QUALITY IMPROVEMENT PROTOCOL FOR SPECIFICATION AND DELIVERY OF CONSTRUCTION MATERIALS REQUIRED BY THE DEPARTMENT OF PUBLIC WORKS AND INFRASTRUCTURE PROJECTS

by

Lehlohonolo Benedict Thulo

Submitted in partial fulfilment of the requirements for the Degree of
MASTER OF ENGINEERING IN CIVIL ENGINEERING
in the Faculty of Engineering and the Built Environment
at the Central University of Technology, Free State

January 2023

Supervisor: Prof. F.A. Emuze

Co-Supervisor: Prof. E. Theron

ACKNOWLEDGEMENTS

Without the support and affection of family and loved ones, completing this dissertation would have been a monumental task. It is impossible to thank everyone who contributed to this research project, but I would like to thank a few people who never stopped encouraging and supporting me, even when I felt like giving up.

First and foremost, I want to express my gratitude to the All Mighty God for providing me with the power and bravery to accomplish this dissertation. Secondly, I express my gratitude to my mother, Agnes Thulo, for her unwavering support and prayers, which have sustained me throughout my life. To my brother Thulo Thulo, thank you so much for your unwavering support since the beginning; you are the one person who has always been by my side and encouraged me never to give up. Thank you to my workplace, the Department of Public Works, for your financial support and access to departmental files, which helped me finish this dissertation.

Finally, I express my gratitude to my co-supervisor, Prof. Lize Theron, for her constant, valuable advice, encouragement, and guidance, as well as for taking time out of his busy schedule to assist me with this dissertation and to Prof. Fidelis Emuze, my supervisor, for his support, encouraging words, and counsel.

DECLARATION

I, Lehlohonolo Benedict Thulo, hereby declare that this master's research dissertation is entirely my own work and has not been submitted for academic credit elsewhere, either by myself or anyone else. I understand what plagiarism entails and disclose that, except where explicitly stated, this dissertation is the outcome of my own ideas, words, phrases, arguments, graphics, figures, results, and organisation. I also understand that any unethical academic behaviour, including plagiarism, is taken seriously at Central University of Technology and is subject to punishment by disciplinary proceedings.

Signed Date: 16 January 2023

ABSTRACT

Materials delivered on public works project sites deviate from technical specifications, with detrimental implications for the quality of the construction process and product (in the form of buildings, roads, sewer lines, and other civil engineering works). The situation implies that Work-As-Done on a construction site is different from Work-As-Imagined. If other variables remain constant in the construction process, Work-As-Done should be Work-As-Imagined, when technical specifications for materials delivered on site are the same as what the designers specified. When delivered materials differ from specifications, quality issues, such as defects and re-work, ensue at greater cost to the clients. These problems suggest a lack of Built-In Quality in the design and construction process in relation to the management of materials. Built-In Quality is not only lacking, but the inadequate application of concepts and techniques of quality improvement also appears to perpetuate the problems. Thus, the study sought to answer the question of what quality improvement protocol would ensure that materials are delivered on construction sites as specified by engineers. Based on pragmatism as a research philosophy aimed at solving real-world problems, a case-based design with multiple data collection techniques and points was expedited in the study. The primary data collected through purposive sampling from the Department of Public Works and Infrastructure technical personnel, and document analysis provided the platform for the compilation of a quality improvement protocol contextualised for the Department of Public Works and Infrastructure in the Free State, which constituted the case study. The statistical and textual data outlined how the Department of Public Works and Infrastructure in the Free State could address quality planning, quality control, and quality improvement concerning the delivery of materials for public works projects. The contribution of the dissertation is the proposed quality improvement protocol that will guide the specification and delivery of construction materials for projects of the Department of Public Works and Infrastructure in the Free Province.

Keywords: Construction, Infrastructure, Materials, Public works, Quality improvement

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

DEFINITIONS OF TERMS

Contractor - an employer who performs construction work (Republic of South Africa, 2014: 5).

Construction procurement - the process that involves invitation, award and management of contracts (Republic of South Africa, 2014: 7).

Construction site - a workplace where construction work is being performed (Republic of South Africa, 2014: 4).

Construction work - means any work in connection with the construction, erection, alteration, renovation, repair, demolition or dismantling of, or addition to, a building or any similar structure (Republic of South Africa, 2014: 5).

Design - in relation to any structure, includes drawings, calculations, design details and specification (Republic of South Africa, 2014: 5).

Principal contractor - any employer employed by the client to perform construction work (Republic of South Africa, 2014: 7).

Procurement - the process of creating, performing and completing a contract which is mutually beneficial to all parties (Steyn *et al.*, 2016: 421).

Quality assurance - planned and systematic actions to help assure that project components are being designed and constructed in accordance with applicable standards and contract documents (Forbes, 2010: 461).

Quality control - the review of project services, construction work, management, and documentation for compliance with contractual and regulatory obligations and accepted industry practices (Forbes, 2010: 461).

Supply chain management - a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses and stores, so that the merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimise system-wide costs while satisfying service level requirements (Republic of South Africa, 2014: 5).

Variation - the divergence of a process from an intended plan (Forbes, 2010: 463).

LIST OF ABBREVIATIONS

APP	Annual performance plan
BIQ	Built-In quality
CDP	Contractor development programme
CIDB	Construction Industry Development Board
DPW&I	Department of Public Works and Infrastructure
DSD	Department of Social Development
DH	Department of Health
DE	Department of Education
ECSA	Engineering Council of South Africa
EPA	Engineering Profession Act
FET	Further Education and Training
FIDIC	International Federation of Consulting Engineers
GC	General contractor
GDP	Gross domestic product
H&S	Health and safety
Pas	Principal agents
QA	Quality assurance
QC	Quality control
QI	Quality improvement
QMS	Quality management system
QP	Quality planning
RFI	Request for information
SACAP	South African Council for the Architectural Profession
SCM	Supply chain management
TVD	Target value design
TQM	Total quality management
WAD	Work-as-done
WAI	Work-as-imagined

CHAPTER 1: RESEARCH BACKGROUND

1.1 Background

The construction industry has a significant global economic impact (CIDB, 2014). As a result, for a variety of reasons, there appears to be a lot of competition among construction companies. As a result, the majority of businesses compete on manufacturing efficiency (Dilawo & Salimi, 2019). In order to satisfy internal and external stakeholders while maintaining the firm's good reputation, the quality of site production operations is frequently considered. Nevertheless, there are several examples of project deviations in the literature, such as non-compliance with quality standards and other expectations (Aigbavboa & Thwala, 2014). Such variations impede firm and industry competitiveness.

Construction industry products are delivered in complicated contexts that are unique to each project in terms of labour, technologies, contract arrangement, location, and owner requirements. The construction sector contributions to global gross domestic product (GDP) ranges between 2.05% and 5.71%, with an average contribution of 3.26% (less than 10%) (SAKA, 2022). The construction industry is a vital aspect of almost every country's economy. The overhead costs paid for developed infrastructure by the entire economy are determined by the efficiency and efficacy of the sector's products, and this has a significant impact on each nation's competitiveness (Shaari *et al.*, 2015).

South Africa is currently experiencing issues with the quality of construction that clients demand (Mbijiwe, 2017). It is noted that completing a project on time, on budget, and to quality standards is a difficult assignment because the shortest duration and lowest cost can conflict with quality (Emuze & Mhlwa, 2015). According to Aiyetan (2019), the four main limitations to consider while managing construction projects, regardless of location, are scope, cost, time, and quality. In sections that clarify the challenge and aims of the research, the correlations between these factors are discussed in this quality-focused dissertation, from a production perspective.

In the latter decades of the previous millennium, a drop in demand for construction services in South Africa resulted in instability and inter-connected structural difficulties within the industry. The South African Government passed laws in 2000 (Government Gazette, 2000) (VAN DIE, 2000) that established a Construction Industry Development Board (CIDB). The CIDB's mission is to implement an integrated plan for the reconstruction, expansion, and development of South Africa's construction

industry. The government has a vision of building a thriving, internationally competitive local construction industry while also creating long-term jobs and redressing historical inequities. It is apparent that the industry will need strong leadership and the promotion of best practices during this process.

In South Africa's construction industry, recent trends reveal a decrease in skills. Graduate engineers in South Africa are expected to work as professional engineers within three years of graduation; however, this is not the case because they do not always perform at the expected levels of responsibility at work (Rooplall, et al., 2016). In previous years, the number of complaints against registered professionals had increased four-fold, according to engineering council of south africa (ECSA) (Mnyandu, 2020). Oyewobi *et al*. (2015) stated in a summary of an industry status report that, even when clients are satisfied with the quality of the construction product provided, they are frequently dissatisfied with the degree of quality of professional services offered.

Many studies have been carried out to quantify the cost of re-work in the construction sector as a result of quality issues. The reported estimates generally specify that they only include the directly measurable cost of re-work, and that additional hidden expenses are not included. Re-work can cost somewhere between 3% and 20% (Hwang & Yang, 2014; Al-Janabi *et al*., 2020; Enshassi *et al*., 2017). Re-work accounted for 12.4% of total project costs, according to one study. On average, re-work appears to be approximately 10% of the entire cost of a project. When quality systems are correctly implemented, re-work can be minimised to less than 1% of the overall project cost, according to (Hwang & Yang, 2014).

Quality variations, such as wrong materials, flaws, and material amounts are widespread in construction, according to international studies (Aigbavboa & Thwala, 2014). Difficulties with material quality can plague construction projects in South Africa, causing cost and schedule over-runs at the expense of clients (Emuze & Mhlwa, 2015). However, how material requirements and delivery affect the quality of construction projects has been considered in a few studies. When the delivered materials differ from the specifications, quality difficulties arise, resulting in defects and re-work, which adds to the overall cost of a project, which is classified as quality cost. Requests for Information (RFIs) are also common, resulting in project delays and duration extensions. There is an inter-relationship between cost, quality, and time in South African construction (Emuze & Mhlwa, 2015). To establish a methodology for the specification and delivery of construction materials required for Department of Public Works and Infrastructure (DPW&I) projects, researchers have examined quality planning (QP), quality control (QC), and quality improvement (QI) (Mitra, 2016).

In order to achieve this goal, empirical approaches were used in the present study to measure QI in DPW&I projects.

1.2 Problem Statement

According to monthly project reports from the Free State Provincial Department of Public Works & Infrastructure in 2020, materials delivered on public works project sites deviated from technical specifications, with detrimental implications of non-compliance with quality requirements and resulting in defects and re-work. The situation implies that work-as-done (WAD) on a construction site is different from work-as-imagined (WAI). If other variables remain constant in the construction process, WAD should be WAI when technical specifications for materials delivered on site are the same as what the designers specified. According to (Hollnagel & Clay-Williams, 2022), WAI and WAD are two ergonomic ideas. WAI is a model for how people believe work should be done in order to attain the desired results. People's thoughts about how others do, or should do, their work, as well as how they prepare their own work, are covered in WAI. WAD, on the other hand, represents the first-hand experience of individuals who execute the task. However, when delivered materials differ from specifications, quality issues ensue as follows:

- Defects and re-work, which lead to additional project cost, which is classified as quality cost. Quality cost consists of: cost of prevention, cost of appraisal and the cost of failure (Forbes & Ahmed, 2020).
- RFIs and waiting for revised designs and specifications, which lead to time delays and extended project duration.

1.3 Research Questions

The problems stated above suggest a lack of built-in quality (BIQ) in the design and construction process in relation to the management of materials. Not only is BIQ lacking, but inadequate application of concepts and techniques of QI also appears to perpetuate the problems. Therefore, the primary research question was: What QI protocol would ensure materials are delivered on construction sites as specified by the engineers?

To address the primary question, the following secondary questions were used to guide the research:

- How does QP determine the specification and delivery of construction materials on public works projects?
- How does QC affect the specification and delivery of construction materials on public works projects?
- How would QI ensure that the specification and delivery of construction materials on public works projects meet the stipulated deliverables?
- What protocol will engender QI in relation to specification and material delivery in public works projects?

1.4 Research Aims and Objectives

The aim of the study was to develop a QI protocol that would ensure materials are delivered on construction sites as specified by the engineers.

The objectives of this study were to:

- Evaluate how QP determines the specification and delivery of construction materials to public works projects.
- Evaluate how QC affects the specification and delivery of construction materials to public works projects.
- Evaluate how QI would ensure that the specification and delivery of construction materials to public works projects meet the stipulated deliverables.
- Develop a protocol that will engender QI in relation to specification and material delivery to public works projects.

1.5 Research Assumptions

Firstly, there is a problem with the specification and delivery of construction materials at the Free State Department of Public Works and Infrastructure (DPW&I). According to monthly project reports for 2020, the main cause of quality deviation was the failure to appoint competent officials and competent service providers in project implementation. As a result, DPW&I management must recognise the need to appoint qualified authorities and service providers to conduct DPW&I projects in the Free State. Secondly, the current problem of quality deviation in the DPW&I stems directly from the fact that quality is neglected during the development and implementation of projects.

Communities in the Free State Province feel disenfranchised and ignored when these projects are implemented (Tshoose, 2015). This causes public discontent and instability.

The following assumptions were applicable to this study:

- Client departments, such as the Department of Social Development (DSD), Department of Health (DH), Department of Education (DE) demand effective and efficient project delivery from DPW&I in the Free State;
- There are mechanisms in place for effective project implementation;
- Construction regulations and legislation are in place to favour optimum project delivery; and
- Quality is a multi-faceted performance requirement in construction and has implications for the specification and delivery of materials on construction sites.

1.6 Significance of the Research

The Provincial Department of Public Works and Infrastructure's mission is to expedite infrastructure delivery at the provincial government level. Departments are expected to provide world-class infrastructure to South Africans from poor and disadvantaged backgrounds through large construction projects in order to achieve socio-economic objectives. Application of a QI protocol has become a well-established mechanism for delivering government services (Tshoose, 2015).

Through the application of QI of construction services, a project's core organisational capabilities can be improved, which typically leads to both long-term financial and operational sustainability. The quality of construction services on large and complex projects can yield short-term profits, but it can have a negative effect on project and organisational sustainability.

The purpose of this study was to develop a protocol that will engender QI in relation to specifications and material delivery in the Provincial DPW&I. The aim of the study was to evaluate how QP determines the specification and delivery of construction materials on public works projects; how QC affects the specification and delivery of construction materials on public works projects; and how QI would ensure that the specification and delivery of construction materials on public works projects meet stipulated deliverables. According to Forbes and Ahmed (2020), the quality management approach is based on three, fundamental, quality-oriented processes: QP, QC, and QI. Each of these processes is universal, with a set of iterative activities.

This study, which highlights the advantages and disadvantages of specification and delivery of construction materials, will be immensely helpful to government departments at both the provincial and national levels. Because provincial departments will be able to use the QI protocol, the research will be part of a larger investigation. In construction, a project is successfully completed if it is on time and within budget and will serve its original goal (Kerzner, 2022). As a result, performance, time, and cost are vital factors of any construction project.

The significance of the study is that the findings of the investigation into technical personnel's perceptions of construction projects at the Provincial Department of Public Works revealed differences in the output of their work. The study's goal was to fill knowledge gaps about the success or failure of implementing projects chosen by decision-makers in infrastructure project execution. This study will benefit all government departments, as intended. The findings of this study will provide DPW&I officials with a QI protocol that will ensure the timely and cost-effective delivery of infrastructure projects.

1.7 Outline of the Study

Chapter 1: Research Background. This chapter contains an introduction to the dissertation, the background, the research questions, and the aims and objectives. It includes a brief overview of the research assumptions, the structure of the research and finally the summary of the chapter.

Chapter 2: Research Literature Review. In this chapter, the available literature relevant to this study is analysed. Past studies are reviewed, analysed, considered and used as a guide. The different components used in the research are also examined and discussed in this chapter.

Chapter 3: Research Methodology. This chapter is focused on the methodology that was applied in the study to achieve the desired results. The research onion model was used to discuss the research philosophy that underpinned the research strategy and methods.

Chapter 4: Results and Discussion. In this chapter, the results of the analysis of data collected from interviews, surveys and review of documents are presented. Outcomes are presented visually in the form of graphs and tables. The results and interpretations of the findings are also discussed in this chapter.

Chapter 5: Conclusion and Recommendation. This chapter contains a summary of the conclusions and recommendations that emerged from the study. Key points are highlighted in relation to the literature reviewed.

Figure 1.1 illustrates the framework of the study.

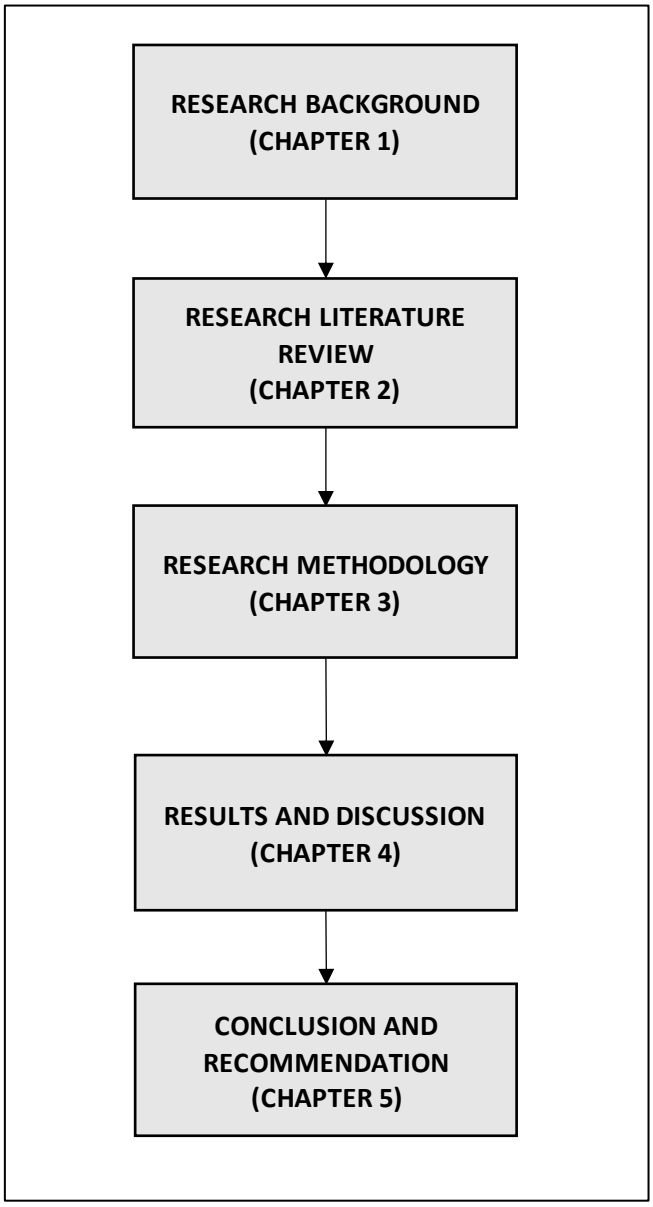

Figure 1. 1: Structure of the Dissertation

1.8 Chapter Summary

This chapter discussed the research background, problem statement, research questions, research aim and objectives, research assumptions, and the significance of the study. The chapter concludes with

a synopsis of the research structure. The following chapter presents a review of related and relevant literature.

CHAPTER 2: RESEARCH LITERATURE REVIEW

2.1 Introduction

This chapter contains an overview of the role of the Free State Provincial DPW&I, and its vision and mission, the role of the National CIDB of South Africa and its regulatory framework, and the role of the South African Board of Engineers and the Architects and Quantity Surveyors Board and its regulatory framework. The chapter includes an overview of the challenges faced in the construction industry and the re-work that results from the discrepancy between construction specifications and the materials delivered. Furthermore, the chapter contains an overview of quality, the origin and implication of QP, project QP, and the requirements for QC and QI. Finally, the implications of deviations in construction from quality requirements and quality management are outlined.

2.2 Free State Provincial DPW&I

The DPW&I envisions a thriving Free State by promoting sustainable built-infrastructure. The mission is to co-ordinate, provide, and encourage infrastructure and asset management (DPW&I, 2022). The DPW&I is specifically tasked with providing leadership in provincial infrastructure planning and development. Works Design, Construction, and Maintenance establish the framework for the Department's mandated infrastructure performance delivery (DPW&I, 2022).

The Department has the responsibility of designing and building new infrastructure as well as upgrading, rehabilitating, and maintaining existing facilities as identified in consultation with client departments such as Education, Health, and Social Development, and others. The Department serves as the provincial departments' technical implementing agent for the construction and maintenance of provincial infrastructure (DPW&I, 2022). All client departments' infrastructure budgets are reflected in the relevant departmental budget votes. As a result, the key functional areas include: construction, maintaining, and upgrading a sustainable, social and economic infrastructure; developing and sustaining small and emerging contractors; and inspiring targeted groups (DPW&I, 2022).

