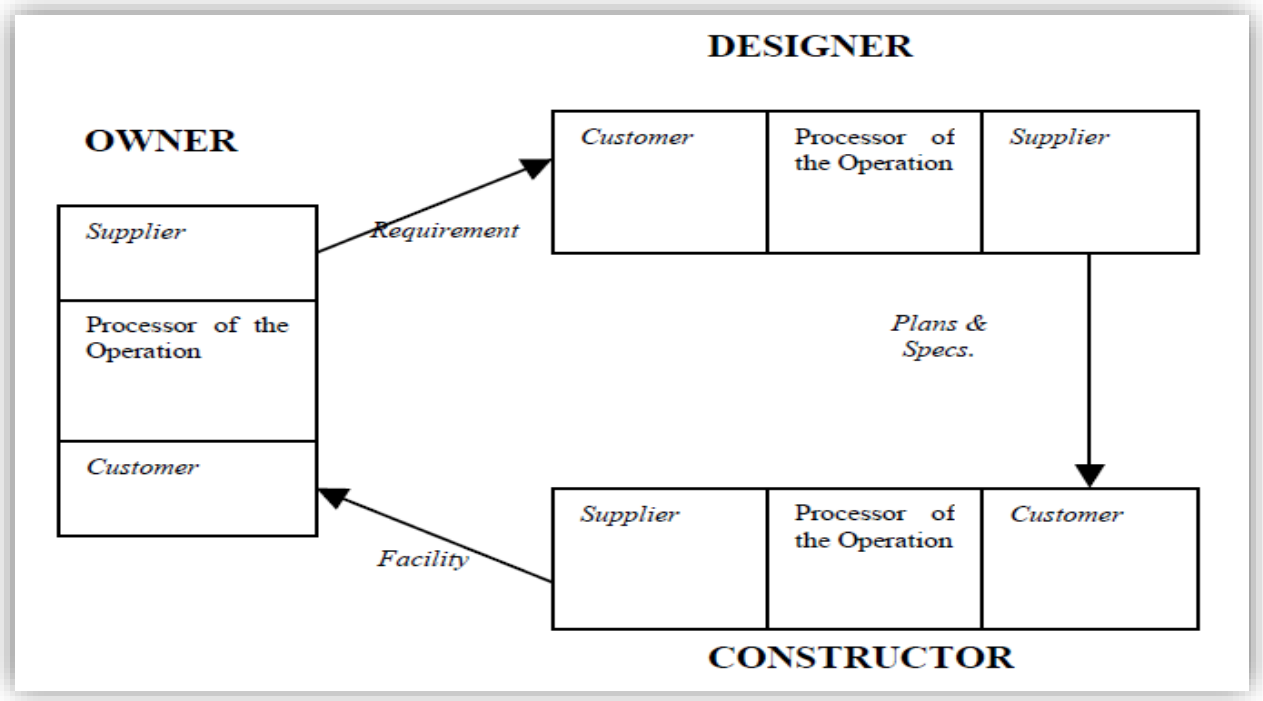

Figure 2.1: Juran's Role Concept to Construction (Source Ahmed et al., 2002)

According to Mohammed and Abdulla (2006), parties involved at the construction stage include the client, consultant, contractor, subcontractors and suppliers).

i. The client

   The role of the client is to define works to be done by giving details about the site requirements to be met in terms of time, quality and cost.

ii. The consultant

   He is the contract manager responsible for the design and supervision of the works to be carried out.

iii. The contractor

   This is the firm engaged to carry out the works up to total completion.

The survey on Quality of Construction by FIDIC within Member Associations in 2001 confirmed that failure to achieve appropriate quality of construction is a problem worldwide. The pressure to reduce initial costs of construction and supervision were found to have had an adverse effect on quality as could be predicted. The problem is serious and is evident in both developed and developing countries. Lack of quality in construction is manifested in poor or non-sustainable workmanship and unsafe structures and in delays, cost overruns and disputes in construction contracts. Sommerville (2007) observes that projects experience non-conformance related to quality which exacerbates cost and time overruns in the construction sector. This results in clients and end users not being satisfied. Lack of quality is recognized through non-conformance of work to the set standards which is evident that constructed work does not meet the client's needs and specifications. (Battikha, 2002).

Defects or failures in constructed works can result in very large costs. Reconstruction is often required even with minor defects resulting in increased costs and delays. Accidents during construction can result in personal injuries and large costs. It is the responsibility of a project manager to ensure that the job is done right the first time and that no major accidents occur on the project.

In order to control costs, most important decisions are made during planning and design stages rather than during construction. Material specifications and functional performance are decided at planning and design stage. Specification of quality requirements during design and contract documentation is very important and quality requirements should be clear and verifiable so that all parties understand requirements for conformance. Quality compliance in construction involves ensuring compliance with minimum standards of materials and workmanship. In order to ensure performance, International Organizations for Standardizations, ISO 9000 standard emphasizes good documentation, quality goals and a series of cycles of planning, implementation and review.

The construction industry has been criticized for its poor performance and productivity during the past decade as compared to other industries. As such quality management has been adopted by the

construction companies as an initiative to solve quality problems and to meet the needs of the customer (Kanji & Wong, 1998).

2.5 Road Deterioration

Construction of new roads cost a lot of money. However, if the roads are not properly maintained, they deteriorate very quickly and may require major repairs or reconstruction before expiry of the design life. Road deterioration affects road transport in general thereby affecting road users. Pavement deterioration is the process by which defects develop in the pavement under combined effects of traffic loading and environmental conditions. Major types of asphalt pavement deterioration include cracking, surface deformation, disintegration (potholes) and surface defects (e.g. bleeding). The causes of such types of deterioration include use of substandard material, low bearing capacity of subgrade, improper or no provision of drainage, lack of adequate supervision on site, faulty workmanship and tendency by contractors of cutting corners in order to maximize on profit

Research has shown how different types of roads deteriorate. It has also demonstrated that some of the most common modes of failure in the tropics are often different from those that occur in temperate regions. Climate related deterioration often dominates performance and emphasis has been on the importance of the design of bituminous surfacing materials in order to minimise this type of deterioration, Paterson (1987).

Roads deteriorate with passage of time if there is strict adherence to proper standards during construction. The rate of deterioration depends on the climate, strength of the pavement layers, traffic volume and axle loading. Changes in temperature and ingress of rain water into the pavement layers often leads to cracking of the bituminous surfacing and pavement failure. Roads will deteriorate faster if maintenance is not given priority. In most cases road maintenance has not received the priority it deserves because people think it is not important as compared to new construction. Funds meant for road maintenance have ended up being diverted to other sectors that have been considered to be more deserving thereby leading to extensive deterioration of the road network.

According to SATCC, (2006), all relevant factors that contribute to distress must be considered during evaluation of the pavement. These include traffic loading, drainage problems, non-traffic induced cracks, the action of pumping under traffic, inadequate insitu properties of pavement materials and expansive subgrades.

2.5.1 Types of Defects on Surfaced Roads

Quality of a road is mainly judged by its riding quality. According to Transport Research Laboratory (TRL), (1993) Road Note 18, roads often deteriorate due to harsh climatic conditions and lack of good pavement materials. In addition, roads suffer from accelerated failures due to high axle load, inadequate quality control during construction and inadequate funding for maintenance. Rough roads are characterized by discomfort, reduction in speed, potential damage to vehicles and increase in vehicle operating costs. American Standard of Testing and Materials (ASTM, 1999) defines roughness as deviations of a pavement from a true planned surface with characteristic dimensions that affect vehicle dynamics, riding quality, dynamic loads and drainage. Deterioration of the pavement can be due to heavy loading and the environment.

TRL Road Note 18 lists the following as some of the defects on surfaced roads:

i. Surface defects e.g. bleeding, fretting and stripping - bleeding and fatting up is due to bitumen being forced out to the surface of the road by action of traffic. Fatting up of the road is a less extreme form of bleeding leading to a very smooth surface. The problem is basically caused by variations in mixing process, over application of tack coat or secondary compaction due to traffic. Bleeding in surface dressing is mainly due to poor quality control during spray and chip operation. If neglected, the road surface becomes slippery when wet. Fretting is the progressive loss of fine aggregates from the road surface. This often leads to loss of course aggregate and formation of potholes.

   Typical repair for such areas include sanding in case of bleeding, applying a chip seal or asphalt overlay.

Figure 2.3: Surface Defect Due to Loss of Chippings

ii Cracking – Five characteristics of cracking include type, intensity, position, width and extent. There is need to establish whether the severity of cracking will affect part of any subsequent new pavement layer by causing reflective cracking. If cracks are left unsealed, they can become central point for fatigue as water seeps under the pavement. In case of surface cracking, local sealing or crack filling is recommended whereas patching is recommended where cracking is severe.

Figure 2.4: Cracking

iii Potholes – These are structural failures which include both surfacing and road base layer. Potholes are usually caused by penetration of water into a cracked surface which ends up weakening the road base. Further traffic on the road causes the surface to break up thereby causing a pothole. See figure 2.5.

Where the fatigue is not severe and is relatively stable, a thin coat of crack reflection treatment can be applied followed by an asphalt overlay. In cases where the fatigue is more severe, the area should be saw cut or excavated. The base should be repaired and asphalt replaced.

Figure 2.5: Pothole

iv Rutting is a load associated deformation and appears as longitudinal depression in the wheel paths. The other cause would be due to shear failure in the pavement layers resulting in shoving at the edge of the road pavement. See figure 2.3 below. Where rutting is not severe, filling of the ruts and depressions is recommended and where there is deep rutting, local restoration of the pavement structure is recommended.

Figure 2.6: Rutting

v Edge failure is caused by poor shoulder maintenance leading to the road pavement being higher than the shoulder. The unsupported edge is further broken down by traffic thereby narrowing the width of the road. This often leads to a compromise in road safety. This can be corrected by restoration of the pavement structure including the shoulder and drainage improvement.

2.6 The ISO 9000

The International Organization for Standardization (ISO) is the world's largest body responsible for developing and publishing standards. It is a network of 163 national standard institutes with its secretariat in Geneva, Switzerland. A number of countries ratified an agreement to recognize ISO 9000 as an International Quality System Standard in 1987. It is the world's most recognized quality system.

2.6.1 Fundamentals Principles of ISO 9000

ISO 9000 provides a framework which an organization can use to formulate and implement Quality Management Systems (QMS). It has eight fundamental principles:

i. Top management participation, commitment and leadership – The success of Quality Management System depends on commitment and level of participation of it gets from top management. There is need for top management to articulate the policy and goals of its QMS and motivate its employees. Commitment of top management is crucial in providing resources for implementation of a QMS.
ii. Continuous improvement – maintaining quality of products while getting continuous feedback from customers should be the main focus. The priority should be prevention of errors or defects in the system rather than detection as it would result in wastage of resources.
iii. Customer focus – the main aim should be to produce a product or service that meets or exceeds requirements of the customer.
iv. People Involvement – People should be involved in QMS. Goals of QMS should be aligned to employee's goals so that the people are motivated to willingly participate in the

implementation of the QMS. There is need to adequately train employees in the system and encourage them to be innovative.

v. Ensure fast and timely response – It is important that errors identified in the system should be followed up with prompt action. A good QMS should give employees enough authority and empowerment to make decisions on quality improvement on behalf of the organization.

vi. Fact based actions – A good QMS should have systems for data collection and be able to analyze and interpret data using statistical tools. This helps in cost reduction and prevents non-conformance. A key determinant of the success of the QMS is the quality of data collected.

vii. Supplier Relationship – A good QMS should be able to recognize that suppliers are partners in delivering superior customer value rather than competing supply chains. The production cycle will be disrupted if quality problems of the supplier affect customer's satisfaction.

viii. A quality culture – True quality can be achieved by creating a culture that appreciates quality. A good QMS therefore needs to have measures aimed at creating quality culture in an organization.

2.7 Quality Assurance

According to Woodward (1997), Quality Assurance is described as the approach adopted by an organization to demonstrate that its work is carried out within strict quality procedures. Quality Assurance is concerned with making sure that quality is what it should be. ISO 8402 defines quality assurance as all planned and systematic activities implemented within the quality system and demonstrated as needed for providing adequate confidence that an entity will fulfil requirements for quality According to PMI (2004), quality assurance involves evaluation of overall project performance on a regular basis in order to have confidence that the project will satisfy the relevant quality standards. The Manual for Professional Practice for Quality in the Construction projects however, defines quality assurance as a program covering activities necessary to provide quality of works in order to meet project requirements. This involves establishing project related policies, procedures, standards, training guidelines and system necessary to produce quality. Quality Assurance provides protection against quality problems through early warning of trouble ahead.

A service may be of superior performance but not conforming to specifications. However, a product or result that does not fully conform to all specification requirements does not necessarily constitute a failure. Josephson (1994) used the word defect instead of rework and defined a defect as non-fulfilment of intended usage requirements. Defects can be corrected while others cannot, however the uncorrected defects may have consequent costs later.

Love et al. (1999) defines rework as the unnecessary effort of redoing a process or activity that was incorrectly implemented first time. Terms like errors, omissions, check orders, failure, damage, defects, and variations are all attributes of rework. Good quality work reduces incidences of rework and also determines client's satisfaction.

2.8 Quality Control

ISO 9000 defines quality control as set of basic elements enabling implementation of quality of product in an economically efficient manner while ensuring customer satisfaction. According to Project Management Institute (PMI) (2000), quality control involves monitoring of specific project results to determine if they comply with relevant quality standards and identification of ways to eliminate causes of unsatisfactory performance. It is important to check whether materials and work done by a contractor meets technical requirements specified in the contract document. Quality control is usually done by consultants' field staff whose job is to be on site and to supervise the contractor during execution of works.

The construction industry has often confused TQM with Quality Control (QC) and Quality Assurance (QA) by believing that compliance with quality assurance standards such as ISO 9001 and 9002 is same as application of TQM in construction projects (Jaafari, 2001). QA and QC are part of sub elements of Total Quality (TQ). They are applied during project implementation while TQM is a strategic philosophy adopted by an organization and implemented on a continuous basis even if the organization is waiting to perform a new project (Harrington & Voehl, 2012).

2.9 Total Quality Management (TQM)

According to Lee and Chen (2011), TQM is an organizational wide quality management approach that places emphasis on leadership commitment, continuous improvement and elimination of

wastes with the aim of increasing customer satisfaction. This paradigm has gained usage in the construction industry besides being widely applied in the manufacturing sector. Joiner (2006) defines TQM as an organization's strategy for improving product and service quality. According to Mohammed and Abdulla (2006), implementation of TQM at project level lags that at company level and many failures are attributed to a misunderstanding of TQM as well as perception that TQM is for manufacturing only. Ahmed et al. (2002), further shows that construction is a process and that TQM principles that have been applied to other processes can be adopted in the construction industry.

Contractors who use TQM reported higher customer satisfaction, improved schedule performance, improved relationships with architect / engineering firms and reduced rework (McIntyre & Kirshenman, 2000). However, implementation of TQM is difficult because of lack of standardization and the many parties involved (Hoonaker et al., 2010). TQM can be a solution for problems that the construction industry is facing (Burati & Oswald, 1993). Although better construction can be achieved by applying TQM, the biggest barrier to quality implementation is the culture of the construction industry.

Figure 2.2 shows a model by Silvestro (2001) called Generic TQM model. According to the model, realization of TQM is based on six core precepts. These are Customer orientation, leadership, empowerment, and continuous improvement, elimination of waste and quality measurement. The precepts require full implementation of the peripheral precepts in a holistic manner rather than a step-wise process of implementing one precept at a time. Considering all the factors in figure 2.2, TQM can be defined as systematic management approach for an organization as a whole, comprehensive and integrated concept for attaining customer satisfaction through improvement of all the six concepts through team work and collaborative effort.

TQM is considered as binomial as one either deploys all the six precepts or does not practice TQM. Thus firms that only focus on customer orientation while ignoring empowerment are not practicing TQM.

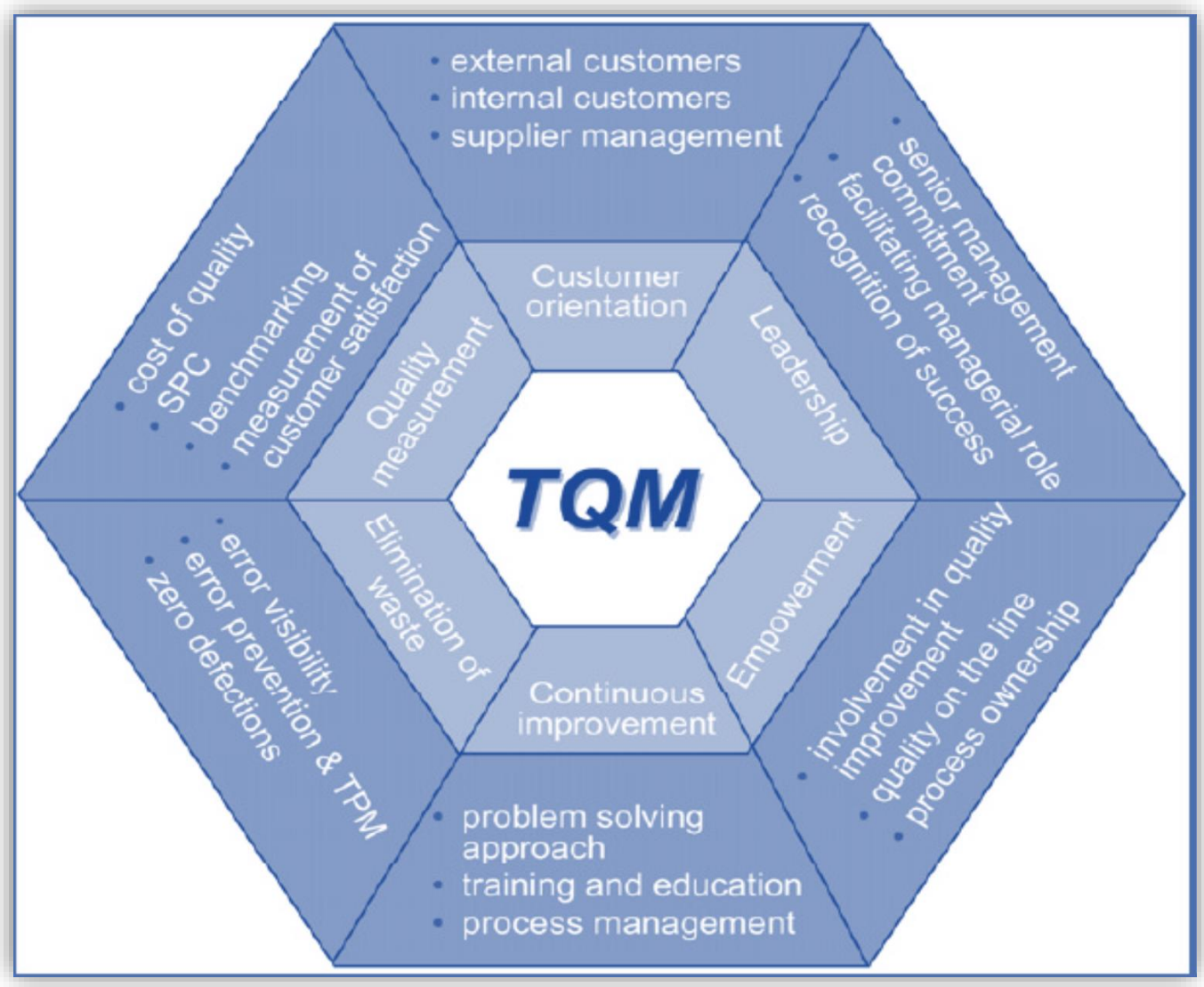

Figure 2.2: Generic TQM Model Figure 2.2 (Source; Silvestro, 2001)

Evans and Lindsay (2008) describe Total Quality by its principles, practices and techniques. All the three must work together because the principles are the foundations of the philosophy, practices are the activities used in the implementation of the principles while techniques are tools and approaches that help managers and employees to make the practices effective.

2.9.1 Total Quality Principles

Total Quality is based on three fundamental principles:

a. Focus on customers and stakeholders

   Quality of a product is better judged by customer. The organization's efforts should extend beyond meeting specifications; reduce defects and errors or resolving complaints. Employees and society represent important stakeholders. The success of an organization depends on knowledge skills, creativity and motivation of employees and partners.

b. Employee engagement and team work – According to Juran, (1988), Japan's quality achievements are due to full use of the manager's knowledge and creativity of the entire work force. Managers should give their employees tools to make good decisions, freedom and encouragement to make contributions in order to have better quality products and production processes.

c. Process focus supported by continuous improvement and learning. Continuous improvement refers to incremental changes and rapid improvements.

2.9.2 Total Quality (TQ) Practices

These are techniques by which total quality principles are managed. TQ practices can be classified into the following basic areas of management:

i. Top Management Commitment

Leadership and management commitment are essential for the success of any TQM program. Management should have a strong understanding of TQM prior to commitment. When management is committed to TQM, it will provide the necessary resources of time and money to allow for improvement (Harrington & Voehl, 2012).

It is a requirement that a quality steering committee should draft a vision and mission statement which summarizes the organization's philosophy with emphasis on customer satisfaction and quality. An advisory committee has the responsibility of establishing and developing policies and procedures for the TQM implementation process. Committee members should be able to determine the needs of the organization, opportunities for improvement and goals for improvement initiatives.

Ardit and Gunayid (1998), argue that the usual method of management practice in construction industry is management by control. All managers are given certain goals for the next year, they set goals and impose controls on each of their subordinates. Thus cost, schedule and quality goals are established for each project. Management by control encourages an organization to look inward than outward to the customer's needs.

ii. Consumer and Shareholder Focus

The main objective of TQM is to achieve customer satisfaction both internal and external. In order to achieve customer satisfaction, there is need to define the customer's needs and wants and then translate them into standards. Harrington and Voehl (2012) argue that customer satisfaction in the construction industry can be achieved by implementing the following:

- The customer must be made aware of the organization's quality management initiative
- Determine customer expectation
- Measure the customers' degree of satisfaction
- Take action to improve satisfaction

According to Ardit and Gunaydin (1998), construction projects should be considered as a process where all customers must be satisfied. The requirements of the owner should be defined clearly at the beginning of the project and agreed to by both the owner and the consultant. Setting of objectives at the beginning is important because it provides a focus for definition of scope, design process, controls construction process and motivation of the project team.

iii. Employee involvement and Focus – top management applies participative management practice which encourages employees to contribute ideas towards identifying and setting organization goals, solving problems and decision making (Ardit & Gunaydin, 1998). In this regards management should encourage suggestions and implement a procedure for taking action on the suggestions. Failure of management to

act on suggestions within a reasonable time discourages employees from spending time in preparation of their suggestions. Harrington and Voehl (2012) suggests elimination of fear because fear makes employees reluctant to submit the suggestions Thus fear prevents employees from being involved.

iv. **Subcontractor and Vendor Involvement –** subcontractors and their workers are critical to quality initiatives by the main contractor. Subcontractors are the ones who actually carry out the work on site. There is need to break down barriers to communication and make the subcontractors understand that TQM is beneficial to both the subcontractor and main contractor so that they can both achieve cost savings and increase on profits (Pheng & Ke-Wei, 1996). The main contractor should have a top – bottom commitment to quality management and ensure that subcontractors understand TQM by translating into a friendly language. There is also need to maintain close and long term relationship with suppliers so as to achieve the best economy and quality.

v. **Cost of Quality –** Cost of quality is considered as the primary tool for measuring quality (Ardit & Gunaydin, 1998). Cost of quality is used to track effectiveness of the TQM process, select quality improvement projects and provide cost justification.

vi. **Training –** There should be customized training plans for management, engineers, technicians and support staff (Smith, 1988). Quality should be everyone's responsibility and that training must be targeted for every level of the organization. Any training should include orientation to basic concepts and procedures of TQM. According to Harrington and Voehl (2012), training program should include cause and effect analysis, team problem solving, interpersonal communication and interaction, cost of quality measurement and collection and evaluation of quantitative information.

2.9.3 Total Quality Techniques

These include a variety of tools and statistical methods to plan work activities, data collection, and analysis of results, monitoring progress and solving problems.

2.10 Benefits of TQM Implementation

According to Love et al. (2004), a major benefit of initiating a TQM program is that there is an increase in awareness and focus by all employees on satisfying both internal and external customers. There is also greater focus by top management on activities and needs of lower level employees in the organization. Other benefits include:

i. Project performance in terms of reductions in rework
ii. Client satisfaction
iii. Market share
iv. Relations with customers / suppliers
v. Measurement of performance
vi. Organization competitiveness e.g. success in bidding

The study by McIntyre and Kirschenman (2000) found similar results. It was found that contractors who use TQM reported higher customer satisfaction, improved schedule performance, improved relationship with the Architect or Engineering firm and reduced rework. According to Love et al, (1999), costs associated with rework were as high as 12% of the total project costs which required about 11% of the total project working hours.

2.11 Barriers to Quality

Smallwood (2000) identifies design, construction and procurement related factors as barriers to achievement of quality as follows:

i. Design Related Factors – These include inadequate details and specifications and poor design coordination.
ii. Procurement Related Factors where more emphasis is on time and budget, shortened project periods, lack of prequalification, competitive tendering and awarding contracts based primarily on price.
iii. Construction Related Factors – These include skills shortage and insufficient work force training, lack of management commitment and lack of strict quality control.

According to Taylor et al. (2008), common obstacles in delivering quality include:

i. Lack of systematic approach to quality
ii. No system to analyze sources of quality problems
iii. Discouragement by management to report quality problems
iv. Lack of management capacity to create groups that collaborate efficiently
v. People see procedures as a deterrent to creativity and that they are there to create extra work
vi. Selection of management personnel to lead quality efforts is not based on competencies as such they are not aware of a quality culture in the organization
vii. Monopolistic nature downgrades the importance of delivering quality products
viii. The perception that top management makes all decisions renders group efforts useless and ultimately results in poor quality.

However, recently corruption is being identified as one of the major barriers to achieving construction quality in South Africa. Regionally in Sub Saharan Africa a study by the Construction Industry Development Board (CIDB, 2011) contends that high level of corruption is equally a major barrier to quality to the South African Construction industry. Prevalence of corruption throughout the procurement and project life cycle, from project identification through to monitoring and enforcement, operation and maintenance is another contributing factor to poor quality. Hawkins and Wells (2006) argue that corruption and fear of corruption is a major inhibitor to improved contractual and social performance.

In the case of Malawi, The National Anti-Corruption Strategy (2008) indicates that Malawi loses a lot of resources through corruption. Perception studies conducted by Transparency International, (TI), ranks Malawi high on Corruption Index. In 2004, Malawi was ranked 90th out of 146 most corrupt countries that were surveyed while in 2007 TI Index ranked Malawi on 118th position out of 180 countries surveyed.

More people are setting up construction firms without pre requisite experience and management skills. According to Kayanula and Quartey (2000) cited by Chilipunde (2010), lack of managerial know how and scarcity of management talent has placed a significant constraint on most small scale and medium enterprises in Malawi. There is need for small and medium scale enterprises to have

experience in the field they want to venture in. However, it has been noted that most construction companies are unable to employ qualified people and are not willing to appoint them to managerial positions although a firm's success depends on its experience and management skills. It is worth noting that sudden change in management structure undermines the contractor's ability to perform effectively.

Muya, Price, & Edum-Fotwe (2006) observes that there is an acute shortage of qualified employees in Sub Saharan Africa even though there is an abundant supply of unskilled labour force in most African countries. In addition, clients' demands are becoming complex thereby putting pressure on available skills in the construction industry due to advancement in technology.

2.12 Reasons for Poor Quality

All parties involved during construction stage must clearly understand their roles, responsibilities and limits and be able to work as a team to fulfil quality specifications as required by the client. Inefficiencies and inconsistencies that might lead to poor quality must be eliminated. The major factors that may lead to poor quality are: compromise in stages prior to construction, workmanship, procurement procedures and shortage of skilled manpower.

2.12.1 Compromise in Stages Prior to Construction

According to Hendrickson (2008) challenges to quality management at construction level can be attributed to compromises at design phase. In a case of the adopted design being inadequate, it is not automatic that the next best design will be adopted. Poor quality control measures may be due to design omissions. Designing using generic solutions without due regard to actual size and local conditions often leads to compromising during construction to suit site conditions with regard to constructability (Conradie & Roux, 2008).

On the other hand, shortage of skilled workforce during design results in adoption of 'typical designs' in a quest to save time and money. This often results in adoption and application of a generic solution to site conditions that are different resulting in preparation of tender documents with huge variations (Rwelamila, 1995). Mahmood et al. (2006) is in agreement that there are excessive variations resulting from lack of constructability of typical designs.

Kwakye (1997) calls for the design team to have experienced design personnel capable of exercising correct quality judgement and specifying unambiguous specifications and standards to be used. It is important that the construction method be known at the design stage for the design to be in line with the construction method.

2.12.2 Workmanship and Associated Challenges

Workmanship on the construction project bears attributes of formal education (Van Wyk, 2004). However, the construction industry has a large number of workers without formal education. Dlungwana, Nxumalo, van Huysten, Rwelamila, and Noyana (2002), notes that contractors face multiple challenges which lead to slow delivery of infrastructure projects. The challenges include lack of capacity for public sector institutions and contractors' personnel, low productivity, low profit margins and poor workmanship. Milford et al. (2000) cites shortage of resources and institutional weaknesses as challenges facing the construction industry in developing countries.

Although the contractors have been categorized according to size and capability, there is poor performance within each category indicated by poor quality and late completion of works. According to Egan (1998), categorizing contractors does not eliminate project oversights that result in cost overruns, losses, possible closure and poor quality management activities.

2.12.3 Procurement Procedures

The tendency to award projects to the lowest bidder in the construction industry puts the client at risk of substandard work (Ngowi, 2000). Construction projects have always been considered unpredictable in terms of completion time, completion within budget and meeting standards of expected quality. The lowest price does not translate into lowest cost and the mentality of clients that low price means low cost often leads to poor delivery of projects (Rwelamila, Talukhala, & Ngowi, 1999).

Selection of contractors exclusively based on tendered price affects quality improvement. As noted by Egan (1998), that the tendency to select constructors based on tendered price is widely seen as

one of the greatest barriers to quality improvement. The construction industry is competitive on price and not quality.

Most contractors would want to bid low and claim high (Latham, 1994). They try all they can to get a job and make profits through claims and extras as the project is in progress. This result in poor quality work, delays and cost escalations which the client may not have anticipated.

It has been observed that acceptance of lowest tender price has negative repercussions concerning achieving social objectives (Hawkins & Wells, 2006). If, however, the tender price is too low, the successful bidder may be led to cut costs by cheating on materials and other shortcuts thereby affecting quality of the product.

Late selection of subcontractors also contributes to poor quality of work. Some subcontractor will tend to make a haste to start works on site without thorough briefing. The situation could be worsened by engaging contractors or subcontractors on bonus schemes because they will concentrate their attention on the speed of production and not quality (Woodward, 1997).

2.12.4 Shortage of Skilled Manpower

Shortage of skilled and experienced manpower can affect quality due to poor supervision, incomplete designs and other project documentation, lack of coordination and organization among parties involved and general lack of efficiency (Rwelamila et al., 1999). In addition, continuously changing and mobile labour force affects continuity and quality in a project. As a result, it is necessary that the construction industry should treat its work force as its greatest asset rather than a commodity.

According to Egan (1998), there is a general a crisis with regard to training. Few people are being trained to replace the ageing skilled workforce. There is lack of mentoring and in house training for young graduates as such they gain experience at the expense of their client.

Nguluma (2005) cited by Kikwasi (2011) has shown that limited opportunity for skilled labour force to access formal training often contributes to poor quality of works, and that studies carried

out in several countries have shown that most skilled labour force learnt their trade on the job or were trained by a relation. A high illiteracy level in Sub Saharan Africa has also made formal training for most skilled tradesmen difficult. In addition, Kikwasi (2011), argues that quality of work done depends mainly on procurement of appropriate skills for both supervision and works. It is further argued that performance of the construction industry in the SADC Region affects quality of works and productivity.

Emuze and Smallwood (2011) therefore recommend recruitment of qualified graduates into responsible government positions with decision making authority so that they cannot be easily overruled by politicians who have little or no technical knowledge and / or background.

In Malawi, lack of technical skills and capacity has also affected the construction industry. The local construction industry faces problems in terms of equipment, qualified and experienced engineers and technicians for design, supervision and implementation of road infrastructure projects (RA, 2018, p. 6). This often leads to unacceptable quality of works being produced.

2.13 Implications of Poor Quality in Construction

Poor quality affects both the client and the contractor. It affects the contractor because poor quality attracts penalties through reworking on the substandard work thereby affecting productivity. Producing quality work reduces incidences of rework and leaves the client satisfied. If, however, quality related problems are concealed during construction, the problems might be exposed at a later stage of the construction process. On the other hand, client's dissatisfaction can lead to a drop in market share and profit of the construction firm that is responsible for a project through its implications with productivity (Rivas, Borcherding, Gonzalez, & Alarcon, 2011). It should be noted that non-conformance affects the contractor because it results in penalties in form of rework which can significantly affect productivity. This therefore demonstrates that quality, time, cost and productivity are always linked in construction.

According to Joubert et al. (2005), top management in construction firms in both South Africa and Botswana do not show enough commitment to quality because of a skewed focus on maximizing profit and reduction in construction period. It is further argued that in cases where management's

commitment is not clearly communicated to the workforce in terms of access to quality policy and goals of a firm, workers are not motivated to deliver work that conforms to requirements.