2.3 National CIDB of South Africa

The CIDB is a schedule 3A public entity that promotes a regulatory and developmental framework that builds the capacity of the construction industry for South Africa's social and economic growth,

along with a proudly South African construction industry that produces according to globally competitive standards (CIDB, 2014). The CIDB is committed to achieving the following goals: long-term growth, capacity development, and empowerment; improved industry performance and best practices; a transformed industry supported by consistent and ethical procurement practices; and increased value for clients and society (CIDB, 2014).

The CIDB is a DPW&I agency that reports to the Minister's Executive Authority. The Minister appoints the CIDB Board as well. The Department of Public Works is in responsible for reviewing and approving CIDB strategies and plans, as outlined in the Strategic Plan and Annual Performance Plan (APP). The CIDB reports quarterly and annually to the Minister on its performance. Annual progress reports are also provided to the Parliamentary Portfolio Committee on Public Works, which is in charge of oversight (CIDB, 2014).

2.4 The South African Built Environment Professional Councils for the following professions: Architecture, Project and Construction Management, Engineering, and Quantity Surveying

The South African Council for the Architectural Profession (SACAP) was established in terms of the Architectural Profession Act 44 of 2000 and regulates professional architects, professional senior architectural technologists, professional architectural technologists, and professional architectural draughtspersons (SACAP, 2022).

The South African Council for the Project and Construction Management Professions (SACPCMP) is mandated by Section 22 of the Republic of South Africa's Constitution. The SACPCMP was established to regulate and promote specific Built Environment Management Professions. It is a juristic person established by the Project and Construction Management Professions Act (Act No.48 of 2000) "to provide for the registration of professionals, candidates, and specified categories in the project and construction management professions; to provide for the regulation of the relationship between the South African Council for the Project and Construction Management Professions and the South African Council for the Project and Construction Management Professions" (SACPCMP, 2022).

The ECSA is a statutory body established in terms of the Engineering Profession Act (EPA) 46 of 2000. The primary role of ECSA is the regulation of the engineering profession in terms of this Act.

Its core functions are the accreditation of engineering programmes, the registration of individuals as professionals in specified categories, and the regulation of the practices of registered individuals (ECSA, 2022).

The South African Council for the Quantity Surveying Profession (SACQSP) was established in terms of the Quantity Surveying Profession Act (Act No. 49 of 2000), which regulates the profession of quantity surveyors in South Africa (SACQSP, 2022).

2.5 The Construction Industry

The construction industry is defined as "a vast agglomeration of industries and sectors that provide value to the creation and maintenance of fixed assets in the built environment" (Lombard, 2010: 8). According to the definition, the industry is responsible for "the provision of a mix of goods and services for the development, extension, installation, repair, maintenance, renewal, removal, renovation, alteration, dismantling, or demolition of a fixed asset encompassing building and engineering infrastructure". Consulting services are defined by the International Federation of Consulting Engineers (FIDIC) as "technology-based intellectual services for the built and natural environment" (Baker *et al*., 2013). Engineering design and quality management are two examples of such services in the construction industry.

2.6 Challenges Faced in the Construction Industry

According to Mbande (2010), there is a skills shortage in the South African skills sector as well as in state-owned enterprises. Moreover, as stated by the South African CIDB (2004), public-sector capacity is a major impediment to infrastructure delivery and long-term growth in the industry. According to Milford (2010), the government's lack of capability has contributed in an inefficient and time-consuming process of financing construction projects, along with payment backlogs of more than six months in some cases. This demonstrates a mismatch between available and required skills in South African construction industry. According to Mbande (2010), there is a link between an increase in community protests in South Africa and a severe shortage of construction skills. According to a CIDB (2004) report, the skills provided to the industry through the Further Education and Training (FET) System are frequently insufficient to meet the needs of the construction industry, resulting in a skills gap and a decline in professional sector functionality.

In another study conducted in the South African construction industry, Bowen *et al*. (2015) stated that, as a result of corruption and political influence: contractors are awarded contracts despite poor performance; policy formulation and governance are entrusted to people who lack the necessary expertise, education, and experience; and economic constraints have resulted in technical specifications being compromised, resulting in the use of low-cost, low-quality materials. One type of corruption, according to Bowen *et al*. (2015), occurs primarily because of opportunities that arise during the building procurement process, notably during the tendering and bid review stages. Bowen *et al*. (2015) stated further that more procedural transparency and stricter control mechanisms would aid in the fight against corruption, and that eliminating or reducing chances for corruption would naturally reduce the incidence. More forensic detection approaches should be developed and used, especially in the tender review process where more advanced, statistical, analytic techniques could be used. This strategy would not only aid in the detection of corruption but would also serve as a deterrent, especially if coupled with harsher punishments for corrupt behaviour.

In this research, quality deviation concerns in South African construction, resulting from quality gaps observed in the literature reviewed, are addressed. The study was motivated by the requirement to assess the quality of QP, QC, and QI data collected in the industry. QI initiatives in the DPW&I projects were investigated in order to gain a better understanding of QI initiatives in the DPW&I projects. According to Emuze and Smallwood (2011), some of the causes of quality deviation in South Africa are a lack of environmental concern, poor design activity management, poor planning, low skills levels, re-work, poor productivity, corruption, and poor quality. This is corroborated by the findings of Tuli and Allopi (2014), who highlighted cost over-runs, re-work, late completion, poor consideration of environmental issues, and poor work habits as reasons for quality difficulties in South African construction industry.

2.7 Rework as a Result of Construction Specifications versus Delivered Materials

Re-work in construction typically begins with the discovery of flaws. According to Li and Taylor (2014), it can also emerge from changes in requirements or when the implemented design does not meet an acceptable standard of quality, necessitating the scrapping and re-working of some of the current design. Depending on when re-work happens in the building process, it has varying effects on project performance. Re-work can occur at any point during the project life-cycle because it is the act of doing a task more than once. Re-work definitely has a major impact on project performance,

whether or not projects can be completed within schedule and cost restrictions, according to Taggart *et al*. (2014). Re-work also has a significant overall impact on the sector, which might be direct or indirect. Although re-work has some benefits, such as improved quality and meeting client requirements, it is a significant factor that negatively impacts the construction process and can result in time over-runs, inflation, cost over-runs, client dissatisfaction, contractor financial difficulties, contractor dissatisfaction, design team dissatisfaction, and lower profitability. There are also other possible effects of re-work, such as end-user discontent, inter-organisational conflict and litigation, stakeholder and worker stress and weariness, work idleness, demotivation, and damage to professional image (Li & Taylor, 2014).

The construction phase of a project is quite complicated. To avoid mistakes, close supervision and attention are required. Suresh *et al*. (2016) supported the conclusions of previous researchers, such as Emuze and Mhlwa (2015), Aziz and Hafez (2013) and others, claiming that re-work can be caused by a variety of factors such as changes in quality, flaws, and so on. On the other hand, Li and Taylor (2014) divided the root causes of re-work into three categories: design-related issues, client-related factors, and contractor-related factors. In addition, Taggart *et al.* (2014) highlighted five key causes of re-work: a lack of human resource competency; a lack of leadership and communication; inefficient engineering and reviews; incorrect construction planning and scheduling; and insufficient supply of materials and equipment. However, the reasons for re-working vary from country to country and project type to project type. As a result, they should not be taken literally and, instead, should be interpreted as suggestions, because quality levels and interpretations will vary. Local practices, industry culture, and contractual agreements might also have a significant influence on the incidence of re-work (Lopez *et al*., 2010).

2.8 Quality

Forbes and Ahmed (2020) cite Juran as taking the view that quality may be interpreted as "fitness for use", "fitness for intended use", "conformance to requirements" or "conformance to specifications" and Deming as saying that quality could be regarded by the customer as meeting their needs and expectations at a cost that represents value. These related definitions suggest that QP is the managerial method that is used to achieve systematic and optimum use of resources in order to achieve a particular objective within limited time and resources (Gulghane & Khandve, 2015).

2.8.1 Quality in South African Construction

The industry in South Africa is facing problems related to the standard of construction quality expected by clients (Emuze & Smallwood, 2011). The cost of poor quality in the construction industry is associated with the prevention, discovery, and resolving of defects (Kerfai *et al.*, 2016). These are caused by failure to prevent defects and wastage during construction work (Aigbavboa & Thwala, 2014). Activities that generate prevention costs include developing and implementing quality inspection procedures, performing systematic product inspections, investigating the causes of quality errors, and educating and motivating personnel on quality management (Van Weele, 2018). Assessment costs are a result of activities performed with the goal of minimising the consequences of errors, such as inspection of purchased goods, handling damaged products, and registering and reporting quality defects (Ellis & Martin, 2019).

2.8.2 Origin and Implication of QP

A demand for items conforming to quality standards has existed throughout history (Baker *et al*., 2013). Assessing and ensuring quality became increasingly difficult as communities became larger and society and products grew more complex. Early trade guilds might be considered to have been an attempt to regulate product quality, as quality systems evolved to satisfy these objectives.

If planning does not include quality aspects, then an incomplete benchmark or reference point will be established (Steyn *et al.*, 2016). This means that the longer the planning stage, the shorter the execution stage. The deliverables in terms of quality from the planning process are as follows: project finished on time; current material delivered on time; no delays during delivery; limited amount of re-work; limited confusion and misunderstanding; up-to-date knowledge of the status of the material by everyone at any given time; accurate, concise reports to management; leading indicators of potential deviations; complete control over the material processes (Rumane, 2017).

It is noted that quality in South Africa has remained a concern from the client perspective. As a result, the industry is constantly confronted with conflicts over client dissatisfaction (Mavetera et al., 2015). The lack of quality is visible in non-conformance of work to established requirements, which is visible when a constructed project does not meet the client's needs and specifications (Chinyamurindi, 2017).

2.8.3 Quality Perspective from Quality Experts

Crosby's Zero Defects: "This process was introduced by Philip H. Crosby in 1979. The Crosby process can help an organization by providing a quality management culture. Lean and Six Sigma can be effective 'tools', but a tool becomes more beneficial when it is put to work regularly. To do that, a quality 'culture' is required to encourage (or insist) that everyone participate in this important process (Taidi, 2015)".

Ishikawa: "The cause-and-effect diagram is the brainchild of Kaoru Ishikawa, who pioneered quality management processes in the Kawasaki shipyards and, in the process, became one of the founding fathers of modern management. The cause-and-effect diagram is used to explore all the potential or real causes (or inputs) that result in a single effect (or output). Causes are arranged according to their level of importance or detail, resulting in a depiction of relationships and a hierarchy of events. This can help to search for root causes, identify areas where there might be problems, and compare the relative importance of different causes (Bilsel & Lin, 2012)".

J. Juran: "Dr Joseph Juran is known for several quality contributions: Three Basic Steps to Progress, Ten Steps to QI, and The Quality Trilogy. Juran's quality trilogy has three components, namely: firstly QP, secondly QC, and thirdly QI. This trilogy of quality processes provides a successful framework for achieving quality objectives. The processes must occur in an environment of inspirational leadership and the practices must be strongly supportive of quality (Forbes & Ahmed, 2020)".

The objective of this study, therefore, was to develop protocols of material quality specification and delivery as an integrating technique, rather than as a sub-set of management, and to develop skills to improve the ability to deliver better quality projects in the department of public works.

2.9 Project QP

Project planning appears to have a considerable impact on project success, according to the literature (Davis, 2014; Marcelino-Sádaba, *et al.*, 2014; Lock, 2017; Heravi, *et al.*, 2015; Zwikael & Smyrk, 2015). Project planning is defined as the creation of a set of instructions that tells the project team exactly what needs to be done, when it needs to be done, and what resources to use in order to create the project's deliverables successfully (Cameron & Green, 2019). Project managers are solely responsible for planning, and they must ensure that the project is completed correctly and to the

satisfaction of all stakeholders. The following are some of the most significant benefits of effective project planning: firstly, it eliminates or reduces uncertainty; secondly, it improves operational efficiency; thirdly, it provides a foundation for monitoring and controlling work; and fourthly, it provides a better understanding of project objectives (Chapman *et al*., 2018).

The project plan is a crucial result of the planning process. During the planning phase of a project, the project team creates this document. The features included in the project plan are: overview, project objectives, general strategy, contractual factors, timetables, resources, personnel, risk management plan, and evaluation methods (Cameron & Green, 2019). Several managerial processes must be carried out in order to establish a project plan. Various sources can be used to compile lists of possible planning procedures. To name a few, Magnaye *et al*. (2020) identified seven planning processes: defining project objectives, identifying activities, establishing precedence relationships, making time estimates, determining project completion time, comparing project schedule objectives, and determining resource requirements to meet objectives. According to Chapman *et al*. (2018), the planning phase comprises nine primary components: objective, programme, schedule, budget, forecast, organisation, policy, process, and standard. The project management body of knowledge (PMBOK) identifies 44 processes, with 21 of them being planning procedures (Crawford *et al*., 2018).

Despite the main planning procedures having been identified, research has yet to identify clearly which of them is more important. As a result, project managers and planners are pressed for time and thus unable to complete all planning stages effectively. As a result, they might opt for the simplest planning processes, such as those required at the outset of a project, rather than those that contribute the most to the project's success, such as: "definition of project activities to be accomplished", "schedule development", "organizational planning", "staff acquisition", "communications planning", and "creating a project plan", according to Gunduz and Yahya (2018).

Some evidence suggests that environmental factors might also have an impact on identifying important project processes. For example, Pollack and Adler (2015) discovered differences in project management knowledge and practices across businesses, regions, and application domains. Yu *et al*. (2018) discovered three critical success factors that influence construction project planning: firstly, investing enough planning time before work begins on-site; secondly, reducing emphasis on developing schedules for project monitoring and control; and thirdly, increasing emphasis on developing operational plans for project implementation.

2.9.1 Quality Assurance and QC

Quality Assurance (QA) is a programme that encompasses the actions that lead to producing high-quality output. It includes establishing policies, procedures, standards, training, and guidelines, as well as establishing a system that makes it possible to produce high-quality work. The system policies (programmes) for the project are the responsibility of the constructors and design professionals (Zhang, 2019). QA provides safeguards against future quality issues. It addresses the construction industry's internal and external issues. QA ensures that the materials, techniques, and processes used in a project are of high quality, ensuring safety and durability (Zhang, 2019). The application of QA policies in an effective and detailed manner is referred to as QC. Changes, revisions, and errors are all avoided through effective QC.

2.9.2 Cost of Quality Deviation

The cost of quality (COQ) is covered in greater detail below. It is a critical quality practice because all modern quality systems, including ISO 9000 and TQM, emphasise the importance of fact-based decision-making. COQ is an approach and potential method for gathering information for fact-based quality decision-making. As previously stated, COQ has been used in several cases in the construction industry.

According to Rivas et al. (2011), inaccurate quality affects customer satisfaction, which may result in additional costs. Client dissatisfaction, conversely, may lead to a drop in the market share and profit of the construction firm that is responsible for a project because of the implications for productivity. This is known as a "external failure cost," and it occurs when customers identify errors (Obunwo et al., 2015). External failure costs include the costs of processing customer complaints, resolving customer claims and disputes, and the loss of "goodwill" (Van Weele, 2018). The cost of lost "goodwill" or reputation is an indirect cost that is extremely difficult to cost and comprehend, but it is a cost that can be disastrous for a company. Furthermore, quality errors discovered before the product is delivered to the customer are referred to as internal failure costs. These quality errors result in correction costs as well as project delays or stalling.

Furthermore, quality costs can be classified as tangible or intangible (Kerfai et al., 2016). Tangible quality costs, according to Moschidis et al. (2018), are costs that can be priced and measured, such as re-work, warranty costs, reclamations, and control personnel costs. Measuring tangible quality costs provides a foundation for developing QIs. However, if QI is solely based on these costs, there is a

high risk that many hidden costs will be overlooked. According to Chatzipetrou and Moschidis (2017), quality costs are primarily invisible, and many businesses are unaware of the extent of their quality costs.

According to Moschidis et al. (2018), hidden or intangible quality costs include engineering time, management time, increased inventory, decreased capacity, and increased project time. These costs are difficult, if not impossible, to quantify, but they have a significant impact on an organisation's profitability. According to Kerfai et al. (2016), some organisations consider intangible costs to be three to four times greater than tangible costs. Kerfai et al. (2016) went on to argue that one issue with measuring intangible costs is that personnel handle problems without accounting for them. This preserves the illusion of effective quality management (Chatzipetrou & Moschidis, 2017).

Furthermore, accountability for quality costs is frequently ambiguous. Nonetheless, it is an issue that must be addressed explicitly in business relationships. The majority of quality issues are discovered during the manufacturing process. However, defects are frequently the result of previous operations in the supply chain. The cost sources can be identified by breaking down the reasons for quality costs into several steps (Forbes, 2010).

2.9.3 Deviation of Construction Material Delivery from Specifications

Moschidis et al. (2018) emphasised that, because many design outcomes are not standardised and simple productivity measurements are difficult to come by, they believe that design effectiveness is far more important than simply attempting to evaluate design productivity. Moreover, true indicators of design performance are discovered only later in the construction, start-up, and operation of the facility. Following the completion of construction, one technique necessitates the evaluation of seven criteria. Plant operation criteria are not examined because the project team disperses after completion. Design documentation accuracy and usability, design effort cost, design constructability, design economy, timetable performance, and start-up ease are the criteria. Depending on the nature of the project, different weights are assigned to each criterion to determine the overall efficacy of the design. One criticism of this approach is that the assessment can only be conducted after the building has been finished; it does not allow for the assessment of design effectiveness while the building is being constructed.

A general contractor's (GC) desire for the best reputation in the construction industry necessitates project performance factors that promote client satisfaction. GCs gain a reputation by meeting the

needs of their clients, and gaining a reputation is the most important criterion for a GC to become more competitive in the industry (Ashworth & Perera, 2015). The inter-connection of the business and project parts of construction management has been deemed critical in the industry's quest for increased profitability (Du Plessis & Oosthuizen, 2018).

The findings of numerous construction management-related studies from South Africa demonstrate the above connection. According to Amoah and Bikitsha (2020), production and quality have decreased in South Africa, while health and safety (H&S) have only increased marginally. As a result, conflicts over client discontent are common in the industry (Bikitsha & Amoah, 2020). This could indicate that contractors have recognised the importance of H&S in the construction business and have begun to prioritise H&S over other project factors such as quality. Non-conformance of work to set requirements, which is evident when a created project fails to fulfil the needs and specifications of the client, is a sign of poor quality (Dilawo & Salimi, 2019).

2.9.4 Implications of Quality Deviations in Construction

Quality-related issues, such as re-work, might be projected to later stages of the construction process (Yaghootkar & Gil, 2012). One of the criteria that determines client satisfaction levels is the quality of work. Client discontent, on the other hand, might result in a decrease in the construction firm's market share and profit as a result of the implications of the project's productivity (El-Gohary & Aziz, 2014). Clients and other supply-chain stakeholders, notably contractors, are affected by quality deviations. Incidents of non-conformance have an effect on the contractor since they result in re-work penalties, which can reduce production dramatically (Rivas *et al*., 2011). Furthermore, this indicates that, in the construction industry, quality, time, cost, and productivity are all inter-related (Dilawo & Salimi, 2019).

According to Baloyi (2013), the upper management of construction enterprises in both South Africa and Botswana is not committed to quality. In some cases, management's commitment to a project's workforce in regards to access to a firm's quality policies and goals may be insufficiently communicated, and/or workers may be demoralised to deliver work that meets criteria (Baloyi, 2013).

Non-conformance of work to requirements can similarly occur when upper management of a project is overly concerned with cutting costs and shortening the timeline. Butt *et al*. (2016) and Akkermans and Van Oorschot (2018) found that, in order to save time and money in the construction business, managers often overlook quality (Butt *et al*., 2016).

This situation, as described, is in direct opposition to the expectations of today's clients, who prioritise quality over cost, particularly in the public sector. In this context, clients do not always prioritise cost-cutting over quality. To address this issue, the most important aspect to consider is commitment to quality, because management has a significant impact on project outcomes (Othman, 2012). The degree to which management participates in and supports the implementation of a total quality management (TQM) system in the construction project environment is critical in ensuring that work meets specifications. QI cannot be executed effectively when management commitment is lacking and, if upper management obviously demonstrates dedication to quality, workers will logically follow suit (Marin-Garcia & Bonavia, 2015).

Furthermore, the literature suggests that staff physically engaged in construction activities and QIs are not adequately trained to provide the desired outcomes, and that this is the primary cause of non-conformance incidents in South African construction (Emuze & Smallwood, 2013). According to Baloyi (2013), there is little, if any, link between worker performance and remuneration in South Africa, which leads to a tendency not to strive to produce a high-quality product. Because of the country's scarcity of qualified tradespeople, a poorly compensated, qualified artisan, for example, has leverage in terms of changing occupations. Unskilled or unqualified craftsmen, on the other hand, who remain in an environment of low-morale, will continue to produce poor craftsmanship, which will result in re-work, reducing the quality of produced projects (Davies *et al*., 2017). A balanced method is required when deciding on salaries, morale, and performance for construction workers.