Poor quality of work may also arise when top management involved in a project focusses too much on minimizing cost and reducing time. Love, Holt, Shen, Li, & Irani (2002) argue that by cutting time and cost in the construction industry, management tends to ignore quality. This contradicts public sector clients who require quality more than price. Often, a client does not look at minimizing cost at the expense of quality. Commitment to quality is the main factor to focus on because management has great influence on what is happening on a project. Lack of management commitment results in lack of quality improvement. According to Pheng and Teo (2004), if management shows commitment to quality, the employees would logically follow suite.

In addition, the major reason for non-conformance in South African Construction is due to involvement of employees who are not well trained to deliver the required results (Emuze & Smallwood, 2011). Performance of workers to some extent is linked to their remuneration such that if their package is not good, they are not motivated to produce a quality product.

Increased use of subcontractors by main contractors also affects quality. It is evident that increased use of subcontractors leads to increased fragmentation of the construction process resulting in such subcontractors almost working in isolation. The subcontractor may aim at completing the works faster while minimizing costs by employing cheap labour. If work does not conform to standards it means that quality management and control by the main contractor is not adequate. It is evident that when work is planned and managed properly, subcontractors will be properly engaged and supervised.

Shortage of experienced monitoring and supervision staff on site affects quality of works because defects are not identified at an early stage. Van Wyk (2004), observed that supervision in South African construction is under strain due to shortage of experienced supervisory employees. This is in line with Joubert et al. (2005) findings that continuous corrective work occurs on project sites due to lack of regular monitoring and supervision or due to supervision quality being below expectations.

2.14 Barriers to Improve Quality of Works in The Construction Industry

Usually construction projects are very large, labour intensive and seldom located in the same location. As a result, there are several participants each with their own perspective and interests brought together to complete a project plan that may change several times during construction because of trying to minimize effects of weather, occupation hazards, time delays and defects.

These changes often lead to delays in completion of the construction project, complaints about quality and rework. This is in agreement with Sommerville (1994) who observes that the primary barrier to success of management system implementation is the nature of the construction process. In addition, involvement of many parties in the construction process affects quality implementation because all the parties will try to protect their own interests. The construction industry consists of three primary participants; the client, consultant and the contractor. Although the project might have a common goal, the participants might differ in what they hope to gain from the construction process. The client might want to spend as little as possible while the contractor might attempt to provide the product as efficiently as possible according to designs but also maximizing on profits.

The construction industry is also characterized by its non-standardization. Gibb and Isack (2001) define standardization as extensive use of processes or procedures, products or components in which there is regularity, repetition and a record of successful practice. There is no standard or specification that can be applied to a product since the production processes are to some extent different from each other. This leads to difficulties in quality assurance. Also changes to details of the designs of a project are typical during construction thereby putting quality at risk.

Another important barrier to quality implementation and management is the bidding process. Competitive bidding normally means that the lowest bidder gets the job. Often it is assumed that that low cost means low quality. Contractors may try to reduce allotted resources towards safety or quality management so as to maximize on profit. Acceptance of lowest bidder has negative repercussions towards achieving social objectives. If the tender price for the successful bidder is very low, the contractor may be led to cut costs by cheating on materials and taking other short cuts thereby affecting quality of the product (Hawkins & Wells, 2006). However, one of the possibilities

to overcome problems of competitive bidding is pre-qualification. Prequalification criteria require bidders to meet a minimum requirement of experience, performance, safety or management program implementation. Therefore, the main contractor can reduce the risk of working with a poor performing subcontractor by requesting evidence of an implemented quality management system which could indicate a more reliable work product.

2.15 Assessment of Road Pavement

In order to assess the adequacy of pavement layers, insitu penetration tests are carried out using either a Standard Penetration Test (SPT) or Cone Penetrometer Test (CPT). The DCP is ideal for identifying weaker subgrade, higher moisture content and changes in materials.

2.15.1 Dynamic Cone Penetrometer (DCP) Test

The DCP is an instrument which is used for rapid measurement of the in situ strength of an existing pavement constructed with unbound layers. Measurement can be done up to a depth of 800mm. Boundaries between pavements with different strengths can be identified and thickness of each layer estimated. According to Road Note 18, DCP test results from different sections that show signs of failure and those that are sound can be compared so as to identify the pavement layer which is the cause of the problem.

DCP test for determining in situ CBR is economical, simple and has the ability to provide a rapid measurement of the insitu strength of pavement layers and subgrade materials without excavating the pavement as is the case in CBR testing (Livneh, 1989).

DCP tests are designed to estimate the structural capacity of pavement layers and embankments. Livneh (1989), shows that results from penetration tests correlate well with insitu CBR values. Thus the relationship between CBR and DCP index values for any given materials is given as

$$LogCBR = 2.2 - 0.71 \times (\log DCP)^{1.5} \quad \text{.....(i)}$$

Where DCP is penetration Index in mm/blow

Figure 2.7 shows the Dynamic Cone Penetrometer. Data from a DCP test is processed to produce a penetration index which is the distance the cone penetrates with each drop of hammer. The penetration index is expressed in terms of millimetres per blow. The Penetration index can then be plotted on a layer strength diagram or directly correlated with a number of common pavement design parameters.

DCP testing can be applied to the characteristics of subgrade and base material properties. It has the ability to provide continuous record of relative soil strength with depth. A profile showing layer depth can be obtained by plotting a graph of penetration index versus depth below the testing surface.

DCP testing can be done during preliminary soil investigations to map out areas of weak material and locate potentially collapsible soils. Kleyn (1975), describes strength balance of a pavement as the change in strength of the pavement layers with strength.

According to Paige-Green and Du Plessis (2009) frequency of testing along the road depends on the purpose of the investigation, degree of variability, expected required level of confidence, road length and availability of funds. Thus, a minimum of 15 tests per uniform section is suggested.

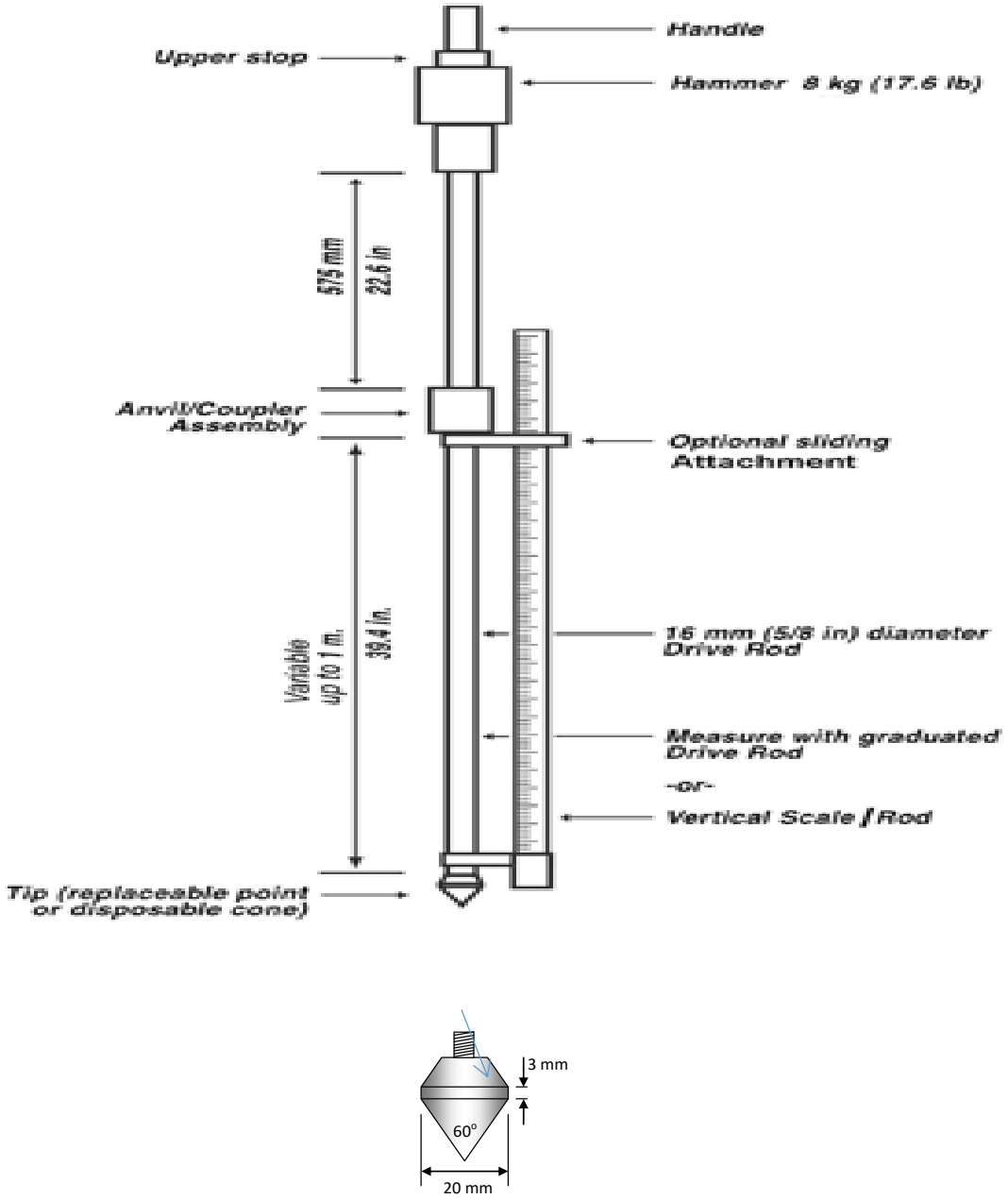

Figure 2.7: Dynamic Cone Penetrometer

The test procedure is as detailed in ASTM D6951-03. The number of blows is recorded with the depth of penetration. The DCP index is defined by the slope of the curve relating to the number of blows to the depth of penetration in mm/blow at a given linear depth segment.

The main types of surfacing being implemented in Malawi are hot mix asphalt, double chip seal and cape seal. The life of a surface treatment depends on design quality, climate pavement strength, binder durability, workmanship and adequacy of maintenance.

2.15.2 Use of DCP Test

The draft manual for Technical Methods for Highways (TMH 6), indicates some important aspects and useful tips that have to be followed during testing. These include:

i. The apparatus must always be held vertically so as to reduce friction between the falling mass and the upper rod which reduces energy imparted to the cone. If there is any deviation from the vertical, it is difficult for one to get reputable reading from the measuring staff.
ii. The hammer must just touch the base of the handle before being released. The hammer must not be thrown down but must be released to fall on its own weight.

2.15.3 Limitations of DCP Test

Main limitations that likely affect DCP test results and interpretations include:

i. Very stony materials
ii. Very hard cemented layers
iii. Roads that have been heavily patched or overlaid
iv. Highly variable pavement structures and materials
v. Old dry asphalt surfaces
vi. Poorly executed tests whereby the hammer does not fall the full distance and if there is excessive movement of the depth measuring rod.

2.16 Chapter Summary

From the literature review it is evident that a number of quality obstacles affect performance and delivery of road infrastructure projects due to the complicated, large and diverse nature of the construction industry. However, the nature of the obstacles has not been fully explored and documented.

In the case of road construction in Malawi, the writer has not been able to find data for implementation of Total Quality Management both at company and project level. There is need for a better understanding of the obstacles encountered at project level because every project is peculiar in terms of size and complexity. This therefore justifies the need for an enquiry into factors affecting quality performance in order to come up with ways of improving the quality performance in road construction projects.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter outlines methods that were used in an effort to explore factors that affect quality of works in road construction projects. Firstly, the study involved understanding the area of study through literature review and objectives of the study in order to explore commonly experienced problems associated with quality of works. The chapter also presents the process of how the roads were selected and details of how primary data collection was done. Also under discussion is the consideration of ethical issues and challenges encountered during the data collection process.

3.2 Location of the Study

This was identified through literature review. Information on roads in Blantyre constructed during the past 10 years was considered. The information included road classification, type of construction method, organisations directly involved in the construction process and key personnel involved. Figure 3.1 below shows Map of Blantyre District showing the main road network.

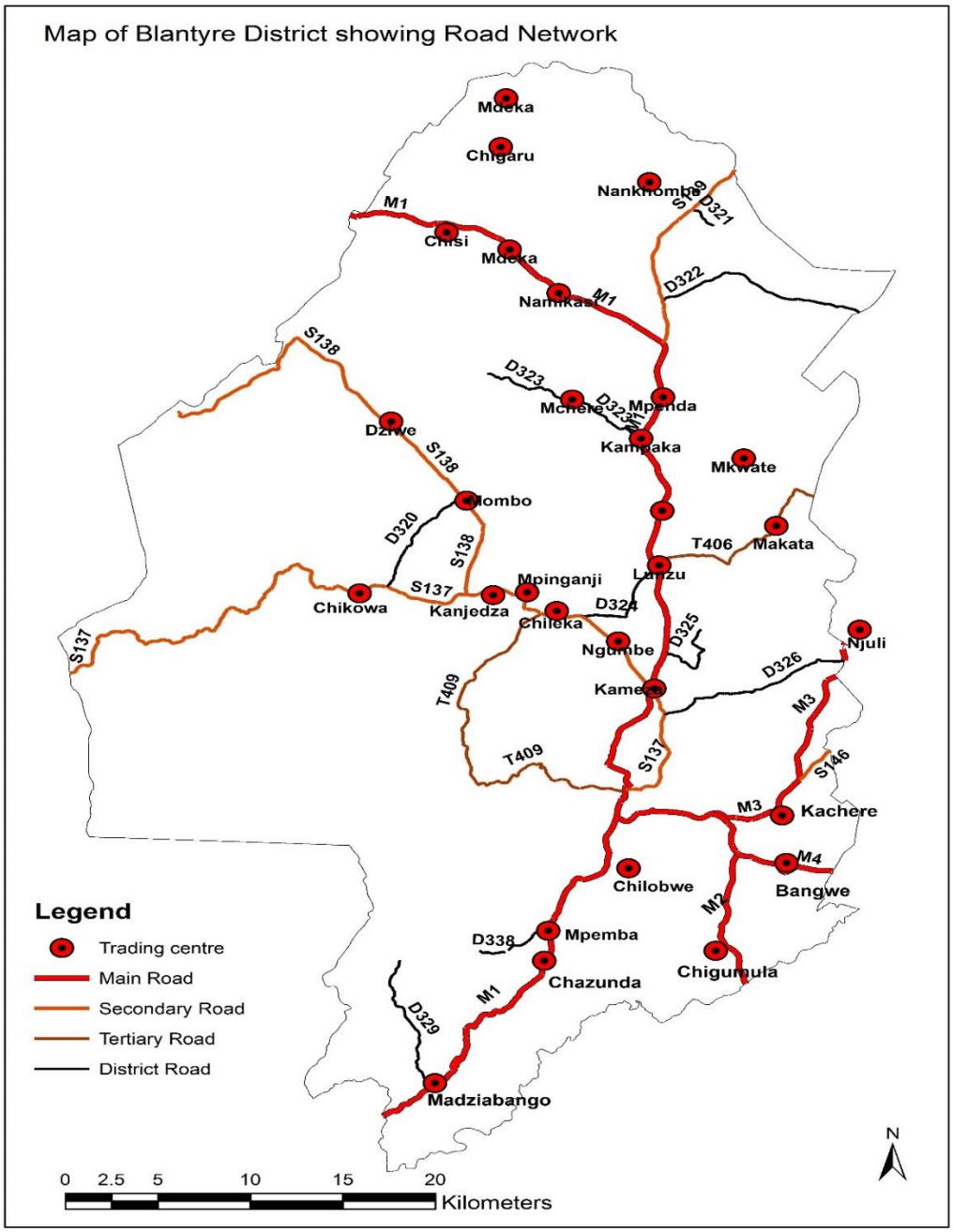

Figure 3.1: Blantyre District Road Network

The choice of the road sections from Limbe - Zomba Road (M3), Limbe – Chisitu (M4) and Limbe – Thyolo – Muloza (M2) roads out of other possible roads for the study was because (i) the roads are located within Blantyre so that the study should not be expensive. (ii) the roads are main roads

and are part of the major trade and travel route linking Malawi and Mozambique as such traffic volumes are high (iii) the method of construction was different so that the researcher would be able to relate construction method to quality of works. The selected roads have undergone maintenance in the course of their life span. Very little maintenance has been undertaken on Limbe – Thyolo road as the road is still in good condition although it was constructed more than 20 years ago. In addition, the road has crushed stone base and 50mm asphalt surfacing. The Limbe – Chisitu road has a gravel base with double chip seal surfacing while the Limbe – Zomba Road has a crushed stone base with double chip seal surfacing.

In order to get more information on the roads, the people involved in road construction and maintenance were approached to participate in the study. Information used in this study was obtained through questionnaires which were sent to contractors, consultants and client organisations. These were chosen because they have different roles in the project cycle. The roles of the clients include conceptualisation of a project and providing funding. The consultant designs and supervises the works according to specifications and the contractor is responsible for executing the works in accordance to design specifications. From contractors' side, Directors, Site Agents and foremen were selected to take part in the survey while from Consultants Team Leaders, Highway Engineers and Technicians were chosen. On the part of client organisations, Directors, Engineers and Road Inspectors were chosen.

The entire group of people, events of things of interest that a researcher wishes to investigate constitutes a study population. The target population of this research was roads that were constructed in the past twenty years (i.e. from 1995 to 2015).

3.3 Sample Frame and Size

This refers to the complete list from which a sample is drawn. In this research only main roads in Blantyre were considered. This is because the roads carry heavy traffic passing through Blantyre to surrounding districts and neighbouring Mozambique. There are three main roads that were constructed in Blantyre within the specified period. Leedy and Ormrod (2005) offers guidelines for selection of a sample size. These are:

i. For a sample population of less than 100, there is no need for sampling
ii. For a population size of around 500, 50 percent of the population should be sampled
iii. For a population size of around 1500, 20 percent of the population should be sampled
iv. Based on the above information, the target population for the survey did not require any sampling.

3. 4 Data Collection Methods

Data for this research consisted of two types, namely primary and secondary data. Primary data consists of information obtained from questionnaires and responses from engineers from contractors, consultants and client organisations. The aim was to design a simple and clear questionnaire that has limited open ended questions with a series of check boxes. The assumption was that this could be easily completed by the respondents.

Secondary data is defined by Mullins (1994) as already published data collected for purposes other than the specific research at hand. In this research secondary data was obtained through a review of existing material such as unpublished thesis, books, internet, conference papers, dissertations and journal publications related quality of road construction works. The secondary data was selected according to relevance to the research.

The information used in this study was obtained through questionnaires that were sent out to contractors, consultants and client engineers who were all expected to complete the questionnaires. The purpose of using the questionnaires was to uncover the real quality issues encountered during implementation of road projects.

The questionnaires were prepared based on the objectives of the study. To a lesser extent direct observations were done during site visits which helped in drawing conclusions for the study. Questionnaires were chosen as a means of collecting data because some of the information could only be provided by the contractors and engineers that were directly involved with the projects being studied as these are the primary sources of information. Some of the information was obtained from the client, RA in order to augment the findings of literature review and questionnaire survey.

There are a wide range of data collection methods and approaches used by researchers. These are different according to the following:

i. Observations which are done while construction is in progress or after a project has been completed
ii. direct observations, analysis of project documents or studying failures gathered from documentation on failure when oral interviews or written questionnaire is used,
iii. Paying visits to construction sites or continuous monitoring of the site
iv. Collection of data by an individual operating in the project or an outside observer

According to Bryman (2008), participant observation is considered one of the best known methods of collecting data. Quality of data obtained is different based on the method used for collecting data.

The overall quality of the research is determined by the effectiveness of data collection method. Quality of data is directly proportional to quality of the research. Carter and Fortune (2004) argues that if data is collected based on poor methods and manners the end result is a poor quality research. Choice of method for an investigation is influenced by:

i. Source and availability of resources
ii. Time required for conducting the study and responding to questions
iii. Expected response rate
iv. Expected biases
v. Type of variables
vi. Required accuracy, collection point and skills of the person collecting data.

There are a variety of research strategies for use in business and management research. These include Action, Archival, Experiments, Ethnography, Grounded theory, Survey and Case study. In this study only experimental, survey and case study have been discussed.

3.4.1 Experimental

This kind of research strategy is mostly used in scientific studies and can either be conducted in a laboratory or in a natural setting systematically. It concentrates on causal relationships where an independent variable is manipulated to observe the effects on a dependent variable (Hakim, 2000).

3.4.2 Survey

This method usually uses email or postal survey to answer the question "how much". The method is appropriate for this study as it helps in establishing levels of awareness among contractors, consultants and clients.

3.4.3 Case Study

Cohen and Manion (1995) describe a case study as follows "… the case study researcher typically observes the characteristics of an individual unit - a child, a class, a school or a community. The purpose of such observation is to analyse intensively the multifarious phenomena that constitutes the life cycle of the unit." According to Kothari (1990), a case study involves a careful and complete examination of a social unit, institution, family, cultural group or an entire community and embraces depth rather than breadth of the study.

With regard to the above definitions, the case study strategy fits well with this research in order to study and analyse the construction process so as to determine where quality is compromised. Case studies are mostly regarded as qualitative. According to Bell (2005), researchers adopting a qualitative perspective are more concerned with understanding individual perceptions of the world rather than statistical interpretations.

According to Yin (2003) there is a distinction between a case study based on a single case and the one based on multiple cases. In a single case the study focusses on one organisation or establishment while that based on multiple cases involves selection of a few organisations on which to conduct an in depth study. Case studies with multiple cases have an advantage over those with single cases because the results can be generalised while the results from single cases may only be a representation of the general situation.

In this research case study data was obtained by conducting interviews and observations. Interviews are an appropriate means of collecting qualitative data and commonly used in case studies. According to Yin (2003), interviews are essential sources of case study information principally because most case studies are human affairs and that interviews can provide insights into complex situations. Thus in this research interviews are appropriate because there is an opportunity for in depth discussions within a focused framework

The interviews were structured to ensure that there is a clear direction and theme. Interviews would also allow respondents to be able to express their views, explain individual perspectives and expand on answers.

3.5 Questionnaire development and Design

This is a method whereby data is collected by pre listing a set of questions on paper and distributing it to the identified people for responses. Depending on researcher's preference and type of the research, the questions can either be open or closed.

The method has the advantage that data can be collected from a large number of people in a short period of time and is therefore faster. Questions are tailored to meet research needs thereby ruling out unnecessary data. The method is suitable for quantitative research where data can easily be converted into charts and graphs. The method if used appropriately is inexpensive and that respondents are free to express their views as they are asked not to disclose their names.

One of the disadvantages of this method is misunderstanding of questions by respondents thereby leading to inappropriate answers. Secondly, a lot of time is needed to prepare the questions and often there is a low response rate which may even go below 50%. However, according to Lahndt (1999), the average response rate for a construction research survey is 16%. Thirdly the method is also limited to literate respondents thereby leaving out views from the illiterate. Furthermore, there is no opportunity for respondents to seek clarification where the question is not clear.

In this research the questionnaire was divided into two sections. The first section sought general information on respondents like age, gender and work experience in years. The second section

sought information on factors affecting quality of works and had three questions. The first question was on the extent to which the listed factors contribute to low quality standards. The second question was specific to contractors, consultants and clients. The third question requested respondents to provide general comments and suggestions on how the listed factors affect quality of works.

The questions were designed to gather survey data that is directly related to quality of road construction works. The questions were formulated in a simple and consistent manner to facilitate accurate feedback which is easy to interpret without distortions. Besides the closed ended questions, the respondents were asked to provide general comments related to poor quality of road construction works. The respondents were assured of confidentiality so that they should give quality feedback with no bias. The research employed a combination of closed and open questions in order to provide an overall structure to the interview (Grummitt, 1980).

The survey was conducted using a questionnaire that was sent to contractors, clients and consultants through email or hand delivery. Prior to sending the questionnaire, the respondents were called by phone to inform them about the research. This was done to personalise the questionnaire and make respondents more willing to participate in the research.

Considering that time is of essence to respondents, the rating system was developed to enable the respondents to give accurate information in as little time as possible. Three Road Inspectors from RA were asked to respond to the questionnaire so as to check if the survey methodology and questionnaire were appropriate for the study. The respondents were oriented on how to respond to the questionnaire. The pilot study was conducted in order to check the reliability and consistency of information obtained and to determine the capability of the questionnaire in providing information for the study.

Improvements in the survey methodology and the questionnaire were done following the pilot survey. Some questions which were not clear or needed clarifications were rephrased so that respondents should not be confused when responding to the questionnaire.

The researcher made several reminders to the respondents through phone calls and emails. Any questionnaire that was incorrectly completed was disregarded. A data base was created using SPSS version 20.0. Data was entered manually from the completed questionnaires into the SPSS file.

3.5.1 Primary Data Collection and Validation of Secondary Data

During the period the survey was conducted, a field check on the correctness and completeness of secondary data was done so that necessary corrections could be made. A validation exercise involving key personnel of selected companies was done. The process involved checking whether respondents had problems in understanding the questionnaire, whether there were omissions in answering the questions or any fears in proving information. Twenty respondents were randomly selected for a face to face interview in order to obtain more accurate information. The interviews were done so as to compliment the information provided by the respondents in the questionnaires and also to validate literature review findings.

3.5.2 Survey Challenges

The main challenges in the study were encountered during the time the questionnaires and interviews were being administered. Since most of the respondents were busy with other projects, they took time to respond to the questionnaire as such the researcher had to remind them several times. In some cases, the researcher had to visit their offices on several occasions in order to get the responses. This proved to be costly to the researcher because the research was not funded compelling the researcher to use her own limited resources.

The other challenge was time. The researcher had to balance time since she was working while studying at the same time. In addition, the research had to be completed within a specified time of 6 months.

This study will adopt mixed strategies in order to adequately achieve its objectives. The primary strategy will be a survey strategy using questionnaires which will be supported by a case study and DCP Tests.

3.6 Dynamic Cone Penetrometer Test (DCP)

In order to gain an in depth understanding of quality, Dynamic Cone Penetrometer Tests were carried out on three selected roads. Dynamic Cone Penetrometer Test is used for rapid in situ strength evaluation of subgrade and other unbound pavement layers. The test can also be used to identify strength and thickness of different pavement layers of newly constructed low volume roads. The method is simple, economical and requires minimum maintenance and provides continuous measurement of underlying pavement layers without excavating existing pavement as is the case with CBR tests.

A survey of trunk roads in Blantyre was carried out in order to select roads for testing. Two roads were selected in Limbe area namely Blantyre–Zomba Road (M3) and Mugabe Highway (M4) to be tested using the DCP test method. The two roads were selected because they are main roads within Blantyre City that had recently been rehabilitated. The Blantyre–Zomba Road was rehabilitated between 2013 and 2014. The final acceptance of the rehabilitated road was in March 2015. However, it was noted that potholes had already started developing on the section from Maselema Round About to Limbe Cathedral immediately after handover. The road has double chip seal surfacing with a 200 mm crushed stone base and 200mm recycled insitu subbase. Figure 3.2 below shows part of the Blantyre Zomba Road with potholes.

Figure 3.2: Potholes on Newly Constructed Blantyre-Zomba Road

The Limbe-Chisitu Road (M4) was constructed more than 14 years ago and several sections on this road have shown failures. The road has a gravel subbase and base with 25mm asphalt surfacing on the first 3km section while the rest has double chip seal surfacing. The road has developed a lot of cracks and potholes. Information sourced from Roads Authority indicates that, the road has not undergone periodic maintenance since its construction as is required. This has resulted in most of the sections developing cracks and potholes as shown in Figure 3.3.

Inventory for the road sections was collected to get information about width of the pavement, width of the shoulders, condition of the drains and thickness and type of pavement layers. DCP tests were carried out on six locations of the selected roads.

Figure 3.3: Heavily Cracked Mugabe Highway

The DCP equipment consists of upper and lower shafts. The upper shaft has an 8kg drop hammer with a fall distance of 575mm and it is attached to the lower shaft through an anvil. The lower shaft contains an anvil and a replaceable cone with a cone angle of 60 degrees. An additional rod is attached to the lower shaft which is used for taking readings.

A minimum of two operators wererequired to run a DCP test. In this case the researcher was assisted by two technicians. One person was dropping the hammer while the reseacher was recording maesurements. Figure 3.4 below was taken on site by the researcher.

An 8kg hammer was dropped from a height of 575mm and a reading was recorded after every ten blows on a standard format. The test was carried out until the cone penetrated to a sufficient depth of the subgrade. Software called UK DCP 3.1 was used to analyse the penetration data. The outputs from the software were pavement layers, thickness of each layer and CBR values with graphical cross sectional details. Typical outputs for a selected pavement section are shown in Appendix V.

Figure 3.4: DCP Test on Mugabe Highway

The DCP test gives valuable information about existing pavement structure and its future structural behaviour. Using the layer strength diagram, the DCP data was processed to give an indication of adequacy in strength of pavement layers.

3.6.1 Advantages of DCP Test

According to Paige Green and Du Plessis, 2009, advantages of DCP test include:

i. It is low cost, robust apparatus which is simple to use
ii. There is very little damage to the pavement being tested.
iii. The pavement is tested in the condition at which it performs.
iv. The test can be repeated in order to minimize errors.

However, the DCP has limitations which include:

i. The method is not suitable for very stony materials, very hard cemented layers and where the road has been overlaid or heavily patched
ii. The test can be poorly executed if the hammer does not fall the full distance, if the DCP is not vertical and if there is excessive movement of the depth measuring rod.

The following five aspects were used to control the testing as outlined by Paige-Green and Du Plessis (2009):

i. The DCP apparatus was held vertically at all times to avoid any deviation from the vertical which results in problems in getting repeatable results from the measuring staff. This is so because the friction effects between the falling mass and the upper rod leads to reduced energy impacted to the cone.
ii. The hammer was held so as to just touch the base of the handle before being released without jolting the equipment vertically. The hammer was then released to fall under its own weight.
iii. The hammer often bounces a number of times on the anvil before coming to rest when testing hard materials. As such the hammer could not be lifted for the next drop before coming to total rest.
iv. Before starting the test, the upper portion of the shoulder of the cone was made flush with the surface of the layer being tested
v. When testing hard materials, uplift or mounding of the layer around the DCP hole may occur resulting in a gradual rise of the measuring staff relative to the test apparatus and subsequent

reduction in the readings obtained. Therefore, care was taken to ensure that the base of the measuring staff was not affected by this mounding.

3.7 Data Analysis

Out of 65 questionnaires that were distributed to various contractors, consultants and clients, only 45 were completed and returned representing a 69.2% response rate. These questionnaires were evaluated in order to determine important factors that lead to poor quality works in road construction.

3.7.1 Ranking Factors Using Relative Importance Index

The Relative Importance Index (RII) was used to rank the factors that lead to poor quality works. Kamanga and Steyn (2011) used a similar method to rank causes of delays in road construction projects. It was used to rank different causes of delays from the perspective of contractors, consultants, clients and other stake holders.

Indices obtained were ranked according to each group. The cause with the highest index was the most important while that with the smallest number was the least important. The formula below was used to analyse the survey data,

$$RII = \sum_{i=1}^{5} W_i X_i \div \sum_{i=1}^{5} X_i \quad \text{.....(ii)}$$

Where i= response category index for 1 (Never), 2 (Rare), 3 (Occasional), 4 (Frequent) and 5 (Always)

Wi= weight assigned to the ith response = 1,2,3,4,5

Xi= Frequency of ith response given as a percentage of total responses for each cause.

3.8 Reliability and Validity

The use of more than two data collection techniques was done in order to achieve triangulation. The concept of triangulation is where different accounts of the same phenomena can be compared and contrasted (Saunders, Lewis, & Thornhill (2009).

3.9 Limitations and Potential Problems

The main challenge with survey questionnaire is the low response rate. Since this is an academic work, it has strict timelines which the respondents are supposed to observe. Every effort was made by sending constant reminders to respondents who were not able to respond in time in order to achieve a reasonable response rate. According to Baruch (1999), for a research involving top management, a response rate of about 35% is considered to be reasonable.

3.10 Ethical Considerations

General ethical issues were followed as indicated by Leedy and Ormrod (2010) that is, the study did not subject the respondents to harm, uninformed consent, exposure and dishonesty with professional colleagues. The researcher sought permission from relevant authorities to conduct the research and that the findings of the research would solely be used for academic purposes.

3.11 Summary

This chapter presented information on how location of the study, sample frame and size were determined. Details of how primary data collection was done, and how interviews were conducted have also been discussed. In order to get an in depth understanding of quality, Dynamic Cone Penetrometer test has also been discussed in terms of how the test was done and analysis of the results.

CHAPTER 4: RESEARCH FINDINGS

4.1 Introduction

This chapter analyses primary data which was collected through questionnaires, DCP tests and a case study. The chapter has been designed to effectively analyse data in order to fulfil the objective of the study which was to identify factors contributing to poor quality standards in road construction. Reliability test was conducted before any analysis of the data obtained from the survey in order to determine its reliability. Data analysis on demographic data was conducted in order to determine proportional representation of the gender, organisation type, general experience and particular experience. Further analysis of data was done by calculating frequencies of factors and the Relative Importance Index (RII).

The Blantyre-Zomba road and Robert Mugabe Highway were chosen as a sample for further testing using DCP test. In addition, Nasundu Bridge Construction in Blantyre rural was used as a case study to further investigate quality of works on bridge structures.

There are a lot of factors that affect quality; however, those factors deemed to have the greatest impact on quality have been investigated. Triangulation method has been used to analyse data obtained from questionnaire survey, data from Roads Authority and data from literature review so as to increase confidence in the results. The raw questionnaire survey data and survey results are shown in Appendices I to IV. The projects Archive data qualifies some of the questionnaire responses and provides the third component of triangulation process.