Another factor affecting quality is the increased use of sub-contractors by GCs. According to Baloyi (2013), increasing employment of sub-contractors has resulted in increased process fragmentation, with sub-contractors performing their responsibilities essentially in isolation. This is especially risky when the project goals of the GC and the sub-contractor differ. For example, sub-contractors might strive to complete work as rapidly as possible, while spending as little as possible by using low-cost labour, and to receive remuneration as soon as possible in order to remain financially viable on a given project. Non-conforming work is a major possibility when a project team has a mismatch of interests (Baloyi, 2013). If the job does not meet the requirements, it indicates that the primary contractor's quality management and control are insufficient because, when the project is effectively planned and managed, sub-contractors are adequately engaged and overseen.

However, as a result of a reported shortage of skilled supervisory workers, supervision in South African construction is under duress (Emuze *et al*., 2014). There is no regular monitoring or

supervision, errors are not recognised early, and continual correction of poor work is common because of the claimed shortage. Continuous corrective work occurs on project sites when work is not monitored and overseen on a frequent basis, or when quality of supervision falls short of expectations (Baloyi, 2013).

2.10 Requirements for QC

QC entails QP, training, clear decisions and directions, regular supervision, quick examination of finished tasks for accuracy and completeness, and documentation of all decisions, assumptions, and suggestions. The designer has a clear obligation in the process of developing the construction plan to guarantee that all project elements are cost-effective, correct, appropriately planned, co-ordinated, checked, and completed (Salvi & Kerkar, 2020). Quality must be as crucial as the schedule and budget in order for the project to satisfy constantly the demands and expectations of the population. In the preparation and assessment of all design products, design staff must follow defined policies for design, methods, standards, and guidelines. The major task of preparing construction plans rests with design consultants, who are the project's agents. QC and adherence to specified design policies are required of consultants (Salvi & Kerkar, 2020).

2.10.1 Contractor Selection for Delivery of Construction Material

The contractor in charge of a construction project's engineering has a significant influence on the final result, but engineering costs are often a small fraction of the total project cost. As a result, the FIDIC recommends that quality rather than price be used to select consultants or contractors to carry out this engineering (Baker et al., 2013). The FIDIC recommends a quality-based selection approach in which contractors are chosen based on quality criteria such as contractor competence, experience, managerial ability, resource availability, integrity, and other factors. Contractors must still bid within a price range determined by estimating prior to the bidding phase, but the final appointment is based solely on quality standards.

2.11 QI

The Japanese were among the first to use quality-improvement techniques in large-scale building, although they did not fully embrace the notion until the 1973 oil crisis (Forbes & Ahmed, 2020). They previously believed that the construction industry was unsuitable for the use of QC because of

the inherent variety in projects and the difficulties in defining "acceptable quality". In several studies in recent years, it has been found that overall project performance is sub-optimal around the world (Aamer *et al.*, 2017). Customers continue to be disappointed with the poor quality of completed roads and unco-ordinated construction activities in Nigerian construction projects, particularly road projects. As observed in the literature, people physically participating in construction operations and quality inspectors are not sufficiently qualified to give the desired results, and this is the primary cause of non-conformances in South African construction (Emuze & Smallwood, 2013).

Identifying the primary sources of customer satisfaction would be an important step toward resolving this long-standing problem (Obunwo *et al.*, 2015). Many public-sector projects require an externally approved ISO 9001 Quality Management System (QMS), leaving SMEs no choice but to establish such a system (Brooks & Spillane, 2017).

Quality costs, scheduling slippages, and operational issues were all blamed for the dismal results (Orstavik, 2018). Forbes & Ahmed (2020) also cite preventative and evaluation expenditures as two more quality cost categories. Since the construction industry has long relied on paper in order to manage records of quality, capturing and analysing data has been difficult, inhibiting historical performance analytics that could lead to better results. According to the literature reviewed, the entire management process should be reviewed and improved in every way feasible.

Construction, particularly in developing economies, frequently brings together employees with diverse skills to complete a given project. When the project is completed, the project participants go their separate ways, with no further interactions that could result in improved work practices. Failure to apply lessons learned can have a negative impact on a GC's bottom line and reputation (Frank, 2011).

Quality should be built into the project components rather than assessed. The optimal way to attain quality is to keep deviation from the target as low as possible. The product should be built in such a way that it is impervious to uncontrollable environmental influences. Quality costs should be calculated as a function of deviation from the standard, and losses should be calculated across the entire system (Forbes & Ahmed, 2020).

2.11.1 Quality Management

Poor site supervision, a lack of or insufficient documentation, and QA, as opposed to QC, all have an impact on the quality of construction products. For example, insufficient work knowledge, inexperience, limited knowledge of quality standards, inability to co-ordinate work activities, and poor scheduling competence (Frank, 2011) all contribute to the manifestation of incapable supervision, which frequently results in poor workmanship and quality in construction. Despite calls for continuous improvement in construction (Sallis, 2014), these problems have persisted. Completing most construction projects on time has been a long struggle because maximising quality, minimising cost, and meeting scheduled milestones are constant challenges in construction, especially in large and complex projects (Mukhopadhyay, 2020). As a result of the cost over-runs and inferior quality that always accompany project delays, construction clients frequently experience low levels of satisfaction. Project re-work is a global phenomenon in the construction industry that tends to exacerbate the failure to deliver infrastructure needs on time. The construction industry's inability to innovate and deliver projects on time has resulted in widespread dissatisfaction among industry clients (Saffar & Obeidat, 2020).

2.11.2 Existing Cost Management Approaches Lead to a Number of Challenges

Other developing countries have revealed project over-runs, but South Africa had yet to do so. Then, in 2010, Ramabodu & Verster (2010) established that cost over-runs were a concern in South Africa, with a focus on the Free State Province. Ramabodu & Verster (2010) went further to identify the elements that contribute to cost over-runs and ranked them in order of priority in order to increase awareness among construction industry professionals. The study relied on professionals' perceptions to identify the variables that they believed were leading to cost over-runs, but there were no data to support the results. Furthermore, no recommendations were made in the study for reducing the likelihood of future cost over-runs in construction projects.

According to Nimbona & Agumba (2014), financial concerns (customers' financial capability, late payment, unreliable source of finance) were the top causes of failed construction projects in South Africa, implying that cost plays a crucial role in project success. Innovative approaches to solving this problem, such as target value design (TVD), give the SA construction industry a better understanding of the challenges of using target costing in contracting, as well as the necessary modifications and adaptations to the approach to make it suitable for the SA construction industry.

2.11.3 Outcomes of Existing Cost Management Practices

Cost management, according to Fewings (2019), is the process of ensuring that the planned development of the design and procurement of a project is such that the price for its construction gives value for money (VFM) and is within the client's expectations. The management of costs in a project is a continuous process that runs throughout a project's life-cycle. The cost and financial sustainability of a project determine its feasibility, and the project is not complete until the final funds and documents are received. According to Steyn *et al*. (2016), cost management starts with a financial feasibility analysis, then proceeds to all of the costs associated with purchasing all of the project's resources and, finally, to cost control to guarantee that all work is completed appropriately.

2.12 Chapter Summary

According to the literature reviewed, many countries' construction industries have quality issues. Although no formal research has been conducted on this current topic, various stories in the news and elsewhere suggest that the country faces similar issues. The background of the study was provided by a review of the literature in which quality in general and quality in service in the construction sector were considered. Furthermore, the critical gaps were identified through a review of the literature.

Methods for addressing the shortage of construction management skills and competence, as well as the development of a comprehensive guide for QI practices across the entire project value chain, were identified. The data has been condensed into practices that can be used to improve the quality of DPW&I projects.

In the chapter, a comprehensive investigation of all factors contributing to the situation in SA construction was conducted through the relevant processes of research, including the evaluation of published literature, data collection, analysis, and evaluation. The entire evaluation was based on the proposed QI protocol for the specification and delivery of construction materials required by the DPW&I projects. The methodology used in the study and how it was used to achieve the desired results will be the focus of the following chapter.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Research is a method of gathering, analysing, and interpreting data to gain a better understanding of a certain phenomenon. Formal research is defined as research in which the goal is to gain a better understanding of a phenomenon and the results are anticipated to be shared with the rest of the scientific community (Creswell & Poth, 2016). As a result, research methodology is the researcher's overall strategy for completing the research project, and to some extent, this approach defines the methods the researcher employs (Babbie, 2020). Because methodology governs research, this chapter explains the approach and methods used to develop a QI protocol for the specification and delivery of construction materials as required by DPW&I projects.

3.2 Research Philosophy

Adopting a research philosophy represents the first step in the research process. Thus, understanding and selecting a philosophy is a crucial stage in research planning and execution (Mayer, 2015). The term "research philosophy" refers to the development of knowledge as well as the nature of that knowledge. As a result, a research philosophy involves key assumptions about the researcher's worldview (Mayer, 2015). The research philosophy chosen influences issues such as the framing of the research topic and the selection of research methodologies. The research philosophy enables the researcher to explain why certain approaches were chosen and to provide specific criteria for evaluating the quality of the research (Mayer, 2015).

According to Saunders *et al*. (2019), the researcher's philosophical perspective is determined by two major components: ontology and epistemology. The term "ontology" refers to assumptions about the nature of reality (Crotty, 2020; Hesse-Biber & Leavy, 2011; Saunders *et al*., 2019). Furthermore, Saunders *et al*. (2019) described the ontological question as requiring academics to ask themselves how they believe the world works, how society is constructed, and how this affects everything in their environment. Epistemology is a division of philosophy that investigates the nature of knowing what constitutes acceptable knowledge in a particular field. This concept is most typically applied in scientific study because it requires facts and information that can be proven beyond a reasonable doubt rather than situations and views that are subject to change (Saunders *et al*., 2019).

Furthermore, six philosophical positions commonly associated with the two major components of ontology and epistemology are: objectivism, constructivism, pragmatism, positivism, critical realism, and interpretivism. Objectivism acknowledges that social phenomena and their meanings exist in their own right, distinct from social actors. Objectivism is opposed by constructivism's philosophical position, which is the view that social phenomena are created by social actors (Saunders *et al*., 2019). Positivism is primarily a philosophical position taken by a natural scientist. The epistemological perspective known as interpretivism is focused on understanding how humans make sense of the world. Pragmatism contends that both constructivism and objectivism are legitimate approaches to inquiry. Pragmatism is based on the concept that, within a study, both positivist and interpretivist viewpoints can be adapted to suit the needs of the research issue (Saunders *et al*., 2019). Thus, knowledge is examined by using methods that are best suited to solving the problem.

As previously stated, it is critical that researchers establish their own philosophical stance. Thus, in trying to answer the research problem of the QI protocol for the specification and delivery of construction materials required by DPW&I, pragmatism was the research philosophy that was adopted. The pragmatist philosophy uses survey and interview instrument to collect and analyse data.

3.3 Research Approach

Deductive research logic refers to reasoning that progresses from a general rule to a specific inference and is commonly used in hypothesis testing. Inductive reasoning is a method of developing theories that begins with a specific observation and leads to the formulation of a general rule (Saunders *et al*., 2019). The deductive approach requires that existing theories be confirmed in terms of their causal relationships with variables. Validation of hypotheses, which is the foundation of quantitative (statistical) procedures, is required to achieve this aim (Bryman, 2016).

For the inductive research approach, available empirical facts about the problem must first be collected and analysed, and then new hypotheses must be generated based on the findings (Glaser & Strauss, 2017). The goal of this approach is to gain a better understanding of the problem and the factors that influence it, and thus to contribute to the development of new theories. This approach refers to theory development or a qualitative approach.

Therefore, an inductive approach was adopted for this research as the data were collected using mixed methods and were required to answer the research question.

Furthermore, the distinction between explanatory and exploratory research is that explanatory research explains why certain phenomena work the way they do, whereas exploratory research explores and investigates an undefined problem (Echeverria, et al., 2018). Explanatory and exploratory research are two types of research that are useful in problem analysis. When the researcher has just started researching and wants to understand and explore the topic broadly, the researcher conducts exploratory research. When the researcher wants to explain why a certain phenomenon occurs, the researcher will conduct explanatory research (Ali, 2020). Thus, an explanatory approach was adopted for this research.

3.4 DPW&I Case Study Approach as a Research Strategy

According to Saunders *et al*. (2019), the main research strategies are: experiment, survey, archival research, case study, ethnography, action research, grounded theory, and narrative inquiry. The strategy adopted for this research was a single case study of DPW&I. This is an acceptable strategy for the exploratory phase of an investigation, according to Bryman (2016), who advocates diverse methodologies for each step of a research project. Case study research is used to explore specific situations in which more variables of interest than obvious data points should be added. As a result, the variables must be identified from a variety of distinct data sources, and the results are merged using triangulation of many points. This is accomplished through the use of pre-defined theoretical assumptions, which characterise the data collection and analysis process. Expressed another way, the case study, as a research method, encapsulates an approach that encompasses design rationale, data collection techniques, and analytical approaches.

Furthermore, case study research is defined as "an intensive study of a single unit for the purpose of understanding a larger class of similar units, observed at a single point in time or over a limited period of time" (Gerring, 2004: 342). The case study research design allows the researcher to gain a thorough understanding of the research problem (Baskarada, 2014). Aside from its widespread use in academia, this research design is popular among practitioners as a tool for evaluation and organisational learning (Baskarada, 2014).

Owing to the constant delivery of sub-standard quality on DPW&I projects, intervention to improve these conditions is necessary. The DPW&I is responsible for infrastructure projects in the Free State Province. As a result, DPW&I have been tasked with implementing new infrastructure projects. The organisation is responsible also for determining the procurement strategy to be used for new projects and maintenance projects. Infrastructure projects are either out-sourced or in-sourced under this

regime. Despite several interventions implemented by DPW&I over the years, poor project quality persists. These interventions were created by combining scholarly reports, policy reports, and peer-reviewed research. Nonetheless, an examination of the relationship between outsourced and in-sourced projects revealed the same outcomes: poor quality, project delays, and cost over-runs. As a result, the goal of this study was to develop a QI protocol to ensure that materials are delivered on construction sites in the manner specified by the specification writer.

3.5 Time Horizon

The time horizons are the centre of the research onion's fifth layer. Cross-sectional and longitudinal temporal frames have been identified. Owing to time constraints and, more importantly, the requirement to establish a case to achieve the goal of the study, a cross-sectional study of the phenomena related to the research questions was undertaken at a certain period, as part of the research strategy (Saunders *et al*., 2019). This is in contrast to the longitudinal time horizon, which is used to analyse change and development, even with time limits, because the primary inquiry is whether there has been any change over time. Data about a population are collected at a specific point in time for a cross-sectional study, which was the time horizon used in this study.

3.6 Study Population

A study population, according to Laura and Bernauer (2013), is made up of all people or groups that share the traits that the researcher is studying. This is a collection of individuals, events, or items of interest that the researcher intends to investigate. The questionnaire for this study was distributed to a sample of 152 respondents, as shown in Table 3.1. The sample population was made up of senior management, engineers, project managers, inspectors, artisans, quantity surveyors, architects, contractors from contractor development programme (CDP), department of social development (DSD), department of education (DE), supply chain management practitioners, monitoring and evaluation practitioners. The contractors from CDP were drawn from the centralised supplier database (CSD) and the senior management, engineers, project managers, inspectors, artisans, quantity surveyors, and architects were drawn from DPW&I and client departments in the Frees State. The original sample consisted of 155 participants, but only 152 participants agreed to take part in the study as shown in Table 3.1 below. The 152 respondents were selected because their offices were located within the Free State Provincial Government. Therefore, the researcher was able to gather and analyse information within a reasonable programme, budget, and time.

Table 3. 1: Sample Size

Sample	No.
Senior Management	7
Engineers	13
Project Managers	14
Inspectors	34
Artisans	41
Quantity Surveyors	9
Architects	6
Contractors from Contractor development programme (CDP)	5
Department of Social Development (DSD)	7
Department of Education (DE)	5
Supply Chain Management Practitioners	6
Monitoring and Evaluation Practitioners	6
Total	**152**

The data were collected to develop a QI protocol that would ensure materials are delivered on construction sites as specified by the engineers and evaluate how QP and QC determine the specification and delivery of construction materials to DPW&I projects. Face-to-face and telephone interviews were conducted with 30 respondents as shown in the Table 3.2 below to collect the required data. The interviews took place only once. Data were collected through semi-structured interviews.

Table 3. 2: Interviews with DPW&I

Interviewees	Frequency	Percentage (%)
Director of Construction and Maintenance	1	3.3
Chief Director DPW&I	1	3.3
Regional Managers	3	10.0
Quantity Surveyors	2	6.7
Architect	1	3.3
Engineers	6	20.0
Project Managers	6	20.0
Inspectors	10	33.3
Total	**30**	**100**

3.7 Sample Technique

According to Creswell and Poth (2016), there are two types of sampling methods: probability or representative sampling, and non-probability or judgemental sampling. Purposive sampling was used in this study. According to Creswell and Poth (2016), purposeful sampling allows the researcher to use judgment to choose examples that will better enable the researcher to answer the study question and meet the objectives. The DPW&I technical personnel were chosen as examples because they work on projects in a wide range of roles.

Purposive sampling was used because the characteristics of a population of interest have the same qualities or attributes. Purposive sampling is a method of addressing research questions using feedback from lived experiences (Laura & Bernauer, 2013). The DPW&I technical personnel were chosen because they work on projects in a variety of capacities. Principal Agents (PAs), for example, act as the primary point of contact for the client and manage construction projects on behalf of client departments. In addition, they design, document, and supervise construction projects. As a result of their role in overall project implementation, they must collaborate with other designated contractors on capital and maintenance projects.

3.8 The Data

The research onion's sixth and final layer is focused on the methodology and procedures of the research. According to Bryman (2016), data collection and analysis are iterative procedures in which the researcher moves back and forth across the data, collecting-analysing-collecting-analysing data rather than in a straightforward, linear manner. Depending on the research questions to be answered, it is possible to generate new information by analysing existing data or to collect new data specifically for the research question. The data for this study came from both primary and secondary sources. Existing data are considered to be secondary data, whereas new data are considered to be primary data, as discussed in greater detail in the following sections.

A researcher using a qualitative method performs a number of activities during the data collection process. According to Bryman (2016), qualitative research employs a variety of data analysis procedures, whereas Creswell and Poth (2016) contend that the researcher employs rigorous data collection procedures. This implies that the researcher collects a variety of data types, adequately summarises them, and spends sufficient time in the field. Researchers must collect data in natural

settings while remaining sensitive to the people being studied, and then inductively analyse the data to establish patterns or themes (Creswell & Poth, 2016).

3.9 Primary Data Collection

3.9.1 Survey Questionnaire

Primary data provide first-hand information that has been obtained, collated, and disseminated for a specific purpose (Saunders *et al.*, 2019). The researcher normally collects primary data from participants using questionnaires. Since information is gathered from novel sources for specific reasons, it necessitates data gathering by the researcher from personal observations and experiences (Queirós *et al.*, 2017). The method of data collection for this study involved a questionnaire that was used to pose the same questions to senior management, engineers, project managers, inspectors, artisans, quantity surveyors, architects, GCs, client department officials, SCM practitioners, and monitoring and evaluation practitioners.

The primary data collection strategy entailed identifying and profiling the target respondents. Participants were asked to select from responses in the survey instrument ranging from disagreement to agreement. The questions were designed to be appropriate for officials involved in various levels of DPW&I capital and maintenance projects. The survey was semi-structured and included both closed- and open-ended questions. The survey was written entirely in English. The majority of the questionnaires were emailed to participants, with a few being handed out in person. Before the questionnaires could be distributed, all participants gave their permission. The questionnaire included 23 questions about the DPW&I projects' QP, QC, QI, and quality challenges.

3.9.2 Interview

The second set of primary data included information gleaned from interviews with various DPW&I key personnel. The interviewees were representatives of the following: director of construction and maintenance, chief director, regional managers, quantity surveyors, architects, engineers, project managers, and inspectors. Data were gathered from people who had experienced the phenomenon. As a result, only people with authority and relevant industry experience were interviewed, allowing the researcher to make accurate and comprehensive comparisons. "In phenomenological investigations, in-depth interviews and several interviews with participants are frequently used to obtain data" (Creswell & Poth, 2016). The interviews provided valuable primary data.

The interview protocol allowed participants to think about the difficulties associated with DPW&I project quality. During interviews, notes were taken. Questions about the QP, QC, and QI were asked in person and over the phone in one-on-one interviews. Between February and May of 2021, semi-structured interviews were conducted with officials from the design, construction, and maintenance divisions. The first step was to identify potential participants and then contact them by telephone and e-mail. A covering letter explaining the purpose of the interviews was delivered by hand to some of the participants, while e-mails were sent to those who requested that the letters be e-mailed when approached by telephone. It was not difficult to gain access to the interviewees.

Interviews are a qualitative data collection method because they can provide depth in a research study, allowing the researcher to gain deep insights from various perspectives and rich narratives. During a qualitative study, the interviewing process allows researchers to gain access to the perspectives of participants and their perspectives on the phenomenon under study (Yin, 2013). Structured, semi-structured, and unstructured interviews are all possible. The semi-structured interview is intended to focus on the phenomenon being studied while remaining flexible enough to allow for individual perspectives on areas common to the study based on their experiences in the field or sector (Singh & Dubey, 2021). Based on the availability of participants, this study used a face-to-face and telephone interview approach.