4.2 Determination of Reliability of Data

In order to ascertain reliability of the data source, reliability test was conducted on the primary data obtained from respondents. Reliability test was determined by evaluating Cronbach's alpha values which were obtained using a statistical software package SPSS version 20.0 (SPSS, 2011). The test was firstly done on each of the five factors identified under question 1 then on all the questions combined. Table 4.1 below shows the results of the analysis.

Table 4.1: Reliability of Test Results

Category	Cronbach's Alpha
1. Human Resource Factors	0.8
2. Construction material Factors	0.7
3. Procurement factors	0.7
4. Construction material Factors	0.7
5. Corruption during project implementation	0.8

From Table 4.1 above, it can be noted that Cronbach's Alpha values are ranging from 0.7 to 0.8. The value of Cronbach's Alpha greater than 0.7 is considered reasonable for the scale to be reliable with the sample (Pallant, 2001). Therefore, the questionnaire data can be said to be valid and reliable.

4.3 Response Rate

Out of 65 questionnaires that were distributed, 45 were responded to representing 69% response rate. After receiving the completed questionnaires, a data base was created using SPSS version 20.0. Data was entered manually from the completed questionnaires into the SPSS file.

4.3.1 Demography of Respondents

The questionnaire targeted civil engineers involved in public road infrastructure development. The respondents were asked to provide some information about themselves, their experience and the organisations they were working for. The majority of the respondents had 6-10years experience in road construction representing 49% of the population, 42% had more than 10 years' experience while only 9% had less than 5 years' experience. This implied that most respondents have considerable experience in road construction activities and are fully conversant with the current working environment in the construction industry and fully understood contents of the questionnaire. Figure 4.1 below shows the experience for the respondents.

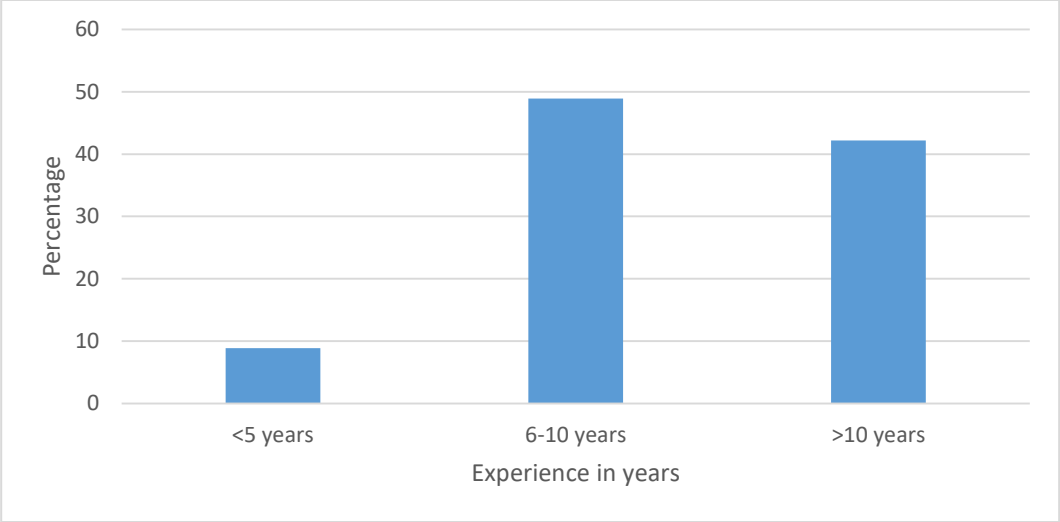

Figure 4.1: General Experience of Respondents

The respondents were in three categories namely those from the client, contractors and consultants. Majority of respondents (47%) were from contractors while 29% were from consultants and 24% were from client organisations. Figure 4.1 shows the organisation type frequencies.

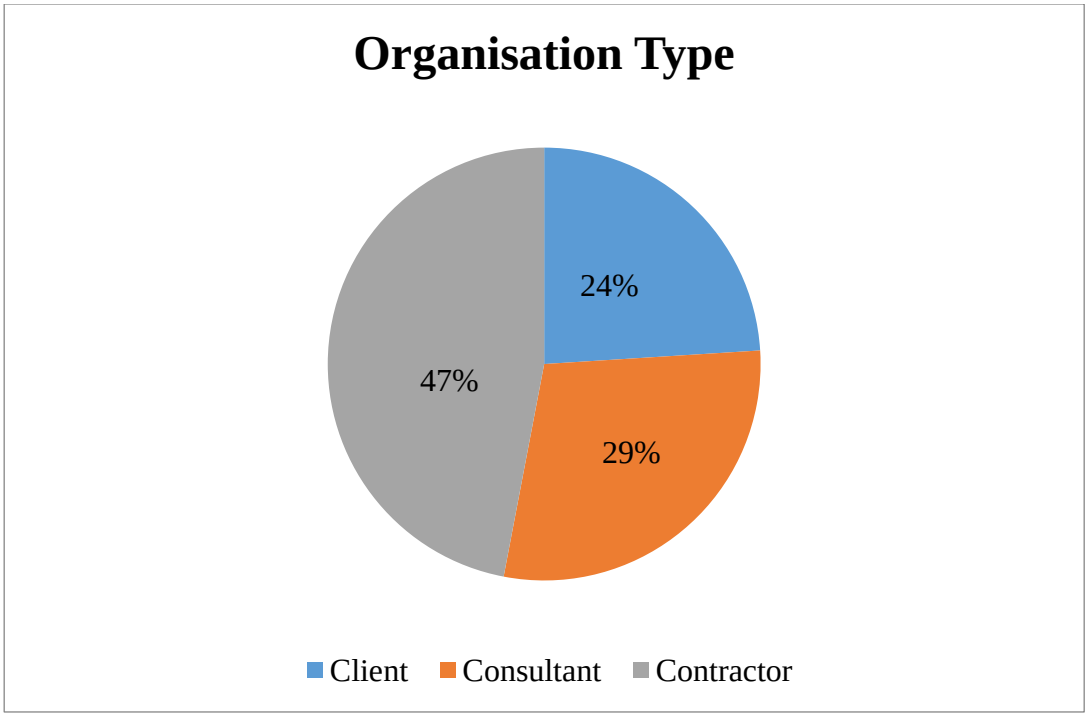

Figure 4.2: Type of Organisation for Respondents

4.3.2 Gender

The respondents were also required to state their gender and the results are shown in table 4.2. It can be noted that there is gender imbalance among the respondents such that 4 out of the 45 respondents were women representing 9% and the rest were men. This shows that the construction sector is still not attracting females as it is a male dominated sector.

Table 4.2: Respondents Based on Gender

		Frequency	Percent	Cumulative Percent
Valid	male	41	91.1	91.1
	female	4	8.9	100.0
	Total	45	100.0	

4.4 Understanding Factors That Contribute to Poor Quality of Road Works

The major factors that contribute to poor quality were identified through literature and experience of the author. These factors were presented to the respondents in order to rate them based on their significance. A five point Likert scale was used to weigh responses from respondents as shown in table 4.3 below:

Table 4.3: Likert Scale: Likert Scale

Never	Rare	Occasional	Frequent	Always
1	2	3	4	5

Where the respondent was in total agreement to the statement, it was rated 5 which stands for Always on the scale while least rating of 1 was given to Never which is a strong disagreement. In the analysis, the top two score approach was used to interpret the results. Percentage scores for frequent and always was added to determine the percentage of respondents that are in agreement to the statement. The highest score for the two added scores was taken as the overall score for the question. In this study, data will be presented in percentage format as presented by other researchers like Mukumbwa (2008) who used a similar approach in presenting data. The method has the

disadvantage of having high scores which if recorded in the negative might lead to complacency (Sambandam & Hausser, 1998). The results are as shown in Table 4.4.

From table 4.4 it can be noted that the factors with the highest ratings are under procurement factors followed by quality monitoring and human resource factors. It further shows that the factors with the highest ratings in contributing to poor quality are related to the contractor's responsibility.

Table 4.4: Frequencies and Ranking Factors

Item No.	Factors	Frequency (%)	Ranking
Question a	**Human Resource Factors**		
1	Lack of qualified personnel for contractors	71.1	2
2	Lack of qualified technical personnel for consultant	53.3	4
3	Lack of qualified personnel for client	22.2	6
4	Failure by contractors to employ engineers	73.3	1
5	Failure by consultants to employ engineers	42.2	5
6	Non Availability of consultant staff on site	60	3
b	**Construction material Factors**		
7	Suitable material not available	38	5
8	Suitable material available at very long distance	53.3	1
9	Available material not meeting specifications	51.1	2
10	Lack of knowledge in stabilising proportions & procedures	46.7	3
11	Available material being sold at exorbitant prices	42.2	4
c	**Procurement Factors**		
12	Contractors' pricing too low (ODPP's decision not to use Engineer's estimate)	95.6	1
13	Contractors' pricing not realistic	91.1	3
14	Non performance due to low pricing	93.3	2
14	Contractors compromising on quality in order to make profits	91.1	3
15	Lack of data base for non performing contractors	40	6
16	Failure by contractors to give correct information on firms capacity	55.6	5
17	Self interest in procurement process	33.3	7
18	The delays in procurement affect overall project implementation	66.7	4
19	Contractors not conversant with specifications during tendering	55.6	5
d	**Quality Monitoring Factors**		
20	Most laboratories using old equipment in testing of materials	51.1	4
21	Lack of proper monitoring by supervisory staff	60	3
22	Lack of expertise in interpretation of results	48.9	5
23	Lack of own laboratory by client for checking results	73.3	73.3
24	Theft of construction materials on site	40	6
25	Absence of monitoring guidelines for consultant's site personnel	51.1	4
26	Lack of contracts with independent labs	71.1	2
e	**Corruption Factors**		
27	Low morale / lack of motivation by site personnel	44.4	2
28	Lack of ethics	42.2	3
29	Lack of sensitization on ills of corruption	35.6	4
30	Lack of incentives	66.7	1
31	Attitude towards one profession	44.4	2

4.5 Ranking of Factors Using Relative Importance Index Method (RII)

The Relative Importance Index (RII) was used to rank the factors influencing low quality from the perspective of clients, consultants and contractors. This method has been used by many researchers like Chan & Kumaraswarmy (1997), Assaf & Al-Hejji (2006) and Kamanga & Steyn, 2011.

RII was calculated based on the responses to question 1; “to what extent do the listed factors affect quality standards”. Ranking of the attributes according to the respondents is presented in Table 4.5. The indices for the causes have been ranked for each sub question. The most important cause is the one with the highest index while the least important is the one with the smallest number.

Table 4.5: Ranking of Factors Using RII

Item No.	Factors	Relative Importance Index (RII)	Ranking
a	**Human Resource Factors**		
1	Lack of qualified personnel for contractors	0.787	1
2	Lack of qualified technical personnel for consultant	0.693	4
3	Lack of qualified personnel for client	0.617	6
4	Failure by contractors to employ engineers	0.773	2
5	Failure by consultants to employ engineers	0.631	5
6	Non Availability of consultant staff on site	0.738	3
b	**Construction material Factors**		
7	Suitable material not available	0.667	4
8	Suitable material available at very long distance	0.693	2
9	Available material not meeting specifications	0.724	1
10	Lack of knowledge in stabilizing proportions & procedures	0.680	3
11	Available material being sold at exorbitant prices	0.662	5
c	**Procurement Factors**		
12	Contractors' pricing too low (ODPP's decision not to use Engineer's estimate)	0.938	1
13	Contractors' pricing not realistic	0.88	3
14	Non-performance due to low pricing	0.898	2
14	Contractors compromising on quality in order to make profits	0.88	3
15	Lack of data base for non performing contractors	0.671	7

Item No.	Factors	Relative Importance Index (RII)	Ranking
16	Failure by contractors to give correct information on firms capacity	0.729	5
17	Self interest in procurement process	0.618	8
18	The delays in procurement affect overall project implementation	0.738	4
19	Contractors not conversant with specifications during tendering	0.693	6
d	**Quality Monitoring Factors**		
20	Most laboratories using old equipment in testing of materials	0.693	4
21	Lack of proper monitoring by supervisory staff	0.738	3
22	Lack of expertise in interpretation of results	0.667	6
23	Lack of own laboratory by client for checking results	0.809	1
24	Theft of construction materials on site	0.658	7
25	Absence of monitoring guidelines for consultant's site personnel	0.684	5
26	Lack of contracts with independent labs	0.8	2
e	**Corruption Factors**		
27	Low morale / lack of motivation by site personnel	0.662	4
28	Lack of ethics	0.684	2
29	Lack of sensitization on ills of corruption	0.596	5
30	Lack of incentives	0.733	1
31	Attitude towards one profession	0.671	3

From the analysis shown in table 4.5 the following has been demonstrated:

(a) Human Resource Factors

It has been observed that; the top five significant human resource factors that contribute to poor quality of works were as follows; lack of qualified personnel for contractors (RII = 0.787), failure by contractors to employ engineers (RII = 0.773), non-availability of consultant's staff on site (RII = 0.738), lack of qualified personnel for consultant (RII = 0.693) and failure by consultants to employ engineers (RII = 0.631).

(b) Inadequate Suitable Local Construction Material

The top five factors related to construction materials were as follows: available materials not meeting specifications (RII = 0.724), suitable material available at very long distance (RII = 0.693), lack of knowledge in stabilising proportions &procedures (RII = 0.680), suitable material not available (RII = 0.667), available material being sold at exorbitant prices (RII = 0.662).

(c) Procurement of Contracts

Factors related to procurement of contracts were as follows: contractors' pricing too low (ODPP's decision not to use Engineer's estimate) (RII = 0.938), non-performance due to low pricing (RII = 898), contractors compromising on quality in order to make profits (RII = 880), contractors pricing not realistic (RII = 0.880), the delays in procurement affect overall project implementation (RII = 738), failure by contractors to give correct information on firm's capacity (RII = 729).

(d) Lack of Quality Monitoring System

With respect to quality monitoring system, the following factors; lack of own laboratory by client for checking results (RII = 0.809), lack of contracts with independent laboratories (RII = 0.8), lack of proper monitoring by supervisory staff (RII = 0.738), most laboratories using old equipment in testing of materials. (RII = 0.693), absence of monitoring guidelines for consultant's site personnel (RII = 0.684) were identified.

(e) Corruption During Project Implementation

Corruption during project implementation had the following factors: lack of incentives (RII = 0.733), lack of ethics (RII = 0.684), attitude towards one's profession (RII = 0.671), low morale / lack of motivation by site personnel (RII = 0.662), lack of sensitization on ills of corruption (RII = 0.596).

Table 4.6 below highlights the ten most influential attributes affecting quality of road construction works. The table shows that the top four attributes are to do with contractors' pricing. This is in agreement with the findings obtained in table 4.4 above which shows that procurement related factors have the highest score indicating that they are the main cause of poor quality of construction works.

Table 4.6: Overall Ranking of Factors

Factors	Relative Importance Index (RII)	Overall Ranking
Contractors' pricing too low (ODPP's decision not to use Engineer's estimate)	0.938	1
Non-performance due to low pricing	0.898	2
Contractors compromising on quality in order to make profits	0.88	3
Contractors' pricing not realistic	0.88	3
Lack of own laboratory by client for checking results	0.809	4
Lack of contracts with independent labs	0.8	5
Lack of qualified personnel for contractors	0.787	6
Failure by contractors to employ engineers	0.773	7
Lack of proper monitoring by supervisory staff	0.738	8
Non-Availability of consultant staff on site	0.738	8
The delays in procurement affect overall project implementation	0.738	8
Lack of incentives	0.733	9
Failure by contractors to give correct information on firms capacity	0.729	10

The procurement method of awarding contracts to the lowest evaluated bidder without comparing with the Engineers' estimate leads to contractors' pricing being too low thereby contributing to poor quality of works. Selection of successful bidders for RA follows the selection criteria set aside

by PPDA which demands that contracts should be awarded to the lowest evaluated bidder without comparing with the engineers. Estimate. This often leads to poor quality of works because if the lowest priced bidder made a price related mistake, he will try to take short cuts during implementation in order to recover such expenses. Thwala and Mvubu (2008) observed that awarding contracts to Small and Medium Contractors (SMCs) who had priced below the engineer's estimate resulted in poor quality of work which did not qualify for payment. This often resulted in conflicts and eventually the SMC were forced out of business.

This is in agreement with a study by Kulemeka (2016) who demonstrated that the most critical factors that affect tender estimation by SMCs are:

- Fluctuation of currency/exchange rate, high taxes,
- Lack of technical know-how and
- Unfair competition through undercutting of contract price by bigger contractors.

4.6 Understanding Contract Management Issues

Question 2 of the questionnaire survey sought to determine how the respondents understand contract management issues during project implementation. The results have been analysed in terms of frequency of occurrence in which respondents were responding with Yes, No or Not Sure. The questions were in three categories; for clients, contractors and consultants. The results are as presented in Table 4.7 below:

Table 4.7: Responses to Contract Management Issues

Item No.	Factor / Question	Yes (%)	No (%)	Not Sure (%)
	Client Responses			
a	Does the consultant provide enough resources to his team	7	72	21
b	Does the consultant provide personnel with relevant qualifications and adequate experience	29	57	14
c	Does the consultant address issues from the client within reasonable time	43	57	0
d	Does the consultant's key staff inspect the works regularly	29	50	21
e	Does the consultant respond to the contractors requests promptly	7	86	7
f	Does the contractor submit Method Statement	21	71	7
g	Does the contractor submit Quality Management Plans	21	71	7
h	Does the contractor require minimal supervision	0	100	0
i	Does the contractor adhere to Quality Assurance plans and specifications	21.4	64.3	14.3
j	Is the contractor's work accepted the first time	21.4	64.3	14.3
	Contractor Responses			
a	Does the contract document provide enough information to be used in project execution	89	11	0

Item No.	Factor / Question	Yes (%)	No (%)	Not Sure (%)
b	Does the client engage a consultant at the beginning of the contract	79	10.5	10.5
c	Does the consultant's engineer visit the site often	21	74	5
d	Does the consultant respond to issues in good time	16	84	0
e	Does the consultant give guidance when asked	79	16	5
f	Do you have site meetings to discuss progress and quality of works	100	0	0
g	Does the consultant provide working drawings / Works orders in good time	26	68	6
h	Does the consultant provide personnel with relevant experience and skills	63	26	11
i	Does the consultant adequate resources to his personnel	26	58	16
j	Does the consultant correct site instructions	63	21	16
k	Do consultants' inspectors stay on site 100%	26	69	5
l	Does the client's representative visit the site regularly	74	21	5
	Consultant Responses			
a	Do contractors provide key technical personnel at the start of the contract	58	42	0
b	Are the key technical personnel the ones provided for in the bid document	8	92	0

Item No.	Factor / Question	Yes (%)	No (%)	Not Sure (%)
c	Are the key personnel able to understand technical issues	67	33	0
d	Is the contractor's work acceptable the first time	50	42	8
e	Do contractors adhere to Quality Assurance Plans	0	92	8
f	Are contractors able to retain key staff for the duration of the contract	42	50	8
g	Do contractors require minimal supervision	8	92	0
h	Is the contractor's plant and equipment reliable	8	75	17
i	Do contractors submit a method statement before commencement of works	25	58	17

4.6.1 Client Responses

Table 4.7 shows client responses in which 64.3% responded "No", 21.4% responded "Yes" while 14.3% were "not sure" as to whether the contractor's work is accepted the first time. This is in agreement with the question on whether contractors work with minimal supervision to which all answered "No" representing 100%. This implies that most of the works have to be redone or reworked as highlighted by Fayek et al, (2003). Love et al, (2010) defines rework as unnecessary effort of redoing a process or activity that was incorrectly implemented the first time. Rework degrades project performance, increase project costs and delays project delivery and causes dissatisfaction to the client (Taylor & Ford, 2006, Love et al, 2008).

In addition, the data obtained shows that 71% of the respondents indicated that the contractors do not provide a method statement and quality management plans.

In this study it can also be seen that presence of consultants on site plays a bigger role in quality of works. Absence of supervising consultants on site has serious repercussions as the contractors end up working without proper guidance from the consultants thereby producing substandard works.

The findings further show that the consultants do not respond to issues in good time (86%), they do not provide adequate resources for their team (72%) thereby leading to the staff relying on the contractor for their daily upkeep.

4.6.2 Contractor Responses

Responses from contractors have also been analysed as shown in table 4.7 in which most of the responses have faulted the consultant for not attending to contractual issues with speed.

Availability of the consultant and responding to issues raised on site is crucial in contract management since road construction is a staged process where commencement of one stage depends on approval of the preceding stage. Delays in conducting site inspections and approving works has a bearing on the continuity of other activities and often results in delays in project completion. In addition, delays from the consultant may mount pressure on the contractor to recover lost time through acceleration of works thereby affecting quality of works.

4.6.3 Consultant Responses

Also shown in table 4.7 are responses from consultants. The questions sought to assess the contractors' performance, their personnel and availability on site.

The responses indicate that the contractors do provide technical personnel at the start of the project however; most of them are not the ones that were provided for in the bid document and these are usually of lesser experience. The respondents further indicated that the contractors do not adhere to quality assurance plans. This is in agreement with the fact that they require maximum supervision on site.

4.7 General Comments

The study also sought to understand other general comments from stakeholders through administration of open ended questions whereby consultants/contractors were asked to state other issues that contribute to poor quality of road construction works. The issues were recorded and analysed qualitatively, the following were the issues that were presented through the study:

i. Comments Related to Procurement

The study demonstrated that awarding of contracts to the lowest evaluated bidder method without comparing with the engineers' estimate is greatly affecting quality of works. This is so because there is a general misconception in which contractors think that the lowest evaluated bidder means the lowest bidder as a result contractors price too low so that they could be awarded contracts. According to Hoonaker et al. (2010) the competitive bidding process is often mentioned by parties involved in construction as one of the biggest barriers against quality implementation. However, a study by Hoxley (2000), showed that introduction of the competitive bidding process did not result in lower quality work. The results further showed that service quality was higher when pre selection of contractors was done.

The study further showed that a contractor may try to underprice on safety or quality management in order to increase the profit margin for the works. This is so because the contractors are in business and they would want to make profits out of the poor rates hence they end up not following specifications. In addition, it has been shown that the system of using the lowest price instead of Engineers Estimate has brought a lot of unqualified contractors in the construction industry. Most contractors are focusing on winning a tender other than focusing on providing quality work at fair and profitable price. As a result, the lowest priced bidders win the contract even though they cannot deliver what is required. The contractors end up compromising on quality by using cheap labour and materials since they want to make profits. This observation agrees with Ngowi, (2000) who suggests that the procedure of contractor selection puts the client at risk of substandard work. Rwelamila et al. (1999) notes that lowest price does not translate directly to lowest cost and the mentality of clients that low price means low cost often leads to poor delivery of projects.

Another observation was that most contracts are signed and, in some cases, commenced without approved designs. In some cases, the period between design and procurement of works would be so long such that other conditions on the ground would have changed or rates may no longer be economical due to time and economy dynamics.

The study also unveiled that procurement of works was the most affected by political interference. Raballand, Bridges, Beuran, & Sack (2013) also argues that public institutions that are involved in project planning were not free from external influence. It has been argued that political interference is at all levels of project planning since politicians have more authority than professionals.

The findings on procurement are in line with the results obtained above where the use of lowest bidder and not Engineers Estimate has the highest RII of 0.938. This means that according to the study, it is the largest cause of poor quality works in road construction.

ii. Comments Related to Inadequate Supervision

On issues related to supervision, it has been observed that most implementing institutions do not have adequate experienced technical personnel. It was observed that key technical personnel for either contractors or consultants did not have adequate qualifications and experience, some inspectors and foremen do not have the necessary technical skills.

It has also been observed that this could be attributed to the type of training the key personnel undergo. Previously the Ministry of Works Training School used to recruit Grade 1 Artisans with more than five years on the job experience and train them for the whole year. However, the National Construction Industry Council recruits even those that are straight from secondary school with no artisan skills or job experience to train them just for weeks to become foremen. This compromises on quality because even if the inspector or foreman is on site, if he does not have the experience, he cannot question the contractor if something is going wrong because he does not know. It is further argued that personnel that do not have proper training in project management may not be able to prepare a proper plan

for executing a project and that they might not be able to appreciate the importance of testing materials to be used in the project.

It has also been established that lack of proper training does not only affect quality of works but also timely completion because of lack of knowledge in scheduling of resources to be incorporated in the works program.

It was also argued that inadequate number of experienced and qualified technical staff causes a great burden on technical staff on site which often leads to poor quality of works, increased responsibility which further leads to delays in completion of works.

It was further observed that Consultants' inspectors are most of the time sent to site without resources like transport and finances, in some cases their salaries are even paid very late prompting the inspectors to depend on the contractor for their day to day survival. This compromises quality as they are demotivated and do not check the contractor as required. In some cases, the inspectors are not full time on site as required thereby prompting the contractor to cut corners and compromise on quality.

With respect to contractors, unavailability of key personnel on site to guide workers in setting out of construction works affects quality and quantity of works. It has also been noted that sometimes the client has a lot of contracts to supervise or monitor resulting in compromise in quality checks as the site personnel are often not checked.

Furthermore, it was observed that often site personnel are not well motivated. They are lowly paid and hence they resort to selling construction materials and altering specifications in the process so that the output looks the same.

It was further observed that there is no tangible punishment for the non performing consultants. Some projects have delayed due to consultants' delays in issuance of instructions in time.

iii. Comments Related to Materials Testing Laboratories

On material testing laboratories, it was observed that most people working in the laboratories do not take the issue of materials testing seriously. It was established that some laboratory staff are either contractors or are working for contractors as site agents thereby compromising on the test results. There is likelihood that test results are doctored to suite the contractors' interests.

iv. Comments Related to Construction Materials

The study revealed that there is poor material estimation at planning stage due to lack of detailed feasibility studies and condition surveys. Quality of construction works to a greater extent depends on quality of the constituent materials over and above workmanship and construction effort. Lack of commitment to specifications of construction materials is one of the factors leading to poor quality. Materials can give rise to quality problems if the specifications are wrong, the material is contaminated, there is improper handling of the material, poor storage on site and not following the recommended construction procedures. Unavailability of suitable materials leads to delays in completion of works due to temporary work stoppages thereby affecting quality. Shortage of these construction materials negatively affects productivity as work cannot be accomplished in the absence of suitable materials resulting in increase in project costs. Unavailability of suitable materials also results in increase in project costs due to inefficient use of other resources deployed on the project like machinery and labour. This is in line with the observations made by Koskela (1992) who indicated that there is a waste of resources due to idle time, transportation, overproduction, inspections and production of defective work or products.

It was further observed that good quality construction materials like gravel and quarry stones are getting depleted or are available at very long distances from the construction sites. This result in contractors cheating by using the low quality materials that are close to their work sites if they are not properly checked.

Furthermore, escalation of material prices leads to contractors compromising on quality so as to make profits. This is so because maintenance contracts for Roads Authority have no provision for escalation.

On the other hand, materials like bitumen are not available locally and often take a long time to come into the country when imported. Contractors do not keep bitumen in stock since they are not sure as to when next they will get a project of that kind. This affects project completion and quality.

v. Comments Related to Contractors' Experience

Regarding the contractor's experience, it has been observed that some contractors provide false information about their companies just to win tenders i.e. contractors indicate that they have done a particular job before when they have never done one. As a result, quality of works is affected.

It was also indicated that most owners of construction companies are not technically qualified and therefore rely on other people to do pricing for them. Those pricing the tenders just price any how without considering market prices because they have a lot of documents to price. The managing directors realize the mistake of underpricing during project implementation when it is too late to turn down the offer. This affects quality as well as time of a project. Thwala and Mvubu (2008) lament that most emerging contractors do not have adequate financial resources and that they lack training before embarking on the actual works. This results in failure because the contractor cannot realize the full potential of its people without training.

It was further observed that lack of continuity in obtaining contracts results in huge employee turnover which becomes costly and increases waste. There is need for contractors to be constantly working on projects in order to maintain staff otherwise they may lose them when there is no work. It has been observed that new employees require training and need time to fit into the culture of the organization. Van Wyk (2004) stress that getting it right requires high competency levels and experience while at the same time limited number of

construction projects do not enable retention of experienced professionals or allow the inexperienced staff to gain the necessary experience.

Woodward, 1997, agrees that past experience helps in delivering quality works by stating that "…most inspired and durable works were not created by books of rules but by intuition combined with keen observation of past experience and common sense…" In the same way experience only matters when it is the experience of doing the right things in a correct manner.

It was also observed that experience of a contractor in similar projects allows him to execute the works more professionally and within a shorter period as compared to a contractor executing the works for the first time. It is worth noting that poor management of works results in poor follow up of progress on site, incorrect distribution of works, non-commitment of site employees and poor project monitoring among other factors which in turn may affect quality of works.

vi Other Factors

Other factors contributing to poor quality of works include:

i. Lack of technical skills – This does not only affect the quality on the ground but also weighs on the growth prospects of construction companies. The greatest battle for Malawi at the moment is the development and production of professionals that have technical skills. For production of skills to take place, the government and related institutions need to make deliberate efforts of doing so through activities such as the introduction of apprenticeship schemes.
ii. Delayed payments by the employer - Delayed payments to contractors by the client affects the contractors' cash flow. There have been incidences where contractors were not able to get advance working capital as is stipulated in the conditions of contract and worse still after doing the works they were not paid in time. This leads to time overruns and in some cases contractors fail to complete the works due to cash flow problems. Furthermore, most contractors

fail to obtain loans from lending institutions due to high interest rates. As a result, they end up incurring costs through idle time for both labour and equipment. Contractors may end up using low quality materials and cheap labour.

iii. Lack of quality monitoring system – Lack of commitment and foresight by management with regard to training on quality presents a significant threat to quality especially when management does not realize the importance of training to the institution. Capacity building is very important to align employees with the culture of the organization in order for them to align themselves with the company objectives on quality. There is need for training in Total Quality Management in order to raise awareness among those implementing road construction projects. Professional regulatory institutions and government departments should take a leading role in encouraging implementation of quality management system in the construction industry.

iv. Low capital or investment for plant and equipment in the industry. Scarcity of construction equipment like graders and rollers affects performance of contractors. Very few contractors have their own plant and equipment such that when machine based contracts are awarded, the hiring institutions are overwhelmed and fail to meet the demand.

v. Long periods between design, procurement and construction - Delays in procurement process i.e. time taken from the time inventory is collected to implementation sometimes is so long such that site conditions during implementation are different. This often required revision of the bill of quantities and in some cases preparation of addenda to the contracts. In some cases, there is ill timing of various works. For instance, grading of earth roads contracts being awarded around September or October when the soils are very dry. This leads to poor quality work.

vi. Fluctuation of currency/ material prices – fluctuation of the local currency often leads to rising of material prices such that contractors find it difficult to procure resources at higher prices than was initially planned. Activities like concrete are greatly affected because the contractors cannot afford to purchase the required number of bags of cement in order to achieve the required strength. This leads

to contractors' poor quality works as the contractors will tend to use materials of low quality.

From the above it has been observed that awarding of contracts to the lowest bidder is the major contributing factor to poor quality of works seconded by inadequate supervision and followed by escalation of material prices.

4.8 Determination of the Strength of Pavement Layers

Dynamic Cone Penetrometer (DCP) tests were carried out on selected sections that have shown signs of failure on Blantyre–Zomba Road (M3) and Mugabe Highway (M4) in order to assess how they have performed after construction. The Blantyre–Zomba Road was being assessed two years after reconstruction while the Mugabe Highway was being assessed after being used for more than ten years. It should be noted that the Zomba road was reconstructed after it reached a stage where routine maintenance was no longer economical. On the other hand, Mugabe Highway has not received major periodic maintenance since it was constructed save for spot rehabilitations on sections that showed severe signs of failure.

Further tests were done on Limbe–Thyolo–Muloza (M2) which had no signs of failure in order to compare the results. The Limbe–Thyolo–Muloza road has not undergone any periodic maintenance since its construction save for routine maintenance works like grass cutting, line marking, pothole patching and cleaning of culverts.

The DCP equipment was placed on the pavement and an initial scale reading noted. The 8kg weight was dropped from a height of 575mm. Readings were recorded in a standard format for every 10 blows. The test was repeated until the desired penetration depth was reached.

The results of the penetration test were analysed using UK DCP 3.1 software. The outputs from the software were pavement layers, layer thickness and CBR values with graphical cross sectional details. Typical outputs for selected pavement sections are shown in Annexe1

4.8.1 Structural Deterioration on the Blantyre-Zomba Road, M3

The section from Chainage 0+00 at Maselema was chosen because visual inspection showed that potholes had started developing. Tests were done on three sections; near Maselema PTC, at Mudi Junction and at Total Filling Station. The road was also constructed by a foreign contractor and was supervised by a local consultant.

The aim of carrying out the tests was to identify the cause for the observed failure because this road had recently been rehabilitated in 2014 and had only been used for a period of less than two years as at the time of the study.

The results were analysed using software called UK DCP 3.1 as shown in Appendix V. The outputs for the software were pavement layers and layer thickness for each layer along with CBR values. For each test four layers were identified as follows: Top layer of chip seal surfacing over a crushed stone base course, subbase and subgrade. Thickness of the four layers varied in all sections. Thickness of the base varied from 40mm to 90mm and thickness of subbase varied from 20mm to 80mm. The compacted thickness of the subgrade ranged from 60mm to 430mm.