3.10 Secondary Data Collection

Secondary data is information that has been acquired by another researcher for a specific purpose and is available for a new research investigation (Saunders *et al*., 2019). This information was first gathered for a variety of purposes and at various times. Secondary data were obtained from existing literature in the form of journal publications, unpublished theses, dissertations, conference papers, and the internet in order to conduct the literature review (Queirós *et al*., 2017). The main source of secondary data was the library of the Central University of Technology, Free State.

Furthermore, data collection methods for this study included reviewing site meeting minutes, monthly regional reports, hardcopies of files, soft copies of project files, and close-out reports (document reviews/analyses).

3.11 Data Analysis

According to Mayer (2015), data coding is a model in which data is broken down, conceptualized, and rearranged to reveal theory. Coding is simply the process of converting data from raw and unstructured data to theory. To accomplish this, interview transcripts were analysed using constant comparison to create categories, and the categories were coded accordingly (Creswell & Poth, 2016). As a result, open coding, axial coding, selective coding, and constant comparison were used holistically in this study to ensure that the emerging theory could be explored.

The statistical data were manually entered into an MS Excel Spreadsheet after carefully checking for errors (data cleaning) and incomplete data. Thereafter, the data was analysed using descriptive statistics to generate mean scores (MSs) and percentages. In analysing the textual data that emerged from the interviews, the inductive data analysis approach was used, as described by Creswell and Poth (2016). In other words, during the analysis, the patterns and themes were developed from the bottom up by arranging the units of information. Hand-written transcripts, hand-written and typed with precise information, were read several times to get a general impression of them.

Significant phrases or sentences from each transcript that were directly related to the lived experience of construction material specification and delivery were identified. The information was compressed into themes and quotes, and relationships between the categories were identified. Finally, the data were displayed in the form of figures, tables, and discussions. Data analysts, according to Creswell and Poth (2016), work through the data (e.g., interview transcriptions) and provide an understanding of how the participants experienced the concept by building on the data from the first to the last research questions. It can be contended that reliability, validity, and generalisability are critical to the decisions underlying data collection and data analysis, as will be discussed further below.

According to Saunders, et al., (2019), the extent to which data collection techniques or analysis procedures will yield consistent findings is referred to as reliability, whereas validity is concerned with whether the findings are truly about what they appear to be about. Firstly, since there can be no validity without reliability, a demonstration of the former [validity] is sufficient to establish the latter [reliability], according to qualitative researchers. Secondly, the issues of reliability, validity, trustworthiness, quality, and rigor are meant to differentiate "good" from "bad" research, and are thus important to the research in any paradigm. In addition to reliability and validity, generalisability is a type of external validity because it is concerned with the extent to which research results can be generalised (Saunders, et al., 2019). Generalisability considers identifying the research population

and how to draw a sample where collecting data from the entire population is impossible or impractical. The research process and chapter summary are now discussed in the immediate subsequent sections.

3.12 The Research Process

The process used in this study is shown in Figure 3.1 below.

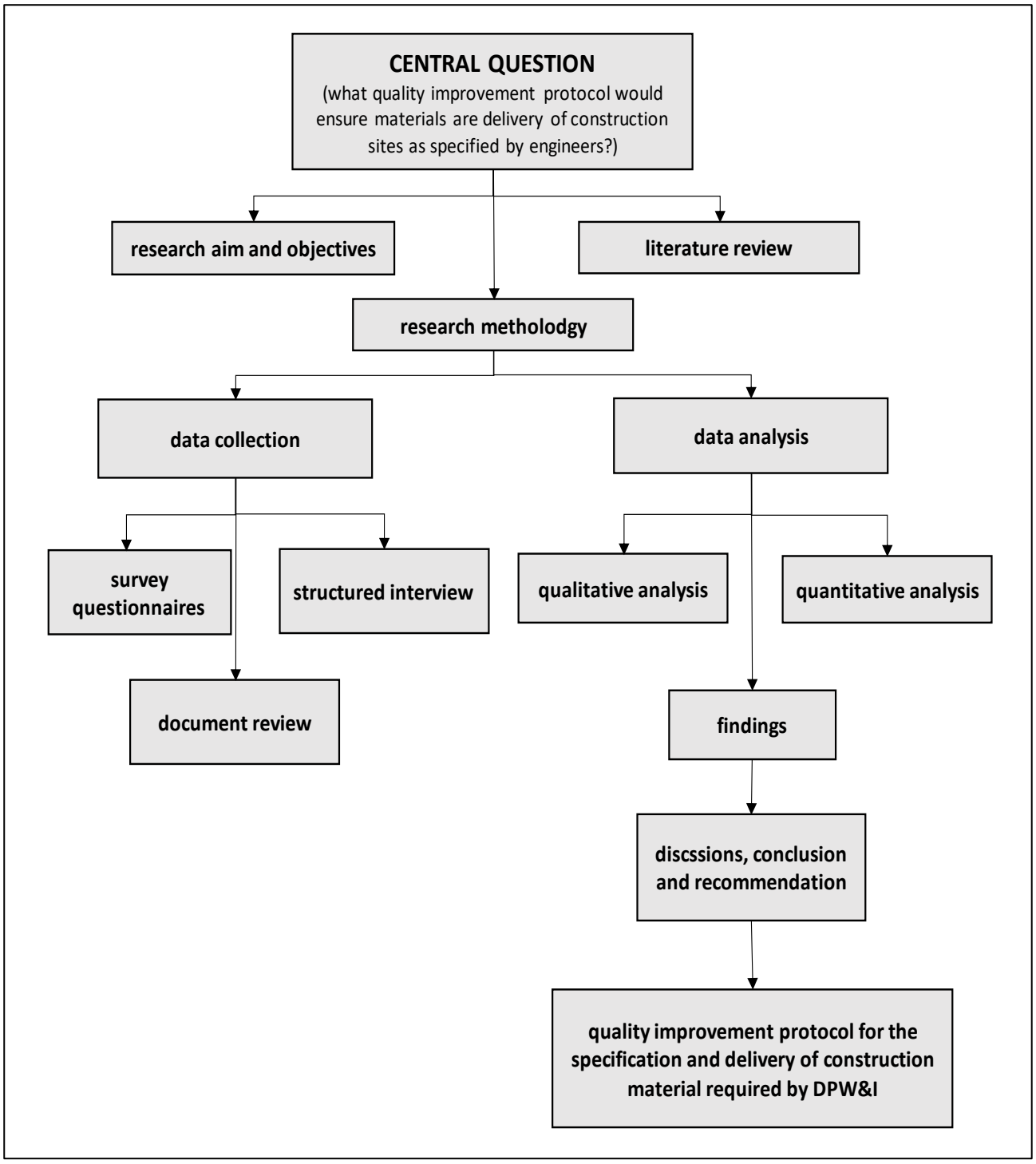

Figure 3. 1: The Research Process

3.13 Chapter Summary

This chapter explained the study's research philosophy, approach, strategy, time horizon, data collection, and analysis. The study's methodology was described, as well as the justification for the approaches used to collect and analyse primary and secondary data. The sample population, sampling technique, sample frame, and size were all part of the research methodology. The research findings are presented and discussed in the following chapter.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The purpose of this chapter is to present and interpret data obtained from survey questionnaires and interview protocols in order to draw conclusions from the research. This chapter is sub-divided into two sections. The first section focuses on the presentation of demographic data, response rate, and data analysis from the survey questionnaire. The second section focuses on the presentation of demographic data, response rate, and data analysis from the interviews. Finally, the chapter is summarised.

4.2 Survey Analysis

Microsoft Excel was used to compute descriptive statistics for the study, as mentioned in Chapter 3. A screenshot of the spreadsheet exemplifies the procedure (Figure 4.1). The spreadsheet was used to collect and analyse data from completed questionnaires. QuestionPro online survey software was used to download Microsoft Excel data. A screenshot of the QuestionPro dashboard exemplifies the procedure (Figure 4.2). The survey questionnaires were edited, distributed, analysed, and integrated using QuestionPro.

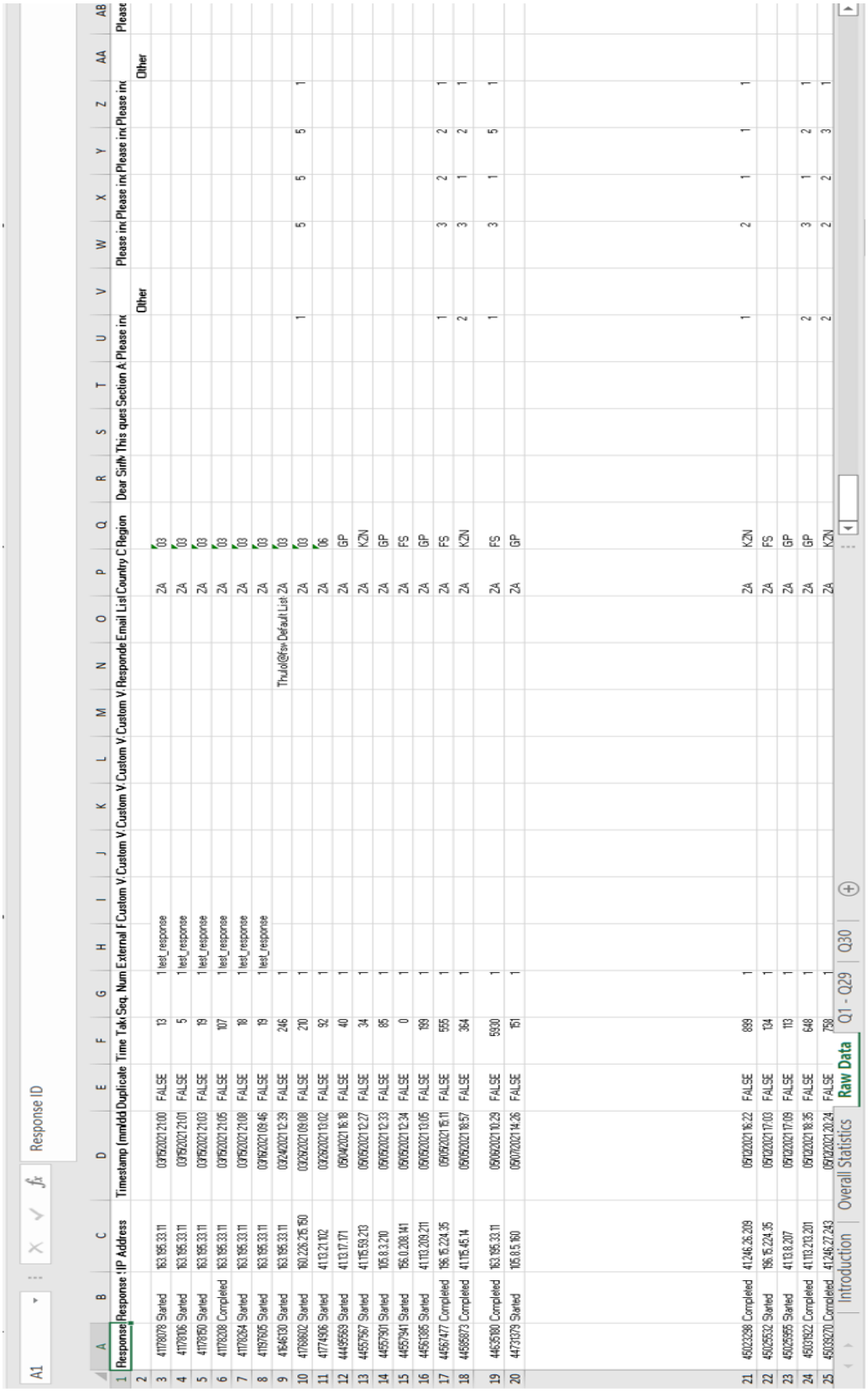

Figure 4. 1: Screenshot Illustrating the Use of Microsoft Excel

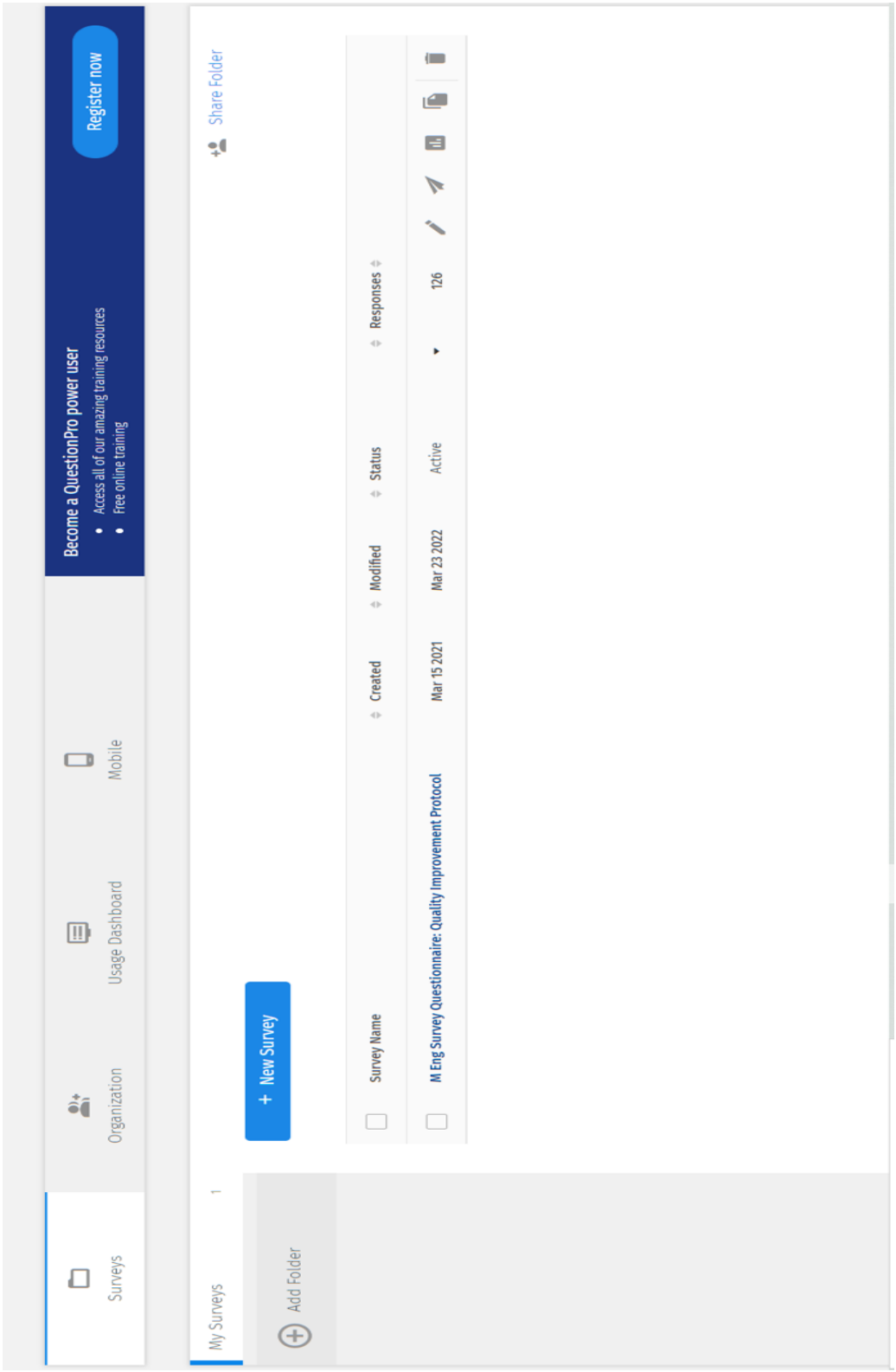

Figure 4. 2: Screenshot Showing the Use of QuestionPro Dashboard

4.3 Response Rate

Upon completion of the questionnaire design, the survey within a single case study was conducted among official members and CDP panel members of the DPW&I. At the end of the survey period that spanned approximately 24 weeks, 135 valid responses were received, which equated to a response rate of 89%.

4.4 Demographic Information

4.4.1 Gender

From Table 4.1 it can be seen that 57.8% of the respondents were males, while 42.2% were females. The data implied that the views of male employees of DPW&I predominated.

Table 4. 1: Respondent's Gender

Gender	No.	Percent (%)
Male	78	57.8
Female	57	42.2
Total	**135**	**100**

4.4.2 Age Group

As shown in Table 4.2 below, participants between the ages of 18-20 years old did not respond to the survey. This could be because there were no employees in that age group within the department or they could still be at tertiary level pursuing their educational studies. The table also shows that participants who were 60 years and older did not participate. There was a high percentage of participants between the ages of 31-40 years (41%) which indicated that the participants in this age group were active in the department.

Table 4. 2: Age Group of Respondents

Age	No.	Percent (%)
18-20 years old	0	0.0
21-30 years old	25	18.5
31-40 years old	55	40.7
41-50 years old	37	27.4
51-60 years old	18	13.3
More than 60 years' old	0	0.0
Total	**135**	**100**

4.4.3 Length of Work Experience

Table 4.3 shows that 43% of respondents had 6-10 years of work experience. Approximately 7% of the respondents had more than 20 years of work experience, while 27.6% had five or less years of service in the industry.

Table 4. 3: Length of Work Experience

Years	No.	Percent (%)
0-5 years of service	37	27.6
6-10 years of service	58	43.3
11-15 years of service	20	14.9
16-20 years of service	10	7.5
More than 20 years of service	9	6.7
Total	**134**	**100**

4.4.4 Highest Level of Education

The results shown in Table 4.4 indicated a high percentage of participants who completed the survey had a diploma/degree (52%); 3% of the respondents had a matric qualification only. One participant did not respond. There were no personnel with a doctoral qualification who participated in the survey.

Table 4. 4: Highest Academic Qualification

Qualification	No.	Percent (%)
Matric	4	3.0
Post matric certificate/s	15	11.1
Diploma/degree	70	51.9
Honours/postgraduate Diploma	32	23.7
Masters	14	10.4
Doctorate	0	0.0
Total	**135**	**100**

4.4.5 Employment Status

As shown in Table 4.5, most of the respondents (97.8%) were employed on a full-time basis. Only 1.5% of the total number of respondents was employed on a part-time basis and 0.7% indicated other. The 0.7% other could have been employed on contract/probation.

Table 4. 5: Employment Status

Employment	No	Percent (%)
Full-time worker	132	97.8
Part-time worker	2	1.5
Unemployed	0	0.0
Student	0	0.0
Other	1	0.7
Total	**135**	**100**

4.4.6 Job Title or Position

Table 4.6 shows the job title or position of the participants in the study. The results indicated that a high percentage of the total number of respondents were inspectors (27%). Inspectors do QC in the departments of public works projects. The results showed that approximately 10% of senior management responded to the survey and only 1% of contractors from the public works Contractor Development Programme (CDP) responded.

Table 4. 6: Job Title or Position

Title/Position	No.	Percent (%)
Senior Management	13	9.6
Engineer	33	24.4
Project Manager	29	21.5
Inspector	37	27.4
Artisan	17	12.6
Contractor	1	0.7
Other	5	3.7
Total	**135**	**100**

4.4.7 Project Type

As shown in Table 4.7, there were more technical personnel involved in maintenance projects (56.3%). Only 41% of the respondents was involved in capital (new projects). Capital projects in the Department of Public Works refer to construction projects which involve the Professional Services Section and Project Management Unit (PMU).

Table 4. 7: Type of Projects Undertaken

Project Type	No.	Percent (%)
Capital (new projects)	56	41.5
Maintenance projects	76	56.3
Other	3	2.2
Total	**135**	**100**

4.5 Adequacy of Quality of DPW&I Projects

Table 4.8 shows that 50.4% of the participants who responded believed that the quality of public works projects was good. This appeared to be favourable for the department, being above 50%. However, 45.7% of them believed that the quality of public works projects was not adequate.

Table 4. 8: Adequacy of quality of DPW&I project

Is quality of DPW&I projects adequate?	No.	Percent (%)
Yes	65	50.4
No	59	45.7
Unsure	5	3.9
Total	**129**	**100**

4.6 Results from the Self-Administered Survey Questionnaire

4.6.1 QP Performance on DPW&I Projects

Table 4.9 demonstrates that 49.6% of the participants who responded believed that QP was done on public works projects. This appeared to be favourable for the department. However, 45.8% of them had a contrary view while 4.6% was not sure.

Table 4. 9: QP Performance on DPW&I Projects

Is QP done on DPW&I projects	No.	Percent (%)
Yes	65	49.6
No	60	45.8
Unsure	6	4.6
Total	**131**	**100**

4.6.2 Professionals Involved in QP

As shown in Table 4.10, a high percentage of project managers (54%) was involved in QP in the Department of Public Works, while 18% of engineers was involved in QP of the project. Only 2%

consisted of architects which was a concern because the Professional Services Section in the department, together with the PMU, should be involved fully in QP.