According to SATCC, it is recommended that pavement layer thickness of greater than 200mm or less 100mm should be avoided. The design for the road specified base and subbase thickness of 150mm. From the DCP results indicated above, it shows that the base and subbase thicknesses were very low ranging from 40 – 90mm and 20 – 80mm respectively. This therefore shows that the specifications were not followed during construction and it can further be argued that supervision was not adequate thereby allowing the contractor to cheat. This agrees with the findings that lack of proper monitoring by supervisory staff contributes to poor quality which has RII of 0.738.

4.8.2 Structural Deterioration on the Mugabe Highway, M4

Three sections which had developed severe potholes were identified for DCP test in order to identify the cause of the severe deterioration of the road. These places are Banja La Mtsogolo, Bangwe Day Secondary School and Banana stage. The Banja La Mtsogolo Section was rehabilitated around the year 2000 while the other two sections were rehabilitated in 2004.The road has a gravel base and subbase. The surface type is 25mm asphalt except for Banana section which has double chip seal.

The first section had severe potholes and left hand side drain has water flowing during most times of the year suggesting that the area is water logged. The road was also constructed by a foreign contractor and was supervised by a local consultant,

From the results, thickness of the three layers varied in all sections. Thickness of the base varied from 40mm to 180mm and thickness of subbase varied from 20mm to 220mm. The compacted thickness of the subgrade ranged from 10mm to 610mm. According to records, the road was designed to have both base and subbase thickness of 200 mm. The inconsistencies in thicknesses indicate that supervision was not adequate and also that the layer thickness were not checked during construction. This also agrees with earlier findings that lack of proper monitoring by supervisory staff leads to poor quality works.

4.8.3 Structural Condition of Limbe – Thyolo - Muloza Road, M2

The Limbe–Thyolo–Muloza Road was considered as a control. The road was constructed more than 20 years ago. The road has gravel base and double chip seal and asphalt surfacing. The current condition of the road is good despite having lasted for more than twenty years. The road was constructed by a foreign contractor and was also supervised by a foreign consultant.

Similar DCP tests were carried out on the road. It was observed that the pavement layers consisted of 50mm surface of premix asphalt, double chip seal, the base course which ranged from 150 mm to 180mm while the subbase ranged from 150mm to 175 mm. All these layers were found to be adequate hence the reason why the road was still in very good condition. This shows that during construction, the pavement layers were properly constructed and compacted according to specifications and may be due to adequate supervision of the works. Another aspect might be that the supervising consultant was very serious on issues of quality unlike the two roads that were supervised by the local consultants.

This is in agreement with the findings from the questionnaire surveys where it was noted that most local consultants:

i. Employ less qualified and inexperienced technical personnel who are readily available on the market at cheaper rates. Most technicians that are employed by the local consultants do not have the required skills as a result their main interest is just to get employment.
ii. Failure by most consultants to provide their site staff with resources results in the staff being demotivated and end up relying on the contractors for their daily upkeep. This often leads to compromising on supervision as contractors work without being checked.
iii. Absence of consultant staff on site due to inadequate staffing as the consultant may have several contracts but few qualified staff.
iv. Have lazy faire attitude possibly because the current contract provisions for consultants do not have punitive measures for consultants who supervise substandard works.

It is a general requirement that the supervising consultant should do routine inspections and conduct routine tests to determine if the quality of materials and workmanship provided complies with specifications. However, the study has revealed a weakness in most local consultants which leads to substandard work.

It has further been established that the Blantyre–Zomba road and Mugabe Highway have deteriorated faster than anticipated due to poor workmanship. It was also observed that most of the sections that showed failure lacked proper drainage hence the frequent occurrence of potholes on these sections. Road designs without paying much attention to site conditions results in poor quality of work as is the case on Mugabe Highway where issues of drainage during designs were not considered.

In addition, subgrade strength is influenced by both densities achieved and the moisture content of the soil. It is important to ensure that the highest density in terms of Maximum Dry Density (MDD) is achieved on all pavement layers in order to minimise deformation due to further compaction under traffic loading. It is also worth noting that insufficient compaction during construction may result in road deformations due to weakness of deeper underlying materials. These parameters are better checked if the supervising consultant is vigilant and providing checks on the contractor.

4.9 Upgrading of Nasundu Timber Deck to Concrete on Chadzunda–Davide Village in Blantyre District

4.9.1 Introduction

The contract for upgrading of Nasundu Timber Bridge to concrete was awarded to a local Malawian construction company at a contract sum of Mk 29,687,020.00. The company is owned by a Civil Engineer and is registered by the National Construction Industry Council (NCIC) in the MK200 million category. The commencement date for the contract was 27th July, 2017 with a contract period of 120 days.

Works on this contract involved removal of the existing two span timber decks, demolition and reconstruction of masonry walls to receive concrete caps, concrete deck, embankment formation and reshaping of the earth road. The contractor delayed mobilising to commence the works and this in turn affected the completion of the works.

4.9.2 Quality of Works

The contractor brought to site construction materials like sand, aggregate and steel for the bridge works. As is the requirement, the sand and aggregate were tested at one of the laboratories in Blantyre. A trial mix design for concrete was also prepared by the same laboratory and was submitted to the supervising consultant for approval. Since the consultant was handling a lot more bridge works contracts, he noted some similarities in trial mix test results for two contractors.

Furthermore, it was also observed on site that the concrete caps cast using the tested materials were of poor quality. Ironically the 7 days' test results for the concrete showed that it had attained the minimum 7 days' strength. It was then agreed that a Schmidt hammer test be done on the concrete to verify the results. The test indicated that the concrete did not meet the specifications.

Tables 4.8, 4.9 and 4.10 below shows Trial Mix Design results of age 7 days submitted by two different and independent contractors:

Table 4.8: Concrete Trial Mix Design Test Results for Class 30/20

CONCRETE CLASS 30 / 20										
CONTRACTOR A (Date Tested: 15th August 2017)						**CONTRACTOR B (Date Tested: 30th June 2017)**				
Slump (mm)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²		Slump (m)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²
25	7	8.515	28.2	**27.9**		25	7	8.515	28.2	**27.9**
25	7	8.480	28.0			25	7	8.480	28.0	
25	7	8.500	27.6			25	7	8.500	27.6	
Type of Cement		DURACRETE				Type of Cement		NJATI		

Table 4.9: Concrete Trial Mix Design Test Results for Class 20/20

CONCRETE CLASS 20 / 20										
CONTRACTOR A (Date Tested: 15th August 2017)						**CONTRACTOR B (Date Tested: 30th June 2017)**				
Slump (mm)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²		Slump (m)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²
45	7	8.430	19.8	**19.5**		45	7	8.430	19.8	**19.5**
45	7	8.495	19.1			45	7	8.495	19.1	
45	7	8.475	19.6			45	7	8.475	19.6	
Type of Cement		DURACRETE				Type of Cement		NJATI		

Table 4.10: Concrete Trial Mix Design Test Results for Class 15/40

CONCRETE CLASS 15 / 40										
CONTRACTOR A (Date Tested: 15th August 2017)						**CONTRACTOR B (Date Tested: 30th June 2017)**				
Slump (mm)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²		Slump (m)	Age (days)	Mass (kg)	Strength N/mm²	Average Strength N/mm²
60	7	8.495	15.1	**14.5**		60	7	8.495	15.1	**14.5**
60	7	8.470	14.4			60	7	8.470	14.4	
60	7	8.435	14.0			60	7	8.435	14.0	
Type of Cement		DURACRETE				Type of Cement		NJATI		

Therefore, with reference to Tables 4.8, 4.9 and 4.10, the similarity in laboratory tests results from different and independent Contractors working on different sites was found to be very unusual. Even if the samples were assumed to have been taken from the same place, prepared, cured and crushed in the same laboratory the results could not be similar as observed in this case due to variations in workmanship. In view of this observation, and with respect to RA's expectation on quality works that are in line with specifications it was agreed that the tests should be re done at the same laboratory in the presence of both the consultant and client.

The trial mixes for concrete class 30/20, 20/20 and 15/40 were re done in the presence of the consultant and the client where it was observed that the results were different. Secondly, crushing of the concrete cubes for the concrete caps after 28 days was also done in the presence of the consultant where the results also showed that the concrete failed to meet specifications.

It was also observed that the reinforcement steel which the contractor used for the deck had started cracking implying that it was of low quality. The contractor was then instructed to remove the steel for the deck and demolish the concrete caps.

Figure 4.3 and 4.4 below show the concrete caps being demolished and the new concrete caps respectively.

Figure 4.3: Demolition of Nasundu Bridge Concrete Caps

Figure 4.4: Nasundu Bridge New Concrete Caps

The case study brought to light the following:

i. That some laboratory technicians lack professionalism and ethics in carrying out their duties. Analysis of mean scores obtained from the survey further indicated that quality monitoring factors had a mean score ranging from 3.27 and 4.04 which means that their occurrence ranges from occasional to frequent. In addition, lack of laboratories by clients for checking test results had the highest mean score of 4.4 meaning that the problem occurs frequently on site.
ii. Further analysis of the contractor's rates showed that his rates were too low as compared to the Engineer's estimate. It was then discovered that the contractor was using substandard materials in order to maximize on profits.
iii. The contractor who is registered in the Mk 200 million category struggled to complete a two span concrete bridge within the specified contract period and quality

4.10 Chapter Summary

This chapter aimed at analysing data which was obtained using questionnaires, DCP tests and one case study on bridge works.

The findings from the data analysis include:

i. Procurement related factors have the highest score indicating that that they are the major cause of poor quality of construction work
ii. Quality monitoring factors like verification of test results and lack of proper monitoring of works by supervision staff also affects quality of works.
iii. Corruption related factors like lack of incentives, lack of ethics, low morale and lack of motivation by site personnel in addition to lack of professionalism and ethics by laboratory technicians leading to issuance of test results without carrying out tests affects quality of works during implementation.

The above findings show that major causes of poor quality of works include method of procurement using lowest evaluated bidder method, lack of qualified and skilled technical personnel, lack of quality monitoring systems and corruption.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses conclusions, recommendations and directions for further study arising from this study. The study mainly focussed on identifying causes of poor quality of road construction works in Malawi.

In order to realise this aim, the study looked at achieving the following objectives:

i. To identify major and common defects on road works projects
ii. To identify possible causes of these defects
iii. To analyze the identified causes in order to come up with those that have a high occurrence
iv. To find out whether quality management systems are used in the road construction industry in Malawi

Literature review underscored the following as factors that lead to poor quality of road construction: compromise in stages prior to construction especially at design stage, workmanship and associated challenges, selection of contractors and shortage of skilled manpower.

The methods adopted for data collection in this study include questionnaires, interviews, DCP test and a case study on bridge construction works. The questionnaire had both closed and open ended questions. The DCP tests were carried out on main roads carrying heavy traffic and have undergone rehabilitation recently.

5.2 Conclusions

From the findings of this study it can be concluded that the major cause of poor quality of road construction works in Malawi is procurement process of road construction works. The lowest evaluated bidder method of selecting contractors has significantly contributed to poor quality of road construction works. Most contractors under-price their bids so that they get a contract. This results in poor quality of works as the contractor will invariably try to make short cuts during implementation in order to recover expenses. Kulemeka, Kululanga, and Morton (2015) suggests that price undercutting by bigger contractors can be eliminated by restricting contractors to only tender for projects that are within their category of registration with the NCIC.

Secondly, lack of well trained and experienced technical personnel also contributes to poor quality of works. If site personnel do not have the required experience, the expected quality standards cannot be achieved. In addition, lack of systems and quality standards also contributes to non-achievement of quality standards. It is also worth noting that lack of commitment to specifications of construction materials affects quality of works. Materials can give rise to quality problems if the specifications are wrong, the material is contaminated, there is improper handling of the material, poor storage on site and not following the recommended construction procedures. Furthermore, pavement design also affects the design life of the road as can be evidenced by the findings from the DCP tests where the road with a gravel base and chip seal surfacing deteriorated faster than the one with crushed stone base and asphalt surfacing.

Corruption during contract award and implementation was also highlighted as a contributing factor to poor quality of works. In most cases incompetent contractors are awarded contracts through corrupt means thereby leading to poor quality of works. During project implementation, the contractor, consultant, and in some cases client's representative may collude to falsify technical results thereby affecting quality of the final product. This can be minimised if staff for all the three parties are well motivated in terms of their remuneration.

The study has shown that quality of works on project sites requires a lot of effort from both workers and supervisory staff on site. Therefore, more focus should be on how improved quality can be achieved without increase in project costs. It was noted during the study that RA usually conducts technical audits on road construction works in order to assess if works are being done according to standards in terms of quality, time and cost. Findings and recommendations from the audit are submitted to management for implementation. It is the responsibility of management to ensure that the audit findings are adhered to.

5.3 Recommendations

Quality of works in road construction in Malawi still remains a big problem as evidenced by the number of roads that develop failure soon after construction. Notable interventions recommended based on the findings from the study include:

(i) Evaluation of Road Construction bids to be based on Technical rather than Financial

During evaluation of bids emphasis should be on technical evaluation as compared to financial evaluation of tenders. Awarding of contracts without use of Engineers' Estimate should be discontinued in order to avoid poor quality works.

It is further suggested that the PPDA should review this policy of awarding contracts to the lowest evaluated bidder without use of engineers' estimate so that contracts will be awarded to those that have genuinely priced for the works and have the capacity to do the works.

Use of local technical experts should be encouraged when preparing cost estimates. The volatile economic nature of the country should also be taken into consideration when preparing the cost estimates.

(ii) Clients to continuously check laboratory test results submitted by contractors

There is need for client organisations to randomly check test results from laboratories by carrying out tests using independent accredited laboratories. It is suggested that Roads Authority should establish its own laboratory for verification of results.

It is further recommended that Roads Authority should involve The Malawi Bureau of Standards in testing of materials like concrete and reinforcement steel, accreditation of materials laboratories involved in materials testing and regulation of construction materials on the market.

There is also need for certification and accreditation of laboratories being used for testing materials for road works in order to check credibility of the results produced in these laboratories. RA should also have a special department/ personnel to be responsible for this.

(iii) Engagement of competent consultants

Roads Authority should engage consultants who can design and supervise the works in order to have continuity. This is so because design and supervision is done by separate consultants, a lot of errors are identified which require the supervision consultant to do design review at an extra cost.

(vi) Thorough scrutiny of contractors' registration upgrading process by NCIC

NCIC should scrutinize contractors' submissions when they are upgrading to a higher category because some contractors do not have the capacity to handle jobs in the higher category they are registered in.

NCIC should also undertake more capacity building at road foreman and inspector level in order to avert the problem of shortage of site technical personnel.

5.4 Study Limitations and Opportunities for Future Research

The study involved road projects in Blantyre, in Southern Region of Malawi. The gaps in the research are due to time and cost limitations, as such its findings could not be a true representation of quality problems in Malawi as the other regions could have different challenges. It is proposed that future studies should look at projects in the other regions in order to establish a general trend of factors affecting quality of works in Malawi and to subsequently assist in coming up with mitigation measures.

The use of self-administered questionnaires for obtaining information as was the case in this study, renders itself to abuse as there is no guarantee that the respondents provided correct information. It is therefore proposed that more interviews and case studies should be used in order to improve validation of the results.

Besides the survey questionnaire and the case study, DCP tests were also conducted on three roads. It is proposed that in future, consideration should be made to carry out more tests before and after the rainy season in order to have a better comparison of the results.

Further research should also examine the extent to which supervision by local and foreign consultants affects quality of works. Issues of Quality Assurance, Quality Control and Total Quality Management should be examined further so that there can be better analysis of the adherence to quality of road works in Malawi.

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APPENDICES

Appendix I: Cover Letter

University of Malawi – The Polytechnic
P/Bag 303
Chichiri
Blantyre 3

Dear respondent

REF: Causes of Poor Quality of Road Construction Works

I am a Master of Science in Infrastructure Development and Management student at the University of Malawi, The Polytechnic conducting a research under the above mentioned title. The main aim of this research is to identify factors contributing to poor quality standards in road construction, analyze the causes and propose ways of improving quality of road construction works.

You have been identified as a potential respondent to this questionnaire as a key stakeholder in road construction projects. Please find attached to this letter a questionnaire based on your professional experience and understanding. Kindly respond to all questions in the stated manner. Please be assured that the information provided shall be used for the sole purpose of this research which is purely academic. The information provided shall be treated with strict confidentiality and you are therefore advised not to indicate your personal or institution details.