Table 4. 10: Professionals Involved in QP

Professionals involved in QP	No.	Percent (%)
Engineer	24	18.3
Project Manager	71	54.2
Quantity Surveyor	26	19.9
Architect	3	2.3
Other	7	5.3
Total	**131**	**100**

4.6.3 Specification for Construction Projects

Table 4.11 illustrates that, of the participants who responded, 31% of project managers did specification for construction/infrastructure projects. This was because project managers in the Department of Public Works were also qualified in specific disciplines such as civil engineering, mechanical engineering, electrical engineering and construction management. Also, 19.1% of respondents who did the specification for a construction/infrastructure project were engineers. In addition, 21% were inspectors which was for small maintenance projects that did not need the expertise of professional services such as engineers. Only 3% of clients received/demanded project specification.

Table 4. 11: Specification for Construction Projects

Who does the specification for a construction/infrastructure project?	No.	Percent (%)
Engineer	25	19.1
Project Manager	41	31.3
Quantity Survey	29	22.1
Inspector	28	21.4
Client	4	3.1
Other	4	3.1
Total	**131**	**100**

4.6.4 Project specification

Table 4.12 shows that, based on the participants who responded, most (44.6%) of the respondents who received/demanded project specification were project managers. This was favourable because, in the department, the person who does specification is the one who must receive the specification. From the results, only 9.2% of architects received/demanded project specification.

Table 4. 12: Project Specification

Who receives/demands project specification	No.	Percent (%)
Engineer	24	18.5
Project Manager	58	44.6
Quantity Surveyor	32	24.6
Architect	12	9.2
Other	4	3.1
Total	**130**	**100**

On a scale of 1 (Never) to 5 (Always), please rate the frequency at which you encounter the following issues at the planning stage of a project? (Please note the "Unsure" option).

Respondents were able to identify performance impediments using a five-point Likert scale where: (1) = Never; (2) = Rarely; (3) = Sometimes; (4) = Often; (5) = Always.

Table 4.13 illustrates the extent to which the listed issues occurred at the planning stage of the project in the DPW&I in terms of percentage responses to a scale of 1 (Never) to 5 (Always), and a mean score (MS) ranging between 1.00 and 5.00. It is noted that the MSs were above the mid-point of 3.00, which indicated that the respondents were of the view that issues in the planning stage occurred always. The results indicated that delays in producing specifications occurred often, followed by delivery of sub-standard materials, and incomplete specifications by the specification writer. Although mistakes by specification writer (poor specification) was ranked 4th, the indication that most of the respondents viewed their contributions to issues at the planning stage of a project to be 3 (sometimes) suggested that they should be considered important contributors.

Table 4. 13: Contributors to Issues at the Planning Stage of a Project

Issue	Response (%)						MS	Rank
	Unsure	Never…….Always						
		1	2	3	4	5		
Delays in producing specifications	3.7	22.2	13.3	31.9	25.9	3.0	3.63	1
Delivery of substandard materials	5.9	18.5	29.6	23.0	18.5	4.4	3.43	2
Incomplete specification by the writer	4.4	30.4	15.6	25.9	22.2	1.5	3.36	3
Mistakes by specification writer (poor specification)	7.4	25.2	37.0	20.0	8.9	1.5	3.02	4

4.7 QC Performance on DPW&I Projects

Table 4.14 illustrates that 62.2% of respondents indicated that QC was done during DPW&I projects. This was favourable for the department. From results, 35.4% of the total number of respondents said that no QC was done on DPW&I projects and 2.4% was not sure.

Table 4. 14: QC Performance on DPW&I Projects

Is QC done on DPW&I projects?	No.	Percent (%)
Yes	79	62.2
No	45	35.4
Unsure	3	2.4
Total	**127**	**100**

4.7.1 Professionals Involved in QC

It is evident from Table 4.15 that project managers (47.4%) were the professionals involved in QC. Project managers are involved in all project management processes. From the results, only 3% of participants who responded indicated that professional architects were involved in QC.

Table 4. 15: Professionals Involved in QC

Professionals Involved in QC	No.	Percent (%)
Engineer	20	14.8
Project Manager	64	47.4
Quantity Surveyor	33	24.4
Architect	4	3.0
Other	6	4.4
Total	**127**	**100**

4.7.2 Construction Materials Delivered

From Table 4.16, it is evident that inspectors (28.35%) checked materials for the correctness of specifications. This was so for maintenance projects for which service providers delivered materials to the maintenance section and inspectors inspect the materials and deliver to sites. From the results, 3.15% of engineers deliver construction materials to sites.

Table 4. 16: Construction materials delivered

Who delivers construction materials?	No.	Percent (%)
Engineer	4	3.15
Project Manager	31	24.41
Quantity Survey	28	22.05
Inspector	36	28.35
Client	11	8.66
Other	17	13.39
Total	**127**	**100**

4.7.3 Construction Materials Received

As shown in Table 4.17, most of the respondents indicated that project managers (36.22%) were responsible for receiving construction materials on site. Project Managers in the department were involved in all project management processes. From the results, 11% of architects received construction materials delivered on-site.

Table 4. 17: Construction Materials Received

Who receives construction materials?	No	Percent (%)
Engineer	24	18.90
Project Manager	46	36.22
Quantity Surveyor	30	23.62
Architect	14	11.02
Other	13	10.24
Total	**127**	**100**

On a scale of 1 (never) to 5 (always), please rate the frequency at which you encounter the following issues during the monitoring and control phase of a project? (Please note the 'Unsure' option).

Table 4.18 shows the frequency at which respondents encountered issues related to monitoring and control, ranging from 1 (Never) to 5 (Always). It is noted that the mean scores (MSs) were above the mid-point score of 3.0, which suggested a frequency ranging from sometimes to always. The data showed that poor project communication among parties, and damage of material during transportation were often or always encountered.

With 9.6% of respondents indicating always (5), and 31.9% of the respondents indicating often (4), poor project communication among parties was ranked 1st amongst issues encountered during the monitoring and control phase of a project. The second most frequent issue encountered was damage

of material during transportation. The frequency distribution showed that 5.2% of the respondents stated that damage encountered during material transportation was always encountered during monitoring and control, while 31.1% stated it was often encountered. However, 8.9% of the respondents stated it was never encountered. Most of the respondents were in agreement that damage during material transportation was an issue of concern.

According to 9.6% of the respondents, delay of payment from clients was always encountered during the monitoring and control phase of a project, 36.3% of the respondents indicated it was encountered often, while 19.3% indicated that it occurred sometimes. Most of the respondents indicated that of payment from clients was encountered during the monitoring and control phase. However, 20% of the respondents stated that delay of payment from clients was never encountered.

Inadequate cash-flow (lack of working capital) was ranked as the fourth most challenging issue encountered during the monitoring and control phase of a project. According to the data available, 3.7% of the respondents stated that inadequate cash-flow was always encountered, 37.8% stated it was encountered often, while 23% indicated that it happened sometimes. There were 18.5% of the respondents who stated that inadequate cash-flow was never encountered during the monitoring and control phase of a project.

The ranking of the other statements is shown in Table 4.18. Based on the respondents views, appointment of incompetent contractors, poor project planning, non-availability of specific materials, variations in material quantities, re-work because of wrong specification or delivered materials, price escalation, wrong interpretation of specifications, material theft on site, poor material management, lack of technical personnel (skills shortage), poor project co-ordination by parties, scope and specification changes by clients, delays in approvals and inspections, contractual disputes between project parties, incorrect project estimate/cost, specification errors, specification additions and omissions ranked from 5th to 21st, respectively.

Table 4. 18: Effects of Issues Encountered during the Monitoring and Control Phase of a Project

Issues	Response (%)							
		Never…..Always						
	Unsure	1	2	3	4	5	MS	Rank
Poor project communication among parties	2.2	14.8	14.8	26.7	31.9	9.6	4.00	1.0
Damage of material during transportation	2.2	8.9	27.4	25.2	31.1	5.2	3.90	2.0
Payment delays from clients	5.2	20.0	9.6	19.3	36.3	9.6	3.90	3.0

Inadequate cash flow (lack of working capital)	3.0	18.5	14.1	23.0	37.8	3.7	3.85	4.0
Appointment of incompetent contractors	3.7	21.5	19.3	14.1	34.1	7.4	3.76	5.0
Poor project planning	1.5	22.2	20.0	20.0	29.6	6.7	3.74	6.0
Non-availability of specific materials	3.0	21.5	17.0	22.2	31.9	4.4	3.72	7.0
Variations in material quantities	2.2	19.3	20.0	25.9	29.6	3.0	3.70	8.0
Rework due to wrong spec or delivered materials	3.0	21.5	17.0	28.1	28.1	2.2	3.64	9.0
Price escalation	5.2	21.5	16.3	21.5	32.6	3.0	3.64	10.0
Wrong interpretation of specifications	3.0	23.7	21.5	19.3	25.2	7.4	3.62	11.0
Material theft on site	3.7	20.7	20.0	27.4	23.0	5.2	3.61	12.0
Poor material management	1.5	25.2	18.5	25.2	25.9	3.7	3.60	13.0
Lack of technical personnel (skills shortage)	4.4	21.5	17.0	26.7	27.4	3.0	3.60	14.0
Poor project coordination by parties	3.0	29.6	16.3	14.8	29.6	6.7	3.59	15.0
Scope and spec changes by clients	4.4	25.9	17.0	20.7	25.9	5.9	3.56	16.0
Delays in approvals and inspections	3.7	23.7	20.7	24.4	22.2	5.2	3.53	17.0
Contractual disputes between project parties	7.4	22.2	18.5	22.2	25.9	3.7	3.48	18.0
Incorrect project estimate / cost	8.1	23.7	17.0	17.8	29.6	3.7	3.48	19.0
Specification errors	5.2	28.1	19.3	26.7	16.3	4.4	3.34	20.0
Specification additions and omissions	4.4	30.4	19.3	25.9	17.8	2.2	3.29	21.0

4.8 Quality Challenges during DPW&I Projects

Table 4.19 demonstrates that 60.8% of the respondents indicated that quality challenges were experienced during DPW&I projects. This result indicated that the department experienced quality challenges during DPW&I projects. From the results, only 34.4% of the total number of respondents said that quality challenges during DPW&I projects were not experienced, and 5 % was not sure.

Table 4. 19: Quality Challenges during DPW&I Projects

Do you experience quality challenges during DPW&I projects?	No.	Percent (%)
Yes	76	60.80
No	43	34.40
Unsure	6	4.80
Total	**125**	**100**

On a scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree), please rate the level of agreement with the following quality challenges during a project? (Please note the 'Unsure' option).

Table 4.20 shows the respondents' perceptions of the level of agreement on quality challenges during DPW&I projects in terms of percentage responses on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree), with a mean score (MS) ranging between 1.00 and 5.00. It is noted that all the MSs were above the mid-point of 3.00, which indicated that the respondents could be deemed to agree as opposed to disagree on challenges occurring during DPW&I projects.

With 3.7% of the respondents strongly agreeing (5), and 37.0% of the respondents agreeing (4), inability to develop long-term strategies was ranked 1st among challenges that could affect quality on DPW&I projects. Based on the respondents' views, corruption, lack of defect prevention, delayed progress payment by the client, poor cash-flow, reliance on inspection to assure quality, lack of QA, and the lack of access to funding were ranked 2nd to 8th, respectively, as issues that could manifest because of the effects of QP on DPW&I projects.

Table 4. 20: Effect of Quality Challenges on a Project

Challenges	Response (%)							
		Str. Disagree….....Str. Agree						
	Unsure	1	2	3	4	5	MS	Rank
Inability to develop long term strategies	1.5	0.7	13.3	43.7	37.0	3.7	4.25	1.0
Corruption	3.7	17.0	18.5	26.7	23.7	10.4	3.81	2.0
Lack of defect prevention	4.4	16.3	17.0	25.2	33.3	3.7	3.78	3.0
Delayed progress payment by the client	5.9	17.0	14.8	26.7	31.9	3.7	3.73	4.0
Poor cashflow	4.4	20.0	20.7	19.3	32.6	3.0	3.64	5.0
Reliance on inspection to assure quality	2.2	23.7	20.7	23.7	25.9	3.7	3.59	6.0
Lack of QA	3.7	25.2	15.6	26.7	23.7	5.2	3.57	7.0
Lack of access to funding	7.4	33.3	17.8	26.7	12.6	2.2	3.10	8.0

4.9 Perception of QI during DPW&I Projects

Table 4.21 shows that a high percentage of 62% from the total number of respondents indicated that QI was done during public works projects. This was favourable for the department. From the results, only 35% of the total number of respondents said that no QI was done during public works projects, and 2% was not sure.

Table 4. 21: Perception of QI on DPW&I Projects

Answer	No.	Percent (%)
Yes	78	62.40
No	44	35.20
Unsure	3	2.40
Total	**125**	**100**

On a scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree), please rate the level of agreement with the following QI aspects during a project. (Please note the "Unsure" option).

Table 4.22 shows that, in general, the respondents concurred with the listed statements. The results suggested that the respondents could be deemed to agree more than disagree that these aspects could occur during DPW&I projects. An analysis of the results suggested that the respondents agreed that promoting effective quality management, ensuring proper material procurement, and allowing price escalation in tender documents were QI aspects during a project.

With 4.4% of the respondents strongly agreeing (5) and 37.8% of the respondents agreeing (4), promoting effective quality management was ranked 1st among aspects that could contribute to QI during a DPW&I project. Based on respondents' views: ensure proper material procurement; allow for price escalation in tender documents; conduct frequent progress meetings; adequate co-ordination of the project team; appoint an experienced technical team; appoint experienced contractors; provide clear information-sharing channels; ensure timely supply of material; adhere to specifications; and undertake effective strategic planning were ranked 2nd to 11th, respectively, were improvements that could manifest because of the effects of QP on DPW&I projects.

Table 4. 22: Contributions to QI Aspects during a Project

Aspects	Response (%)							
	Unsure	Str. Agree 1	2	3	4	Disagree….....Str. 5	MS	Rank
Promote effective quality management	0.7	4.4	11.9	40.7	37.8	4.4	4.24	1.0
Ensure proper material procurement	1.5	14.8	9.6	19.3	48.1	6.7	4.18	2.0
Allow for price escalation in tender documents	3.0	11.1	11.1	30.4	33.3	11.1	4.13	3.0
Conduct frequent progress meetings	3.7	21.5	12.6	20.7	28.1	13.3	3.88	4.0
Adequate coordination of the project team	3.0	17.0	17.8	27.4	26.7	8.1	3.82	5.0
Appoint an experienced technical team	2.2	19.3	20.7	20.7	28.9	8.1	3.79	6.0
Appoint experienced contractors	2.2	18.5	26.7	16.3	24.4	11.9	3.78	7.0
Provide clear information-sharing channels	2.2	16.3	17.8	34.1	25.9	3.7	3.76	8.0
Ensure timely supply of material	0.7	23.7	14.8	28.1	26.7	5.9	3.74	9.0
Adhere to specifications	1.5	24.4	15.6	23.7	31.9	3.0	3.69	10.0
Undertake effective strategic planning	2.2	32.6	20.0	25.2	16.3	3.7	3.32	11.0

4.10 Results from the Semi-Structured Interviews

4.10.1 Demographic Information

Table 4.24 shows the profile of the interviewees in terms of gender, age, work experience, qualification, employment status, and position within the DPW&I organisation. The table shows that males predominated and most of the interviewees were older than 31 years.

Table 4. 23: Profile of Interviewees

Gender	No.	Percent (%)	Age	No.	Percent (%)
Male	20	64.5	21-30 years' old	2	6.5
Female	11	35.5	31-40 years' old	15	48.4
Total	**31**	**100**	41-50 years' old	10	32.3
			51-60 years' old	4	12.9
			Total	**31**	**100**
Years of Service			**Qualification**		
0-5 years	4	12.9	Matric	4	12.9
6-10 years	10	32.3	Post matric certificate/s	7	22.6
11-15 years	7	22.6	Diploma/degree	18	58.1
16-20 years	6	19.4	Honours/postgraduate Diploma	0	0
20 years plus	4	12.9	Masters	2	6.5
Total	**31**	**100**	**Total**	**31**	**100**
Employment			**Title/Position**		
Full-time worker	31	100	Senior management	5	16.1
Total	**31**	**100**	Engineer	6	19.4
			Project manager	4	12.9
			Inspector	9	29
			Artisan	7	22.6
			Total	**31**	**100**

4.11 Interpretation of the Interview Results

The interview findings revealed how QP, control, and improvement influence the specification and delivery of construction materials for DPW&I projects. Interviewees were asked about their understanding of quality, the impact of QP, control, and improvement in terms of specification and delivery of construction materials.

4.11.1 Perception of Quality on DPW&I Projects

Regarding quality during public works projects, Interviewee 3 stated that it was good but declining. Interviewees 4, 7, 8, and 10 indicated that the general perceptions of quality during public works projects were negative although Interviewees 12, 14, 15, and 17 indicated it was good. Interviewee 18 indicated that the quality was not good and not up to government standard. Interviewee 19, made the comment that wrong materials were used on the projects and, also, projects were finished late. He stressed the importance of QP on DPW&I projects. A common concern among the Interviewees 20, 21, 22, and 25 was that quality during public works projects had declined and was no longer up to the required standard. In contrast, Interviewee 27 stated that:

> … quality is no longer important, quality dropped and officials are not competent. Service providers are incompetent, even government officials are incompetent. Quality has dropped immensely in the past years.

Interviewee 29 said that quality during DPW&I projects had dropped and were no longer maintained partly because of interferences from politicians. However, Interviewee 30 indicated that the quality of public works was satisfactory and adhered to the highest possible standards.

4.11.2 How is QP Done during DPW&I Projects?

According to Interviewee 1, a major part of activities performed during DPW&I were related to planning, co-ordinating, and executing projects. However, an Interviewee 5 commented that some DPW&I projects did not meet their targets because of the poor quality of management practices such as planning. One of the practices of poor quality of management cited was top management failure to discipline individuals that did not meet key performance areas or at least provide training for them.

Interviewees 6, 9, and 11 said that planning of projects had significant impact on the success of the projects. In summary, according to the results, Interviewees 16, 18, 23, and 26 emphasised that regular meetings were held with all responsible government officials and regular site visits were done. These meetings ensured that quality guidelines, regulations and procedures for specification, resources and quality of standard practices and activities were followed. Interviewee 27 mentioned that:

> … there needs to be specification and bill of quantities and also important aspects of projects should be determined. There is a design, monitoring and evaluation project team that ensures that labour and materials that are procured follow established standards. This monitoring and evaluation ensures inspection is done to check quality and also make sure service providers comply with specification.

It is very important that service providers comply with project specifications through inspection to check for quality. Interviewees 28, 29, and 30 indicated that problem identification, solution development and review of results were ways to ensure QP during DPW&I projects.

4.11.3 How do You Think QP Processes Related to Specification and Delivery of Construction Materials on DPW&I Projects is Expedited?

Interviewees 1, 2, 4, 5, 7, 8, 9, and 15 suggested that it is essential to expedite the QP processes related to specification and delivery of construction materials during DPW&I projects. For instance, some of them said planning processes could be expedited through planning for the entire project and establishing major deliverables. It is also important to deal with service providers who are able to deliver materials in time through the use of a supply chain management (SCM) section. Interviewees 16, 17, 18, and 20 indicated that the process was expedited by use of established standards and specification and also identified key stakeholders responsible for the projects. The use of established standards makes work easy and makes it possible to identify specification errors during delivery. Interviewee 21 mentioned that materials for the project should be available, the needs of customers should be identified, and process and controls should be developed. Interviewee 22 said "there is the need to encourage stakeholder participation and bring all stakeholders up to speed on the project as well as establish project specification and delivery of construction materials". Interviewees 25, 26, 28, 29, and 30 argued that QP processes could be expedited through the use of established standards, QP, control and improvement, and performance reviews.

4.11.4 What Challenges do You Come Across at the Planning Stage of a Project?

Overall, the responses of Interviewees 3, 5, 6, 7, 9, and 10 showed that challenges were usually encountered at the planning phase of a project. For example, Interviewees 11, 13, 14, and 15 identified late delivery of materials and incompetent officials with inadequate skills as some of the challenges. Ineffective communication among stakeholders, lack of accountability and differences among stakeholders were cited as some of the challenges at the planning phase of a project. Interview 17 made the comment that "… corruption, lack of competent officials and budget constraints affect planning of projects".

However, Interviewees 18, 19, and 20 mentioned that lack of details, accountability, lack of clear goals and unrealistic deadlines also posed a challenge to projects, especially at the planning stage. Interviewee 22 revealed that "limited engagement of different stakeholders and parties in the project, changing needs of clients and major decisions taken by management, even though they are not directly involved in the projects, were some of the many challenges faced at the planning stage of the project". Interviewees 23, 25, 26, and 30 said that, in some cases, there was lack of clarity on goals which affected the successful completion of projects.