Yours faithfully,

Flora Hauya
Cell 0888843918
Email: FHauya@ra.org.mw

Research Supervisor
Dr W.S. Kuotcha
Email: wkuotcha@poly.ac.mw

Appendix II: Questionnaire for Client Staff

SECTION A – PARTICIPANT PARTICULARS

Please provide the information as requested below

Participant's Particulars

Age

Gender (Please tick one) 1. Male ( ) 2. Female ( )

Work Experience in years:

	Contractor's staff	Consultant's Staff	Roads Authority Staff
Less than 5 years	……	……	……
6 - 10 years	……	……	……
10 years or more	……	……	……

SECTION B – Information on Factors Affecting Quality of Works

Please answer questions by circling level of impacts. Scale of impact used is as follows:

1 – Never, 2- Rare, 3 – Occasional 4 Frequent 5 - Always

Question 1

To what extent do these factors lead to low quality standards

a. Lack of technical skills / Human Resource Factors

Challenge	Description	Scale of Impact				
Human Resource related	Lack of qualified technical personnel for contractors	1	2	3	4	5
	Lack of qualified technical personnel for consultants	1	2	3	4	5
	Lack of qualified technical personnel for client	1	2	3	4	5
	Failure by contractors to employ engineers	1	2	3	4	5
	Failure by consultants to employ engineers	1	2	3	4	5
	Non availability of consultant staff on site	1	2	3	4	5

b. Inadequate suitable local construction material e.g. gravel

Challenge	Description	Scale of Impact				
Material Resource related	Suitable material not available	1	2	3	4	5
	Suitable material available at very long distances	1	2	3	4	5
	Available material not meeting specifications	1	2	3	4	5

	Lack of knowledge in stabilizing proportions and procedures	1	2	3	4	5
	Available material being sold at exorbitant prices	1	2	3	4	5

c. Procurement of contracts

Challenge	**Description**	**Scale of Impact**				
Procurement related	Contractors pricing too low (ODPP decision to not to use Engineer's estimate)	1	2	3	4	5
	Contractors pricing not realistic	1	2	3	4	5
	Nonperformance due to low pricing	1	2	3	4	5
	Contractors compromising on quality in order to make profits	1	2	3	4	5
	Lack of data base for nonperforming contractors	1	2	3	4	5
	Failure by contractors to give correct information on firms capacity	1	2	3	4	5
	Self interest in procurement process	1	2	3	4	5
	The delays in procurement affect overall project implementation	1	2	3	4	5
	Contractors not conversant with specifications during tendering	1	2	3	4	5

d. . Lack of quality monitoring System

Challenge	Description	Scale of Impact				
Quality monitoring related	Most laboratories using old equipment in testing of materials	1	2	3	4	5
	Lack of proper monitoring by supervising staff	1	2	3	4	5
	Lack of expertise in interpretation of results	1	2	3	4	5
	Lack of own laboratory by client for checking results	1	2	3	4	5
	Theft of construction materials on site	1	2	3	4	5
	Absence of monitoring guidelines for consultant's site personnel	1	2	3	4	5
	Lack of contracts with independent Labs	1	2	3	4	5

e. Corruption during project implementation

Challenge	Description	Scale of Impact				
Implementation related	Low morale / lack of motivation by site personnel	1	2	3	4	5
	Lack of ethics	1	2	3	4	5
	Lack of sensitization on ills of corruption	1	2	3	4	5
	Lack of incentives	1	2	3	4	5
	Attitude towards own profession	1	2	3	4	5

Question 2

Kindly tick (√) or cross (×) appropriately

a. Does the consultant provide adequate resources to his team?

Yes ☐	No ☐	Not Sure ☐

b. Does the consultant provide personnel with relevant qualifications and adequate experience?

Yes ☐	No ☐	Not Sure ☐

c. Does the consultant address issues from the client within reasonable time?

Yes ☐	No ☐	Not Sure ☐

d. Does the consultant key staff inspect the works regularly?

Yes ☐	No ☐	Not Sure ☐

e. Does the consultant respond to contractor's request promptly?

Yes ☐	No ☐	Not Sure ☐

f. Does the contractor submit Method Statement?

Yes ☐	No ☐	Not Sure ☐

g. Does the contractor submit Quality Management Plans?

Yes ☐	No ☐	Not Sure ☐

h. Does the contractor require minimal supervision?

Yes ☐	No ☐	Not Sure ☐

i. Does contractor adhere to Quality Assurance plans and specifications

Yes ☐	No ☐	Not Sure ☐

j. Is the contractor's work accepted the first time

Yes ☐	No ☐	Not Sure ☐

Question 3

Please provide any general comments and suggestions on how the above factors affect performance in terms of quality of works.

Appendix III: Questionnaire for Consultant Staff

SECTION A – PARTICIPANT PARTICULARS

Please provide the information as requested below

Participant's Particulars

Age

Gender (Please tick one) 1. Male ( ) 2. Female ( )

Work Experience in years:

	Contractor's staff	Consultant's Staff	Roads Authority Staff
Less than 5 years	……	……	……
6 - 10 years	……	……	……
10 years or more	……	……	……

SECTION B – Information on Factors Affecting Quality of Works

Please answer questions by circling level of impacts. Scale of impact used is as follows:

1 – Never, 2- Rare, 3 – Occasional 4 Frequent 5 - Always

Question 1

To what extent do these factors lead to low quality standards

f. Lack of technical skills / Human Resource Factors

Challenge	Description	Scale of Impact				
Human Resource related	Lack of qualified technical personnel for contractors	1	2	3	4	5
	Lack of qualified technical personnel for consultants	1	2	3	4	5
	Lack of qualified technical personnel for client	1	2	3	4	5
	Failure by contractors to employ engineers	1	2	3	4	5
	Failure by consultants to employ engineers	1	2	3	4	5
	Non availability of consultant staff on site	1	2	3	4	5

g. Inadequate suitable local construction material e.g. gravel

Challenge	Description	Scale of Impact				
Material Resource related	Suitable material not available	1	2	3	4	5
	Suitable material available at very long distances	1	2	3	4	5
	Available material not meeting specifications	1	2	3	4	5

	Lack of knowledge in stabilizing proportions and procedures	1	2	3	4	5
	Available material being sold at exorbitant prices	1	2	3	4	5

h. Procurement of contracts

Challenge	**Description**	**Scale of Impact**				
Procurement related	Contractors pricing too low (ODPP decision to not to use Engineer's estimate)	1	2	3	4	5
	Contractors pricing not realistic	1	2	3	4	5
	Nonperformance due to low pricing	1	2	3	4	5
	Contractors compromising on quality in order to make profits	1	2	3	4	5
	Lack of data base for nonperforming contractors	1	2	3	4	5
	Failure by contractors to give correct information on firms capacity	1	2	3	4	5
	Self interest in procurement process	1	2	3	4	5
	The delays in procurement affect overall project implementation	1	2	3	4	5
	Contractors not conversant with specifications during tendering	1	2	3	4	5

i. Lack of quality monitoring System

Challenge	Description	Scale of Impact				
Quality monitoring related	Most laboratories using old equipment in testing of materials	1	2	3	4	5
	Lack of proper monitoring by supervising staff	1	2	3	4	5
	Lack of expertise in interpretation of results	1	2	3	4	5
	Lack of own laboratory by client for checking results	1	2	3	4	5
	Theft of construction materials on site	1	2	3	4	5
	Absence of monitoring guidelines for consultant's site personnel	1	2	3	4	5
	Lack of contracts with independent Labs	1	2	3	4	5

j. Corruption during project implementation

Challenge	Description	Scale of Impact				
Implementation related	Low morale / lack of motivation by site personnel	1	2	3	4	5
	Lack of ethics	1	2	3	4	5
	Lack of sensitization on ills of corruption	1	2	3	4	5
	Lack of incentives	1	2	3	4	5
	Attitude towards own profession	1	2	3	4	5

Question 2

Kindly tick (√) or cross (×) appropriately

k. Do the contractors provide key technical personnel at the start of the contract?

Yes ☐	No ☐	Not Sure ☐

l. Are the key technical personnel the ones provided for in the bid document?

Yes ☐	No ☐	Not Sure ☐

m. Are the key personnel able to understand technical issues on site?

Yes ☐	No ☐	Not Sure ☐

n. Is the contractor's work accepted the first time?

Yes ☐	No ☐	Not Sure ☐

o. Do contractors adhere to Quality Assurance Plans?

Yes ☐	No ☐	Not Sure ☐

p. Are contractors able to retain key staff for the duration of the contract?

Yes ☐	No ☐	Not Sure ☐

q. Do contractors require minimal supervision?

Yes ☐	No ☐	Not Sure ☐

r. Is the contractors plant and equipment reliable?

Yes ☐	No ☐	Not Sure ☐

s. Do contractors submit a method statement before commencement of works

Yes ☐	No ☐	Not Sure ☐

Question 3

Please provide any general comments and suggestions on how the above factors affect performance in terms of quality of works.

Appendix IV: Questionnaire for Contractor's Staff

SECTION A – PARTICIPANT PARTICULARS

Please provide the information as requested below

Participant's Particulars

Age

Gender (Please tick one) 1. Male ( ) 2. Female ( )

Work Experience in years:

	Contractor's staff	Consultant's Staff	Roads Authority Staff
Less than 5 years	……	……	……
6 - 10 years	……	……	……
10 years or more	……	……	……

SECTION B – Information on Factors Affecting Quality of Works

Please answer questions by circling level of impacts. Scale of impact used is as follows:

1 – Never, 2- Rare, 3 – Occasional 4 Frequent 5 - Always

Question 1

To what extent do these factors lead to low quality standards

k. Lack of technical skills / Human Resource Factors

Challenge	Description	Scale of Impact				
Human Resource related	Lack of qualified technical personnel for contractors	1	2	3	4	5
	Lack of qualified technical personnel for consultants	1	2	3	4	5
	Lack of qualified technical personnel for client	1	2	3	4	5
	Failure by contractors to employ engineers	1	2	3	4	5
	Failure by consultants to employ engineers	1	2	3	4	5
	Non availability of consultant staff on site	1	2	3	4	5

l. Inadequate suitable local construction material e.g. gravel

Challenge	Description	Scale of Impact				
Material Resource related	Suitable material not available	1	2	3	4	5
	Suitable material available at very long distances	1	2	3	4	5
	Available material not meeting specifications	1	2	3	4	5

	Lack of knowledge in stabilizing proportions and procedures	1	2	3	4	5
	Available material being sold at exorbitant prices	1	2	3	4	5

m. Procurement of contracts

Challenge	**Description**	**Scale of Impact**				
Procurement related	Contractors pricing too low (ODPP decision to not to use Engineer's estimate)	1	2	3	4	5
	Contractors pricing not realistic	1	2	3	4	5
	Nonperformance due to low pricing	1	2	3	4	5
	Contractors compromising on quality in order to make profits	1	2	3	4	5
	Lack of data base for nonperforming contractors	1	2	3	4	5
	Failure by contractors to give correct information on firms capacity	1	2	3	4	5
	Self interest in procurement process	1	2	3	4	5
	The delays in procurement affect overall project implementation	1	2	3	4	5
	Contractors not conversant with specifications during tendering	1	2	3	4	5

n. Lack of quality monitoring System

Challenge	Description	Scale of Impact				
Quality monitoring related	Most laboratories using old equipment in testing of materials	1	2	3	4	5
	Lack of proper monitoring by supervising staff	1	2	3	4	5
	Lack of expertise in interpretation of results	1	2	3	4	5
	Lack of own laboratory by client for checking results	1	2	3	4	5
	Theft of construction materials on site	1	2	3	4	5
	Absence of monitoring guidelines for consultant's site personnel	1	2	3	4	5
	Lack of contracts with independent Labs	1	2	3	4	5

o. Corruption during project implementation

Challenge	Description	Scale of Impact				
Implementation related	Low morale / lack of motivation by site personnel	1	2	3	4	5
	Lack of ethics	1	2	3	4	5
	Lack of sensitization on ills of corruption	1	2	3	4	5
	Lack of incentives	1	2	3	4	5
	Attitude towards own profession	1	2	3	4	5

Question 2

Kindly tick (√) or cross (×) appropriately

t. Does the contract document provide enough information to be used in project execution?

Yes		No		Not Sure	

u. Does the client engage a consultant at the beginning of the contract?

Yes		No		Not Sure	

v. Does the consultant's Engineer visit the site often?

Yes		No		Not Sure	

w. Does the consultant respond to issues in good time?

Yes		No		Not Sure	

x. Does the consultant give guidance when asked?

Yes		No		Not Sure	

y. Do you have site meetings to discuss progress and quality of works

Yes		No		Not Sure	

z. Does the consultant provide working drawings / Works Orders in good time?

Yes		No		Not Sure	

aa. Does the consultant provide personnel with relevant experience and skills?

Yes		No		Not Sure	

bb. Does the consultant provide adequate resources to his personnel?

Yes		No		Not Sure	

cc. Does the consultant issue correct site instructions?

Yes		No		Not Sure	

dd. Do the consultants' inspectors stay on site100%?

Yes		No		Not Sure	

ee. Does the client's representative visit the site regularly?

Yes		No		Not Sure	

Question 3

Please provide any general comments and suggestions on how the above factors affect performance in terms of quality of works.

Appendix V: DCP Test Results

a) Penetration Data

UK DCP V3.1

Penetration Data Report

Project Name: BANJA LA MTSOGOLO

Chainage (km):	1.000	Surface Type:	Thin bituminous seal
Direction:		Thickness (mm):	20
Location/Offset:	Carriageway/1.00m	Strength Coeff.:	0.20
Cone Angle:	60 degrees	Base Type:	
Zero Error (mm):	50	Thickness (mm):	
Test Date:	09/06/2017	Strength Coeff.:	

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	50	0.00					
2	10	10	90	4.00					
3	10	20	120	3.00					
4	10	30	160	4.00					
5	10	40	210	5.00					
6	10	50	320	11.00					
7	10	60	500	18.00					
8	10	70	730	23.00					
9	10	80	930	20.00					

Report Date: 22-Jun-2018

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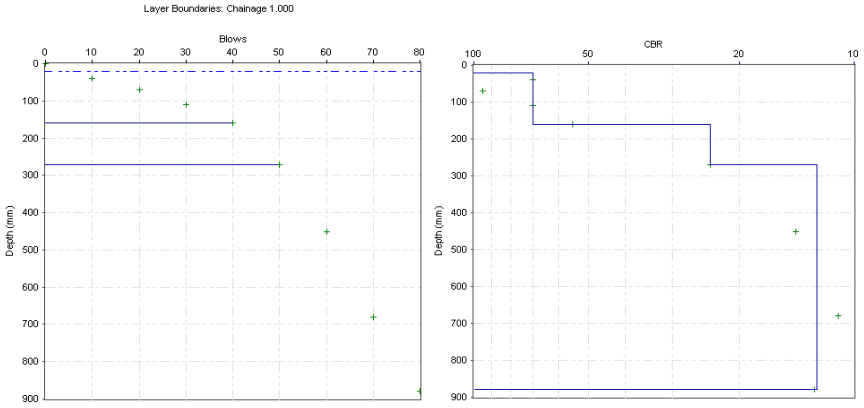
Appendix VI: Layer Strength Diagram

UK DCP V3.1

DCP Layer Strength Analysis Report

Project Name: BANJA LA MTSOGOLO

Chainage (km):	1.000	Surface Type:	Thin bituminous seal
Direction:		Thickness (mm):	20
Location/Offset:	Carriageway/1.00m	Strength Coeff.:	0.20
Cone Angle:	60 degrees	Base Type:	
Zero Error (mm):	50	Thickness (mm):	
Test Date:	09/06/2017	Strength Coeff.:	



Layer Boundaries Chart

CBR Chart

Layer Properties

No.	Penetration Rate (mm/blow)	CBR (%)	Thickness (mm)	Depth to layer bottom (mm)	Position	Strength Coefficient	SN	SNC	SNP
1	4.00	70	140	160	Base	0.12	0.67	0.67	0.67
2	11.00	24	110	270	Sub-Base	0.09	0.41	0.41	0.44
3	20.33	13	610	880	Subgrade	--	--	--	--

Pavement Strength

	Layer Contribution		
Layer	SN	SNC	SNP
Surface	0.16	0.16	0.16
Base	0.67	0.67	0.67
Sub-Base	0.41	0.41	0.44
Subgrade	--	1.40	1.50
Pavement Strength	1.24	2.64	2.77

CBR Relationship:

TRL equation: $\log_{10}(CBR) = 2.48 - 1.057 \times \log_{10}(Strength)$

Report produced by .....

Report Date: 22-Jun-2018

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Appendix VII: Test Summary Report

UK DCP V3.1

Tests Summary Report

Project Name: BANJA LA MTSOGOLO

Test Details					Upper Layers			Test Layers			Pavement Strength	
No.	Test Date	Chainage (km)	Location	Offset (m)	Surface Type	Surface Moisture	Base Type	Base Thickness (mm)	Sub-base Thickness (mm)	Subgrade CBR (%)	SN	SNP
1	6/9/2017	1.000	Carriageway	1.00	Thin bituminous seal	n/a	--	140	110	13	1.24	2.77
2	6/9/2017	2.000	Carriageway	1.00	Thin bituminous seal	n/a	--	180	230	15	1.91	3.38
3	6/9/2017	3.000	Carriageway	1.00	Thin bituminous seal	n/a	--	90	190	13	1.37	2.81

Report Date: 22-Jun-2018

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