4.11.5 How is QC Done during DPW&I Projects?

Interviewees 2, 5, 6, 7, and 10 stated that quality is one of the most important factors in the success of construction projects. Interviewees 11, 13, and 16 acknowledged that quality of DPW&I projects, as well as project success, could be regarded as fulfilment of expectations. Interviewees 17 and 19 argued that QC measures in the construction industry are a key method in managing the goal of the client's satisfaction. They expressed further that "QC measures on public works projects could be achieved by daily visits to work sites to inspect works done, hold regular meetings and discuss, matters relating to the quality of the work and ensure that the right thing is done by the contractor". Interviewees 22, 24, 27, 29, and 30 elaborated that QC was done on public works by ensuring that high quality materials were used, adherence to bill of quantities, and compliance with specification.

4.11.6 How do You Think QC Process Related to Specification and Delivery of Construction Materials on DPW&I Projects is Expedited?

Interviewees 2, 4, 8, and 11 acknowledged that QC processes related to specification and delivery of construction materials to the Department of Public Works needs to be expedited. Interviewees 12, 13, 14, and 15 indicated that this could be achieved by complying with government standards, and following the public works' procedures and standards. Interviewees 16, 17, 18, 20, and 22 commented that it is important to identify quality issues, record and address them and appoint qualified and deserving contractors to undertake projects. They added that regular meetings should be held to discuss quality issues which are identified, and materials should be stored closer to the project sites.

4.11.7 During the Monitoring and Controlling Phase of a Project, what Challenges Do You Come Across?

Interviewee 19 stated "many challenges are encountered during monitoring and evaluation phase of projects". Interviewees 20, 22, 23, 26, and 27 indicated that some of the challenges included delayed payment to contractors or service providers, disputes between parties involved in a project which are often taken onto project sites, inability to meet deadlines, and contractors not following specified standards and specifications of the job. They cited lack of communication, lack of customer satisfaction, non-compliance with specification and bill of quantities, incorrect quantities of materials delivered to project sites and also, in some cases, incorrect delivery of materials as some of the

challenges encountered. Interviewees 28, 29, and 30 revealed that some of the contractors were incompetent and also changes during the course of the projects were some of the challenges.

4.11.8 How do You Think QI Process Related to Specification and Delivery of Construction Materials on DPW&I Projects is Expedited?

Interviewees 2, 3, 6, 10, 11, and 18 mentioned that QI processes related to specification and delivery of construction materials to Department of Public Works could be expedited through a continuous QI process and proper planning with involvement of all stakeholders participating at the beginning of the project. Interviewees 20, 22, 24, 25, 27, and 30 cited the use of quality materials according to standard specification, continuous training of service providers and using competent contractors and artisans with experience as some of the ways in which QI could be expedited.

4.11.9 What are the Challenges Associated with QI of a Project?

According to Interviewees 1, 3, 7, and 15 delivery of quality projects on time in the construction industry is critical to the satisfaction of clients. However, Interviewee 17 stressed that, in some cases, the delivery was hampered by challenges, while other interviewees revealed that lack of funding, budget constraints, slow delivery of construction materials to site and limited resources, in some cases, posed a challenge to QI. Interviewee 19 and 22 emphasised further that lack of an integrated model for QI management, lack of appropriate training for officials, lack of communication, lack of co-operation among the officials and staff members, and interference from management were possible challenges encountered. Interviewees 23, 24, 25, 26, and 29 indicated that “employees were not interested in acquiring more knowledge to improve their level of understanding of QI”. Also, the lack of a data collection and monitoring system was a major challenge that affects QI of projects.

4.12 Discussion

The purpose of this study was to develop a QI protocol that would ensure materials are delivered to construction sites as specified by the engineers in the DPW&I. QI protocol, and the impact of QP and QC were examined in the study. The results supported the literature reviewed that material quality difficulties are phenomenon of construction projects in South Africa, causing cost and schedule over-runs to the detriment of clients. When delivered materials differ from specifications, quality concerns arise in the form of defects and re-work, which adds to the overall cost of projects, which is referred to as quality cost (Emuze & Mhlwa, 2015).

The South African construction industry is widely acknowledged to be presently experiencing issues with the quality of construction that customers demand, resulting in projects completed late, over budget, and to unacceptable quality standards (Emuze & Mhlwa, 2015). The findings of the literature review reveal that construction contractors do not fully comply with the specification, culminating in re - work at the expense of the contractor. As a consequence, the literature suggests that specification and delivery of construction materials in South African construction lags behind that of developed countries. To address the issue, clients have been persuaded and mandated to use the contract award mechanism to promote quality improvement protocols. The CIDB (2014), states that by prequalifying and/or selecting contractors based on quality practices, clients are in a unique position to drive quality performance improvement or the behavior of project participants (including contractors).

4.13 Improvement Factors

The results showed a possible association between factors concerning planning, monitoring, challenges and improvement (Siddiqui *et al*., 2016). There was a positive relationship between the planning stage of a project and the monitoring and control phase of a project, as well as quality challenges on a project. However, there is no significant relationship between the planning stage of a project and the aspect of QI of a project. There was no significant relationship between the monitoring and control phase of a project and the QI aspect of a project. There was a statistically significant relationship between the monitoring and control phase of a project and quality challenges during a project. There was a statistically significant relationship between quality challenges during a project and the QI aspect during a project.

4.14 Implications of Survey Questionnaire Results

The major contributing issues at the planning, monitoring and control phase of a project, such as poor project communication among parties, damage of material during transportation, delays in producing specifications, and delivery of sub-standard materials, identified during the study, should be addressed in order to avoid the occurrence of a range of situations that can limit the realisation of QI during DPW&I projects. According to Wanberg et al. (2013), one important factor that contributes to the production of poor-quality design information is designers' reluctance to thoroughly check for errors due to the high demands of their job. However, as evidenced by construction management literature, design information is frequently insufficient (Wanberg et al., 2013). When this deficiency

occurs, it can result in an increase in design revisions, co-ordination issues, re-work and, in the worst-case scenario, deaths (Lopez *et al*., 2010).

In this context, aspects such as inability to develop long-term strategies, corruption, to promote effective quality management, and to ensure efficient material procurement that could affect quality during projects should be prevented from occurring during project delivery for DPW&I. Furthermore, because most of the variables, relating to issues contributing to QI protocol, identified in this empirical survey, achieved MSs above the mid-point score of 3.00, it is arguable that, in future, a way to improve project quality during DPW&I projects is to embrace QP and QC perspectives and/or interventions.

Although it was found in this study that a person's competence is determined by a combination of formal education and experiential training, it was suggested in a study from South Africa that this combination is only true when both education and training are acceptable (Akampurira & Windapo, 2018). In short, this combined relationship explains why the skills levels of designers and construction managers are vital for successful project completion. Inadequate knowledge and a lack of relevant skills, for example, are factors that contribute to errors in design documentation. (Lopez *et al*., 2010).

4.15 Implications of Interview Results

In this study, specification was linked with delivery of construction materials in DPW&I projects. The widely reported perception (Chen & Luo, 2014) that incorrect specifications and poor delivery of construction materials are the fore-runners of unacceptable quality during DPW&I projects was confirmed by the results of this study. Similarly, it was confirmed in this study that quality deviation factors existed during DPW&I projects. Of the widely reported quality deviation factors (Tabish & Jha, 2015), which included defects, re-work and RFIs leading to additional project cost, it was suggested in this study that the factor of RFIs was dominant during DPW&I projects. The implication is that deliberate deviation from policies and regulations, which are known as “violations” are common among construction projects. As a result, it appears that non-compliance has become the "standard", to the point where interviewees argued that regulations must be enforced, and specification and delivery of construction material must be reviewed and inspected regularly.

However, the observations from this South African study concur with the Vilnius study reported by Tchidi *et al* (2012). The findings of the Vilnius study enhance the construction process, increase quality resistance to a variety of performances, and recommend the appropriate mix proportion

(Tchidi *et al.*, 2012). Parallel to the opinions of the interviewees in the South African study, the quality deviation in terms of the link between specification and delivery of construction materials appears not to be a deliberate act of sabotage according to the model in Vilnius. Rather, "the gap between WAI and WAD" is examined regularly in construction projects (Forbes & Ahmed, 2020). An example of quality deviation was illustrated by the interviewee who said "… quality is no longer a priority; quality has deteriorated, and administrators are incompetent, incompetent service providers, and incompetent government officials". In recent years, quality has deteriorated dramatically. As an illustration, an interviewee indicated that: "… corruption, lack of competent officials and budget constraints affect planning of projects".

A common concern was that quality during DPW&I projects has declined and was no longer up to the required standard. The decline and sub-standard of quality has gradually become a norm and accepted during DPW&I projects. Quality deviation occurs when delivered materials differ from specifications, and quality issues ensue as defects and re-work. Context-specific variables, such as time pressure, workload, incorrect tools, and unsuitable equipment drive non-compliance and sub-standard quality (Hale & Borys, 2013). Consequently, work pressure resulting from tight deadlines and rush activities in the construction industry reduces levels of compliance (Goh *et al*., 2018) and, by so doing, work pressure is promoting quality deviation in construction projects.

The quality deviation factors identified in this South African study emphasise the influence that DPW&I technical personnel, engineers and specification writers have on specification and delivery of construction material. The influence corroborates critical ideas found in the "person model" and "system model" (Lindelof & Hansen, 2015). Time pressures, training, experience, risk perception, safety culture, and management, for example, all influence worker behaviour in the construction sector (Maio *et al*., 2018).

The above discussion suggests that the detrimental nature of the causes of quality deviation require a better understanding of how to eliminate them in DPW&I projects.

4.16 Chapter Summary

This chapter consisted of two parts: the results and the discussion. The first part of the chapter was focused on the analysis of information from the survey questionnaire and the structured interviews, the results of which were presented in tables and figures. The second part of the chapter consisted of the discussion of the results and how they were accomplished. The next chapter is focused on the

conclusions and recommendations. The next chapter also includes a summary of the whole study and elaboration on whether the aim and objectives of the study were accomplished. Finally, recommendations for future research are made to identify concepts for improvement.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter concludes the study with a presentation of conclusions and recommendations based on the objectives of study.

5.2 Conclusions

Specification and delivery of construction materials are essential variables must be considered as they exhibit a persistent ability to inhibit high-quality performance during DPW&I projects. Every project involves specification and delivery of construction materials. It was suggested in the literature reviewed that the elimination of poor specification and delivery of construction materials might lead to QI. This can be achieved through re-designing and/or restructuring how QP and QC tasks are carried out. As a result, the examination of existing processes by identifying and analysing them could lead to new processes and ways of working.

Using the DPW&I as a case study, quality issues and their origins that might contribute significantly to poor quality were identified. The clarifications that were provided suggested that, unless these quality issues are addressed, they tend to increase in the DPW&I. Notable aspects of QI, such as a lack of promoting effective quality management, must be addressed in DPW&I. Perhaps, the elimination of major challenges, such as inability to develop long-term strategies, the effects of issues encountered during the monitoring and control phase, such as poor project communication among stakeholders, and contributors to issues at the planning phase, such as the causes of delays in producing specifications, indicates a way forward. The findings of the study emphasise the importance of implementing lean construction principles in the DPW&I in order to solve specific quality-related implications.

The findings of this study reinforced the notion that quality deviation in the form of specification and delivery of construction material produces unacceptable project quality. For example, in the study, it was suggested that defects, re-work and RFIs are linked through quality deviation factors. Such factors are manifested in attitudes and behaviours of people in construction. Also, the defects and re-work conditions created by people ensue in numerous ways. Defects and re-work lead to additional project costs, which are categorised as quality costs. The narrative in this study shows that quality

deviation can be managed and modified if the people concerned are prepared to make the effort. Although the interviewees in the study mentioned that addressing the lack of an integrated model for QI management, lack of proper training for officials, lack of communication, lack of co-operation among the officials and staff members and interference from management would reduce the problem, there is reason to argue that these measures can only produce marginal improvements until there is a definite shift in the mind-set of the people concerned. The change in the mind-set is what would alter the attitudes and behaviours of management, specification writers and the suppliers so that they do not engender unacceptable project quality outcomes.

The shift in mind-set is also required to tackle quality deviations that produce both defects and re-work during DPW&I projects. There is a clear indication that, no matter how procedures are implemented or imposed during DPW&I projects, without commitment from concerned parties quality deviations caused by incorrect specification and poor delivery of construction materials will continue in the department. Defects, re-work and RFIs are therefore of major concern during DPW&I projects where they have the tendency to transform into practice “norms”. In effect, DPW&I officials must learn that quality begins with them and, then, it has to start from officials at management level where standards in workplaces are controlled and managed.

5.3 Conclusions Related to the Research Objectives

5.3.1 Objective 1: Evaluate how QP Determines the Specification and Delivery of Construction Materials to Public Works Projects

The findings indicated that QP during DPW&I projects is done partially. Professionals from the DPW&I's engineering services division and PMU were not involved in QP and should be. According to the findings, issues such as delays in producing specifications are common, followed by the delivery of sub-standard materials. These issues are likely to manifest as: inability to develop long-term strategies; corruption; a lack of defect prevention; delayed progress payments; poor cash-flow; reliance on inspection to assure quality; a lack of QA; and a lack of access to funding.

Major contributing issues during the project planning phase, such as poor project communication among parties, material damage during transportation, delays in producing specifications, and delivery of sub-standard materials, should be addressed to avoid the occurrence of a variety of situations that can marginalise the realisation of quality during DPW&I projects. Stakeholder

participation must be encouraged, and all stakeholders must be kept up to date with progress on the project.

5.3.2 Objective 2: Evaluate how QC Affects the Specification and Delivery of Construction Materials to Public Works Projects

Specification and delivery of construction materials are critical variables to consider because they exhibit a persistent ability to hinder high-quality performance during DPW&I projects. Every project involves the specification and delivery of construction materials. According to the findings of the study, eliminating poor specifications and delivery of construction materials could result in QI. This can be accomplished by re-designing how QC tasks are carried out. However, the findings indicated that QC during DPW&I projects is only partially done.

Respondents argued that the QC measurement in the construction industry is a key method in managing the goal of the satisfying the client. It was shown in the study that project managers were the professionals involved in QC. They were involved in all the project management processes, while inspectors performed QC during DPW&I projects by inspecting materials for compliance with specifications. Nevertheless, a uniform, standard form for QC is required for neutrality and greater understanding amongst project managers and inspectors.

Furthermore, respondents expressed that QC measures on DPW&I projects could be achieved by: daily visits to work sites to inspect work done; holding regular meetings to discuss matters relating to the quality of the work; and ensuring that the work is done according to specification by the contractor. They added that regular meetings should be held to discuss quality issues that have been identified and that materials should be stored closer to the project sites. The findings indicated that this can be achieved by complying with government standards and following DPW&I procedures and standards.

Furthermore, it was determined in the study that RFIs might lead to increased re-work, which might be delayed by approval of designs. Nevertheless, when the revision work is complete after the design developments have undergone appropriate QC measures to remove errors, the design information might be deemed to be adequate and the material specification revised. It is arguable that a way forward in order to improve quality during DPW&I project is to embrace QC interventions.

5.3.3 Objective 3: Evaluate How QI would Ensure that the Specification and Delivery of Construction Materials to Public Works Projects meet Stipulated Deliverables

The findings corroborated those of the literature survey, indicating that quality deviation issues are a phenomenon of construction projects, causing cost and schedule over-runs to the detriment of clients. When specifications and delivered materials differ, quality issues arise in the form of defects and re-work, which add to the overall cost of the project. Furthermore, since the variables identified in Table 4.22 achieved MSs greater than the mid-point score of 3.00, this suggested that embracing the perspectives of QP and QC is a way forward in order to improve quality during DPW&I projects.

The responses of the interviewees established that addressing the lack of an integrated model for QI management, a lack of proper training for officials, a lack of communication skills, a lack of co-operation among officials and staff members, and management interference would all help to alleviate the problem. There is reason to believe that these measures will only produce marginal improvements until there is a significant shift in the mind-set of those involved.

Based on the study, it was found that QI processes related to construction material specifications and delivery in the DPW&I could be accelerated through a continuous QI process and proper planning with the participation of all stakeholders from the start of the project. The responses of the interviewees also revealed that using quality materials according to standard specifications, continuous training of officials, and hiring experienced contractors and artisans were some of the ways in which QI could be accelerated. Other respondents stated that, in some cases, QI was hampered by a lack of funding, budget constraints, slow delivery of construction materials to the job site, and limited resources.

Quality issues and their roots that might significantly contribute to poor quality were identified using the DPW&I as a case study. According to the study, unless these quality issues are addressed, they tend to proliferate in the DPW&I. Significant QI issues identified in Table 4.22, such as a lack of effective quality management, must be addressed in the DPW&I. The findings of the study emphasised the importance of implementing lean construction principles in the DPW&I in order to address specific quality-related issues.

5.3.4 Objective 4: Develop a Protocol that will Engender QI in Relation to Specification and Material Delivery to Public Works Projects

A QI protocol model has been proposed based on data analysis and common construction processes. Figure 5.1 depicts an attempt to improve quality during DPW&I projects. Based on a case study of DPW&I, the variables identified in Tables 4.13, 4.18, 4.20, and 4.22, and the responses of the interviewees, a QI protocol (Figure 5.1) was developed. Based on the findings of this study, the quality of designs and specifications compiled for project tasks is determined by designers' skills, albeit to varying degrees due to skill-based errors in the form of lapses and slips. When due diligence is not observed in task execution, skill-based errors, as opposed to lapses and slips that typically occur as a result of carelessness and/or neglect, may result in unexpected outcomes. However, once the disruptive tendencies of errors are eliminated from the execution process, designers' abilities will have a significant impact on the adequacy of design information (1-3 in Figure 5.1).

Nevertheless, if the adequacy of information falls short of expectations, RFIs may be issued, typically by site management to designers (5 in Figure 5.1). RFIs may result in more re-work (6 in Figure 5.1). However, once the revision work is completed and the design processes have been subjected to appropriate QC procedures to eliminate errors, the design information may be considered sufficient and the material specification revised (7 in Figure 5.1).

When the design work presented to the contractor is deemed adequate by the users, it is commonly assumed in the construction industry that improved quality may become relatively low during the project (4 in Figure 5.1).

It should be noted that proper QP and QC lead to higher project quality (8, 9 and 10 in Figure 5.1). Nonetheless, within the same analogy, the levels of skill of specification writers may impact the reliability of their decision-making attributes (11 and 12 in Figure 5.1) along with their ability to lead DPW&I officials, which may lead to improved project quality (14 and 15 in Figure 5.1).

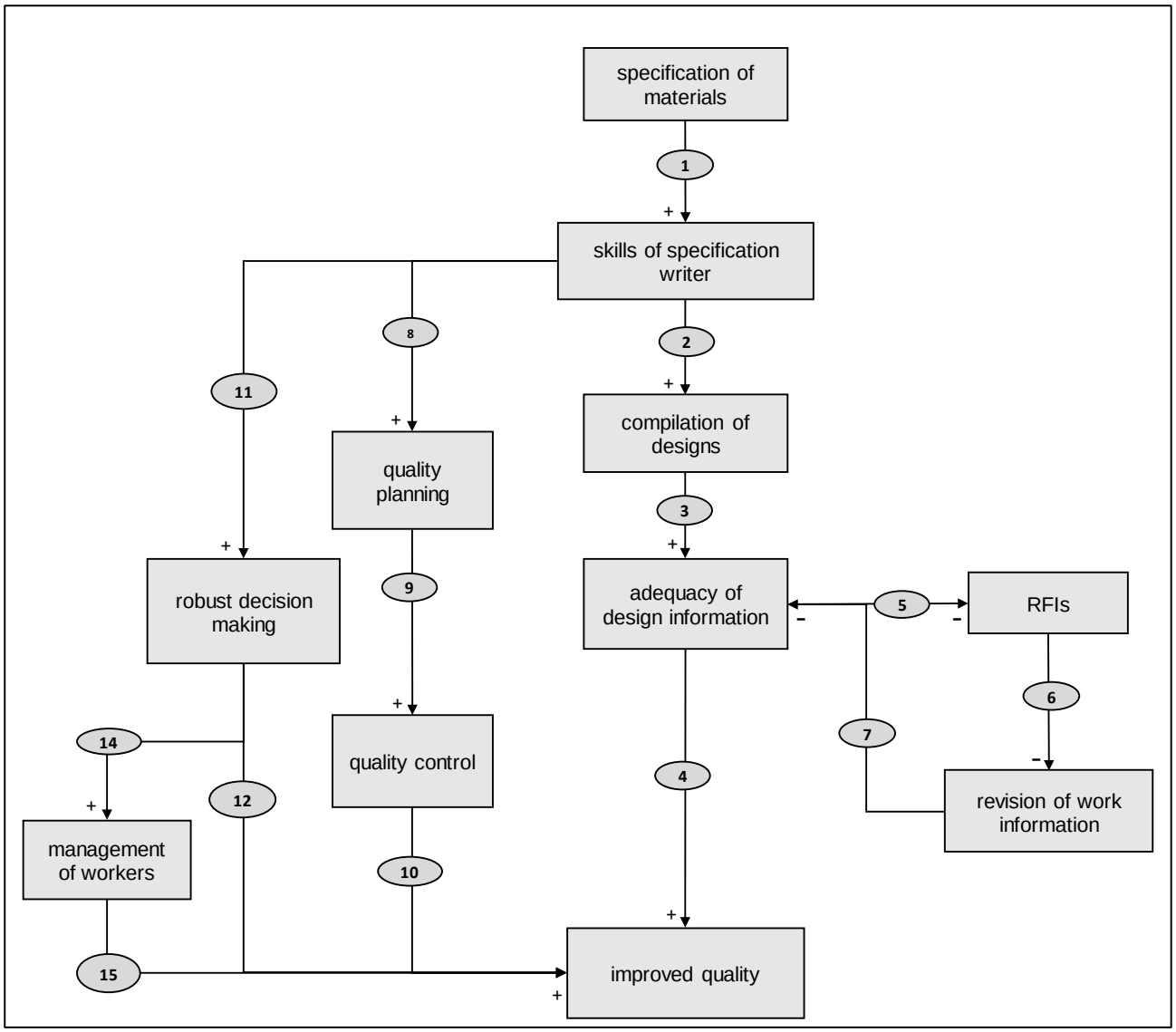

Figure 5. 1: QI Protocol

5.4 Recommendations - Practice

All parties involved in DPW&I projects should collaborate to accomplish the objectives of: evaluating how QP determines the specification and delivery of construction materials to public works projects; evaluating how QC affects the specification and delivery of construction materials to public works projects; evaluating how QI would ensure that the specification and delivery of construction materials to public works projects meet stipulated deliverables; and developing a protocol that will engender QI in relation to specification and material delivery to public works projects. The DPW&I should aim for best practices in enforcing the QI protocol by taking into account the following factors: employment of qualified engineering and building environment professionals, as well as competent contractors.

The DPW&I must also regulate current consulting and construction service providers and verify that they are registered with the NQF (National Qualification Framework) and SAQA (South African Qualifications Authority). To compel all key players to collaborate in the execution of improved project quality in the DPW&I, the DPW&I must implement a blanket strategy to ensure competence among all engineering and built-environment professionals. All professionals must be required to register with the SACAP, SACPCMP, ECSA and SACQSP.

According to the responses of the interviewees, QI practices related to construction material specification and delivery to the DPW&I could be accelerated, with special attention needed to address ongoing training of officials and hiring experienced service providers such as contractors. This implies that the methodologies proposed in this study should be regarded for adoption in DPW&I projects, and that the department should continue to seek out new best practices to adopt as needed. Capabilities can also be addressed from both the supply and demand sides. On the supply side, the DPW&I must train and develop a pool of engineering and built-environment professionals capable of meeting the public's construction goals. Methodologies to automating specific aspects of construction work and using tools to improve productivity should also be considered on the demand side.

The DPW&I should make information about the QI protocol available on their website. It would be extremely beneficial to the officials if the DPW&I encouraged and enforced the implementation of the QI protocol. When it comes to construction procurement, client departments must take a consistent approach. This can be accomplished by developing and agreeing on pre-qualification criteria for principal contractors who bid using bid documents. It is also suggested that the DPW&I take into account systems that have the potential to improve performance and quality.

The CIDB must also take into account re-classifying principal contractors as contractors and principal contractors as CIDB grade levels 1-4 and 5-9, respectively. In this case, client departments may also need to re-classify their appointment criteria. This is significant because the majority of so-called "emerging contractors" do not have the level of competence and resources to produce acceptable results.

Given the negative impact that schedule constraints can have on project quality and the possibility that they will increase pressure, careful consideration must be given to reducing these pressures through detailed planning and correlating realistic schedules to the resources available.

5.5 Recommendation - Research

Because this study was exploratory in nature, several future research topics can be proposed.

It is necessary to conduct research on methods to address the shortage of construction management skills and competence. This is the topic that drew the most interest from the interviewees. Research on supply- and demand-side solutions to the skills shortage and competence can be conducted.

This research identified practices that can be used to enhance the quality of DPW&I projects. International best practices for improving quality throughout the construction value chain are likely to apply to DPW&I projects and construction in general in South Africa. This proposition should be researched, and if found to be true, additional research should be conducted to develop a comprehensive guide for QI practices throughout the entire project value chain.

Further research should help to reduce some of the limitations of this study. Future research should focus on the "how" that will aid in the development of a QI protocol that will result in QI in relation to specification and material delivery to DPW&I projects. The strategy would benefit both client departments and contractors. Another future research topic is the 'why' of the limited internal engineering and built environment professionals in government departments that regularly procure construction services. While service providers can be used for a variety of tasks, it is critical for a client department to be knowledgeable about its requirements and regulatory compliance. This opportunity is provided by an internal expert to the client departments.

This study relied on academic literature and the local press to create a protocol that will result in QI in DPW&I project specifications and material delivery. Although related literature was reviewed, a survey of concerned stakeholders was conducted, and interviews with stakeholders were conducted on the subject in this study, the findings are far from exhaustive. Formal research to validate the research results and conduct a comparative study on the extent of quality focus and challenges in various sectors of the construction industry will help to confirm the assumptions and determine where QI efforts are most needed.

There has been no research on the cost of re-work in the South African construction industry. It is suggested that research be conducted to determine the re-work cost per sector in the construction industry. Such data would be beneficial in informing key players about the true cost of quality issues,

as well as encouraging and focusing QIs in the industry. Such progress will benefit not only the industry, but also the economy as a whole.

The study's limitations included its exploratory nature, small sample size, and focus on DPW&I as a case study. More research with a larger sample size is required to determine how far these findings can be applied to other sectors of the construction industry. Public infrastructure spending is an example of a sector with delivery issues that should be addressed further.

Appendix 1: Questionnaire Request Letter

19 February 2021

Dear Sir/Madam,

Re: Invitation to participate in MENG's research on quality improvement protocol

We write to humbly request your assistance in an ongoing Master of Engineering in Civil Engineering research project by completing the **attached questionnaire** as part of the study's data collection process. The research project is entitled *"Quality improvement protocol for the specification and delivery of construction materials required by the Free State department of public works infrastructure projects"*. Mr LB Thulo carries out the study under Prof E Theron and Prof FA Emuze at the Central University of Technology, Free State.

The purpose of this phase of the study, specifically this survey, is to evaluate how quality planning, control and improvement determines the specification and delivery of construction materials on the department of public works infrastructure projects. We thereby kindly request your support by filling the attached questionnaire.

Your participation, although voluntary, is essential for the achievement of the research objectives. The completion of the questionnaire shall not exceed 20 minutes. If necessary, please provide any additional information related to each question at the end of the questionnaire. Results will be used on an aggregated level and will never be traced back to an individual. Please note that all responses will be treated with the utmost confidentiality and shall be used for only academic purposes.

Upon completion of the questionnaire, could you kindly return same via email to

lehlohonolothulo@ymail.com

In case you want to enquire about this study, please contact Mr LB Thulo using the same email address provided above. Alternative you may call Mr Thulo on 0795080902.

Thank you for your attention. We are looking forward to your reply.

Sincerely,

LB Thulo (MENG Candidate)

Prof E Theron (Supervisor)

Prof FA Emuze (Co-supervisor)

Appendix 2: Questionnaire

QUESTIONNAIRE

Purpose of Survey: To evaluate how quality planning, control and improvement determines the specification and delivery of construction materials on the department of public works infrastructure project

This questionnaire consists of sections A, B, C, D, & E

Answer all questions/statements honestly. Do not write your name or any contact details on the questionnaire. You do have the right to withdraw at any time without prejudice. Tick your answers. √ Likert scales: Frequency = 1 (never), 2 (rarely), 3 (sometimes), 4 (often), 5 (always) Agreement = 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree)

Section A: Demographic Information

1. Please indicate your gender.

Male	
Female	
Others	

2. Please indicate your age

18-20 years' old	
21-30 years' old	
31-40 years' old	
41-50 years' old	
51-60 years' old	
More than 60 years' old	

3. Please indicate the length of work experience in the construction/infrastructure sector

0-5 years of service	
6-10 years of service	
11-15 years of service	
16-20 years of service	
More than 20 years of service	

4. Please indicate your highest academic qualification.

Matric	
Post matric certificate/s	
Diploma/degree	
Honours/postgraduate Diploma	
Masters	
Doctorate	

5. Please indicate your current employment status.

Full-time worker	
Part-time worker	
Unemployed	
Student	
Other	

6. Please indicate your job title or position.

Senior management	
Engineer	
Project manager	
Inspector	
Artisan	
Contractor	
Other	

7. Please indicate the type of projects you undertake.

Capital (new projects)	
Maintenance projects	
Other	

8. Based on your lived experience, please indicate if the quality of public works projects is adequate.

Yes	
No	
Unsure	

Section B: Quality Planning

9. Based on your lived experience, please indicate if quality planning is done on public works projects.

Yes	
No	
Unsure	

10. Please indicate the professionals involved in quality planning.

Engineer	
Project Manager	
Quantity Surveyor	
Architect	
Other	

11. Who does the specification for a construction/infrastructure project?

Engineer	
Project manager	
Quantity survey	
Inspector	
Client	
Other	

12. Whom receives / demand project specification?

Engineer	
Project Manager	
Quantity Surveyor	
Architect	
Other	

13. On a scale of **1 (never)** to **5 (always)**, please rate the frequency in which you encounter the following issues at the planning stage of a project? **(please note the 'Unsure' option)**

	Issue	**Unsure**	**Never…….. Always**				
			1	**2**	**3**	**4**	**5**
13.1	Mistakes by specification writer (poor specification)	U	1	2	3	4	5
13.2	Delivery of substandard materials	U	1	2	3	4	5
13.3	Incomplete specification by the writer	U	1	2	3	4	5
13.4	Delays in producing specifications	U	1	2	3	4	5

Section C: Quality Control

14. Based on your lived experience, please indicate if quality control is done on public works projects.

Yes	
No	
Unsure	

15. Please indicate the professionals involved in quality control.

Engineer	
Project Manager	
Quantity Surveyor	
Architect	
Other	

16. Who delivers construction materials to the site?

Engineer	
Project manager	
Quantity survey	
Inspector	

Client	
Other	

17. Who receives delivered construction materials on-site?

Engineer	
Project Manager	
Quantity Surveyor	
Architect	
Other	

On a scale of **1 (never)** to **5 (always)**, please rate the frequency in which you encounter the following issues during the monitoring and control phase of a project? **(Please note the 'Unsure' option)**

	Issue	**Unsure**	**Never……..…… Always**				
			1	**2**	**3**	**4**	**5**
18.1	Damage of material during transportation	U	1	2	3	4	5
18.2	Specification errors	U	1	2	3	4	5
18.3	Specification additions and omissions	U	1	2	3	4	5
18.4	Variations in material quantities	U	1	2	3	4	5
18.5	Rework due to wrong spec or delivered materials	U	1	2	3	4	5
18.6	Delays in approvals and inspections	U	1	2	3	4	5
18.7	Scope and spec changes by clients	U	1	2	3	4	5
18.8	Incorrect project estimate / cost	U	1	2	3	4	5
18.9	Payment delays from clients	U	1	2	3	4	5
18.10	Appointment of incompetent contractors	U	1	2	3	4	5
18.11	Poor project communication among parties	U	1	2	3	4	5
18.12	Poor project coordination by parties	U	1	2	3	4	5
18.13	Inadequate cash flow (lack of working capital)	U	1	2	3	4	5
18.14	Poor project planning	U	1	2	3	4	5
18.15	Poor material management	U	1	2	3	4	5
18.16	Wrong interpretation of specifications	U	1	2	3	4	5
18.17	Non-availability of specific materials	U	1	2	3	4	5
18.18	Contractual disputes between project parties	U	1	2	3	4	5
18.19	Lack of technical personnel (skills shortage)	U	1	2	3	4	5
18.20	Price escalation	U	1	2	3	4	5
18.21	Material theft on site	U	1	2	3	4	5

Section D: Quality Challenges

18. Based on your lived experience, please indicate if quality improvement is made on public works projects.

Yes	
No	
Unsure	

On a scale of **1 (strongly disagree)** to **5 (strongly agree)**, please rate the level of agreement with the following quality challenges on a project? **(Please note the 'Unsure' option)**

	Challenge	Unsure	Strongly Disagree……Strongly Agree				
			1	2	3	4	5
20.1	Inability to develop long term strategies	U	1	2	3	4	5
20.2	Lack of access to funding	U	1	2	3	4	5
20.3	Delayed progress payment by the client	U	1	2	3	4	5
20.4	Poor cash-flow	U	1	2	3	4	5
20.5	Corruption	U	1	2	3	4	5
20.6	Reliance on inspection to assure quality	U	1	2	3	4	5
20.7	Lack of defect prevention	U	1	2	3	4	5
20.8	Lack of quality assurance	U	1	2	3	4	5

Section E: Quality Improvement

21. Based on your lived experience, please indicate if quality improvement is made on public works projects.

Yes	
No	
Unsure	

On a scale of **1 (strongly disagree)** to **5 (strongly agree)**, please rate the level of agreement with the following quality improvement aspects on a project? **(Please note the 'Unsure' option)**

	Aspect	Unsure	Strongly Disagree……Strongly Agree				
			1	2	3	4	5
22.1	Promote effective quality management	U	1	2	3	4	5
22.2	Undertake effective strategic planning	U	1	2	3	4	5
22.3	Provide clear information-sharing channels	U	1	2	3	4	5
22.4	Adhere to specifications	U	1	2	3	4	5
22.5	Adequate coordination of the project team	U	1	2	3	4	5
22.6	Conduct frequent progress meetings	U	1	2	3	4	5
22.7	Ensure proper material procurement	U	1	2	3	4	5
22.8	Appoint an experienced technical team	U	1	2	3	4	5
22.9	Appoint experienced contractors	U	1	2	3	4	5
22.10	Ensure timely supply of material	U	1	2	3	4	5
22.11	Allow for price escalation in tender documents	U	1	2	3	4	5

23. Please state any general comments or concerns you would like to share below:

Comments/Concerns:

_____

_____

_____

_____

—The End—

Thank you very much for taking the time to complete the questionnaire

Appendix 3: Interview Request Letter

Central University of Technology, Free State

22 February 2021

Dear Sir/Madam,

Re: Invitation to participate in MENG's research on quality improvement protocol

We write to humbly request your assistance in an ongoing Master of Engineering in Civil Engineering research project by attending an **interview** as part of the study's data collection process. The research project is entitled *"Quality improvement protocol for the specification and delivery of construction materials required by the Free State department of public works infrastructure projects"*. Mr LB Thulo carries out the study under Prof E Theron and Prof FA Emuze at the Central University of Technology, Free State.

The purpose of this phase of the study, specifically this interview, is to evaluate how quality planning, control and improvement determines the specification and delivery of construction materials on the department of public works infrastructure projects. We thereby kindly request your support by attending an interview.

Your participation, although voluntary, is essential for the achievement of the research objectives. An interview will last for at least one hour on average. Please note that all responses will be treated with the utmost confidentiality and shall be used for only academic purposes.

In case you want to enquire about this study, please contact Mr LB Thulo on lehlohonolothulo@ymail.com. Alternative you may call Mr Thulo on 0795080902.

Thank you for your attention. We are looking forward to your reply.

Sincerely,

LB Thulo (MENG Candidate)

Prof E Theron (Supervisor)

Prof FA Emuze (Co-supervisor

Appendix 4: Interview Protocol

INTERVIEW QUESTIONS

Purpose of Survey (Interview): To evaluate how quality planning, control and improvement determines the specification and delivery of construction materials on the department of public works infrastructure project

This interview consists of sections A, B, C, & D

Section A: Demographic Information

1. Tell me about quality on public works projects?

Section B: Quality Planning

2. How is quality planning done on public works projects?
3. Please take me through quality planning processes related to specification and delivery of construction materials on department of public works projects.
4. What challenges do you come across at the planning stage of a project?

Section C: Quality Control

5. How is quality control done on public works projects?
6. Please take me through quality control process related to specification and delivery of construction materials on department of public works projects.
7. During monitoring and controlling phase of a project, what challenges do you come across?

Section D: Quality Improvement

8. Please take me through quality improvement process related to specification and delivery of construction materials on department of public works projects.
9. What are the challenges associated to quality improvement of a project?

What are your general comments or concerns you would like to share?

Comments/Concerns:

_____

_____

_____

_____

—The End—

Thank you very much for taking the time to complete the interview

Appendix 5: Interview Transcripts

Interview 9

1. On average, fairly poor overall performance on public works projects. Quality standards is no longer maintained.
2. On capital (new projects) project inspectors from public works does quality control. They visit sites to do site inspection to check quality and to ensure that the service provider is complying with the specification set in the bill of quantities. On maintenance projects which are also referred to as in-house projects, the quality planning is not done and that becomes a problem during construction.
3. Making quality happen through managerial process and sequence of activities that produce the intended results. The process is through quality planning, quality control and quality improvement.
4. Challenges:
    - There are budget issues or constraints
    - Incompetent team members and inadequate skill
    - Lack of risk management

Interview 10

1. Quality and standard at Public Works is no longer important. Service providers are incompetent, even government officials are incompetent. Quality has dropped immensely in the past years.
2. Quality planning on maintenance projects is very poor because it is done in-house by maintenance personnel such as artisans and artisans' foreman. Then on capital projects quality is good. This is because new projects are outsourced to the private consulting or service providers.
3. Step 1: Establish project specification and delivery of construction materials
   Step 2: Identify and discover customer\s needs
   Step 3: Then develop solutions
   Step 4: Develop the process and controls
4. Challenges: Scope charges over and over
   - There is lack of communication
   - Lack of clear goals
   - Lack of success criteria
5. Regular meetings are held such as formal site meetings, informal site meetings. These meetings are held to discuss matters relating to quality.
6. By choosing the controls subjects:
   - Control the compilation of specification and delivery of construction materials
   - Choose the units at measurement and follow the measurement properly
7. Too many details.
   - Incorrect delivery of construction material to site
   - Incorrect quantities of construction material delivered to site
   - One of the biggest challenges is the customer satisfaction.
8. Quality improvement is a continuous process.
9. Lack of funding and resources and lack of integrated model of quality improvement management.

Interview 11

1. Quality on Public Works projects is very poor. Wrong materials are used and projects completed late.
2. Quality planning is not done at Public Works.
3. For in-house projects (maintenance projects) which are done by artisans from public works. There are also inspectors from inspectorate directorate which compile the bill of quantities and specification in the BOQ needs to be correct for the service provider. So quality planning process related to specification and delivery of construction material is that specification in the BOQ must be correct so that delivery of material is correct.
4. Team member do not want to take responsibility and accountability
    - There is limited engagement of stakeholders and parties involved in a project
    - Having unrealistic deadlines is another challenges
5. Site construction book is used to record work that is not acceptable work done on site according to the bill of quantities.
6. Comply with the standards of performance. Measure the actual performance. Quality control process follows the following procedure:
    - Identify quality problem
    - Record quality on site diary or site instruction book
    - Address quality among project meetings
7. Too much documentation

Some information on the daily site diary and the site instruction book.

Disputes between government officials and the service providers.

8. Projects that are 100% complete should be selected lessons learned for each project recorded for future improvement.
9. The challenges are:
    - Lack of proper training of staff officials
    - Poor morale

Interview 12

1. According to me quality is realized performance over expectation and that is not the case at Public Works. Quality on project is poor.

2. Quality is supposed to be maintained throughout all the project stages. There are no longer standards and procedures to follow.

3. Quality planning process

    - Bring all stakeholders up to speed on the project
    - Training in new and improved techniques
    - Select and apply the correct value improving practise
    - Perform reviews
    - Approve key steps and procedures

4. Scope creep: due to clients' needs not clearly defined.

    - Miscommunication: ineffective communication affects the teamwork
    - Project plan: there is no clarity in goals which affects the successful completion of a planning stage. Lack of clear success criteria

5. Work done according to specification and BOQ. Quality is inspected regularly on site by Public Work Inspectors.

6. I think it can be expected by simply following the Public Works procedures and standards. Following the standards will control the quality.

7. Too much rigidity; like it the system is too tight it becomes very difficult to improve. Compliance with specification and bill of quantities. Payment delays by client departments to pay the service providers.

8. Quality improvement process must be a continuous process because there is always a need for improvement.

9. There is lack of cooperation among the officials and staff members and resistance against change by the team members.

REFERENCES

Aamer, A., Al- Awlaqi, M. & Alkibsi, S. M., 2017. TQM implementation in a least developed country: an exploratory study of Yemen. *The TQM Journal,* 29(3), pp. 467 - 487.

Aigbavboa, C. & Thwala, W., 2014. *An assessment of critical success factors for the reduction of the cost of poor quality from construction projects in South Africa.* s.l., s.n., pp. 773-782.

Aiyetan, O., 2019. Influence of the Management Styles and Quality of Management on Project Delivery. *Journal of Construction Business and Management,* 3(1), pp. 38-44.

Akampurira, E. & Windapo, A., 2018. Factors influencing the quality of design documentation on South African civil engineering projects. *ournal of the South African Institution of Civil Engineering,* 60(3), pp. 41-48.

Akkermans, H. & Van Oorschot, K., 2018. Relevance assumed: a case study of balanced scorecard development using system dynamics. *In System dynamics,* pp. 107-132.

Ali, M., 2020. Digitization of the emerging economy: An exploratory and explanatory case study. *Journal of Governance and Regulation,* 9(4), pp. 25-36.

Al-Janabi, A., Abdel-Monem, M. & El-Dash, K., 2020. Factors causing rework and their impact on projects' performance in Egypt. *Journal of civil engineering and management,* 26(7), pp. 666-689.

Ashworth, A. & Perera, S., 2015. *Cost studies of buildings.* s.l.:Routledge.

Aziz, R. & Hafez, S., 2013. Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal,* 52(4), pp. 679-695.

Babbie, E., 2020. *The practice of social research.* s.l.:Cengage learning.

Baker, E., Mellors, B., Chalmers, S. & Lavers, A., 2013. *FIDIC contracts: law and practice.* s.l.:CRC Press.

Baloyi, T., 2013. *The application, utilisation and implementation of total quality management in the South African manufacturing industry: A case study.* s.l.: University of Johannesburg (South Africa).

Baskarada, S., 2014. Qualitative case study guidelines. *The Qualitative Report,* 19(40), pp. 1-25.

Bikitsha, L. & Amoah, C., 2020. Assessment of challenges and risk factors influencing the operation of emerging contractors in the Gauteng Province, South Africa. *International Journal of Construction Management,* pp. 1-10.

Bilsel, R. & Lin, D., 2012. Ishikawa cause and effect diagrams using capture recapture techniques. *Quality Technology & Quantitative Management,* 9(2), pp. 137-152.

Bowen, P., Edwards, P. & Cattell, K., 2015. Corruption in the South African construction industry: experiences of clients and construction professionals. *International Journal of Project Organisation and Management,* 7(1), pp. 72-97.

Brooks, T. a. S. J., 2016. *Does inappropriate quality control demotivate workers.* s.l., s.n., pp. 871-880.

Brooks, T. & Spillane, J., 2017. Lies, Damned Lies and Quality Management Systems: A Pilot Case Study In: Chan, P W and Neilson, C J (Eds). *Proceeding of the 33rd ARCOM Conference,* pp. 582-591.

Bryman, A., 2016. *Social research methods.* s.l.:Oxford university press.

Butt, A., Naaranoja, M. & Savolainen, J., 2016. Project change stakeholder communication. *International Journal of Project Management,* 34(8), pp. 1579-1595.

Cameron, E. & Green, M., 2019. *Making sense of change management: A complete guide to the models, tools and techniques of organizational change.* s.l.:Kogan Page Publishers.

Chapman, W., Bahill, A. & Wymore, A., 2018. *Engineering modeling and design.* s.l.:CRC Press.

Chatzipetrou, E. & Moschidis, O., 2017. An exploratory analysis of quality costing in Greek F&B enterprises. *The TQM Journal.*

Chen, L. & Luo, H., 2014. A BIM-based construction quality management model and its applications. *Automation in construction,* Volume 46, pp. 64-73.

Chinyamurindi, W., 2017. The role of information management in project management success: Narratives from entrepreneurs operating within the South African construction industry. *South African Journal of Information Management,* 19(1), pp. 1-9.

CIDB, 2004. *SA construction industry status report-2004: Synthesis review on the South African construction industry and its development,* s.l.: s.n.

CIDB, 2011. *Construction Quality in South Africa, a Client Perspective.,* s.l.: s.n.

CIDB, 2014. *The CIDB Construction,* s.l.: s.n.

Crawford, L., Ba, H. & Stretton, A., 2018. *Bodies of knowledge and competency standards in global project management. The AMA handbook of project management.*. New York: American Management Association.

Creswell, J. & Poth, C., 2016. *Qualitative inquiry and research design: Choosing among five approaches.* s.l.:Sage publications.

Crotty, M., 2020. *The foundations of social research: Meaning and perspective in the research process.* s.l.:Routledge.

Davies, A., Dodgson, M., Gann, D. & MacAulay, S., 2017. Five rules for managing large, complex projects. *MIT Sloan Management Review,* 59(1), p. 73.

Davis, K., 2014. Different stakeholder groups and their perceptions of project success. *International journal of project management,* 32(2), pp. 189-201.

Dilawo, R. & Salimi, Z., 2019. Understanding TQM implementation barriers involving construction companies in a difficult environment. *International Journal of Quality & Reliability Management.*

DPW&I, 2022. *Infrastructure.* [Online]
Available at: http://www.publicworks.fs.gov.za/
[Accessed 11 December 2022].

Du Plessis, H. & Oosthuizen, P., 2018. Construction project management through building contracts, a South African perspective. *Acta Structilia,* 25(1), pp. 152-181.

Echeverria, V. et al., 2018. Exploratory versus explanatory visual learning analytics: Driving teachers' attention through educational data storytelling. *Journal of Learning Analytics,* 5(3), pp. 72-97.

ECSA, 2022. *Home.* [Online]
Available at: https://www.ecsa.co.za/default.aspx
[Accessed 11 December 2022].

El-Gohary, K. M. & Aziz, R. F., 2014. Factors influencing construction labor productivity in Egypt. *Journal of management in engineering,* 30(1), pp. 1-9.

Ellis, L. & Martin, H. a. R. S., 2019. *Factors influencing triple constraints in public sector projects in Trinidad and Tobago.* s.l., s.n., pp. 157-169.

Emuze, F., 2017. *The human contribution to unsafe construction acts and conditions in the central region of South Africa.* s.l., s.n., pp. 330-339.

Emuze, F. & Mhlwa, C., 2015. Managing quality on construction sites in South Africa: An Eastern Cape study. *Journal of Construction Project Management and Innovation,* 5(2), pp. 1224-1237.

Emuze, F. & Smallwood, J., 2011. Improving project delivery in South African construction. *n Proceedings of the 27th Annual Association of Researchers in Construction Management (ARCOM) Conference* , pp. 5-7.

Emuze, F. & Smallwood, J., 2013. *Construction motor vehicle accidents in South Africa: causes and impact.* s.l., READING, p. 4.

Emuze, F. & Smallwood, J., 2013. *Mapping 'rework' related findings in South Africa?.* s.l., s.n., pp. 1615-1620.

Emuze, F., Smallwood, J. & Han, S., 2014. Factors contributing to non-value adding activities in South African construction. *Journal of Engineering, Design and Technology.*

Enshassi, A., Sundermeier, M. & Zeiter, M., 2017. Factors contributing to rework and their impact on construction projects performance. *International Journal of Sustainable Construction Engineering and Technology,* 8(1), pp. 12-33.

Fewings, P. a. H. C., 2019. *Construction project management: an integrated approach.* s.l.:Routledge.

Forbes, L. a. A. S., 2010. *Modern construction: lean project delivery and integrated practices.* s.l.:CRC press.

Forbes, L. & Ahmed, S., 2020. Lean in the construction phase of the LPDS. *In Lean Project Delivery and Integrated Practices in Modern Construction,* pp. 86-114.

Forbes, L. & Ahmed, S., 2020. *Lean Project Delivery and Integrated Practices in Modern Construction.* s.l.:Routledge.

Frank, G., 2011. *Construction quality: Do it right or pay the price.* s.l.:Pearson Higher Ed.

Gerring, J., 2004. What is a case study and what is it good for?. *American political science review,* 98(2), pp. 341-354.

Glaser, B. & Strauss, A., 2017. *The discovery of grounded theory: Strategies for qualitative research.* s.l.:Routledge.

Goh, Y., Ubeynarayana, C., Wong, K. & Guo, B., 2018. Factors influencing unsafe behaviors: A supervised learning approach.. *Accident Analysis & Prevention,* Volume 118, pp. 77-85.

Gulghane, A. & Khandve, P., 2015. Management for construction materials and control of construction waste in construction industry: a review. *International Journal of Engineering Research and Applications,* 5(4), pp. 59-64.

Gunduz, M. & Yahya, A., 2018. Analysis of project success factors in construction industry. *Technological and Economic Development of Economy,* 24(1), pp. 67-80.

Hale, A. & Borys, D., 2013. Working to rule, or working safely? Part 1: A state of the art review. *Safety science,* Volume 55, pp. 207-221.

Heravi, A., Coffey, V. & Trigunarsyah, B., 2015. Evaluating the level of stakeholder involvement during the project planning processes of building projects. *International Journal of Project Management,* 33(5), pp. 985-997.

Hesse-Biber, S. & Leavy, P., 2011. *The Practice of Qualitative Research.* s.l.:SAGE.

Hollnagel, E. & Clay-Williams, R., 2022. Work-as-Imagined and Work-as-Done. *In Implementation Science,* pp. 175-177.

Hwang, B. & Yang, S., 2014. Rework and schedule performance: A profile of incidence, impact, causes and solutions. *Engineering, Construction and Architectural Management.*.

Kerfai, N., Bejar Ghadhab, B. & Malouche, D., 2016. Performance measurement and quality costing in Tunisian manufacturing companies. *The TQM Journal,* 28(4), pp. 588-596.

Kerzner, H., 2022. *Project management case studies.* s.l.:John Wiley & Sons.

Laura, M. & Bernauer, J., 2013. *Quantitative Research for the Qualitative Researcher.* s.l.:SAGE Publications.

Lindelof, A. & Hansen, L., 2015. alking about theatre: Audience development through dialogue. *Participations,* 12(1), pp. 234-253.

Li, Y. & Taylor, T., 2014. Modeling the impact of design rework on transportation infrastructure construction project performance. *Journal of Construction Engineering and Management,* 140(9), p. 04014044.

Lock, D., 2017. *The essentials of project management.* s.l.:Routledge.

Lombard, F., 2010. *Managing the quality of engineering on large construction projects in the South African context,* Pretoria: Doctoral dissertation, University of Pretoria.

Lopez, R., Love, P., Edwards, D. & Davis, P., 2010. Design error classification, causation, and prevention in construction engineering. *Journal of performance of constructed facilities,* 24(4), pp. 399-408.

Love, P., Wang, X., Sing, C. & Tiong, R., 2013. Determining the probability of project cost overruns. *Journal of Construction Engineering and Management,* 139(1), pp. 321-330.

Magnaye, R., SSC, B. & Varma, N., 2020. Bridging the Gap between Practice and Undergraduate Teaching of Operations Management: The Case of Public Liberal Arts Colleges. *International journal of operations and quantitative management,* 26(1), pp. 59-64.

Maio, G., Haddock, G. & Verplanken, B., 2018. *The psychology of attitudes and attitude change.* s.l.:Sage.

Marcelino-Sádaba, S., Pérez-Ezcurdia, A., Lazcano, A. & Villanueva, P., 2014. Project risk management methodology for small firms. *International journal of project management*, 32(2), pp. 327-340.

Marin-Garcia, J. & Bonavia, T., 2015. Relationship between employee involvement and lean manufacturing and its effect on performance in a rigid continuous process industry. *International Journal of Production Research*, 53(11), pp. 3260-3275.

Mavetera, N., Sekhabisa, K., Mavetera, C. & Choga, I., 2015. Factors Influencing Success Of Construction Projects By Emerging Contractors In South Africa: A Case of Mahikeng area. *Journal of Corporate Ownership and Control*, 13(1), pp. 1- 9.

Mayer, I., 2015. Qualitative research with a focus on qualitative data analysis. *International Journal of Sales, Retailing & Marketing*, 4(9), pp. 53-67.

Mbande, C., 2010. *Overcoming construction constraints through infrastructure delivery.* s.l., s.n., pp. 18-20.

Mbijiwe, L., 2017. *Design Factors Influencing The Quality Of Government Funded Building Projects (Doctoral dissertation, University of Nairobi)*, s.l.: s.n.

Milford, R., 2010. *Public capacity payment and procurement issues should be a challenge to the operations of contractors in South Africa.* Durban, South Africa, s.n., pp. 18-20.

Mitra, A., 2016. *Fundamentals of quality control and improvement.* s.l.:John Wiley & Sons.

Mnyandu, T., 2020. *The economic impact of engineering project quality management in the construction industry in Richards Bay, South Africa.*, s.l.: s.n.

Moschidis, O., Chatzipetrou, E. & Tsiotras, G., 2018. Quality costing and quality management maturity in Greece: an exploratory multi-dimensional data analysis. *International Journal of Productivity and Performance Management.*

Mukhopadhyay, M., 2020. *Total quality management in education.* s.l.:SAGE Publications Pvt. Limited.

Nimbona, Y. & Agumba, J., 2014. *Perception of construction industry stakeholders on the critical attributes that contribute to project success.* s.l., s.n.

Obunwo, C., Chinyio, E. .. & Suresh, S., 2015. Relative contributions of project quality to customer satisfaction in Nigerian road construction projects In: Raidén, A B and Aboagye-Nimo, E (Eds). *Procs 31st Annual ARCOM Conference,* pp. 763-772.

Orstavik, F., 2018. *September. Negotiating and Knowing Built Quality.* s.l., s.n., pp. 3-5.

Othman, A., 2012. An innovative protocol for improving the ethical behaviour of the quantity surveying profession in South Africa. *International Journal of Construction Management,,* 12(3), pp. 43-62.

Oyewobi, L., Windapo, A. & James, R., 2015. An empirical analysis of construction organisations' competitive strategies and performance Luqman Oyekunle Oyewobi Abimbola Oluwakemi Windapo Rotimi Olabode Bamidele James. *Built Environment Project and Asset Management,,* 5(4).

Oyewobi, L., Windapo, A. & Rotimi, J., 2015. Measuring strategic performance in construction companies: a proposed integrated model. *Journal of Facilities Management.*

Pandey, P. a. P. M., 2021. *Research methodology tools and techniques.* s.l.:Bridge Center.

Pandey, P. & Pandey, M., 2015. Research Methodology: Tools and Techniques. *Bridge Center.*

Paraschivescu, A. O. & COTIRLET, P. C., 2015. Quality Continous Improvement Strategies Kaizen Strategy--Comperative Analysis. *Economy Transdiscipilinary Congition,* 18(1).

Patel, K. a. V. C., 2011. *Construction materials management on project sites.* s.l., s.n., pp. 1-5.

Pollack, J. & Adler, D., 2015. Emergent trends and passing fads in project management research: A scientometric analysis of changes in the field. *International Journal of Project Management,* 33(1), pp. 236-248.

Queirós, A., Faria, D. & Almeida, F., 2017. Strengths and limitations of qualitative and quantitative research methods. *European journal of education studies.*

Ramabodu, M. & Verster, J., 2010. *An evaluation of cost overruns in public sector projects: in the Free State province of South Africa.* s.l., s.n., pp. 18-20.

Republic of South Africa, 2014. *Strategic Plan,* Pretoria: Department of Labour.

Rivas, R., Borcherding, J., Gonzalez, V. & Alarcon, L., 2011. Analysis of factors influencing productivity using craftsmen questionnaires: case study in a Chilean construction company. *Journal of Construction Engineering and Management,* 137(4), pp. 312-320.

Rooplall, N., Marnewick, A. & Pretorius, J., 2016. *"Trends preventing engineers from obtaining professional registration with ECSA in the required time,".* s.l., Industrial Engineering and Engineering Management (IEEM).

Rumane, A., 2017. *Quality management in construction projects.* s.l.:CRC press.

SACAP, 2022. *About Us.* [Online]
Available at: https://www.sacapsa.com/about
[Accessed 11 December 2022].

SACPCMP, 2022. *About.* [Online]
Available at: https://sacpcmp.org.za/about-sacpcmp/
[Accessed 11 December 2022].

SACQSP, 2022. *Home.* [Online]
Available at: https://www.sacqsp.org.za/
[Accessed 11 December 2022].

Saffar, N. & Obeidat, A., 2020. The effect of total quality management practices on employee performance: The moderating role of knowledge sharing. *Management Science Letters,* 10(1), pp. 77-90.

SAKA, N., 2022. AN ASSESSMENT OF THE IMPACT OF THE CONSTRUCTION SECTOR ON THE GROSS DOMESTIC PRODUCT (GDP) OF NIGERIA. *Journal of Surveying, Construction and Property,* 13(1), pp. 467-487.

Sallis, E., 2014. *Total quality management in education.* s.l.:Routledge.

Salvi, M. & Kerkar, M., 2020. Quality Assurance and Quality Control for Project Effectiveness in Construction and Management. *International Journal of Engineering Research & Technology (IJERT),* 9(2), pp. 26-29.

Sarhan, S. a. F. A., 2013. Performance measurement in the UK construction industry and its role in supporting the application of lean construction concepts. *Australasian Journal of Construction Economics and Building*, 13(1), pp. 23-35.

Saunders, M., Lewis, P. & Thornhill, A., 2019. *Research methods. Business Students 8th edition.* England: Pearson Education Limited.

Scott, L. & Kanjanabootra, S., 2019. The Productivity, Performance and Quality Paradox: An Alternative Perspective In: Gorse, C and Neilson, C J (Eds). *Proceedings of the 35th Annual ARCOM Conference*, pp. 134-142.

Shaari, N. et al., 2015. Practices for project quality management systems (PQMS) in construction project. *Jurnal Teknologi*, 77(26).

Siddiqui, S., Ullah, F., Thaheem, M. & Gabriel, H., 2016. Six Sigma in construction: a review of critical success factors. *International Journal of Lean Six Sigma.*

Singh, Y. & Dubey, B., 2021. *Introduction of Research Methods and Publication Ethics.* s.l.:Friends Publications.

Staples, C. & Spillane, J., 2019. *EXPLORING THE POTENTIAL IMPROVEMENT OF QUALITY CONTROL IN THE CONSTRUCTION INDUSTRY WITH THE USE OF DIGITAL TECHNOLOGY.* s.l., s.n., p. 406.

Steyn, H. et al., 2016. *Project management: A multi-disciplinary approach.* s.l.:FPM Publishing.

Suresh, S., Olayinka, R., Chinyio, E. & Renukappa, S., 2016. *Impact of knowledge management on construction projects.* s.l., s.n., pp. 27-43.

Tabish, S. & Jha, K., 2015. Success factors for safety performance in public construction projects. *The Indian Concrete Journal*, 89(2), pp. 58-72.

Taggart, M., Koskela, L. & Rooke, J., 2014. The role of the supply chain in the elimination and reduction of construction rework and defects: an action research approach. *Construction Management and Economics*, 32(7-8), pp. 829-842.

Taidi, R., 2015. Cost of Poor quality: Quality management in Lean manufacturing and the effectiveness of the “Zero defects” goal”. *Scientific Cooperations International Journal of Finance, Business, Economics, Marketting and Information Systems*, Volume 1.

Talebi, S. et al., 2021. Causes of defects associated with tolerances in construction: A case study. *Journal of Management in Engineering*, 37(4), p. 05021005.

Tchidi, M., He, Z. & Li, Y., 2012. Process and quality improvement using Six Sigma in construction industry. *ournal of Civil Engineering and Management*, 18(2), pp. 158-172.

Tripathi, K. a. J. K., 2018. An empirical study on performance measurement factors for construction organizations. *KSCE journal of civil engineering*, 22(4), pp. 1052-1066.

Tripathi, K. H. A. a. N. J. K., 2021. Evaluating performance of construction organizations using fuzzy preference relation technique. *International Journal of Construction Management*, 21(12), pp. 1287-1300.

Tshoose, C., 2015. *Dynamics of public participation in local government: A South African perspective*, s.l.: s.n.

Tuli, B. & Allopi, D., 2014. Impact of inadequate experience and skill on the construction sector in KwaZulu-Natal, South Africa. *Engineering, Technology & Applied Science Research*, 4(1), pp. 570-575.

VAN DIE, R., 2000. *Government Gazette*, s.l.: Presidency 1(785).

Van Weele, A., 2018. *Procurment and Supply Chain.* seventh ed. Netherlands: Cengage Learning EMEA.

Venkatesh, V., Brown, S. & Bala, H., 2013. Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS quarterly*, pp. 21-25.

Wanberg, J., Harper, C., Hallowell, M. & Rajendran, S., 2013. Relationship between construction safety and quality performance. *Journal of construction engineering and management*, 139(10), p. 04013003.

Yaghootkar, K. & Gil, N., 2012. The effects of schedule-driven project management in multi-project environments. *International Journal of Project Management*, 30(1), pp. 127-140.

Yan, F. X. J. a. H. B., 2015. Material transportation problems in construction projects under an uncertain environment. *KSCE Journal of Civil Engineering*, 19(7), pp. 2240-2251.

Yin, R. K., 2013. Validity and Generalization in Future Case Study Evaluations Research: design and methods. *Evaluation*, pp. 321-332.

Yu, M. et al., 2018. Integrating sustainability into construction engineering projects: Perspective of sustainable project planning. *Sustainability*, 10(3), p. 784.

Zhang, X., 2019. *Integrating Lean Construction, BIM and Quality: A New Paradigm for the Improvement of Chinese Construction Quality*, s.l.: Doctoral dissertation, University of Bath.

Zwikael, O. & Smyrk, J., 2015. Project governance: Balancing control and trust in dealing with risk. *International Journal of Project Management*, 33(4), pp. 852-862.